OMEGA/Mars Express: South Pole Region, water vapor daily variability

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The Martian Water cycle is one of the main cycles that controls the Martian atmosphere. Recent observations has shown a highly spatial and temporal variability (Fedorova et al. [1], Sprague et al. [2] and Encrenaz et al. [3]), specially concerning the Polar Regions (Melchiorri et al. [4]). It is not yet clear in which proportion these variability are locally produced or if they are redistributed dynamically in/by the atmosphere.

The water vapor abundance is strongly correlated to the temperature cycle, therefore a maximum during the day and a minimum at night time and in the early morning occur. It has been suggested that this is could be a signature of regolith "breathing" forced by the change in temperature (Titov [5]). Regolith-atmosphere water exchange was also proposed as a mechanism to explain water enhancement above Tharsis volcanoes observed by ISM/Phobos experiment (Titov et al. [6]).

Models have been developed to study the adsorption of water onto regolith grains (Zent et al. [7], Zent and Quinn [8] and Houben et al. [9]). In particular (Zent et al. [7]) used a basalt regolith model to show that daily 'breathing" of the regolith altered the column water vapor abundance by around 1 pr- μ m. But different materials could introduce a stronger effect.

Neverthless recent works ([10], [11] and [12]) show that models and observations are not in agreement and that other phenomena than regolith should be taken into account.

The water vapor is then an important factor in understanding the exchange of the atmosphere with the surface and subsurface reservoirs on several timescales as well as the transport of water within the atmosphere

Polar regions on Mars are the most suitable places to observe water vapor daily variability because in any observation crossing the Pole we can observe very different local time and because the poles are considered to be the main water reservoir of the planet.

We report on a daily variability of water vapor on the south pole region (SPR), observed by OMEGA/Mars Express during the south spring-summer period (LS$\sim$250° - 270°) outside the CO_2 ice cap, that has never been observed before by other instruments. We have been able to estimate an increase of few precipitable microns during the day.

A possible scenario includes the presence of regolith, or other component that could gather water from the atmosphere, adsorbing the water under the ground during the night time and desorbing it as soon as the sun reaches sufficient height to heat the ground. This hypothesis is even more plausible considering the presence of observed local enhancements in the morning sections associated with the illumination of the Sun and the total absence in the data of water ice.

Data analysis

The selected OMEGA data-set has been divided into three periods (LS=250°-259°, 260°-269° and 270°-279°).

Analyzing the data we may assume with a good approximation that inside the SPR (latitudes lower than -60°N) different regions have similar values of water vapor for same local time.

In Fig.2, 3 and 4 the daily variability of water vapor is shown compared to the albedo variability. In all the three periods albedo presents a slightly constant value over local time (with some small change in the early morning or late afternoon). Moreover in Fig 1 the water vapor has been plotted as a function of the incidence angle. Negative value of the angle indicate a morning value. It possible to observe that for all the three periods the water vapor value increases following the incidence angle from -90° to +90° (less evident for LS=270°). Which means that for equal values of incidence angle, in the morning and in the evening, we have different values of water vapor, which implies a non correlation, which implies that scattering is not a main protagonist of the daily variability.

The Water vapor values can be identified in three different groups:

1. values ranging between 0 and 15 ppt-μm
2. values around 30ppt-μm
3. values above 30 ppt-μm

The first group presents in the first two selected periods (LS=250° and 260°) a clear daily variability. We can

LS=250 **LS=260** **LS=270**

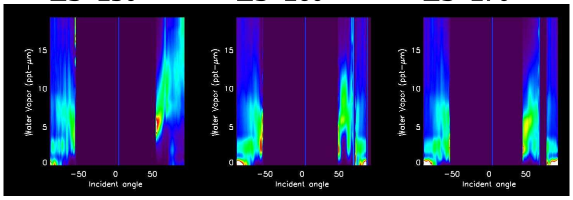


Figure 1: Water Vapor distribution over the incidence angle for the three LS= 250°,260° and 270°. Negative values indicate morning values. It is visible a constant increase of the water vapor in all the three images moving from -90° to +90° (more evident in LS=250° and less evident for LS=270°). This shows a non correlation between the water vapor variability and the incidence angle, which implies that scattering is not the main cause of the water vapor variability.

