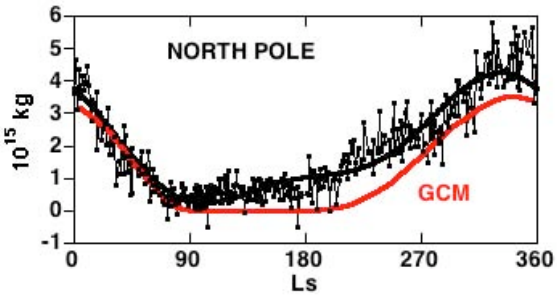
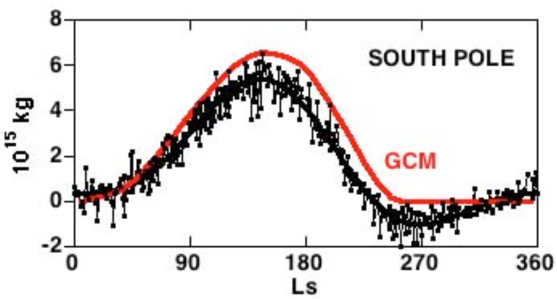
CHANGES IN THE MASSES OF THE SEASONAL POLAR ICECAPS OVER 3 MARS YEARS. Maria T. Zuber[1] and David E. Smith[2], [1]Dept. of Earth Atmospheric and Planetary Science, Massachusetts Institute of Technology, Cambridge, MA 02139, zuber @mit.edu; [2]Solar System Exploration Division, NASA Goddard Space Flight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

Introduction: Tracking of the Mars Global Surveyor spacecraft [1] has continued almost uninterrupted for 7 years since the beginning of mapping in February 1999. The tracking data provide detailed information about the motion of the spacecraft around Mars, including the small perturbations due to the changing masses of the icecaps arising from the seasonal deposition and sublimation of carbon dioxide with the atmosphere. We have analyzed over 3 Mars-years (six Earth-years) of these data to obtain 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 over 340 5-day arcs covering over 3 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 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 [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 [3] and the height decreased linearly with cap size. The theoretical gravity field of each cap was derived for every 5 degrees in size and assuming the seasonal material was of nominal density [3]. 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 Because the polar deposition is composed of carbon dioxide that is being withdrawn from the atmosphere and returned to the atmosphere during sublimation, there is a (minute) variation in the mass of the atmosphere that also perturbs the spacecraft and needs to be accounted for in the analysis. We effectively also solved for the variation in mass of the atmosphere and applied a constraint to our solution that requires 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 results for the polar masses are shown in Figures 1 and 2 as a function of Ls together with the variation predicted by the Ames GCM [4]. Variations from year to year are evident and are revealed as scatter about a mean curve, but it is not clear whether the scatter represents real short-term variability or alternatively is the result of observational error.





Figures 1&2. Results for the north pole (top) and south pole (bottom) for all 3 Mars-years in black. The data for the three years is superposed. Ames GCM predictions [3] are shown in red. Agreement between the gravity results and the GCM is only expected to be qualitative in the above figures because the masses of the polar caps include the atmosphere above the caps, since this mass is observationally inseparable from the surface deposition. A correction for this effect can be performed but is not included here.

In both charts the data suggest that at the time of the summer solstice (Ls = 90 and 270) the accumulation of precipitation begins immediately after the end of the sublimation phase. This is surprising since it is the beginning of summer but may be associated with the inclusion of the atmospheric mass above the poles in the estimates for the polar masses. Ultimately separability may be attempted by comparisons with column density estimations from other sensors [e.g. 5]. These temporal records of Mars' hemispheric mass distribution are beginning to approach the level required to study interannual variability suggested by changes in polar surface morphology [6].

References: [1] Tyler, G.L. et al. (2001) JGR 106, 23327-23348. [2] Zuber M.T. and Smith D.E. (2003) Third Mars Polar Conf. Banff. [3] Smith D.E. et al. (2001) Science 294, 2141-2146. [4] Haberle R.M. (2003) Third Mars Polar Conf, Banff. [5] Mitrofanov, I. et al. (2003) *Science 300*, 2081-2084. [6] Malin, M.C. et al. (2001) *Science*, *294*, 2146-2148.