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Spatial & Seasonal Variations in Saturn's Haze & Vertical Phosphine Distribution at 3 Microns from 2005 to 2010

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Abstract

We acquired spectra of Saturn from two complementary instruments: the SpeX spectrograph at NASA's Infrared Telescope Facility and the Visual and Infrared Mapping Spectrometer (VIMS) onboard the Cassini spacecraft. We obtained these spectra between 2005 and 2010, when Saturn's southern hemisphere transitioned from summer to fall, at two distinct latitudes: 15 deg S and 30 deg S. We extracted these spectra in the wavelength range 2.4-3.2 microns, where tropospheric haze and phosphine gas absorb reflected sunlight.

We examined the spatial and seasonal variations in Saturn's haze and vertical phosphine distribution. We accomplished this by producing synthetic spectra using the adding-doubling method to characterize radiative transfer through atmospheric layers and the correlated k distribution method to model molecular absorption.

1. Introduction

Studying Saturn's haze helps us understand chemical and thermodynamic processes and Saturn's energy balance. As a disequilibrium species, the presence of phosphine indicates continual replenishment via upwelling from below Saturn's cloud decks. Therefore, studying phosphine is important as a tracer of vertical dynamics.

2. Figures

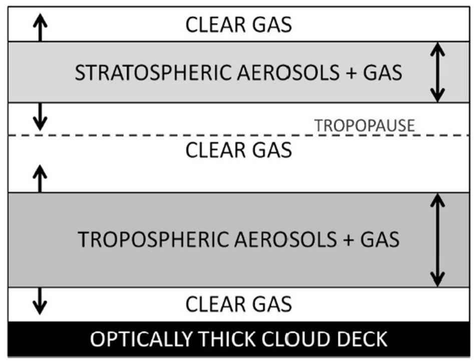

Figure 1: We modeled this haze structure above the upper cloud deck.

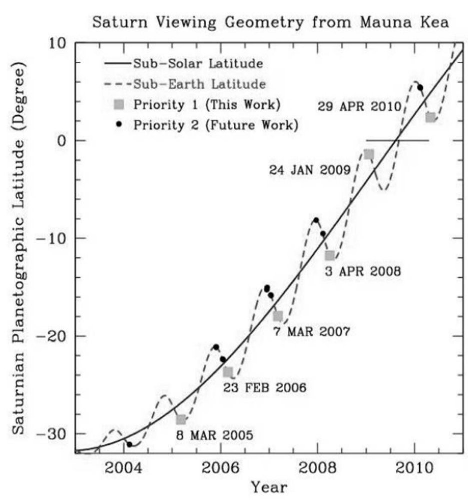

Figure 2: Timeline of our observations.

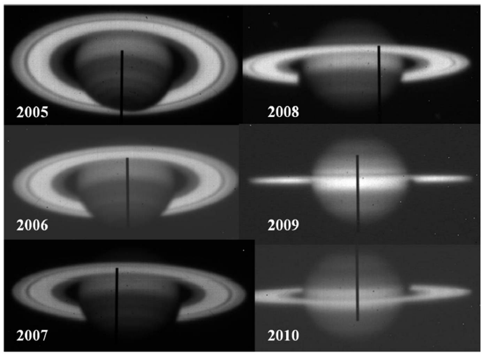

Figure 3: SpeX slit-viewer images of Saturn from 2005 to 2010. Besides having a spectrograph, SpeX has a slit-viewer/guide camera. We show here images from this camera obtained at a wavelength of 1.644 microns from each of our data sets. The vertical black lines indicate the slit positions. During the span of these 6 years, as Saturn's southern hemisphere changed seasons from spring to summer, our view of the inclination of Saturn's rings changed drastically. In 2005, the rings almost completely covered Saturn's northern hemisphere.

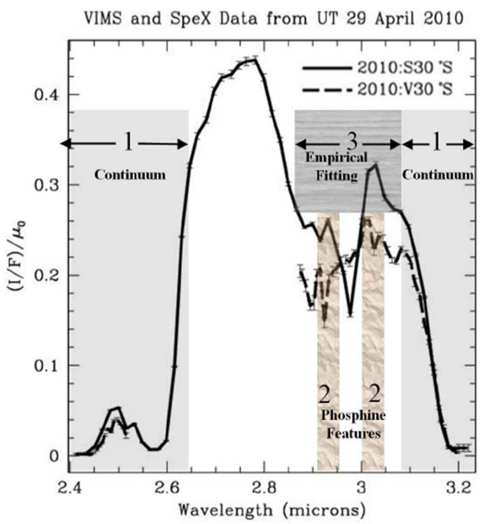

Figure 4: VIMS and SpeX modeling regions. We developed a modeling methodology involving three steps. Here, we show the wavelength regions of each of these steps along with VIMS and SpeX data.

3. Summary and Conclusions

Compared to the tropospheric haze at 30 deg S, we found that the haze at 15 deg S was denser, optically thicker, located higher in Saturn's atmosphere, and composed of aerosols with a larger effective radius but a smaller imaginary refractive index. We determined, at both latitudes from 2005 to 2010, that the haze became less dense and descended deeper into Saturn's atmosphere and the radius of the haze aerosols decreased. By comparing our modeled imaginary refractive indices with lab results, we excluded pure ammonia ice as the composition of the aerosols.

We found that Saturn's vertical phosphine distribution followed a power law in the troposphere such that the mixing ratio decreased with height. We also determined that the phosphine abundance was greater at 15 deg S than at 30 deg S during all years and varied slightly at both latitudes from year to year but not seasonally.

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