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On the use of the local ensemble transform Kalman filter (LETKF) for ionospheric data assimilation

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1. Introduction

Many ionospheric data assimilation schemes are based on the Kalman Filter [1]. A classical Kalman filter relies upon the assumption that observation errors are Gaussian, a linear model can be used to propagate the states and a linear observation operator can move the observations into the model space. In reality these assumptions rarely hold. Further, the error covariance matrix scales with the square of the size of the state. For large states this leads to the need for large matrix inversions and makes the equations very difficult to work with, especially in a reasonable time scale. A number of variants of the Kalman filter have been developed to address these issues.

2. LETKF

The local ensemble transform Kalman filter (LETKF) is an ensemble Kalman filter variant first described by Hunt et al. [2]. The LETKF combines the transform ensemble Kalman filter (ETKF) [3] with the local ensemble Kalman filter (LEKF) [4]. The localization in the LEKF allows the analysis to be performed around each grid point and in parallel. The individual analyses are then combined to form the global analysis. The ETKF uses ensemble perturbation matrices, where the ensemble mean (or some other control) is removed from each ensemble member. The distance from the control to the ensemble member provides information about the spread of the ensemble, from which one can estimate the model covariances. The LETKF results are equivalent to the LEKF [5] results but are calculated in a more efficient manner, similar to the ETKF.

3. AENeAS

The Advanced European electron density (Ne) Assimilation System (AENeAS) is a new ionosphere/thermosphere LETKF assimilation model being developed at the University of Birmingham in the UK. AENeAS uses the Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) [6] as its background model. This is extended to GPS altitudes using the NeQuick [7] topside. The advantage of using a physics-based background model is that the model can be used to provide accurate and actionable forecasts. The paper will describe the use of the LETKF in AENeAS, results from current testing and plans for its future development.

4. References

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