OZONE RETRIEVAL ON MARS FROM SPICAM/MEX UV/IR NADIR MEASUREMENTS.

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Introduction

The european mission Mars Express arrived at Mars in January 2004, during Mars's late northern winter. On board, the dual UV/IR spectrometer SPICAM is dedicated to monitor the martian atmosphere, and has recorded spectra for more than half a martian year, covering the seasonal range L_s=330–270°. We analyse spectra of the backscattered solar light from SPICAM UV spectrometer in the [110–320] nm range. They were recorded on the day side in a nadir geometry (downward looking mode) where the surface of Mars is observed through the atmosphere. Some of these spectra show a strong absorption band around 250 nm, which is the spectral signature of ozone in the UV. The analysis of the complete dataset is presented. We discuss the comparison with predictions from Global Circulation Model. In the infrared, SPICAM is able to measure O_2 emission at 1.27 μm and water vapor at 1.38 μm. We explore the correlation between these different datasets and their implications on the martian photochemisty.

SPICAM UV nadir measurements

The UV spectrometer is one of the two SPICAM spectrometers, observing in the range [115–310] nm. Day side nadir measurements presented here are mostly probing the lower part of the atmosphere. The whole vertical column quantity of O_3 is determined from the ozone absorption in the Hartley's band (220-280 nm), imprinted on the backscattered solar radiation (Figure 1).

During the first year of observations (from January 2004 to March 2005), a large number of observations have been collected (578 orbits dedicated to nadir observations for the 330°–270° L_s range), so that a global coverage of the planet is now available.

Results

For each orbit, spectra are averaged over 50 secunds and divided by a data reference spectrum taken above Olympus Mons. We use a SHDOM radiative transfer code to retrieve ozone column. For the major part of the orbits, including dust is not needed to obtain a satisfactory fit (Figure 2 shows an example of fit).

The overall behaviour of the ozone seasonal evolution retrieved from SPICAM data may be examined in

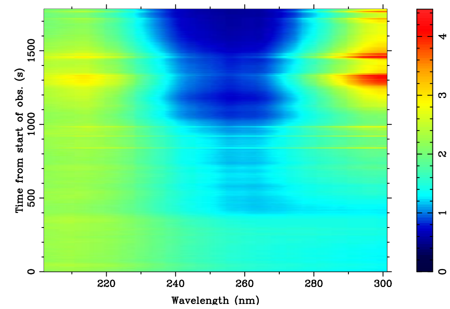

Figure 1: *Spectro-temporal image of orbit 262 observation. The x-axis is the spectra, and the y-axis is the time. The color code represents the relative intensity (all spectra were divided by the same Data Reference Spectrum). This observation begins from equatorial latitudes towards the north pole. Ozone absorption is visible at high latitudes.*

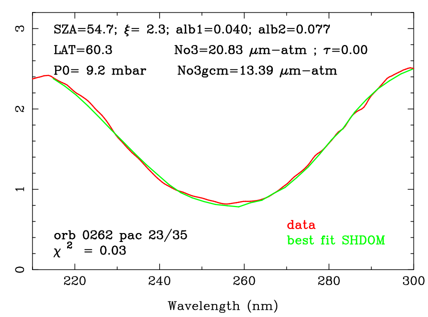

Figure 2: *An example of fit for orbit 262, at a latitude of 60°N*

Figure 3, showing the ozone column as a function of latitude and season.

The dataset coverage in season and latitude is variable, depending on observational and technical constrains. Strong spatial and temporal variations in the ozone column-density are observed. At high latitudes of both hemispheres, ozone seems to be present at fall, winter and early spring, to disappear during the spring, and to be totally absent during the summer.

Comparison to GCM predictions

The nadir SPICAM UV results are compared to the three-dimensional distribution of ozone computed by the

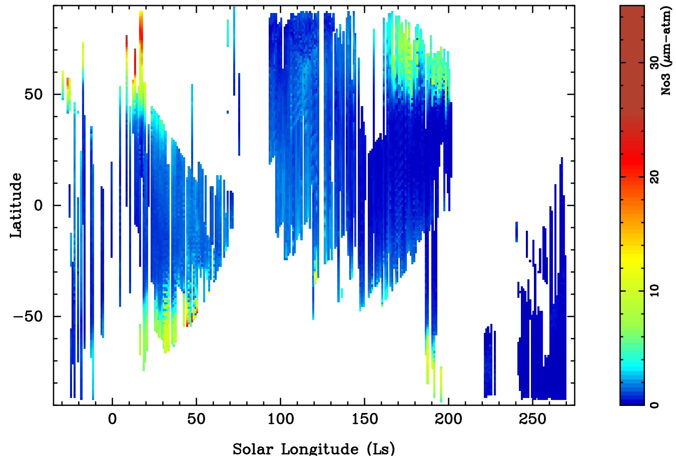

Figure 3: *Ozone column (µm-atm) as a function of latitude and solar longitude (L_s), from L_s=330° to 270°.*

General Circulation Model (GCM) described by *Lefevre at al, 2004*.

