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Prediction of Mars' Ionosphere Impact on Radio-Science Experiment.

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A new empirical model of the Mars' ionosphere called MoMo was developed [1]. The model provides the vertical Total Electron Content (vTEC) as a function of solar zenith angle, solar activity, solar longitude and the location. For the validation, the model is compared with Mars Express radio occultation data as well as with the numerical model IPIM (IRAP Plasmasphere-Ionosphere Model).

The model output is discussed in terms of climatologic behaviour of the Mars' ionosphere. We also used the output of MoMo to quantify the impact of the Martian ionosphere on radio-science experiments. From our results, the effect is of the order of 10^{-3}mm.s^{-1} in Doppler observables especially around sunrise and sunset. Consequently, this new model could be used to support the data analysis of any radio-science experiment and especially for present InSight RISE [2] and future ExoMars LARA [3] instruments aiming at a better understand of the deep-interior of Mars.

Finally, we focused on the impact of the ionosphere on InSight RISE radio-science experiments. For that purpose, we produce vTEC maps for Mars with MoMo. We then use these maps to estimate the slant TEC in the line of sight of the Earth, and we quantified the impact on different wave propagation parameters: phase delay, and Doppler shift at X-band frequencies.

From the first results, the maximum phase delay is obtained around 12:20 SLT with a stronger effect at lower elevation. In that case, the values in phase delay reach more than 2 cm in X-band. The effect on the Doppler measurements is maximum during local sunrise and sunset (around ~06:00 and ~18:45 SLT). The maximum shift is of the order ± 5 x 10^{-2} mHz (± 1.0 x 10^{-3} mm.s^{-1}) in X-band when considering 20° elevation with respect to the asset.

This is about one order of magnitude below the estimated noise of RISE but is of same order of magnitude as the contribution of the liquid core in the Doppler (~10^{-3}-10^{-2}mm.s^{-1}). Consequently, the predictions made with MoMo suggests that radio-science teams will have to either correct their data using our model for instance or adapt the mission to avoid operating during sunrise and sunset when TEC rapidly varies.

References

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