Ionosphere in TIEGCM simulations: visualizations and comparison with Swarm measurements

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Outline

Brief summary of work done and experience gained during the project on utilization of the TIEGCM numerical model in studies of ionospheric dynamics

Possible future work

TIEGCM model

Self-consistent numerical model

Includes dynamics, energetics and chemistry of the ionosphere

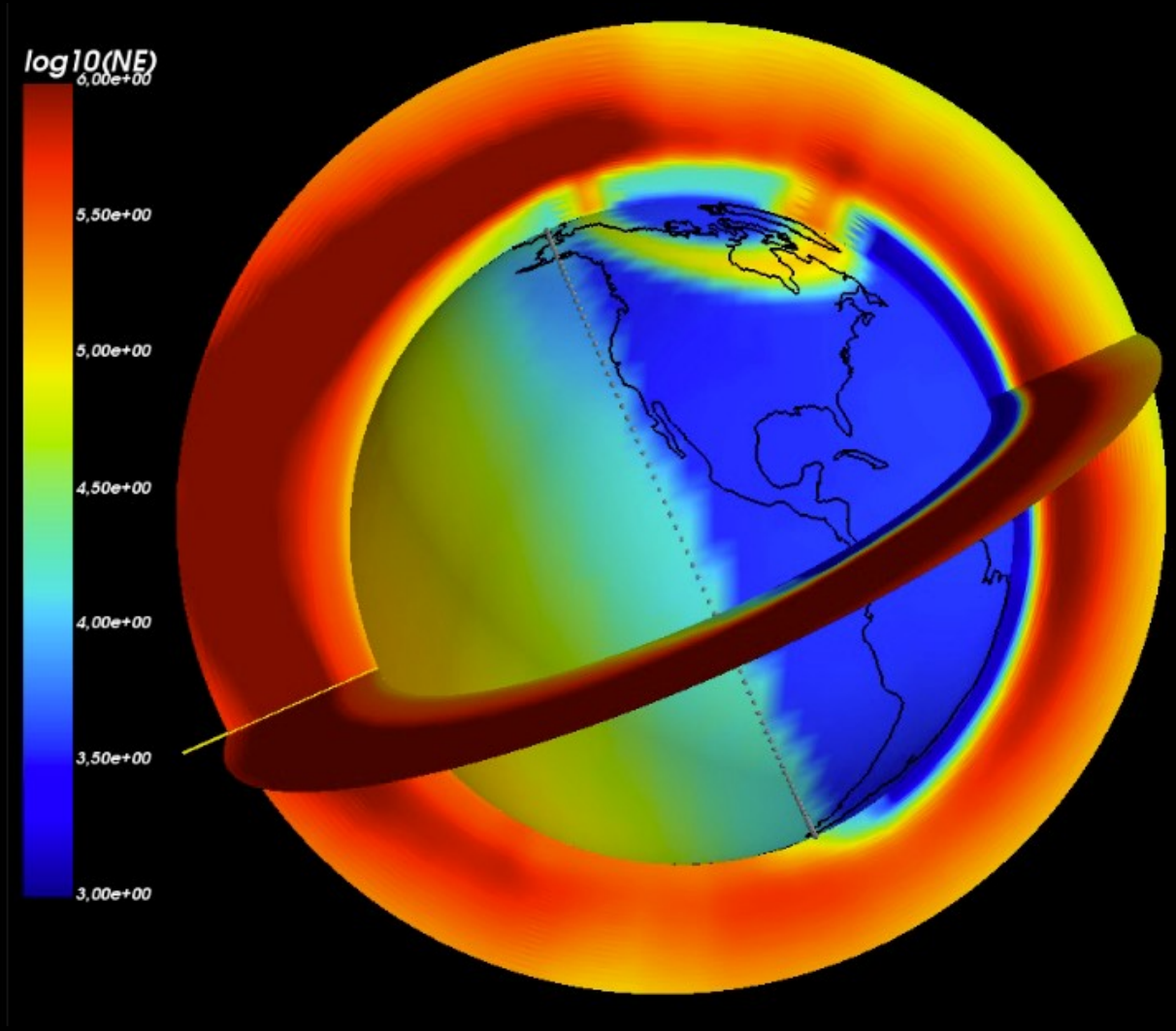
Uses realistic magnetic field from IGRF-12 model

