GLOBAL DISPERSION OF DUST FOLLOWING IMPACT CRATERING EVENTS ON MARS.

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Introduction: Hypervelocity impacts on Mars inject dust and vapors into the upper atmosphere. If the particles (derived from the projectile or surface) are widely distributed, impact events could drive intense weather patterns and perhaps transient climate change on Mars [1]. For ~10 to ~100 km-sized impactors, dust and greenhouse vapors may be delivered to the upper troposphere and lower stratosphere, where the long residence time has the potential for regional or even global effects on the weather.

In this work, we investigate the mechanisms that control the dispersion of dust injected into the upper troposphere from large impact events, using a high-resolution global atmospheric dynamics model. The spreading rates, dispersal extent, and the potential for weather and climatological perturbations from both medium-sized (~10 km) impactors and giant (~100 km) impactors are studied. The overarching goals in this study are to identify locations of persistent concentrations of aerosols and to estimate the smallest impact which may generate transient rainfall on Mars.

Approach: We start the atmospheric simulations several minutes after the impact, when the ejecta plume is a few times larger than the final crater diameter. The impact shock propagates radially outward from the impact site through an atmosphere initialized with balanced zonal winds, which are representative of the seasons — e.g., northern winter (L_s = 270 to 300) at ~50 km altitude [2]. The Mars Orbiter Laser Altimeter (MOLA) topography is included in the simulations. The combination of shock, nonlinearly evolving wind, and topography redistributes the initial ejecta plume. Here, we restrict out attention to the dispersal pattern of fine (micron-sized) particles and neglect radiative heating/cooling effects and chemistry in the days immediately following the impact event.

Model Description: At high altitudes on Mars, motions are predominantly horizontal, due to the strong vertical stability. Hence, features whose lateral extent is large compared to the scale height of the atmosphere (~10 km) may be modeled with the shallow-water equations (SWE) [3]. SWE are vertically integrated version of the set of primitive equations of meteorology, used in general circulation models (GCMs). SWE constitute the simplest atmospheric dynamics model which allows the effects of stratification, horizontal compressibility, topography, and differential rotation to be included and studied at high spatial resolution over long simulation times.

Results: Our simulations show the following generic features:

1. Both the impact shock and variable topography produce complex dispersal patterns.
2. Over several days, the evolved zonally averaged wind patterns in the atmospheric dynamics calculations agree very well with results from general circulation models of the Martian atmosphere [e.g., 4].
3. Dispersal patterns from northern impacts are simpler compared to the southern impact, due to the topographic dichotomy on Mars, as emphasized in a recent GCM study of the tropospheric circulation [5].
4. Particles from ~100 km and smaller size impact craters are dispersed along a narrow range in latitude.
5. The particles from 100's km impact craters are dispersed hemispherically within several days. We find the efficiency of dispersion across latitudes increases with increasing topographic variability (Fig. 1).
6. The equivalent of a basin-forming impact is necessary for global dispersion of the ejected particles.

Results: From our simulations, we find that modeling of the climatological response from basin-forming impact events may assume nearly spatially homogeneous aerosol distribution. Understanding the atmospheric response to the more frequent smaller cratering events requires explicit treatment of the spatial inhomogeneities caused by atmospheric motion. Hence, 2-D or 3-D models are needed.

Future Work: The effects of different seasons on on the dispersal of impact-lofted material is being investigated using two-dimensional wind fields derived from GCM calculations [e.g., 4]. As the wind pattern is closely coupled to the topography, we will also explore the effects of Martian paleotopography. The evolved wind field in the dynamical model will be compared to lower-resolution GCM calculations over a few months of simulations time to determine the time scales where effects such as radiative feedback become important.

References: [1] Segura, T. L., et al. (2002) *Science* 298, 1977. [2] Forget, F., et al. (1999) *JGR* 104(E10), 24155. [3] Gill, A. E. (1982) *Atmosphere-Ocean Dynamics*, Academic Press: San Diego, p. 95-246. [4] Richardson, M. I., et al. (2002) *JGR* 107 (E9), 5064. [5] Richardson, M. I. and Wilson, R. J. (2002) *Nature* 416, 298.

