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Abstract:
Digital Archives: A Shift Towards the Meteorological

#digitalarchives #cloud

Digital archives are structured around data centres and the Cloud. I navigate these two research objects as both real and imaginary spaces. The cloud is an important realm in the spatial imagination of daily digital archiving practises. Data centres exist for most users only as abstract representations of stylized, clinical rows of blinking lights arranged in potentially endlessly repeated server rack units. To most, data centres remain as physically inaccessible as the cloud itself.

The materiality, spatiality and temporality of today's digital archives are situated at the threshold between the physical, the imaginary, the object and the metaphor. The nature of digital archives can be approached via two overarching themes, the geological and the meteorological. For the data centres, I investigate the geological materiality of digital technologies and notions such as redundancy and resilience. Here, the materiality, spatiality and temporality are more geological featuring e.g. stratification and layering. To describe the cloud, I draw on historical precedents such as the Renaissance religious theatre cloud machinery, on the meteorological cloud and the archival capacities of its aerosols, which e.g. carry biological and geographical information, and traces of nuclear or volcanic events. A more meteorological temporality of phasing, a spatiality of dispersal and patterning, and a materiality of scattered particles/data characterize the cloud.

Paper:
Digital Archives: A Shift Towards the Meteorological

The architecture of digital archives is underexplored because it is situated at the threshold of the imaginary and the inaccessible. The inaccessibility of data centres and the intangibility of the cloud result in the underuse of these evocative spaces as architectural references and lead to their capitalist exploit as sovereign territory. A detailed description of the spatiality, materiality and temporality of the cloud and data centres remedies their abuse of elusiveness and illustrates their architectural qualities. To begin, I invite the reader to delve into the dominant aesthetic description of data centres.

Imagine walking along a 2.8 metres wide corridor. The floor is covered in large, light grey, glossy tiles that are separated by prominent dark grey joints. Above you, there is a generic suspended ceiling, divided into panels that are about two-thirds smaller than the floor tiles. At roughly one metre intervals there is a rectangular, one panel wide light band stretching from left to right above the central part of the corridor, its flat brightness illuminates the scenery.

Uninterrupted rows of identical server racks line the corridor walls on both sides. They are made of near-black, dark grey frames with reflective Perspex doors. There are no visible handles to open the cabinets. At the very bottom, each rack features a centrally placed, flickering, pale green light source, suggesting activity. The cabinets contain 14 neatly stacked server units that slot perfectly into the width of the rack system. If each of these is one U in height, they are topped by a two U ventilation unit. The racks are ca. two metres tall and do not reach the ceiling, leaving a substantial gap. Above the racks, in line with the light panels, there are rectangular ventilation grids, covered by vaguely labyrinthine grates.

As you keep walking, there is no change in your spatial experience; the light remains even, every step feels like the previous step. The corridor is curving towards your right. As you can never quite see around the bend, you apprehend that the corridor may in fact describe a circle. There is no outside—no windows, no doors—just the slick, potentially endless repetition of racks, as far as you can see, before and behind you. Suddenly a kind of blur seems to materialize in the distance, where the corridor disappears into the curvature. As you approach, you recognize the blur as a small, picture-perfect cloud, hovering at about hip-height.

The speculation ends here, before physical contact can be made between the hypothetical data centre visitor and the non-meteorological cloud symbol. Save for the cloud, the imagined experience is a detailed description of a Shutterstock stock-video rendering loop titled "Seamlessly looping animation of rack servers in data center". The copyright belongs to Saginbay, the image format is 16:9 and the clip lengths is 0:08. The HD version costs 79 USD, the cheapest (Web) version costs 39 USD. Such video loops are typical depictions of data centres—the outsourced and mostly inaccessible sites of digital archives.

I have enhanced the looping scenario with a cloud, because it is characteristic of visualizations that are designed to allude to not merely the data centres but also the digital cloud (google-image search "data centre and digital cloud"). The meteorological cloud becomes a strange, entirely abstract anecdote amidst deadpan renderings of data centre corridors.

The existing imagery of the architecture of digital archives is limited and insufficient: Abstract, generic and often computer-generated images of rows of server racks, with the intermittent rendered or photoshopped meteorological cloud suspended between the racks, or against a graded-blue sky that fades into the data centre corridor floor. It reveals little about archiving systems and archived data, other than its intense abstraction. My thesis counteracts this foggy symbolism of glossy surfaces and repetitive loops with an in-depth analysis of the spatial, material and temporal implications of the cloud metaphor.