Altitudes from ~97 to ~600 km

Solar UV from EUVAC model based on F10.7 proxy

Inner boundary: atmospheric tides, GSWM model

High-latitude energy input: cross-tail potential, hemispheric power (auroral precipitation)



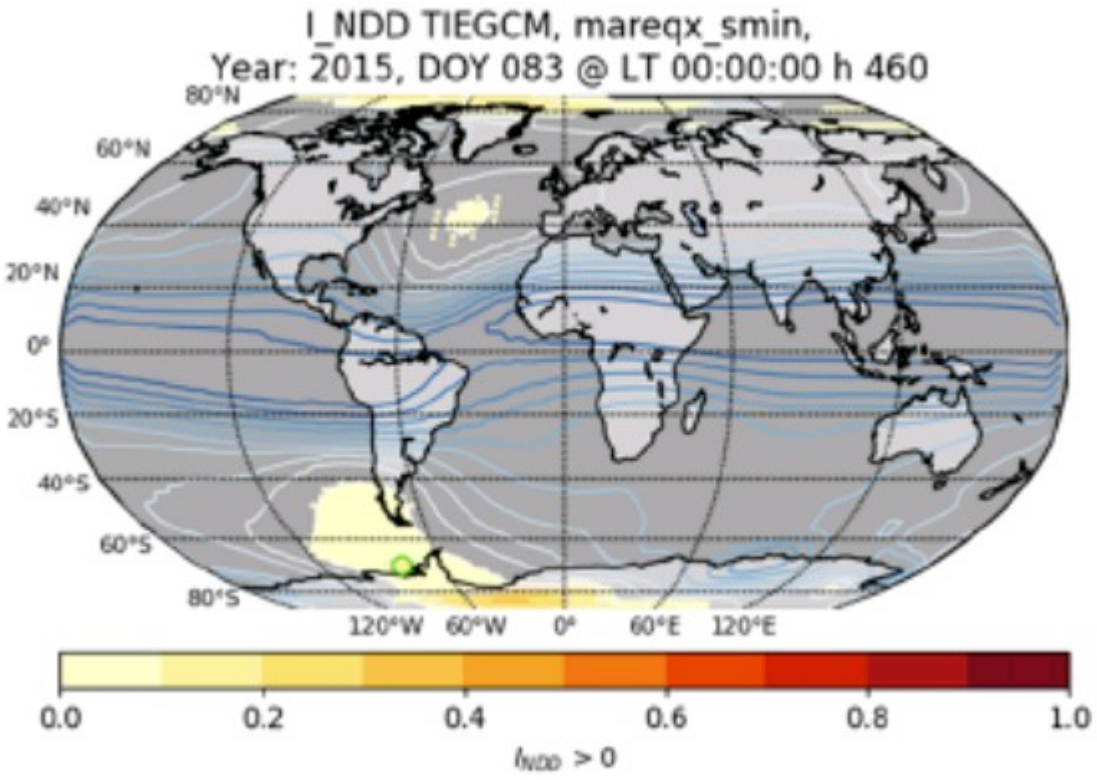
Studies of WSA

