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Is the Earth an Optical Medium? An Interview with Chris Russill

KATE MADDALENA
University of North Carolina at Wilmington

CHRIS RUSSILL
Carleton University

A discussion between Canadian media theorist Chris Russill, associate professor at Carleton University, and Kate Maddalena, assistant professor at the University of North Carolina Wilmington, articulates Russill's work in terms of current conversations in media-related cultural studies. Russill uses media theory, particularly the intersecting lineages of Michel Foucault, Harold Innis, and Friedrich Kittler, to describe planetary media that record, store, and transmit light. He then discusses implications for the technical media apparatus being created, largely in earth systems sciences, to read, process, and deploy appropriate action in response to the same. The conception of earth as optical medium affords insight into the power politics of ozone holes, climate change, the photosynthetic machines of science fiction, and sunscreen.

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Kate Maddalena:
This symposium is called *Media, Epistemology, Power*, so let's start by talking about how your work addresses media, knowledge making, and power dynamics.

Chris Russill:
I ask how media theory can engage crises disclosed by the earth sciences.

Dipesh Chakrabarty (2009) argues that the earth sciences force a distinction between the planetary and the global, and he claims the politics of climate change turn on taking up how the planetary is disclosed by contemporary earth science, a nice approach to Gayatri Spivak's (2005) call for the planetary to overwrite the global. How do we register, record, and process the planetary? The problem challenges media theory in interesting ways.

We get glimpses of "the planetary" in the mid-20th century. The first off-planet imaging of the atmosphere by missiles and satellites, and the first computations of global atmosphere, these challenge how we imagine, see, know, sense, and measure the world. Yet, these glimpses—the satellite imaging of the earth's atmosphere, the prehuman atmospheres found in ice cores, the atmospheres modeled

computationally as dynamical systems by Lorenz—these fail to register with culturally and politically authoritative actors. These glimpses don't figure into the politics that were scaling up how we know and manage environments into globalist terms. The "whole earth" photographs, the "global village," these concepts deflect or recode such glimpses into globalist conceptions. The events, institutions, practices shaping the global, whether they be world war, economic expansion, ecological politics, all efforts to code the earth in global terms, they fail to register or organize the signals of planetary operation we get in the 1960s with cloud imagery, ice cores, and computer modeling of the atmosphere. There is a different conception of the earth that media—planetary media—are disclosing. These media sense, capture, and manipulate temporal processes that exceed us, they afford us some access to a planetary sensibility.

Ice cores, for example, hold atmospheres predating humanity. When I began my dissertation work at Penn State, Richard Alley (2000), a professor of earth science on campus, had just published *The Two-Mile Time Machine*. You drill two miles into the earth and you get a new answer to the oldest questions in climate science. How do ice ages work? How do they begin and end? The answer is: fast. They can end brutally fast. They can end within a decade. That's bad news. It means global environmental regulation has been working with a flawed conception of the planet. We should have noticed that with the ozone-hole crisis; it should have disclosed how technical media afford us glimpses of the planetary, but it didn't. Alley was also chairing a synthesis on abrupt earth systems change for the National Academy of Sciences around this time, around 2000 or 2001, and the report illustrated that there were lots of moments when planetary operation shifted abruptly and on timescales accessible to humans as well. It was just that this hadn't yet happened while there were humans on the planet—which hasn't been for very long. A new paradigm for planetary science was congealing, one entirely out of step with the conceptions of the global environment governing international policy.

I set out to observe this capacity to record and process planetary cycles, recursions, and temporalities, and specifically how it disrupted key sites of culture, politics, and policy. Chakrabarty illustrates how this science creates rifts in our thinking. I didn't have the benefit of his work at the time, but the tipping point essays I wrote understood the rift in genealogical terms and as a disruption of the epistemic communities governing global atmosphere.

The UN assessment reports on climate change—this is around 2001, the third assessment, when Alley's group is publishing syntheses of the abrupt change science—the UN Intergovernmental Panel on Climate Change (IPCC) assessments prioritized modeling that incorporated the socioeconomic, sociocapitalist future the international system wants to protect or entrench. It worked probabilistically and sought to integrate cost-benefit analyses, and so it continues to prioritize planetary changes that its methodologies and institutional organization can accommodate. But the conceptions of environmental change that are operative in the models used to inform policy represented only a narrow slice of the sorts of changes that Alley's work finds characteristic of the planet. They didn't permit or prioritize what we today call tipping points. Abrupt shifts in climate, discontinuous changes in planetary operation, these are outside of human experience, and so these were treated as anomalies by global institutions seeking to manage climate change. The Alley synthesis illustrates that large-scale discontinuities, as they are artfully called, are not anomalies at all. They are geophysical regularities, evident when you are able to set aside the temporalities that structure modern life.

