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Earth observing media and environmental crisis: New Zealand 2011

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On 25 February, Google released satellite images of Christchurch acquired days after the 2011 earthquake. Google obtained the imagery from GeoEye, a paramilitary commercial satellite company, with which it has an exclusive agreement to digitally map data transmitted from the GeoEye-1 satellite for online circulation. Disseminated globally via press release, Google included several "before and after" images of Christchurch taken March 2009 and February 24, 2011. Geo-Eye-1 images were also used on the "Google Crisis Response" page established to aid emergency response in Christchurch, with information overlain graphically on a Google Map of the affected area (depicting shelters, water tanker deliveries, operating medical centers, open supermarkets and pharmacies, payphones, and geographic areas with working electricity).

Christchurch, March 2009

Christchurch, 24 February, 2011

In addition, the United States Geological Survey (USGS) produced a 'shake map,' which visualizes the intensity of post-quake ground shaking via an automated computer program for generating maps from seismic data, as well as a 'Community Internet Intensity Map,' the product of an algorithm that aggregates and weights the reported observations of humans as filtered via a standard questionnaire.

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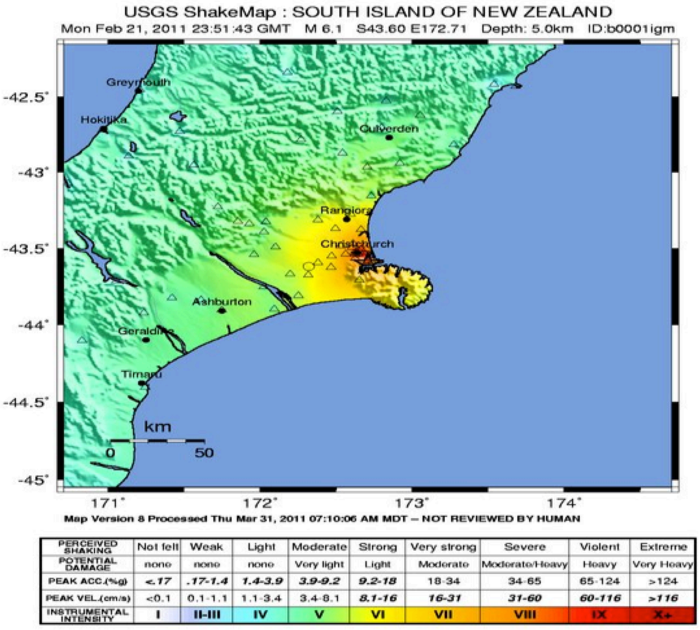
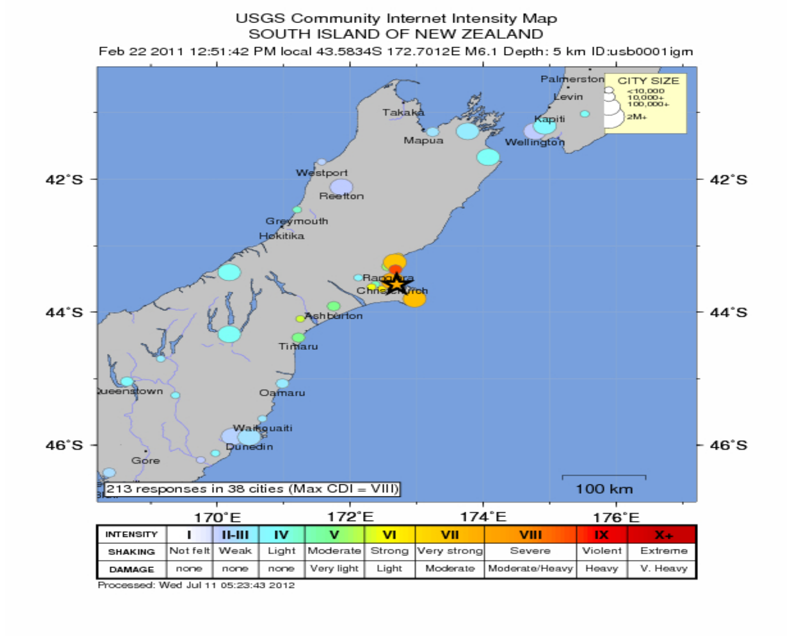
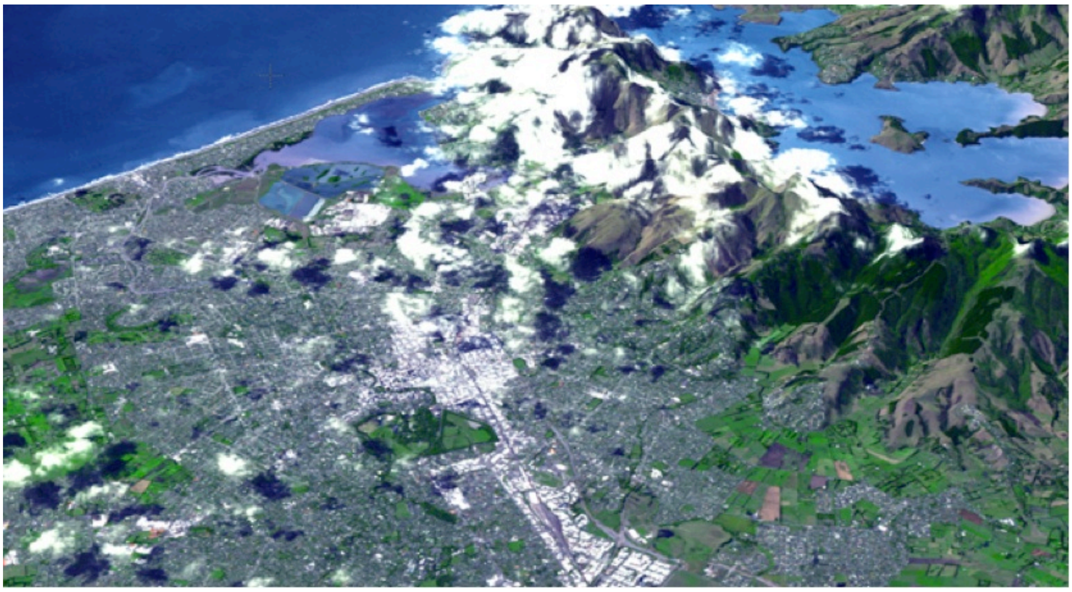


United States Geological Survey



United States Geological Survey

The USGS also activated the International Charter on Space and Major Disasters, an agreement aiding the provision of satellite intelligence for response, relief, and security efforts in prominent crises. Images from US and French commercial remote sensing services were produced, as were visualizations created from a Japanese radiometer on NASA's flagship earth observing spacecraft, Terra (using the Advanced Spaceborne Thermal Emission and Reflection Radiometer). Images provided under the Charter are freely accessible and can be viewed online.



