COMPREHENSIVE SURVEY OF RECURRING SLOPE LINEAE IN TIVAT CRATER, MARS.
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Introduction: Recurring slope lineae (RSL) are narrow (0.5-5 m), relatively dark features found on steep martian slopes (25-40°), primarily in the southern midlatitudes. First identified by [1,2], RSL are observed to form and extend downhill in southern summer but fade in cooler seasons. RSL also prefer equator-facing slopes and are active in places where peak temperatures reach ~250-300 K [2]. Although several "dry" mechanisms might explain RSL formation, briny flow very near the surface is more consistent with current observations, especially the apparent temperature dependence [2]. On the other hand, the source for such liquid is unclear [2].

Given their recent discovery, RSL have yet to be quantitatively characterized in detail, a vital step in understanding these unusual features and constraining their evolution. Indeed, our ultimate goal is to compare such constraints to laboratory simulations [e.g., 3] and terrestrial analogs [e.g., 4]. As a first step, the current study will comprehensively document RSL evolution in Tivat crater. This location was chosen because nearly a dozen HiRISE images record RSL activity there and because the RSL are sufficiently few (~150) to make their comprehensive characterization feasible.

Methods: We first generated a high-resolution Digital Terrain Model (DTM) [5] from HiRISE [6] images ESP_012991_1335 and ESP_013624_1335 and simultaneously coregistered and orthorectified 9 additional images for a total of 11 coincident HiRISE images from the southern summers of two martian years [Table 1].

We then made a composite image, with each pixel corresponding to the lowest value taken by that pixel across all 11 images. Thus, this "dark" composite image generally shows the RSL at their time-integrated maximum extent. Further, because RSL frequently trace nearly identical paths each year, this composite image approximates the annual maximum extent of RSL [**Fig. 1**].

We visually captured all RSL in the composite image into a GIS database and will use this as our "master" template [**Fig. 1**] for RSL captured at each individual time step (i.e., for each HiRISE image). By trimming and deleting, as appropriate, the polygons from this master template, RSL can be captured much more efficiently than beginning capture afresh for each image.

Nonetheless, there are some difficulties with this approach. First, there are local differences in background values between HiRISE images; that is, some HiRISE images, at least locally, are brighter or darker than others, perhaps due to atmospheric conditions of differences with phase angle. As a consequence, RSL that occur only in a relatively bright area of one or more HiRISE images may not appear at all in the composite image, because such RSL may have higher brightness values than the background values of the corresponding area in another HiRISE image. Each HiRISE image thus still requires a comprehensive survey and, possibly, addition of RSL to the master template.

A second difficulty is that RSL, by definition, involve a darkening *with time* relative to some otherwise expected background value. The composite image is thus insufficient, on its own, to rigorously distinguish RSL from perennial low-albedo features. For this reason, we selected ESP_021628_1335 (Ls 251°) as a baseline, which was taken earliest in the summer of all 11 images. A comprehensive survey further confirmed that this image has nearly no RSL-like features. Because all HiRISE images are taken at the same approximate time of day, this baseline also helps to distinguish RSL from shadows. Although we alternatively explored using a "bright" composite image (created analogously to the aforementioned "dark" composite image) as a baseline, we found that many faint RSL are still expressed in such an image due to the previously described background value complication. Nonetheless, it is possible that this issue could be fully resolved by photometric correction.

Interpretation in this study has two major components: identification and delineation. To maximize the utility of our results, we document both of these components explicitly. Whenever a feature is captured as an RSL, we assign a level of confidence (high, moderate, or low) to this identification. In practice, only low-confidence RSL likely have a significant proportion of false positives; high- and moderate-confidence RSL are distinguished primarily by distinctiveness and degree of darkening, the latter of which is also separately documented to assess the evolution of RSL albedo changes.

Delineation is most problematic where RSL cease to be continuous linear features, for example, where RSL are semicontinuous, coalesce, or grade into a broader area of relatively low albedo. To minimize the degree of interpretation, we capture RSL only where they are clearly distinct from their background, and thus truncate them at these problematic areas. However, where RSL segments may be reasonably interpreted as part of a single continuous train, we connect these segments with somewhat arbitrary polygons. Similar polygons are also included where relatively high-albedo areas form small islands within RSL.

