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Application of a Data Assimilation System in the Presence of Model Bias

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Extended Abstract

This talk will outline the basics of an accurate and efficient data assimilation system for atmospheric flows, called the Local Ensemble Transform Kalman Filter (LETKF), and its application to the Thermosphere Ionosphere Electrodynamics Global Circulation Model (TIEGCM). Of particular interest are potential methods for handling systematic biases in the model, as may occur when key model parameters are suboptimally specified. Observing system simulation experiments have been carried out during a geomagnetic storm event, when magnetospheric and solar inputs may be difficult to specify accurately. The goal is to reduce the effect of model bias in 1-hour forecasts of electron density under such circumstances.

The bias correction is implemented using a state augmentation approach within the LETKF, and the estimated bias is handled during the evaluation of the forward operator, which is carried out at each analysis interval. We apply a simple growth/relaxation parameterization of the model bias during the transitionary periods that bracket the main geomagnetic disturbance.

The simulation consists of a known "truth," obtained from a run of the TIEGCM for the period 26–27 September 2011, during which a geomagnetic storm was observed, using published values of the $F_{10.7}$, Hp, and Cp indices. Data from this simulation is used to generate synthetic electron density profiles at actual observing locations. We then consider ensembles of forecasts in which the TIEGCM is run for the same interval but with values of the $F_{10.7}$, Hp, and Cp indices that vary systematically from the published ones, and apply the bias correction scheme. This "perfect model" setup lets us quantify the effects of the bias correction scheme separately from other issues (such as discrepancies between the dynamics of the actual ionosphere and the modeled one).

Compared to a naive application of the LETKF, the application of the bias correction reduces root mean square measures of 1-hour prediction error by 25 to 40 percent, depending on the geographical region. The proposed scheme merits further investigation for ionospheric predictions.

References

[1] Juan Durazo, Eric J. Kostelich, and Alex Mahalov, "Data Assimilation for Ionospheric Space-Weather Forecasting in the Presence of Model Bias," *Frontiers in Applied Mathematics and Statistics*, **7**, 2021, 679477. doi: 10.3389/fams.2021.679477.