A MARS DUST MODEL WITH INTERACTIVE DYNAMICS, RADIATION, AND MICROPHYSICS.

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Introduction: Aeolian processes are well known to locally suspend dust that is then advected globally. Radiatively active dust particles crucially impact atmospheric thermodynamics and circulation and therefore represent an important factor that should be considered when modeling the Martian global climate. Significant work has already been accomplished studying the impact of individual aspects of the Martian dust cycle [1,2].

A common parameterization when investigating the atmospheric response to dust loading remains imposing a non-evolving constant background dust field or temporally fixing atmospheric dust levels to observational measurements. Similarly, several studies have investigated the accuracy of various dust lifting schemes and the role of dust particles as CCN for water and CO_2 ice clouds [3,4]. These models reveal the global impact of radiatively active dust. However, it is likely that global events experience feedbacks on much smaller scales. The ultimate goal of this work is to create a fully interactive dust cycle for Mars coupled with an advanced microphysical cloud scheme. It may therefore become easier to pinpoint positive or negative feedbacks between the atmospheric dust load and the hydrological cycle and possibly help resolve the stochastic nature of global dust storm events and the preferred locations for dust deposition.

Water-ice clouds have been observed high in the modern day Martian atmosphere [5]. Even at the low atmospheric temperatures observed in the upper troposphere, it is likely that cloud droplets heterogeneously condense on dust particles acting as ice nuclei (IN). High altitude water-ice clouds have shown potential as a positive forcing mechanism to warm the Noachian climate above the requisite freezing point of water for a sustained period [6]. However, cloud parameters that produce substantial forcing are highly constrained [6]. An assessment of the probability of specific parameters including cloud droplet size, fractional cloud cover and cloud base altitude is therefore required. This can best be achieved with an advanced microphysical cloud scheme fully coupled with an interactive dust model.

Here, we show results from the NCAR Community Atmosphere Model (CAM) for Mars coupled with the Community Aerosol and Radiation Model for Atmospheres (CARMA). Our first step successfully incorporates wind driven dust lifting as the primary mode for producing the observed atmospheric dust load.

Modeling Approach: MarsCAM is a three-dimensional coupled climate aerosol model adapted from NCAR's 4th generation Community Atmosphere Model (CAM3.1) for Earth and coupled with the University of Colorado/NASA Community Aerosol and Radiation Model for Atmospheres (CARMA). The finite-volume (FV) dynamical core conserves mass of advected tracers and is therefore particularly suited to studies of Martian dust. Dust aerosol microphysics including emission, dry deposition and coagulation is treated by CARMA as a bin-resolved, one-dimensional column sectional model. MOLA topography maps are smoothed to 4x5 degree resolution. The model is vertically discretized into 26 hybrid sigma pressure levels.

Wind Driven Dust Lifting. Dust mobilization is logically tied to the flux of momentum to the Martian surface. Local soil properties including erodibility and roughness length, particle size and atmospheric stability determine small-scale mass fluxes of dust. Here, we use the scheme for wind driven dust lifting to parameterize the saltation-sandblasting process suggested by [2]. Deflation is assumed to occur in regions with wind stress in excess of 22.5 mN m^{-2}. Martian topography is extremely varied. However, because wind stress is a function of frictional velocity and atmospheric density, a wind stress based scheme allows for the use of a constant global threshold. Mass is distributed into 20 size bins with a central radius range of 0.1 to 8 microns. The initial radial size distribution is log-normal with a sigma value of 1.5. In this first model, the entire Martian surface represents a potential source region, however, future iterations will include global maps of roughness length and erodibility.

Results: Dust is allowed to advect horizontally and is removed from the atmosphere by dry deposition. It is radiatively active and contributes to atmospheric heating. In the future, dust will be coupled with an advanced cloud microphysics scheme.

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