MULTIPHASE THERMAL MODELING OF MARTIAN RECURRING SLOPE LINEAE. R.E. Grimm[1], T. Michaels[2], and D.E. Stillman[1], [1]Southwest Research Institute, 1050 Walnut St. #300, Boulder, CO 80302 (grimm@boulder.swri.edu; dstillman@boulder.swri.edu), [2]SETI Institute, 189 Bernardo Ave. #200, Mountain View, CA 94043, tmichaels@seti.org.

Introduction. Recurring Slope Lineae (RSL)—dark, narrow streaks on steep slopes that appear annually in warm seasons, grow incrementally, and fade in cold seasons—are the best evidence for contemporary liquid water flowing at the surface of Mars [e.g., 1-3], yet some observations and the perceived challenges with having a near-surface liquid source reservoir has led some workers to investigate dry alternatives [e.g., 4-6]. We are rigorously assessing the liquid endmember concept by computing the melting cycle, liquid and vapor transport, and annual water budget required under different conditions of insolation, soil properties, and freezing-point depression. Preliminary calculations show that freezing temperatures near 252 K (the NaCl-water eutectic) can reproduce RSL behavior at a variety of locations if subsurface geology differs. Alternatively, brine composition must vary, with freezing temperatures as low as 240 K ($MgCl_2$-water eutectic). No cases required the extreme freezing-point depressions characteristic of perchlorates.

Model. We used the computer code MarsFlo [7,8], a three-phase simulator for water migration in partially frozen porous media. Conservation of H_2O (as ice, liquid and vapor) and CO_2 (in the gas phase and dissolved in liquid water) are coupled to a heat transport equation. Multiphase flows are described by generalizations of Darcy's Law and the van Genuchten relative permeability and capillary pressure relationships. We have previously used this model for an initial treatment of RSL [9] as well as global groundwater evolution [7,10]. Here we focus on annual-duration 1D thermal models that seek to explain the timing of RSL activity as a function of location and slope facing. We subsequently discuss the extension to 2D water and vapor transport.

The nominal model consists of a 1-cm thick silty cap, a 9-cm thick sandy layer, and underlying bedrock to 10 m (i.e., deeper than the annual thermal wave). The entire domain is H_2O-saturated. An alternative model limits the "bedrock" to a few cm thick—which can now be interpreted as a dry caliche layer, deposited by previously evaporated/sublimated flows—with dry sand below. External surface energy balance terms (radiative transfer and atmospheric turbulent transport) are calculated using a concurrent 1-D MRAMS (similar to that in [3]) simulation, given the current MarsFlo surface temperature.

Results. We examined five representative RSL sites (**Table 1**) that vary by latitude and slope facing. The typical L_s of RSL appearance is used to estimate the melting temperature and this is compared for consistency with freezing to the times when RSL cease lengthening or fade. RSL onset at the mid-southern-latitude Palikir site is well-matched by a melting temperature of 251 K (**Fig. 1**). The maximum melting depth is ~0.5 m and near southern solstice liquid is present the entire day except just before dawn. Complete freezing occurs between the observed stop and fade dates. The behavior at low-latitude Garni-S is similar if the alternative model with an underlying dry layer is used (melting point of 250 K). Without an insulating substrate, the melting point must be set to 240 K. Results comparable to Garni-S are obtained for W-facing Valles Marineris RSL (typified by Garni-W) in both cases, although the west facings are more sensitive to small changes in temperature. Finally, RSL activity is observed for much of the year at mid-northern-latitude Rauna, but the best-fitting 250 K melting temperature using the nominal bedrock structure still somewhat exceeds this time interval. The result for Garni-N is similar.

Table 1. RSL Seasonality

Site	Facing	L_s Start	L_s Stop	L_s Fade
Rauna Crater 35.2°N, 327.9°E	SW	330	155	215
Garni Crater 11.5°S, 290.3°E	N	320	175	225
Garni Crater	S	175	320	355
Garni Crater	W*	110	360	45
Palikir Crater 41.6°S, 202.3°E	W	200	300	15

*Representative of most W-facing Valles Marineris RSL.

Discussion. Annual RSL onset in five different environments can explained with a consistent melting temperature 250-251 K if subsurface structure differs. The coincidence with the NaCl eutectic temperature suggests groundwater that has evolved close to saturation. Alternatively, the same thin sand-over-bedrock configuration at all five sites requires melting at 240 K for Garni-S and W-facing Valles Marineris, close to the $MgCl_2$ eutectic. If a percolation-threshold porosity/temperature exists for porous flow through progressively melting ice, then the eutectic temperature could be lower, e.g., for $CaCl_2$ or perchlorates.

