

Analysis of Cloud Feature Evolution in the Middle and Lower Cloud Decks of Venus

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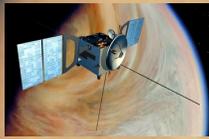
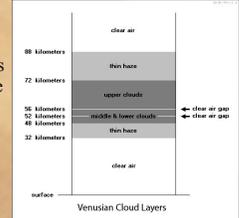
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1. Motivation:

Analysis of the microphysics in the Middle and Lower Cloud Decks of Venus can provide important clues as to the ways in which the atmosphere works on the large scale. Issues include:
 --Convection & Heat Transfer
 --Air gaps between cloud layers
 --Mechanism for superrotation of atmosphere.
 --The potential for human and robotic exploration/colonization.

2. Background:

The middle and lower cloud decks occupy the atmosphere at altitudes of ~50-60km; in contrast to the low variability upper cloud decks, the middle clouds are susceptible to convection and exhibit features which develop and evolve on the order of hours. This feature evolution has been studied previously for 2 orbits worth of data; here we present work from 8 orbits worth of data, with 115 features analyzed to give us a much larger dataset to look at.



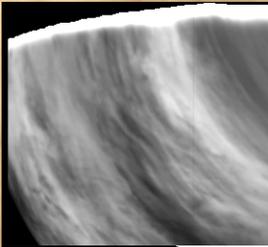
Artist's rendition of Venus Express copyright European Space Agency.

3. Observations:

ESA Venus Express VIRTIS (Visible and Infrared Thermal Imaging Spectrometer) observations at 1.74 microns of Venus **nightside** to study cloud features in Middle Cloud Decks.

Analysis done on VEX orbits 299-302 (mid-latitude) and 306-309 (low latitude).

Atmosphere beneath clouds glowing, dark clouds scattering light.

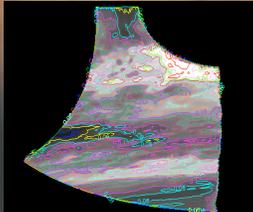


Unmapped VIRTIS image VIR0308_02 at 1.74 micron.

Image Processing for Features:

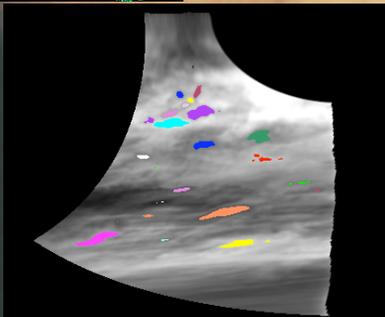
Raw images from VIRTIS are mapped onto a cylindrical projection with a limb darkening correction and a masking of all data points 5° within the terminator (line between day & night).

Mapped VIRTIS image VIR0308_02 at 1.74 micron with radiance contours overlaid.



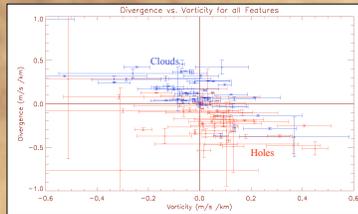
Radiance contours to define "Regions of Interest"; bright or dark features that persist through three or more images. Features on order of 100s of km in size.
Features:
Bright = Holes.
Dark = Clouds.

Mapped VIRTIS image VIR0308_02 at 1.74 micron with "Regions of Interest" overlaid in color.

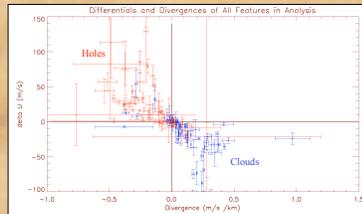


4. Feature Analysis:

Defined "Regions of Interest" allow us to extract latitude, longitude, spectral radiance information and emission angles for each point in our features. Using this information, we can calculate windspeeds, divergences, differentials, vorticities, and evolution timescales on peak intensities for all features in the analysis.



An approximate negative correlation between divergence and vorticity, along with the distribution of holes and clouds suggests that downdrafts are causing the holes.



Nearly all holes were found to be converging with negative W-E differentials while nearly all clouds were found to be diverging with positive W-E differentials. This indicates that the evolution of these features is mostly zonally driven.

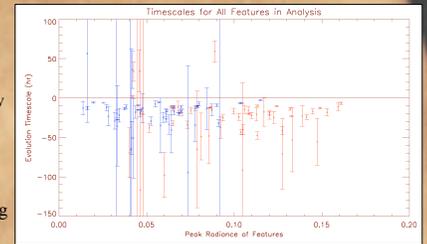
6. Conclusion/Future Directions:

- We are seeing zonally dominated feature evolution with evidence for downdrafts and updrafts.
- To do in Future:
- More analysis of images at different solar hour angles to determine if a solar scattering correction can account for the negative timescales.
- More observations of features at mid-to-high latitudes will be useful to look for latitudinal trends in vorticity and divergence.

Background image copyright NASA, Ames Research Centre; Pioneer Orbiter Image.

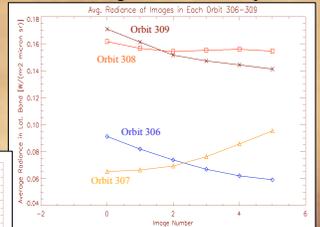
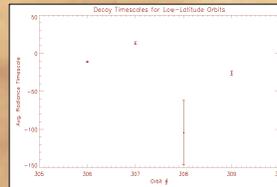
5. Evolution Timescales:

A natural decay fit to peak radiances of features yields a timescale telling us how fast they develop or diminish. Most timescales were found to be **negative**; that is, they are growing darker.



Negative Evolution Timescales could be caused by some sort of systematic error or uncertainty; either incorrect parameters in our limb darkening correction or a greater effect due to scattered sunlight than was anticipated.

Having chosen a most featureless latitude band (present only at low-latitude orbits), performed an avg. radiance analysis to find that in 3 out of 4 orbits, the avg. image radiance decreases with time.



Applying a fit to these avg. radiances yields timescales on the same order as features analyzed.

A test for error in Limb Darkening via fitting a new correction to orbits 306 and 309 yielded inconsistent results. Below you can see the avg. radiances plotted against emission angle, with the aforementioned fits. This leads us to conclude that the negative timescales are either due to an unexpected scattering of sunlight past the terminator or atmospheric physics not yet understood.

