Season-dependent behavior of Dark Dune Spots on Mars. A. Kereszturi[1,2], A. Sik[1,2], A. Horvath[1,3], D. Reiss[4], R. Jaumann[4,5], and G.Neukum[5] ([1]Collegium Budapest, [2]Eotvos Lorand Univ. of Sciences., [3]Konkoly Observatory, Hungary, [4]Institute of Planetary Research, German Aerospace Center (DLR), [5]Dept. of Earth Sciences, Inst. of Geosciences, Freie Universität, Berlin, Germany; email: akos@colbud.hu)

Introduction: The origin and formation of strange seasonal patterns on frost-covered Martian polar terrain is a great enigma. Their latest grouping was given by [1] classifying them into spots, fans, blotches, and halos, where fans are analyzed in details by [2, 3] and probably formed by geyser-like activity [4]. In the analysis of defrosting structures, polar dunes are particularly interesting because they trap the frost for longer period than the surrounding terrain [5] and show gullies formed possibly by melting of ice recently [6]. The aim of our work is to correlate two kinds of spot appearance with surface temperature values in order to eliminate whether they could have formed by melting or not.

Methods: We have combined various datasets from HRSC (Mars Express), MOLA, MOC and TES (Mars Global Surveyor) to analyze the seasonal behavior of surface frost at a sample area on a 10 km diameter dune complex in an unnamed crater at 69°S 209°E. The temperature values were calculated form TES observations for various solar longitudes. Only those temperature values were considered as useful where the bolometric quality values for the lamp were zero and the emission angle bellow 3° (nearly nadir observation). The visual data is from MOC and HRSC observations. We analyzed the annual temperature changes based on only solar longitude, and did not take into account which year the measurement was realized. Our basic assumption is that the annual temperature changes follow the same trend in every Martian year. To compare the changes on dunes and on the surrounding crater floor surface we analyzed a region next to the dunes. The spatial resolution of TES data [7] is approximately 3 km and as a result individual data is useful to analyze the trends only.

Results: The areal distribution of 1071 TES data points (Fig. 1.) shows that the dune surfaces are relatively colder then the crater floor between Ls=270°–360°, and between 315°–360°. The reason for this could be the longer coverage of dunes by frost and/or the difference in the thermal behavior of dune material [8], caused by the presence or absence of cementing ice content in the shallow subsurface. Though more data is necessary for detailed conclusion.

We can identify two main stages of Dark Dune Spot (DDS) [9] development according to their appearance, temperature, and surface-covering ice (Fig. 2.). During the first phase (Ls=150°–200°) the surface temperature is constant around the freezing point of CO_2 at 145° K. In this phase fan-shaped dark albedo structures emanates from DDSs sometimes radially, sometimes into one or more preferred orientations, in accordance with the geyser model [4].

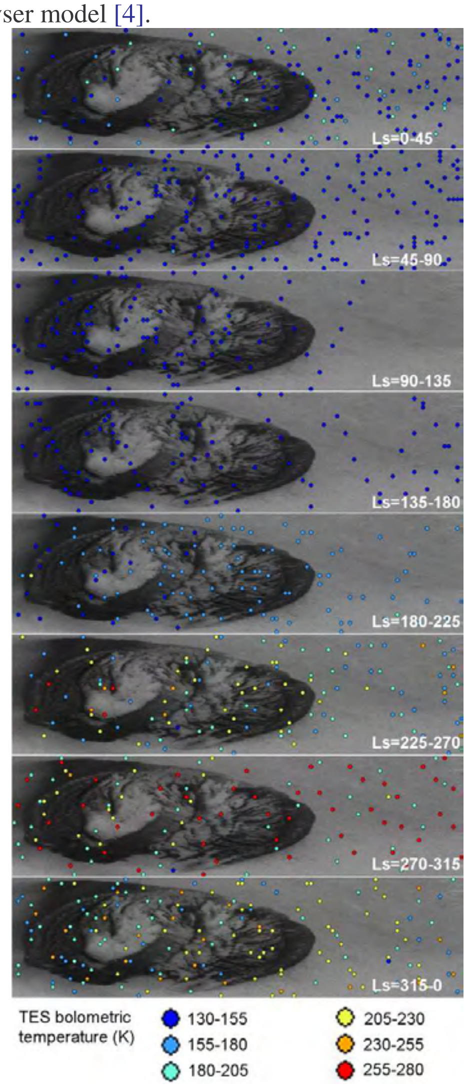

Figure 1.: The no. 2201 HRSC nadir image form Mars Express spacecraft of the dune (in the background) and the TES temperature values as colored dots for eight different Ls intervals

