HAL
open science

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

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

To cite this version:

Loïc Rossi, Emmanuel Marcq, Nicolas Bott, Franck Montmessin, Anna Fedorova, et al.. Retrieval of Venus' clouds and hazes properties with polarimetric data from SPICAV/VEx. European Planetary Science Congress 2015, Sep 2015, Nantes, France. pp.EPSC2015-119. insu-01213216

HAL Id: insu-01213216

https://insu.hal.science/insu-01213216v1

Submitted on 8 Oct 2015

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

EPSC Abstracts
Vol. 10, EPSC2015-119, 2015
European Planetary Science Congress 2015
© Author(s) 2015

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

Loïc Rossi (1), Emmanuel Marcq (1), Nicolas Bott (1), Franck Montmessin (2), Anna Fedorova (3)(4), Daphne Stam (5), Jean-Loup Bertaux (2), Oleg Korablev (3)(4)
(1) UVSQ, LATMOS-IPSL, Guyancourt, France. (2) CNRS/INSU, LATMOS-IPSL, Guyancourt, France. (3) Space Research Institute (IKI), Moscow, Russia. (4) Moscow Institute of Physics and Technology (MIPT), Dolgoprudny, Russia (5) Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands

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].

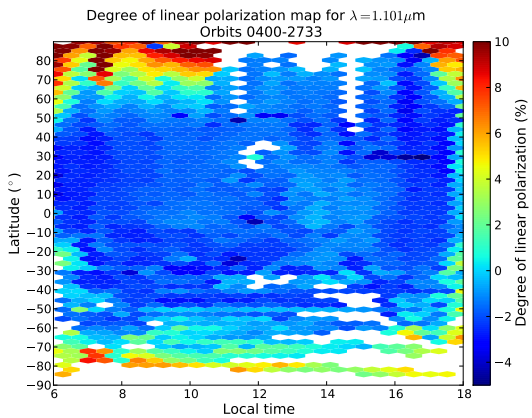

Figure 1: SPICAV data polarization map as a function of local time and latitude for orbits #400 to #2733.

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

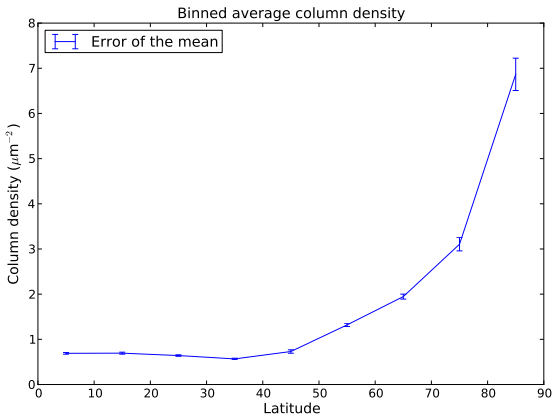

Figure 2: Column density of the haze layer in northern hemisphere of Venus as a function of latitude. The corresponding optical thickness at 1.101 µm varies from 0.039 to 0.343

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

This PhD thesis is funded by the LabEx "Exploration Spatiale des Environnements Planétaires" (ESEP) N° 2011 LABX-030.

We want to thank the State and the ANR for their support within the programme "Investissements d'Avenir" through the excellence initiative PSL*(ANR-10-IDEX-0001-02).

References

[1] J. F. de Haan, P. B. Bosma, and J. W. Hovenier. The adding method for multiple scattering calculations of polarized light. A&A, 183:371–391, September 1987.

[2] W. A. de Rooij and C. C. A. H. van der Stap. Expansion of Mie scattering matrices in generalized spherical functions. A&A, 131:237–248, February 1984.

[3] J. E. Hansen and L. D. Travis. Light scattering in planetary atmospheres. Space Sci. Rev., 16:527–610, October 1974.

[4] K. Kawabata, D.L. Coffeen, J.E. Hansen, W.A. Lane, M. Sato, and L.D. Travis. Cloud and haze properties from Pioneer Venus polarimetry. J. Geophys. Res., 85:8129–8140, dec 1980.

[5] W. J. J. Knibbe, J. F. de Haan, J. W. Hovenier, and L. D. Travis. A biwavelength analysis of Pioneer Venus polarization observations. J. Geophys. Res., 102:10945–10958, 1997.

[6] O. Korablev, A. Fedorova, J.-L. Bertaux, A.V. Stepanov, A. Kiselev, Y.K. Kalinnikov, A.Y. Titov, F. Montmessin, J.P. Dubois, E. Villard, V. Sarago, D. Belyaev, A. Reberac, and E. Neefs. SPICAV IR acousto-optic spectrometer experiment on Venus Express. Planet. Space Sci., 65:38–57, may 2012.

[7] W.J. Markiewicz, E. Petrova, O. Shalygina, M. Almeida, D.V. Titov, S.S. Limaye, N. Ignatiev, T. Roatsch, and K.D. Matz. Glory on venus cloud tops and the unknown uv absorber. *Icarus*, 234:200–203, 2014.

[8] Loïc Rossi, Emmanuel Marcq, Franck Montmessin, Anna Fedorova, Daphne Stam, Jean-Loup Bertaux, and Oleg Korablev. Preliminary study of venus cloud layers with polarimetric data from spicav/vex. *Planetary and Space Science*, (0):–, 2014.

[9] D. M. Stam, J. F. De Haan, J. W. Hovenier, and P. Stammes. Degree of linear polarization of light emerging from the cloudless atmosphere in the oxygen A band. J. Geophys. Res., 104:16843–16858, 1999.