THE MARTIAN UPPER ATMOSPHERE DURING PHASE 2 OF MARS GLOBAL SURVEYOR AEROBRAKING: COMPARISON TO PREDICTIONS

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Introduction: The Mars Global Surveyor accelerometer [1] provided density, density scale height, and temperature data for each orbit at periapsis and 130 km altitude (both inbound and outbound). It observed large and unexpected variations in upper atmospheric density with longitude. A stationary wave fit to these variations changed in both amplitudes and phases with latitude and did not correlate precisely with topography. Longitudinal variations were not predicted at all and the mean behaviour of the upper atmosphere was only partially predicted, with the south polar region being particularly poorly predicted.

Background: Mars Global Surveyor (MGS) has completed aerobraking. During phase 2 of aerobraking (September 1998 - February 1999) the elliptical, near polar orbit penetrated the atmosphere for ~10' either side of periapsis. Periapsis precessed from ~60'N to the south pole and back to ~60'S, sampling various longitudes. The local solar time range of periapsis was more restricted, being ~1500 until periapsis neared the south pole when it quickly changed, through midnight, to ~0200 as periapsis crossed the terminator. Periapsis altitude was ~110 +/- 10 km. During this period Mars was passing through aphelion and the season was northern spring.

The accelerometer (ACC) data, intended for mission support, is also a valuable scientific resource. Future processing by the instrument team will generate vertical profiles of density, density scale height, and temperature for each orbit.

Predictions of these three properties during aerobraking were made by the Mars Thermosphere Global Circulation Model (MTGCM) for mission support [2]. These predictions failed to completely capture some aspects of the martian upper atmosphere as measured by MGS [3].

Comparision to Predictions at 130km:

Latitudinal variations in mid-latitudes. Mean densities and density scale heights are accurately predicted. ACC densities vary by a factor of two from orbit to orbit and ACC density scale heights by 25%. MTGCM temperatures are too warm by ~40K compared to mean ACC temperatures. ACC temperatures vary by 25% from orbit to orbit.

South polar region. Mean densities and density scale heights are not accurately predicted in the south polar region. MTGCM densities are too small by a factor of three, density scale heights by 25%. Mean temperatures are reasonably accurately predicted.

Diurnal variations. South of 50'S data was acquired at a local solar time of ~1500 as periapsis precessed towards the pole and ~0200 as periapsis precessed away from the pole. North of 70'S densities, density scale heights, and temperatures were greater at ~1500 than at ~0200. South of 70'S, as the local solar time of periapsis passed through midnight, diurnal variations were negligible, as expected for the polar night.

Longitudinal variations. Unexpected stationary variations in density with longitude of a factor of three were observed (figure 1). No such variation is observed on Venus or the Earth. A stationary wave fit to these variations changed in both amplitudes and phases with latitude and did not correlate precisely with topography (figure 2). The stationary nature of the waves suggests that they are generated by topographic effects, then propagate upwards. The MTGCM does not predict any longitudinal variation in the upper atmosphere.

Discussion: The mean behaviour of the martian upper atmosphere is incompletely predicted by MTGCM. A vertical offset in coupling to a lower atmospheric global circulation model enables mean densities and density scale heights (but not temperatures) to be correctly predicted outside polar regions. Longitudinal variations are not predicted at all but are a major contribution to upper atmospheric structure. They are probably the major surprise of the MGS upper atmospheric studies to date.

MTGCM and other models will be used to support Mars Climate Orbiter in its scheduled 6 weeks of aerobraking across the north polar region and along the terminator in dust storm season.

