

## *Earth-in-Circuit: Transmissions of time and the August 21<sup>st</sup> Solar Eclipse*

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Figure 1: Oceanic plume identified at sunken site of SS MIRA, August 2017; *The Guardian*

In Don DeLillo’s 1985 novel *White Noise*, an accident involving a tank car releases, “a feathery plume” and then “a black billowing cloud” that finally becomes “an Airborne Toxic Event”. On August 28<sup>th</sup> 2017, a mist drifted toward the Sussex coastline at Birling Gap Beach, causing acute respiratory illnesses in over 150 people before dissipating without being identified. A symptom of the Airborne Toxic Event in DeLillo’s novel is an acute sense of *déjà vu*. The Sussex toxic mist was later traced to an oceanic plume emerging at the same spot that the *SS Mira*, a 3,700-tonne armed tanker, was sunk by a mine from a German submarine on October 11<sup>th</sup> 1917, almost exactly 100 years ago.<sup>1</sup> Atmospheric histories haunt an atmospheric present. Time folds uncannily on itself as we remember, and forget again, the heavy weather that once disturbed a night’s sleep or an aerial journey; the repeated and prolonged violence of tropical storms in the Caribbean; the *El Niño* season that returned far too soon. Intrinsic to this forgetting, and to

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<sup>1</sup> See Matthew Weaver’s article in *The Guardian*, “Shipwreck investigated as potential cause of Sussex coast toxic plume” Available at: <<https://www.theguardian.com/uk-news/2017/sep/01/shipwreck-investigated-as-potential-cause-of-sussex-coast-toxic-plume>> Interestingly, Neodaas, a facility of the UK Natural Environment Research Council that works with the Plymouth Marine Laboratory, later tweeted on August 31st that the direction of the plume was inconsistent with wind direction, so it was most likely carried by tides, thanks to research by P. Land, P. Cazenave, M. Yang, F. Hopkins from the Plymouth Marine Lab. This ruled out the *SS Mira* is most likely source. Other sources were investigated.

the frequent *déjà vu*, is our (in)capacity to *feel* the atmospheric present. While in some ways our bodies are more alive to the atmosphere than ever before – the mobile technologies we constantly carry with us monitor the atmosphere, searching for signals – we are also enveloped in bubbles of distraction and immunity. There is an urgent need for wider participation in practical experiments that expose us to the tangible, sensible matters of the air we breathe. We need stories, too, that inspire novel investments in the atmospheric commons in which we are immersed.

In this text and in my work in general, I am concerned with collective events in sensing space, atmosphere and matter that expose human bodies to phenomena at the edge of perception. I am haunted by examples of suspension and perturbation, such as when an unknown mist rolls darkly onto a summertime beach in Sussex, and equally I am attracted to moments of collective interest and affective flourishing in Earth's atmosphere, such as that occurring in the picture shown here.



*Figure 2: Aerocene, launches at White Sands (NM, United States), 2015*  
*The launches in White Sands and the symposium “Space without Rockets”, initiated by Tomás Saraceno, were organized together with the curators Rob La Frenais and Kerry Doyle for the exhibition “Territory of the Imagination” at the Rubin Center for the Visual Arts. © Photography by Studio Tomás Saraceno, 2015*

Indeed I have spent the last four or five years of my life working from within the Studio of Tomás Saraceno in Berlin, and later collaborating with Tomás on a series of collective experiments in solar-powered flight that are now called the Aerocene project.



*Figure 3: Aerocene Flight, University of Lancaster; Image by Joaquin Ezcurra and Sasha Engelmann.*

Now, there is a thread I am trying to trace between the aforementioned atmospheric and cosmic experiences. The highly troubling occasion of an Airborne Toxic Event, or the collective launch of a lighter-than-air, solar powered artwork, are not only aesthetic occasions. They also trace forms of politics in which bodies are extended toward each other and toward the cosmological media that flow between them and among them. They are moments in which a Guattarian ‘rupture’ is felt in spatial, temporal and physical constraints. Atmosphere is a medium and a force for thought, and it is also a realm of transmission through which space and time are made legible and synchronous. At the same time, the atmosphere is a space of transmission through which time might bend uncannily on itself, and as I will related further, through which the measure of time may wobble on its path.



