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A fast, parameterized model of upper atmospheric ionization rates, chemistry, and conductivity

Abstract:
Rapid specification of ionization rates and ion densities in the upper atmosphere is essential when many evaluations of the atmospheric state must be performed, as in global studies or analyses of on-orbit satellite data. Though many models of the upper atmosphere perform the necessary specification, none provide the flexibility of computational efficiency, high accuracy, and complete specification. We introduce a parameterized, updated, and extended version of the GLobal AirglOW (GLOW) model, called GLOWfast, that significantly reduces computation time and provides comparable accuracy in upper atmospheric ionization, densities, and conductivity [McGranaghan et al., JGR, 2015]. We extend GLOW capabilities by: 1) implementing the nitric oxide empirical model; 2) providing a new model component to calculate height-dependent conductivity profiles from first principles for the 80-200 km region; and 3) reducing computation time. The computational improvement is achieved by replacing the full, two-stream electron transport algorithm with two parameterizations: 1) photoionization (QRJ from Solomon and Qian [2005]) and 2) electron impact ionization (F0810 from Fang et al. [2008, 2010]). We find that GLOWfast accurately reproduces ionization rates, ion and electron densities, and Pedersen and Hall conductivities independent of the background atmospheric state and input solar and auroral activity. Our results suggest that GLOWfast may be even more appropriate for low characteristic energy auroral conditions. We demonstrate in a suite of 3028 case studies that GLOWfast can be used to rapidly calculate the ionization of the upper atmosphere with few limitations on background and input conditions. We support these results through comparisons with electron density profiles from COSMIC.