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Retrieval of Venus' clouds and hazes properties with polarimetric data from SPICAV/VEx

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Abstract

1. Introduction

The study of Venus' cloud layers is important in order to understand the structure, radiative balance and dynamics of the Venusian atmosphere. Polarization measurements have given important constraints for the determination of the constituents of the clouds and haze. From ground based observations, Hansen and Hovenier[3], using a radiative transfer model including polarization, found that the main cloud layers between 50 and 70 km consist of $r \sim 1$ µm radius spherical droplets of a H_2SO_4-H_2O solution. In the early 1980s, Kawabata[4] used the polarization data from the OCPP instrument on the spacecraft *Pioneer Venus* to constrain the properties of the overlying haze. They found that the haze layer is composed of smaller particles with $r \sim 0.25$ µm and similar refractive indices.

Our work reproduces the method used by Hansen and Kawabata[3, 4]. We applied a radiative transfer model with polarization on the polarization data of the SPICAV-IR instrument on-board ESA's *Venus Express*. Our aim is to better constrain haze and cloud particles at the top of Venus's clouds, as well as their spatial and temporal variability.

2. SPICAV-IR observations

The SPICAV-IR spectrometer on *Venus Express* is based on an Acousto-Optic Tunable Filter (AOTF) working in the $0.65 - 1.7$ µm range, with two output beams linearly polarized in perpendicular directions, allowing us to measure the degree of linear polarization for different phase angles[8, 6].

The data give a good latitudinal and phase angle coverage. Latitudinal variations in polarization are visible in the observation data for orbits up to #2700 with a strong increase of polarization towards the poles (Fig. 1). At lower latitudes, polarization is quite homogeneous and we observe the glory in polarization at low phase angles, in accordance with VMC observations in photometry[7].

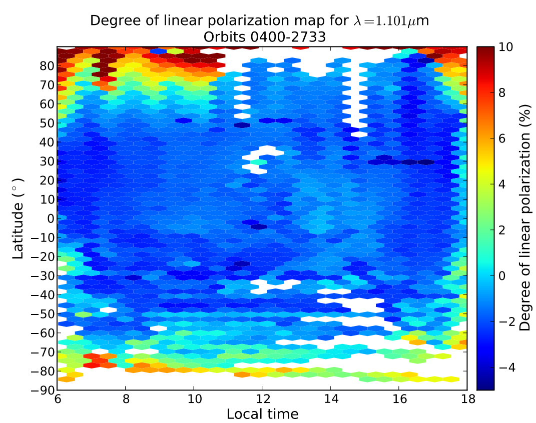

Figure 1: SPICAV data polarization map as a function of local time and latitude for orbits #400 to #2733.

3. Analysis

We use a radiative transfer model taking polarization into account in order to model the clouds[2, 1]. We consider a two layered model: an optically thick cloud layer of micrometric particles made of a concentrated sulfuric acid solution. Above lies the haze layer of $r \sim 0.25$ µm particles with a varying column density C_h.

3.1. Glory

At low phase angle, the main feature is the glory which gives information about the main cloud particles. We retrieve the effective radius and refractive index of the particules and effective variace of the particle size

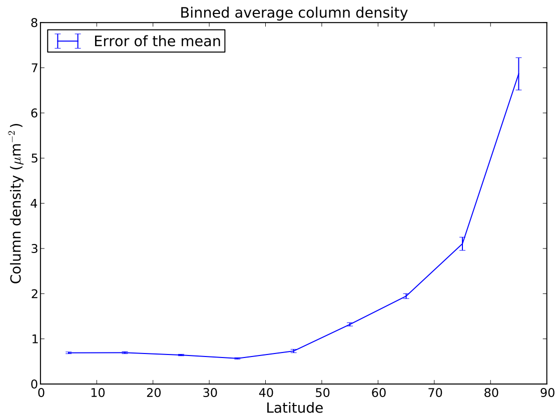

Figure 2: Column density of the haze layer in northern hemisphere of Venus as a function of latitude. The corresponding optical thickness at 1.101 µm varies from 0.039 to 0.343

distribution for a dozen glory observations. The retrieved values are in agreement with previous results: the cloud particles are spherical, with radii between 0.8 and 1.3 µm, $\nu_{\text{eff}} < 0.15$ and refractive indices between 1.39 and 1.44 at $\lambda = 1\mu$m.

3.2. High latitudes

At higher latitudes, the main contributor to polarization is the submicrometric haze. The modeling allows us to measure the column density of the haze layer in the northern hemisphere (Fig. 2). We observe a small decrease of C_h with increasing latitude up to $50°$ followed by a sharp increase of C_h towards the poles. C_h varies from 0.8 μm^{-2} at low latitudes up to 7 μm^{-2} at higher latitudes.

4. Conclusion

SPICAV-IR provides global measurements of polarization of Venus clouds and allows us to retrieve the parameters of the cloud droplets, in agreement with previous measurements. We confirm that the clouds are made of spherical micrometric droplets of sulfuric acid while the hazes are made of $r \sim 0.25$ µm particles. The column density of the haze increases towards the pole, in agreement with other studies[5].

5. Perspectives

We aim to generalize the retrievals to both hemispheres and will investigate in more details the latitude and local time dependence of the haze column density. The long-term variations during the *Venus Express* mission and comparison with OCPP will also be explored. We will also attempt to retrieve the vertical properties of the clouds using the polarization contained in the CO_2 absorption band as illustrated in [9].

Acknowledgements

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