Future Work. With these 1D results as starting parameters, we will evaluate full 2D flow models that introduce H_2O at the top of a slope and allow the flow to advance by capillarity and gravity until it reaches equilibrium with evaporation. The silty cap is now important in controlling the evaporation rate. For example, we anticipate that evaporation may shorten the duration of visible RSL activity at Rauna. Agreement of freezing with the L_s of fading is interpreted as flows that have reached equilibrium, whereas freezing that coincides with the stop Ls is interpreted as a one-time "slug" flow [9]. The Mars-year-long models will also allow assessment of sublimation, which must clear the way for the next season's flow.

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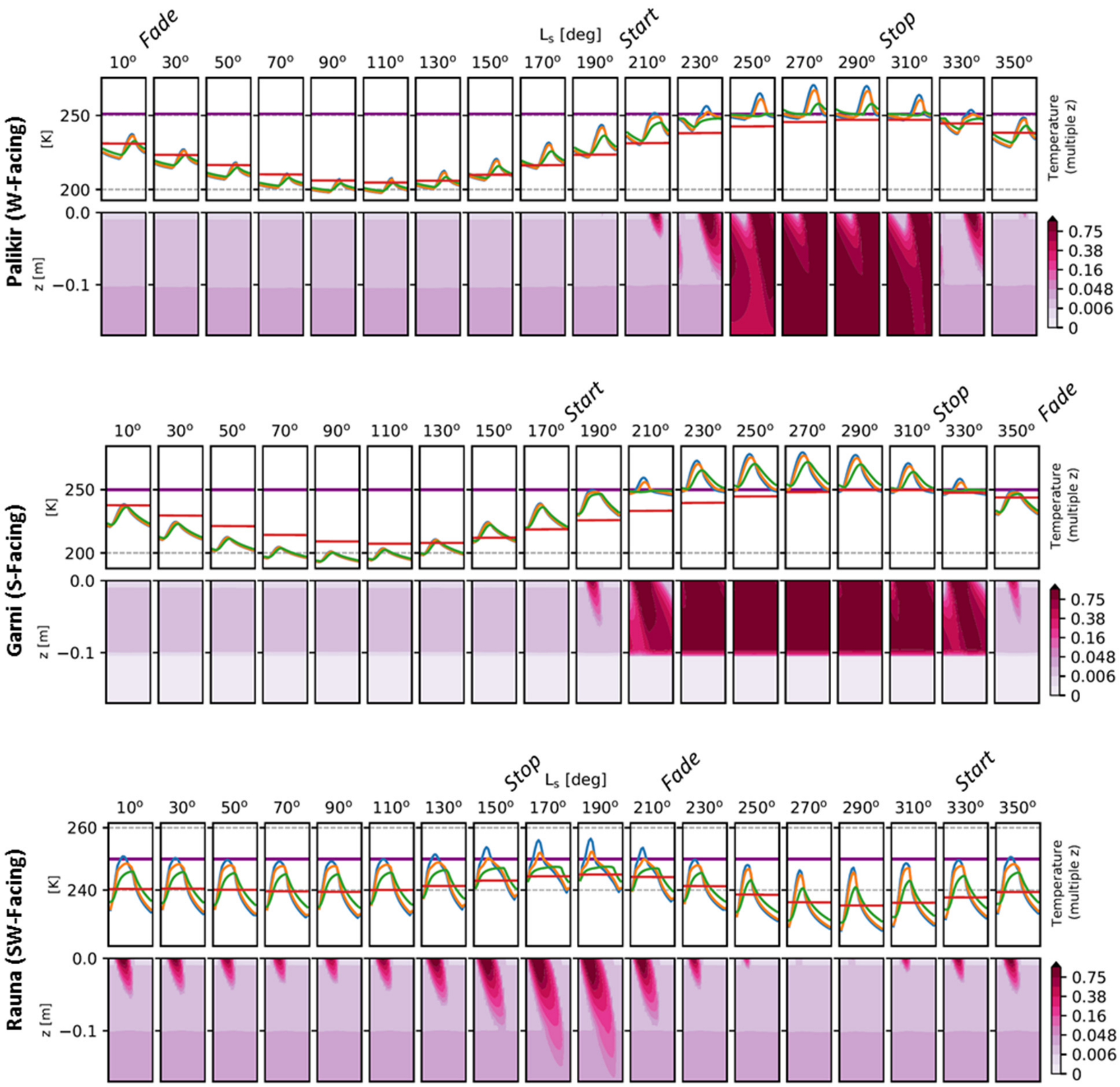

Figure 1. Panels of diurnal temperature and melting patterns at equally spaced L_s over a full martian year, for best fits to three representative RSL environments. Each panel is 0-24 h LMST on the abscissa. Top row for each site shows temperatures at depths of 0 (blue), 2 (orange), 10 (green), and 100 cm (red). Horizontal purple line is melting temperature. Bottom row is liquid saturation (as a fraction of porosity) in the top 17 cm; note that capillary forces retain a small quantity of liquid water year-round. Typical dates of observed RSL start, stop, and fading are noted.