ISARD-2025-upper009

Tidal analysis of thermosphere and ionosphere parameters during the geomagnetic storm on May 9-14, 2024

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This paper investigates the global effects of the extreme geomagnetic storm of May 9–14, 2024, on thermospheric and ionospheric parameters using the Global Self-Consistent Model of the Thermosphere, Ionosphere, and Protonosphere (GSM TIP). Geomagnetic storms profoundly impact both neutral and ionized components of the upper atmosphere, and tidal analysis serves as an effective tool for studying such large-scale disturbances.

It was shown that the GSM TIP reproduces well the complex of changes in the thermosphere and ionosphere associated with a geomagnetic storm. Tidal analysis of the obtained model results showed that under calm conditions, solar-migrating tides predominate, and in the lower thermosphere the amplitudes of daily and semidiurnal tides are small and comparable in magnitude. In the upper thermosphere, diurnal migrating tides dominate, their amplitude exceeding the semidiurnal tides several times.

During the peak of the geomagnetic storm, the amplitudes of the diurnal and semidiurnal tides in the lower thermosphere increase at high and middle latitudes. In contrast, the upper thermosphere exhibits a decrease in the amplitude of the diurnal migrating tide, particularly near the equator, while the SW2 amplitude shows a slight enhancement, primarily in the southern hemisphere. The storm also alters the tidal mode composition, especially in the lower thermosphere. For the diurnal tide, the DW2 mode is excited and becomes dominant at high latitudes. In the semidiurnal tide, the SW4 mode develops and prevails during the main storm phase (May 10–11). The recovery phase lasted two days, after which the tidal modes returned to their pre-storm configuration.

To validate the tidal analysis results from the GSM TIP model, we performed a similar procedure with the global total electron content maps (GIM) produced by the Jet Propulsion Laboratory (JPL). The diurnal and semidiurnal tidal structures obtained from the model show good agreement in the upper thermosphere with those derived from the GIM TEC data.