The capabilities of the Coupled Thermosphere Ionosphere Plasmasphere electrodynamics (CTIPe) physics based model in reproducing the extreme geomagnetic storm on the 20th of November 2003

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ABSTRACT

One of the largest geomagnetic storms ever recorded took place on the 20th of November 2003. It produced significant perturbations in the thermosphere-ionosphere-magnetosphere system. Modelling the ionosphere under these extreme conditions is a challenging task due to energy flow uncertainties. Here, we show how the Coupled Thermosphere Ionosphere Plasmasphere electrodynamics (CTIPe) physics based numerical code [1,2] reproduces ionospheric perturbations over Europe. Comparisons with observations of the Total Electron Content (TEC) derived from Global Navigation Satellite System (GNSS) measurements [3] and ionosonde measurements are presented.

The storm produced a strong enhancement of TEC over Europe on the 20th of November 2003. While the ionosondes did record significant increases in critical frequency foF2, the height of the F2-layer did not rise significantly. The TEC enhancement is associated with Travelling Ionspheric Disturbances (TIDs) observed in TEC, which are signatures of atmospheric surges causing neutral composition changes.

Comparisons with CTIPe results show that the TEC enhancement (Fig.1) and TEC rate over Europe are underestimated by the model. However, CTIPe reproduces the strong perturbations in Joule heating and neutral winds over Europe. The perturbations are located at exactly the location of the source region of TIDs. Even the signatures of atmospheric surges with similar characteristics of the observed TIDs are reproduced by CTIPe. Joule heating initiated meridional winds [4] and the associated storm-time neutral circulation seem to be the main driver of the ionospheric perturbations observed over Europe.

The results provide valuable information on the physics of the processes that operate in the ionosphere/thermosphere during this extreme geomagnetic storm, even if CTIPe is not able to reproduce the ionosphere TEC values with sufficient accuracy. The model results may be improved by using better estimates of the thermosphere/ionosphere forcing during the storm.

Key words: CTIPe, Ionosphere, Storm, GNSS, TEC

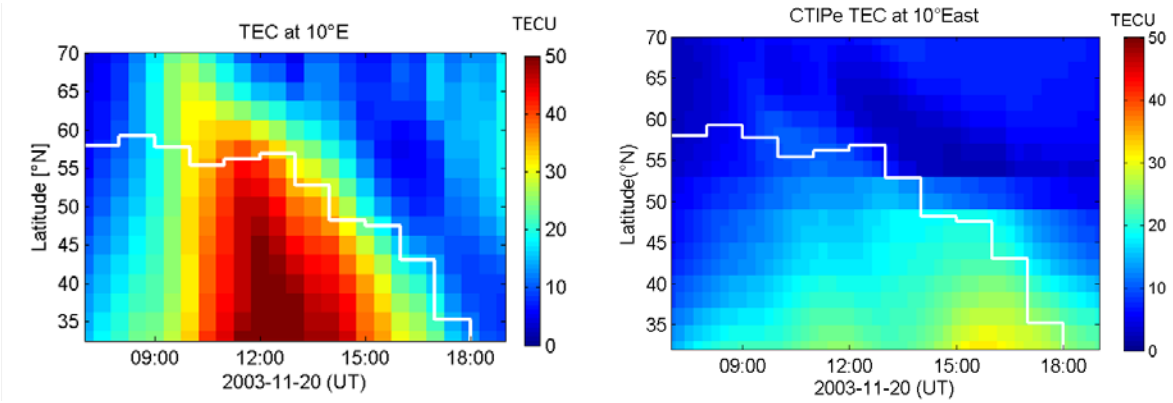

Figure 1**.** Comparison between TEC derived from GNSS measurements (left) and CTIPe model results (right) over Europe during 20th of November 2003 geomagnetic storm.

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Acknowledgements: The authors would like to thank Mariangel Fedrizzi, for providing support to this research.