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18

Sky: Atmospheres and Aesthetic Distance in Planetary and Lunar Environments

David Madacsi
Department of Physics, University of Connecticut

Abstract. While much of Western aesthetics has been influenced by early concepts of ideal beauty and a later ideal of disinterested contemplation of works of art, some contemporary aestheticians argue for an aesthetics of environment itself, both built and natural. Sensory perception is by definition implicit to aesthetic perception, and an artist, working in an environment which not only is a source of sensory information but additionally may be a source of personal aesthetic experience, produces works which may have aesthetic value as reflections of aspects of an intelligible universe – aesthetic value which may be informed by the artist's own aesthetic experience of environment.

To the earthbound observer, that portion of environment referred to as 'the sky' is a subjective uniquely-framed window to the rest of the universe, individually cropped by local horizons and nearby physical/structural barriers. An individual's sky field-of-view may vary from a restricted few degrees of visual angle defined by an opening in a rainforest canopy to the unrestricted panorama of sky seen from a mountaintop and viewable in its entirety only by fully turning ones gaze through all points of the compass.

Though Earth's clear night sky is essentially transparent, the daytime lighting of its atmosphere, whether cloudy or clear, blinds earthbound observers to extraterrestrial astronomical phenomena with the exception of those involving the sun, moon, and (somewhat briefly) the brightest stars and planets. Similarly throughout the solar system, the absence, presence, and properties of atmospheres will be fundamental determinants of aesthetic distance and therefore of aesthetic experience of planetary and lunar environments as well as of extraplanetary and extralunar astronomical phenomena.

Introduction

INSAP is a conference devoted to questions related to the inspiration of artists, both past and present, by both the day sky and the night sky. Whether originating in either the day or the night sky, all such inspiration

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involves visual sensory perception that includes the transfer of information from sky to artist via light. This author's own primary interest lies in the day sky, and in the particular question of whether the natural light in some locations on Earth is qualitatively 'better' or more inspiring than in others. Is there really something special about the light in Southern France or Cornwall or Venice or Taos, for example? Many artists appear to think so. This paper looks outward, to the limits of our solar system, for insight into such earthly questions.

This same question of the relationship between light and place was addressed previously by the author at the INSAP III conference, but with the concept of place extending only as far as the to surface of our own moon.[1] That presentation concluded with the juxtaposition of two images. The first was Vincent van Gogh's familiar 'The Starry Night', INSAP's adopted logo, with its sky of swirling light: bright blues and yellows encircling stars and crescent moon; more subdued blues and greens and browns of a small village in the foreground; blue hills meeting the colored sky to define the local horizon. Juxtaposed with van Gogh's image was another titled 'The Starry Lunar Night', an almost completely monochromatic image formed (with all due apologies) by digital manipulation of the former. The landscape, including village, vegetation and hills, had been converted to a range of neutral grays. The sky was now a field of black with the exception of mere points of light representing the stars and a blue crescent Earth (NASA image) replacing van Gogh's yellow crescent moon. The point of this (subtractive rather than additive) digital graffiti was to illustrate that, by comparison to Earth, the moon was (is) a visually impoverished place – not just by virtue of its lack of flora and fauna, but more fundamentally by virtue of the inability of the lunar environment to support more than a paucity of physical optical phenomena. The surface of the moon is, of course, essentially monochromatic, and its lack of an atmosphere leaves its sky perpetually black even with the sun high. The only optical phenomena supported by the lunar environment are the absorption and diffuse reflection of light. Visually, the only interesting element in 'The Starry Lunar Night' is the blue splash of color of the crescent Earth.

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[1] D. Madacsi, 'Opto-Diversity, A Key to Artistic Inspiration--Case Study: Moonscapes vs Earthscapes', INSAP III The Inspiration of Astronomical Phenomena, Palermo, 2001, *Memorie Della Societa Astronomica Italiana* (*Journal of the Italian Astronomical Society*) 73, Special No. 1 (2002): pp. 147–50.

By contrast, Earth's environment is capable of supporting a full complement of natural optical phenomena including both diffuse and specular reflection, scattering, refraction, and dispersion, and these are supported in greater or lesser proportions in various terrestrial micro-environments. (Additionally, of course, Earth's flora, fauna and geology exhibit highly-varying coloration spanning the full range of the visible spectrum.) Earth and its moon thus represent opposite extremes of possibility for characterization of the optical diversity of planetary and lunar environments. An objective of the present paper is to offer an overview of planetary and lunar environments throughout the solar system, characterizing those environments optically as they fit into a range between the rich optical diversity of Earth and the optical poverty of the moon, and considering implications relative to the possibilities for inspiration of artists in those environments.

