EPSC Abstracts
Vol. 8, EPSC2013-171-1, 2013
European Planetary Science Congress 2013

SPICAV-SOIR mesospheric aerosols observations characterization and modelling

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Abstract

From independent retrievals for the 3 channels of the SPICAV/SOIR instrument, it has been postulated that the upper haze on Venus includes, in some instances, a bimodal population, one type of particles with a radius comprised between ~0.1 and 0.3 µm and the second type, detected in the IR, with a radius varying between ~0.4 and 1 µm. In addition, a high temporal variability in the aerosol loading was inferred from SOIR observations over 4 years, as well as a latitudinal dependency.

We propose to refine the size distribution retrieval of aerosols based on the Mie theory and on the observed spectral dependence of light extinction in the spectra through a unique retrieval procedure combining the data from the 3 channels of the instrument. We also search for a dependence on altitude of the aerosol particles size distribution and of aerosol composition and compare the variations in aerosol loading to other key parameters retrieved such as water and SO_2 composition or temperature.

1. Introduction

SPICAV/SOIR on-board Venus Express is able to target the layer of aerosols above the cloud layer at the terminator in the 118–320 nm (SPICAV-UV), the 0.65–1.7 µm (SPICAV-IR) and the 2.2-4.3µm (SOIR) spectral region [1]. A high temporal variability in the aerosol content in Venus' atmosphere was inferred from SOIR observations, as well as a latitudinal dependency of the aerosol loading [2]. This is in agreement with results from previous missions and with the facts that (i) H_2SO_4 aerosol particles are formed through SO_2 photo-oxidation and hydration at the cloud top of Venus, (ii) SO_2 photolysis is more efficient at low latitudes, (iii) the altitude of the cloud top is up to one scale height lower in the polar region than at the equator.

A increasing SO_2 abundance with increasing altitude was recently observed with SPICAV-UV at altitudes of ~85-105 km [3] but also from microwave ground-based spectra in the Venus mesosphere [4], which suggest a source of SO_2 at high altitudes.

Zhang et al. [5] proposed a one dimensional photochemistry-diffusion model in order to reconcile these puzzling findings; he suggested that H_2SO_4 might be a source of SO_2 above 90 km through aerosol evaporation followed by SO_3 photolysis. This model and the observations are however disputed by others demonstrating the necessity for a more global interpretation of the observations and for modeling of the upper haze layer.

2. Results

The retrieval of the size distribution of aerosols [1] based on the Mie theory and on the observed spectral dependence of light extinction in the SOIR spectra was first improved. This extended optical model search for a dependence on altitude of the aerosol particles size distribution and of the aerosol composition (previously fixed at 75% H_2SO_4). In order to fit the SOIR data of the normalized extinction, both uni- and bimodal lognormal distributions are used.

The optical model was built using mean radius values (r1 and r2) between 0.1 µm and 1.0 µm, while the mean radiance is set to 0.18 (sigma1) for values of the mean radii $\leqslant$ 0.3 µm and to 0.26 for values of the mean radii > 0.3 µm. For bimodal size distributions, the ratio between the number of bigger particles and the number of small particles (n2/n1) can vary between 10^{-4} and 10^{-1}. For the spectral window targeted by SOIR, values of the refractive index for H_2SO_2/water droplets were found in the literature for concentrations between 64% and 87% H_2SO_4

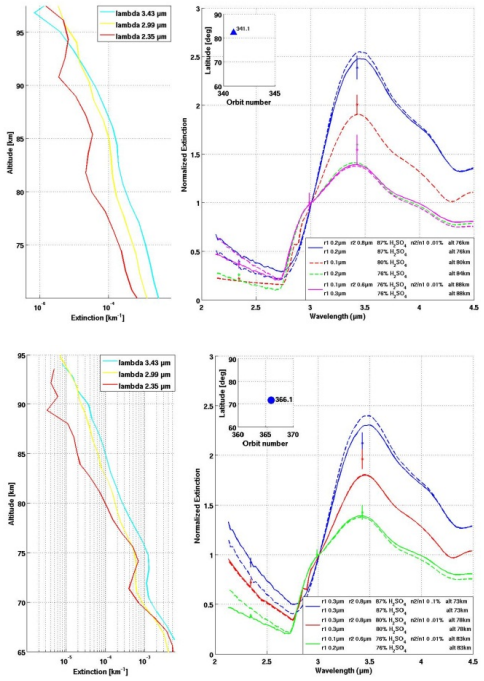

Figure 1: Fit of the spectral dependence in the SOIR spectra for orbit 341 (upper panels), 366 (lower panels). On the left are the local extinction vertical profiles at different wavelength. On the right are the results of the best fit of the spectral dependence. Plain and dashed lines are for fits obtained with a bimodal and unimodal lognormal size distributions.

An estimation of the particle radius and of the H_2SO_4 concentration was obtained by fitting the normalized experimental aerosol extinction at different wavelengths, to theoretical values of the model. This was done by minimizing the squared difference between values of the model and the normalized experimental extinction. First results are given in Figure 1, where it is shown that the H_2SO_4 concentration in the particles decreases with increasing altitudes and that in some instances (Fig. 1B) the fit in the 2.3-2.5µm region is improved when using a bimodal size distribution. At the equator (data not shown), the upper haze lays higher than near the North Pole and the H_2SO_4 concentration found is lower for a given aerosol loading.

3. Perspectives

We plan to extend the analysis to the full SOIR data set. We will build an H_2SO_4 concentration gradient with altitude, in order to retrieve only the size distribution when fitting the spectral dependence of the extinction. Dedicated SOIR observations will be planed to target the spectral regions that are the most dependent on the particle size distribution (2.2-2.6µm) and/or on the H_2SO_4 concentration (around 3.5 µm).

More importantly, the SPICAV-UV (118-320nm) and near-IR (0.65-1.70µm) data will also be used for a better discrimination between uni- and bimodal size distribution.

We also aim at developing a microphysical model to calculate the time dependent haze particle size distributions assuming an initial size distribution of background aerosols. The model would simulate the formation, growth, evaporation, and sedimentation of particles. Results of this on-going research will be presented and discussed.

Acknowledgements

The research program was supported by the Belgian Federal Science Policy Office and the European Space Agency (ESA, PRODEX program, contracts C90268, 90113, and 17645).The research was performed as part of the “Interuniversity Attraction Poles” programme financed by the Belgian government (Planet TOPERS). A. Piccialli acknowledges funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 246556.

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