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Improving nightside ionosphere simulations with an empirical model of electron precipitation. M. L. Marquette¹, R. J. Lillis¹, D. J. Pawlowski², J.-Y. Chaufray³, Y. J. Ma⁴, F. Gonzalez-Galindo⁵, D. L. Mitchell¹, J. S. Halekas⁶, M. Benna^{7,8}, M. K. Elrod^{7,9}, J. R. Espley⁷, J. L. Gruesbeck⁷, and S. M. Curry¹⁰, ¹UC Berkeley Space Sciences Laboratory, ²Department of Physics and Astronomy, Eastern Michigan University, ³LATMOS Paris, ⁴Department of Earth, Planetary, and Space Sciences, University of California Los Angeles, ⁵Instituto de Astrofísica de Andalucía-CSIC, ⁶Department of Physics and Astronomy, University of Iowa, ⁷NASA Goddard Space Flight Center, ⁸Center for Space Science and Technology, University of Maryland Baltimore County, ⁹University of Maryland College Park, ¹⁰Laboratory for Atmospheric and Space Physics, University of Colorado Boulder.

Introduction: Electron precipitation is the dominant source of energy input to the nightside of Mars (e.g. [1]), and there are two main sources of precipitating electrons: photoionization and solar wind electrons. Solar wind electrons can precipitate directly onto the Martian nightside along open field lines. Additionally, photoelectrons produced by photoionization on the dayside can be transported across the terminator to the nightside [2] [3]. As electrons are carried onto the nightside, they interact with neutrals---with CO₂, N₂, Ar, O, and CO as the most abundant neutral species at high altitudes---through ionization, dissociation, and excitation. Variable magnetic and solar wind conditions result in variable ionization rates, which produce a patchy and fluctuating nightside ionosphere.

Abstract: With the aim of improving global simulations of the Martian ionosphere, we have built an empirical model of 137 electron impact processes—including ionization, dissociation, and excitation—on the nightside of Mars, based on MAVEN in situ data collected between 2014 and 2023, and expanding upon the empirical study presented in [4]. The empirical model demonstrates the significant impact magnetic conditions have on nightside ionization rates, with different magnetic topologies reversing trends previously seen in ionization dependence on magnetic field strength: closed field lines on the nightside show a decrease in ionization with stronger fields, while topologies where field lines connect to a source of plasma at one or more end show an increase of ionization with stronger fields. This empirical model is then coupled with MHD [5] simulations of the Martian magnetosphere as input to the PCM-Mars (Planetary Climate Model-Mars) [6,7] and M-GITM (Mars-Global Ionosphere-Thermosphere) [8] thermosphere-ionosphere models to provide a source of ionization on the nightside. We present new simulations of the global ionosphere with ionization sources on both the day and nightside.

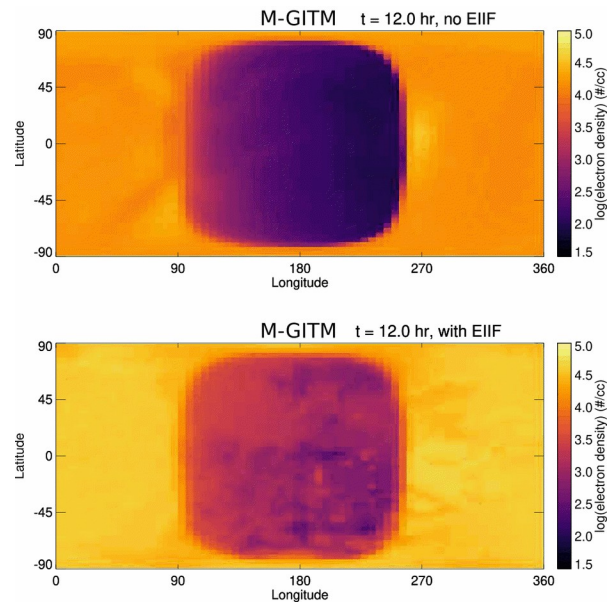


Fig 1: *Top panel:* global ionospheric electron density modeled in M-GITM **without** electron precipitation included. *Bottom panel:* global ionospheric electron density modeled in M-GITM **with** electron precipitation included.

Acknowledgments: Data used in this study can be found in the MAVEN In situ Key Parameters Data Collection in the PDS (doi: 10.17189/1414242)

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