MODELING PARTICLE SIZE DISTRIBUTIONS THAT CAUSE THE UNIQUE THERMOPHYSICAL VARIATIONS IN DAEDALIA PLANUM, MARS. C. M. Simurda[1], M. S. Ramsey[1], and D. A. Crown[2], [1]Department of Geology and Environmental Science, University of Pittsburgh, 4107 O'Hara Street SRCC, Room 200, Pittsburgh, PA, 15260 (cms256@pitt.edu), [2]Planetary Science Institute, 1700 E. Fort Lowell Road, Suite 106, Tucson, AZ, 85719.

Introduction: Analyses of individual lava flows in Daedalia Planum, Mars using THEMIS IR data suggest a minor compositional variability may be detectable despite being located in a high-albedo region [1]. This could be the result of cooling-induced changes in lava properties during flow emplacement, or changes in magma characteristics across the flow field. In order to investigate these subtle variations, the spectral and thermophysical signatures of exposed lava outcrops must be separated from the signature(s) of dust and sand covering the flows. Thermal properties can be used to identify particle size based on the grain-size dependence of thermal conductivity [2]. Modeled thermal conductivity measurements under Martian conditions suggest that low thermal inertia (TI) regions, such as Daedalia Planum, may be explained by a mixture of coarse plus fine-grained material [3]. For lava flows, such a mixture may consist of larger outcroppings of lava with sand in low-lying regions and an optically thin, spatially heterogeneous layer of dust covering the region.

Both high spatial and spectral resolution datasets have been used to identify and characterize the flow surfaces [4]. High spatial resolution visible (VIS) images are used to identify the physical surface structure, and high spectral resolution thermal infrared (TIR) data are used to determine composition, particle size, and thermophysical properties of the flows. Flows with observed mixtures of outcrops and sand in low-lying regions, plus some amount of dust, are then used to estimate the areal percentage of each component. Ultimately, knowing the fraction of lava will assist with deconvolving the spectral signature in the THEMIS data.

Background: Daedalia Planum contains one of the main flow aprons, predominantly basaltic composition, originating from the SW flank of Arsia Mons [5-7]. The study area was selected for its coverage by multiple datasets, extensive lava flow fields, and flow field mapping [4,8-9]. Recent detailed geologic mapping and thermophysical characterization using the visible and thermal infrared datasets suggests the presence of rugged outcrops of lava distinct from the fine-grained material in low lying regions [4,9].

Methods: VIS and TIR datasets were examined to quantify the thermophysical variability of 48 lava flows ranging in length from roughly 6 km to 170 km [4]. VIS datasets used include CTX and HiRISE; TIR datasets include TES dust cover index, THEMIS day and night IR brightness temperature, and TI derived from THEMIS night data [10-11]. CTX images were used to define individual flow boundaries and interpret surface morphology as either smooth or rugged [8-9]. Statistical analysis was performed on the THEMIS data and four categories were defined based on day and night brightness temperature (Table 1 and Fig. 1). TI and temperature data were compared to the morphologic-based mapping to assess the thermophysical response of flows in relation to surface morphology. Rough flows with low day and high night brightness temperature were determined to have the highest potential for a mixed surface of sand and outcrop. This is supported by HiRISE data that show ripples in low-lying regions of the rough flows.

Category	IR Day Temp.	IR Night Temp.
A	High	High
B	High	Low
C	Low	High
D	Low	Low

Table 1. *Four categories based on THEMIS-derived brightness temperature data.*

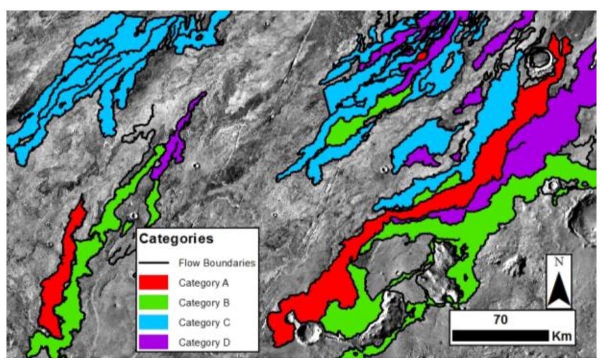

Figure 1. *Lava flows with colors corresponding to the categories in Table 1 overlain on the THEMIS IR day brightness temperature mosaic [7]. Flow boundaries taken from [8-9].*

To investigate variations in TI between the flows, the MARSTHERM tool was used to numerically model two-component diurnal and seasonal temperature curves [12]. This is a thermophysical model in which material properties and location are used to calculate the variation in brightness and surface temperature. To produce the most accurate model results, three idealized surface components were defined all having a basaltic composition but with different particle sizes (dust, sand, and rock) (Fig. 2). Following the method defined by Putzig and Mellon [13], fixed values of albedo, TI, density, and heat capacity were defined for each particle size. A two-component model was then run with different areal percentages summing to 100% with either sand plus rock or dust plus rock as the idealized surfaces. Each successive run varied by 10% to produce a comprehensive suite of mixed surfaces and the TI was calculated for each mixture variation. The brightness temperature results of the runs were compared with the average day and night brightness temperatures, calculated from the THEMIS data for each flow. Then, the TI of each run was matched with the TI calculated from night THEMIS data for each flow.

