EPSC Abstracts
Vol. 8, EPSC2013-149, 2013
European Planetary Science Congress 2013

CO_2 ice state during active Dark Spot

F. Andrieu (1, 2), F. Schmidt (1, 2), S. Douté (3)

(1) Univ Paris-Sud, Laboratoire IDES, UMR8148, Orsay, F-91405; (2) CNRS, Orsay, F-91405; (3) Institut de Planétologie et d'Astrophysique de Grenoble, CNRS-Univ. Joseph Fourier, France
(francois.andrieu@u-psud.fr ; frederic.schmidt@u-psud.fr)

Abstract

MOC and HiRISE high-resolution images permitted the identification of various active seasonal processes such as cold CO_2 jets or dark flows [7] on Mars seasonal caps, triggered by the caps' seasonal variations [5]. The purpose of this work is to retrieve quantitative information about the CO_2 ice physical state, and its evolution, to constrain the active processes. To this end, we perform a radiative transfer inversion of CRISM near-infrared spectra before, during and after the event. After atmospheric gas and aerosols contributions correction [3], we use a radiative transfer model [2] that simulates reflectance spectra of granular icy material to create a look up table, and then a spectral inversion based on the likelihood that allows taking into account possible bias in atmospheric correction [1]. Using that inversion method, we are able to retrieve the spatial and temporal evolutions of various parameters of the icy surface.

1. Introduction

Various active processes occurring at high latitude during the local spring [4,5,7] have been described. One example is the phenomenon illustrated on Figure 1 : cold CO_2 jets through the ice layer, carrying dust from the regolith, and possible granular flows of the dust at the surface [4]. Even if it is a very local process (typical scale of a few hundred meters), its spatial concentration is high enough to decrease the albedo at a regional scale, impacting the global climate. Different processes have been proposed [4,8], but we still lack quantitative description based on spectroscopic evidences. CO_2 ice state and composition, evolutions during spring of the thickness of the layer and the water and dust contents are keys to constrain the physical processes. We chose to use a bayesian radiative transfer inversion method to retrieve quantitatively those properties.

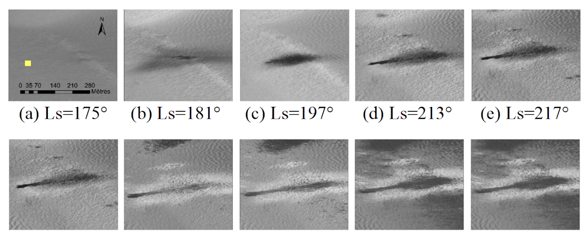
(a) Ls=175° (b) Ls=181° (c) Ls=197° (d) Ls=213° (e) Ls=217°
(f) Ls=220° (g) Ls=238° (h) Ls=241° (i) Ls=243° (j) Ls=248°

Figure 1 : *HiRISE image series of the evolution of a dark spot during spring, 72°S/179°E. An important ejection happened between (a) and (b), then the spatial extension of the spot decreases, (c) and a very slow flow appears (~meter per day), surrounded by a brighter halo (d) to (j). The yellow square in (a) shows the spatial extension of a CRISM pixel (20m × 20m).*

2. Method

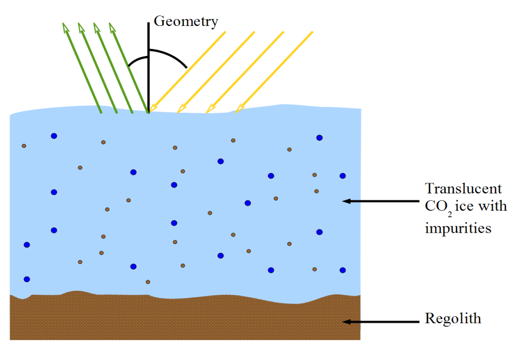

Figure 2 : Illustration of one possible scenario of the surface used for the direct model [4] : CO_2 slab ice layer, containing impurities. Free parameters : layer thickness, impurities (water ice and dust) proportions and grain sizes. The geometry used depends on the observation.

The first step is to select and correct the data. We used the CRISM [9] imaging spectrometer that gives a *20 m* resolution per pixel, each pixel containing the NIR spectrum of the surface. After the atmospheric gas and aerosols contributions are compensated [3], we can perform the inversion itself. This inversion consists in a two-step process : generation of a spectral library (lookup table), using a radiative transfer model [2], and comparison with the data. This method separates the sampling of the parameter space (direct model) and the comparison between the data and the direct model in calculation [1]. The results are interpreted in the bayesian framework, improving the computation cost of a Monte Carlo. The free parameters in the direct model are : the granular or slab nature of CO_2 ice, CO_2 ice grain size if granular, slab thickness if slab, and the proportions and grain sizes of impurities. Impurities are water ice and dust (see Figure 2 for an illustration).

