Imaging Earth's three-dimensional conductivity structure using geomagnetic observatory data from ionospheric and magnetospheric currents

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SUMMARY

The Earth's internal conductivity structure is highly sensitive to mantle thermal parameters such as water content, temperature, and melt composition. This structure can be inferred from global geomagnetic observatory datasets, which are primarily influenced by currents from both the magnetosphere and ionosphere. Current methodologies predominantly utilize magnetospheric sources due to the complex spatiotemporal nature of ionospheric currents. However, because magnetospheric sources typically have periods ranging from several days to months, the resulting conductivity models have high resolution in the lower mantle but lack detail in the upper mantle and transition zone. To address this limitation, we developed a joint inversion algorithm that simultaneously processes induced magnetic field datasets from both magnetospheric and ionospheric currents. Our approach incorporates several state-of-the-art techniques, including parallel acceleration and nested modeling and inversion grids, to enhance computational speed and reliability. Additionally, we use unstructured tetrahedral grids to account for the effects of realistic continental, oceanic, and coastal geometries. We validated our global electromagnetic joint inversion algorithm using synthetic datasets derived from a checkerboard model and a real conductivity model. The results demonstrate that jointly inverting magnetospheric and ionospheric datasets significantly enhances resolution and robustly delineates the electrical structure of the upper mantle and transition zone. In future work, we will apply this new tool to interpret field data collected by global geomagnetic observatories.

Keywords: Geomagnetic induction; Magnetospheric sources; Joint inversion; Ionospheric sources

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