observe an increase of the water vapor from 5am (2ppt-μm)to 4pm (10ppt-μm). Moreover low values present in the early morning and in the late evening disappear between 5am (lower than 2ppt-μm) and 4pm (lower than 4ppt-μm). Concerning LS=270°, values seams to be more constant and spread which makes impossible to state if there is or not an increment of water vapor between 5am and 3pm, neverthless in the morning and in the evening there are only few values higher than few ppt-μm.

The second group seams to be correlated with regions close to the ice cap, but still ice free. This could implies that the ice cap is the main source of the H_2O in the atmosphere, even if water ice has not been detected on the surface of the ice cap. It is mainly constant and appears mostly in the middle of the day (7am - 1pm).

The third group should not be considered as water vapor. High water vapor detections (over 30 ppt-μm) have a good correlation with high albedo regions (50%-80%), which confirms the sensitivity of our water vapor retrieval method to the CO_2 ice.

Data outside the selected period (before LS=250° and after 270°) do not present strong evidence of a daily variability (as the one presented in this work), further studies will be conducted to determine if daily variability may occur (and can be detected) on the North Pole or in the equatorial region, too.

LS 250

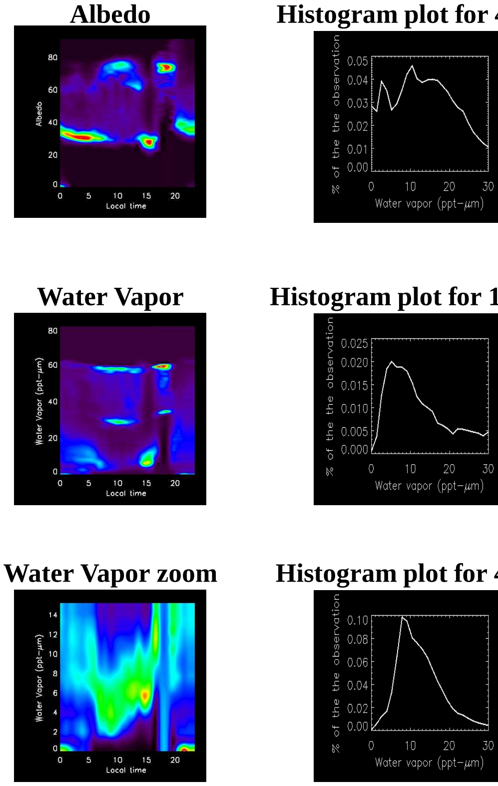
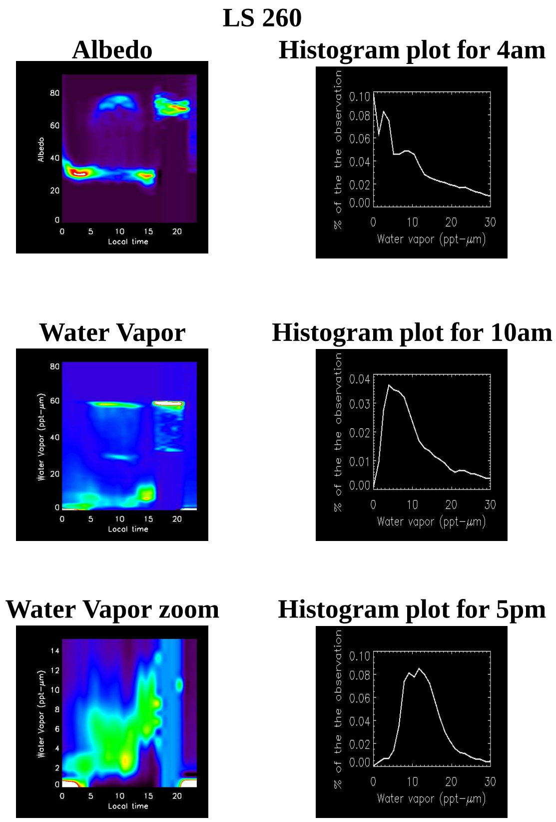


