Towards the Meteorological

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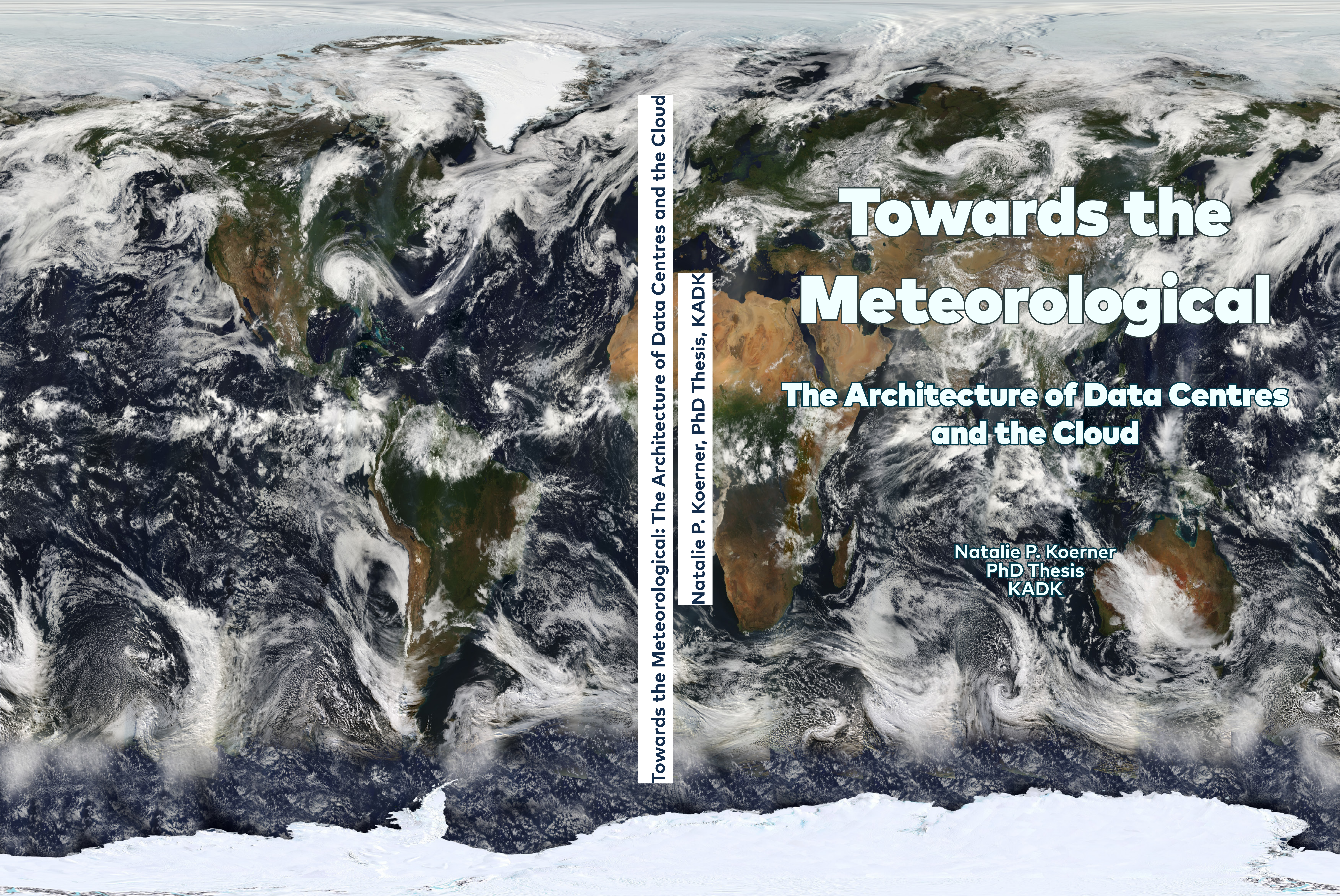

Towards the Meteorological: The Architecture of Data Centres and the Cloud

Natalie P. Koerner, PhD Thesis, KADK

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I would build that dome in air,
That sunny dome! those caves of ice!

Samuel Taylor Coleridge, *Kubla Khan*, 1815

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Excerpts of the Thesis have been published in the following articles

2020	"Beyond Millions of Plans: A Geometry of Clouds," chapter in *Drawing Millions of Plans*, Birkhäuser, editors Anna Katrine Hougaard and Martin Søberg
2019	Forthcoming, peer reviewed: "Il Grande Cretto and the Shifting Ground: Temporalities of the Geological Mode" in *Emotion, Space and Society*, Special issue: "Losing Ground: A Collection of Holes", editors Marijn Nieuwenhuis and Aya Nassar
2018	Peer-reviewed Chapter "Embodied Time: Chronotopes of Negation, Expansion, Presence, and Suspense" in *Architecture and Control*, ed. Henriette Steiner, Kristin Veel and Annie Ring (London, Brill Rodopi).
	Peer-reviewed article "Theatres of the Mind: Embodied Memory" in *Nordic Journal of Architectural Research.*
	"The Dreamclouds of 1966" in *66*, San Rocco
2017	"The Digital Cloud and the Great Outdoors" in *Future Legacy*, The Site Magazine
2016	"The Suspension of Memory" in *PAPER,* Issue #27 "Nature, Time, and the Anthropocene" with Henriette Steiner *in Esse Arts + Opinions,* Number 88.

Abstract

The digital cloud permeates daily life. The $174 billion industry is fuelled by 3.6 billion users and constitutes three per cent of global energy consumption. This thesis examines the cloud metaphor and the data centres it denotes to reveal the cloud's temporality, spatiality and materiality from an architectural perspective. By creating analogies with cloud variations—meteorological, fictional and artificial clouds—the research seeks to uncover what the metaphor discloses about digital archives. Despite the (digital) cloud's ample presence in adjacent fields, a theoretical framework for it has yet to be established in architecture. Tapping into the planetary imaginary, I show that digital archives embody the meteorological mode: like meteorological clouds, they are extremely responsive and governed by an archival impulse to continuously update their animated, mobile data.

Part I addresses the geological implications of data centres, the physical backbone of the cloud, as servers are made of materials extracted from the ground: metals, minerals, rare earth elements (Parikka). The beginnings of geology as a science (Hutton, Lyell) defined the planet as an archive. In dialogue with a variety of thinkers (Ruskin, Smithson, Ernst, Leopold, Bjornerud, Cohen, Deleuze and Guattari), I develop the geological mode—a temporal, material and spatial method that embodies the logic of the ground. It guides my analysis of three case studies. The first is the Lamont-Doherty Earth Observatory, New York. This archives sediment cores, extracted from ocean floors, which contain geophysical and environmental histories embodied in fossils. Thinking with Meillassoux, I explore the vast temporal horizons stored in the formerly animated matter. To further gauge the ground's temporalities, I turn to the large-scale memorial *Il Grande Cretto* (1984–2015) by artist Alberto Burri. It archives geological matter that used to constitute the built fabric of Gibellina before the latter was destroyed in an earthquake. In line with the planet's intrinsic movement (Clark), affect theory (Ahmed, Berlant)

and art-historical references, I understand *Il Grande Cretto* as Burri's attempt to suspend persistent geological activities. The geological mode engenders archives that incessantly update their content. This mode is embodied in Henning Larsen's Nordea Bank headquarters data centre (2017). Data centres harness the archival capacities of geological matter. Their ingrained secrecy, resilience and redundancy invite architectural comparison to the bunker (Virilio, Hu). The bunker is positioned in tension with vast infrastructure networks from which data centres cannot be isolated (Koolhaas, Easterling).

In Part 2, against the backdrop of the firm but active (geological) ground of data centres, I turn to the cloud and the meteorological mode. Beginning with the philosophical context of the sky and its clouds as media (Durham Peters), I describe meteorological clouds' aerosols as data points that literally store and transmit information. Like data in the digital cloud, the continuously transforming and shifting aerosols compose ever-new adjacencies and juxtapositions. Referring to early computing (Babbage), I postulate meteorological clouds as analogue computers. For an architectural constellation of weather and computing, I turn to meteorologist Richardson's speculative Forecast Factory (1922)—a combination of a cloud and a globe, designed to compute and archive the planet's weather. I then turn to the archiving history that has affected the cloud metaphor. The example of an early databank proposed by the American government in 1966 reveals how the cybernetic archive, in combination with the constant presence of radioactivity during the Cold War, fuelled archive (Derrida) and network fever (Wigley), finally culminating in our digital cloud. The outsourcing of nonconscious cognitive processes (Hayles) to technical beings is an attempt to cool these fevers. I pair the digital cloud's nonconscious realm of machine learning and Big Data with the notion of a great outdoors (Meillassoux, Bennett). Artificial clouds mediate the inaccessible. Architectural examples during the 1960s (Wright, Ant Farm) actualised the cloud mediator at a time of budding instant global communication and space travel.

The digital cloud thus constitutes an exterior, a physically inaccessible realm that is paradoxically filled with intimate and identity-defining information about its externalised users. The digital cloud is more than a metaphor: it articulates an increasingly pervasive spatiality of the threshold, of bodies without surfaces, of space as media, of our built world extended into the intangible—in short, a great outdoors.

Resumé

Den digitale sky gennemsyrer det daglige liv. 3,6 milliarder brugere føder den 174 $ millionindustri som udgør 3% af det globale energiforbrug. Afhandlingen undersøger metaforen og de datacentre som det er tegn på for at afsløre skyens midlertidighed, rumlighed og materialitet fra et arkitektonisk perspektiv. Ved at skabe analogier med skyvariationer – meteorologiske, fiktive og nedfalds-skyer – søger undersøgelsen at afdække hvad sky-metaforen afslører om digitale arkiver. På trods af den (digitale) skys omfattende tilstedeværelse i beslægtede fagområder, har den stadig ikke etableret en teoretisk ramme i arkitektur. Gennem "planetary imaginary" viser jeg at digitale arkiver legemliggør det meteorologiske modus: som meteorlogiske skyer er de ekstremt responsive og opdaterer konstant deres animerede mobile data, styret af en arkiveringsimpuls til at opdatere.

Del I undersøger geologiske konsekvenser af datacentre, skyens fysiske rygrad, da servere er lavet af materialer udvundet af jorden: metaller, mineraler, sjældne jordarter (Parikka). Da geologi var en ung videnskab defineredes planeten som et arkiv. I dialog med en række tænkere (Ruskin, Smithson, Ernst, Leopold, Bjornerud, Cohen, Deleuze og Guattari) udvikler jeg den geologiske modus – en tidslig, materiel og rumlig metode der legemliggør jordens/terrænets logik. Det guider min analyse af tre casestudier. Først Lamont-Doherty Earth Observatory. Det arkiverer sedimentkerner udtaget af fra havbunden, der indeholder geofysiske og miljø historier legemliggjort i fossiler. Med Meillassoux undersøger jeg de store tidslige horisonter i det før animerede stof. For yderligere at vurdere terrænets tidsligheder, vender jeg mig mod stor-skala mindesmærket *Il Grande Cretto* (1984–2015) af kunstneren Alberto Burri. Det arkiverer geologisk materiale der engang udgjorde Gibellina´s byggede struktur, før det blev ødelagt af jordskælv. I tråd med planetens immanente bevægelse (Nigel Clark), affekt teori (Sara Ahmed og Lauren Berlant) og kunsthistoriske referencer, forstår jeg *Cretto* som Burri's forsøg på at skabe

et ophold, en pause i de vedvarende geologiske aktiviteter. Den geologiske modus frembringer arkiver der uafbrudt opdaterer deres indhold. Denne modus er legemliggjort i Nordeas hovedkvarters datacenter af Henning Larsen, 2017. Datacentre tæmmer det geologiske stofs kapacitet til at arkivere. Deres indgroede hemmelighedsfuldhed modstandsdygtighed og redundans inviterer den arkitektoniske sammenligning til bunkeren (Virilio, Hu). Bunkeren er som en modvægt overfor den omfattende infrastruktur som datacentrerne ikke kan isoleres fra (Koolhaas, Easterling).

I Del II med datacentrers faste men aktive (geologiske) terræn som baggrund, har jeg vendt mig mod skyen og den meteorologiske modus. Begyndende med den filosofiske kontekst af skyen og dets skyer som medie (Durham Peters) beskriver jeg de meteorologiske skyers drivgas som datapunktskyer, der bogstaveligt lagrer og overfører information. Som data i den digitale sky, komponerer den konstant foranderlige og omskiftelige drivgas stadigt nye forbindelser og sammenstillinger. Med reference til tidlig "computing" (Babbage) taler jeg for meteorologiske skyer som analoge computere. For en arkitektonisk konstellation af vejr og "computing" vender jeg mig mod meteorologen Richardsons spekulative Forecast Factory (1922) – en kombination af en sky og en klode, designet til at beregne og arkivere planetens vejr. Jeg vender mig mod den arkiveringshistorie som har påvirket skymetaforen. Eksemplet med en tidlig databank foreslået af den amerikanske regering i 1966, afslører hvordan det kybernetiske arkiv i kombination med den kolde krigs konstante tilstedeværelse af radioaktivitet, gav næring til arkiv- og netværkfeber, kulminerede afslutningsvis i vores digitale sky. Udlicitering af ubevidste kognitive processer (Hayles) til "technical beings", er et forsøg på at dæmpe disse febertilstande. Jeg kobler den digitale skys domæne af ubevidstes "mschine learning" og big-data med forestillingen om et "great outdoors" (Meillassoux, Bennett). Kunstige skyer medierer det utilgængelige. Arkitektoniske eksempler fra 1960-erne (Wright, Ant Farm) aktualiserer skymediatoren i en tid hvor det globale, øjeblikkelig kommunikation og rumrejser spirede.

Den digitale sky udgør et eksteriørt og fysisk utilgængeligt domæne der paradoksalt nok er fyldt med intime og identitet-definerende information om dets eksternaliserede brugere. Den digitale sky er mere end en metafor: den artikulerer, stadig mere gennemtrængende, tærsklens rumlighed, af kroppe uden overflader, af medie som rum, af vores byggede verden udvidet til det uhåndgribelige – kort sagt et ”great outdoors”.

Thank you

To the KADK, for the opportunity to pursue this research.

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To my family and friends, for your encouragement.

Foreword

My research is affiliated with the Institute of Architecture and Culture at the Royal Danish Academy of Fine Arts' Schools of Architecture, Design and Conservation, to which my supervisors Carsten Thau and Peter Bertram belong. The institute emphasises historical and theoretical trends in society and their connection to the practice of architecture. My research is twofold. As a practitioner, I work with spatial installations to explore my research topic. These objects will be exhibited at the PhD defence. As they are best experienced through their spatial presence, you will only find abstract representations throughout this print document, which contains my academic research. Both parts of the PhD are understood as autonomous projects dedicated to the same research questions.

Beginning in the autumn of 2015 with a historical approach, I undertook preliminary research into spatial analogies used throughout history to describe the invisible workings of memory as a mental storage and retrieval system. This exploration revealed the most intriguing of all archival imaginings: the cloud. In September 2016, the experience of an earthquake site 10 days after the event (August 2016 Central Italy earthquake) made me acutely aware of the fundamental phenomenological disconnection that separates humans from the intrinsic geological activities that permeate the ground. Participation in the summer school "Planetary Futures" (August 2017) at Concordia University (organised by interactive design theorist Orit Halpern, among others) fortified my understanding and use of planetary-scale imaginaries and phenomena. A period as visiting scholar at the Parsons School of Design at the New School in New York was fruitful for my artistic and interdisciplinary academic research. Access to classes such as media theorist Shannon Mattern's on smart cities gave insight into media and urbanity from a non-architectural media studies perspective. The interdisciplinary approach in my project, and its focus on a "great outdoors", was further strengthened in conversations with my external supervisor, Henriette Steiner, Associate Professor in Landscape Architecture and Planning at the University of Copenhagen.

General Introduction

Preface

> The gap between the physical reality of the cloud, and what we can see of it, between the idea of the cloud and the name that we give it—"cloud"— is a rich site for analysis.[1]

The architecture of digital archives—the *cloud* and its data centres—is underexplored, perhaps because it is situated at the threshold of the imaginary and the inaccessible.[2] In the words of media scholar Tung-Hui Hu, "the data centre remains among the least studied areas of digital culture, with cloud computing producing a layer of abstraction that masks the physical infrastructure of data storage".[3] Not only in digital culture, but also in the field of architecture, these elusive spatial phenomena have received little attention.[4] The intangibility of the cloud, and the nondescript data centres it masks, results in the underuse of these rich and fascinating spaces as architecture references, and lends itself to abuse as an opaque territory of neoliberal exploitation.[5] This PhD thesis describes the spatiality, materiality and temporality of the cloud and data centres in great detail. Making the cloud more concrete in the spatial imagination forecloses its political non-inclusiveness and illustrates its architectural potential. To begin, I invite the reader to delve into the dominant aesthetic description of data centres.

[1] Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2015), loc. 77, Kindle.
[2] See for example Louise Amoore, "Cloud Geographies: Computing, Data, Sovereignty", *Progress in Human Geography* 42, no. 1 (2018): 4–24.
[3] Hu, *Prehistory*, loc. 81–82.
[4] As I will show in section 1.3, data centres belong to the domain of engineering and infrastructure planning.
[5] Hu, *Prehistory*; Amoore, "Cloud Geographies"; Wendy Hui Kyong Chun, *Updating to Remain the Same: Habitual New Media* (Cambridge, MA and London: MIT Press, 2016).

Imagine you are walking along a two-metre-wide corridor. The floor is covered with large, highly reflective light grey tiles that are separated by prominent dark grey joints. There are three full tiles in the centre part, flanked by a one-third tile on each side. Above you, a typical suspended ceiling is divided into panels that are about two thirds smaller than the floor tiles. At roughly one-metre intervals there are rectangular, one-panel-wide light bands stretching from left to right above the central part of the corridor. Uninterrupted rows of server racks line the corridor walls on both sides. They are made up of near-black, dark grey frames with reflective Perspex doors. There are no visible handles to open the cabinets. All of these racks are identical. All the racks feature small, pale green light sources. Each cabinet contains 14 neatly stacked server units that slot perfectly into the width of the rack system. The racks are taller than you but do not reach the ceiling. Above the substantial gap between them and the ceiling, in line with the light panels, there are rectangular ventilation grids, vaguely labyrinthine.

The corridor is curving to the right. As you can never quite see around the bend, you apprehend that the corridor may in fact describe a circle. You continue, but there is no change in your spatial experience. The light remains even, and every step feels like the previous one. You wonder whether you have already passed through this part before. There is no outside—no windows, no doors—just the slick, potentially endless repetition of data racks, as far as you can see, before and behind you. Suddenly a kind of blur seems to materialise in the distance, where the corridor leaves your field of vision in the curvature. As you approach you recognise the blur as a small, picture-perfect cloud, hovering at about hip height. Will it feel cool to the touch? Will it dissipate as you approach?

The speculation ends here, before physical contact can be made between the hypothetical data centre visitor and the out-of-place cloud. The imagined experience is a detailed description of a Shutterstock stock video titled "Seamlessly Looping Animation of Rack Servers in Data Centre".[6] I have enhanced the looping scenario with a cloud, because it is typical of this genre of renderings to represent not merely data centres but also the digital cloud. Such video loops are emblematic depictions of data centres—the outsourced and physically inaccessible sites of digital archives.[7] The meteorological cloud is a strange, entirely abstract anecdote amid glossy data centre corridors. The focus of this thesis is on the nature of the cloud. Data centre legend has it that in the summer of 2011, an actual cloud formed in Facebook's first data centre in Oregon because of climatisation issues, and it rained on a number of servers that were sustaining the digital cloud. Apart from this event, clouds are only metaphorically present in data centres.[8] The existing imagery of the spatiality of digital archives is limited and insufficient: generic and often computer-generated renderings of rows of server racks, with the odd Photoshopped meteorological cloud suspended between the shelves, against a graded blue sky that fades into the data centre corridor floor. This thesis' close spatial, temporal and material analysis of the cloud and data centres will contribute to making today's digital archiving practices more concrete and tangible.

Archival Metaphors

The term "cloud computing" was developed as a marketing name in 1996 by Compaq marketing executive George Favaloro and technologist Sean

[6] The video can be watched here: https://www.shutterstock.com/video/clip-1914619-seamlessly-looping-animation-rack-servers-data-center. The copyright belongs to Saginbay, the image format is 16:9, and the clip length is 0:08. The HD version costs $79; the cheapest (web) version costs $39. Saginbay's portfolio on the Shutterstock website extends to 1,187 clips; most visualise smart technologies, but there are also DNA strands, and ultrasound loops of human embryos.
[7] See for example Andrew Blum, *Tubes: Behind the Scenes at the Internet* (London: Penguin, 2012), Kindle.
[8] "Humidity Excursions in Facebook Prineville Data Center", *Electronics Cooling*, 10 December 2012, https://www.electronics-cooling.com/2012/12/humidity-excursions-in-facebook-prineville-data-center/. See also Everest Pipkin, "It Was Raining in the Data Center", *Medium*, 12 June 2018, https://medium.com/s/story/it-was-raining-in-the-data-center-9e1525c37cc3.

O'Sullivan, of the now defunct Netscape.[9] The cloud had made visual appearances since the early 1970s as an icon on maps drawn by administrators of communication networks composed of computers or even phones, for example in offices. Replacing the more rigid box icon, the flexible cloud symbol would encompass the fluctuating conglomerate of devices and cable networks.[10]

The cloud currently represents a $174 billion (revenue) industry, operational with iCloud and Amazon Cloud Player since 2010–2011.[11] At the end of 2017 there just below 400 hyperscale data centres in operation, run by 24 companies. Hyperscale data centres generally exceed 5,000 servers (sometimes more than a million servers) and 1,000 square metres.[12] In 2016, global data centres accounted for around three per cent of global energy consumption (circa 416 terawatts, or 4.16 times 1,014 watts), which equals nearly 40 per cent more than the entire energy consumption of the United Kingdom. This number is projected to double every four years.[13] In 2018, of the planet's 7.7 billion inhabitants, 3.6 billion internet users accessed cloud computing services.[14] The cloud backs up smartphones, coordinates intranets, and powers websites and email accounts. The digital cloud—part radio waves, part meteorological metaphor, part spatial imagination—has come to conceptually embrace and safeguard all digitalised, externalised memories and archived data. In the name of

[9] The term did not catch on, and was replaced by their superiors at Compaq with "internet computing". Antonio Regalado, "Who Coined 'Cloud Computing'?", *MIT Technology Review*, 31 October 2011, https://www.technologyreview.com/s/425970/who-coined-cloud-computing/.
[10] See Hu, *Prehistory*, loc. 64.
[11] Hu, *Prehistory*, loc. 64.
[12] Chrissy Kidd, "What Is a Hyperscale Data Center?", BMC Blogs, 11 July 2018, https://www.bmc.com/blogs/hyperscale-data-center/.
[13] Radoslav Danilak, "Why Energy Is a Big and Rapidly Growing Problem for Data Centers", *Forbes*, 15 December 2017, https://www.forbes.com/sites/forbestechcouncil/2017/12/15/why-energy-is-a-big-and-rapidly-growing-problem-for-data-centers/.
[14] "Consumer Cloud Computing Users Worldwide 2018", Statista, accessed 23 January 2019, https://www.statista.com/statistics/321215/global-consumer-cloud-computing-users/.

convenience,[15] most of us do not know where our cloud is anchored or what the name reveals about the service. I investigate the elusive spatiality, materiality and temporality of these inaccessible archives—which are metaphorical and imagined as much as they are material and infrastructural—in more depth, with the purpose of making them accessible to the architectural imagination.

More than a fleeting metaphor in the history of archiving, the cloud embodies a spatiality that withdraws from the Cartesian order of assigning fixed positions in a space defined by three axes. Its indefinite, ever-changing presence opposes outmoded spatialities of modernity for which no alternatives have yet been formulated. Modern space is about negotiating the threshold between inside and outside, private and public, to some extent blurring traditional boundaries of enclosure.[16] The cloud, as a body without a surface,[17] transcends the concept of boundaries and suggests space itself as an extended threshold of varying densities rather than defined outlines. This updated notion of space as all-encompassing and ever-shifting reverberates with recent scholarship on infrastructure space as uncontainable[18] and media as an environmental presence.[19] It seems as if the promise of a cloud spatiality is not quite yet within the grasp of the spatial imagination, even as the cloud metaphor permeates digital archiving practices. The cloud describes a shift in spatiality that invites us to step into uncharted, unmappable territories and leave the

[15] Tim Wu, "The Tyranny of Convenience", *New York Times*, 20 February 2018, sec. Opinion, https://www.nytimes.com/2018/02/16/opinion/sunday/tyranny-convenience.html.
[16] Beatriz Colomina, *Privacy and Publicity: Modern Architecture As Mass Media* (Cambridge, Massachusetts and London: The MIT Press, 1994), 51–52.
[17] From Leonardo da Vinci's notebooks, cited in Hubert Damisch, *A Theory of /Cloud/: Toward a History of Painting* (Stanford: Stanford University Press, 2002), 218, 124, 141, 218, and in John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: University of Chicago Press, 2015), 256.
[18] See for example Rem Koolhaas, "Junkspace", *October* 100 (2002): 175–90. See also Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (London and New York: Verso, 2014), iBook. See also Ilka Ruby and Andreas Ruby, eds., *Infrastructure Space* (Berlin: Ruby Press, 2017).
[19] See for example Durham Peters, *Marvelous Clouds*.

comfort of fixed floor plans behind.[20] Although it hovers in our technologically enhanced architectures, permeating concrete and brick and infiltrating infrastructure, this cloud spatiality is still difficult to imagine.

Structure

The thesis is divided into two parts, followed by a concluding argument. The first part consists of three chapters that closely examine the spatiality, materiality and temporality of data centres as a typology. Beginning with the formulation of geology as a science at the beginning of the 19th century, and with early geology's postulation of the planet as an archive, I will describe the concept of a geological mode and its relationship to archiving. Geologists James Hutton (1726–1797) and Charles Lyell (1797–1875) understood the geologist as the decipherer of the planet's archival structure of geological strata arranged across planetary deep time. I reference writings on geology, land art, philosophy, architecture and media theory to portray the ground as an active entity.[21] In line with the geological theme, recent research on media materiality, geology and archaeology has shown that the media of digital archives—the servers and their hard drive disks, the cables, the electrical hardware—all consist of a geological materiality. The animation of the ground thus permeates the physical backbone of digital archives, as archival media such as servers are composed of geological materials, predominantly metals. The dominant temporality these archives engender manifests as a continuously animated, updated present. The principles of geology—layering, inner tensions, frictions, upheavals, vents, bursts, leaks—precipitate in a mode of operation that is applicable to the spatial phenomenon of data centres.

[20] To some extent, this thesis embarks on the fulfilment of the wish of a protagonist in David Mitchell's novel *Cloud Atlas*: "what I wouldn't give now for a map of the ever constant ineffable? To possess, as it were, an atlas of clouds". David Mitchell, *Cloud Atlas* (London: Hodder and Stoughton, 2004), 389.
[21] For example Bernard Cache, *Earth Moves: The Furnishing of Territories* (Cambridge, MA and London: MIT Press, 1995); also Lucy R. Lippard, *Undermining: A Wild Ride Through Land Use, Politics, and Art in the Changing West* (New York: New Press, 2014), Kindle.

The latter are governed by the geological mode—by a spatiality of stratification, a deep time of petrified flows, and a materiality of minerals, metals and rare earths.

The sense of animation that permeates the ground also governs the cloud. But rather than *geology*, the metaphor of the cloud suggests *meteorology* as a methodological and spatio-temporal point of reference for digital archiving practices. Continuing the theme of the planetary imaginary, Part 2 develops the meteorological mode as a way of understanding the materiality, spatiality and temporality of the cloud, both as a metaphor for digital archives and in its relationship to the meteorological version. The meteorological mode is closely entwined with the beginnings of computing. Charles Babbage (1791–1871), inventor of the first programmable computer,[22] believed the air to be a "vast library".[23] With sufficient computational power, this ephemeral, ever-adjusting archive could reveal the planet's history (and future). The meteorological cloud can be understood as an atmospheric archive. An important figure in global weather, the cloud ties this data and computing-voracious science to today's digital archives—united by a constantly morphing spatiality, and a temporality of simultaneity and prediction. The archival modes of the meteorological and digital clouds engage, overlap and inform one another. They operate according to a logic that enables animation, continuous responsiveness, the promise of absolute freedom of association, and accessibility, independent of temporal or spatial adjacencies. The meteorological spatiality of dispersal and patterning, a temporality of phasing, and a materiality of scattered data particles characterise the cloud.

As descriptive and analytical tools, I thus develop what I call two archival *modes*: the *geological mode* in relation to the data centres, and the *meteorological*

[22] This statement refers to Western history. For information on medieval Arab mechanics and its effects on contemporary computer engineering, see Siegfried Zielinski and Peter Weibel, eds, *Allah's Automata: Artifacts of the Arabic-Islamic Renaissance (800–1200)* (Berlin: Hatje Cantz, 2016).
[23] Charles Babbage, *The Ninth Bridgewater Treatise: A Fragment* (London: J. Murray, 1837), 113.

mode inspired by the characteristics of the cloud. The overarching themes of the geological and meteorological modes in this thesis guide my analysis of the elusive spatiality of digital archives. The term "mode" refers to "a way or manner in which something occurs or is experienced, expressed, or done".[24] The use of the term relates directly to the interdisciplinary nature of this thesis, which spans architecture and media. Analogously, "mode" is used in relation to the operation of devices to indicate a change in the method of operation; in computing, to denote ways of operating a system; and in physics, to describe "any of the distinct kinds or patterns of vibration of an oscillating system".[25] My use of the term "mode" is in dialogue with philosopher Gilbert Simondon's 1958 book *On the Mode of Existence of Technical Objects*.[26] He describes technology as ensembles that constantly evolve in connection to their environment. The existence of technical objects is based on a continuous process of individuation: this is their mode of being.

Similarly, I use the word "mode" as a way of describing an ever-adjusting approach to space, time and material. Throughout this text, "mode" points to a manner of organising material in a way that engenders a particular type of spatial and temporal structure: material carries, transmits and stores information. Data flows are never completely ephemeral—they are enabled by glass fibre or copper cables, aluminium silicate interfaces, in other words the infrastructural hardware that forms the backbone of digital archives. The modes I develop throughout this thesis can be understood in the context of Russian literary scholar Mikhail Bakhtin's (1895–1975) logic of the chronotope.

His notion of the artistic chronotope establishes a close interconnectedness between space and time. Combining *topos* (place/topic) and *chronos* (time), Bakhtin's chronotope served as tool for

[24] Oxford English Dictionaries, s.v. "mode (n.)", accessed 23 January 2019, https://en.oxforddictionaries.com/definition/mode.
[25] Oxford English Dictionaries, s.v. "mode (n.)".
[26] Gilbert Simondon, *On the Mode of Existence of Technical Objects* (Minneapolis: Univocal, 2017).

analyzing the interplay between place and time in narratives. In the context of the history of novels, the ways in which the narrative imagination articulates chronotopes reflects changing world views on time (and history). Bakhtin emphasises the ability of the artistic chronotope to unify spatial and temporal markers in a way that allows time to materialise: "time becomes, in effect, palpable and visible; the chronotope makes narrative events concrete, makes them take on flesh, causes blood to flow in their veins".[27] To paraphrase, a narrated (here, archived) event remains mere information unless it is represented through a chronotope. The chronotope allows it to become a concrete figure thanks to its specific delineation of tangible time markers within a clearly defined locus.[28] The geological and meteorological modes can be understood as narrative or perceptive tools that create archival chronotopes whose materiality constitutes data carriers.

Connecting these modes with the constitution of today's global digital archives, clarifies their implications for the architectural imagination more tangible. The modes that I develop and apply as analytical tools grow out of a close description of my research objects: the data centres and the cloud. The aim of this method is to make theses archival spaces more accessible, and to make them more palpable in the architectural imagination. I draw on various sources—scientific and also poetic, such as artist Robert Smithson's "abstract geology"—as generative tools to elaborate these modes. Smithson's "abstract geology" also understands the ground as a "jumbled museum" and elucidates the artistic potential of a geocentric approach.

Methodology

I develop the two modes in relation to case studies, which range from memorial sites to geophysical archives. The cases were selected according

[27] Mikhail M. Bakhtin, *The Dialogic Imagination: Four Essays*, ed. Michael Holquist (Austin: University of Texas Press, 2011), 249.
[28] Bakhtin, *Dialogic Imagination*, 250.

to their capacity to reveal aspects of the geological and meteorological modes. The case studies thus tap into planetary imaginaries. I have personally visited the case studies in Part 1: the Lamont-Doherty Core Repository at Columbia University in New York, the memorial *Il Grande Cretto* by Italian artist Alberto Burri in Sicily, and the Nordea Bank headquarters' data centre in Copenhagen. In September 2016 I happened to experience the site of the recent 'August 2016 Central Italy earthquake', which had completely flattened the village of Pescara del Tronto. I was driving through the region around cracks in the road, across bridges and through tunnels that now seemed precarious and untrustworthy. Only firefighters could access the streets of the destroyed towns, which were void of people and filled with rubble. The experience of this region, 10 days after the event, revealed the ground as governed by a temporal mode which remains utterly disconnected from human temporalities. Only when a sinkhole opens in the ground, or when a town is flattened by an earthquake, do we become aware of this disconnected temporality that governs the ground beneath our feet. Because the geological mode deals with temporalities and spatialities that are phenomenologically inaccessible to humans, I focussed on giving detailed accounts of the spaces and archived objects I encountered.

In Part 2, the referenced projects—including medieval theatre props and Diller Scofidio + Renfro's 2002 Blur Building—form part of a spatial repertoire pertaining to the meteorological mode. Rather than bridging the phenomenological disconnection with detailed descriptions based on physical experience, I offer technical and scientific detail beyond the strictly architectural, in order to give the reader access to phenomena which influence the architectural spatio-temporal imagination. In the introductory section on the meteorological mode (section 2.1), for example, I include a detailed description of the behaviour of aerosols, to draw analogies between the materiality and spatiality of a meteorological cloud and the organisational structure of the digital cloud. My methodology thus merges spatial experience with speculation and the creation of analogies. The elusiveness of the digital cloud resists definitive definitions and requires that I approximate it from all angles. By describing the spatial implications of the cloud metaphor, I formulate the pillars of a meteorological spatiality.

Throughout the text you will repeatedly find vocabulary that relates to the meteorological mode. For example, I use "approximate" rather than "explain" or "define", because in the context of elusive phenomena such as the digital and meteorological cloud and cyberspace, which hover between the metaphorical, the imagined and the tangible, it is more productive to embrace the slippery subtleties than to try to pin them down or cage them in. In line with Donna Haraway, this method of approximation rather than definition is a way of "staying with the trouble".[29] Continuing with the meteorological vocabulary, the term "precipitate" links to the precipitation of rain or snow, and I use it to show correlations between different states that manifest in different places and times. For example, I use it to show how certain occurrences enabled the architecture of digital archives as it is today. It is the meteorological equivalent of the geological term "crystallise". "Tapping into" is a term I like to use to signal that when we use our spatial imagination, we draw from what is known and perceptible to us. Consequently, a changing understanding of the planet—for example, through Hutton's and Lyell's work, of the planet as a *deep* archive—opens up new ways not just of imagining the world, but also of conceptualising archives.[30]

The images at the end of each chapter recreate the kinds of atmospheres I encountered throughout this research. Some of them stem from site visits to the case studies, some are referenced directly throughout the texts, and others have visually influenced the thesis.

[29] See Donna J. Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham and London: Duke University Press, 2016).
[30] On paradigm shifts, see Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962). The way I use "tapping into" also evokes the processes that access Carl Jung's "collective unconscious".

The Planetary Imagination and the Geological and Meteorological Modes

The digital cloud can only be approximated, never completely defined or pinned down. Like the amorphous spatiality of its H_2O counterparts, it is an elusive, multifariously entangled entity. Conceptually, the cloud is only loosely bound to the data centres that sustain it. The cloud metaphor evokes a planetary phenomenon as pervasive as the digital cloud has become: clouds continuously cover nearly 70 per cent of the world. The meteorological aspect engendered by the cloud, and the geological materiality embodied by digital media, struck me as expressions of a planetary imaginary, a term that was put forward and explored in relation to architecture by the contributors to the edited volume *Climates: Architecture and the Planetary Imaginary* in 2016.[31] In one of the chapters, architectural theorist and practitioner Jorge Otero-Pailos investigates the atmosphere as a cultural object. He shows how the atmosphere's scattered materiality bears a "temporal depth"[32] that draws parallels to monuments such as the Parthenon of the Greek Acropolis, whose material remainders have been distributed across several heritage sites and museums. Like the atmosphere, the Parthenon can never be experienced at once, and its materiality engenders spatial dispersal and temporal depth. Otero-Pailos thus looks to the planetary to make inferences about the architectural, in particular the monumental. Similarly, I draw on the geological and the meteorological as narratives which evoke the archival in different ways—or modes—to connect planetary phenomena to data centres and the cloud. I thus contribute to scholarship that links planetary imaginaries to architectural concerns. The planetary imaginary guides this project towards an understanding of space as media: architecture is interlaced with and transmits information.[33]

[31] James Graham and Caitlin Blanchfield, eds, *Climates: Architecture and the Planetary Imaginary* (Zurich: Lars Müller, 2016).
[32] Jorge Otero-Pailos, "The Atmosphere as a Cultural Object", in Graham, *Climates*, 250.
[33] See for example Beatriz Colomina, *Privacy and Publicity: Modern Architecture as Mass Media* (Cambridge, MA and London: MIT Press, 1994). See also Bernhard Siegert, "Architectures of the Ocean" (lecture), Princeton, School of Architecture, 2017, https://vimeo.com/215503386.

There are continuities in today's digital phenomena that embed them in a coherent history of a spatial imagination linked to planetary narratives. Clouds as sky media and weather makers are closely linked to the beginnings of planetary awareness, long before satellite images and their white-and-blue marble. The science of weather forecasting required globe-spanning observation networks. This kind of thinking has been associated with explorers such as von Humboldt and scientist-Romantics Goethe and Ruskin. The latter famously addressed the need for global cooperation among weather observers and forecasters at the Meteorological Society in London in 1839, bringing von Humboldt's dream of a global network of weather stations closer to realisation. The sciences linked to geology and meteorology were always linked to travel and global networks.

In recent years, the idea of a "planetary, geo-centred perspective"[34] approach has increasingly moved to the forefront, not least because of the anxiety over global threats exemplified by global warming, which was first measured in 1968[35] and has increasingly infiltrated the general imagination since the 1970s. The beginnings of meteorology and geology as sciences in the 19th century can be linked to the modern (Western) idea of the world as a coherent, interconnected planetary system. Important contributors were projects such as von Humboldt's *Kosmos* ("cosmos"), consisting of five volumes published between 1845 and 1862. In this work, von Humboldt as the famous explorer-scholar included maps of the planetary phenomena he had personally observed. Beautifully detailed infographics of planetary systems show maps overlaid with global systems of electromagnetic currents and the flows of water and air traversing the planet. Von Humboldt sought to illustrate nature in its entirety, as an

[34] Rosi Braidotti, *The Posthuman* (Cambridge: Polity Press, 2013), 81.
[35] E. Robinson and R.C. Robbins, "Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants: Final Report and Supplement" (1968), https://www.osti.gov/biblio/6852325; Richard Wiles, "It's Fifty Years Since Climate Change Was First Seen: Now Time Is Running Out", *Guardian*, 15 March 2018, https://www.theguardian.com/commentisfree/2018/mar/15/50-years-climate-change-denial.

interconnected system animated and permeated by inner forces ("die Erscheinung der körperlichen Dinge in ihrem Zusammenhange, die Natur als durch innere Kräfte bewegtes und belebtes Ganzes"[36]).

The planet in its entirety became real in the popular imagination with one of the world's most famous and reproduced photographs, named *The Blue Marble*. This image was taken aboard the Apollo 17 space shuttle en route to the moon, five hours and six minutes after the launch of the mission, on 7 December 1972. The image really shows a planet that is white as much as it is blue. A significant portion of the body is covered in clouds and Antarctic ice. The crew could easily have named the image "cloud marble". In fact, the blue marble really only became blue in Nasa's 2012 update, a video stitched together from satellite-captured image data, cleaned of cloud cover and showing a year's worth of footage to reveal the colour change of the land masses from green to white to yellow. In light of the continuous cloud coverage, the planet could be called a cloudy maelstrom rather than a blue marble. This nickname would more accurately reflect the planet not as a solid entity, but rather as an open-ended, tentacled hyperobject[37] whirl that creates and visualises continuous change. A marble is hard, smooth, slick and *geological*—it is made of molten sand mixed with added minerals to give it colour. Marbles are made up of several layers of differently coloured glass that are continuously built up in a melting and cooling process. A craftsperson forms the glass mass with rotating, rolling and reeling movements. The cloudy maelstrom, on the other hand, evokes a contained yet dynamic and constantly changing responsive and generative system, opaque and not quite mappable or predictable. This is an understanding of the planet that responds much

[36] Alexander von Humboldt, *Kosmos (Erster Band, Kapitel 2)* (Stuttgart and Augsburg: J. G. Cotta'scher Verlag, 1845), http://gutenberg.spiegel.de/buch/kosmos-erster-band-6674/2.
[37] On "tentacles", see Donna J. Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham, NC and London: Duke University Press, 2016). The hyperobject stems from Timothy Morton, *Hyperobjects: Philosophy and Ecology After the End of the World* (Minneapolis and London: University of Minnesota Press, 2013). See also Timothy Morton, "From Modernity to the Anthropocene: Ecology and Art in the Age of Asymmetry", *International Social Science Journal* 63 (2014): 47.

more accurately to the current difficulties of predicting climate change and its consequences. What is the temporality of a maelstrom? It evokes the white whale in *Moby-Dick*, which drags Captain Ahab and his ship into unfathomable depths after the captain's continued and relentless aggression. It evokes Ada Louise Huxtable's description of the ground floor atrium of the Trump Tower in New York City as a pink marble maelstrom,[38] which also refers to the impenetrable power relations at play behind a smooth and expensive surface that combines geological accumulation with meteorological immeasurability.[39] It suggests hurricanes (the first "blue marble" photograph showed the Tamil Nadu cyclone), which constitute an ur-labyrinth. Clouds offer this way of looking at space, in a way that dissolves all binaries and Cartesian restrictions. They indicate a spatio-temporal multitude that resonates with Otero-Pailos' understanding of the atmosphere: "just as we can never see the Parthenon all at once, we cannot see the atmosphere in one glance. Even the famous 1972 'Blue Marble' photograph from Apollo 17 shows only half of it, and only an instant of it".[40] From Ruskin, who read marble as "volumes as precious as those of our libraries",[41] to architectural theorist and practitioner Keller Easterling, who imagines "the movement of clouds in the atmosphere [as] a wet information system more common than a digital cloud",[42] the planetary imaginary informs our understanding of both space and information.

Literature Review

[38] Ada Louise Huxtable, "Donald Trump's Tower", *New York Times*, 6 May 1984, sec. Magazine, https://www.nytimes.com/1984/05/06/magazine/l-donald-trump-s-tower-170724.html.
[39] Kate Marvel, 'The Cloud Conundrum', *Scientific American*, no. 317 (14 November 2017): 72–77.
[40] Otero-Pailos, "Atmosphere", 250.
[4141] John Ruskin, *The Stones of Venice: The Fall*, iBooks, vol. III (London: Smith, Elder, And Co., 1851), 55.
[42] Keller Easterling, "The Year in Weather", Artforum International, accessed 4 December 2018, https://www.artforum.com/print/201710/the-year-in-weather-72467.

Interdisciplinarity

A study of data centres and the cloud is by default an interdisciplinary project, as the topic requires familiarity with technical as well as architectural and media culture-related scholarship. Due to the variable nature of the cloud and data centres, and the amount of research that exists in their shadow, I have relied on literature from a rich variety of scientific fields. Beyond architecture theory and history, my research overlaps with the fields of media theory, computing history, geology, meteorology and the history of weather forecasting to gain insight into the nature of today's digital archives. The histories of geology and meteorology were part of the territory I needed to roughly sketch out in order to develop the two modes I use as analytical and descriptive tools. These adjacent fields phase in and out of the more architectural analysis, allowing me to expand the study of data centres and of the spatiality of the digital cloud beyond traditional architectural scholarship.

Geology and Meteorology

Geology is particularly interesting in relation to architecture. Buildings and ground are connected, as buildings are made of the ground and are physically connected to its inherent movement. Larger construction sites require a geological analysis before the foundations can be built. Buildings engage more directly with the ground's temporalities than humans can—the clash of temporalities manifests, for example, in earthquake damage. Rather than turning to technical literature on earthquake-proof architecture, I looked to geological writers to acquire a less mediated sense of the spatialities, materialities and temporalities inherent in the ground. Among these I focussed on writers who describe world views or philosophies based on geological practices. A recent publication, geologist Marcia Bjornerud's *Timefulness: How Thinking Like a Geologist Can Help Save the World*,[43] published in August 2018, shows that at this time of rapid

[43] Marcia Bjornerud, *Timefulness: How Thinking Like a Geologist Can Help Save the World* (Princeton and Oxford: Princeton University Press, 2018).

environmental change, and of humans as catalysts of geological change, turning to geology provides a framework to deal with the urgency of planetary shifts. Palaeontologist Stephen Gould's classic *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*[44] reflects on the effects of geological discoveries on human thought and the spatio-temporal imagination of deep time.

The immensity of our planet's history is so epic that we can only describe in metaphors. I paired such philosophical and historical temporal reflections with technical details from publications in marine geology. These furnish my reflections on the case study of the Lamont-Doherty Core with background scientific knowledge. Contemporary philosopher Quentin Meillassoux bases his speculative realist reflections on the same types of fossils that I encountered at the Lamont-Doherty. In *After Finitude: An Essay on the Necessity of Contingency* (2008),[45] he explores the implications of *thinking* about "ancestral matter" such as fossils that predate human existence. Like the explorers of *deep time*, he addresses the human disconnectedness from the vast timescales embodied in geological matter. Philosopher Timothy Morton addresses these immensities in his notion of "hyperobjects", which encompass phenomena such as global warming and radiation.[46] They describe entangled planetary phenomena beyond the scope of human temporal and spatial imagination. They escape all known modelling and mapping techniques, as their formation is enmeshed with too vast a set of factors. In this quality they overlap with cyberspace, which is also fundamentally unmappable. Morton writes: "hyperobjects are objects that are massively distributed in time and space, relative to human scales. They are immersive, phenomenologically viscous entities".[47] In order to contribute to the narrative of an active ground, I

[44] Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*, 9th ed. (Cambridge, MA and London: Harvard University Press, 1987).
[45] Quentin Meillassoux, *After Finitude: An Essay on the Necessity of Contingency* (London and New York: Bloomsbury, 2008), Kindle.
[46] Morton, *Hyperobjects*.
[47] Morton, "Modernity to Anthropocene", 47.

turn to Deleuze and Guattari's *A Thousand Plateaus*[48] and Nigel Clark's *Inhuman Nature*.[49] Feminist theorist Sara Ahmed's *Queer Phenomenology*[50] offers ways of approaching spatial and temporal multitudes, as does Lauren Berlant's *Cruel Optimism*.[51]

Histories of meteorology focus less on temporality than do their counterparts in geology. Instead, they emphasise spatial aspects, most importantly the need for a global network of data collection. Scholars John Durham Peters[52] and Paul Edwards[53] have significantly contributed to connecting weather, data gathering and computation with a global network spatiality. Durham Peters' *The Marvelous Clouds* also links environmental elements such as water and fire to the history of media. In architecture, this has been adapted by Keller Easterling.[54] On his BLDGBLOG, author Geoff Manaugh, inspired by "the geological nature of harddrives – how certain mineral arrangements of metal and ferromagnetism result in our technological ability to store memories, save information, and leave previous versions of the present behind,"[55] muses on the possibility of turning the entire planet into a harddrive: "The earth would become a kind of spherical harddrive, with information stored in

[48] See for example the chapter "10,000 B.C.: The Geology of Morals (Who Does the Earth Think
It Is?)" in Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis and London: University of Minnesota Press, 1987).
[49] Nigel Clark, *Inhuman Nature: Sociable Life on a Dynamic Planet* (Los Angeles: Sage, 2011), Kindle.
[50] Sara Ahmed, *Queer Phenomenology: Orientations, Objects, Others* (Durham, NC and London: Duke University Press, 2006).
[51] Lauren Berlant, *Cruel Optimism* (Durham, NC and London: Duke University Press, 2011).
[52] Durham Peters, *Marvelous Clouds*.
[53] Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA and London: MIT Press, 2010).
[54] Keller Easterling, "The Year in Weather", Artforum International, accessed 4 December 2018, https://www.artforum.com/print/201710/the-year-in-weather-72467.
[55] Geoff Manaugh, 'Planet Harddrive', BLDGBLOG, 23 January 2009, http://www.bldgblog.com/2009/01/planet-harddrive/.

those moving webs of magnetic energy that both surround and penetrate its surface."[56]

This thesis offers narratives for a meaningful approach to data against the backdrop of the often-lamented overabundance of data[57] and acceleration.[58] Saying there is too much information is like saying there is too much world: "the empire voraciously gathers as little information as it can".[59] In light of this, the metaphor of the cloud becomes symptomatic of the insatiable amassing of fleeting data that is too vast to be truly meaningful, but from which—when it is stared at hard enough, with a healthy dose of imagination—meaning can be conjured.[60]Aerosols form an intriguing, open-ended and inclusive order. The rhizome lawn is superseded by the aerosol cloud.

In the social sciences, the cloud has often been apprehended as a threat to freedom.[61] In response to WikiLeaks founder Julian Assange's arrest in 2010, critics warned that "the internet is a sovereign territory".[62] Hu and Amoore explain the notion of sovereign power in terms of the cloud's tendency to be exclusive and linked to surveillance as an omnipresent "network of networks".[63] It is a private domain that users (indirectly) have

56 Manaugh.
57 See for example Kenneth Cukier and Viktor Mayer-Schönberger, *Big Data: A Revolution That Will Transform How We Live, Work, and Think* (Boston and New York: Houghton Mifflin Harcourt, 2013), iBook. See also Schumpeter, "Too Much Information: How to Cope with Data Overload", *Economist*, 30 June 2011, https://www.economist.com/business/2011/06/30/too-much-information.
58 See for example Lev Manovich, "New Media from Borges to HTML", in *The New Media Reader*, ed. Noah Wardrip-Fruin and Nick Monfort (Cambridge, MA: MIT Press, 2003). See also Morton, "Modernity to Anthropocene". For a critique of "labelling speed as the culprit", see Wendy Hui Kyong Chun, "The Enduring Ephemeral, or the Future Is a Memory", *Critical Inquiry* 35 (2008): 148–171.
59 Geoffrey C. Bowker, *Memory Practices in the Sciences* (Cambridge, MA and London: MIT Press, 2005), loc. 624, Kindle.
60 For da Vinci on clouds see Damisch, *A Theory of /Cloud/: Toward a History of Painting*.
61 For a list of these, see Amoore, "Cloud Geographies". For more references, see Hu, *Prehistory*; David F. Ronfeldt and John Arquilla, *Networks and Netwars: The Future of Terror, Crime, and Militancy* (Santa Monica: Rand, 2001).
62 Hu, *Prehistory*, loc. 2176.
63 Hu, *Prehistory*, loc. 128.

to buy their way into. Hu extends this admonition to the digital cloud, and explores its political menace beyond the threats implied by philosopher Gilles Deleuze's control society. Here, the mechanisms of control ooze beyond the enclosures of institutions and invisibly permeate the lives of its subjects via constant and limitless manipulation, adjustment and updating. Deleuze describes the shift in a way that is evocative of the constantly adjusting spatiality of a meteorological—and by analogy, the digital—cloud's spatiality: "enclosures are molds, distinct castings, but controls are a modulation, like a self-deforming cast that will continuously change from one moment to the other, or like a sieve whose mesh will transmute from point to point".[64] Hu then situates the anachronistic resurgence of the sovereign power of the cloud "in the gap between the real and the virtual".[65] He identifies older physical networks, such as the railway, onto which the cloud has grafted its support system. Further, he traces the concept of security as a dangerously exclusive promise of the cloud, and links it to physical types such as the bunker. Military remnants, cotton-wrapped menaces and camouflaged control infiltrate Hu's mapping of the cloud's physical manifestations.

The lack of comprehensive visualisations and descriptions beyond the purely technical for data centres and the cloud strengthens the cloud as a territory of sovereign power shrouded in vagueness, and undermines its potential as an architectural reference. Looking behind the cloud veil is currently an arduous task.[66] The inconvenience of not being a cloud user seems intolerable.[67] We therefore have to find ways of increasing its presence not as an elusive service infrastructure, but as an entity that deserves and requires our conscious awareness. My aim is to contribute to undermining the cloud as a site of sovereign threat by closely describing it and thus lifting its veil of mystery and intangibility. Unlike James Bridle,

[64] Gilles Deleuze, 'Postscript on the Societies of Control', *October* 59 (Winter 1992): 4. See also Hu, *A Prehistory of the Cloud*, loc. 154.
[65] Hu, *Prehistory*.
[66] Blum, *Tubes*.
[67] Wu, "Tyranny of Convenience".

whose 2018 bestseller *New Dark Age*[68] claims that the information age has catapulted us into a new dark age of 'the destruction of knowledge', my aim is to embrace Haraway's credo and 'stay with the trouble'[69] of big data and its cloud.

The cloud can easily be described as a site of dismay—runaway algorithms, incongruous data, nonsensical correlations, fake news, manipulation of public opinion,[70] spam, hackers, cookies and surveillance, the illusion of choice versus the 'tyranny of convenience', the privatisation of public cyberspace, etc. However, the digital cloud metaphor is also a site of potential. It suggests ways of embracing and allowing multiplicities, indefinite order, the irrelevance of binaries, post-cartesian geometries. Finally, the cloud is updating the architectural imaginary. It is important for architects to know where their understanding of space—which has been influenced by digital archives—comes from. Hu summarises its importance: "it is clear that the cloud, as an idea, has exceeded its technological platform and become a potent metaphor for the way contemporary society organizes and understands itself".[71] However, while most authors focus on the cloud metaphor's military origins and its political implications, I turn to the materiality, spatiality and temporality suggested by its metaphorical relationship to the meteorological cloud. Its nature gives surprisingly accurate insight into the way data archiving and processing is organised. Instead of focussing on military precedents and

[68] James Bridle, *New Dark Age: Technology and the End of the Future* (New York: Verso, 2018).
[69] Haraway, *Staying with the Trouble: Making Kin in the Chthulucene.*
[70] The Cambridge Analytica scandal involving Brexit and Donald Trump's 2016 Presidential Campagin (and in 2012) is a good example. See Adrian Chen, 'Cambridge Analytica and Our Lives Inside the Surveillance Machine', 21 March 2018, https://www.newyorker.com/tech/annals-of-technology/cambridge-analytica-and-our-lives-inside-the-surveillance-machine. And Jane Mayer, 'New Evidence Emerges of Steve Bannon and Cambridge Analytica's Role in Brexit', 18 November 2018, https://www.newyorker.com/news/news-desk/new-evidence-emerges-of-steve-bannon-and-cambridge-analyticas-role-in-brexit.
[71] Hu, *Prehistory*, loc. 128.

analogies as Hu does, or on geographical concerns as Amoore does,[72] I aim to access the imagined cloud and its sealed data centres through the overarching planetary imaginary. I evoke feminist authors such as Rosi Braidotti who insist on a "planetary, geo-centred" perspective"[73] in order to think beyond nature-culture dichotomies. The cloud and its geological roots are a particularly fruitful site of enquiry for the anxieties and potentials of a time that many have chosen to call the Anthropocene. The cloud brings together archiving—the dream of human legacy—and a geo- or meteoro-centred entanglement with the planet. The cloud is *beyond here and now*, as it establishes what Meillassoux might call *le grand dehors*: an utterly removed, barely imaginable, yet ever-present great outdoors.[74]

Media Theory

Media theory, which deals with the cultural implications of technologically enhanced means of communication, has also turned towards the ground. Media geology and archaeology emphasise the geological materiality and temporal depth of media practices. I integrate media as geologically entangled into my definition of the geological mode. Media theory has absorbed the connection between the digital cloud and its concrete materiality: "insights that once seemed liked epiphanies are now widely shared: that the Internet is a place made of material things".[75] Media scholar Shannon Mattern explores the archaeology of smart media in an urban context, which she reads as inscribed in bricks, antenna signalling and paper flows. The meteorological and geological modes echo her notion of media as governed by "ether and ore".[76] The digital cloud is anchored in a vast infrastructural field built on media-archaeological strata.

72 Amoore briefly mentions Luke Howard and the classification of meteorological clouds. Amoore, "Cloud Geographies".
73 Rosi Braidotti, *The Posthuman* (Cambridge: Polity Press, 2013), 81.
74 Meillassoux, *After Finitude*.
75 Shannon Mattern, "Cloud and Field", *Places Journal* (2016), https://doi.org/10.22269/160802.
76 Shannon Mattern, *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media* (Minneapolis and London: University of Minnesota Press, 2017), Kindle.

These strata inform media archaeology, as its proponents endeavour to approximate past temporalities inscribed in media systems rather than contextualising these in the cultural narratives usually associated with media history. This approach is informed by the understanding of media as governed by a particular inherent temporality, the *Eigenzeit*—literally, "an entity's own time". I understand the *Eigenzeit* of today's digital archives—anchored in data centres and dispersed via the metaphorical cloud—as temporal modalities that can be accessed through the geological and meteorological modes. Neither historical nor strictly chronological, these modes form part of a planetary imaginary which is in flux and has varying means of manifesting itself. Thus, my approach resonates with media archaeologist Wolfgang Ernst's methodology: "archaeology, as opposed to history, refers to what is actually there: what has remained from the past in the present like archaeological layers, operatively embedded in technologies".[77]

The term "archaeology" is used by media archaeologists to denote an approach to time that is freed from history—the human temporal prejudice. Driven by the Foucauldian intention "to be freed by machines from one's own subjectivity", [78] the media-archaeological gaze is "immanent to the machine".[79] With an approach that is thus "enumerative rather than narrative, descriptive rather than discursive, infrastructural rather than sociological", media archaeology unearths "a kind of stratum—or matrix—in cultural sedimentation that is neither purely human nor purely technological, but literally in between (Latin *medium*, Greek *metaxy*)".[80] Granting media autonomy is perceived by media archaeologists as going beyond McLuhan's notion of media as "extensions

[77] Wolfgang Ernst, *Digital Memory and the Archive*, ed. Jussi Parikka (Minneapolis and London: University of Minnesota Press, 2013), loc. 57, Kindle.
[78] Ernst, *Digital Memory*, 69–70.
[79] Ernst, *Digital Memory*, 67.
[80] Ernst, *Digital Memory*, 70.

of man",[81] and hence "media themselves become active archaeologists of data".[82] Ernst focusses on signal processing, which sensitises him to the unique temporalities of different media. He writes: "those temporalities then impact how media record their own existence and operation: how they 'archive' their own pasts, in their own codes, at their own speeds, on their own disks or membranes".[83]

Applying the notion of inherent temporalities to the cloud opens up two fields of enquiry. On the one hand, there is the temporality anchored in the materiality of the storage devices in data centres. In his 2015 *A Geology of Media*, media scholar Jussi Parikka shows that their materiality is in turn bound to the ground: "inside the earth one finds an odd chemical, rocky, and metallic reality, which feeds into metal metaphysics and digital devices".[84] Parikka's media geology ties the geological ground to contemporary media by focussing on their materiality. The materiality of the data carriers of servers in data centres is distinctly geological. Building on his material analysis, I trace how data centres incarnate the animated aspects of geological materiality, not only in the way magnetic fields of information are imprinted onto hard drive disks, but also in how these need to be continuously animated by electricity, i.e. spinning, in order to be decipherable by the disk sensors. Beyond the individual temporalities of media as signal inferring devices, the geological ground itself engenders an *Eigenzeit*—one that might be characterised as the deep time of continuous animation. The second field of the cloud's temporality develops from taking the metaphor "cloud" seriously. The meteorological cloud is permeated by an *Eigenzeit* that reveals characteristic qualities of today's archiving practices. Like the aerosols in the meteorological clouds, which are in constant flux, data circulates assiduously "between the needs

[81] Wolfgang Ernst, "Radically De-Historicizing the Archive: Decolonizing Archival Memory from the Supremacy of Historical Discourse", in *Decolonizing Archives*, ed. Rado Ištok and Nataša Petrešin-Bachelez (online: L'Internationale Online, 2016), 67.
[82] Ernst, "Radically De-Historicizing", 67.
[83] Mattern, *Code and Clay*, loc. 282.
[84] Jussi Parikka, *A Geology of Media* (Minneapolis and London: University of Minnesota Press, 2015), loc. 767–771, Kindle.

of an inquiring present and the archival documents".[85] These media-archaeological approaches have not, to my knowledge, been applied in architectural analyses of digital archives. I thus contribute the translation of the above-mentioned findings into an architectural context.

Animation

Throughout this research on digital archives and their relationship to the geological and meteorological modes, I frequently return to the theme of animation. As digital archives increasingly manifest a continuous transfer of data[86] the focus shifts from storage as a space of static data carriers, to a realm of data in a continuous state of animation. Digital archives must allow their data to be retrieved at any moment, instantaneously, from anywhere. The user relies on the immediate activation of the required data, facilitated by the digital archive type. Continuous movement permeates the cloud and data centres. This kind of animation can be related to the ontology of becoming of philosopher Gilbert Simondon,[87] cybernetics,[88] and philosophers such as Deleuze and Guattari.[89]

Animation affects all perceiving bodies, in an arc of philosophical thinking that extends from phenomenologist Merleau-Ponty (who conceives of the perceiving body's sense receptacles as vibrating in unison with the perceived characteristics)[90] to medieval philosopher Campanella. Mostly remembered for his utopian city planning, Campanella also understood the world as a large sensing animal, permeated and animated by an all-

[85] Ernst, *Digital Memory*, 100.
[86] Ernst, *Digital Memory*, 100.
[87] Simondon, *Mode of Existence*.
[88] Orit Halpern, *Beautiful Data: A History of Vision and Reason Since 1945* (Durham, NC and London: Duke University Press, 2014), Kindle.
[89] Gilles Deleuze and Félix Guattari, *What Is Philosophy?* (New York: Columbia University Press, 1994).
[90] Maurice Merleau Ponty, *Phenomenology of Perception* (Milton Park: Taylor & Francis Ltd, 2013).

encompassing "sense".[91] This kind of non-physical connectedness resonates with the world view of environmentalist John Muir (1838–1914), who convinced the American government to protect stretches of land in the form of national parks. His writings manifest a poetic way of perceiving the world as interconnected by invisible cords—possibly inspired by the new rail and telephone networks of his time, and by reading Alexander von Humboldt's cosmos quite literally, as a physical network of connected nodes. Similarly, philosopher Bergson begins his *Matter and Memory* with the image of his body extending outwards towards other images via perceptive nerve cords that quiver in response to the world.[92] Recent scholarship associated with new materialism picks up on this, such as Jane Bennett's *Vibrant Matter* (2009), although Bennett focusses on the matter more than on the data exchange between a perceiving and a perceived entity. Art historian Jacob Wamberg reminds us that "vibrant matter" is ancient and that rocks had active (cultural) lives in premodern theories.[93] Literary scholar Kathrine Hayles emphasises the cognitive similarities between all "animated" entities, be they humans, plants or technical, by describing them all as cognizers, which partake nonconscious cognition: scanning the environment for input, patterning data and forwarding relevant information to consciousness.[94] Nonconscious cognition also runs the cloud.