I have since moved into the infrastructural work dealing with epistemology and media. Infrastructural inversion lets you talk about information processing in ways reflecting the complexity of earth and planetary science. It is conversant with geophysics, it doesn't reduce earth sciences to ecology or greening-talk, and it lets you escape naïve or silly conceptions of data. It lets you think about how we access the heterogeneity of temporal processes that condition our existence without trying to force them into narratives of ecological consciousness or conceptions of agency built around human vision, human sight. I feel Lisa Parks' (2005) book on satellites and the visual remains an outstanding example in this respect, of television and satellites as epistemological infrastructure, especially her chapter on the Hubble telescope. I'm currently trying to articulate how the relationship of epistemology and infrastructure has developed through the notion of infrastructural inversion, particularly Paul N. Edwards' work, but also Geoffrey Bowker's (1994) old book on oil drilling, his work with Susan Leigh Star, Stephen Jackson's research, and of course, John Durham Peters. The importance of an infrastructural approach to epistemology hit home when I moved from the trade press, gray literature, and published science into textbooks on earth science. You are all set for physics, fluid dynamics, and bracing yourself for math. But they begin with discussions of what programming language to select. Go learn Python. It isn't quite Heidegger having you read Aristotle for 10 years or 15 years before getting to Nietzsche, but still.

Kate Maddalena:
Computer languages point to a question I wanted to ask, because I'm familiar with other work of yours that I would call more rhetorical scholarship, maybe: Why media theory? I'm thinking it has something to do with how this kind of science escapes phenomenological and pragmatic frames. Computation is difficult when you want to talk about (ostensibly sensible) objects.

Chris Russill:
The earth is an optical medium.

We think of it as a medium of life, as a medium of the biological, but the earth is first and foremost a medium of light. It is a medium of life *because* it is a medium of light. The planet's habitability rests on how it processes light. Usually, this condition of existence doesn't figure into our thinking. We don't keep time with sundials anymore. We don't think much about whether the conditions of life originated as stardust. The sun will eventually envelop and destroy the planet, but it's a ways off. This sort of elemental curiosity doesn't figure into our thinking, unless you seek to attune with the elemental sources of being. The sort of thing Heidegger seems to bring out of people. Alex Garland wrote a fantastic screenplay on facing a dying sun, on the ultimate time-axis manipulation problem, which was if and how to extend humanity's eventual extinguishment given stellar evolution, and the difficulties of inserting oneself in the temporal management of the most elemental process. I really wish we had that film. The resulting film was unwilling to stay with that thought and became just an awful mess by the end. But it is important to think this through now because industrial systems have messed profoundly with the planetary dynamics of light processing. Now the elemental matters a lot. We need to recover how habitability is connected to the evolution of optical media. I have the sense that Peters' (2015) new book is doing this work—a Gaiaturn for media theory perhaps.

Kate Maddalena:
It resonates. Peters is filling out media theory by looking at historical examples of how the elements are media, so when you say, "the earth is an optical medium," I think we are definitely taking part in that conversation.

Chris Russill:
I wonder if I stole the notion from him. It is certainly a consequence of Chakrabarty's call to take planetary science seriously. One project is to take a single-spectrum average of each planet to disclose information about its atmospheric composition. Life alters atmospheric composition, alters how a planet's atmosphere processes light, so it's the best chance to find traces of habitability—each planet reduced to a pixel. In a sense, planets become matters of programmable light. It hints at how the problem of finding, monitoring, and observing inhabitable environments is bound to the evolution of optical media. Geoengineers understand the planet this way. They propose to program the atmosphere to admit less light to retain the habitability of the planet for contemporary societal systems. You release sulfate aerosols into the atmosphere to dim the planet, to facilitate global dimming, in order to cool down the surface temperature of the earth. We may not want to call this programming, but when you are altering the chemical composition of the atmosphere at the level of parts per million, when you seek to set the atmosphere at 450 parts per million of carbon dioxide equivalent, and do so in order to regulate how sunlight is processed by the earth, in order to keep the earth in a particular temperature range, well, it is a style of thinking influenced by notions of programming. Is this not the programming of light processing?

To return to your question, media theory is crucial because it provides theoretical frameworks for the *abstraction of vision* that any effort to disclose the planetary will entail.

The ozone hole is probably a better example. Ozone holes are reasonably simple illustrations of the abstraction of vision. We don't sense ozone. We record ultraviolet light from the ground and outer space as it interacts with the atmosphere. So you need a system for recording sunlight itself, a network for making sunlight an object of technical mediation. We infer upper atmospheric ozone by comparing wavelengths of light recorded by ground-based and satellite-flown sensors. The contrast of two wavelengths, a wavelength pair, or the contrast across different pairs of wavelengths, that is how you determine how much ozone is up there. So, you are abstracting from human vision to record light. And the ozone measure, that is done in Dobson units, and a Dobson unit equals a layer of ozone[1] at zero degrees and surface-level air pressure. I think I have that right. My point is that this too is a remarkable abstraction, particularly since we are not interested in ozone at that temperature or surface pressure—ozone down here with us we definitely want to avoid. Anyway, when the concentration of ozone in the stratosphere falls below 220 Dobson units, we call it a hole. So the hole is an abstraction symbolized in number and wrapped in a metaphor. You can't see the hole. You don't sense it directly. We don't use UV intensity meters or Geiger counter–like devices. It is the numerical processing of the earth as an optical medium that disclosed the first environmental crisis. We are attached to wider planetary processes via numbers.

