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Slab ice in the seasonal south polar cap of Mars

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Abstract

The cryptic region is a fascinating part of the seasonal south polar cap (SSPC) defined by a low albedo, the presence of CO_2 ice and the activity of the spiders [1, 2]. The exotic but generally accepted scheme of the CO_2 jets formed by sublimation beneath a translucent slab ice [3] has been challenged by OMEGA observation that showed that there is no slab ice in the cryptic region during the Martian year 27 [4]. We built a new spectral index, apply it to OMEGA observations for both Martian year 27 and 28 in order to follow the ice evolution and in particular the potential presence of slab ice.

Method

We used the Gaussian regularized SIR method [5], validated by a recent application on the Permanent South Polar Cap (PSPC) [6]. The methodology consists on (i) forward modelling of different spectra of granular and translucent CO_2 ice with varying depth, impurities of granular CO_2 and dust content [7]; (ii) obtain the best linear projection to estimate the depth of the translucent ice with the minimum contribution of other parameters (such impurities of granular CO_2 and dust content) and also estimate the functional relation between the linear projection and the actual slab ice depth; (iii) apply the linear projection and functional relation to estimate the "equivalent slab ice depth" to the actual data. The "equivalent slab ice depth" will not be interpreted as a real slab ice depth but more as a indicator of a large free mean path of photons in the CO_2. We will interpret a large value of this indicator as a high probability of the slab ice. Thus, we will refer to it as the "slab index". Interestingly, the slab index seems to be independent of the aerosols contribution since we obtain the same values with and without aerosols correction.

Results

Figures 1 to 4, present the slab index map for Ls = 170-180, Ls = 180-190, Ls = 220-230 and Ls = 260-270 for Martian year 27 and 28 when OMEGA observations are available. We defined the cryptic region as the South Polar Layered Deposits (SPLD), following previous geomorphology studies [2]. The first interesting results is that the slab index is always relatively low (below 16) for the cryptic region from Ls=170 (first direct light) to Ls=280 (end of the CO_2 ice cover). This should indicate that the CO_2 is never in a perfect translucent ice but rather covered by a dust layer or a granular CO_2 layer, as shown in previous analyses [4].
The PSPC is likely covered by a slab ice - slab index of 30 - early in Ls=180 but the free mean path is going down during the season - reach the value of 5. This behaviour cannot be explained by usual processes. There is a significant interannual change at Ls=220-230, as seen by the mismatch between Martian Year 27 and 28 strips.
The rest of the SSPC has a relative high value of the slab index in the border during the whole recession. There is a significant region in the quadrangle from latitude 75S to 85S, and from longitude 70W to 20W that evolve from a non-slab state at Ls=220-230, to a slab state at Ls=260-270. We interpret this evolution by the self cleaning [8] and/or metamorphism mechanism [9].

Conclusion

1.) We show that the SSPC texture is evolving with time. In particular, the increase of the free mean path until the slab state can be due to self cleaning and/or metamorphism. The decrease of the free mean path, could sign the effect of the jets that could add a layer of dust or granular CO_2 at the top of the slab ice.
2.) For the cryptic region, defined by the SPLD area, the slab ice state is never reached even the early spring. This may be an effect of the lack of spatial resolution of OMEGA or could also be a sign that non-solar energy source is responsible of the jets, subsurface heat wave for instance [10].
3.) The decrease of the mean free path of photons in the PSPC evolution from slab to granular is challenging the regular view of the seasonal frost because no

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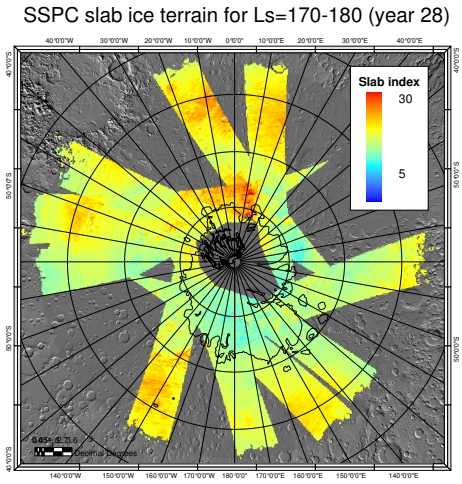

Figure 1: Slab index from 5 (minimum in blue) to 30 (maximum in red). The thick black lines represents the Permanent South Polar Cap (PSPC) and the South Polar Layered Deposits (SPLD). The blackground represents the shaded MOLA topography.

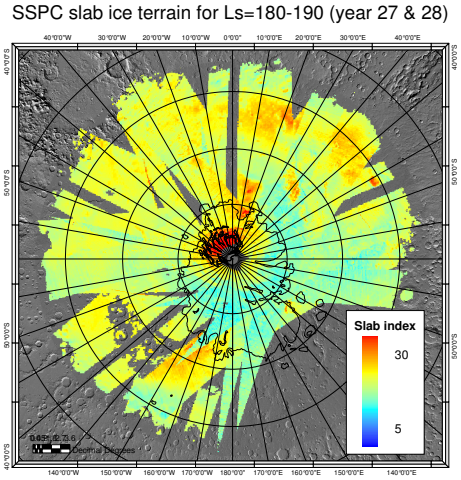

Figure 2: Idem that fig. 1 but for Ls=180-190.

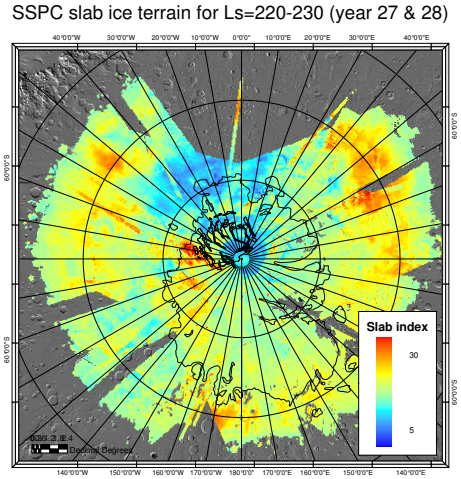

Figure 3: Idem that fig. 1 but for Ls=220-230.

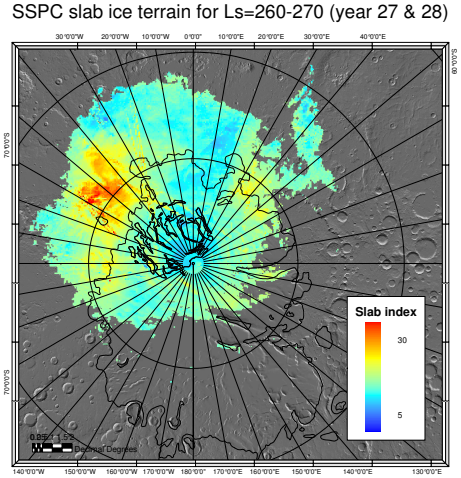

Figure 4: Idem that fig. 1 but for Ls=260-270.

spiders are observed there.

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