Historical Memory Metaphors

The metaphor of the cloud can be situated in a tradition that extends to antiquity. A brief overview of these memory metaphors reveals continuities between the archives of contemporary digital culture and an

[91] Daniel Heller-Roazen, *The Inner Touch: Archaeology of a Sensation* (New York: Zone Books, 2009).
[92] Henri Bergson, *Matter and Memory*, trans. Nancy Margaret Paul and W. Scott Palmer, 8th ed. (New York: Zone Books, 2005).
[93] Jacob Wamberg, *Landscape as World Picture: Tracing Cultural Evolution in Images*, vol. 1 (Aarhus: Aarhus University Press, 2005), 250–86.
[94] N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious*, Kindle (Chicago and London: The University of Chicago Press, 2017).

extensive history of spatial imaginings of the functioning of the human faculty of memory. The cloud can thus be understood as one of the most recent spatial metaphors for outsourced memory. 369 BCE, Greek philosopher Plato (427 BCE) pictured pigeon coops as an analogy to the mental faculty of memory; Saint Augustine (354-430) imagined "fields and spacious palaces" to hold his memories; and Giulio Camillo (1480-1544) invented a memory theatre to contain all the world's knowledge.[95] Most famously, Simonides, the mythical progenitor of the architectural mnemotechnique, walked through mental memory palaces, where he retrieved information triggers in the form of memory images. He inferred that memories are composed of space and time. Memory's power of temporal synthesis—of joining disparate moments of the past—is supported by place's ability to contain and draw vicinities. An early articulation of this intricate relationship was formulated by the ancient Greeks in the form of an architectural art of memory, also called the "method of loci".[96] Its practitioners would create an imaginary or perfectly memorised building in their minds, with varied architectural features, such as niches, an atrium, differently sized rooms, distinct staircases, etc. Next, they would define a particular route through the construction, which they would always adhere to when inside the memorised building. This course determined a temporal and spatial sequence, which was important for establishing and supporting a structure for memories, as the mental faculty of memory thrives if there is a *before* and an *after* to individual fragments. Along the determined route, the "memory artists" would then place striking images that triggered certain topics or memories. These images would often be grotesque or absurd: strange, vivid images are more

[95] In Plato's Theaetetus, birds, and especially pigeons, were used to imagine memories, souls and thoughts, so the pigeon coop was a likely metaphor for the mental faculty of memory. Bees and honey cells have evoked similar associations. Memory was understood as a gathering activity which accumulated a texture of associations related to a certain topic. Quintilian compares the orator, who gathers bits of knowledge and composes them to generate ideas and arguments, to bees, which "turn various kinds of flowers and juices into that flavour of honey". See Frances Yates, *The Art of Memory* (London: Routledge and Kegan Paul, 1966). See also Mary Carruthers, *The Book of Memory: A Study of Memory in Medieval Culture*, Second (Cambridge: Cambridge University Press, 2008).
[96] Yates, *The Art of Memory*.

memorable and more likely to activate the associated information. The unknown author of *Rhetorica ad Herennium* (circa 86–82 BCE) advises that the images should have features that are "exceptionally base, dishonourable, unusual, great, unbelievable, or ridiculous",[97] because these out-of-the-ordinary assets were likely to be more easily remembered. To access the stored material at some later point, practitioners would simply recollect it along the route by walking from one image in its particular location to the next.

The architectural mnemonic points to the potential of architectural design to activate the inherent memorability of a space, and to make use of the effect of organised space on the perception of time. In a memory building, the spatial and the temporal rely on one another. The more detailed and varied the space and the more specific the route, the easier it becomes to experience and remember the building through a clear temporal sequence. The "method of loci" is thus based on the logic that, in Cicero's words, "the order of the places will preserve the order of the things, and the images of the things will denote the things themselves".[98] Cicero explains the relationship between memory and building by the fact that memory images, which are more easily remembered than abstract concepts, "require an abode", for "the embodied cannot be known without a place".[99] He implies that memories only transmit meaning if they are recollected from a context that situates them.

Since its beginnings, the art of memory was built on memory's power of temporal synthesis.[100] Memory contains and stores information. Memory itself was thus understood as a place that contains. Aristotle defines place as "a non-portable vessel" that functions as "the innermost motionless

[97] Yates, 25.
[98] Yates, 17.
[99] Mary Carruthers, *The Book of Memory: A Study of Memory in Medieval Culture*, Second (Cambridge: Cambridge University Press, 2008), 91.
[100] Edward S. Casey, *Remembering: A Phenomenological Study* (Bloomington: Indiana University Press, 2000), 202–3.

boundary of what contains".[101] His concept of place as container, as *periechon*, can easily be extended to buildings. They contain space for particular activities. In the context of the architectural mnemotechnique, they contain memories, and they function as memory storages: they organise memories and make them accessible. Consequently, memory buildings establish spatial sequences in order to unify temporal difference, as they gather memories pertaining to disparate moments in absolute time. In contrast, the ever-changing morphology of a cloud conjures a variety of different images. There is no clear route or outline in relation to a cloud. It negates all continuity except change. The *periechon* is somewhat diametrically opposed by the spatiality of the cloud, which as a "body without a surface" has no definitive outlines. It is a mobile vessel that contains but does not confine. This is the field of tension suggested by the chronotope of a cloud as archive.

In their shared functions of storage and retrieval, the imagining, explanation and requirements of memory can be extended into archival practices. As a spatial phenomenon that challenges traditional conceptions of place, boundaries, accessibility and stability, the digital cloud raises the problem of an intriguing spatiality, possibly relatable to that of a more medieval context. The medieval craft of memory was understood as a practice of interlinking, gathering and texturising meaning. At the time, memorising was closely related to internalising the content, in a process named "textualisation". Mary Carruthers explains in her detailed analysis in *The Book of Memory*: "the Latin word *textus* comes from the verb meaning "to weave". […] *Textus* also means "texture", the layers of meaning that attach as a text is woven into and through the historical and institutional fabric of a society".[102] In relation to the classical imagery of memory as a field of flowers where bees gather the pollen, memory becomes an exercise of gathering, layering, weaving together in order to (re)compose or find insight or knowledge. A space for the recomposition of memories—or in a contemporary context, the recomposition of data

[101] Casey, 191.
[102] Carruthers, *The Book of Memory: A Study of Memory in Medieval Culture*, 14.

points in order to make sense of them—resonates with the archival practices associated with digital memory.

Roadmap

Part 1 develops the geological mode of archiving in relation to three case studies, which I read as "data centres": as archives, they gather (raw) data and manifest spatialities, materialities and temporalities characteristic of the geological mode. First, the Lamont-Doherty Core Repository at Columbia University, New York, is one of the world's largest sediment core archives. At the Lamont-Doherty, the archived geological *data* is the moist or dried-out mud cores extracted from the world's ocean floors. The newer cores are preserved at 4.5 degrees Celsius to prevent their drying out. From the compressed sediment, scientists extricate information by isolating the remnants of former plankton. Thanks to oxygen isotope dating, the miniscule skeletons reveal CO_2 levels, global temperatures, the extent of ice caps, etc. from the past. The Lamont-Doherty can thus be understood as an analogue data centre.

A similar reading, but one situated within an art-historical context, leads to the selection of the next case study, the memorial *Il Grande Cretto* ("the great crack") by Italian artist Alberto Burri (1915–1995) in Sicily. Here, I apply the geological mode in an investigation of a large-scale land art piece that commemorates Gibellina, a small town which was completely destroyed during the 1968 Belice earthquake. The lithic materiality of *Il Grande Cretto* is itself a storage medium, for cultural history as much as for material processes. The *Cretto* is exemplary, both in its conception and in its slowly eroding presence, of the implications of an active ground that extends far beyond a passive projection plane for our notions of nature.

After the geophysical and cultural archives, I turn to the third case study, a recently completed data centre for the Nordea Bank headquarters (2017) by Danish architects Henning Larsen. Shrouded in secrecy and high-tech monitoring, the data centre's infrastructure aspires to maximum resilience by incorporating heavy levels of redundancy to ensure continued uptime. I describe the materiality, spatiality and temporality of the data centre to reveal that the quality of animation of geological matter extends to the practice of animating archives.

In Part 2, the meteorological serves as point of departure. In terms of spatiality, the meteorological cloud is a continuously changing form without surfaces. It visualises atmospheric conditions, and constantly updates its shape to respond to the vast number of parameters that influence the cloud. British pharmacist Luke Howard (1772–1864) recognised clouds as processes rather than fixed forms in his cloud nomenclature of 1802, which ensured the success and durability of his flexible classification system. I will turn to the materiality of the meteorological and describe the archival capacities of clouds and their aerosols, which for example carry biological and geographical information and traces of nuclear or volcanic events. I will draw out the similarities with the spatiality of the idea of the cybernetic archive—decentred, externalised, non-hierarchical—to illustrate the spatiality of the meteorological mode. These similarities govern both the meteorological cloud and the spatial imaginings of cyberneticians, precursors of today's spatial imaginings of the digital cloud. This method of comparative description leads to a delineation of meteorological temporality. The latency of aggregate change, and the governing temporality of phasing, applies to meteorological clouds; it also emerged in cybernetic computing, which incorporated Bergsonian time and the latency of self-destruction in the black box, the predictive element of Norbert Wiener's anti-aircraft device.

In section 2.1, I describe clouds as analogue computers that constantly update their own content and morphology to model the world. Meteorologist Lewis Fry Richardson's (1881–1953) speculative Forecast Factory (1922) is a curious combination of cloud and globe, designed to compute and archive the planet's weather. It is emblematic of today's archival condition as "in transfer".[103] The meteorological mode is connected to meteorology as a science: global, data-hungry, driven by prediction and updates, and network-dependent.

In section 2.2 I turn to the origins of the digital cloud, referencing an early American databank proposal from 1966, the effects of prolific atomic bomb testing during the 1950s and 1960s, and the nature of the cybernetic archive. Radioactivity, nonconscious filtering processes and the weather—these are the ingredients of the spatial imaginary that contributed to the concept of today's digital cloud. I thus argue that it was not so much the networks constituting the cloud's infrastructural backbone[104] that inspired the metaphor, but rather the spatiality, temporality and materiality that constitute the meteorological mode. The spatiality of a cloud embodies an order and engenders a temporality akin to that of the cybernetic archive: continuous updates, somewhere between empty and overflowing with information, intelligible only via an interface. In order to show how this has been quite literally translated into a (non-)architecture, I turn to the Blur Building by Diller Scofidio + Renfro. An integral part of this project is the never-realised media environment, in which the Blur Building would literally have been activated as a data conglomerate.

In the final section, I refer to medieval theatre cloud props and 1960s experimental architecture, including Frank Lloyd Wright's little-known project for an inflatable mobile Rubber Village, to explain how clouds generate a timeless and borderless space. I will describe the cloud as an unattached accessing and mediating device that hides the hardware necessary for the exchange. I will show that there is a history of clouds/satellites as mediating devices with the use of cloud props in religious theatre. The digital cloud, like the cloud prop and the satellite, creates its own temporality and spatiality. A cloud's lack of surface and its innate mobility allow it to navigate otherwise inaccessible spaces. The

[103] Ernst, *Digital Memory*.
[104] See for example Hu, *Prehistory*.

spatiality of the cloud is like the information it reveals: veiled and blurred, it is never quite graspable. As long as the digital cloud remains shrouded in an elusive and barely imaginable spatial ephemerality, it can constitute a site of sovereign exclusivity. The disembodiment that occurs in the "reduction of other to data"[105] and the impenetrable intangibility of the digital cloud can be counteracted with historical spatial references that point to characteristics inherent in the digital cloud. The less ephemeral and more spatially unpacked this construct is, the less evasive and potentially exclusive today's data archives can become.

I conclude Part 2 with a theoretical exploration of the Great Nonconscious generated by the digital cloud. Using Katherine Hayles' terminology,[106] I suggest that with today's digital system, humans have outsourced not their thinking process (as implied by "artificial intelligence") but rather the nonconscious data processing strategies that now govern Big Data analysis in the cloud. The spatiality of the nonconscious realm can be understood as a great outdoors. The great outdoors is the spatial articulation of the anxieties of the Anthropocene.

[105] Wendy Hui Kyong Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics* (Cambridge, MA: MIT Press, 2006), 29.
[106] N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago and London: University of Chicago Press, 2017), Kindle.

Shutterstock Loop described in Preface (still)

Data centre and cloud visualisation

Data centre and cloud visualisation

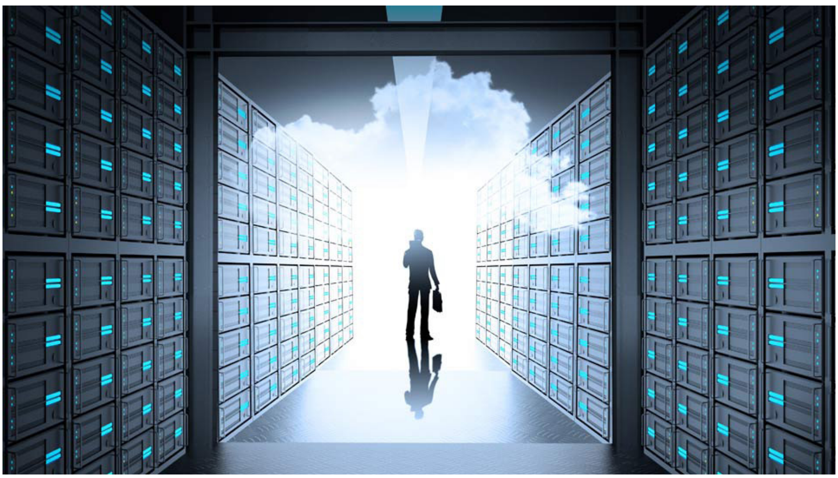
Data centre and cloud visualisation

Actual data centre (case study of section 1.3), looks like a rendering

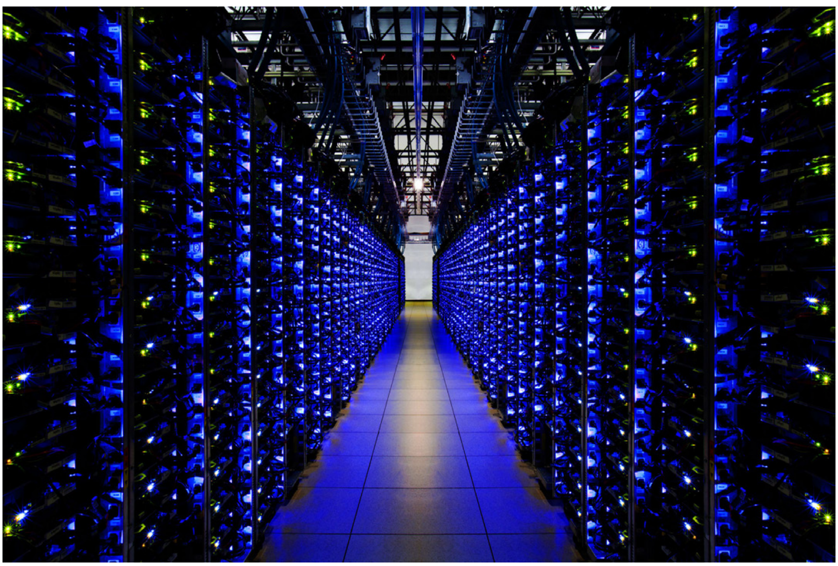
Data centre and cloud visualisation
https://www.scmp.com/tech/enterprises/article/1843096/chinas-alibaba-targets-data-centres-bid-replace-amazon-cloud

Data centre and cloud visualisation
www.technologydecisions.com.au

Data centre and cloud visualisation
www.zdnet.com/article/cloud-v-data-center-key-trends-for-it-decision-makers/



Data centre and cloud visualisation
carrier.huawei.com



Connie Zhou, where the internet lives, commissioned by Google to make the secret world of data centres available to the public imagination in 2012. The artist modified the images, creating exaggerated symmetries, for an effect of serenity and beauty.

PART 1

DATA CENTRES AND THE GEOLOGICAL MODE

1.1 THE GEOLOGICAL MODE AND ITS RELATIONSHIP TO ARCHIVING

Geology conjures a temporality of sedimented chronologies, a layered spatiality of strata, and a materiality of crystalline, compressed, solidified or petrified products of time. Once geology had come into existence as a science in the early 19th century, the planet was understood as a steady archive of its own history. This introductory chapter to Part 1 develops the notion of the geological mode, which will serve as an analytical ground for the study of data centres and associated digital archiving practices. I will outline the concept of the geological mode—a state of constant activity and its continuous, immediate archiving. The geological mode exemplifies a modality that is associated with the movement inherent in the earth's crust. I will then show the implications of this mode in relation to three case studies, and I will conclude with the fact that data centres, like the ground they contain, are architectures of animation.

Geology as Mode

Geology is connected to history, as its material embodies and preserves traces of its past activities. Because of their endurance, objects of geological origin embody particularly *deep* archives. Informatics scholar Geoffrey Bowker describes how a rock is an archive, as "striations on the surface indicate past glaciation, strata indicate complex stories of deposition over time, and the relative presence of radioactive isotopes of various kinds indicates, among other things, journeys through the mantle".[107] Not only can geology be understood as an archive of its own past, but it also preserves human history: "most human vestiges from the time before writing survive because their substance is rock (axe, statue,

[107] Geoffrey C. Bowker, *Memory Practices in the Sciences* (Cambridge, MA and London: MIT Press, 2005), loc. 579–582, Kindle.

windbreak) or because they have petrified (bone, body, footprints)".[108] By extension, human history is entangled with geological time.[109] Because geological time frames are so much larger than human temporal horizons, the preservative qualities of geological matter, in particular of rocks, are often emphasised.

There is, however, another side to the lithic. In the words of medievalist Jeffrey Jerome Cohen, "rock moves like any liquid, restless and ephemeral: sedimented, recycled, engulfed, pulverized, melted, metamorphized, eroded, rebirthed. We think stone persists only because it outlasts. We trust stone as archive and monument, but we may as well write on water".[110] Geology can be understood as an archival mode of both endurance and transience, characterised by internal activities that remain inaccessible to human perception unless they erupt as volcanoes, implode as sinkholes or manifest as earthquakes and thus clash with human temporalities. The geological mode of archiving embodies the tension between the enduring and the ever-changing. This mode will then be used as a descriptive and analytical tool in the analysis of data centres (section 1.3) as archives that incorporate the geological ground (section 1.2).

The planet as archive is a relatively recent idea and is closely bound to the beginnings of geology as a science. In *Theory of the Earth* (1795), Scottish geologist James Hutton (1726–1797) developed a way of looking at the history of the world that was groundbreaking in that it departed from a linear narrative of continued erosion towards a cyclical planetary temporality: he formulated the planet as a self-renewing entity.[111] The catastrophists of his time based their understanding of the planet on the

[108] Jeffrey Jerome Cohen, *Stone: An Ecology of the Inhuman* (Minneapolis and London: University of Minnesota Press, 2015), 85.
[109] See also Jussi Parikka, *A Geology of Media* (Minneapolis and London: University of Minnesota Press, 2015), loc. 243–245, Kindle: "Human history is infused in geological time".
[110] Cohen, *Stone*, 256.
[111] In relation to Charles Lyell, who later popularised this concept, see also Bjornerud, *Timefulness: How Thinking Like a Geologist Can Help Save the World*, 28.

notion that it had formed in a hot molten or gaseous state and had been cooling ever since. The crust was cooling more and more deeply into the planet, which still had a boiling core. The cooling process caused the planet to contract, which in turn resulted in friction and upheaval—earthquakes, volcanoes etc.[112]

Informed by his conviction that the planet must have a "purpose" and could not just continue to disappear due to cooling, contraction and erosion, Hutton's theory of the world included mechanisms to neutralise erosion. Resonating conceptually (and architecturally) with Buckminster Fuller's (1895–1983) much later Spaceship Earth[113] and Corbusier's "machine for living in", Hutton understood the earth as a machine for inhabitation.[114] In his treatise he thus refers to "this mechanism of the globe, by which it is adapted to the purpose of being a habitable world".[115] In an understanding formed by notions of progress of the time, the world was still considered to be at the service of humankind: the planet was "a world peculiarly adapted to the purpose of man, who inhabits all its climates, who measures its extent, and determines its productions at his pleasure".[116]

An important mechanism which enabled the functioning of Hutton's planetary machine was his concept of the "mechanism for uplift"[117] to counteract erosion. Uplift forms part of the tectonic processes in the

[112] See for example Stephen Jay Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*, 9th ed. (Cambridge, MA and London: Harvard University Press, 1987), 130.
[113] Richard Buckminster Fuller, *Operating Manual for Spaceship Earth* (Carbondale: Southern Illinois University Press, 1968).
[114] Gould, *Time's Arrow*, 65.
[115] James Hutton, *Theory of the Earth. Transactions of the Royal Society of Edinburgh* (Edinburgh: J. Dickson, 1788), http://pages.uwc.edu/keith.montgomery/Hutton/Hutton.htm.
[116] Hutton. See also Gould, *Time's Arrow*, 74: "For the purpose of this cycling, he advances an unswerving conviction that we might brand as crass hubris today, but that seemed self-evidently true in his age. The earth was constructed as a stable abode for life, in particular for human domination".
[117] Gould, *Time's Arrow*, 63.

earth's crust. The most drastic uplift results from tectonic plate collisions and creates mountain ranges. Uplift can be perceived in the geological phenomenon of unconformities. An unconformity is a geological formation where two accumulations of rocks that differ significantly in age meet. Unconformities thus signify a temporal gap in rock adjacencies. One of these, at Siccar Point in Scotland, was named after Hutton, because it impacted on his geological treatise. Images of the site document a rock wall which is marked by two patterns of sedimentation: the strata of the lower part of the rock seem to have been arranged standing upright. This part of the rock wall is capped by another layer of more horizontal grain, rotated upwards by roughly 10 degrees. The bottom layer used to be horizontal, before uplift rotated it upwards. Then sedimentation piled up on top of it and was compressed into rock. Hutton understood rocks as witnesses to these transformations, which the planet continuously experiences and archives.

Hutton's notion of the planet as an archive in constant motion was popularised by lawyer turned geologist Charles Lyell (1797–1875). In his seminal book *The Principles of Geology* (1830), Lyell famously portrays the planet as its own archive-archivist—always changing, and keeping track of its own changes.[118] The planet's geology is an archive of change. It was the role of the geologist to make sense of this somewhat messy archive.[119] He created a geological methodology, later named "uniformitarianism", which can be understood to have transformed the philosophy of geology into a science. Lyell defined his science through a set of "uniformities" which were governed by the overarching observation that "the present must be our key to the past".[120] The first, "the uniformity of law", entailed that "natural laws are constant in space and time".[121] The second, "the uniformity of process", held that geologists should "explain the past by

[118] *The Principles of Geology* shows classical temples on the frontispieces, emphasising an architectural/cultural aspect to the geological "building" of the world.
[119] Bowker, *Memory Practices*, loc. 899.
[120] Gould, *Time's Arrow*, 105.
[121] Gould, *Time's Arrow*, 119.

causes now in operation".[122] There were also Lyell's "uniformity of rate, or gradualism", referring to the gradual and steady pace of change,[123] and the "uniformity of state, or nonprogressionism", which denoted that the "planet always looked and behaved just about as it does now. Change is continuous, but leads nowhere".[124]

In Lyell's understanding of the history of the world, there had always been change, but not much was changing. So while erosion worked continuously on mountain tops, and uplift always created new elevations, the overall balance—to use financial terminology—remained zero: "the sum of creative and destructive forces (credit and debit) is always precisely zero".[125] In Gould's words, "Lyell's vision [was] of a world in constant motion, but [it was] always the same in substance and state, changing bit by bit in a stately dance toward nowhere".[126] The paradoxical continuous movement "toward nowhere" resonates with descriptions of today's "voracious desire to collect information of all kinds",[127] which according to informatics scholar Bowker is also "a drive to save as little information as possible about something".[128] Geoffrey Bowker sees Lyell's geological approach as a "system for the classification of […] information". Lyell's geology mirrored larger trends in archiving of the time. Bowker writes: "the tools that we have to think about the past with are the tools of our own archive so that we generally project onto nature our modes of organizing our own affairs".[129] Lyell understood "the earth itself [as] a sort of record keeper—perhaps not a very good one, but a record keeper nonetheless".[130] He fortified Hutton's observation of a temporality of cyclicity rather than linear development in the planet's evolution.

122 Gould, *Time's Arrow*, 120.
123 Gould, *Time's Arrow*, 120.
124 Gould, 123.
125 Bowker, *Memory Practices*, loc. 1097–1101.
126 Gould, *Time's Arrow*, 132
127 Bowker, *Memory Practices*, loc. 615.
128 Bowker, *Memory Practices*, loc. 617.
129 Bowker, *Memory Practices*, loc. 320–326.
130 Bowker, *Memory Practices*, loc. 320–326.

Gould refers to Hutton's geology as his "Theory of the Earth: A Machine without a History".[131] In Hutton's understanding, and later in Lyell's, it made little sense to speculate on "ultimate beginnings and ends".[132] Gould further clarifies that geological beginning and end points would exist outside the uniformity of state and were thus, in the newly systematised geological world view, not scientifically coherent. Instead, the focus was on the planet's perpetual, steady self-renewal.[133] The "nondirectional world machine with endlessly cycling phases of uplift, erosion, deposition, consolidation, and uplift"[134] serves as an insightful point of departure for this thesis' investigation of digital archives, which as I will show are also in a continuous state of change and animation. Like geology, they dissolve the difference between past and present, as all digitally stored data is continuously updated into an ever-extended present.[135] This is how I will instrumentalise the geological mode in the following chapters.

Geology is a system—a logic or method—that engenders a specific kind of spatiality, temporality and materiality. Building on my description in the introduction, the term "mode" denotes a way of existing,[136] perceiving and being. The geological mode refers to how geological material (the lithic and the metallic) is organised, and how it behaves. I will show that its materiality engenders a particular type of spatial and temporal structure, which can be found in the architecture of digital archives as they are materially entangled with the geological. The shared geological materiality of the ground and of servers in data centres entails that both archival systems share the geological mode of existence.

[131] Gould, *Time's Arrow*, 61.
[132] Gould, *Time's Arrow*, 123.
[133] Gould, *Time's Arrow*, 123.
[134] Gould, *Time's Arrow*, 128–129.
[135] See Bjornerud, *Timefulness*, 161. On digital archives, see Wolfgang Ernst, *Digital Memory and the Archive* (Minneapolis and London: University of Minnesota Press, 2013), loc. 99–100, Kindle.
[136] For the relationship to technical objects see Simondon, *On the Mode of Existence of Technical Objects*.

How can we apply the geological mode? The following selection of historical examples, read in relation to the findings of contemporary media theory, show how the geological mode can be used as an analytical and archival method. American environmentalist Aldo Leopold (1887–1948) proposed "thinking like a mountain".[137] Leopold had discovered that every living element in nature plays an irreplaceable role: for example, the wolf controls the deer population. If the wolf is made extinct, the deer population mushrooms, resulting in extensive grazing of the mountain slopes, fewer new trees to stabilise the ground on steep slopes, and hence unhindered dust bowl formations.[138] For him, "thinking like a mountain" meant an awareness of a large-scale, even planetary system of interdependencies and interconnections—in the style of von Humboldt, as briefly discussed in the introduction.

However, understood from the context of the geological mode, the evolution of a mountain is not just about optimising functionality in a specific context, which in itself results from a sensitive but still mechanical view of nature. Instead, the mountain is a reflection of the world and the lithic material's physical response to the world's impulses, such as moisture, wind, rotation, gravity or magnetic forces. The mountain embodies ancient, even antemundane and certainly prehuman planetary activity.[139] In the context of this description of the geological mode, Leopold's motto can be understood as a processual credo, resonating with Cohen's description: "whether a pebble or a volcano, a mountain or a meteor, the lithic offers passage into action, a catalyst, a cause".[140] The geological mode is thus a way of resonating with the world; and this resonance is a theme that will keep recurring in the following chapters.

137 See also Bjornerud, *Timefulness*, 179.
138 Aldo Leopold, *From A Sand County Almanac: And Sketches Here and There* (Oxford: Oxford University Press, 1949).
139 As the Anthropocene envisions an end of the human race and its role as a geological force, the prehuman is gaining ground.
140 Cohen, *Stone*, 4–5.

Not quite "thinking like a mountain" but certainly "thinking with the ground" defines media theorist Jussi Parikka's approach to new media. He uses geology as a conceptual starting point for his investigation into the temporality and materiality of media. In the course of his material analysis of media devices, he extends the meaning of geology beyond the ground, to encompass a way of thinking and researching that is governed by "ambulant flows, transversal connections, and teasing out the materiality of matter in new places".[141] Geology is a particular mode of understanding assemblies between life forms and technological systems. It sustains "organic life as much as the technological worlds of transmission, calculation, and storage".[142] In its manifold infiltrations of life and culture, Parikka sees the potential of geology as "a conceptual trajectory"[143] which connects media and culture on a material and temporal level. His "geology of media" is thus "a different sort of temporal and spatial materialism of media culture than the one that focuses solely on machines or even networks of technologies as nonhuman agencies".[144] Parikka draws attention to the geological materiality, and what I would call the geological mode of operation, that characterises digital archives.

Media geology was developed in dialogue with media archaeology: Parikka, for example, translated one of the field's major voices, Wolfgang Ernst.[145] Media archaeology attempts to go beyond the human-centred historical narrative and instead focus on the *Eigenzeit* (intrinsic temporality) of media devices, which transmit their inherent temporal realities independently of the human observer. This method of enquiry recalls Hutton's and Lyell's, who left behind the biblical narrative and its temporal restrictions to directly probe the ground for an intrinsic planetary temporality. With media *geology*, Parikka thus sheds another layer of the anthropocentric by focussing directly on the ground rather than using archaeology, a system infused with anthropological objectives. My

141 Parikka, *Geology of Media*, loc. 564–569.
142 Parikka, *Geology of Media*, loc. 192–199.
143 Parikka, *Geology of Media*, loc. 192–199.
144 Parikka, *Geology of Media*, loc. 181.
145 Ernst, *Digital Memory*.

definition of the geological mode builds on his use of geology as a conceptual foundation for media.

Parikka is also inspired by Deleuze and Guattari's geological approach, which he detects in their *A Thousand Plateaus* (1980) and *What Is Philosophy?* (1991) amid "notions of strata, sedimentations, double articulations".[146] Here he reads the foundation of "a postanthropocentric theory",[147] a geocentric alternative: "Deleuze and Guattari's philosophy maps the geology of thought, which moves from the geophilosophical territories in which thinking happens in relation to the grounds, undergrounds, and territories where the immaterial events of thinking and affect are always tied to stratified assemblages".[148]

Another useful example is the idea of the "geology of thought",[149] which formed the groundwork of American artist Robert Smithson's (1938–1973) "abstract geology". Remembered for his land art interventions, Smithson saw the ground as a "jumbled museum",[150] in line with Hutton's and Lyell's notion of the planet as a—sometimes difficult to decipher—archive. Smithson was a spokesperson for the land artists, and his articles published in the contemporary art journal *Artforum* present a cross-section through the scene and its preoccupations. He consolidated the use of the term "earthworks" for artworks made of earth in an article published in June 1967, drawing attention to the budding geological methodology among his peers: "a 'boring,' like other 'earth works' is becoming more and more important to artists. Pavement, holes, trenches, heaps, paths, ditches, roads, terraces., etc all have an esthetic potential".[151] Smithson was acutely aware of the potential of the geological as an artistic process, mode

[146] Parikka, *Geology of Media*, loc. 515–516.
[147] Parikka, *Geology of Media*, loc. 515–516.
[148] Parikka, *Geology of Media*, loc. 518–521.
[149] Parikka, *Geology of Media*, loc. 518–521.
[150] Robert Smithson, "A Sedimentation of the Mind: Earth Projects", *Artforum* 7, no. 1 (1968): 87.
[151] Robert Smithson, 'The Monuments of Passaic', *Artforum* 6, no. 4 (December 1967). See also Suzaan Boettger, *Earthworks: Art and the Landscape of the Sixties* (Berkley: University of California Press, 2004).

of operation and descriptive analogy for mental processes. While the practitioners of earth art—the makers of earthworks—did not necessarily emphasise the archival, there are relevant overlaps: the earthworks of the 1960s and early 1970s are understood in tension with technology, and in interaction with budding environmentalism—themes that are at the forefront of today's discussions around media as anchored in the environmental, the planetary.[152]

In the article "A Sedimentation of the Mind: Earth Projects", published in 1968 in *Artforum*, Smithson juxtaposes his notion of an "abstract geology" of the mind with the "climate of sight" as two overarching artistic modes that bear similarities to my proposed archival modes of the geological and the meteorological. "Abstract geology" allowed the artist to translate the barely perceptible geological activities of the planet into the workings of the mind, which like geological processes leave traces but remain invisible. For Parikka, Smithson's "abstract geology" describes "how tectonics and geophysics pertain not only to the earth but also to the mind; abstract geology is a field where a geological interest is distributed across the organic and nonorganic division".[153] Smithson's evocative description of geological processes lends itself to describing the geological mode as readily as to describing the artistic imagination:[154]

> One's mind and the earth are in a constant state of erosion, mental rivers wear away abstract banks, brain waves undermine cliffs of thought, ideas decompose into stones of unknowing, and conceptual crystallizations break apart into deposits of gritty reason. Vast moving faculties occur in this geological miasma, and they move in the most physical way. This movement seems

[152] See also John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: The University of Chicago Press, 2015).
[153] Parikka, *Geology of Media*, loc. 211–214.
[154] See also Parikka, *Geology of Media*.

> motionless, yet it crushes the landscape of logic under glacial reveries.[155]

Smithson exclusively refers to erosion; the uplift processes discussed in relation to Hutton and Lyell are missing. Whereas Smithson identifies the geological with amnesia by erosion, I am interested in the archival potential of geology. Smithson was keen to distance himself from naturalism[156]—yet the idea of a direct correspondence between the creative mind and the movements of the earth bear connotations of the Romantic artist inspired by nature. The correlation is relevant in the present context: on the one hand, it shows a resemblance to contemporary philosophical and theoretical interests in breaking down the mind-matter dualism; on the other hand, it provides us with a range of useful geological metaphors that are already archival notions, as an animation of the ground. Rather than focussing on the corrosive aspects of geological forces, however, I am interested in sedimentation, layering and rearrangement through upheaval and friction, as will now become clear as I turn to the materiality of these strata to explore the material relationship between the ground and digital archives in my three case studies. The geological mode is a generative tool for the analysis of processes that are not directly related. Philosopher Etienne Turpin writes: "the cognitive processes are not, in this description, merely metaphorically connected to the material geological tendencies. It therefore is key to note that Smithson's emphasis suggests that there is a contiguous, rather than comparative, relation between mind and matter".[157] As I will show, when applied to data, Smithson's idea of "abstract geology" can be useful, because data, like thoughts in Smithson's description, is in constant motion. The movement is hidden as electrical currents in cables, as invisible radio waves, as

[155] Smithson, "Sedimentation", 82. See also Etienne Turpin, 'Robert Smithson's Abstract Geology: Revisiting the Premonitory Politics of the Triassic', in *Making the Geologic Now*, ed. Elizabeth Ellsworth and Jamie Kruse (New York: Punctum Books, 2012).
[156] Philip Ursprung, *Allan Kaprow, Robert Smithson, and the Limits to Art*, iBooks (Berkley and Los Angeles: University of California Press, 2013), 203.
[157] Turpin, 'Robert Smithson's Abstract Geology: Revisiting the Premonitory Politics of the Triassic', 174.

spinning server disks hidden behind plastic cases, while only the small quivering LED lights in data centres indicate the invisible data flow. In line with these thinkers of geological references, therefore, I will use geology throughout Part 1 as an analogy to describe temporalities, materialities and spatialities in a way that blurs the difference between the imagined and the real, the hidden and the accessible, interpretation and analysis, in relation to the cloud as a data archive.

Deep Time Permeates Geological Materiality

Media technologies consume a large amount of *the ground*—rare earths, minerals and metals, such as cobalt, gallium, indium, tantalum, antimony, platinum, palladium, niobium, neodymium and germanium. Geologist Richard Alley, whose work I will discuss again in section 2.2, points out the geological materiality of digital technology in an ingredient list of the mobile phone: "a cell phone is just a cup of oil, a handful of sand, a few of the right rocks…".[158] Similarly, the devices on which digital content in data centres is archived can be understood as materially composed of rearranged geological archival layers. Information is saved on hard drive disks and deciphered by a sensor head that scans the surfaces of disks layered with magnetic fields of zeros and ones.

The server platters are composed of a number of extremely thin layers, to generate the necessary smoothness and magnetic storage capability. The first layer contains platinum group metals and functions as an optimised "soft magnetic underlayer" for the perpendicular field on which the data is imprinted. Two CoNiFe (cobalt, nickel, iron) layers separated by a four-atom-thick layer of ruthenium constitute this stratum.[159] The next layer is for the magnetic storage. It is made of sublayers of CoCrPt (cobalt, chromium, platinum) alloys. The materials used define the abilities of

[158] Richard B. Alley, *The Two-Mile Time Machine: Ice Cores, Abrupt Climate Change, and Our Future* (Princeton: Princeton University Press, 2000), ix.
[159] "Properties of PGM", Johnson Matthey, accessed 12 October 2018, http://www.platinum.matthey.com/about-pgm/applications/properties-of-pgm.

these incredibly thin layers: "the cobalt provides the necessary orientation of the crystals; the chromium improves the signal-to-noise ratio, while the platinum provides thermal stability. Ruthenium […] help[s to] orientate the magnetic grains, as well as reducing interference between layers".[160]

Each material thus plays a precisely defined role in the archival strata of digitally deciphered, reorganised geological disks. The ground as the source of digital materiality and archival temporalities resonates with the multidisciplinary scientific probing of "the Big Data of ice, rocks, soils, and sediments".[161] The extended field of geology pierces the ground, extracts core samples, and preserves these in their "muddy, icy, soggy"[162] states in order to analyse, classify and archive them in ways that "acknowledge the Earth as a vast geo-informatic construct".[163] Smithson was aware of the geological materiality of technology—even if analogue technologies were implied when he pointed out the difference between technological processes and those "of a more fundamental order": "the breakup or fragmentation of matter makes one aware of the sub-strata of the Earth before it is overly refined by industry into sheet metal, extruded I-beams, aluminium channels, tubes, wire, pipe, cold-rolled steel, iron bars, etc".[164] The artist's observation that technology consists of "the ground" connects with Parikka's awareness of geology as linked in logic to new media, and by extension to archiving. Digital technology, with its archival purpose, has created a geological spatiality that engenders a rich geological temporality that retains some of the "fundamental" that Smithson valued in the "unrefined" ground and that he missed in "refined" technological objects.

[160] "Properties of PGM".
[161] Shannon Mattern, "The Big Data of Ice, Rocks, Soils, and Sediments", *Places Journal*, https://placesjournal.org/article/the-big-data-of-ice-rocks-soils-and-sediments/, November 2017.
[162] Mattern, "Big Data".
[163] Mattern, "Big Data".
[164] Smithson, "Sedimentation", 87.

Probing the ground for narratives of the past was also embraced as a practice by artist and historian John Ruskin (1819–1900), who applied his two great passions, geology and meteorology, to his writing on architecture and art. In *The Stones of Venice* (1851–1853), Ruskin compares rocks to paper to be "written on" by the sculptor-architect. Simultaneously, he understands rocks as archives of their lore and history. For example, his reading of marble strikingly resembles the current understanding of media and their origins in the natural elements—the earth, clouds, wind, water etc. Ruskin infers historical data from the hues of marble. These "veins and zones, and flame-like stainings, or broken and disconnected lines" reveal and "record the means by which that marble has been produced, and the successive changes through which it has passed".[165] In a poetic interpretation, Ruskin muses on these inscribed "legends, never untrue, of the former political state of the mountain kingdom to which they belonged, of its infirmities and fortitude, convulsions and consolidations, from the beginning of time".[166]

Rocks as "paper" and archive resonate with geologist Marcia Bjornerud's description of rocks and landscapes as palimpsest,

> the term used by medieval scholars to describe a parchment that was used more than once, with old ink scraped off to allow a new document to be inscribed. Invariably, the erasure was imperfect, and vestiges of the earlier text survived. […] In the same way, everywhere on Earth, traces of earlier epochs persist in the contours of landforms and the rocks beneath, even as new chapters are being written. The discipline of geology is akin to an optical device for seeing the Earth text in all its dimensions.[167]

165 Ruskin, *The Stones of Venice: The Fall*, III:55.John Ruskin, *The Stones of Venice* (Place: Publisher, Date), 28.
166 Ruskin, *Stones of Venice*, 28.
167 Bjornerud, *Timefulness*, 22.

Similarly, Ruskin believes that if one were continuously exposed to marble, "this language of theirs would soon begin to be understood",[168] revealing the rocks' history and origin. With increased familiarity, the marble would freely reveal its archived data:

> It would not be possible to stand for a moment at a shop door, leaning against the pillars of it, without remembering or questioning of something well worth the memory or the inquiry, touching the hills of Italy, or Greece, or Africa, or Spain; and we should be led on from knowledge to knowledge, until even the unsculptured walls of our streets became to us volumes as precious as those of our libraries.[169]

The rocks are thus understood as an information system, recalling today's writing on media as linked to environmental origins (see also section 2.1).[170]

To Ruskin, looking at rocks thus reveals an archive of their coming into existence. This experience was shared in 1788 by Hutton and his friend John Playfair (who later rewrote Hutton's treatise *Theory of the Earth* for more clarity) at the now famous Hutton unconformity at Siccar Point in Scotland. From their boat, they looked at the rocky coastline, which—where the rock is layered in two directions—points to an abrupt meeting between rocks originating from vastly differing epochs. Hutton noted that these rocks were "a vivid record of vanished landscapes".[171] In his spatial imagination he could fathom that the lower stratum of vertical rocks must have been a mountain range, built up over millennia of compressed marine sediments that were tilted upwards by crustal uplift. Enough time must then have passed for erosion to even out the peaks, and for another layer

[168] Ruskin, *Stones of Venice*, 28.
[169] Ruskin, *The Stones of Venice: The Fall*, III:55.
[170] In a similar vein to Ruskin's planetary archival imaginary, Keller Easterling and John Durham Peters see the potential of meteorological clouds as vast information systems.
[171] See for example Bjornerud, *Timefulness*, 24.

of rock (red sandstone) to build up on top of it.[172] The sudden change of sediment direction points to a temporal rupture (of 65 million years), prompting Playfair's often-cited observation: "the mind seemed to grow giddy by looking so far into the abyss of time".[173] The geological reveals temporalities of the archival that exceed human temporal horizons.

The abyss of time forms part of the temporal repertoire of the geological mode and is now known as "deep time", a concept developed by Hutton but named by John McPhee in 1981.[174] The notion of deep time is associated with the tempo of geological events, and it is interlinked with the understanding that geology is based on gradual processes such as erosion, sedimentation and uplift that continuously and steadily affect the planet. The theory of uniformitarianism created the need for a much longer (deeper) history of the planet than had previously been assumed, when Western planetary theories of a much younger world had still been dominated by biblical events.

Media theory has embraced this temporal depth. In particular, Siegfried Zielinski's *Deep Time of Media*[175] pays tribute to the temporal ties between geology and media theory. Media archaeology[176] (Zielinski's anarchaeology[177]) and modern geology both share an interest in deep time. The materiality of new media is geological and thus permeates digital temporality. The geological ground is the foundation of data centres, and it houses archival devices, literally and by analogy. Media geology and media archaeology emphasise the archival qualities of the ground.

[172] See for example Bjornerud, *Timefulness*, 24.
[173] Gould, *Time's Arrow*, 62.
[174] See John McPhee, *Basin and Range* (New York: Farrar, Straus and Giroux, 1981).
[175] Siegfried Zielinski, *Deep Time of the Media Toward an Archaeology of Hearing and Seeing by Technical Means* (Cambridge, MA and London: The MIT Press, 2006).
[176] See also Wolfgang Ernst, "Radically De-Historicizing the Archive: Decolonizing Archival Memory from the Supremacy of Historical Discourse", in *Decolonizing Archives*, ed. Rado Ištok and Nataša Petrešin-Bachelez (L'Internationale Online, 2016), 12.
[177] See Zielinski, *Deep Time of the Media Toward an Archaeology of Hearing and Seeing by Technical Means*.

The link between ground and archives is especially straightforward in an archaeological context. Relating archaeological findings to media studies, Shannon Mattern tracks civic media archives in *Code and Clay, Data and Dirt* (2017). She shows how urbanity has enabled communication and its transmission, has archived records of itself, and has embodied its own source code—the list of commands that constitute its program.[178] These archives are the sediments of the archaeological ground, which can be understood as an analogue data centre. In her study of the manifold and complex entanglements between media and their physical precipitations within cities, she draws on the relationship between geological materiality and urban media: "for millennia mud and its geologic analogs have bound together our media, urban, architectural, and environmental histories".[179] Writing surfaces, such as stone and clay tablets, and the construction materials of the city were often materially the same. Buildings and city walls stand in as text (media) substrates.[180]

Geology and media merge on a material level and constitute the foundation and archaeological leftovers of civic life. Media in an urban context are manifest on one hand as archaeology, and on the other as infrastructure: the medium of the message and how it is transmitted (see section 1.3). In Mattern's study, the link between materiality, the architectural (urban) unit and data runs through history, from sound-reflecting stones in acoustic spaces for the auricular dissemination of information in Greek cities, to clay bricks and clay tablets in ancient cities of the East, via paper in the statistics-driven (American) metropolis of the late 19th- and 20th-century city, to invisible radio wave transmission in the antenna-enhanced urbanity of today.[181]

[178] Shannon Mattern, *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media* (Minneapolis and London: University of Minnesota Press, 2017), loc. 119–127, Kindle.
[179] Mattern, *Code and Clay*, loc. 2224–2229.
[180] Mattern, *Code and Clay*, loc. 2224–2229.
[181] See Mattern, *Code and Clay*. See also Ruby and Ruby, *Infrastructure Space.*

In summary, the temporality of the geological mode is one of cyclical depth[182] as strata, both material and temporal, are accumulated, compressed, pushed upwards and rotated to emerge in distant presents. This temporality is embedded in the geological material, a point to which I will return in the context of my case studies of geological archives in the next chapters.

A Spatiality of Animation

The idea of temporal and spatial depth governs theorist Benjamin Bratton's unambiguously geological understanding of computing as a planetary-scale "stack". This construct is composed of digital and infrastructural layers. Bratton describes it as a "cybernetic landscape"[183] that quivers like the geological ground "in barely accountable rhythms".[184] Stacking evokes a geological spatiality that results from stratification, layering and piling. The foundational layer is earth, as Bratton "argues for a foregrounding of the geological substrate of computational hardware and of the geopolitics of mineral and resource flows of extraction, consumption, and discarding".[185] The stack is architectural. Architecture and ground are entwined, including beyond media-centred contexts. Just as the human body must return to the ground as dust to dust, the architectural body returns to the ground as stone to stone, as ruin to geological remnant. Rather than calling new or yet-to-be-built monuments "ruins in reverse"[186] like Robert Smithson, Bratton understands the built as mimetic and accelerated geology: on a material level, architecture is isolated, sifted and reassembled ground. To make steel, mined iron ore has to be melted in a furnace (also known as a stack) to separate the iron from the impurities. Cement is quarried limestone and clay that is then

182 See also Eldridge and Gould's concept of a punctured equilibrium: Gould, *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*, 179.
183 Benjamin H. Bratton, *The Stack: On Software and Sovereignty* (Cambridge, MA: MIT Press, 2015), loc. 669–1671, Kindle.
184 Bratton, *Stack*, loc. 1669–1671.
185 Bratton, *Stack*, loc. 2051–2053.
186 Smithson, 'The Monuments of Passaic'.

crushed and baked in a kiln. Speeding up geological processes, the raw ground is cooked to make architecture's building materials, which will eventually return to the ground as archaeological strata. The shift in perception of the built environment over time, from the eventual or perpetual ruin to a geological process, is a shift from the anthropocentric narrative to a more planetary imaginary in which humans and non-humans (rocks, tectonic plates, mineral veins etc.) engage in similar activities at different tempos.

There has been a drastic shift, from Hutton's and Lyell's notion of the human geologist as decipherer of the planetary archive, to the human as a geological force in today's Anthropocene. The current preoccupation with the notion of the Anthropocene is a manifestation of an obsession with the ground. Chemist Paul Crutzen proposed the Anthropocene as the planet's new geological age in 2000. Crutzen's narrative begins with James Watt's steam engine as a catalyst of the Anthropocene.[187] The Anthropocene is closely linked with industrialisation and the extraction of coal as the beginning of a land-mass-moving age of which humans are the main cause. This has been criticised by Haraway[188] and others as too short-sighted, as the spirit of moving land masses and inhabitants really began with colonisation, when people, animals, plants and other entities were moved on a large scale. As such, the Western story of the Anthropocene is bound up with Western (land) explorers such as von Humboldt and Darwin, who gathered and transported geological samples and organic entities across the globe, and who followed in the footsteps of the first seafaring planet traversers. This enhanced story of the Anthropocene is closely entwined with the budding awareness of the planetary: Magellan's three-year circumnavigation of the world, Darwin's awareness of local optimisations versus global evolution, and von Humboldt's maps of

[187] Parikka, *Geology of Media*, loc. 461–462.
[188] Donna J. Haraway, *Staying with the Trouble: Making Kin in the Chthulucene* (Durham and London: Duke University Press, 2016). Lippard, *Undermining: A Wild Ride Through Land Use, Politics, and Art in the Changing West*. Kathryn Yusoff, 'Queer Coal: Genealogies in/of the Blood', *PhiloSOPHIA* 5, no. 2 (Summer 2015): 203–29.

planetary magnetic fields, wind and ocean currents, and climate zones, to which I now turn.

Von Humboldt's drawing "Idealer Durchschnitt von der Bildung der Erdrinde" (1841), a diagram of a cross-section of the earth's crust, depicts an "ideal" section that shows the development of the earth's crust.[189] Von Humboldt based his visualisation on fieldwork. Famed for his many adventurous travels before his scientific discoveries, he based his planetary depictions on empirical observations of rock formations during his explorations. His travelling lifestyle impressed Lyell, who promoted empirical fieldwork and was inspired by both Hutton and von Humboldt in his seminal book *Principles of Geology* (1830).

Von Humboldt's drawing displays a focus on stratification; one might say that it depicts a "stack" of mostly pastel-coloured layers. The strata are meticulously labelled with the types of rock they represent. Where these layers fold, they are pierced by lava flows and other petrified rivers. Rootlike vertical strands thus connect the bottom layer of lava with the crust's surface, where an active volcano is spewing smoke and molten rock. Von Humboldt's drawing transmits an understanding of the evolutions that took place to form the various types of rock we find on the planet today. Formerly animated flows, now petrified amid other layers, hint at continuous if barely perceptible change. By basing the defining description of our age on geology, we link our time to the opening of the ground, the reassembling of that "jumbled museum" and "messy archive", as Geoffrey Bowker has suggested.[190]

Philosopher Jacques Derrida (1930–2004) based his archival thinking on the both erosive and productive nature of archives. Derrida wrote his *Archive Fever: A Freudian Impression* (1995) "on the edge of Vesuvius".[191]

[189] Alexander von Humboldt and Heinrich Berghaus, *Physikalischer Atlas*, 2nd ed. (Gotha: Justus Perthes, 1852).
[190] Bowker, *Memory Practices*, loc. 320–326.
[191] Jacques Derrida, 'Archive Fever: A Freudian Impression', *Diacritics* 25, no. 2 (Summer 1995): 61.

The destructive and restorative nature of a volcano, which burns organic life but contributes to lithic "uplift", thereby counteracting erosion, must have influenced Derrida's idea of archive fever. He traces the origins of the word "archive" to the Greek *arkheion*: "initially a house, a domicile, an address, the residence of the superior magistrates, the archons, those who commanded".[192] The archived documents require "at once a guardian and a localisation".[193] Derrida's archons "have the power to interpret the archives".[194] Archives are permeated by the archontic principle that is "a principle of consignation, that is, of gathering together". [195] In Derrida's understanding, the essence of the archive is "to shelter itself and sheltered, to conceal itself".[196] Alongside the gathering and preserving activity intrinsic to archives, in Derrida's Freudian interpretation, is the will to destroy: the archive's death drive, or archive fever.

Derrida's archive fever has become superseded by archival meltdown: the processes necessary to extract (melt) and separate the materials of our digital archives usually involve extreme heat. Lyell's earth archive (the geologist as archon) is opened up, drilled into, pierced and probed, its documents extracted and isolated; the metaphorical archival ink is removed from the pages, distilled and poured into new words. Throughout this chapter we have encountered the inherent tension of the geological mode. On the one hand, it is preservative and near-static, traversed by barely noticeable, steady (and sometimes drastic) activity. On the other hand, the geological mode can be defined by precisely these movements. Which aspect prevails is a question of tempo—of whether one looks through the lens of human or lithic temporalities.

[192] Derrida, 9.
[193] Derrida, 10.
[194] Derrida, 10.
[195] Derrida, 10.
[196] Derrida, 10.

This understanding resonates with those of Jesuit polymath Athanasius Kircher[197] (1602–1680), who offers a visualisation of the ground as an animated archive—an active entity—in another historical section through the planet. Far from being an archival entity which keeps balance sheets of its activities,[198] the ground is shown not as relatively stable, but as full of animation due to internal forces and histories of change. As an animated, baroque archive, this visualisation combines both the archival and the fluctuating inner life of the earth. Kircher had been to Vesuvius and Etna and had personally experienced earthquakes, which informed his theories. In each corner of Kircher's infographic from his *Mundus Subterraneus* (1664), there are so-called wind faces that structure the four cardinal directions. The faces, framed by dishevelled curls, are exhaling visibly. They connect the drawing to the tradition of cartography, as they were common symbols on maps, along with wind roses (compasses). These wind faces recall the fact that initially, at the time of the ancient Greeks, rather than structuring the world into north, south, east and west, the four directions were established by the four main prevailing winds. The structure of the world was thus organised around mobile, dynamic forces. The configuration of the earth's core, in Kircher's understanding, is also built on active forces and flows.

The image is thus strikingly energetic. The clouds that surround the planetary sphere are congregating tightly; they seem on the verge of bursting. Below, on the planet's surface, animated oceans and mountainous landscapes with active volcanoes alternate rhythmically. Ships with billowing sails traverse the oceans. The centre of the planet is energetically coloured in. It is organised around a central fireball furnace, from which channelled molten earth is radiating outwards, through smaller furnace nodes and underground canals, until it reaches the volcanoes. These function as release valves for some of the molten stones produced at the centre of the earth. The channels resemble a root system

[197] He also occupies a prominent place in Zielinski's media anarchaeology for his invention of a musical apparatus, often mentioned by Ernst.
[198] Bowker, *Memory Practices*.

(at the time, stones were thought to grow like plants at the centre of the planet). Some of the lava canals end in meandering and thinning rootlike tips, suggesting a mutually nurturing exchange between the dark, dense mass and the contained blazing flares.

In Kircher's image, the sky with its many dense clouds and the forceful-looking winds enclose the planet. Proliferating volcanoes are producing large exhaust clouds that reach the meteorological clouds. Here, geological processes meet meteorological phenomena. The earth and sky communicate and are linked at the level of clouds. The earth below the surface, unscathed, unopened, unpierced, unexcavated, has not always been thought of in terms of layers. Although von Humboldt is remembered and praised as one of the first modern Western scientists who understood nature as a planet-spanning system, Kircher expresses this understanding much more directly. Kircher's drawing is permeated with animation: everything is in flux, vibrant and vigorously shaping the planet.

These different and eclectic descriptions of the earth as animated ground emphasise my use of geology as a mode that engenders a particular kind of spatiality, temporality and materiality, which reveals particular organisational and archival principles because of the extensive time frames it embodies. The ground, however, in this understanding, is just as much an active entity as it is an archive. The idea of a shifting ground that emerges with increased mining and extraction processes[199] draws attention to the temporal disconnection between humans and the ground. Iain Hamilton Grant describes the loss of the ground as a horizon of reference, with the realisation that there is no absolute or finite stable ground: "the lines of serial dependency, stratum upon stratum, that geology uncovers do not rest on anything at all, but are the records of actions antecedent in

[199] See also Lucy R. Lippard, *Undermining: A Wild Ride Through Land Use, Politics, and Art in the Changing West* (New York: New Press, 2014), Kindle.

the production of consequents".[200] I now turn to my first case study and field trip, and I will explore the archival potential of the animated ground in relation to a core repository, to show how the active ground's qualities are extracted with the ground and reverberate with the practice of animated archives. Building on Hutton's and Lyell's deep time, "geologists today have expanded this record-keeping function enormously, seeing traces of the distant past (beyond revolutions in the earth's surface and even before the creation of the earth) in various isotope ratios".[201] This becomes especially apparent in geological archives, which literally archive the ground, such as the Lamont-Doherty Core Repository, as I will now show.

The Lamont-Doherty Core Repository

I visited the Lamont-Doherty Core Repository, one of the three largest core repositories in the United States, twice in 2018. This experience pointed me to the notion of animation, which I encountered among the trays and tubes of archives of geological material, and which I had also found characteristic of the data centres I had visited earlier. The Lamont-Doherty Core Repository illustrates the geological mode. The facility houses 18,700 cores of 1.5- and 2.4-metre lengths, adding up to approximately 72,000 metres of core. These cylindrical drilling cores, approximately five centimetres in diameter, are extracted from ocean floors and used in the geosciences by climate palaeontologists to gather information about the planet's climate history. The extracted samples are packaged into polystyrene containers and stored horizontally on shelves: the vertical extraction becomes a horizontal body. The cylindrical samples are sliced along the centre to create an untouchable archive core and a dissectible analysis core. If a scientist requests a particular section of the analysis core half, the resulting gaps are filled with foam placeholders.

200 Iain Hamilton Grant, 'Mining Conditions', in *The Speculative Turn: Continental Materialism and Realism*, ed. Nick Srnicek, Levi Bryant, and Graham Harman (Melbourne: re.press, 2010), 44.
201 Bowker, *Memory Practices*, loc. 320–326.

Ideally, these extracted samples are archived under climatic conditions that resemble their site of extraction. This atmospheric conditioning can be observed at the Lamont-Doherty Earth Observatory. Here, sediment cores from every major ocean and sea are preserved in a sequence of large rooms. One of these contains cores taken after 1985 and is consistently refrigerated at 4.5 degrees Celsius to preserve the moisture contained in the mud. The moist samples are contained in closed plastic tubes, the dry samples in open rectangular metal trays. There are four main archive spaces arranged around a central exhibition space: two non-refrigerated and two refrigerated units. One of these is new and still under construction, a noticeable change since my previous visit six months earlier, adding to the sense of expansion and active use. Sitting on a mobile ladder tower with wheels, its grey handrails framing me and the Mac on my lap, I overlook a 2.5-metre-wide space. It is bordered by compactly stacked metal trays labelled with densely handwritten numbers and letters. The labels are on the fronts of deep trays, 6.6 centimetres wide by 3.5 centimetres high.

What makes this archive so appealing is the repetitiveness of the trays, and how they are neatly held in place by an invisible shelving system. Some of the trays stick out a few millimetres more than their neighbours, or have been pushed back deeper into the structure. The chalky-white fronts are labelled with text and numbers on three lines. They are tidy, but vary with different handwriting in markers of different thicknesses. In some cases, the label has been rewritten, and you can see the faded yellow-grey-pinkish outline behind the new text. The trays are made of folded galvanised steel, one millimetre thick. Their insides were painted quickly and with excess paint. On one shelf unit to my left, which has no neighbours, I can see where the paintbrush dripped tassels of runny paint along the outside surfaces as it ran across the inside edges of the tray.

The 2.4-metre-long containers are held in place at their centres by shelving "cages". Because the trays are flatter than the slots they sit in, they seem to float horizontally: 44 yellowish-white-to-rusty-brown rows suspended above black shadows. An empty grid cage is sitting in the middle of the corridor, right in front of me, waiting to be filled and stacked. It is 96.5 centimetres tall, 93 centimetres deep and 123 centimetres wide. Its roof is covered in an even grid of six-millimetre diameter bars, spaced at intervals of roughly five centimetres. The sides of the rectangular cage are also divided into grid fields. The corners are messily welded. The entire cage must have been dipped into a galvanising bath, but on the surfaces the trays rub against, the bars have turned rusty. There are always two trays slotted into the space between the place-holding verticals. There are eight rows of two trays across and 15 up, including the lowest box, which is always left empty. Three such cages are stacked on top of each other.

The serenity of the repetitive unit-based system is counterpoised by noisy air-conditioning coming from above the entrance, down the corridor behind me on the right, and a more quietly rhythmic vent hidden somewhere at the back end of the space I am overlooking. There is also a less audible humming, probably coming from the four double-caged neon lamps that sit between the three columns and cantilevers which structure the space. The floor is painted concrete, a greenish grey, with marks of objects that have been pulled or pushed across it.

The refrigerated archive feels entirely different and can only be entered in brief stints. Upon opening the climate door of the refrigerated room, you are hit with icy air that blasts loudly from three industrial air-conditioning units. This space is messier and less homogenous. You can tell that it is still growing and changing whenever the R/V Marcus G. Langseth[202] returns from a cruise. New cores come into the refrigerated space; precious, not-yet-classified, labelled, packaged and pigeonholed PVC tubes are standing upright in large buckets. They still have to be sliced down the middle before the resulting archive and research half-cores can

[202] "Cruises", Lamont-Doherty Earth Observatory, accessed 18 January 2019, accessed 01 December 2018, https://www.ldeo.columbia.edu/research/office-of-marine-operations/cruise-summaries.

be placed in their D-tube containers and slotted into one of the shelving systems. The most recent tubes are labelled with QR codes, which link them directly to online databases such as the Sesar register of International Geo Sample Numbers, unique identifiers for earth samples.

D-tubes are the containers in which the halves of the sediment cores are stored long term and protected from contamination and moisture loss. They come in two sizes: 135 millimetres wide by 73 millimetres high, and 100 millimetres wide by 55 millimetres high, in varying lengths. The shape of these off-white, semi-translucent tubes is rather ornate, as concave dents at the bottom form a (half-)honeycomb front. When many of these tubes are stored in their grid box shelving, they conjure an image of oversized hive architecture, with precious organic matter hibernating within.

I pulled off the labelled vertical cap at the front end of a few of these tubes, and found small pink and green synthetic sponges perched between the cap and the plastic half-cylinder (of different colours—for example, one was red) containing the sediment core. These moist sponges regulate the humidity inside the D-tubes.

I opened a small D-tube, labelled with the name of the research vessel, the name of the core, the section in centimetres (154–313 centimetres), the name of the core section (2), and that it was an archive core (A) rather than a working core (B). As I pulled out the colourless, translucent half-cylinder, I found that it contained densely caked white-grey mud, which had fissures and looked exactly like a strip cut out of an Alberto Burri *Cretto* painting. The cracks varied in thickness and mostly traversed the tube orthogonally. In several places, small chunks no wider than my fingertip had been extracted from the mud and replaced with white, almost crystalline-looking hard extruded Styrofoam cubes, which were brittle and enclosed a lot of bubble-shaped cavities. My inspection was briefly interrupted when a group of scientists barged into the icy archive, together carrying a bulky tray to a far corner.

Animated Archives

The archived cores, in their storehouse of the planet's extracted geo-informatic data, convey a distinct sense of *being animated*. Only substances that *used to be alive* are singled out for analysis: microscopic fossils of foraminifera. These miniscule animals have a calcium carbonate shell. For example, polar foraminifera only thrive in very cold waters, and currently do so only north of Iceland. If polar foraminifera fossils are discovered in the cores retrieved from more southern regions, scientist can deduce that the temperature in these waters used to be much lower. Thus, low-temperature ocean maps across history, and estimates of the extent of the ice caps, can be constructed just from the locations of extraction and from dating these fossils.

To understand the archival value of these shells, one has to know about the two relevant varieties of oxygen:

> Like all elements, oxygen is made up of a nucleus of protons and neutrons, surrounded by a cloud of electrons. All oxygen atoms have 8 protons, but the nucleus might contain 8, 9, or 10 neutrons. "Light" oxygen-16, with 8 protons and 8 neutrons, is the most common isotope found in nature, followed by much lesser amounts of "heavy" oxygen-18, with 8 protons and 10 neutrons.[203]

When the shells form, they integrate oxygen. At lower temperatures, the ratio of heavy to light oxygen increases. If a fossil contains larger proportions of heavy oxygen, scientist therefore conclude that the shell formed in colder water.[204] All microfossils contain oxygen—this applies

[203] Holli Riebeek, 'Paleoclimatology: The Oxygen Balance', Nasa Earth Observatory, 6 May 2005, accessed 01 December 2018, https://earthobservatory.nasa.gov/Features/Paleoclimatology_OxygenBalance.
[204] "Paleoclimatology".

to the fossil remnants of formerly living matter, be they the calcium carbonate shells of foraminifera or plankton algae coccoliths, or the silicon dioxide shells of radiolarians (animals) and diatoms (tiny plants).[205] Calcium carbonate ($CaCO_3$) is the same as limestone or chalk, and silicon dioxide (SiO_2) is similar to the compound common in quartz sand. The compressed remains of these foraminifera form large limestone formations. The sphinx and pyramids of Egypt are made of such limestone, "preserved in a vast offshore formation that, 40 million years ago, extended from France to Burma".[206]

The distribution and density of these microfossils in core samples or geological formations reveal information about wind and water currents in the planet's past.[207] The ratio of occurrence of heavy and light oxygen isotopes reveals information about ice caps, temperature, CO_2 values, and by extension ocean currents, prevailing winds and water levels at the time of living of the dissected fossils. The study of sediment cores is thus an analysis of the compressed remnants of life, as these formerly animated articles activate the archival potential of the sediment cores. Dating these fossils is akin to dating tree rings. The annual cycle of heavy oxygen ($\delta^{18}O$) concentrations is tied to regional temperature variations. This makes it possible to count the years in terms of $\delta^{18}O$ peaks/dips along the cores, using a spectrometer.[208]

[205] "Coccolithophore", ScienceDirect, accessed 15 December 2018, https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/coccolithophore.
[206] "What Is Micropaleontology?", Micropaleontology Press, accessed 01 December 2018, http://www.micropress.org/what.html.
[207] "A Record from the Deep: Fossil Chemistry", Nasa Earth Observatory, 27 September 2005, accessed 01 December, 2018https://earthobservatory.nasa.gov/Features/Paleoclimatology_SedimentCores/paleoclimatology_sediment_cores_2.php.
[208] "Ice Core Dating Using Stable Isotope Data", University of Copenhagen, Niels Bohr Institute, Centre for Ice and Climate, accessed 20 December 2018, http://www.iceandclimate.nbi.ku.dk/research/strat_dating/annual_layer_count/ice_core_dating/.