Weddell Sea Anomaly: reversed diurnal cycle of density variations

Typically investigated by using maps for constant local time, e.g., of midnight

The index $I_{NDD}=(NE_t-NE_{t-12h})/(NE_t+NE_{t-12h})$ can characterize WSA

Slominska et al. 2020

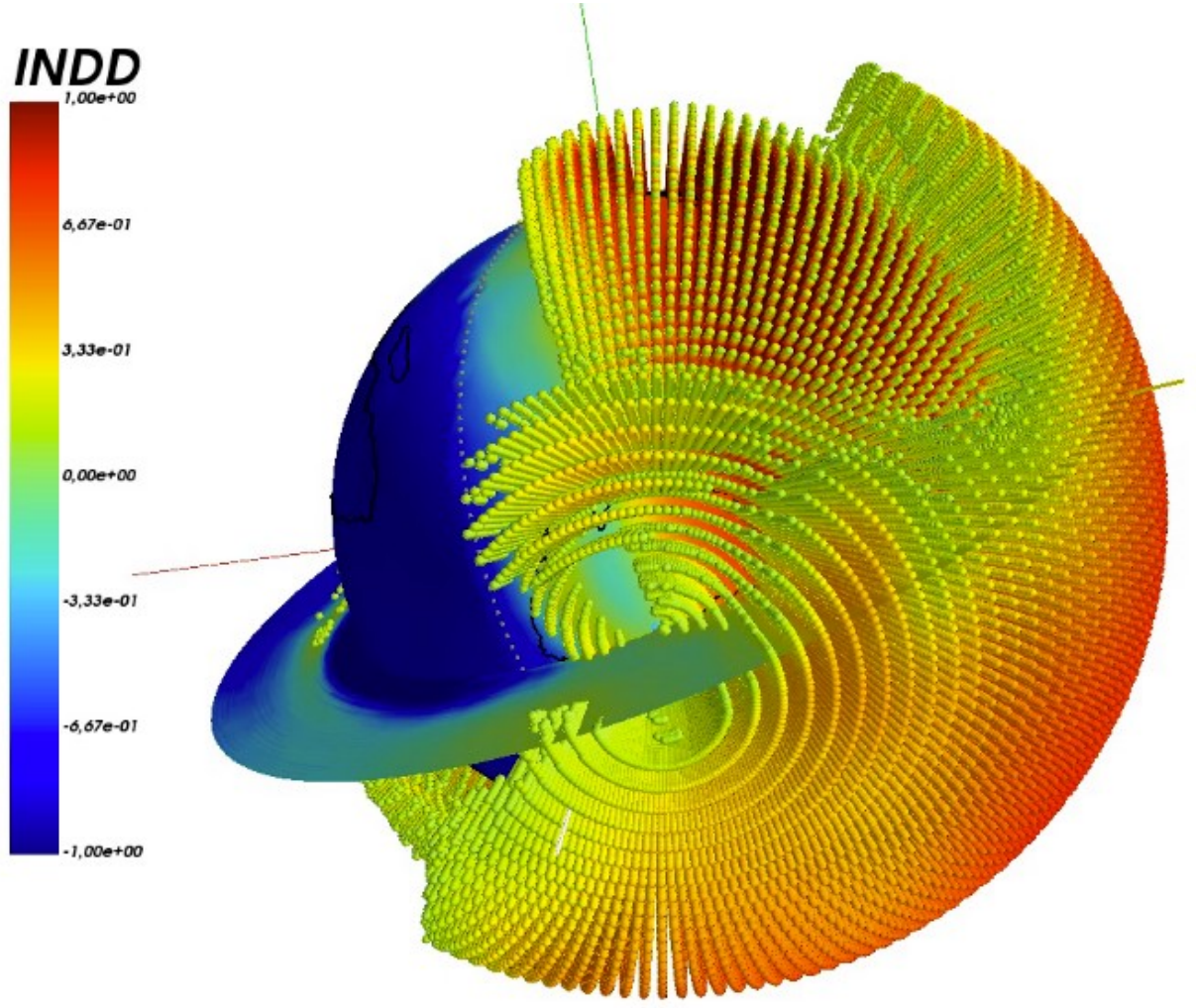


Tracking down the WSA origin

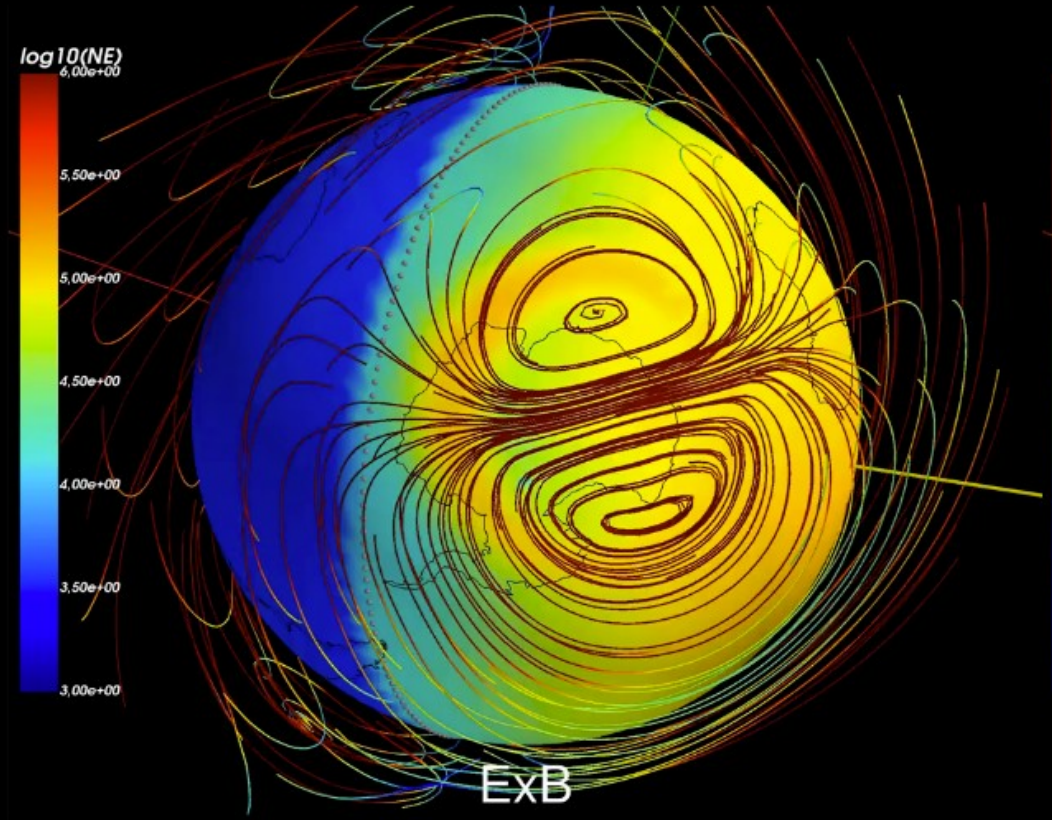
I_{NDD} distribution shown in the ionospheric volume

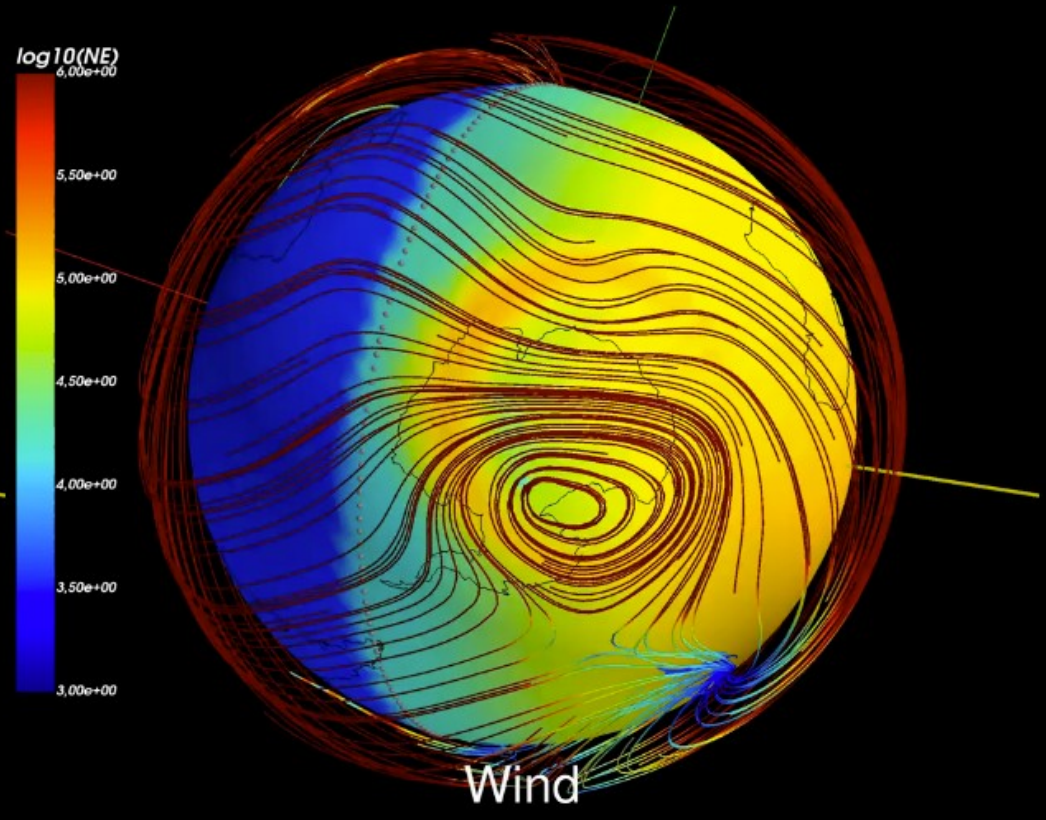
Inner sphere and midday-midnight plane: I_{NDD} distribution (see the color scale)