[1] 0.01 millimeters

This is why NASA's breathless claims to peer into the ozone hole are a little disingenuous. There is no hole, at least not in the sense of a complete absence of ozone, and it is only the dominant convention for visualizing the hole that suggested these holes were not vertically stratified in the first place. Everyone knows the atmosphere is vertically stratified, but the visualization of numerical media, the plotting of numbers via isolines on global diagrams, is misleading in this respect. You know, the first graph disclosing the ozone hole, the simple plotting of numbers with numbers, remains the most informative depiction because it correlated ozone levels with the presence of CFC levels. The accompanying statements were wrong. The causal explanation was mistaken, but the association was crucial. All visualizations and animations of the hole subsequent to that tell you less.

We need to detach our understanding of the ozone hole from the mythos of global environmental crisis, to stop treating it as a discrete environmental issue, and certainly to move away from the presumption that a visual representation motivated global environmental politics. Instead we ought to initiate theoretical work on the abstraction of vision to orient our approach to observing and imaging the planet. Recordings of invisible light disclose the chemical composition of the atmosphere, and this alerts us to the radiation threat that life faces from the sun when you alter the material composition of the earth's atmosphere—the industrial churning of the atmosphere has altered the habitability of the planet and has necessitated observation in the infrared and UV bands to discern global warming and ultraviolet radiation threats.

Kate Maddalena:
That's interesting. When I hear you talk about those thresholds—the discrete numerical border that denotes hole versus not-hole, which sounds a bit like the data "bins" that astronomers use when they analyze spectra, I think about work I'm doing to describe what I'm calling "a digital episteme" as a facet of knowledge-making power. And Friedrich Kittler's two (falsely) distinct discourse networks are a touchstone for my theory—the jump from the literary to the digital as a result of the need for discrete, nonsemantic (or noise-free), units of information. Quantifiable. Manipulable. Abstraction is another smart way to get at the nonsemantic that I hadn't thought of.

Chris Russill:
The optical realm, the earth or nature as optical media, it definitely complicates the usual way Kittler is understood, at least over here, which is in terms of an abrupt disruption of the monopoly of writing by the differentiation of optical and acoustical recording from writing. Optical recording is perhaps not so subordinated by writing as is usually assumed.

You are working with Kittler, so you will like this. It was the computer programmer on the research team who found the ozone hole in the data. Optical media detected the ozone hole long before it was discovered. The evidence was recorded before anyone recognized it. The programmer hired to automate the analyses, to calibrate the instruments, and automate how UV light is made a measure of ozone concentration, Jon Shanklin, he was the one noticing the anomaly. He is sent out to quell public concern with ozone depletion. His strategy for doing so is to share the data—classic deficit model thinking, right? Well, good thing for the deficit model then. In doing so, he notices abrupt declines in springtime levels, and so the hole is discovered. Not instantly, mind you, not as an epiphany or sudden realization. He just followed up this strange depletion found in the data, and the research team inverted their infrastructure,

and they couldn't make it go away, and so this artifact of the real forced the overturning of their understanding of how the atmosphere could change. There are other stories. That one is my favorite. Even the more atmospheric science friendly tales of discovery, those stories also converge on how optical media recorded evidence of an abrupt planetary change that exceeded what humans had imagined possible.

It reminds me that with the ozone hole, it isn't just the abstraction of vision. You are processing the recording of light. The hole was experienced as a surprise, as a shock, as an existential disruption, because it violated the episteme governing atmospheric science; it was a manifestation of the planetary that did not conform to how globalist institutions hoped to manage, model, and know the atmosphere. Whatever hubris might have animated atmosphere science before 1985, whatever hubris was left after Lorenz showed weather control was impossible, the ozone hole eradicated it. It is tempting to say atmospheric scientists were trained not to see it, that the episteme governing how earth science informed global politics did not permit it. There is no doubt earth science is now organized infrastructurally by a completely provisional conception of knowledge, as Paul N. Edwards has demonstrated, and that it is now caught up and consciously organized as an unceasing process of infrastructural inversion. You might say this is how the hole was discovered. Steven Jackson (2014) has a wonderful phrase—"broken world thinking"—and it is precisely how we should approach the hole, not in terms of discovery, but repair and amelioration on a longer timeline.

Theoretically, you need to link optical recording and information processing in different ways than was the norm in the 1980s; you have machines sensing and processing the planetary in ways that exceed how we sense, feel, and know the planet. The prevailing episteme for atmospheric change was wrong. We were lucky that Shanklin was ignorant of that episteme—he was busy removing people from their intermediary role in light processing so that light recording was made automatically into measures of planetary ozone.

