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Venus winds at cloud level from UV, visible and near infrared observations from VIRTIS on Venus Express over 2006-2012

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Abstract

After more than 6 years orbiting Venus the Venus Express mission (VEX) has provided the largest database of observations of Venus atmosphere at different cloud layers with the combination of VMC and VIRTIS instruments. We present measurements of cloud motions in the South hemisphere of Venus analyzing images from the VIRTIS-M visible channel at different wavelengths sensitive to the upper cloud haze at 65-70 km height (dayside ultraviolet images) and the middle cloud deck (dayside visible and near infrared images around 1 μm) about 5-8 km deeper in the atmosphere.

1. Introduction

Venus atmospheric circulation is characterized by a global zonal superrotation that peaks at cloud level where cloud features spin 60 times faster than the planet's surface. Current Venus general circulation models reproduce a superrotating atmosphere but the origin and intensity of the atmospheric superrotation is not well understood. Venus Express has been orbiting Venus for more than 7 years obtaining data of the cloud motions which can be used to measure the atmospheric winds at different altitudes. A long-term analysis of the mean winds and their temporal variations may provide observational constraints to understand Venus super rotating atmosphere. We present such a study here from data obtained by the visible channel of the VIRTIS-M instrument providing spectroscopic images of the planet from 0.3 to 1 μm.

2. Data Analysis

We combine VIRTIS images in nearby wavelengths to increase the contrast of atmospheric details. We studied three wavelength ranges: UV (360-400 nm); visible (570-680 nm) and near IR (900-950 nm). The UV images show the upper cloud top and are comparable to UV images obtained by the VMC instrument onboard Venus Express. The visible and near IR images showed the same cloud features with different contrast and are assumed to correspond to cloud features about 5-8 km below the UV cloud details. Motions of the cloud features were measured using a semi-automatic cloud correlation algorithm with human supervision.

3. Results

We obtained about 20000 precise wind measurements in about 115 orbits covering the time period from April 2006 to February 2012.

For both cloud levels we present global mean zonal and meridional winds, latitudinal distribution of zonal and meridional winds with local time, maps of the global horizontal divergence at each cloud level and the vertical wind shear between both altitudes.

3.1. UV results

For the UV cloud features we find a significant structure of the zonal and meridional winds at tropical latitudes that confirm VMC [1] and previous VIRTIS results [2, 3]. Both the zonal and meridional winds accelerate with local time peaking 14-16h. The global behavior of winds is in excellent agreement with VMC data [1]. Two periods of time with different circulations are identified: Years 2006-2008 with slower winds and 2009 -2012 with faster winds specially at afternoon hours (15 m/s faster). This wind variability is slightly different from the analysis of VMC data that suggests a global sustained increase of winds over the course of the VEX

mission while VIRTIS data from this work suggests a sharp change of winds at the end of 2008 or early 2009.

3.2. Visible and Near IR results

The same cloud features are observed in visible and near infrared images, although with different contrast. Altimetry of this cloud layer is not well constrained but these features are assumed to lie 5-8 km below the upper UV cloud tops. The cloud features move slower at tropical latitudes and wind profiles converge with the upper UV wind motions at subpolar latitudes. Overall this layer presents a more regular behavior. Winds are constant at all local times without the characteristic morning to dusk acceleration of the UV cloud layer. Temporal variability is also absent from this data.

The global results are briefly summarized on Figure 1.

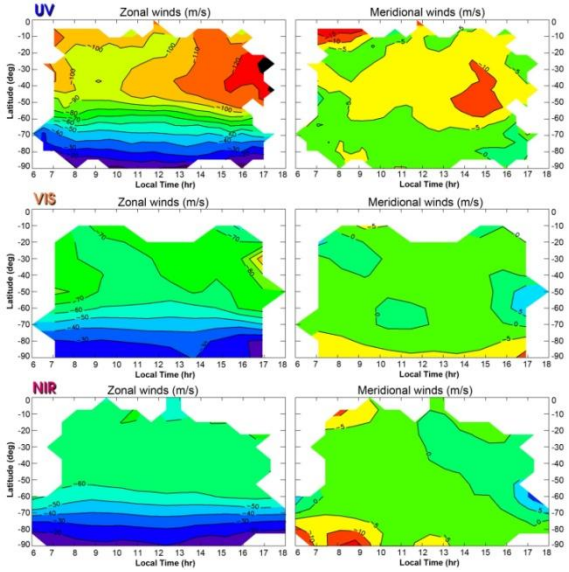

Figure 1: Zonal (left) and meridional (right) winds. Results are based on averages over bins of 5º in latitude per 0.5 hr in local time for the UV features. The spatial resolution of the VIS maps is based on bins of 10º per 1.0 hr and the spatial resolution of the NIR map is based in bins of 7º in latitude per 0.7 hr in local time.

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