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Cyclostrophic winds in the Venus mesosphere from VIRTIS-H/VEx temperature sounding

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Abstract

We present zonal thermal winds derived by applying the cyclostrophic balance from VIRTIS-H temperature retrievals. The VIRTIS-H instrument probes the nightside (6 pm ï 6 am) of Venus mesosphere on both the northern and southern hemispheres thus allowing us for the first time to derive a global picture of the wind fields at the cloud tops.

1. Introduction

Venus mesosphere (60 ï 100 km altitude) is a transition region characterized by different dynamical regimes. A retrograde super-rotation dominates in the lower part above the cloud top (>70 km) with wind speeds of about 100 m s^{-1}, while a solar-antisolar circulation, driven by the day-night contrast in solar heating, can be observed above 120 km. The processes responsible for maintaining the zonal super-rotation in the lower atmosphere and its transition to the solar-antisolar circulation in the upper atmosphere are still poorly understood [1].

Different techniques have been used to obtain direct observations of wind at various altitudes: tracking of clouds in ultraviolet (UV) and near infrared (NIR) images give information on wind speed at cloud top (~70 km altitude) [2] and within the clouds (~61 km, ~66 km) [3] while ground-based measurements of dopplershift in CO_2 band at 10 εm [4] and in several CO millimeter lines [5] sound thermospheric and upper mesospheric winds, showing strong variability.

In the mesosphere, at altitudes where direct observations of wind are not possible, zonal wind fields can be derived from the vertical temperature structure using thermal wind equation. Previous studies [6,7,8] showed that on slowly rotating planets, like Venus and Titan, the strong zonal winds at cloud top can be described by an approximation of the Navierï Stokes equation, the cyclostrophic balance in which equatorward component of centrifugal force is balanced by meridional pressure gradient (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. This equation gives a possibility to reconstruct zonal wind if the temperature field is known.

2. VIRTISï H/VEx temperature sounding

The Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) is one of the experiments on board the European mission Venus Express. It consists of two channels: VIRTIS-M and VIRTIS-H. VIRTIS-H is a high resolution spectrometer (R ~1200) operating in the spectral range 1.84 ï 4.99 εm [9]. It sounds both hemispheres of Venus in the altitude range 65 ï 80 km (100 ï 4 mbar) with a very good spatial and temporal coverage [10]. For this study, we used average vertical temperature profiles obtained by VIRTIS-H between December 2006 and January 2010. Fig. 1 shows the latitude-altitude temperature field obtained combining VIRTIS-H average profiles.

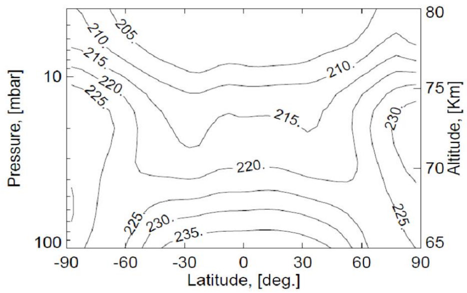

Figure 1: Meridional cross section of atmospheric temperature (K) obtained from VIRTIS-H average profiles.

3. Zonal thermal winds

Zonal thermal winds were retrieved from VIRTIS-H temperature fields on both the northern and southern hemispheres (Fig. 2).

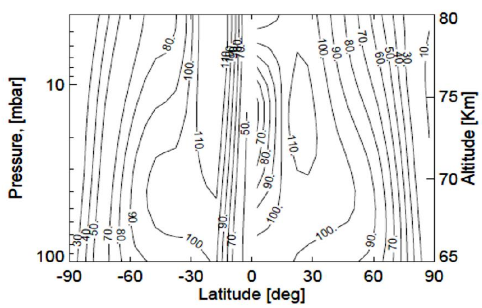

Figure 2: Latitude-altitude cross section of zonal thermal wind speed (m s^{-1}) derived from VIRTIS-H average temperature profiles assuming cyclostrophic balance.

The most significant features that can be observed in the wind field in both hemispheres are: (i) a midlatitude jet related to the thermal feature known as the cold collar; (ii) the decrease of the wind speed towards the pole. In the northern hemisphere the maximum of the jet ~114 m sī 1, occurs at a latitude of ~22.5°S and an altitude of about 16 mbar. In the southern hemisphere the jet extends between 50°S and 20°S with a velocity that increases from ~104 m sī 1 at an altitude of 31.6 mbar and a latitude of 32.5°S to ~ 110 m sī 1 at 15 mbar and 27.5°S. Differences in the thermal structure between the northern and southern hemispheres account for the differences observed in the wind field.

VIRTIS-H observations completely cover Venus nightside, therefore we plan to analyze the dependence of wind fields on local time. Furthermore, wind retrievals will be compared to several literature results obtained from ground-based observations, previous missions, and the Venus Express mission.

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