DOES INSOLATION CONTROL THE SEASONAL SOUTH CAP RECESSION OF MARS ?

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Introduction: According to some authors, different factors can explain the stability of both CO2 and H2O ices and the temporal evolution of the Seasonal South Polar Deposit (SSPC) during recession: insolation[1], albedo[1,2], slopes at small scale [3]. Other factors like: thermal inertia of the ground, cumulative thickness of the deposits at the end of winter or wind ablation can be relevant. We will discuss here only one question: to which extent insolation, albedo and roughness that are interrelated control the recession of the SSPC ?

Method: We propose to compare the SSPC recession observed by the imaging spectrometer OMEGA/MEX with computed isolation taking account relief and roughness and observed albedo.

OMEGA Observations. The SSPC has been observed by OMEGA between 2004-2006. See [4] for more details about the dataset and first results. We use both NIR channels C and L (1-5 microns). We use here the Wavanglet method: an automatic spectral identification algorithm based on a wavelet transform [5]. For this study, we use 4 spectral endmembers : 3 endmembers used in the latter reference (synthetic CO2 ice, synthetic H2O ice and observed dust) and one observed OMEGA spectrum of water ice clouds. The algorithm produces a detection mask for each endmember and for each observation included in the dataset of interest. We will focus here on CO2 ice only. Data are analyzed per 0.3° and 10° bins respectively by in latitude and in longitude. Along one latitude profile corresponding to a given central longitude, we extract two limits from those detection masks : 1. the outer limit of the SSPC : transition bin, closest to the equator, that contains a fraction of pixels with positive detection of CO2 ice between 0% and 1% - 2. the inner limit of the SSPC : transition bin, closest to the pole, that contains a fraction of pixels with positive detection of ice between 100% and 99%. For each observation and for each bin along a longitude, mean and standard deviation of the lambertian albedo at 1.012 microns are computed only for pixels that contains CO2 ices. This wavelength appears to be the best compromise to estimate the albedo[4].

Modeling of the insolation. Insolation is a sum of 3 terms: direct insolation, diffuse illumination by scattering of solar light from the atmosphere, and IR radiation from the atmosphere. The terms originating from the surface are neglected here. Based on the parameterization of the "instantaneous" insolation Q made by Kieffer [6] and adapted by [3], we compute the daily averaged radiation incoming at the local surface of mars using the integration method proposed by [7]. Roughness casts substantial shadows onto the surface that change the incoming flux on slopes. We use the fact that surface topography can be statistically described by a density function with scaling symmetry[3]. Such a description is introduced in the self shadowing function proposed by [8]. For the Martian terrain, we use a constant value of parameter H=0.8 in agreement with the average martian value and the local value estimated for the south polar region[3]. At the local scale, we integrate numerically the roughness-modulated insolation, using a Simpson scheme[9]., The resulting daily average radiation is computed from Ls=90° to 355° with a time step of 5°, using local slopes derived from MOLA data[10]. It is represented on south stereographic polar maps with a resolution of 920,8 m. Cumulative radiation is also calculated over the time interval [90°,Ls], Ls being the current Martian subsolar longitude.

Results: In our graphs, the SSPC limit follows a line, i.e. the regression front proceeds with a constant latitudinal velocity except in the cryptic region and at the Mountain of Mitchell. In the cryptic region, the recession accelerates after Ls=230°. The bright Mountain of Mitchell have an effect between Ls=250° to 280°. Longitudes between 320° to 330°, presented in figure 1, are representative of the constant recession velocity. Along the recession front the cumulative radiation at Ls=240° and at latitude 68°S is about 10,000 W.m-2, whereas at Ls=310° and latitude 86°S it increases by about 4 times. According to measurements made by Litvak[11], the ratio of accumulation of CO2 ice at those two latitudes is ~2. The recession did not follow the incoming radiation wave. Recession velocities of the inner/outer limits are not similar: sometimes very close in latitude (less than 2° at Ls=250°) and sometimes very far (more than 6° at Ls=260°) for central longitude 310°. Tails of the distribution of absorbed energy must control the differential of recession velocity. Recession velocities of the inner and outer limits must diverge when this energy is very different among the facets inside the bin. Absorbed energy is the combination of two factors : insolation and albedo. Width of the distribution (WOD) of absorbed energy is determined by WOD of insolation and/or albedo.

