VARIATIONS IN THE MASSES OF THE SEASONAL POLAR ICECAPS OVER 3 MARS YEARS. Maria T. Zuber[1] and David E. Smith[2], [1]Department of Earth Atmospheric and Planetary Science, Massachusetts Institute of Technology, Cambridge, MA 02139, USA (zuber@mit.edu), [2]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD, 20771, USA. (dsmith@tharsis.gsfc.nasa.gov)

Introduction: Tracking of the Mars Global Surveyor spacecraft has continued almost uninterrupted for over 7 years since the beginning of mapping in February 1999 and provided detailed information about the motion of the spacecraft around Mars. These data reveal the small perturbations of the orbit due to the changing masses of the icecaps arising from the seasonal exchange of carbon dioxide with the atmosphere. We have analyzed over 3 Mars-years (over six Earth-years) of these data to obtain variations in the gravity field and the seasonal masses of each of the icecaps and their variation throughout the Martian year.

Approach: We processed the tracking data in orbital arcs of approximately 5 days and, after editing time-periods of minimal data and poor quality, we analyzed 400 5-day arcs covering over 3.5 Mars years. The data consisted of X-band Doppler and range data; the Doppler were accurate to about 0.1 mm/s and the range to about 2 m. We determined the orbit of MGS for each orbital arc and estimated one or more low degree coefficients of the Mars gravity field. We found considerable difficulty in obtaining reliable values for the C2,0 gravity coefficient that we ascribed to the small effect that this parameter has on the orbit of MGS. The estimation of the C3,0 coefficient was remarkably robust and inline with expectations in terms of amplitude of variation and phase from GCM predictions. Further, the recovery of the C3,0 did not change when it was estimated simultaneously with the C2,0 coefficient. We interpret this result as an indication that the C3,0 result is robust and is a reasonable estimate of the lumped effect of the odd zonal coefficients, primarily C3 and C5 but also those of higher degree. However, because we were unable to estimate a reliable value for the C2,0 gravity coefficient we were not able to reliably estimate the hypothetical mass of the seasonable icecaps based upon point masses at each pole.

We also used the tracking data to make direct estimates of the masses of the icecaps. We modeled each icecap as a circular cone centered on the pole where the size of the cone in latitude was derived from observations obtained from MOLA radiometry [1] and TES data [2] and the height of the cone from MOLA altimetry [3]. The northern cap extended down to a maximum of 55 degrees and the southern cap extended to latitude 50. The maximum height of both caps was taken as 1 meter and the height decreased linearly with cap size. The theoretical gravity field of each cap was derived for every 5 degrees in cap size, assuming the seasonal material was of nominal density. Subsequently we solved for scale factors from the tracking data for the densities, and obtained the total mass of each icecap. Because the polar deposition is composed of carbon dioxide that is being withdrawn from the atmosphere and returned to the atmosphere during sublimation, there is a variation in the mass of the atmosphere that also perturbs the spacecraft and needs to be accounted for in the analysis. We used GCM [4] results for the *a priori* mass of the atmosphere and effectively solved for the variation in mass of the atmosphere simultaneously with the two icecaps and applied a constraint to our solution requiring the sum of all mass changes at both poles and in the atmosphere to sum to zero, thus maintaining a constant volatile mass of the planet.

Results: Our gravity field coefficient solutions did not enable us to estimate the masses of the seasonal caps even though the C3,0 variation showed the seasonal affect.

The results of the direct estimation of the polar masses indicated variations similar to those predicted by the Ames GCM. However, variations are seen from year to year and are revealed as deviations, some systematic, about a mean, and we believe represent real inter-annual variability in the seasonal cycle.

For the north pole the data suggest that the winter accumulation of precipitation begins immediately after the autumnal equinox (Ls 180), rises to a maximum around Ls 325 and has completely sublimated back into the atmosphere by Ls 70. For the south pole the data suggest the accumulation does not begin until around Ls 45, reaches a maximum around Ls 145, and that sublimation back into the atmosphere is complete by Ls 235. No two Mars years appear to be exactly the same and there is some indication that there are long term trends in the polar results that could indicate involvement of other components of the Martian hydrological system.

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