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The many faces of the Venus' polar vortex

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Abstract

The elliptical shape with apparently two centers of rotation of the Venus' vortex, observed by the Pioneer Venus in 1980 in the northern hemisphere for the first time at 15 microns, induced to label it as "dipole", and since then, we refer to the Venus vortex as the "dipole of Venus". The VIRTIS (Visible and InfraRed Thermal Imaging Spectrometer) instrument on board the Venus Express mission [1,3], right at the beginning of the mission, observed for the first time a very similar shape in the southern hemisphere at a wavelength of 5.1 microns, probing at the clouds top. This confirmed simultaneously the symmetry N-S of Venus and, at a first glance, the stability of the dipole after many years since 1980.

However, after many systematic observations of VIRTIS in orbit, we can now say that the dipole is not a stable feature on Venus and it is just one shape among the others, so that the polar region itself shows a variability of its dynamics that needs to be further studied. We present here the results after many observations of VIRTIS of the polar vortex and its surroundings.

1. Introduction

The polar region of Venus shows a dynamics very peculiar and quite different from the rest of the planet. The region poleward of 60-70 deg latitudes shows in average an almost solid body rotation with essentially no vertical wind shear, in contrast to the mid-to-low latitudes where the vertical shear is instead significant, with winds doubling from the lower clouds to the clouds top. The ring surrounding the polar region is known as cold collar and it represents a separation zone of two different dynamic regimes. This barrier owns a thermal structure with significant vertical thermal inversion and large temperature contrast at the clouds top level between the inner part of the vortex and its surrounding.

2. Observations

The polar vortex dominates the dynamics in the polar region with a rich amount of details and enhanced contrast. It has been observed in a dipole configuration right at the beginning of the mission [4]. The dipole-like shape was similarly observed in the north by the past Pioneer Venus mission and thus it seemed to be a stable feature. However, in the course of the Venus Express mission, a large number of different shapes of the vortex have been observed, from single mode to mode 3 or even more complex configurations with a not well identified stable feature, see Fig.1.

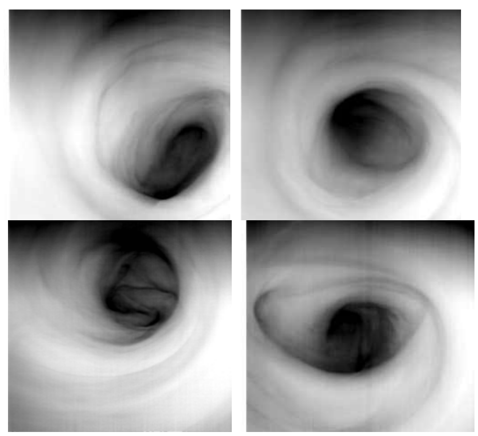

Figure 1: The polar vortex at a wavelength of 3.8 μm, probing the temperature on the clouds top. The shape varies significantly with time. The darker region corresponds to higher temperature and lower altitude

The instantaneous 3-D thermal structure of the vortex has been exploited for the first time by using the VIRTIS data in the thermal infrared at about 4.3 microns [2,4]. The thermal contrast is highest at the clouds top layer altitude, with temperature relatively high within the vortex in contrast with the cold collar surrounding region where also a significant thermal inversion is present.

Clouds tracking has also been used to measure the winds speed [5]. Measurements at different altitude level are possible by using the UV and IR solar reflected radiances at 350 nm and 980 nm in the day side, see Fig.2. These two wavelengths probe the altitude level at about 65 and 61 km altitude respectively. Additionally, in the night side of the planet, the radiance in the window at 1.74 μm provides the way to measure winds in the lower clouds at about 47 km altitude. The winds speed shows a significant vertical shear at low latitudes with values from about -50, -70 and -110 m/s in the 3 probed layers, with a speed relatively constant poleward up to about -60°S where the vertical shear disappeared in combination with a decreasing speed toward the pole.

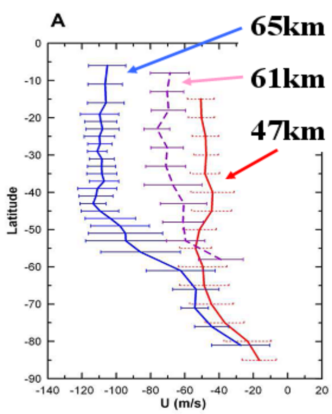

Figure 2: Winds speed from clouds tracking at different altitudes (different probing wavelengths)

The clouds morphology also shows different dynamical regimes. At low latitudes is visible a significant convection on both day (at an altitude of about 65-70 km) and night (at an altitude of about 45-50 km) sides of the planet. The mid-latitudes show a more regular streaky clouds, very elongated and less turbulent. Toward the pole the clouds tend to be more spiraling and in close connection with the vortex structure.

3. Summary and Conclusions

The polar region of Venus shows a dynamics regime quite different than the rest of the planet, with a separation region delimited by the cold collar zone. Average wind speeds presents an almost solid body rotation, while instantaneous view highlights the complex dynamic structure with air flowing almost toward all directions. The so called dipole shape is not a stable feature and the morphology of the vortex is significantly variable on both short and long timescales.

Acknowledgements

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