MARS GLOBAL REFERENCE ATMOSPHERIC MODEL (MARS-GRAM) UPGRADES.

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Introduction: The Mars Global Reference Atmospheric Model (Mars-GRAM) is one of the most widely used engineering models of the Martian atmosphere. Mars-GRAM is developed and maintained by the NASA Marshall Space Flight Center (MSFC). The NASA Science Mission Directorate (SMD) has provided funding support to upgrade the planetary GRAMs in Fiscal Year 2018 and 2019. This presentation will provide a summary of the upgrades that have been made to Mars-GRAM, the release status of Mars-GRAM, the new planetary GRAMs that are under development, and future Mars-GRAM upgrade plans.

Mars-Global Reference Atmospheric Model (Mars-GRAM): Mars-GRAM is an engineering-level atmospheric model applicable for engineering design analyses, mission planning, and operational decision making. Mars-GRAM provides mean values and variability for any point in the Martian atmosphere as well as seasonal, geographic, and altitude variations. Mars-GRAM outputs include winds, thermodynamics, chemical composition, and radiative fluxes. Mars-GRAM has been widely used by the engineering community because of its ability to create realistic dispersions; Mars-GRAM can be integrated into high fidelity flight dynamic simulations of launch, entry, descent and landing (EDL), aerobraking and aerocapture. MSFC has been developing and updating GRAMs since 1974 with GRAMs currently available for Earth, Mars, Venus, Neptune, and Titan.

Mars-GRAM and Overall Planetary GRAM Upgrade Status:

Code Upgrades. All planetary GRAMs have been redesigned around a common C++ framework. The source code for the GRAM suite has been reorganized in a modular fashion. A common framework has been developed upon which all GRAM models are built which is then coupled with the models specific to that particular planetary body. This will make the user interface with all of the planetary GRAMs uniform. The first C++ releases of the existing planetary GRAMs will be a straight conversion from the latest Fortran version.

Model Upgrades. The focus of the model upgrade task has been to improve the atmosphere models in the existing GRAMs and to establish a foundation for developing GRAMs for additional destinations. The GRAM ephemeris has been upgraded to the NASA Navigation and Ancillary Information Facility (NAIF) Spacecraft Planet Instrument C-matrix Events (SPICE) toolkit (version N0066). Meetings with planetary modelers, mission data providers, and experts are ongoing to determine new data sets and models that are currently available to upgrade existing planetary GRAMs and to develop new planetary GRAMs (Saturn, Uranus, and Jupiter-GRAM).

It is anticipated that a subsequent release of Mars-GRAM will include the latest data from the NASA Ames Mars General Circulation Model (MGCM) and University of Michigan Mars Global Ionosphere-Thermosphere Model (M-GITM) and update the fairing between these models.

Upcoming GRAM Releases. The upgraded planetary GRAM software release is targeted for August 2019. This release will include the new common C++ framework as well as SPICE. It will include the rearchitected versions of Mars, Venus, Neptune, Titan, Jupiter, Saturn, and Uranus-GRAM. The original atmosphere models will be utilized in the existing planetary GRAMs (Venus, Mars, Neptune, and Titan) with individual profiles used for new GRAMs (Jupiter, Saturn, and Uranus). A GRAM Programmer’s Manual, User Guides for each GRAM destination, test cases, and trajectory code interfaces will be included in this release.

Conclusions: Upgrades of Mars-GRAM and the other existing planetary GRAMs and development of new planetary GRAMs are continuing. The funding provided by the NASA SMD has been essential to upgrading this critical tool set.

Acknowledgments: The authors gratefully acknowledge support from the NASA SMD.