# Mesospheric $CO_2$ clouds at Mars: 6 Martian years of survey by OMEGA/MEx.

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**Introduction:** Mesospheric clouds have been detected first from Earth (Bell et al 1996 [1]), then from Mars orbit (MGS/TES and MOC, Clancy et al 1998 [2]). Their composition (CO2) was inferred from temperature. Similar detection and temperature-inferred composition was then performed by SPICAM and PFS on board Mars Express (Montmessin et al., 2006 [3]; Formisano et al., 2006 [4]).

**Observations and results:** The first direct detection and characterization (altitude, composition, velocity) was performed by OMEGA/ Mars Express, further coupled to HRSC/ Mars Express, and confirmed by CRISM/MRO (Montmessin et al., 2007 [5]; Maattanen et al., 2010 [6]; Scholten et al., 2010 [7]; Vincendon et al., 2011 [8]).

OMEGA is very well suited to the study of these clouds as it enables the identification of their $CO_2$ composition, based on a diagnostic near-IR spectral feature located at 4.26 µm [5] (fig. 1 and 2) and 2.7 µm (fig. 3). The clouds are also observed through their high reflectivity in the VIS (shown at 0.5 µm on fig. 3), together with their shadows (fig. 4), which gives access to their altitude. The OMEGA survey so far extends from the very first operations of the mission, back in early 2004. Thanks to the highly eccentric polar orbit of Mars Express, OMEGA observes these clouds from a variety of altitudes (from > 10,000 km at apocenter, down < 500 km at pericenter), and at a variety of local times, at essentially all seasons, both in "nadir" and "limb" modes.

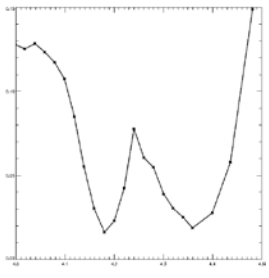


Figure 1: Cloud spectrum with 4.26 µm emission

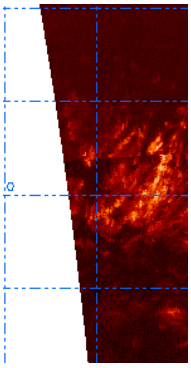
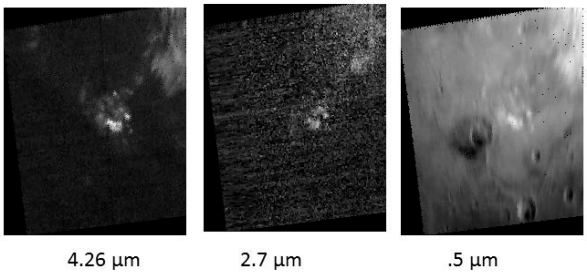


Figure 2: Cloud at 4.26 µm




Firgure 3: Cloud detection at 4.26 µm, 2.7 µm and .5 µm

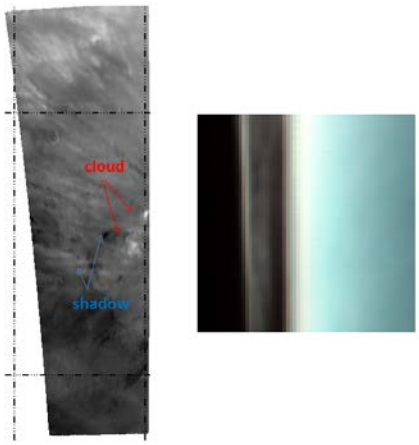
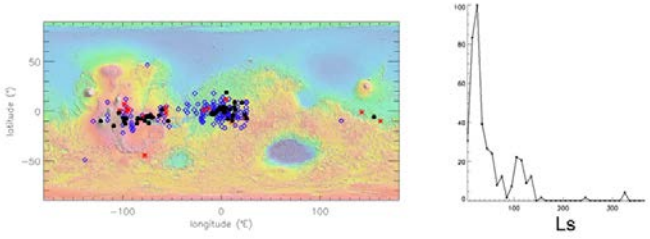



Figure 4: thanks to the shadow (left) and observation at limb (right), cloud altitude can be calculated (here ~70 kms).

Results over 6 Martian years of observations can now be plotted, with their spatial and temporal distributions (Figures 6 and 7). As a major feature, these $CO_2$ clouds appear at specific locations in space and and time (seasons), as exhibited in figures 6 and 7.