*Figure 4: Oceanic plume identified at sunken site of SS MIRA, August 2017; The Guardian*

Let us return to a moment last summer, and more precisely let us return to the month of August 2017.



Figure 5: Solar eclipse viewing; Source: Daniel Acker / Bloomberg / Getty

Only a few days before the toxic mist drifted onto Birling Gab beach in Sussex, a solar eclipse occurred over North America. Thousands of people flocked to the *path of totality*, purchasing special sunglasses to enable viewing of the cosmic event. *Man can be in ecstatic contact with the cosmos only communally*, Walter Benjamin wrote in 1923. Like a solar eclipse, these words have a dark ring to them, since at the time of his writing, Benjamin was referring to the communal event of planetary war in which, “gases [and] electrical forces were hurled into the open country, high-frequency currents coursed through the landscape, [and] new constellations rose ...” (Benjamin, 1923). These are conditions that describe the present even more than they described the time of Benjamin’s writing. And they are conditions that are as cosmic as they are atmospheric and political.



Figure 6: Viewing the eclipse at St. Oberholz café, Berlin. Source: Author’s own.

I watched a NASA live stream of the August 2017 solar eclipse from St. Oberholz café in Berlin. The force of the event was palpable even from afar. I could feel the drama of the wait, the intrigue of the commentary from astronomers, the hypnotic possibilities, the craning of peoples' necks to the sky.... Yet what exactly were these crowds of people sensing as they participated together in this cosmic event? Was it simply a visual spectacle, or were their other politics and presences at work?

In fact the sunglass wearing throngs may have been the most visible, but the eclipse also inspired many other groups to express a different kind of outpouring of sensual attention. In particular the eclipse inspired a range of attentions and observations of cosmic properties of Earth's atmosphere.

There were many who *listened* to eclipse. There were those who *tuned in* to the eclipse on the radio spectrum. Like so many voices hurled into the air, thousands of radio amateurs across the nation "lit up the ionosphere" with a nationwide "QSO" (radio contact) party. It was necessary to have a *party* because the more radio amateurs were transmitting during the eclipse, the greater the amount of information that could be gathered on how an eclipse alters the conditions of amateur radio bands. In addition, amateur astronomers recorded the musical phenomena caused by interactions between Earth's magnetosphere and the Sun. Still others recorded specific AM radio transmissions in order to catch unusual glitches, wobbles and distortions caused by the brief, cosmically enhanced nightfall.



Figure 7: The WWVB station during sunrise; Source: NIST

Perhaps most unusual among these group of listeners were those who tuned in to the ways in which the eclipse altered the transmission of time. They were able to do so because time is transmitted through the atmosphere, and the atmosphere was affected by the solar eclipse. I find this case compelling because, notwithstanding the constellations of orbiting satellites that also synchronize global time, it suggests that the measure and reception of time are not necessarily as constant as most of us might think. Time can be altered by the qualities of Earth's atmosphere, and by the various cosmic forces that influence it. And inscribed in the fact that time is transmitted through the air, are histories and legacies of human experiments in atmospheric and cosmological space. For the remainder of this text I would like to focus on this point.



*Figure 8: Alphonse Berget; Eiffel Tower Radio Station, 1914*

Time has been transmitted through the air since as far back as humans employed bells, gongs and other sound instruments to communicate the hour of day. However a shift in time's transmission occurred in 1913 when the Eiffel tower began its wireless telegraphy of time signatures (Kern, 2003). Before this point, local times could vary dramatically even within France. Following the Eiffel tower's transmissions, a series of other experiments in transmitting time emerged at the MSF radio stations in the UK, the DCF77 station in Germany and the WWVB station in the U.S. Like MSF, the WWVB station is still active today, and given its geographical location in Fort Collins, Colorado, its transmission of time

was hypothesized to change during the solar eclipse that would pass over North America on August 21<sup>st</sup> 2017.



