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Thermal winds in Venus mesosphere derived from the VIRTIS and VeRa temperature sounding

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Abstract

The Venus mesosphere (60 – 100 km altitude) is a transition region characterized by a complex dynamic: strong retrograde zonal winds dominate the lower mesosphere while a solar-antisolar circulation can be observed in the upper mesosphere. The super-rotation extends from the surface up to the cloud top with wind speeds of only few meter per second near the surface and reaching a maximum value of ~100 m s^{-1} at cloud top. The solar-antisolar circulation is driven by the day-night contrast in solar heating, it occurs above 110 km of altitude with speeds of 120 m s^{-1}. Different techniques have been used to obtain direct observations of winds at various altitudes: tracking of clouds in ultraviolet (UV) and near infrared (NIR) images can give information on wind speed at cloud top (~70 km altitude) [1,2] and within the clouds (~47 km, ~61 km) [2] while groundbased measurements of dopplershift in CO_2 band at 10 µm [3] and in several CO millimiter lines [4] provide thermospheric wind speeds. At altitudes where direct observations of winds can not be retrieved it is possible to derive zonal wind speeds from the vertical temperature structure using an approximation of the thermal wind equation: the cyclostrophic balance. On slowly rotating planets, like Venus, strong zonal winds at cloud top can be assumed to be in cyclostrophic approximation, this consists in the balance between equatorward component of centrifugal force and meridional pressure gradient force (eq. 1).

$$\frac{u^2 \tan\phi}{r} = -\frac{1}{\rho}\frac{\partial p}{\partial y} \qquad (1)$$

where ϕ is latitude, u is zonal wind velocity, r is radius of the planet, ρ is density, p is pressure and y is poleward Cartesian coordinate. Previous studies [5] have shown that the cyclostrophic approximation gives an accurate description of zonal winds at cloud top in the midlatitude range but fails near the equator and at the pole [6].

Here we derive zonal winds using the cyclostrophic approximation from VIRTIS and VeRa temperature retrievals. VIRTIS sounds the Venus southern hemisphere in the altitude range 65 – 90 km with a very good spatial and temporal coverage [7]. VeRa observes both north and south hemispheres between 40 – 90 km of altitude with a vertical resolution of ~500 m [8]. The main features of the winds are (Fig. 1): (1) the midlatitude jet with a maximum speed of 80 – 90 ± 10 m/s which occurs around 50°S latitude at 70 km altitude; (2) the fast decrease of the wind speed from 60°S toward the pole; (3) the decrease of the wind speed with increasing height above the jet [9].

The comparison with cloud tracked winds shows a good agreement at midlatitudes; a disagreement is observed near the equator due to the breakdown of cyclostrophic approximation. A good description of zonal winds at midlatitudes is obtained applying the cyclostrophic balance but a more general expression for the thermal wind equation is needed

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especially at higher latitudes where eddies and turbulent motions can not be neglected.

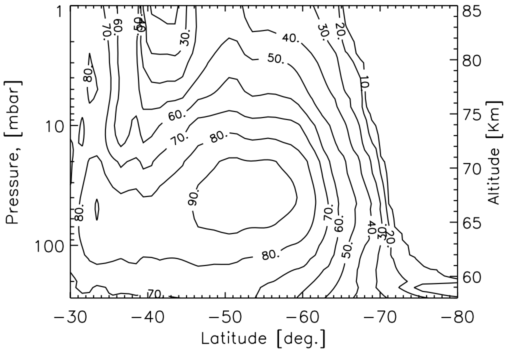

Figure 1: Contours of the zonal thermal wind speed (m/s) derived from VIRTIS temperature retrievals assuming cyclostrophic balance. Contour interval is 10 m/s.

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