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Thermal structure of Venusô nightside upper atmosphere measured by SPICAV UV on Venus Express

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Abstract

The SPICAV UV instrument offers the possibility to probe the nightside of Venus upper atmosphere by means of stellar occultation. Here we analyse the entire SPICAV database, collected during seven years of operations, which consists of more than 550 vertical density and temperature profiles. The thermal structure of Venus mesosphere and thermosphere shows a large temporal and spatial variability.

1. Introduction

The Venus upper mesosphere/lower thermosphere is a dynamical and chemical transition region between the strong zonal superrotation at the top of the cloud layer and the solar ï antisolar circulation in the thermosphere (above 120 km). Previous observations acquired by ground-based campaigns [1,2] and spacecraft missions [3,4] suggested that the atmospheric temperature decreases from values of ~ 240 K at the cloud top (~ 65 km) to 170 K at ~ 90 ī 100 km altitudes on the dayside of the planet and reaching minimum values of less than 120 K during the nighttime in the upper atmosphere [3]. More recently, a layer of warm air has been detected at altitudes of 90 ï 120 km on the nightside both by SPICAV/SOIR [5,6] and by ground-based [7] observations. Furthermore, the thermal structure of Venus upper atmosphere shows a significant variability both on day-to-day as well as longer timescales [7,1,2].

2. SPICAV-UV stellar occultation observations

The SPICAV (Spectroscopy for the investigation of the characteristics of the atmosphere of Venus) instrument has been operating on board of the European spacecraft Venus Express since 2006 [8]. In the stellar occultation mode the ultraviolet channel (118 ï 320 nm) provides CO_2 local density and temperature vertical profiles of Venus upper atmosphere (90 ï 140 km) with a vertical resolution ranging from 500 meters to ~ 7 km. For this study we analyze data from 587 stellar occultations acquired between December 2006 and February 2013. The observations cover all latitudes on the nightside (6 pm to 6 am local time).

3. Results

The main features observed in the temperature structure are: (i) a warmer layer at 90 ï 100 km altitude, (ii) a constant decrease of temperature with altitude reaching minimum values of 100 ï 130 K above 120 km.

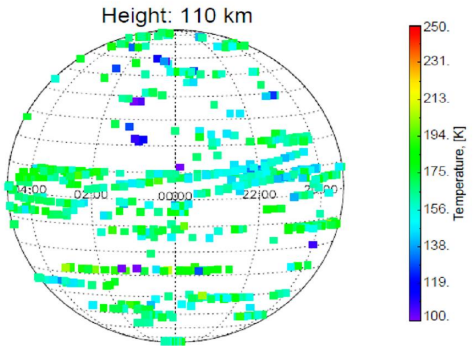

Figure 1: Global map of SPICAV temperature as function of latitude and local time at an altitude of 110 km.

Spatial and temporal changes in the thermal structure were analyzed. In good agreement with previous observations, SPICAV thermal structure exhibits a symmetry in terms of latitude between the two hemispheres (Fig. 1).

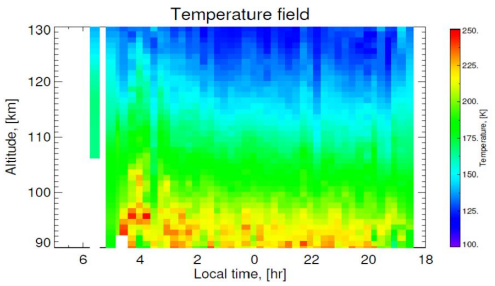

Figure 2: Local time-altitude cross section of atmospheric temperature (K) obtained combining the whole SPICAV dataset.

Local time variations dominate the structure of Venus atmosphere at these altitudes: temperatures show an increase of about 20 K on the morning side compared to the evening side (Fig. 2). Furthermore, a significant variability both on day-to-day as well as longer timescales affects the thermal structure of Venus upper atmosphere/lower thermosphere. Temperatures can display variations of ~10 K on timescales of 24 h up to ~50 K on timescales of few (Earth) months.

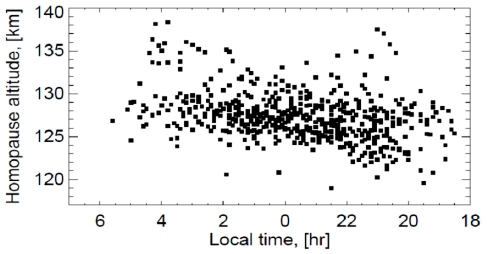

Figure 3: CO_2 homopause altitudes derived from SPICAV data as a function of local time.

The CO_2 homopause altitude was also determined; it varies between 119 and 138 km of altitude, and it exhibits a high variability. The altitude shows a strong dependence on the local time, increasing from the evening side to the morning side (Fig. 3).

SPICAV temperature profiles were averaged over several latitudinal and local time bins in order to exclude the influence of orbit-to-orbit variations, and mean profiles were then compared to several literature results from ground-based observations [1,7], previous spacecraft missions [3,4] and the Venus Express mission [6,9]. Average temperature profiles are generally in agreement with literature data above 100 km.

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