# MARS-GRAM 2010: ADDITIONS AND RESULTING IMPROVEMENTS

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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 has been utilized during previous aerobraking operations in the atmosphere of Mars. Mars-GRAM has also been used in the prediction and validation of Mars Pathfinder hypersonic aerodynamics, the aerothermodynamic and entry dynamics studies for Mars Polar Lander, the landing site selection process for the Mars Science Laboratory (MSL), the Mars Aerocapture System Study (MASS) as well as the Aerocapture Technology Assessment Group (TAG). Most recently, Mars-GRAM 2010 was used to develop the onboard atmospheric density estimator that is part of the Autonomous Aerobraking Development Plan. The most recent release of Mars-GRAM 2010 contains several changes including an update to Fortran 90/95 and the addition of adjustment factors. Following the completion of a comparison analysis between Mars-GRAM, Thermal Emission Spectrometer (TES), as well as Mars Global Surveyor (MGS), Mars Odyssey (ODY), and Mars Reconnaissance Orbiter (MRO) aerobraking density data, adjustment factors were added to Mars-GRAM 2010 that alter the input data from National Aeronautics and Space Administration (NASA) Ames Mars General Circulation Model (MGCM) and the University of Michigan Mars Thermospheric General Circulation Model (MTGCM) for the mapping year 0 user-controlled dust case. The addition of adjustment factors resolved the issue of previous versions of Mars-GRAM being less than realistic when used for sensitivity studies for mapping year 0 and large optical depth values, such as tau equal to 3. Mars-GRAM was evaluated at locations and times of TES limb observations and adjustment factors were determined. For altitudes above 80 km and below 135 km, Mars-GRAM (MTGCM) densities were compared to aerobraking densities measured by Mars Global Surveyor (MGS), Mars Odyssey (ODY), and Mars Reconnaissance Orbiter (MRO) to determine the adjustment factors. The adjustment factors generated by this process had to satisfy the gas law as well as the hydrostatic relation and are expressed as a function of height (z), Latitude (Lat) and areocentric solar longitude ($L_s$). The greatest adjustments are made at large optical depths such as tau greater than 1. The addition of the adjustment factors has led to better correspondence to TES Limb data from 0-60 km altitude as well as better agreement with MGS, ODY and MRO data at approximately 90-130 km altitude. Improved Mars-GRAM atmospheric simulations for various locations, times and dust conditions on Mars will be presented at the workshop session. The latest results validating Mars-GRAM 2010 versus Mars Climate Sounder data will also be presented. Mars-GRAM 2010 updates have resulted in improved atmospheric simulations which will be very important when beginning systems design, performance analysis, and operations planning for future aerocapture, aerobraking or landed missions to Mars.