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The vertical structure of the ionosphere of Mars

P. Withers, K. Fallows, Z. Girazian, A. Lollo and **M. Matta**
Boston University, Massachusetts, USA (withers@bu.edu / Fax: +1-617-3536463)

Abstract

The vertical structure of the ionosphere of Mars consists of two main photochemical layers. Maximum electron densities are produced in the M2 layer, which occurs at approximately 140 km, and is created by extreme-ultraviolet solar photons. The weaker M1 layer occurs at approximately 120 km and is produced by solar soft X-rays and associated electron impact ionization. Many vertical profiles of ionospheric electron density have been obtained by radio occultation experiments on the MGS and MEX spacecraft. Many properties of the M2 layer, including its altitude and density, have been interpreted in the context of idealized Chapman theory. However, the ionosphere of Mars is much more complicated than the simple assumptions underlying Chapman theory. Here we investigate how well the shape of the M2 layer is represented by a simple Chapman layer. Some observed profiles have an almost perfect Chapman layer shape over tens of kilometers, yet others have distinctly different shapes. We also investigate the shape of the M1 layer, whose properties are highly variable due to substantial variations in the relevant region of the solar spectrum. We identify several morphological classes that cover many of the observed M1 layers. Finally, we present several instances of highly unusual features in the vertical structure of the ionosphere, including truncated M2 layer shapes, multi-peaked M2 layer shapes, small-scale oscillations at photochemically-controlled altitudes that may result from plasma instabilities, and relatively abrupt transitions in the topside ionosphere.