The time frames dealt with in this archive are gigantic. They exceed the imagination. Speculative realism philosopher Quentin Meillassoux grapples with the "thinkability" of prehuman occurrences. In *After Finitude* (2008), he uses the scientific procedure of dating fossils as a starting point to explore the question, "how are we to grasp the meaning of scientific statements bearing explicitly upon a manifestation of the world that is posited as anterior to the emergence of thought and even of life—posited, that is, as anterior to every form of human relation to the world?"[209] He questions correlationism—the connection between thought and being. Meillassoux shows that when we are approaching such phenomena as the age of fossils and life before humans—or even more drastically, the world before life—we are entering the territory *outside* (human) being.

Meillassoux's starting point is material. He begins with the "arche-fossil" or "fossil-matter", the materials that indicate not just "the traces of past life", as a fossil does, but also "the existence of an ancestral reality or event; one that is anterior to terrestrial life".[210] This matter can reveal to us—via isotopic dating—temporal realities that precede perceivable human reality. In order to make the ancestral matter *thinkable*, in a thought that must transcend the tight correlation between thinking and being, one must think "an absolute".[211] This absolute is an absolute outside, disconnected from human—or even the planet's—*being*. Even without going into the intricacies of Meillassoux's philosophical argument at this point, his process begins with the geological, hardly imaginable timescales of ancestral archives, and ends with the liberation of thought into a mysterious great outdoors that exists beyond us who attempt to imagine it. The fossil matter at the Lamont-Doherty opens up a realm as impossibly gigantic as Meillassoux's *After Finitude*: a history of the planet, and projections into climates of the future, which may or may not sustain humanity. Throughout the following chapters, I will show that our digital

209 Quentin Meillassoux, *After Finitude: An Essay on the Necessity of Contingency* (London and New York: Bloomsbury, 2008), 9–10, Kindle.
210 Meillassoux, *After Finitude*, 10.
211 Meillassoux, *After Finitude*, 28-30.

archives create a great outdoors, so full of raw data and so vast that we can hardly access them with our thoughts and spatial imaginations. But attempting to do so will give us a sense "of being entirely elsewhere",[212] in a world that is increasingly documented and *archived*. The cores at the Lamont-Doherty Earth Observatory attempt to bridge the gap between the great outdoors and the "island of Now".[213]

There are thus two levels of animation linked to the analogue geological data centre at the Lamont-Doherty Earth Observatory. First, the dateable remainders in the drilling cores were formerly alive. Second, the cores are being sustained, like living organisms, under favourable environmental conditions with the help of a continuous, hypothetically never-ending electricity supply. The trend is towards ever-perfected sustenance by imitating the native conditions of the habitat of the archived cores.

Somewhere between the detail in my description of this archival space, its muddy raw data and the unthinkability of the associated "abyss of time"[214] lies the nature of digital archives. Spatially, the archive presents a complex assemblage of places. The research vessel Marcus G. Langseth, and the Vera and Conrad in the past, traverse the world's oceans and extract drilling cores along the way. Sometimes these are specifically chosen, sometimes they are extracted because of the "one core a day" policy established by the founder and first director, Maurice Ewing. The points of extraction (15,178 in 2017) are marked as dots on interactive maps of databases that link the archived data to its original locations. Raw data from all over the world is thus gathered at the Lamont-Doherty Archive, surrounded by a forest 15 miles north of Manhattan and reachable only by car or shuttle bus from Columbia University's main campus. The extracted data's location gains relevance by being situated in relation to other cores. The archive is thus built on a critical mass that needs to be reached before the data analysis can really become meaningful. This

212 Meillassoux, *After Finitude*, 7.
213 Bjornerud, *Timefulness*, 161.
214 Gould, *Time's Arrow*, 62.

critical mass, however, is also an elusive concept, as the majority of the cores have remained unexamined to date. And the analysis of one core can easily generate terabytes of data.

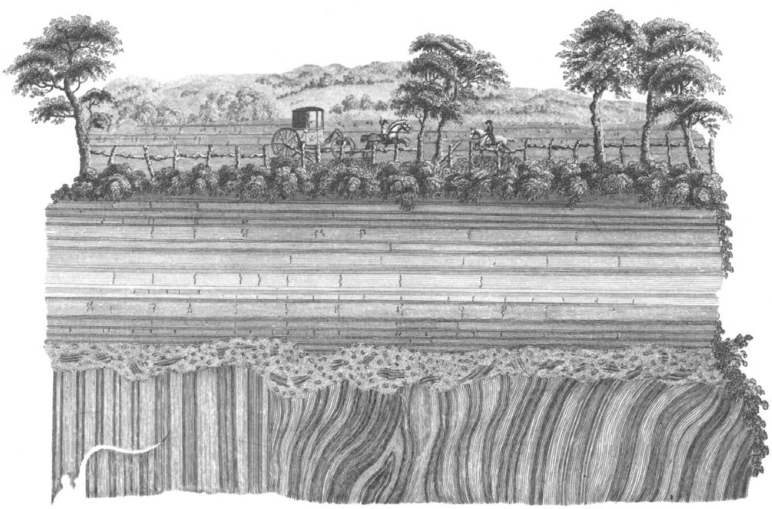
The temporal complexity permeating the Lamont-Doherty Earth Observatory exemplifies "this 'polytemporal' way of thinking"[215] that geologist Marcia Bjornerud understands as emblematic of her profession. First, there is the temporality of the core age—how long it has been out of the ground. This affects how it was preserved: if extracted prior to 1968, the core is likely to have been contaminated with heavy metals from the galvanised tubes in which it was stored; if extracted before 1980, the core is now dust, its layers crumbled and contracted, affecting the temporal analysis. This temporal layer affects the cores as data carriers. From today's scientific perspective, contaminated or dried-out cores are similar to legacy systems in the digital world: outmoded, illegible, almost trash ("almost" because future scientific developments might restore these cores to usefulness). Second, there is the temporality of the miniscule fossils. Tinier than sand grains, they exemplify Meillassoux's ancestrality—a life form whose aliveness precedes human consciousness and can only really be grasped mathematically. And yet, these tiny objects reveal histories of our world, which shaped it to become what it is now. Third, there are the temporalities of the scientific procedures, which can extract increasing amounts of information from the raw data of the cores and thus make possible ever-changing, ever-concretising assumptions about the past.

The earth is thus a record keeper: "our earth weaves its own history into its texture. Similarly, life itself writes its history into the earth".[216] Its archival nature can be instrumentalised to think about archives. The archival mode of continuous change and its embedment in its own materiality generates a temporality of deep time that opens up a great outdoors or an out-side of human perception and spatial imagination. The geological mode thus transcends human history. It opens up a world of

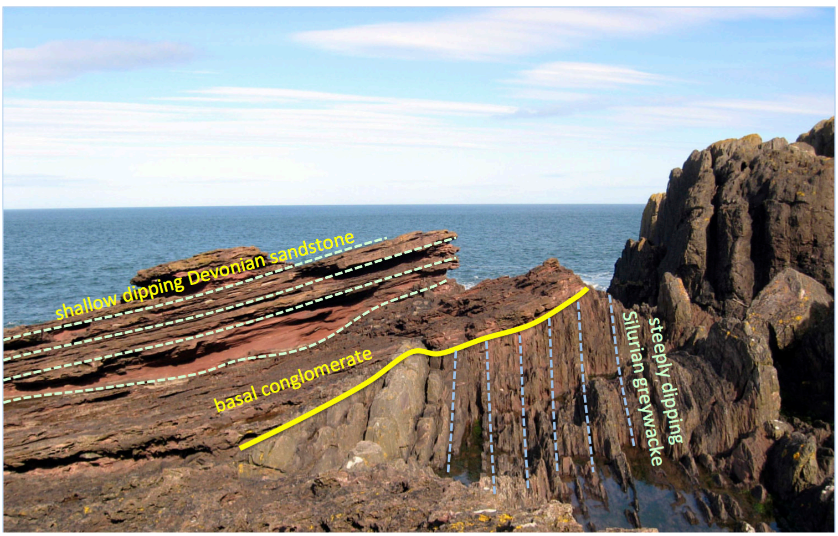
[215] Bjornerud, *Timefulness*, 163.
[216] Bowker, *Memory Practices*, loc. 320–326.

animated archives whose polytemporalities and strata in flux help us to reimagine the concept of archives as spaces that update[217] as much as preserve their content.

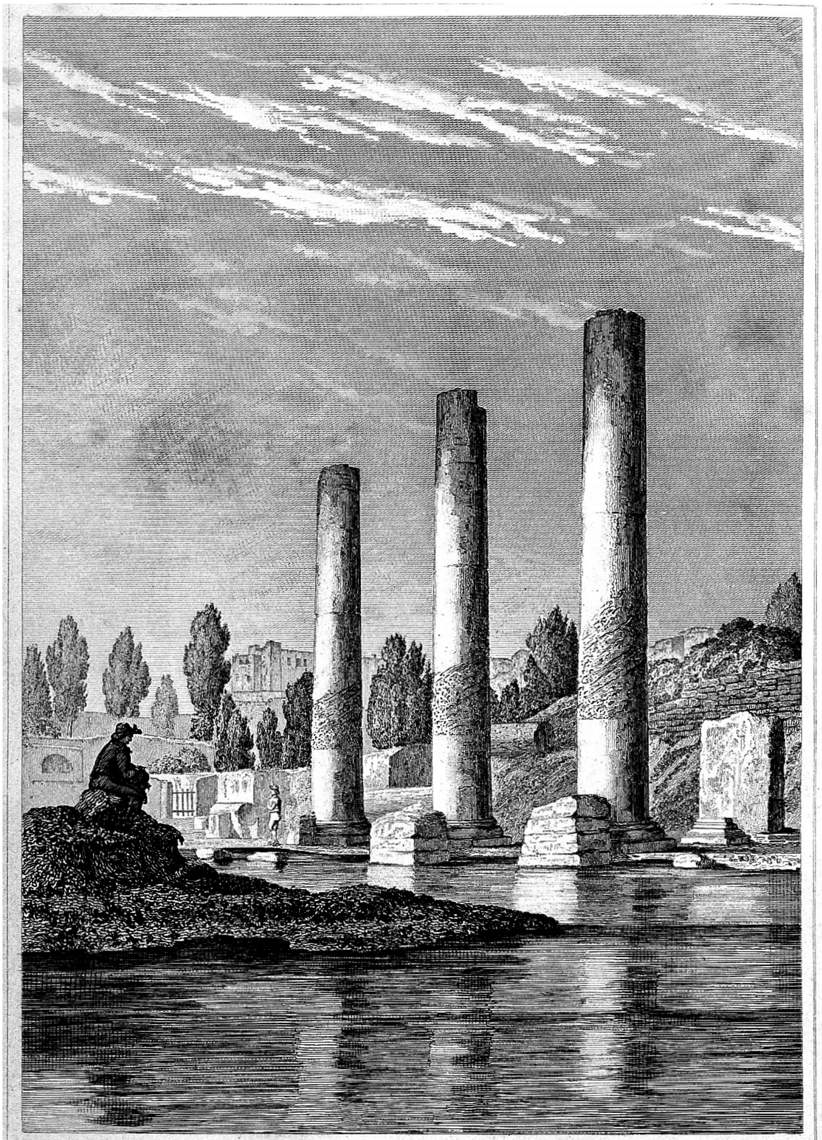
[217] For updates and digital media see Chun, *Updating to Remain the Same: Habitual New Media*.



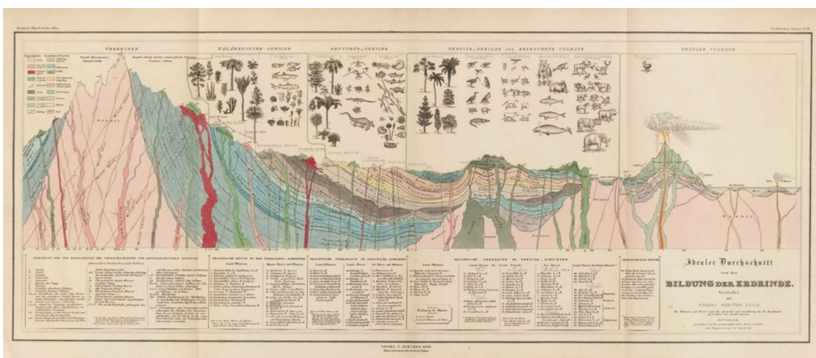
Engraving after a drawing by John Clerk of Eldin (1787) of the unconformity at Jedburgh: Plate III in the Theory of the Earth Volume 1, by James Hutton (1795). "Vertical Silurian greywackes and shales are unconformably overlain by Upper Old Red Sandstone basal breccia and overlying sandstones."



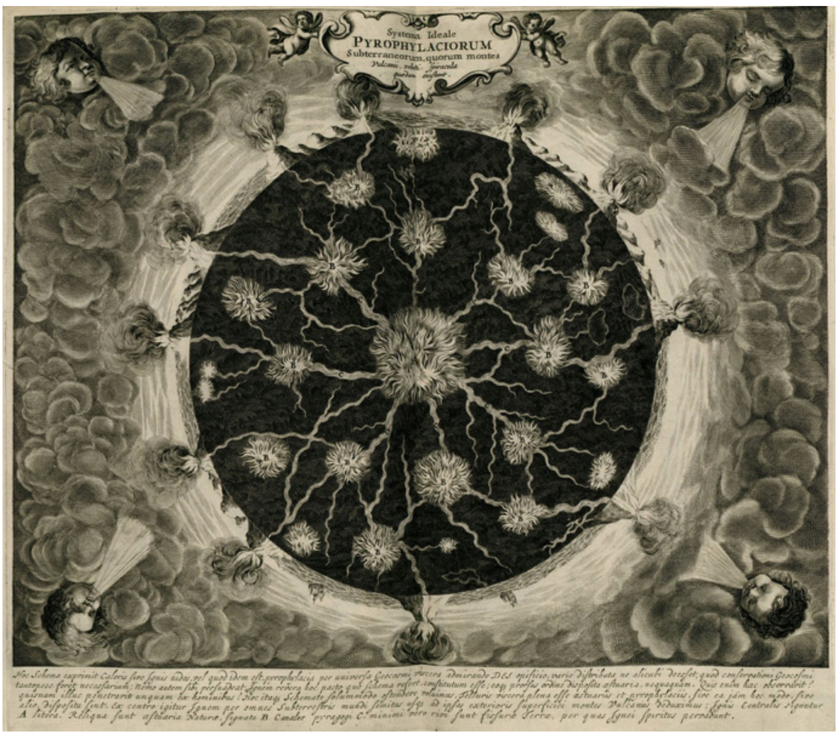
Annotated "Hutton Unconformity" at Siccar Point, Scotland (http://www.geopoem.com)



Charles Lyell, Principles of Geology, 1830. Frontispiece illustration of the Temple of Serapis at Puzzuoli.



“Idealer Durchschnitt von der Bildung der Erdrinde” (1841) from Heinrich Berghaus, Physikalischer Atlas (Gotha-J. Perthes, 1852).



Athanasius Kircher, Mundus Subterraneus, 1664

Information is saved on hard drive disks and deciphered by a sensor head that scans the surface of the discs layered with magnetic fields of zeros and ones. These platters are composed of a number of extremely thin layers to generate the necessary smoothness and magnetic storage capability. The first layer contains platinum group metals (pgm) and functions as an optimized "soft magnetic underlayer" for the perpendicular field on which the data is imprinted. Two Co-Ni-Fe (cobalt-nickel-iron) layers separated by a 4-atom thick layer of ruthenium constitute this stratum. The next layer is for the magnetic storage. It is made of sub layers of Co-Cr-Pt (cobalt, chromium, platinum) alloys. The materials used define the abilities of these incredibly thin layers:

"The cobalt provides the necessary orientation of the crystals; the chromium improves the signal-to-noise ratio, while the platinum provides thermal stability. Ruthenium is also to be found here, although performing a somewhat different role than in the soft underlayer. Its role is to help orientate the magnetic grains, as well as reducing interference between layers."

Photograph of an earth work (Spiral Hill or Broken Circle) by Robert Smithson (Stedelijk Museum Amsterdam)

Lamont-Doherty Core Repository

Lamont-Doherty Core Repository

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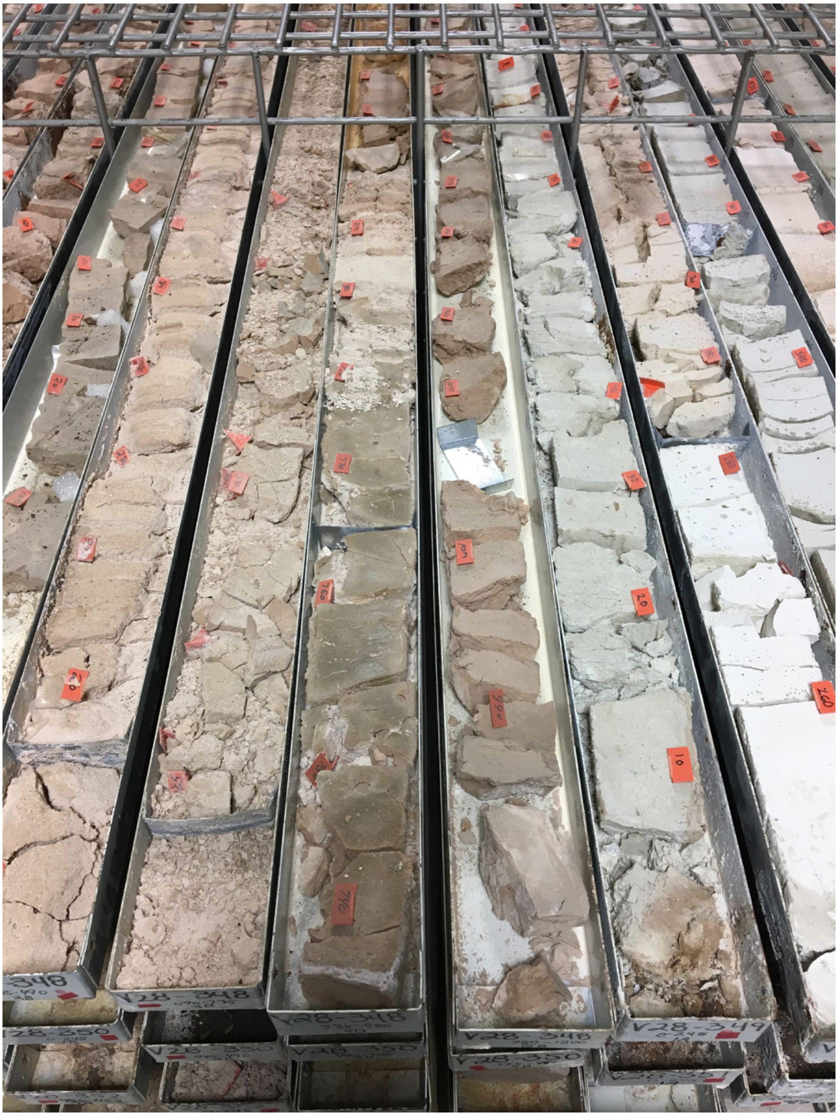

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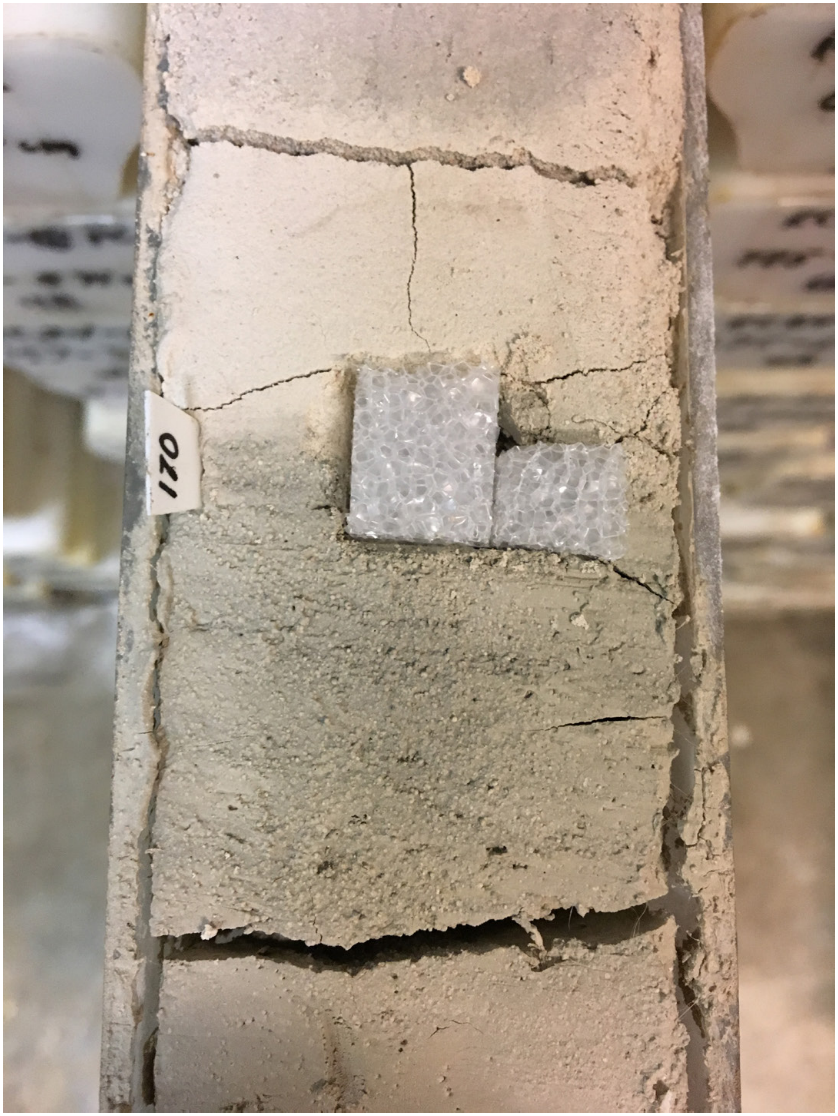

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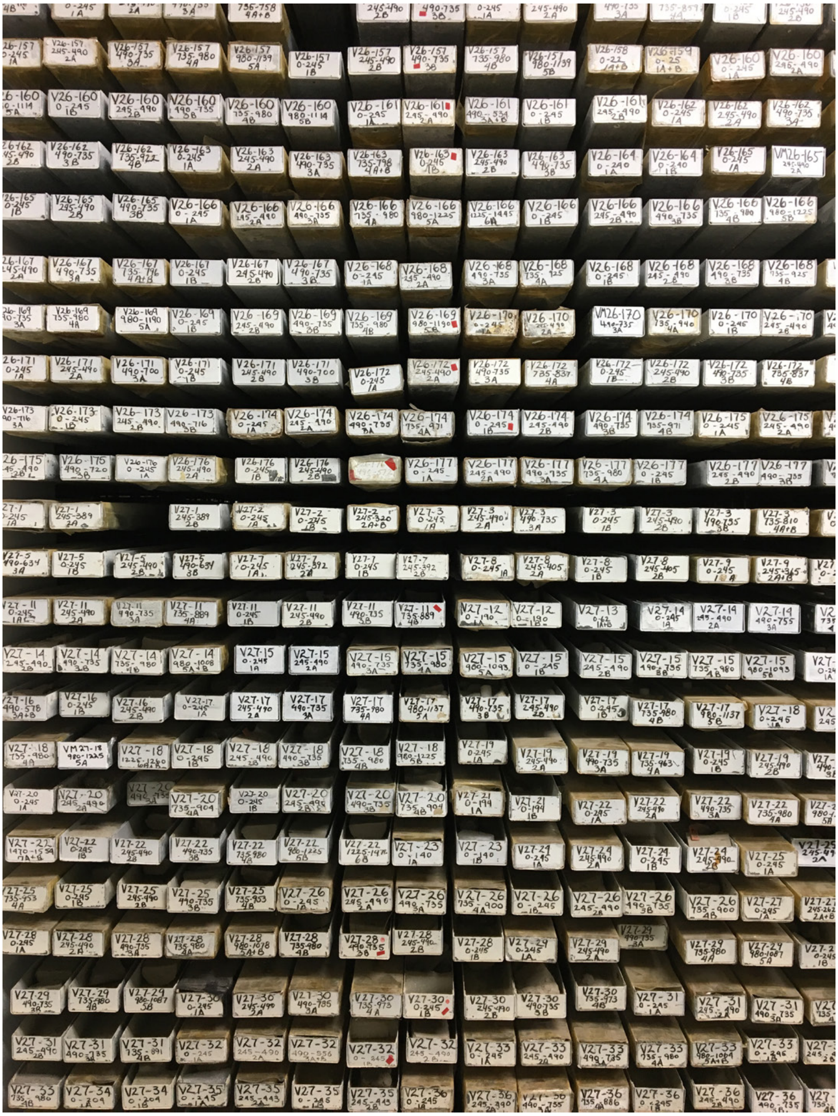

Lamont-Doherty Core Repository

1.2 The Shifting Ground: *Il Grande Cretto* and the Temporalities of the Geological Mode

Sinkholes, earthquakes and volcanic eruptions are closely associated with trauma.[218] Beginning with my experience of a (sink)hole at the commemorational site of a town lost to an earthquake, I show that the reaction of shock at traumatic manifestations of the ground as an active entity points to a fundamental temporal disconnection. Sinkholes happen when a cavity develops under the surface layer and unexpectedly caves in. As the ground's subterranean movements and activities are beyond our scope of temporal perception, we seemingly remain temporally disengaged. The false conception of nature and the ground as the *passive* foundation for *active* humans dangerously flattens the temporal complexity of the ground-human relationship. The question "what happens when the ground gives way?" confronts an existential error: that the natural ground should be static and stable.[219]

In order to contribute to a counternarrative of the active ground, I will investigate a set of literal and conceptual holes in the physical, temporal and social fabric of a small Sicilian town known as Gibellina before it was completely destroyed by the 1968 Belice earthquake and subsequently rebuilt at a different site as New Gibellina. *Il Grande Cretto* (*The Great Crack*) is a large-scale land art piece by Italian artist Alberto Burri (1915–1995) that commemorates Old Gibellina. The artwork covers a rectangular area of about 350 by 280 metres, and consists of concrete blocks that enclose the remnants of the collapsed buildings, separated by concrete walkways. Some of the incisions correspond to Old Gibellina's main street. The rest

[218] For geographies of trauma that map its temporalities see Cathy Caruth, 'Trauma and Experience: Introduction', in *Trauma: Explorations in Memory* (Baltimore and London: The John Hopkins University Press, 1995), 3–12. For its traces on the body see Gail Adams-Hutcheson, 'Spatialising Skin: Pushing the Boundaries of Trauma Geographies', *Emotion, Space and Society*, no. 24 (August 2017): 105–12. For its spatial affect see Janet Walker, 'Moving Testimonies and the Geography of Suffering: Perils and Fantasies of Belonging after Katrina', *Journal of Media & Cultural Studies* 24 (2010): 47–64.
[219] Anna Lowenhaupt Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015), 7, iBooks.

of the cracks formed independently of historical meaning, or "spontaneously",[220] like intrinsic growth patterns. Construction began in 1984, paused short of completion in 1989 due to lack of funds, and was finally completed in 2015.

Il Grande Cretto is exemplary, both in its conception and in its slowly eroding presence, of the implications of an active ground that extends far beyond a passive projection plane for our notions of nature. An approximation of holes, and the question of the implications of the ground giving way, requires an answer in what I call the geological mode. The geological mode is a temporal, material and spatial method that embodies the logic of the ground: in the previous chapter I showed that the deep time of continued cyclicity permeates its materiality, and that it engenders a state of animation. In line with this mode, I will engage with Nigel Clark's *Inhuman Nature* (2011), which deals with "the consequences of the earth mobilizing itself" and "the collisions of its own temporalities and spatialities with the times and spaces of human life".[221] The experience of these temporalities is closely bound to the notion of affect, in particular Sara Ahmed's description of disorientation in *Queer Phenomenology* (2006) and Lauren Berlant's *Cruel Optimism* (2011).

Beyond the perception of the ground as increasingly instable, land artist Robert Smithson's concept of "abstract geology"[222] offers insight into the poetic and interpretative potential of the geological mode. Reading Burri's *Il Grande Cretto* through the logic of "abstract geology" shows that the sculpture itself is a not-quite-petrified entity in the flux of geological processes. As much as it apparently seals the scarred settlement whose place it takes, it cannot suspend the mnemonic and physical holes in the formerly dense urban fabric.

[220] Robert Smithson, 'The Monuments of Passaic', *Artforum* 6, no. 4 (December 1967).
[221] Nigel Clark, *Inhuman Nature: Sociable Life on a Dynamic Planet* (Los Angeles: Sage, 2011), 2, Kindle.
[222] Robert Smithson, 'A Sedimentation of the Mind: Earth Projects', *Artforum* 7, no. 1 (September 1968): 44.

Burri's related *Cretti* works—craquelure paintings begun in 1970—further manifest the geological on a material level, as the artist uses temporal suspension to manipulate material processes. They give insight into ways of navigating the temporalities inherent in different material processes and how to negotiate the plane where such temporalities meet—just below and just above the surface. I traced these temporalities on a site visit to *Il Grande Cretto* in spring 2017. The experience of the artwork and the active ground it embodies formed an important step in developing the geological as an archival mode.

Archaeology of the Future: Fissures in Time and Place

When I first saw *Il Grande Cretto* through a dusty car window, against the low late-afternoon sun, the artwork seemed to blend into the mountainous and agricultural landscape of western Sicily like a dense, barren field. It lay still on a slope, amid terraced vineyards, half disappearing behind an adjacent elevation, while windmills animated the hills' crest above it. The narrow country road leads unceremoniously up to the edge of the monument, and swerves past the concrete field and a gravel parking lot, undisturbed. You can enter the labyrinthine terrain from anywhere; there are no designated entry points.

I accessed the sculpture through its newest region, where the concrete is still immaculately white. The walls look like soft pillows in some places, and like crumpled paper in others—the imprints of the plastic sheets that covered the formwork during the *in-situ* casting process. The corners of the concrete blocks are rounded: here, no sharp edges inhibit the flow. The horizontal edges, on the other hand, are sharp and rough.

As I wandered deeper into the liminal concrete sphere, I left the material and spatial logic of the world outside the sculpture behind. Within the sculpture, there is no destination, only the exploration of a homogenous space. The experience of exploration is emphasised, since at most points in the sculpture one cannot see beyond the next turn; there can thus be no destination. The only material that exists within the sculpture is concrete, with the exception of heaps of detached waste vegetation gathered by the wind. From within the sculpture, it is difficult to get a sense of the overall shape of the concrete islands, as they are too large and tall to be grasped from any standpoint. The spatial experience changes with the topography of varying slopes, which affect the views within and beyond the sculpture. At one instant, the visitor overlooks the surrounding land; in the next, her visual field is delimited by concrete walls and the sky.

The sense of disorientation is palpable. Maybe it is this feeling that lies at the core of the spatial experience of *Il Grande Cretto*. Affect scholar Sara Ahmed reminds us:

> Moments of disorientation are vital. They are bodily experiences that throw the world up, or throw the body from its ground. Disorientation as a bodily feeling can be unsettling, and it can shatter one's sense of confidence in the ground.[223]

By letting the visitor get lost, does *Il Grande Cretto* help her to become aware of her tools of reorientation? Understanding "how we become orientated in moments of disorientation" reveals "what it means to be orientated in the first place".[224] Is *Il Grande Cretto* thus what Ahmed calls a "homing device"?

Unfamiliar but consistently homogenous, the sculpture presents the visitor with clues for orientation, beginning with a horizon line at eye level. This line undulates, and it is interrupted by pathways. It aligns itself in myriad ways with the surrounding landscape, yet despite these variations, it reliably accompanies the visitor throughout the *Cretto*. This edge, where the block roofs meet the walls, heightens the visitor's awareness of her

223 Sara Ahmed, *Queer Phenomenology: Orientations, Objects, Others* (Durham, NC and London: Duke University Press, 2006), 157.
224 Ahmed, *Queer Phenomenology*, 8.

own body in the sculpture. The walls are always 1.6 metres tall, but depending on where the visitor is on the slope and which way she is facing—uphill/downhill—she recalibrates her body against the concrete horizon edge.

Similarly, the surfaces of the concrete blocks serve as homing or situating devices: the smoothness of the horizontal walls, the crisp whiteness of the newer blocks, the rough surface of the floor, brittle edges, rounded corners. The body is the constant in this monochrome and undulating landscape, continuously updating the sculpture according to its own parameters of height, speed and orientation: the body climbs steep slopes, slows down, speeds up, chooses directions within the maze—a hand brushing, sometimes scraping against concrete, a shoulder leaning against a sun-warmed wall.

The consistency of the material and spatial logic of the sculpture contributes to a growing sense of familiarity as time is spent within *Il Cretto*. The experience of the sculpture thus extends from the visitor's body, as "the starting point for orientation is the point from which the world unfolds: the 'here' of the body".[225] Thus, even as the visitor is conscious of disorientation within *Il Grande Cretto*, it is not a threating sensation: increasing intimacy with *Il Cretto*, along with occasional glimpses of the surrounding landscape and the logic of the topography, help the visitor to situate herself. The sculpture offers an experience of safe disorientation and heightens the visitor's awareness of her homing or orientating device—her body.

As I kept exploring, I wondered about the tops of the blocks, which mostly withdrew from my field of vision. It is possible, but not easy, to climb onto these to overlook the sculpture. After clambering onto one of the roofs, I was surprised to find that this particular unit was punctured by an unplanned hole. I approached the cavity carefully, as if treading on

[225] Ahmed, *Queer Phenomenology*, 9.

thin ice. Thin wooden battens, weathered and grey, marked the opening, like a broken picture frame. Down the concrete hole, I could see what looked like a former facade wall, white render still clinging to the yellow stone blocks in some places. The block's roof had fallen into the hollow it preserved, onto a bed of stinging nettles and other weeds, their lush green starkly contrasting with *Il Grande Cretto*'s materiality. If the block had been packed tightly with the rubble of the destroyed town at the time of construction, water must have hollowed out this particular block, resulting in a kind of sinkhole in the midst of the otherwise perfectly sealed concrete world.

The whole sculpture, its 12-hectare expanse, collapsed here, into a hole small enough to be jumped across. The idea of an enduring lithic monument, the illusion of thoroughly sealed archival capsules, the concept of a final and permanent physical marker—akin to a tombstone commemorating a site of loss—crumbled and disintegrated into the haphazard hole that I had chanced upon. Maybe it is the only hole, maybe there are more, or perhaps they are currently forming. This hole revealed to me the persistence of geological activity, unchecked by this vast expanse of concrete that mummifies the destruction caused by the Belice earthquake. The opening, a literal sinkhole caused by undermining, can—like an earthquake—be understood as a conceptual sinkhole[226] that in turn undermines the notion of a stable ground—that fantasy of a permanent plane of reference.

Abstract Geology

At the time of its destruction, Gibellina was a town of 12 hectares and home to 6,500 people. The 1968 Belice earthquake not only erased Gibellina and three neighbouring towns, but also severely damaged many more villages, leaving 231 people dead, more than 1,000 injured and

[226] Lucy R. Lippard, *Undermining: A Wild Ride Through Land Use, Politics, and Art in the Changing West* (New York: New Press, 2014), Kindle.

100,000 homeless.[227] The victims were sheltered in temporary homes, which most inhabited for nearly a decade[228] because of delays in construction. In the tradition of other Sicilian towns—most famously, Noto in 1693—Ludovico Corrao, the then-mayor of Gibellina, decided to build New Gibellina, at a distance of 18 kilometres away, as a paragon of modern architecture, including works by Ludovico Quaroni, Rob Krier, Oswald Mathias Ungers, Pietro Consagra, Arnaldo Pomodoro, Renato Guttuso and Joseph Beuys.

Corrao was determined to add the internationally successful artist Alberto Burri to his built catalogue of the architectural and artistic avant-garde. Diverging from Gibellina town council's initial vision, Burri chose not to contribute to the new town, and decided instead to commemorate the lost Gibellina. A site visit to Old Gibellina and a subsequent excursion to the nearby ruins of Segesta, an ancient Greek amphitheatre, formed the foundation of Burri's contribution. At Segesta,

> he decided to create a large *Cretto* over the ruins of the destroyed city. "Above all" he said, "strength like history had to emerge from the comparison of the great civilizations of Segesta, Selinunte, Motia and the ruined world of the poor and the dead." He defined his work as "the archaeology of the future".[229]

Burri resolved to harness the power of historical endurance to commemorate the site of Old Gibellina's demise. His notion of the "archaeology of the future" indicates the inevitability of temporal flow, and its precipitation in the transience of the present and the petrification

[227] Lorenzo Tondo, "50 Years Since Sicily's Earthquake, an Urban Disaster of a Different Kind", *The Guardian*, 15 January 2018, Cities, https://www.theguardian.com/cities/2018/jan/15/sicily-earthquake-1968-50-years-belice-valley-poggioreale.
[228] Adrian Forty, "Happy Ghost of a Possible City: Il Cretto, Gibellina", *AA Files* 66 (2013): 101.
[229] Judith Rozner, "Alberto Burri: The Art of the Matter" (PhD thesis, University of Melbourne, 2015).

of built traces. Burri's work encapsulates the temporally disrupted layers of Gibellina's urban fabric. The 122 concrete time capsules preserve the architectural rubble and its then-remaining content—including all the remnants still found among the ruins, such as wine bottles, clothing, toys, furniture and household goods[230]—for future archaeologists to decipher and reassemble.

To some extent, the built world is always also archaeological, because architecture and ground are closely entwined. Just as the human body returns to the ground as dust to dust, the architectural body returns to the ground as stone to stone, ruin to geological remnant. The built can be understood as mimetic and accelerated geology: on a material level, architecture is mined and reassembled ground. The shift in perception of the built environment over time, from the eventual or perpetual ruin to a geological process, is a shift from an anthropocentric narrative to a more planetary imaginary in which humans and non-humans (rocks, tectonic plates, mineral veins etc.) engage in similar activities at different tempos.

Like a stone that embodies ancient, even antemundane and certainly prehuman planetary activity, Burri's artwork activates the imagination of a forgotten past. It resonates with Jeffrey Jerome Cohen's understanding of the lithic as an animating force, empowered by which each stone

> opens an adventure in deep time and inhuman forces: slow sedimentation of alluvium and volcanic ash, grinding tectonic shift, crushing mass and epochal compaction, infernal heat, relentless turbidity of the sea.[231]

Similarly, we could tell the story of Gibellina through the lithic components of *Il Grande Cretto* that will be discovered by future

[230] Rozner, "Alberto Burri", 162.
[231] Cohen, *Stone: An Ecology of the Inhuman*, 4.

archaeologists.[232] They will discover the rocks that composed Gibellina's houses, assembled over the centuries, on the same plane as a large amount of newer concrete rubble and white cement, like a parallel settlement.

Deleuze and Guattari's statement "art preserves"[233] can be thought in relation to Burri's *Il Grande Cretto*, which as a monument not only commemorates the old town but also literally archives its remnants. In the last chapter of *What Is Philosophy?* they postulate the artwork as monument, "a bloc of sensations, that is to say, a compound of percepts and affects […] whose validity lies in themselves",[234] thus imbuing the artwork with the autonomy to "stand up by itself". Deleuze and Guattari's definition of monuments is fruitful, because it extends beyond memory and expects the artwork to take on a life of its own. The artwork does not commemorate as much as it embodies the event that inspired its becoming, in this case the loss of Gibellina in the Belice earthquake. The monument-artwork gives the epitomised event "a body, a life, a universe".[235] Burri accomplishes this by constructing a large-scale, abstract, narrative landscape[236] that in its materiality quite literally embodies Gibellina and its trajectory.

Not only is *Il Cretto* for potential future archaeologists, but it is also an "archaeology of the future" in itself, a description of a future state of lithic entropy contained in mineral archival pockets. The concept strongly resonates with land artist Robert Smithson's "ruins in reverse", a phenomenon he observed on an excursion to suburban Passaic, New Jersey, in 1967. Burri and Smithson shared an interest in the relationship between the geological, the built and the temporal. And both artists

232 This speculative exercise resembles Cohen's thoughts on the Jewish Memorial in Berlin by Libeskind: "Who knows what future archeologists will make of the stelae in their meticulous rows". Cohen, *Stone*, 196.
233 Deleuze and Guattari, *What Is Philosophy?*, 163.
234 Deleuze and Guattari, *What Is Philosophy?*, 164.
235 Deleuze and Guattari, *What Is Philosophy?*, 177.
236 Tim Ingold, "The Temporality of the Landscape", *World Archaeology* 25, no. 2 (1993): 152.

responded to holes. Compared with the dense urban fabric of New York City, the suburb "seems full of 'holes'", Smithson noted, "and those holes in a sense are the monumental vacancies that define, without trying, the memory traces of an abandoned set of futures".[237] These forsaken futures echo Gibellina's forcefully abandoned future, stripped away first by the earthquake and then by the town's transplantation. The hole Burri found was an inescapable sinkhole in the foreclosed history of Old Gibellina, which had come to an unceremonious end.

While Burri worked with what Smithson termed "romantic ruins"—buildings that "*fall* into ruin *after* they are built"—Smithson's interest was in the "anti-romantic", unbuilt suburban constructions that "*rise* as ruins before they are built".[238] Whereas suburbs exist "without the 'big events' of history",[239] Burri's experience of Gibellina's rubble and the Greek ruins was all history and "big events". The hole—literally and metaphorically, in terms of an "abandoned set of futures"—defines the common *shifting ground* for both artists.

Burri's interest in the geological, and the enormous scale of his outdoor intervention, connects his work to that of the American land artists active in the 1960s and 1970s, to whom Smithson also belonged.[240] Smithson's notion of "abstract geology",[241] discussed in the previous chapter, is like his "ruins in reverse": a generative tool of analysis for understanding the ground as an active entity in *Il Grande Cretto*. "Future archaeologies" and "ruins in reverse" point towards sinkholes and fissures in the continuously evolving fabric of the imagination of the ground. Burri mobilises the

[237] Robert Smithson, "The Monuments of Passaic", *Artforum* 6, no. 4 (1967): 72.
[238] Smithson, "Monuments of Passaic", 72.
[239] Smithson, "Monuments of Passaic", 72.
[240] "The fact that the work is largescale and in the environment relates him to Robert Smithson and the American earthworks artists, but that it is a memorial with social relevance distances him from that more conceptually oriented movement" D Cohen, 'Alberto Burri at Mitchell-Innes & Nash', *Artcritical* (blog), 22 January 2008, http://www.artcritical.com/2008/01/22/alberto-burri-at-mitchell-innes-nash/.
[241] Robert Smithson, "A Sedimentation of the Mind: Earth Projects", *Artforum* 7, no. 1 (1968): 44.

archival potential of geology: *Il Grande Cretto* exposes sedimentation, layering and rearrangement through upheaval and friction to show that not only "the earth is built on sedimentation and disruption",[242] to create an archive caught up in the flux of continuous updates.

As I showed in the previous chapter's discussion of Hutton and Lyell, the modern understanding of geology is closely bound to the archival. When Smithson wrote "the strata of the Earth is [sic] a jumbled museum",[243] he was translating the definition of geology as formulated by its founding fathers, James Hutton and Charles Lyell, into the art context. From its scientific beginnings in the 19th century, geology postulated the planet as archive-archivist—always changing, and continuously documenting its transformations. Glaciers were understood as "endless scrolls, as streams of time engraved with the succession of events", and mountains as "archives of the earth".[244]

Il Grande Cretto embodies the archival dimension of the geological. In an act of documentary encapsulation, Burri sealed the debris of Gibellina's destroyed houses in concrete blocks. The artwork spreads across the site like a petrified layer of geological activity, enclosing pockets of temporal debris from another epoch. The sculpture creates preservative memory capsules, inaccessible hollows that preserve the strata of Old Gibellina. These pockets are voids as much as they are dense archives that simultaneously encapsulate the former town and "the might of the geological or the cosmic […] in a literal way".[245] The lithic materiality of *Il Cretto* itself becomes a storage medium. In Cohen's words, "stone materializes history to guard against forgetting, slowing for a while the erosive power of time. The engulfing grey expanse is sombre, a space of potent remembrance".[246]

242 Smithson, "Sedimentation", 87.
243 Smithson, "Sedimentation", 87.
244 Denis E. Cosgrove and Veronica della Dora, eds, *Cultural Geographies of Mountains, Ice and Science* (London: IB Tauris, 2009), 13.
245 Clark, *Inhuman Nature*, 84.
246 Cohen, *Stone*, 196.

Not only the sculptural end product, but also the artistic process itself embodies the geological mode. Burri first began creating a painting series of cracks in 1970. The *Cretti* series (1970–1979) manifests the geological on a material level, as the artist created craquelure effects by coordinating the interplay of the chemical, physical and atmospheric parameters of the substrate of Celotex insulation board, zinc white pigment powder, polyvinyl acetate (PVA) as binder and varnish, and white or black (vinyl) acrylic paint.[247] Emily Braun, art historian and curator of the 2015 Alberto *Burri* retrospective "The Trauma of Painting" at the Solomon R. Guggenheim Museum in New York, explains:

> The word craquelure (from the French term craquelé, or "cracked") describes a phenomenon common to aging paintings, wherein the surface develops tiny fissures and cleavage due to stress, strain, and environmental changes over the years.[248]

During the time of the *Cretti* series, Burri spent the winters in Los Angeles, from where he visited Death Valley and its cracked desert mudflats—a visual reference. More importantly, he came into close contact with the minimalist movement, which was consumed with surfaces. Similarly, Burri's ambition was "to demonstrate the energy of the surface".[249] He accessed the geological via an acute awareness of surfaces and the action potential below, which he harnessed in the artistic process of making the *Cretti*:

> As water evaporated from the underbound paint, the small amount of PVA could not sustain the integrity of the paint layer. The volume of the thick paste decreased and tension mounted within the shrinking material, which ruptured gradually as it dried.

[247] Emily Braun, ed., *Alberto Burri: The Trauma of Painting* (New York: Guggenheim Museum Publications, 2015), 236.
[248] Braun, *Alberto Burri*, 236.
[249] Rozner, "Genesis and History".

> Prolonged time and the material's natural tendency to release energy, became key factors in the making of the picture.[250]

Burri orchestrated the interplay of material properties and atmospheric conditions in the studio, such as temperature and humidity. The energy of the surface can be seen to stem from the material and mechanical processes it encloses, and from the atmospheric input it receives from its surroundings. This process echoes Deleuze and Guattari's reflections on painting. They note that "the area of plain, uniform colour vibrates, clenches or cracks open because it is the bearer of glimpsed forces".[251] Their description of these forces resonates with my description of the geological mode: "the forces of gravity, heaviness, rotation, the vortex, explosion, expansion, germination, and time".[252] Burri's work harnesses the geological mode to explore material temporalities just below the surface, and their archive in the resulting form.

Deleuze and Guattari, like Burri, found that "painting's eternal object is this: to paint forces".[253] And, like Burri, they understood the potential of artistic material to embody forces and transmit them to the observer as sensation.[254] Burri's thick paint paste was a medium for the forces of expansion, contraction, time etc. The *Cretti* paintings are monuments that embody these forces and their deferment, as Burri learned to manipulate these processes and to suspend them at will: "after the formation of the craquelure, or whenever he decided arbitrarily to suspend the process, Burri consolidated the medium"[255] by sealing the material with a plastic layer.

Temporal Suspension

[250] Braun, *Alberto Burri*, 237.
[251] Deleuze and Guattari, *What Is Philosophy?*, 182.
[252] Deleuze and Guattari, *What Is Philosophy?*, 182.
[253] Deleuze and Guattari, *What Is Philosophy?*, 182.
[254] Deleuze and Guattari, *What Is Philosophy?*, 166.
[255] Braun, *Alberto Burri*, 237.

Burri can thus be seen as the conductor of a tempo-material choreography, which he "suspends" to create the finished piece. Burri achieved "a conscious deferral of the primary gesture in the creative process to the forces of nature".[256] The "play of responses between human and nonhuman elements"[257] defines the *Cretti* paintings as much as *Il Grande Cretto*. Besides the composition of "chance and control",[258] I am particularly interested in Braun's choice of words: *to suspend* suggests creating a pause in—rather than an end to—the physical and chemical processes at play, as if they could be released in the future to continue their craquelure.

Il Grande Cretto responds to the historic rupture in the town's history by articulating not only a material but also a temporal suspension. I now briefly touch upon Burri's biography and the notion of the liminal to show that *Il Grande Cretto*, with its labyrinthine, liminal, transformative qualities, preserves a temporal moment, establishes a parallel time zone, creates a gap in chronological time, and maintains the suspension of historical time. Despite the artist's reticence, aspects of healing are often inscribed in interpretations of Burri's artistic practice. These stem in part from his pre-World War II training as doctor, and his three-year stint as a war medic before he took up painting as a prisoner of war in Camp Hereford, Texas, in 1943. This biographical background, in conjunction with his artworks of cuts, combustions, cracks and the prevalence of the colour red, earned him the label "artist of wounds".

Whereas an artist such as Joseph Beuys (1921–1986) was interested in taking on the role of post-war shaman for a nation, Burri steered clear of obvious references to trauma and healing. Informed by his medical knowledge of psychological trauma, he irritably clarified in an interview, "contrary to what so many have hypothesized and written, I never had 'flashbacks' of any type [with images] of gauze, blood, wounds or the

[256] Clark, *Inhuman Nature*, 82–83.
[257] Clark, *Inhuman Nature*, 82–83.
[258] Braun, *Alberto Burri*, 237.

like".[259] As Emily Braun observes, the context of "personal victimhood or instrumental psychotherapy" distracted from his "work's radical means, affective power, and historical relevance".[260] However, for his contemporaries, it seemed hard to shake the notion of the medical Burri—if not as traumatised victim, then as healer. His friend, the architect Alberto Zanmatti, who worked on *Il Grande Cretto*, described Burri's work at Gibellina as being in "the spirit of Asclepius, the Greek God of Medicine".[261]

Gibellina can be understood through the lens of socio-medical healing, as a performative archive or liminal zone. The concept of liminality—the term comes from the Latin for threshold—was first proposed by the ethnographer Arnold Van Gennep (1873–1957) in his research on temporally transitional rites of passage, which he linked with spatial territorial crossings.[262] Van Gennep emphasised that before they became today's mapped (out)lines, borders were constituted of neutral areas, usually deserts, marshes or virgin forests. The transition from one (political and biographical) state to another was therefore extended spatially, through these liminal regions that created "a special situation for a certain length of time"—an extended "waver[ing] between two situations".[263] Because of the temporal logic of the memory pockets assembled in the open time grid, the linearity of chronological time is suspended in the *Cretto*; it is literally a hiatus in historical time. There is no sense of sequence, nor of history, despite the monumental commemoration.

The monument creates a liminal zone that enables the engaged individual to experience physically, and not just cognitively, the temporal effect of an entire town's erasure. British anthropologist Victor Turner (1920–1983)

259 Braun, *Alberto Burri*, 33.
260 Braun, *Alberto Burri*, 34.
261 Rozner, "Genesis and History".
262 Arnold Van Gennep, *The Rites of Passage* (London: Routledge and Kegal Paul, 1960), 21.
263 Van Gennep, *Rites of Passage*, 18.

later developed the concept of the liminal phase, an in-between space and time during rituals that opens a temporal break from the familiar experience of chronological time, as does *Il Cretto*. According to Turner, "in liminality people 'play' with the elements of the familiar and defamiliarize them",[264] which then results in the transformed perception necessary in post-rite-of-passage existence. From this perspective, *Il Grande Cretto* creates a field of reflection and of coping with the loss of Gibellina, by creating a zone of suspension. Barren and uninhabitable, *Il Grande Cretto* suspends agricultural growth (except where the *Cretto* has cracked) as much as human habitation. The artwork emphasises the impossibility of the town's return to its original site or to its lost organic structure.

Suspension also explains my experience of nostalgia at New Gibellina. Mid-morning, I entered a café where *carabinieri* in ornate uniforms were downing *espressi* at the bar and conversing with the local morning crowd, mostly men, on their *colazione* break. From a conversation with the barista I learned that the latter had been six years old when the earthquake occurred. He and his mother had moved into temporary housing for nine years while the new town was under construction. During that time, around half the population gradually left the Gibellinas to become migrant workers in Germany and northern Italy. Others at the bar joined in, and soon they were unanimously criticising New Gibellina and reminiscing fondly about the old town—where it had been cooler during the summers, and where life had been sweeter, with a more vibrant community and closer proximity to the fields. I was intrigued by the nostalgia, which, it seemed to me, should have been buried under Burri's concrete casket. From the age of 23 the barista would have known Gibellina only as ruins, and he must have been living in New Gibellina since he was 15, like most of the others at the bar.

[264] Victor Turner, *Dramas, Fields, and Metaphors: Symbolic Action in Human Society* (Ithaca: Cornell University Press, 1974), 60.

So what evoked the nostalgia? Affect theorist Lauren Berlant's notion of cruel optimism offers insight: "cruel optimism is the condition of maintaining an attachment to a significantly problematic object".[265] Old Gibellina can be understood as an "object of desire" for the inhabitants of New Gibellina. It is a "cluster of promises" that "hovers in its potentialities"[266] at the site of the no-longer-accessible old town. This "being drawn to the scene" of the object of desire points to "optimism as an affective form".[267] "Cruel optimism", Berlant continues, is "a relation of attachment to compromised conditions of possibility whose realization is discovered either to be impossible, sheer fantasy, or too possible, and toxic".[268] The local inhabitants thus use *Il Grande Cretto* to project a complex and vague set of desires onto a site of trauma.

One could argue that the inhabitants of New Gibellina experience an opposite temporality to those who left Gibellina, as described by Berlant in relation to migrant workers who "look forward to getting ahead, to making it, and to a condition of stasis, of being able to be somewhere and to make a life, exercising existence as a fact, not a project".[269] This temporality is governed by upward and forward mobility to overcome social and economic limitations, yet it aspires towards an eventual inertness built on future achievement. New Gibellina's inhabitants, by contrast, have inherited a communal stasis: they are the ones who stayed then, so they must stay now, to prevent New Gibellina from suffering the fate of another abandoned town.

Il Grande Cretto, built to avoid another ghost town trope, is the projection plane of the locals' fantasy of no return, no mobility, no way out of New Gibellina—and no way *in*. There is literally no access to the entombed remnants of Gibellina, and this embodies the object of desire that

[265] Lauren Berlant, *Cruel Optimism* (Durham, NC and London: Duke University Press, 2011), 24.
[266] Berlant, *Cruel Optimism*, 23.
[267] Berlant, *Cruel Optimism*, 24.
[268] Berlant, *Cruel Optimism*, 24.
[269] Berlant, *Cruel Optimism*, 179.

continues to hover at the site of trauma. The impossibility of return or advance precipitates the nostalgia—the repeated reminiscence of a barely remembered and even less personally experienced place—that I observed at the bar. Berlant explains nostalgia as a way of actively coping with living the perceived "bad life": "one might read these repetitions as nostalgia for nostalgia, […] a form of bargaining with what is overwhelming about the present, a bargaining against the fall between the cracks".[270]

Berlant's bleak description of nostalgia as a coping mechanism powerfully addresses the trauma of no return. This trauma is twofold at Gibellina. The town was first lost in the earthquake, made inaccessible by collapse. It was then lost a second time, sealed for an imagined eternity in Burri's memory capsules. Memory, conserved amid these capsules, demands continuous reconstruction to avoid absolute loss: maintaining this memory of a lost town is thus the active result of nostalgia as a repetitive activity of care. These are thus cruel optimism's "strange temporalities of projection into an enabling object that is also disabling".[271] *Il Grande Cretto*, like all objects of optimism, "promises to guarantee the endurance of something, the survival of something, the flourishing of something, and above all the protection of the desire that made this object or scene powerful enough to have magnetized an attachment to it".[272]

Suspension then occurs on three levels in *Il Grande Cretto.* First, the work is made of concrete, an aggregate material that hardens over time and thus entails the specific temporality of an extended chemical process of indefinite duration. Second, it suspends further erosion by rigorously sealing the ruins. Third, Burri's intervention consequently also suspends the reclamation of Gibellina's original site, fostering a sense of no return that results in nostalgia.[273] Suspension becomes an affective state, situated between the stifling repetition of nostalgic reconstruction and the

270 Berlant, *Cruel Optimism*, 180.
271 Berlant, *Cruel Optimism*, 25.
272 Berlant, *Cruel Optimism*, 48.
273 Tondo, "50 Years".

suspense of the inherent potential for utter change. The latter sentiment evokes Marx's famous material metaphor for the rumbling anticipation of revolution activated when the people reach critical mass:

> The so-called revolutions of 1848 were but poor incidents of small fractures and fissures in the dry crust of European society. However, they denounced the abyss. Beneath the apparently solid surface, they betrayed oceans of liquid matter, only needing expansion to rend into fragments continents of hard rock.[274]

Whereas cultural-political geographer Ben Anderson quotes this passage to speak of affective atmospheres,[275] for me it denotes the metaphorically geological qualities of affect in the context of suspension, as activated in *Il Grande Cretto* and described by Smithson's "abstract geology". The cracks reveal a latent action, a potential beneath the surface. They conjure the hope for the right trigger to activate these forces, be they geological, political or emotional. Nostalgia is the impossible hope in the affective potential of the cracks—of that which lies dormant and seems inaccessible but has caused visible traces.

Suspension is a temporally anticipative state, because it acknowledges that both continuity and change are inherent—much like geological change in the uniformist geological understanding. And thus, the entombed town, now incorporated into the ground as *Il Grande Cretto*, also continues to dwell:[276] when I inspected the hole in the roof, the walled void and its contents below, I saw what Burri had chosen to gather, preserve and hide behind concrete memory seals. The hole granted visibility to what was meant to be hidden: the inevitability of change, the latent premonition of collapse, a buried memory of temporal disconnection between the dwelling activities of the ground and the humans that settle on it.

[274] Karl Marx, "Speech on the Anniversary of the People's Paper", in *Karl Marx: Selected Writings*, ed. David McLellan (Oxford: Oxford University Press, 2000), 27.
[275] Ben Anderson, "Affective Atmospheres", *Emotion, Space and Society* 2 (2009): 77–81.
[276] In the Heideggerian sense: Martin Heidegger, 'Building Dwelling Thinking', in *Basic Writings* (London: Routledge, 1993), 343–64.

The Ground Dwells: Temporal Disconnection

Like humans, the ground too can be seen as inherently engaged in dwelling activities in a geological sense. It builds up mountain chains, creates linear chasms, and disgorges melted stone at punctiform openings. The tectonic plates follow their own rhythm: slowed down by basal drag, accelerated by convection forces and slab suction, writhing with internal tension. Water makes its way through limestone, aggregate material is moved along invisible arteries, caves form, stone dissolves, the ground shifts.

This shifting ground, and the adjusting surface complete with its buildings and dwellers, are fundamentally disconnected by disparate rhythms and frames of activity. The fault lines that pattern the world, subterranean caves and channels, nodes of tension and friction, are rendered visible only at moments of shock: shock at the inherent temporal disconnection between the historical tempo of human dwelling and the contiguous extra-historical geological events. In her novel *The Volcano Lover*, Susan Sontag evokes a comparable sense of apprehension linked to impeding catastrophe with a list of uncontainable forces: "like a wind, like a storm, like a fire, like an earthquake, like a mud slide, like a deluge, […] a hole opening. Like a volcano erupting".[277] Sontag inventories consequences of internal forces that cannot be confined or constrained.

Clark's reading of *Il Grande Cretto* echoes Sonntag's evocative conjuring of planetary forces: while "it stands as an acknowledgement of the frightening forcefulness of the earth itself, so too does the Cretto seem to answer back with a boldness that confronts earth processes on their own terrain and scale".[278] Clark appreciates the geological prowess of the *Cretto* as it holds its ground in the face of the earth's tremors and shifts. However, instead of stressing the apparent unbudgingness of the

[277] Susan Sontag, *The Volcano Lover: A Romance*, Kindle Edition (London: Penguin Books, 2004), 158–59.
[278] Clark, *Inhuman Nature*, 83.

anthropogenic masses of concrete, I would like to draw attention to the coexistence of the starkly differing tempos at which the ground and humans operate. Philosopher Michel Serres describes his experience of an earthquake as ecstasy, precisely because of his body's brief unity with the ground's embodied temporality. The sensation of the shifting ground profoundly affected his sense of self:

> Who am I? A tremor of nothingness, living in a permanent earthquake. Yet for a moment of profound happiness, the spasmodic Earth comes to unite herself with my shaky body. Who am I, now, for several seconds? Earth herself.[279]

Serres describes a brief union of tempos, which allowed him to transcend his own limited temporal mode of operation. The human being is a mere short-lived vibration, a fleeting flicker, when viewed against geological time spans. "Living in a permanent earthquake" points to the innate tremors, tensions and writhing within the planet's core. The earthquake is that rare moment when these movements become perceptible to the human phenomenological apparatus. The spasmodic and the shaky—two modes of operation, two differing tempos—earth body and human body unite in the earthquake as they quiver in unison with the local planetary tectonics.

Serres' experience of the earthquake shifts the commoner narrative of a moment of utter uprooting to one of complete belonging. Naturally, Serres is also aware of the loss and destruction associated for humans with earthquakes, but he presents this in a strikingly different light:

> All of a sudden the ground shakes off its gear: walls tremble, ready to collapse, roofs buckle, people fall, communications are interrupted, noise keeps you from hearing each other, the thin technological film tears, squealing and snapping like metal or

[279] Michel Serres, *The Natural Contract* (Michigan: University of Michigan Press, 1995), 124.

> crystal; the world, finally, comes to me, resembles me, all in distress. A thousand useless ties come undone, liquidated, while out of the shadows beneath unbalanced feet rises essential being, background noise, the rumbling world: the hull, the beam, the keel, the powerful skeleton, the pure quickwork, that which I have always clung to.[280]

As the world's tempo overtakes the human body, the imperceptible and unbridgeable temporal abyss that usually separates humans' and the ground's dwelling activities closes for a brief moment of pure sensation.

Like Serres, literary scholar and media theorist Friedrich Kittler (1943–2011) drew attention to the revelatory, awe-inspiring consequences of sensing an earthquake. In Kittler's case it was via the auricular. He heard an accelerated seismographic record of the "inaudible slow vibrations of the earthquake".[281] The emergent 10-second sound recordings of earthquakes, such as the 1995 Kobe earthquake, which caused more that 5,500 causalities in Japan, reflect the tectonic movement that causes them:

> In the case of earthquakes that, like those in the Pacific, result from the clash of two tectonic plates, the sound will resemble a high-pitched slap, in the case of those that, like those in the Atlantic, are the result of the drifting apart of two continental plates, it will, conversely, sound like a soft sigh.[282]

A slap and a sigh are thus Kittler's interpretations of the vibrations of earthquakes made audible. Like Serres, Kittler was deeply impressed by the sensations of the quake: "I was privileged to hear the timbre of such quakes and I will not forget it for the rest of my life".[283] To Kittler, making these otherwise inaccessible frequencies perceivable was a transcendental

[280] Serres, *Natural Contract*, 124.
[281] Friedrich Kittler, "Lightning and Series—Event and Thunder", *Theory, Culture & Society* 23, nos 7–8 (2006): 69.
[282] Kittler, "Lightning and Series", 69.
[283] Kittler, "Lightning and Series", 69.

act that blurred the lines between human and superhuman, mortal and immortal: "when we measure frequencies, we are on the other side of death, in an immortality that has replaced the old gods".[284] Phenomenological access to such frequencies transcends human temporality. If the earthquake—an unknown, unpredictable entity that operates at a tempo and rhythm that are either imperceptible, unpredictable or unendurable for humans—becomes perceivable and thus comprehensible, a threshold is crossed. "On the other side of death" we are invincible, because we can either predict or avoid such erratic occurrences as earthquakes and sinkholes.

