Tangent to the Earth: Tracking Site Conditions According to Horizontal Solar Light

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> "Red sky at night, sailor's delight. Red sky in the morning, sailor take warning."

As the adage above suggests, sunrise and sunset, when light passes along tangent to the surface of earth, are optimum times of the day to "read" the sky and realize thermodynamic properties influencing a site. Solar light arriving tangent to the Earth travels through roughly forty-five times more troposphere (figure 1) on its way to reaching a site and, most likely, will have encountered various clouds, particulates, and pollutants along the way. We experience these dynamic moments, the last of visible light (figure 2), as perceptual shifts in our environment, and physiological shifts in our eyes as cones and rods tradeoff absorption responsibility of the electromagnetic spectrum[1]. The qualitative measurement of light tangent to Earth's surface is inevitably more than the altitude and azimuth reading of solar light. Site tracking during sunrise or sunset draws together often separate analysis of meteorological and terrestrial features towards an environmental ecology. (figure 3).

This particular exploration in horizontal light relative to a site developed as an outcome from my field study documenting atmosphere illumination along a trans-hemispherical line[2]. Over the course of seven months, three mechanical objects of a dome, dish, and bowl, were used to photograph changing light qualities in effort to visualize thermodynamic patterns specific to each site, with the goal of producing a catalogue of atmosphere conditions as a means of contributing to the language of design and architecture. And while light arrives tangent to our atmosphere nearly everywhere on Earth, not all sites exhibit the characteristics necessary for receiving horizontal light. Integral to a sailor's assessment of the sky is an understanding that the "reading" takes place out at sea with unobstructed views. Similar geomorphologies retain the necessary far reaching horizons from which to connect sky to site, such as deserts and plateaus. During seven month project, titled Light 110, I set out to prioritize the sunset by recording light on the West Coast of North and South America. Retaining the shoreline consistency for all fourteen sites guaranteed a westward far-reaching horizon to welcome the evening horizontal light.

Exceptional tools tracking thermodynamic properties of our atmosphere are at our disposal. The National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), and the National Aeronautics and Space Administration (NASA) provide a handful of resources that make available satellite data from Earth's various atmosphere layers. These resources enhance the ability to track solar performance on site, and make it possible to extend an analysis of light beyond light-ray diagrams and sun polar charts. This paper introduces a logic of understanding solar light inclusive of the thermodynamic properties evident in the atmosphere surrounding a site.

LIGHT IN ARCHITECTURE

The reference to horizontal light has context in 1615 Vincenzo Scamozzi two-volume treatise, "The Idea of a Universal Architecture" in which he publishes a catalogue of six light qualities, listing among them horizontal light, (lume vivo orizontale)[3]. Scamozzi is among one of the first architects to qualify and catalogue light in effort to better visualize the impacts various illumination levels have on Renaissance architecture. Scamozzi work indelibly with Andrea Palladio assisting with many of his project, most famously Teatro Olimpico in Vicenza, Northern Italy. In his treatise, Scamozzi includes a diagram of his architecture analyzing this light catalogue emanating from the sky dome rather than a specific azimuth and altitude. This approach favors the atmosphere over the line, including the various light distribution and extinctions that take place traveling from the sun to Earth's surface. Previous to Scamozzi's qualitative cataloging, solar light was primarily considered in functional terms aligning program position with rising and setting sunlight, with Vitruvius mentioning these rules in this ten books of architecture. Andrea Palladio worked from the functional arrangements and encouragement that interiors were ideally lit through diffused light, organizing openings to avoid direct light entering into spaces. References to Horizontal Light also appears in literary text. Particularly memorable is T.S. Eliot's reference of the "Violet Hour"[4] in the Wasteland, which he aligns particular actions in one's day with the change in atmosphere due to horizontal light. While light has been a continuous subject of interests for artists dating back to the fifteen hundreds with the Dutch Landscape painters, architects have intermittently incorporated solar light into formal strategies beginning with Vitruvius in the ten books of