L_s=330-360°

In the northern hemisphere late winter, SPICAM observes very low O_3 columns at low and mid latitudes, and an increase at high latitudes with a large variability (maximum values in the 10-20 µm-atm range). This is qualitatively consistent with the model results, but the predicted quantities are substantially overestimated at latitudes higher than 20°. The ozone increase, which appears in the data in the 40°–50°N latitude range, begins at lower latitudes in the model (around 20°N). This may indicate that the seasonal decrease in polar ozone from mid- to late winter is not fast enough in the model. Alternately, an overestimation of the size of the polar vortex may also explain an increase in ozone which occurs at a latitude that is too low compared to the observations. Equatorward of 20°N, SPICAM observes small quantites of ozone, between 0 and 4 µm-atm. This is consistent with GCM simulations. In the southern Hemisphere, SPICAM detects no more than 2 µm-atm of ozone over the 330-360° L_s range, which is also constitent with GCM predictions.

L_s=0-90°

Figure 4 shows all the SPICAM observations performed during early spring, in the 0–18° L_s range. The comparison with GCM computations (solid lines) shows an excellent agreement at every north latitude. The strong increase in ozone observed at latitudes north of 40°N is now well in line with the GCM prediction, both in intensity and latitudinal position. This suggests that the size of the polar vortex and/or the distribution of water vapour is correctly simulated by the model at this time of the year. We note however a sharp variability of the

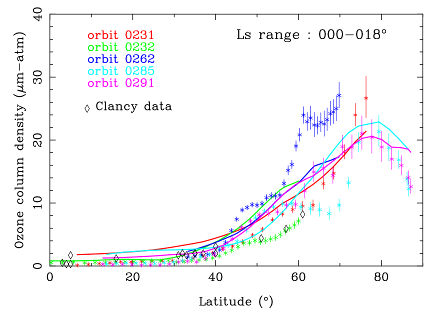

Figure 4: *Comparison between data (stars) and GCM (solid lines) for the 0–18° L_s range (early spring), in the northern hemisphere. The error on SPICAM ozone measurements is around 10%.*

O_3 column measured by SPICAM, similar to the model variability slightly earlier in the season.

In the southern hemisphere, a good agreement with GCM is obtained, expect when passing above Hellas Planitia, where GCM predicts two or three times more ozone than measured by SPICAM. This is also a place where dust opacity is important (0.6 inside Hellas), leading to a greater uncertainty over ozone values.

L_s=90-180°

During NH summer, the data indicate O_3 columns of the order of 1 µm-atm for northern hemisphere latitudes, from L_s=90° to L_s=160°. This is fully consistent with GCM, which predicts no more than 2 µm-atm of O_3 from LAT=-10 to 80°N. Ozone is detected at high latitudes of northern hemisphere, at the very end of summer (from L_s=160°). This is also well reproduced by GCM.

L_s=180-270°

There are no observations of northern Hemisphere between L_s=200° and 270°. In southern hemisphere , SPICAM observes less than 1 μm-atm of ozone at L_s=210°, and less than 0.5 μm-atm betwwen L_s=220° and 270°. The GCM predictions are consistent with these observations. Near the south pole, O_3 is rapidly decreasing at this season, as a result of the release of wator vapor from the receding south polar cap.

Comparison to SPICAM IR measurements

SPICAM UV/IR is the first instrument able to measure simaltaneously the vertical column density of ozone in the UV and O_2 emssion in the IR (at 1.27 μm), which is an indirect way to probe ozone above 20 km. SPICAM is also able to measure, simultaneously with ozone, the column density of water vapor in the near IR at 1.38 μm, yielding to the first global experimental correlation between H_2O and ozone distributions.

Conclusion

This work describes the analysis of nadir SPICAM/Mars Express UV data. The resulting dataset is the most complete ever obtained of the dayside ozone distribution in the martian atmosphere. The results are in general good agreement with the overall of aspects of the ozone behavior that is described by the chemical Global Circulation Model. However, a few differences exist between SPICAM data and this model, most of which possibly explained by the high variability of ozone on various scales of time and space. The model fails to reproduce O_3 column at northern late winter (L_s=330°–0°), but a good quantitative agreement is found during the aphelion period.