SAND TRANSPORT ON MARS: PRELIMINARY RESULTS FROM MODELS;

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Summary:

Most studies of active aeolian processes on Mars have focused on dust [1], i.e., particles ~1 µm in diameter that are transported in suspension by wind. The presence of sand dunes on Mars [2-8] indicates that larger grains (≥60 µm, transported primarily in saltation) are also present. Although indirect evidence suggests that some dunes may be active [9], definitive evidence is lacking. Nonetheless, numerous studies [10-11] demonstrate that sand is substantially easier to transport by wind than dust, and it is reasonable to infer that sand transportation in saltation occurs under present martian conditions. In order to assess potential source regions, transportation pathways, and sites of deposition for sand on Mars, an iterative sand transport algorithm was developed that is based on the Mars General Circulation Model of Pollack et al. [12]. The results of the dust transport model are then compared with observed surface features, such as dune field locations observed on images, and surficial deposits as inferred from Viking IRTM observations. Preliminary results suggest that the north polar dune fields in the vicinity of 270°W, 70°N originated from weathered polar layered plains centered at 280°W, 85°N, and that Thaumasia Fossae, southern Hellas Planitia, and the area west of Hellespontus Montes are sand depositional sites. Examples of transportation "corridors" include a westward pathway in the latitudinal band 35°N to 45°N, and a pathway southward from Solis Planum to Thaumasia Fossae, among others.

Technique:

An algorithm was developed that enables the flux of sand as a vector-mass to be calculated for each of 960 spatial bins covering Mars, at 1.5 hour intervals of time. The program is run iteratively and displayed as a series of images portraying the net changes in sand deposits on Mars through time. Each bin is 7.5° lat. by 9° long., corresponding to the geographic cells of the GCM. The GCM provides the wind shear stress vector for each 1.5 hours under specified conditions of temperature, pressure, and atmospheric opacity (i.e., "dust-loading") appropriate for the martian season, as calibrated against measurements of the Viking landers [13]. In addition, topography to a one kilometer contour interval is taken into account. The predicted wind shear stress values on the surface are then used in the White [14] expression for sand flux on Mars. As initial conditions, we assume a layer of sand (average grain size, 100 µm) .1mm thick, spread uniformly over the entire planet. For sake of simplicity, this is the equivalent to a single 100 µm grain (the size moved by the lowest winds [11]) weathered free on the surface. The vector-mass of sand transported (for wind shears above threshold) is then partitioned to adjacent bins for the 1.5 hour period of each iteration. The output is summed over a martian year of GCM data, being careful not to move sand from bins that have become empty. This gives the net sand transport for that year, which is then converted into a color image for viewing. This result is used as the initial condition for the next year, and the process is repeated.

Discussion:

The results described in the summary represent model parameters of: a) 150 years, b) threshold stress of .04 N/m^2, c) initial sand thickness of .1 mm, and d) a sand density of 2.65 g/cm^3. In the northern hemisphere, there is westward transport of sand in saltation along a subtropic latitudinal band from 35°N to 45°N. This band extends around the planet, pinching out in the vicinity of Deuteronilus Mensae and 130°W, 50°N. Material in this band is transported to the south and west, depositing sand in Western Arcadia Planitia, in the vicinity of Cassini crater (325°W, 30°N), in the Cerberus region (190°W, 20°N), and in the vicinity of 315°W, 60°N. In the north polar area, sands are transported from 280°W, 85°N to two regions, 270°W, 70°N and 240°W, 75°N, corresponding to some of the dune fields observed around the northern pole. This result suggests that the source of the material forming these dunes are the polar layered deposits, as suggested by Thomas [5]. In addition, the model shows sand deposition in the vicinity of

315°W, 60°N, corresponding to a region of dark albedo, suggested by Edgett [15] to be sand deposits. The modeled sand deposits of western Arcadia Planitia and Cerberus correspond to regions containing bright streaks, an indication of active dust deposition [16].

The southern hemisphere is typified by four main regions of modeled sand transport. In the model, sands appear to be eroded from Solis Planum and transported to Thaumasia Fossae. In addition, sand is eroded from western Hellespontus Montes and is deposited to the west and south. Model results suggest erosion from northern Hellas Planitia and deposition to the south, possibly correlating with small dune fields observed in the area. Lastly, the model shows sand transport from the vicinity of Sirenum Fossae to the vicinity of the Mars 2 landing site (210°W, 40°S), a region associated with bright wind streaks.

Conclusion:

Preliminary results using the sand motion algorithm, suggests a pattern of erosion, transportation, and deposition on Mars that correlates well with some observed dune fields and surficial deposits. Other regions of primary deposition correlate well with areas known to contain bright streaks, although this association is poorly understood at present. Ongoing modeling is testing this relationship, exploring the effects of varying input parameters including the threshold and nonuniform initial sand distributions, and incorporating refinements to the algorithm, such as inclusion of variable surface roughness.

References:

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