3. Results and discussion

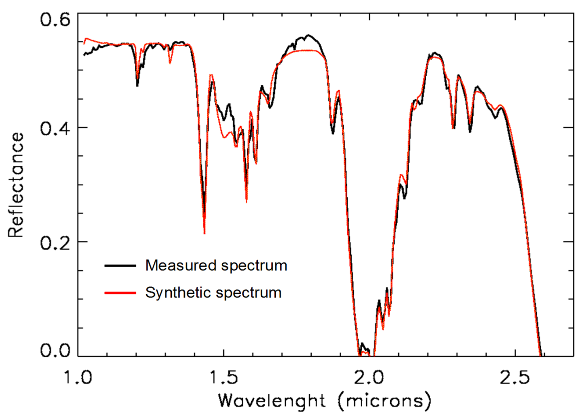

Figure 3 : *(Black) Measured spectrum in Richardson crater dune field (72,0085°S/179,4218°E) at Ls=217.5°. (Red) Synthetic spectrum of 35 mm thick CO_2 slab containing 2 ‰wt of 30 µm wide water ice grains and 0,1 ‰wt of 10 µm wide dust grains, over the regolith, given as the best match by the inversion.*

We used this method to follow the same CRISM pixels throughout the local spring, until the total sublimation of the seasonal ice layer. The preliminary results show good agreement of our look up table with the data (see Figure 3). Also the preliminary results about the CO_2 slab thickness as a function of time is decreasing as expected from general sublimation of the seasonal cap (figure 4). The Mars Climate Database [6] gives results of the same order of magnitude but always larger. That could be due to a local effect of slope.

4. Conclusion

These study shows that a quantitative estimation of the CO_2 ice state and its evolution during the local spring is possible, and the preliminary results about CO_2 thickness are consistent with the expected values. Other surface parameters shall be discussed in order to understand the dark spot active processes on Mars.

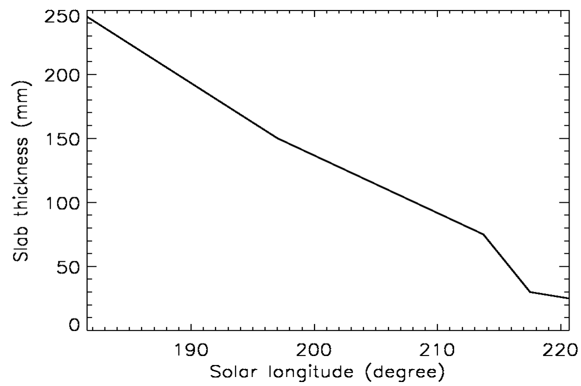

Figure 4 : *Preliminary results. Evolution of the slab thickness for one pixel (72,0085°S/179,4218°E) throughout the local spring. The local solar time when the data is taken is 16:00.*

References

[1] Andrieu, F.; Schmidt, F.; Douté, S.; Radiative tranfer inversion for hyperspectral data set on Mars, *EPSC, abstract submitted.*

[2] S. Douté and B. Schmitt, A multilayer bidirectional reflectance model for the analysis of planetary surface hyperspectral images at visible and near-infrared wavelengths, J. Geophys. Res., vol. 103, no. E13, pp. 3136731389, 1998.

[3] Doute´, S., E. Deforas, F. Schmidt, R. Oliva, and B. Schmitt (2007b), A comprehensive numerical package for the modeling of Mars hyperspectral images, Lunar Planet. Sci., XXXVIII, Abstract 1836.

[4] Kieffer, H. H.; Christensen, P. R. & Titus, T. N. CO2 jets formed by sublimation beneath translucent slab ice in Mars' seasonal south polar ice cap, *Nature,* 2006*, 442*, 793-796

[5] Leighton, R. B. & Murray, B. C. Behavior of Carbon Dioxide and Other Volatiles on Mars, *Science,* 1966, 153, 136-144

[6] Lewis, S. R.; Collins, M.; Read, P. L.; Forget, F.; Hourdin, F.; Fournier, R.; Hourdin, C.; Talagrand, O. & Huot, J.-P. A climate database for Mars, *J. of Geophys Res: Planets,* 1999*, 104*, 24177-24194

[7] Malin, M. C. & Edgett, K. S., Mars Global Surveyor Mars Orbiter Camera: Interplanetary cruise through primary mission, *J. Geophys. Res., AGU,* 2001*, 106*, 23429-23570

[8] Mohlmann, D. & Kereszturi, A. Viscous liquid film flow on dune slopes of Mars, *Icarus,* 2010*, 207*, 654-658

[9] Murchie *et al.,* Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on Mars Reconnaissance Orbiter (MRO) *J. Geophys. Res., AGU,* 2007*, 112*, E05S03-