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Constraining SO_2 in the atmospheres of Venus and Mars using SPICAV-UV & SPICAM-UV in nadir mode

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Abstract

Comparative studies of SO_2 in Mars and Venus atmospheres using the UV channel and nadir mode observations of SPICAV and SPICAM onboard *Venus Express* and *Mars Express* could be done thanks to the strong similarities between both instruments. In Venus' atmosphere extensive measurements of SO_2 column density above the cloud top have been made, and yielded strong spatial and/or temporal variability. For Mars, studies are still in progress and conclusions are not yet established; nevertheless local uper bounds for SO_2 column densities could be retrieved.

1. Introduction

The strong similarities between the UV channels of the SPICAV instrument onboard *Venus Express* and the SPICAM instrument onboard *Mars Express* enable common scientific objectives for the nadir observations of the atmospheres of Mars and Venus. One possible objective is the detection or measurement of sulphur dioxide (SO_2) thanks to its two absorption bands near 210 and 280 nm. On Mars, the main goal is the detection of integrated SO_2 content down to the surface, or at least yielding an upper bound on its local column density – SO_2 detection would have far-reaching implications in terms of current geological activity as well as favouring an abiotic origin of CH_4. On Venus, UV nadir sounding can only probe down to the upper cloud level between 65 and 75 km in altitude, but SO_2 has been measured at various latitudes since the 1970s [1, 2, 3]; the main goals here are to characterize the spatio-temporal variability of SO_2 and providing interpretation in terms of dynamics, chemistry and, ultimately, geological activity of the planet.

2. Observations

Our observations were exclusively acquired in nadir mode on the dayside between 170 and 320 nm and at a medium spectral resolution $R \simeq 200$. Several tens of *Venus Express* orbits were processed to obtain radiance factors at various latitudes and local time. For *Mars Express*, the data we used included only the first Martian year, and we worked only with relative radiance factors taking a reference spectrum recorded above *Olympus Mons* using the same method as in [6].

3. Modeling

For both atmospheres, CO_2 absorption and Rayleigh scattering plays a major role. In the case of Venus, including SO absorption as well as accounting the thick cloud layers was necessary to explain the observations, whereas for Mars, O_3 absorption and dust opacity had to be taken into account. All these parameters were included in a radiative transfer model able to cope with high Solar Zenith Angles (SZA) thanks to the pseudo-spherical mode of SPS-DISORT. Inversion of the model provide estimates of SO_2 column density and scale height in the Venusian atmosphere. For Mars, simple heuristics for SO_2 detection among numerous spectra was used.

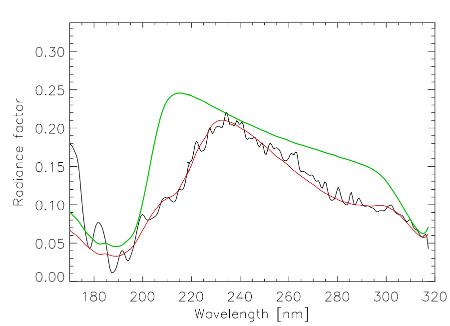

Figure 1: Radiance factor near the equator during orbit #325 for Venus and model with (red) and without (green) SO_2+SO (from [7]).

4. Results

Venus' SO_2 column densities show strong variability (at least two orders of magnitude), but a latitudinal gradient with usual mixing ratios at cloud top between 0.1 and 1 ppmv at low latitudes and below 0.1 ppmv in the north polar region, usually correlated with changes in cloud top altitude as seen by SPICAV-IR and VIRTIS as well SO_2 scale height variations with a shorter scale height at higher latitudes. We are in agreement with previous observations [4, 5] regarding the scale height of SO_2, but find an opposite latitudinal gradient. Furthermore, some polar regions exhibit a stronger SO_2 content and are yet poorly understood. The average mixing ratio lie in the high range of the measurements, indicating that the steady decline of SO_2 observed during the 1980s and early 1990s [3] may have stopped or even reversed.

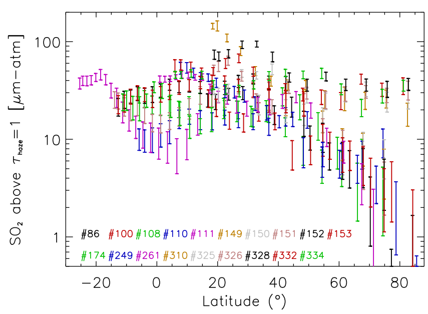

Figure 2: Variations of SO_2 column densities with latitude for several orbits (from [7])

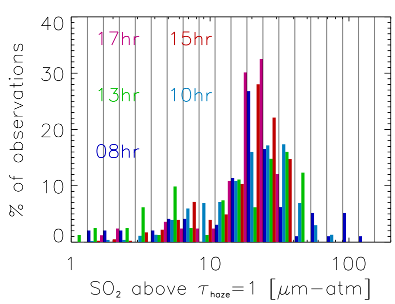

Figure 3: Histograms of SO_2 column densities with local solar time for several orbits (from [7])

Furthermore, there appers to be a steady decrease of the maximal SO_2 column densities within a given orbit from morning to evening, suggesting a lifetime of SO_2 at cloud top close to 10^5 s. This suggests, along with the latitudinal gradient, that photochemistry is dominated by dynamics/advection for establishing SO_2 variations.

As for Mars, work is still underway with a local detection threshold ranging from 10 to 100 ppb for any single SPICAM observation. Results for Venus are currently under press [7].

Acknowledgements

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