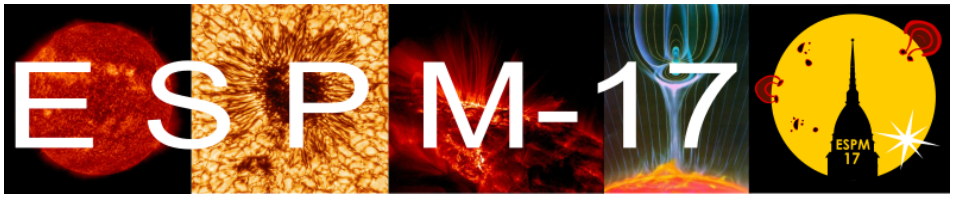

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Satellite Orbital Decay and Solar Wind Interactions: A Data Driven Case Study of May 2024 Space Weather Events

In May 2024, a G5-class geomagnetic storm, the most intense since the Halloween solar storms of 2003, hit Earth. Over a dozen X-class flares were observed by GOES, and several Coronal Mass Ejections were launched towards Earth. These events caused significant disturbances in the Earth's upper atmosphere, impacting satellite orbits and causing auroras to be visible at mid-latitudes globally. Our goal is to assess the critical impact of Space Weather on the decay of Earth-orbiting satellites at different altitudes.
We make use of semi-major axis data from a precise orbit determination method and publicly available two-line-element data, to which we apply a robust time series decomposition method iteratively to remove the most significant periodicity in the data. We compute the orbital decay using this processed data, given the absence of accelerometer data, and analyze the correlation between orbital decay and solar wind parameters, solar activity proxies, and geomagnetic indices, accounting for the solar wind propagation time to the orbits. For the first half of May, we observe a 15-hour delay between solar wind measurements and their effect on the orbits, and strong associations between orbital decay and several parameters. Consequently, we model orbital decay as a function of solar wind inputs and identify flow speed, electric field, proton densities, and magnetic field strength in the Z direction as the most impactful features. Despite challenges posed by satellite maneuvers and varying wind propagation times, we hypothesize that combining real-time orbital decay with these parameters could facilitate predicting its evolution.

Primary author: MERCEA, Vanessa (University of Bern)

Co-authors: KLEINT, Lucia (University of Bern); Dr ARNOLD, Daniel (University of Bern); Prof. JÄGGI, Adrian (University of Bern)

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