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Optical extinction due to aerosols in the mesosphere of Venus

V. Wilquet (1), A.C. Vandaele (1), S. Robert (1), R. Drummond (1), A. Mahieux (1) and J.-L. Bertaux (2,3)
(1) Belgian Institute for Space Aeronomy, Brussels, Belgium, (2) LATMOS, Guyancourt, France, (3) Institut Pierre Simon Laplace, Université de Versailles-Saint-Quentin, Guyancourt, France (valerie.wilquet@aeronomie.be)

Abstract

The variability of the aerosol loading in the mesosphere of Venus is investigated from a large data set obtained with SOIR, a channel of the SPICAV instrument suite onboard Venus Express. Vertical profiles of the extinction due to light absorption by aerosols were retrieved from many solar occultations ($\sim$ 200) from September 2006 to September 2010. For this period, the continuum of light absorption is analyzed in terms of spatial and temporal variations of the upper haze of Venus.

1. Introduction

Aerosols have been studied extensively because their optical properties impact the radiative balance through absorption and scattering of solar radiation. The upper haze on Venus lies above the cloud layer surrounding the planet, ranging from the top of the cloud ($\sim$ 70 km) up to as high as 90 km [1]. Data on the climatology of the upper haze of Venus were rather sparse but since its arrival at Venus in 2006, both VIRTIS-M IR on the nightside [2] and SPICAV/SOIR at the terminators [3] are able to target the upper haze above the cloud layers for further investigation. Stellar occultations by SPICAV UV on the nightside are also useful in this context.

SOIR is designed to measure the atmospheric transmission of the solar light in the infrared (IR). The instrument uses the self-calibrated technique of solar occultation for remote measurements of atmospheric gases. It gives therefore access to important information about the vertical structure and composition of the Venus mesosphere and lower thermosphere [3, 4, 5].

The continuum of absorption in the SOIR spectra is primarily shaped by the extinction caused by the aerosol particles present in the upper haze (between $\sim$ 70 and 90 km) of the Venus mesosphere. This information allows us to retrieve the aerosol slant opacity and the local extinction profiles. In this paper, we present an analysis of the optical extinction by aerosols in the upper haze over a period of 4 years of the VEX mission, covering the whole latitude range.

2. Data and Method of Analysis

The onion peeling approach is used, in which the atmosphere is considered as an onion-like structure composed of successive homogenous spherical layers. To invert all the observed transmittances corresponding to one occultation in one go, the Optimal Estimation (OE) method has been implemented in the retrieval algorithm ASIMAT [5].

As the aerosol signature is a continuum of absorption, the impact of aerosols on the observed spectra is therefore a decrease of the mean transmittance levels, what is called the baseline of the spectra, with decreasing altitude. The aerosol optical depth (τ) was retrieved from the series of transmittances averaged in the selected spectral window. Applying the onion-peeling method leads to the determination of the local extinction (β_i) in each atmospheric layer (see Equations 1 and 2).

$$\tau = -\ln(T) = -\ln\left(\frac{I}{I_0}\right) \tag{1}$$

$$\beta_N(\lambda) = \frac{\tau - \sum_{i=1}^{N-1} \mathrm{d}z_i \beta_i(\lambda, z)}{\mathrm{d}z_N} \tag{2}$$

3. Effect of the Latitude

It was recently confirmed that the altitude of the cloud top decreases when reaching the poles of Venus [6]. We therefore investigated the latitudinal variations of the extinction due to aerosols in the haze above the clouds.

Figure 1 presents a global picture of all observations considered in this study regarding the latitudinal dependency of the extinction. For each profile, the value of the extinction at 80 km of altitude was plotted as a function of the latitude of the observation. For both terminators (morning on the left panel and evening

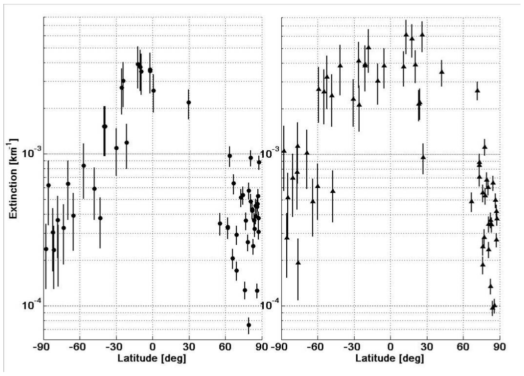

Figure 1: Latitudinal variations of the extinction at 80 km of altitude for the whole data set. On the left-hand panel, the values of the extinction for SO at the morning terminator are plotted as a function of the latitude and on the right-hand panel, for observations at the evening terminator. The vertical bars represent the error on retrieved β.

on the right), it is observed that the extinction due to aerosols is significantly lower towards the poles (by a factor 10 at least) compared to the values around the equator, this is observed in both hemispheres. However, there is apparently no correlation between the extinction due to aerosols and the latitude in the region comprised between -30^o and +30^o around the equator.

4. Discussion

Recently, Marcq et al. [7] showed that the SO_2 mixing ratio derived from column density above the clouds obtained with SPICAV-UV also presents latitudinal variation. It is even more correlated with the cloud top altitude obtained with SPICAV-IR. The highest values of SO_2 mixing ratio are found near the equator, which is in disagreement with results from previous missions and with the fact that SO_2 photolysis is more efficient at low latitudes for evident reasons. To explain these results, Marcq et al. [7] favours a dynamical interpretation of the data over sporadic volcanism: SO_2 is brought from lower altitudes to the top of the clouds through convection due to higher solar heating at low latitudes, ultimately resulting in advection towards higher latitudes. If this hypothesis is correct, it is relevant to the present work as H_2SO_4 aerosol particles are formed through SO_2 oxidation and hydration at the cloud top of Venus.

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