Even in the immediate wake of a sinkhole, earthquake or volcanic eruption, the mappings, measurements and catastrophe prevention strategies do not change the fact that this radically extensive and entangled phenomenon is beyond our current scope of understanding.[285] The dwelling activities of the ground *withdraw* from our realm of temporal and spatial experience, and the shock of (for example) sinkholes just creates glimpses of awareness of these greater ongoing activities. Kittler wrote, "in order to know what something is, we need time to recognize it".[286] It is precisely a temporal disconnection that hinders us from truly recognising the ground as a shifting entity. So again with Kittler, "if our ears could descend into the vibrations caused by sea and earthquakes, we could hear them approach. […] But just as the gods confined us to finite lives in the temporal domain, our bodies restrict us to a limited spectrum in the immeasurable range of frequencies".[287]

Since Kittler's article, satellites—our technological sensory prostheses—have advanced further into the realm of Olympian frequencies. The 2011 earthquake triggered not only the tsunami waves that caused a partial

[284] Kittler, "Lightning and Series", 69.
[285] See Timothy Morton, *Hyperobjects : Philosophy and Ecology after the End of the World* (Minneapolis and London: University of Minnesota Press, 2013).
[286] Kittler, "Lightning and Series", 71.
[287] Kittler, "Lightning and Series", 71.

nuclear meltdown at Fukushima Daiichi Power Plant, but also powerful sound waves that reached the European Space Agency satellite 260 kilometres above the Earth. Theorist Kodwo Eshun writes, "seismic incidents of this intensity resound like a giant subwoofer, generating waves that travel through the surface of the earth, producing infrasonic waves that catapult through the ionosphere".[288] The Gravity Field and Steady-State Ocean Circulation Explorer, launched in 2009 to map the Earth's gravity in detail and with unprecedented accuracy, was able to detect infrasonic frequencies linked to the earthquake, 20 minutes after the event. Eshun wonders, "could these satellites sense the frequencies of active fault-strands before they surface?"[289] as he imagines bridging the temporal disconnection between humans and the ground. Technology is thus changing the ways the temporal gap between the active ground and human perception can be negotiated and reconciled.

If satellites now can hear earthquakes and translate their temporality into audible frequencies for humans, like amplified heartbeats, experiences such as Serres' and Kittler's could become commoner: experiences that, like the sinkhole in the roof of one of Burri's memory capsules, access the otherwise imperceptible activities of the ground. Sensorial access to these will unfold the nuances between catastrophe and unknowingness that have hitherto characterised human experience of the ground's intrinsic movements. The divergent temporalities of the ground and human perception point to the "radical asymmetry of the relationship between human existence and nature".[290] Clark reminds us that it is essential to insist on this asymmetry now, in the Anthropocene, when the consequence of the loss of the stable ground[291] appears to have turned into a determination to make our own ground. However, even as land reclamation, the filling of sinkholes, the erection of sea walls, the piling of

[288] Eshun Kodwo, 'Medium Earth: Seismic Sensitivity as Planetary Prediction', in *The Whole Earth. California and the Disappearance of the Outside*, ed. Franke Diederichsen and Diedrich Anselm (Berlin: Sternberg Press, 2013), 159.
[289] Kodwo, 159.
[290] Clark, *Inhuman Nature*, 50.
[291] Clark, *Inhuman Nature*, 51–52.

islands, the anthropogenic moving of landmasses etc. continue relentlessly, the ground in all its unfathomability remains the unnegated foundation of existence. Rather than engaging in further "ungrounding the ground",[292] it may be more beneficial to navigate the ground as it is: an unfixed, mobile, active entity.

Thinking and perceiving in the geological mode counteracts "the retraction of support from a ground, a field, a cosmos" that, as Clark argues, "carves deep fissures in our experience of the phenomenal world".[293] These fissures, like the holes I investigated in relation to Gibellina, are always metaphorical as much as literal, and evoke another passage from Sontag's *The Volcano Lover*: "The future is a hole [...]. When you fall in it, you cannot be sure how far you will go".[294] The future reveals the past as it swallows the present in a temporal rupture. After all, the perception of the stability of the ground changes over time. The concept of the ground as fixed or unfixed is as volatile as the notion of stones as inanimate matter: as Cohen reminds us, "by the thirteenth century, […] the philosopher and scientist Albertus Magnus had to refute the idea that stones possess souls, so lively do rocks appear when examined not simply in comparison to humans but in their native thriving".[295] Burri's concrete blocks claim a geological liveliness, a right to dwell and to transform that draws attention to the temporality of the ground, which is not a threat as much as a fact, as the ground goes its way along the fault lines that pattern the planet like the *cretti* that structure Burri's concrete field. The Cretto is an archive, an analogue data centre in the widest sense. In this chapter I have focussed more on the inherent activity levels of the ground.

[292] Clark, *Inhuman Nature*, 53.
[293] Clark, 53.
[294] Sontag, *The Volcano Lover: A Romance*, 53.
[295] Cohen, *Stone*, 2.

Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

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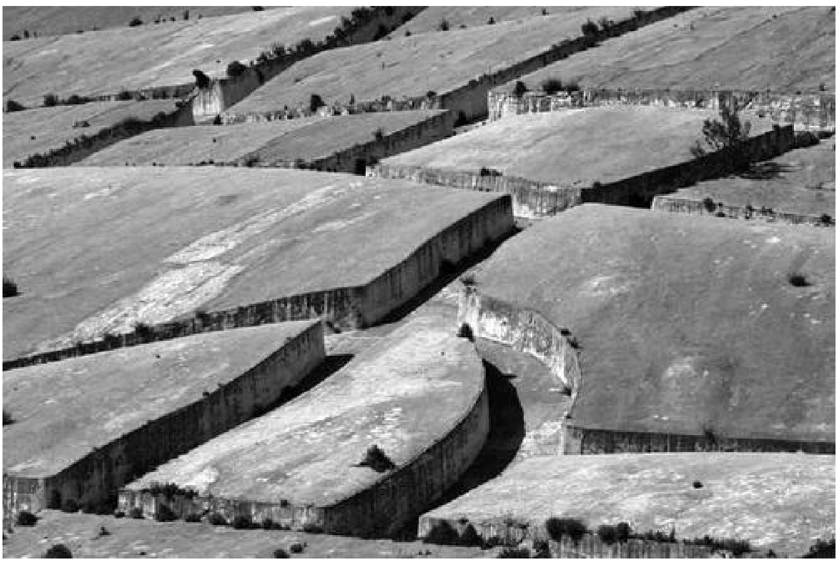
Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

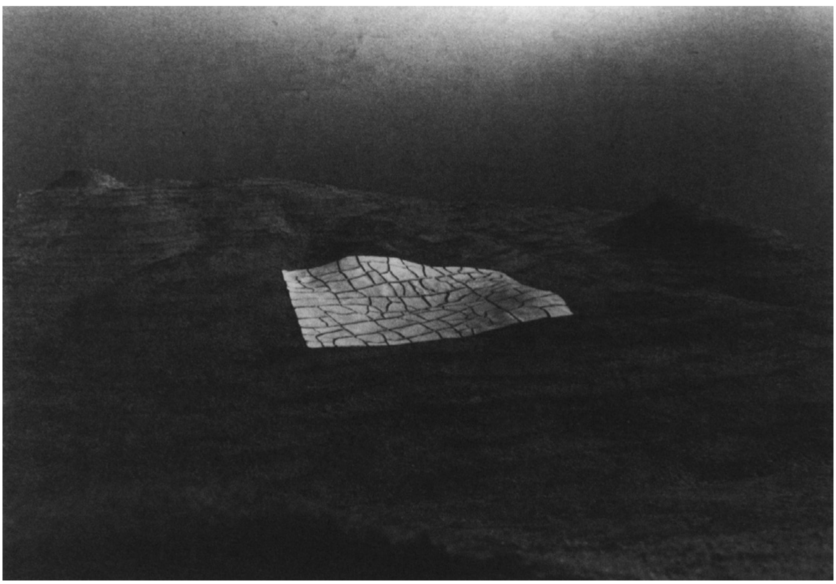
Il Grande Cretto, Albert Burri, Sicily



Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily



Il Grande Cretto, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

Cretto Blanco, Albert Burri, Sicily

Il Grande Cretto, Albert Burri, Sicily

Gibellina, Sicily

Arquata del Tronto, Italy, September 2016

Pescara del Tronto, Italy, September 2016

Pescara del Tronto, Italy, September 2016

Artistic Research Rocking Rock, Furniture.

1.3 ANIMATING DATA

Data centres are a lucrative business. By 2023, the global data centre market is forecast to reach revenues of $174 billion, at an estimated compound annual growth rate of four per cent for the period 2018–2023.[296] By comparison, Denmark generated around $172.5 billion in 2017.[297] In light of the vast economic potential of data centres, it makes perfect sense that on the "Invest in Denmark" frontpage of the Danish Ministry of Foreign Affairs there is an invitation to foreign investors to build data centres in Denmark, "the data hub of northern Europe".[298] Here is the statement:

> WHY DENMARK IS THE BEST PLACE FOR YOUR INTERNATIONAL DATA CENTRE:
>
> - A reliable power grid with an uptime of 99.99% and 80% of power lines underground.
> - A mild climate that allows low-energy cooling all year round.
> - Low-risk sites available with N-1 132/150 kV power supply.
> - Good access to large-scale sites due to low population density.
> - 72% of the Danish power supply comes from renewable sources.

[296] "Global Data Center Market to Reach Revenues of $174 Billion by 2023", Business Wire, 21 June 2018, accessed 8 January 2019, https://www.businesswire.com/news/home/20180621005832/en/Global-Data-Center-Market-Reach-Revenues-174.
[297] "Economy of Denmark", Wikipedia, accessed 20 January 2019, https://en.wikipedia.org/wiki/Economy_of_Denmark.
[298] "Welcome to Denmark, #1 in Europe for Ease of Doing Business", Ministry of Foreign Affairs of Denmark, accessed 21 January 2019, https://investindk.com/.

- Reuse of waste heat for district heating, which warms 64% of all Danish homes.
- Best in Europe when it comes to ease of doing business and dealing with construction permits, according to the World Bank.[299]

Apple's data centre at Foulum, Jutland (Denmark) represents the largest foreign capital investment in the country's history.[300] As data centres continue to be built around the world, they also take up increasingly significant amounts of land. Google's data centre, completed in 2016 in The Dalles, Oregon, takes up 15,236 square metres. As data grows exponentially, data centre footprints need to keep up. Two and a half quintillion bytes of data are created each day, and 90 per cent of the world's data was generated in just the past two years.[301] Data centres are completely entwined with our daily data production: "every second, 2.8 million emails are sent, 30,000 phrases are Googled and 600 updates are tweeted. The amount of data uploaded to the Internet in a single second is a staggering 24,000 gigabytes".[302] Soon, data centres might be outsourced to ocean surfaces: in 2008, Google obtained a patent for a wave-powered data centre that would harness the ocean for cooling and the waves' kinetic action for generating power. The patent foresees potential data centre locations five to 11 kilometres from shore at depths of 50 to 70 metres.[303] As the ground below the water surface can be

299 "A Power Hub for International Data Centres", Ministry of Foreign Affairs of Denmark, accessed 10 January 2019, https://investindk.com/set-up-a-business/cleantech/data-centres.
300 Ray W., "Apple Investing Billions in Denmark", *CPH Post Online*, 3 October 2016, http://cphpost.dk/news/business/apple-investing-billions-in-denmark.html.
301 "Data Never Sleeps 5.0", Domo, accessed 16 January 2019, https://www.domo.com/learn/data-never-sleeps-5.
302 "ADS8: Data Matter: Digital Networks, Data Centres & Posthuman Institutions", Royal College of Art, accessed 16 January 2019, https://www.rca.ac.uk/schools/school-of-architecture/architecture/ads-themes-201819/ads8-data-matter-digital-networks-data-centres-posthuman-institutions/.
303 "Google Data Center FAQ, Part 2", Data Center Knowledge, accessed 11 January 2019, https://www.datacenterknowledge.com/google-data-center-faq-part-2.

harvested for planetary history, the data centres floating on the surfaces would gather the world's current data. Data centres, with their walls of secrecy and hugely expensive equipment, are usually outsourced to the hinterlands, the "middle of nowhere" in safe, cheap and unfrequented regions with access to the internet and energy. The Nordea headquarters' data centre in Copenhagen, the case study for this chapter, constitutes an exception, as do most financial data centres. It is situated as close as possible to the trading floor it serves, to save milliseconds on transactions.

There is a strong correlation between the three case studies I investigate as part of the geological mode. Visiting *Il Grande Cretto*, I understood and experienced the ground as a mobile entity and its qualities as an active archive. Earlier, at Columbia University's Lamont-Doherty Core Repository, I had encountered a sense of animation that permeated the archiving and analysis of the extracted ground samples. The geological raw material is stored in favourable climatic conditions. The intense energy consumption parallels the extreme energy usage necessary to maintain the climatic conditions in data centres, where the servers of a geological materiality are conserved. Now, as I turn to the data centre case study in a building designed by Henning Larsen and completed in 2017, I again focus on the sense of animation exuded by the continued need for upkeep of the energy-hungry and fragile data stored within. The experience of visiting was different, since there was no tangible data—only tangible infrastructure. The actual data remained a mystery, unlike at the Lamont-Doherty, where I could touch the moist mud, and in Sicily, where I could peek through the hole into the concrete hollow.

I understand the three case study archives as geological data centres, in which data is conserved under varying degrees of environmental conditioning. The geological ground is still comprehended—as first advocated by Hutton and Lyell—as an archive of geological, environmental, climatic, planetary and archaeological information, inscribed into the more or less chronological layers of sedimentation. As geological processes continue to impact on the architecture of the ground even when the latter has been extracted and archived, the notion of animation permeates data centres spatially, temporally and materially. Extracting a cylinder of compressed ground which at one point consisted of loose or molten stone, living and organic particles, reveals the otherwise imperceptible. The ground is taken for granted as much as it resists access, as anyone who has dug a hole has physically experienced. Sinkholes, landslides, construction site pits and mines exude an air of marvel, as they reveal usually hidden cross-sections through the ground. The practice of sampling and archiving the ground in these (non-)digital data centres expands our notion of the ground as geo-informatic repository. Similarly, servers in data centres—also geological carriers of archival information—are sustained in carefully calibrated environmental conditions. Temperature is kept within a range of 21–24 degrees Celsius, the dew point between minus-nine and plus-15 degrees Celsius, and the relative humidity at close to 60 per cent.

Nordea Bank Headquarters' Data Centre: A Data Centre as Geological Archive

In the summer of 2017, I took a tour of the Nordea data centre just before it was fully operational, when security was therefore still flexible. We began on the roof, where there is a large air ventilation and solar panel plant. The data centre has its own dedicated area on the roof, an autonomous part of which is dedicated to the backup system in case the main structure fails. From the very beginning of the tour, two defining characteristics crystallised: a data centre is an environmental machine designed to "never stop", and inbuilt redundancy ensures that continued service is its main quality. The data centre is in the basement, surrounded by smaller rooms which contain the supporting functions. These tech areas include a room filled with rows and rows of box-shaped batteries on shelves. The entire room could support the data centre for a few minutes if there were a power outage. In another room there are two large backup generators, one of which is always preheated so that it can jump into action faster. This is the so-called uninterruptible power supply. There are separate spaces for the chiller plant full of chrome pipes, valves and pumps where the cooling liquid is channelled. A small control room houses a screen on which the system for electricity, liquid, air and data can be inspected.

The set-up reminded me of a high-tech farm: the batteries like chickens, the generators the size of cows, the rack systems like a delicate variation of a prize crop or a rare breed kept in special pens. The greatest fear is to experience loss: if the species were not continuously attached to its electricity lifelines, or if the climatic conditions of its habitat were to vary even slightly, then the species would overheat; fire and chaos would ensue. It is a delicate assemblage, with cables and pipes all over the ceiling, neatly arranged in various colours, and beneath the floating floor. The language to describe different archival facilities has adapted to reflect the pseudo-organic nature of data. "Cold storage" is the term used for less frequently accessed data. *Cold* does not actually refer to the temperature in data centres, but to slower response times. Thus, to retrieve colder data takes longer, as if it had to be warmed up first. It is also the kind of data, such as backup or legal data, that has to last longer, like frozen organic goods. Temperature thus denotes levels of animation or activity. Not only does the environment need to be maintained, but the actual servers also need to be continuously animated by a stream of electricity. In order for the information to be retrievable, the disks contained in server hard drives have to *animated*: they need to be spinning, so that the static sensor can read the entire disk's embedded information.

I have referenced research on the close material link between servers and resources that come from the ground, such as metals, minerals and rare earths. Considering the compressed geological materiality of the server disks, they can be read as sediment cores "in reverse". If we think back to the (half-)cylindrical slithers scientists extract from sediment cores to extract formerly animate particles—which in turn can be used to mine isotropic information—a server disk is the result of a reversal of this process. Rather than extracting a compressed cylinder which is then separated into atoms-thin temporal disc-slivers containing flattened information about formerly animated entities, the hard drive disk is the result of a process of maximised compression of information onto magnetic, geological material. Information is printed on fine cylindrical slices of geological material in the form of square magnetic fields. These fields in turn preserve the information by making it decipherable by the sensor head within the server. The disks are animated electrically so that they spin and all the magnetic squares periodically enter the field of vision of the sensor head. In the geological mode that permeates data centres, flattening, stratification, compression and petrified flows become activated in the animated archive.

Bunker Mentality

During my visit to the data centre in Copenhagen, I was struck by the pride my guide took in the inbuilt redundancy. At least half of the floor surface seemed to be covered by only the redundant energy backup systems and emergency functions. Data is usually mirrored so that it exists at two different locations simultaneously—and only the data centre manager knows the whereabouts of the data for certain. The various power backups, the generators and batteries, can extend the accessibility of the data by between 20 minutes and two hours. Describing data centres in terms of disposition, resilience and redundancy gives an insight into their connection to infrastructure space, particularly its temporality and materiality.

In *A Prehistory of the Cloud* (2015)—a study of the infrastructural embodiment of the digital cloud—Hu traces the physical overlaps between new digital data storage infrastructures and older networks of transatlantic telephone cables, railway tracks, television circuits, sewer systems, and most importantly, military infrastructure pertaining to World War II and the pre-emptive structures of the Cold War. Hu emphasises a narrative that connects data centres with security and military structures. Data centres must be safe first and foremost, as is often emphasised in advertising for data storage and cloud services. They protect and sustain the fragile, resource-voracious servers and the more or less precious data they process. They are heavily guarded and built to withstand the harshest of assaults. All types of dangers are considered:[304] climatic (hurricanes), geological (earthquakes), political (terrorism), religious (terrorism), juridical (regulations), human (unsolicited entry), fire hazards, animal intrusions etc. Redundancy is built into data centres for resilience at every level to counteract these potential dangers.

Hu gives examples of data centres that occupy bunkerlike spaces that have several disaster-proof safeguarding systems in place to protect data from "hardware malfunctions, human errors, software corruption and man-made or natural disasters".[305] In some instances, data centres literally occupy redundant bunkers, such as Pionen underground in Stockholm, and the "Swiss Fort Knox" located at a secret location in the Alps. The latter was built by the Swiss military in 1946 and converted to its current use in 1993.[306] Physical and digital safety are closely connected, even though the scattered and locationless decoy space of the cloud is a distraction from their tangible relationship. The notions of secrecy and protection invite the architectural comparison to the typology of the bunker. To illustrate what he identifies as the "bunker mentality"[307] characteristic of the cloud, Hu draws analogies between the melancholy of data loss and the fear of invasion of data centres by evoking Paul Virilio's *Bunker Archeology* (1975) and David F. Bell's writings on imagined disasters after 9/11.

[304] Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2015), 99.
[305] Hu, *Prehistory*,
96, 39. For more on planetary disaster, see Susan Sontag, 'The Imagination of Disaster', in *Against Interpretation, and Other Essays* (New York: Picador, 1966), 209–25. An example of the language of safety can be seen on the website of this data storage provider: 'Iron Mountain', accessed 9 January 2019, https://www.ironmountain.com/.
[306] Pete Brook, 'See What's Buried in the Swiss Bunkers Turned Into Secretive Data Centers', *Wired*, 29 September 2014, accessed 20 November 2018, https://www.wired.com/2014/09/yann-mingard-deposit/.
[307] Hu, *Prehistory*, 78, 98–99.

To understand the bunker, we need to turn to the interplay between the ground, the new atmospheres generated by 20th-century warfare, and an architecture inspired by geological erosion. This relationship is the topic of Paul Virilio's treatise on the typology of the bunker. He investigates the Atlantic Wall, a linear network of 15,000 fortification nodes along the coastline from Spain up to Norway. The bunker was a response to a new wartime climate that encompassed the atmospheric danger of poisonous gas and flamethrowers from above, via aeroplanes that could bombard the earth. Aeroplanes amplified the destructive potential of the sky. They delivered asphyxiating wafts of poisonous mist and radioactive mushroom clouds. They released hailstorms of artillery and explosive hurricanes. Virilio connects the bunker to this new enhanced environment: "the bunker was built in relationship to this new climate; its restrained volume, its rounded or flattened angles, the thickness of its walls, the embrasure systems, the various types of concealment for its rare openings; its armor plating, iron doors, and air filters—all this depicts another military space".[308]

The enhanced, uninhabitable atmosphere brought about a geological response: "it was no longer in distance but rather in burial that the man of war found the parry to the onslaught of his adversary".[309] The thick walls of the bunker imitated the "very thickness of the planet",[310] and their geometry the geological processes at work on the planet. Virilio explains, "linked to the ground, to the surrounding earth, the bunker, for camouflage, tends to coalesce with the geological forms whose geometry results from the forces and exterior conditions that for centuries have modelled them. The bunker's form anticipates this erosion by suppressing all superfluous forms".[311] A bunker, like a data centre, could be anywhere while also being situated very precisely, just as "siting a data centre is like the acupuncture of the physical Internet, with places carefully chosen with

[308] Paul Virilio, *Bunker Archeology* (New York: Princeton Architectural Press, 1994), 39.
[309] Virilio, *Bunker Archeology*, 38–39.
[310] Virilio, *Bunker Archeology*, 38–39.
[311] Virilio, *Bunker Archeology*, 44.

pinpoint precision to exploit one characteristic or another".[312] There is thus an interrelationship between the enhanced atmosphere and the bunker's response of maximum withdrawal—into the ground, behind thick walls. This duality governs the spatial imagination of the cloud and the extremely protected data centres.

Military intelligence creates "a new landscape" as much as "its own atmosphere".[313] New technologies make space accessible in different ways. During World War II, the battleground became three dimensional; the enemy could strike from all directions.[314] This recalls Uexküll's understanding of the world as composed of myriad worlds, depending on the action potential of its perceiving dweller/subjects. To imagine this through the example of a common meadow,

> we must first blow, in fancy, a soap bubble around each creature to represent its own world, filled with the perceptions which it alone knows. When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colorful features disappear, others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble we see the world […] as it appears to the animals themselves, not as it appears to us. This we may call the phenomenal world or the self-world of the animal.[315]

With the famous example of the tick, Uexküll observed that each animal recognises potential and opportunity according to its perceptive apparatus and the accessible realm of its physical movements.[316] The self-world of

[312] Andrew Blum, *Tubes: Behind the Scenes at the Internet* (London: Penguin, 2012), loc. 232, Kindle.
[313] Virilio, *Bunker Archeology*, 42.
[314] Virilio, *Bunker Archeology*, 40.
[315] Jakob von Uexküll, 'A Stroll Through the Worlds of Animals and Men: A Picture Book of Invisible Worlds', in *Instinctive Behavior: The Development of a Modern Concept*, ed. Claire H. Schiller (New York: International Universities Press, 1957), 5.
[316] See the introduction of von Uexküll, 'A Stroll Through the Worlds of Animals and Men: A Picture Book of Invisible Worlds'.

the human can thus be understood to change according to the technologies that enhance our perceptive apparatus and spatial experience. During World War II these changes included "the new ballistics of a war in three dimensions" and "the war of imminent danger, everywhere at once".[317] This self-world is closely related to the concept of "potential agency" or disposition, which Easterling uses to assess the latent agency that permeates infrastructure space: "Disposition, in common parlance, usually describes an unfolding relationship between potentials. It describes a tendency, activity, faculty, or property in either beings or objects—a propensity within a context".[318] Beyond indicating "potential agency", disposition also indicates forms of power, and it corresponds with Uexküll's notion of action potential. Due to its condition as a "latent potential or tendency",[319] disposition describes "a changing set of actions from which one might assess agency, potentiality, or capacity".[320] It hints at infrastructure space's hidden forms of power, at "political chemistries and temperaments of aggression, submission, or violence".[321] The delicate interplay of forms and flows that characterises disposition is best imagined as a network,[322] a topological entanglement of multipliers and switches.

Bunkers have a dual disposition, isolating as much as infrastructurally connecting. They have an inherent disposition to wait, to endure and to preserve. Hu relates Virilio's bunkers to today's data centres on several levels: both are "a type of temporal architecture",[323] they protect against intrusions, and they embody melancholy. Hu links bunkers as a kind of funeral architecture to the melancholy of data loss associated with data storage. Further, Hu establishes the temporal link between bunkers and sleeper cells by emphasising a temporality of waiting comparable to that

[317] Virilio, *Bunker Archeology*, 45.
[318] Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (London and New York: Verso, 2014), loc. 143–144, iBooks.
[319] Easterling, *Extrastatecraft*, loc. 113.
[320] Easterling, *Extrastatecraft*, loc. 113.
[321] Easterling, *Extrastatecraft*, loc. 99.
[322] Easterling, *Extrastatecraft*, loc. 106.
[323] Hu, *Prehistory*, 100.

of the archival: latent reactivation has replaced the temporality of sheltered waiting in bunkers.

> The sleeper cell hides within a population, biding time until sleeper agents can emerge in the future. […] Like the sleeper agent, the bunker's temporality is also predicated not just on hiding but also on waiting: waiting out the conflict until foreign powers withdraw, for instance. […] The opposite of quickness and virtuality, the bunker posits endurance, the longue durée of the wait. The bunker waits, as if asleep, for an attack or a disaster that may never come.[324]

Hu uses bunkers and sleeper cells to describe the latent activation that pertains to archives in general. He draws attention to the large vocabulary of digital culture dedicated to variations of waiting: "lag, latency, slowdown, buffer, throttle, hold, downtime, interruption, freeze, congestion, chop, blockage, traffic, delay".[325] Virilio demonstrates that defensive architecture is "instrumental, existing less in itself than with a view to 'doing' something: waiting, watching, then acting or, rather, reacting. […] These buildings are no longer just receptacles but binnacles, which is what distinguishes them from ordinary architecture and what gives them this anthropomorphic character".[326] Virilio describes an architecture that visualises impacting environmental and military forces. Data centres combine the promise of the safety of bunkers and the latent activation of sleeper cells in a narrative that is laced with military analogies.

Standardised Secrecy

The protection associated with data centres is not only physical; it also manifests in the layers of secrecy that envelop data centres. Journalist Andrew Blum, who researched data centres and was able to get into data

[324] Hu, loc. 2327.
[325] Hu, loc. 2423.
[326] Virilio, *Bunker Archeology*, 43.

centres only with much difficulty, writes: "a culture of secrecy developed in the data centre world, with companies fiercely protecting both the full scope of their operations, and the particularities of the machines housed inside".[327] This secrecy seems over the top to the layperson. My research on data centres revealed that from a non-engineer's perspective, the logic of a data centre seems to be built on simple infrastructural and climatic rules. The architecture of data centres is based on the rack unit U: the height of a thin server, 44.5 millimetres. A typical server rack is 42 U high, and different types of server equipment range between one and four U in height. Amount X of server equipment is stored in Y number of server racks. These racks are usually "four-post" racks, which means that they are rectangular frames with structural support on all the edges, the bottom of which can be fixed to the floor. The racks are standardised infrastructural furniture—for example, the 482.6-millimetre ("19-inch") racks were officially normed by the Electronic Industries Alliance before it ceased operations in 2011. Variations still exist among the different providers, but generally a rack takes up 600 millimetres in width, 1,067 millimetres in depth, and variable heights—for example, a 42-U rack is often 2,210 millimetres.

The space taken up by the racks, and the power needed or available for consumption by the servers, dictates the environmental requirements. In a data centre there are rows of racks, on which the IT equipment is mounted. These have a front and a back. Usually, the fronts of the rows face each other, and the space between two forward-facing rows is called a "cold aisle". The aisles which separate the back ends of the racks are "hot aisles", as more exhaust heat is generated here. Aisle pitch is the distance between the centres of adjacent cold aisles.[328] Aisle pitch defines the density of the equipment, which in turn defines the power and thermal management requirements of the centre. The commonly applied seven-tiles pitch rule in "from-scratch" data centres presumes the use of 610-

[327] Blum, *Tubes*, loc. 239.
[328] 'Aisle Arrangement: What Is Aisle Pitch? | The Server Rack FAQ', accessed 27 January 2019, https://www.server-racks.com/aisle-pitch.html.

millimetre-square (two-foot-square) floor tiles, and advises the following arrangement:

> Each cold aisle width should be 2 tiles which is equal to 4 feet and each hot aisle should be 3 feet wide. It's important the front facing edge of the rack matches the edge of the floor panels facing the front of the opposite rack with 1 mm of front clearance, and.6 mm rear clearance. A standard 42-inch-deep rack will cover 1 and a half tiles.[329]

These guidelines need to be adjusted if the data centre in question is of higher capacity (with a wider cold aisle), or in relation to sustainability-related priorities or existing spatial constraints, all of which affect the layout. In any case, the seven-tiles pitch rule points to the fact that data centres are fundamentally based on standardised units, environmental requirements, power consumption and spatial availability. The rule aligns a standardised size of floor tile on a raised floor (also called a floating floor), and the tiles can be lifted off their grid supports for access to the technical space below, which features electrical cables, outlets and ventilation ducts. Even the rendering I described in the introduction adheres to the seven-tiles pitch rule.

At the Nordea centre, the racks are clustered into seven-tile-wide cabinet units, which can be locked. The data racks are part of a long history of archive furniture. In the past, archive furniture juggled two opposing concerns: to show enough of the detail of the archived documents to help with orientation, and simultaneously to grant undistracted overview and safekeeping.[330] The challenge was understood to play out between the content-structuring potential of (closed) cabinets and the loss of visibility of the content.[331] Today's archive furniture—simple black plastic and steel

[329] "Aisle Arrangement".
[330] Markus Friedrich, *Die Geburt Des Archivs: Eine Wissensgeschichte* (Munich: Oldenbourg Wissenschaftsverlag, 2013), 172.
[331] Friedrich, *Geburt*, 177.

frames, with utterly nondescript servers slotted into them—gives absolutely no insight as to what data might be spinning on its server platters. Only the characteristic LED spots on the server boxes that signify movement or life, like data fireflies on a server matrix, give a slight indication of information where secrecy prevails.

The actual data is intangible, decipherable only on mediating interfaces[332] and transported via subterranean cables or Wi-Fi waves. By contrast, in the data-rich metropolis of the 20th century, the dominant unit was the carrier of information itself—the piece of paper. High-rises and their open-plan offices were organised to optimise the archiving, retrieval and flow of paper documents, establishing "a true assembly line of signatures, stamps, or other addenda".[333] Le Corbusier's Casiers filing cabinets, as well as his office designs, were organised around this smallest spatial unit: they were "generated from the inside out, dimensioned by the path of standardized white paper".[334] Paper would thus structure the layout of office furniture, and to some extent the office tower architecture. Today, these are influenced by the absence of physical archives, which have been expelled from offices into remote data centres, resulting in the uncoupling of the sites of data production and data archiving. Today's obsession with saving is the equivalent of 20th-century filing: "what was printed or written on those sheets of paper was often beside the point. It was the processes of printing and filing that created the semblance of productivity".[335] The actual data saved in data centres often seems less relevant than the assurance that it is saved, as this kinship with bunkers shows.

[332] For more on interfaces see Alexander R. Galloway, *The Interface Effect* (Cambridge and Maden, MA: Polity Press, 2012). And Tiziana Terranova, *Network Culture: Politics for the Information Age* (London and Ann Arbor MI: Pluto Press, 2004).
[333] Shannon Mattern, *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media* (Minneapolis and London: University of Minnesota Press, 2017), loc. 1975–1976, Kindle.
[334] Mattern, *Code and Clay*, loc. 1978.
[335] Mattern, *Code and Clay*, loc. 1979–1980.

Despite the known regulatory planning practices and restrictions, access to official information on the Nordea data centre was practically impossible. I first spoke to project architect Debbi Hededam Thuesen at Henning Larsen Architects, who oversaw the headquarters. I then contacted two of the engineers at COWI, to which the data centre project was subcontracted. One of them returned my email with an apology and a reference to a non-disclosure agreement (NDA) with Nordea. The second, Jannich P. Jensen, spoke to me in generalities about data centres, steering clear of specifics pertaining to the Nordea centre. I asked Mr Jensen why, considering the above-described generic foundations of data centres, there was a need to retain such high levels of secrecy. He explained that the need for secrecy was a consequence of the NDAs COWI signed with all its data centre clients: "I don't know their motives for the NDA, I don't know why exactly there is so much secrecy". He referred to Apple's ongoing construction of a data centre in Foulum: "everybody knew Apple was in conversation about the data centre but no one was allowed to talk about it".

Secrecy is an obstacle encountered by all of us who are interested in data centres. Andrew Blum explains that "more often the secrecy isn't because of concerns over privacy or theft, but competition. Knowing how big a data centre is, how much power it uses, and precisely what's inside is the kind of proprietary information technology companies are eager to keep under wraps".[336] Mr Jensen and I also speculated that the reasons for Apple's secrecy must be mostly financial: Apple must be reluctant to reveal its financial capacities, since doing so might make it possible for competitors to draw conclusions about the market size. Similarly, detailed information about military intelligence or police data centres would make it possible to deduce the encryption power of those organisations. This would give hackers an insight into how much decryption is feasible within certain time frames.

[336] Blum, *Tubes*, loc. 239.

When engineers such as those at COWI plan a data centre, their clients begin by stipulating a number of racks as a starting point, or the amount of power the equipment can consume. Area or volume and power consumption are thus the starting points for all the remaining calculations and planning. All data centres typically contain the same kinds of spaces—a variation of a data centre with tech areas. It is the client, not the engineer, who hires the staff to monitor the data centre. The staff receive notifications from software if values approach the unacceptable, so they do not actually enter the data centres much. The secrecy of data centres is thus, quite naturally, tied up with the intangible forces of cybercrime and economic and political power. Interestingly, this level of security is somewhat removed from the tangible, architectural and infrastructural reality of the data centre that I am researching. The architect is completely removed from the architecture of the data centre. Head architect Debbi Thuesen did not set foot in the data centre area of the building—which she oversaw—during the year before completion. On Henning Larsen's construction drawings, the areas that belong to the data centre are covered with special hatching to mark the "off-limits area". I recognised the different spaces on the plan from my visit, and I made a rough, inaccurate sketch and jotted down generic labels for the different rooms, such as "ele" for "electrical". After being cc'ed in an email with an NDA note from one of the COWI engineers, Thuesen wrote to me: "just to be on the safe side, I need to say that even a sketch of the plan layout of the Nordea data centre should not be shown in your project. Unfortunately, as we talked about, a data centre must be kept secret". And thus, my peephole into the data centre closed.[337]

You will have to imagine the sketch, which would have revealed the spatial relationship between the largest space—the data centre below the trading floor—and the smaller support spaces adjacent to it. The chiller plant

[337] For more on the difficulty of accessing data centres see for example recent research done at Het Nieuwe Instituut on Automated Landscapes: Data Centres. 'Data Centres', Automated Landscapes, 9 October 2018, accessed 10 January 2019, https://automated-landscapes.hetnieuweinstituut.nl/research/data-centres. And Blum, *Tubes: Behind the Scenes at the Internet*.

takes up a significant proportion of the floor plan, roughly as much as the circulation, which wraps around the data centre and the electricity spaces. All in all, the hatched-in area constituted 2,100 square metres (1,100 square metres in the computer room, a 115-square-metre ventilation heat exchanger, a 300-square-metre chiller plant and a 29-square-metre service room).

The stored data was kept well away from the data centre planners. The architects were forbidden to enter the data centre during the year before operations began. The engineers only planned the infrastructure for the space, which was handed over to them as a shell building. They left the site once the racks were in place, not getting involved with the actual IT equipment. The engineers may know the maximum data processing capacity of the data centre, but they have no knowledge of the actual data processing capacity in place. Jensen said, "I have no idea about what is on the servers. I just know there are a lot of racks". The client then installed the IT equipment. The only people who fully understand this are the IT managers, who in turn are completely dissociated from the data production. (Jensen does not know whether the data is mirrored, i.e. whether it is at two locations: "that's up to the IT specialists".) This dissociation of archived data from the person in charge of looking after the archive differs drastically from the curatorial role at the Lamont-Doherty of Nichole Anest, who is involved with the archive structure on a very immediate level, and who is also fully familiar with the stored data.

Data centres, their inbuilt redundancies, and their extreme focus on security and secrecy not only evoke the bunker, but also embody the continuous fear of accidents. Data centres are architectural manifestations of the fear of accidents. They form infrastructural nodes designed to (avoid or) survive accidents with the data in their custody intact. Virilio sees accidents as an inevitable consequence of a "society which rashly privileges the present—real time—to the detriment of both the past and the future".[338] He continues: "a civilisation that sets immediacy, ubiquity and instantaneity to work brings acidents and catastrophes on to the scene".[339] The data centre illustrates Virilio's apprehension that "the accident has suddenly become inhabitable".[340] He postulates an atmosphere of latency, of collective waiting for "the *Great* (eco-eschatological) *Accident*".[341] Virilio's notion of the accident resonates with a short book by philosopher Quentin Meillassoux titled *Science Fiction and Extro-Science Fiction* (2015). Meillassoux imagines a world in which accident prevails over natural laws, thus resulting in the end of science. The two thinkers resonate as Virilio emphasises the excess of human-made accidents, which have recently become commoner than "natural catastrophes". He quotes the 2001 Sigma study by the prominent insurance company Swiss Re, which found that human-made (accidental) damage trumped natural catastrophes by representing 70 per cent of all accidents.[342] The data centres are geared towards avoiding catastrophes, to the point of restricting access to humans and their accident-causing potential. Data centres are thus an architecture against accidents.

The comparison of bunkers (or sleeper cells) as temporal agents to data centres gives an insight into the latter's temporality of secure waiting for latent activation. However, the temporality of data in data centres is more nuanced than waiting suggests. Data on a server platter is always being animated. As data is continuously animated, the temporal difference between activation and waiting, between archiving and retrieval, diminishes. Waiting suggests inactivity, suspended movement. On closer inspection, Virilio gives clues as to how to bridge this temporal dichotomy in spatial terms with his description of bunkers: "the bunker is not really founded; it floats on ground that is not a socle for its balance, but a moving and random expanse that belongs to the oceanic expanse, and extends it. It is this relative autonomy that balances the floating bunker, guaranteeing

338 Paul Virilio, *Unknown Quantity* (London: Thames & Hudson, 2003), 59.
339 Virilio, *Unknown Quantity*, 59.
340 Virilio, *Unknown Quantity*, 129.
341 Virilio, *Unknown Quantity*, 132.
342 Virilio, *Unknown Quantity*, 59.

its stability in the middle of probable modifications to the surrounding terrain".[343] The bunker itself is never completely still, yet it is simultaneously unwavering, resisting environmental impact while moving with the terrain. By analogy, a data centre is an archival node that is continuously animated by networks of electricity, information transfer, animation and retrieval, while remaining still enough to form a protective archival envelope.

Infrastructure

However, rather than being isolated in a parallel interior world, data centres are tightly embedded in planetary infrastructural networks. Whereas Virilio still understood the bunkers on the Atlantic coast as concrete landmarks indicating "the place where the long organization of territorial infrastructures comes to an end, from the steps of the empire, to the borders of the state, to the continental threshold",[344] now there is no end to planetary infrastructures. The continental threshold is no longer an obstacle to terrestrial infrastructures, which continue into oceans and between continents. Submarine telecommunications cables' landing points dot coastlines. Internet networks literally extend all over the world with their tentacles of tubes,[345] the ambiguous, all-devouring anti-hero of Rem Koolhaas' rant-cum-glorification of all those (infrastructure) spaces that were not directly planned by architects but have come to define much of today's "additive and layered"[346] spatial experience, such as shopping malls, leftover corridors and niches, outdated and superimposed airport terminals, public lounges furnished with palm trees etc. His text does not include data centres, but it could:

[343] Virilio, *Bunker Archeology*, 45.
[344] Virilio, *Bunker Archeology*, 46.
[345] See Thomas Pearce, "'...So It Really Is a Series of Tubes': Google's Data Centers, Noo-Politics and the Architecture of Hegemony in Cyberspace", *Enquiry*, 10, no. 1 (2013): 43–53. See also Blum, *Tubes*.
[346] Rem Koolhaas, "Junkspace", *October* 100 (2002): 176.

> Continuity is the essence of Junkspace; it exploits any invention that enables expansion, deploys the infrastructure of seamlessness: escalator, air-conditioning, sprinkler, fire shutter, hot-air curtain. [...] It is always interior, so extensive that you rarely perceive limits; it promotes disorientation by any means (mirror, polish, echo). […] Junkspace is sealed, held together not by structure but by skin, like a bubble. Gravity has remained constant, resisted by the same arsenal since the beginning of time; but air-conditioning—invisible medium, therefore unnoticed—has truly revolutionized architecture. Air-conditioning has launched the endless building. If architecture separates buildings, air-conditioning unites them.[347]

With his emphasis on the continuity and seamlessness enabled by air-conditioning, Koolhaas might in fact be describing data centres. A Google Images search for "data centre" reveals only interiors: clinical corridors that are lined with racks of computing equipment lit with horizontal bands of colourful LEDs, mostly green and a purple shade of blue. When Google revealed artistically enhanced images of its data centres in 2013 in a publicity campaign titled "Where the Internet Lives", internet users' spatial imagination was given access to seemingly endless rows of server racks. Among these generic, potentially endlessly repeated stacks, there is no depiction of an outside: no windows, no openings, usually not even a wall that could be imagined as delimiting the outdoors. Since architecture usually happens at this border between the inside and the outside, data centres present a particularly interesting architectural phenomenon: buildings that negotiate the outside world by suggesting the loss of exteriority.

Their sealed interiority, even though it is physically inaccessible to most of us, expands voraciously across the world, ravenously consuming electricity and conditioned air. Its purpose—trafficking data while embedded in

[347] Koolhaas, "Junkspace", 175–176.

myriad flows and routes—echoes Koolhaas' statement that "traffic is Junkspace, from airspace to the subway; the entire highway system is Junkspace, a vast potential utopia clogged by its users".[348] Junkspace and data space share a common enemy: ageing. Outdated data centres are not an option. Similarly, "aging in Junkspace is non-existent or catastrophic".[349] Ageing creates vulnerabilities such as leaks ("because it is endless, it always leaks somewhere in Junkspace"[350]), which for data centres especially signify doom, data leaks being the most pervasive anxiety after data loss. Finally, both data centres and Junkspace are shrouded in phenomenological insignificance: "because it cannot be grasped, Junkspace cannot be remembered. It is flamboyant yet unmemorable, like a screen saver; its refusal to freeze ensures instant amnesia".[351] Blankness nourishes their secrecy.

Infrastructure and geological archives are entangled. The extracted solid drilling cores conjure the kinds of hollows that are usually created in order to house infrastructure: pipes and pipelines to be filled with other forms of extracted elements—copper and steel, oil, gas, water etc. Infrastructure requires excavations: digging and drilling into the ground to interlace geological layers with infrastructural channels. For example, to extend the internet, the ground needs to be excavated to make space for tubular hollows, the domain of glass fibres. These in turn are also harvested from the ground, as they consist of molten and quickly cooled silica (SiO_2) sand. Orit Halpern emphasises that the internet and information have become materially and functionally equivalent to the concrete infrastructure spaces that characterise roads and buildings: "the internet and information has become concrete, literally utilizing the sand and metals of our earth to transmit its data in a manner not so different than constructing roads and buildings".[352] Keller Easterling also points out the material link between

[348] Koolhaas, "Junkspace", 180.
[349] Koolhaas, "Junkspace", 180.
[350] Koolhaas, "Junkspace", 178.
[351] Koolhaas, "Junkspace", 177.
[352] "Orit Halpern: Hopeful Resilience", E-Flux Architecture, accessed 10 December 2018, http://www.e-flux.com/architecture/accumulation/96421/hopeful-resilience/.

infrastructure and information. She writes, "both urban space and telecommunications are technologies and mediums of information".[353]

Like roads or the "information superhighway", infrastructure is usually thought of in terms of facilitating exchange and movement. For millennia, as Mattern shows, it has been formed by "calculation, coding, and 'embedded' technologies".[354] Infrastructure space established the scattered physical backbone of the ephemeral cloud.[355] It constitutes and enables data centres and defines their architecture. Infrastructure space as the physical pendant to the increasingly seamless integration of (environmental) media translates those aspects of today's information culture that do not withdraw—via metaphors[356] and radio waves, behind unyielding interfaces, as flashes of light racing through glass fibre cables—into inaccessible space. In an age of data accumulation, generation, harvesting and consumption, even architecture may, as Easterling suggests, "reincarnate as something more powerful—as information itself".[357] She continues, "infrastructure space has become a medium of information".[358] As an operating system that organises urbanity, infrastructure space is thus a tripartite structure that consists of medium, message and space. The latter is losing its foothold, as infrastructure space is increasingly defined by its ability to channel information flows through barely mappable routes, be they tubes, bridges, tunnels or overpasses.

Easterling implies this shift away from space towards agency when she distinguishes the "object forms" of buildings from the active forms that govern infrastructure space: "information resides in the, often undeclared,

[353] Easterling, *Extrastatecraft*, loc. 29–30.
[354] Mattern, *Code and Clay*, loc. 138–144. See also Shannon Mattern, 'Infrastructural Tourism', *Places Journal*, 1 July 2013, accessed 27 January 2019, https://doi.org/10.22269/130701.
[355] See for example Hu, *A Prehistory of the Cloud*. And Bratton, *The Stack: On Software and Sovereignty*.
[356] One could refer to Graham Harman's understanding of the metaphor as a descriptive tool.
[357] Easterling, *Extrastatecraft*.
[358] Easterling, *Extrastatecraft*, loc. 16

activities of this software—the protocols, routines, schedules, and choices it manifests in space. McLuhan's meme, transposed to infrastructure space, might be: the action is the form".[359] Infrastructure space exemplifies space as information—as medium and message; it redefines space as active form. Infrastructure space is less about space as form than it is about its action potential.[360] As in Rem Koolhaas' description of Junkspace, infrastructure space is "doing something"[361] and can be understood as "an updating platform unfolding in time to handle new circumstances, encoding the relationships between buildings, or dictating logistics".[362] In infrastructure space, the inherent virtual or potential actions form the space, which is thus difficult to map (see also Part 2. Like cyberspace, which has a real tubular network foundation, infrastructure space seems to expand and compress spatial relationships, depending on the information flows it channels. Cyberspace, infrastructure space and Junkspace infiltrate buildings and define space as a medium, an information channelling system.

Similarly, water, air and earth, however, do enter through the bullet-, fire- and hurricane-proof seals of data centres. Air-conditioning cools the interior climate. More immediate and energy-efficient cooling systems feature integrated water pipes in "liquid cooling data racks" to cool the heat-producing servers. Some data centres feature water nozzles that will sprinkle extremely fine water mist (instead of a gas solution) in case of fire, as the technical equipment would survive that kind of water exposure. In this reading, the data centre resembles a black box that is understood in terms of inputs and outputs—of energy and data carried by currents (electricity, water) and waves (microwaves)—with less focus on its inner workings, which is to some extent characterised by the sustenance of a certain climatic situation.

359 Easterling, *Extrastatecraft*, loc. 23.
360 von Uexküll, 'A Stroll Through the Worlds of Animals and Men: A Picture Book of Invisible Worlds'.
361 Easterling, *Extrastatecraft*, loc. 23.
362 Easterling, 7.

John Muir (1838–1914), an avid von Humboldt reader and the founding father of the concept of the American national park, built a primitive kind of hut which can be used as a revealing analogy for the data centre. In 1869 Muir spent his first summer in Yosemite, an area that would influence his writing and conservation activities. It was a time of budding connectivity in the US. The American railway now covered the entire continent, and east-to-west-coast communication had come to resemble real-time communication with a continent-spanning telegraph cable system. Rather than making use of telegraph lines, Muir spent much of his time in Yosemite conversing with nature via the cords that connected him to the universe. His perception of nature—inspired by von Humboldt's cosmos of climatic, geological and organic entanglements—was permeated by interconnecting lines and cords. In Muir's writing, there is a recurring theme of "a thousand invisible cords" and "innumerable unbreakable cords" that made it impossible to look at "anything by itself" as an isolated entity.[363] To Muir, everything seemed "hitched to everything else in the universe".[364] The Sierra revealed its geological histories to him. For example, he was ahead of contemporary scientists in understanding that Yosemite Valley had been shaped by glaciers rather than the results of cataclysmic eruptions. In his geological reading, he was close to Charles Lyell's uniformitarian understanding of geology. Incidentally, six years before Muir's arrival in Yosemite, on 2 July 1863, William H. Brewer and Charles F. Hoffmann of the California Geological Survey had named a mountain after Charles Lyell at a distance of roughly 26 kilometres as the crow flies from El Capitan—a geological formation that has come to ornament most Mac users' desktops.

At the time, John Muir built himself a wooden hut close to Yosemite Creek. He channelled water through his hut, which acted as a nature amplifier, to experience nature in an enclosed setting.

[363] Andrea Wulf, *The Invention of Nature: Alexander von Humboldt's New World* (New York: Alfred A. Knopf, 2015), 379.
[364] Wulf, 379.

> I had built a little cabin in Yosemite, and for convenience in getting water, and for the sake of music and society, I led a small stream from Yosemite Creek into it. Running along the side of the wall it was not in the way, and it had just fall enough to ripple and sing in low, sweet tones, making delightful company, especially at night when I was lying awake. Then a few frogs came in and made merry with the stream—and one snake.[365]

I read this hut in line with the duality of the data centre. It is a building in isolation, just as Muir sought to experience the nature of Yosemite Valley as "purely" as possible, untainted by human intervention. Simultaneously, the hut is embedded in infrastructural flows: the channelled stream and the network of invisible cords that connect everything, rendering isolation a futile fantasy. This amplification of the experience of nature, mixed with the functional (washing, drinking, cleaning) aspects of channelled water, recurs in today's high-tech data centres. Piped water runs amid masses of cable, up and down rack systems that contain black-boxed servers in a climate shed; all this and the small channelled creek in Muir's hut share ontological common ground. The hut reveals the duality between the search for connectivity through (infrastructural) flows and the isolation that governs data centre architecture.

Data centres are essentially technologically enhanced primitive huts, and as such they are emblematic of how today's architecture is situated in nature, how it responds to climate, and how it channels and utilises natural forces. Data centres are characterised by a complex infrastructure of redundancy. They are meticulously furnished with sensors to detect fire, temperature variations and dirt particles. Hundreds of metres of pipes and cables sustain the data centre's digital inhabitants with electricity, cooling water, ventilating air. Smaller rooms filled with ventilation pipes, pump stations, backup batteries, control stations, ammonia compressors and preheated backup generators surround the actual server rooms. The data

[365] John Muir, *Our National Parks* (1901), chap. 6, http://vault.sierraclub.org/john_muir_exhibit/writings/our_national_parks/.

centre is enveloped not in a *skin* that separates inside from outside, but in an infrastructural system, an environmental interface. The interiority that dominates the depiction of data centres has become a climatic outdoors, more akin to atmospheric conditions than a walled climate. Data centres, which tap into the archival and active nature of the geological ground, feign isolation while serving as nodal points in a planetary infrastructural system, creating a chronotope of animation.

Data centres offer fertile ground for speculation on architecture, memory culture, politics, geology and economics. Spatially, they can be read as bunkers crippled by the melancholy of data loss,[366] as a layer in a global stack of planetary computing,[367] as voracious, expansive resource consumers,[368] as strategic points in legislating networks, as the stronghold of a new ruralism,[369] and as alternative architectures not for human habitation but for data climates. Because of their functionalist architecture, data centres are often described as large-scale computers or black boxes. On the one hand, the black-box analogy links data centres to their cybernetic origins, as I will show in Part 2; on the other, it describes their connection to the world as channelling a set of incoming and outgoing flows. In line with this system of information streams, media scholar Alexander Galloway relates black boxes to a broad spectrum of phenomena, such as "a call centre employee, a card reader at a security check point, a piece of software, a genetic sequence, a hospital patient".[370]

Data centres are clearly such black boxes in the minds of their users. They obfuscate on several levels by means of their physical inaccessibility, their often unknown locations, their extreme security installations, and the

366 Hu, *Prehistory*.
367 Benjamin H. Bratton, *The Stack: On Software and Sovereignty* (Cambridge, MA: MIT Press, 2015), Kindle.
368 Jussi Parikka, *A Geology of Media* (Minneapolis: University of Minnesota Press, 2015), Kindle.
369 See Rem Koolhaas, http://www.spatialagency.net/database/amo.
370 Alexander R. Galloway, 'Black Box, Black Bloc', in *Critical Digital Studies: A Reader*, Second (Tornoto: University of Toronto Press, 2013), 218–26.

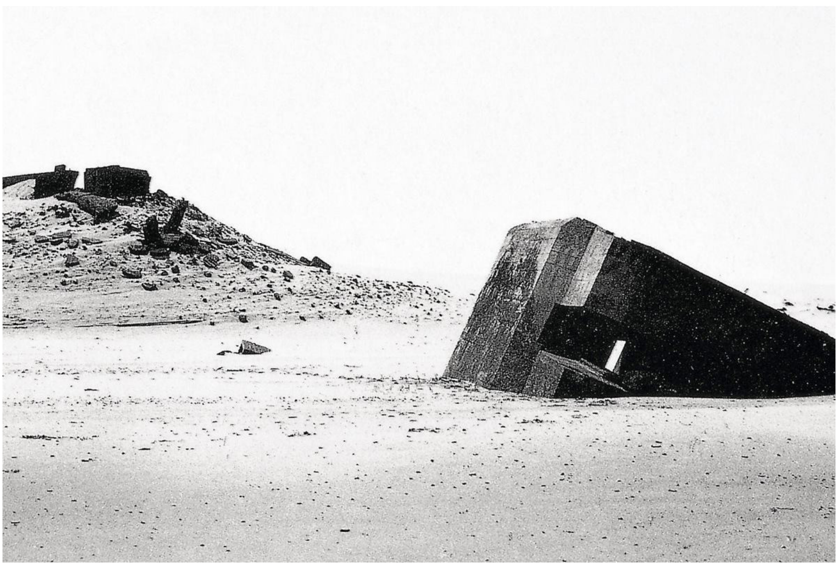
ephemeral nature of "the cloud". Identifying the key elements of today's architecture as the information flows, spatial encapsulation, function and radiant surfaces of billboards and projections that seem to have replaced facades, Galloway links architecture to the notion of the black box. His description of the essence of the black box can be seamlessly applied to data centres: "connectivity, but only under strict conditions; high bandwidth throughput, inside a low bandwidth profile; unprecedented quantities of information, and unprecedented curbs on legibility".[371] Data centres are nondescript buildings with a rich inner life that usually remains physically inaccessible to the general public, and is instead defined by the incoming and outgoing information flow. However, as shown, the secrecy is somewhat redundant. The data centre as architectural type prompts a rearticulation of architectural aspirations. The data centre as *Urhut* frames an unprecedented architectural starting point, as it is not inhabited by humans: it creates a microclimate, as did most architecture before it, but in this case the microclimate is designed for machines. Sheds, storage spaces and cooling rooms preceded the data centre, yet the ubiquitous nature of the cloud and our digital archival practices seem to demand an expanded formulation of the data centre as an architecture that claims an undeniable presence in our spatial imagination.

Despite being rich projection planes for a variety of interpretations, data centres are first and foremost spatial constructs. The data centre as spatial type raises a curious paradox. On the one hand, it is embedded in the internet's rich entangled landscape of tubes[372]—in other words, in the global expanse of infrastructure space, or what Rem Koolhaas calls Junkspace. On the other hand, the black-boxed secrecy surrounding these nondescript buildings on the outskirts of glass fibre access and

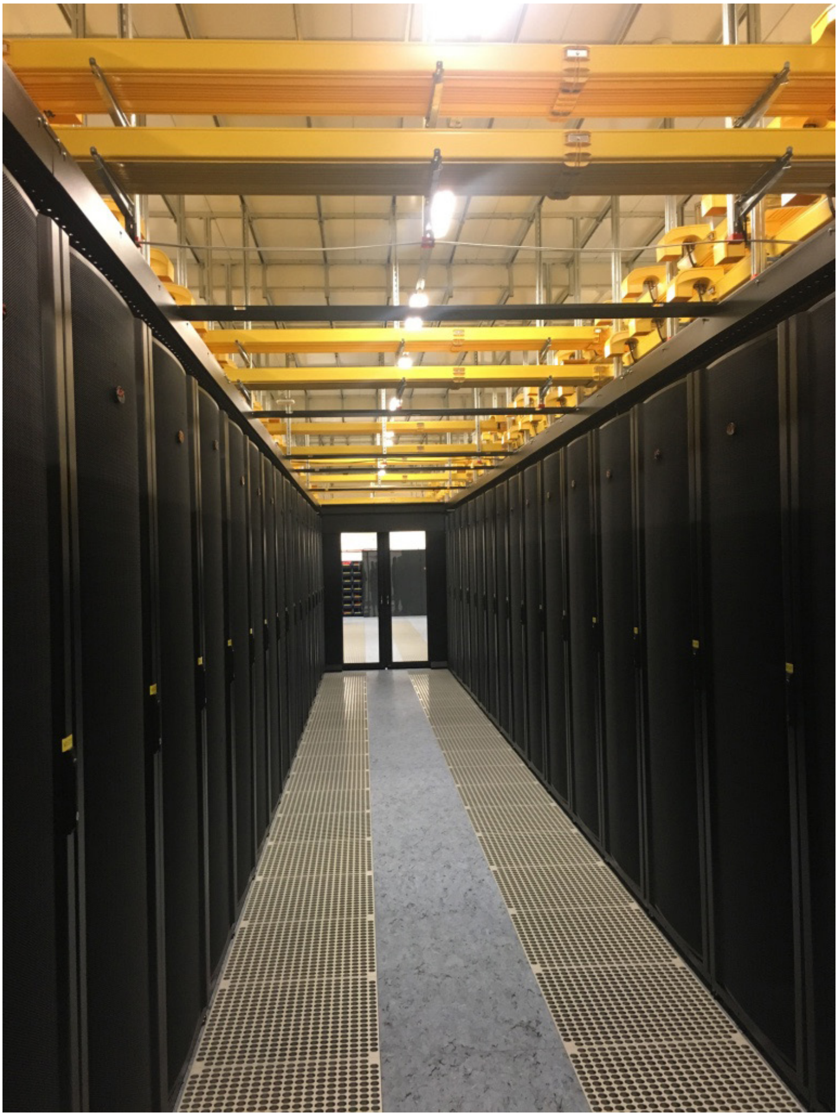
[371] A. Ring, H. Steiner, and K. Veel, *Architecture and Control* (Brill, 2018), 16, https://books.google.com/books?id=LbFHswEACAAJ.
[372] "Everything you do online travels through a tube. Inside those tubes (by and large) are glass fibers. Inside those fibers is light. Encoded in that light is, increasingly, us": Blum, *Tubes*, loc. 5–6. "The Internet is a strange landscape…": Blum, *Tubes*, loc. 9. "The Internet exists—it has a physical reality, an essential infrastructure…": Blum, *Tubes*, loc. 10.

settlements, and their insistence on isolation, conjures a comparison with the remote bunker, or with hermits' and philosophers' huts. It is an extreme architectural species that creates spaces to channel and utilise natural forces: data centres stage a black-box climate, with pseudo-natural phases, cycles and flows.

Data Centre, Copenhagen



Bunker, Virilio



Data Centre, Copenhagen

Data Centre, Copenhagen

Artistic Research, Horse Hair, Violin Bow

Data Centre, Copenhagen

Felted wool with horse hair, artistic research.

Data Centre, Copenhagen

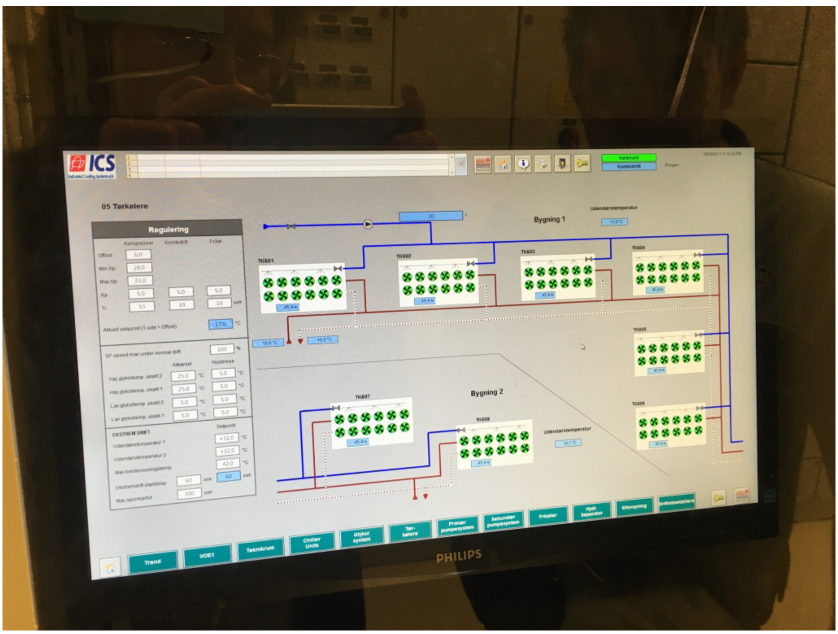
Data Centre, Copenhagen

Muir's "Hangnest" in Yosemite.

Muir, wrote, "I boarded with Mr. Hutchings' family, but occupied a cabin that I built for myself near the Hutchings' winter home. This cabin, I think, was the handsomest building in the Valley, and the most useful and convenient for a mountaineer. From the Yosemite Creek, near where it first gathers its beaten waters at the foot of the fall, I dug a small ditch and brought a stream into the cabin, entering at one end and flowing out the other with just current enough to allow it to sing and warble in low, sweet tones, delightful at night while I lay in bed.

Data Centre, Copenhagen

Data Centre, Copenhagen



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PART 2

THE METEOROLOGICAL MODE

2.1 The Meteorological Mode, or the Air as a Vast Archive

The digital cloud—part radio waves, part meteorological metaphor, part spatial imagination—has come to conceptually umbrella, safeguard and process all digitalised and externalised data. The metaphor "cloud" stands in for the data centres that physically contain archived data and are connected to sites of document production via Wi-Fi and usually subterranean fibre optic cables. The term "cloud" blurs the physical materiality of these concrete storage facilities: "the cloud is a metaphor that obfuscates and obscures"[373] not just physical infrastructures, but also the territories of information politics.[374] The cloud as metaphor is a placeholder for the complexity of cyberspace,[375] and as a marketing strategy to simplify the use of remote storage, obviating the need for an explanation of the infrastructure, stakeholders, judicial regulations, distances, programming and maintenance staff necessary to run services such as iCloud. Beyond the practicalities of marketing strategies and political obfuscation, the term "cloud" suggests meteorology as a kind of methodological and spatio-temporal point of departure for digital archiving practices and data analysis. As a ubiquitous phenomenon, the cloud has featured prominently in social sciences and media studies. The cloud is a spatial metaphor that pervades the spatial imagination of daily archiving rituals. Without it, basic tasks such as accessing one's Gmail would be impossible. The cloud thus merits spatial analysis, both as metaphor and in relation to the meteorological counterpart it evokes.