In the second phase (Ls=200°–250°) the temperature rises above the frost point of CO_2, therefore the surface can be mostly or purely covered by warming H_2O frost. During this phase the appearance of spots and the streaks emanating from them change and two kinds of features can be observed: diffuse streaks (showing fan-like appearance, but only in one direction) and confined streaks. The difference from the previous phase is probably related to the change of the ice-cover on the surface: from CO_2 to H_2O. Confined streaks on steep slopes somewhere show curved pattern and accumulation at their end (Fig. 2. 5, 6, 7 subsets). The last traces of surface frost on images are visible around Ls=238° when the daytime temperature is in the order of 200° K suggesting that the whitish frost is water ice. The above mentioned arguments suggest a layered structure of seasonal frost with H_2O ice below and CO_2 ice above, in agreement with the predictions of [9].

Conclusion: Based on the correlation of visual appearance and TES temperature data two stages can be identified in the evolution of Dark Dune Spots. 1.: fan-shaped streaks emanate from the spots is in agreement with the CO_2 geyser model based on temperature values. 2.: more confined spots and streaks are present when CO_2 only partly covers the surface or does not exist at all, suggesting layered structure of the seasonal frost: H_2O ice below the CO_2 ice.

As a result confined DDS-slope streaks are probably in connection with the frozen water-ice layer and not the CO_2. The most interesting question: could the streaks formed by liquid water/brine below the thin ice crust or not. Regarding the atmospheric pressure values, the dune it too height in elevation (700-1000 m), to have surface pressure above 6,11 mbar, required for pure liquid water. The pressure values varies in a year between 4,6 and 5,5 mbar there. Today it is known that strongly bonded adsorbed water [10] may form a very thin veneer on the surface of rocks on Mars and solid-state greenhouse effect [11] may also increase the temperature. But it is not clear, is the heat insulator capacity of the thin water ice layer enough to maintain liquid water on the grain surfaces or not. Simple computations mostly may show the heat insulator capacity is too low for this, but more sophisticated models has not been presented yet. It is possible that the volume decrease of the ice, melting may produce a thin water vapor layer between the liquid water and the covering water ice making inducing even lower heat conductivity to the full system. The possible presence of ephemeral seasonal liquid water on Mars is of high importance for any kind of possible life [9, 12, 13], but unfortunately the available data are not sufficient for firm conclusion yet.

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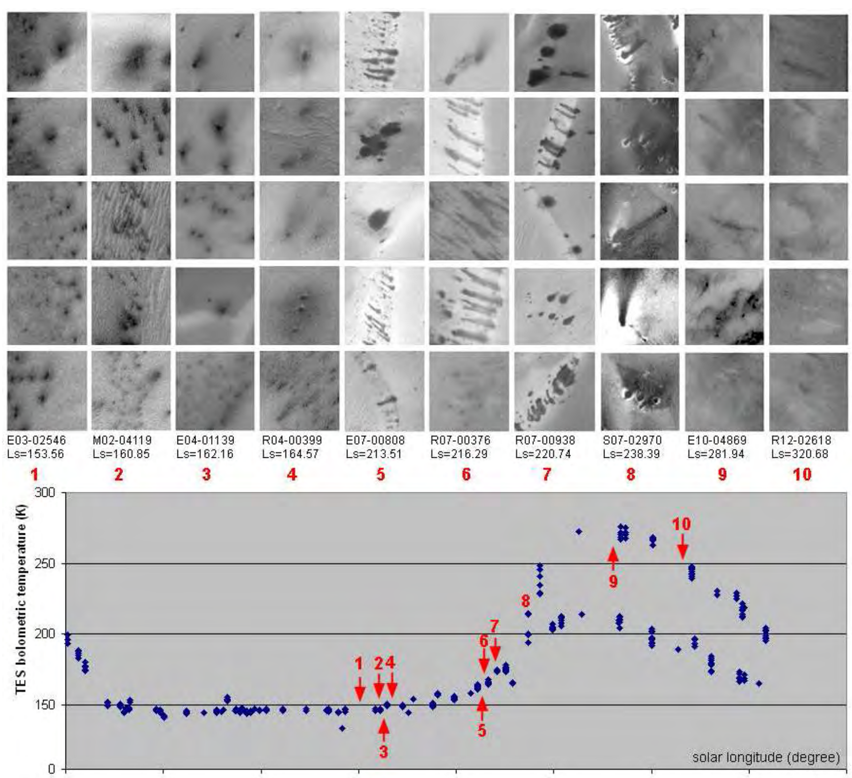

Figure 2.: The graph of TES temperature data (bottom) for different Ls values and 300x300 m insets of MOC images for different seasons with DDSs