IMPROVED MARS-GRAM FOR AEROCAPTURE, AEROBRAKING, OR LANDED MISSIONS TO MARS

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The Mars Global Reference Atmospheric Model (Mars-GRAM) is an engineering-level atmospheric model widely used for diverse mission applications. Mars-GRAM's perturbation modeling capability is commonly used, in a Monte-Carlo mode, to perform high fidelity engineering end-to-end simulations for entry, descent, and landing (EDL). It has been discovered during the Mars Science Laboratory (MSL) site selection process that Mars-GRAM when used for sensitivity studies for Thermal Emission Spectrometer (TES) MapYear = 0 and large optical depth values, such as tau = 3, is less than realistic. Traditional Mars-GRAM options for representing the mean atmosphere along entry corridors include: (1) TES mapping year 0, with user-controlled dust optical depth and Mars-GRAM data interpolated from the NASA Ames Mars General Circulation Model (MGCM) results driven by selected values of globally-uniform dust optical depth, or (2) TES mapping years 1 and 2, with Mars-GRAM data coming from MGCM results driven by observed TES dust optical depth. From the surface to 80 km altitude, Mars-GRAM is based on the NASA Ames MGCM. Above 80 km, Mars-GRAM is based on the University of Michigan Mars Thermospheric General Circulation Model (MTGCM). MGCM results that were used for Mars-GRAM with MapYear = 0 were from a MGCM run with a fixed value of tau = 3 for the entire year at all locations. This choice of data has led to discrepancies that have become apparent during recent sensitivity studies for MapYear = 0 and large optical depths. Unrealistic energy absorption by time-invariant atmospheric dust leads to an unrealistic thermal energy balance on the polar caps. The outcome is an inaccurate cycle of condensation/sublimation of the polar caps and, as a consequence, an inaccurate cycle of total atmospheric mass and global-average surface pressure. Under an assumption of unchanged temperature profile and hydrostatic equilibrium, a given percentage change in surface pressure would produce a corresponding percentage change in density at all altitudes. Consequently, the final result of a change in surface pressure is an imprecise atmospheric density at all altitudes. In determining a possible solution to this discrepancy, Mars-GRAM was evaluated at locations and times of TES limb observations and adjustment factors (ratio of observed TES density to Mars-GRAM density) were determined. For altitudes above 80 km, Mars-GRAM (MTGCM) densities were compared to aerobraking densities measured by Mars Global Surveyor (MGS), Mars Odyssey (ODY), and Mars Reconnaissance Orbiter (MRO). The adjustment factors generated by this process had to satisfy the gas law: $p = \rho RT$ as well as the hydrostatic relation: $dp/dz = -\rho g$. The adjustment factors [F(z,Lat,Ls)] are expressed as a function of height (z), Latitude (Lat) and areocentric solar longitude (Ls). The latest release of Mars-GRAM, Mars-GRAM 2010, includes these adjustment factors that alter the input data from MGCM and MTGCM for the Mapping Year 0 (user-controlled dust) case. The greatest adjustment occurs at large optical depths such as tau>1. The addition of the adjustment factors has led to better correspondence to TES Limb data from 0-60 km as well as better agreement with MGS, Odyssey and MRO data at approximately 90-130 km. Examples of this improvement in results for various locations, times and dust conditions on Mars will be presented at the workshop session. Mars-GRAM 2010 has been developed, validated and is ready for distribution. Updates that have been made to the coefficients for the functions within Mars-GRAM 2010 relating density, latitude and longitude of the sun will result in improved atmospheric simulations. These improved simulations utilizing Mars-GRAM 2010 will be vital when designing and planning systems for aerocapture, aerobraking or landed missions to Mars.