In this section I focus on meteorological analogies that shed light on the digital cloud. Meteorological clouds can be understood as fleeting archives that constantly update their own content and morphology to reflect the

[373] "Trevor Paglen Offers a Glimpse of America's Vast Surveillance Infrastructure", ASX, 2014, accessed 15 November 2018, http://www.americansuburbx.com/artists/trevor-paglen.
[374] See for example Louise Amoore, "Cloud Geographies: Computing, Data, Sovereignty", *Progress in Human Geography* 42, no. 1 (2018): 4–24.
[375] Amoore, "Cloud Geographies", 7.

global input they receive—like analogue computers that model the world. When they precipitate as snow, their externalised archival data can be harvested as ice cores. Meteorologist Richardson's speculative Forecast Factory (1922) –the combination of a cloud and a globe designed to compute and archive the planet's weather—will give further insight into the meterological mode of archiving. In the following section (2.2), I will then describe the digital cloud in relation to artificial clouds and earlier archival trends, especially in relation to cybernetics. In the last section, I will analyse the nonconscious processes that make sense of (big) data stored in the cloud and show that they establish a Great Outdoors that cannot be accessed—only *mediated* via the cloud medium.

The H_2O variant of the cloud can also be understood materially as an animated archive—in the meteorological mode. It consists of water, and it transports the particles onto which water condenses: aerosols. These transmit a range of physical information, for example about deserts and flora, nuclear events, explosions, volcanic activity and CO_2 pollutants. There is a rich history of the sky as media: it is a medium of communication, more in terms of timekeeping than archiving. The nature of sky media is twofold: one part pertains to the constant cyclical movements of astronomical bodies; the other relates to the variable occurrences of the meteorological. Astronomy and meteorology—the two sciences focusing on sky-borne events—reflect the duality of the Greek temporalities *chronos* (duration), linked to the cyclicity and potential reversibility of the movement of the planets and stars, the sun and the moon, and *kairos* (opportunity), associated with the weather and clouds.[376] Durham Peters describes the systems associated with the temporalities of the sky:

> The sky is a compass, calendar, and clock […] The sky is also a map: if you know the time, date, and sky well enough and have

[376] For more on sky media and related temporalities, see John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: University of Chicago Press, 2015), chaps 4 and 5.

> an unobstructed view of the horizon, you can figure out where you are on the face of the earth or sea. The heavens are also a newspaper, or at least a weather report.[377]

Compass, calendar, clock, map and weather report—these can be understood as representations of the world, as manageable models of planetary phenomena: "calendars and clocks are 'quasi-objects' between nature and culture. They model rigid environmental facts, the realia of the earth and sky".[378] Like the map in Borges' story that covers the entire country for maximum accuracy,[379] the sky as model of the earth covers the entire planet. At different points the onlooker can deduce information from this map about the entire planet. As such, the sky can be understood as an inspiration for modelling the world, and as a model of the world itself. This idea of the model, as I will show, plays an important role in digital data practices.

Not only has the sky originated communications media,[380] but it is also itself an enabling medium, most importantly for clouds. Whether they are anthropogenic or naturally occurring, clouds mediate data and signal information: smoke-signal clouds are an ancient long-distance communication method ("fire is one of the oldest sky media"[381]); aeroplane vapour trails tell of distances overcome and gravitational pulls (globalisation); volcanic eruption clouds transmit news of geological events. Meteorological clouds are omnipresent: they continuously cover 67 per cent of the planet. Planet Earth is thus more a cloudy haze than a

[377] Durham Peters, *Marvelous Clouds*, 169–170.
[378] Durham Peters, *Marvelous Clouds*, 176. He refers to Bruno Latour, *We Have Never Been Modern* (Cambridge, MA: Harvard University Press, 1993).
[379] See Jorge Luis Borges, "On Exactitude in Science", in *Collected Fictions* (London: Penguin Books, 1946).
[380] Durham Peters ties this representative function to communications and digital media: "as constructs that synchronize earth and heaven, culture and nature, and the periodic events of history and astronomy, calendars and clocks remain among the oldest and most important of all theopolitical media of communication, with legacies visible everywhere in digital media". Durham Peters, *Marvelous Clouds*, 176.
[381] Durham Peters, *Marvelous Clouds*, 165.

blue marble. Despite their continuous presence, clouds remain fundamentally elusive: they are unmappable, and difficult if not impossible to model or predict accurately, because they visualise immense amounts of data—not all of which is fully understood by scientists. This data is a constant flux of updates as it interacts with other elements. "Data in flux" continues the theme of "animated archives" from Part I.

In the meteorological mode, I explore "archived" data in analogy to aerosols. Aerosols—fine anthropogenic or naturally occurring solids and droplets, also known as "seeds" or cloud condensation nuclei—are found in the tropo- and stratosphere, where they travel as physical data points on air currents. They vary in size from "a few nanometres—less than the width of the smallest viruses—to […] about the diameter of human hair".[382] Aerosol particles stay in the air for four to seven days, and they reach travel speeds of around five metres per second. Depending on their origin, aerosol types conglomerate in characteristic areas. For example, oceans are veiled by a thin mist of salt and sulphates produced by whitecaps and microalgae. Close to the time of writing, a map of aerosols produced on 23 August 2018 by Nasa's Goddard Earth Observing System Forward Processing shows sea salt (blue), black carbon (orange) and dust (purple) aerosol concentrations. Light blue concentrations indicate strong winds, such as Hurricane Lane, about to reach Hawaii, and typhoons Soulik and Cimaron approaching South Korea and Japan. Wildfires have caused vast swaths of black carbon across the western US. The coastal area is bathed in bright orange, months before another series of devastating fires will hit in November. The lower half of the African continent is also covered in bright orange from agricultural burning. Africa's northern half is covered in purple Saharan dust particles, spreading eastwards just north of the equator. I recall an earlier day this year when Copenhagen was misty with an especially hazy pink sunset, because of unusual winds that had carried Sahara dust all the way to Scandinavia. Aerosols can thus be understood as data bits that infuse the

[382] "Aerosols: Tiny Particles, Big Impact", Earth Observatory, 2 November 2010, https://earthobservatory.nasa.gov/Features/Aerosols/page1.php.

atmosphere as well as the lungs of all breathing entities with physical information from all across the planet. The air is the medium of these data specks, which are too minuscule to be observed directly, but in their masses they cause (for human senses) perceptible phenomena such as unfamiliar sunsets and darker clouds.

The data carried by clouds constitutes their materiality and influences their spatial formation. Aerosols differ in their surface topography and chemical composition, which affects their ability to seed clouds, how much light they reflect, and how much energy they store. One cloud might assemble volcanic ash, pollen, sea salt and soot. The soot might then cover the surface of sea salt crystals. This mix in turn will determine how much heat the cloud retains or reflects, and when it precipitates as rain. Just like their chemical and physical composition, the morphology of clouds is consequently also in constant flux. They are therefore difficult to classify. Until the beginning of the 19th century, meteorological clouds were as enigmatic as the mysterious space occupied by the digital cloud in the imagination of its users. Only when pharmacist and amateur meteorologist Luke Howard (1772–1864) presented a nomenclature for clouds at a popular science theatre in London in 1802 did clouds become more tangible.

Howard's nomenclature came after a century characterised by great advances in taxonomy, spearheaded by Swedish botanist Carl Linnaeus, who established a binomial classification system for organic life with the publication of his *Systema Naturae* in 1735. The revolutionary aspect of Howard's system was that it classified occurrences that were not entities in themselves. Howard understood that clouds were the "visible signs of vast atmospheric processes".[383] His basic categories—cirrus, stratus, cumulus (and later the nimbus)—reflected atmospheric processes rather than the resulting cloud shapes, and could be combined to describe further cloud variations. One could now distinguish a plump nimbus cloud,

[383] Richard Hamblyn, *The Invention of Clouds: How an Amateur Meteorologist Forged the Language of the Skies* (New York: Farrar, Straus and Giroux, 2001), loc. 1989.

consisting of condensed water, from a delicate cirrus cloud with its thin, featherlike strands of ice crystal formations. In their twofold existence as nebulous evasiveness and excessively accurate visualisations of near-infinite parameters, clouds defy the Cartesian. Howard's classification embodied the flexibility necessary to classify the unstable and ever-changing evanescence of clouds, thereby rendering them more graspable as a scientific phenomenon.

Since Howard's time, when clouds could only be studied from the ground, much has been learned by watching clouds from above, enabled by long-term observations by Nasa's Moderate Resolution Imaging Spectroradiometer system aboard the Terra and Aqua satellites, launched in 1999 and 2002 respectively. Looking at cloud patterns points to two archival aspects of the cloud. First, there is the information embodied in the particles, their origin, travels and interactions. Second, there is the continuously changing context of the cloud. A cloud visualises its surroundings, and by extension clouds model the world. They continuously gather visual data about the entire planet's surface and atmosphere, in less than 48 hours. From above, it becomes clear just how responsive clouds are: cloud patterns reflect the topography and temperature of the planet's surface and reflectivity, ships and aeroplanes, winds and atmospheric pressure. A striking example is wave clouds. Seen from above, these form large V-shaped fields of alternating clear and clouded strips, like air ripple moiré patterns. The bands visualise the collision of air masses of different temperatures and moisture content. They occur when tall icebergs or islands push circulating air masses upwards, where they meet the higher-travelling air masses.

A comparatively small iceberg thus impacts on a vast field of clouds. This example actualises Charles Babbage's (1791–1871) idea of the air as an archive. The notion of the air as archive points to the origins of computing as an archivist practice closely linked to the planetary imaginary. Charles Babbage (1791–1871) held the prestigious title of Lucasian Professor of Mathematics at Cambridge University from 1828 to 1839, and was an important figure in setting this trend for linking planetary archival imaginaries with computing. Rather than seeing the ground as an archive, as did his friend Charles Lyell, Babbage declared "the air itself is one vast library"[384] of all the words that have been spoken, and all the winds and currents that have acted upon it. His view of the air as an archive was informed by a computational logic that also led to his mechanical computing inventions—Difference Engines I and II, and the conceptually more complex Analytical Engine, which constituted the concept of a digital, programmable computer. Babbage's atmospheric vision has important parallels with today's digital data archive, and contributes to my definition of the meteorological mode.

According to Babbage, when we speak, we set airwaves into irreversible motion, affecting every atom of the atmosphere and changing their trajectories forever. Babbage believed with "Laplacean determinism"[385] that given enough computational power, "an intelligence who at some given moment knew all the forces that animate nature, and the respective situation of the beings that compose it"[386] would be able to determine the components' past and future trajectories. For example, speech would have an irretrievable effect on the atmosphere's molecules:

> The pulsations of the air, once set in motion by the human voice, cease not to exist with the sounds to which they gave rise. […] The motions they have impressed on the particles of one portion of our atmosphere, are communicated to constantly increasing numbers. […] The waves of air thus raised, perambulate the earth and ocean's surface, and in less than twenty hours every atom of its atmosphere takes up the altered movement.[387]

[384] Babbage, *The Ninth Bridgewater Treatise: A Fragment*, 113.
[385] Geoffrey C. Bowker, *Memory Practices in the Sciences* (Cambridge, MA and London: MIT Press, 2005), loc. 1024–1033.
[386] Bowker, *Memory Practices*, loc. 1024–1033.
[387] Charles Babbage, *The Ninth Bridgewater Treatise*, 2nd ed. (London: John Murray, 1838), 108–109.

Every uttered word would thus influence all the world's air particles in less than a day. With enough computational capacities, and with knowledge of the air's behaviour and the causes acting on it, the atmosphere's past and future trajectories could be deduced.[388] The air in Babbage's view is an archive as much as a predictive tool. It is a visualisation of the forces that act on it, just as the clouds are responsive visualisations of extensive information and processes. They embody the phase behaviour of water, wind movement, atmospheric conditions, the topography below (including its temperature and reflectivity), chemical and physical aerosol behaviour and interactions, and the history of those particles, i.e. their origins and travels.

Environmental Media

In light of this modelling capacity of clouds, a fruitful approach to meteorological clouds in connection to the digital cloud metaphor is to think of them as analogue computers.[389] This line of thinking pays tribute to the beginnings of computing and to recent scholars—among whom I primarily reference media scholars John Durham Peters and Jochen Hörisch, as well as architect/theorist Keller Easterling. They draw attention to the origins of media not in communication institutions, but in the natural elements. I have shown that our digital archive databanks

[388] Babbage, *Ninth Bridgewater Treatise*, 111.

[389] As I write this, I am watching a continuous stream of feathery white smoke emerge from a chimney, at my eye height, maybe 20 metres from my window. There is a thin metal roof above the chimney pipe, to protect it from the rain. The stream of smoke dissipates at about 1–1.5 metres from the outlet. It thus looks as if there is a small cloud attached to the space between the metal sheet and the chimney outlet. It encircles the chimney, continuously changing direction and width, extending further upwards, then moving lower. Its speed constantly varies. At one moment it seems like a shy, tiny cloud clinging to the protected space, then it billows into a tall column, dissipating into thin wisps at the edges. This chimney-wind-smoke assemblage models the direction of the wind. I also see pines out of my window, and their branches are moving slightly, but if it were not for the smoke I would not have the faintest indication of how readily the air movements are changing direction today. Now the smoke stream has stopped, and the world looks very still, as if the air has stopped moving too, and the gently stirring pine branches follow a rhythm more akin to trees than to air.

are infrastructurally entangled in planetary glass fibre and piping networks of water, air and electricity. Beyond the cloud metaphor, they are physically linked to the planetary systems of water, earth and air. In Durham Peters' words, "the idea that media are message-bearing institutions such as newspapers, radio, television, and the Internet is relatively recent in intellectual history".[390] He quotes Jochen Hörisch to clarify that "well into the nineteenth century, when one spoke of media, one typically meant the natural elements such as water and earth, fire and air".[391]

Hörisch traces the history of the elements as media (in covert competition with holy books such as the Bible and the Quran) and reads Spinoza, Goethe and Hegel as proponents of the notion that "the medium is the message" long before Marshall McLuhan. When Goethe muses on nature as both medium and message, according to Hörisch, he sums up the origins of media in natural elements, and prefigures McLuhan's dictum:

> *Das Höchste wäre: zu begreifen, daß alles faktische schon Theorie ist. Die Bläue des Himmels offenbart uns das Grundgesetz der Chromatik. Man suche nur nichts hinter den Phänomenen: sie selbst sind die Lehre.*[392]
>
> The greatest would be: to understand that everything factual is already theory. The blueness of the sky reveals to us the fundamental law of the theory of colours. [But] one is not to search beyond the phenomena: they are themselves the lesson.[393]

Here, Goethe imagines that the phenomenon of blueness could itself be the colour's scientific "message" as much as its medium. Goethe had a great scientific and artistic interest in the sky. He was familiar with the cyanometer, a device to measure the blueness of the sky, and he extended

[390] Durham Peters, *Marvelous Clouds*, 2.
[391] Jochen Hörisch, *Ende Der Vorstellung: Die Poesie Der Medien* (Frankfurt: Suhrkamp, 1999), 134, 140.
[392] Goethe quoted in Hörisch, 140.
[393] Author's translation.

Saussure's original colour wheel to include a more nuanced palette. He was a passionate cloud watcher and initiated a personal exchange with Luke Howard,[394] whose research inspired him to write an encomium (*Howards Ehrengedächtnis*, 1821). When it comes to elemental media, particularly sky media, phenomenon (the "thing appearing to view", from "to show") and noumenon ("something that is thought", from "to think, to mean") merge—a state which could be understood as a version of "the medium is the message". The blueness of the sky is both the manifestation and the law of the phenomenon "blue skies": the blue sky can be understood as both medium and message.

Goethe's prompt to recognise theory in the actuality of the sky is an implicit reference to the ancient Greek origins of theory, which fittingly sprang from the sky itself. The sky has a rich history of being understood as the realm of pure theory (mathematical abstraction, astronomical models based only on computed theory): "theory, as all our metaphors still suggest, was at first related to the sky".[395] θεωρία (*theōria*) denotes the "act of viewing" in terms of "looking or watching" and relates to "an ancient Greek public spectacle".[396] The notion of theatricality is often associated with clouds, as they dramatically perform for those who are willing to read their morphology, as was Goethe:

> *Nun regt sich kühn des eignen Bildens Kraft,*
> *Die Unbestimmtes zu Bestimmtem schafft;*
> *Da droht ein Leu, dort wogt ein Elefant,*
> *Kameles Hals, zum Drachen umgewandt*[397]

[394] Hamblyn, *Invention of Clouds*.
[395] Durham Peters, *Marvelous Clouds*, 167. Durham Peters writes about *theōria* in relation to sky media.
[396] Merriam-Webster, s.v. "theoric (*n.*)", accessed 12 November 2018, https://www.merriam-webster.com/dictionary/theoric.
[397] Johann Wolfgang von Goethe, 'Howards Ehrengedächtnis', in *Goethes Werke*, vol. 1 (Munich: C. H. Beck, 1996), 350–52.

Then boldly stirs imagination's power,
And shapes there formless masses of the hour;
Here lions threat, there elephants will range,
And camel-necks to vapoury dragons change.[398]

In *Howards Ehrengedächtnis* (1821), Goethe discovers a lion, an elephant, a camel and a dragon in the clouds, and he is aware of the role of his own imagination in conjuring visual meaning into accumulations of vapour. This selection of animals evokes an earlier ephemeral zoo, conjured in Aristophanes' "comedy of ideas" *The Clouds*.[399] At one point Socrates asks: "have you not sometimes seen clouds in the sky like a centaur, a leopard, a wolf or a bull?"[400] Why would Goethe, like Socrates, spot only exotic animals, one of them a fabled creature? In Aristophanes' play, Socrates explains that the clouds "take what metamorphosis they like. If they see a debauchee with long flowing locks and hairy as a beast, […] they take the form of a Centaur".[401] They thus mirror what they observe. Speculating on Goethe's inspiration, one might assume that he was imagining the clouds travelling above exotic places and bringing images from afar in the form of fleeting mirages (recalling the practise of sending out research vessels to gather sediment samples from all over the planet). Cloud-watching and Greek theatre can both be understood as observing a mediated representation of the cosmos. Linking this exotic vision in the sky back to *theōria*, watching the theatre grants access to the theoretical world of noumena.

This alignment of the sky, which grants an unobstructed overview of the world and thus mediated access to *theōria*, contextualises the following exchange in *The Clouds* between Socrates and Strepsiades, who cannot

398 "In Honour of Mr Howard", Tottenham Clouds, accessed 15 October 2018, http://www.tottenhamclouds.org.uk/goethe-in-honour-of-mr-howard.html.
399 Aristophanes, 'The Clouds', The Internet Classics Archive, 419AD, http://classics.mit.edu/Aristophanes/clouds.html.
400 Aristophanes.
401 Aristophanes.

fathom why Socrates chooses to sit in a suspended basket in his "Thoughtery" (an early philosopher's hut):

> Strepsiades: First, what are you doing up there? Tell me, I beseech you.
>
> Socrates: *pompously* I am traversing the air and contemplating the sun.
>
> Strepsiades: Thus it's not on the solid ground, but from the height of this basket, that you slight the gods, if indeed […].
>
> Socrates: I have to suspend my brain and mingle the subtle essence of my mind with this air, which is of the like nature, in order clearly to penetrate the things of heaven. I should have discovered nothing, had I remained on the ground to consider from below the things that are above.[402]

To access knowledge, Socrates thus seeks to tap into the temporality and spatiality of sky media (like the sun) that are associated with *chronos*, with cyclicity, recurrence and endurance. Socrates seeks to "mingle" his mind "with the air", the medium of the "things of heaven", to discover the knowledge suspended and mediated in the air. The clouds, that "bright Aether"[403] evokes the air as a field that mediates *messages*—knowledge or *theōria*—which may at any moment manifest or materialise like clouds. The clouds "take what metamorphosis they like." They reflect incidents in the world, just like meteorological clouds visualize their defining parameters: Aristophanes' clouds' *reflections* are of a moral kind, for example, "If they see a debauchee with long flowing locks and hairy as a beast, like the son of Xenophantes, they take the form of a Centaur in derision of his shameful passion."[404]

It seems that Goethe embraced the meteorological as a way of thinking. He decided: "as I have perhaps paid too much attention to the study of

[402] Aristophanes.
[403] Aristophanes.
[404] Aristophanes.

geology, I am now tackling the domain of the atmosphere. If it were only to discover how one thinks or may think, that in itself would be a considerable profit".[405] As Hubert Damish explains, for Goethe, clouds were a "special sign of the *Unvergängliches* (the imperishable)",[406] which aligns with the premises of the archival. The meteorological is again coming increasingly to the fore with the discussion of media as natural elements, concepts such as Morton's *hyperobject*, and the general preoccupation with weather and climate.[407]

In a recent version of such concepts, Keller Easterling speculates on the spatial consequences of readopting the logic of *media* as entangled with the natural elements: "and if focus were given to the medium—to the field instead of the object, the ground instead of the figure—our sense of the world would be inverted".[408] She sees this shift in perception as having the potential to lead to a more fluid, adaptable, resilient and *real* urbanism. Easterling suggests an evocative media-infused understanding of the environment, rather than an object-focussed approach, echoing her reflections in *Extrastatecraft* (2014), where she traces socio-economic power structures and their space-shaping potential in infrastructure space. Embracing the logic of media would align human endeavours with elemental forces, rather than positioning them in opposition and danger: "attuned to ebbs and flows of development and environment, this more

[405] Goethe, cited in Kurt Badt, *Wolkenbilder und Wolkengedichte der Romantik* (Berlin: De Gruyter, 2014), 36. See also Hubert Damisch, *A Theory of /Cloud/: Toward a History of Painting* (Stanford: Stanford University Press, 2002), 195.
[406] Damisch, *Theory of /Cloud/*, 195.
[407] Despite his focus on the geological, Parikka also touches upon a more meteorological mode when he delves into the topic of dust: "indeed, we need to understand how the air and atmosphere of digital culture is one heavy with metals and chemicals, and the ground of digital culture is opened up for mining operations, such as minerals. The materiality of minerals and metals, from silicon to coltan, is entangled with the materiality of the lungs. In other words, this is the materiality of the nonorganic at the hardware end of things and a materiality of hardwork that connects to the labor sustaining the hardware". Jussi Parikka, *A Geology of Media* (Minneapolis and London: University of Minnesota Press, 2015), loc. 1817–1820, Kindle. "Entanglement of fossil fuels, miners' lungs, bronchitis, and emphysema with computer culture". Parikka, *Geology of Media*, loc. 1948–1949.
[408] Easterling, 'The Year in Weather'.

kinetic and cosmopolitan urbanity would be most successful when in a constant state of imbalance".[409] Reassigning the "dark magic" usually associated with weather to financial systems, Easterling emphasises that "human constructs are a form of economic occult. Weather is real".[410] Changing coastal lines are a site of potential, not of bankruptcy; hurricanes generate energy, not just destruction. In a world where humanoid organisms read clouds as a "wet information system more common than a digital cloud",[411] they might appropriate the air, earth and water as organisational forms, rather than attempt in vain to contain them.

The weather had become *hyperreal* during World War I, when the first artificial cloud was created. At six in the evening on 22 April 1915 at Ypres Salient, the first poison gas cloud had been dispatched across the trenches. This gas cloud, in philosopher Peter Sloterdijk's opinion, officially ushered in the 20th century with a muffling, blurring, suffocating and dissipating anti-bang, accompanied by panic, coughing and ringing ears. The first artificial chlorine gas cloud marked the discovery of the "*Umwelt*" ("*Entdeckung der 'Umwelt'*"[412]). According to Sloterdijk, environmental thinking was one of three defining features of 20th-century civilisation, and its origins are rooted in this yellow cloud of 150 tons of chlorine, six kilometres wide and 600–900 metres deep, which moved at a rate of two to three metres per second[413] and temporarily transformed the French and Canadian soldiers' air environment into barely visible enemy territory.

Three years later, philosopher Martin Heidegger arrived at the front, where he served "as a military meteorologist on the western front, northeast of Verdun, France, in the Ersatz-Bataillon Infanterie-Regiment 113, Frontwetterwarte 414, from late August until November or December 1918": In an unusual reading of Heidegger, Durham Peters

409 Easterling.
410 Easterling.
411 Easterling.
412 Peter Sloterdijk, *Sphären 3: Schäume* (Berlin: Suhrkamp, 2004), 98.
413 Sloterdijk, 9–10.

describes him as a "weatherman".[414] He contextualises Heidegger not in his well-known hut, but in towers: "Heidegger spent much time in his youth in the tower of the church where his father worked as a sexton", and "he also perched in a military observation tower during World War I, reading the winds".[415] The activity associated with these elevated skyscraping architectures is not *wohnen* (dwelling) but *wachen* (vigilance). This shifts the occupational temporality towards the future. Chances are that Heidegger spent more time on the telephone than in the tower, as a letter to his wife Elfride suggests: "sits at the telephone and gives a copious amount of numbers to artillery, air ship troopers, gas office, etc.".[416] In any case, as these clouds were used increasingly frequently, Heidegger's tasks would have implicitly contributed to cloud warfare, since he gathered "essential data about wind speed and direction for war in the air".[417] The end of an era, or possibly a beginning, was also observed from weather observation towers such as Heidegger's, "a front-row seat before one of the twentieth century's most distinctive atmospheres: the cloud of poison gas".[418]

Durham Peters links Heidegger's interest in "kairological time" immediately following World War I to his observations of *kairos* in the weather during the war, noting that his 1919 lectures were "written on the back of unused military weather reports". In particular, Heidegger's interest in an excerpt from the Bible (Matthew 24), in which Jesus describes the signs of his return amid "the clouds of heaven", can be linked to an interest in the weather (*kairos* is both time and weather) and cloud-watching. While the time of Christ's return is unknown—"but concerning that day and hour no one knows, not even the angels of heaven, nor the Son, but the Father only" (Matthew 24: 36)—the disciples are instructed to watch out for signs in the sky: "the sun will be darkened, and the moon will not give its light, and the stars will fall from heaven,

[414] Durham Peters, *Marvelous Clouds*, 241.
[415] Durham Peters, *Marvelous Clouds*, 241.
[416] Durham Peters, *Marvelous Clouds*, 241.
[417] Durham Peters, 241.
[418] Durham Peters, 241.

and the powers of the heavens will be shaken" (Matthew 24: 30). Only the vigilant will note the events in the sky and understand their meaning as harbingers of Christ's return. In this section, meteorological events (*kairos*) are used as media: they communicate the impending "end of the age" (Matthew 24: 3). Durham Peters concludes:

> Watching the weather gives a new, historically specific cast to Heideggerian tropes of vigilance, hüten (guarding or watching), kairos, and observance. Time, as Heidegger's central preoccupation, shows up as weather. It is not hard to imagine a meteorological inspiration for the fourfold—das Geviert—as Heidegger peered from his perch between heaven and earth toward the western front a few kilometers away where mortals died in trenches and gods, maybe, looked on. Somehow the twentieth-century notion of vigilance as a paramount ethical duty has something to do with those sublime objects in the sky such as vapor trails, weather maps, air raid alarms, wireless signals, and smoke from ovens. Every time in Heidegger that we read of watchfulness, shepherding being, or the event (Ereignis), we should think of weather, and remember that he was reading the winds to carry weather balloons, airplanes, ordnance, and poison gas.

The meteorological mode governed by *kairos*, imbalance and ever-actualising spatialities has thus potentially already infiltrated the architectural discourse through Heidegger's fourfold, and more recently in writings such as Easterling's. Architecture is increasingly moving away from the Cartesian object locatable in an absolute grid system, towards a logic of infrastructure governed by disposition.[419] Infrastructural space channels agencies, activities, information and material that—much like their users—navigate space by correlation. The concern with space that has dominated modern architectural discourse gives way to a cloudy

[419] Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (New York: Verso, 2014).

gathering of what traverses it, be it bodies without surfaces,[420] withdrawing objects or channelled resources. The meteorological mode governs the infrastructure of today's archives and its emergence in the spatial imagination: vapours, winds, electric currents caused by aerosol friction that transmit, blur and store data.

Clouds are Analogue Computers

The "elemental" of environmental media philosophy differs from the discrete, which has come to govern digital media and "the computer as we know today, a programmable and digital machine".[421] The digital, composed of discrete units of ones and zeros, has been reduced to the binary. The history of computing reveals an alternative trajectory that was less flat and more in line with the meteorological mode of continuous updates: analogue computing, prevalent until the 1940s, is defined by "continuous representation and physical analogy".[422] To further quote computer historian Charles Care, "the history of analogue computing [...] appears to be the consequence of a complex and evolving relationship between two technological strands: continuous calculating devices (the 'equation solvers'), and the technologies developed for modelling".[423]

Analogue computing's close relationship with experimental physical and analogous modelling grounds this strand of computing more in the tradition of natural science experimentation than in the history of calculating devices.[424] For example, the Moniac, a famous analogue computer built in 1949 by Bill Phillips, modelled the UK's financial market *by analogy*, with a large-scale, wall-sized model of tanks, tubes and pipes that represented different funds, monetary institutions and players. The

[420] From Leonardo da Vinci's notebooks, cited in Hubert Damisch, *A Theory of /Cloud/: Toward a History of Painting* (Stanford: Stanford University Press, 2002), 218, 124, 141, 218.
[421] Charles Care, *Technology for Modelling: Electrical Analogies, Engineering Practice, and the Development of Analogue Computing* (London: Springer, 2010), 22.
[422] Care, *Technology for Modelling*, 39.
[423] Care, *Technology for Modelling*, 20.
[424] Care, *Technology for Modelling*, 40.

hydraulic flow was mediated by valves and pumps representing the flow of money: "hydraulic flow was *analogous* to monetary flow—the machine was an 'analogue'".[425] Analogue computers used hydraulics, mechanics and later electricity to animate models as varied as the Wing Calculator for aircraft manufacture, which "could solve the equations governing a lifting wing",[426] and "electrical analogies" of the dynamics of subterranean oil reservoirs.[427] Electrical computers relied on a mediating field, whether conductive paper or electrolytic liquids, as *analogue media*.

These computers, i.e. analogue models, were also significant in early non-digital meteorology. In 1918, Lewis Fry Richardson (1881–1953), remembered for his numerical weather forecast method, used a bowl of water spinning on a gramophone to model the rotational movement of the atmosphere. These spinning bowls were fairly common. In 1929 at the United States Weather Bureau, meteorologist Carl-Gustaf Rossby used a two-metre-wide salt water bowl with different dyes to model thermal currents. He visualised the large-scale motions of the atmosphere using fluid mechanics. Ludwig Prandtl (1875–1953), remembered for his research on aerodynamics, created an entire rotating room, three metres in diameter. From 1940 onwards, these spinning models began to produce quantitative data besides the qualitative experience, especially under meteorologist Dave Fultz (1921–2002) at the University of Chicago,[428] who created "dishpan" experiments—analogue models of atmospheric processes to provide "insight into the fundamental large-scale air movements that create weather"[429].

In the early 20th century, weather forecasting usually relied on comparing current observations with vast amounts of archival data and deducing the

[425] Care, *Technology for Modelling*, 5.
[426] Care, *Technology for Modelling*, 45.
[427] Care, *Technology for Modelling*, 46–47.
[428] Care, *Technology for Modelling*, 168–170.
[429] "Dave Fultz, Meteorologist, 1921–2002", University of Chicago News, accessed 4 December 2018, http://www-news.uchicago.edu/releases/02/020731.fultz.shtml.

weather to come,[430] as if the weather looped in ever-recurring patterns. One of the most influential meteorologists of the early 20th century, Lewis Fry Richardson developed formulas for computing (calculating) the weather numerically: "the methodology proposed by him is essentially that used in practical weather forecasting today".[431] He thus "laid the foundations for the theory behind [today's] computerized weather predictions".[432] Richardson published the method in his book *Weather Prediction by Numerical Process* (1922), partly funded by the Royal Academy and the Meteorological Office. Peter Lynch summarises Richardson's forecast method as follows:

> The fundamental idea is that the numerical values of atmospheric pressures, velocities, etc., are tabulated at certain latitudes, longitudes and heights so as to give a general description of the state of the atmosphere at an instant. The physical laws determine how these quantities change with time. The laws are used to formulate an arithmetical procedure which, when applied to the numerical tables, yields the corresponding values after a brief interval of time, Δt. The process can be repeated so as to yield the state of the atmosphere after $2\Delta t$, $3\Delta t$, and so on, until the desired forecast length is reached.[433]

The first step was therefore to divide the globe into a grid, so that measurements of the atmospheric conditions could be taken at the grid points at specific heights. Richardson applied his numerical method to a retroactive forecast for the weather of 20 May 1910, applying his computational method. He worked on the extensive calculations while

430 See for example Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA and London: MIT Press, 2010).
431 Peter Lynch, *Richardson's Dream: The Emergence of Scientific Weather Forecasting* (Cambridge: Cambridge University Press, 2006), 1.
432 Kenneth E. Boulding quoted in Care, *Technology for Modelling: Electrical Analogies, Engineering Practice, and the Development of Analogue Computing*, 160.
433 Peter Lynch, *Richardson's Dream: The Emergence of Scientific Weather Forecasting* (Cambridge: Cambridge University Press, 2006), 19.

serving as an ambulance driver in the Friends Ambulance Unit in Champagne on the Western Front during World War I (his Quaker pacifism prevented him from fighting), just 100 kilometres away from Heidegger. The forecast failed, because he did not use enough smoothing techniques to correct the data; applying these would have produced accurate results.[434]
Richardson's calculations, which used quantitative atmospheric observations and equations to predict and reconstruct future and past climates, evoke Charles Babbage's vision of reading the air's particles as predictive and archival cues.

Because of the global nature of Richardson's hypothetical computational and data-gathering grid, media theorist Seb Franklin identifies 1922's *Weather Prediction by Numerical Process* as a precursor of distributed processing—and therefore of cloud computing. With his meteorological method based on overlaying physical space with an abstract computational network, Richardson imagined a potentially worldwide web for predicting the weather. His model of human computer nodes (mathematicians), linked by telegraph lines for communication that allowed the system to compile and process the individual nodes' computational results, shares basic principles with the systems we rely on today.[435] Data centres, like Richardson's mathematicians, enable the cloud and sustain its ever-accessible online programs and services, yet they remain mostly invisible and unnoticed by the cloud's users. It seems appropriate to trace the origins of the concept of a computational process uninhibited by spatial constraints in meteorology, which is essentially global and all-pervasive. Ruskin powerfully summed up the global, transnational network nature of

[434] See Lynch, *Richardson's Dream*, introduction and chap. 9. The forecast was thus not the "complete failure" Edwards makes it out to be. The fact that the surface pressure prediction was "150 times larger than the actual observed change", and the laboriousness of the calculations, however, "discouraged meteorologists from further attempts to apply Richardson's technique until the advent of electronic digital computers in the 1940s". Edwards, *Vast Machine*, 94.
[435] Seb Franklin, "Cloud Control, or the Network as Medium", *Cultural Politics* 8 (2012): 452–454..

meteorology, which is also characteristic of cloud computing and the digital cloud. He understood the Meteorological Society as "the central point, the moving power, of a vast machine" [436] dedicated to gathering data. For accurate prediction, its network must "be omnipresent over the globe so that it may be able to know, at any given instant, the state of the atmosphere on every point on its surface".[437] Meteorology and the digital cloud certainly share a voraciousness for data and space.

Not only did he pioneer the numerical (digital) method, but Richardson was also constantly engaged in empirical research. Not even the hardship of the Western Front—where his unit transported wounded soldiers, at times under shellfire[438]—deterred him from keeping "a weather eye on the elements",[439] as one of his comrades in Section Sanitaire Anglaise (SSA) 13 put it. He was remembered as kind and dignified, and was nicknamed "prof" because he was constantly working on either his calculations or practical meteorological experiments: "he spent a lot of his time setting up meteorological instruments and taking readings: we thought nothing of seeing him wandering about in the small hours checking his instruments",[440] remembered another SSA 13 member. It was also in France that Richardson built his gramophone bowl model to "compute" the atmosphere.[441] Back in England, he continued to experiment with weather balloons, which would be necessary for the various height measurements at the nodal points of his envisioned planetary grid.[442] This significantly shifts the focus in the history of the computer, from number crunching to environmental modelling by analogy. Continuing this train of thought, one might imagine clouds as analogue computers. As I have

[436] John Ruskin quoted in Edwards, *Vast Machine*, preface.
[437] John Ruskin quoted in Edwards, *Vast Machine*, preface.
[438] Oliver M. Ashford, *Prophet or Professor? The Life and Work of Lewis Fry Richardson* (Bristol and Boston: A. Hilger, 1985), 55, http://archive.org/details/prophetorprofess00ashf.
[439] Arthur Molyneux quoted in Ashford, *Prophet or Professor?*, 56–57.
[440] Herbert Morrell quoted in Ashford, *Prophet or Professor?*, 57.
[441] Care, *Technology for Modelling*, 166. See also Lewis F. Richardson, *Weather Prediction by Numerical Process* (Cambridge: Cambridge University Press, 1922).
[442] For more on his technical instruments, see Care, *Technology for Modelling*.

shown, they visualise, they model, they *compute* the planet by continuously reconfiguring to manifest the conditions of the planetary assemblage of competing parameters. *Modelling* is the fundamental premise of climate and weather studies. Edwards summarises this as follows:

> Understanding and predicting the climate is very difficult. In fact, it's one of the hardest challenges science has ever tackled, because it involves many interlocking systems, including the atmosphere, the oceans, the cryosphere (ice and snow), land surfaces (soil, reflectance), and the biosphere (ecosystems, agriculture, etc.). You can't study global systems experimentally; they are too huge and complex. Instead, as I will show you, everything we know about the global climate depends on three types of computer models.[443]

Understanding *clouds* is precisely as complex—they respond to the listed "interlocking systems" more accurately than any computer model ever could. They are thus hyper-accurate analogue models of what our digital climate models are attempting to achieve. Therefore, clouds give insight into a non-binary computational potential that exemplifies the meteorological mode. The meteorological is utterly non-Cartesian, and it is non-digital if the digital is tied to the binary, the discrete.

In a moment of creative speculation in the final pages of *Weather Prediction by Numerical Process*, Richardson came up with a spatial construct that was both analogue and digital computer, the often-cited Forecast Factory. Richardson's "dream", as Lynch calls it, was to eventually "advance the computations faster than the weather advances".[444] To this end, he imagined a giant globe building, with rows of galleries lining the inside. A map of the world was to be painted onto the interior walls of the globe structure, with the North Pole on the ceiling and Antarctica "in the pit". This globular map would be overlaid with a grid, dividing the galleries into

[443] Edwards, *Vast Machine*, xiv–xv.
[444] Richardson, *Weather Prediction by Numerical Process*, vii.

fields corresponding to geographical locations. Each field would be occupied by one of 64,000 human computers, calculating the weather for this precise region using slide rules and calculating machines. Each person thus "attends only to one equation or part of an equation", making their jobs much more manageable than the feat Richardson himself braved when he went through pages and pages of calculations to accomplish the retrospective forecast during World War I. The incremental numbers attained by each computer would be displayed in the direction of the information flow, on three sides of his or her gallery-cubicle.

Each region would be "coordinated by an official of higher rank", and the entire *performance* would be synchronised by "the man in charge of the whole theatre" at the centre of the space, suspended mid-height in a large pulpit supported on a tall column. "Like the conductor of an orchestra", this central figure would orchestrate the timing: "but instead of waving a baton he turns a beam of rosy light upon any region that is running ahead of the rest, and a beam of blue light upon those who are behindhand". This central figure would be supported by a staff of assistants and messengers: "four senior clerks in the central pulpit are collecting the future weather as fast as it is being computed, and dispatching it by pneumatic carrier to a quiet room. There it will be coded and telephoned to the radio transmitting station. Messengers carry piles of used computing forms down to a storehouse in the cellar". This emphasises the importance of immediate transmission/communication for the forecast to remain relevant (ahead of actualisation).

Richardson imagined support functions in adjacent buildings, such as finance and administration offices, and a research department where potential improvements to "the complex routine of the computing theatre" would be tested before implementation. Beneath "Antarctica", in the basement, he imagined "an enthusiast [who] is observing eddies in the liquid lining of a huge spinning bowl". Richardson added a cautious "but so far the arithmetic proves the better way". However, considering the representative potential of clouds as computers, there may yet be a benefit in studying analogue models of the weather.

Peter Lynch has an interesting reading of Richardson's Forecast Factory, which he finds "remarkably prescient" in its similarities to the modern massively parallel processor (MPP).

> Richardson envisaged a large number of processors—64,000 by his estimate—working in synchrony on different sub-tasks. The fastest computer in the TOP500 list as of June 2005 was the IBM BlueGene/L with 65,536 processors! The silicon-based processing elements of modern computers are incomparably more powerful than the carbon-based "computers" proposed by Richardson. The IBM machine is rated at 136.8 TFlops (136 trillion calculations per second; see http://www.top500.org). The BlueGene is perhaps nine orders of magnitude faster than Richardson's Forecast Factory. In the fantasy, the forecasting job is sub-divided, or parallelized, using domain decomposition, a technique often used in MPPs today. Richardson's night signs provide nearest-neighbour communication, analogous to message-passing techniques in MPPs. The man in the pulpit, with his blue and rosy beams, acts as a synchronization and control unit. Thus, while the processing speeds differ by many orders of magnitude, the logical structures of the Forecast Factory and the MPP have much in common.[445]

[445] Lynch, *Richardson's Dream*, 244. Also: "a processual memory concept already inheres in the computer's so-called von Neumann architecture: namely, a principle of memory programming (also present in a rudimentary form in Charles Babbage's concept of the Analytical Engine) that facilitates the self-accessing of temporarily stored data during computation itself (archival cybernetics [internal feedback])—a dynamic memory culture in contrast to resident archive memory, which is updatable but not permanently and dynamically regroupable. Digital archives are closer to the computer's memory aesthetic than are the traditional (and medium-of-tradition) emphatic coupling of archive and cultural memory. The classical archive is preserved time. But the digital archive has no intrinsic macrotemporal index, as the 'year 2000' problem made clear. It operates at a microtemporal level instead". Wolfgang Ernst, *Digital Memory and the Archive*, ed. Jussi Parikka (Minneapolis and London: University of Minnesota Press, 2013), loc. 82, Kindle.

Lynch thus understands Richardson's weather-computing theatre as a precursor to the digital computer, in which carbon-based computers are replaced by silicon-based processors. Similarly, Edwards remarks, "this was truly the world in a machine".[446] In its theatricality, however, the Forecast Factory is also an analogue model of the world's weather, more in the tradition of analogue computing. The individual animated units are all interlinked in the complex global structure of the factory. They are governed by a delicately balanced temporality that is necessary to keep up the ceaseless flow of information, that is to say, the interrelation between the continuously updated parameters. Richardson's wording—"a myriad computers are at work upon the weather of the part of the map where each sits"—is interesting, as it suggests that computing the weather is related to producing the weather. The Forecast Factory is "at work upon the weather": the computational theatre produces forecasts—still *theōria* before they are proven accurate—and it is a spectacle in itself, as is suggested by the author's recurring theatrical vocabulary. The conductor's role is "to maintain a uniform speed of progress in all parts of the globe". He stands on the central axis of what one might interpret as the planetary rotational movement: in this model the computers are "moving", guided by the light signals, and the globe stands still. It is a truly planetary model, both in what it represents by analogy, and in its accessibility to the entire globe via Richardson's conception of a planet-spanning network of radio stations.[447]

Ice Cores: The Clouds' Externalized Archives

If clouds model the world as analogue computers, then their externalized archives, as in Richardson's Forecast Factory, are "at the bottom of his

[446] Edwards, *Vast Machine*, 94.
[447] At the time, Richardson's numerical method was not pursued further, because pre-digital computers seemed too laborious and impractical. Considering how much it resembles today's methodologies, there is hope that his formulas for peace will also eventually find an application.

globe", just below Antarctica. While Richardson imagined a cellar where "piles of used computing forms" documenting past weather forecasts are heaped on top of one another, for today's climate scientists, Antarctica is an important storehouse of the globe's past climate (which they expect to give insight into the climate's future). To be precise, it is Antarctica's ice shield that guards this archival data. To further clarify my notion of the meteorological mode in relation to an archival imaginary that diverges from the geological, I now turn to ice cores, which challenge the geological temporality that corresponds to the spatiality of stratification, as identified in Part 1.

Ice core drilling is thus a relatively simple technical endeavour under challenging environmental conditions, with an enticing promise: drill deep enough, and the past as well as a projected future will be revealed, macro-layer by macro-layer. Close-up photographs of these cores show strata of compressed snow, which is inscribed with data about past temperatures, snowfall, wind, forest fires, solar activity levels, carbon dioxide levels, plant life, the composition of the atmosphere—in short, "a surprisingly complete history of climate changes over much of Earth's surface".[448] Like the sediment cores of section 1.1, ice core research exemplifies the quest to reach "deep time and deep history" in the scientific endeavour to unearth the planet's past climate and make projections regarding its future.

Ice cores can be described as compressed clouds: archives of precipitation that assemble global information. Their extraction poses spatial problems that exemplify the meteorological mode, as they assemble uncontainable and inherent fluidity, motion and animation. The site of drilling, in its bare simplicity and its entanglement with climatic conditions, again evokes the "inverted sense of the world" described by Easterling in relation to field and object, ground and figure. To begin with, the drilling site's coordinates are ever-updating, because ice *flows.* An example is the so-called Summit Camp, a year-round climate observatory and research station of the

[448] Richard B. Alley, *The Two-Mile Time Machine: Ice Cores, Abrupt Climate Change, and Our Future* (Princeton: Princeton University Press, 2000), 13, 31.

National Science Foundation and National Oceanic and Atmospheric Administration. It is situated on the apex of the Greenland Ice Sheet, 3,216 metres above sea level.[449] Every year the camp moves a few centimetres. The camp "figure" is thus bound up in the field of snow, a peak in the slowly moving ice mass. The drilling site exists outside the Cartesian grid; it is part of an environmental media space.

Richard Alley, who was part of the team of scientists drilling at the Summit Camp from its beginning, gives a detailed account of the trench and adjacent drilling tent and tower in *The Two-Mile Time Machine*. His description of the GISP2 camp evokes a sense of ever-diminishing or endangered cavities. The processing site is a trench cut into the compressed snow, with a roof that suspends the increasing weight of the snow above the void. More space is generated by carving out blocks from the artificial cave's boundaries. The cave space is challenged horizontally by the flow of the ice masses, and vertically by the piling on of new snow layers. It thus shifts in both directions, as it becomes increasingly buried and drifts with the movement of the ice masses.
The site conjures a sense of continuous motion: the wind causes drift snow, the snowfall piles on new layers, the drill is operated day and night. Meanwhile, the trench and camp slowly wander along towards the coast, as attachments of the ice sheets.

After extraction, the cores are left to relax and dry off from the liquid in the drilling hole. They are then submitted to chemical analysis and run through the processing line in the trench, before they are transported to the US, usually to be archived at the National Ice Core Laboratory in Lakewood, Colorado: "the trays with ice were then pushed along on roller tracks, from saw to electrical-conductivity measurement, visual examination, and packaging, with slices shunted off into special side

[449] This station was founded in April 1989 to support Greenland Ice Sheet Project Two's (GISP2) deep ice-coring effort. GISP2 extracted an ice core to a depth of 3,053.44 metres, which hit bedrock, and then drilled 1.55 metres further into the bedrock. By 1993, it was the deepest ice core in the world.

alcoves for further analyses".[450] At the National Ice Core Laboratory, a giant freezer of roughly 1,550 cubic metres preserves 18,900 metres of ice rods from ice sheets and glaciers at minus 33 degrees Celsius.[451] The oldest ice here is 417,000 years old and was extracted from Princess Elizabeth Land, Antarctica. A 3,404-metre-long core stored at the lab, extracted from the West Antarctic Ice Sheet, "is an archive of atmospheric history going back 68,000 years".[452] In an adjacent decontaminated "clean room", scientists wrapped in winter coats gather data from core slices and individual ice crystals for their climate models: "the study of air bubbles, dust and ash particles, isotopes, gases and organic materials frozen in the ice helps scientists understand past climates and predict future ones".[453]

For the analysis of ice cores, two chronologies need to be produced: one that documents the age of the ice, and a different timeline that captures the age of the trapped gases within it, since gas can diffuse through firn, granular snow not yet fully compressed into ice. At any point in the core, the ice can thus be significantly older than the gas it contains. In order to approximate the relationship between the two timelines, models attempt to reconstruct the depth at which the gases were initially enclosed. These estimates become highly unreliable when the ice cores come from places with low snowfall, such as Vostok, Antarctica, where "the uncertainty in the difference between ages of ice and gas can be over 1,000 years".[454] Considering that some of these ice cores date back 70,000 years, 1,000 may not seem like much. However, when it comes to determining our own climatic fate, a millennium is all but beyond our capacity to imagine. The constellation of an archive next to a physical research site, where devoted staff brave icy temperatures to examine crystals and bubbles to make deductions about the planet, strongly recalls Richardson's Forecast Factory, where in the basement, below "Antarctica", "an enthusiast is

[450] Alley, *Two-Mile Time Machine*, 24.
[451] Wollan, "Arks of the Apocalypse".
[452] Wollan, "Arks".
[453] Wollan, "Arks".
[454] Jean Jouzel, "A Brief History of Ice Core Science Over the Last 50 Years", *Climate of the Past* 9, no. 6 (2013): 2525–2547.

observing eddies in the liquid lining of a huge spinning bowl". Back then, the numerical method "proved better", whereas now the physical materiality of precipitated clouds, which are themselves analogue models, seems to provide more insight into the climate's planetary phenomena.

As with the sediment core samples I visited in Part 1, there is again a sense of animation inscribed in the language relating to the ice cores. They are described as *tense* and *stressed*. For example, they are "often allowed to rest in storage at the drill site for some time, up to a full year between drilling seasons, to let the ice gradually relax".[455] Scientists must let the ice cores "chill", in a rather anthropomorphising manner.

Naturally, the ice cores, like the muddy sediment cores, and by analogy servers, need to be maintained under ideal environmental conditions that mimic their natural *habitat*: at between minus 33 and minus 36 degrees Celsius. Not only would the ice quality diminish at even slightly higher temperatures, but more importantly, the oxygen in the air bubbles gradually diffuses towards the core's surface at higher temperatures.[456] The oxygen is as relevant as the CO_2 values in the air bubbles, because the "relative ratios of oxygen and nitrogen, and their isotopes, can also reveal temperature variations and help to date the trapped gas".[457] False ratios resulting from the loss of oxygen distort the scientific findings. The Japanese researchers who first became aware of the correlation between temperature and the movement of oxygen fitted Tokyo's National Institute of Polar Research with technology employed to preserve high-grade tuna at minus 50 degrees Celsius.[458] This harks back to the cold storage of data I discussed in Part 1, and the likening of data to organic matter. Here, the data is quite literally frozen: the air bubbles also enable the more accurate dating and synchronisation of different cores.

455 Pavel G. Talalay, *Mechanical Ice Drilling Technology* (Beijing: Springer, 2016).
456 The temperatures of core facilities used to be at -20 to -30, thus corrupting the data quality. Rex Dalton, "Ice-Core Researchers Hope to Chill Out", *Nature*, 11 August 2009, https://www.nature.com/news/2009/090811/full/460786a.html.
457 Dalton, "Ice-Core Researchers".
458 Dalton, "Ice-Core Researchers".

Timescales for ice cores from the same hemisphere can be cross-referenced by using the layers containing atmospheric particles from volcanic eruptions. Thus, the emissions from geological events precipitate elsewhere as meteorological traces and temporal markers that have affected the entire hemisphere. The air bubbles need to be kept in place for as long as possible—or until a scientist exhausts their information potential, which is continuously pushed towards a future date as technology advances. Hypothetically, the ice cores thus need to be stored indefinitely, at temperatures whose maintenance in turn fuels climate change by consuming significant amounts of energy.

Ice cores can be understood as fattened section lines through compressed clouds. As cores that were extracted from the ground, they seem to embody the geological mode; yet their composition of precipitated clouds, and their analysis, opens up a temporality and spatiality that is decidedly meteorological. Ice cores contain meteorological history trapped in meteorological precipitation (compressed snow). The way the gas travels through the static layers of ice neatly exemplifies the difference between the geological and the meteorological. The meteorological is harder to contain, entrap and pin down.[459] It does not settle as strata, even though the snow seems to do so. Meteorological temporality traverses the layers of geological materiality. Approximating the meteorological, which tends to escape any definitive terms, the air bubbles in the ice cores are symptomatic of an inherently meteorological characteristic that diffuses geological materiality.

In their tiny air bubble pockets, in their dust and ash particles, in their isotopes and between their thin slices, ice core samples contain proof of an imminent catastrophe—of a kind unknown to the human species—that may force-induce drastic changes, much as the Oracle of Delphi did in Ancient Greece and the Roman Empire until roughly the fourth century

[459] Again, Timothy Morton's *hyperobject* comes to mind. Timothy Morton, *Hyperobjects: Philosophy and Ecology After the End of the World* (Minneapolis and London: University of Minnesota Press, 2013).

BCE. Here, an older local peasant woman would be selected as the Pythia, who would interpret the words of Apollo (god of truth and prophesy, among other titles) from the fumes that escaped their geological entrapment in the chasm within her temple sanctum. The fumes are believed to have consisted of hydrocarbons such as ethylene and ethane, which can induce a trance. The words spoken by the sibyl in her trance were translated into neat verses by the priests (including Plutarch, who worked there as a priest). The oracle was consulted by some of the most influential leaders, such as Hadrian, on topics of paramount importance, such as wars and colonialising expansion.[460] Escaping raw data in the form of gas governs both the oracle and the interpretation of ice cores. If the gas that escapes its geological enclosure is interpreted correctly by tapping into an enhanced realm of knowledge governed by trance or science respectively, the future can hypothetically be determined. In both cases, there is an interplay between a more meteorological mode of evasive permeation, dispersal and phasing, and the geological mode of enclosure and chasmic reverberation.

Archive in Transfer

The clouds as analogue computers and the idea of ice cores as their outsourced archives indirectly explores a fundamental aspect of today's digital archives, which I began to describe as *animated archives* in Part 1. The ice cores as archival data carriers or entities are continuously in motion: they are extracted, placed on conveyor belts, flown across the world, carried onto archive racks, taken out again, sliced into slithers, shoved under microscopes. Additionally, they are inherently animated: brittle, writhing with internal tension, traversed by expanding gas bubbles as the ambient temperature rises. Similarly, media archaeologist Wolfgang Ernst describes today's archival condition as "in transfer":

[460] Not immune to the movements of the active ground, the oracle itself was at one point destroyed by an earthquake.

> The idea of an archive in motion is a paradox: the archive is traditionally that which arrests time, which stops all motion. For nineteenth century historians, the archive was in its essence an institution that made it possible to access "frozen" sections of past time. […] Later, the transition from an archive of motion to the notion of an archive in motion is associated with the advent of computer technologies and ultimately, the Internet, where constant transfer and updating functions as well as "live" communication and interaction redefine the temporality of the archival document itself.[461]

Archives have a long tradition of being in transition, however. During medieval times, if a city was in danger of being invaded, part of the precautions taken by the authorities was to move the city archives onto archive ships, to keep them out of the enemy's reach.[462] Ernst talks about the *Eigenzeit* of archives: "archives have their inherent temporality […]. The archive oscillates between 'temporalities' and 'tempo-realities'".[463] Maybe this *Eigenzeit* is in fact linked to archival animation.

Ernst also draws attention to the shift from storing information to immediate feedback and retrieval: "against the background of archives which are increasingly in motion, […] future cultural emphasis will be rather on permanent transfer, not storage (without undoing storage, though)".[464] In Part 1, I explained data centres as animated archives; this theme now recurs in relation to the cloud. Ernst goes so far as to expel the digital archive in its entirety into the realm of the metaphorical, drawing explicitly not on the concept of the cloud but rather on vector dynamics:

461 Wolfgang Ernst, "Radically De-Historicizing the Archive: Decolonizing Archival Memory from the Supremacy of Historical Discourse", in *Decolonizing Archives*, ed. Rado Ištok and Nataša Petrešin-Bachelez (L'Internationale Online, 2016), 14.
462 Markus Friedrich, *Die Geburt des Archivs: Eine Wissensgeschichte* (Munich: Oldenbourg Wissenschaftsverlag, 2013).
463 Ernst, "Radically De-Historicizing", 15.
464 Ernst, *Digital Memory*.

> With supremacy of selection over storage, addressability over sorting, there is no memory in the emphatic sense anymore; archival terminology—or rather the archive itself—becomes literally metaphorical, a function of transfer processes. The Archival "Field" in the age of Net-based information, the static notion of the rigidly coupled archival classification of documents is being replaced by a kind of vector dynamics. […] Archival order, in analogy, is being replaced by the dynamics of the archival field, which in the new media environment is itself based on the dynamics of electromagnetism and (mathematically as well as logically) mastered by cybernetic reasoning, resulting in electronics. Although the traditional archive used to be a rather static memory, the notion of the archive in Internet communication tends to move the archive toward an economy of circulation: permanent transformations and updating.[465]

Ernst describes the fundamental shift, from the archive as "final destination" to its embodiment of a site of constant retrieval, actualisation, update and feedback. In section 2.2 I will trace the origins of an ever-updating cybernetic archive that lost its autonomy and was incorporated into an organism engaged in continuous feedback loops. The archive in a state of constant updates actualises the archival temporality of an extended present: "the digital archives, once online, will not be separated from the 'present' anymore".[466] What Wendy Chun calls ephemeral[467] is in fact the archive poised in a continuous actualising process, always catching up with the fleeting present.

This fleetingness can be approximated through the notion of meteorological clouds as a planetary model, constantly updating and

[465] Ernst, *Digital Memory*, 97–99.
[466] Ernst, *Digital Memory*, 204.
[467] Wendy Chun, "The Enduring Ephemeral, or the Future is a Memory", in *Media Archaeology: Approaches, Applications, and Implications*, ed. Erkki Huhtamo and Jussi Parikka (Berkeley: University of California Press, 2011).

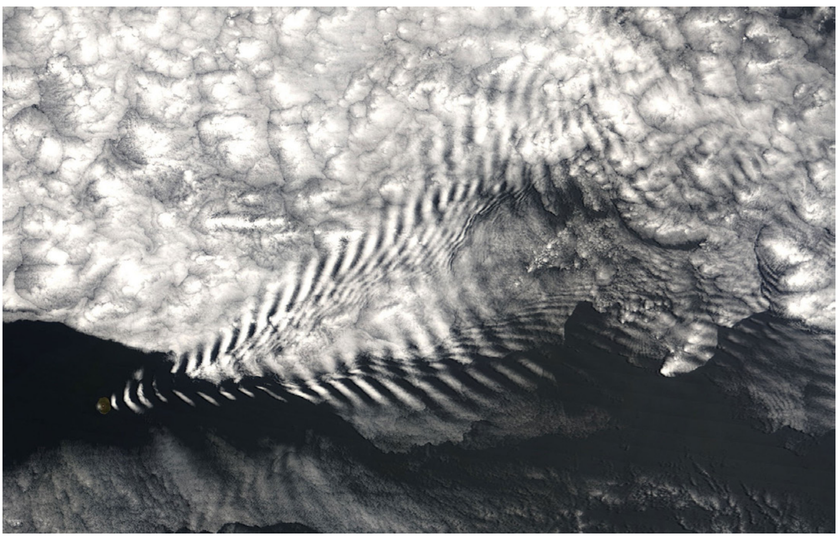
fleetingly precipitating in the form of snow to result in ice cores as archives. The meteorological mode is a tool for identifying an essential shift in the spatio-temporal demands on today's (digital) archives. Nasa's current Blue Marble is a complex, continuously changing animation that brings together millions of data points, gathered over the course of years by satellites and assembled by algorithms and curators, to show our cloudy planet stripped of its cloud camouflage during a year of seasons: green, yellow, white and blue. The Blue Marble is no longer shown on one reproduced photograph taken by one astronaut at one moment on one trip towards one moon circling one world. Just as truth is no longer convincing when it is set in stone, but rather must be continuously updated, factoring in new parameters, angles and findings, so the archive no longer remains amid the geological strata but has embraced the meteorological mode, in the spirit of Edwards' perception of climate models:

> Since both observing systems and data models evolve, global data also change. We have not one data image of the global climate, but many. The past, or rather what we can know about the past, changes. And it will keep right on changing. I call this reverberation of data images "shimmering".[468]

This *shimmering* is beginning to take hold of the spatial imagination. The meteorological mode is a way of looking at archives that allows constant actualisation. This mode is formulated in juxtaposition, but not opposition, to the geological mode. Both archival modes share the qualities of animation. The clouds and their computing abilities have shown that the meteorological mode is vibrant,[469] highly responsive and embodies the ability to align and integrate vast amounts of data.

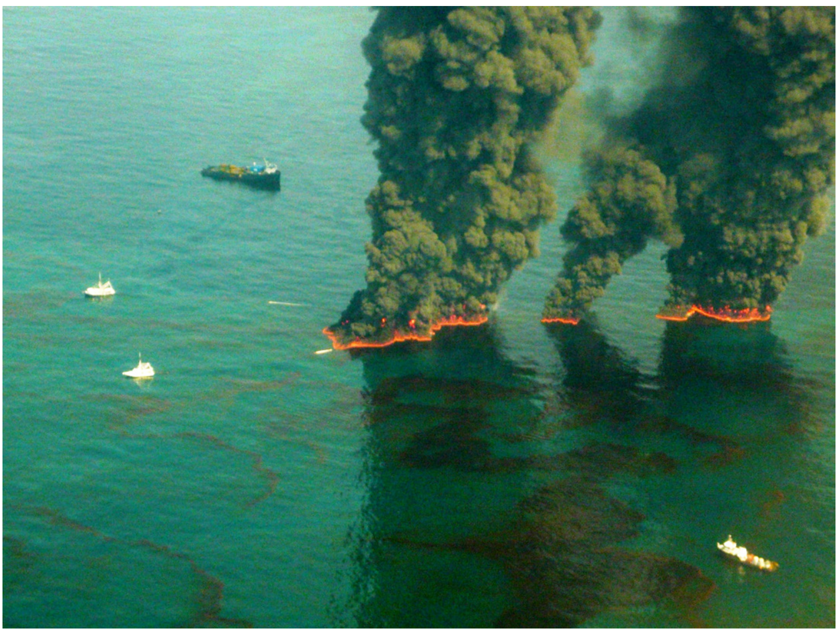
[468] Edwards, *Vast Machine*, xiii.
[469] See also Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham and London: Duke University Press, 2010).

“Fallstreak holes” or “hole-punch clouds”: When an airplane passes through cloud carpets consisting of liquid drops at super-cooled temperatures below 0° Celsius, its exhaust particles can trigger freezing. The ice crystals the “literally fall out of the sky”. Ship exhaust, which consists of very fine aerosols, can also seed clouds.



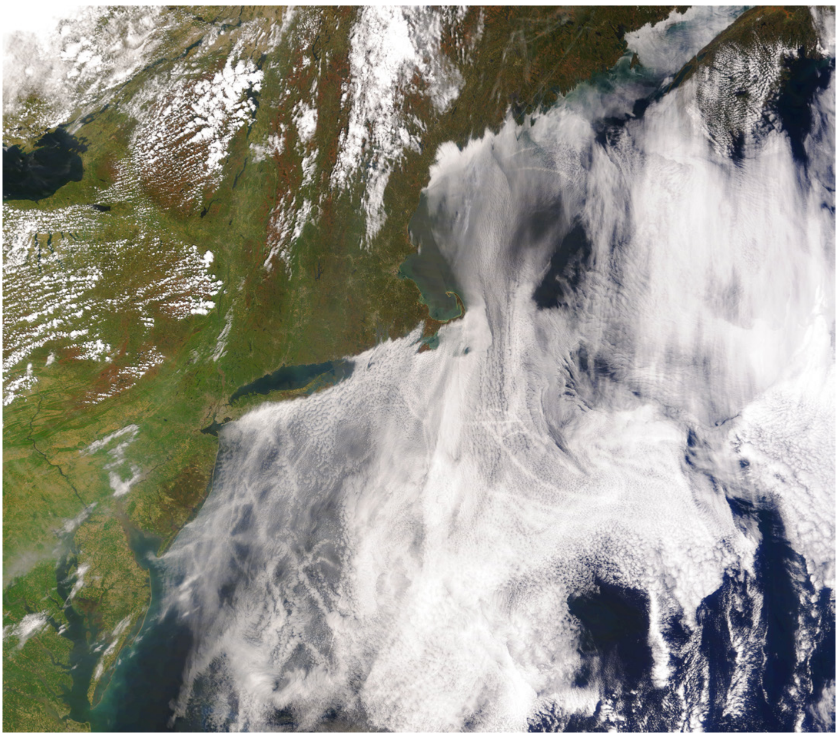
Wave cloud responding to upwind above Amsterdam Island (NASA)

The first poison war cloud of WWI at the Ypres front, 2015 (www.
independent.co.uk)



Clouds tranfer infomration, for example of the May 19th 2010 deepwater horizon spill. Pictures: controlled burning of oil

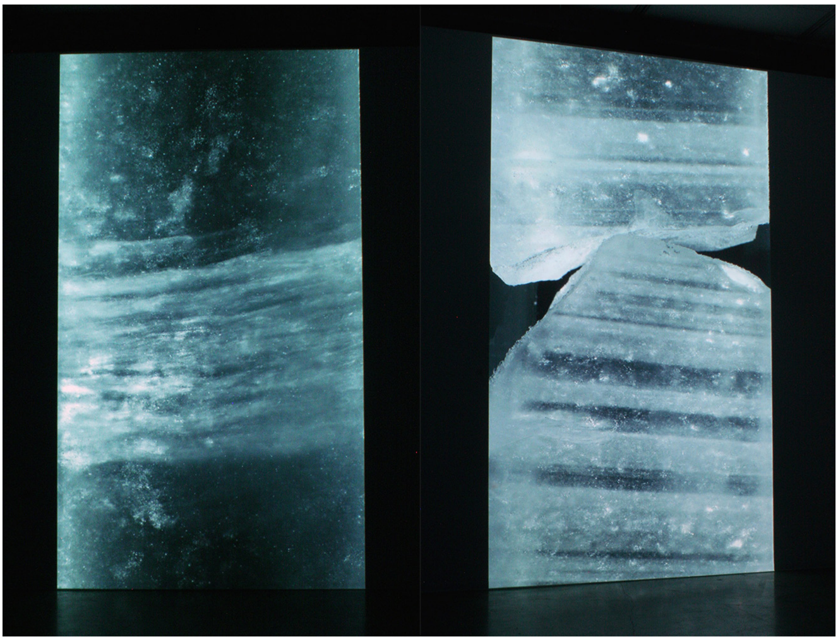
Cloud resulting from controlled burning of oil



Ship Tracks MODIS 11 May 2005

Surtsey Island formed from 1963-1967. The volcanic clouds transmit the news to onlookers as far as Reykjavik.

