Geographic distribution of zonal wind and UV albedo at cloud top level from VMC camera on Venus Express: Influence of Venus topography through stationary gravity waves vertical propagation

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Geographic distribution of zonal wind and UV albedo at cloud top level from VMC camera on Venus Express: Influence of Venus topography through stationary gravity waves vertical propagation.

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Abstract

Based on the analysis of UV images (at 365 nm) of Venus cloud top collected with VMC camera on board Venus Express [4,5], it is found that the zonal wind speed south of the equator (from 5°S to 15°s) shows a conspicuous variation with geographic longitude of Venus, correlated with underlying relief of Aphrodite Terra. We interpret this pattern as the result of stationary gravity waves produced at ground level by the up lift of air when the horizontal wind encounters a mountain slope. The cloud albedo map at 365 nm varies also in longitude and latitude, perhaps the result of increased vertical mixing associated to wave breaking, and decreased abundance of the UV absorber which makes the contrast in images.

1. Introduction

The comparison of two consecutive UV images of the UV-markings cloud pattern collected by VMC camera on board VEX allowed to derive a large number of wind measurements at altitude 67±2 km from tracking of cloud features [1] in the period 2006-2012. Both manual (45,600) and digital (391,600) individual wind measurements over 127 orbits were analyzed, showing various patterns with latitude and local time. A new longitude-latitude geographic map of the zonal wind shows a conspicuous region of strongly decreased zonal wind, a remarkable feature that was unknown up to now (fig.1 top). While the average zonal wind near equator (from 5°S to 15°s) is -100.9 m/s in the longitude range -160 to -30°, it reaches -83.4 m/s in the range 60-100°, a difference of 17.5 m/s.

When compared to the altimetry map of Venus (fig.1 bottom), it is found that the zonal wind pattern is well correlated with the underlying relief in the region of Aphrodite Terra, with a downstream shift of about 30° (~3,200 km).

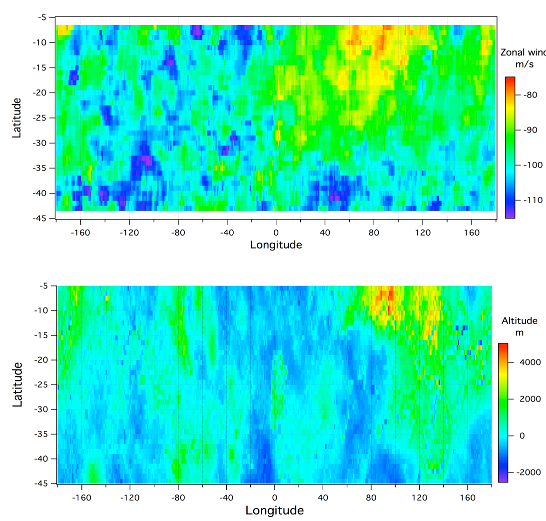

Figure 1 **Top**: Map of the zonal wind speed is in m/s (color coded). There is a region of strong minimum (in absolute value) which is located ~30° downstream of the high lands. **Bottom**: Partial topographic map

of Venus. Altitude is color coded. The latitude coverage of the map is limited from 5° S to 45° S to match the map of zonal wind. The zonal wind is oriented from right to left, from East to West, toward decreasing longitudes.

2. Influence of stationary gravity waves.

We interpret this pattern as the result of stationary gravity waves produced at ground level by the up lift of air when the horizontal wind encounters a mountain slope (fig.2). These waves can propagate up to cloud top level, break there and transfer their momentum to the zonal flow. A similar phenomenon is known to operate on Earth with an influence on mesospheric winds [3]. The LMD-GCM for Venus was run with or without topography, with and without a parameterization of gravity waves do not display such an observed change of velocity near equator.

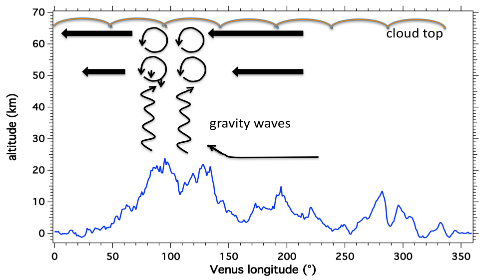

Figure 2. Sketch of gravity waves generated by interaction of the zonal wind on the mountains (blue line), propagating upward, breaking in the altitude region 50-60 km and decelerating the zonal wind at this altitude and higher. The blue line represents the actual average altitude of the mountains (5°S to 15°S), multiplied by a factor ~6.

3. UV albedo mapping.

The cloud albedo map at 365 nm varies also in longitude and latitude. On figure 3 is displayed a geographic map of the UV albedo at 365 nm measured by VMC. It is an average of 1442 images obtained over 7.5 years from May 2006 to September 2013. While the albedo poleward of 40°S is pretty uniform and higher than near the equator, a well known fact [2], there are totally unexpected structures at other places nearer the equator, both in longitude and latitude. We speculate that it might be the result of increased vertical mixing associated to wave breaking, and decreased abundance of the UV absorber which makes the contrast in images.

The impact of these new findings about velocity and albedo on current super rotation theories remains to be assessed.

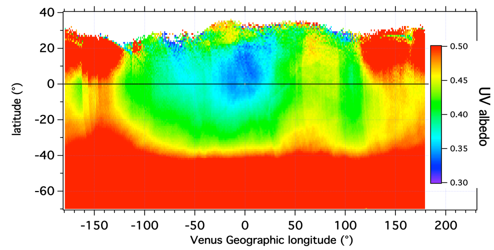

Figure 3. Venus geographic map of the UV albedo. The albedo A is derived from the VMC measured UV radiance (345 to 385 nm) assuming a Lambert behavior. A= π radiance/(solar flux cos(sza)), sza=solar zenith angle. A was averaged in each 1x1° bin of longitude-latitude (only sza<70°). The number of points per bin ranges from ~1000 to 5000.

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