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Photochemistry in Saturn's Ring-Shadowed Atmosphere: Hydrocarbon Modulation & Observations of Dust Content

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Abstract

Cassini has been orbiting Saturn for eleven years. During this epoch, the ring shadow has moved from covering a relatively large portion of the northern hemisphere (Figure 1) to covering a large swath south of the equator and continues to move southward. At Saturn Orbit Insertion on July 1, 2004, the ring plane was inclined by ~24 degrees relative to the Sun-Saturn vector. At this time, the projection of the B-ring onto Saturn reached as far as 40ºN along the central meridian (~52ºN at the terminator). At its maximum extent, the ring shadow can reach as far as 48ºN (~58ºN at the terminator). The net effect is that the intensity of both ultraviolet and visible sunlight penetrating into any particular latitude will vary depending on both Saturn's axis relative to the Sun and the optical thickness of each ring system. In essence, the rings act like venetian blinds.(Figure 2).

Our previous work [1,2] examined the variation of the solar flux as a function of solar inclination, i.e. ~8 year season (Figure 3) at Saturn. Here, we report on the impact of the oscillating ring shadow on the photolysis and production rates of hydrocarbons in Saturn's stratosphere and upper troposphere, including acetylene, ethane, propane, and benzene. Beginning with methane, we investigate the impact on production and loss rates of the long-lived photochemical products leading to haze formation are examined at several latitudes over a Saturn year. Similarly, we assess its impact on phosphine abundance, a disequilibrium species whose presence in the upper troposphere is a tracer of convection processes in the deep atmosphere. Comparison to the corresponding rates for the clear atmosphere and for the case of Jupiter, where the solar insolation is known to be insignificant (~3 degree inclination), will also be presented. We will present our ongoing analysis of Cassini's CIRS, UVIS, and VIMS datasets that provide an estimate of the evolving haze content of the northern hemisphere (Figure 4) and we will begin to assess the implications for dynamical mixing. In particular, we will examine how the now famous hexagonal jet stream acts like a barrier to transport, isolating Saturn's north polar region from outside transport of photochemically-generated molecules and haze..

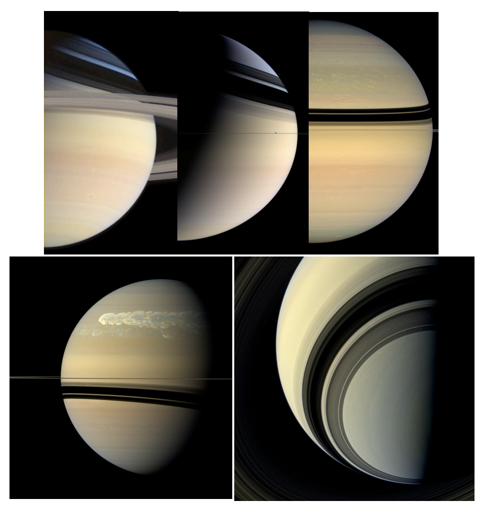

Figure 1. Saturn's atmosphere changes in response to the changing inclination of the ring plane relative to the Sun. (a) Saturn image taken on December 14, 2004. (b) Saturn image taken on March 16, 2006. (c) Saturn image taken on April 23, 2008. (d) Saturn image taken on July 6, 2011. (e) Saturn image taken on July 29, 2013. Images are courtesy of NASA/JPL/Space Science Institute.

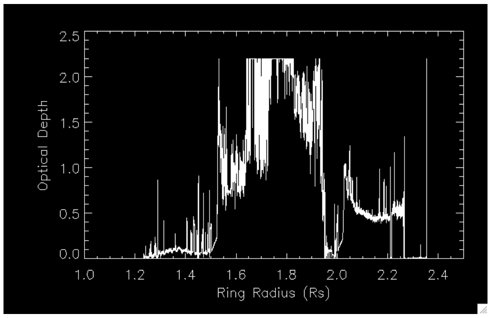

Figure 2. The optical depth of Saturn's rings in the ultraviolet (Josh Colwell, *pers. comm.*) The rings act like a periodic Venetian blind that will shield atmospheric molecules from solar photons.

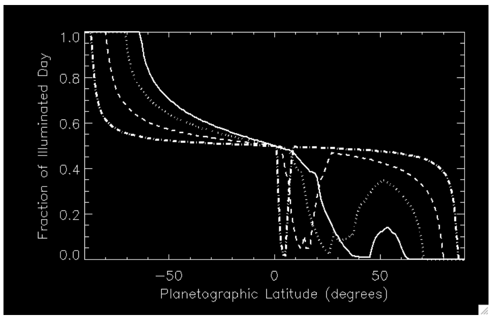

Figure 3. This plot illustrates the fraction of Saturn's day that is illuminated by the Sun as a function of solar declination, i.e. season. The curves correspond to sub-solar points of 26.7ºS (solid), 19.6ºS (dotted), 10.7ºS (dashed), and 3.5ºS (dot-dashed). Ultimately, this will determine the flux of photons allowed to enter the atmosphere relative to those of a clear, un-shaded atmosphere.

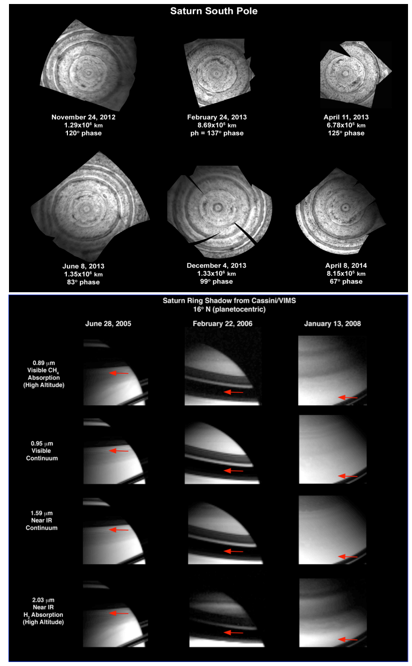

Figure 4. One of the aims of this exercise is to characterize the haze content Saturn's atmosphere. Several Cassini data sets from ISS (above) and VIMS (below) are being used to meet this goal.

Acknowledgements

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References

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[2] Edgington, S.G., R.A. West, K.H. Baines, S.K. Atreya, E.H. Wilson, G.L. Bjoraker, L.N. Fletcher, and T. Momary, 2012. Photochemistry in Saturn's Ring Shadowed Atmosphere: Modeling, Observations, and Preliminary Analysis. *Bull. American. Astron. Soc.*, **38**, 499 (#11.23).