I find Kittler helpful here. If you can disentangle the way Kittler links optical recording and information processing from his teleology of automated digital computing, which we should reject, then his treatment of the abstraction of vision gets us access to the planetary. The planetary as disclosed by what Paul Virilio (1994) calls big optics. I think this work can be reread with contemporary earth science as the horizon, instead of Claude Shannon or Albert Einstein, instead of the war answer to media.

Our usual approach to the abstraction of vision elicits 19th-century experiments in human physiology. These experimental programs afford new conceptions of the body, of the embodiment of the observer, and so the developmental logic of technical media is bound to these experimental incursions into the bodily, right? Marshall McLuhan generates his "extensions of man" theory, his media as prosthetics approach, by abstracting from the physiological science available to him. Jonathan Crary (1990) gets us there. Crary's history of optical devices is brilliant in this respect. The innovations commonly associated with modernist art comprise elements and tendencies found much earlier in the century in the realms of science and technology.

Anyway, Kittler can't have it. He can't permit the history of the "abstraction of vision" to be so fully colonized by the physiologically embodied optics that Crary lays out. He extends the timeline of optical media to reposition Crary's work as an anomalous moment in media theory. McLuhan's too.

The principle underlying Kittler's objection to Crary is essential. But the way Kittler pivots out from Crary is a bit suspicious. It creates all sorts of theoretical problems and I'm not sure anyone fully buys it. So, even if we resist the move to Shannon's model, even if we oppose recoding McLuhan as an evolutionary blip toward information theory, Kittler is right to emphasize that optical recording need not have anything to do with how humans register, handle, or process light.

Let's back up. I know you work on this yourself, Kate.[2] Consider how Kittler approaches Crary and McLuhan. Kittler narrates the prehistory of the digital by linking developments in computation to the launching and tracking and simulating of projectiles moving through the atmosphere. The matter is shaped up as a problem of intermittent motion to give mathematical techniques a way to handle movement through the atmosphere. Kittler frequently notes how all first-generation automated computers, save one, were deployed for this purpose. The atmosphere is a field of computation. Kittler then observes, I assume with lament, that the problem jumps. What I think you [Kate] would call a digital episteme is organized by the problem of the computation of atmospheric space, and it then jumps to a new domain, and so now this way of formulating problems is applied to bodily operations, bodily thresholds, to vision as bodily. The history through which atmospheric motion was made a nascent problem of digital computation instead becomes a fascination with thresholds of human perception. The computation of atmospheric trajectories is now a problem of mathematizing the thresholds of sense perception. Crary sees this as characteristic of modernity, as operations of power externalizing the interiority of the human. McLuhan sees this as characteristic of media. Media are extensions of man. Technical media emerge in this physiological moment and media theory follows. Kittler is a bit vague about how all of this works, but the fact of the relationship is clear enough.

Kate Maddalena:
Yes, and the "episteme" part of what I want to call a digital episteme is trying to get at the fact that all of these media-enabled, media-entangled moves preclude any scientific way of knowing that allows for or makes visible the continuous, the whole, the uninterrupted. We don't even have a way to conceive of what that is. And much of it is, as Kittler presses upon, trying to deny, or escape, or bypass the body.

Chris Russill:
Right. Well, wait, I mean, yes. I think Kittler recognizes the paradox, in that the planetary is accessed and recorded in ways the human cannot do, but planetary processes are analog, and digital machines require discrete information, and so digital machines access continuous planetary processes in ways different and broader than we can, hence the paradox. I feel that Kittler was aware that quantum computing would disrupt any account resting on a teleology of the digital.

[2] See Maddalena & Packer, 2014.

At any rate, Kittler is determined to close the theoretical circuit by rendering the human obsolete. He extends the timeline to encompass radar and television. The shift to physiologically embodied optics is an anomalous moment. Radar and television are understood to represent signal-processing techniques humans cannot directly apprehend, and so this authorizes Kittler's encompassing of media by information processing techniques, and this is the point at which the teleology of the digital takes leave of the human. So Kittler moves past Crary and McLuhan by tying the dynamics of media to the strategic exigencies of military escalation, which begin to systematize in terms of the clear advantages of faster information processing, and these exceed what the human can process and so this is how Kittler runs the human out of the picture, right? This "so-called man . . ."

Kate Maddalena:
Mm-hmm, the "so-called human."

Chris Russill:
So McLuhan's media as prosthetics and Crary's body talk make sense, but only for a moment, only for this moment in the 19th century, as Kittler is already prizing open a different intellectual horizon for media, one displacing embodiment for the technical escalations provoked by the strategic exigencies of war. You enter the realm of big optics, of Virilio, of the electromagnetic conditioning of the planet. McLuhan's extensions approach is no use anymore when you get to radar and television, right?

Kate Maddalena:
Right.

Chris Russill:
So Kittler accepts McLuhan and Crary to a degree, but is always already moving to close the theoretical circuit. I mean there is another reading in which the McLuhanist account of media is crucial because it obscures the dynamics of media evolution, and so we misunderstand the importance of humans to technical media, which is that media use us to fulfill their digital destiny. I feel you end up talking about Skynet if you take that path.