Surtsey Island



Peggy Weil, *88 Cores,* 2017

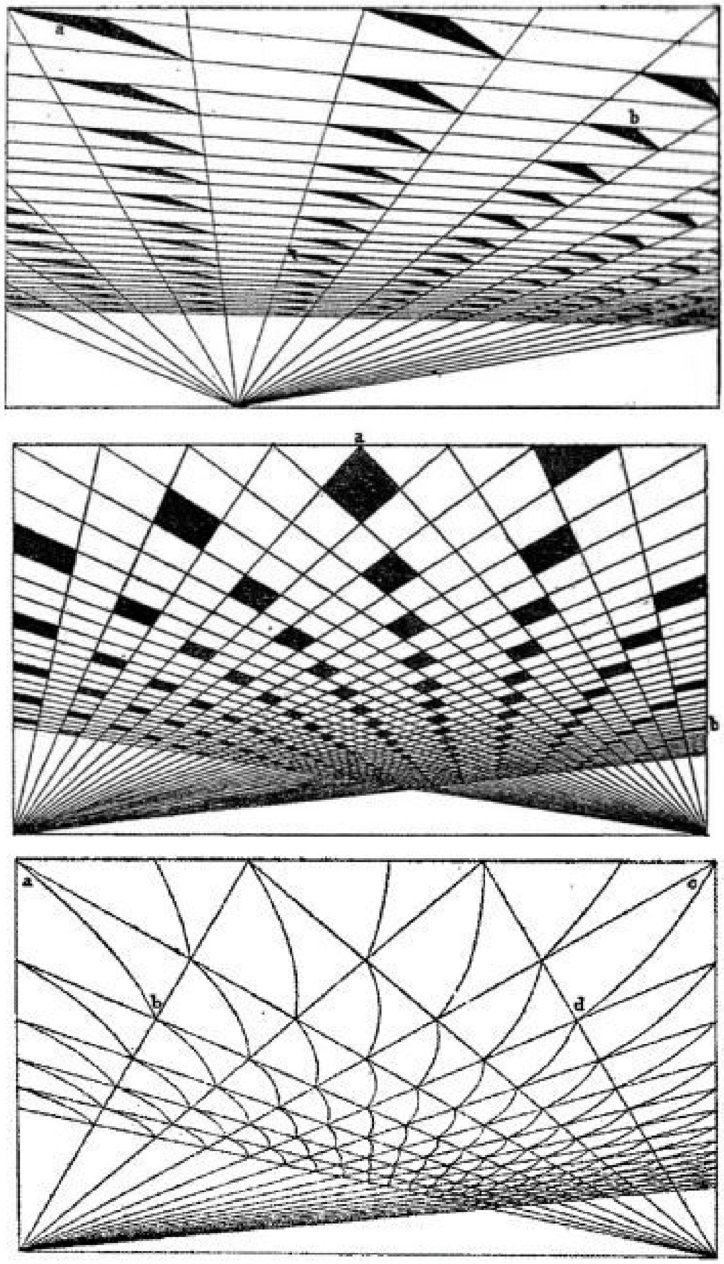
Artist Peggy Weil's 2017 film *88 Cores* documents a 3.2-kilometre-long ice core. She describes the filmic motion as a "video descent in one continuous pan down through the Greenland Ice Sheet". Over the course of 4.5 hours, she shows over three kilometres of ice, the equivalent of 110,000 years of embodied climate history, thus visualising the quest to reach "deep time and deep history" and the scientific endeavour to unearth the planet's past climate and make projections regarding its future.

US National Ice Core Lab GISP2

Cores—be they ice, rock, sediment or mud—are not collected and stored for today, so much as for a future when scientists will be more skilled at deciphering the linearity of these literal timelines: “the plan is to study these specimens now but also to deliver them to the future, when scientists will presumably be more advanced than we are, technologically—and hopefully smarter”. (Wollan) The extraction and accumulation is undertaken through faith in future science.

The architecture of ice core drilling sites.
“A 2-meter section of ice core from Combatant Col, British Columbia, is removed from an electrothermal drill.” icecores.org

The architecture of ice core drilling.
“The DISC Drill’s sonde and tower tilt from vertical to horizontal to aid in the removal of the ice core and chips. In this image the tower and sonde are at a ~45° position inside the drill slot.” icecores.org

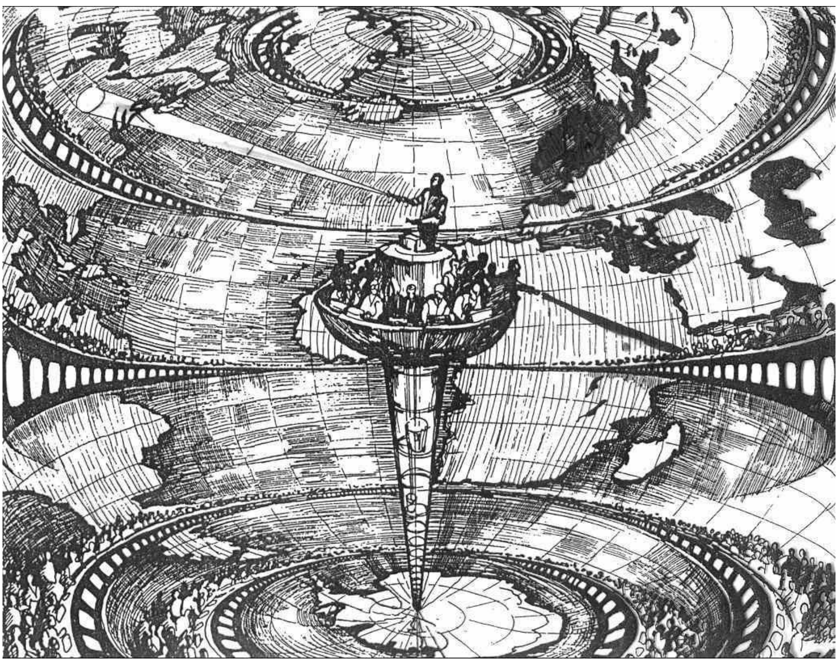


John Ruskin, Cloud Perspective: Rectilinear. (Modern Painters, Vol V.)

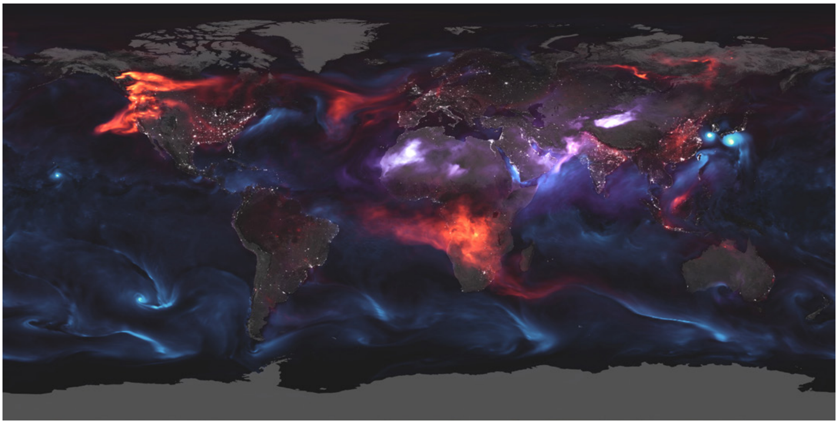
Pythia, The Oracle of Delphi sitting above the geological crevice

Robert Smithson, Spiral Jetty, 1970 Great Salt Lake, Utah, 1970.

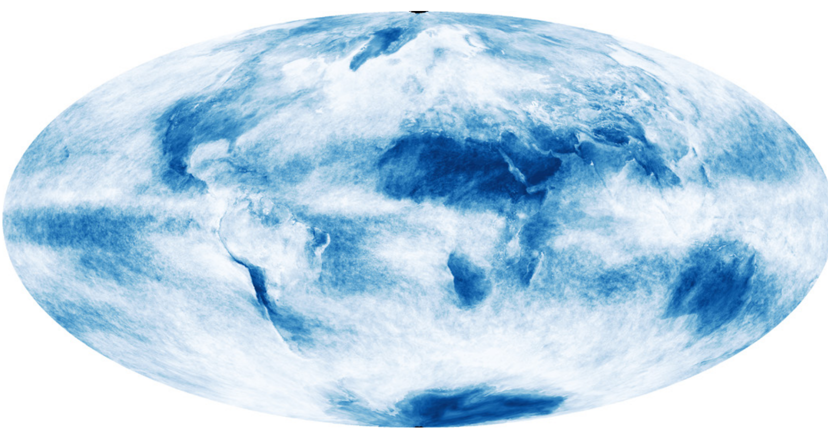
In Part 1 on the geological mode, I referenced Smithson's abstract geology. Smithson was aware of alternative planetary imaginaries that are more meteorological, as can be inferred from his discussion of "climates of sight"—the "climatology of the brain and eye". He dismisses those who have wet "mental weather" and a "dank brain" that prefers lush hills over the arid desert. Yet while Smithson promotes the desert as an antidote to moist urban tendencies, his terms are somewhat murky or muddy: he appreciates the creative potential of mud and rust, which in turn do require dampness in order to exist. Smithson's terminology also runs into unclarities when it comes to his discussion of boundaries and the oceanic. In a way, Smithson belongs to the pre-meteorological era. I do not mean to suggest an absolute chronology, but in Smithson's writing there is an awareness of different modes, one of these being geological. He dismisses the damp when he touches upon climate and the mind's weather, and he cannot grasp the potential of meteorological temporalities.



Richardon's Forecast Factory (1922)



NASA Aerosol map



NASA Planetary Cloud Cover

2.2 THE DIGITAL CLOUD: FEVERISH ORIGINS

There is a curious relationship between early computing developments, digital archiving practices and the meteorological phenomena of wind and clouds. The origins of computing are often associated with military research and advances in warfare technology.[470] However, in an alternative narrative, the history of computing is closely linked to the planetary imaginary, as an archivist practice in what I call the meteorological mode. As I trace the cloud metaphor as a tool to translate the materiality, spatiality and temporality associated with the digital cloud, I draw on a proposal for an early data centre, radioactivity and its influence on network fever, and the cybernetic archive. These three topics feed into the meteorological mode of archiving, which is characterised by a state of becoming, actualisation and continuous updates.

This chapter encompasses three aspects that have informed the phenomenon of the digital cloud as archive. First, radioactivity and its repercussions in the spatial imagination are explored here via the first proposed databank in America. This evoked a passionate debate on the dangers of the computerized age, which was seen as potentially disastrous as the nuclear threat. Second is the somewhat twofold telos of the cybernetic archive, which was emptied out in favour of updates while also accumulating everything to maximise predictive accuracy. Third, this chapter gives a brief overview of network fever, for which the cloud can be understood as a cooling antidote. In order to integrate these three phenomena, I will draw on Diller Scofidio + Renfro's Blur Building, which can be understood as synthesising the cybernetic archive in a medialess medium that embodies the drama of weather and the archival drive of cybernetics in order to cool the network fever of the 1960s.

[470] See for example Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, Massachusetts: The MIT Press, 2015).

I will outline the qualities that are characteristic of digital archives: their accuracy, and the paradox between their centralised information storage, which is independent of the site of data production, and data retrieval, which they make possible from anywhere. The spatiality of meteorological clouds closely matches that of the idealised cybernetic archive. The roots of the digital cloud as an archival concept thus connect cybernetic archival fantasies with the spatiality of meteorological clouds. The digital cloud is entangled with meteorology, not only on a metaphorical level: there is a dense overlap of data voracity, continuous transfer, continuous modelling and updates, global connectivity and permeation. The kinds of spatial networks that were imagined or initiated for deterministic understandings and ultimately globe-spanning weather-forecasting practices in the 19th century contributed to the development of the earliest computers—the background against which the Advanced Research Projects Agency's (ARPA) computing networks were formed.

In the previous chapter, I showed that clouds on planet Earth are a phenomenon that is still unmappable, as it is exceedingly difficult to model or predict clouds accurately. Clouds visualise immense amounts of data—not all of which is known to scientists—that changes according to what other data it interacts with. As a planetary system, clouds are embedded in meteorological time, which is marked by phasing, cyclicity, recurrence and variation, flux and patterning. In this chapter, I turn to the relationship between the meteorological mode and the spatial imagination of digital archives, beginning with those of cybernetics. These were governed by two differing understandings of the cybernetic archive and its relationship to memory. Cybernetics enabled a shift in the understanding of the archive which permitted the meteorological mode to unfold—most importantly due to the black box, a never-fully-knowable, mobile archival object which brackets the *other* and makes it manageable *at a total remove*. I will show that the spatiality of meteorological clouds closely matches this idealised cybernetic archive.

In today's digital memory culture, the trend of externalising more and more information, knowledge and personal memories is symptomatic of a "database complex", which media theorist Lev Manovich characterises as "the irrational desire to store everything".[471] Storing an ever-increasing "everything" requires digital storage media with growing capacities. Paradoxically, these media come with decreasing lifespans. Floppy disks, DVDs and hard disks are all either already inaccessible to the layperson or in danger of becoming obsolete. New hope came with the digital cloud: an ostensibly boundless place rather than an object, able to perpetually gather ever more data. As I showed in the previous chapter, the storage abilities of the cloud are governed by transfer: data never stands still in today's digital archives. The wish to collect, and the continuous animation, might be understood as an echo that has gained autonomy, becoming increasingly independent of its sources in the cybernetic archive, which was driven by optimisation and prediction. The practice of accumulation is continuously adjusting, most notably with the shift in emphasis from information to data. The digital cloud is the result of network and archive fever; the meteorological analogies offer hope of cooling relief.

By tracing the spatialities associated with the origins of the digital cloud, I will provide a point of reference for designers to situate spatial concepts of nodal connectivity, the waning role of specific location, and the concept of spatial "bodies without surface" and without fixed forms, which all characterise the spatiality of the digital cloud. The cloud as today's digital archive metaphor has outgrown the approximation of any telos and the temporality of predictability. The cloud, and the affiliated gathering of *everything*, is an end in itself. Like the meteorological cloud, the imaginary digital cloud gathers data points on which it relies in order to manifest itself. It also simply reflects the world in its actuality as a digital representation, much as the meteorological cloud visualises vast numbers of parameters.

[471] Wendy Hui Kyong Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics* (Cambridge, MA: MIT Press, 2006), 46.

A Databank for Computerised Man

In 1966, in the heyday of cybernetics, never-realised plans for America's first centralised data centre were made public. The proposed federal archive was to gather together in one place digitised information on US citizens from various government agencies. The promise of unprecedented archival efficiency immediately caused strong unease and resulted in the creation of a special subcommittee on "the computer and invasion of privacy".[472] From 26 to 28 July 1966, the committee invited computer scientists, law professors, sociologists and state officials to a hearing on the proposed "National Data Centre" or "Data Bank". The speakers issued statements assessing the problem of privacy the centralised Data Bank would engender, besides its promise of economic benefits and improved organisation.

The controversy was perceived to play out between efficiency and privacy. Promoters of a national data centre stressed the need for "integrated information systems" and shared data flow "across departmental boundaries".[473] Advocating the national databank in order to keep better track of the government's substantial number of employees, John Macy, then chairman of the US Civil Service Commission and author of the article "Automated Government",[474] anticipated: "direct tape-to-tape feeding of data from one department to another may become common".[475] It was precisely this vision of direct digital information exchange between different departments that alarmed those investigating the computer's infringement of privacy. Unchecked digital information

[472] *The Computer and Invasion of Privacy: Hearings Report, Subcommittee of the Committee on Government Operations House of Representatives*, 89th congress, 2nd session (26 July 1966).
[473] *Computer and Invasion*, 37.
[474] John W. Macy Jnr, "Automated Government: How Computers Are Being Used in Washington to Streamline Personnel Administration—to the Individual's Benefit", *New Computerized Age*, 23 July 1966, 23–25, 70.
[475] Macy, "Automated Government", 25.

flow was apprehended as the cornerstone of looming authoritarian government, unchecked by human scrutiny.[476]

The computational force was seen as so potent that the potential for abuse was a serious threat. In his statement, computer scientist Burton Squires emphasised the awe-inspiring nature of the archival capacities of computers. He described the technological shift that had transformed the computer from "merely an arithmetic device" to an "automatic data processor".[477] A computerised archive would command immense information processing and storing capacities. Squires attempted to make the sheer immensity of the computer's archival capacities imaginable by using the comparison of "a typical 300-page book".[478] Such a book stores one million characters, while a piece of magnetic tape "packs information at a density of about 1½ million characters per cubic inch".[479] He infers that a building with storage space of 10,000 square feet by 10 feet in height "could conceivably store a book of information about every man, woman, and child in the United States".[480] This information could be read at more than 100,000 characters per second and be "transmitted along any given telephone line within a few minutes".[481]

Squires' description perfectly summarises the unprecedented potential for data storage and retrieval achievable by computer memory. While this accessibility scenario has become normality in today's information society, it caused serious unease just 50 years ago. The data centre would not produce data so much as organise and compile in one place all the information that would previously have been duplicated in several agencies, possibly been annotated somewhere, become outdated and got

[476] The protection of privacy could also be read against the background of the Cold War. For example, because of initiatives such as Executive Order 9835 (1947), the FBI screened government workers to weed out potential communist "infiltrators".
[477] *Computer and Invasion*, 136.
[478] *Computer and Invasion*, 136.
[479] *Computer and Invasion*, 136.
[480] *Computer and Invasion*, 136.
[481] *Computer and Invasion*, 136.

lost elsewhere. The fear was that making data coherent, ostensibly correct, irrefutable (because of its existence in only one place), up to date and available to all states would undermine the privacy-enhancing, loophole-enabling, *questionable* nature of data. Chairman Frank Horton summarises this point in his opening statement:

> Good computermen know that one of the most practical of our present safeguards of privacy is the fragmented nature of present information. It is scattered in little bits and pieces across the geography and years of our life. Retrieval is impractical and often impossible. A central data bank removes completely this safeguard.[482]

In other words, the prevailing *mess* was seen as the most efficient precaution against the creation of "Computerised Man", who in the words of Democratic representative Cornelius E. Gallagher "would be stripped of his individuality and privacy".[483] An archived person would lose her right to annotations or updates. Gallagher was horrified by the idea of momentous and statically assembled information on an individual "neatly bundled together into one compact package",[484] an easy target for information abuse. He opened the hearings with an outline of his apprehension of the Computerised Man whose societal status would be "measured by the computer",[485] resulting in a loss of human personal identity. Computerised Man's "life, his talent and his earning capacity would be reduced to a tape with very few alternatives available".[486] A computer's perfect memory, according to Gallagher, was opposed to the committee's "Judeo-Christian concept of 'forgive and forget'".[487] Today, computerised users of the cloud have mostly accepted the loss of privacy in favour of accessibility and the partially self-elected "tyranny of

[482] *Computer and Invasion*, 6.
[483] *Computer and Invasion*, 2.
[484] *Computer and Invasion*, 3.
[485] *Computer and Invasion*, 2.
[486] *Computer and Invasion*, 2.
[487] *Computer and Invasion*, 3.

convenience".[488] The scattering of information from different times in several places seemed to best represent the evolving biography of a person—one's fluctuating financial conditions, evolving character, changing social life and developing professional abilities. This idea of data dispersal conceptually persists in the archival *cloud*—the ultimate scattered space.

Not only would one's individuality be subjected to an archived representation, static and undisclosed to oneself, but it would also be accessible to any hypothetical enquirer from any imaginable (and connected) place, via a mere phone call. Thus, while all data was to be gathered in one location, access would be possible from anywhere. Vance Packard, author of *The Naked Society*,[489] a book on technology's invasion of privacy, warned the committee that beyond the data centre, the new networks of computers, such as the Advanced Research Projects Agency Network (ARPANET), represented the threat of accessibility. From these "giant systems", he said, "information can be either put in or retrieved from a number of different locations, including distant ones and even including telephoning information into the computer or calling and getting information by telephone out of the computer".[490] This dreaded scenario characterises today's computer omnipresence, which precipitates in the analogy of the digital cloud.

It may have been this omnipresence that prompted subcommittee chairman Frank Horton (who later introduced the Whistleblower Protection Act while a Republican congressman in 1987) to relate the data centre to the nuclear threat: "I have become convinced that the magnitude of the problem we now confront is akin to the changes wrought in our national life with the dawning of the nuclear age".[491] This drastic

488 Tim Wu, "The Tyranny of Convenience", *New York Times*, 20 February 2018, sec. Opinion, https://www.nytimes.com/2018/02/16/opinion/sunday/tyranny-convenience.html.
489 Vance Packard, *The Naked Society* (Philadelphia: David McKay Publications, 1964).
490 *Computer and Invasion*, 16–17.
491 *Computer and Invasion*, 5.

assessment is further developed in a later statement by computer scientist Burton Squires. He points out that despite the comparable gravity of both threats, the looming invasion of privacy is stealthier than the obvious destruction caused by an atomic bomb: digitising and centralising personal information "threatens to carry out a destructive mental process on a gradual, less perceptible scale, under the guise of causes that individually seem justified".[492] Squires' statement was made at a time when there was little concrete understanding of how accurately this gradual, imperceptible threat applied to radioactivity (and to the loss of privacy we are facing today[493]).

As Richard Miller shows in his book *Under the Cloud: The Decades of Nuclear Testing* (1991), there was little awareness of the devastating effects of fallout carried by clouds and winds all across the United States and beyond due to the bomb testing at the Nevada site, where more than 900 documented nuclear detonations were carried out between 1951 and 1992. Until 1963 these were mostly detonated above ground, resulting in the atmospheric release of over 12 billion curies between 1951 and 1963; for comparison, Chernobyl leaked an estimated 81 million curies of radioactive material.[494] Squires' and Horton's nuclear analogies to the invasion of privacy by digitalisation is in fact more accurate than they likely knew. The dispersal of radioactive fallout was supported by its unpredictable and unrelenting mobility via atmospheric, cloud-bound movement. Miller relates the various directions in which the explosion cloud of radioactive dust and smoke dispersed across the United States, based on the reports of the Atomic Energy Commission, who tracked fallout levels with a fleet of monitoring stations during the 1950s, creating

[492] *Computer and Invasion*, 136.
[493] See for example the reference to Cambridge Analytica in the introduction and Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics*.
[494] Keith Meyers, "Some Unintended Fallout from Defense Policy: Measuring the Effect of Atmospheric Nuclear Testing on American Mortality Patterns", Keith A. Meyers, last modified 16 June 2017, https://www.keithameyers.com/research/.

"an official record […] of the paths of many of these clouds and their associated fallout levels".[495]

Drawing on one of these reports, Miller traces the full extent of fallout following the firing of Upshot-Knothole Simon (with a yield of 43 kilotons, "the most powerful continental shot to date"[496]) at 4.30 am Pacific Standard Time on 25 April 1953. After the explosion, monitors measured the Simon cloud, a "stream of nuclear debris—300 roentgens/hour hot", roughly 130 kilometres wide, its tip reaching up to 13 kilometres above sea level. The Simon explosion cloud is best understood in terms of three levels, which each travelled according to the prevailing currents. As the cloud caught up with different winds at different altitudes, it left an enormous footprint across the continent. The cloud delivered fallout to southern Utah, South Dakota, and from Idaho all the way to Ohio, until more fallout rained down to cover "each square foot of Albany, New York"[497] during the night of 25 April, before the cloud left the country.[498] Apparently, some people tried to scrub the radiation off roofs and walls, but it "stuck like glue".[499] Low fallout values in cities closer to the Nevada Test Site, contrasting with the dense fallout in New York, suddenly made it "obvious that as far as fallout exposure was concerned, distance from the test site was of small importance. Towns and cities across the entire continent were at risk".[500] When Miller concludes that "every person alive during the 1950s and early 1960s lived under the atomic cloud",[501] this strongly resonates with the title of another statement from the *Computer and Invasion of Privacy* hearings. General David Sarnoff, then chairman of the board of the Radio Corp. of America, called his testimony "No Life Untouched".[502]

[495] Richard Lee Miller, *Under the Cloud: The Decades of Nuclear Testing* (Woodlands: Two Sixty Press, 1986), 8.
[496] Miller, *Under the Cloud*, 169.
[497] Miller, *Under the Cloud*, 170.
[498] Miller, *Under the Cloud*, 6–7.
[499] Miller, *Under the Cloud*, 170.
[500] Miller, *Under the Cloud*, 8.
[501] Miller, *Under the Cloud*, 9.
[502] *Computer and Invasion*, 289.

Computing and its invasion of privacy through digital archiving was correlated with the intangible, not fully understandable, not directly perceivable and often classified effects of radioactivity. Sometimes radioactivity appeared on Geiger counters by chance, in unexpected places. Eventually, its traces were found in the baby teeth of the nation.[503] Radioactivity exemplifies the meteorological mode: it is dispersed as tiny particles, born in an epic cloud, dispersed by the air. It merges with the wind and the rain to become part of the weather. Nuclear tests seemed necessary to protect the nation, yet they created an ever-present, ever-looming, stealthy creeping force that would strike when least expected—years later as cancer (uncanny growths held in check with more radiation), and miles away as "hot" puddles and tap water. The radioactivity released by a nuclear explosion radically changes its environment without being directly perceptible to humans. Only its effect can be perceived, not the radioactive force itself. Files that used to be distributed all over the country inside different government agencies, as tangible, physical files, were now to be on magnetic tape. These tapes were like today's server disks, decipherable only via a computer and interface—just as radioactivity levels are only legible on a Geiger counter. In the imagination of the assessment committee, there was a link between the not-directly-perceptible force of radioactivity and the not-quite-comprehensible power of computing. One

[503] Louise Zibold Reiss, "Strontium-90 Absorption by Deciduous Teeth", *Science* 134, no. 3491 (1961): 1669–73. An important factor in public opinion regarding nuclear tests was the "Baby Tooth Survey". This study linked the fallout from nuclear tests—precipitated as rain onto meadows and then consumed by milk cows—to strontium-90 levels in the teeth of children who consumed the milk. Preliminary results, published in 1961 in the journal *Science*, revealed that the later children were born in the 1950s, the more pronounced was the increase in strontium-90 levels in their teeth. A comprehensive later study revealed that the amount of strontium-90 in the teeth of children born after 1963 was 50 times higher than in babies born before large-scale atomic testing. These levels also correlated with cancer. The study coincided with nuclear weapons research on reduced fallout: the biggest bomb ever tested, the Tsar Bomba in 1961, proportionally generated the lowest levels of fallout. The United States Atomic Energy Commission eventually conceded that even low levels of radiation presented a health risk. In 1963, the Partial Nuclear Test Ban Treaty banned all above-ground nuclear weapons testing.

witness referred to the "blind force of the computerized age",[504] pointing on the one hand to the morally undiscriminating information processing power of the computer, and on the other hand to its invisible and impenetrable realm of action. Squires spoke of the need to contain this power of computerisation—to "put boundaries around" it, so that it would serve "rather than become a tyrant".[505]

Computers in 1966 were shrouded in a cloudlike incomprehensibility. Packard explained, "people are more frightened of things they cannot understand".[506] He related that despite having visited the IBM factory and having computing explained to him by many computer experts, he still could not confirm that he understood it, as "it is changing so rapidly and so swiftly".[507] This aspect of the unknown and the ever-changing incomprehensible foreshadowed the ever-transforming morphology of clouds that saturates the spatial imagination of today's digital archives. The apprehensive reception of the proposed databank delayed the digitisation and centralisation of the archive. In retrospect, it might have been interesting to develop the databank then, in such a critical climate, which might have ensured more stringent privacy protections such as those envisioned by Squires, which later, with the increased focus on convenience, were sidestepped.

Networks

While the Data Bank committee fiercely defended the privacy of Computerised Man, elsewhere in the USA, ARPANET—the Western world's precursor to the internet, and arguably a harbinger of the end of privacy full stop—was being knitted across a network of university facilities. The nuclear threat has also been conceptualised as a driving force of this network. In the 1960s, network fever—to use a term coined by

[504] *Computer and Invasion*, 15.
[505] *Computer and Invasion*, 14.
[506] *Computer and Invasion*, 15–16.
[507] *Computer and Invasion*, 15–16.

Mark Wigley—was born. In the following I will briefly introduce two relevant nodes of the network—ARPANET in computing, and the Delian network spun around Ekistics in architecture—which covered all disciplines as infectiously as did cybernetics. In this context, the cloud materialises as the ultimate culmination of network fever, as much as it also soothes the network delirium.

The agency intermittently known as ARPA and DARPA (Defense Advanced Research Projects Agency) was founded in 1958 by President Eisenhower. Created in the year following the launch of the Soviet Sputnik 1, the agency formed part of the American endeavour to remain at (or return to) the cutting edge of international technological and scientific advances—beyond military applications. ARPA's Information Processing Techniques Office (IPTO), founded in 1962, had several computing facilities scattered across the United States. These research centres usually specialised in different aspects of computing research, such as time sharing, artificial intelligence, graphics and supercomputing. The different sites' computers were adapted to the specific uses of the affiliated research facilities, and they used optimised input/output devices. Researchers interested in combining different modes of computing had to travel or purchase more machines. In response to the problem of physical inaccessibility, there was the idea of a network: to make the computers usable from anywhere in the network, so that "hardware, software, and data could be efficiently pooled among contractors".[508]

In addition to the financial and logistical benefits of an interactive computing network, Robert Taylor (1932–2017), IPTO's director from 1966, envisioned research "metacommunities". He therefore recruited engineer Lawrence Roberts to apply his research on a distributed packet switching system, for minimum transmission costs, maximum reliability, and possible application in resilient military communications systems: "the network would extend across the United States, matching the distribution

[508] Janet Abbate, *Inventing the Internet* (Cambridge, MA and London: MIT Press, 2000), 44.

of ARPA sites. It would link time sharing computers to support both remote terminal access to distant computers and high-volume data transfers between computers".[509] Thus ARPANET was built, implementing early packet switching and the protocol suite TCP/IP—both of which now form the technical backbone of the internet.

Even though the link between nuclear warfare and ARPANET—a connection that was originally deduced from a paper published by Baran in 1960—was dissipated, the analogy persists, maintaining "in the popular imagination […] a digital cloud shaped like the elegant mesh of Baran's diagram".[510] Hu thus asks, "if the Internet never had this nuclear-proof shape, then why do scholars continually tell or write this idea back into existence?"[511] He suggests that the cloud is "as much a cultural fantasy as a technological specification: in some sense, the cloud is its fevers".[512] If protecting a country from complete standstill during nuclear war was not the main reason for the notion of the network, the persistence of the analogy might be explained not so much by nuclear *warfare* as by the nature of radioactivity, which loomed large over the spatial imagination during the Cold War.

Radioactivity significantly evolved in the public understanding during the 1950s and 1960s. When the Nevada Test Site was chosen because of its stable weather and low population, officials thought that the locals were safe and that any nuclear debris could be washed off: "if people were

[509] Orit Halpern, *Beautiful Data: A History of Vision and Reason Since 1945* (Durham, NC and London: Duke University Press, 2014), loc. 383–384, Kindle. Halpern goes on to point out that "much of our contemporary thinking about ubiquitous computing and smart cities in urban planning emanated from Nicholas Negroponte's Architecture Machine Group, which was started in 1967 at MIT with funding from major corporations and the Cybernetics Technology Division of the Advanced Research Projects Agency (ARPA, after 1972 DARPA), of the U.S. Department of Defense for the purposes of integrating computers into architecture and urban planning". Halpern, *Beautiful Data*, loc. 383–384.
[510] Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2015), loc. 9–10, Kindle.
[511] Hu, *Prehistory*, loc. 9–10.
[512] Hu, *Prehistory*, loc. 97.

exposed they could take showers".[513] I have shown that as early as 1953, it became clear that radiation could not be "scrubbed off". Even if radioactivity could be showered off, it would persist in the run-off water, dispersing further through the groundwater. Radioactivity permeated the planet, as it travelled with the winds in clouds across borders and for unpredictable time spans. By 1961, "milk tooth" research had shown that radioactivity permeated everything and everyone. It is not only sticky, but also infiltrates the geology of human bodies.

If, as Hu writes, "the network is […] primarily the idea that 'everything is connected'",[514] then radioactivity is the ultimate network-creating force. To appropriate the terminology of Paul Baran's genealogy of networks, radioactivity creates the ultimate "distributed network".[515] These networks are like the meteorological currents that disperse them: planetary, inexorable, not fully graspable in their immensity, and persistent.[516] In their immensity and constant flux, they are like cyberspace, unmappable. They exemplify the meteorological mode that permeates the digital cloud. The connection explains the nuclear analogies drawn with the first databank and later with the origins of the internet.

The radioactive debris produced in the mushroom cloud never gets lost, just dispersed. To understand radioactive material as archival particles that document the explosion from which they originated is to postulate the radioactive cloud as a mobile archive that disperses its—in human timescales—near-eternal data for maximum presence across the globe. As such, the nuclear bomb is permeated with the networked archive *fever*[517]

[513] "Nuclear Nevada", National Endowment for the Humanities, **31 July 2011,** https://www.neh.gov/news/nuclear-nevada.
[514] Hu, *Prehistory*, loc. 10.
[515] Paul Baran, *On Distributed Communications Networks* (Santa Monica, CA: RAND Corporation, 1962), https://www.rand.org/pubs/papers/P2626.html.
[516] See also Morton, *Hyperobjects : Philosophy and Ecology after the End of the World.*
[517] Mark Wigley, 'Network Fever', *Grey Room*, no. 04 (Summer 2001): 82–122. And Derrida, 'Archive Fever: A Freudian Impression'.

that also drives today's database complex. It is closely linked to the network fever of the 1960s and 1970s, which never quite subsided:

> Network fever is the desire to connect all networks, indeed, the desire to connect every piece of information to another piece. And to construct a system of knowledge where everything is connected is, as psychoanalysis tells us, the sign of paranoia. In other words, network fever cannot be separated from the network, because the network is its fever. The cloudlike nature of the network has much less to do with its structural or technological properties than the way that we perceive and understand it; seen properly, the cloud resides within us.[518]

Mark Wigley explores network fever among a group loosely assembled by Greek architect and urban planner Constantinos Doxiadis (1913–1975) on boat trips, in meetings modelled on the International Congresses of Modern Architecture, and in his journal *Ekistics*.[519] In the best case, network fever is the desire to create connections in favour of an all-inclusive, all-embracing, omnipresent togetherness. At worst, it is like the web spun by a spider that had been drugged with amphetamines—an image instrumentalised by Doxiadis in 1972 to offset his own geometrically neat urban planning networks. Wigley remarks, "at this point, network fever had him firmly in its grip".[520] Network thinking is all-encompassing. Since the 18th century, the body has been understood as a network of veins, muscles and nerves. Sine the 19th century, the world has been described as networked "systems of rivers, canals, railways, cables, electricity, sewers, etc".[521] On the next level, the network extends from the

[518] Hu, *Prehistory*, loc. 682.
[519] "Doxiadis launched the field of 'Ekistics' in the mid-fifties and founded the Athens Technological Institute in 1958 as a research centre and architecture school based on the idea of global statistics. The idea was to think at the largest possible scale by domesticating vast amounts of global information. If the data could be controlled, cities could be controlled". Mark Wigley, "Network Fever", *Grey Room*, 4 (2001): 87.
[520] Wigley, "Network Fever", 94.
[521] Wigley, "Network Fever", 94.

human body, to encompass the immaterial of media and politics. The network architect thus connects the human body network with the world network. Doxiadis took his role as designer of networks very seriously: "the architect is seen as a networked animal that networks networks that are themselves animate. In extending the body, networks have to extend its organic logic".[522] He was dedicated to a global[523] network of networks: "we must coordinate all of our Networks now. All networks, from roads to telephones".[524] Resonating with the earlier discussion of cybernetics, network thinking in architecture is infectious. It is an important prequel to the logic and narrative of today's digital cloud.

Doxiadis' network of network thinkers was kicked off on an eight-day journey aboard the New Hellas around the Greek islands in July 1963. This trip included Buckminster Fuller and Marshall McLuhan, whose "influential discourse about networks during the sixties was exactly paralleled by that of experimental architects during the same years".[525] They immediately bonded over technology as an extension of humankind via networks.[526] Architect Kenzo Tange was also a "major accelerant of the fever".[527] Like Doxiadis, he thought of cities as technological-biological organisms. Influenced by cybernetics and the strong focus on communication, he saw the media of the "information revolution"—the telegraph, telephone, radio and computer—as a turning point in the prosthetic extension of the nervous system into cities and the world:[528] "in large contemporary urban complexes, communications networks twist and interlink into a complex which must be something like the nervous

522 Wigley, "Network Fever", 94.
523 Doxiadis was a global architect. His firm, established in 1951, had branched out onto "every continent" (not including Antarctica) by 1961. See Wigley, "Network Fever", 87.
524 Wigley, "Network Fever", 94.
525 Wigley, "Network Fever", 112.
526 See Wigley, 121. He quotes Fuller: "All the tools are externalizations of originally integral functions of humans". From Buckminster Fuller, "Letter to Doxiadis", *Main Currents in Modern Thought* 25 (1969): 87–97.
527 Wigley, "Network Fever", 104. He was a passenger on the fourth Delos boat trip, in 1966.
528 Wigley, "Network Fever", 104.

system of the brain. […] Whirling around in these brains are the people and the information".[529] In July 1961, Doxiadis' journal *Ekistics* had published Tange's Tokyo Bay project of 1960, which was "tied together by the invisible cords of a communication system".[530]

In line with Tange and Doxiadis, Fuller dreamed of a "one world town", but his vision of unity was more autonomous, less embedded:[531] "everything in it is mobile and physically disconnected. Buildings are dropped by airplane, have autonomous service systems of plumbing and electricity, and are only interconnected by invisible air and radio links".[532] Fuller's "Instant City!" and "Cloud 9" projects were hypermobile, unhindered by physical connection, more dispersed than a distributed network; in them, "technologically upgraded and endlessly circulating bodies [were] the new spaces".[533] The ability "to disconnect from a system was as important as the capacity to connect".[534] Fuller's understanding of the network thus resembles a cloud more than it does the literal clusters based on actual lines, cords, streets, tentacles, telephone lines, electricity cables etc.

Like Richardson, who wrote mathematical formulas for the weather and for world peace, Fuller was a forecaster. He characterised himself as "practically experienced in the powerfully effective forecasting arts of celestial navigation, pilotage, ballistics, and logistics, and in the long-range, anticipatory, design science".[535] Concerned with "the direction in which all humanity is trending",[536] his future-oriented prognostics connect him to the meteorological mode. McLuhan and Fuller fuelled each other in

529 Wigley, "Network Fever", 104.
530 Wigley, "Network Fever", 104–5.
531 The fundamental difference between his thinking and Dioxides' was that he questioned the very concept and necessity of settlement, the starting point of the Delos events and Dioxides' primary architectural concern. See also Wigley, "Network Fever".
532 Wigley, "Network Fever", 112–13.
533 Wigley, "Network Fever", 112–13.
534 Wigley, "Network Fever", 112–13.
535 Fuller, *Operating Manual for Spaceship Earth*, 2.
536 Fuller, 2.

exploring Fuller's rejection of "physical infrastructure, no matter how flexible, preferring atomized nomadic systems".[537] Fuller's habitation model to "accommodate human unsettlement" advocated a "global physical instability"[538] enabled by immaterial and invisible networks.

Fuller's interest in the ephemeral, the hypermobile and the ever-adjusting connects him to John Ruskin and his devotion to clouds and cloud space. Ruskin "defined a cloud as a mixture of something and nothing".[539] Similarly, by going beyond the physical network, Fuller described the meteorological spatiality of new media—the spatiality of the meteorological mode. Fuller and Ruskin evoke meteorological space, the study of which necessitated the "first world wide web".[540] Meteorological networks are tied to the data voracity of weather forecasts. John Ruskin famously emphasised the importance of "nonlocal coordination"[541] in 1839, while addressing the Meteorological Society of London: "the meteorologist is impotent if alone; his observations are useless; for they are made upon a point, while the speculations to be derived from them must be on space".[542] Ruskin understood the Meteorological Society as a truly global, transnational enterprise commanding "a vast machine" of myriad "simultaneous observations" of the planet's weather conditions. For maximum impact, this vast machine "wishes its influence and its power to be omnipresent over the globe so that it may be able to know,

[537] Wigley, "Network Fever", 112–13.
[538] Wigley, 114.
[539] To Durham Peters this serves as a definition of "media" John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: University of Chicago Press, 2015), 259.
[540] See Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA and London: MIT Press, 2010). See also Durham Peters, *Marvelous Clouds*, 252.
[541] Durham Peters, *Marvelous Clouds*, 251.
[542] "Remarks on the Present State of Meteorological Science", *Transactions of the Meteorological Society*, vol. 1 (London: Smith, Elder, and Co., 1839), 57, 59. See also John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: The University of Chicago Press, 2015). And Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming.*

at any given instant, the state of the atmosphere on every point on its surface".[543]

Ruskin's statement resonates with descriptions of today's digital cloud: simultaneity, omnipresence, immediacy, instantaneity. His conceptualisation of a global weather-documenting and weather-generating network inspired Paul N. Edwards' *A Vast Machine* (2010). Edwards traces weather forecasting as the first worldwide web, "a global network for the exchange of data, not only in creating a genuinely global project, but also in terms of computer technology".[544] Durham Peters links the emergent global-network imaginary to media, explaining that Ruskin's "dream of global omnipresence awaited […] the telegraph",[545] a prerequisite for the network fever of the 1960s architectural avant-garde. The origin of the digital cloud can be proposed as "a public computing resource"[546] to meet weather forecasting's "insatiable appetite for data".[547] Durham Peters thus links computing, the atomic bomb and meteorology: "next to simulating nuclear explosions, meteorology is the most important motive in the rise of supercomputing. John von Neumann, a mastermind of the postwar computing infrastructure, is well known for designing computers to model the bomb and its effects, but he was an equally fierce advocate of computational meteorology".[548] The digital cloud has been conditioned by generative catalysts, creating networks of networks—be they meteorological or cybernetic—and the all-pervasive radioactivity of the 1950s and 1960s. The meteorological mode encompasses their global, ubiquitous and expansive omnipresence.

543 "Remarks on the Present State of Meteorological Science", *Transactions of the Meteorological Society*, vol. 1 (London: Smith, Elder, and Co., 1839), 57, 59.
544 Durham Peters, *Marvelous Clouds*, 252.
545 Durham Peters, *Marvelous Clouds*, 252.
546 Durham Peters, *Marvelous Clouds*, 252.
547 Durham Peters, *Marvelous Clouds*, 252.
548 Durham Peters, *Marvelous Clouds*, 252.

Cybernetic Archives: Void versus Accumulation

There is a continuous narrative that connects computing and the meteorological. A century after Babbage's air-computing fantasies, Project Whirlwind I was launched in 1944. The Office of Naval Research approached the Massachusetts Institute of Technology's Servomechanisms Laboratory and requested the development of a universal flight trainer that would simulate flight:[549] "the initial intention was to build a machine for simulating the behaviour of large aircraft, based on data derived from wind tunnel tests, and to provide an associated cockpit in which a test pilot could evaluate aircraft behaviour".[550] In the process of developing this programme, the team, led by Jay Forrester (1918–2016), developed random access memory on a three-dimensional array of magnetic cores, and realised the first digital computer capable of operating in real time. The computer was understood as a "research facility"[551] comparable to "a wind tunnel or a nuclear particle accelerator".[552] Like the analogue computers that modelled environmental conditions, discussed in section 2.1, this computer was comparable to a laboratory or a (wind) tunnel. It simulated, but it was also the space of simulation. In the 1950s, Whirlwind led to Sage, a real-time, radar-based computer network designed as an "early-warning system for incoming nuclear missiles".[553] Hu identifies Sage as one of the "all-but-forgotten

[549] "Historical Note", Guide to the Project Whirlwind Collection, MIT Libraries, accessed 17 September 2018, http://libraries.mit.edu/archives/research/collections/collections-mc/mc665.html#ref152.
[550] Jay W. Forrester, "Discussion of the Comments on Project Whirlwind Made by the Ad Hoc Panel on Electronic Digital Computers of the Basic Physical Science Committee of the Research and Development Board", MIT Servomechanisms Laboratory, 13 January 1950, 11, https://dome.mit.edu/bitstream/handle/1721.3/45948/MC665_r28_L-16.pdf?sequence=1.
[551] Forrester, "Discussion", 16.
[552] Forrester, "Discussion", 16.
[553] "Project Whirlwind", MIT Museum, last updated 9 December 2011, http://museum.mit.edu/150/21. See also Hu, *Prehistory*, loc. 195.

infrastructures that undergird the cloud's physical origins" in his *Prehistory of the Cloud*, which focusses on the relationship between the cloud and the military.[554]

Rather than in military connections, I see the origins of the digital cloud in the spatial behaviour of radioactivity and in the philosophy of cybernetics. Just as Geoffrey Bowker explores how modes of scientific practice were projected directly onto nature,[555] I argue that our perception of the planet enables certain archival imaginaries. The cybernetic perception, which is tied to cybernetics' quest to seek out information flow, influenced the meteorological mode. Cybernetics was omnipresent and infiltrated all sciences in its mission to rework "human history—and even the history of the universe".[556] Cybernetics was *in the air*: "the cybernetic revolution [could] be found 'in the air'. This banal image 'in the air' is in fact profound: the idea was everywhere invisibly present, such that the spark of a book [Wiener's] set off the conflagration".[557]

Cybernetics was not only *in* the air, it also behaved *like* air, spreading unchecked with global currents and manifesting anywhere, ephemerally, like clouds that condensate on archival data points. This scientific approach has its roots in a project that, like Whirlwind I and Sage, quite literally revolves around objects suspended in the air. It famously began with Norbert Wiener's research during World War II on an anti-aircraft predictor to help ground-based arms technology to anticipate the trajectory of an (enemy) aeroplane.[558] The objective was to take meteorological conditions into account as much as the behaviour of

554 Hu, *Prehistory*, loc. 195.
555 For example, when Lyell used capitalist double-entry bookkeeping as a way of understanding planetary evolution. See also Geoffrey C. Bowker, *Memory Practices in the Sciences* (Cambridge, MA and London: MIT Press, 2005), loc. 1300–1301, Kindle.
556 Bowker, *Memory Practices*, loc. 1487–1488.
557 Bowker, *Memory Practices*, loc. 1482–1484. Original: P. de Latil., *La pensée artificielle* [compte-rendu] Revue d'histoire des sciences Année 1954 7-2 p. 196
558 Rosenblueth, Wiener and Bigelow's research on the "antiaircraft predictor" was published the seminal article "Behavior, Purpose and Teleology" in 1943. The article is known as the first published formulation of cybernetics.

enemy pilots. While the spatiality of the experiment related to air in terms of movement in all directions, unhindered by obstacles or gravity, the temporality of the research revolved around predictability. Due to the fact that it would take roughly 20 seconds for a missile shot from the ground to reach the aeroplane, the project was about anticipating an unknown enemy *other*'s decisions. Wiener and his team never managed to predict more than one second into the future, yet the research, as I will show, had profound consequences for the imagination of archival spaces.

Cybernetics is "the science of feedback—how information can help self-regulate a system",[559] whether that system is organic or technical. Sociologist Andrew Pickering defines cybernetics as an ontology of becoming based on the premise that the universe is composed of feedback loops of information. Feedback denotes "the property of being able to adjust future conduct by past performance".[560] Negative feedback is the corrective response to an input signal. In the case of the anti-aircraft predictor, if "a missile seeking a target swings afar and misses", it will correct "its flight path in response to the signal given from its target". Theorist Orit Halpern summarises: "negative feedback assumes that both entities are in relationship to each other, are both communicating, and are both changing their behaviours in relation to the other".[561] Negative feedback thus integrates continuous updates about an entity on a trajectory of ever-adjusting or "optimising" behaviour.

Norbert Wiener, Julian Bigelow and technician Paul Mooney devised a flight simulator that consisted of a moving projector and a lever coupled to a second projector and trace recorders. Pilots were asked to chase a moving point of light projected onto the wall and ceiling. The gear stick—the first steering wheel of the cyberneticians—was used to chase the point

559 Clive Thompson, "'Dark Hero of the Information Age': The Original Computer Geek", *New York Times*, 20 March 2005, sec. Sunday Book Review, https://www.nytimes.com/2005/03/20/books/review/dark-hero-of-the-information-age-the-original-computer-geek.html.
560 Wiener quoted in Halpern, *Beautiful Data*, loc. 1041–1048.
561 Halpern, *Beautiful Data*, loc. 1041–1048.

by indirectly imitating the movements of the projector, thus approaching the light source in a process of negative feedback. The act of tracing or chasing has connotations of the labyrinth, which can only be solved and represented by retracing (reconstructing) its outline. Through trial and error, the pilots approximate the original route. This reconstructive approximation bears strong similarities to the understanding of memory as a reconstructive process. The often-recited "space becomes time" in the age of cybernetics finds confirmation here, in this simulation of a negative feedback target chase, where space becomes the abstract context for two graphs that approximate real time—the origin and the reconstruction.

The anti-aircraft research combined Wiener's understanding of information, such as aeroplane models and weather conditions, with the unknowable "other", in this case the enemy pilot. The latter was framed as a black box. The concept of the black box was a way of negotiating or circumnavigating the unknown. The black box is technically rooted in a radar instrument, and epistemologically in a rationalised conception of the enemy. The magnetron was a World War II device which emitted microwaves that reflected off a target and could thus generate a radar map. It was usually encased in opaque copper housing. As a source of warfare information, it needed to remain inaccessible to the enemy, so magnetrons were commonly equipped with self-destruct mechanisms. Black boxes thus posed the challenge of analysis without access to their interior. This concept—a mechanism that could only reveal information in terms of its input and output, and not in regard to how it generated them—extended the black box from describing the enemy pilot to describing the pilot in general, which allowed Wiener to conceptualise "the pilot-plane assembly as a complex machine—a servomechanism—that once characterized could be simulated in order to predict what it would do".[562]

[562] http://www.cabinetmagazine.org/issues/12/najafi2.php

Cybernetic philosophy was thus "premised on the opacity of the Other",[563] which signified a fundamental paradigm shift in the approach to knowledge itself. In his study of the black box, media theorist Alexander Galloway emphasises this transformation:

> Cybernetics put in place a new black-box epistemology in which the decades if not centuries old traditions of critical inquiry, in which objects were unveiled or denaturalized to reveal their inner workings—from Descartes's treatise on method to both the Kantian and Marxian concepts of critique to the Freudian plumbing of the ego—was replaced by a new approach to knowledge, one that abdicated any requirement for penetration into the object in question, preferring instead to keep the object opaque and to make all judgements based on the object's observable comportment.[564]

Disclosure was thus uncoupled from access. The "black-box epistemology" allows the unknown to remain inaccessible without obfuscating the production of data about that unknown. In Halpern's words, "Wiener dreamed of a world where there is no 'unknown' left to discover, only an accumulation of records that must be recombined, analysed, and processed".[565] Even while the unknown remained unknowable, it would still produce assessable and accessible data. Accessibility became secondary to inferences based on observation at a distance. The idea of the black box also released its subjects of enquiry from *context*. Since the black box is by definition portable, part of its defining premise is that it might fall into the *wrong territory*. A black-box problem is therefore analysed independently of its origin: "behind the black box is the concept of a world that can be remade into exportable processes that point away from their initial sites of inception".[566] This

563 Galloway, *The Interface Effect*, 243.
564 Galloway, 'Black Box, Black Bloc', 243.
565 Alexander R. Galloway, *The Interface Effect* (Cambridge and Maden, MA: Polity Press, 2012), 241–242.
566 Halpern, *Beautiful Data*, loc. 1041–1048.

points to a fundamental spatial condition of data centres—which in their spatial anonymity might just as well be locationless for their users—and to the cloud metaphor as ever in transit. The cybernetic black box contributed to the spatial imagination of a locationless archive, where the "sites of inception" and of data storage or retrieval are irrelevant.

The unknowable became even more removed from the "here and now" as the focus shifted to predicting the black box's future behaviour. Not only was the environment mobilised as a territory of warfare, as with the gas cloud (see section 2.1), but so was the enemy's future. Thinking in terms of black boxes had extensive consequences: the world came to consist "of black-boxed entities whose behaviour or signals were intelligible to each other, but whose internal function or structure was opaque, and not of interest. We can say that this view of the world concentrated on process, not structure or difference".[567] The cybernetic temporality is one of back and forth, of approximation, alignment, chase and prediction. This temporality articulates a departure from the geological mode, which continuously archives the traces of change. The cybernetic temporality, which was characteristic of the meteorological mode, manifested quivering approximation, processual optimisation, and tentative and reversible trials, rather than definitive, finite strides.

There are two somewhat contradictory readings of the cybernetic archive, which on the one hand was emptied out in favour of updates, and on the other was filled with everything in order to maximise predictive accuracy. For example, Geoffrey Bowker stresses the notion of progress in his description of the cybernetic archive—an empty archive. Memory is made redundant by updates in the behavioural code that bring the organism closer and closer to optimum functioning. He writes: "the destruction of memory is the temporal extension of the central notion of feedback".[568] A teleological organism is caught in an ever-emergent negative feedback loop, and in Bowker's words, "neither the temporality of the Now nor

[567] Halpern, *Beautiful Data*, loc. 1027–1034.
[568] Bowker, *Memory Practices*, loc. 1600–1601.

that of the Eternal needed any history, any specific memory".[569] Bowker emphasises the "destruction of memory"[570] and distinguishes between "past knowledge",[571] which became integrated into updated behaviour, and "a conscious holding of the past in mind",[572] which became redundant. For example, a dog that has been run over by a car does not need to remember the particular accident, as long as it has adopted cautious behaviour around cars as a consequence.[573] The negative feedback loop as a suspended state of emergence: as an ever-ongoing approximation that updates rather than accumulates, thereby encompassing a temporality of the ever-adjusting now—a loss of duration.[574] With its profound reformulation of memory, cybernetics thus changed the notion of archiving.

The cybernetic archive is related to "past knowledge" as much as it is a repository for prediction. Cybernetics was concerned with a future-oriented temporality of prediction, with a focus on the probability of actuality. In *Beautiful Data* (2015), Orit Halpern describes the cybernetic archive as a tool for predicting behaviour. She relates developments in psychology (Freud), philosophy (Bergson) and computing, which all pointed towards an externalisation process in mnemonic practices.[575] It has been argued that this externalisation was closely linked to developing technological media. Freud's "mystic writing pad", the camera, and the age of mechanical reproduction all contributed to the expectation that memory should be accessible. Symptomatic was Freud's effort to lay open even the most repressed memories, non-chronologically. Expectations of full disclosure and all-encompassing storage were reflected in an "an

[569] Bowker, *Memory Practices*, loc. 1311–1313.
[570] Bowker, *Memory Practices*, loc. 1576–1586.
[571] Bowker, *Memory Practices*, loc. 1576–1586.
[572] Bowker, *Memory Practices*, loc. 1576–1586.
[573] Bowker, *Memory Practices*, loc. 1576–1586.
[574] Bowker, *Memory Practices*, loc. 1581–1585.
[575] "Friedrich Kittler has already suggested that this was, indeed, the initial effect of psychoanalysis: the externalization of the psyche and its incorporation into larger discursive networks". Halpern, *Beautiful Data*, loc. 1543–1547.

obsession with the minute, unimportant, and indiscriminately recorded, which characterized the nascent media technologies of the time".[576]

Psyche and memory had become "technical projects".[577] Memory became increasingly interesting to cyberneticians, not so much as a site of storage but as a site of processing. Memory had to both gather *everything* without discrimination and simultaneously to process and filter the masses of data in order to convey legible insight and prevent its drowning in noise. These tasks clash, as they are mutually exclusive. The two conflicting tasks mirror Freud's dual interest in maximum accumulation[578] and its simultaneous "total representation"[579] or cataloguing. As a temporally non-hierarchical realm, "memory records everything", like a "vast storehouse of contents and processes that are immune to the corrosive effects of temporality".[580] In Halpern's account, Wiener somewhat obsessively archived his own life and had much interest in Freudian concepts of memory.[581] Cybernetics is situated at the hinge between a kind of geological temporality of amassing information and what I call the meteorological—the fluid, cyclical, pattern-based, ephemeral and "obsessive interest in prediction, the future, and the virtual".[582]

It was accepted that analysing this unfiltered mnemonic repository was an impossible aspiration. To mediate, consciousness was introduced as an interface: "consciousness was the filter, the translation zone, that allowed the organism to function and produced a teleological and functional temporality—a temporality not of infinitude and flow but of marked

[576] Halpern, *Beautiful Data*, loc. 1543–1547.
[577] Halpern, *Beautiful Data*, chap. 1
[578] Halpern, *Beautiful Data*, loc. 1564–1575.
[579] Halpern, *Beautiful Data*, loc. 1564–1575.
[580] Halpern, *Beautiful Data*, loc. 1564–1575.
[581] "Wiener almost appeared to anticipate his future popularity. His archive at MIT is a fascinating exemplar of a life turned into data. Carefully curated, every letter mimeographed and saved, it is as though Wiener was already preparing his life for transmission, assuming a seamless translation between personal experience and historical analysis". Halpern, *Beautiful Data*, loc. 929–931.
[582] Halpern, *Beautiful Data*, loc. 970–975.

events and history". Whereas psychoanalysis still attempted to reach the black-boxed unconscious realm or memory archive beyond the filter, cybernetics shifted its focus to accumulation and its instrumentalisation in prediction, without requiring or seeking direct access to memory: "Wiener fundamentally sought to displace these questions by problematizing accumulation and not memory's inaccessibility and representability".[583] The cybernetic thus starkly contrasted with the psychoanalytical: "we are truly, in this view of the world, like black boxes with inputs and outputs and no access to our or anyone else's inner life".[584]

The unconscious, which can be understood as an analogy for the imagination of the cybernetic archive (see also "The Great Non-Conscious", section 2.3), was understood as an externalised space. Although it is hypothetically accessible, it is better not to enter this realm directly, as its content would be overwhelming. Consciousness—a kind of meta-interface—filters the data from the (temporally) three-dimensional mnemonic realm and arranges it on a temporally situating *filtering plane* for access, translation and patterning. In Halpern's words, "consciousness was simply the visible and articulatable residue or symptom of this memory; a memory that is now 'out there' and outside of representation but whose excesses of information could overwhelm and incapacitate the subject".[585] Halpern ascribes the unconscious to an "out there", which I will turn to again in my description of the externalisation of digital archive sin the next chapter. In summary, the kind of space the cybernetic archive required would allow all data to be at once accessible and filtered through a patterning screen. The hypothetical space for the ideal cybernetic archive would arrange data in a way that created no chronologies or temporal hierarchies. As in psychotherapy, *all* memories/data would be valuable and accessible.

583 Halpern, *Beautiful Data*, loc. 1570. .
584 Galloway, 'Black Box, Black Bloc', 243.
585 Halpern, *Beautiful Data*, loc. 1568–1570.

Freud's notion of "the past as an unconscious reservoir of stored stimuli"[586] contrasted with his contemporary Henri Bergson's idea of "becoming".[587] Whereas Freud was interested in a temporality akin to Lyell's *deep time*, Bergson's temporality of memory was fluid, asynchronous and future-oriented: Bergson "always combined the memory of an event with its future, producing possibility out of the synaptic, or embodied space, that merges historical temporality and sensation with its processing and response".[588] Halpern shows that Bergson and Wiener overlapped in their interest in a temporality that "had become probabilistic and synchronous—inexorably linking the past with future potentials through an inaccessible and mediated present".[589] Both were concerned with "how one might remember, recall, and distinguish moments of experiential meaning from an endless flow of stimuli".[590] Memory as a static site of accumulation versus a dynamic space of reassembly, reconfiguration, processing and *becoming* sums up the two differing approaches, which created a tension over mnemonics during the beginnings of cybernetics. Wiener's approach finds a specifically Bergsonian "vitalist" temporality embodied in feedback systems: "a temporality that is nonreversible and probabilistic",[591] but not by default progressive.

In Henri Bergson's *Matter and Memory* (1896), the body, "an instrument of action",[592] is understood as an image suspended in a web of lines that link back to the central body image like rays.[593] The body perceives other object-images, animated by quivers transmitted along these (nerve) lines. Perception is a kind of exercise of the imagination: the perceiving body imagines virtual actions evokes by the perceived images. Perception,

586 Halpern, *Beautiful Data*, loc. 1217–1219.
587 Halpern, *Beautiful Data*, loc. 1217–1219.
588 Halpern, *Beautiful Data*, loc. 1199.
589 Halpern, *Beautiful Data*, loc. 1201–1205.
590 Halpern, *Beautiful Data*, loc. 1217–1219.
591 Halpern, *Beautiful Data*, loc. 1125–1131.
592 Henri Bergson, *Matter and Memory*, 8th ed. (New York: Zone Books, 2005), 225.
593 Bergson is thus in my understanding linked to John Muir, who also perceived the world as a web of gently quivering lines, connecting, interweaving and animating the world and its perceivers, like electrical, musical or nerve cords (see section 1.3).

which is always linked to memory, is animation and virtual action. As the present is continuously turning into the past, perception is an activity of the past. Ernst embeds Bergson's "media aware" philosophy in the context of the technologising of the "dramaturgy of time" with the onset of new media: "Henri Bergson's reflections on the duration, compression, and stretching of time […] culminate in the argument that perception is a function of time itself".[594] Memory, on the other hand, is a "progression from the past to the present". It can be understood as an actualisation of virtual images, as it comes into being across a number of actualising planes: "we start from a 'virtual state' which we lead onwards, step by step, through a series of different planes of consciousness, up to the goal where it is materialized in an actual perception; that is to say, up to the point where it becomes a present, active state—up to that extreme plane of our consciousness".[595]

The planes are situated loosely between the plane of action—the domain of one's body—and the most virtual plane of pure memory. The planes are ever-shifting and transforming as the intellect continuously moves between them, accessing and building new planes:

> We can discover thousands of different planes of consciousness, a thousand integral and yet diverse repetitions of the whole of the experience through which we have lived. To complete a recollection by more personal details does not at all consist in mechanically juxtaposing other recollections to this, but in transporting ourselves to a wider plane of consciousness, in going away from action in the direction of dream.[596]

Bergson's language—loose and evocative—lends itself to describing cyberspace, which to the average user (one who is not writing or reading

[594] Wolfgang Ernst, *Digital Memory and the Archive*, ed. Jussi Parikka (Minneapolis and London: University of Minnesota Press, 2013), loc. 50, Kindle.
[595] Bergson, *Matter and Memory*, 239–240.
[596] Bergson, *Matter and Memory*, 241.

code) consists of images. Bergson's writing hovers between fantasies of the network and the cloud. A productive way of thinking of his "images" (movement-images, as Deleuze calls them) is in terms of data points—or aerosols—moving in unison, merging in chemical reactions, separating through mechanical friction, dissolving, serving as nuclei, precipitating as rain, rising as dust etc. There is no end and no beginning to the meteorological temporality; there are phases of virtual potential and stages of actualisation.