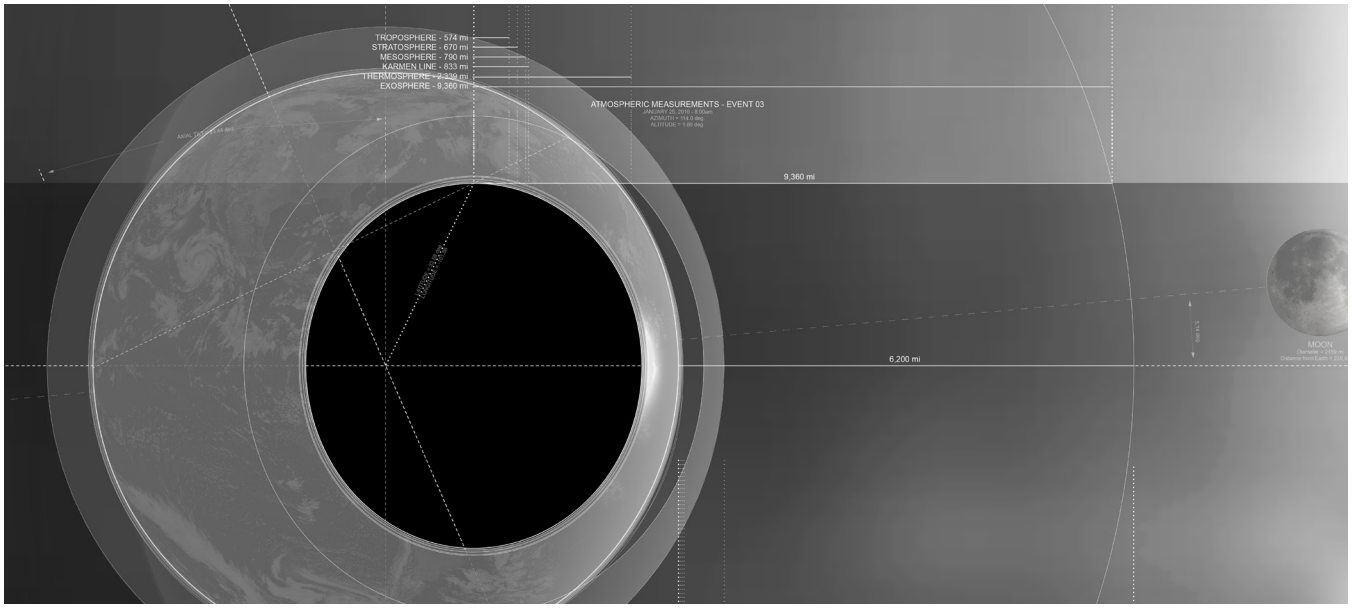


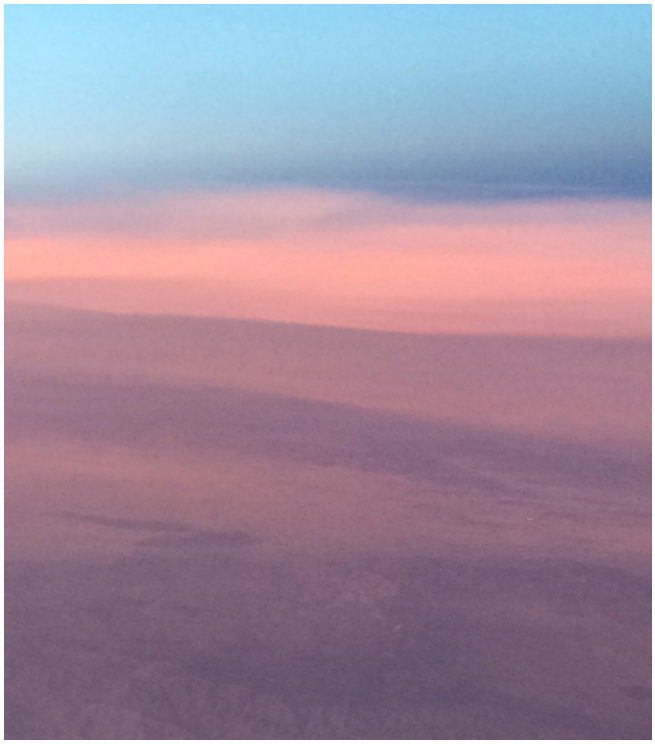
Figure 1. Solar Light Crossing Earth's Atmosphere. Steven Roop, V. McReynolds Studio ***Eight Minute Monument and Other Luminary Happenings***.