Christchurch, 23 February, 2011, NASA:
http://www.jpl.nasa.gov/news/news.cfm?release=2011-061

Within New Zealand, John Hamilton, the National Controller of New Zealand Civil Defense (NZCD), commissioned aerial images of Christchurch from New Zealand Aerial Mapping Limited (NZAM), a private media service. Land Information New Zealand (LINZ) made geographic information system (GIS) analysts available to the National Crisis Management Center (presumably to aid in the production, interpretation and use of this media). Finally, the New Zealand Geospatial Strategy office within LINZ campaigned publically for better integration of earth observing capabilities into the preparedness strategies of commercial and government planners. The NZ Crown released its collection of aerial photography supporting the disaster response late in March 2011.

http://www.stuff.co.nz/national/christchurch-earthquake/4809621/High-quality-aerial-pictures-of-Christchurch-available

A little later in the year, a new and seemingly unrelated warning began to circulate through New Zealand, the "Sun Protection Alert," a message redefining geographical spaces as sites of radiation danger.

SUN PROTECTION ALERT

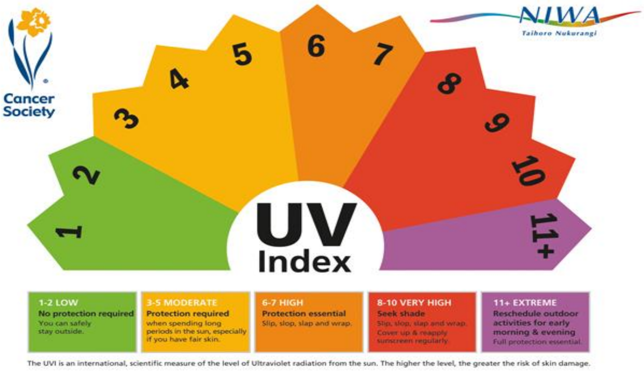
10:15 AM – 3:45 PM

PROTECTION REQUIRED

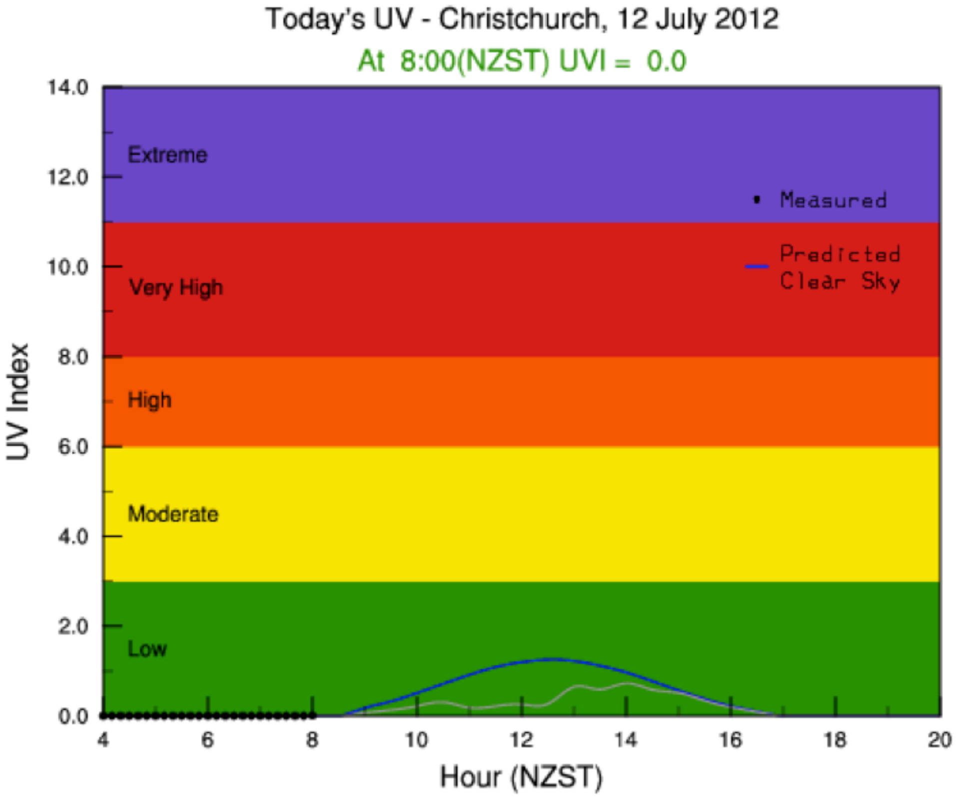
Seek shade, reapply sunscreen

Data provided by NIWA

The "Sun Protection Alert" replaced the public reporting of the UV Index, a description of environmental conditions disseminated in various numerical and graphical forms over the years. The UV Index, a globally reported measure of radiation danger, was prominently displayed in New Zealand between 2003-2011 through the "fire danger" alert format.



Here is a graphic depiction of the ultraviolet radiation threat in Christchurch displayed in more conventional terms at the time of this writing:



UV Index (Christchurch):
http://www.niwa.co.nz/our-services/online-services/uv-and-ozone/todays-uv-index

These image fragments either flashed into global media flows during the fast crisis from below (the earthquake) or assumed banality in the daily updates of the slow atmospheric crisis from above (the industrially transformed atmosphere). Offered as evidence of destabilized and unsafe environments, these images disclose a class of media not commonly discussed, "earth observing media," and offer us a fleeting glimpse into their operation. Yet, how is one to respond? How should we interpret or use such media? Why do brief snippets of earth observing systems enter public discourse or circulate in this manner? These questions are difficult to answer since little is known about the history, organization, and politics of earth observing practices.

In this paper, I adapt the scholarship on media infrastructures to chart a path for addressing these questions. My intention is threefold: to illustrate the way earth observing media underpin our understanding of environmental crisis, to discuss the integration of earth observing media into the governance of New Zealand life through select examples, and to illuminate how the institutionally and technically converging media infrastructure for earth observing (its medial configuration or 'settings' if you will) increasingly reflects the operational exigencies involved in adapting human populations to dangerous environmental changes. We have difficulty thinking about environmental crisis because we fail to understand contemporary earth observing processes and their medial infrastructure.