These additional polygons serve two related purposes: they allow automated identification of semicontinuous groups of RSL polygons and facilitate automatic generation of realistic RSL centerlines so that meaningful length changes between successive HiRISE images can be automatically calculated. This length change algorithm is currently under development.

Any other values that can be derived from the HiRISE images or DTM can also be found automatically for each time step and for changes between time steps. As only two examples, the distributions of slope angles at which new RSL form and at which inherited RSL extend can be compared and contrasted, and the spatial heterogeneity of length changes can be mapped for each time step. For the second Mars year, the median temporal resolution is ~19 sols.

State of Research: The RSL in the composite and first 2 HiRISE images have been captured, and their annotation is very nearly complete; the third HiRISE image is ESP_021628_1335, which we have used as a baseline image. The current study will ultimately capture, annotate, and analyze the evolution of RSL across all 11 images. This comprehensive undertaking will not only inform our quantitative understanding of RSL and help to constrain their formative mechanism but also develop semi-automated methods for continued monitoring of RSL sites.

References: [1] Ojha L. et al. (2011) *LPS XLII*, Abstract #2101. [2] McEwen A. S. et al. (2011) *Science*, *333*, 740-743. [3] Conway S. J. et al. (2011) *Icarus*, *211*, 443-457. [4] Levy J. (2011) *Fifth Martian Polar Sci. Conf.*, Abstract #6054. [5] Kirk R. L. et al. (2008) *JGR*, *113*, E00A24. [6] McEwen A. S. et al. (2007) *JGR*, *112*, E05S02.

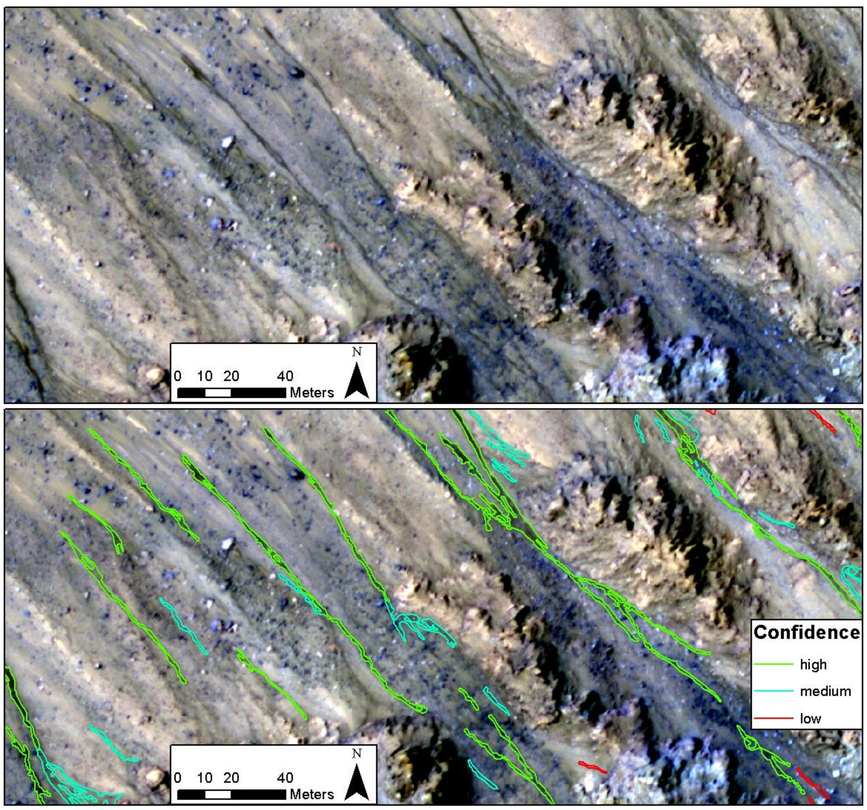

Fig. 1
A southeast portion of Tivat crater showing the RSL captured there for ESP_013624_1335, with that HiRISE image as the background. In the depicted area, the master template is identical to the RSL captured for this image.

Table 1

HiRISE Image	Ls°
ESP_012991_1335	259.492
ESP_013624_1335	290.287
ESP_021628_1335	250.613
ESP_021773_1335	257.783
ESP_022195_1335	278.482
ESP_022406_1335	288.641
ESP_022762_1335	305.34
ESP_022973_1335	314.929
ESP_023184_1335	324.266
ESP_023329_1335	330.532
ESP_023540_1335	339.437