South polar dynamics of the Venusian atmosphere from VIRTIS/Venus Express mapping in the thermal range

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The atmosphere of Venus is superrotational, a state in which the averaged angular momentum is much greater than that corresponding to co-rotation with the surface. Characterizing the zonal and meridional circulation, as well as their variability, is crucial for understanding the mechanisms that maintain super-rotation.

Winds at 45 and 65 km can be detected from cloud motion monitoring by the VIRTIS-M subsection. Our objective is to provide direct wind measurements at cloud tops and in the lower cloud level, in order to help interpret the Venus Express (VEX) observations concerning the mesospheric wind regime and temperature fields. In particular, we present direct measurements of the zonal and meridional winds at both altitudes.

For this work we selected nadir-pointing, high-spatial resolution VIRTIS data cubes obtained from apocenter in order to minimize the geometric distortion of the polar region. On average these contain latitudes extending from the pole to 70S. Since the VIRTIS field of view is rectangular, lower latitudes are also present but cannot be observed over full latitude circles.

Cloud tracking has been performed using the method of digital correlation described in Luz et al. (New Ast., 13, 2008, p224–232). VEX orbits were selected so as to have in each one at least one pair of images suitable for tracking, i.e., with a considerable spatial overlap. Tracking has been performed on pairs of monochromatic images at wavelengths of 1.74 μm, 2.3 μm, 3.93 μm and 5 μm.

In the data cubes obtained with longer integration times (3s) the long-wavelength range of the spectrum, above 4.3 μm, is saturated. In those cases we selected the 3.93 μm radiance map instead of the one at 5 μm. The monochromatic radiance maps are first extracted from data cubes that have undergone the standard VIRTIS calibration procedures. The maps are then projected onto a polar stereographic grid and the wind retrieval procedure is applied. A total of 20 latitude bins, separated by 1 degree were used. For the analysis of transient motions the spatial averaging was done in 72 longitude bins at 5 degree intervals.

In order to evaluate the variability over the time scale of one orbit, we have computed the orbital averages, i.e., averages of all measurements coming from one given orbit. These orbital averages are only approximations to temporal averages, since they do not cover one full rotation. The differences between same-orbit averages are apparent in both day and night side averages. Some notable features indicating different day and night side regimes also start to become apparent in the orbit averages, and the boundary of the cold collar appears to be a transition latitude. Moreover, the variability that can be observed from orbit to orbit and between series of observations from the same orbit indicates that departures from this mean flow are large and a persistent feature of the global circulation.

The correlation between the radiance maps at 1.74 micrometers and at 3.9 and 5.0 micrometers in the cold collar region, combined with the correlation between wind retrievals from the respective wavelengths, are a strong indication of co-rotation of the atmosphere at the levels of 45 km and 65 km. Given that this correlation breaks at the lower latitudes, it indicates that the cold collar region is not only thermally isolated from the southern midlatitudes, but also dynamically isolated.