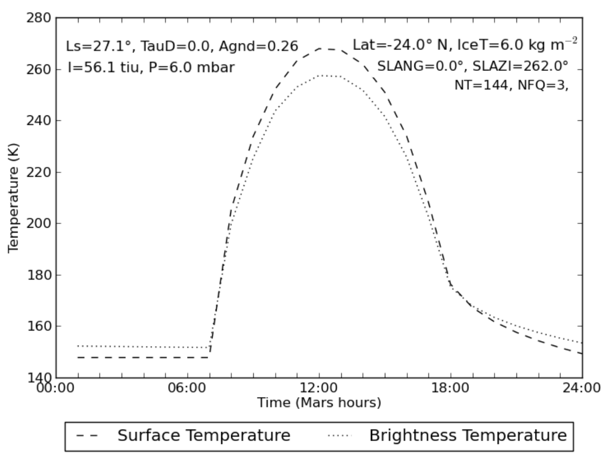

Figure 2. *Example of the diurnal curve produced by an ideal dust surface [12].*

Results and Discussion: Comparison of the idealized mixed surface TI and brightness temperature with the corresponding values calculated directly from THEMIS data for the rough category C flows suggest the predominant presence of dust in Daedalia Planum. With only the use of idealized single layer components, the models indicate the presence of around 60% dust and 40% rock (Fig. 3). However, these idealized mixed component runs do not yet take into account any vertical layering that may also occur in the area. Future model runs will include a thin layer of dust over both the sand and rock components. This will potentially provide a more realistic scenario in which both sand and dust are present on these flows. Since distinct ripple features can be seen in HiRISE data on the rough flow surfaces, the most accurate model should include a sand component.

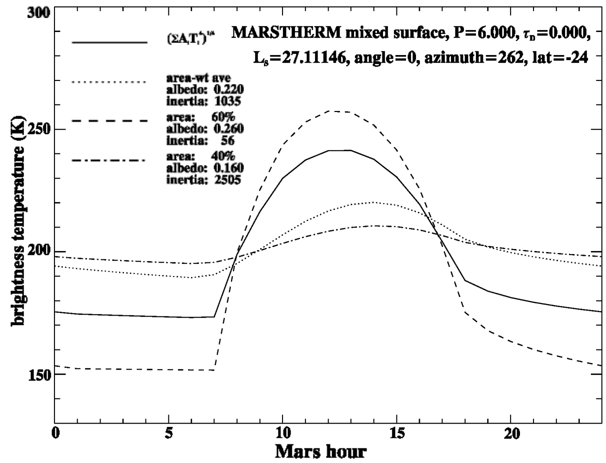

Figure 3. *Diurnal temperature of the 60% dust and 40% rock surface mixture that best matches the THEMIS data. The solid line is a linear mixture of the Stefan-Boltzmann function and the dotted line is the area-weight average [12].*

Summary: Analyses of surface thermophysical properties and flow morphology reveal that individual flows in Daedalia Planum respond differently to diurnal heating suggesting that the area is not completely (or uniformly) dust mantled. Modeling the temperature and TI responses of idealized surface mixtures to determine the areal percentages of outcrop and fine-grained material provides better definition of the particle size distribution on the surface. With the defined areal percentages of the different particle sizes, the spectral and thermophysical signatures of the outcrop within the flows can now be targeted. We expect these results will allow us to constrain any changes in the composition between flows and ultimately the emplacement process over time. Such an approach should be also applicable to other regions on Mars with a small amount of dust cover.

References: [1] Ramsey M.S. et al. (2016) *JVGR 311*, 198-216. [2] Presley M.A. and P.R. Christensen (1997) *JGR*, *102*, E3, 6551-6566. [3] Mellon et al. (2014) *8th Intern. Conf. on Mars*. abs. 1107. [4] Simurda C.M. et al. (2017) *LPSC XLVIII*, abs. 2784. [5] Crumpler L.S. et al. (1996) *Geol. Soc. Spec. Publ.*, *110*, 725-744. [6] Lang N.P. et al. (2009) *JVGR*, *185*, 103-115. [7] Edward C.S. et al., (2010) *JGR*, *116*, E10008. [8] Crown D.A. and M.S. Ramsey (2016) *JVGR*, *342*, 13-28. [9] Crown D.A. et al. (2015) *LPSC XLVI*, abs. 1439. [10] Fergason R.L. et al. (2004) *JGR*, *111*, E12004. [11] Christensen P.R. et al. (2001) *JGR*, *106*, 823-871. [12] Putzig N.E. et al. (2013) *AGU Fall*, abs. P43C-2023. [13] Putzig N.E. and M.T. Mellon (2007) *Icarus*, *191.1*, 68-94.