



**HAL**  
open science

## Preparing EnVision: SO<sub>2</sub> measurements below and above Venus' clouds

Emmanuel Marcq, K. L. Jessup, Thérèse Encrenaz, Lucio Baggio, Ismaïl Amine, Marc Duquesnoy, Franck Montmessin, Franck Lefèvre, Jean-Loup Bertaux, A. C. Vandaele, et al.

### ► To cite this version:

Emmanuel Marcq, K. L. Jessup, Thérèse Encrenaz, Lucio Baggio, Ismaïl Amine, et al.. Preparing EnVision: SO<sub>2</sub> measurements below and above Venus' clouds. EPSC-DPS Joint Meeting 2019, Sep 2019, Geneva, Switzerland. pp.EPSC-DPS2019-253-1. insu-02262580

**HAL Id: insu-02262580**

**<https://insu.hal.science/insu-02262580v1>**

Submitted on 2 Aug 2019

**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.

## Preparing EnVision: SO<sub>2</sub> measurements below and above Venus' clouds

E. Marcq (1), K. L. Jessup (2), T. Encrenaz (3), L. Baggio (1), I. Amine (1), M. Duquesnoy (1), F. Montmessin (1), F. Lefèvre (1), J.-L. Bertaux (1), A. C. Vandaele (4), S. Robert (4), J. Helbert (5), T. Widemann (3), C. Wilson (6), R. Ghail (7)  
(1) LATMOS/IPSL/CNRS/UVSQ/SU, Guyancourt, France, (2) SWRI, Boulder, CO, USA, (3) LESIA/Obs. Paris/CNRS/UVSQ, Meudon, France, (4) BIRA-IASB, Brussels, Belgium, (5) DLR, Berlin, Germany, (6) AOPP, Oxford, UK, (7) Royal Holloway, Univ. of London, UK (emmanuel.marcq@latmos.ipsl.fr)

### Abstract

One of the primary objectives of the preselected EnVision M5 proposal is the monitoring of volcanogenic species in Venus' atmosphere, one of the most prominent being sulphur dioxide (SO<sub>2</sub>). Monitoring SO<sub>2</sub> below the clouds can be performed on the nightside near 2.4 μm, and is one science objective of the VenSpec-H channel (P.I.: A. C. Vandaele, BIRA) on-board EnVision. Monitoring SO<sub>2</sub> above the clouds can be performed on the dayside in the 200-300 nm range, and is the main science objective of the VenSpec-U channel (P.I.: E. Marcq, LATMOS). Here we present the analysis of two analogous datasets, namely IRTF/iSHELL ground based observations on the nightside of Venus, and the most recent reanalysis of the Venus Express/SPICAV-UV dataset on the dayside of Venus.

### 1 SPICAV-UV dataset

SPICAV [1] was a UV and IR spectrometer on board Venus Express, ESA's first mission in orbit around Venus (2006–2014). Observations of the reflected UV sunlight (170 to 320 nm,  $R \sim 200$ ) by SPICAV during the whole mission were sensitive to many variable quantities near Venus' day side cloud top (65 to 75 km): (1) gaseous constituents such as SO, SO<sub>2</sub> [3, 4] and O<sub>3</sub>, (2) UV absorption caused by a yet unknown UV absorber mixed with submicron particles, and marginally (3) cloud top altitude (via differential CO<sub>2</sub> absorption). The most recent analysis of SO<sub>2</sub> measurements [9] mostly confirm the results obtained previously [6, 8]: SO<sub>2</sub> variability is strongest at lower latitudes, with short-lived bursts more prevalent in the 2006-2009 epoch (Fig. 1). We also observe a possible enhancement over the western slope of *Aphrodite Terra*, hinting at an influence of topog-

raphy on the vertical mixing between the lower and upper atmosphere.

These results will play a key role in defining the science requirements of the analogous instrument VenSpec-U on board EnVision (measurement accuracy, spatial and temporal coverage, spatial resolution, etc.)

