Scientific Rationale for Amateur Photometry of Titan 29/6/00
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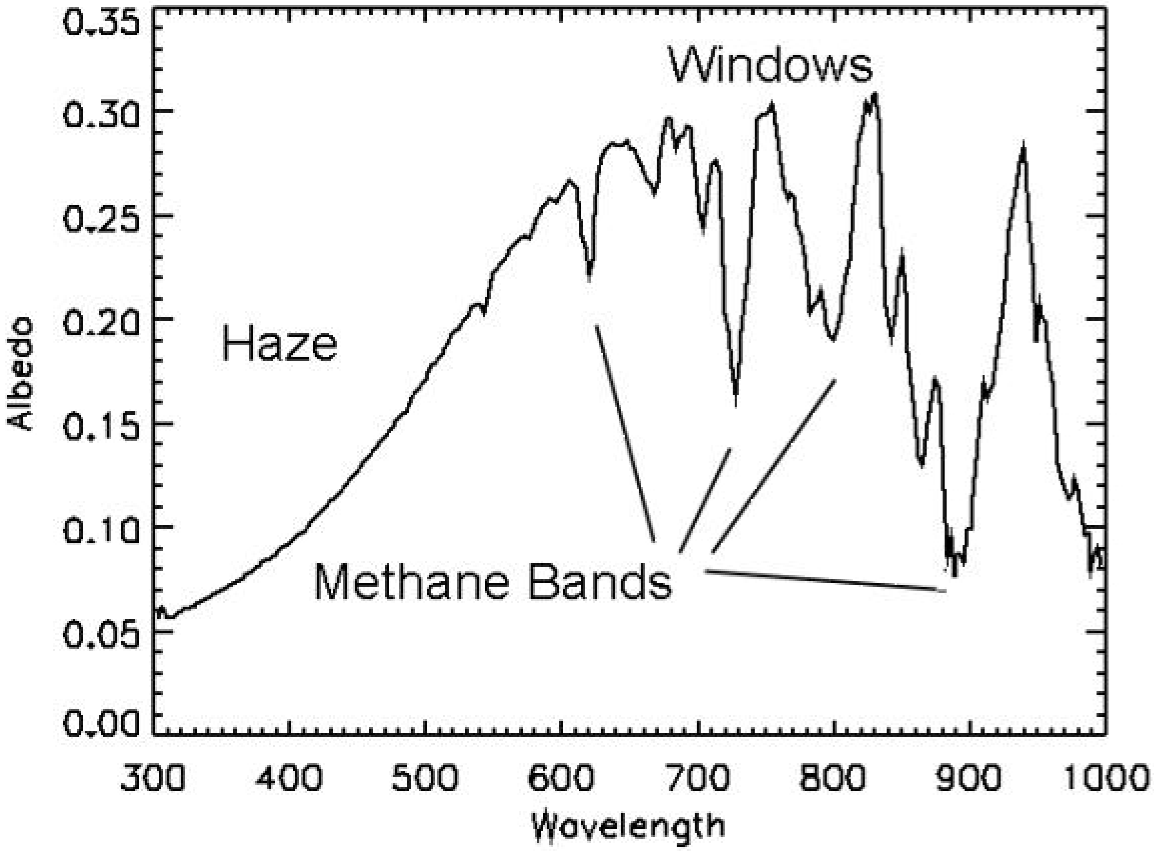
Titan is a dynamic object, which shows changes on daily, weekly and yearly timescales (for quite different reasons). Although Titan has been (intermittently) studied with advanced instruments such as Keck and HST, there is a clear need for systematic observations, even with simple instrumentation.

Spectroscopic Observations would be ideal, and Titan has an interesting spectrum, making it rewarding to observe. Between 300 and 600nm, Titan's color is dominated by the reddish haze in its atmosphere. Above about 600nm, progressively deeper methane absorption bands bite out the spectrum, between which are 'window' regions that probe the lower atmosphere and surface. Day-to-day photometric or spectrophotometric monitoring in the windows will be useful for cloud and surface studies, while longer-term (year-year) monitoring of the other regions will follow Titan's seasonal variations.