Kate Maddalena:
Definitely. And it's important to talk about Skynet. I don't think we should reject Kittler's *Terminator* teleology, as you suggested earlier—I would say that we should set it aside for now, for the purposes of this project. You could reject it, I suppose, if you wanted theory to work as some kind of pure dialectic, but there's no need for that, really—we can hold both in our minds at once, because it's important, for certain critical considerations, to look at ourselves as a means to some material/media end. But I'm on board with you if you mean that's not this story, the story you want to tell—the story of earth systems science. If it were this story, we'd end up with computers remote-sensing and assessing environments for health and sustainability and then culling human populations accordingly. The ecologist's Skynet dystopia. We're not going there, today.

Chris Russill:

Ha-ha, no—I mean, hopefully we aren't going there ever. So I do steer around the Skynet take on Kittler, as I feel it situates the many anxieties about technological automation in a rather inflexible dichotomy of intelligent machine and biological human, and so despite the critical leverage that a "war" account of media might afford you, it always seems to scrub out or subsume the planetary, and so I take Kittler differently.

Kate Maddalena:
Oh, excellent—yeah, that's more nuanced. I often take Kittler's insistence on "all hardware" as a sort of radical intellectual practice that's trying to accustom us to materialism—the fact that we, also, are only hardware. But you remind me that he completely avoids our [bodily] hardware. And if we're talking about the earth system as a medium, that's a real problem.

Chris Russill:
I take Kittler as attuning being to recursive planetary processes that media are processing—and remember that earthly media are composed of planetary materials, as are we. Humans facilitated that, if you like, humans were intermediaries, but we can be freed from ourselves in his account because the processing of the planetary so completely outstrips the human mind, however important it was at a particular point in time. We can be freed from having our senses and nervous system tuned to the requirements of modern information processing, and freed from the debasement of conceptions of light as sense-data received by the eye, and freed from cinematic models of perception, wherein fragmented frames are run at speeds that our phenomenological experience has to synthesize, and Kittler perhaps is inviting us instead to attune to an evolving intelligence of pure light as it were. I know, it sounds nuts. But what else do we do with those delirious pages that end his lectures on optical media (Kittler, 2009)? It seems he is even trying to attune digital computers to the delirium of light processing! At any rate, if you are attending to media that are not for the human senses, the human nervous system, human cognition, and so if we open to media attuned to planetary dynamics, that capture and process a wider stretch of the planetary, you open up this elemental side of Kittler, which situates the planetary in light processing dynamics. Carl Sagan once tried to soft-pedal this matter with his earth pixel image: the "pale blue dot" image of the earth in its solar context, as a glimmer in a vast light processing system. It is all on a grandiose scale, on the scale of interstellar evolution, of course.

But it does rebound upon us—it is accessible to us in the register of crises of inhabitability—and it permits access to crises that can be registered in bodily dimensions and by banal things—the UV index, SPF rated sunblock, UVA and UVB sunglasses, UPF rated clothing—all these efforts to retrofit the bodily to a widening sense of an industrially disrupted planet. Not to mention the development of optical devices for peering into the skin to find lesions to biopsy for signs of UV damage; these reincorporate the body as a medium marked by planetary light processing and in ways that I find interesting.

Plus, I preferred *The Matrix*! Just don't deprive the machines of the sun. Geoengineers beware! Sulfate aerosols are a first-strike weapon.

Kate Maddalena:

Absolutely. As long as we're promoting science fiction technologies, let's go with Geoff Ryman–type tech. Photosynthesizing, breathing bladder spaceships. Replace some oxygen, already.

Chris Russill:
Nice. More Canadians, by all means.

My point is that if we want to position the planetary as a horizon for media theory, if we want a horizon that displaces the priority of the human and disrupts the digital teleology of Kittler, then we should stay with the problem of atmospheric light processing, because the efforts to imagine and model its dynamics open us to different accounts of the abstraction of vision and computation.

Take Virilio's work on big optics. Virilio is known for his concerns with the speed of information transmission. The technical exploitation of the electromagnetic spectrum affords information transfer exceeding the temporal pacing of human politics or deliberation or thought even. The logistics of maintaining or interrupting those capabilities begin to figure prominently in war and entrain politics, human judgment, and the rest.

Big optics is not simply a matter for transmission though; it is also an epistemological system. In the 1920s, at the latest, systems had already been developed to record light, to record broader slices of the electromagnetic radiation the sun distributes to the earth. Light is manipulated not to transmit information but to know the earth. The imaging of clouds, the photographic imaging of light that materializes water as clouds to our eyes, this is understood by Alfred Stieglitz as liberating photography from the notion of subject matter, and as an innovation in the abstraction of vision. But it is especially evident in the devices dating to the 1920s for recording UV light, for sunlight in the UV wavelengths, which is how we detect ozone holes. Big optics gives us a bomb-proof Internet, sure, and the transmission of data as light, yet we are also recording and processing light to observe space and disclose planetary dynamics.