My point of departure is Paul Edwards' (2010) two-phase description of earth observing systems, which develops from his historically attuned analyses of meteorology. While Edwards' (2010) work is concerned primarily with the interplay and friction between the weather data network and the requirements of climate observation, my discussion begins to anticipate the integration of these fields of meteorology with other modes of earth observing. I do so with some hesitation since this approach deflects immediate attention away from Edwards' emphasis on climate change; I do claim, however, that the history of stratospheric observation illustrates both the precautionary nature of earth observing media and an especially powerful logic for integrating earth observing capacities into an interoperable infrastructure. In this respect, I extend Edwards' (2010) work to other forms of earth observing and bring it into more direct conversation with media studies perspectives.

We can develop a historical framework for earth observing from Edwards' (2010) discussion of shifts in the nature of "informational globalism". In the first phase, weather and climate observation contribute to an emergent "informational globalism," a multifaceted project of constituting 'the global' as an object of knowledge and institutional regulation. While many media scholars have detailed the contribution of postal services, news agencies, and telegraphs to globalizing processes, Edwards makes a compelling case for the importance of meteorological systems, which are "arguably the oldest of all systems for producing globalist information" (24).[1] For example, international standards for observing and recording weather data in the logbooks of seafaring ships originate in the mid 19th century and constitute one of the longest continuous records of a quasi-global nature (Edwards 2010, 24).[2] The media of other geophysical sciences may hold similar lessons. Networks for knowing the ground (seismology), water (oceanography), and air (other atmospheric specialties) proliferate in the early 20th century and await their definitive media theoretical accounts.

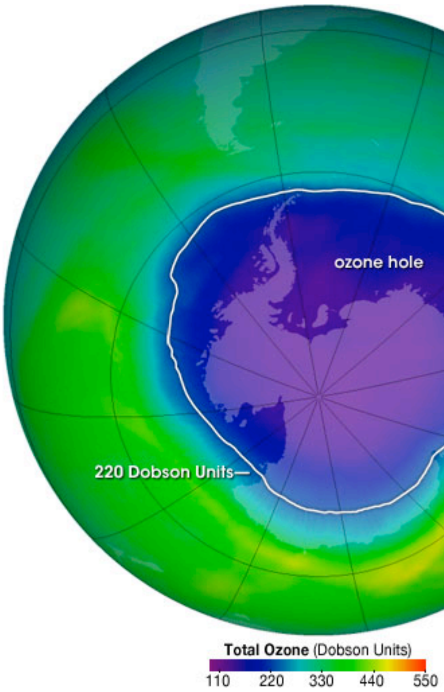
The second phase involves a transition in the nature of ‘informational globalism,’ a pronounced shift from voluntary internationalism (rooted in a confluence of shared but mostly non-formalized interests) to a quasi-obligatory “infrastructural globalism”. The term “infrastructural globalism” is intended to call attention “to how the building of technical systems for gathering global data helped to create global institutions and ways of thinking globally” (p. xviii). Infrastructure is the key word here, and Edwards emphasizes how data-processing infrastructures restructure our engagements with dangerous forms of environmental change. I find this terminology particularly useful. Whereas the “network” imaginary has dominated contemporary thinking about how widely dispersed technological, institutional, and cultural processes are interlinked, the term infrastructure is meant to distinguish between systems, networks, and internetworks (or ‘webs’) in a way that illuminates how dispersed observing practices become converged and coordinated by globally-oriented actors. And, as Edwards emphasizes, any discussion of the global scale “will put you in the business of *infrastructural globalism*” (xix, emphasis in orginal).

Edwards’ book is perhaps most useful in offering a framework for understanding the almost dialectical relationship between political contention and the consolidation of technical and institutional systems into an infrastructure, a process that helps contextualize difficulties and disputes involved in climate change. The case of upper atmospheric observation suggests a more one-sided conclusion: dominant models of infrastructural globalism suborn political contention to the logistics of earth observing processes. To be sure, the situation is complex, and Edwards’ own unwillingness to make general pronouncements of this sort should give us pause. Indeed, earth observing is bound up with other globalist infrastructures in frightfully confusing ways: futures and derivatives markets integrate and reshape weather data collection; epidemiological surveillance involves environmental monitoring; intelligence gathering uses commercial remote sensing platforms, and so on. As well, earth observing is part of longer colonial patterns (Parks, 2005, Kaplan, 2006, Berland, 2009), a feature marking the contemporary situation of Canada and New Zealand in distinct ways. However, despite complexity, I believe a powerful trend is clear: earth observing media are data-processing devices for accommodating human populations to industrially and militarily destabilized environments, and in ways that both obscure and normalize the determinants of the dangers of these spaces.

In the text that follows, I provide a “series of vignettes” (cf. Edwards, 2010) – “image,” “index,” “alert,” – to illustrate the origins and main tendencies of the dominant model for integrating human populations and data-processing infrastructure in various mediations of atmospheric composition. We will track the recording, storage, and imaging of sunlight through these vignettes, as this data is constituted as ozone holes, UV indexes, and precautionary protocols. Collectively, these vignettes illustrate Edwards’ two-phase notion of earth observing, as an informal network for understanding the chemical composition of the atmosphere reflects a variety of political exigencies – weather and disaster forecasting, national pride, intelligence-gathering during the war, military strategizing, and anticipations of the effects of nuclear war – before consolidating into an earth observing infrastructure, one concerned primarily with retrofitting humans to an industrially transformed atmosphere.

Imaging Ozone

Ozone hole images are among the most famous of all earth observing media and probably the most familiar evidence of an industrially destabilized earth system with global scale effects.



Ozone hole, NASA, Source: NASA, 2011, http://ozonewatch.gsfc.nasa.gov/facts/hole.html

The discovery of the hole is often attributed to a team of British scientists using ground-based photographic instruments at Halley Bay, Antarctica, to record light and measure stratospheric ozone concentration. In 1985, Farman, Gardiner, and Shanklin reported dramatic and surprising change in the seasonal variation of ozone concentration over their Antarctica reporting station through the first half of the 1980s. While data was graphed in an unusual manner in order to produce a dramatic figure, there was no mention of a 'hole' or visualization of depletion in the manner suggested by the image above.[3]

Ozone hole images originate with NASA and orbital platforms. The term, 'hole,' is of more diffuse origin, but was already in circulation as "shorthand" a year later in 1986 (cf. Stolarski, 2003). NASA scientists publishing a confirmation of Farman et al. (1985) used satellite observations to detail the "deep minimum," or "hole," to which ozone concentrations would fall (Stolarski et al. 1986, 810). Interestingly, their original paper was titled, "Nimbus 7 satellite measurements of the springtime Antarctic ozone hole," with the word 'hole' changed to 'decrease' in the final published version to appease a peer-reviewer (cf. Stolarski, 2003). Although no numerical value was used to distinguish a 'hole' from severe depletion, the data was visualized over a geographical map by using shading to depict differences in the regional concentration of ozone. One year later, Stolarski would have no trouble titling papers with the phrase, "ozone hole," as a raft of such publications appeared, and soon even Farman (1989) himself was using the "hole" metaphor to describe his team's discovery.

