NUMERICAL MODELING OF MARTIAN RECURRING SLOPE LINEAE AS WIND-CACHED, OVERPRINTING GRAIN FLOWS. R.E. Grimm[1], E.L. Barth[1], A. Egan[1], and D.E. Stillman[1], [1]Southwest Research Institute, 1050 Walnut St. #300, Boulder, CO 80302 (grimm@boulder.swri.edu).

Introduction. Recurring Slope Lineae (RSL) —dark, narrow streaks on steep slopes that appear annually in warm seasons, appear to grow incrementally, and fade in cold seasons—have been considered the best evidence for contemporary liquid water flowing at the surface of Mars [e.g., 1-3]. However, groundwater discharge is problematic due to RSL occurrence on isolated topographic highs [4], lack of concentrated salt deposits that would be left by evaporating brines, and an incomplete conceptual understanding of how fluid would be transported from stable aquifers at depth to a seasonally melted layer. Furthermore, we have been unable to find consistent brine composition (freezing temperature) or geological substrate even for RSL that occur within a few km of each other (Garni crater, [5]). Alternatively, a granular-flow mechanism is best supported by termination of RSL near the expected angle of repose [6-8]. In this case, it is uncertain how seasonal triggering occurs or how RSL continue to form thereafter [9]. The apparent incremental advance of RSL is much more easily explained as liquid flow in a porous medium [10,11] than as a slowly advancing grain flow.

Building on the prior literature [12], we propose a new model for RSL as wind-cached, overprinting grain flows (**Fig. 1**). RSL onset is due to seasonally favorable winds that loft fine-grained sand into crevices and alcoves on steep slopes. Our preliminary meteorological modeling indicates that RSL formation is consistent with seasons of upslope winds. Grains are temporarily cached either dynamically or statically, i.e., until the wind stops blowing or slope failure occurs. The discharged sand creates a dark linea as it displaces dust. This occurs repeatedly, with overprinting of the RSL track both by smaller flows that do not go as far and by larger ones that extend the dark linea (Fig. 1). We are modeling grain flows using the Discrete Element Method (DEM) in order to assess the minimum flow volumes that can displace dust yet not build resolvable levees or toes. In this model, RSL onset at surface temperatures broadly comparable to briny ice melting is a coincidence, and the apparent incremental advancement of RSL is an illusion of grain-flow and orbital-imaging history. Additionally, any aeolian features are below the resolution of HiRISE [6,12]. In this view, RSL are wind-driven sedimentological phenomena and may hold no implications for water in adsorbed, hydrated, or liquid states.

Wind Modeling. We use the Mars Regional Atmospheric Modeling System (MRAMS, [13]) to assess surface-wind direction and velocity at RSL sites as a function of solar longitude L_s. MRAMS is a non-hydrostatic atmospheric modeling system capable of simulating meso- and microscale wind flows over complex topography. Our preliminary investigation focused on Palikir crater (41.6° S, 202.3°E, 16-km dia.), one of the original type locations for RSL [1]. Here RSL grow dominantly on W-facing slopes from L_s 240-315 (with peak activity around Ls 270) and are completely faded by L_s 15 [15].

We used 2 nested grids to capture the crater, with the finest grid 50-km across with 1-km spacing. The outputs of a global General Circulation Model (GCM, [14]) form the top-level MRAMS inputs and the model is run for 4 sols at the beginning of each martian month to obtain a uniform distribution of Ls. This procedure is repeated for each level. The results for Palikir **(Fig. 2**) demonstrate that winds are dominantly upslope during RSL activity and downslope at other times. This supports the hypothesis that sand is blown upslope into temporary caches.

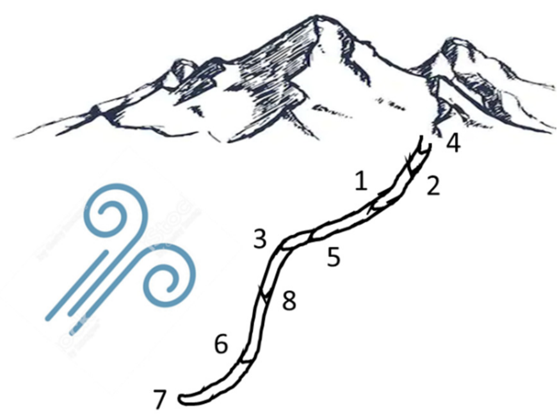

Fig. 1. Cartoon of wind-cached, overprinting grain-flow mechanism of RSL formation. Wind blowing at slope face caches sand in crevices and alcoves, which releases (either promptly or delayed) to sweep away dust and form dark linea. Some flows extend the linea (marked to the left) and some do not (marked to the right). RSL activity ceases when wind direction and strength are no longer favorable, and lineae fade by dust deposition.