References:

[1] Keating G. M. et al. (1998) *Science, 279,* 1672-1676. [2] Bougher. S. W. et al. (1997) *Adv. Space Res., 19*, 1255-1260. [3] Bougher S. W. et al. (1999) *Adv. Space Res.*, in press

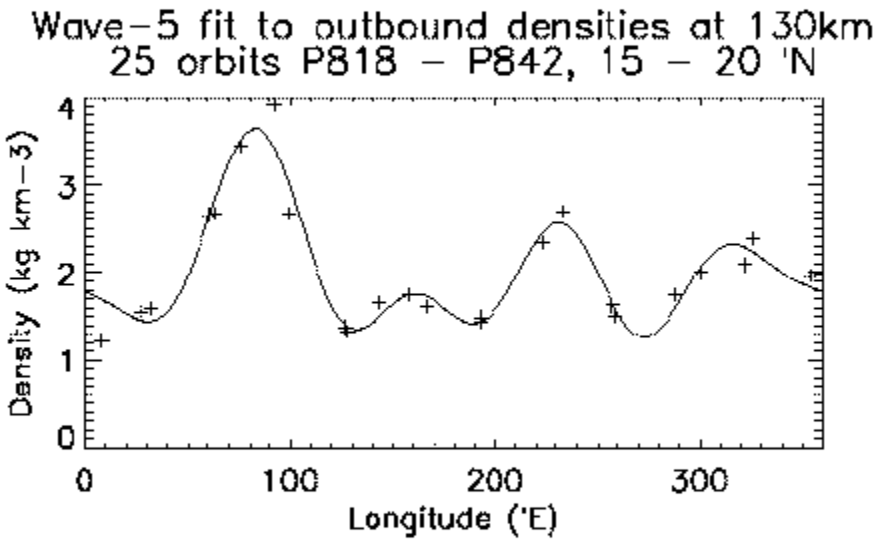

Figure 1: Longitudinal variation in outbound density at 130 km. A wave 5 fit is shown to 25 orbits (P818 – P842). Latitude changed from 20 to 15 'N during the 25 orbits.

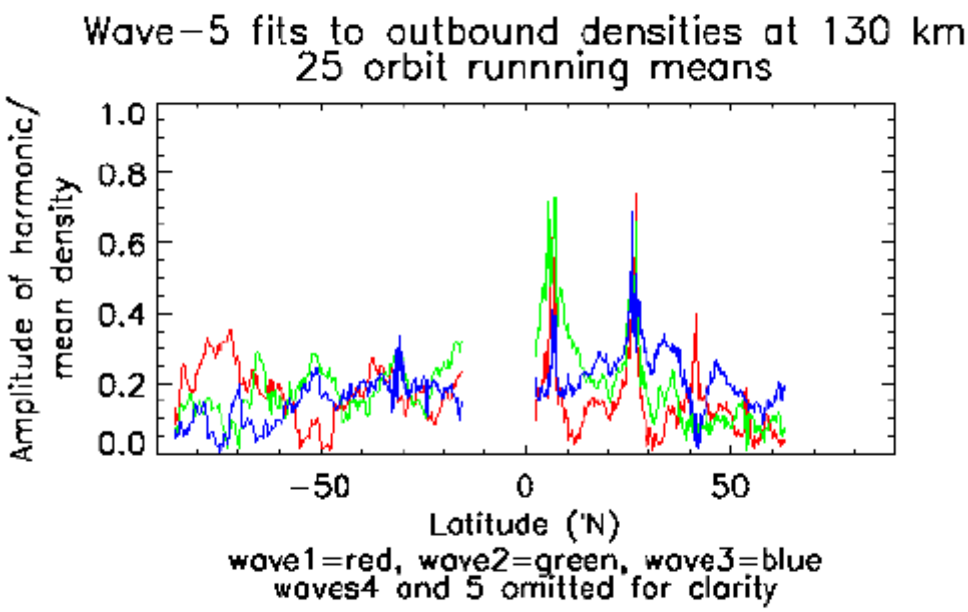

Figure 2: Amplitudes of waves 1, 2, and 3 normalized to mean density as a function of latitude for outbound densities at 130 km during Phase 2. A wave 5 fit to 25 orbit running means was used. Colour scheme: wave 1 red, wave 2 green, and wave 3 blue.