WATER VAPOR RETRIEVAL IN THE ATMOSPHERE OF MARS: RESULTS FROM THE OMEGA EXPERIMENT ONBOARD MARS EXPRESS

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Introduction:

The OMEGA imaging spectrometer mounted on the Mars Express spacecraft is well-suited to monitor the complex Martian water cycle. Thanks to its high spatial resolution, the seasonal, spatial and diurnal variability of atmospheric water can be analyzed both globally and on specific locations. Our retrievals during the Northern spring and summer well reproduce the seasonal behavior observed by previous instruments and predicted by models. We also analyze in more detail the behavior of water abundance on Olympus Mons.

The instrument:

OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces, at l'Activité) is a mapping spectrometer onboard Mars Express, whose aim is to acquire spectral maps of Mars in the visible and in the near-infrared [1] spectral ranges.

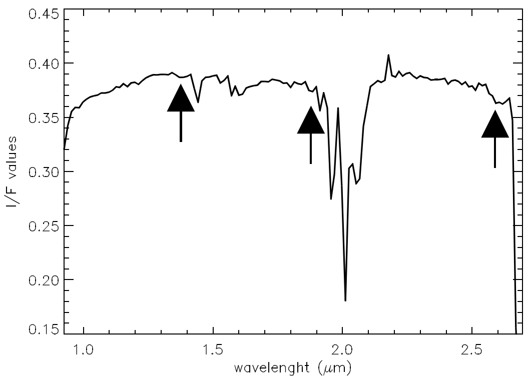

Figure 1: Example of the OMEGA spectrum (Short Wavelength channel) with the most relevant water bands at 1.38, 1.85 and 2.6 µm shown with the arrows.

OMEGA has an instantaneous field of view (IFOV) of 1.2 mrad, corresponding to a spatial resolution on the surface of ~ 300 m at periapsis and 1 – 2 km at medium elevation of the spacecraft, while the FOV varies from 16 to 128 IFOV, depending on the observing mode of the instrument. Its high signal-to-noise ratio (> 100) usually allows the analysis of individual spectra without the need of any averaging procedure, consenting to exploit fully the high spatial resolution of the instrument.

Aim and method:

We employ OMEGA observations to study the abundance of water vapor in the atmosphere of Mars. We use as diagnostics the 2.6 µm water band (see Figure 1), which is the most favorable in the OMEGA spectral range because it is stronger than the other bands and it is expected to be free of mineralogical features. Moreover, from our tests we saw that it is also the most sensitive to water amount, compared to the other water bands.

To retrieve the water abundance we fit our measured spectra with a synthetic one using mixing ratio of water vapor f_{H2O} as the only free parameter. In Figure 2 you see an example of our best-fits. We compute the synthetic spectra from the HITRAN 2004 spectroscopic database, using the temperature and pressure profiles extracted from the European Martian Climate Database (EMCD).

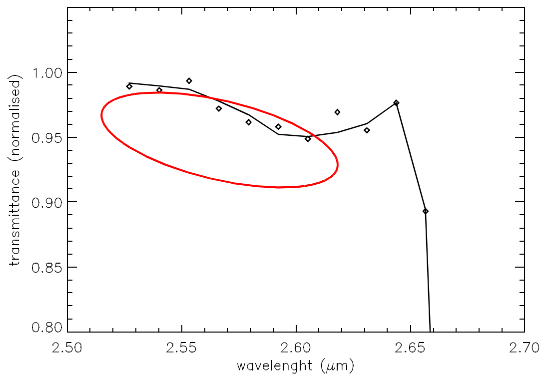

Figure 2: Example of best-fit of the 2.6 µm water band. We used for fitting only the seven points in the red oval, because the two points on the right wing of the band have some instrumental problems.

Results:

We retrieved the water vapor for several OMEGA orbits covering two different Martian seasons: around the northern spring equinox (Ls ~ 330 – 50), and during early northern summer (Ls ~ 90 – 140), as shown in Figure 3. The results show a dramatic increase of water exceeding 80 pr. µm at high latitudes of the northern hemisphere, during the summer and especially after Ls ~ 110. We can explain this behavior, known since the Viking measures in the late 1970s [2], by sublimation of water from the residual northern polar cap. During the spring equinox, on the contrary, the water vapor is much more uniformly distributed with latitude, with an average of 10 pr. µm.

