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Atmospheric Density Variations and Orbit Perturbations in Relation to Isolated Solar X-flare Events

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The relationships between solar flares and the way they modify the density of the Earth's thermosphere, as revealed by perturbations induced on artificial satellites orbits, are of crucial importance for satellite operators. A wide literature dealing with the solar flare events and their relationships with geomagnetic storms already exists ; but, it appears to the authors that there is a lack of research focusing only on the effects of the solar flares, i.e. solar events without any accompaniment of Coronal Mass Ejections (CMEs).

This paper is focused on the investigation of the thermosphere's response to X-class solar flare events from 2002-2017. The thermosphere density is derived from the on-board accelerometers of the Gravity Recovery and Climate Experiment (GRACE) twin satellites, and the CHallenging Minisatellite Payload (CHAMP) satellite. The accelerometric data are also compared to the accelerations provided by classical and recent atmospheric drag models, thanks to a post-fit residual analysis of the orbits of those spacecrafts.

As a result, the consequences of the density disturbances on satellite re-entry are enlightened. It appears in particular that the trajectory of the GRACE satellites are sensitive to those single events, as their effects to the orbits is higher than the current accuracy of the trajectory. As expected, the effects of such single events are all the higher as the area-to-mass ratio is high, and some examples based on major events (such as the ones that occured in early december 2006) are also provided.