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Conductance Distributions for Empirical Orthogonal Function Analysis and Optimal Interpolation

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We show the first characterizations of the primary modes of ionospheric Hall and Pedersen conductance variability as empirical orthogonal functions (EOFs). These are derived from six satellite years of Defense Meteorological Satellite Program (DMSP) particle data acquired during the rise of solar cycles 22 and 24. The 60 million DMSP spectra were each processed through the Global Airlglow Model. This is the first large-scale analysis of ionospheric conductances completely free of assumption of the incident electron energy spectra. We show that the mean patterns and first four EOFs capture $\sim$50.1 and 52.9% of the total Pedersen and Hall conductance variabilities, respectively. The mean patterns and first EOFs are consistent with typical diffuse auroral oval structures and quiet time strengthening/weakening of the mean pattern. The second and third EOFs show major disturbance features of magnetosphere-ionosphere (MI) interactions: geomagnetically induced auroral zone expansion in EOF2 and the auroral substorm current wedge in EOF3. The fourth EOFs suggest diminished conductance associated with ionospheric substorm recovery mode.

These EOFs are then used in a new optimal interpolation (OI) technique to estimate complete high-latitude ionospheric conductance distributions. The technique combines particle precipitation-based calculations of ionospheric conductances and their errors with a background model and its error covariance (estimated by EOF analysis) to infer complete distributions of the high-latitude ionospheric conductances for a week in late 2011. The OI technique captures: 1) smaller-scaler ionospheric conductance features associated with discrete precipitation and 2) brings ground- and space-based data into closer agreement. We show quantitatively and qualitatively that this new technique provides better ionospheric conductance specification than past statistical models, especially during heightened geomagnetic activity.