Let's back up. The industrialization of war in the 20th century forces militaries to hide their people and supplies in the earth, to dig into the planet, to fortify their inhabitations to escape the reach of increasingly destructive weapons. You get trenches, bunkers, and that sort of thing. The classic Virilio stuff, right? War, for some, is now a matter of illusion and deception, a game of hide-and-seek. Hannah Rose Shell (2012) has a really smart book on this subject.

My interest is not in the hiding and illusion, but the shift in the nature of aggression. Entrenched armies are difficult to attack. You can't stick bayonets in them very easily. Bullets don't bend. So forget the biological, forget attacking the biological being. Attack the conditions of possibility for the biological. Combat strategy evolves along these lines. The trick is to render environment and earthly fortifications uninhabitable—alter geography and geophysics to attack the biological.

Kate Maddalena:
The actual physical earth.

Chris Russill:

Right! If you hide people in the earth, if your combatants dig into the earth, it calls out innovations in aerial optics, in aerial bombing, in the sighting of bombing, and in the observation of its effects. Bombing then churns the earth. You need more frequent and better observations if you are churning the terrain in hellfire, if you destabilize the habitability around which human vision is conventionally organized. Observing is unhitched from lived or inhabited environment, as these environments are increasingly destabilized and reorganized by the strategic exigencies of war. Virilio's phenomenological sensibility is quite powerful on this point, such a contrast to Kittler's approach. I think Peter Galison talks about how the postwar suburbs in the U.S. are linked to this history—you distribute rather than concentrate your capacity to engage in war by internalizing the threat of aerial attacks into the design of cities. It isn't only the Internet that is decentralized to become bomb proof. Jeremy Packer (2006) brought that to my attention. You inhabit the earth differently by incorporating atmospheric threats.

You might also attack the atmosphere your enemy inhabits. Canadians are reminded of this moment incessantly. Canadian soldiers held their ground, so to speak, when the Germans gassed their atmosphere in 1915. You render space uninhabitable by altering the chemical composition of the air. This is Peter Sloterdijk's point. Geoffrey Winthrop-Young has spoken well about this event.

A scientific concern with the material composition of the atmosphere originates in chemical warfare. You alter the geophysical to attack the biological. It culminates perhaps in the nuclear winter scenarios, where the capacity to disable the inhabitability of the entire planet was debated. You might incinerate entire cities, which is bad enough, but the smoke and soot in the atmosphere damages the inhabitability of the entire planet. The mushroom clouds, so to speak, are not the worst part from the perspective of planetary inhabitability. The smoke clouds get you by blocking out the sun. Ironically, as that debate was happening, we were failing to register the ozone hole, the problem of an atmosphere altered to permit too much of the wrong kind of sun to the earth's surface.

At any rate, war is forcing you to look at the atmosphere very closely, at its material composition and dynamics. If you want to breathe, if you want bombs to go where you want, if you want to see what those bombs do, if you want to decide where to drop them next, the exigencies of war are driving innovations in optical media. These stratagems come together with Agent Orange when the U.S. goes to war against plants. You spray plants to destroy the inhabitability of regions in Vietnam, Laos—you destroy ecosystems to afford better perception of those areas, to see them from above, and to drive the threats inhabiting those areas into places you can better observe, contain, or attack. At any rate, I find it interesting that just after WWI, just after you are looking intensely at the atmosphere, you have the beginning of this intense imaging of the atmosphere in its materiality, this effort to record and process how the atmosphere processes light to know the composition of the atmosphere itself. In fact, you also had astronomers musing about the potential to cut a hole in the ozone layer, in the 1930s, so they could see deeper into the UV, so their telescope lens could register and record UV light that our upper atmosphere was absorbing before they could see it. Oh, and of course, Lewis Fry Richardson is trying to model the atmosphere computationally—of course, his computers were people, and so they were brutally slow, but his initial effort also failed only because the data weren't processed, were not smoothed.

Kittler's take on Virilio ties in digital computation. Kittler's history of computing involves missiles and cannon balls and the ballistics of things that churn up inhabitable space, and the importance of computation is bound to the launching of these weapons through the atmosphere. Gilbert Plass' global warming model, the first automated computer model for understanding how CO2 doubling affects heat in the atmosphere, that is preceded by his work on heat-seeking missiles.

I realize I'm flattening out a rich body of work in a brutal sort of way.

Kate Maddalena:

But you're continuing to point out, as these others have, that the history of war coincides with (and we mean to imply more than mere coincidence) the history of technology, media, and science, specifically environmental science.

Chris Russill:

The question is whether our theoretical accounts of optical media, of the abstraction of vision in optical media, whether we can separate them from the model of war animating Kittler and Virilio, whether the planetary disruptions of war can be recast with the more encompassing problem of the planetary disclosed by earth science.