1. Near-IR lightcurve. Titan rotates around Saturn with a 15.945 day period, and is tidally-locked so that one face remains fixed pointing at Saturn. Above about 700nm, the absorption due to haze is quite small (the haze is bright at these wavelengths, so it is like looking through fog, rather than looking through smoke.) The haze scattering optical depth is still significant, however, so surface reflectivity contrasts are muted. Atmospheric methane has absorption bands that get progressively stronger with wavelength - the first really prominent one is at 889nm, and this is sufficiently absorbing that no light returns from below about 100km altitude.

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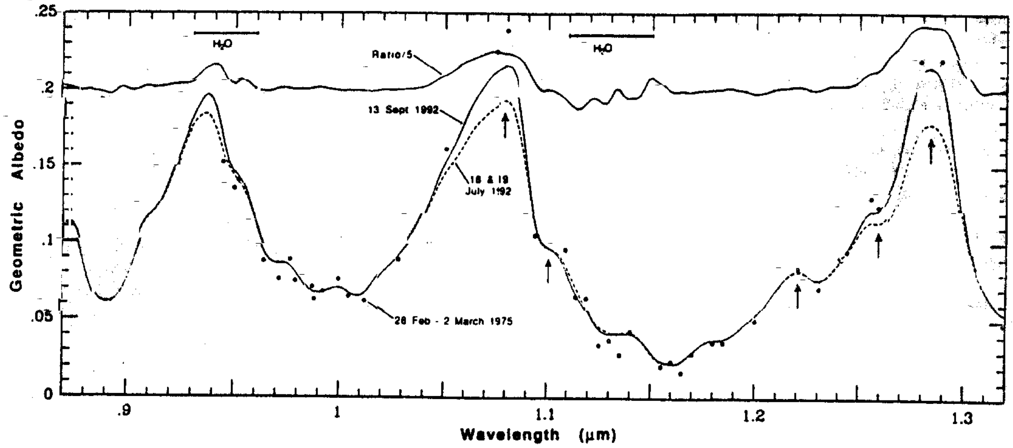


FIG. 1. Titan's geometric albedo spectrum from 0.87 to 1.32 μm. Our observations on different nights (solid and dashed curves) have a spectral resolution of 0.01 μm. The ratio between our two spectra (top) clearly distinguishes regions of significant variations (methane windows) from regions of no variation (methane bands). The Fink and Larson (1979) spectrum has much higher spectral resolution, but is shown subsampled here (open circles). The bars on top indicate a minor (0.95 μm) and a major (1.13 μm) telluric absorption band where observations are unreliable. Outside of the telluric absorption, the errors of the ratio spectrum are estimated to be less than 3%. The five arrows show the selected wavelengths of Fig. 2.

Between these absorption bands, at 940nm for example, the combination of low gas opacity, and low haze absorption, allows sensing of the surface. Surface features on Titan have different reflectivities, and the disk-integrated albedo of Titan showed (in 1992) a variation of about 8% at 940nm, about 4% at 930 and 950nm.

The surface was subsequently imaged by HST at these wavelengths, using a 953nm filter, a 1040nm filter, and (with better signal:noise) a 850nm long pass filter. Photometry in R, I, J bands, or even simple CCD photometry with a long-pass (700-900nm cutoff) filter, should show modulation by Titan's rotation.

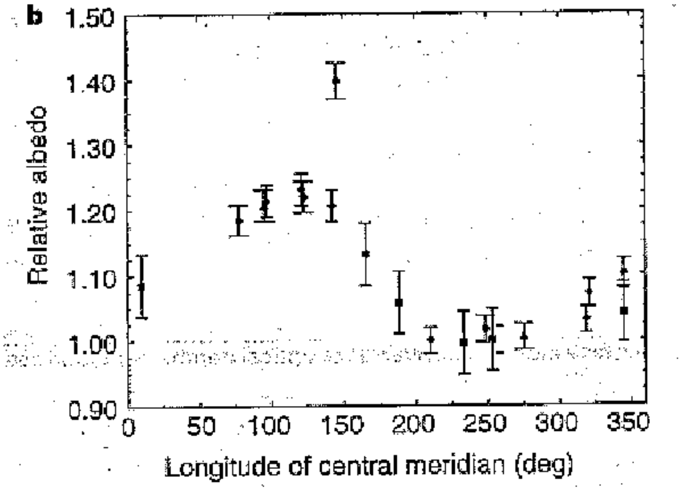
(NB the contrast between leading and trailing hemispheres is even greater at longer wavelengths – 10% at 1070,1080nm ; 20% at 1270-1290nm)