Today, a 'hole' is drawn (or suggested) when measurements decrease below 220 Dobson Units (DU), the standard unit of measure (NASA, 2009a). It is a threshold based on the historical claim that sub 220 DU were not found over Antarctica prior to 1979 (NASA, 2009a), which is when satellite based observations became available and sub 220 DU levels were recorded. Over the last decade, the imaging of such data has expanded immensely. The concentration of stratospheric ozone is given visual form in the historical record, in apparent 'real time,' and also in the future, via computer simulations. A few examples:

- The past is rendered visually, as historical readings of DU levels can be used to construct images, and to show that the hole found in 1985 did not seem to exist prior to the late 1970s (NASA, 2009a). It is also possible to track the widening and 'healing' of the hole across decades. Thus, while the 'hole' was discovered in 1985, we have images of it dating from the early 1980s.
- The present state of ozone concentration is depicted in seeming real-time, and we can watch the Antarctica ozone hole widen each September.
- The future can be modeled as both "avoided" and "expected". NASA (2009b) scientists simulate the expected future of stratospheric ozone depletion, and these simulations underpin widespread claims that the hole will be healed/repaired by 2050.
- The "avoided future" of a globally depleted ozone layer is also simulated by NASA (2009b) in order to argue for the effectiveness of international ozone regulations, and the colorized contrast between the expected and avoided future leaves little doubt about which condition is to be preferred.

How should we interpret or respond to these images? Lisa Parks (2005) suggests that images associated with orbital platforms are routinely inscribed with diachronic omniscience, or beliefs in the capacity of media to comprehensively record global space through time. These assumptions obscure the infrastructural conditions and selection principles involved in rendering images. As Parks explains, a satellite image doesn't exist "until it is sorted, rendered, and put into circulation… (91)." The data depicted "only becomes a document of the 'real' and an index of the 'historical' if there is a reason to suspect it has relevance to current affairs" (Parks, 91).

Ozone imaging is a good example of Parks' point. The ozone hole pictured above is a digital image of stratospheric ozone concentration plotted over a geographical area. It displays a composite measure of data, which is collected at various times and spaces over the course of a day or month. It is not a snap shot of a particular moment. It is, following Parks (2006), "only an approximation of an event, not a mechanical reproduction of it or a live immersion in it" (136).

A bit of context: In the 1970s and early 1980s, it was not believed that one could detect ozone depletion due to industrial transformations because the anticipated changes were expected to remain quite small for a long period of time (and thus beyond observational capacities). As a result, satellite data lay backlogged (stored in computers) for 5-6 years before it was retrieved as 'evidence' of a 'hole' and used to generate images. The main problem was that researchers did not know how to properly compile and analyze the overwhelming flow of data to detect massive depletion (cf. Stolarski, 2003). It would be seasonal averages, not yearly averages, that disclosed dramatic depletion in the Antarctica, and the authoritative atmospheric models used to simulate anticipated depletion had directed attention to the tropics (not the poles) as the best place to detect a significant trend.

In the case of satellite observations, there were 200 000 measurements made per day, and measurements that deviated too far from expectations (like those used to image the first ozone hole) were flagged as suspect and excluded from initial analyses (Stolarski, 2003). NASA's proposed Earth Observing System (EOS) had initially been conceptualized with a data-processing model derived from SAGE, the Department of Defense air defense system, which was centralized and required calibration of instrumentation and validation of datasets before they reached researchers (Conway, 2008).[4] Calibration of instrumentation required assumptions about the sorts of data they would record.

In the case of ground-observations, researchers had not automated the calculation of ozone concentration through digital computers until the late 1970s; indeed, it was the computer programmer and physicist on the British team, not the atmospheric scientists, who produced the initial graphs illustrating dramatic springtime depletion. Interestingly, he produced these graphs with the intention of assuring an alarmed public that the ozone layer was relatively unperturbed by industrial activity (cf. Shanklin, 2010)! As well, there were not formal processes in place to share and compare ground, aerial, and satellite data.

It is worth clarifying that the images generated do not represent or photographically depict the ozone above our heads. Ground-based, aerial, and satellite instruments record ozone concentration only indirectly. The Dobson spectrophotometer (the medium Farman et al. used in discovering the 'hole') measures the intensity of UV radiation reaching the earth's surface; initially, this was done using photographic plates to record various wavelengths of light.[5] NASA's Total Ozone Mapping Spectrometer (TOMS) measured the solar radiation scattered back into space by the earth's atmosphere (these are the recordings used to produce the first images of an ozone hole). Stratospheric ozone concentration is measurable in this way because its absorptive capacities are well understood. Put simply, if you know how much solar radiation reaches the earth's atmosphere, and how much penetrates through to the surface level (or is reflected back into space), you have an idea of the absorptive and reflective properties of the atmosphere; the usual method was a contrastive one, with wave-length pairs chosen so that one strongly absorbed by ozone would be contrasted with the measures of another wavelength that ozone did not absorb well (Dobson, 1931). For example, by comparing how much UV-A and UV-B radiation reaches the earth, one can calculate the presence of ozone, given its capacity to absorb UV-B. Modulations in ozone concentration are calculated from recordings of solar radiation (spectrograms of sunlight). We picture the earth by recording the sun.

Ozone hole images depict data produced by these calculations. At risk of repetition, the images are not visual records of solar radiation intensity, or representations of environmental processes more generally. They do not extend the eye or human senses, as with a telescope or photographic lens. The images render calculation in familiar symbols and cultural forms. The images are simply composites of data and the output of earth observing logistics. Parks (2005) describes this quality by suggesting satellite images are more like impressionistic paintings than realistic photographs; or, as Berland (2009) puts it, these imaging techniques "create images with qualities brazenly independent of their referents" (251).

What does this mean? There is no ozone 'hole'. At least there is no hole as this is usually imagined. The 'hole' is a metaphor interpreting/framing the significance of the data reported by these visualizations. In the 1980s, ozone 'hole' suggested the earth's shield had been breached and that dangerous radiation could now penetrate to the surface. The dramatic colorizing of ozone levels appears designed to provoke such associations, although the green/purple coloring of the atmosphere might be interpreted in other ways, as a bruise, creeping ugliness, or viral threat.[6] Data depicted non-visually provokes little of that sense or related anxieties.

