Latitudinal and temporal variability of Venus clouds and hazes observed by polarimetry with SPICAV-IR

Loïc Rossi, Emmanuel Marcq, Franck Montmessin, Jean-Loup Bertaux, Anna Fedorova, Oleg Korablev, Daphne Stam

LATITUDINAL AND TEMPORAL VARIABILITY OF VENUS CLOUDS AND HAZES OBSERVED BY POLARIMETRY WITH SPICAV-IR.

L. Rossi, *Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands*, **E. Marcq, F. Montmessin, J.-L. Bertaux,** *LATMOS-IPSL, Guyancourt, France*, **A. Fedorova, O. Korablev,** *Space Research Institute (IKI), Moscow, Russia*, *Moscow Institute of Physics and Technology (MIPT), Dolgoprudny, Russia*, **D. Stam,** *Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands*.

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[1], using a radiative transfer model including polarization, found that the main cloud layers between 50 and 70 km consist of $r \simeq 1$ µm radius spherical droplets of a H_2SO_4 -H_2O solution. In the early 1980s, Kawabata[2] 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 $r \simeq 0.25$ µm and similar refractive indices. Our work reproduces the method used by Hansen and Kawabata[1, 2]. We applied a radiative transfer model with polarization on the 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.

SPICAV-IR

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[4, 3]. The data give a good latitudinal and phase angle coverage. Latitudinal variations in polarization are visible in the observation data for orbits up to #2733 (Oct. 2013) with a strong increase of polarization towards the poles. 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[5].

Cloud model

We use a radiative transfer model taking polarization into account in order to model the clouds[6, 7]. We consider a two layered model: an optically thick cloud layer of micrometric sulfuric acid particles. Above lies the haze layer of $r \simeq 0.25$µm particles with a varying column density C_h.

The 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 variance of the particle size 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, $\nu_{eff} < 0.15$ and refractive indices between 1.39 and 1.44 at $\lambda = 1$ µm. We observe latitudinal variations with higher radii and refractive indices being observed near the equator. We also find a secular increase in the size and indices during the duration of the mission (fig 1).

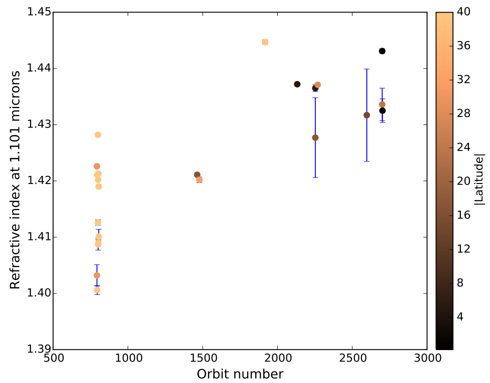

Figure 1: Retrieved refractive indices at 1.101 µm as a function of orbit number and latitude (in color). The indices increase during the mission and reach values that are higher than those expected from sulfuric acid at this wavelength (1.418 for 75% sulfuric acid and 1.425 for 95%).

The haze

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. We observe that the haze column density stays relatively constant up to 50° of latitude after which C_h increases sharply towards the poles. C_h varies from 10^{-2} μm^{-2} at low latitudes up to 1 μm^{-2} at higher latitudes, in agreement with [8]. We also observe an asymmetry with respect to local time with higher column densities on the morning side than on the evening side.

Conclusion

SPICAV-IR provides global measurements of the polarization of Venus' clouds and allows us to retrieve the parameters of the cloud droplets, in agreement with previous measurements. The refractive indices and effective radii are found to be higher near the equator. Increase with mission time of these parameters is also observed, which origin remains unexplained. The haze column density is evaluated and a strong latitudinal variation is confirmed, along with a local-time variability. A coming paper (Rossi et al. 2016, in prep) will present these results in further details.

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