It will be interesting to compare such lightcurves with those done in the 1990-1994 timeframe : because of Titan's obliquity we are now looking at essentially a different part of Titan. In 1990 the sub-earth point was at around 22 degrees North ;in 1995 it was at the equator. We are now (June 2000) at around 22 degrees south, so features that were invisible beyond the southern limb during previous observations are now visible.

The rotational modulation of the brightness gives an early result; instant gratification! Building up a good lightcurve with ~ 1% precision is essential as a precursor for detecting clouds – see e.g. Gennet and Binzel 'Solar System Photometry Handbook'

In principle a lightcurve should exist (albeit at only a few percent at most) at wavelengths between about 650nm and 870nm : measuring this would be novel and useful.

2. Weather monitoring. disk-integrated spectra taken by Griffith et al show anomalous brightening at 3 microns over a couple of days. The brightening is in fact higher than is possible for a surface feature - and must be a 'cloud' or transient atmospheric feature. The same brightening event produced a notable brightening at 2 microns, that stands well away from the background lightcurve.



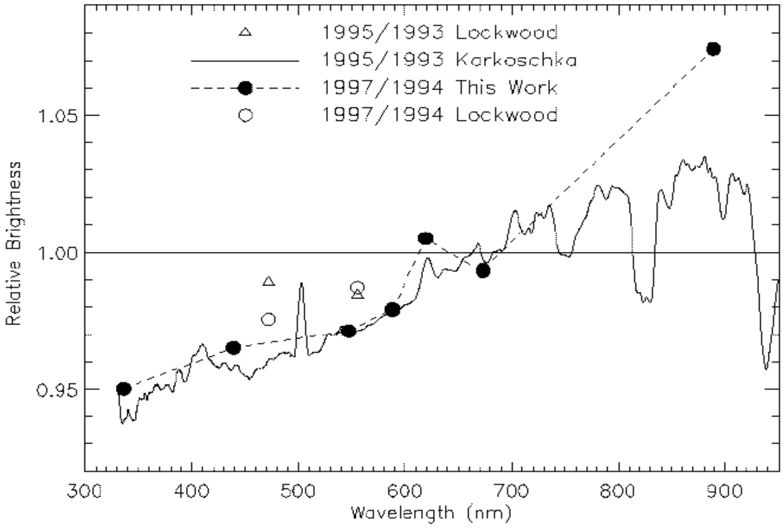
Wenkert and Garneau (1987) analyzed some extremely contrast-stretched Voyager images and reported tracking a couple of cloud features : however, the signal to noise was extremely poor (Voyager's cameras worked only out to about 650nm, so the haze opacity above the clouds was still quite high, and most of the signal came from wavelengths which didnt penetrate deeply)

Lorenz et al. (in preparation) reported an apparent cloud feature in HST images, seen at 619, 673 and 850nm. A subsequent observation showed another transient feature, brightest at 673nm. This feature was several per cent of Titan's total brightness at this wavelength. Careful monitoring of near-IR spectra might detect similar events.

Careful monitoring of Titan's brightness at these wavelengths (and comparing with the 'surface' lightcurve) could determine how frequent cloud activity is on Titan.

3. Seasonal Monitoring Lockwood has patiently measured Titan's brightness at 470 and 550nm over the last 30 years : Titan shows a brightness variation of about 10% and 6% at these wavelengths respectively, both with a 15 year period.

Photometry with HST also shows this variation, and the hint of an even stronger variation at 889nm. Continued photometry at these wavelengths (and others - especially between 600 and 900nm) would be valuable - especially over many years. Lorenz et al. 2000 showed that at 889nm (a strong methane band, so affected only by high-altitude haze changes and insensitive to surface reflectivity), Titan's brightness seems to have increase by 7% in only 3 years (see below, from Lorenz et al., 2000)



Acknowledgement

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