While an exploration of the planetary imaginary and its influence on archives is beyond the scope of this paper, I explore the spatiality, materiality and temporality of digital archives through two modes of the planetary imaginary that I identify as characteristic: the geological and the meteorological. Research on media materiality, media geology and media archaeology has shown that the physical components of digital archives—the servers and their hard drive disks, the cables, containers and infrastructure—all draw on a geological materiality. The cloud on the other hand suggests meteorology as a kind of methodological and spatio-temporal point of reference for digital archiving practices.

In this paper, I will briefly outline these modes and their consequences on digital archives. The geological and the data centres lay open the concept of animated archives. The meteorological mode as engendered by the cloud, metaphorical and meteorological, open up the field of the nonconscious. I will conclude on my thesis of a great outdoors engendered by an updated variation of Romanticism in the Anthropocene.

The Geological Mode

Geology is a system—a logic or method—that engenders a specific kind of spatiality, temporality and materiality. New media theorist Jussi Parikka (*1976) describes geology as "the science about the ground beneath our feet, its history and constitution, the systematic study of the various levers, layers, strata, and interconnections that define the earth."[1] Parikka values geology as *a way of thinking* about the assemblies between life forms and technological systems:

> It connects to the wider geophysical life worlds that support the organic life as much as the technological worlds of transmission, calculation, and storage. Geology becomes a way to investigate materiality of the technological media world. It becomes a conceptual trajectory, a creative intervention to the cultural history of the contemporary. [2]

Like media historian John Durham Peters (1958*) and thinkers associated with the Canadian media theory tradition, such as Harold Innis and Marshall McLuhan, Parikka is interested in media not merely as apparatuses but as systems that "refer back to cosmology and geology" and the "idea of the earth, light, air, and time as media."[3] He postulates the concept of a "geology of media: 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."[4] Parikka thus draws attention to the geological materiality and, what I would call, the geological mode of operation that characterises media culture.

The geological mode is also temporal. Media theory has established temporal ties between geology and media theory by emphasizing temporalities discovered by media archaeology and its shared notion of deep time.[5] Deep time is a concept first established by the founding father of geology, James Hutton (1726-1797). Geologic or deep time is tied to uniformitarianism—the understanding that geology is based on gradual processes such as erosion and sedimentation that continuously change the planet. Hutton's theories were popularized by his successor, Scottish geologist Charles Lyell. In his seminal book *The Principles of Geology*, Lyell describes the planet as its own archive-archivist—always changing and keeping track of its own changes: the planet's geology as an archive of change. It was the role of the geologist to make sense of the somewhat messy archive.

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[1] Jussi Parikka, *A Geology of Media* (Minneapolis: University of Minnesota Press, 2015), locations 192-199, Kindle for Mac.
[2] Ibid., locations 192-199.
[3] Ibid., locations 181-185.
[4] Ibid., location 181.
[5] Ibid., locations 249-255.

The notion of the planet as archive historicizes theorist Benjamin Bratton's (*1968) unambiguously geological understanding of computing as a planetary scale *Stack* composed of digital and infrastructural layers: A "cybernetic landscape"[6] that quivers like the geological ground "in barely accountable rhythms."[7] 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."[8]

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. The devices on which digital content in data centres is archived can be understood as materially composed of rearranged geological (archive) layers. 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.[9] 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 …. Its role is to help orientate the magnetic grains, as well as reducing interference between layers.[10]

Each material thus plays a precisely defined role in the archival strata of digitally deciphered, re-organized geological disks. The ground as the source of digital materiality and archival temporalities resonates with the multidisciplinary scientific dissection and archival of "the Big Data of ice, rocks, soils, and sediments."[11] The extended field of geology pierces the ground, extracts core samples, preserves these in their "muddy, icy, soggy"[12] states in order to analyse, classify and archive them in ways that, in media scholar Shannon Mattern's words, "acknowledge the Earth as a vast geo-informatic construct."[13] Unlike the Big Data gathered in the cloud, this geological data is "resolutely material"[14] and demands preservation of its atmospheric and climatic conditions in order not to wither.

