JEDI Space Weather Workshop (2025)

Title: Enhancing Thermospheric Specification via Ensemble Data Assimilation

Author: Nicholas Dietrich (Naval Research Laboratory)

Increasing the predictability of the ionosphere-thermosphere (I-T) system requires accurate specification of external forcing and initial conditions. Here, we detail efforts to improve I-T predictability by estimating initial model conditions through constraining neutral atmospheric states within physics-based I-T models. Ensemble data assimilation (DA) approaches use observations to constrain model states on regional scales; however, they require abundant observational coverage to be effective. Our approaches include two strategies. In the first approach, we assimilate satellite position observations to constrain the NEPTUNE model, the Navy's advanced weather forecasting system extending to ~500 km, using an ensemble Kalman Filter and the JEDI framework. Through simulated experiments using synthetic observations, we assess how well we can extract neutral density information and evaluate improvement to thermospheric state specification. Second, we evaluate using abundant plasma observations within a strongly coupled I-T DA framework to constrain neutral states. With a considerable effort devoted to ensemble initialization, we demonstrate improved model-observation agreement, achieving a 10% observation rejection rate. Furthermore, we see improved model performance during storm-time when compared against independent neutral density observations. These studies contribute to the development of thermospheric DA systems that will enhance our representation of the I-T system and improve forecasting capabilities.