Deutsches Zentrum
DLR für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Comparison between operation and research simulations with CTIPe model during geomagnetic storm conditions

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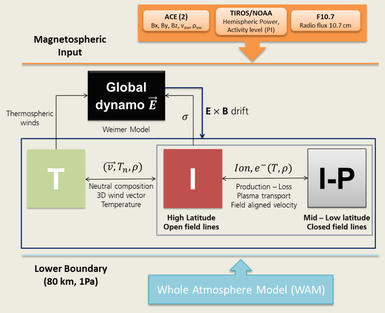
Introduction

The perturbations in the magnetosphere-ionosphere-thermosphere system are significant during geomagnetic storm conditions. The response in the ionosphere-thermosphere (IT) system to these conditions can be analyzed with the Coupled Thermosphere Ionosphere Plasmasphere electrodynamics physics based model (**CTIPe**).

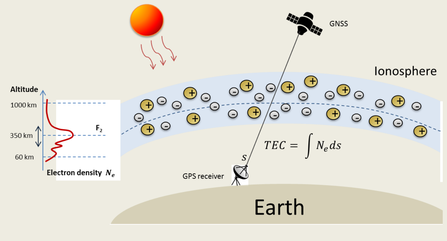
We perform simulations using first the model inputs available in real-time (**operational run**) and second with the best estimate obtained after the event (**research run),** and compare the results.

CTIPe Model and Observations

CTIPe is a global non linear physics based model that solves the equations of momentum, energy and composition for neutral and ionized atmosphere

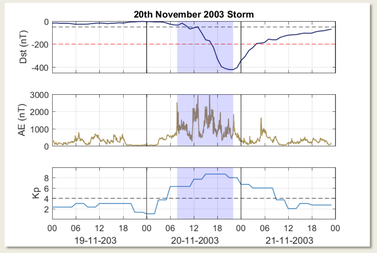


Comparing CTIPe results with **GNSS TEC** and **CHAMP satellite neutral mass density** observations allows validating the CTIPe results and complete the interpretation of the physical mechanisms behind the perturbations during the event.



CTIPe Operation vs. Research

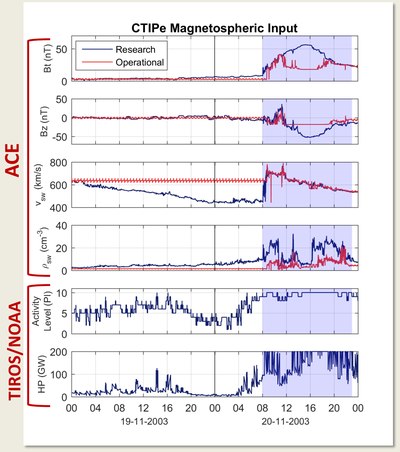
Storm Morphology: 20th November 2003



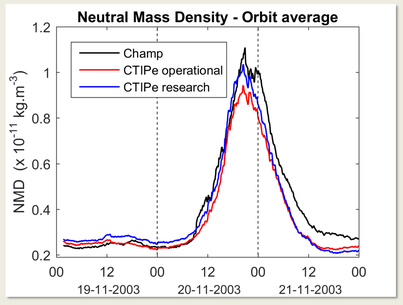
20th November 2003 superstorm *Dst, AE and Kp indexes as indicators of the geomagnetic storm magnitude and storm phases .*

CTIPe operational real-time (red) and research (blue) model input for 19-20 November 2003. Solar wind particles can introduce noise in the **ACE** detector and make the signal fluctuate (B_t, B_z, v_{sw} and ρ_{sw}).

Hemispheric power in GW and Activity level (PI), derived from **TIROS/NOAA**, does not differ between real time and research runs.



Thermosphere response

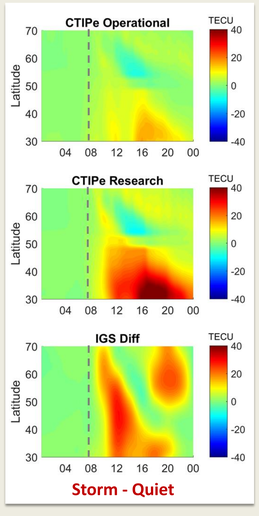


*Changes in the **thermosphere** are evaluated using CHAMP satellite neutral mass density (black), and compared with CTIPe operational (red) and research (blue) model results.*

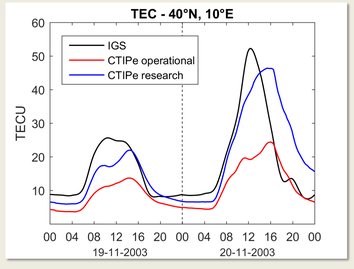
NMD	Peak Difference	Average Difference	RMSE
Operational (x10^{-11} kg.m^{-3})	0.17	0.05	0.08
Research (x10^{-11} kg.m^{-3})	0.07	0.02	0.06

Neutral mass density operational – research discrepancies during maximum peak of the storm with measurements are not larger than 8.4%. The research results are closer to observations and a good representation of the thermosphere can be assumed.

Ionosphere response



*Changes in the **ionosphere** during storm conditions are evaluated using GNSS TEC, and compared with CTIPe operation and research model results.*



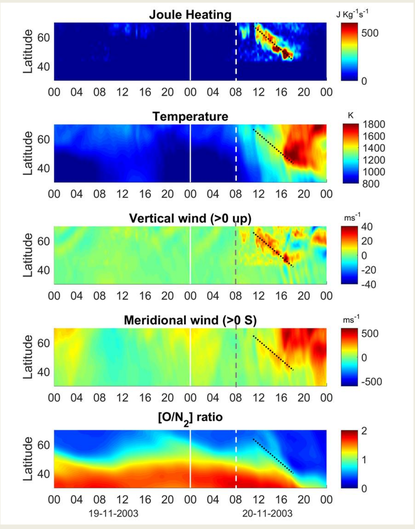
19-20 November 2003 storm TEC differences for a fixed location of 40°N latitude and 10°E longitude.

TEC	Peak Difference	Average Difference	RMSE
Operational (TECU)	27.5	7.5	10.8
Research (TECU)	6.0	0.4	7.2

Significant differences between operational and research runs can be identified. The deviation from the **TEC** observations are considerable in the operational, while research is closer to measurements with a 17% deviation.

Storm Dynamics

Strong **Joule heating** in the auroral region driving storm wind cell is visible in the **CTIPe research run** and it is suggested to be the main driver of the positive ionospheric storm over Europe.



Conclusions

- CTIPe simulations show input dependent global changes in neutral winds, temperature, and composition which are reflected in the global electron density structure.
- Comparing the research run results with GNSS and CHAMP satellite observations allows validating the CTIPe results and complete the interpretation of the physical mechanisms behind the perturbations during the event.

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