I think in particular of how global circulation modeling has upended how we understand observation and data, and of the series of technical, institutional, and workflow innovations that changed how we understand data. We remain stuck with recording and storage and transmission conceptions of data in many respects—earth science forces upon us a processing conception of data and that is rather challenging to take on.

Kate Maddalena:

And so modeling media are a set of computational methodologies, and the modeling methodologies that the earth sciences use—that's also new, fertile ground for thinking with Kittler because he's thinking about recording, containing, transmitting, and you're talking about projecting [forward in time].

Chris Russill:

The challenges of planetary observation create problems that require observing practices that challenge what most people mean by data, observation, and modeling. They challenge how information processing is understood. You have to move from recording and storage conceptions of observation and data to processing conceptions of observation and data. Modeling seems to challenge how observation is understood historically—at least with regard to the accounts that Lorraine Daston (2008) and her colleagues have recovered. Processing isn't something that happens after that fact.

Naomi Oreskes, a wonderful historian of earth science, taught us that our histories, philosophies, and sociologies of science generate conceptions of science that don't work very well for the earth sciences (see Oreskes, 1999). These accounts of science are conversant mostly with math, physics, and sometimes biology. It is why I think Charles Peirce's notions of science and inquiry and pragmatism are so divergent, because of his work in geodesy, whereas other pragmatists were caught up with Darwin and debates common to physiological psychology. Oreskes helped me see it. Physiology was lab-based and you hop

across the pond to Germany to see what was going on, but it was lab-based. Geodesy required a different sort of extended community that Peirce theorized, it required what we today call information infrastructure.

Paul N. Edwards (2010) did something similar by unhitching our understanding of earth science from prevailing conceptions of information processing and computing. It fits with neither the history of ideas, nor with the history of engineering and institutions that govern most approaches to computing. Just as earth science is not a special or applied science, not simply an application of physics or math, neither does it fit with how we like to think of data and computation. It requires an infrastructural configuration. Edwards' (2010) book on the question is definitive and astonishing. The work it must have required is astonishing. When I met him, I said it took him a decade if it took him a day. He laughed. It took him 15 or 16 years, or something like that.

Kittler would have titled the book *There Is No Data*. I reckon that would have turned the politics of climate change on its ear. Oreskes puts it in more politic terms. She notes that it is now models all the way down.

The upshot is that there is no data, no data without models, no data without processing. I think media theorists probably can understand this more easily. Our popular conceptions of observation are the problem, as they color how we think of data. We think of data as observed, as recorded, as transmitted, and usually as *only then* processed. We work with a recording or transmitting conception of data. Edwards shows us that processing is primary, not observing, not recording, and of course not transmission. It means we must understand data as fully temporal and infrastructural.

Kate Maddalena:
Yes. And this is the next chapter in social studies of science, too—data are produced, in ways that may more explicitly be called artifice. No one can be purely positivist, here. We must have a (media-oriented) theory.

Chris Russill:
It is interesting to ask how we ended up with a processing approach to data.

If I schematize in praxeological terms what happened, I would compress Edwards' work to say this: Global models need global data. It is hard to get that. You cannot get observational data for every potential grid point on the planet. Or you can't get something you trust entirely, or something that is made easily commensurable to other data you use. Yet, you need something. What do you use? Well, you guess. Or you use some kind of average or norm for the point in question. You find a proxy. You do the best you can.

Kate Maddalena:
At the most basic level, you use a quadrat, or some representative block that can fill in for the unknown spaces. Smoothing.

Chris Russill:
Yes, the planet is blocked out, made into a bunch of discrete blocks, but how do you attach a number to these blocks, or rather, what if the best numbers come from the model itself, from another run of the model, and what if that data works better than any guess, average, proxy, or even the observational techniques currently deployed? Do you use that? Of course you do. You don't say, science doesn't work that way. You work the problem. The habitability of the planet is at stake. So now you are in the business of modeled data, simulated data, synthetic data.

Kate Maddalena:
And heretofore may no one ever again ask, "why media theory?"!!

Chris Russill:
Edwards pushes us toward a life-cycle account of data. Data don't just sit there in data sets. This is the storage-dominant conception of data. The "Netflix catalog of films" view perhaps. We need a processing conception of data. Data or data sets are processed continually—repaired, maintained, put to new purposes, all the things that Edwards describes as infrastructural inversion. The meteorological is inverted for the climatological is inverted for earth system science. Data are subject to continual processes of infrastructural inversion as a condition of maintaining the operability of planetary observing capacities. You go backward to project forward to situate the present in various recursions or temporal cycles. But, and here is the kicker, when you do that, you proliferate and expand our senses of the planetary. I hope Paul will forgive that rather brutal compression of his book—maybe we can run it by him first. Fifteen years of work into 60 seconds. The book definitely repays close attention.

Kate Maddalena:
So, I see your work as working against what science studies calls "capture," or the use of arguments about science to undermine science's access to power via expertise, or knowledge. Would you comment on what you see as the role of critique that problematizes that power/knowledge relationship? Your work, I think, functions in support of the scientific endeavor. For example, eco-media that help us make knowledge about ecologies can help us adjust our role in those ecologies.