To further emphasize the visual importance of atmospheres, comparison is made between an image of a barren desert Earth environment and a NASA image of a lunar environment of very similar topography. The lunar image contains monochromatic dunes, foreground rocks with sharp shadows evidencing the height of the sun in the sky, and stark black sky (as always) despite the height of the sun. In contrast, the desert image, taken at White Sands, New Mexico, virtually explodes in soft color. The photograph was taken shortly after sunset with a full moon rising. Despite the fact that the sun is well below the horizon, the entire sky is lighted with the colors of twilight, and the same range of colors is subtly imparted as well to the intrinsically monochromatic dunes. The dramatic visual difference between the two images is fully attributable to the existence of an atmosphere at White Sands. If that atmosphere could be removed, the next image taken would be quite similar to the lunar image. It would show a completely black sky with the exception of the disk of the moon that would provide weak illumination and soft shadows to monochromatic dunes of sand. With the atmosphere, the refraction of light makes possible the illumination of the entire sky by particle scattering, even after sunset, and the dispersion of light results in the separation of colors into a twilight spectrum above the horizon that is shared in turn with the dunes.

Planetary and Lunar Skies

Throughout the solar system, the absence, presence, and properties of atmospheres are fundamental determinants of aesthetic distance and therefore of aesthetic experience of planetary and lunar environments as well as of extraplanetary and extralunar astronomical phenomena. Optical and visual characteristics of atmospheres are determined by gaseous composition and density, presence and types of particles, and presence of water or other liquid in a hydrologic-like fluid cycle.

To begin with, only two moons in the solar system, Saturn's Titan and Neptune's Triton, have permanent atmospheres, while only one planet, Mercury, does not. The remaining terrestrial planets and all of the gaseous Jovian planets (by definition) and Pluto, do have atmospheres. Some general implications for the inspiration of astronomical phenomena are immediately obvious. The surfaces of Mercury and of all the moons other than Titan, Triton, and Jupiter's Io (to be discussed below) will have completely transparent black skies regardless of their relative position of the sun. In each case then, inspiration from their skies would derive exclusively from occultations, conjunctions, eclipses, and other relative motions of the sun, sister moons, central planet (especially ringed Saturn), stars and comets, and in some instances occasional showers of cold non-luminous meteoroids striking the surface.[2] Dusk/dawn and all other atmospheric effects, by definition, would be absent.

The Jovian planets, on the other hand, have dense atmospheres within which any detailed observation surely would be completely obscured. From their moons (or from spacecraft), however, such weather phenomena as Jupiter's Great Red Spot (with lightning several orders of magnitude more energetic than in Earth storms) and Neptune's Great Dark Spot could prove to be significant sources of visual inspiration.[3] The terrestrial planet Venus similarly has a dense (carbon dioxide) cloud cover that completely obscures its volcanic surface, and as with the (hydrogen/helium) gas giants, would also prevent observation of astronomical phenomena from any vantage point on its surface, both day and night.

In this context of potential sites of astronomical inspiration, the remaining planets and moons still to be considered are Pluto, Mars, Saturn's Titan and Neptune's Triton, to which should be added Jupiter's Io. Taking the last of these first, data and images collected by Voyagers 1 and 2, the Galileo spacecraft, the Hubble Space Telescope and Cassini

[2] Nasa, 'Photojournal', *Jet Propulsion Laboratory*, at http://photojournal.jpl.nasa.gov/target/Saturn?start=0.
[3] Nasa, 'Mission Galileo', *Nasa Science Solar System Exploration*, at http://galileo.jpl.nasa.gov/gallery/top10science-9.cfm.