Grain-Flow Modeling. We use the LIGGGHTS open-source discrete element method particle simulation code [16] to treat grain flows in (near) vacuum at martian gravity. Our preliminary geometry represents an idealized, narrow valley on a slope just above the angle of repose. The overall slope is 31.3° and the perpendicular slope into the valley is 10°. Spherical sand particles are broadcast into the top of the domain, with rate varied in different simulations. The material parameters varied in this cohesionless simulation are centered at the LIGGGHTS defaults. We restricted the model domain in these preliminary simulations in order to begin parametric studies, so the results describe quasi-steady-state velocities on the idealized surface rather than runout distances.

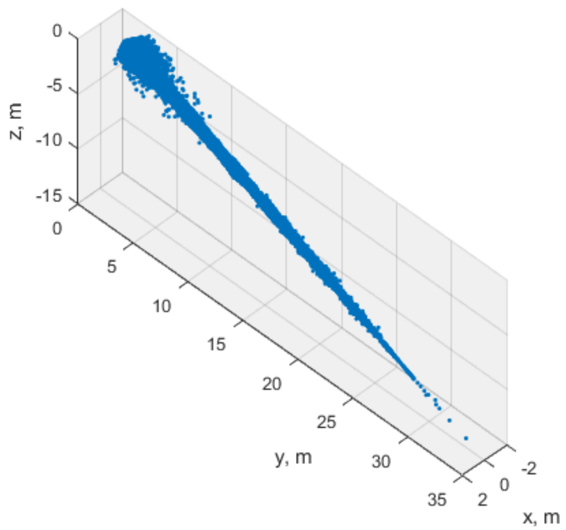

Fig. 3. Preliminary model of RSL as grain flows, showing particle distribution at 10 s for baseline case (substrate not shown). See text for details.

The baseline case (**Fig. 3**) achieved a velocity of ~2.8 m/s (median of furthest 0.02% of particles over 10-s simulation of particles in contact with the ground. Velocities were roughly inversely proportional to the rolling-friction coffficient; other parameter variations had little effect. A 30x increase in source rate only increased the velocity by 50%, which suggests that source volumes have little impact. This geometry is idealized, however, and we expect microtopography to exert strong control on small-volume flows.

Future Work. We will continue to test the wind-cache hypothesis by searching for correlations between predicted wind strength and direction vs. observed RSL location, facing, and seasonality [9], including (1) annual variations at each of the half-dozen principal regions of RSL occurrence, (2) variations in timing with different facings at one location, and (3) multiple pulses from the same slope. The grain-flow modeling will use Digital Elevation Models (the other kind of DEM) of RSL sites to assess the volumes and any special material properties required to produce observed runout without topographic construction. Note that sand producing RSL can, however, be part of overall buildup or recirculation of the fans on which they form.

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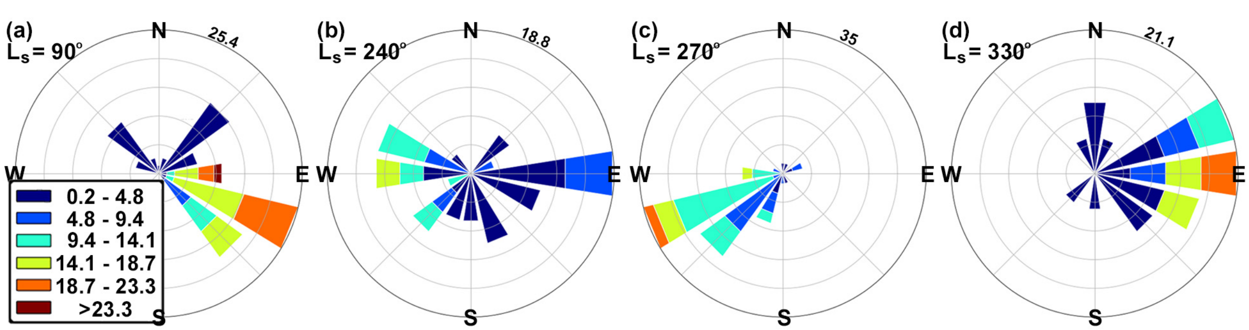

Fig. 2. Simulations of surface winds at a west-facing slope in Palikir crater. Radials show directional frequency (%) and colors show speed (m/s). (a) Ls 90, RSL inactive, wind from ESE. (b) Ls 240, earliest RSL activity, winds shifting from E to W, (c) Ls 270, peak RSL activity, wind from WSW. (d) Ls 330, RSL inactive, wind from E.