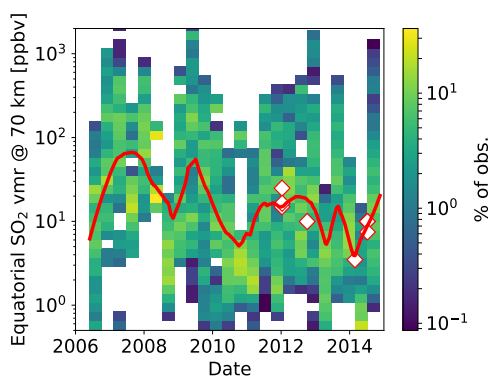


Figure 1: Temporal evolution of cloud top SO<sub>2</sub> seen by SPICAV. White diamonds indicate TEXES measurements from [8]

### 2 iSHELL dataset

On January 2nd to 4th, we were able to observe the night side of Venus at a high spectral resolution ( $R \sim 24500$ ) in the 2.3 μm infrared window, thanks to the iSHELL instrument [7] located at NASA IRTF facility. Previous studies [2, 5] have shown that numerous gaseous species can be retrieved in the 30-40 km altitude range: CO, OCS, H<sub>2</sub>O, HDO, HF, and SO<sub>2</sub>. We are currently in the first stages of the analysis of this dataset, but our preliminary studies (Fig. 2) show that

SO<sub>2</sub> retrievals can be performed at a quite high accuracy (better than 10%) once other gaseous species have been properly constrained.

Future analysis will play a key role in defining the science requirements of the analogous VenSpec-H instrument on board EnVision (measurement accuracy, spatial and temporal coverage, spatial resolution, etc.)

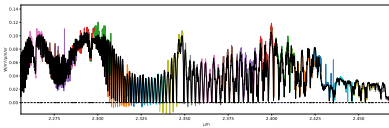


Figure 2: Processed night side spectrum sample acquired on 2019-01-03 compared with the radiative transfer output from B. Bézard (in black)

## References

- [1] Bertaux, J.-L. et al.: SPICAV on Venus Express: Three spectrometers to study the global structure and composition of the Venus atmosphere, PSS, Vol. 55, pp. 1673-1700, 2007.
- [2] Marcq, E. et al.: A latitudinal survey of CO, OCS, H<sub>2</sub>O, and SO<sub>2</sub> in the lower atmosphere of Venus: Spectroscopic studies using VIRTIS-H, JGR, Vol. 113, 2008
- [3] Marcq, E. et al.: An investigation of the SO<sub>2</sub> content of the venusian mesosphere using SPICAV-UV in nadir mode, Icarus, Vol. 211, pp. 58-69, 2011
- [4] Marcq, E. et al.: Variations of sulphur dioxide at the cloud top of Venus's dynamic atmosphere, Nature Geoscience, Vol. 6, pp. 25-28, 2013
- [5] Arney, G. et al.: Spatially resolved measurements of H<sub>2</sub>O, HCl, CO, OCS, SO<sub>2</sub>, cloud opacity, and acid concentration in the Venus near-infrared spectral windows, JGR Planets, Vol. 119, pp. 1860-1891, 2014
- [6] Jessup, K. L. et al.: Coordinated Hubble Space Telescope and Venus Express Observations of Venus' upper cloud deck, Icarus, Vol. 258, pp. 309-336, 2015
- [7] Rayner, J. T. et al.: iSHELL: construction, assembly, and testing, SPIE, Vol. 9908, 2016
- [8] Encrenaz, T. et al.: HDO and SO<sub>2</sub> thermal mapping on Venus. IV. Statistical analysis of the SO<sub>2</sub> plumes, A&A, Vol. 623, 2019
- [9] Marcq, E. et al.: Climatology of SO<sub>2</sub> and UV absorber at Venus' cloud top from SPICAV-UV nadir dataset, submitted to Icarus, 2019