The three-dimensional ionospheric tomography in Japan using the adaptive Kalman Filter algorithm

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A regional three-dimensional (3-D) ionospheric tomography was developed in Japan by adopting the Kalman Filter (KF) algorithm, where the adaptive Sage-Husa KF (SHKF) was proposed to deal with the unknown priori information of the noise covariance encountered in the conventional KF (CKF) iterations. Here, slant TEC (STEC) data detected by 55 GPS (Global Positioning System) ground receivers was employed for IED reconstructions with the spatial resolution of 1°×1°×30 km in latitude, longitude and altitude, and temporal resolution of 1 hour, respectively. By comparing the simulated NmF2 (F2 layer peak electron density) during April 3-9, 2018 from SHKF, CKF, and the IRI (International Reference Ionosphere) model with the observed values from 4 Japanese ionosondes, the results demonstrated that SHKF-derived NmF2 was apt to capture the trend of diurnal variations more accurately. Subsequently, annual variation characteristics were studies between the year 2013 (high solar activities) and 2018 (low solar activities). By evaluating the root-mean-square error (RMSE) and correlation coefficient (ρ), bar graphs visually illustrated that the efficiency of SHKF is superior to CKF and IRI during both low and high solar activities. Then, seasonal variations as well as the vertical profiles inverted by SHKF and IRI were investigated successively, where the results also manifested that SHKF was outperformed the other methods. In the end, taking a strong geomagnetic storm happened on 26 August, 2018 as an example, the results indicate that the IED around Japan developed by SHKF-based tomography is promising for ionospheric studies and practical applications.

Keywords: Ionospheric Tomography, Sage-Husa Kalman Filter, Ionospheric Electron Density, Total Electron Content