Chris Russill:
I would say that the conception of science and technology developed by those adopting an infrastructural orientation has been effectively detached from the problem of how technocratic authority is organized and legitimated, and instead [it] is concerned with developing an epistemology that permits us to diversify the ways and models and problems through which knowledge and power are co-constituted. In this respect it locates the politics of science and technology at the infrastructural level, such that disclosing the infrastructural, making it visible, revealing its scope, its norms and standards, its operations and logistics, is understood to invite inversion, to afford opportunities for inversion, and to develop the politics of provisional knowledge that inversion affords you.

Inversion, in this respect, is much better than techniques of implosion that animated those sprawling critiques of technoscience that were the fashion in the 1990s, wherein the trick was to dissolve the agency afforded to users by collapsing the description of media devices back into the system of rules and

networks of power that made them operational in the first place. It worked well to offend the sensibilities of liberal subjectivity, but it got a bit stale.

Kate Maddalena:
Absolutely. I also think that version of critique becomes philosophically and politically irresponsible if it isn't put into context as a conceptual exercise. The notion of the subject is a pretty important one.

Chris Russill:
I say inversion because I'm following Edwards, but there are broader materialist traditions of media studies that are important here. It seems to me there is an interesting divergence between the way epistemology is retained or abandoned with respect to the move toward ontology, phenomenology, or agency, and I find it interesting that the two key theorists of light for me, Kittler (2009) and Barad (2007), both permit you to retain the epistemological, despite the emphasis on ontological theorizing and despite how differently they do so.

I'm situated more in line with the Innis-Kittler-Peters-Packer approach to infrastructure, particularly as an epistemological question, but there is the wonderful phenomonological work that Lisa Parks (2005) and Darin Barney (2013) have advanced, and it permits inversion to be conceptualized in more overtly pedagogical and political terms, and to take on the implications of infrastructure for subjectivity and culture in important ways. I think of Nicole Starosielski (see Parks & Starosielski, 2015) here too.

Barney, for example, speaks of sabotage, and of how sabotage is afforded by systems, by energy infrastructure, and he develops this along the lines of Timothy Mitchell's (2011) work on oil exploitation. Sabotage is afforded by the kind of energy infrastructure we have, one organized by oil exploitation, the priority of which unfolds as part of the sabotage of democratic organization, and so the politics of energy is deeply infrastructural, and sabotage is not some mindless destruction or terrorist aggression, but an essential dimension of the politics of inverting infrastructure. There is some work to do in seeing sabotage as an infrastructural inversion, but given that Bowker used infrastructural inversion to discuss how oil exploitation moved from material incursions into the earth to a signal processing approach, I think it is open to a more politicized epistemology. If I understand Barney correctly, and if I understand Mitchell, the fossil fuel infrastructure organized around coal was sabotaged and reconfigured around oil to address the challenges that organized labor posed to industrial capitalism, and so the exigencies of securitizing the social order from political challenge lead to the prioritization of liquid flows—oil could flow through pipelines and be carried by tankers and thus circulate in ways that didn't make the infrastructure accessible to democratic forms of political contestation by workers implicated in coal extraction. If you see fossil fuels as buried sunshine, if you see coal and oil as made of biological matter compressed by the earth, you can loop this question of energy infrastructure back around to the earth as a light processing medium, one sabotaged by industrial exploitation if you wish. But we don't need to do that. And I think Barney is showing how to think the political in infrastructural terms.

Lisa's work on infrastructural intelligibility and infrastructural resocialization, and her way of bringing ecological concerns into media studies, it is this careful way of bringing together feminist studies of

science and technology, new materialism, geography, and media. I say careful in the sense that Karen Barad means careful and in the sense that it attends to the dynamism and agential possibilities of infrastructure and seeks to figure these in terms that expand one's sense of the political—the media turn for infrastructure outlined by Parks and Starosielski, in this respect, has been an important corrective and challenge to the Innis-Kittler line of theory. It doesn't let the legacy of colonialism, the fact of environmental racism, or the inequalities generated by capitalist organization slip from the discussion as often happens when moving to a grandiose or planetary scale.

Kate Maddalena:
So, what's next?

Chris Russill:
Well, I'm going to teach some classes on the media turn in infrastructure and pay closer attention to some theoretical and political questions that are raised when this work is considered in terms of the planetary. The way Lisa and Darin have tried to bring media scholarship into the field of contestation over energy seems essential in this respect and there is certainly room for deeper engagement in the field with Chakrabarty. I'd also like to examine the different ways that Kittler and Barad both ask us to attune to light, to learn from the scientific observation of light, to suss out how the light processing of the planet organizes or inflects the materialism they propose. I'm looking forward to Peters' new book. And now that Alex Garland is a director, we need to get him to remake *Sunshine* as it was originally intended. This is essential.

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