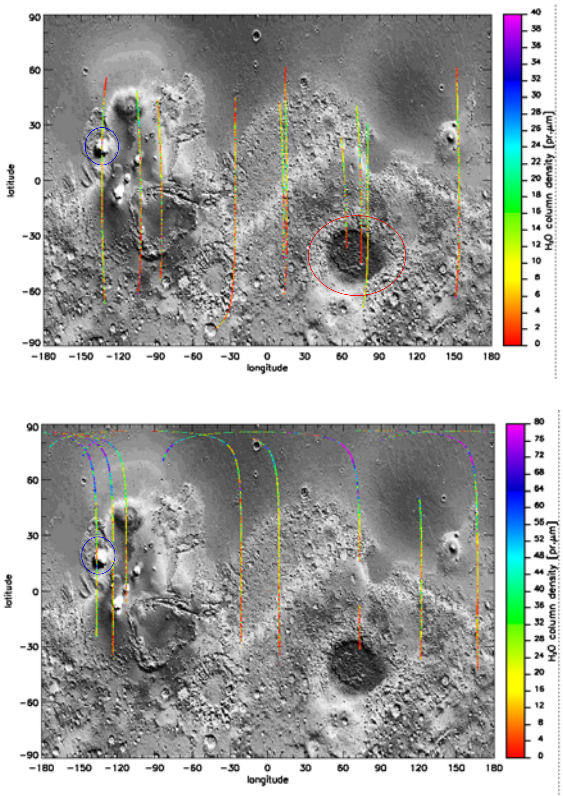

Figure 3: Maps of water vapor column density around the northern spring equinox (*top*) and in early northern summer (*bottom*) over the topographic map of Mars. The red oval marks Hellas Basin and the blue oval Olympus Mons. Note that the color scale is up to 40 pr. µm for the spring and to 80 pr. µm for the summer.

We notice however a correlation with surface morphology, in some regions. For example, in the Hellas basin the column density shows an evident decrease. Olympus Mons is another interesting case. In Figure 4 we show the water retrieval around the volcano for Orbit 37, which was acquired just before the northern spring equinox (L_s = 337.1°). Each cross is the best-fit on the average of 320 spectra (10 pixels along the latitudinal direction, 32 along the longitudinal one).

On the summit we find water mixing ratio almost 10 times higher than that at the bottom, resulting in almost constant column density throughout the mountain and its surroundings. Similar behavior of the atmospheric water on the flanks of Olympus Mons was first found in the ISM/Phobos-2 observations [4]. This result is in contrast with the usual assumption about small quantities of water vapor on the top of the volcanoes [5]. High values of the column density are retrieved also on the southern flank of Olympus during the summer.

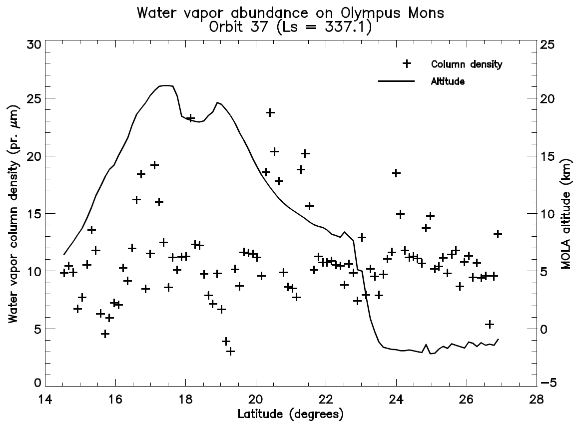

Figure 4: Retrieval of the water column density on Olympus Mons, averaged in latitude bins (*crosses*), with the altitude profile from MOLA (*solid line*). The column density is almost constant throughout the latitude range.

Conclusions:

Our first results of the water vapor retrieval in the northern spring and summer are in agreement with the current picture of the seasonal water cycle on Mars [3]. Moreover, some correlation between atmospheric water and surface morphology exists, at least in specific locations. Virtually constant H_2O column density retrieved on the slopes of Olympus Mons could indicate that water is not uniformly mixed but is rather confined to the surface.

Future work will include a more complete seasonal (and, eventually, diurnal) coverage through the analysis of other Mars Express orbits, and a more comprehensive study on the relation between water abundance and morphological features, particularly around the volcanoes.

References:

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[3]: Titov D., Adv. Space Res. 29, 183-191

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[5]: Encrenaz T., Melchiorri R., Fouchet T. et al., 2005, A&A 441, 9L