Using Auxiliary Weighted Least Squares with the Extended Kalman Filter To Forecast Unobservable Regions in the Thermosphere

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To determine Global Positioning System corrections and propagation parameters of high-frequency radio waves, an accurate forecast of the ionosphere is desirable. Forecasting the ionosphere, especially during geomagnetic storm times, is strongly dependent on perturbations in the neutral composition. Because of the coupling between the ionosphere and neutral atmospheric chemistry, accurate knowledge of the neutral composition is critical in forecasting the ionosphere. However, changes in the neutral composition may occur suddenly during storm times, and these regions may not be observed due to limited satellite coverage. Additionally, the use of a physical model to propagate the information to the unobservable regions is insufficient due to the comparatively short time period of the storm. Therefore, an alternative method is applied with the extended Kalman filter to estimate these unobservable regions using empirical orthonormal functions (EOF's). The EOF's are calculated in parallel with the extended Kalman filter using an auxiliary weighted least squares method. These EOF's, calculated from the available observations and weighted based on the Kalman state error variance-covariance matrix, are then used to estimate the composition in the unobservable regions. Results show improvements in the composition forecast for these regions and demonstrate a lower overall root mean square error during geomagnetic storm times.