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Ionospheric Data Assimilation and Forecasting During Storms

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ABSTRACT

Ionospheric storms can have important effects on radio communications and navigation systems. Storm-time ionospheric predictions have the potential to form part of effective mitigation strategies to these problems. Ionospheric storms are caused by strong forcing from the solar wind. Electron density enhancements are driven by penetration electric fields, as well as by thermosphere-ionosphere behavior including Traveling Atmospheric Disturbances (TADs) and Traveling Ionospheric Disturbances (TIDs) and changes to the neutral composition. This study assesses the effect on one-hour predictions of specifying initial ionospheric and thermospheric conditions using TEC observations under a fixed set of solar and high-latitude drivers. Prediction performance is assessed against TEC observations, incoherent scatter radar and in-situ electron density observations. Co-rotated TEC data provide a benchmark of forecast accuracy. The primary case study is the storm of 10 September 2005, while the anomalous storm of 21 January 2005 provides a secondary comparison. The study uses an ensemble Kalman filter constructed with the Data Assimilation Research Testbed and the Thermosphere Ionosphere Electrodynamics General Circulation Model. Maps of pre-processed, verticalized GPS TEC are assimilated, while high-latitude specifications from the Assimilative Mapping of Ionospheric Electrodynamics and solar flux observations from the Solar Extreme Ultraviolet Experiment are used to drive the

model. The filter adjusts ionospheric and thermospheric parameters, making use of time-evolving covariance estimates. The approach is effective in correcting model biases, but does not capture all the behavior of the storms. In particular, a ridge-like enhancement over the continental USA is not predicted, indicating the importance of predicting storm-time electric field behavior to the problem of ionospheric forecasting.

Key words: Ionosphere, Thermosphere, GNSS, Storms, Data Assimilation.

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