HYDRATION OF THE MARTIAN SOUTHERN HEMISPHERE USING THE OMEGA DATASET. D. Jouglet, F. Poulet, Y. Langevin, J.P. Bibring, B. Gondet, M. Vincendon. Institut d'Astrophysique Spatiale, Université Paris-Sud, 91405 Orsay Cedex, France. Contact : denis.jouglet@ias.fr

Introduction: Surface hydration is one of the water reservoirs on Mars, aside ice at the poles, vapor in the atmosphere and sub-surface permafrost. This type of water reservoir is commonly known to be water adsorbed on the surface of minerals or confined inside them, water structurally bound to minerals and hydroxyl groups [e.g. 1,2,3]. The bending and stretching vibrations of water molecules in hydrated phases are responsible for a strong absorption band at 3 µm in reflectance spectra [4]. The visible / near infrared global mapping of Mars done by OMEGA [5] gives the first opportunity to study the global and detailed characteristics of this feature on the Martian surface. A previous study [1,6] based on the OMEGA nominally calibrated data (35 million spectra) provided the hydration of ~30% of the Martian surface. We now present the methods we developed to recalibrate a large part of the OMEGA non-nominal dataset (up to orbit 3050). This allows us to derive the hydration of the southern hemisphere that was very poorly covered by the previous analysis [1].

OMEGA data reduction: The OMEGA observations are released as the light flux (in Digital Numbers) received from Mars by the detector in the [0.3–5.1 µm] wavelength range. These raw data are calibrated to radiance emitted by the surface through the division by the OMEGA Modulation Transfer Function (MTF). Radiance spectra are then converted to albedo spectra through the division by the solar incident flux assuming Lambert's diffusion, the correction of the thermal emission (after an estimation of the surface brightness temperature at 5 µm) and the correction from the atmospheric absorptions [1].

Calibration of the non-nominal data: The measure of the OMEGA calibration level is performed at the beginning of each orbit through the acquisition of the spectrum of an included lamp, named the Response to the Calibration Lamp (RCL) [7]. The 3 µm absorption band is acquired by the OMEGA L channel ([2.5-5.1 µm]), for which [8] showed that the RCL exhibits strong variations with time. Only orbits 40-511 and 923-1224 are nominal, and the non-nominal orbits are mainly organized in calibration stable stages. [1] showed that the albedo spectra of the non-nominal data processed with the nominal MTF are not reliable for scientific purposes. A new MTF has therefore to be generated for each non-nominal calibration stage. The exact origin of the calibration variations being unknown, the new MTFs are generated thanks to an empirical methodology [8,9].

Our approach is based on the comparison of two OMEGA observations of a same area, acquired close in time, one observation taken at a nominal level and the other taken during a non-nominal calibration stage. The time proximity makes smaller the effects due to eventual variations of the surface composition and atmospheric conditions. The nominal radiance observation is modified to fit the solar insulation conditions and the thermal emission of the non-nominal observation. The division of the two radiance spectra is therefore assumed to be the ratio between the nominal MTF and an MTF adapted to this non-nominal calibration level. A new MTF is thus generated from this couple of pixels. This operation is performed for each couple of pixels of each couple of overlapping orbits having an observation during the non-nominal calibration stage. All the new MTFs are averaged to get a unique MTF for the stable calibration stage. This methodology was first applied in [8] to derive a new MTF for orbits 515-916; now five new MTFs have been derived for the calibration stable stages of orbits 1237-1500. Orbits beyond 1500 cannot be recalibrated by this way because their time gap with nominal data is too large. Another methodology is therefore compulsory as described below.

The five new MTFs enable us to derive a general law between the RCL and the MTF [9]. Since the RCL is known for each orbit, such a relationship can be used to recalibrate a large part of the OMEGA dataset. A power law is considered. Its free parameters are calculated for each wavelength element to fit the relationship between the six known MTFs (five non-nominal and one nominal) with their associated RCLs. New MTFs are thus generated for orbits up to 3050, which represents a surface coverage of ~70%. The new calibrated data mainly correspond to the southern hemisphere, during spring and summer, when frost is not covering the surface. The surface coverage is illustrated on Figure 1 with the projection of the averaged albedo of the south pole.

