GEOSTATISTICAL ANALYSIS OF ALL RSL WITHIN RAUNA CRATER TO DISTINGUISH BETWEEN RSL FORMATION MECHANISMS. 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.

Summary: 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, there has been little documentation regarding the rate at which RSL lengthen or what percent of existing RSL incrementally lengthen. While we do not discuss different RSL formation mechanisms, we intend that our quantitative descriptions of the behavior of all the RSL at a site will lead to improved formation mechanism hypotheses that will better fit the observations.

Here, we concentrate on ~3,000 RSL mapped within 23 images from Mars Year (MY) 31–32 at Rauna crater (35.3°N, 327.9°E). Rauna crater was chosen for this analysis, as previous work [6] mapped a few RSL that indicated rapid lengthening rates at initially >1 m/sol that then fell to ~0.25 m/sol. Additionally, Rauna crater possesses a large number of RSL that merge less frequently than other mapped sites (e.g., Garni crater), enabling better individual RSL measurements. We find that the assumed lengthening rate of new and existing RSL do not significantly vary over the lengthening season. Furthermore, the lengthening rate of the new RSL is only slightly above that of the lengthening rate of existing RSL. Additionally, 88% of individual RSL are static during the lengthening season.

Methodology: All RSL at Rauna crater were mapped manually using publicly available orthorectified images and Digital Elevation Maps (DEM). We then gathered geostatistical parameters of each RSL, such as: length, area, orientation, mean slope, starting slope, stopping slope, incremental lengthening slope, incremental lengthening distance, and incremental and new lengthening rate. The RSL geostatistics are based on the 1.01m resolution DEM downloaded from the PDS. 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 [7].

Non-contacting mapped RSL were given an individual identification number for each HiRISE image. We then compared pairs of sequential HiRISE images to determine how individual RSL changed. We defined the start (end) of each RSL as the highest (lowest) elevation point within the RSL (see *Fig. 1*). We found: (a) *Static RSL*-where the start and end points did not change between images; (b) *Fading RSL*-where the start and end points were closer together in the latter image; (c) *Incremental Lengthening RSL*-where the start and end points where further apart in the latter image; (d) *New RSL*-where no RSL existed in the former image; (e) *Merging RSL*-where an RSL in the latter image overlaps with more than one RSL from the former image; (f) *Splitting RSL*-where a single RSL in the former image fades and splits into multiple RSL in the latter image. Note, the total number of RSL present can decrease during the lengthening phase when multiple RSL merge into a single RSL.

The 3-D length of each RSL was calculated by finding the distance from the starting point (highest elevation) to the stopping point (lowest elevation). Since RSL do some meandering between the starting and stopping point, the RSL may be longer than the calculated length.

Lengthening rates were estimated for RSL that demonstrated lengthening between two sequential images (*Incremental Lengthening RSL* and *New RSL)*. For *Incremental Lengthening RSL* we divided the increase in length by the number of sols between the two images to obtain the (average) rate. To calculate the lengthening rate of the *New RSL*, we must assume the number of sols that the RSL has existed. Thus, we make two assumption, (1) the minimum rate assumes that the new RSL appeared immediately after the former image was taken and slowly grew over the full number of sols that elapsed before the latter image; (2) the "maximum" rate assumes that the RSL only existed during the last 10% of the time interval between the two images. While this is not a true "maximum" rate as the time interval could be shrunk to a single sol or even an hour before the image was acquired. This "maximum" rate serves to get an indication on the sensitivity of the newly lengthening rate.

Results: The number of non-contacting Rauna RSL identified in each HiRISE image is shown in *Figure 2*. The number of RSL decreases as they fade between solar longitude (L_s) 177-255°. The number of new RSL jumps as the RSL become active between L_s 325-8°. From L_s 37-125°, most RSL are static with only ~12% of existing RSL incrementally lengthening along with an additional ~7% of newly formed RSL.

Figure 3 shows the total length of all the RSL. 72% of the total length appears between L_s 325-24° or in 28% of the duration in which the RSL are active. From L_s 37-125°, RSL incrementally lengthen on average 40 m while new RSL add 72 meters.

Figure 4 shows the lengthening rate of mapped RSL as a function of MY and L_s. We find that the calculated lengthening rate of new and existing RSL do not significantly vary over the lengthening season. Furthermore, the lengthening rate of new RSL is only slightly above that of the lengthening rate of existing RSL.

Discussion: The geostatistical analysis of mapped RSL at Rauna crater shows that only ~12% of the individual RSL were active during MY 31-32. We continue to investigate our dataset to determine why certain RSL lengthen, while others do not. We have no answer yet to this question, but have found that the angle at which the incremental lengthening occurred does not correspond to the length of the incremental lengthening.

The results of the lengthening rate in *Fig. 4* appear to contradict those previously made by [6]. We argue that the statistics in this work cover many more mapped RSL ~3,000 compared to ~5 in [6] and are thus more reliable.