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6 Benjamin H. Bratton, *The Stack: On Software and Sovereignty (Software Studies)* (Cambridge, MA: The MIT Press, 2015) locations 669-1671, Kindle for Mac.
7 Ibid., locations 1669-1671.
8 Ibid., locations 2051-2053.
9 http://www.platinum.matthey.com/about-pgm/applications/properties-of-pgm
10 http://www.platinum.matthey.com/about-pgm/applications/properties-of-pgm
11 Shannon Mattern, "The Big Data of Ice, Rocks, Soils, and Sediments", *Places Journal*, November 2017, https://placesjournal.org/article/the-big-data-of-ice-rocks-soils-and-sediments/, last accessed 20 June, 2018.
12 Ibid.
13 Ibid.
14 Ibid.

Animated Archives

This necessary atmospheric conditioning can be observed for example in the Lamont-Doherty Earth Observatory of Columbia University, one of the three largest core repositories in the United States. Here, sediment cores from every major ocean and sea are preserved in two large rooms. One of these contains cores taken after 1985 and is consistently refrigerated at 4.5°C to preserve the moisture contained in the sediment samples. The facility houses 18700 cores of 8 and 5 foot lengths, adding up to approximately 72,000 meters of core. The moist samples are contained in closed plastic tubes, the dry samples are in open rectangular metal trays. The samples are divided into an untouched archive core and the *dissectible* analysis core. If a scientist requests a particular section of the analysis core half, these gaps are filled with foam placeholders.

These archived cores in their storehouse of the planet's extracted geo-informatic data convey a distinct sense of *being animated*. Only the substances that *used to be alive* are singled out for analysis. In a first step of analysis, scientists thus extract fossils of plankton species from the cores. These fossils allow the dating of contained oxygen isotopes ("light" oxygen-16 and "heavy" oxygen-18). The ratio of occurrence of these two isotopes reveals information on 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.

On a second level of animation, the cores are being sustained, like living organisms, under certain 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. 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 °C, the dew point within −9 to 15 °C and the relative humidity close to 60%. The language describing different archival facilities has adapted: 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 back-up 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, 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.

Considering the compressed geological materiality of the server disks, they can be read as sediment cores 'in reverse'. Rather than extracting a compressed cylinder, which is then separated into atoms-thin temporal disc-slivers containing flattened information of formerly animated entities, the hard drive disk is the result of a process of maximized compression of information onto magnetic, geological material. In my thesis, I further explore the spatial nature of digital archiving through the geological mode of flattening, stratification, compression and petrified flows—processes that become activated in the animated archive.

Meteorological Mode

The digital cloud—part radio waves, part meteorological metaphor, part spatial imagination—has come to conceptually umbrella and safeguard all digitalized and externalized data and its analysis. It stands in for the data centres that physically contain the archived data and blurs their physical materiality. The cloud suggests meteorology as a kind of methodological and spatio-temporal point of reference for digital archiving practices and data analysis and is, as I will show, also an animated archive in the meteorological mode. I will show that the meteorological engenders a way of organizing information that has been imitated by the digital cloud and explains the use of *cloud* as metaphor for data analytics and storage services tied to static, generic and firmly situated data centres.

The term "digital cloud" is a metaphor because it really refers to digital storage on servers in data centres that are connected to sites of document production via Wi-Fi and fibre optic cables. The cloud, meteorological and digital, is an archival entity, a *space* of inaccessible archives and elusive materialities—imagined as much as material and infrastructural. It is a body without surface[15] that visualizes information, unbound by geographical coordinates.In order to describe the spatial and temporal potential of this metaphor, as encapsulated in the meteorological mode, I explore a variation of the cloud that arguably originates the metaphor: the meteorological cloud.

67% of the planet are always covered by clouds. Planet Earth is a cloudy haze more than a blue marble. Despite their continuous presence, clouds remain fundamentally elusive: They are unmappable and difficult, if not impossible to model or predict accurately, because clouds visualize immense amounts of data—not all of which is fully understood by scientists. This data is in a constant flux of updates as it interacts with other elements. The meteorological cloud can be understood materially as an archive. It consists of water and transports the particles onto which water condensates, the aerosols, also known as "seeds" or cloud condensation nuclei. Aerosols transmit a variety of physical information, for example of deserts and flora, of nuclear events, explosions, volcanic activity, and CO_2 pollutants.

