

Improvement and case analysis of three dimensional ionospheric tomography based on GNSS-TEC observation with ionosonde data assimilation

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Structures of the electron density in the ionosphere cause reflection, absorption, and delay of radio waves, which can lead to interference in radio communications. Therefore, the observation of the ionospheric electron density is of great importance. One method of ionospheric analysis is tomography, which estimates the three-dimensional structure of the ionosphere from the GNSS-TEC observation data. The original algorithm employed to cover the Japanese archipelago and the nearby surrounding region was the constrained least-squared fitting method implemented by Seemala et al. (2014) and Suzuki (2016). The method used the spatial gradient of the electron density as the constraint, and in addition, introduced boundary conditions at the top and the bottom to stabilize the results. The original algorithm was stable and useful. But it had problems with negative electron density as the solution. It also tended to estimate the peak electron density higher than the true height during autumn and winter. To solve these problems, Ssessanga et al. (2021) proposed an improved algorithm based on a 3D-VAR method by adding ionosonde data. Recently we analyzed the improved version, and a discussion with the authors (private communication) revealed some inconsistencies in the background error covariance matrix (\mathbf{B}), which specifies the correlation of voxels in vertical and horizontal directions. This study presents results after improving \mathbf{B} ; a comparison of the tomography solution of the modified algorithm and the original algorithm using MU radar's observation confirmed that the modified algorithm improved the accuracy of peak height estimation. Also, a case study was conducted on the traveling ionospheric disturbance (TID) event from the Tonga eruption in January 2022. This is a unique ionospheric event, and the results were validated by modifying the algorithm.

キーワード：トモグラフィ、データ同化、3次元変分法

Keywords: Tomography, Data assimilation, 3D-VAR