LOOKING FOR SO_2: A SPECTROSCOPIC STUDY OF MARTIAN UV ALBEDO USING SPICAM.

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Introduction

The detection of SO_2 in the Martian atmosphere would have far-reaching implications in our knowledge of the planet, much akin to the (actual) detection of CH_4. First of all, it would be a major point in discussing the level of geologic activity under the surface of Mars, since SO_2 photochemical is short enough – less than a year according to Wong et al.(2003) – so that it would need to be constantly replenished from a sub-surface source. Its presence would also help in discriminating the origin of CH_4 in the atmosphere; if SO_2 were present and correlated to CH_4, the source of both gases could be assigned to geological processes, thus ruling out the need for a biological source of CH_4.

Unfortunately, all recent measurements have failed to detect any significant amount of SO_2. Krasnopolski (2005) set an upper limit at 1 ppbv using TEXES at NASA IRTF, and more recently Nakagawa et al. (2009) found an upper limit at 2 ppbv in the submillimeter range using ASTE. Nevertheless, these upper limits were found by integration upon the whole Martian disk, and thus do not preclude higher mixing ratios locally, provided localized sources exist.

Our goal is to use SPICAM-UV in nadir geometry to yield upper limits (or mixing ratios in case of detection) of SO_2 in the atmosphere of Mars, but this time on a localized basis. Even though SPICAM is not a real mapping spectrometer, its proximity to Mars enables a good spatial resolution and the duration of the mission ensures that most of the surface has been observed several times since 2003.

Observations

The UV channel of SPICAM is fully described in Bertaux et al. (2006), and we give here only a brief summary of its relevant characteristics: observed range is between 115 and 310 nm. Resolving power si about 1 nm. Typical FOV at pericenter is 1.2×2.4 km. Several thousand orbits are available now

Pre-processing of data is very similar to Perrier et al. (2006). Correction of DC and straylight are performed first, and then relative radiance factors are derived using a reference obseration of *Olympus Mons* recorded during orbit #1448. Proceeding to spectral ratios enables many calibration issues to be solved, but require a very good knowledge of the reference observation used as a denominator.

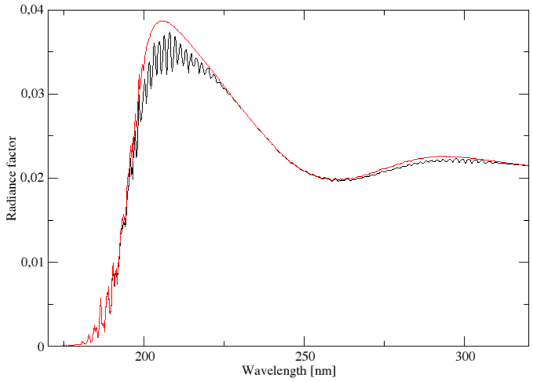

Figure 1: Synthetic radiance factors with 10 μm-atm (black) and without SO_2 (red). Absorption near 250 nm is due to O_3.

Modelling

Our spectrum forward model is based on Perrier et al. (2006) model, devised to measure O_3 column density. We used the same radiative core (SHDOM), and (P, T) profiles are extracted from the LMD-GCM as well as surface pressure and O_3 relative vertical profile. UV cross-sections are kept the same, except that we now add SO_2 using Wu et al. (2000) values. CO_2 clouds are not taken into consideration, and dust is assumed to follow a Conrath distribution. Sensitivity measurements yield a detection threshold at around 10 μm-atm for SO_2 column density, mainly thanks to its 215 nm band (see Fig. 1). If vertically uniform, this column density translates into a mixing ratio threshold ranging from 10 to 100 ppbv. This is one or two orders of magnitude higher that globally averaged upper limits, so that we do not expect to find SO_2 in more than a few percents of SPICAM spectra.

Strategy

Our first strategy to derive SO_2 was an extension of Perrier et al. (2006). A Levenberg-Marquardt χ^2 optimization was realized in a 5-dimensional parameter

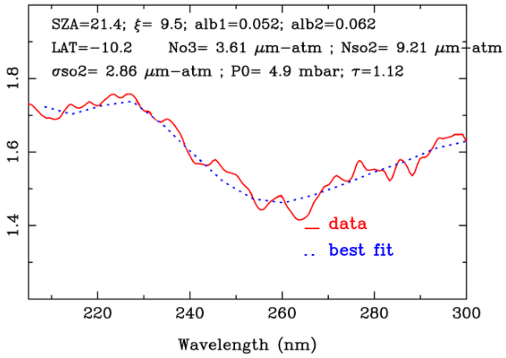

Figure 2: Observed relative radiance factor during orbit #61 and its best fit allowing SO_2

space: O_3 and SO_2 column densities, dust opacity, surface albedos at 200 and 320 nm. However, degeneracies cannot be avoided with such a high number of fitted parameters. A way to test this is to compare the fitted parameters when constraining SO_2 to be null and without this constraint: where high discrepancies occur, they cast doubt on the interpretation. The assumption of a surface albedo varying linearly between 200 and 320 nm is especially dubious.

That is why we are currently implementing another approach based on directly fitting radiance factors (instead of radiance factor ratios as we did previously). The spectral distortion induced by O_3, dust, CO_2 is then corrected using externally derived values, for example using Perrier et al. (2006) values. The corrected radiance factor would then contain information about mostly two parameters: ground albedo in the UV and, sometimes, SO_2 spectral signature. This method should be more robust than the first.

Preliminary Results

Provisional results are available only following the first strategy at the time of abstract submission, but nevertheless encouraging as can be shown on Fig. 2 and 3. The spectral slope near 210 nm is especially encouraging in our search for SO_2. Nevertheless, the robustness of the fitting must be checked before any detection claim, especially since this fetaure seems present on a higher proportion of data than expected. We checked that this spectral feature is not primarily due to a faulty straylight removal in the pre-processing stage, but did not check its sensitivity versus CO_2 pressure – a strong CO_2 band below 200 nm could interfere with our fit. And of course, some ground albedo feature at the observed location and/or at our *Olympus Mons* reference spectrum cannot be ruled out at the present stage.

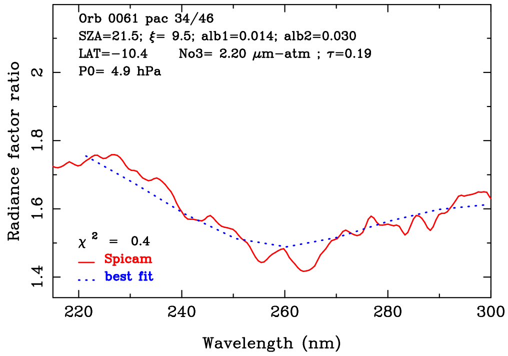

Figure 3: Observed relative radiance factor during orbit #61 and its best fit without SO_2

Bibliography

- Bertaux et al., SPICAM on Mars Express: Observing modes and overview of UV spectrometer data and scientific results, JGR **111** (2006)
- Krasnopolski, A sensitive search for SO_2 in the martian atmosphere: Implications for seepage and origin of methane, Icarus **178** (2005)
- Nakagawa et al., Search of SO_2 in the Martian atmosphere by ground-based submillimeter observation, PSS **57** (2009)
- Perrier et al., Global distribution of total ozone on Mars from SPICAM/MEX UV measurements, JGR **111** (2006)
- Wong et al., Chemical markers of possible hot spots on Mars, JGR **108** (2003)
- Wu et al., Measurements of High-, Room-, and Low-Temperature Photoabsorption Cross Sections of SO_2 in the 2080- to 2950-Å Region, with Application to Io, Icarus **145** (2000)