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Seasonal variation in Mars zonal gravity from MGS

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In February 1999, the Mars Global Surveyor (MGS) spacecraft was set in a frozen orbit about the planet with a constant argument of perigee (about 270 deg) and eccentricity (about .008). This ensured that at a given latitude, the satellite always passes at the same altitude: about 440 km over the North pole at periapse and 375 km over the South pole. These characteristics influence our ability to determine the planet's gravitational influence on the spacecraft. We have analyzed X-band Doppler and range tracking observations of MGS collected by the Deep Space Tracking Network over three Mars years (1999 to 2005). We describe a study of the ability of these data to sense changes in the planet's zonal gravity field. Orbit sensitivity to the odd zonals is influenced by the argument of periapse, and an estimate of J3 represents the sum of the odd zonal effects. We present analytical functions which can be employed to assess the relative sensitivities of zonal terms in the total signal. The odd zonal variation is found to be well determined and has a similar signature in each term. The MGS orbit characteristics yield a weaker determination of the even zonal variation. The variation in J3 can be combined with measures of the Martian atmosphere and models of the ice cap distribution to infer seasonal mass exchange between the poles.