MODEL HELENE: RECONSTRUCTING THE HISTORIES OF SATURNIAN TROJAN SATELLITES USING LANDFORM EVOLUTION MODELING.

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Introduction & Considerations: A compendium abstract to this conference details the current state of knowledge regarding Saturn's L4 Trojan moon Helene [1]. It sits in Saturn's E-ring wherein containing other Trojan moons. Close inspection of Helene's landscape shows evidence of the presence of intriguing rheological processes which, if interpreted properly, indicate reasonable narratives of its (surface) geologic history. A procedure which successfully narrows down evolution histories will likely shed light upon the corresponding histories of the other Trojans of the E-ring. The programme we describe in this abstract focuses on developing a modeling framework to characterize and help parameter constrain the range of geomorphological processes active on such bodies.

Helene as a model development platform: As described in [1] Helene exhibits features consistent with many processes, not all of which may be active, including mass-wasting and creep, possibly due (but not limited) to micrometeorite impacts, vibrational displacement due to large body impacts, electrostatic levitation, and slumping. Visual evidence as well as spectroscopic color observations [2] indicate the presence of small grain ("powdery") materials of unknown origin but possibly arriving from Dionne or the E-ring itself (the latter being composed of micron sized ice grains, also carry some charge [3]). These appear to have been adverted downslope. Interestingly, the slope angles (with respect to the Helene's gravitational field) are quite low (<10 degrees) suggesting that the flow patterns are evidence of debris/glacial type of flow activity (a deep seated creep process). Additionally challenging is the non-spherical ("eggy") shape of the satellite in which the non-uniformity of the direction and magnitude of the satellite's gravitational field vector with respect to the surface coordinate complicates assessing slope gradients and magnitudes.

Modeling Strategies: The MARSSIM landform evolution model [4-6] will be adapted to model the variety of process conceived to be active on this moon. This general all-purpose model will be fitted with a module called "GLACIAL" to model flow induced by non-Newtonian processes characterizing slurries, debris flows and glaciers. An appropriate model of mass transport is the so-called Glen Law which effectively captures the dynamical response of plastic-like substances experiencing gravitational stresses. The quantity q measures the height integrated mass flux rate and is given by the following

$$q_{glen} = \frac{K\rho^{\alpha+1} g^{\alpha} \sin^{\alpha}\theta}{\alpha+2} h^{\alpha+2}$$

Where h is the height of the plastic layer g is the external field and θ is the local slope angle, K is the scaling constant, and ρ is the material density (assumed constant). The index α characterizes the degree of plasticity. Quantitative analysis shows that a value α=4 closely mimics the effects of a Bingham fluid. In the continuous formulation, the above law mathematically induces nonlinear diffusion, differing from other mass colluvial mass flux models used in MARSSIM (like nonlinear creep processes supporting landslides characterized by critical angles of repose).

Since MARSSIM is built on a flat two-dimensional grid (x,y), part of the program will be modified to include a calculation procedure that takes the surface variations of the gravity vector (assessed from shape models of Helene) and calculates effective slope angles $k_{ef}(x,y)$ as determined from a given simulation produced height map h(x,y). These effective slopes are to be used in assessing and correctly quantifying the various examined mass-flux processes .

Initial modeling examinations: All simulations will start with the same freshly cratered artificially generated surface profile. In a piecemeal exhaustive way we will hierarchically explore the parameter space of various processes and compare the simulation results of several evolution scenarios (qualitative and statistically) to Helene landform DEMs:

Classic nonlinear creep. A uniformly thin regolith covered surface undergoing classical nonlinear creep characterized by low angles of repose. Process parameters guided by previous studies of Callisto and Hyperion [5-6].

Glacial flow. Uniformly covered thin surface regolith experiencing glacial flow dynamics.

Classic nonlinear creep with accretion. A bare bedrock surface experiencing steady regolith accretion.

Glacial flow with accretion. Initially bare bedrock surface undergoing steady powder accretion which is subsequently subject to glacial flow dynamics.

The above are in increasing degree of complexity. Combinations of these various processes will be considered, compared and contrasted with another.

Other possible novel effects to be included in the future: If powdery material is E-ring fallout, the possibility that thin surface layers behave as fluidized beds due to electrostatic effects is an intriguing route to explore. This is physically plausible only because Helene's surface gravity is so small (<0.5 mm/s^2) and the E-ring ice grains are sufficiently charged (1 volt per grain) [3] that sticking processes may not be sufficient to grow ice grains and cause settling [7]. A layer (possibly only a thin surface layer of Helene's regolith) behaving like a fluidized bed through this (or some other mechanism) will have a low effective viscosity because of very low intergranular friction and flow more easily down gentle slopes as a low viscosity fluid. As dispersive mechanisms responsible for fluidization dissipate, the current local state of the evolving landform can lock and, consequently, stopping flow. Environmental conditions for which this transition can occur will be examined.

References: [1] Moore J. M. et al. (2014) *LPS XLV,* this convergence [2] Thomas, P.C. et al. (2013) *Icarus 226,* 999-1019. [3] Horanyi, M. et al. (2009) in *Saturn from Cassini-Huygens*, eds. Dougherty, M.K. et al. (Springer) 511-536. [4] Howard, A. D. (2007) *Geomorphology 91*, 332-363 [5] Howard, A.D. and Moore, J. M. (2008) *GRL 35*, L03203 [6] Howard, A.D. et al. (2012) *Icarus 220*, 268-276. [7] Cuzzi, J. et al. (2009) in *Saturn from Cassini-Huygens*, eds. Dougherty, M.K. et al. (Springer) 459-510.