The development and validation of a photochemical model for atomic oxygen ion retrieval from ground-based airglow observations

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Three photochemical inversion models are derived to retrieve atomic oxygen ion density ($[O^+]$) from 630.0 nm intensity emitted by $O(^1D)$ excited state, to understand the relation between 630.0 nm airglow emission and $[O^+]$. Three experiments are performed in this study. The first experiment validated our inversion models with Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) results, with the derived $[O^+]$ showing high correlation with the TIE-GCM model truth. Sensitivity testing results show that molecular oxygen density ($[O_2]$) used in the inversion process is most effective in determining the trends of calculated $[O^+]$. The second and third experiments are applied with ground-based spectrometer 630.0 nm data from Geophysical Observatory of the Russian Academy of Sciences Siberian Branch near Irkutsk, Russia (51.8˚N, 103.1˚E) in 2016, but with unobserved background inputs from TIE-GCM and empirical models, respectively. A new height profile based on emission layer thickness and *hmF2* derived 630 nm airglow intensity peak altitude for Gaussian distribution (GD) is applied for converting Rayleighs into Volume Emission Rate (VER) (*Adachi et al.,* 2009), and is consistent with the TIE-GCM calculated airglow peak altitude. Future work will replace GD with Chapman distribution which should be closer to reality. With the new inversion models and preliminary height profile, estimations of $[O^+]$ using empirical models and airglow observation are possible and may be extended to estimate $[O_2]$ if combined with electron density measurements.

Keywords: Airglow, Atomic Oxygen Ions, Photochemical models, TIEGCM, Irkutsk