RSL GEOSTATISTICS SHOW SLOPES ABOVE THE ANGLE OF REPOSE AND SIGNIFICANT ENHANCEMENT AFTER MARS YEAR 34 DUST STORM. D. E. Stillman (dstillman@boulder.swri.edu)[1], K. M. Primm[2], B. Bue[3], K. L. Wagstaff[3], J. H. Lee[3], A. Ansar[3], [1]Dept. of Space Studies, Southwest Research Institute, 1050 Walnut St. #300, Boulder, CO 80302. [2]Planetary Science Institute, Tucson, AZ. [3]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109.

Introduction: Recurring Slope Lineae (RSL) are seasonal dark features that occur on relatively low-albedo steep slopes [1-4]. While hundreds of RSL sites have been observed via multiple HiRISE [5] observations, only a handful of sites have been quantitatively evaluated [6-7]. We found that the vast majority of starting and stopping slopes are greater than the angle of repose at Garni crater (11.5°S, 290.3°E), Krupac crater (7.8°S, 86.0°E), and Rauna crater (35.3°N, 327.9°E). In this work, we determined that S- and SW-facing slopes at Krupac crater increased in area by a factor of ~6 shortly after the Mars Year (MY) 34 dust storm abated. Our mapping is consistent with a dry RSL formation mechanism, however the details of such a dry mechanism remain elusive.

Methodology: Each RSL at Rauna and Krupac crater was mapped manually using publicly available orthorectified images (orthoimages) and Digital Elevation Maps (DEM) (**Table 1**). All RSL in Rauna crater were mapped, while only RSL in the northeast portion (>–7.763°N) of Krupac crater were mapped. This captured all S-facing RSL and likely most of the SW-facing RSL at Krupac crater. We also used the Garni crater RSL database previously published [7], in which all RSL were mapped.

Table 1. Number of RSL mapped at each site over a range of orthoimages.

Site	Range	Number of orthoimages	Number of RSL
Rauna	MY 31 L_s 135° – MY 32 L_s 343°	23	2,938
Krupac	MY 32 L_s 98° – MY 34 L_s 324°	29	1,658
Garni	MY 31 L_s 133° – MY 32 L_s 324°	22	2,910

Once the RSL were outlined, we gathered geostatistics on the length, area, orientation, mean slope, starting slope, and stopping slope on each RSL. The RSL geostatistics are based on the 1.01m resolution DEM. We applied a bilateral filter with a 9x9 pixel kernel to the DEM to reduce the impact of local artifacts prior to computing a slope map [8]. We measured the total darkened area for the set of RSL outlined in each orthoimage, as well as the newly darkened rate (m^2/sol) and fading rate (m^2/sol).

Slope: The Rauna and Krupac slope measurements show that few slopes occur below the assumed angle of repose of 28° on Mars [10-11]. Thus, our results are consistent with other findings of 151 individual mean slopes over 10 RSL sites [11] and numerous RSL slopes mapped at Tivat crater (45°S, 190°E) [6]. However, the results are inconsistent with those of *Tebolt et al.* [12], who found an even larger range of slopes at 16 locations. Further investigation of the *Tebolt et al.* [12] RSL picks shows that some picks are likely not RSL, but instead shadows that imitate RSL. However, we do agree with *Tebolt et al.* [12] that much of the range in the slope histograms (**Fig. 1**) is due to artifacts in the DEM. Additionally, our starting and stopping slopes indicate that starting slopes on average are higher and near the static angle of repose, while the stopping slopes are greater than the dynamic angle of repose (**Fig. 1**).

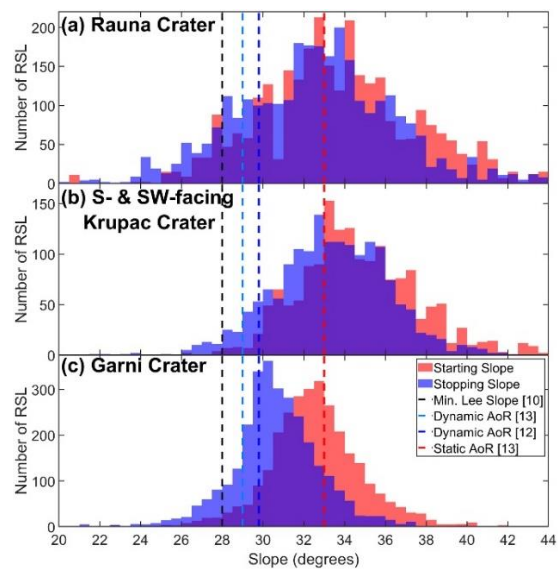

Fig 1. Histogram of starting and ending slopes of RSL at **(a)** Rauna, **(b)** Krupac, and **(c)** Garni crater. The majority of the stopping slopes are above 28°, which is lower than the minimum lee slope [10]. The mean of the starting slopes is similar to the 33° static angle of repose (abbreviated to AoR in the legend) [13]. Additionally, the mean of the stopping slope is similar to the 29° and 29.8° dynamic AoR [12-13], respectively. Overall, starting slopes appear to be greater than stopping slopes and that the majority of slopes are greater than the dynamic AoR.

