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Long-term behaviour of Venus winds at cloud level from VIRTIS/VEX observations

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Abstract

The Venus Express (VEX) mission has been in orbit to Venus for more than three years now. The VIRTIS instrument onboard VEX observes Venus in two channels (visible and infrared) obtaining spectra and multi-wavelength images of the planet. Images in the ultraviolet range are used to study the upper cloud at 66 km while images in the infrared (1.74 μm) map the opacity of the lower cloud deck at 48 km. Here we present an analysis of the overall dynamics of Venus' atmosphere at both levels using observations that cover a large fraction of the VIRTIS dataset. We will present results concerning the zonal winds and their long and short term variability and the meridional winds in the lower cloud.

Introduction

Observations from the VIRTIS instrument on the night-side and the day-side of the planet have provided an unique dataset to study the atmospheric dynamics at cloud level of the Southern hemisphere [1, 2]. Observations of the Venus clouds with the VIRTIS instrument provide a particularly novel view of the lower cloud deck which is observable in the night-side of the planet by observing the thermal radiation emitted from the lower atmosphere as it escapes through the lower clouds. These clouds are located at 50 km and 1.74 mm images map efficiently its opacity. On the other hand, VIRTIS observations on the day-side of the planet in ultraviolet wavelengths are used to study the upper cloud at 66 km.

Previous results

The analysis of the cloud motions observed by VIRTIS on the first stages of the VEX mission has been published recently [1]. This analysis was based on an analysis of 35 selected orbits from the first 400 days of observations. In this work we have largely extended this sample a timeline of 900 days (more than 3 Venus years).

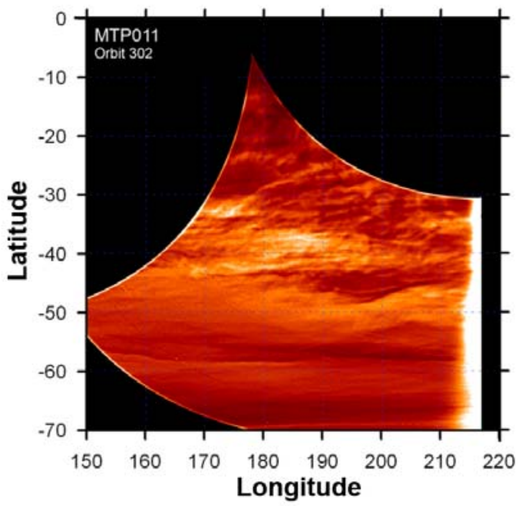

Figure 1: Cylindrical map of cloud features near the local sunset (on the right) observable in the lower cloud of Venus using 1.74 μm images in the night side. Tracking of these features on images separated by 1-3 hours provide the wind data.

Mean wind

The zonal circulation in both cloud layers could be measured tracking the cloud motions on images separated in time. The zonal wind changes sharply at 55ºS latitude. At latitudes <55ºS, winds in both cloud layers winds are nearly constant with latitude but exhibit strong vertical shear, with mean westward velocities of 60–70 ms^{-1} at the base of the cloud and 105 ms^{-1} at the top of the cloud. Poleward of 55ºS latitude, however, zonal wind speeds decrease linearly to the pole with virtually no vertical wind shear, indicating a vertically coherent structure that ends at the poles

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forming the dipolar feature [3]. Meridional winds consistent with the upper branch of a Hadley cell were observed on the upper cloud and are limited in magnitude to values of 10 ms-1 poleward.

Short-term variability at the upper cloud

Significant variability of 10 m/s is found on the upper cloud. This is similar to the typical estimated error of each individual measurement but the statistical analysis of the wind data shows that part of the variability is real. In particular, most of this variability can be interpreted in terms of a solar tide component of the wind [1, 2] but other sources of variability remain. In this work we examine the data in close detail to search for periodic oscillations of the mean wind field with various characteristic periods that could be representative of a global oscillation of the cloud field. We will also present our search of a systematic long-term variability of the wind.

Long-term variability at the lower cloud

The lower cloud deck seems to be less variable with regular zonal motions that do not exhibit significant variation. In particular, and as expected, in the lower cloud we do not detect any effect of the solar tide [1] in contrast to the upper cloud.

The largest data sample used in this work has allowed us to select observations of the same cloud field separated by 2-3 hours that were used to track the winds with a large precision separating the noise of the measurements and random small errors from sources of true variability. In particular we have measured the meridional circulation of the lower cloud details with a precision of 5 ms^{-1} showing variable results from one orbit to another that seem to correspond to local motions instead of a global mean meridional circulation. A global average of our data for all orbits results in a global mean meridional circulation at this cloud of less than 5 m/s.

A particularly interesting latitude is the transition point from the constant wind regime to the poleward decrease situated at 55ºS. In many images this latitude shows the transition from a more laminar structure of the flow in the sub-polar latitudes to the more turbulent and full of structure cloud field typical of the tropical and middle-latitudes. Depending on the local morphology showing more or less cloud features available for tracking slightly lower or higher velocities are found at this latitude.

References

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