architecture, reemerging with renaissance, baroque, and gothic architecture, only to fully escape shadows with Joseph Paxton's Crystal Palace in 1851. Since Modernism, light was capable of serving both performative and metaphorical roles, such as Le Corbusier's design for Ronchamp Chapel and La Tourette. More recently Steven Holl recognizes the duality of science and arts in his quote, "The physics of light is evident in shadows. The boundary between light and shadow - usually the gray area of 'penumbra' - is filled with the mysteries of the mathematics of light"[5]. The mechanical and poetic duality of light introduces two lines of inquiry, one calculated through engineering information and a separate metaphorical interpretation. Tadao Ando's structures, such as the Church of Light, best resemble architecture that embodies the duality of science and arts where the cross of light at the end of the chapel exists as an engineering feat in order for light to convey a message. Contemporary artist Robert Irwin shapes light to be the message. Starting the in 1970's with the Space Light Movement in California, Irwin developed art work that engaged space, perception, and light. His recent installation Untitled (Dawn to Dusk), 2016 at the Chinati Foundation introduces material that blurs one understanding of edge and depth dependent upon the angle of light passing in space - essentially synthesizing material engineering with light phenomenon. This tending towards uncertain edges and diaphanous enclosures can also be found in architecture with recent proposals by architects OficinaA, Z4Z4, and Philip Rahm. Meteorologically sensitive architecture design is an emerging field where projects, such as "Domestic Astronomy" designed by Philip Rahm architects in 2009 serves as a prototypical apartment for organizing program according to thermal convection and radiation. These interior strategies for reconsidering architecture form and organization has potential to be harnessed in the environment. An environment which is inclusive of atmosphere as a medium, matter, and material.

SOLAR RESOURCES

Considering the desires for architecture of atmospheric effects and meteorological conditions, it is significant to take stock of the tools at our disposal. Traditional means of designing with solar light rely upon quantitative measurements of the light ray. Charts, diagrams, and software compute the object-ness of illumination. Gregory Bateson, in Steps to an Ecology of Mind, writes, "It is important to see the particular utterance or action as part of the ecological subsystem called context and not as the product or effect of what remains of the context after the piece which we want to explain has been cut out from it"[6] urging that object and field, or figure and ground, are analyzed in relation to the other. By extension then the light-ray geometry of solar light is in context with the atmosphere and corresponding meteorological elements (figure 4). Essential site features such as wind patterns, particulate density, moisture content, and terrestrial formation incorporate a contextual reading of light and offers a bridge between the quantitative geometry to qualitative experience of a particular place (figure 5).

Visualizing light is an exercise in seeing the material evidence of what we often assume as an inmaterial portion of site. For example, the atmosphere boundary layer is the scientific term for the thermal blanket of heat that is lifted off of the land at the end of the day or brought back to the ground surface with the rising sun. This thermal exchange between day and night triggers other atmosphere effects such as air instability and the formation of cumulus and stratocumulus clouds, while a stable boundary layer will usher in fog.



Four significant atmosphere features can be cross-mapped to arrive at an atmosphere topography-like map: viewshed (inclusive of site photographs and hue values), topography registering terrain changes, surface altitude wind vectors and particulate count, along with the Jet Stream altitude wind vectors and particulate count. These four components address the various readings of individual on site, topography interrupting solar light, wind trajectories near the ground, and wind trajectories at roughly 30,000 to 50,000 feet altitude.

Troposphere, the layer of atmosphere closest to the Earth's surface, exhibits particularly dynamic movement in response to varying topographic and meteorological conditions. Ranging from roughly 4 miles thick towards the poles to near 12 miles thick above the equator, this layer of Earth's atmosphere contains the majority of the gasses and water vapor, and thus the formation of clouds. By capturing wind trajectory readings at the surface and near the jet stream account for data at the lower and upper limits of the Troposphere.

