Altitudinal and Latitudinal Evolution of the Equatorial Ionization Anomaly During the May 10–11, 2024, Superstorm: Insights from DMSP and Swarm Observations

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This study examines the response of plasma density (Ne) and electron temperature (Te) to the May 10-11, 2024, superstorm using data from the Swarm and DMSP satellites. During the storm’s initial phase, a strong eastward electric field generated a super-fountain effect, resulting in a pronounced double-peak structure in the topside ionosphere, reaching DMSP altitudes. A significant enhancement in plasma density was observed at both 450 km and 840 km altitudes. At 450 km, the equatorial ionization anomaly (EIA) crests extended to approximately 25°-35°N and 22°-40°S, whereas at 840 km, the northern and southern crests were located around 5°-25°N and 12°-32°S, respectively. Notably, the poleward boundary of the EIA crest at DMSP altitudes remained equatorward edge of the EIA crest at SWARM altitudes. Electron temperature (Te) exhibited contrasting behavior at different altitudes, it increased within the EIA trough at 450 km but decreased within the EIA crests at 840 km. The elevated Te at Swarm altitudes may result from reduced electron-ion collision cooling, driven by the rapid upward transport of Ne via ExB drift. In contrast, the higher Ne concentrations at DMSP altitudes likely led to enhanced cooling, lowering Te locally while promoting heat transfer along magnetic field lines to greater altitudes. These temperature variations also likely influenced electron heat conduction between ionospheric layers along magnetic field lines. These findings provide new insights into the vertical and latitudinal structure of the EIA and its coupling with electron temperature during extreme geomagnetic disturbances.

