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Global Ionospheric and Thermospheric Responses to Solar and Magnetic Activity Derived from Models and Geodetic Observations

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The interpretation of spatial and temporal changes in the Ionospheric Electron Density (IED) and the Thermospheric Neutral Density (TND) is important for various applications such as global communication, precise orbit determination (POD), estimating mission lifetimes or re-entry predictions of Earth orbiting objects, as well as the analysis of possible collisions between active satellites and space debris. Empirical and physical models are frequently applied to estimate IED and TND, for example, to correct GNSS signals and to compute drag forces at satellite positions. The accuracy of these models, however, is limited due to the model simplifications and the sampling limitation of solar and magnetic indices used as inputs. In this study, we investigate the global ionospheric and thermospheric responses to solar and magnetic changes. For this purpose, model derived IED and TND simulations are compared with on-board acceleration measurements of GRACE and SWARM, as well as in-situ GNSS observations. These changes are then evaluated within the period of known physical events such as solar and magnetic storms. Our results indicate that geodetic variables such as IED and TND indicate stronger responses to environmental changes, compared to the outputs of available models. Therefore, we suggest to include the IED and the TND fed by geodetic techniques as essential geodetic variables in studies that address changes in the Earth system and characterise the geodetic properties on Earth.