DEBRIS FLOWS ON MARS: GLOBAL DISTRIBUTION AND THEIR CORRELATION TO PRESENT DAY MAXIMUM SURFACE PRESSURES AND TEMPERATURES.

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Introduction: The observation of debris flows in high resolution MGS–MOC images suggests that liquid water was involved in their formation in the recent past [1]. The fact that many debris flows on Mars start from the top of isolated peaks [2, 3] and from the crest of dunes [4, 5, 6] favors an origin by melting of near–surface ice by solar heating. The minimum requirements for pure liquid water are surface pressures above 6.1 mbar and temperatures above 273 K. Haberle et al. [7] tested the distribution of the debris flows against these minimum requirements using a general circulation model (GCM). They found no correlation mainly because of the low pressures in the southern hemisphere.

Methods: The surface pressure primarily depends on the topography. The 6.1 mbar pressure level on Mars occurs at a MOLA–topographic height of approximately –1600 m at L_S=0°, but varies by 1.5–2.5 km within a Martian year over this mean value [8] due to the annual CO_2 condensation–sublimation cycle [9]. Maximum surface pressures above 6.1 mbar can occur seasonally at MOLA topographic heights up to about 1000 m. Figure 1 shows a global MOLA–topographic map with a resolution at 1/128 degrees per pixel (463 m/pixel). Elevations lower as 1000 m are shaded in gray, higher elevations where 6.1 mbar are not reached are white.

To produce a global maximum ground temperature map we used the TES brightness temperature data [10]. Only brightness temperatures above 273 K and nadir measurements (<1°) were used. The temperature values were binned to a 12 km global grid using the maximum temperature value of each bin (Fig. 2).

Correlation with debris flows: We identified nearly 420 MOC–images (AB–M23) with debris flow features. The distribution of debris flows correlates well with areas of maximum surface pressures above 6.1 mbar (Fig. 1). Also in the southern hemisphere many local areas (mostly in craters) correlate with debris flows (a detailed statistical analysis is in preparation). These confined regions are in contrast to the GCM results [7], but explainable by the low horizontal resolution (7.5° x 9.0°) of the model and the high resolution MOLA–grid (1/128 degree). These regions at latitudes between 27°S to 65°S (except high southern latitudes >65°S) in the southern hemisphere also correlate with the maximum temperatures above 273 K (Fig. 2). The maximum pressures and temperatures in the southern hemisphere occur at the same time in spring/summer around L_S=270°. Liquid water is conceivable at southern latitudes between 27°S to 65°S in these confined areas.

At higher southern latitudes (>65°S) debris flows, which occur on slopes of pitted terrains, mostly correlate with regions of maximum pressures above 6.1 mbar. These areas do not reach the melting point of water. The low temperatures at these latitudes are in contrast to GCM–modeled maximum temperatures for these latitudes, which reach 273 K at latitudes up to about 75°S [7]. Possibly, there were no TES measurements at these latitudes in the southern summer where temperatures could probably reach 273 K.

Surface pressures in the northern hemisphere (>30°N) are mostly above 6.1 mbar during the entire year, but the maximum temperatures do not reach the melting point. Maximum temperatures at latitudes between 30°N to 60°N, where nearly all northern hemisphere debris flows occur, are in the range of ≈260 K to ≈270 K. These TES–brightness temperatures are in good agreement with the GCM–modeled temperatures of Haberle et al. [7]. An interesting point is that the debris flows in the northern hemisphere occur on the warmer equator–facing slopes (Fig. 3). Furthermore, the high–latitude debris flows (>65°S) in the southern hemisphere occur mostly either on the warmer equator–facing slopes or poleward–facing slopes (Fig. 3).

Conclusions: The distribution of debris flows correlates well with areas where the minimum requirements for transient liquid water in the southern hemisphere at latitudes between 27°S to 65°S are met. Most debris flows on Mars occur in these latitudes. A detailed global and regional statistical analysis is still in progress and will be presented at the conference.

Transient melting of water ice is possible under present day climatic conditions [11] and could explain the preservation of many fresh–appearing debris flows, for example in the Russell Crater dune field [6].

