Mars Global Reference Atmospheric Model (Mars-GRAM) and Database for Mission Design

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EXTENDED ABSTRACT

Mars Global Reference Atmospheric Model (Mars-GRAM 2001) is an engineering-level Mars atmosphere model widely used for many Mars mission applications (Justus and Johnson, 2001; Justus et al., 2002a). From 0-80 km, it is based on NASA Ames Mars General Circulation Model (MGCM; Haberle et al., 1993), while above 80 km it is based on Mars Thermospheric General Circulation Model (Bougher et al., 1990). Mars-GRAM 2001 and MGCM use surface topography from Mars Global Surveyor Mars Orbiting Laser Altimeter (MOLA; Smith and Zuber, 1998).

Validation studies (Justus et al., 2002b,c) are described comparing Mars-GRAM with Mars Global Surveyor Radio Science (RS; Hinson et al., 1999) and Thermal Emission Spectrometer (TES; Smith et al., 2001) data . RS data from 2480 profiles were used, covering latitudes 75° S to 72° N, surface to ~ 40 km, for seasons ranging from areocentric longitude of Sun (Ls) = 70-160° and 265-310°. RS data spanned a range of local times, mostly 0-9 hours and 18-24 hours. For interests in aerocapture and precision landing, comparisons concentrated on atmospheric density. Figure 1 shows that, at a fixed height of 20 km, RS density varied by about a factor of 2.5 over ranges of latitudes and Ls values observed. Evaluated at matching positions and times, Figure 2 shows average RS/Mars-GRAM density ratios were generally 1±0.05, except at heights above ~ 25 km and latitudes above ~ 50° N. Average standard deviation of RS/Mars-GRAM density ratio was 6%.

TES data were used covering surface to ~ 40 km, over more than a full Mars year (February, 1999 – June, 2001, just before start of a Mars global dust storm). Depending on season, TES data covered latitudes 85° S to 85° N. Most TES data were concentrated near local times 2 hours and 14 hours. Observed average TES/Mars-GRAM density ratios were generally 1±0.05, except at high altitudes (15-30 km, depending on season) and high latitudes (> 45° N), or at most altitudes in the southern hemisphere at Ls ~ 90 and 180°. Compared to TES averages for a given latitude and season, Figures 3-5 show that TES data had average density standard deviation about the mean of ~ 2.5% for all data, or ~ 1-4%, depending on time of day and dust optical depth. Average standard deviation of TES/Mars-GRAM density ratio was 8.9% for local time 2 hours and 7.1% for local time 14 hours. Thus standard deviation of observed TES/Mars-GRAM density ratio, evaluated at matching positions and times, is about three times the standard deviation of TES data about the TES mean value at a given position and season.

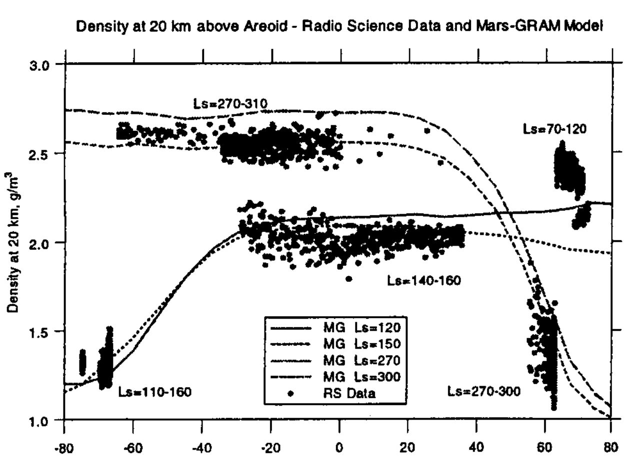

Figure 1 – Comparison of density at 20 km altitude from Mars Global Surveyor Radio Science observations and Mars-GRAM 2001 model.

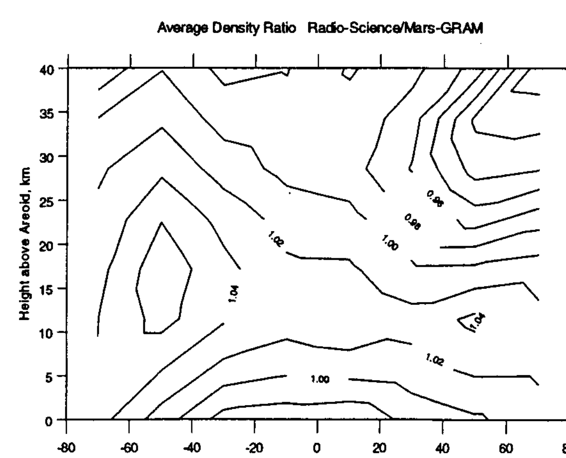

Figure 2 - Height-latitude cross section of average observed density ratio (Radio-Science/Mars-GRAM 2001) for all Ls and times of day.

issues for accidental break-up and burn-up scenarios. For lander missions, applications include analysis for entry, descent and landing (EDL), guidance and control analysis for precision landing, and (with the new near-surface environment features) systems design and analysis for lander operations.

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