Forecasting of the Upper Atmosphere via Assimilation of Electron Density Data

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This study presents experiments of driving a physics-based thermosphere model (TIE-GCM) by assimilating radio occultation electron density (Ne) profiles from the COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) mission using an ensemble Kalman filter. This study not only helps to gauge the accuracy of the assimilation, to explain the inherent model bias, and to understand the limitations of the framework, but it also demonstrates the capability of the assimilation technique to forecast the highly dynamical thermosphere in the presence of realistic data assimilation scenarios.

Experiments cover both solar minimum (March 2008) and solar maximum (June 2014) periods. The results show that data assimilation improves the model state. Here the improvement is shown with comparisons to Ne and neutral density data from Swarm-A, Swarm-C, CHAMP, and GRACE-A satellite missions. The root mean squared error (RMSE) of Ne is reduced in the Ne-guided lower thermosphere more than that of the higher altitudes (e.g. 1.7×10⁴ electrons/cm³ at 200 km vs 2.9×10⁴ electrons/cm³ at 400 km). The average RMSE in the forecasted Ne is approximately 1.3×10⁵ electrons/cm³ at altitudes between 200 and 400 km, and drops to 0.7×10⁵ electrons/cm³ at 500 km. The study also reveals that only a limited number of bonafide Ne profiles are available for assimilation tasks in the experiments. These results also provide insights into the biases inherent in the physics-based model. The systematic biases that this study highlight could be an indication that the specification of plasma-neutral interactions in the model needs further adjustments.