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Information Science and Technology Seminar Speaker Series

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Assimilative Modeling of the Ionosphere: Implementation, Validation and Applications

Wednesday, October 3, 2012
3:00 - 4:00 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: We present an overview of a relatively simple physics-based ionospheric model and a data assimilation system that corrects model forecast using slant TEC measurements from a network of ground-based GPS receivers. The numerical global 3-D model utilizes magnetic (p-q-l) coordinates and empirical models for neutral composition, winds, and ExB drift. The model computes the spatial distribution and temporal evolution of H+, O+, He+, O2+, NO+, N2+, N+ and electrons. It solves momentum and mass conservation equations for all seven ion species and electrons and the energy conservation equation for the three major ions (H+, O+, and He+) and electrons.

Two data assimilation frameworks have been implemented in order to assimilate GPS data into the model and to correct model results: a sub-optimal sequential Kalman Filter and the Ensemble Square Root Kalman Filter. An ionospheric nowcasting system consisting of the physical model and the sequential Kalman Filter has been deployed operationally and generates quantitative estimates of the ionospheric state (concentrations, velocities, and temperatures of ions and electrons) continuously with a 6-hour delay from real time. Results of validation against various correlative data are presented.

A second system, based on the Square Root Kalman Filter has been deployed as a research tool. Results of Observing System Simulation Experiments (OSSE) are shown, demonstrating the assimilation system's ability to restore unknown ExB drift velocities at the equator and neutral winds.

Practical applications of the developed systems are discussed, the primary one being calculations and delivery of ionospheric corrections for GPS and GLONASS users.

References:

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B. Khattatov, M. Murphy, M. Gnedin, J. Sheffel, J. Adams, V. Yudin and T. Fuller-Rowell, Ionospheric nowcasting via assimilation of GPS measurements of ionospheric electron content in a global physics-based time-dependent model, Quarterly Journal of the Royal Meteorological Society, Vol. 131, October 2005.

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Biography: Boris Khattatov received a degree of Engineer-Physicist in Molecular and Chemical Physics from the Moscow Institute of Physics and Technology in 1991. He obtained a PhD in Atmospheric Sciences from the State University of New York at Stony Brook in 1995. From 1996 through 2004 he worked at the National Center for Atmospheric Research on problems of photochemical numerical modeling, satellite data assimilation and inverse modeling. Since 2001 he was employed at Fusion Numerics Inc and was involved in a variety of DoD and NASA funded projects, one of which was devoted to the development and operational deployment of a numerical assimilative model of the ionosphere based on an approximate Kalman filter sequential assimilation scheme. Recently the system was modified to employ an ensemble Kalman filter technique for estimation of equatorial ExB velocity and neutral wind speeds in the ionosphere.

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