OBSERVATIONS AND UPDATED WATER BUDGET OF RECURRING SLOPE LINEAE (RSL) IN GARNI CRATER. D. E. Stillman[1], B. D. Bue[2], K. L. Wagstaff[2], T. I. Michaels[3], and R. E. Grimm[1], [1]Dept. of Space Studies, Southwest Research Institute, 1050 Walnut St #300, Boulder, CO 80302 (dstillman@boulder.swri.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, [3]SETI Institute

Introduction: Recurring slope lineae (RSL) are narrow (0.5–5 m) low-albedo features that incrementally lengthen down steep slopes during warm seasons, fade, and then recur the follow year [1-3]. All RSL sites have steep slopes, outcropping bedrock, and lower albedo (less dusty surfaces) than average for Mars. Evidence of surficial material transport by RSL is generally not detected. Hydrated salt spectral signatures were detected at four confirmed RSL sites, suggesting the presence of water at RSL sites [10]. Wet, dry, and hybrid origins have been suggested, but water-based hypotheses best match observations that correlate incremental lengthening with higher surface temperatures [1-12].

Over 575 candidate and confirmed RSL sites have been cataloged in four regions: the southern mid-latitudes (SML) [1,3,8], Valles Marineris (VM) [2,6,7], Chryse and Acidalia Planitiae (CAP) [9], and equatorial (EQ). Some RSL sites have more than 1000 individual RSL. Manually mapping each RSL in every image at all sites (some have more than 20 HiRISE images) is impractical. Therefore, we largely automated RSL mapping/characterization using computer-assisted analysis (CAA). We report here an updated water budget estimate for Garni crater (11.5°S, 290.3°E; 2.4 km in diameter) on the floor of Melas Chasm in VM, using 16 orthorectified HiRISE images spanning more than a Mars year. We combined this result with analysis of non-orthorectified HiRISE images and thermophysical modeling to update our previous water budget estimate, which covered only 40% of a Mars year [4].

Observations: HiRISE has been monitoring Garni crater for over 2.5 Mars years (MY 31, L_s 133.1° to MY 33, L_s 269.1°). Garni has large north- and south-facing RSL. However, the length and width of the north-facing RSL drastically changed between MY 31 and 32 (**Fig. 1**; no data in MY 33). These variations were not accounted for in [5], when they estimate RSL have <3 wt% water. If MY 31 was a statistically anomalous RSL year for Garni, then the water estimates of [3] are not correct.

Two slumps have also formed at the terminus of the north-facing RSL [6,7]. These slumps moved material much further downslope than the RSL ever reach. Both slumps occurred between L_s 43-106° in MY 32 and 33 [7]. At this season, north-facing RSL are beginning to lengthen downslope, but typically have not reached the origination elevation of these slumps. Lastly, the observed slumps show fading on the same timescale as an RSL, but fade much faster than the majority of slope streaks (that stay darker than their surroundings for decades). We speculate that these slumps may have faded so quickly because the removal of the overburden exposed a relatively water-rich darker regolith layer that then desiccated over ∼30−170 sols.

Computer-Assisted Analysis (CAA): We analyzed a chronologically-ordered sequence of HiRISE images to identify areas of RSL change and then calculated the total change in RSL area at each time step. For each image, we normalize the observed pixel values using a linear illumination model, scaling values according to the maximum intensity observed at each pixel across time. This operation improves discrimination between potential RSL pixels (i.e., dark pixels in well-lit areas) versus shadow pixels and compensates for different surface materials. We select an initial set of RSL candidates by grouping spatially-contiguous regions of normalized darkening above a threshold. We use machine learning to filter out spurious candidates by applying a statistical classification algorithm trained using ~15-30 manually-labeled RSL detections from each image in the sequence.

CAA mapping can be used in many different ways to quantify the behavior of RSL. Here, we discuss the L_s and slope-orientation dependence of dark, darkened (lengthening), and brightened (fading) RSL areas. We find that unlike SML and CAP RSL, some VM RSL lengthen at the same time that neighboring RSL fade [7]. This indicates high evaporation/sublimation loss rates and source regions that quickly become depleted. Furthermore, CAA confirms that slope orientation strongly modulates the lengthening of RSL at this site [2] (**Fig. 2**).

Thermophysical modeling: To convert the CAA-derived surface areas into volume, we estimated the amount of water within the subsurface of RSL and how much water has been lost via evaporation/sublimation. We used 1D Mars Regional Atmospheric Modeling System (MRAMS) and 1D MarsFlo [7-9] for this. We modeled different subsurface layering and melting temperatures for a slope of 32.5° at different slope orientations. We varied the brine melting temperature, the thickness of the brine, and the flow regime (slug - a burst of RSL activity where the volume of inflowing water never reaches the evaporation/sublimation volume; or equilibrium - where the volume of inflowing water equals the amount being evaporated and sublimated). The brine-saturated regolith is assumed to be covered by 2 cm of unsaturated regolith. We also assume that the bottom of the brine-saturated layer never melts or sublimates away in the off-season and thus acts as an impermeable boundary. Lastly, we assume that below the impermeable boundary the subsurface is unsaturated, thus keeping more heat within the near surface during the summer.