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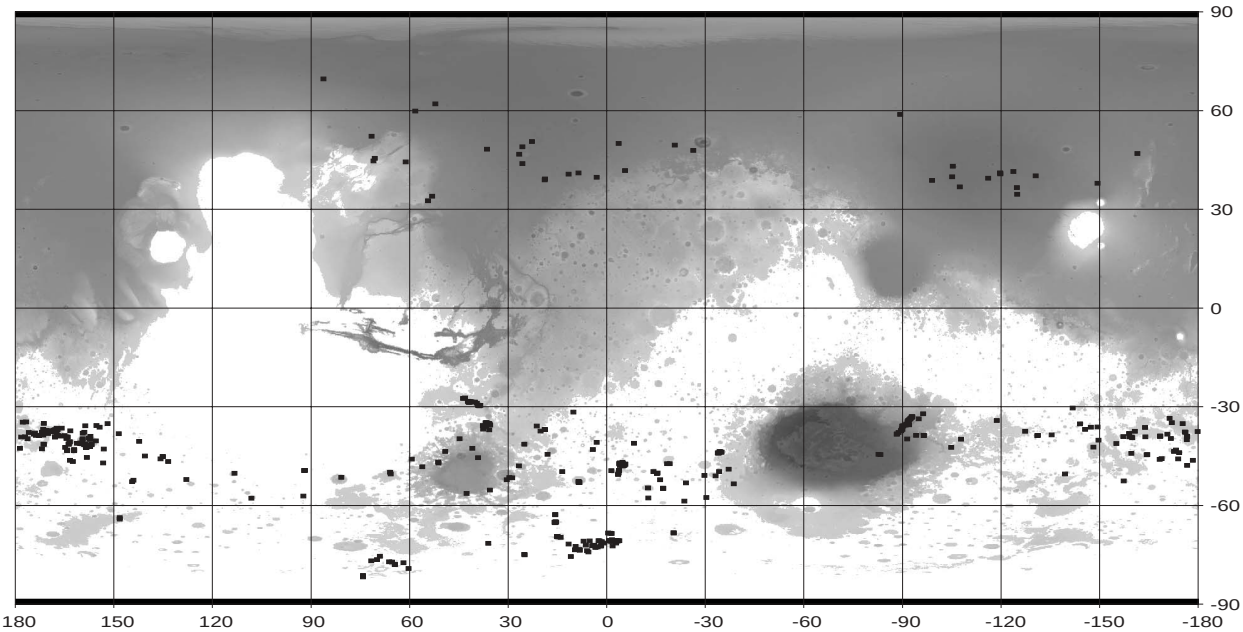

Figure 1. Global MOLA–based DTM. Grey areas show regions where pressures can reach 6.1 mbar. Darker regions are at lower elevations and therefore higher maximum surface pressures. Black squares show the location of debris flows.

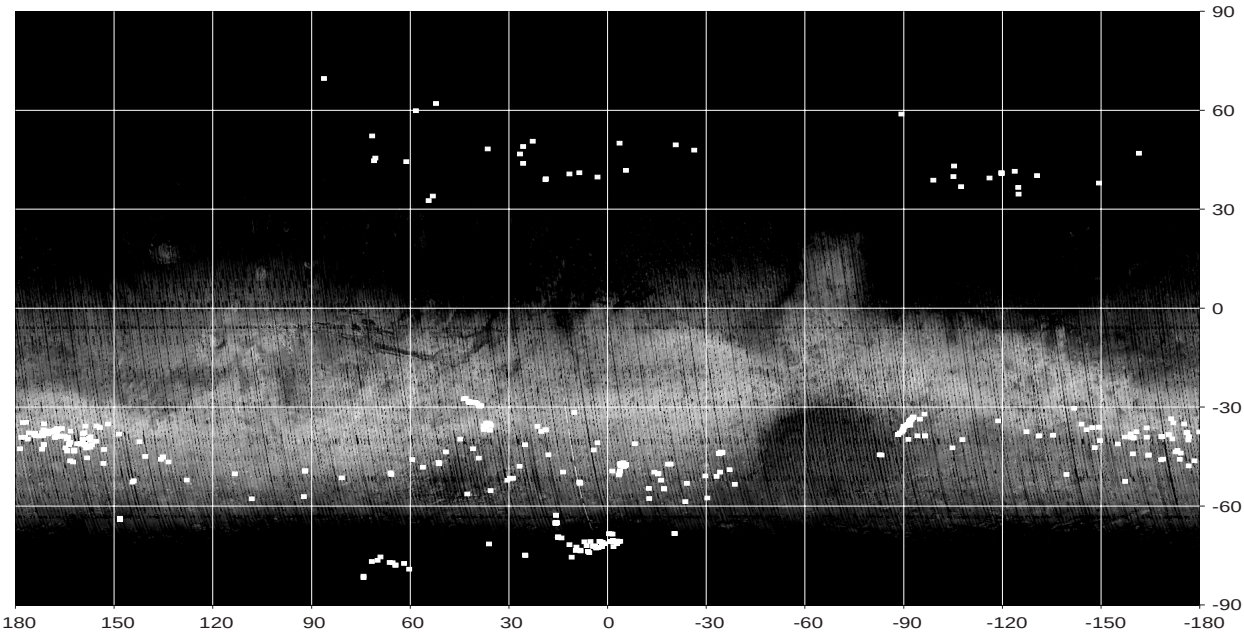

Figure 2. Global TES brightness temperature map. Only temperatures above 273 K are shown in grey. Brightest areas have temperatures up to around 300 K. White squares show the location of debris flows.

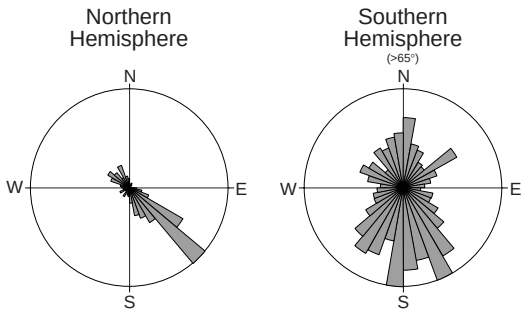

Figure 3. Orientation of individual debris flows in the northern and high latitude (>65°S) southern hemisphere. In contrast to the debris flows in the southern hemisphere at latitudes between 27°S to 65°S, which occur almost on the colder poleward–facing slopes, nearly all debris flows in the northern hemisphere occur on the warmer southeast–facing slopes. The high latitude debris flows mostly occur either on the warmer equator–facing or at poleward–facing slopes.