THE EFFECT OF THE ATMOSPHERE OF MARS ON THE PLANET'S ROTATION AND GRAVITY FIELD; *M.T. Zuber*[1,2], *D.E. Smith*[2], *and R.M. Haberle*[3], [1]Dept. of Earth, Atmospheric, and Planetary Sciences, MIT, Cambridge, MA, [2]Laboratory for Terrestrial Physics, NASA/ Goddard Space Flight Center, Greenbelt MD, [3]NASA/Ames Research Center, Moffett Field, CA

Movements in the atmosphere of Mars cause changes in the distribution of mass and in the angular momentum that affect the planet's rotation and gravity field. As atmospheric material moves seasonally toward the summer pole the angular momentum of the atmosphere decreases and the rotation rate of the solid part of the planet increases to conserve the planet's total angular momentum. Similarly, as atmospheric material moves away from the pole the body of the planet slows down. The coupling between the atmosphere and the surface is through wind stress acting on the planet's topography. As the atmospheric mass is redistributed during the Mars year the gravity field of the planet is changed and a small seasonal variation in the gravity field is produced. Imbalance in the distribution of atmospheric material with respect to the rotation pole introduces a torque on the rotation axis that excites polar motion.

Approximately 25% of the CO_2 in the Mars atmosphere moves from one pole to the other as the seasons change [1]. Water and carbon dioxide evaporate at the summer pole and move toward the equator decreasing the mass at the pole while increasing the mass at the equator thereby increasing the J_2 term (flattening) of the gravity field. Further, as the atmospheric material moves toward the winter pole, some of it condenses out as ice (CO_2 and H_2O), forming an additional mass layer on the surface, thus increasing the mass at the winter pole at the expense of mass at the equator and the summer pole. This mass re-distribution also changes the gravitational (dynamic) flattening (J_2) and the "pear shape" (J_3) terms in the gravity field of Mars. The annual movement of atmospheric material thus causes annual and semi-annual variations in the long wavelength terms in the gravity field and in the angular momentum of the solid body of Mars.

We have estimated these effects for Mars from pressure, precipitation, and wind fields generated by the Ames General Circulation Model (GCM) [2] for one Mars year. Mean atmospheric conditions were used for each 33 days during a Mars year. The distribution of surface pressures in Figure 1 is seen to be closely related to the Mars topography model used in the GCM. Using the geopotential topography model developed recently by Smith and Zuber [3] in the Ames GCM [2], we derived the pressure field, precipitation and wind fields [4,5] and from these calculated their changing effect on the low degree terms of the gravity field, the length of the Martian day, and the position of the pole of rotation [6,7,8].

Our preliminary analysis of the magnitudes of these effects indicates semi-annual variations in the length of the Mars day to be a few milliseconds of time, the annual changes in the gravity field to be of the order 10^{-9} (principally in the flattening), the polar motion to be very small at the millimeter level, and annual changes in the geoid to be of order a few centimeters. At least some of these effects may be observable via radio tracking of the Mars Global Surveyor spacecraft during its nominal mission [9]. In addition, we have concluded that the largest global component of the Mars topography, the 3 km center-of-mass/center-of-figure offset down the rotation axis that causes the topography in the southern hemisphere to be several kilometers higher than the northern hemisphere [3], is an important influence in the global atmospheric circulation and in the rotation of the planet.

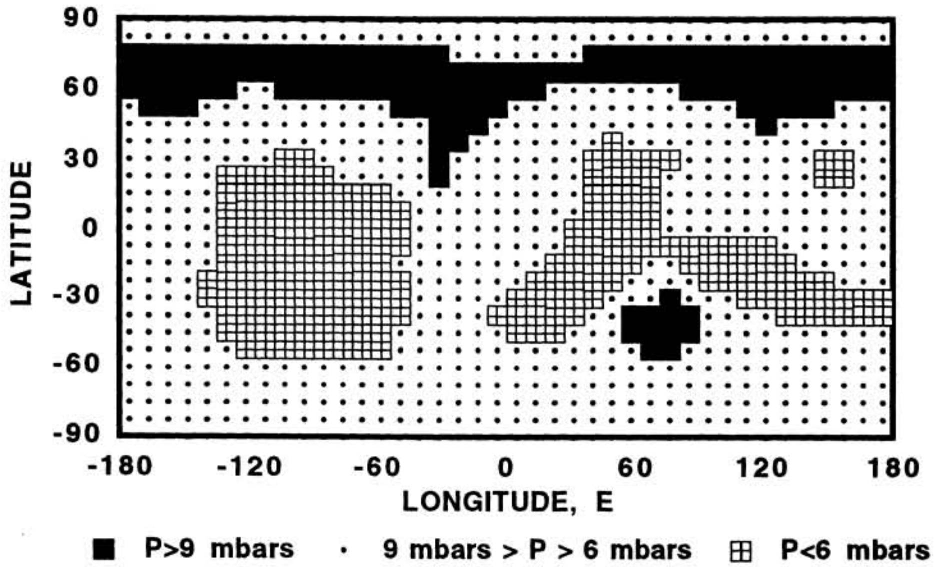

Fig. 1 Average surface pressure for 33 days (LS=77 deg) produced by the Ames GCM. The pressure distribution is used to compute the forces and torque on the body of the planet.

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