Vast amounts of terrain information can be gleamed from a specific latitude and longitude. Working from a single datum, one can identify topographic elevations often at 100 foot intervals, along with interpolated surface mapping. In general determining the distance to the horizon is an easily rationalized equation, yet determining the site specific boundary proves more challenging. When analyzed according to pure geometry, a six foot person standing on an abstract spherical surface, sees roughly three miles. On the Earth, this distance varies drastically dependent upon air to land temperatures, and particulate density. Sightlines through atmosphere can extend even greater distances, easily viewing a cumulonimbus cloud 25 miles away. ArcGIS assists in determining this visual horizon through the viewshed calculation. The resulting vector , based upon location and height, provides an outer visual limit specific to the topographic complexities of that region.

Extending from the ground surface into the atmosphere, the NASA based EOSDIS powered website EarthDATA visualizes the Earth Science Data being collected globally into a digitally accessible map. In turn, one can track aerosols, air quality, atmospheric chemistry, and radiation in our atmosphere as a few examples. NASA also provides a separate Atmospheric Science Data Center interface organizing information into Aerosols, Clouds, Radiation, and Tropospheric categories. These data maps when coupled with site photos provide useful information for the atmospheric conditions treating the light prior to its arrival on site. Subsequently, familiar particulate disruption in the atmosphere such as haze can be regionally identified. Often thought to be a natural particulate in the air, haze is in fact most often an industrial produced pollutant. Meterologist Stephen Corfidi explains, "[m]ore specifically, haze is a form of 'wet' air pollution — a veil of tiny droplets (aerosols) of condensed pollutants. The adjective 'wet' is used to distinguished this type of haze from the dry forms that consist of fine dust particles..."[7] Data maps tracking particulate density assist in making visible the material qualities of our atmosphere.

ORCHESTRATING ATMOSPHERE DATA

Managing these four visual data sources becomes an exercise in itself. By applying James Corner's "Game-board"[8] mapping technique, new opportunities emerge from a site coded in the atmospheric and meterological properties of a wider territory. An understanding into the illuminating qualities of a site during the ends of the day suggest a greater range of contrasting light qualities than one would anticipate or generally design for during the normalized day time sun angles. "Tangent to the Earth: Tracking Site Conditions According to Horizontal Solar Light" outlines the atmospheric conditions that influence light and the ability to cast a broad more inclusive reading of site through the properties of solar light.

"The Neoplatonists saw the cosmos as a machine of unending emanations, a radiation of light from a pristine and uncontaminated source above to the manifold and variegated world of things below. This light no sooner departs from its source than it encounters the viscosities of darkness, like sculpting clay as each animated substance presses its own path through that of the other. The admixture is nothing other than what we call world; as one descends, the mixture becomes less pure, and more diffuse. All appearances - all things - are the product of some combination of light and obscurity, of pure and impure. But most importantly, the world and everything in it is understood to be arrayed along a gradient, a flow from above that is screened and resisted and shaped by the material below."[9]

Figure 3. The Last Battle Between Form and Light. Stills from “Nadir” V.McReynolds director, X.Tavera videographor, J.Escobar Mellado lighting .