*Figure 9: WWVB/ WWVL station dedication, 1963. Source: NIST*

A brief history of WWVB is important here. In the US, since 1919, there had been a series of experiments with the synchronization of radio frequencies operated by the National Bureau of Standards. The experimental station WWV (a predecessor to WWVB) was set up in a ground floor room of an apartment block in Washington DC, yet it soon moved to Maryland and then to Boulder, Colorado (Nelson et al., 2005). WWV began sending time messages in telegraphic code every five minutes in October 1945 (Nelson et al., 2005). However the advent of Cesium standard atomic clocks in 1960 would change the kind of time that was transmitted. Cesium standards represented the new “atomic clock” technology, which later became, and remains today, the basis for the International System (SI) second. The device that standardizes the second, also standardizes frequency. The WWVB station was officially born in 1963, and among other services, one of its purposes was the experimental transmission of Cesium standard time to the continental US on a 60Khz carrier wave (Nelson et al., 2005).



Figure 10: The WWVB station; Source: NIST

60 KHz is in the low frequency band, with a wavelength of 5000 meters. Large wavelengths require large broadcast antennas.

WWVBs signal is not transmitted by a single tower, but relies on a wire mesh suspended over a 400-acre antenna field (Nelson et al., 2005). The soil chemistry beneath the antenna grid is highly alkaline, which makes it a good conductor for electricity. Because the soil conducts so well, WWVB can actually use the Earth as part of the antenna apparatus (Nelson et al., 2005).



Fig. 4. Artist's conception of the original WWVL antenna in Fourmile Canyon, west of Boulder.

Figure 11: An artist's conception of the original WWVL antenna in Fourmile Canyon, west of Boulder, CO. Source: NIST

The relationship of antennas to the Earth is even more interesting when we consider that these long-wavelength signals can reach around the curvature of the planet by clinging to the semi-conductive surface of the planet. On a clear night, a radio-controlled watch can pick up WWVB's 60 kHz signal as far away as Patagonia or New Zealand (Nelson et al., 2005). WWVL pictured here was a sister station of WWVB that was invented to transmit time *to the entire globe*. As you can see, the antenna is integrated spatially in a mountain range. An even larger antenna array for WWVL was planned at Fort Collins, CO. However the financial and political resources for this station did not materialize, and it was never built (Nelson et al., 2005).



*Figure 12: Frost on receiving antenna and trees. Source: NIST*

Let us then return to WWVB and its transmissions of atomic time through the atmosphere. What kind of time is this? It is one regulated by 9,192,631,770 energy transitions of the cesium atom. These transitions determine frequency. On WWVB's 60Khz carrier wave, time of day takes one minute to be transmitted through techniques called Pulse Width Modulation and Phase Modulation (Nelson et al., 2005). The time code information is transmitted in a format known as binary coded decimal (BCD) where four binary digits (bits) are required to transmit one decimal number. Bits are modulated by simply lowering and raising the power of the 60 kHz carrier wave. The power is held low for 0.2 s to send a binary zero or for 0.5 s to send a binary one.<sup>2</sup>



*Figure 12: The WWVB station – 60 KHz antenna lowered. Source: NIST*

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<sup>2</sup> Published research conducted outside of the National Bureau of Standards indicates that WWVB was utilized during its early years for a variety of scientific applications, including the correlation of seismic events and astronomical observations, including the measurement of radio emissions from Jupiter, studies of underwater sound propagation, and studies of the attenuation of VLF and LF radio signals as they pass through the Earth's surface.

<EMBED AUDIO FILE of WWVB sounds – see attached file ‘the real WWVB’>

WWVB transmitted time in this way through the 70s, 80s, and 90s, but it wasn't until the 1990s that advances in microprocessors combined with an increase in the power of the WWVB station, spurred the production of 'radio-controlled clocks' that were both cheap and able to easily decode the signal (Nelson et al., 2005). As a result, a steady stream of wall clocks, desk clocks, and wristwatches were introduced to US consumers, and new products continue to be released. WWVB now transmits time to a vast number of clocks and consumer electronics in North and South America: atomic time is transmitted atmospherically across an attentive techno-collective of devices and objects.