One effect of this 'brazen independence' is the conflation of different imaging processes. Ozone hole images are different from forecasts or computer simulations informing projections of future atmospheric conditions. Depleted ozone is a reality, but the projected recovery of the ozone layer by 2050 is not. One can rarely tell the difference between data and simulation by simply examining an unanchored 'image'; one must understand the imaging process, its place in an epistemological system, and the technical means by which data is made perceptible. Indeed, it is not uncommon for experts to become confused about the status of an image (cf. Lahsen, 2005).

While this conflation can have serious consequences, the distinction between empirical measurement and simulations of future conditions is not an absolute one, as Edwards (2010) goes to great lengths to demonstrate. While I accept his account, my purpose is to illustrate how ozone observing (empirical measurement and simulation) emerges from an earth observing system designed for precautionary purposes. If images and interpretation of earth observing processes are purpose-dependent, in the way that Parks suggests, then the fact that ozone imaging is intended to institute a precautionary relationship to atmospheric and earth system change requires further discussion. This is more evident when one looks away from specific 'contents' to the patterns of social re-organization produced by earth observing media.

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Upper atmospheric ozone data originates in the 1920s from an informal network of observing stations funded on the promise of improving weather forecasts and scientific understanding of cyclone formation (cf. Harrison, 1929). Photographic equipment was used to record the intensity levels of solar radiation reaching the earth's surface at least once a day. Instrumentation, standard units of reporting, and protocols for using equipment were developed by G. M. B Dobson and his associates, a small Oxford-based research team utilizing national meteorological services to establish a preliminary observing network. Photographic plates were shipped to observing stations, used to record light on specialist equipment, inscribed with meta-data by human operators (documenting the time, date, and site), and returned via postal or diplomatic services to Dobson, who assembled the data and disseminated the results (occasionally plotting it on weather maps) (Dobson, 1968). The pre-war network was small, although it did extend instruments as far north as Sweden, and as far south as Christchurch, NZ.

In its early history, ozone observing was situated rather tightly within weather forecasting networks in three ways: first, researchers adopted conventions from weather maps to display data and suggest significant correlations of ozone to routine weather measurements (like pressure or temperature), second, researchers utilized the institutional framework established by meteorologists to expand the observational base for recording UV intensity and to solicit funding, and third, researchers advocated for a *vertical* expansion of observational capacity into the upper atmosphere by arguing that these more global measurements were integral for understanding meteorological phenomena (cf. Harrison, 1929; Dobson, 1931).

Plans to further automate recording processes, improve the transmission speed of data, and expand the geographical base of observing stations occurred with the International Geophysical Year (IGY) (1957-58), which led to 100+ ground stations and continuous time-series data from many of them. The IGY facilitated "adoption internationally of agreed procedures," (Farman, 1989), which included instrument calibration as well as observation and reporting protocols (the details are described in Dobson 1967). A global science institution, the World Meteorological Organizations (WMO), took responsibility for collection, storage, and dissemination of the IGY ozone results (Dobson 1967, 403), and sponsored the World Ozone and Ultraviolet Data Center (located in Toronto), as one of several "World Data Centers" initiated by the Atmospheric Watch Program of the WMO.

There are hints of some broader exigencies on earth observing found in the wartime activities of ozone observers. During the war, meteorological collaborations in Europe were interrupted and left military forecasters seeking other means of compiling records for weather prediction. Interest in using ozone measurements to inform weather prediction heightened during this period (Dobson 1968, 398).

More importantly, ozone observation was integrated directly into military intelligence gathering strategies. The British Royal Air Force employed long range, high altitude spy planes during the war, yet their location was easily inferred by the visible nature of the clouds produced by their exhaust (contrails). How could the presence of these aircraft be concealed in the upper atmosphere? This question prompted high altitude research on temperature, humidity, and chemical composition of the atmosphere, and opened access to the flights of a Boeing Fortress aircraft for aerial observations. Military systems could provide what meteorological networks could not.[7] Airborne instrumentation revealed the dry nature of the stratosphere, or its relative lack of water vapor, and this made evident the importance of ozone concentration (since ozone rather than water vapor is absorbing UV-B and providing the protective radiation shield). Of course, these relationships were not entirely new. Scientific ballooning to the stratosphere in the US was a military operation in the 1930s (although underwritten by large media corporations) and meteorological services were sometimes located in war departments.

These military exigencies open a line of research leading to interest in ozone destabilization in the 1970s. It was concern with high altitude transportation emissions, particularly from supersonic transport (SST) and space shuttles, which initiated close study of human effects on the ozone layer. In effect, a variety of researchers started canvassing possible effects of human activity on the upper radiation shield, and this lead to science on jet and spacecraft exhaust, nuclear explosions, and forms of industrial waste. Ozone observations, from this perspective, are part and parcel of a communication and transportation network, and a window into an emergent observing system for registering industrial and military alterations in earth systems.

Ultimately, it was not nuclear war, air transport, or space travel that destabilized the ozone layer, but industrial chemicals, as man-made chlorofluorocarbon (CFC) compounds were released into the atmosphere. This led to a concentration of chlorine in the atmosphere that destroyed ozone given certain environmental conditions (cf. Soloman, 1990). It is difficult to compress the history of the CFC threat, and most narratives of this period center on the discovery of the ozone hole.[8] It does bear remarking that the CFC threat emerged in the mid 1970s in a political context defined by contestation between a nascent environmental movement and a conglomerated chemical industry, one centered in the 1960s on the proliferation of pesticides and nuclear weapons, and symbolized by an ecologically minded scientist, Rachel Carson (1962) opposing the manufacture and sales strategies of major producers, including DuPont (the main manufacturer of CFCs). When scientific warnings regarding CFC production emerged in the mid 1970s, ecological activists raised public skepticism of industrial chemical production and engaged an industry prepared to defend one of its most profitable products in CFCs, a $100 billion USD global industry in Haas' (1992b) account. Debate congealed around the scientific detection of damage as the standard for regulation, and atmospheric modelers using simulation tools assumed authority, since it was presumed that direct empirical detection of an industrially destabilized atmosphere by CFCs would be impossible in the near term (Haas, 1992; Solomon, 1990). The discovery of the ozone hole gains much of its drama in falsifying that assumption – and in correcting the scientific understanding on which it was based.

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Narratives of the discovery of the ozone hole are symptomatic of broader views of the relationship of earth observing processes to the global regulatory infrastructure governing human/environment relationships, as these develop conjointly from the mid-1970s to the late 1980s.

