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Water vapour, clouds, and the UV absorber near the cloud tops of Venus from VIRTIS and VMC / Venus Express data

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Abstract

Observations of the dayside of Venus with VIRTIS [1] and VMC [2] instruments on board Venus Express have been used to measure the cloud top altitude and water vapour abundance near this level and search for their possible correlation with the UV absorption. An extended analysis of these measurements by Cottini et al. [3] was limited by a northern hemisphere due to geometry of observations on first 1000 orbits of the mission. Further measurements significantly improve the latitudinal coverage and demonstrated symmetric behaviour of clouds and water vapour in both hemispheres.

1. Introduction

The significant part played by water vapor in the cloud formation, thermal balance and chemistry of Venus atmosphere makes it one of the most important objects for remote sensing studies. Numerous observations have demonstrated high variability of water vapor, which have been attributed to real variability, model errors, and different effective altitude ranges of sounding (see, e.g., a brief review and references in [3]). Recent ground based spectroscopic measurements [4] and those by Venus Express [3, 5] demonstrate a good agreement with, however, some differences, which deserve to be understood better: in particular, temporal variability and absolute values of H_2O abundance measured from different spectral ranges.

1.1 Instrument and observations

VIRTIS, the Visible and Infrared Thermal Imaging Spectrometer, is a mapping spectrometer with spectral range from UV to thermal IR: 0.3-5 μm. Its high-resolution subsystem (-H), used in this study, is an echelle grating spectrometer with eight diffraction orders focused on a 270x438 pixel array detector. A complete spectrum, which covers a spectral range from 2 to 5 μm, is thus composed of eight partially overlapped spectra with variable spectral resolution of 1–3 nm. CO_2 and H_2O bands between 2.48 and 2.60 μm in the spectrum of sunlight scattered and reflected by the Venus atmosphere are used to determine the cloud top altitude and water vapour abundance near this level. Background ultraviolet imaging to these measurements is provided by the VIRTIS' moderate resolution mapping subsystem (-M) and VMC, the Venus Monitoring Camera, with the UV channel at 365 nm. A typical track of the VIRTIS-H field of view footprint on the cloud surface during one measurement session (orbit) extends along meridian from one pole to another or covers just a limited latitude range. A detailed description of the measurements, data, model and method of data analysis, and first results are given in [3].

1.2 First results

Results obtained from measurements up to orbit 922 can be summarized as follows [3]. At low latitudes (±40º) mean water vapour abundance is equal to 3±1 ppm and the corresponding cloud top altitude at 2.5 μm is equal to 69.5±2 km. Poleward from middle latitudes the cloud top altitude gradually decreases down to 64 km, while the average H_2O abundance reaches its maximum of 5 ppm at 80º latitude with a large scatter from 1 to 15 ppm. The calculated mass percentage of the sulphuric acid solution in cloud droplets of mode 2 (~1 micron) particles is in the range 75-83%, being in even more narrow interval of

80-83% in low latitudes. No systematic correlation of the dark UV markings with the cloud top altitude or water vapour has been observed.

2. Recent results

New measurements (Figs. 1–3) confirmed the first analysis [3] and demonstrated high symmetry with respect to equator in the average cloud top altitudes and water vapour abundances. In the talk we discuss also implications of these results for cloud particle properties, dynamics, and location of the unknown UV absorber.

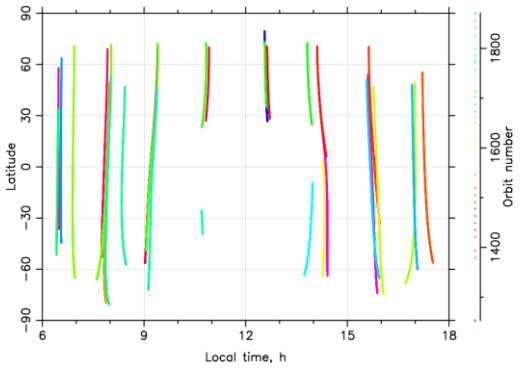

Figure 1: Local time – latitude coverage of VIRTIS-H observations after Venus Express orbit 1000 used in this study. Color coding designates orbit number (right scale).

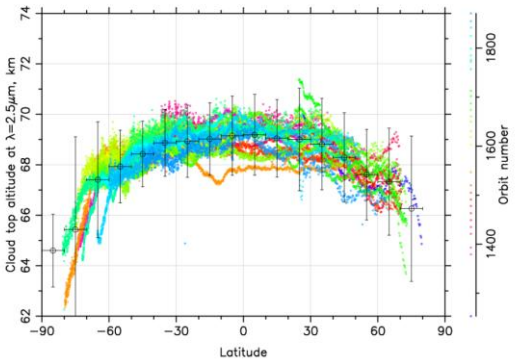

Figure 2: Cloud top altitude as a function of latitude for measurements shown in Fig. 4.

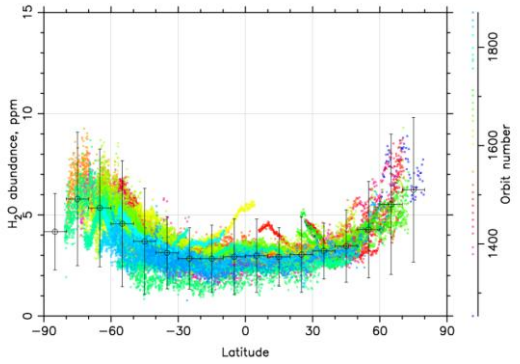

Figure 3: Water vapour abundance as a function of latitude.

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