

Mesospheric CO₂ 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 CO₂ 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.

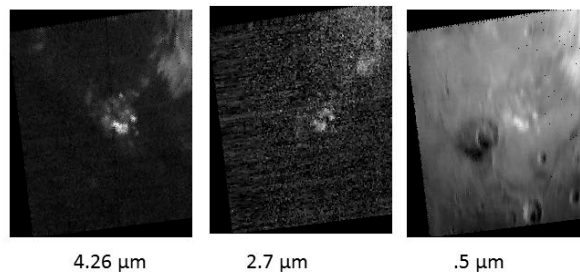


Figure 3: Cloud detection at 4.26 μm, 2.7 μm and .5 μm

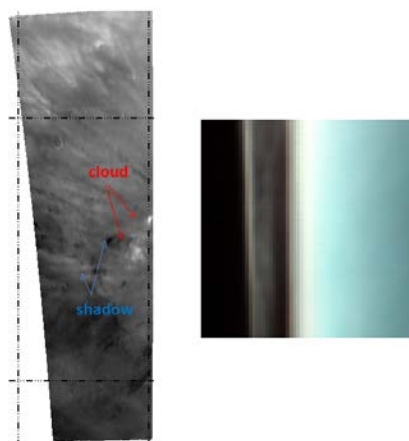


Figure 4: thanks to the shadow (left) and observation at limb (right), cloud altitude can be calculated (here ~70 kms).

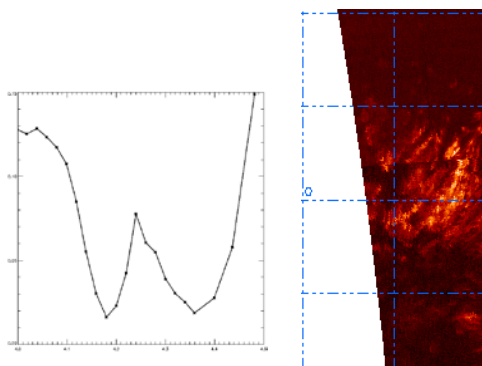
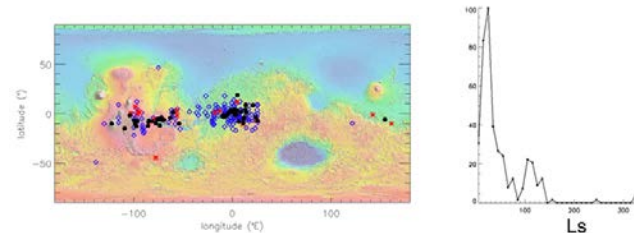


Figure 1: Cloud spectrum with 4.26 μm emission

Figure 2: Cloud at 4.26 μm

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 CO₂ 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

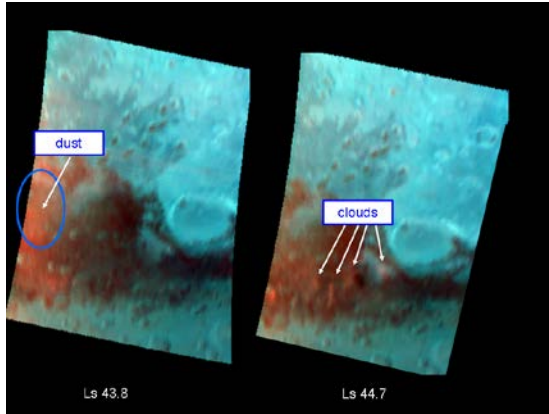


Figure 8: Clouds in RGB
MY 31, local time: 09:00, MEx altitude 7000 kms
3 days between the 2 observations

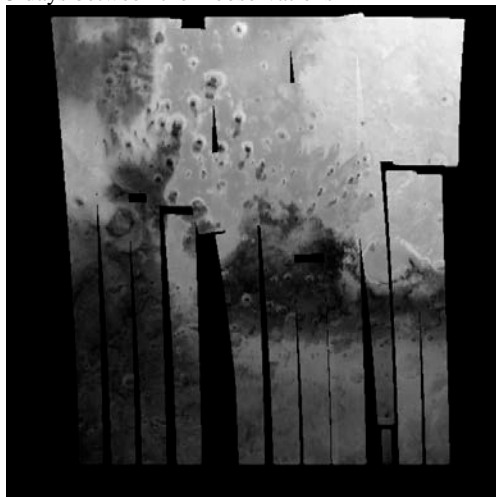


Figure 10: Coverage at Ls 110 (30W to 30E) during MY32. No cloud detected

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.

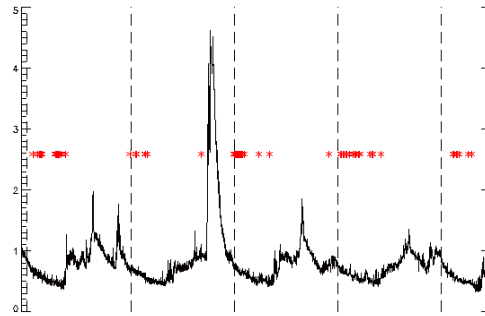


Figure 9: comparison between atmospheric opacity (black) @ Opportunity (PanCam) and clouds appearance (red)

Finally, it is noticeable that some mesospheric H₂O clouds were observed by OMEGA, which will also be presented [8].

The discoveries and monitoring of the mesospheric H₂O and CO₂ 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., *Mars8 conf.*