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The Changing Face of Titan : A 2012 report on Seasonal Change in the Stratospheric Haze

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Abstract

I report ongoing and dramatic year-to-year changes, observed both by Cassini and groundbased telescopes.

1. Introduction

Titan's stratospheric haze is optically-thick at visible wavelengths : the sunlight driving Titan's weather is controlled in part by the haze, which is itself influenced by solar-driven Hadley circulation and variable production and removal processes - the system is thus complex and rich with feedbacks. Seasonal change on Titan was summarized in [1] : while much recent attention has been devoted to gas composition variations in the stratosphere as documented by Cassini/CIRS, and variations in tropospheric weather observed by Cassini/VIMS, Cassini/ISS and groundbased IR telescopes, it is timely to re-examine the haze as seen in optical data. A >30 yr photometry record exists, in addition to HST observations 1990-2009 (notably of the north-south hemispheric albedo asymmetry), comparisons with Voyager in 1980/1981, as well as the Cassini record over the last 8 years.

2. Cassini Imaging

The most profound Cassini imaging result on Titan's haze so far is the observation by West et al. [2] of the sudden drop in 2009 of the altitude of the detached haze layer. This had been seen to be at ~350km by Voyager, but was near 500km when Cassini arrived in 2004. It remained there until ~2009, when presumably the circulation maintaining the layer altered as the sun crossed north into what had been the winter hemisphere.

Comparable changes now appear (Fig.1) to be visible in the polar hood (which is dynamically linked to the detached haze). The dark polar hood around the north pole has been widely anticipated to fade or break up (by analogy with the Earth's ozone hole). This appears to be happening, but the early onset of the counterpart southern hemisphere feature is surprising. Images at other wavelengths (fig.2) highlight the structure at other latitudes - notably, the albedo boundary (perhaps not the only one) is not equatorial. It presumably indicates a changing latitude of a meridional circulation cell.

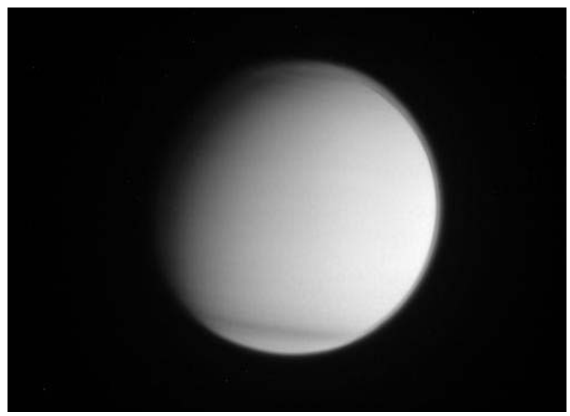

Figure 1. April 2012 near-ultraviolet (UV3, 336nm) image showing dark collars at both poles.

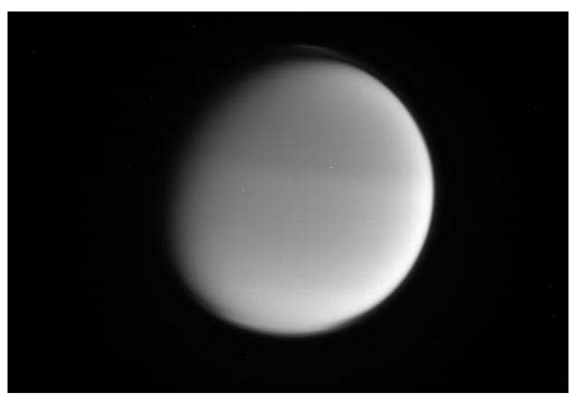

Figure 2. April 2012 methane-band (MT3, 889nm) image showing the pronounced north-south asymmetry.

3. Disk-Integrated Photometry

In many ways the most remarkable new result emerges from the simplest and least expensive observation, groundbased disk-integrated photometry, which now extends over some 40 years. The seasonal cycle does not repeat perfectly, suggesting some kind of interannual variability, and Titan's disk-integrated blue albedo is lower than it has ever been since systematic observations began by Wes Lockwood at Lowell in 1972 [3]. (Such observations are well within the technical capabilities of amateur astronomers, as is disk-integrated spectroscopy : of course, a useful long-term record requires diligent attention to calibration.) It is not known whether the variability is due to solar activity differences between Titan years, or some 'hidden variable' in the Titan climate system, analogous to the earth's oceans or Martian dust which cause interannual variability on those worlds.

4. Future Work

The recent imaging informs the model with which the long-term photometric record can be interpreted. It has been long noted that while the changing equatorial north-south albedo asymmetry yields a disk-integrated history with the correct phase as that observed, it only explains half of the observed amplitude. The presence of two dark collars, and the latitudinal excursion of the 'interhemispheric' boundary provide mechanisms for providing stronger darkening than the original north-south asymmetry alone. Further, it may be that the effective height of the main haze layer changes along with the height of the detached haze, providing an additional 'lever' via the disk area to affect the total amount of light intercepted and reflected by Titan. These mechanisms may finally allow the long-term record to - finally - be fully understood, and these observations will provide much-needed constraints on global circulation models.

References

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