In the apocryphal 'environmentalist' account, the 'ozone hole' was a shocking discovery, one that raised consciousness, produced political consensus, and facilitated global regulation of an intransigent industry interested primarily in a short-term profit-oriented approach. The 'ozone hole', in this account, figures both as proof of industrial despoliation and a potent symbol for social protest. Scientists had warned of danger since the mid 1970s, industry obfuscated, governments delayed, and nature – or earth observing processes – finally provided definitive proof. Ecology, in this instance at least, trumps industry; or as Stephen Schneider (1990) once said, "nature finally stood up and took center stage—with much help from the media" (225).

In the 'diplomatic' or 'elitist' account, there is episodic yet gradual progress on regulation between 1975-1987. The scientific warnings of atmospheric chemists drew government attention, were used to create precautionary regulation, and underpinned the development of an earth-observing infrastructure for environmental monitoring lead by the US (and, to some extent, Canada). The 'ozone hole', in this account, had no impact on actual regulation, though it did consolidate public opinion and spurred efforts to accelerate the convergence of earth observing processes within NASA. The main proponent of this view is Richard Benedick, the lead US negotiator for the ozone protocol. He claims the negotiations producing the 1987 Montreal Protocol contained no discussion or reference to the hole, and that the decisions were based on a longer history of atmospheric science. Regulation, on this account, reflects a rather small and cohesive "epistemic community" (Haas 1992, 187), one composed of atmospheric scientists and policymakers, and interested primarily in providing "a reasonable degree of protection" (Benedick 1998, 22). A precautionary approach to reasonable protection – of life, of earth processes, and of a valued chemical industry – was used to craft regulation that would modulate with the observations of earth systems, yet it was 'science' that strongly informed the direction of the regulation, not environmental activism.

In the work of Karen Litfin (1994), we get a more nuanced account of the impact of the ozone hole on the relationship of scientists, regulators, and public opinion, one in which the precautionary logic animating earth systems governance reflected a wider range of influences. Litfin believes the discovery of the ozone hole motivated a profound shift to precautionary regulation. Between 1975-1985, precautionary reasoning was a subordinate influence on regulatory proceedings, which were elitist in the manner suggested by Benedick; the ozone hole, however, upset the regulatory process, surprised scientists, destabilized the hegemony of atmospheric models, and helped make salient a wider range of knowledge practices. The precautionary logic implied by the treaty – and the observing infrastructure supporting it – did not depend upon or derive simply from scientific authority or an elite knowledge community; it expressed a precautionary orientation of diffuse and complex origins that directed and helped interpret how scientific knowledge figured in the governing process producing global regulation.

These three accounts offer differing explanations of regulatory processes with respect to the public imaging of ozone concentration in the atmosphere. In some respects, these differences no longer matter today. Whether the image itself compelled civil society to demand regulation of industrial transformations of the atmosphere, or whether the image emboldened a wider range of political actors to shape regulatory processes, or whether regulators had already decided on a precautionary logic for marrying observing process to regulation, the result is a regulatory system informed by an earth observing infrastructure that expresses a precautionary logic. This is a form of reasoning about environmental change that requires further extension and integration of observing processes into governmental decision-making, since the lesson of the ozone hole was that upper atmospheric processes were not well understood (Solomon, 1990). The upshot for all actors was that decisions about environment change should be made responsive to the continuously updating knowledge produced by earth observing processes. The visualizations of the ozone hole, from this perspective, imply integration of consciousness, knowledge, and political activity into earth observing processes, and the new centrality of these processes refigures key dimensions of social organization and everyday experience.

In misunderstanding the new centrality of these processes, the politics of appropriate precaution, as I argue below, is soon suborned by the logistics of earth observing; precaution no longer emerges from processes infused with political contention, as with ozone activism in the 1980s or the competing accounts of the significance of the ozone hole on regulatory deliberations, but sinks deeply into the pre-programmed settings of a complex technical infrastructure. Put differently, these competing accounts of the significance of the ozone hole are important, since these explanations express differences over how appropriate precaution is determined and involve varying degrees of acceptance for the role of political contention in social change. The problem is that the nature of earth observing media today prejudges those questions and handles determinations of precaution at the logistical level of operation. In Edwards' (2010) terminology, the opportunities for "infrastructural inversion" are severely restricted. Political contention organized around a politics of representation or designed to foster varying interpretations of the significance of imagery are not well suited to contesting the notions of precaution informing such infrastructure.

Index

Indexes illustrate how precaution precedes and orients representation in a more direct way than ozone imaging. Indexes are not unlike the composite nature of the imaging processes discussed above; various recordings of environmental change feed algorithms to produce calculations, and these numerical products may or may not take visual form. In some cases, the index is intended to *predict* our 'feel' for various meteorological conditions, as with "wind chill" measures; in other cases, it is designed to *improve* our 'feel' for conditions we cannot properly sense or experience as dangerous, as with UV Indexes. Whereas barometer and thermometer readings have been used for centuries to guide anticipations of weather, contemporary indexes combine these measures and add other relevant data to link assessments of meteorological condition to physiological function.

Meteorological and earth observing instruments, in a manner of speaking, extend our senses (cf. McLuhan, 1964). Indexes displace our senses and automate the anticipations or inferences we might typically derive from instrument readings. Anticipations based in personal experience are displaced by an explicit calculation of recorded environmental changes; in some cases, the algorithm for the index is known and shared publically, although increasingly these are considered proprietary, protected by patents, and treated as trade secrets by commercial weather services. Indexes typically presume the insufficiency of responding to environmental changes as felt, as perceived, or as inferred via ad hoc assessments of the various public measures that are routinely available (temperature, humidity, wind speed, etc.). Instead, we are to respond to a calculated approximation of an environment that is pre-programmed by assumptions of appropriate precaution. "Real feel" indexes, in particular, teach us how to respond to environments we may improperly 'sense' or 'experience', especially if we rely upon a simple measure like temperature. Indeed, given the industrial alteration of landscapes, atmospheres, oceans, and climates, one might argue there is little alternative, since habitual ways of knowing and responding to environmental change presume regularities that no longer hold.

Indexes integrate our capacities to feel into data processing infrastructures designed to retrofit human populations to an industrially transformed planet. The UV Index and New Zealand's Sun Protection Alerts are good examples. The UV Index incorporates various environmental measures (ozone concentration, wavelength, ground elevation) and simulated conditions (cloud cover, weather forecasts) to calculate how anticipated radiation exposure damages human skin.[9] Usually expressed as a simple number, 0-15 or 0-20, the UV Index converts select variables into an appraisal of potential danger to determine acceptable loads of radiation with respect to the ameliorative techniques available for managing such loads (such as SPF rated sunscreen, appropriate eyewear, etc.). It does not represent an environment; it anticipates an environmental effect. Anticipations of effects structure depictions of environmental crisis.

