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Spectroscopic evidence for translucent CO_2 ice in Richardson crater

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Abstract

The Martian climate is mainly controlled by CO_2, as it represents 95% of the atmosphere. Understanding the behavior of surface/ atmosphere interactions is a major scientific issue. Here we focus on ices, and particularly on the physical structure of the seasonal CO_2 ice deposits, that is still a debating point. Ices show very different behaviors according to their structure. We propose in this study to determine if the CO_2 ice is translucent in Richardson crater. We use two radiative transfer models to simulate spectroscopic data corresponding to these two different structures. We then discuss the consistency of each hypothesis comparing them to actual data. The result is a strong evidence of slab structure for CO_2 ice, and thus the detection of translucent ice.

1. Introduction

The CO_2 ice condensation and sublimation cycle is the major climatic process on Mars. During the polar night, the CO_2 from the atmosphere condenses into seasonal ice caps, that sublimate during spring [1], triggering various processes, such as jets or flows [2]. The structure and the composition of these ices are keys to constrain the way they trigger one or an other seasonal process, and how fast they will sublimate. It is commonly accepted that the CO_2 ice deposits have a compact structure [3], but previous studies [4,5,6] have put forward contradictions and difficulties in the detection of translucent ices. Indeed, the behavior of the cryptic region and TES observations suggested a structural difference between cryptic region covered by slab and non-cryptic regions covered by granular ices [4]. Thermal emission models [5] seemed to confirm this, but NIR spectral observations and simulations concluded that cryptic region has an exceptional dust cover [6]. In this study, we compare the consistency of each structure (slab/granular) to the spectroscopic data, using two different radiative transfer models. The purpose is to look for spectroscopic evidences favoring one structure or the other.

2. Method

Model overview. We used an existing radiative transfer model for semi-infinite granular ices [7]. We also improved a two layer slab ice model [6]. The bidirectional reflectance of a slab can be described as the sum of specular and diffuse reflectance contributions. We model the specular reflectance using a realistic probability density function describing the surface roughness [8]. The diffuse reflectance of the slab is estimated considering the first optical path in the slab to be anisotropic, corresponding to a collimated solar irradiation.

Comparisons of the two models. We used an inversion method [8] on both models, using the same optical constants [9] and the same spectroscopic data.

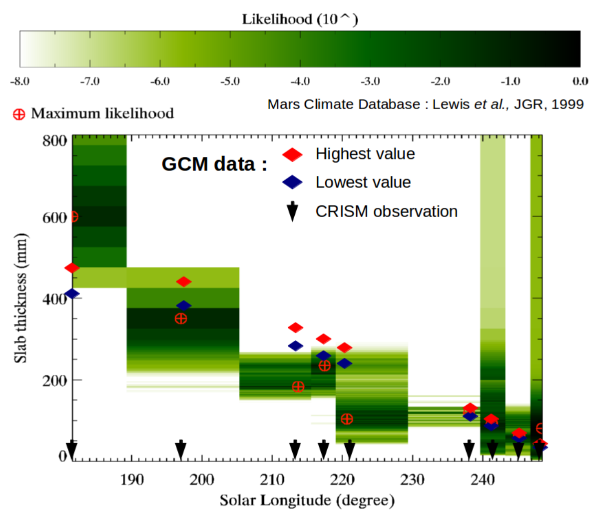

Figure 1: Preliminary result showing the evolution of the slab thickness throughout the local spring during

the Martian year 28 for all CRISM observations on the Richardson crater. The levels of green represent in log scale the likelihood of the thickness for a given observation, the maximum being marked with a circled red cross. The red and blue diamond represent the values predicted by the GCM [10]. There is a good agreement between the two sets of values.

3. Results

Agreement with the data. It is difficult to strictly compare two models that do not depend on the same parameters. Nevertheless, the best fits in both cases show a good agreement with the data. The data used was composed of CRISM spectra from Richardson Crater (72,0085°S/179,4218°E ; Ls from 180° to 250°). The residual errors for the granular and the slab models are the same order of magnitude. This criterion cannot be used in this case to favor one structure against the other.

Consistency of the results. The Figure 1 shows the evolution of the slab thickness through spring of a small area in Richardson Crater (72,0085°S/ 179,4218°E ; Ls from 180° to 250°), given by the inversion considering a compact CO_2 ice structure, and the ice thicknesses predicted by general circulation models [10]. The results are very consistent and suggest that the slab model is compatible with the data. To the contrary, the results given by the granular model suggest grain sizes for CO_2 ice always larger than *10* cm, that is very unrealistic for a granular media. These results are consistent with previous works [11].

4. Discussion and conclusions

The spectral agreement with the data cannot discriminate the two types of structures. Both compact and granular models are able to fit satisfactorily the data. Nevertheless, the granular model give results for the ice grain size that are not self consistent. A grain size that is the same order of magnitude that the expected thickness of the layer strongly suggests a compact structure. We consider this to be a strong evidence of the slab nature of the seasonal CO_2 ice deposits. As the diffusion of radiation in granular or slab media are very different, we cannot deduce an equivalent layer thickness from the grain sizes given by the granular model. The compact model is able to reproduce the data and seems to correctly extract the surface properties. We consider this to be a strong evidence of translucent CO_2 ice detection.

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