In preparation for the Solar Eclipse of August 2017, a team of scientists calling themselves EclipseMob initiated a nationwide citizen science project to crowd source information on the effect of the eclipse on the WWVB time transmission (Nelson, 2017). Students, teachers, volunteers and non-specialists contributed to this effort. The scientists based primarily at George Mason University distributed EclipseMob Kits that, with some basic assembly, would pick up the 60Khz signal and shift it into the audible range. Then the signal would be input into a computer or cellphone via the headphone jack (Nelson, 2017). The WWVB transmission was chosen not only because of its quality, but because the 60Khz carrier wave is influenced by the quality of the ionosphere (Nelson, 2017). Changes in the ionosphere, namely changes in the D Layer of the Ionosphere during the solar eclipse, would alter the way that the carrier wave was reflected. As the ions in the D Layer decreased under the temporary nighttime conditions, the layer would allow the signal into the E and F layers of the ionosphere, and transmission of the signal could (in theory) spike (Nelson, 2017). In other words, changes in the ionization of the lower layers of the ionosphere would shift the strength of the 60khz wave. Time would thus travel further.

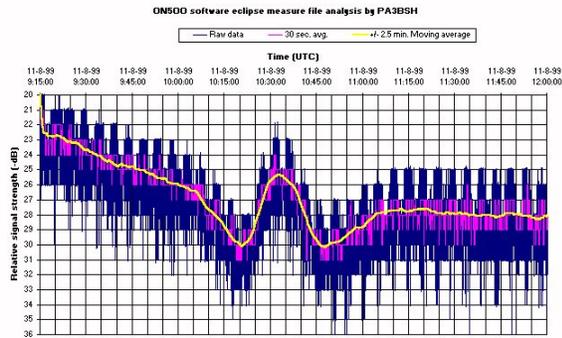


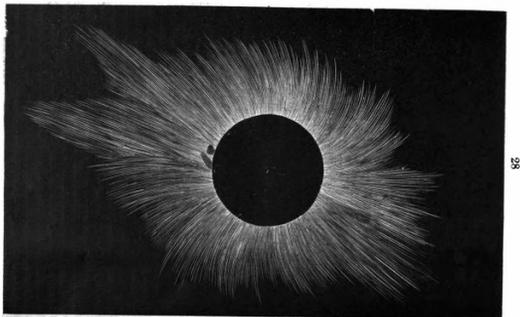
Figure 13: ON500 Software eclipse measure file analysis by PA3BSH

However what happened is likely much more complex. For several months, and together with my frequent collaborator Sophie Dyer, I have been in touch with radio amateur Bill Liles, NQ6Z, and one of the inventors of the EclipseMob experiment. Bill told us that the effect of the eclipse on the time signal could be more like a wobble. This is a phenomenon documented first by famed radio scientist William Eccles in 1912 (Nelson, 2017). It was again observed on transmissions from the Eiffel Tower. During the solar eclipse that passed over Europe in 1999, five amateur radio operators, each at a different location, observed a signal from a 75 KHz transmitter making various types of “W’s” on their spectrum graphs (Liles, personal communication). Why this happens is not fully understood. The transitions of a Cesium atom might stay constant in the midst of an eclipse, but human, technological and planetary bodies are affected and repositioned. The wobble in the very-low-frequency signal is the trace.



Figure 14: View from the top of one of WWVB's towers. Source: NIST

At the same time I do not want to hyperbolize the enigma in this question of how an eclipse event influences the transmissions of, and in, our atmosphere. The results of the EclipseMob experiment are to this day under evaluation (Liles, personal communication). But I *do* want to highlight that the beauty in this experiment in sensing the relations between cosmos, atmosphere, Earth and time lies in the modest and attentive work of hundreds of citizens as they erected their makeshift antennas to receive the transmission of time during an eclipse. Like sculptors they adjusted and aligned their materials as the moon neared the sun. There is something ancient in this image which is impossible to articulate in plain text, but has to do with the ways in which life on this planet has advanced through acts of attunement to earth and cosmos. The kinds of publics that are manifested in this experiment have a crucial role to play in seeking out wobbles in the infrastructures that define and control our atmospheric and earthly spaces.



*Figure 15: The Solar Eclipse of July 29, 1878. Source: Chicago Astronomical Society.*

While all of those sunglass-wearing people were experiencing the dimming of solar light, and while the citizen scientists were listening to the moon eclipsing the sun, I like to imagine all of the radio clocks in North America sensing the wobble of the radio transmission of time. Perhaps they began flickering, perhaps stalling or delaying, perhaps peaking or dipping in performance... like so many subjects in the grip of the Cesium atom, momentarily given a dance.

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