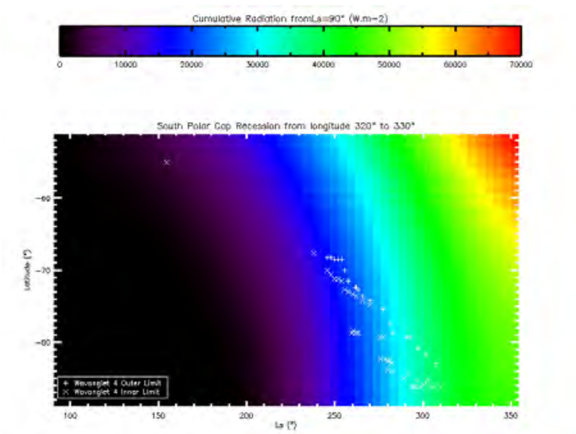

Figure 1: Points: SSPC Recession for longitude 320°-330° : inner limit (*), outer limit (+). Background: Cumulative Radiation from Ls=90°.

After Ls=220°, when the presence of H2O ice clouds/frost is negligible [4], the albedo at 1.012 microns is a good estimator of the Lambert albedo of the surface. We will use the ratio: Standard deviation divided by the Mean in %, as an indicator of the WOD. Comparing figure 2 and 3: time and space correlations between observed velocities and WOD of the insolation are small. On the other hand, both regions at latitude -78°S and -83°S with a relative high dispersion of albedo from Ls=220° to the end of the recession are correlated to the divergence of the defrost lines. The second argument is based on the relative WOD importance for albedo, compared to WOD of insolation modulated by the roughness. The previously defined ratio, indicator of the WOD, is less than 2% for the insolation and about 30% for the albedo.

Conclusion: The general pattern of the SSPC recession seems to be controlled by the cumulative insolation until Ls=250°. After, the recession velocity does not change despite the fact that the cumulative insolation increases. At second order, a more accurate model, estimating real energy balance, should correct it. First we need to estimate more realistically the bolometric albedo in visible and IR. Also we need to take into account the thermal outgoing radiation, controlled by surface temperature and pressure. Despite this fact, we can conclude that the local pattern of the recession is controlled by the distribution of albedo rather than by the distribution of insolation.

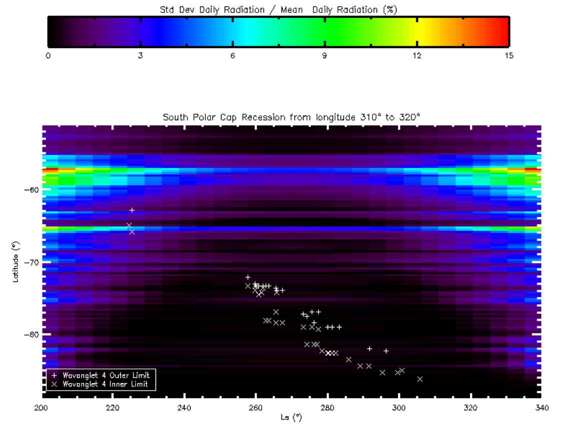

Figure 2: Points: Idem fig 1. Background: Standard deviation divided by Mean for the mean daily radiation.

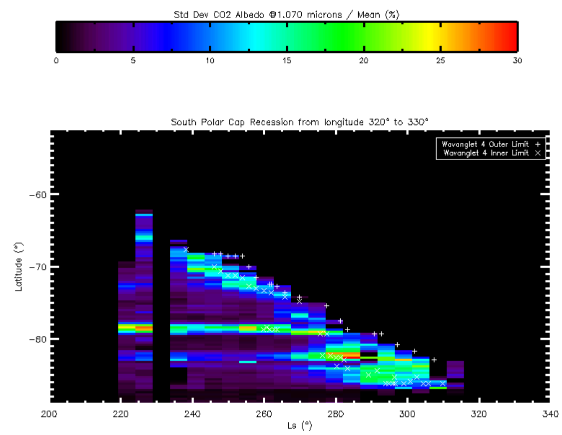

Figure 3: Points: Idem fig 1. Background: Standard deviation divided by Mean for the CO2 albedo in the continuum at 1.012 microns measured by OMEGA.

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