Bergson's perceptive apparatus, which consists of *flat* images, becomes particularly interesting in relation to the consciousness interface and externalisation. While "perception is theoretically lodged within the real, within the referent, and is external to the subject",[597] it remains inaccessible, because it is always immediately moved to the realm of past, interlaced with memory. In *actual* perception, he writes "memory intervenes" and "our consciousness, which begins by being only memory, prolongs a plurality of moments into each other, contracting them into a single intuition".[598] *Outside reality* can never be directly *accessed* or perceived. It can only be negotiated via memory, which actively produces the present and future. The *real* in Bergson is closely linked to Wiener's (and Freud's) understanding of the overwhelming amount of *data* that constitutes the world. Whether because of Bergson's understanding of inaccessibility or because of the inherent uselessness and noise that too much data entails, this constitutes the realm of an inaccessible *outside*, which I will develop in more detail in my discussion of the Great Outdoors in section 2.3.

The cloud is also an "operative" outside. Like the Bergsonian "real", it is composed of memory "images" or data that we produce. There is a new Great Outdoors, which resulted from the dawning awareness that *knowing the world* and having *no unknowns left* was not in itself desirable. As soon as it became possible to store *everything* in abstracted form, there was a shift in mnemonic practices, away from hoping to access all information in

597 Halpern, *Beautiful Data*, loc. 1250–1258.
598 Bergson, *Matter and Memory*, 219.

order to situate it in a chronological timeframe (which was Lyell's planetary agenda). Instead, memory and the storing of information became outsourced. Cybernetic storage is a black box that does not need to be accessed (and should not be opened, as that would be *dangerously* disruptive) as long as it produces intelligibly patterned data arrays on a mediating interface. To summarise, cybernetics faced the dilemma between perfect communication unhindered by noise and the accumulation of a vast "residue of these interactions".[599] On the one hand, "the desire to predict from past behaviour called into being some form of recording, storing, and retrieving information";[600] on the other, there was the need to filter—not just in the form of updates, as discussed, but also in the form of a "process of selection by which only that information necessary for response would be stored".[601] Consciousness was seen as the exemplary filter: "Wiener, and other adherents of cybernetic theory, including psychologists, became obsessed by nonconscious acts of abstraction that permit negative feedback to commence without error".[602]

Memory had thus become the idealised "space of processing; a space where the trace of a stimulus could be utilized to dispense with the totality of the original in order to utilize this abstracted form—this 'essence' of the object—for future operations".[603] It could be argued that this kind of non-conscious cybernetic archive leaves behind the tradition of recording as producing the world. Derrida articulates this tradition in his 1994 *Archive Fever*, where "archivization produces as much as it records the event".[604] Derrida acknowledges the potential of changing mnemonic technology to create an "entirely different logic"[605] of the archive, yet he does not think it through to its full realisation. The cybernetic archival model did not "produce" events; instead, it generated what Wiener called

599 Halpern, *Beautiful Data*, loc. 1385–1390.
600 Halpern, *Beautiful Data*, loc. 1385–1390.
601 Halpern, *Beautiful Data*, loc. 1399–1402.
602 Halpern, *Beautiful Data*, loc. 1399–1402.
603 Halpern, *Beautiful Data*, loc. 1379–1384.
604 Halpern, *Beautiful Data*, loc. 1686–1694.
605 Halpern, *Beautiful Data*, loc. 1686–1694.

the "potential for many similar worlds", depending on how the archival data was analysed. With its emphasis on accumulation and the unfiltered mass of stored data, the world-making process of the archival act no longer occurred at the moment of recording, but rather at the moment of retrieval. The cybernetic archive engendered the potential for embedding any event in myriad large-scale assessment/analytical patterns. Gilles Deleuze identified Bergson's temporality as one of "coexistence" rather than chronology ("succession").[606] This points to the collapse of temporal hierarchy in the cybernetic archive, which is more concerned with the potential simultaneity of any moment and any data point in order to make new information patterns or assemblages.

Cybernetics was built on the optimistic assumption[607] of all-encompassing communication between all entities—be they humans, machines or animals—based on a measurable, mappable and ultimately predictable two-directional flow of information. One the one hand, cybernetics "emptied the archives" as memories became updated behaviour; on the other hand, it aimed to accumulate *everything* to maximise the accuracy of prediction. Ultimately, this dichotomous understanding of the archive is best explained by cyberneticians' future-oriented optimisation of negative feedback loops and their interest in probability (prediction). In Halpern's words: "rather than describe the world as it is, their interest was to predict what it would become".[608] There was thus a loss of duration[609] in favour of predictability, requiring the reconciliation of two sets of archival aspirations. The first aspiration was to empty the archives by channelling the past into updates—as opposed to accumulating as much data as possible, as was common in weather forecasting—in order to be able to make accurate predictions from an enormous data pool. The second was the need to distinguish between noise and necessity. Here, the unconscious became an important analogy for thinking about the archive.

[606] , loc. 1264–1266.
[607] Halpern, *Beautiful Data*, loc. 1072–1077.
[608] Halpern, *Beautiful Data*, loc. 1072–1077.
[609] Bowker, *Memory Practices*, loc. 1581–1585.

Information was filtered by the mediating interface of consciousness, which rearranged data points according to momentary relevance.

Radioactivity, non-conscious filtering processes and the weather—these are the ingredients of the spatial imaginary that affected the concept of today's digital cloud. I thus argue that it was not so much the networks—which constitute the infrastructural backbone of the cloud[610]—that inspired the metaphor, but rather the spatiality, temporality and materiality that constituted the meteorological mode. The spatiality of a cloud embodies an order and engenders a temporality akin to that of the cybernetic archive: continuous updates, somewhere between empty and overflowing with information, intelligible only via an interface. In order to show how this has been quite literally translated into a (non-)architecture, I will now turn to the Blur Building by Diller Scofidio + Renfro. An integral part of this project is the never-realised media environment, in which not only is the Blur Building literally activated as a data conglomerate of aerosols and water droplets, but each visitor also becomes an active data point.

Blur

The closest architecture has come to a model of a cloud is Diller Scofidio + Renfro's 2002 Blur Building. Conceived for the Swiss Expo in 2002, this temporary structure was constructed on Lake Neuchâtel and was accessible only via a bridge. The pavilion consisted of an infrastructure—a network of 35,000 nozzles—that redistributed lake water, "the indigenous material of the site",[611] as mist. The resulting artificial cloud distorted and hid the lake views, part of the architects' agenda to disturb a clichéd and often-reproduced setting for tourist photos. In their words, "it was a reaction to the new orthodoxy of high-definition and simulation

[610] See for example Hu, *Prehistory*.
[611] Diller + Scofidio, *Blur: The Making of Nothing* (New York: Harry N. Abrahams, 2002), 44.

technologies. We wanted to create a low-definition space, a blur".[612] Seen not from within the structure, but from the shore or the bridge, the cloud also hid the infrastructure that supported and generated it. There is an obvious representation gap between the plan drawings of the project and the more atmospheric visualisations (collages) and actual experience, as the plan drawings mostly focus on the infrastructure of nozzles and pipes. The actual cloud is only visible in sketches, collages, and of course photographs. The photographs reveal that the cloud took on a variety of forms, depending on the direction and strength of the prevailing winds.

Just as the cloud could not really be fully anticipated despite prototypes and tests, or even accurately drawn, it could also not really be *touched*. As a "body without surface", the Blur Building withdrew from touch. Even while experiencing its displacing "white out", "white noise"[613] effect, visitors to the Blur Building were not *inside* the artificial cloud, merely surrounded by it. When a person (or any solid thing) touches it, a cloud changes its aggregate state and becomes liquid. As water, the substance no longer forms part of the cloud.

The Blur Building was primarily a media installation. By this point, Diller Scofidio + Renfro were known for media design,[614] in the tradition of immersive environments such as those created by Ant Farm (section 2.3) and arguably prefiguring the effect of virtual reality—without the psychedelics, and without the headset. Most importantly—and this is an aspect of the Blur Building which is usually ignored—the project can be embedded in a narrative of the architecture of digital archives. The Blur

[612] Laurie Anderson, "Interview with Elizabeth Diller and Ricardo Scofidio", in *Scanning: The Aberrant Architectures of Diller + Scofidio*, ed. Aaron Betsky (New York: Whitney Museum of American Art, 2003), 147.

[613] Diller + Scofidio, *Blur*, 33.

[614] An interactive, early theatre project of theirs, on the Brooklyn Bridge Anchorage, NY, was inspired by Giulio Camillo's Memory Theatre. For a connection between the Blur Building and his Memory Theatre see: Natalie P. Koerner, 'Theatres of the Mind: Embodied Memory', *Nordic Journal of Architectural Research*, no. Proceedings Series 2018-1 (January 2018): 175–96. BROOKLYN BRIDGE ANCHORAGE, NEW YORK, UNITED STATES

Building quite significantly deals with memory and the lack thereof. Diller Scofidio + Renfro stress the white-out and white noise effect, which hits the visitor somewhere along the bridge.

From the very beginning, the project was to exclude architecture. At the first meeting in Zurich between West 8 and Vehovar & Jauslin with Diller Scofidio + Renfro, the team agreed on a "media landscape" and that "architecture would be absent".[615] The proposal consisted of a site on land, the bridge and the cloud. The cloud was understood as a media installation, not as a pavilion. The idea of the cloud as medium was directly explained by Ric Scofidio in the presentation:

> Unlike entering a space with an inside and outside, entering Blur is like stepping into a habitable medium. […] If immersion in the fog is like ether, the glass box is the perfect context for the experience of another all-pervading, yet infinitely elastic, massless medium—one for the transmission and propagation of information: the Internet. The project goal is to produce a "technological sublime", parallel to the "natural sublime" experienced in the scaleless and unpredictable mass of fog. This notion of sublimity, however, is based on making palpable the ineffable and scaleless space and time of global communications.[616]

A cloud is itself a medium: Ruskin's definition of "a mixture of something and nothing" is echoed in Ernst's notion of media as "literally in between (Latin *medium*, Greek *metaxy*)".[617] Easterling describes clouds as wet information systems,[618] and Peter Durham understands them as the archetypal sky media.[619] The Blur team envisioned a variety of projections

[615] Diller + Scofidio, *Blur: The Making of Nothing*.
[616] Diller + Scofidio, *Blur*, 162.
[617] Ernst, *Digital Memory*, loc. 70.
[618] Easterling, 'The Year in Weather'.
[619] John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: The University of Chicago Press, 2015).

onto the fog and the water, as an environmental media spectacle. Once Sunrise, a mobile phone provider, became their main media sponsor, the team worked on a project which focussed on communication. In their final presentation to Sunrise—just before they lost this sponsor because of a hostile takeover by Tele Danmark, which had no interest in a Swiss Expo—the Blur was enhanced by "Babble".

Babble was an experiment in non-verbal media communication that activated the cloud as an animate archive. The team, which now included Ben Rubin of the media design studio EAR, wanted to "[socialise] this atmosphere though a technological experiment".[620] They explored the question, "what if these wireless technologies acquired more intelligence to expand telecommunications beyond conventional language?"[621] The idea was to furnish every visitor with a "communication system that will extend the body's natural system of perception". This was envisioned as a "prosthetic skin"[622] in the form of a technologically enhanced raincoat, the "braincoat". The proposal thus conjures the topic that preoccupied Fuller, Dioxides and McLuhan aboard the New Hellas: technology as a prosthetic extension of the human body. The Blur team understood this as temporarily granting "a 'sixth sense' [that] allow[s] each visitor to navigate the cloud and interact with other visitors without speech. This new form of 'social radar' will produce a condition of *anonymous intimacy*".[623]

The designers imagined that all visitors would enter at "the log-in station at the base of the entrance ramp",[624] where they would begin the experience by filling out a questionnaire. This questionnaire was itself conceived as an art project by architectural fiction author Douglas Cooper, and it revolved around more or less intimate details. In the following

[620] Diller + Scofidio, *Blur*, 208.
[621] Diller + Scofidio, *Blur*, 208.
[622] Diller + Scofidio, *Blur*, 211.
[623] Diller + Scofidio, *Blur*, 211.
[624] Diller + Scofidio, *Blur*, 211.

description from the proposal presentation, Liz Diller gives an account of the media project as a databank:

> Answers to the questions will be used to produce a response profile for each visitor; these are continually added to a database. Each visitor will also be given a "braincoat", a smart raincoat with technologies embedded in its skin. [...] The basis for this communication will be this cumulative database. This multidimensional statistical matrix will comprise a "data cloud", which will complement the fog cloud.[625]

Although the unrealised Babble project revolves mostly around the sensuality suggested by the Expo brief, it also strikingly reveals the spatialities of a "data cloud", as Babble "introduces proxi-communications: a telecommunications network recalibrated to a human scale and used to enhance communication in our immediate surroundings".[626]

The braincoats are basically matchmaking devices, fitted with a number of signalling enhancements, such as LEDs and a vibrating device, which have lost some of their awesomeness now that smartphones are ubiquitous. When two people whose questionnaire answers reveal an affinity approach each other in the cloud, their coats take on a red hue, the intensity revealing the degree of the match. The braincoat knows more than their bodies do, and thus blushes (*rot werden*) on behalf of those bodies. The filter in this cloud archive is not consciousness; it is a signal of similarity. A perfect match is signalled with a vibration.

Really interesting, although never realised, was the twist of Semperian *Vergeistigung* with which the architects conceived the pavilion as an immaterial architecture in which the media event was "integrated with

[625] Diller + Scofidio, *Blur*, 211.
[626] Diller + Scofidio, *Blur*, 211.

the enveloping fog".[627] They aimed "to weave together architecture and electronic technologies, yet exchange the properties of each for the other. Thus, architecture would dematerialise and electronic media, normally ephemeral, would become palpable in space. Both would require sophisticated technologies that would be entirely invisible, leaving only their effects".[628] Even though the final project had no integrated media event and featured only unenhanced—dumb—raincoats, it can still be understood as a data cloud.

The process, from the first meeting in September 1998 to the opening of the Expo in May 2002, as described in Diller + Scofidio's *Blur: The Making of Nothing* (2002), is as dramatic as the weather itself. This drama is overlaid with notes of sensuality inspired by Pipilotti Rist's "Expo Brief", which seems bravely sexual to the reader today, just two decades later. There is enthusiasm and bitter disagreement between the different team members, who begin the collaboration wanting to share all the roles, until the end of the "honeymoon period" when disagreements over roles and design ensue, culminating in the loss of core team members. From the notification that they have won in February 1999 to the opening of the Expo, the team unexpectedly gain and lose funding, and have to deal with collapsing prototypes, dangerous levels of bacteria in the lake water, and the difficulty of keeping a cloud in place. Not only does the process of planning and building Blur mirror the drama of weather, but so does the conception of the pavilion itself. The architects stress the experience—the guided promenade from firm land, across the bridge, into a blur. In the first presentation to Sunrise, Liz Diller explains:

> The Blur Building, undoubtedly a spectacle, puts into question the very convention of spectacle. The word "spectacle", of course, privileges vision and vison is the central dilemma of Blur. In our technological culture that privileges high definition, that measures satisfaction in pixels per inch, Blur is decidedly low-

[627] Diller + Scofidio, *Blur*, 44.
[628] Diller + Scofidio, *Blur*, 44.

> definition. The strongest feature of Blur is its atmospheric luminosity and lack of focus. This spectacle will be featureless, depthless, scaleless, spaceless, massless, surfaceless, and contextless. […] Blur replaces focused attention and temporal intensification with attenuated attention dispersed across the fog mass, sustained by a sense of continued apprehension commonly experienced with disorientation and fear of the unknown.[629]

Being *among* clouds—for example, on an aeroplane or in the mountains—can be even more disorienting than being above them, as the clouds conceal the horizon, landmarks and all other points of spatial reference.[630]

The office reached out to Fujiko Nakaya, who found the idea "really beautiful" and offered her consultation services. She was just about to install a fog sculpture using 1,000 Mee nozzles at the new Guggenheim Museum in Bilbao in May 1999: "the length is about 80 metres. It will be in the Museum's permanent collection. No tricks. […] The nozzles are simply installed in 2 files under an arched bridge designed by Frank O. Gehry".[631] The artwork was gifted by Robert Rauschenberg, who was also the first to buy one of Nakaya's fog works. They collaborated on the Osaka pavilion, as Rauschenberg was affiliated with Experiments in Art and Technology, who were hired by Pepsi Cola to design their pavilion. As explained in *Pavilion: Experiments in Art and Architecture* (1972)—a book that documents the Osaka pavilion, and in its format could be understood as a precursor to *Blur: The Making of Nothing* 30 years later—there are three ways of making water fog: the cooling method, the heating method and the atomising method.[632] The first two methods also occur naturally, in the first instance when the air reaches saturation point and its water vapour content condenses on aerosols (or nuclei). The "heating method"

[629] Diller + Scofidio, *Blur*, 162

[630] Some artworks that come to mind that have created similar effects are Olafur Eliasson's and Anthony Gormley's glass boxes filled with fog.

[631] Diller + Scofidio, *Blur*, 64.

[632] Billy Kluver, Julie Martin, and Barbara Rose, eds., *Pavilion: Experiments in Art And Technology* (New York: Dutton, 1972), 209.

can be observed “on a cold morning over warm lake water where rapid evaporation takes place”.[633] For the third method, “small droplets of water are sprayed into the air by compressed air or pressure nozzles”.[634] The Pepsi Cola fog system was conceived with the help of Choji Magono, professor of meteorology and cloud physics, and Akira Higashi, professor of physics, both at Hokkaido University. The fog system of “2,520 jet-spray nozzles, organized in ten-foot strands of PVC pipe with one nozzle every foot placed in the ridges and valleys on the top section of the roof. The system, controlled by turning nine pumps on or off in different combinations, could generate a six-foot-thick, 150-foot-diameter area of low-hanging cloud”. It ran for six months in 1970, and the nozzles were developed with cloud physicist Tom Mee in Pasadena, California. Mee Industries, Inc. still exists and provides fog technology.

The Blur Building was more technologically interactive, as it housed a weather station which would analyse the weather and adjust the nozzle output accordingly. Like most of the projects I discuss here, Diller + Scofidio are thus also directly connected to weather forecasting, which is clearly articulated in the following excerpt from the Extasia competition presentation: “a built-in weather station reads the weather and electronically adjusts water pressure in response to shifting temperature, humidity, wind direction, and wind speed. The resulting fog mass is thus a dynamic form that combines natural and artificial weather forces”.[635]

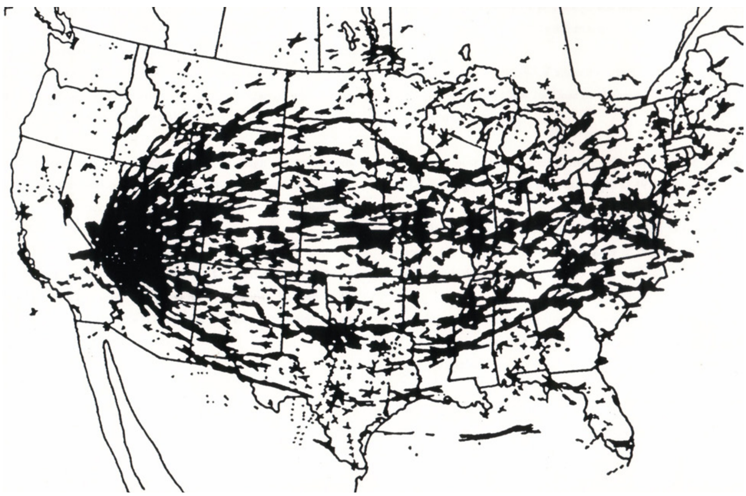
Despite some recognisable patterns, the complexity of the interlocked parameters that determine the behaviour of aerosols means that clouds remain a phenomenon that cannot be represented. As in Brunelleschi’s experiment, clouds can only be *reflected*—captured as fleeting, ever-changing, unpredictable phenomena: “clouds, like coastlines and cauliflowers, are fractal beings that defy the straight line and benefit from the modern ability to reckon with indefinites. Together with flowing water,

[633] Kluver, Martin, and Rose, 209.
[634] Kluver, Martin, and Rose, 209.
[635] Diller + Scofidio, *Blur*, 44.

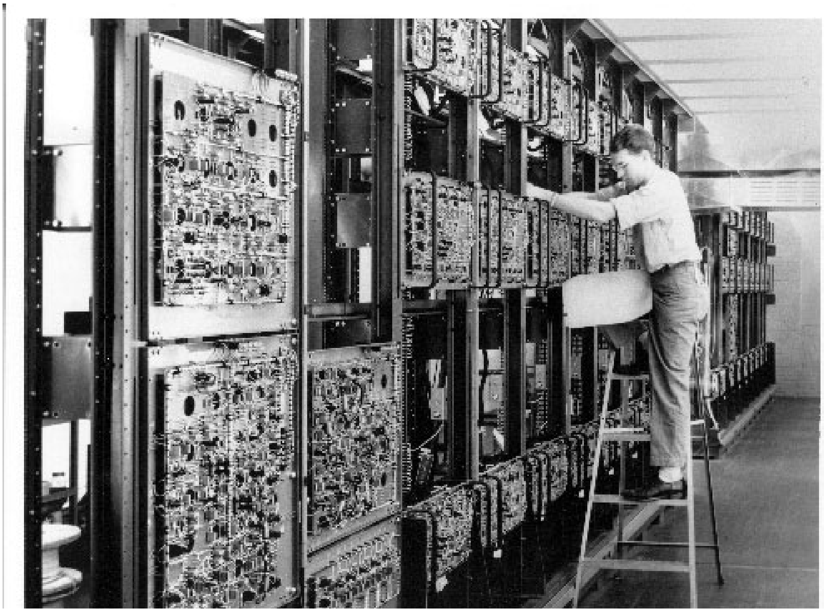
they are the hardest thing to render convincingly in animation".[636] Consequently, in their technical drawings, the architects never showed the actual cloud, just the perimeter within which the cloud movement would be acceptable.

The meteorological mode is connected to meteorology as a science: global, data-hungry, driven by prediction and updates, and network-dependent. Radioactivity, which disperses in a meteorological manner, gives insight into the spatiality of the meteorological. It also fuels network fever and near-infinite archival accumulation.[637] The cybernetic archive, also locationless, taps into these fevers and obsessions, as it continuously updates in feedback loops that keep archived data in the present.[638] The digital cloud fuels and cools these feverish tendencies. It offers the concept of an infinite archival realm that never has to be dealt with directly, as it withdraws into a cloudy outdoors, thus preventing archival overwhelm. This outdoors is the subject of the next chapter.

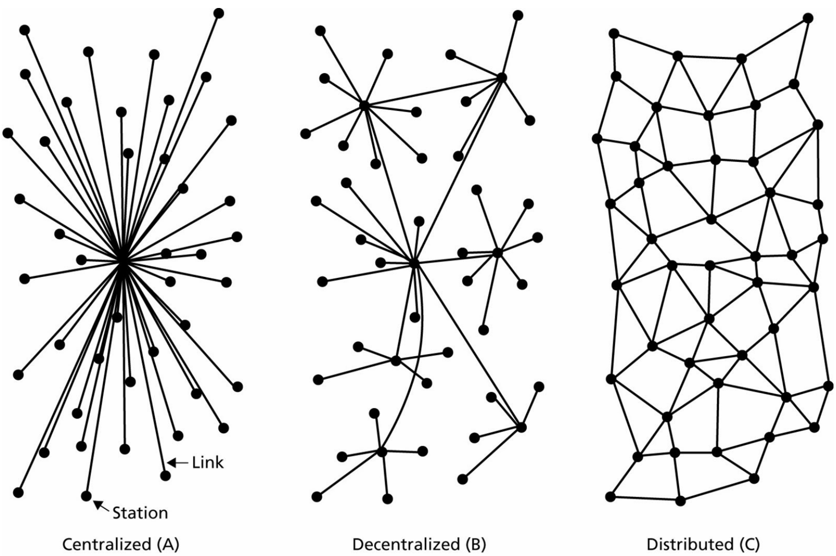
[636] Durham Peters, *Marvelous Clouds*, 259.
[637] For links between the digital cloud and the cloud chamber that visualises radioactivity, see Louise Amoore, "Cloud Geographies: Computing, Data, Sovereignty", *Progress in Human Geography* 42, no. 1 (2018): 4–24.
[638] Ernst, *Digital Memory*, loc. 101.



Richard Miller, *Under the Cloud*, 1986
Map of the 'areas crossed by two or more radioactive clouds during the era of nuclear testing (1951-1962) in the American Southwest.'



Project Whirlwind. Room-filling computers



Paul Baran: Centralized, Decentralized and Distributed networks (1964)

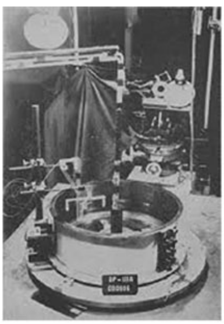


Figure 1. Streak photographs taken to illustrate three typical top-surface flow patterns, the first in the axisymmetic régime, the second in the regular non-axisymmetric régime (of 'vacillation') with M=3, and the third in the irregular ('chaotic') non-axisymmetric régime (of 'geostrophic turbulence'). The respective values of Ω were 0.34, 1.19 and 5.02 radians per second; other impressed conditions were held fixed.

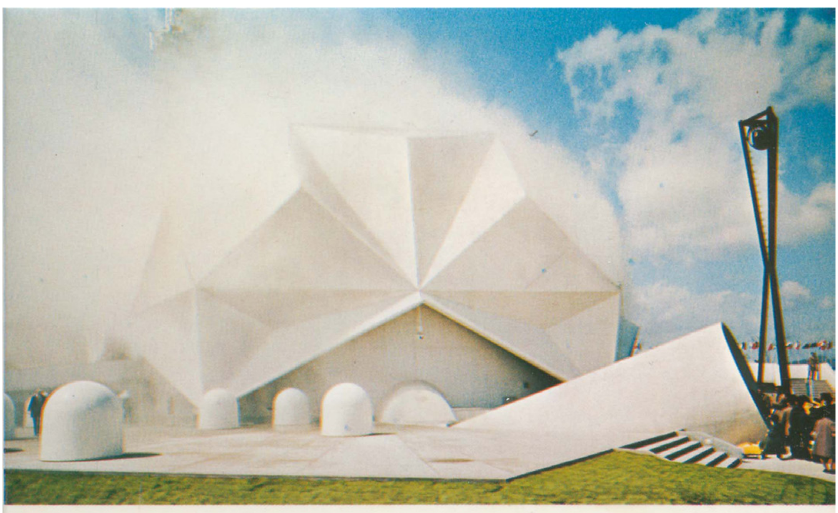
Raymond Hide, at Cambridge, Dishpan experment

Diller Scofidio + Renfro, Blur Building, 2002

Diller Scofidio + Renfro, Blur Building, 2002

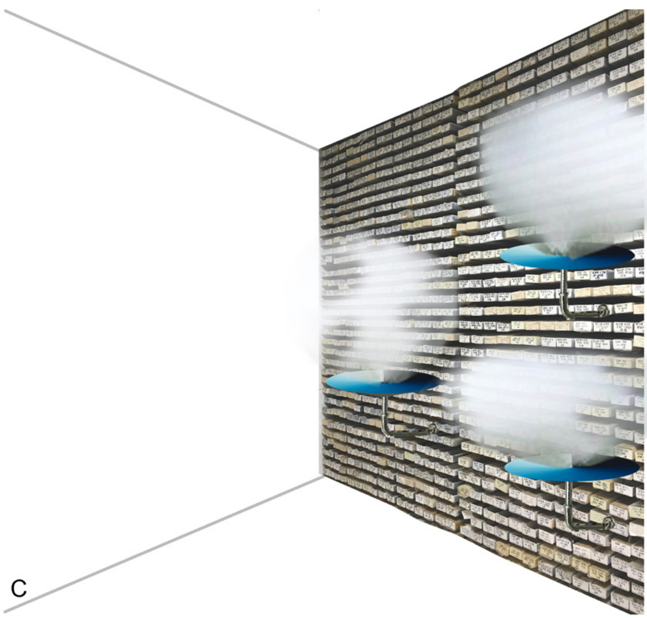
Diller Scofidio + Renfro, Braincoat for Blur Building, 2002

EAT and artist Fujiko Nakaya: First test of the fog engulfing the Osaka Pepsi pavilion, 1970.

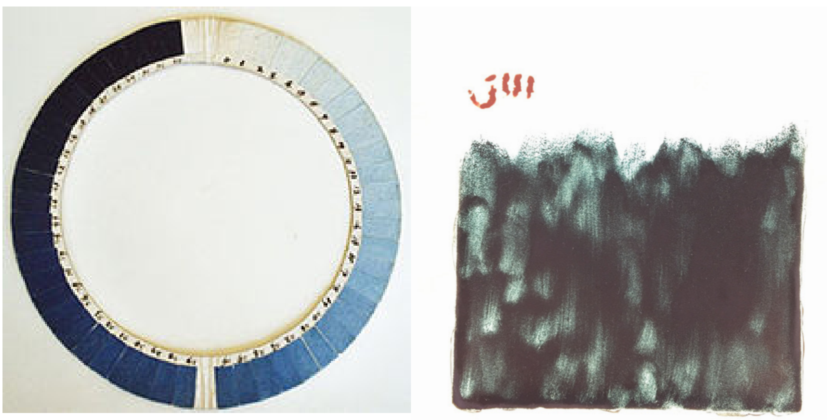


EAT and artist Fujiko Nakaya, Osaka Pepsi Pavilion, 1970.

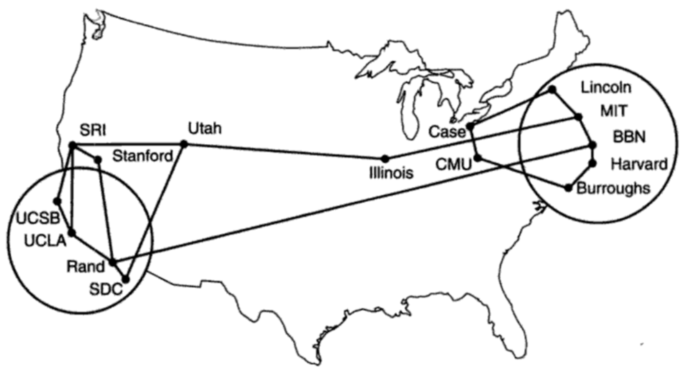
Whirlwind Computer Core Memory Unit



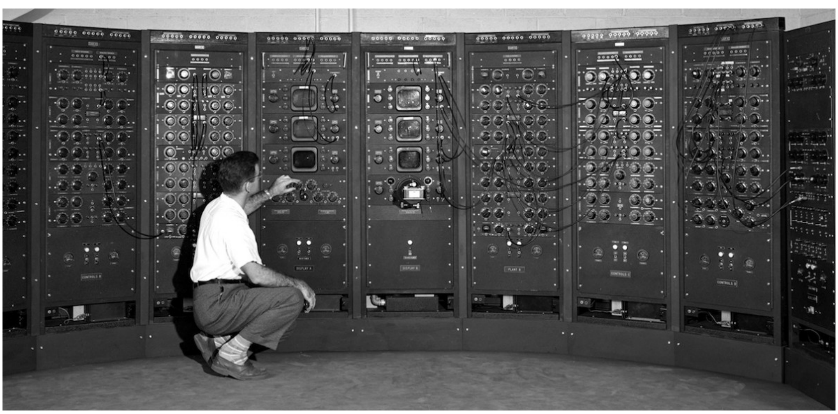
Cloud Fountains Artistic Research



Cyanometer to determine the blueness of the sky
Minerals on Glass, Artistic Research



Map of the 15-node ARPANET in 1971



Bell Computer

2.3 Great Non-Conscious, Great Outdoors

Unlike the postulated danger to the territory of sovereignty associated with the cloud of Big Data, a politics/perception/geometry based on the spatiality of the cloud might result in a more fluid, less exclusive concept: a concept oriented in line with da Vinci's understanding of bodies without surface that "readily melt into and mingle with other thin bodies". By consequence, these bodies' extremities "are mingled with the bodies near to them, whence by this intermingling their boundaries become confused and imperceptible".[639] In Durham Peters' understanding, media "are vessels and environments, containers of possibility that anchor our existence and make what we are doing possible".[640] This rich entanglement of vast varieties of parameters mirrors the spatio-temporal structure of today's digital archives, which are governed by the meteorological mode: a spatiality of dispersal, a temporality of phasing, and a materiality of patterned particles. Clouds mark the threshold of an increasingly inhabited yet under-described spatiality of inclusive variability, fluid accuracy and unbound locatabilty. The point cloud supersedes rigid spatialities and renders the meteorological mode more imaginable. Cloud space can be explored and sculpted, but not flattened. The spatial imagination of bodies that remain in a state of becoming—through exploration and variation—are beyond the scope of finite drawings.

An Alien Cloud

Imagine a being that travels the universe as a gaseous conglomerate—an intelligent cloud. This alien entity has descended from outer space to hover above planet Earth. Here, it scans the atmosphere for any radio signals emitted on our planet, which it can intercept and modify. It can communicate with other entities via radio signals of different bandwidths,

639 From Leonardo da Vinci's notebooks, cited in Hubert Damisch, *A Theory of /Cloud/: Toward a History of Painting* (Stanford: Stanford University Press, 2002), 218, 124, 141, 218.
640 John Durham Peters, *The Marvelous Clouds: Toward a Philosophy of Elemental Media* (Chicago and London: University of Chicago Press, 2015), 2.

in any language, visually and aurally. It can store, compute, analyse and assimilate more data than all archives and all computers—analogue and digital—put together. The cloud synthesises and processes vast amounts of information, unhindered by bonds to location or form.

This being—as similar as it sounds to today's digital cloud—is the intelligent, communicative and well-travelled alien protagonist of Fred Hoyle's 1957 novel *The Black Cloud*. English astronomer Sir Fred Hoyle (1915–2001) was a highly imaginative and controversial scientist. He held important positions as the renowned Plumian Professor of Astronomy and Experimental Philosophy and founding director of the Institute of Astronomy, both at the University of Cambridge. Himself a proponent of the steady-state universe, Hoyle famously coined the name for the competing "Big Bang theory" live on BBC radio in 1949.[641] Besides a substantial list of scientific publications, Hoyle wrote 19 science fiction books, of which *The Black Cloud* was the first.[642]

Like the digital cloud and its high energy consumption, the black cloud entails environmental catastrophes for planet Earth. As the intelligent interstellar gas cloud approaches Earth to harvest the sun's energy, it

[641] "Hoyle on the Radio: Creating the 'Big Bang'", Fred Hoyle: An Online Exhibition, St John's College, University of Cambridge, accessed 12 June 2018, https://www.joh.cam.ac.uk/library/special_collections/hoyle/exhibition/radio/. Many believe that it was due to his provocative behaviour that he was denied a share in the 1983 Nobel prize for physics, awarded to William Alfred Fowler for research on "the stellar origins of the elements from which our bodies, solar system and universe are made". Robin McKie, "Fred Hoyle: The Scientist Whose Rudeness Cost Him a Nobel Prize", *Observer*, 3 October 2010, https://www.theguardian.com/science/2010/oct/03/fred-hoyle-nobel-prize. This research was published in the 1957 paper "Synthesis of the Elements in Stars", known as the B^2FH paper from the initials of its four authors, among whom Hoyle was a principal collaborator-cum-initiator.

[642] There are links to his scientific work, for example the non-fiction book *Lifecloud: The Origin of Life in the Universe*. From a feminist perspective, the novel has serious shortcomings: the only female of any importance is tricked into getting locked in the scientists' retreat by the main character, for his (musical) entertainment. There is, however, interesting criticism of governments and their aggressive responses towards the alien (foreign, unknown). The cloud actively decides not to harm humanity, even though nuclear weapons have been fired at it in an attempt to poison its cognitive centres.

blocks all daylight for a period during which an ice age descends upon the planet. The imagery conjures frozen tropical forests in complete darkness, icy oceans of petrified wave crests, and still cadavers under a looming and incomprehensible cloud body. Hoyle's alien intelligence cloud is also useful for describing clouds' communicative tendencies, voracious absorbency and perceived cognitive difference from humans. Like the digital cloud, the black cloud is "communicative" and data-hungry. The protagonist, government-critical scientist Dr Christopher Kingsley, and his team initiate communication with the cloud being. After they initially read to the cloud from books in order to establish as much of a shared knowledge base as possible, the voracity of the cloud demands faster information transmission. The alien cloud's first intelligible response to a direct message containing the basics of Western science, mathematics and the English language is ravenous: "message received. Information slight. Send more".[643] And like the digital cloud, which promises endless storage and computing capacities, the black cloud is a seemingly infinite brain-cum-archive. Its neurological structures are arranged on the surfaces of solid bodies—aerosols—of the gas, plasma and dust that compose interstellar clouds. Its processing capacities can increase endlessly, as it is capable of building additional brains: "and the logic of brain-building seems to have some relation to our programming of a computer", observes one of the scientists.[644]

Once data is absorbed by the black cloud, it becomes part of its vast realm of data. It does so in a way that proves incomprehensible to humans. The novel ends with Kingsley's death. He has insisted on attaching himself to a kind of telepathic communication device that the team has built according to the instructions of the cloud—an ambiguous constellation of flashing lights, "filter circuits and a whole bank of cathode ray tubes".[645] His brain cannot assimilate the knowledge structures transmitted by the cloud with his own information system. Kingsley dies from the relentlessly

[643] Fred Hoyle, *The Black Cloud* (Richmond: Valancourt Books, 2015), loc. 2875, Kindle.
[644] Hoyle, *Black Cloud*, loc. 3143–3172.
[645] Hoyle, *Black Cloud*, loc. 3651–3652.

increasing mental disruption. His doctor speculates, "I think it was a kind of chain reaction in his thoughts that got out of control".[646] The scene resonates with philosopher Timothy Morton's understanding of hyperobjects: "the more data we have about hyperobjects the less we know about them—the more we realize we can *never* truly know them".[647]

Big Data

It is somewhat eerie to think of the similarities between the invented alien intelligence (AI) of the black cloud in Hoyle's 1950s novel and today's digital cloud processed by machine learning artificial intelligence (AI). We feed the digital cloud with data, just as the scientists fed the black cloud with as much input as they could transmit. Hoyle, who has been called "the most creative and original person in astrophysics after World War II", thus incredibly imaginatively predicted today's digital archives.[648] The digital cloud is the terrain of the vast information conglomeration known as Big Data. Advertised on the Google Cloud Platform, it "offers access to data storage, processing, and analytics on a more scalable, flexible, cost-effective, and even secure basis than can be achieved with an on-premises deployment"[649] for exponentially growing data volumes. Faced with the

[646] Hoyle, *Black Cloud*, loc. 3804–3806.

[647] Timothy Morton, *Hyperobjects: Philosophy and Ecology After the End of the World* (Minneapolis and London: University of Minnesota Press, 2013), 180.

[648] Walter Sullivan, "Fred Hoyle Dies at 86; Opposed 'Big Bang' but Named It", *New York Times*, 22 August 2001, http://www.nytimes.com/2001/08/22/world/fred-hoyle-dies-at-86-opposed-big-bang-but-named-it.html?mcubz=0.

[649] "Cloud computing offers access to data storage, processing, and analytics on a more scalable, flexible, cost-effective, and even secure basis than can be achieved with an on-premises deployment. These characteristics are essential for customers when data volumes are growing exponentially--to make storage and processing resources available as needed, as well as to get value from that data. Furthermore, for those organizations that are just embarking on the journey toward doing big data analytics and machine learning, and that want to avoid the potential complexities of on-premises big data systems, the cloud offers a way to experiment with managed services (such as Google BigQuery and Google Cloud ML Engine) in a pay-as-you-go manner". "Why Is the Cloud the Best Platform for Big Data?", Google Cloud, updated 13 November 2017, https://cloud.google.com/what-is-big-data/#why_is_the_cloud_the_best_platform_for_big_data.

cloud, Chun asks, "So what is Big Data? We are told, over and over again, that Big Data defines our era. According to IBM, if the twentieth century was the era of Big Science, the twenty-first is the era of Big Data: in 2014, 2.5 quintillion bytes of data were produced every day and this number is expected to grow exponentially."[650] Big Data refers to "the flood of digital data from many digital earth sources, including sensors, digitizers, scanners, numerical modeling, mobile phones, Internet, videos, e-mails and social networks. The data types include texts, geometries, images, videos, sounds and combinations of each".[651]

The advertising around the cloud focusses on its ability to seamlessly assimilate all data growth and increasing service demands. The digital cloud resonates with the black cloud's voracious appetite and assimilative capacity. Cloud services are based on exponential absorption and acceleration, which in the digital cloud arena are known as the five Vs of Big Data: "volume, velocity, variety, veracity and value".[652] Hoyle's cloud could easily be described in hyperboles of the five Vs. Its volume essentially spans the entire universe, as it plants intelligence in suitable gas clouds wherever it encounters them. It travels close to the speed of light, gathering space data.[653] The alien is cloud *is* data, conglomerated around gaseous aerosols, and processed via electromagnetic circuits and radio waves, which is what makes it such an interesting prequel to the digital information cloud.

There is one decisive difference, however: the black cloud has an agenda, a higher goal, which is also ultimately the reason for its departure. It receives a signal from a kin intelligence implying the discovery of the

[650] Wendy Hui Kyong Chun, 'Big Data as Drama', *ELH* 83, no. 2 (Summer 2016): 363–82.
[651] Chaowei Yang et al., 'Big Data and Cloud Computing: Innovation Opportunities and Challenges', *International Journal of Digital Earth* 10, no. 1 (2017): 13–14.
[652] Yang et al., 13–14.
[653] Space data is increasingly moving into the foreground as the "new Big Data", thanks to the promise of an overview effect offered by satellites. "Why Space Data Is the New Big Data", Bernard Marr & Co., accessed 10 September 2018, https://www.bernardmarr.com/default.asp?contentID=1197.

"solution to the deep problems"—to the question of whether there is a larger-scale intelligence that structures the laws of physics and the behaviour of matter. So far, our digital cloud has not yet manifested a will of its own, but we also have not managed to establish two-way communication with it. The cloud is still at the level evaluates our data for us, but it does not communicate any intentions to us.

However, early theories by John von Neumann, and more recently by Stephen Hawking and Elon Musk, postulate the possibility that artificial superintelligences might trigger "runaway technological growth"[654] and result in the singularity. The technological singularity would follow the "intelligence explosion" of a self-improving artificial technological superintelligence that would completely surpass all human intelligence. The singularity resonates with the behaviour of Hoyle's superintelligent alien cloud: it travels the universe, communicates with entities in all regions of deep space, and searches for deep wisdom.[655] The concept points to anxieties related to machine learning. The apprehension is that the algorithms used by cloud analytics to make sense of raw data, which are perceived as increasingly autonomous of human supervision, are out of the control of human intelligence. Big Data is analysed by "highly efficient and scalable data reduction algorithms" which filter "potentially irrelevant, redundant, noisy and misleading data" and turn it into intelligible information.[656]

The Great Non-Conscious

However, theories of non-conscious cognition put the disquiet associated with machine learning and the concept of cognitive otherness into perspective. The organisational processes that govern the digital cloud

[654] Irving John Good, *Speculations Concerning the First Ultraintelligent Machine*, May 1964, https://web.archive.org/web/20010527181244/http://www.aeiveos.com/~bradbury/Authors/Computing/Good-IJ/SCtFUM.html.
[655] Explored, for example, in the movie *Her* (2013) by Spike Jonze.
[656] Yang et al., 'Big Data and Cloud Computing: Innovation Opportunities and Challenges', 19.

give insight into its spatialities—but this time not in analogy to the meteorological cloud. I turn to recent research in the field of cognition to show that the realm of the cloud—again, in all its manifestations (digital, meteorological and alien)—can be understood as a terrain of the Great Non-Conscious. Non-conscious cognition can be found in non-organic and organic life alike. In her 2017 book *Unthought: The Power of the Cognitive Nonconscious*, literary critic and theorist N. Katherine Hayles explores cognition as an activity that humans, technical systems and organic beings alike engage in. Separating cognition from consciousness opens up a rich field of information processing that is independent of a sense of self[657]. The non-conscious overcomes the Cartesian dichotomy between the adult human who *thinks* and all other non-thinking entities, including children and animals. The non-conscious proposes the more inclusive, post-anthropocentric categories of "cogniser" and "non-cogniser". The first category includes not only humans but also other biological and technical organisms.[658]

"Consciousness" has many nuances, and has often been reserved for a human "higher consciousness" linked to an autobiographical self and to *thought*.[659] Cognition, however, is not tied to consciousness. Hayles understands cognition as a process "that extends far beyond consciousness into other neurological brain processes".[660] This inclusive definition sets Hayles apart from the tradition of associating cognition with human thought.[661] She aligns her approach with Humberto Maturana and Francisco Varela's writing on cognition and autopoiesis, developed in their seminal work *Autopoiesis and Cognition: The Realization of the Living* (1972). Combining biology, neuroscience and so-called second-order

657 See also Heller-Roazen, *The Inner Touch: Archaeology of a Sensation*. His book is an investigating of "the sense of being sentient" and has overlaps with Hayles' study of the non-conscious.
658 N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago and London: University of Chicago Press, 2017), loc. 10–11, Kindle.
659 Hayles, *Unthought*, loc. 9, 14.
660 Hayles, *Unthought*, loc. 9.
661 Hayles, *Unthought*, loc. 15.

cybernetics, they develop a biology of cognition in which perception and cognition are interchangeable, liberated from (self-)consciousness and thought. They view "all organisms as engaging in systematic acts of cognition as they interact with their environments".[662] Even the simplest organisms manifest awareness in the form of embodied knowledge of their context as they engage with it.[663] Maturana and Varela extend their findings to technical systems by defining the autopoietic machine in the second part of the book.

Core or primary consciousness in humans, octopuses and many mammals encompasses "an awareness of self and others".[664] This level of consciousness is associated with the "new unconscious" of "broad environmental scanning in which events are heeded and, when appropriate, fed forward to consciousness".[665] The non-conscious differs from the psychoanalytic unconscious of Freud and Lacan in terms of accessibility. Conscious thought cannot rummage the non-conscious archive for clues, triggers or suppressed memories. Although the new unconscious is "in continuous and easy communication with consciousness",[666] it also remains inherently "inaccessible to consciousness, although its outputs may be forwarded to consciousness through reverberating circuits".[667] Like a filtering algorithm, this unidirectional exchange ensures that consciousness is not overwhelmed by floods of interior and exterior information streaming into the brain every millisecond. In the pyramid of cognition, non-conscious cognition is situated between conscious and unconscious *modes of awareness* on the one side, and purely material processes on the other.

[662] Hayles, *Unthought*, loc. 264.
[663] Hayles, *Unthought*, loc. 14–15. Even bacteria manifest cognitive processes such as "integrating information from multiple sensory channels to marshal an effective response to fluctuating conditions; making decisions under conditions of uncertainty; communicating with conspecifics and others (honestly and deceptively); and coordinating collective behavior to increase the chances of survival". Hayles, *Unthought*, loc. 282.
[664] Hayles, *Unthought*, loc. 174.
[665] Hayles, *Unthought*, loc. 500.
[666] Hayles, *Unthought*, loc. 501.
[667] Hayles, *Unthought*, loc. 507.

Non-conscious cognition is paramount for information processing, filtering and patterning. It is the filtering system that Norbert Wiener and his fellow cyberneticians sought in order to better deal with noise. Halpern writes: "perception came to be defined by the ability to respond, and memory as the site of processing. Abstraction could facilitate transmission. Wiener, and other adherents of cybernetic theory, including psychologists, became obsessed by nonconscious acts of abstraction that permit negative feedback to commence without error".[668] The non-conscious responds to environmental signals, patterns input, and makes decisions as to what requires the attention of consciousness. In Hayles' words, non-conscious cognition "comes online much faster than consciousness and processes information too dense, subtle, and noisy for consciousness to comprehend. It discerns patterns that consciousness is unable to detect and draws inferences from them; it anticipates future events based on these inferences".[669] Non-conscious cognition is thus more immediately related to the world as it processes the raw data of the various inputs: "nonconscious cognition is closer to what is actually happening in the body and the outside world; in this sense, it is more in touch with reality than is consciousness".[670] Hayles also emphasises the fact that the non-conscious is unaffected by the narrative tendencies, "the confabulations of conscious narration",[671] that permeate consciousness, especially the human "higher consciousness" [672] associated with the autobiographical self and thinking.

Hayles suggests that what we have outsourced to technological systems is not the intelligence associated with our conscious thought processes (artificial *intelligence*), but rather our non-conscious cognition. She shows that the presence of cognitive processes in these technical systems is the

[668] Orit Halpern, *Beautiful Data: A History of Vision and Reason Since 1945* (Durham, NC and London: Duke University Press, 2015), loc. 1399–1402, Kindle.
[669] Hayles, *Unthought*, 28.
[670] Hayles, *Unthought*, 28.
[671] Hayles, *Unthought*, 28.
[672] Hayles, *Unthought*, 9, 14.

logical consequence of "the exteriorization of cognitive abilities, once resident only in biological organisms, into the world, where they are rapidly transforming the ways in which human cultures interact with broader planetary ecologies". Thus, "biological and technical cognitions are now so deeply entwined" [673] that the all-pervasive, omnipresent cloud[674] accurately describes their inseparable interconnectedness.[675]

The kinds of cognitive activities that Hayles describes as non-conscious are akin to those that govern cloud computing, archiving and processing. Hayles emphasises that cognitive processes in technical systems resemble human cognition: "like human nonconscious cognition, technical cognition processes information faster than consciousness, discerns patterns and draws inferences and, for state-aware systems, processes inputs from subsystems that give information on the system's condition and functioning".[676] The non-conscious thus unites human and technological data and signal processing. Machine learning refers to computer systems (software applications) that harness algorithms and statistical models to increase their accuracy at predicting outputs while updating these with new data.

[673] Hayles, *Unthought*, 11.
[674] For scientific concerns regarding the involuntary and inescapable *exposure to radio frequency radiation of all living beings everywhere on the planet once 5G is fully implemented, see* "International Appeal: Stop 5G on Earth and in Space", International Appeal, updated 11 January 2019, https://www.5gspaceappeal.org/the-appeal/?fbclid=IwAR0wejelGyQMqrD3FEZE3Hlg68mmE87xJnUw4K2ZyrOtyO2H0VFKtJc3oUA.
[675] Hayles has accomplished for technological systems what was popularised for plants in the early 21st century. For example, journalist Michael Pollan and biologist Daniel Chamovitz introduced cognition to the world of plant life. Pollan connects neurobiology and biology to show that plants are "capable of cognition, communication, information processing, computation, learning and memory"; he refers to "more than a dozen senses, among them kin recognition, detection of chemical signals from other plants" that show that plants are, to use Hayles' term, "cognisers". Chamovitz also insists that plants are "aware" and references "behaviors observed in plants which look very much like learning, memory, decision-making and intelligence". See Hayles, *Unthought*, loc. 17, 20. See also Michael Pollan, "The Intelligent Plant", *New Yorker*, 16 December 2013, https://www.newyorker.com/magazine/2013/12/23/the-intelligent-plant.
[676] Hayles, *Unthought*, loc. 11.

Machine learning seems alien, but in Hayles' line of reasoning it is entwined with the human non-conscious. Technical systems are cognisers, as they sense, analyse and initiate responses to environmental or intrasystemic input. Such non-conscious cognitive devices include "medical diagnostic systems, automated satellite imagery identification, ship navigation systems, weather prediction programs".[677] Both the technical and the human non-conscious deal with "ambiguous or conflicting information",[678] resulting in uncertain conclusions at best. In this line of argument, neither the human nor the technical non-conscious are about certainty or truth. Consequently, we still need to consciously consider and question the actions suggested by digital systems such as the cloud, as a way of counteracting the "tyranny of convenience".[679]

The cloud, in all its manifestations is also a cognizer. It can be imagined as a large, "extremely sensitive animal",[680] referencing Renaissance philosopher Tommaso Campanella (1568–1639). Tommaso Campanella was a contemporary of Descartes, yet his understanding of perception differed dramatically, as it did not separate the conscious "I" from the surrounding world. As explained earlier (section 2.1), in Campanella's inclusive understanding, the whole world is "an extremely sensitive animal"[681]—a perceptive entity pervaded entirely by just one sense, the spirit. This *sensus rerum*—sense of things—"can be found in every thing".[682] Campanella explains the link between perception and response with his theory that while perceiving a certain quality, the sensing entity is affected by and appropriates a fragment of the perceived quality: if I touch fire with my finger, then my finger becomes hotter. In section 2.1, I linked this theory with the clouds, which also continuously mutate to visualise everything they *perceive*: the geology they float above, the temperature, materiality and reflectivity of the ground, the winds, the cosmic rays,

[677] Hayles, *Unthought*, loc. 24.
[678] Hayles, *Unthought*, loc. 24.
[679] Wu, 'Opinion | The Tyranny of Convenience'.
[680] Heller-Roazen, *The Inner Touch: Archaeology of a Sensation*, 172.
[681] Campanella, *Metafisica*, quoted in Heller-Roazen, *Inner Touch*, 172.
[682] Campanella, *Compendium physiologiae*, quoted in Heller-Roazen, *Inner* Touch, 171.

atmospheric pressure, and the myriad chemical interactions among the aerosols they transport.

There are correlations between Campanella's and Merleau-Ponty's understandings of perception as a process of mutual affect. In *Phenomenology of Perception* (1945), Merleau-Ponty postulates that "in order to perceive things, we need to live them".[683] This relates directly to Campanella's theory that in order to perceive, one must be affected by the perceived quality to the extent of partially becoming what one perceives. Similarly, Merleau-Ponty describes perception as a mutual embodiment and synchronisation of the quivering modalities of existence of perceiver and perceived. The perceiving body "echoes the vibrations" of perceived entities.[684] The act of perception requires a merging of the observer with the observed, a "becoming one". As an example of this "living the perceived", Merleau-Ponty describes the process of anticipating a sound or sight: "suddenly the sensible catches my ear or my gaze; I deliver over a part of my body, or even my entire body, to this manner of vibrating and of filling space named 'blue' or 'red'".[685] The evoked imagery is vivid: the waves of the vibrations emanating from the perceived sensory stimulation virtually take hold of the perceiver's body, and they synchronise. The perceived object takes hold of the sensory receptacle, and the observer hands over (part of) her body to be engaged in the mutual resonating. Definitions of an active subject and a passive object do not apply, as perception constitutes a mutual embodiment of the perceiver and the perceived. As in Campanella's explanation of perception, they live a moment of shared existence; they "vibrate in unison" in the transfer of the perceivable qualities. Perception is thus a synchronisation of the essential, modal vibrations of two bodies—one perceiving, the other perceived. This understanding of perception resonates with Hayles' non-

683 Maurice Merleau-Ponty, *Phenomenology of Perception* (London and New York: Routledge, 2002), 379.
684 Merleau-Ponty, *Phenomenology*, 272.
685 Merleau-Ponty, *Phenomenology*, 219.

conscious cognition, which describes a direct and immediate engagement with the world.

While Campanella dedicated his academic life to the dismantling of Aristotle,[686] his work resonates with important aspects of phenomenology and current philosophical movements that are dedicated to softening the categorical boundaries between humans and non-humans.[687] He lived "in an age when the geocentric and anthropocentric view of reality was breaking up" and conveyed "the need for wider horizons of knowledge and for a new relationship of man with nature and society during the tempestuous transition towards the modern world".[688] It is thus natural that he addressed notions that are now re-emerging in the context of the Anthropocene. As described above, Hayles seeks to unite humans with organic and technical non-humans under the umbrella of "cognisers". There are also obvious similarities between vibrancy, agency—explored by Deleuze, and later by Delanda and Jane Bennett, among others—and Campanella's understanding of spirit: they all imbue non-organic material ("vibrant matter"[689]) with the capacity to affect and be affected. In the meteorological mode, spatiality may still be governed by geometrical systems, yet this nebulous geometry is one that updates rather than dictates: the geometry of the cloud rejects the metaphorical motionlessness that would be required to experience a perfectly curated *trompe l'oeil* from a designated spot.[690] Instead, the spatiality of the cloud *is* the drama, the stage, the illusion, the fact and its representation. Clouds approximate a geometry that spatialises Campanella's notions of perception and Hayles' terrain of the non-conscious.

[686] Germana Ernst, *Tommaso Campanella: The Book and the Body of Nature* (Dordrecht: Springer, 2010), chapt. 1.
[687] These often reference Aristotle.
[688] From the magazine description of Bruniana and Camanelliana
[689] See Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC and London: Duke University Press, 2010).
[690] As in Bruneleschi's experiemnt.

The Drama of Clouds

In the context of Wendy Chun's description of Big Data as drama, and Derrida's concept of archive fever, I will now show that the non-conscious processes of Big Data are governed by a neurosis that precipitates in the cloud as its spatial symptom. The digital cloud of Big Data has recently been postulated as drama by digital media theorist Wendy Chun.[691] In a 2016 article titled "Big Data as Drama", Chun delves into the role of the user, who has become social media's medium as the singular-plural "you". She emphasises that McLuhan's "medium as message" has been superseded in the digital age by the medium as an active audience classified as various compartmentalised yous. The mass of mass media has been dissolved into "you"—the generic version of you and people like you. "You" have become "characters in a universe of dramas putatively called Big Data". [692] In the "endless prequels and sequels" of this dramatic universe co-produced by corporations and governments, "our roles change constantly because of evolving plotlines determined by actions of others like us (people who like us and who are determined to be like us)".[693] Big Data is thus understood as an ever-updating drama catering to a collective singular in which "you" are never alone but neither an autonomous individual. Participation is compulsive—even if "we participate in our own undoing",[694] as participation in mass media threatens democracy. The cloud has come to be seen as a new site of sovereign power that infringes on democracy.

There is a theatrical, performative aspect to the spatiality of the digital cloud and its wafts of Big Data. Clouds have served as dramatic "screens". For example, in Mantegna's *San Sebastian* (1456–1459), a cloud in the top left corner becomes the stage-cum-stand-in for a hurried horseman, possibly an allusion to Saturn, the god associated with the destructive

691 Wendy Hui Kyong Chun, "Big Data as Drama", *ELH* 83, no. 2 (2016): 363–382.
692 Chun, "Big Data", 363.
693 Chun, 363.
694 Chun, 367.

passage of time. Casper David Friedrich, like his fellow Romantics, read the clouds as a spectacle of emotions. Clouds are drama, or rather, dramatic. These ever-changing, ever-elusive and fleeting bodies without surface and their dramatic morphologies outline the realm of speculative narrative.

Undeniably, there is drama in clouds and their representation. As early as 423 BCE, they inspired playwright Aristophanes to devise a leading role for these all-knowing, influential and elusive entities as spectators and actors alike, like the "you" in the drama of Big Data. *The Clouds*, the first comedy of ideas, was also a drama about data: one main character, Strepsiades, tries to learn the skill of processing and communicating data in a manipulative and convincing way—which was then known as rhetoric—at the Thinkery, Socrates' school. In Aristophanes' play, the clouds are actors and spectators: they address the audience; they transmit information through their morphology and through song. Beyond the drama, the cloud's fleeting morphologies and its dreamlike, elusive patterns once again conjure the notion of archive fever. In *Archive Fever: A Freudian Impression* (1995), Jacques Derrida conjoins the gathering and preservation intrinsic to archives with destructive tendencies: this is the archive's *death drive* or *archival fever*. Aristophanes' play ends in feverish confusion as Strepsiades tries to outdo his son with his newly acquired rhetorical skills.

Beyond the drama, the digital cloud is also closely related to a kind of fever: the "database complex", characterised by media theorist Lev Manovich as "the irrational desire to preserve and store everything".[695] Its veil of secrecy is one of fear: fear of information loss, and fear of infiltration.[696] Beyond the feverish associations of the previous chapter and of drama, there seems to be an element of Big Data that points to neurosis. Up close, the processes that govern the storage and reading of

695 Lev Manovich, *The Language of New Media* (Cambridge, MA and London: The MIT Press, 2001), 235.
696 See Tung-Hui Hu, *A Prehistory of the Cloud* (Cambridge, MA: MIT Press, 2015).

Big Data in the cloud are best described as neurotic: anxious, hyperaware of correlations, and obsessively preoccupied with blunders. Symptoms of neurosis typically include insecurity, compulsive behaviour and anxiety. The latter has been implied throughout this thesis. In section 1.3, it forms the subtext of bunker mentality, the emphasis on secrecy and security, and the redundancy built into the infrastructure of data centres to accommodate the fear of data loss. Anxiety has been a steady presence since the 1950s, the heyday of Freudian psychoanalysis, when "any symptom or personality trait was attributed to an anxiety neurosis".[697] World War II and the ensuing Cold War, a period of latent catastrophe, contributed to widespread anxiety: "if you weren't anxious, you were scarcely normal".[698]

Anxiety, like the Cold War, engenders a temporality of latency, since unlike fear it is not the result of an immediate cause but the "expectation of future threat". The result is a pre-emptive hyperactivity that can be observed in Big Data analysis. Anxiety, "a feeling of uneasiness and worry, usually generalized and unfocused as an overreaction to a situation that is only subjectively seen as menacing", is an increasingly present mental health challenge in Western culture. As New Yorker and millennial author Lena Dunham, the self-proclaimed "voice of her generation", recently confided, "I don't remember a time not being anxious".[699] *The Age of Anxiety* (1947), a book-length poem by W.H. Auden, is easily overlooked amid the long list of self-help publications in Amazon's search results. In June 2017, Alex Williams wrote an article for the *New York Times* titled "Prozac Nation Is Now the United States of Xanax". Williams thematises the prevalence of anxiety, a condition confronted by 40 million American

[697] Peter D. Kramer, Brown University psychiatrist and author of the 1990s bestseller *Listening to Prozac*. Alex Williams, "Prozac Nation Is Now the United States of Xanax", *New York Times*, 10 June 2017, https://www.nytimes.com/2017/06/10/style/anxiety-is-the-new-depression-xanax.html.
[698] Alex Williams, 'How Anxiety Became Society's Prevailing Condition | The Independent', Saturday 17 June, https://www.independent.co.uk/news/long_reads/anxiety-prozac-nation-depression-mental-health-disorder-america-panic-usa-memoirs-self-help-book-a7785351.html.
[699] Williams.

adults. He quotes Sarah Fader, CEO and founder of the mental health non-profit organisation Stigma Fighters, who appreciates that anxiety has become accepted as a mental health challenge, losing the stigma of drama: "people with anxiety were previously labeled dramatic". [700] *Drama* has become a *condition*.

The shift from an imminent cause or threat to an assumed latent cause is embedded in the larger theme of correlation and Big Data, in the form of what one might call hyper-correlation. Another form of hyper-correlation can be seen in neurotic behaviour, which implies an altered processing of the world that encompasses a "more dramatic" response to negative stimuli and a "tendency to interpret ambiguous situations negatively instead of positively or neutrally". Neurosis replaces a clearly definable cause, i.e. a threat, with a correlative interpretation of (potential) events that are potentially—but not necessarily menacingly— related; similarly, correlation replaced causality with the advent of Big Data. This is an argument first made by Viktor Mayer-Schönberger, professor at the Oxford Internet Institute, and Kenneth Cukier, data editor at *The Economist*, in their bestselling book *Big Data: A Revolution That Will Transform How We Live, Work, and Think* (2014). They explain that Big Data "shows that the what matters more than why. Rather than causality, what matters is correlation—how things are related, not why we think they are".[701] The connection between a situation and a thing thus matters more than the reason why they are linked.

David Hume challenged causality in favour of correlation, and in Chun's words has become "the favored philosopher of Big Data analytics". [702] In his famous billiard ball experiment, he wonders what it would mean if a ball suddenly moved without being pushed. French philosopher Quentin Meillassoux uses this thought experiment as a starting point for his

[700] Williams.
[701] Chun also refers to the much-cited statement by *Wired* editor Chris Anderson: "the data deluge makes the scientific method obsolete". Chun, 'Big Data as Drama'.
[702] Chun, "Big Data", 34.

speculations about a universe of accidents (see section 1.3). This world is governed not by rules or any scientific (and reproducible) logic, but rather by one-off events. This extro-scientific world is eerily similar to the universe of the cloud and its Big Data, which in a state of neurosis feeds off potential correlations that may or may not exist. Chun writes: "Big Data, as currently conceived, depends on the archiving and recycling of data—the linking of seemingly unrelated databases—in order to make surprising 'discoveries'".[703] She mentions as an example that thanks to data analysis, Fico's Medication Adherence Score found a correlation between people who pay for car insurance and those who take their pills on time.[704]

This correlation is as much common sense (this group of people may simply be conscientious and dutiful) as it is accidental, and one might also find a correlation between people who pay for car insurance and those who brush their teeth twice a day: "many of the supposed correlations Big Data discovers are not only obvious, they are also linked to questions of race/gender/sexuality/class".[705] Even when they are not tied to prejudice, the potential correlations seem endless and random, i.e. accidental. Hyper-correlationism is linked to hypersensitivity. Everyone and everything becomes a sensor in the internet of things, as "every click—every change of state—is stored and interconnected across time and space".[706] This collection of data is harvested by algorithms, which are also hypersensitive and thrive on the predictable as much as on errors, one-off events and accidents. In Chun's words:

> Algorithms need mistakes—deviations from expected or already known results—in order to learn. Singular events or crises are thus not exceptions, but rather opportunities to improve: they

[703] Chun, "Big Data".
[704] Chun, "Big Data". See also https://well.blogs.nytimes.com/2011/06/20/keeping-score-on-how-you-take-your-medicine/
[705] Chun, "Big Data".
[706] Chun, "Big Data".