UV indexes are good examples of how earth observing media produce precaution; precaution is not a judgment made with reference to a prior representation of an environment, but a constitutive element in how environments are observed and depicted. The UV index conveys a radiation threat that we cannot see, feel, or otherwise sense reliably, and while it is often expressed graphically (by plotting it on a map using shades of color to express geographical differences in threat level), it is strictly numerical, and serves to order a population in dangerous circumstances. The agreed upon settings for the chemical composition of the atmosphere were decided on by the 1987 Montreal Protocol and subsequent updates, and this decision recognized, accepted, and ratified radiation damage to living beings as a result of industrial transformations; the UV index, like the legal protocol, is a tool to ameliorate damage at the scale of human populations. The atmosphere itself, its chemical composition, acquired a precautionary setting.

The UV Index treats all sunlit space as a field of radiation danger. In this way, the scale (0-15, 0-20) acquires significance by registering invisible threats in a graduated manner, and one either enacts precautionary protocols or fails to do so. It resembles a weather forecast more than a Geiger counter; almost all publically disseminated indexes of this sort are forecasts, not real-time measures of radiation risk. Perhaps it is the integration of UV warnings into weather reports that transforms political contention into anxious adherence to observational logistics. It is difficult to imagine that hourly updates to forecasts of radiation danger from detonated nuclear bombs would escape critical attention, yet what are nuclear weapons, ozone depleting substances, and anthropogenic climate change if not different modes of industrially and militarily transforming the atmosphere and related earth systems? The UV Index, its suborning of politics to earth observing logistics, and its synching of human behavior to a precautionary environment – rather than a represented or actually experienced one – is worth deeper consideration.

Let's situate this in deeper historical context. There is nothing new in linking physiological ailments to atmospheric change, or in the development of ameliorative strategies to meet such anticipations. In the 19th century, climates were prescribed for chronic conditions so routinely that Nietzsche predicted, "the whole earth will be a collection of health resorts". Environmental conditions, it was recognized widely, are registered physiologically and often sub-consciously, with aching joints and headaches only the most well known of human responses to an ever modulating atmosphere. Indeed, the dominance of physiological psychology in the 19th century involved a profound fascination with the effects of insensible shifts in light, weight, and other environmental alterations. According to Peters (2004), such intense inquiry underpins the development of 19th century media and remains a crucial horizon for our understanding of media theory. To be sure, such fascinations far outpaced the conscious development of media for recording environmental processes, or so it would seem.

Contemporary indexes extend and reconfigure older ideas regarding the relationship of physiological and environmental change, while displacing our reliance on human senses, while automating the anticipations and inferences once drawn from instrument readings, and while more finely synching physiological response to environmental condition. Environments, then, are not another word for nature or wilderness, but a composition of data given coherence by a precautionary orientation. Earth observing media extend, shape, and mobilize bodies – our senses, our nervous systems – to make them compatible with industrially transformed environments. McLuhan's (1964) thesis of media as prostheses for traumatized inhabitants of modern society might be renewed in this context, even if his remedies for avoiding numbness seem quaint. In making over the earth, we remake ourselves.

Alert

New Zealand has long sought to integrate its population into precautionary protocols to reduce the incidence of skin cancer, deadly melanoma, and other ailments associated with an industrially destabilized atmosphere by reporting the UV index. These messages are designed to accommodate populations to industrially transformed environments by setting thresholds of permissible damage (at the scales of individual exposure and population level cancer incidence), by normalizing environmental conditions previously considered an object of political contestation, and by disseminating an individual oriented precautionary protocol that interrupts the formation of community or social organization in favor of techniques provided by consumer industries.

The most iconic and popular warning is the "slip, slop, slap, wrap' advice[10], which encourages individuals to wear shirts, hats, sunscreen, and eyewear when exposed to sunlight, and to adapt to the degree of risk indicated by the index through ameliorative techniques. The message originated in Australia in the 1980s through a series of public health announcements. Today, both a technical vocabulary and consumer industry have emerged to support – and arguably entrench – this model for meeting dangerous environmental change. UPF (ultraviolet protection factors) for clothing, SPF (sun protection factors) for sunscreen, and UV-A and UV-B protection for sunglasses meeting the AS/NZ10672003 are part of the discourse, standards, and regulation informing an industry tasked with proofing the human organism against dangerous forms of atmospheric change. UPF rated clothing, for example, is needed for the same reason that UV indexes are needed; some fabrics block visible light but not exposure of skin to UV radiation. Interestingly, such clothing was briefly regulated as a medical device in the United States, but is simply recognized as a consumer product with health benefits today. Each person a health resort, Nietzsche might have said.

The most well known intervention is the national scale "Sun Smart" program, which includes special emphasis on the education and behaviour of New Zealand school children. The Sun Smart program derives from widely admired Australian examples, which have been encouraged as models by the World Health Organization (WHO), a body seeking standardization of the measures, display, and use of UV indexes at the international level. The prominence of Australian models reminds of Kittler's (2010) cutting remark that the damaged "lie like corpses on the technical path to the present" (120).

How should one respond to precautionary protocols that embed an individualistic framework in the media infrastructure modulating our relationship to dangerous environmental change? One might suggest that government agencies have little other choice. Children born in the 1980s, for example, must live with and carry the traces of an industrially destabilized atmosphere their entire lives. Such conditions, it would seem, can only be experienced as normal, since there is no 'fixing' the ozone layer beyond the hopeful expectation it will return to its previous condition by 2050 or 2080 if further industrial destabilization is avoided. What, it is insistently asked, would one have governments do?

The global standardization of warnings to integrate diverse cultures and creatures into narrowly construed precautionary protocols relies upon the difficulty in imagining novel answers to this question.

Whether it is a well posed question or not, there is still no overlooking the incongruity of scale between individual consumer choice and earth system change, nor the fact that the determinants of danger – industrial modification of our environments – are both disguised and normalized in the process. Precautionary protocols reduced to the individual scale have displaced if not interrupted the conditions necessary for the formation of communities of political contestation by delimiting how environmental changes are observed and managed. The pragmatic effort to ameliorate unavoidable risk has instituted a philosophical model for modulating human physiology to industrially transformed environments, one in which industrial transformations are regarded as normal (if not an entrepreneurial opportunity).

