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Climatology of the Venus upper haze as measured by SOIR onboard Venus Express

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Abstract

The use of all three channels of the SPICAV instruments' suite has already been demonstrated for the characterisation of the Venusian aerosols [1]. Here we investigate the possibility to use the SOIR channel alone, to obtain information on the aerosols present in the mesosphere of Venus. This offers a larger data set, although less informative in terms of microphysical properties. The temporal and geographical variations of the vertical profiles of the aerosol extinction were investigated for a particular spectral window around 3.0 µm; this was registered in many solar occultations (~170 SO) over a period of almost 4 years, from September 2006 till June 2010.

1. Introduction

Aerosols have been studied extensively because their optical properties impact the radiative balance through absorption and scattering of solar radiation and because of their crucial role in heterogeneous chemistry. Important information on aerosol extinction can be obtained from satellite remote measurements. However the retrieval of extinction coefficients is known to be difficult due to the lack of spectral signatures of aerosols. We recently demonstrated the potential of the SPICAV/SOIR suite of instruments onboard the Venus Express spacecraft to characterize the aerosols in the mesosphere of Venus [1].

SOIR is an echelle grating spectrometer onboard the Venus Express (VEX) spacecraft [2]. It is designed to measure the atmospheric transmission in the IR (2.2–4.3 µm) using the SO method. The continuum of absorption is primarily shaped by the extinction caused by the aerosol particles known to be present in the upper haze (between ~70 and 90 km) of Venus' atmosphere.

2. Theory

The continuum is obtained by fitting the baseline of a spectrum, using the ASIMAT retrieval code [3], the baseline being the observed transmittance (T) from which absorption signatures have been removed. The aerosol optical depth (τ) and the local extinction coefficient (β) were retrieved (see equations 1 and 2) from the series of transmittances averaged in each selected spectral window. The onion-peeling method [4] is used to determine the extinction (β_i) in each atmospheric layer supposed to be homogenous.

$$\tau = -\ln(T) = -\ln(I / I_0) \qquad (1)$$

$$\beta_{ext}^{N} = \frac{\tau - \sum_{i=1}^{N-1} dz_i \cdot \beta_{ext}^{i}\left(\lambda, z\right)}{dz_N} \qquad (2)$$

3. Results

The general trend of the vertical profiles of aerosol extinctions is a decrease of the extinction with increasing altitude, except when aerosol layers are observed. Within such layers, the dependence of β on wavelength was shown to be high [1]. In addition, in some SO for which the extinction profile is smooth for each spectral window, a wavelength dependence of β was observed that could also be used to derive information on the size of the aerosol particles (Fig. 1).

We also took advantage of the fairly good geo-temporal coverage to analyze the latitudinal and temporal variations of the extinction vertical profiles obtained within one spectral window. The extinction clearly shows a latitudinal dependence with the local extinction at a particular altitude decreasing towards the poles (Fig. 2).

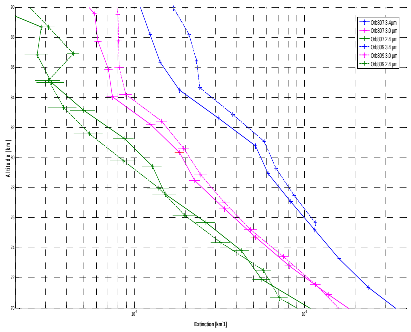

Figure 1. The wavelength dependence of β. The vertical profiles for 2 SO are plotted. β was derived from T obtained at 3.4 (blue), at 3.0 (pink) and at 2.4 µm (green). The horizontal bars are the error on β.

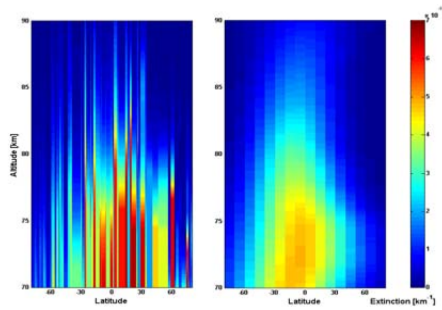

Figure 2. Variation of β with the latitude. An interpolation of β along the altitude axis is plotted on the left panel and on the right panel, a polynomial fit of 2nd order through each altitude. The data set covers a period of ~500 days and comprises 83 SO.

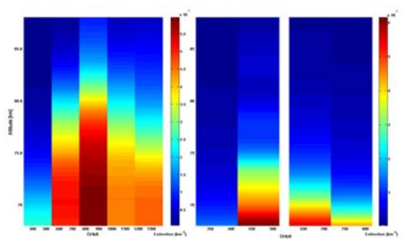

Figure 3. Temporal variation of β. The left panel covers a period of ~1050 days (34 SO at latitudes between -25° and +25°). β is averaged over 5 periods of 210 days. The right panel covers 4 periods of 100 days (with a gap w/o data) for 84 SO at latitudes between +70° and +90°.

In order to eliminate latitudinal variations, the time-dependence of the extinction profiles was analyzed for two groups of SO occurring at similar latitudes, i.e. one group of SO at high northern latitudes and one group of SO around the equator (Fig. 3). The vertical profiles were averaged for each period of time. Despite the fact that seasons are almost absent on Venus, the extinction due to aerosol particles in the upper haze is clearly not constant over time and this variation over time is not the same at all latitudes.

4. Summary and Conclusions

We can conclude that the SOIR channel is well suited to study the vertical distribution of the aerosols in the atmosphere of Venus. The present data set shows temporal and latitudinal variability of the aerosol loading. The profiles also demonstrate a wavelength dependence of the extinction which is being exploited for the microphysical characterization of the particles.

Acknowledgements

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