Figures 6 and 7 : Spatial and temporal distribution

These distributions correspond to the coldest mesospheric areas as deduced from the simulations of winds and temperature by the LMD/GCM ([9] , [10], [11]). The appearance of these clouds are also well correlated with the dust activity (fig. 8 and 9). However, some variations in their time of appearance/disappearance, from year to year, have been observed, and will be presented. In particular, clouds expected for Ls 20-50 did not show up, until now (Ls 130), although the dust season is comparable (MY 32) to MY31.

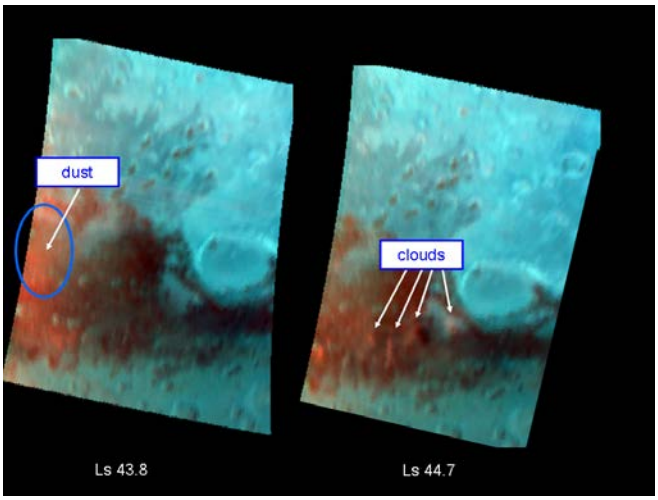



Figure 8: Clouds in RGB
MY 31, local time: 09:00, MEx altitude 7000 kms
3 days between the 2 observations

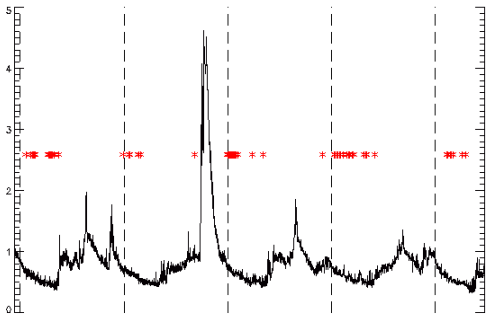


Figure 9 : comparison between atmospheric opacity (black) @ Opportunity (PanCam) and clouds appearance (red)

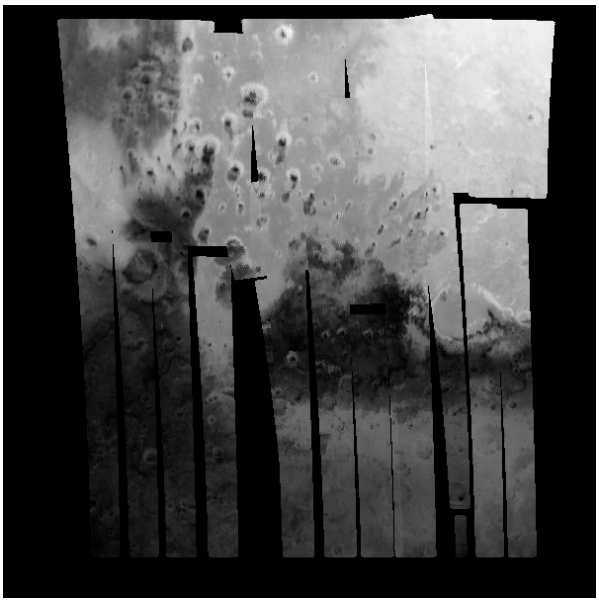


Figure 10: Coverage at Ls 110 (30W to 30E) during MY32. No cloud detected

Finally, it is noticeable that some mesospheric $H_2O$ clouds were observed by OMEGA, which will also be presented [8].

The discoveries and monitoring of the mesospheric $H_2O$ and $CO_2$ clouds, in their time and space location, give direct insights in the global atmospheric circulation and, beyond, on the physics of the upper Martian envelopes in their complex interactions

**References** [1] JF Bell. et al., *JGR 1996*; [2] RT Clancy et al., *GRL 1998* [3] F. Montmessin et al., *JGR 2006*; [4] V. Formisano et al., *Icarus 2006*; [5] F. Montmessin et al., *JGR 2007* [6] A. Määttänen et al., *Icarus 2010*; [7] F. Scholten et al., *PSS 2010*; [8] M. Vincendon et al., *JGR 2011*; [9] Gonzalez-Galino et al., *Icarus 2011*; [10] Spiga et al., *GRL 2012* [11] Määttänen et al., *this conference*.