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Assimilation of Radio Occultation Data for Ionospheric and Thermospheric Modelling

Sean Elvidge(1), Gareth Dorrian(1) and Elizabeth George(1)
(1) SERENE, University of Birmingham, UK, e-mail: s.elvidge@bham.ac.uk

Comprehensive, global and timely specifications of the Earth's ionosphere and thermosphere are required to ensure the effective operation, planning and management of a diverse range of systems impacted by space weather. To this end, the University of Birmingham has developed the Advanced Ensemble electron density (Ne) Assimilation System (AENeAS), a physics-based data assimilation model of the coupled ionosphere-thermosphere system. AENeAS assimilates data using the local ensemble transform Kalman filter (LETKF) into a background model (the Thermosphere Ionosphere Electrodynamics General Circulation Model [TIE-GCM]). This approach is computationally efficient whereby the background covariance matrix is replaced by the ensemble from which sample variances and covariances can be derived. The use of the ensemble also provides a method to propagate the covariances in time, since each member of the ensemble can be evolved using the physics model.

One of the difficulties with such models is that measurements of the upper atmosphere are extremely sparse. Not only are the data scarce, but have rarely been 'designed' for space weather monitoring; instead they are 'signals of opportunity' and the observations are usually limited to regions over land. Radio occultation (RO) data provides a unique opportunity to not only increase the quantity of assimilated data but also the spatial distribution.

This paper will demonstrate the impact and effectiveness of assimilating RO data into AENeAS in terms of both ionospheric nowcasting and forecasting. Furthermore, using the ensemble-estimated covariances, the RO data will be used to update the thermospheric components of AENeAS. The improvement in total neutral density, which can be used to better forecast satellite orbits, will be demonstrated by comparison against in-situ derived neutral density from the ESA Swarm satellites.

References

[1] S. Elvidge and M. J. Angling "Using the local ensemble Transform Kalman Filter for upper atmospheric modelling," *Journal of Space Weather and Space Climate*, 9(1-2):A30, January 2019, doi:10.1051/swsc/2019018.