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Variability of SO_2 and HDO at the cloudtop of Venus from high-resolution infrared spectroscopy

T. Encrenaz (1), T. K. Greathouse (2), M. J. Richter, (3) C. DeWitt (3), J. H. Lacy (4), T. Widemann (1), B. Bézard (1), T. Fouchet (1), S. K. Atreya (5), H. Sagawa (6)
(1) LESIA, Paris Observatory, France, (2) SwRI, San Antonio, TX, USA, (3) University of California Davis, CA, USA, (4) University of Texas at Austin, TX, USA, (5) University of Michigan, MI, USA, (6) Kyoto Sangyo University, Japan
(therese.encrenaz@obspm.fr/ Fax: +33-145072806)

Abstract

Since January 2012, we have mapped the SO_2 and HDO mixing ratios at the cloudtop of Venus using the Texas Echelon Cross Echelle Spectrograph (TEXES) at the Infrared Telescope Facility (IRTF). The HDO maps appear homogeneous over the Venus disk. In contrast, the SO_2 maps show strong variations over the disk and within a time scale of two hours. Both molecules show long-term variations with no apparent correlation between the two species.

1. Introduction

SO_2 and H_2O play a key role in the atmospheric chemistry of Venus [1]. Both molecules are strongly depleted at the level of the main cloud due to SO_2 photodissociation and H_2SO_4 condensation processes. As a complement to the Venus Express campaign, we have started an observing program using TEXES at IRTF to map SO_2 and HDO at the cloudtop. Results of the January and October 2012 runs have been published in [2, 3]. We present here the results of the following runs (February and July 2014, March 2015).

2. Observations

We selected the 1343-1353 cm^{-1} range (7.4 μm) where weak transitions of CO_2, SO_2 and HDO can be found. At this wavelength, the radiation probes the cloud top at an altitude of about 63 km. We mapped the SO_2 and HDO mixing ratios by making the ratio of the line depth of these molecules with respect to the CO_2 line depth. The maps were achieved by orienting the 8-arcsec slit along the north-south celestial axis and moving it from west to east by 0.5 arcsec steps to map the whole planet. The diameter of Venus ranged from 12 arcsec (July 2014) to 33 arcsec (February 2014), so several scans were recorded from north to south in order to map the whole planet. The resolving power was 8×10^4. As in the case of our October 2012 observations, we selected a CO_2 transition at 1345.2 cm^{-1}, SO_2 transitions at 1345.12 and 1345.28 cm^{-1}, and a HDO transition at 1344.90 cm^{-1}.

3. Results

Figure 1 shows maps of HDO recorded between October 2012 and March 2015. It can be seen that the maps are globally uniform, with a drop of intensity by about a factor of 2 in July 2014, observed during two consecutive days. The mean H_2O mixing ratio, assuming a D/H value in Venus of 200 SMOW (Standard Mean Ocean Water) [4] is about 1.0 +/- 0.5 ppmv, in agreement with previous ground-based and space measurements [4-7].

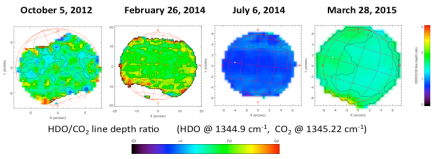

Figure 1: Maps of the HDO/CO_2 line depth ratio at the cloudtop of Venus between October 2012 and March 2015. A HDO/CO_2 line depth ratio of 1.5 corresponds to a H_2O mixing ratio of about 1 ppmv [3, 4]. A drop of the water content by a factor 2 is visible in the February 2014 dataset.

Figure 2 shows maps of SO_2 recorded in July 2014 and March 2015. Both sets of maps show strong spatial variations (as already observed in 2012 [2, 3]). The disk-averaged mixing ratio of SO_2 is about constant. Temporal variations (also observed in 2012) are noticeable on a time scale of two hours.

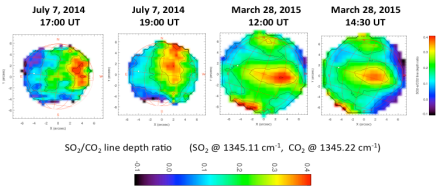

Figure 2: Maps of the SO_2/CO_2 line depth ratio at the cloudtop of Venus in July 2014 and March 2015. A SO_2/CO_2 line depth ratio of 0.2 corresponds to a SO_2 mixing ratio of about 120 ppbv at the cloudtop [3].

The SO_2 mixing ratios are in overall agreement with other past and recent measurements in the same altitude range [6, 8 – 10]. All studies illustrate the high spatial and temporal variability of SO_2.

Figure 3 shows the long-term variations of the SO_2 and H_2O (inferred from HDO) mixing ratios at the cloudtop, between January 2012 and March 2015. The HDO curve shows a moderate depletion (by a factor of about 2) in July 2014. The SO_2 curve is constant over time, except for a drop by a factor 3 (significantly outside the noise level) in February 2014. It is interesting to note that there is no correlation between the SO_2 and H_2O curves. In the same way, the absence of spatial and short-term variations in the HDO maps illustrate that different processes are at work in the behaviors of the two species at the cloudtop. In the case of SO_2, its short photochemical lifetime is probably responsible for its high spatial and short-term variability.

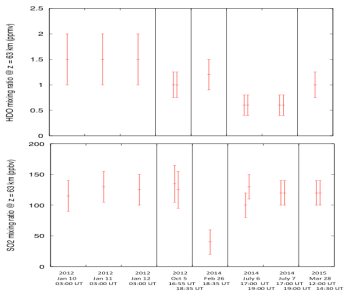

Figure 3: Temporal variations of the disk-integrated SO_2 and HDO mixing ratios at the cloudtop of Venus between January 2012 and March 2015.

Acknowledgements

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