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Cloud Characteristics and Trace Gas Abundances near Distinctive Nightside Cloud Features on Venus

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Abstract

Venus' middle and lower cloud decks are backlit by thermal photons emitted from Venus' surface and lower two scale heights. Within CO_2 windows at 1.74 and 2.3 μm, the clouds show up as silhouettes on Venus' night hemisphere. The Akatsuki mission's IR2 camera has imaged some distinctive cloud features in these wavelength bands, such as paired vortices and sharp discontinuities, thousands of km long in the N/S direction (Peralta et al. 2019). Following the lead of the IR2 camera, we obtained image sequences and spectral image cubes of Venus' nightside from the IRTF using the SPEX spectrograph for periods of ~3 weeks during each of the last two inferior conjunctions (April-May 2017 and Nov-Dec 2018). SPEX observations were generally taken from 6 to 10 AM local time (HST). Each 4h observing window consisted of thousands of 0.5s exposures in selected filters (1.74 or 2.26 μm) and simultaneous image cubes, which were produced by obtaining spectra while moving the spectral slit across Venus' disk slowly, over a 15- or 30-min period. These image cubes cover wavelengths that are sensitive to certain trace gases (notably CO, H_2O and OCS) and cloud properties (particle sizes and H_2SO_4 concentrations) [1], [2]. We report on cloud properties and trace gases found near distinctive cloud features.

1. Introduction

In general, Venus' cloud tops (at ~70 m altitude) have horizontal velocities corresponding to a circumnavigation of the planet every 4-5 days, while the lower and middle cloud decks (~48 – 55 km) circumnavigate Venus in about 7-8 days. Figure 1 shows two examples of unusual cloud feature that were seen in the IRTF campaigns: a sinuous cloud running E-W for thousands of km and a sharp discontinuity running N-S. We have some indication that sharp discontinuities are different from most of the other cloud features seen on the night side: they maintain a recognizable pattern for weeks, and they circumnavigate the planet in 4-5 days, much faster than the usual 7-8 period for nightside cloud features. The spectra taken across the discontinuities lets us, in theory, investigate cloud properties such as particle sizes and H_2SO_4 concentrations [1], as well as map concentrations of trace gases CO, OCS and H_2O. We report on the spectral information for clouds on the night side and compare spectral results for cloud features with particular morphologies.

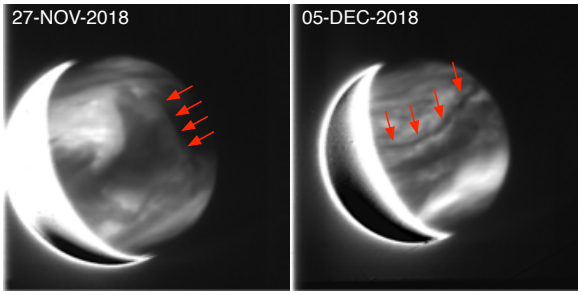

Figure 1: The left panel shows an example of a sharp discontinuity. The right panel shows a sinuous E-W oriented cloud feature.

2. Venus Spectral Cubes

We want to investigate cloud features for spectral clues to their composition and, in turn, to their dynamical origins. Figure 2 shows slices from a spectral image cube at 1.74 and 2.30 μm (two windows in Venus' CO_2 atmosphere); Figure 3 shows spectra from various locations on Venus' disk.

The relative brightness of clouds at 1.74 vs. 2.3 μm is sensitive to cloud particle sizes. Absorption features within the 2.25 - 2.5 μm window are diagnostic of CO, H_2O and OCS. We report on the spectral analysis within these windows over spatial regions that are roughly 150 km in extent.

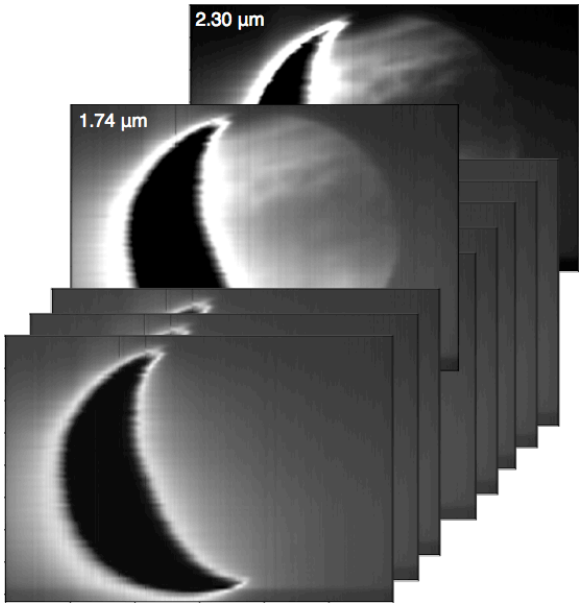

Figure 2: An image cube obtained from the IRTF on 01-DEC-2018 with the SpeX instrument in PRISM mode. These slices at 1.74 and 2.30 µm show photons that traverse Venus' atmosphere, but because they are re-assembled from many slit observations, their spatial acuity is not as sharp as images from the SpeX guide camera (Fig. 1)

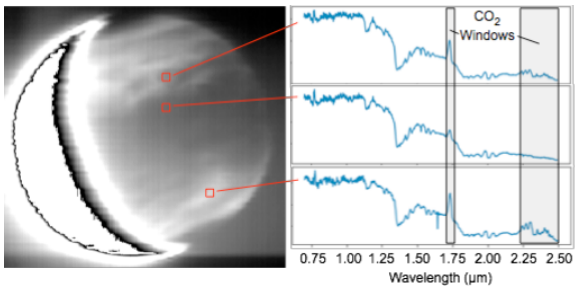

Figure 3: Nightside spectra from two cloudy regions (top two panels) and a clear region (bottom panel). Features within the CO_2 windows at 1.74 and 2.25 – 2.5 µm are diagnostic of cloud particle size and several trace gas abundances. *Spectra shown here have not been corrected for scattered light or telluric absorptions.*

References

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[2] Arney, G, et al.: Spatially resolved measurements of H_2O, HCl, CO, OCS, SO_2, cloud opacity, and acid concentration in the Venus near-infrared spectral windows, Journal of Geophysical Research: Planets, Volume 119, Issue 8, pp. 1860-1891, 2014.