Data Assimilation for Space Weather: Specification of the Ionosphere-Thermosphere Environment

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Space weather has a dominant effect on many climate and weather patters across the globe. Therefore, it is important to understand and correctly specify the various space weather environments that influence Earth. Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of spaceborne and groundbased technological systems, as well as endanger life or health. In this part of this talk we present an overview data assimilation for space weather problems, including heliophysics, radiation belts, magnetosphere, and ionosphere-thermosphere to name a few. In the second part we present our current efforts to correctly specify the ionosphere-thermosphere environment through the assimilation of direct and indirect data sources.

One of the most commonly used data assimilation technique for space weather is the ensemble Kalman filter (EnKF). The EnKF has been implemented to specify and predict radiation belts [1,2], Solar geomagnetic photosphere [3,4], Solar corona [5], and ionosphere-thermosphere-magnetosphere [6], among other problems. We will give an overview of the application of the EnKF to these and other problems, the challenges currently facing the predictability of extreme space weather events, and the future developments currently underway by a number of research groups to enhance the real time predictability of space weather environments.

In recent years, the accurate specification and prediction the global ionospheric-thermospheric environment has attracted much attention due to efforts in understanding the effect of the upper atmospheric environment on climate and weather patterns. In order to understand and accurately estimate the ionosphere-thermosphere environment, this talk presents the implementation of the local ensemble transform Kalman filter (LETKF) assimilation method to a global ionosphere-thermosphere model. In particular, the LETKF is utilized to estimate not only the model state, but also key model parameters that have a significant impact on the evolution of the total upper atmospheric density. The main parameters of interest are those who represent solar activity, such as $F_{10.7}$ and solar EUV spectrum parameters. A series of assimilation results are presented where the EnKF estimated a model bias correction through the parameters to obtain the correct model state. The assimilation experiments are shown for observational total density data from CHAMP and GRACE satellites, as well as indirect observation such as total electron content from a number of ground stations.

References

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