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Effects of the CO_2 defrosting cycle at martian mid-latitudes

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Abstract

CO_2 seasonally condenses and defrosts at the surface of Mars which leads to the ejection of gas and materials leading to the formation of dark spots on top of the seasonal CO_2 layer. This process has been primarily described at the south polar regions where the process is more efficient. However, dark spots are also observed at lower latitudes, but little is known about the CO_2 defrosting process at those latitudes: is it the same process as those observed at the polar caps? what is the impact on the surface erosion? Are the defrosting features randomly distributed? We will present results at the global and local views in order to provide constraints on the effect of the current CO_2 defrosting cycle on the mid-latitude surface.

1. Introduction

A part of the atmospheric CO_2 alternately condenses in fall and winter forming the seasonal polar caps [1] and sublimates in spring when the insolation increases. The solar light penetrates the CO_2 slab and heats the regolith creating a basal sublimation. CO_2 gas and materials from the underlying regolith are then ejected leading to the formation of dark mineral dust spots and fans on top of the bright seasonal CO_2 layer [2, 3, 4]. The CO_2 defrosting process has a major impact on the surface erosion in polar regions, especially on the stratigraphic record [5] and the northern polar dunes [6, 7].

At lower latitudes, the CO_2 defrosting has been observed in many locations as for instance on dunes [6, 7, 8] and also on gully landforms [9, 10, 11, 12, 13] where basal sublimation may occur [14]. However, little is known on the current impact of the CO_2 defrosting process on the mid-latitude surface. Based on numerical modelings and combined with the observed temperature evolution, the dark material thickness on top of the CO_2 ice was estimated to range from a few hundreds of microns to a few millimeters at the polar regions [15]. Morphologic clues at the high spatial resolution scale should provide quantitative constraints on the surface evolution. This process may also has been an important process in the past Martian history when obliquity was higher allowing a seasonal CO_2 cap to extend up to 30° latitude.

2. Methodology and preliminary results

Thanks to the high resolution imaging science experiment (HiRISE) camera on-board Mars Reconnaissance Orbiter (MRO), high resolution images can be used to identify and to characterize the dark spots (e.g., size, morphology, density) but also the underlying materials (e.g., indurated or loose materials). This information is useful to evaluate the type of surfaces affected by CO_2 defrosting process.

Moreover, since 2006, the instrument has operated during 4 southern and 4 northern polar springs monitoring several sites on Mars which can be used to have constraints on the temporal evolution of these morphologies and the surface materials.

Previous detailed studies have already been conducted using monitoring and coupled HiRISE and compact reconnaissance imaging spectrometer for Mars (CRISM) observations at the south and north polar regions [e.g., 4, 16, 17, 18]. Those studies are used as supports for the characterization of the dark spots at lower latitudes in order to use same morphological classifications/terminologies and to evaluate the similarities and the differences in order to provide new constraints on the CO_2 defrosting process model [2, 3].

In this ongoing study, all the available HiRISE observations were studied to first localize regions driven by CO_2 defrosting by identifying potential dark spots which is considered as the result of the CO2 gas ejections. Our HiRISE survey gives an overview of the dark spot global occurrence at mid-latitudes. However, to due the narrow spatially and temporally covering of the HiRISE images, biases exist which do not imply that the process does not occur where HiRISE images are not acquired. Once identified, each site where dark spots are observed was classified as a function of its context and as a function of type of surface (e.g., dune, crater slope, permafrost). For instance in the HiRISE scene displayed in Figure 1 which has been acquired at Ls=172.6°, dark spots are observed inside a crater over pre-existing gullies in the walls of the crater as well as over sand dunes that are lying down the floor of the crater. We noticed that the dark spots in and around gullies are less well-developed and less numerous.

In addition to the global survey, several sites were studied in details in order to quantify the temporal evolution of the surface materials and the dark spots. The results of this ongoing study results will be presented during the conference.

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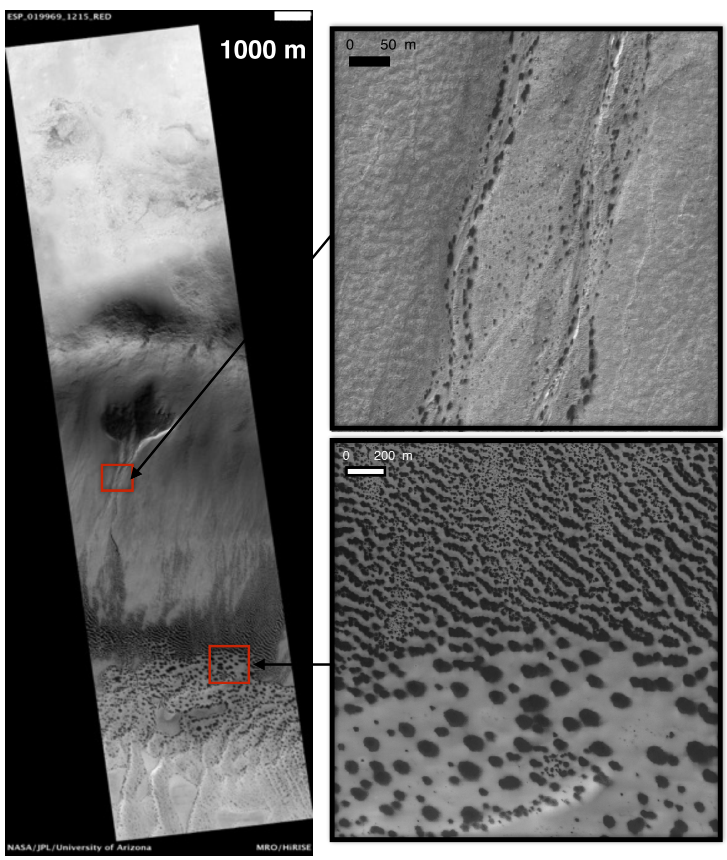

Figure 1: A HiRISE image (ESP_019969_1215_RED) and close-up located at lat. -50.378° and lon. 305.355° (Ls=172.6°, northern summer) showing dark spots in the crater slope associated with gullies and in granular sand dune inside the crater.