

VENUS GLOBAL REFERENCE ATMOSPHERIC MODEL STATUS AND PLANNED UPDATES. H. L. Justh¹ and A. M. Dwyer Cianciolo², ¹NASA Marshall Space Flight Center, EV44, Huntsville, AL 35812 hilary.l.justh@nasa.gov, ²NASA Langley Research Center, MS 489, Hampton VA 23681 alia.m.dwyercianciolo@nasa.gov.

Introduction: The Venus Global Reference Atmospheric Model (Venus-GRAM) was originally developed in 2004 under funding from NASA's In Space Propulsion (ISP) Aerocapture Project to support mission studies at the planet. Many proposals, including NASA New Frontiers and Discovery, as well as other studies have used Venus-GRAM to design missions and assess system robustness.

After Venus-GRAM's release in 2005, several missions to Venus have generated a wealth of additional atmospheric data, yet few model updates have been made to Venus-GRAM. This paper serves to address three areas: (1) to present the current status of Venus-GRAM, (2) to identify new sources of data and other upgrades that need to be incorporated to maintain Venus-GRAM credibility and (3) to identify additional Venus-GRAM options and features that could be included to increase its capability. This effort will depend on understanding the needs of the user community, obtaining new modeling data and establishing a dedicated funding source to support continual upgrades. This paper is intended to initiate discussion that can result in an upgraded and validated Venus-GRAM being available to future studies and NASA proposals.

Background: Venus-GRAM is an engineering model of the atmosphere. While it does not allow for predictive forecasting capability, it does provide mean density, temperature, pressure and wind components at any height from 0 to 1000 km. The model also allows the simulation of random perturbations about the mean. This is sufficient for mission planning and system analysis.

Currently the lower atmosphere model in Venus-GRAM (up to 250 km) is based on the Venus International Reference Atmosphere (VIRA) [1]. The Venus-GRAM thermosphere (250 to 1000 km) is based on a MSFC-developed model [2]. In the lowest altitudes (below 100 km) the VIRA model only depends on latitude. In the middle altitudes (100 to 150 km) the VIRA model only depends on local solar time. At high altitudes (150 to 250 km), VIRA only depends on solar zenith angle. The MSFC-developed thermosphere model assumes an isothermal temperature profile initialized using VIRA conditions at 250 km [3]. The original version of VIRA that is included in Venus-GRAM included Pioneer Venus Orbiter and Probe data as well as Venera probe data, but it did not include a

solid planet model, nor a high resolution gravity model [4].

New Sources of Data: Several additional Venus atmosphere models and data sources are available that can be utilized to update Venus-GRAM. First, work to update the VIRA model has been ongoing. Second, Earth observation data of Venus extends two decades. Third, Venus Express has collected nearly a decade of data at the planet. Fourth, Magellan data of the surface and gravity field are available. Fifth, the development of a Venus Global Ionosphere-Thermosphere Model (V-GITM) will be of benefit to future versions of Venus-GRAM.

Identifying and collecting available data is only the first part of the task for updating Venus-GRAM. Developing methods to assimilate or incorporate this data into Venus atmosphere models as well as Venus-GRAM will be needed. Verification of the model performance using this data is also necessary to verify Venus-GRAM credibility.

Model Capability: Additional capability can also be included in Venus-GRAM. For example, Venus-GRAM is in the process of being upgraded from Fortran to C++. Object oriented code offers additional options not previously available. GRAM developers are also interested in hearing from the user community to identify high priority items that would enable mission modeling that is not currently available. One example includes a higher resolution topography model for probe mission analysis.

Looking Ahead: NASA has released the 2016 New Frontiers and there is also scheduled to be a 2018 Discovery Announcement. Both calls include Venus as a target destination. Sustained funding opportunities are being sought in order to maximize the contribution that updates to Venus-GRAM can make to the mission planning phases of proposals. Additionally, NASA is interested in bringing together atmospheric modelers, GRAM users and GRAM developers to identify high priority tasks for GRAM improvements. This forum will provide an opportunity to gain insight from the Venus modeling community.

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