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Insights on Venus' Cloud Top Chemistry, Convective Activity and Topography from HST

Kandis-Lea Jessup(1), Emmanuel Marcq(2), Jean-Loup Bertaux(2), Franklin P. Mills(3,4), Sanjay Limaye(5), Anthony Roman (6); **Affiliations:** (1) Southwest Research Institute, Boulder, USA; (2) LATMOS/IPSL, UVSQ Université Paris-Saclay, Sorbonne Université, CNRS, Guyancourt, France; (3) Space Science Institute, Boulder, USA; (4) Australian National University, Canberra, Australia; (5) University of Wisconsin, Madison, USA; (6) Space Telescope Science Institute

Abstract

Hubble Space Telescope (HST) spectra recording Venus' cloud top properties over Aphrodite Terra (at 200-600 nm) and plains region located downwind of Aphrodite (at 200-300 nm) were obtained in 2010/2011 [1-2]. Our analysis of these data [1-3] revealed the following key trends:

- Absorption at 245 nm that is not controlled by SO₂ multiple scattering.
- Parallels in the 245 and 365 nm cloud top albedo latitudinal variations which suggest that the same material and/or mechanism controls the distribution of the species responsible for absorption at those wavelengths. As the source of the 365 nm absorption remains unidentified, these results support that the unknown absorber either has more than one source [e.g., 4-6] and/or it has a continuum extending shortward of 300 nm [7-8]
- Consistent detection of the minimum albedo (at 245 or 365 nm) at the equator, and increased brightness with increasing latitude (Fig 1); which is consistent with Hadley cell circulation of the absorbing species [9].

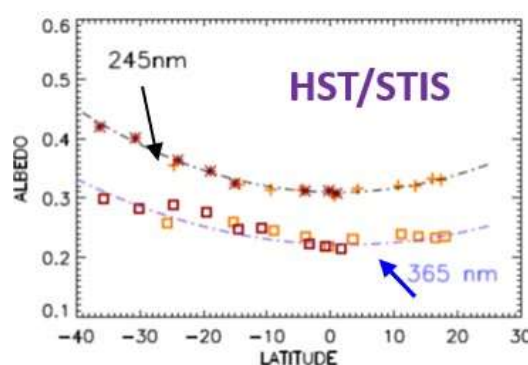


Figure 1: (a) Comparison of the 245 and 365 nm albedo latitude variations observed over Aphrodite by HST/STIS in 2011

- Terrain dependent local solar time (LST) darkening was observed at 245 nm, such that the albedo darkened by 20% over the plains between 10 and 11 hr, while over Aphrodite only limited (~0-10%) darkening was observed between 10 and 11 hr. The onset of the LST darkening correlates directly with the onset of previously observed and well documented subsolar convective activity at Venus' cloud tops [10-12] which occurs in a shallow mixing zone [13].
- The peak SO₂ abundance over Aphrodite was 10-25x lower than observed over the plains 30 days prior, suggesting that the large-scale mixing via the Hadley cell circulation above Aphrodite was

significantly lower than the plains on the dates of the HST observations. Additionally, reversal of the SO₂ latitude distribution from decreasing with increasing latitude, to increasing with increasing latitude reveals the vertical mixing rates above Aphrodite were low enough to allow photochemical depletion of the low-latitude SO₂ gas abundance within a 5-day period. [1,9].

- There was no sensitivity of the cloud top albedo latitude distribution gradient to the observed SO₂ gas latitude distribution gradient—implying the unknown absorber abundance is not directly linked to the SO₂ photochemical process.

1. Conclusions & Recommendations

Based on the HST observed LST and latitude albedo variations we conclude that topography impacts the vertical distribution of Venus' unidentified absorber(s) through both large and small-scale mixing processes. As this (these) species have a direct impact on Venus' radiative balance, climate and cloud super-rotation, we strongly advocate for future observations that can uniquely and contemporaneously characterize Venus' cloud top albedo and chemistry relative to Venus' underlying surface topography and zonal cloud motions.

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