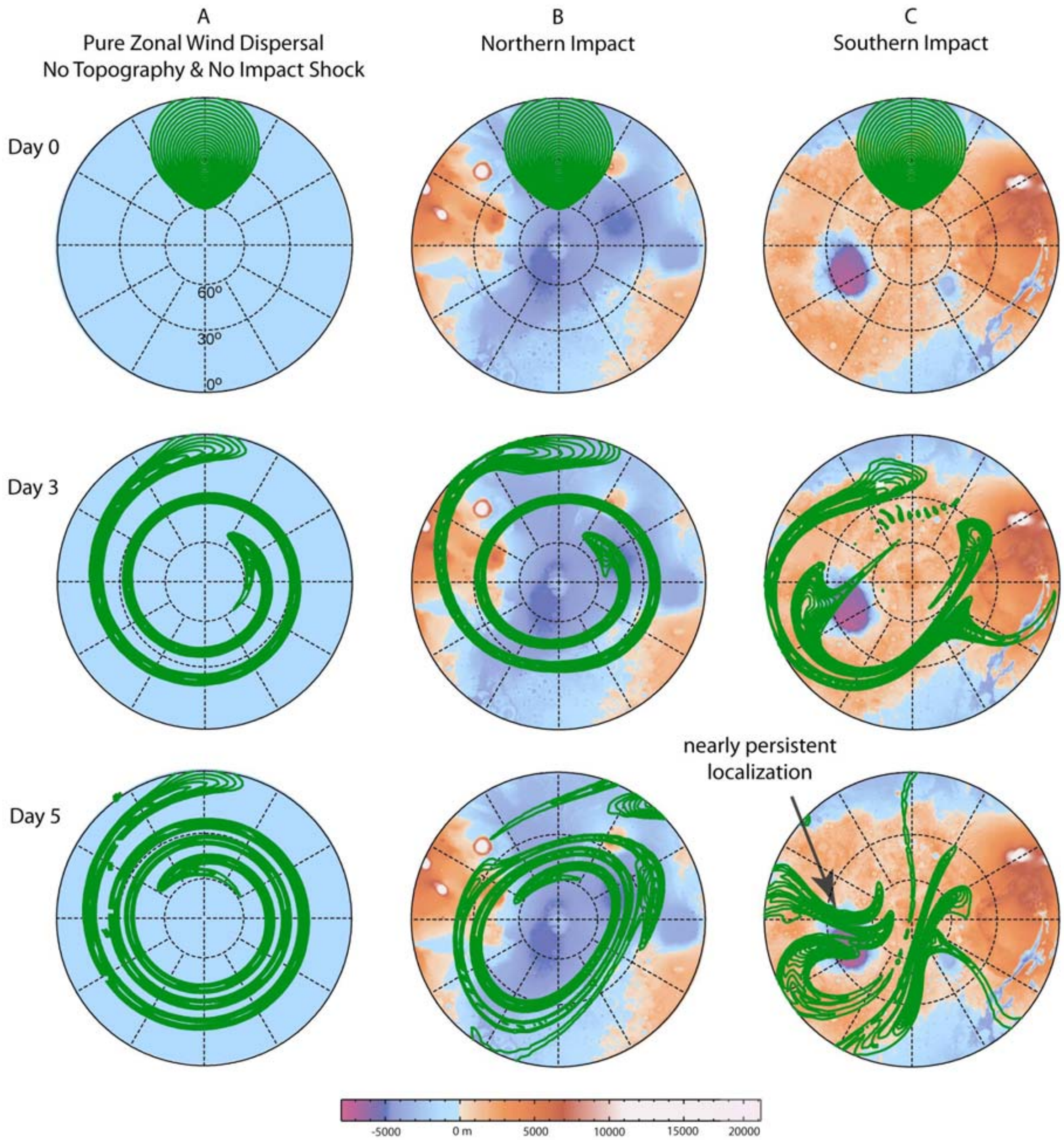

Figure 1. Topography Effects on Dust Dispersion. Polar stereographic projections showing MOLA topography under tracer distribution (green contours) for an impact event creating a crater several 100 km in diameter using the atmospheric dynamics model. The initial plume radius is 2000 km and initial shock radius is 4800 km. Without topography, the dust plume is sheared into zonal spirals (A). The larger topography variations in the south (C) compared to the north (B) increases the complexity in the dispersal pattern and latitudinal range.