HiRISE has already captured a number of images of the dramatic early season surge in RSL activity in MY 33-34, 34-35, 35-36, with shorter time intervals between images. Unfortunately, these images have not yet been orthorectified. These more frequently imaged locations would allow for more detailed analysis. They would allow the "new" RSL to be mapped earlier so that their duration interval could then be known, which would then allow for a better estimate of RSL lengthening during the most active period. In the future, a campaign to image Rauna crater at a cadence of 14 sols from L_s 325-24° would be highly beneficial.

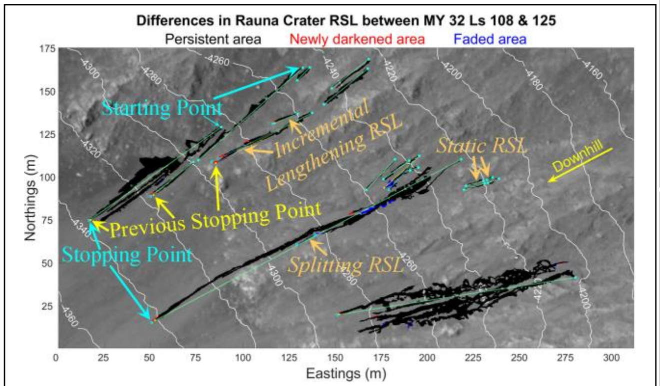

Fig. 1. RSL mapped at Rauna crater from HiRISE images acquired MY 32, L_s 108° and 125°. Newly darkened area (red) at the bottom of the RSL were used to calculate the amount of lengthening and the lengthening rate. Three classification types are shown annotated in orange: *Incremental Lengthening RSL, Static RSL, and Splitting RSL*.

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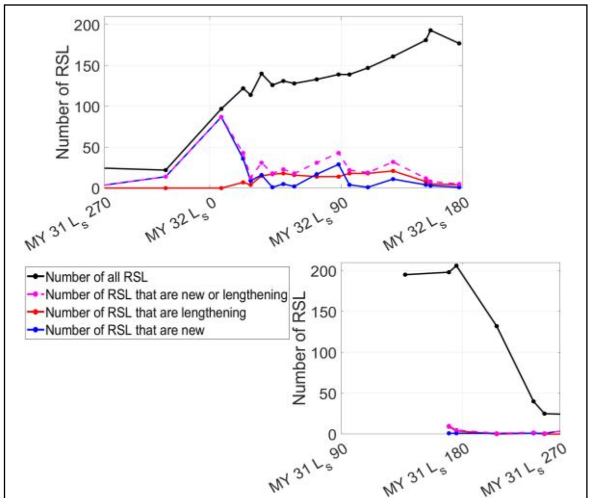

Fig. 2. Total number of mapped RSL as a function of Mars Year and Solar Longitude (L_s).

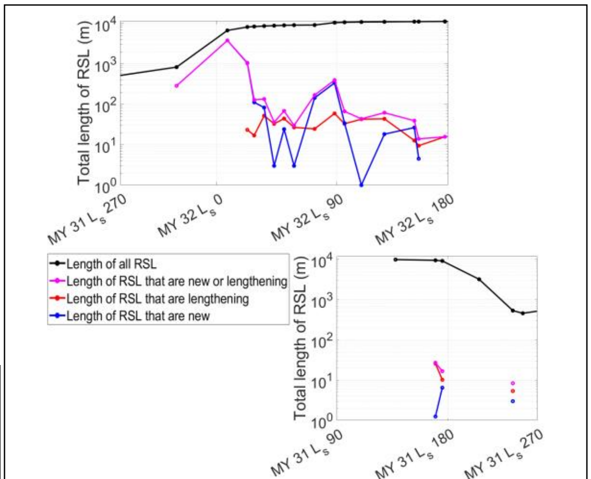

Fig. 3. Total length of mapped RSL as a function of Mars Year and Solar Longitude (L_s).

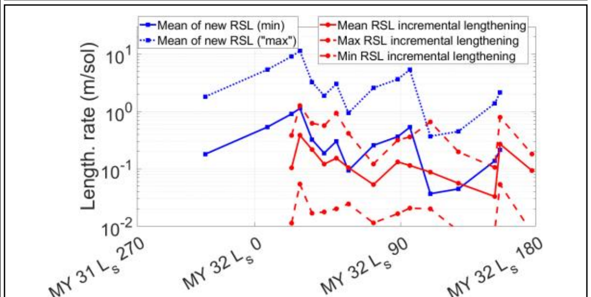

Fig 4. Lengthening rate of mapped RSL as a function of Mars Year and Solar Longitude (L_s). We do not show MY 31 activity, as little lengthening occurred then.

References: [1] McEwen, et al., (2011) *Science*, 333, 740-743. [2] McEwen, et al., (2014) *Nature GeoSci*, 7, 53-58. [3] Stillman, et al. (2014) *Icarus*, 233, 328-341. [4] Stillman, (2018) In: *Dynamic Mars*, 51–85. [5] McEwen et al., (2007) *J. Geophys. Res.*, 112, E05S02. [6] Stillman, et al., (2016) *Icarus*, 335, 125-138. [7] Horn (1981) *Proc. IEEE.*, 69, 14-47.