We then use the modeled output temperatures to determine the evaporation/sublimation rate as well as porosity and thickness of injected brine. This allows us to find an upper and lower bound for the water budget of the RSL.

Conclusions: Garni crater has dynamic RSL, with those on different slope orientations lengthening and fading at different seasons. These RSL also have considerable inter-annual variations. Other processes like debris flows are occurring on the same steep slopes as the RSL. Our CAA is capturing the vast majority of RSL and is able to provide a large amount of geostatistical data. Unfortunately, we do not report updated water budget numbers in this abstract as we are still perfecting our modeling and would not want others quoting preliminary values that will likely change before the meeting.

Acknowledgments: This work was carried out at SwRI, the SETI Institute, and the Jet Propulsion Laboratory (California Institute of Technology) under the NASA Mars Data Analysis Program.

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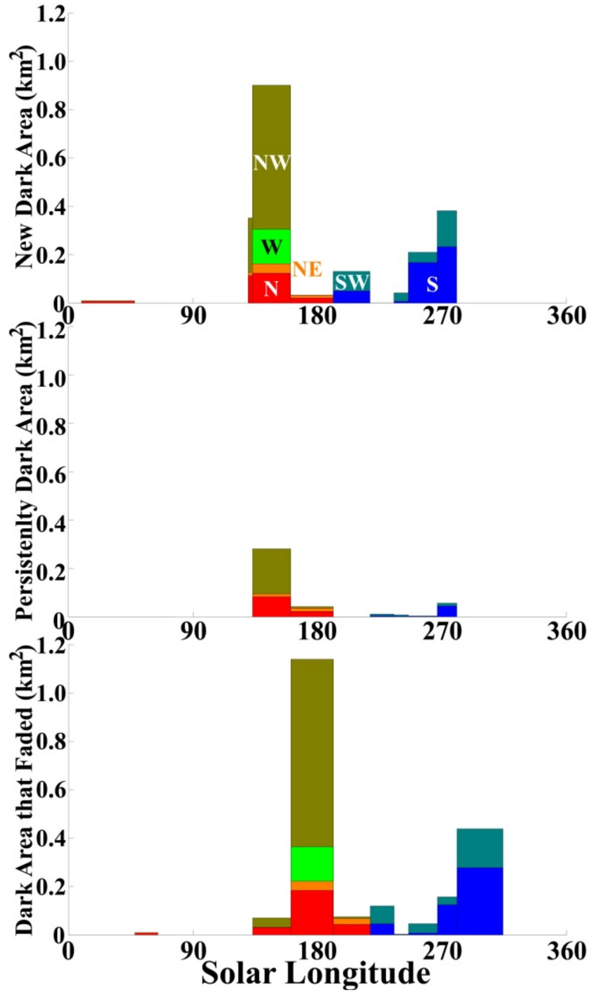

Figure 2. CAA-derived statistics as a function of slope facing direction and L_s. **(a)** New RSL observed area versus season. **(b)** Persistent RSL observed area versus season. **(c)** Faded RSL observed area versus season.

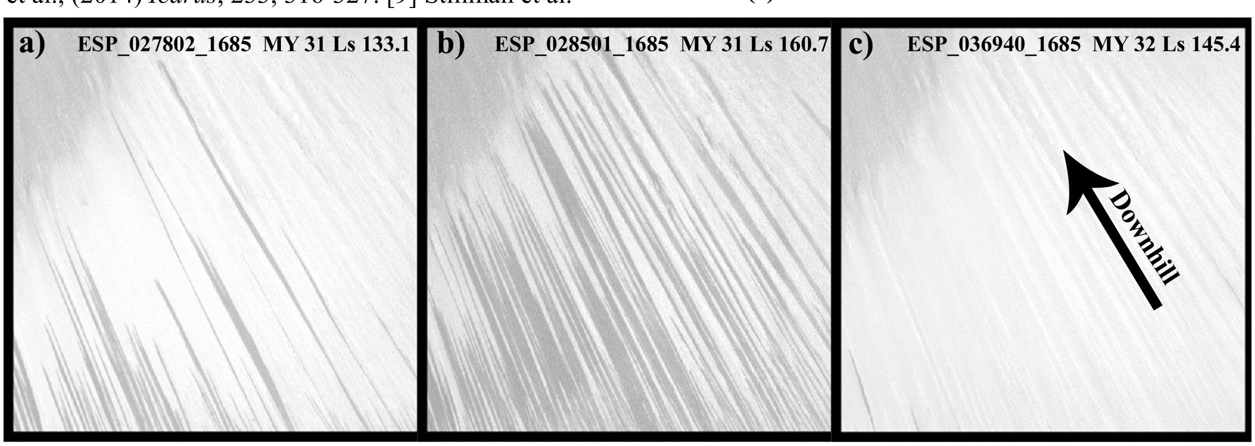

Figure 1. These HiRISE images (north is up) show the 300 x 300 m location where Edwards and Piqueux [5] did their analysis. Note the RSL in MY 32 are much smaller than in MY 31. Figure modified from [7].