2024 Workshop: Advances in Data Assimilation

Long title
Advances in Ionospheric and Thermospheric Data Assimilation
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Description

Data assimilation is the art and science of combining imperfect and sparse measurements with incomplete models to estimate the most likely state of a system. It is a relatively new and rapidly growing field for the ionosphere-thermosphere system despite being long-established in meteorology and control engineering. There is a spectrum of methods that trade accuracy, complexity, and computational effort for understandability, simplicity, fidelity, and speed. Assimilation can be used in a ‘retrospective’ mode (reanalysis) to analyze past events of interest, such as large geomagnetic storms with high fidelity. Alternatively, assimilation can be used in real-time to nowcast or forecast the present or future state of the ionosphere to allow for real-time decision support. Data assimilation also forms a critical element of space mission design, allowing for the simulation of the relative impact or capability of instruments for space weather monitoring and for the optimization of spacecraft formation and orbital elements. This workshop will contain an overview of the fundamentals of data assimilation, as well as emerging techniques and results.

Justification

The ionosphere and thermosphere are tightly coupled and both affect critical technologies for our space-faring society. The thermosphere perturbs the orbits of all Low Earth Orbit (LEO) satellites through drag. Drag is the most variable aspect of

LEO orbit prediction, so better understanding the thermosphere results in better predicting LEO orbits. This is crucial since LEO is becoming crowded with controlled spacecraft as well as debris which could collide and make LEO unusable. The ionosphere is also highly variable and can harm satellites and signals that pass through it. The ionosphere also enables technologies like High Frequency (HF) communications and Over The Horizon (OTH) radar which both refract signals off the ionosphere that return to earth much farther away than would be possible for line-of-sight communications.
For both domains, it is crucial to hindcast, nowcast, and forecast the state of the system. This is done by combining both novel and established measurements and models. Typically, there is not enough data to specify the system at all places and all times. Assimilation can fill these gaps by adjusting global models to best fit the available measurements. Assimilation can also use parameterized representations of the system to reduce the state space.
Since assimilation is vital to our continued utilization and exploration of space, it is also vital to coordinate efforts for continued study within the CEDAR community. We will provide a forum for such discussion as part of the overall workshop agenda.

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ionosphere, thermosphere, assimilation, uncertainty
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