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Preferred orientations of Martian rock cracks through radiative transfer and geometric analyses

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Abstract

This abstract presents a study of rock crack orientation preferences across Mars stemming from differential insolation of v-shaped rock cracks of a variety of relative depths. This work uses a new extended radiative transfer model of Mars covering the 200-1000nm wavelength range at 10° intervals in Ls and planetary latitude. The outputs of this code are used as input to an original geometric algorithm to determine the most illuminated orientations of cracks as a function of position and season.

1. Introduction

Preferred orientations of rocks exist on Earth and have also been reported along the traverse of Mars Exploration Rover A (MER A, “Spirit", [1]). On Earth it was shown [3] that preferred orientations could be due to differential insolation received by the cracks due to self-shielding by their own geometry. This abstract extends this work to Mars to identify whether differential insolation could also play a role in detected Martian preferred orientations.

2. RT and Geometric algorithms

In this work, we use a combination of a radiative transfer code (Doubling and Adding, D&A, [2]) and an original geometric algorithm. The Martian atmosphere is modelled using the former code by extending the UV model of [4] so it covers the wavelength range 200-1000nm. The atmosphere was modelled for entire sols at 10° increments in planetary latitude and solar longitude. The geometric algorithm models the cracks as v-shaped and ranging from depth:width ratios of 1:1 to 4:1 with 10 degree increments in rotation clockwise from north. We identify the preferred orientations as those that receive the most energy, in contrast to works carried out on Earth, as moisture would require sufficient insolation to melt and thus be mobilised.

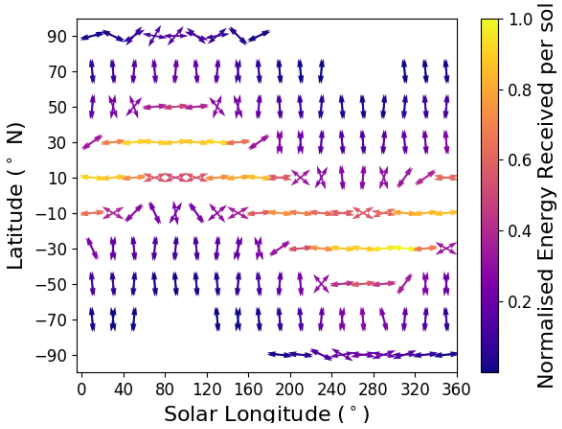
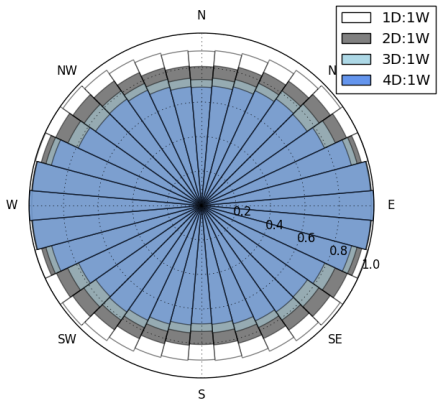


Figure 1: Primary and secondary orientations at 20° intervals in Ls (abscissa) and planetary latitude (ordinate). Colours indicate the relative amount of energy received by the bottom third of the cracks

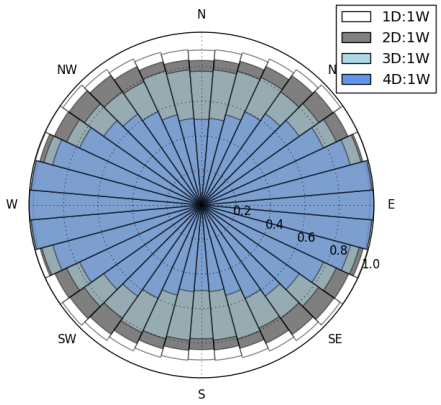
3. Whole Mars results

Across Mars, depending upon the latitude and Ls of a particular position, we identify three primary modes: an E-W mode most prominent around the equator, a N-S mode, most prominent at higher latitudes, and a cross-mode (NE-SW/NW-SE) which appears at the interface between the two other modes and becomes more significant for deeper cracks. The primary and secondary orientations of cracks with dimensions 2:1:5 (depth:width:length) is shown in Fig. 1. These, for ease of viewing, are shown only at every 20° in Ls and planetary latitude - for the full figure we refer you to [5].

With increasing crack depth in comparison to crack width, we observe a decrease in the region of E-W mode dominance, and an associated increase in the width of the region where cross-modes are dominant. There is a slight increase in the size of the region where N-S modes are dominant, but this is a much less



(a) No minimum energy threshold.



(b) With minimum energy threshold.

Figure 2: Normalised insolation received by cracks with depth:width:length ratios of 1:1:5 and 4:1:5 at -10° N over the whole Martian year.

significant effect than with the cross-mode region.

4. Spirit Site

Spirit's landing site (Gusev Crater) is found at -14.7° N, 175.5°E. Using our Full Mars Model, extracted at the nearest grid point, shows differential insolation would result in a general E-W mode for shallow cracks, leading up to a cross-mode for the deepest cracks, as shown in Fig. 2(a). Requiring a minimum threshold of energy to allow cracks to propagate in a given direction (equal to the amount of energy required to melt a 0.5mm layer of water ice) increases the prominence of the cross mode and reduces the offset from North of the primary cross mode's orientation (Fig. 2(b)).

[1] report preferred orientations of $46° \pm 20°$ (offset from North). The cross modes of our results in the NE-SW direction are in agreement with the upper limit of [1], but in order to get only one of these two modes visible, crack growth would need to be diurnally restricted.

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