have revealed Io to be the volcanically most active body in the solar system.[4] With a radius comparable to Earth's moon, about a quarter that of Earth, Io's surface displays mountains approaching twice the height of Everest's 29,000 feet, active volcanoes, lava lakes, volcanic geysers, giant calderas and pateras. The energy for Io's volcanic activity is generated by tidal forces in its irregular orbit of Jupiter which produce tectonic surface bulges as great as 100 meters.[5] The Galileo spacecraft recorded a visible wavelength image of a feature with volcanic fountains forming a lava curtain 25 kilometers long and one kilometer high.[6] Though not sufficiently massive to retain a permanent atmosphere, Io emits voluminous quantities of volcanic gases and particles in nearly continuous eruptions of its ubiquitous volcanic features. Varied colors of surface features include red and black lava flows, sulfurous yellow, green and white. Colors observable in its sky may be likely via scattering of sunlight by volcanic gases and dust during the day. Additionally, its night-time sky exhibits vivid multi-color auroral displays resulting from interaction of ionized volcanic gases with Jupiter's magnetic field.

Returning to a consideration of the remaining planets, it is significant in the present context that Pluto is not a gaseous planet and that its atmosphere is thin.[7] Its sky may thus behave in some fundamental ways similarly to the sky of Earth and the sky of Mars, although, owing to its great distance from the sun, full sunlight on Pluto will be comparable to a moonlit night on Earth. Pluto may exhibit some atmospheric phenomena related to the optical processes of scattering, refraction and dispersion of light, and may to a limited extent share with Earth and Mars the experience of dusk and dawn, 'the time of retreat of the stars'.[8] These planets have skies that exhibit diurnal cycles of relative transparency following relative opacity to extraplanetary astronomical phenomena. The relative opacity results from the daytime lighting of even the clearest

[4] NASA, 'Photojournal', *Jet Propulsion Laboratory*, at http://photojournal.jpl.nasa.gov/target/Io.

[5] NASA, http://solarsystem.nasa.gov/planets/profile.cfm?Object=Jup_Io; NASA, https://solarsystem.nasa.gov/moons/jupiter-moons/io/overview/.

[6] NASA, 'Mission Galileo', *Nasa Science Solar System Exploration*, at http://galileo.jpl.nasa.gov/gallery/top10science-5.cfm.

[7] http://www.solarsystem.nasa.gov/planets/profile.cfm?Object=Pluto&Display= Overview Long.

[8] See discussion in the accompanying INSAP IV paper by Petra Schmidl, 'Dusk and Dawn in Medieval Islam'. Also see http://www.2hajj.com/.

sky via the scattering of the sun's light by atmospheric particles. Insufficient information about the atmosphere of Pluto has been obtained to date to permit any meaningful speculation about additional visual characteristics of its sky and possible visual atmospheric phenomena. In contrast, the atmosphere of Mars has been found to support daily weather including fogs and clouds, exhibit seasonal changes, and harbor dust storms. The best 'approximate true-color' images obtained to date by NASA's Mars Exploration Rovers Opportunity and Spirit, e.g., the 'Santa Anita Panorama',[9] show a yellowish-brown sky. This color may be related to the characteristics of dust particles in the Mars atmosphere as well as to the scattering of light in the atmosphere that previously has been reflected from the red Martian surface. Observations and images of 'inspiring' atmospheric phenomena such as colorful sunrises or sunsets, including refracted colors of dusk and dawn, thus far have not been reported. These phenomena may be subtle at best, or they may occur in more dramatic 'Earthly' fashion only as rare or highly location-specific occurrences, perhaps with conditions favorable at places or times of minimal atmospheric dust content.

Among some one hundred forty moons discovered to date in the solar system, only two, Triton of Neptune and Titan of Saturn, have permanent atmospheres, as mentioned above. In its 1989 fly-by of Neptune, Voyager 2 obtained high-resolution color images of Triton, found it to have a very thin nitrogen-dominated atmosphere, and measured its surface temperature to be the coldest in the solar system.[10] A composite image revealed frozen surface features, probably frozen nitrogen, exhibiting coloration ranging from pinkish to reddish of its polar ice caps to bluish and greenish tints of other such features in non-polar regions. It is likely that Triton's sky is dominated by Rayleigh scattering, as with Earth, and would be lighted during the day and would be blue. However, at some thirty times Earth's distance from the sun, sunlight on Triton is three orders of magnitude less intense. At least equally importantly, Triton's thin atmosphere is in the range of four additional orders of magnitude less dense than Earth's, with proportionately fewer scatterers of that rarefied sunlight. Hence Triton's sunlit sky is likely to be comparable in luminance to Earth's during deep twilight at best. However, more intense

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[9] NASA, 'Photojournal', *Jet Propulsion Laboratory*, at http://photojournal.jpl.nasa.gov/catalog/PIA06689.