Dust Storm: The Krupac crater mapping shows a factor of ~6 increase in total darkened area after the MY 34 dust storm for S-facing RSL compared to MY 32 (**Fig. 2**). Like Garni, the unmapped W- and NW-facing slopes of Krupac crater also have significant RSL activity right after the dust storm when they would typically have no activity.

Discussion: The motivation of this mapping is to provide more quantitative data for RSL mechanism modeling. At the three mapped sites, the RSL geostatistics are consistent with a dry RSL mechanism [16]. However, more work is needed to determine a dry RSL mechanism that can fit the observations. Recently [15], we discussed atmospheric mesoscale modeling results that did not support the leading dry mechanism [16]. Thus, we currently speculate that sand may be blown into the craters via downsloping winds. Such sand is trapped in wind shadows near the bedrock-regolith interface. Once these traps build up to a slope larger than the static angle of repose they fail, producing grainflows that remove the bright dust from the surface. Downsloping wind gusts that are most probable in warmer temperatures then help to trigger grain flows. RSL are also more numerous after dust storms because these dust storms likely move sand around and recharge many RSL source zones. Additionally, these dust storms deposit a thin veneer of dust that allow RSL to be mapped much more easily, but that also cause higher surface temperatures (dust has a low thermal conductivity) and thus more turbulence, which could make the wind field more turbulent with a higher probability of gusts that can exceed the fluid threshold needed to start saltation.

Conclusion: Detailed mapping of thousands of RSL quantitatively demonstrate the importance of steep (above angle of repose) slopes and the enhancement of RSL activity after dust storms. The majority of these observations are consistent with a dry mechanism. However, additional modeling is needed to determine the exact dry mechanism. Meanwhile, we intend to map additional RSL sites and evaluate additional geostatistical parameters to look for other consistent patterns. Additionally, we are investigating processes to create DEMs that create far fewer artifacts to ensure any low slope values are indeed due to artifacts.

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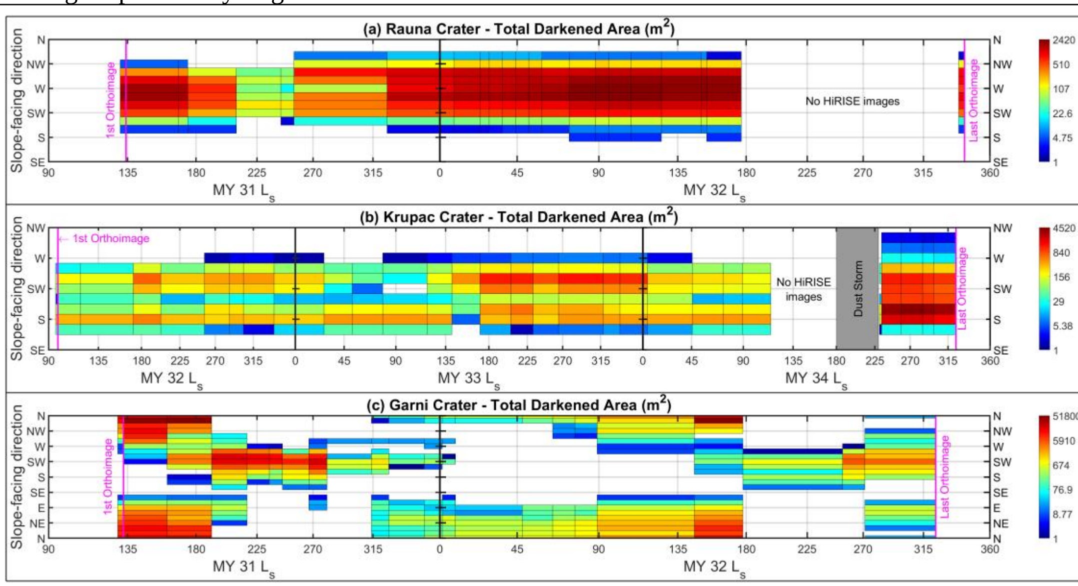

Fig. 2. Total RSL darkened area for **(a)** Rauna, **(b)** Krupac, and **(c)** Garni craters. Each colored "brick" represents the RSL darkened area in m^2 for a given slope-facing orientation. The value of the darkened area for a brick is colored by the value mapped on the latter image (right part of the "brick") and stretches to the earlier image (left part of the "brick"). If a "brick" does not exist, it indicates no RSL darkening or, when labeled, that no HiRISE images were acquired within 90° of L_s. **(a)** Rauna crater shows a similar pattern of darkening between MY 31 and 32. Additionally, we find that many RSL never fully fade in Rauna and Krupac craters. **(b)** In Krupac crater, MY 33 had many more RSL than in MY 32. However, after the MY 34 dust storm there was an even greater amount of RSL darkening at Krupac crater. Note, we mapped only the S-facing and the majority of the SW-facing RSL in Krupac crater, and there exist additional W- and NW-facing RSL at Krupac crater. **(c)** Garni crater shows many more SW-facing RSL in MY31 than MY 32, while N-facing RSL where about the same in MY 31 and 32.