Figure 2: On the left: Water vapor and Albedo maps for the period LS=250°. Color table shows the ratio of how many observations per local time has a selected value; each of these values are divided by the total number of observations per each local time. On the right: Histograms of the water vapor distribution for selected local times (4am, 10am and 4pm). The albedo presents a constant value of 0.35, with a little decreasing slope with time (inside the error bar). Sligthly higher values after 8pm (~0.4) suggest the possible presence of ice on the ground, which, otherwise, has not been spectrally detected. The higher values from 7am to 1pm is due to the presence of the CO_2 ice present in the ice cap. Water Vapor can be divided in three groups: values ranging between 0 and 15 ppt-μm, values around 30ppt-μm and values above 30ppt-μm. The first group (between 5am and 4pm) increases and it is noticeable like values under 2 ppt-μm in the morning and then 4 ppt-μm in the afternoon are not detected, which is the case for the early morning and the late afternoon. The secong group seams to be correlated with the regions close to the CO_2 ice (but still free of ice), which may imply that ice cap is a main source of H_2O. The third group is a detection of CO_2 ice, these values should not be interpreted as Water Vapor. This group is higly correlated with high albedo regions (from 50% to 80%, due to ice), which confirm the sensitivity of our method to the CO_2 ice.



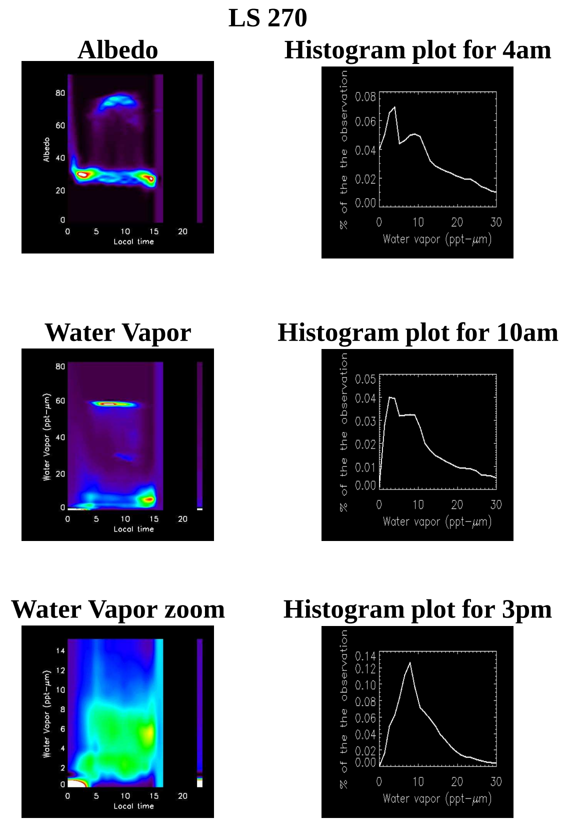


Figure 3: As for LS=250°, but data represent LS=260°. Histograms of the water vapor show selected local times (4am, 10am and 5pm). The albedo presents a constant value of 0.35; a small increase is detected in the morning (∼38%). The higher values from 7am to 12pm is due to the presence of the CO_2 ice, observations over the ice cap. Water Vapor second group (30ppt-μm) shows an increase for values between 4pm and 8pm, this should be taken very carefully because could be due to a very small contamination of CO_2.

Figure 4: As for LS=250°, but data represent LS=270°. Values range only between 12am to 4pm. The first group of water vapor (ranging between 0 to 15 pptμm) shows a quasi constant value over time (between 2am to 3pm). A small increase is visible (but under the error bar) between 1am to 3am. Low values are present only in the early morning (12pm - 4am).

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