Seasonal variations of depth and density of Martian snow from time-variable altitude and gravity

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95 percent of the current atmosphere of Mars is carbon dioxide. The Martian atmosphere seasonally exchanges CO_2 with the surface by repeating condensation and sublimation. The CO_2 snow accumulates on the surface of the high-latitude regions causing waxing and waning of the polar ice caps composed of CO_2 and H_2O. Such variations of polar cap let the gravity field of Mars evolve with season.

In this study, we estimate Martian snow density and its seasonal variation from time-variable altitude and gravity associated with the changing mass of the snow. The short term altitude variation reflects seasonal variations of snow depth. We calculate seasonal variations of gravity coefficient J_3 using the observed snow depths, and compare them with J_3 observed by the Doppler Tracking. We utilize data from Mars Orbiter Laser Altimeter (MOLA) on board Mars Global Surveyor (MGS), and Ultra Stable Oscillator for Doppler measurement (USO/RS MGS between 28 February 1999 and 25 May 2001. We use the time-variable altitude data (snow depth) from Smith et al [2001]. They collected over 66 million altitudes at crossover points and applied profile analysis to obtain a longitude-averaged zonal data set. For the gravity data, we used J_3 time series from Konopliv et al [2006], who estimated the Stokes' coefficients using the Earth based two-way Doppler measurement data allowing only the J_2 and J_3 terms to take different values in time.The snow depth data can be converted into the J_3 value by assuming an appropriate value for the snow density. Smith et al. [2001] estimated a constant average snow density comparing the altimetry and gravity data and obtained the value 910 kg/m^3. Here we hypothesize that the average density of snow increase with time by compaction, and estimate the two parameters with the grid-search, i.e. the initial density of fresh snow and its linear rate of increase with time due to compaction. We find the best combination of the two parameters by minimizing the root mean square (RMS) between J_3 calculated with the snow depth and J_3 measured with the Doppler Tracking.

We found that the fresh snow density of 600 kg/m^3 and density variation of 650 kg/m^3/year result in the best-fit. J_3 will change by other factors including seasonal change of atmospheric pressures and elastic deformation of Mars by snow loading .We will consider such factors to obtain more reliable values of time-variable average density of Martian snow.

- References -

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