[10] NSSDCA Photo Gallery, Neptune, at http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-neptune.html.

atmospheric effects may be possible via scattering of sunlight from low-lying thin nitrogen ice clouds and from particles emitted by Triton's volcanic geysers.

The smog/cloud-covered sky of Saturn's largest moon, Titan, until now has hidden from view both the surface features of this body and the visual character of its sky as viewed from its surface. Though that cloud cover is global, it does not have a density or thickness comparable to the atmospheres of the gaseous planets or of Venus. At the time of submission of the final version of this paper, the Cassini/Huygens mission had transmitted its first images, both during descent and from the surface of Titan.[11] These images revealed an orange-ish sky somewhat similar in hue, though not in brightness, to that of Mars. (Its distance from the sun reduces the intensity of solar radiation for Titan by nearly a factor of one hundred relative to Earth, while that for Mars is reduced by a factor between two and three.) Surface features of Titan observed by Huygens during descent suggest at least the possibility of atmospheric phenomena yet to be observed. Dramatic evidence of complex dry river systems feeding lakebeds with offshore islands, together with the observation of apparent methane springs, suggest that though the rivers and lakes appeared dry when Huygens arrived, there may have been rain (liquid methane) in the recent past and by implication there may be rain in the not-too-distant future. Titan thus may have a meteorology based on a methane fluid cycle. It's surface environment therefore could be capable of supporting the same full complement of natural optical phenomena as the does Earth's, including both diffuse and specular reflection, scattering, refraction, and dispersion. As on Earth, these likely would be supported in greater or lesser proportions in various seasonal and geographical micro-environments.

Conclusions

On Earth, even on the clearest and brightest of days, the day sky observable from any point on the planet's surface is only a fraction of a percent of the full (hemi-global) day sky covering the lighted portion of the Earth. More significantly, though a cloudless sky may be highly transparent, the Rayleigh scattering of sunlight in the atmosphere produces what might be considered a form of blue 'light pollution' which in effect makes the day sky 'opaque' to extraterrestrial astronomical

[11] The European Space Agency, 'Cassini-Huygens', at http://www.esa.int/SPECIALS/Cassini-Huygens/.

phenomena with the exception of those involving the Sun, Moon, and (in limited circumstances) the brightest stars and planets. This limited range of astronomical phenomena nevertheless has been a significant historic source of artistic inspiration perhaps because the Earth's lighted sky perceptually functions as a local canvas that links the extraterrestrial directly with the terrestrial. Of the planets, Mars is known with certainty to have a sufficiently transparent atmosphere to exhibit similar behavior of its daytime sky. Pluto's dimly-lit day sky also may exhibit such behavior if its atmosphere is sufficiently transparent. Among the moons, although Neptune's Triton has an atmosphere that is sufficiently transparent that its day sky should behave similarly, that sky may be very dimly-lit at best, with the possible exception of stronger scattering from thin clouds and volcanic particle plumes. Saturn's Titan seems to be perpetually cloud-covered, which would preclude daytime observation of any astronomical phenomena. It is possible to speculate, however, that rare breaks in Titan's cloud-cover, associated with a dynamic methane-based meteorological system, might occur over time, making feasible the observation of inspiring astronomical phenomena involving Saturn, its rings and thirty-two additional moons, and the sun. Rarity would add to the inspirational nature of such phenomena.

The atmospheres of this small group of planets and moons support, to varying degrees, the optical phenomena of refraction and dispersion, in addition to scattering, which together may produce, again to varying degrees, phenomena such as colors of dusk/dawn, sunrise/sunset coloration of clouds, fogs, halos… These may enhance external astronomical phenomena, or alone may enhance environmental aesthetic qualities. For most of this same handful of planets and moons, there is a fundamental disparity in aesthetic distance of day sky vs. night sky, in that other planets and the distant stars may become visible only in the depths of the dark night sky. Atmospheric effects may add enhancements such as twinkling and halos, but may reduce night-sky stellar visibility and the sense of depth of space due to increasing scattering when viewing toward the horizon. On planets and moons that are completely devoid of atmosphere, however, the apparent depth of space should be the same looking toward the horizon as looking toward the zenith, both day and night.