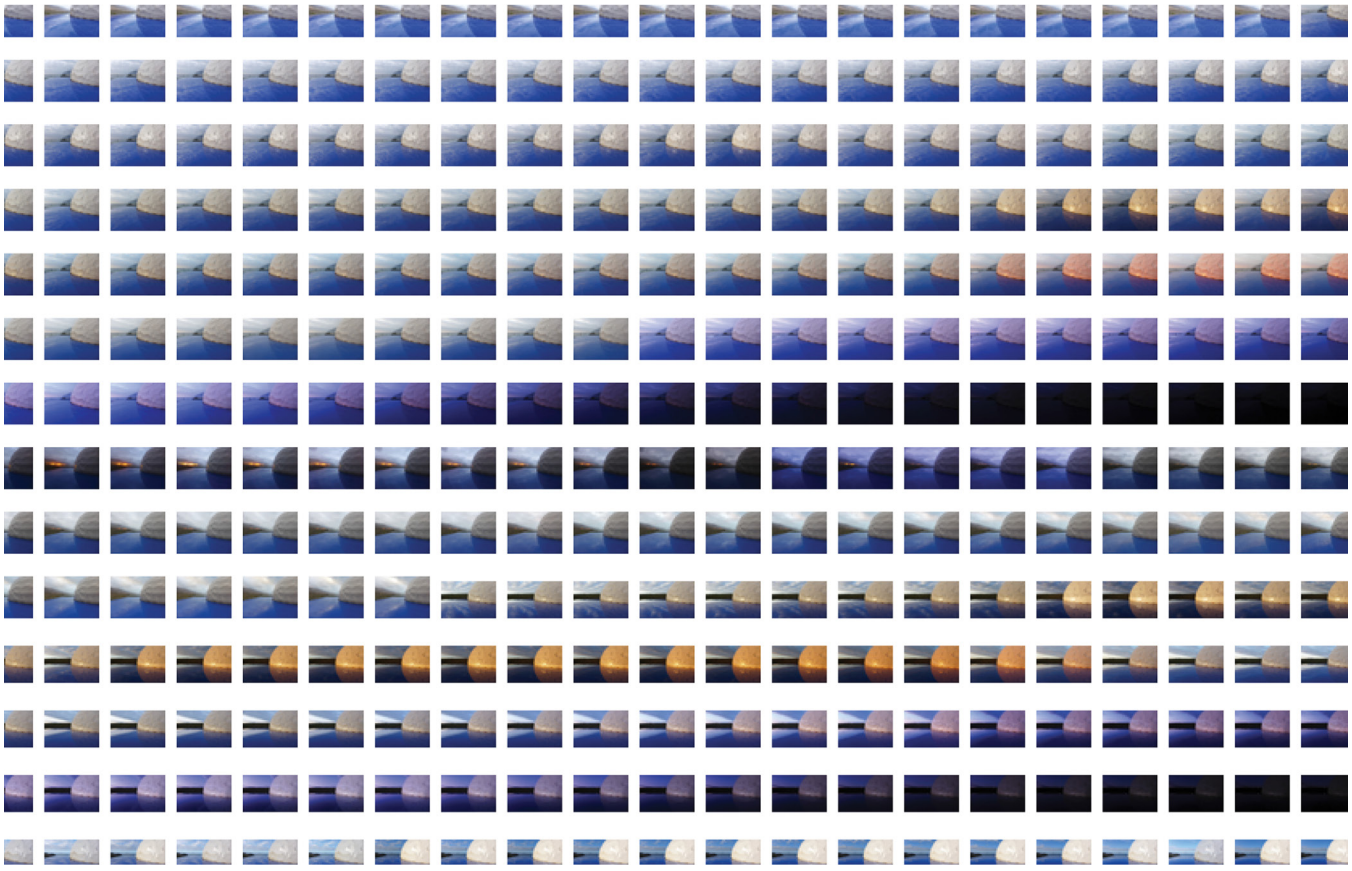


Figure 4. Light 110, South 25 Latitude. November 2015. ***Dome time-lapse images***

ENDNOTES

1. "Nadir", 2016. Collaborative project documenting formal dissolution during twilight.
2. "Light 110", 2015. Documentation on Violet Light at fourteen sites along the West Cost in North and South America.Sites are mirrored across the equator, spaced every five degrees latitude from 55 to 25 degrees.
3. Ann Marie Borys, "Lume di Lume: A Theory of Light and Its Effects," Journal of Architectural Education, Vol. 57, No. 4 (May 2004): 8.
4. T.S. Eliot, The Waste Land (New York: Liveright, 1922): 31.
5. Steven Holl, Parallax (New York: Princeton Architectural Press, 2000), 108
6. Gregory Bateson, Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry (Chicago: University of Chicago Press, 1972), 338.
7. Stephen F. Corfidi, "Haze Over the Central and Eastern United States," National Weather Digest (March 1996)
8. James Corner, "Agency of Mapping" in Mappings, ed. Denis Cosgrove (London: Reaktion Books, 1999), 231-252
9. Kwinter, Sanford. "Plenum" Steven Holl: Color, Light, Time. Lars Muller Publishers, Switzerland, Zurich. 2012, pg 69.

Figure 5. Light 110, South 25 Latitude. November 2015. ***Dish time-lapse images***