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Ground-based thermal mapping on Venus: temperature fields and variations of SO_2 & HDO

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Abstract

As a continuation of our ground-based thermal imaging campaign of Venus, we have been mapping Venus in December 2016 and January 2017 to monitor the behaviour of SO_2 and H_2O (through its proxy HDO). The SO_2 mixing ratio was at its maximum since 2012. As during our previous runs, short-term variations of SO_2 (with a timescale of a few hours) were observed. There is still no evidence for a correlation or an anti-correlation between SO_2 and HDO. The thermal maps might show some correlation with the topography, but this remains to be confirmed with further observations.

1. Introduction

Thee atmospheric photochemistry of Venus is known to be mainly driven by two minor species, SO_2 and H_2O [1, 2]. Since 2012, we have mapped the planet in the thermal infrared spectral range to monitor the behaviour of these two species [3-5], using the TEXES instrument (Texas Echelon Cross Echelle Spectrograph) at the InfraRed Telescope Facility (IRTF) at Maunakea Observatory. Our observations have shown evidence of strong spatial and temporal variations of SO_2, on both short-term and long-term. In contrast, the HDO maps are relatively uniform and show little variation with time. The origin of the SO_2 plumes is still poorly understood.

2. Observations

We observed Venus on December 16-23, 2016 and January 21-22, 2017. The planet size was 20 arcsec in December and 26 arcsec in January, with illumination factors of 60% and 46% respectively. Two spectral ranges were monitored, at 7.4 μm (1343-1348 cm^{-1}) and 19 μm (529-531 cm^{-1}). At 7.4 μm, SO_2 and HDO are probed at the cloudtop, while, at 19 μm, SO_2 is probed a few kilometers below the cloudtop [3-5].

3. Results

Figure 1 shows maps of the brightness temperature of Venus at 7.4 μm, on Dec. 22, 2016 and Jan. 21, 2017, respectively. It can be seen that the maximum radiance corresponds to a high-altitude region (Aphrodite Terra in December, Maats Mons in January) in both instances. Such correspondence, that was also observed at other wavelengths, was not found in our previous observations, which were centered on different longitudes of lower elevation. They might be associated to gravity waves as observed by Venus Express [6] and Akatsuki [7]. More observations will be needed to confirm this effect.

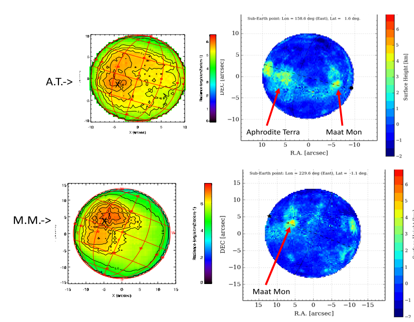

Figure 1: *Continuum maps of Venus on Dec. 22, 2016 (top) and Jan. 21, 2017 (bottom), compared with topography maps of Venus for the same observing conditions. The maximum radiance coincides with high elevations (top: Aphrodite Terra; bottom: Maats Mons).*

Figure 2 shows maps of the SO_2 mixing ratio, derived from the line depth ratio of two weak transitions of SO_2 and CO_2 at 7.4 microns, recorded on Jan. 21, 2017. Four maps are shown within a time interval of about 5 hours. They illustrate the patchy distribution of SO_2 and the short timescale of its variations. In the present case, there is no evidence for a correlation with the zonal wind rotation. In contrast, the HDO maps inferred from the same spectra are uniform, as previously mentioned (Fig.3).

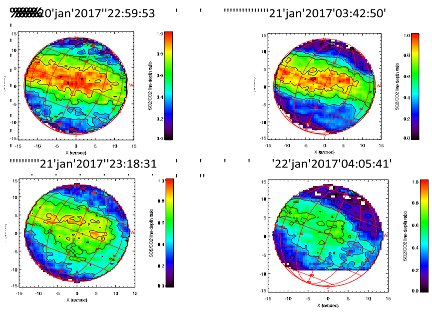

Figure 2*: Maps of the SO_2/CO_2 line depth ratio, recorded on January 21, 2017. The SO_2 line at 1345.11 cm^{-1} and the CO_2 line at 1345.22 cm^{-1} were used (see [5]).*

Figure 4 summarizes the long-term variations of H_2O and SO_2 between 2012 and 2017, as derived from the TEXES data. It can be seen that the SO_2 abundance is strongest in January 2017, and more than 10 times its value of February 2014. The SO_2 values derived at 19 μm are usually equal or larger than the ones derived at 7.4 μm, which is expected since the 19-μm probe a few kilometres below the cloudtop observed at 7.4 μm. There is an exception in December 2016 that is presently unexplained. In contrast with SO_2, H_2O varies by less than a factor 2 as a function of time. There is no evidence for a correlation or an anti-correlation between H_2O and SO_2.

Acknowledgements

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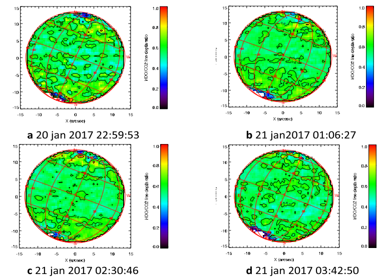

Figure 3*: Maps of the HDO/CO_2 line depth ratio, recorded on January 21, 2017. The HDO line at 1344.90 cm^{-1} and the CO_2 line at 1345.22 cm^{-1} were used (see [5]).*

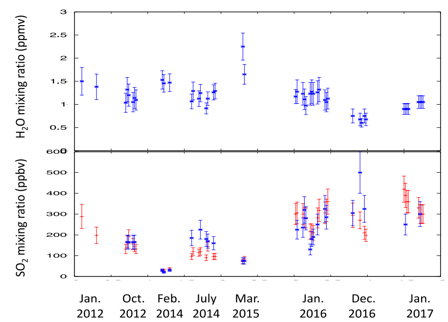

Figure 4*: Long-term variations of the H_2O and SO_2 mixing ratios between 2012 and 2017. Top: HDO. Bottom: SO_2, 7.4-μm data (red), 19-μm data (blue).*

References

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