New results about hydration: The hydration strength is assessed on correctly calibrated albedo spectra through the Integrated Band Depth (IBD) between the 3 µm band and a linear continuum [1]. The IBD value is plotted for the southern hemisphere on Figure 2. We notice a significant increase of the hydration poleward ~60°S. The albedo also increases with the southern latitude (figure 1) but the borders of this increase are little correlated with the hydration. Moreover the southern hydration increase is greater than the usual albedo-hydration trend observed in the northern hemisphere by [1]. On figure 2 thinner red tracks close to the pole are superimposed to previous larger tracks. These thin tracks indicate a larger hydration than the former observations. Since they were acquired at lower solar incidence, the increase of hydration is likely due to a smaller pathlength through the aerosol layer. Note however that a temporal evolution as observed in the north [1] can also contribute to the increase of hydration. In any case, this confirms that the poleward hydration increase is due to the surface and not to the atmosphere.

In the southern hemisphere the increase of the 3 µm band is associated to an increase of the 1.9 µm hydration band beyond 60°S. [6,10] observed the same trends in the northern hemisphere. Notable difference between the two hemispheres is that the hydration values are generally higher in the north than in the south.

The GRS instrument aboard the Mars Odyssey probe observes the amount of hydrogen in the first meter of the Martian surface, assumed to be water [11]. GRS detected a strong increase of the water content beyond 60°N and beyond 60°S, which is best explained by the presence of permafrost in the sub-surface. As the OMEGA observations provide the hydration of the few top microns of the surface, the OMEGA/GRS correlation suggests a constant exchange between the subsurface and the atmosphere, enriching the surface hydration.

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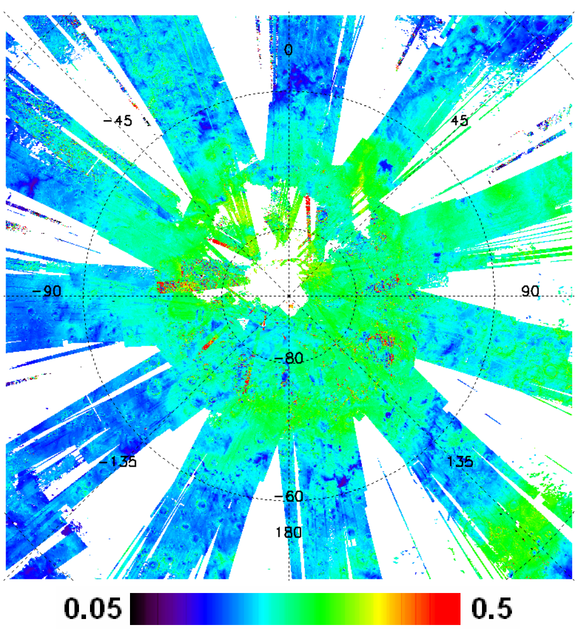

Figure 1 : Map of the mean albedo of the range [2.3-2.5 µm] over the Martian southern hemisphere. The dataset corresponds to orbits 40 to 3050 with adapted transfer functions. White areas: no available data.

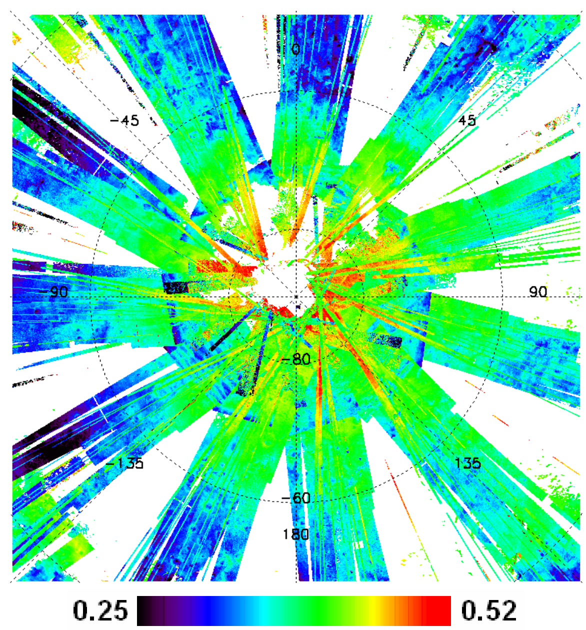

Figure 2 : Map of the 3 µm hydration feature estimated by the integrated band depth over the Martian southern hemisphere. The dataset corresponds to orbits 40 to 3050 with adapted transfer functions. White areas: no available data.