Aerosols—fine solids and droplets—are found in the tropo- and stratosphere. They vary in size from "a few nanometres—less than the width of the smallest viruses—to … about the diameter of human hair."[16] 90% of them occur naturally, 10 % are anthropogenic. Aerosol particles stay in the air for four to seven days, and they may travel at speeds of five metres per second. Depending on their source, aerosol types conglomerate in characteristic areas. For example, oceans are veiled by a thin mist of salt and sulfates aerosols produced by whitecaps and microalgae. Enormous dust plumes form above deserts.

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. The information clouds carry constitute their materiality and influences their spatial formation. One cloud might assemble volcanic ash,

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[15] Leonardo da Vinci, C.A., 132rb; *The Notebooks of Leonardo da Vinci*, ed. Edward MacCurdy (London, 1938), vol. 2, pp. 363-64. See Hubert Damisch, *A Theory of /Cloud/: Toward a History of* Painting, trans. J. Lloyd (Stanford: Stanford University Press, 2002), 281.

[16] https://earthobservatory.nasa.gov/Features/Aerosols/page1.php

pollen, sea salt and soot. The soot might then cover the surface of sea salt particles. This mix in turn will determine how much heat the cloud retains or reflects, and when it precipitates as rain.

The morphology of clouds is in constant flux, just as their chemical and physical composition. They are thus difficult to classify. Prior to 1802, meteorological clouds were similarly enigmatic as the mysterious space that the digital cloud of invisible non-ionizing microwaves occupies 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, clouds became considerably more tangible. Howard's nomenclature came after a century characterised by great advances in taxonomy, spear-headed by Swedish botanist Carl Linnaeus, who established a binomial classification system for organic life with the publication of his *System Naturae* in 1735. However, the revolutionary aspect about Howard's system was that it classified occurrences that are not entities in themselves, but that are the "visible signs of vast atmospheric processes."[17] His three basic categories of clouds—cirrus, stratus, and nimbus—reflected atmospheric processes instead of their resulting shapes and could be combined to describe further cloud variations. One could now distinguish a plump nimbus cloud consisting of condensed water from a delicate cirrus cloud, with its thin, feather-like strands of ice crystal formations.

Since Howard's time, when clouds could only be studies from below, much insight has been gained by seeing clouds from above, enabled by long-term observations[18] from NASA's Terra and Aqua satellites launched in 1999 in 2002 respectively. From above it becomes clear just how responsive clouds are: cloud patterns reflect the topography and temperature of the planet's surface, and its reflectivity, ships and airplanes, winds and atmospheric pressure.

A striking example are wave clouds. Seen from above, these form large V-shaped fields of alternating clear and clouded strips, like air ripple moiré patterns. The bands visualize 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 by comparison miniscule iceberg impacts a vast field of air surrounding it. Looking at cloud patterns thus points to two archival aspects of the cloud: On the one hand, there is the information embodied in the particles, their origin, travels and interactions. On the other hand, there is the continuously changing context of the cloud. A cloud visualizes its surroundings, and by extension, the world.

This notion resonates with the origins of computing as closely linked to the planetary imaginary as an archivist practise. Charles Babbage (1791–1871), Lucasian Professor of Mathematics at Cambridge University from 1828 to 1839, was an important figure in setting this trend. Rather than seeing the ground as archive, as did his friend Charles Lyell, Babbage declared, "the air itself is one vast library"[19] of all the words that have been spoken, and all the winds and currents that have acted upon it. His view of the world as archive was informed by a computational logic that also led to his computing inventions – the Difference Engines I and II and the conceptually more complex Analytical Engine.

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[17] Richard Hamblyn, *The Invention of Clouds: How an Amateur Meteorologist Forged the Language of the Skies* (New York: Farrar, Straus, and Giroux, 2001), location 1989, Kindle for Mac.
[18] (http://ieeexplore.ieee.org/document/6422379/)
[19] Ibid.

Babbage believed with "Laplacean determinism"[20] 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"[21] would be able to compute the components' past and future trajectories. According to Babbage, when we speak, we set airwaves into irreversible motion, affecting every atom of the atmosphere and changing their trajectories forever. He describes the irretrievable effect of speech on the atmosphere's molecules as follows:

> 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 ….[22]

With enough computational power, knowledge of the air's behaviour and causes acting on it, the atmosphere's past and future trajectories can be deduced.[23] The air in Babbage's view is thus an archive and a predictive tool, a visualisation of the forces that act on it, just as the clouds are responsive visualizations of extensive information and processes: the phase-behaviour of water, wind movement, atmospheric conditions, chemical and physical aerosol behaviour and interactions, the history of these particles—their creation and travels—and nearby physical bodies—the air movement these cause, their temperature and trajectories.

