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[Abstract]

Thermospheric Response to Geomagnetic Storms and Impacts on Satellite Orbital Decay: A Comparative Analysis of the 2003 and 2024 Events

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Abstract: Geomagnetic storms inject significant energy into the upper atmosphere, increasing thermospheric temperature and density and, consequently, increase the atmospheric drag experienced by satellites in low Earth orbit (LEO). This study compares the effects of the October 2003 geomagnetic superstorm and the May 2024 storm on satellite orbital decay by quantifying changes in thermospheric density and their influence on drag force. Using analytical models combined with empirical density data from the NRLMSIS model, we calculated drag-induced decay rates for a representative LEO satellite at 400 km altitude. Results show that the decay rate increased from 73 m/day to 104 m/day in 2003, and from 155 m/day to 258 m/day in 2024, demonstrating a significant increase in drag on satellites which may affect their useful life. These findings highlight the critical importance of accounting for space weather conditions in satellite mission planning, particularly during solar maximum periods.

Keywords: Geomagnetic storms, Thermospheric density, Satellite drag, Orbital decay, Space weather, LEO satellites

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