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Abstract

Ionospheric Total Electron Content (TEC) is a critical indicator of the space weather environment, with its spatial-temporal variations driven by complex geophysical forcing from both above and below. While physics-based models provide deep insights, they are often constrained by the need for comprehensive driving inputs and heavy computational costs. In contrast, data-driven approaches offer a robust alternative for accurate TEC forecasting. However, many current deep learning models lack physical interpretability.

In this study, we propose a Graph Neural Network (GNN) framework specifically designed to find neighboring interactions for predicting the global TEC map. Rather than employing a conventional latitude-longitude grid, we construct a global graph based on an icosahedral spherical triangular grid with multi-level subdivision to ensure spatial uniformity. To enhance the model's utility for data assimilation systems, we utilize a custom loss function optimized for long-term forecasting through the autoregressive iteration of a one-step prediction model, ensuring temporal consistency. Furthermore, our model uses different solar and geomagnetic indices to identifying which factors serve as leading indicators for ionospheric variability. This approach not only improves prediction accuracy but also moves toward a more interpretable data-driven representation of the ionosphere system.

Key words : Global Ionospheric Map, Graph Neural Network, Space Weather

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— 中英雙語摘要格式說明 —

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