This apparently disconnected interaction is 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 materiality of patterned particles. The meteorological mode has already precipitated in the architectural discourse, for example in Keller Easterling's *Extrastatecraft* (2014), which traces socio-economic power structures and their space-shaping potential in infrastructure space. Architecture is moving away from the Cartesian object locatable in an absolute grid system towards the logic of infrastructure, governed by disposition,[24] Simondonian flows and the channelling of agencies, activities, information and material that—much like much like its users—navigate space by correlation. The concern with space that has dominated modern architectural discourse gives way to a cloudy gathering of what traverses it, be it bodies without surfaces, withdrawing objects or channelled resources.

A politics/perception/geometry based on the spatiality of the cloud could, unlike the postulated danger of the territory of sovereignty associated with the cloud of Big Data, result in a more fluid, less exclusive concept: oriented along da Vinci's understanding of bodies without surface that "readily melt into and mingle with other thin bodies." By consequence, their extremities "are mingled with the bodies near to

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[20] Geoffrey C. Bowker, *Memory Practices in the Sciences (Inside Technology),* (Cambridge, MA: The MIT Press, 2005), location *1024-1033*, Kindle for Mac.
[21] Ibid., location *1024-1033*.
[22] Charles Babbage, *The Ninth Bridgewater Treatise*, 2nd edn. (London: John Murray, 1838), p. 108-109.
[23] Ibid., p. 111.
[24] Keller Easterling, *Extrastatecraft: The Power of Infrastructure Space* (New York: Verso Books, 2014).

them, whence by this intermingling their boundaries become confused and imperceptible."[25] Clouds thus mark the threshold to an increasingly inhabited yet under-described spatiality of inclusive variability, fluid accuracy and unbound locatabilty.

The Great Outdoors

The cloud can be seen to establish what French philosopher Quentin Meillassoux calls "le grand dehors": an utterly removed, barely imaginable, yet ever-present great outdoors.[26] 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…that outside which thought could explore with the legitimate feeling of being on foreign territory—of being entirely elsewhere."[27] The digital cloud is "entirely elsewhere"; it is an agglomeration of information that was once interior to its users, but it withdraws from them, becoming a convergence of three lines of inaccessibility: spatial disorientation, the impossibility of touch, and inconceivable accuracy.

The Anthropocene romanticizes the notion of a *pure* nature, uncorrupted by human presence. Human activities are now a dominant influence for the entire planet, including even its climate, which raises the concern that all unchartered, 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 an expulsion from paradise, or the separation of a world of ideas from a world of things, or the dawn of the Anthropocene. The digital cloud is "entirely elsewhere": despite being generated by human content, it is inaccessible to human bodies and 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.

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[25] Leonardo da Vinci, C.A., 132rb; *The Notebooks of Leonardo da Vinci*, ed. Edward MacCurdy (London, 1938), vol. 2, pp. 363-64. See Hubert Damisch, *A Theory of /Cloud/: Toward a History of* Painting, trans. J. Lloyd (Stanford: Stanford University Press, 2002), 281.

[26] Timothy Morton describes this as a clumsy translation of the French "le grand dehors" in *Hyperobjects: Philosophy and Ecology after the End of the World* (Minneapolis: University of Minnesota Press, 2013), 64.

[27] To Quentin Meillassoux, George Berkley was one of the first "critical" thinkers because he divided perceivable qualities into primary and secondary: "Those properties of the world which are a function of our relation to it, and those properties of the world as it is 'in itself,' subsisting indifferently of our relation to it." To Meillassoux, the problem is defined by the fact that "thought cannot get outside itself in order to compare the world as it is 'in itself' to the world as it is 'for us,' and thereby distinguish what is a function of our relation to the world from what belongs to the world alone." Quentin Meillassoux, *After Finitude: An Essay on the Necessity of Contingency,* trans. Ray Bassier (London: Bloomsbury, 2008), location 97, Kindle for Mac.