> feed the algorithm. Deviations are encouraged, rather than discouraged; deviant decoding makes better encoding possible.[707]

There is an obsessive component to this continuous world-scanning and to the repatterning of its sensorial output, which is coincidental as much as it is predictable. Errors, accidents, anxieties, hypersensitivities and the residue of drama all become engulfed in the Big Data veiled by the cloud. In section 1.1, I showed the hypersensitivity of meteorological clouds, which are too responsive to be mapped, and which behave like analogue computers. Their characteristic hypersensitivity (in the positive sense) and neurosis (in a more stigmatised reading) connect the digital and the meteorological. There is thus another analogy that can be drawn between the meteorological cloud and the digital Big Data cloud. Meteorological clouds, and by analogy their digital counterparts, are fleeting, like a cool fever dream; the regeneration they promise is linked to cloudy obsessions, a neurotic emphasis on correlations that exist but may not matter. Anxiety motivates the redundancy built into power-shortage-fearing data centres and glitch-greedy machine learning.

The processes that govern digital cloud services are permeated with neurosis: the Big Data cloud is hypersensitive. It tends to overanalyse, and to detect correlations that exist but in a healthier psyche would acquire less anxiety-inducing meaning. Its many sensors gather and pattern the world's data. The same can be said for the meteorological cloud. In section 2.1, I showed that the meteorological cloud is a visualisation of the world; its defining parameters even extend beyond the planet.

The Grid and the Cloud

Clouds are bodies "without surface".[708] As such, they are not typically related to either geometrical plan drawings or architecture, unless they float like a dreamy anecdote through what still constitutes one of

[707] Chun, "Big Data". She adds "Constant participation grounds surveillance".
[708] Da Vinci, C.A., 132; da Vinci, *Notebooks*, 363–364.

architecture's origin stories: Brunelleschi's perspectival peeping onto the Florence Baptistery, which is now understood as a turning point in architectural representation. Linear perspective became an indispensable tool to navigate architectural design and depiction. However, as shown by French philosopher Hubert Damisch (1928–2017), this geometrical method has a fundamental inadequacy: its inability to depict clouds[709] and other bodies that are subject to continuous morphological updates.[710] According to an oral history first transcribed by Antonio Manetti in the 1480s, Brunelleschi's perspectival apparatus enabled the accurate and lifelike representation of architecture's static geometry against an animated background—the sky and its ever-changing clouds. Brunelleschi's constellation consisted of two planes, two points, an architectural object, and a viewer with two arms and one eye. The two planes were a mirror and the roughly 30-centimetre-square panel depicting the architectural object: Brunelleschi had made a perspectival drawing of the octagonal baptistery of San Giovanni in Florence. Instead of colouring in the sky with paint, he covered it with silver, so that the surface would reflect the sky. The viewing point and the vantage point overlapped on a hole in the panel. An observer positioned at the point from where the drawing was made could move the mirror in and out of view, and the perceived image would remain the same: a baptistery in linear perspective, with a sky full of animated clouds above it. From personal experience, the Renaissance historian Manetti confirms: "with the aforementioned elements of the burnished silver, the piazza, the viewpoint, etc., the spectator felt he saw the actual scene when he looked at the painting". [711] The "burnished

[709] Damisch, *Theory of /Cloud/*, 123

[710] Six hundred years later, with the emergent application of the digital point cloud, the architectural toolkit has finally grown to include a geometricised cloud. This addition to the profession's repertoire comes just in time to articulate a new kind of spatiality that has increasingly expanded the spatial imagination, especially with the mushrooming of the digital cloud and its Big Data. Clouds also represent a last insurmountable frontier for climate modelling. These digital variants of the meteorological cloud, wavering in and out of reach, immediately behind screens, among fingertips and cursors, defy the Cartesian harness and suggest an incorporeal spatiality.

[711] Manetti quoted in Samuel Y. Edgerton, *The Mirror, the Window, and the Telescope* (New York: Cornell University Press, 2009), 46.

silver" embeds the momentary and ever-changing in the representation: the weather. The time of day and the clouds are all reflected in the mirrored sky of Brunelleschi's apparatus.

The clouds in the perspectival apparatus, however, can also be understood as temporal entities. Not of a *linear* temporality, as might fit the perspectival method; nor of the cyclical temporality associated with the daily rhythms apparent in the sky. Instead, the clouds embody a temporality of constant actualisation or updates, connecting the representation with a continuous present, in line with the temporal nature of the digital cloud archive (see sections 2.1 and 2.2). The experiment is thus part of a long history of understanding the sky as a temporal medium (as explained through Durham Peters in section 2.1[712]). To draw now on French philosopher Maurice Merleau-Ponty's description of time, the clouds as temporal embodiments create a situating milieu for the viewer in Brunelleschi's perspectival experience: "time […] is a milieu to which one can only gain access and that one can only understand by occupying a situation within it".[713] The viewer's gaze, the nebulous embodiments of time and the horizon line all merge on the planes of Brunelleschi's experiment, creating a dense (real) experience that would be impossible without the incorporation of the clouds.

712 Media scholar John Durham Peters reminds us that the sky is not merely fluctuation, but also eternity. There are thus two types of heavenly bodies: those with a surface, such as planets, and those without—the clouds. Each category comes with its own temporal mode, as it traverses space with different degrees of visibility to the human eye: "for millennia the sky has presented two faces to humanity: constants and variables, the regular motions of the heavenly bodies and the unpredictable events of the atmosphere. Correspondingly, the sky has yielded two great but very different sciences, astronomy and meteorology. One is the oldest of all sciences, and the other is quite recent, at least as a predictive science. One dealt traditionally with the χρόνος (chronos) of sun, moon, planets, and stars, with their cyclical constants, and the other with variables, the καιρὸς (kairos) of weather, rain, hail, thunder and lightning, temperature, and clouds". Durham Peters, *Marvelous Clouds*, 166.
713 Merleau-Ponty, *Phenomenology*, 347.

As in later drawing aid machinery[714] that incorporated an orientation device for the painter's eyes to ensure the fixity of the vantage point, Brunelleschi's perspectival illusion only worked as long as the viewer remained immobile. In Brunelleschi's technique, the viewing point and the vanishing point merge on the central axis of the representation. The exchangeable static viewer, the fixed gaze, and the immobile building built for eternity are thus distinguished from the sky, which functions as the ever-actualised present.

Brunelleschi's doubly mirrored sky retains this duality of cyclicity and variability. Plato's appreciation of vision as enabling an understanding of the universe seems like a commentary on the silver reflection of the sky above the baptistery:

> The vision of day and night and the months and the revolutions of the years has created the art of number, and has given us the notion of time as well as the ability to seek out the nature of the universe. From these things we have gained philosophy and there is no greater good the gods have given us than this.[715]

The representation of the baptistery and its sky can be interpreted as the metaphorical birth site of *number* in reference to the geometricisation of representation, and simultaneously of "the ability to seek out the nature of the universe" which encompasses phenomena beyond numbers, such as the clouds. In recent years, the digital point cloud has given rise to a geometrical alternative to the representational spatiality of lines oriented towards a vanishing point. Point clouds are interesting phenomena

714 German painter Albrecht Dürer (1571–1528) depicted some of these in detail. Dürer's drawings showing drawing machinery rely on Alberti's instructions; Alberti had been the first to commit a perspectival method to text in *De pictura* (1435). Alberti can be seen to have merged the milky diffuseness of the cloud with the geometrical grid in the method of the *velo* (veil). There is an interesting analogy between this veil of accuracy—itself a paradox—and the point cloud.

715 Plato, *Timaeus*, 47a–b; translation slightly modified from Andrea Wilson Nightingale, *Spectacles of Truth in Classical Greek Philosophy: Theoria in Its Cultural Context* (Cambridge: Cambridge University Press, 2004), 173. Durham Peters, *Marvelous Clouds*, 168.

because, like the hazy reflections in Brunelleschi's apparatus, they defy representation as a momentary section through space—i.e. in plan or section. Instead, as I will show, they require a rethinking of architectural diction in terms of densities, fields and fluctuations.

Cloud Machinery

Wiener defined cybernetics as the ability to communicate between different entities through a controlling device— a steering mechanism, as the term "cybernetics" suggests.[716] The cloud in its various forms, does precisely this. A closer look at the spatiality of the cloud stage prop, which influenced painters and the general public's imaginings of immanence, reveals how today's concept of the digital cloud as a data transfer medium can be linked to the theatricality of the Middle Ages and the Renaissance, which dealt with an equally invisible and inaccessible space. In this reading, the cloud stands for a tool that enables mobility and communication while partly blurring the hardware that enables the exchange. The cloud was chosen as mediating device because it was locationless and borderless, "a body without surface". The cloud is here understood as a veil, a blur that reveals information in the very act of obscuring it.

The cloud in all its variations thus constitutes a realm of the great non-conscious. Not only does the cloud have a history of representing this physically inaccessible region, but it also has a history of mediating. In an earlier chapter, we encountered the cloud as (sky) medium.[717] It played a similar role in late medieval and Renaissance religious theatre. "Cloud machinery" was a theatre prop commonly used in religious enactments of biblical scenes to facilitate an exchange between the earthly realm and the otherwise physically inaccessible heavens. In Florence, this initially simple stage device was especially popular. Throughout the 15th and 16th centuries, it gradually evolved into a sophisticated theatrical device known as "heaven machinery". By the mid-16th century, it was being used in the

[716] Halpern, *Beautiful Data*, loc. 1533–1534.
[717] See Durham Peters, *Marvelous Clouds*.

court theatre of the Medicis.[718] It was so influential that painters incorporated it into their depictions of religious events, and clearly distinguished it from the meteorological clouds of the painted skies.[719]

The cloud machinery can be understood as the quattrocento theatrical equivalent of early 21st-century virtual machines that depend on cloud computing. Virtual machines are installed on software to simulate hardware. Whereas hardware and software used to be clearly distinguished as physical and intangible respectively, innovations such as cloud computing and virtualisation have increasingly blurred the distinction.[720] This blurring has an important spatial component. Cloud computing and virtualisation remove the physical hardware that enables the computing not just from the visible realm of the user, but even from an identifiable location. The location of the clustered hardware—of data centres—is mostly undisclosed, for reasons of security, simplicity and user convenience. The conceptual cloud veils the location, spatiality and materiality of the machinery that is necessary to sustain cloud computing and data storage. The notion of veiling the "hardware" via the meteorological phenomenon of a cloud can be seen as part of a larger tradition that has its roots in theatricality as much as in data mediation and mobility.

The cloud machinery developed out of a simple plinth—"a flat pedestal, camouflaged as a cloud"[721]—into a complex, technologically ingenious illusionary system that could be lifted and suspended, thus creating the illusion of flight or ascension from ground to sky. These props were common in European theatre and known generally as "cloud" or *nughola/nuvola* (Italian), *nuée* (French) or *nube* (Spanish).[722] The sturdy iron

718 See Alessandra Buccheri, *The Spectacle of Clouds, 1439-1650: Italian Art and Theatre* (Abingdon: Routledge, 2014).
719 See Damisch, *Theory of /Cloud/*.
720 Andrew S. Tanenbaum and Todd Austin, *Structured Computer Organization*, 6th ed. (Amsterdam: Vrije University, n.d.).
721 Buccheri, *The Spectacle of Clouds, 1439-1650: Italian Art and Theatre*, 2.
722 Buccheri, *The Spectacle of Clouds, 1439-1650: Italian Art and Theatre*.

or wood structure and pulley system were hidden by wadding, feathers and painted fabric to create the imitation of a cloud. The props would range in size from larger heaven floats to single clouds or mandorla.[723] In Buccheri's words, the props "were used mainly for the representation of the episodes which involved some communication between heaven and earth".[724]

Religious theatre productions were initially staged in churches and made strategic use of the narrative potential of their architectural features. Cloud props were used to transport actors playing holy characters into the more elevated regions of the church space, which represented heaven. Often, the artificial clouds would be raised to the choir area, close to the altar, to emphasise the proximity of the divine. At the time, the rood screen also played an important spatial role: it established a tangible, emblematic and impenetrable interface between the worldly and the heavenly realms—an elusive border of two realms that meet but do not mix. Actors who represented the saints, the Virgin Mary, Jesus or even God were able to navigate this interface with the help of the cloud machinery: it quite literally lifted them from one realm into the other.

Cloud machinery evolved throughout the centuries, and the props advanced in complexity and craftsmanship. The Roman Church continuously advocated the use of elaborate cloud machinery and theatrical re-enactments, because chanting, music, light effects and actors contributed to a representation of heaven that was more emotive, impressive and memorable than any two-dimensional depiction could ever be. These theatre productions, with their illuminated and kinetic cloud machinery, were thus valued for creating a more *real* representation of heaven.

The cloud machinery has important links to quattrocento painting, which often shows the feet of angels supported by small, sometimes barely

[723] Konigson, 1969
[724] Buccheri, *The Spectacle of Clouds, 1439-1650: Italian Art and Theatre*, 14.

visible clouds. A good example is the 1428 *Assumption* by Masolino da Panicale (1383–1435) (Figure 1). The 144-by-76-centimetre panel shows the Virgin Mary's ascension to heaven against an abstract golden realm. The seated Virgin is framed by a mandorla cloud that is densely patterned with putti and flanked by angels, which are in turn supported by small individual cloud fields. The practical clouds situate the angels in the otherwise infinite and placeless sky space. These little aid clouds can be read as cognitive supports for the observer to comprehend the flight of the angel, suggesting that the cloud relieves the angel of the earth's pull. The panel was produced in for the Compagnia di Sant'Agnese, a group that was famous for the magnificent Ascension play it performed in Florence every year. The depiction of the Virgin Mary's ascent is itself inspired by the shape of the cloud machinery that would have accompanied the celebrations. In fact, Mary takes the position of the actors that would usually mount the three-dimensional props.

Between 1460 and 1464, Andrea Mantegna (1431–1506) painted a triptych of *The Ascension of Christ*, *The Adoration of the Magi* and *The Circumcision*. Both the *Ascension* and *Adoration* feature cloud machinery, which supports Jesus in the former, and Mary with the Christ child in the latter. In both paintings the cloud machinery is mandorla-shaped and covered with alternating fields of blue, wadding-like cloud patches, and orange-and-yellow winged cherubs. The ascension cloud differs starkly from the meteorological clouds in the distance: these are white, their consistency is less dense, and their sizes and shapes are more irregular than the machinery's wadding. Christ is standing in the cloud machinery, suspended above a group of astounded admirers. He is holding a thin pole that ends in a cross and hoists a flag. It recalls the pulley system.

The *Adoration* at the centre of the triptych also clearly references quattrocento theatre. Mary's cloud machinery is parked on the ground, so that the Magi can approach her and the holy child. It resembles the *Ascension* cloud, but it is connected to a second piece of cloud machinery—suspended mid-air above Mary's—via a thin, straight rod. The hoisted cloud is occupied by four angels. Damisch draws attention to the close connection between these painted "ascension tools" and religious theatre: "with all the precision of an ethnographer, Mantegna carefully represented the vertical metal rod, the tip of which upheld a star and a foursome of angels in a cloud of wadding".[725] The painted cloud machinery navigates "the juncture of reality and the imaginary" and refers "to a theatrical representation rather than to a natural reality or an intellectual notion".[726] It is intriguing that Mantegna depicts the prop rather than a "real" meteorological cloud. Cloud machinery in these instances became *more real* than what the painter could imagine.[727]

The cloud prop came to signify and explain the physical mediation between the earthly and the heavenly realms. Clouds in religious theatre were a tool to conceal as much as explain and enable the transition from earth to heaven, from secular to divine. The quattrocento thus invented a cloud device that was inspired by the meteorological phenomenon—borderless and locationless, concealing and revealing, transcendentally mobile—yet entirely different: the cloud prop and its pulley system formed part of a greater mechanical context that structured the heavenly and earthly realms. The cloud machinery mediated an exchange of bodies and of information.

In the late 14th-century Christian treatise *The Cloud of Unknowing*, the anonymous author advises that those who wish to be truly close to God must approach through non-intellectual contemplation. The best strategy is to focus on the "cloud of unknowing, that is betwixt thee and thy God"[728] and to attempt to truly occupy this darkness. By darkness the author means "a lacking of knowing: as all that thing that thou knowest not, or else that thou hast forgotten, it is dark to thee; for thou seest it not

[725] Damisch, *Theory of /Cloud/*, 71.
[726] Damisch, *Theory of /Cloud/*, 71.
[727] See also Alberti's treatise *On Painting*, which offers insight into the relationship between "what the painter sees" (the theatrical performance) and truth—which the painter must then represent in his or her work.
[728] Anonymous, *The Cloud of Unknowing*, loc. 410–412, Kindle.

with thy ghostly eye. And for this reason it is not called a cloud of the air, but a cloud of unknowing".[729] Like the cloud prop, the "cloud of unknowing" is a mediating tool between the devoted Christian and God.

The cloud creates an intermediate space. Acting as a mediator between earth and heaven, the cloud apparatus pre-empted any enquiries into the *how* of the ascension. This being in-between recalls Ernst's writings on media.[730] In light of this historical precedent, the metaphorical, pseudo-meteorological cloud, which so omnisciently umbrellas remote computing and archiving, can be situated in a long tradition of enabling communication between two bordering but ultimately distinct realms. Much like today's digital storage cloud, cloud machinery bridged and blurred the (hardware) gap between the earthly ground and divine heaven. The cloud prop can be read as a data transfer tool, thus closely relating to today's digital cloud. Like the cloud prop in religious theatre, the digital cloud accesses an elusive realm—of the great non-conscious, or more precisely, of digital, physically intangible data. The cloud is thus a connective device, or rather a mediating environment, as its responsive nature defies clearly defined boundaries. The cloud acts as an interface: between heaven and earth, between user and data.

The Great Outdoors

However, while the stage prop could to some extent be physically accessed, the digital cloud is experienced exclusively at the elusive level of the interface. It constitutes an exterior: a physically inaccessible realm, despite being filled with intimate and identity-defining information about its externalised users. In the case of meteorological clouds, the interface is hard to locate. Besides their lack of surface, if one gets too close, they precipitate, because of an aggregate change from being suspended in the air to falling as water drops. Digital clouds engender the same effect: a kind of aggregate change happens "upon touch", at the digital interface.

[729] Anonymous, *Cloud of Unknowing*, loc. 410–412.
[730] Ernst, *Digital Memory and the Archive*.

The interface is a "significant surface", a term coined by Vilém Flusser to designate a two-dimensional plane that transmits meaning.[731] As soon as an image or a document appears on the interface screen, it becomes active information and no longer forms part of the cloud. As users, we are always outside the cloud, even though it surrounds us constantly and contains our personal data. The possibility of accessing it via a device is always (given an internet connection) present, but never the possibility to enter. The interface demarcates a definitive separation between user and storage. Like a semipermeable membrane, it allows data osmosis but is resistant to human thought or spatial imagination. The cloud user at the interface may get a sense, as in Michel Foucault's heterotopias, of "places which are absolutely other", and of that "unreal space that opens up potentially beyond its surface".[732] However, whereas heterotopias are localisable, cyberspace and the cloud cannot be situated or mapped.[733]

We remain external to the cloud, just as our stored data is external to us: users save to forget. The cloud thus not only acts as a mediating device, it also *is* that realm of inaccessible otherness. It can be seen to establish what French philosopher Quentin Meillassoux calls "*le grand dehors*": an utterly removed, barely imaginable, yet ever-present great outdoors.[734] Meillassoux's term emerges from his discussion of pre-critical thinkers, who still had access to "the absolute outside": "that outside which was not relative to us, and which was given as indifferent to its own givenness to be what it is, existing in itself regardless of whether we are thinking of it or not; that outside which thought could explore with the legitimate feeling of being on foreign territory—of being entirely elsewhere".[735] The digital cloud is such an "entirely elsewhere": it is an agglomeration of

731 Alexander R. Galloway, *The Interface Effect* (Cambridge: Polity Press, 2012), 30.
732 Michel Foucault, "Of Other Spaces: Utopias and Heterotopias", in *Rethinking Architecture: A Reader in Cultural Theory,* ed. Neil Leach (New York: Routledge, 1997), 332.
733 Wendy Hui Kyong Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics* (Cambridge, MA: MIT Press, 2006), 52; Foucault, "Of Other Spaces", 332.
734 Timothy Morton describes this as a clumsy translation of the French *le grand dehors*. Morton, *Hyperobjects*, 64.
735 Meillassoux, *After Finitude*, loc. 7.

information that was once interior to its users, but it withdraws into a great outdoors where physical data dissolves into a cloudy non-conscious governed by machine learning. The great outdoors occupied and generated by the cloud is thus a spatial step beyond heterotopia, exiting the common ground of geography despite its data centre lifelines.

Jane Bennett is interested in emphasising "the active role of nonhuman materials in public life […] to give voice to a thing-power". In her understanding, "things" are objects that have acquired agency and are no longer merely defined by their subject.[736] The great outdoors is the subject of Bennett's first chapter in *Vibrant Matter* (2010). Here she seeks to describe "the force of things" through "thing-power and the out-side".[737] She describes an out-side that—like Meillassoux's great outdoors—points to a realm of the *absolute*, where the thing's "independence or aliveness" constitutes "the outside of our own experience"[738] as it is beyond "the milieu of human knowledge".[739] She bases her definition of this "out-side" on Henry David Thoreau's "the Wild", and on the political theology of Hent de Vries' "the absolute" as "that which tends to loosen its ties to existing contexts".[740]

In architecture the outside has been negotiated since modernism, as the focus turned from definitive, delimting wall or facade to a threshold that mediates interior and exterior. The outside was then shifted beyond the horizon line, first of the horizontal window and then the actual horizon. Theorist Beatriz Colomina writes, "The horizon is an interior. The horizon is "not that at which something stops but, as the Greeks

[736] Bennett quotes W.J.T. Mitchell to elucidate the difference between object and thing: "objects are the way things appear to a subject—that is, with a name, an identity, a gestalt or stereotypical template. [...] Things, on the other hand, [... signal] the moment when the object becomes the Other, when the sardine can looks back, when the mute idol speaks, when the subject experiences the object as uncanny". Bennett, *Vibrant Matter*, 2.
[737] Bennett, *Vibrant Matter*, xvi.
[738] Bennett, *Vibrant Matter*, xvi.
[739] Bennett, *Vibrant Matter*, 2.
[740] Bennett, *Vibrant Matter*, 2.

recognized, that from which something begins its presencing”.[741] Architecture thus shifted from the facade to the horizon.

The Anthropocene romanticises the notion of a *pure* nature uncorrupted by human presence. Human activities are now a dominant influence on the entire planet, including even its climate, which raises the concern that all uncharted, pristine or “healthy” territory has been corrupted. In light of these anxieties, the cloud recreates a precious, unknowable and inaccessible space that has been lost to us since our expulsion from paradise, or since the separation of the world of ideas from the world of things, or since the dawn of the Anthropocene. The digital cloud is “entirely elsewhere”:[742] despite being generated by human content, it is inaccessible to human bodies and human comprehension. The spatial intangibility of the cloud and the incomprehensible accuracy of its data points cause the cloud to withdraw, pulling it further and further away from us as it transforms into our great outdoors.

Externalisation is a recurring theme in this thesis. We saw that externalisation became an important aspect of archival conceptualisation during the age of cybernetics. Digital archives are by definition an externalisation of otherwise internalised information. There is an important history of spatial externalisation that occurred in parallel to the externalisation in archival practices. This development is linked to communication. In this section I will briefly relate the history of communication satellites and the related spatial imagination of escape, mobility and inflatable architecture. A less-known work—the so-called Rubber Village—by the prolific American architect Frank Lloyd Wright reflects how the focus on communication corresponded with an emphasis on mobility: satellites and inflatables.

[741] Beatriz Colomina, ‘Battle Lines’, in *Rethinking Borders*, ed. John C. Welchman (Houndmills and London: Macmillan Press LTD, 1996), 51.
[742] Meillassoux, *After Finitude*, loc. 7.

"You cannot build clouds. And that's why the future you dream of never comes true".[743] Philosopher Ludwig Wittgenstein's observation was curiously prescient regarding the architecture of 1966, the closest approximation to *constructing clouds* to date. The 1960s, influenced by cybernetics, was the prototype period of spaces for maximum mobility, unfettered by gravity—a time of architectural instantaneity, lightness, transience, and a growing sense of global, even interplanetary, connectivity. Technological euphoria brought clouds within reach, as architecture emancipated itself from the ground, from its permanence and its heaviness.

An uncharacteristic Frank Lloyd Wright project from 1957 forms a curious point of connection between America's first passive communications satellite, Echo 1, launched in 1960, and the Dreamcloud of Ant Farm's Real©ity proposal for the 1970 Osaka Expo. All three spatial phenomena explore the spirit of the meteorological mode on different scales: those of a portable home, a 30.5 metre-diameter satellite sphere, and a festive conglomerate of space-enhancing agents. The projects are expressions of a generous, collective and bold architecture that gravitates towards the cloud and its humanmade equivalent, the parachute. They articulate a relationship between human and world, between habitat and environment, that encircles the first traces of the planetary imaginary in the architecture of the 20th century.

Parachute Housing

Three years before his death, Frank Lloyd Wright (1867–1959) made a radical departure from his site-specific and landscape-integrating architecture with his design of the Fiberthin Air Houses for the US Rubber Company. These hemispherical, colourful plastic mobile homes were inflated and sustained merely by an exterior air pump. Essentially contextless and foundationless, the Fiberthin Air Houses were anchored

[743] Ludwig Wittgenstein, *Culture and Value*, ed. Georg Henrik von Wright (Oxford: Basil Blackwell, 1970).

not by means of a connection *with* the ground, but rather by a weight *on* the ground: zippered Fiberthin tubes filled with sand or water and placed along the perimeter of the hemisphere.[744]

Wright's 1956 drawings reveal four different Fiberthin Air House constellations, ranging from one- to four-domed versions. The 11.5-metre and seven-metre domes were connected via inflatable "hallways" attached with "giant brass zippers" and accessed through zippered airlock doors.[745] Less space-agey was the central fireplace in the dome houses, a prominent feature in Wright's drawings. The pianos consistently depicted in the larger houses also create a heavy moment in the otherwise boldly mobile proposal. When the Fiberthin Air Houses were unveiled in April 1957, at the New York International Home Building Exhibition, they featured inflatable plastic furniture and a Miss Home Show.

Inflatable architecture has its origins in the airborne transport technology of hot air balloons and airships. Later, during World War II, Allied forces experimented with inflatable decoys. Most notably, they staged a huge army aimed at Calais, consisting of thousands of inflated rubber tanks and trucks "coated in metallic paint to ensure they glinted in the light like [real vehicles]".[746] The ruse worked: distracting the Nazis from the actual landing site in Normandy, the decoy army contributed significantly to the success of the Allied invasion. The war years also saw extensive research into portable hangars and radomes.

Before collaborating with the Irving Air Chute Company on inflatable housing units, the US Rubber Company had developed a series of

[744] When the Fiberthin Air Houses did not stand the test of time, the architect downplayed the mishap and minimised his personal involvement: "all I did for them was to make a tidy little village for exhibition out of their transient balloon shelters". Marc Dessauce, *The Inflatable Moment: Pneumatics and Protest in '68* (New York: Princeton Architectural Press and Architectural League of New York, 1999), 132.
[745] "Lexington Firm Develops a House That You Can Blow Up Yourself", *Courier-Journal*, 28 July 1957, 20.
[746] Sean Topham, *Blowup: Inflatable Art, Architecture, and Design* (Munich: Prestel, 2002), 36–41.

rectangular air-supported structures for industrial purposes, as (temporary) storage and production sites. For the Irving Air Chute Company, which made parachutes during the war and later pioneered the production of "geodesic domes for military use as field shelters, hangars, hospitals and warehouses", air houses were a natural next step in the manufacturing of lightweight structures.[747]

Wright's hemispherical design was reminiscent of Irving's earlier parachute production. The domes were made out of electronically seamed double panels of Fiberthin, a sturdy, linen-like derivative of DuPont nylon that US Rubber had originally developed for lightweight tarpaulins for trucks. The neoprene coating on both sides ensured that the material was protected against fire, tearing, oil, most acids and weathering.[748] Once the houses were inflated, an external air pump with integrated air-conditioning/heating maintained the continuous stream of low-pressure air necessary to sustain the dome.[749] Air was thus the only structural element.

Air houses are an affordable and mobile architecture built around *atmosphere*. Inexpensive homes and a reverence for mobility were recurring themes in Wright's opus.[750] His lifelong pet project, the futuristic Broadacre City, made up of partially prefabricated one-family DIY homes, was structured around total mobility. Its automobile citizens had not only cars and specially designed helicopters but also radio, telegraph and telephone for maximised communication—another type of mobility that shrank spatio-temporal distances. Wright observed of his time: "everywhere now human voice and vision are annihilating distance—

747 Sue McClelland Thierman, "Lexington Firm Develops Shelter That Demands No Support but Air and Is Suited To Many Purposes", *Courier-Journal*, 28 July 1957, 6.
748 "Tomorrow's House: From Frank Lloyd Wright: A Collapsible 'Air House' of Plasticized Fabric", *American Builder*, 2 May 1957, 15.
749 Frank Lloyd Wright, *Complete Works, Vol. 3: 1943–1959*, ed. Bruce Brooks Pfeiffer (Cologne: Taschen, 2009), 340.
750 See the American System-Built Houses (1911–1917), Quadruple Block Plan (1900), Suntop Houses (1939–1940), Willey Houses (1932–1934) and Broadacre City (lifelong project).

penetrating walls".[751] The digital cloud is the culmination of this development.

Echo in Orbit

Just three years after the Fiberthin Air Houses were unveiled, Frank Lloyd Wright's utopia of "distance-annihilating" mobility and "wall-piercing" communication took a leap towards realisation with the successful launch in 1960 of an inflated, perfectly spherical and impeccably lustrous satellite balloon, Echo 1, which was called "the most beautiful object ever put into space". A "big and brilliant sphere" 30.5 metres in diameter, its smooth silver surface was made of the recently invented DuPont plastic film Mylar (PET), micro-coated with aluminium.[752]

Echo 1's size and reflectivity ensured its maximum visibility from earth, an important consideration given the distress occasioned by the USSR's head start in the space race with Sputnik's presence in the skies—even *American* skies—for 21 days in 1957. The US satellite was just as shiny as Sputnik, but 51 times bigger, and it stayed in orbit for eight years.[753]

Echo 1, like Wright's air houses, was an inflatable. In fact, the manufacturer of Echo 1, the firm G.T. Schjeldahl, specialised not only in plastic high-altitude research balloons, adhesive tapes and polyethylene bags, but also in inflatable buildings called "Schjeldomes".[754] The nine-metre-diameter translucent inflatable office domes they constructed in

[751] Frank Sdoutz, "Utopia: Broadacre City", Architecture Theory.Net in the Making, updated 6 September 2015, http://www.mediaarchitecture.at/architekturtheorie/broadacre_city/2011_broadacre_city_en.shtml.
[752] Greg Allen, "The Satelloons Of Project Echo: Must. Find. Satelloons", Greg.org, updated 7 October 2007, http://greg.org/archive/2007/10/07/the_satelloons_of_project_echo_must_find_satelloons.html.
[753] Sputnik was 58 centimetres in diameter.
[754] "Plastic Form Picks Controller", *Minneapolis Star*, 19 November 1957, 18.

1958 in Northfield, Minnesota bear a close resemblance to Wright's Fiberthin houses.[755]

Advances in global audiovisual communication formed a major objective of the Echo programme (circa 1956–1964). When Langley engineer William J. O'Sullivan presented the idea of the satellite at a 1958 congressional hearing, he explained that it could be used "for worldwide radio communications and, eventually, for television, thus creating vast new fields".[756] When it was launched, the passive satellite's signal-reflecting surface echoed the first live transmission to radio operators, a voice message from President Eisenhower declaring: "this is one more significant step in the United States' programme of space. […] The satellite balloon, which has reflected these words, may be used freely by any nation for similar experiments in its own interest".[757] Echo 1 also enabled the first satellite-transmitted coast-to-coast telephone call, and the first satellite transmission of an image, a portrait of Eisenhower. America's next "significant step" in the space age was of course the Apollo 11 mission's moon landing in 1969, which further fuelled the spatial imagination of a generation of activist techno-hopeful architects by supplying new spatialities and imagery, such as the Blue Marble.

Hey, Space Age Cowboy[758]

Among that generation was the boldly playful art/architecture collective Ant Farm (1968–1978), who seized on the intrinsic "time warp" between the US's technological capabilities for space travel and the much less advanced means of communication by which its achievements were

[755] "Firm to Build Factory from its Own Product", *Minneapolis Star*, 19 November 1957, 18.
[756] Allen, "Satelloons".
[757] Charles Q. Choi, "1st Communication Satellite: A Giant Space Balloon 50 Years Ago", Space.com, 18 August 2010, http://www.space.com/8973-1st-communication-satellite-giant-space-balloon-50-years.html.
[758] These are the opening words of Ant Farm's manifesto no. 583, "Allegorical Time Warp". See Felicity D. Scott, *Living Archive 7: ANT FARM: Allegorical Time Warp: The Media Fallout of July 21, 1969* (Barcelona and New York: Actar, 2008), 13.

relayed to the world.[759] Ant Farm's own experiment in air-sustained architecture took the form of the Dreamcloud, an 18.2 metres nylon cargo surplus parachute. Animated naturally by wind or technologically by fans, the billowing parachute created a mobile "response environment" that could be entered or climbed. It oscillated between enclosure and surface, as it functioned simultaneously as kinetic shelter and projection screen.[760]

Conveniently photogenic, the Dreamcloud often served as a background for the group's enviro-images. The space age induced a weariness with permanence, with the confines of rootedness. Characteristically, the young architects of Ant Farm preferred to explore architecture as an (activist) information device—imaginative and radical, like the bold and unprecedented imagery that Nasa had created of a flagged moon and a serenely illuminated Earth suspended in the fathomless blackness of space.

On 14 April 1969, with the staging of an important photograph, Ant Farm began a practice of communicating space via "image technologies".[761] The picture shows two Ant Farm collaborators, Ellen Goodman and Kelly Gloger, hooked up to a large computer set-up via data input nodes. The media printed the image and described the apparatus as Ant Farm's "laboratory instrument which can program the human brain with entire environments from around the world and across the ages". Such "real" environments "might include lurking in a Louisiana swamp […] or a spaceship landed in the Arabian Desert".[762] In line with the group's emphasis on narrative, this instrument existed only in the imagination—mediated through the suggestive image. Ant Farm went on to produce enviro-images that visualised what the imaginary machine would implant in its users' heads. Ant Farm thus extended architectural practice into the imagination—conscious and non-conscious.

[759] Scott, *Living Archive 7*, 13–22.
[760] Scott, *Living Archive 7*, 41.
[761] Scott, *Living Archive 7*, 17.
[762] The quotes are from the Rolling Stones and the Los Angeles Free Press. See Scott, *Living Archive 7*, 46.

The collages overlaid real cloudscapes and landscapes with ephemeral spatial framing via the Dreamcloud and other “mobile equipment”, “experimental prototypes” and “enviro-machines”. The images evoke an unrealised “non-pavilion” intended to promote the transformation of “self and environment” at the 1970 Osaka Expo: “Real©ity”, the copyright symbol in the name being a punning reference to commercialised urbanity, in deliberate counterpoint to Ant Farm’s proposal for a “constantly changing physical/non-physical environment”.[763] Real©ity was composed of a catalogue of “environmental equipment”—various searchlights and machines—designed to produce vast quantities of non-toxic ultraviolet foam, pink mist and artificial snow, along with reality props such as baby llamas. The proposed programme also included “transportation equipment”—reality-enhancing spatial tools—produced by like-minded architects such as the Austrian group Haus-Rucker-Co.[764] At the same time, Experiments in Art and Technology was working on the Pepsi Pavilion and its pink cloud for Osaka, which later was to inspire the Blur Building.

What might be mistaken for an overly youthful, provocatively playful scheme is in fact best understood as an attempt at *building a cloud*. Like a cloud, Real©ity would continuously respond to the atmospheric conditions generated by its props and users. The “intended indeterminacy keeps the future response open-ended”, Ant Farm explained. Under the canopy of the Dreamcloud, Real©ity creates a mobile, traceless and responsive architecture where *atmosphere* is the essential constructive element—much like Wright’s Fiberthin Air Houses. Equally, Reyner Banham’s epithet “monumental wind-bags”—the term he used in a 1968 article to describe inflatable architectures like the Fiberthin Air Houses—is also a perfect portrayal of the Dreamcloud: “the beauty of that simple wind-bag was the directness and continuity of its response. Every slight change of state inside or out—even a heated conversation—brought

[763] Ant Farm Proposal for Expo ’70. Scott, *Living Archive 7*, 27.
[764] Scott, *Living Archive 7*, 25–27.

compensating movement in the skin". Banham appreciated the organic autonomy and responsiveness of inflatables: "as an adjustable and largely self-regulating membrane it is […] truly like the skin of a living creature". "I like that", he concluded.[765]

Ant Farm's proposal for Osaka was turned down, but the Dreamcloud found its way into a series of workshops for architecture students at the University of Houston in 1969. A Texas beach was the setting for "architectural performances" involving the construction of an overnight "moment village" that summoned the protective non-shelter of the Dreamcloud cargo parachute. Ant Farm also pitched a new architecture course, "Enviro-Communication", that would focus on increased environmental awareness, "global consciousness" and global communication systems.[766] They suggested Nasa and US Rubber as possible collaborators, an indication of their regard for extreme (outer-)space exploration and unconventional, mobile, air-sustained space-making.

Globes and Spheres

The somewhat autocratic Frank Lloyd Wright and the tripping Ant Farm boys would have bonded over cars and communication technology. Both used the automobile as the starting point for an idealised mobility. The heroes of Ant Farm's manifestos—Space Cowboy and Enviroman—were the mobile inhabitants of enhanced environments rather than fixed enclosures. And to move they needed the Cadillac, or Ant Farm's specially designed Media Van and their Phantom Dream Car (which crashes through a wall of screens in 1975's *Media Burn*).[767] Wright also designed cars (and helicopters) for the citizens of Broadacre, avidly collected automobiles, invented the term "carport", emphasised semicircular

[765] Reyner Banham, "Monumental Wind-bags", *New Society* 11, no. 290 (1968): 762–763.
[766] See also Scott, *Living Archive 7*, 41–43.
[767] See *Ant Farm*, ed. Marie-Ange Brayer and Emmanuel Cyriaque (Orleans: FRAC Centre, 2007).

parking spaces on the site plan of the air house Rubber Village, referenced the parking garage for his masterpiece the Guggenheim, and even installed petrol pumps at his home in Oak Park III.[768] All these dreams of advances in global mobility and communication would be reflected back by the distance-shrinking architecture of the first American satellite, circling the planet.

Planetary communication enabled by Echo 1, beyond-planetary mobility exemplified by Nasa's Apollo 11 mission, and a new understanding of the planet as a Blue Marble Whole of interconnected but limited resources together fostered a new kind of spatial understanding.[769] The inflated globe acted like the cloud prop in accessing regions formerly out of reach. A spatial preoccupation with the globe—inflated or otherwise—permeated the architectural avant-garde as it watched miniature planet-shaped satellites orbit the earth. The isolated bubble promised amplified interconnectivity through distance-defeating mobility and communication technology. Wright's air houses, uprooted from his "organic architecture", and Ant Farm's enviro-machine Dreamcloud are manifestations of the unprecedented planetary imaginary that originated in the 1960s.

The (Dream)clouds point towards a future in which architecture finds itself confronted with an unusual phenomenon: today's planetary imaginary encompasses an unprecedented spatial disconnection. Cyberspace has sundered the body from its realm of action, just as digital clouds have caused *les mots et les choses* to drift away from a locatable, passive archive. Yet the simple fact remains: you cannot build clouds, because they are not objects but visualisations. Already in 1802 the man who named clouds, Luke Howard, understood that clouds are renderings of atmospheric conditions such as air pressure, temperature, wind and dust

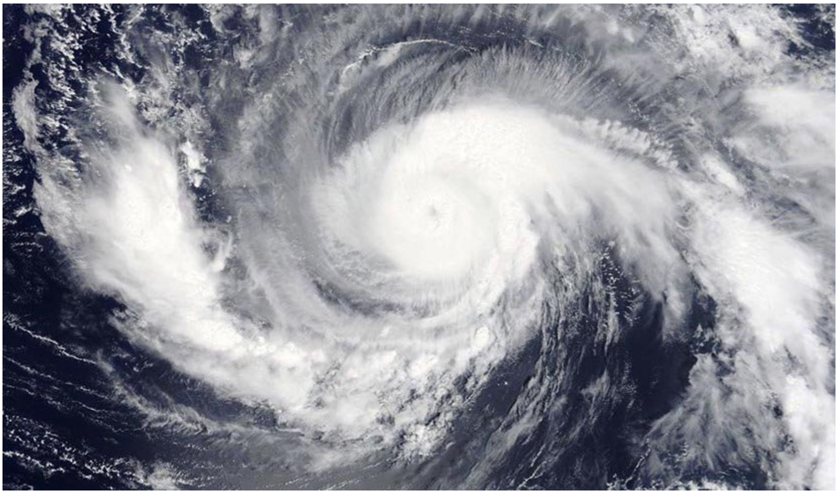
[768] Ingrid Steffensen, "The Auto as Architect's Inspiration", *New York Times*, 6 August 2009, http://www.nytimes.com/2009/08/09/automobiles/09wright.html.
[769] *The Blue Marble* is the name of a photograph taken on 7 December 1972 that shows the Earth as seen by the Apollo 17 crew en route to the moon. See also Laura Kurgan, *Close Up at a Distance: Mapping, Technology, and Politics* (New York: Zone Books, 2013), 8–11.

particle densities. Their shape responds and adjusts to constantly changing conditions that are too complex to be predicted, even with today's advanced weather forecasting and climate simulation models. And like the climate, the future is too global and complex to be predicted with any certainty: Wright's futurologist scheme has proven too characteristic of the past, and Ant Farm's Real©ity has remained caught in a moment.

In regard to the imaginability of the spatial qualities of the digital cloud, the material I have discussed identifies several of these. The cloud creates its own spatiality. The theatre props and paintings described above show that clouds generate a timeless and borderless space. A cloud's lack of surface and its innate mobility allow it to navigate otherwise inaccessible spaces. The spatiality of the cloud is like the information it reveals: veiled and blurred, it is never quite graspable. As long as the digital cloud remains shrouded in an elusive and barely imaginable spatial ephemerality, it can constitute a site of sovereign exclusivity. The disembodiment that occurs in the "reduction of other to data"[770] and the impenetrable intangibility of the digital cloud can be counteracted with historical spatial references that point to characteristics inherent in the digital cloud. The less ephemeral and the more spatially unpacked this construct is, the less evasive and potentially exclusive today's data archives can become. The digital cloud creates a realm of the non-conscious. It is the territory of Big Data harvesting, storing and patterning. This non-conscious creates a realm; it occupies a space which can be imagined but not physically accessed. The spatiality of the non-conscious operates in the meteorological mode. It is extremely perceptive, constantly morphing in response to its perceived surroundings. For Ruskin, "who lacked knowledge of the great cloud systems that encircled the globe—clouds were the great unknown".[771] Now, despite the satellites that monitor their every formation and the algorithms attempting to decipher their "wet information system", the clouds still constitute an "unknowable"—the great outdoors. Clouds, be

[770] Chun, *Control and Freedom: Power and Paranoia in the Age of Fiber Optics*, 29.
[771] Mary Jacobus, 'Cloud Studies: The Visible Invisible', *Gramma: Journal of Theory and Criticism* 14 (2006): 231.

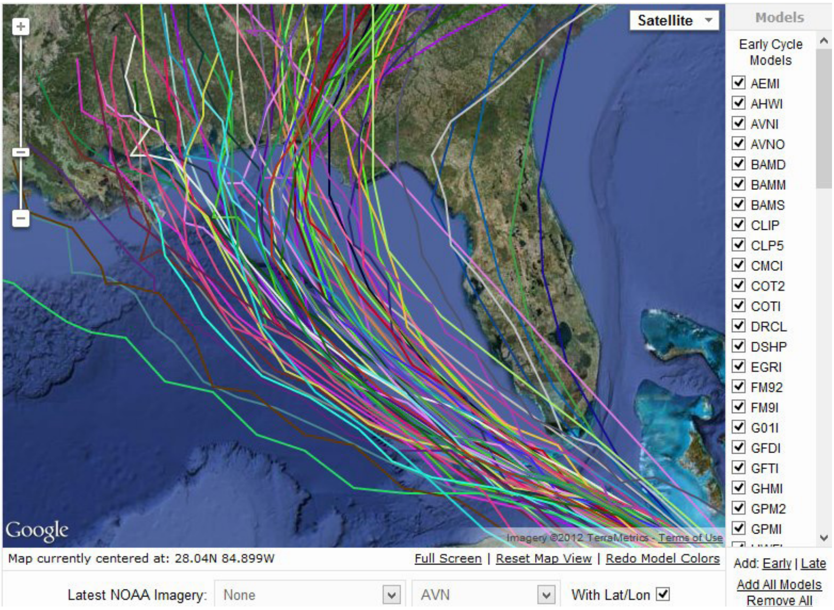
they digital, meteorological or imaginary, exemplify what I call the meteorological mode: a spatiality of dispersal, a temporality of phasing, and a materiality of patterned particles.



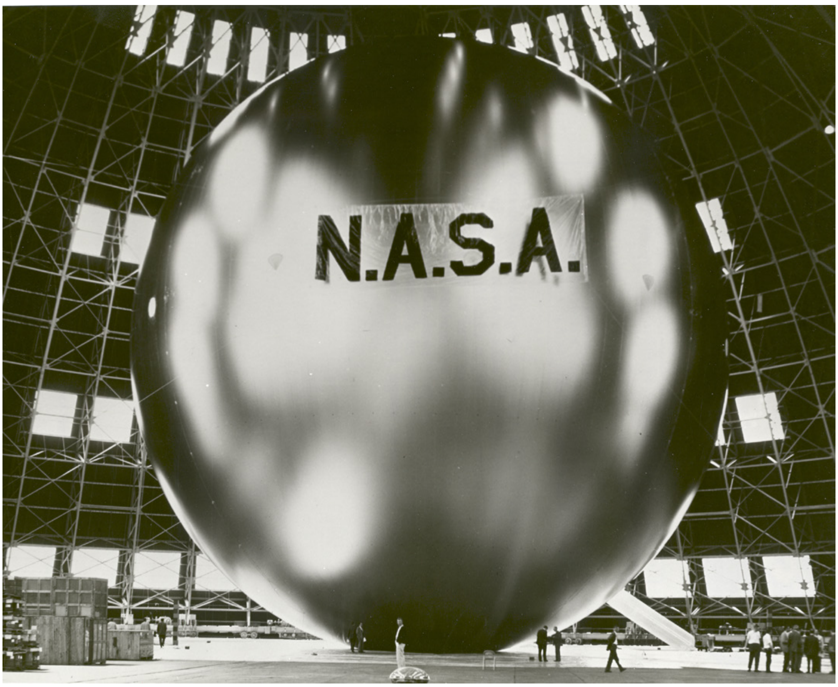
MODIS image of Hurricane Irma, September 3, 2017

The analysis of Big Data occurs via algorithms. This can be thought of as data patterning: besides the pattern recognition that algorithms are designed to carry out, they also assemble raw information into patterns that speak to human cognitive faculties: they make sense. Taking the term “pattern recognition” quite literally ties AI to one of the oldest human forms of visual expression. One pattern type that is especially useful for thinking about data patterning is apotropaic patterns. These are usually a variation of the labyrinth (a diagrammatic reference to the gut as much as to the brain). The hope is that evil spirits will get lost in the labyrinthine windings of the pattern, for eternity. They are thus traps for entities with a cognitive interest in pattern-solving, not unlike Big Data analysts and the near-endless variations of data set interpretations. Hoyle’s novel ends with an incongruity of thought patterns: the alien’s cognition is so different from human cognition that they are fundamentally incompatible. The cloud transmits its information via visual patterns packaged in light signals. The dark cloud in says: “and it is through the eyes that I intend to open up a new world to you”. Despite being made accessible, this world proves to be incomprehensible, like an especially intricate labyrinth.

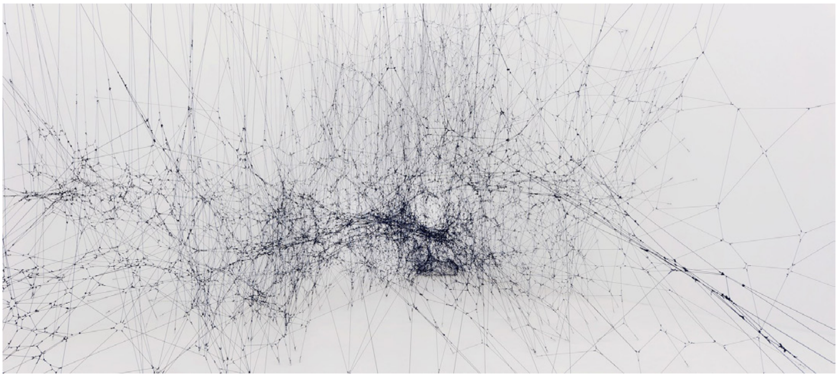
Christian Kerez Swiss Pavilion Venice Biennale 2016, Incidental Space



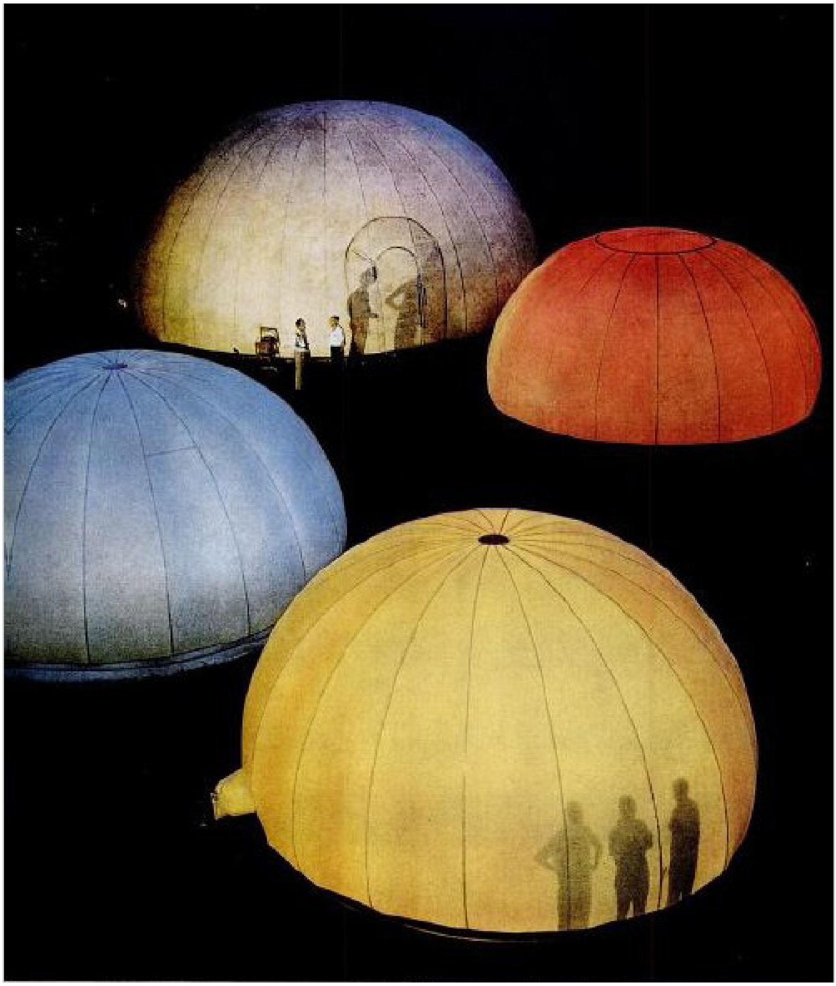
At the time of writing, America had just been held in suspension because of three catastrophic hurricanes. Harvey, Irma and Maria all hit American territory within a space of just 26 days—from 25 August to 20 September 2017. In the run-up to landfall, American television channels would almost exclusively cover the advance of the hurricanes and the preparations that people were making in the areas of anticipated catastrophe. TV channels used several types of mapping to show the projected trajectory: spaghetti models and cone models.



Echo I Satellite



Tomas Saraceno, Aerocene



Frank Lloyd Wright, Rubber Village

Ant Farm, Dreamcloud

Buckminster Fuller and Shoji Sadao, Project for Floating Cloud Structures (Cloud Nine), 1960

Conclusion

The digital cloud permeates daily life. I dedicated my research to this metaphor and the data centres it denotes, to reveal its temporality, spatiality and materiality from an architectural perspective. My goal was to show how the spatial imagination is affected by the concept of a cloud that contains our data, and to explore the reasons for this particular spatial formation: a cloud is a body without surfaces, it is locationless, it forms as swiftly as it dissipates, it defies Cartesian geometry, it withdraws from representation and the possibility of touch, and it offers near-infinite variations of spatial constellations. In its fleeting intangibility and ever-changing morphology, it seemed an unlikely archive. With this thesis, I have shown that in fact the cloud is a revealing metaphor. Like clouds, digital archives embody the meteorological mode: they are extremely responsive and continuously update their animated data, which is in a state of constant transfer.

The data carriers in data centres are linked to geology. Servers are made of materials extracted from the ground: metals, minerals, rare earths. Part 1 was dedicated to exploring the spatial and temporal implications of this material condition of today's digital archives.

Section 1.1 opened with a short history of the beginnings of geology as a science, focussing on James Hutton and Charles Lyell. At that time, the methodology shifted: geology now combined the observation of geological formations with the speed of presently unfolding processes, such as erosion and volcanic eruptions. This practice engendered a drastically changed perception of time and of the planet itself: the geological materiality of the ground was permeated with deep time—time frames that vastly exceed human temporal horizons. The ground, with its enduring materiality spatially arranged by geological processes, came to be understood as an archive. The geologist was dedicated to deciphering the planet's archival logic.

The historical narrative was paired with more recent thinkers who adopted geology as a method. They included art historian John Ruskin's reading of histories in rocks, artist Robert Smithson's "abstract geology" and ground as "jumbled museum", media theorists Wolfgang Ernst's media archaeology and Jussi Parikka's media geology, environmentalist Aldo Leopold's credo of "thinking like a mountain", geologist Marcia Bjornerud's "thinking like a geologist", and medievalist Geoffrey Jerome Cohen's ecology of the lithic, along with Deleuze and Guattari's language in *A Thousand Plateaus*, which was written in the geological mode.

In a next step, I used the preliminarily defined geological mode as an analytical guideline for my first case study, the Lamont-Doherty Earth Observatory, which I visited in 2017. A detailed examination of the archived material, and of the scientific processes used to extract geophysical and environmental information from the cakey mud, revealed that the seemingly still, earthy archive teemed with animation. The cores are treated like animate entities whose archival habitat attempts to imitate their natural environmental conditions. The data they contain is tied to formerly living beings. These are then filtered out, examined and evaluated. Quentin Meillassoux's reflections on the arche-fossil guided my reflections on deep time as archived in the depository's trays and tubes. The Lamont-Doherty as an archive archives the archival materiality of the (ocean) ground and thus embodies the geological mode: deep time permeates its materiality, its spatial structure is generated by movement, and it steadily transforms due to inherent movement that is preserved in the continuously updating spatiality of geological formations. The geological mode is a temporal, material and spatial method that embodies the logic of the ground.

I further explored the notion of the ground as an active entity in section 1.2. To gauge the temporalities at work in the ground, which are largely imperceptible to—and therefore disconnected from—humans, I turned to my second case study, *Il Grande Cretto* ("the great crack") of 1984–2015. Italian artist Alberto Burri conceived this large-scale land art piece to commemorate Gibellina, a Sicilian town that was completely destroyed by the 1968 Belice earthquake. *Il Grande Cretto* is exemplary, both in its conception and in its slowly eroding presence, of the implications of an active ground that extends far beyond a passive projection plane for our notions of nature. Like the analogue data centre at the Lamont-Doherty, *Il Grande Cretto* conserves the geological matter that used to constitute the built fabric of Gibellina.

As with the Lamont-Doherty, I enhanced the description of my experience of the site with an analysis through the lens of the geological mode. My reading of the site was supported by a theoretical framework. Nigel Clark demonstrates the planet's intrinsic temporalities and spatialities. The experience of these is closely bound to the notion of affect, in particular Sara Ahmed's description of disorientation and Lauren Berlant's *Cruel Optimism*. Art-historical references, such as a brief engagement with American land art and Burri's *Cretti* works, further explore the sculpture's material, spatial and temporal manifestations of the geological mode to approximate the temporal complexity of the ground-human relationship. Burri can here be understood as a conductor of a tempo-material choreography which seeks to suspend the persevering geological activities of the ground and the concrete. The geological mode engenders archives that never cease to update their content.

In section 1.3 I apply what I have developed as the geological mode to a (digital) data centre, the third case study. The Nordea Bank headquarters' data centre, like any data centre, is also a geological archive that harnesses the archival abilities of geological matter. From my own experience of accessing the secret world of data centres, I reflect on the practice of secrecy associated with data centres. The secrecy resonates with the fearful safeguarding of the data and with ensuring its continuous access to energy. I reflect on the apprehension and nature of the accidents which data centres need to avoid at all costs. High levels of redundancy and back-up characterise the data centre infrastructure. A natural architectural comparison is thus the bunker, a typology of endurance, as shown by Hu and Virilio. The bunker type is positioned in tension with the vast infrastructure networks that data centres form part of and cannot be isolated from. Koolhaas' Junkspace and Easterling's infrastructural disposition flesh out my description of this inherent typological tension. Infrastructural space is more akin to cloud space than to the architecture object situated on a Cartesian grid. The trajectory that began with the modernist interest in infinite space has conglomerated in infrastructure space. There is a growing interest in architecture not as object but in planetary assemblages of performative space.

The abstract video loop described in the introduction can now be overlaid with the much more concrete, haptic and *real* geological mode. Everything that seemed glossy, static and repetitive in that representation is actually teeming with a rich history of the planet. Behind the reflective surfaces, server disks are continuously spinning, animated in a complex electrical infrastructure that taps into wind, water and solar resources as much as the burning of fossil fuels. These are not far removed from the actual materiality of the server disks themselves: their geological materiality embodies the deep time of planetary histories. Ruskin's musings on reading past legends in the colour swirls of a marble column or wall can be applied to the seemingly mute data racks and server cases. With a speculative gaze, we can decipher the remnants of an archive that extends far beyond the data imprinted on the server disks. Like the plankton fossils at the Lamont-Doherty, the materials assembled in a server have been extracted from the ground. They were then melted, refined, isolated, mixed with *bits of ground* in a process of heat and high energy consumption that resonates with Derrida's archive fever.

In Part 2, against the background of the firm but active (geological) ground of data centres, I turned to the cloud, with the help of the meteorological mode. Section 2.1 is the introductory chapter to the digital cloud, beginning with the philosophical context of the sky and its clouds as media. I amplify this reading through Durham Peters, for example, characterising the meteorological clouds' aerosols as data points that literally store and transmit information across the sky.

Aerosols form in infinite variety: organically, non-organically, on the ground, in chemical reactions with other aerosols. They travel, they disappear, and they return to the ground as precipitation. Aerosols are beyond modelling and beyond prediction. They make the climate unpredictable. They completely escape human grasp, and as such quite literally become part of a planetary non-conscious that "computes" the planet like an analogue model. The meteorological logic supersedes the rhizome, a mode of thought postulated by Deleuze and Guattari in *A Thousand Plateaus*. As the aerosols continuously transform and shift, the cloud clusters they compose create ever-new adjacencies and juxtapositions of data, like data points in the digital cloud.

Referring to early computing—in particular Charles Babbage, who imagined that with enough computing power the particles in the air could be used to compute the planet's history and future—I postulate the clouds as archives. Before the prominence of digital computers, meteorologists used analogue computers to model the atmosphere and other planetary phenomena. Embedded in this tradition, I describe clouds as archives of the world that constantly update their own content and morphology to reflect the world.

Continuing the narrative I began with the cores at the Lamont-Doherty, I turn to ice cores, which—unlike sediment cores—embody the meteorological mode. When clouds precipitate as snow, their externalised archival data can be harvested as ice cores. Whereas at the Lamont-Doherty formerly animate matter would be extracted, in the case of ice cores, scientists have to prevent enclosed air bubbles from travelling through the historical strata and distorting the chronology. The meteorological is highly responsive and immediate, and continuously creates alternative juxtapositions of data. For a spatial constellation of weather and computing, I turn to Richardson's speculative Forecast

Factory. It is a curious combination of a cloud and a globe, designed to compute and archive the planet's weather.

In section 2.2 I explore the digital cloud less in analogy to the meteorological cloud, and more through the arcing history that has affected it. An early databank proposed by the American government in 1966 caused serious concerns over privacy and centralisation, and was perceived to be as dangerous as atomic warfare. The nuclear fallout cloud was looming above America in the 1950s and 1960s due to frequent tests at the Nevada Nuclear Test Site. The relationship between archiving at a time of cybernetics and the constant presence of radioactivity fuelled archive and network fever, finally culminating in our digital cloud. The cybernetic archive attempted to mediate two concerns. On the one hand, there was a desire to accumulate maximum amounts of information to support prediction endeavours. On the other hand, there was a tendency to empty out the archives in favour of updated behaviour, which needed no memory because it was caught up in the continuous self-improvement of negative feedback loops. This resonates with section 2.2, in which the meteorological cloud is shown to visualise "everything" as a fleeting archive. Today's media theory shows that like these clouds, the digital cloud is governed by an archival impulse to update. Static archiving is superseded by data in motion.

In section 2.3, I delved into neuroscience, especially Hayles' description of non-conscious cognition, to show how technical and biological organisms deal with "everything"—all incoming perceivable data. Non-conscious cognition processes and patterns incoming signals, and selects those that need to be forwarded to the attention of consciousness. This data processing governs the human non-conscious as much as it is characteristic of machine learning. The non-conscious is vital for data processing, but it is part of a realm that conscious thought cannot access. I postulate that the space it occupies might be imagined as a great outdoors. This term builds on Meillassoux's *grand dehors* and references Bennett's "out-side". The digital cloud of Big Data, governed by our outsourced non-conscious, not only constitutes this great outdoors, but can also be understood as a mediating device to access this realm. This function relates it to a history of clouds as mediating devices. The example of the theatre cloud prop of the Christian quattrocento is an earlier instance of using artificial clouds to mediate between our "here and now" and an inaccessible, barely imaginable realm: the heavens reserved for divinities. More recent examples from the 1960s—Frank Lloyd Wright's Rubber Village and Ant Farm's Dreamcloud—actualised the Renaissance cloud mediator in architecture during the heyday of cybernetics. At a time when global, instant (real-time) communication and space travel became possible, these architects developed spatial constructs to access the great outdoors.

The digital cloud as object exists on the one hand in the spatial imagination as ephemeral and abstract yet infinite and secure storage. On the other hand, it is a concrete, if largely invisible, unnoticed and even camouflaged assemblage of networked infrastructure. The digital cloud phases in and out of its users' perception, and is experienced exclusively at the elusive level of the interface—the detached surface of its non-body. The cloud constitutes an exterior, a physically inaccessible realm paradoxically filled with intimate and identity-defining information about its externalised users. The digital cloud is thus more than a metaphor: it articulates an increasingly pervasive spatiality of the threshold, of bodies without surfaces, of space as media, of our built world extended into the intangible—in short, a great outdoors.

The meteorological mode, developed in relation to digital archives, offers the vocabulary and conceptual framework for thinking about architecture in a way that engages directly with the environment, embracing change and variability, entangled multiplicities, and unpredictable correlations. The meteorological mode also encourages an updated understanding of architecture as media, situated between various systems of information transmission and archival.

The original Blue Marble, 1972 (cloudy)

Still from Nasa's 2005 Blue Marble Animation (no clouds)

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