EPSC Abstracts
Vol. 8, EPSC2013-141-1, 2013
European Planetary Science Congress 2013

Composition of the upper Venus atmosphere using SPICAV-SOIR on board Venus Express

A.C. Vandaele (1), A. Mahieux (1), S. Robert (1), V. Wilquet (1), R. Drummond (1), J.L. Bertaux (2,3)
(1) Belgian Institute for Space Aeronomy, Belgium (a-c.vandaele@aeronomie.be), (2) LATMOS, France, (3) IPSL, Université UVSQ, France

Abstract

The wavelength range probed by SOIR/VEX allows a detailed chemical inventory of the Venus atmosphere. Several trace gases, such as H_2O/HDO, HF, HCl, CO, or SO_2, are observed together with CO_2, leading to the derivation of their vertical density profiles. Temperature and total density profiles are deduced from the CO_2 density profiles and VMR are obtained for all trace gases.

The measurements all occur at the Venus terminator, morning and evening sides, covering all latitudes from the North Pole to the South Pole. The vertical resolution is between 100 and 500 m in the Northern hemisphere, and is poorer at southern latitudes (between 1 and 2.5 km). The typical vertical extent of the profiles ranges from 70 to 120 km (for CO_2: from 70 to 170 km), encompassing thus the mesosphere and the lower thermosphere of the planet. The Venus atmospheric region probed by SOIR is very special as it acts as a transition region between two distinct dynamic regimes characterized by different flow patterns: the zonal retrograde flow below 70 km and the subsolar to antisolar circulation above 100 km. Some of the detected trace gases play important roles in the chemistry of the atmosphere. The study of CO, which is mainly produced through photodissociation of CO_2 at high altitudes by solar ultraviolet radiation, can lead to significant information on the dynamics in this region. Investigation of trace gases leads to a better understanding of the processes occurring in the upper atmosphere of Venus.

1. Introduction

The SOIR (Solar Occultation in the IR) instrument has been designed to measure spectra in the IR region (2.2 – 4.3 μm) of the Venus atmosphere using the solar occultation technique [1]. This method derives unique information on the vertical composition and structure of the mesosphere and lower thermosphere [2-5]. SOIR is an extension mounted on top of the SPICAV instrument [6]. SPICAV/SOIR is one of the seven instruments on board Venus Express, a planetary mission of the European Space Agency (ESA) that was launched in November 2005 and inserted into orbit around Venus in April 2006 [7].

The instrument has already been extensively described elsewhere [1, 8] and will only be briefly outlined here. SOIR is an Echelle grating spectrometer operating in the IR, combined with an acousto-optic tunable filter (AOTF) for the selection of the recorded wavenumber interval. The wavenumber range covered by the instrument extends from 2250 to 4370 cm^{-1} (2.2 – 4.3 μm) and is divided into 94 diffraction orders (from 101 to 194). The definition and limits of these diffraction orders are given in [1]. The bandwidth of the AOTF was originally designed to be 20 cm^{-1}, as measured on ground before launch [1], to allow light from only one order into the spectrometer. However, the measured bandwidth of SOIR is ~24 cm^{-1}, creating some order leakage on the detector. The fact that the AOTF transfer function is wider implies that information from adjacent orders will leak onto the detector. This is called superposition of orders in the following.

The SOIR instrument is unique in terms of spectral coverage and spectral resolution (0.15 cm^{-1}), and is ideally designed to probe the Venus atmosphere for CO_2 as well as trace gases.

2. Results

The retrieval of CO has been analyzed in detail and has served as a case study to analyze the influence of several parameters.

The first improvement included in the treatment of the SOIR spectra concerns the spectral calibration of the spectra. This was initially done by considering well defined solar lines. However, it was shown not to be sufficient, and a second step in the calibration is now based on the use of atmospheric lines present in each spectrum. .

Similarly, the resolution was deduced from the study of several solar lines and has now been extended to well defined and isolated atmospheric lines. This greatly improved the determination of the SOIR resolution which varies along the spectral interval. This was particularly critical for the retrieval of CO, whose bands are located at the far end of the sensitive spectral range of SOIR.

The impact of those improvements will be described and discussed, considering CO as an example.

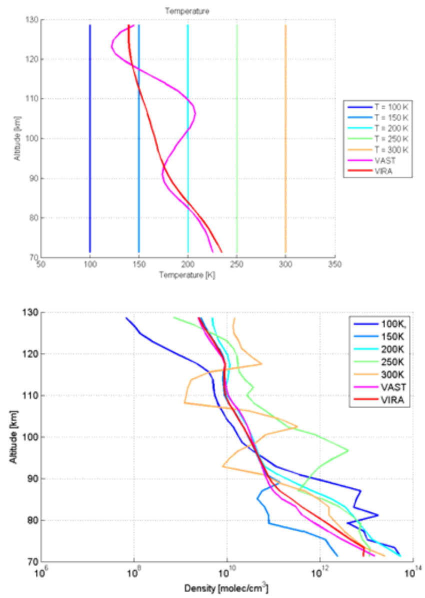

Figure 1: Sensitivity study wrt temperature. Top Panel: Different temperature profiles considered in the study. Bottom: Corresponding CO density profiles.

Sensitivity studies wrt to temperature and other retrieval parameters were also conducted. The detailed analysis of these studies will be described and discussed. Some results obtained for the temperature impact are presented in Figure 1. On the top panel, the different temperature profiles used for the study are shown, and in the bottom panel the corresponding CO density profiles are illustrated. Differences between the VIRA and VAST [4] models are negligible.

Results concerning trace gases detection (CO, HCl, HF etc.) 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).

References

1. Nevejans, D., et al., *Compact high-resolution space-borne echelle grating spectrometer with AOTF based on order sorting for the infrared domain from 2.2 to 4.3 micrometer.* Applied Optics, 2006. **45**(21): p. 5191-5206.
2. Fedorova, A., et al., *HDO and H_2O vertical distributions and isotopic ratio in the Venus mesosphere by Solar Occultation at Infrared spectrometer onboard Venus Express.* J. Geophys . Res . 2008. **113**(E00B22): p. doi:10.1029/2008JE003146.
3. Mahieux, A., et al., *Densities and temperatures in the Venus mesosphere and lower thermosphere retrieved from SOIR onboard Venus Express: Retrieval technique.* J. Geophys. Res., 2010. **115**(E12014): p. 10.1029/2010JE003589.
4. Mahieux, A., et al., *Densities and temperatures in the Venus mesosphere and lower thermosphere retrieved from SOIR on board Venus Express: Carbon dioxide measurements at the Venus terminator.* J. Geophys. Res., 2012. **117**(E07001): p. doi:10.1029/2012JE004058.
5. Vandaele, A.C., et al., *Composition of the Venus mesosphere measured by SOIR on board Venus Express.* J. Geophys. Res., 2008: p. doi:10.1029/2008JE003140.
6. Bertaux, J.-L., et al., *SPICAV on Venus Express: Three spectrometers to study the global structure and composition of the Venus atmosphere.* Planet. Space Sci., 2007. **55**: p. 1673-1700.
7. Titov, D.V., et al., *Venus Express science planning.* Planetary and Space Science, 2006. **54**: p. 1279-1297.
8. Mahieux, A., et al., *In-flight performance and calibration of SPICAV/SOIR on-board Venus Express.* Applied Optics, 2008. **47**(13): p. 2252-65.