How is sense made of this situation? How are the precautionary media underpinning our sense of dangerous environmental change integrated into cultural symbols and daily life? Consider an example that I think exemplifies the difficulty even if it is not representative of how most people think. I refer to the prize-winning video produced by young students at Wairakei School (Christchurch) for the "SunSmart Schools" competition, a contest encouraging children to produce media encouraging their schools and peers into precautionary protocols.

http://www.youtube.com/watch?v=hcL3X0QXkcI

There is a lot one could say about the video, the contest that produced it, and the cultural politics of Aotearoa that are reflected in it. Clearly, schoolchildren mixed the warnings and precautions insisted upon in governing protocols with the semiotic and cultural materials available to them to produce an explanation for a dangerous situation. In the absence of a clear narrative of why sunlight is especially dangerous today, a mythic explanation was invoked. However unfortunate the idea of the sun seeking revenge on humanity for Maori aggression, it is, if nothing else, an *explanation,* as opposed to a mere demand that government protocols inform personal behavior based on an obscure account of geophysical change. The rather rough treatment of the cultural inheritance conveyed by the myth perhaps says something about the interruption of tradition require to justify and enact given systems of precautionary regulation.

The insufficiency of the current system is widely recognized in New Zealand and this concern has provoked recent changes. The main difficulty from the perspective of health managers was interpretation, not intention or strategy; based on a variety of research methodologies, the agency tasked with improving the warning system, the Health Sponsorship Council, chose to further reduce opportunity for interpretation (Grey and Beckman, 2011). Their new tool, the Sun Protection Alert, simply tells people what to do, when to do it, and how to do it. Thus, the UV Index has been replaced by geographically targeted, temporally specific alerts. These no longer report environmental conditions in terms of graded risk to physiological or biological function, but simply declare alarm and prescribe a protocol of action. The forecast of the UV index still underpins and triggers the warning. However, the index reading is no longer reported directly. The population is no longer expected to respond to the even this rudimentary mediation of environment change; it is to react to an automated governmental warning declaring a space dangerous and insecure.

SUN PROTECTION ALERT

10:15 AM — 3:45 PM

PROTECTION REQUIRED

Seek shade, reapply sunscreen

Data provided by NIWA

New Zealand is relatively unique in its proximately to the most dangerous consequences of an industrially altered stratosphere, yet not in terms of the assumptions, model, or practice of constituting precautionary protocols from earth observing media. As mentioned, the World Health Organization (WHO) has sought to standardize the measure, reporting, display, and models of precautionary action taken with respect to radiation threats of sunlight exposure across the planet. While the details of the algorithm unpinning the UV index, its visualization, and the recommended behaviours synched to such measures will all change, the commitment to accommodating populations to industrially transformed environments in a fashion that both obscures and normalizes the determinants of danger to secure existing political order is an enduring pattern.

By way of conclusion

The themes evoked by these vignettes elicit two different trajectories for discussions of media as an infrastructural accomplishment. On the one hand, there is McLuhan's idea of media as prosthetic devices for damaged humans. As extensions of self, media and information technology are responses to the crises occasioned by our industrially transformed living environments. The practical exigencies of our bodies are the key moments for understanding media technology and its implications. The splicing of our consciousness and nervous system into data-processing infrastructures may have entailed the suborning of political contention to the logistics of earth observing, but it is the human organism – our bodies – that helps steer the direction and evolution of media more generally. Things still make sense, since senses still aid in the constitution of things.

On the other hand, there is the anti-humanism associated with Kittler, and the idea that the occasional concessions to human perception or sense making in the operation of contemporary data-processing infrastructures are the least interesting moments. The removal of human agency, observation, and interpretation from determinations of dangerous space points not only to the technological nature of earth observing but to the fundamental inability of humans to process anything other than the narrowest sliver of ongoing environmental changes. When the recording and processing of environmental changes (its temporality, its spatial scale, its complexity) exceeds the communicative, and when the logistics of managing data streams reorganizes how we initiate warnings or precaution, humans become defined primarily by their fallibility. The ozone hole went undetected by humans for years after it was recorded. Our inability to process such recordings took additional years. And our subsequent inability to project a collective response into the future required a policy protocol that hitched restrictions on human activity to a more fully developed (and semi-autonomously operating) earth observing system.

If this paper vacillates between the humanist and anti-humanist perspectives, it is because environment, as reconfigured by earth observing technology, promises to reposition the terrain upon which the evolution of humanity and technology is usually imagined.

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Notes

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[1] As well, it was the telegraphic transmission of weather patterns that Marshall McLuhan often had in mind when speaking of the 'instantaneous sweep of information' characterizing a global village.

[2] New Zealanders might recall that their second governor, Vice-Admiral Robert FitzRoy, was instrumental in establishing this network for weather forecasting, although FitzRoy is more commonly remembered for captaining Darwin's famous voyage.

[3] On the drawing of the graph to portray a dramatic curve, see Shanklin (2010).

[4] There is an interesting matter to pursue here. NASA's initial data processing model for earth observing was derived from SAGE, a centralized computer system designed to facilitate military management with a 'big engineering' ethos, a quality Conway (2008) identifies as the Achilles Heel of NASA's earliest EOS proposals (p. 274). The first satellites flown specifically for NASA's EOS mission did not reach orbit until 1999, by which time an 'Internet' based data distribution system had replaced the SAGE model (Conway, 2008). My sense is that a centralized SAGE like model was employed initially in processing ozone data, and that this explains the inability to properly handle data flow. Stolarski (2003) offers personal observations supporting this claim. As well, accounts of NASA's involvement with the Hubble Telescope suggest similar problems. To my knowledge, the difficulties faced by researchers in obtaining ozone data in the 1980s has only been explained anecdotally or via oral history, and I have not read a definitive and convincing account on this point.

[5] For a brief history of spectroscopy that is unsurpassed in producing delight, see Burnett (2009).

[6] For example, the image could depict a bruise, creeping ugliness, or a gap in the "earth's natural sunscreen," as NASA (2009b) recently put it. See Unger (1998) for an excellent discussion of the cultural meanings of ozone depletion.

[7] Of course, many meteorological services were located in war/defense departments, and this is the case with Britain. Thus, this distinction should be approached with some caution.

[8] See Haas, 1992a, 1992b, for a good summary, but also Barrett, 2003; Benedick, 1991; Cagin and Dray, 1993; Dotto and Schiff, 1978; Edwards, 2010; Gribbin, 1988; Lambright, 1995, 2005; Litfin, 1994; Pearce, 2008; and Pielke and Betsill, 1997.

[9] This is done using the McKinlay-Diffey Erythema action spectrum.

[10] The integration of this advice can be seen on the UV Index displayed using the 'fire danger' alter format. See Image 8 above.

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