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# Climatology of Martian water ice clouds from Mars Express/OMEGA observations: derivations of the diurnal cycle

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## Abstract

Images derived from the slope of the water ice absorption band between 3.4 and 3.525 µ m from the OMEGA spectrometer onboard Mars Express have been used to detect clouds. From a series of OMEGA images covering 4 Martian years (between 2004 and 2011), the pixels are used to construct a cloud coverage database over a regular 4D grid in longitude, latitude, solar longitude and Martian local time. It can be used to observe the evolution of clouds over specific regions, and their diurnal and annual cycle. As an example, the diurnal cloud life cycle in the tropics (-25°S to 25°N) during the Northern summer shows the presence of thick clouds in the early morning (possibly haze), which dissipate before noon (local time). In the afternoon, the cloud cover grows again, possibly due to convection generated by the increased solar heating.

## 1. Introduction

Water ice clouds have been first observed from space in the 1970's (by Mariner and Viking spacecrafts), and more intensively in the 1990's, starting with the MGS mission. But due to their heliosynchronous orbits, most past and current Martian satellites have observed the planet only at a specific local time (LT) during the day (for example at 2pm and 2am LT for MGS) , and therefore cannot provide information about the daily cloud life cycle. In this study, we use OMEGA nadir data at different local times. This is possible due to the unusual Mars Express satellite orbit phasing, which induces a slow drift of the local time between consecutive orbits.

## 2. Methodology

Following preliminary work by Gondet et al. (e.g. [1]) using the 1.5 µm ice band, a study by Madeleine et al., (2012) [2] has shown the feasibility of extracting (water) ice clouds with an ice clouds index, a parameter derived from the depth of a water ice absorption band around 3.4 µm. After comparison with a threshold value, this IceCloudsIndex indicates if the pixel is cloudy or not (figure 1).

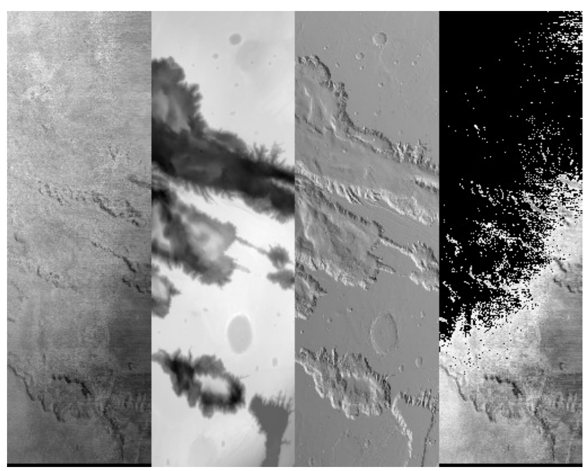

Figure 1 : OMEGA-derived images along a portion of an orbit. From left to right : IceCloudsIndex, MOLA elevation, incidence wrt. local normal, cloudy IceCloudsIndex (from dark gray : thick clouds, to white : thinnest clouds ; black : no cloud).

In a first step, the IceCloudsIndex is calculated and quality-checked for each pixel of all the nadir observing orbits, over a period covering four Martian years (MY 26 to 30).

In a second step a cloud climatology is constructed. The pixels are binned into two 4-dimensional arrays (cloudy and cloudy+non-cloudy) according to their longitude, latitude, solar longitude (Ls) and local time (LT). The bins have sizes of 1° in latitude and longitude, 5° in Ls and 1 (Martian) hour in LT. These arrays are sparsely populated (pixels come from 0 to 3 orbits per bin).

The cloud coverage of each bin is obtained by dividing the number of cloudy pixels in the first array by the number of all pixels in the corresponding bin in the second array.

In a third step, several 4D bins covering larger spatial areas and longer time periods are assembled in order to form 2D our 1D subsets showing temporal evolutions of clouds.

# 3. Observations and interpretation of results

In the preliminary global part of this study, the percentage of cloud coverage has been averaged temporally over all solar longitudes and local times (figure 2). It shows the almost complete spatial coverage of the planet by the OMEGA instrument, and the main areas where clouds form during the Martian year : the tropical area around Tharsis (in summer), the temperate regions at the edge of the polar hood in both hemispheres, the Hellas basin…

In the second part of this study, cloud percentages have been averaged over several geographic areas. On figure 3, all the percentages of cloudy pixels have been averaged over an area covering all longitudes, tropical latitudes between -25°S and 25°N, and over the Northern summer for Ls between 60 and 120°. This figure shows an important cloud coverage early in the morning (around 6am LT), possibly due to haze formed in the (late) night, a decrease of the cloud coverage resulting from solar heating in the late morning, and an increase again in the afternoon, possibly following the onset of convection.

# 4. Conclusion

OMEGA data, available at different local times of the Martian day can be used to investigate the diurnal cloud life cycle, over sufficiently large regions. The 4D cloud climatology will also constitute a data product for the validation of outputs from Martian climate models, such as the Martian Global Climate Model developed at LMD.

# References


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[2]. J.-B. Madeleine, F. Forget, A. Spiga, M. J. Wolff, F. Montmessin, M. Vincendon, D. Jouglet, B. Gondet, J.-P. Bibring, Y. Langevin, and B. Schmitt, 2012. Aphelion water-ice cloud mapping and property retrieval using the OMEGA imaging spectrometer onboard Mars Espress. Jnl. Geophys. Res., 117, E00J07.


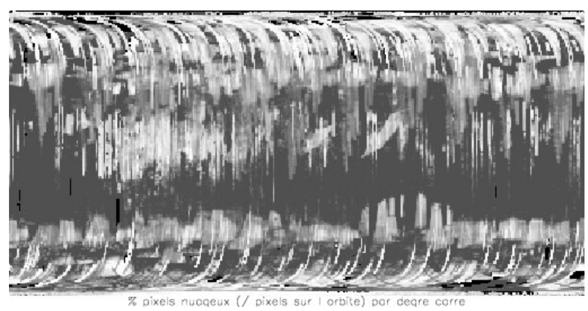


Figure 2 : global map of cloud cover percentage (black : absence of data ; dark grey : no cloud ; bright white : full (100 %) cloud cover) for all solar longitudes and local times, -180°W to 180°E longitude.

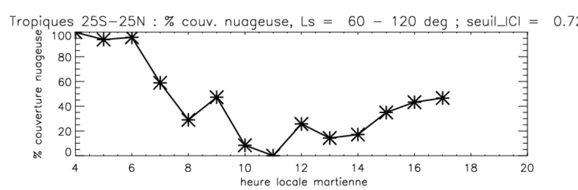


Figure 3 : percentage of cloud cover in the tropics [-25°S ; 25°N] for different local times, during Northern summer (Ls = [60°; 120°]), all longitudes.