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Estimate of the Total Electron Content of the Martian Ionospheric M1 Layer from Mars Express Ionospheric Sounding

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The topside sounder of the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) on board the Mars Express spacecraft, in orbit around Mars, can measure the electron density profile down to the peak of the Martian ionosphere. Computing the electron content below the spacecraft down to the peak is a matter of integrating this profile. The bottom of the principal (M2) layer can be estimated by fitting the profile to a Chapman layer and combining the measured profile with the computed Chapman layer below the peak. However, the Martian ionosphere has at least two, and probably more, layers. In particular, there is a persistent secondary layer (M1), just below and overlapping the M2 layer. This layer cannot be measured directly by the topside sounder. However, the total electron content (TEC) below the spacecraft is measurable if the radar surface reflection shows enough variation with frequency to be fit to a curve. Even where the surface reflection shows no curvature, it is possible to make an estimate using the minimum surface reflection frequency. By subtracting the estimate of the M2 electron content from the TEC, the electron content of the M1 layer can be estimated. In this paper, we do derivations of the electron content of both M1 and M2 layers for several cases. Comparisons are made with TECs from Mars Global Surveyor and Mars Express Radio Science occultation studies, as well as with subsurface estimates of the TEC to validate the technique. We hope that this technique can be used to gauge variation in the two principal ionspheric layers for future correlations with solar cycle, x-ray flux, and seasonal variation.