“Hedgehog” structure around the sphere: points of TIEGCM grid where I_{NDD}>0.1

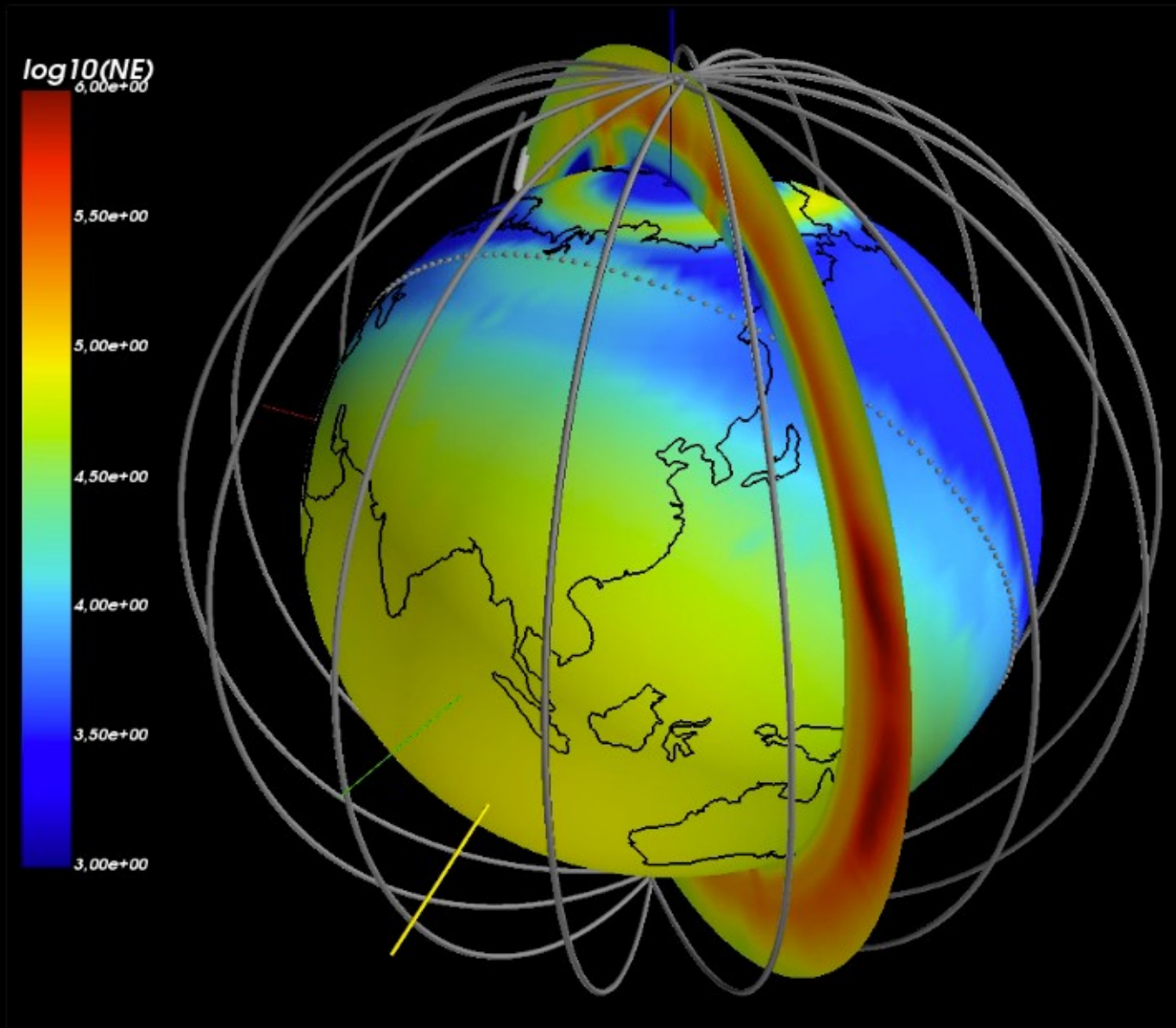


Tracking down the WSA origin: roles of ExB drift and neutral wind



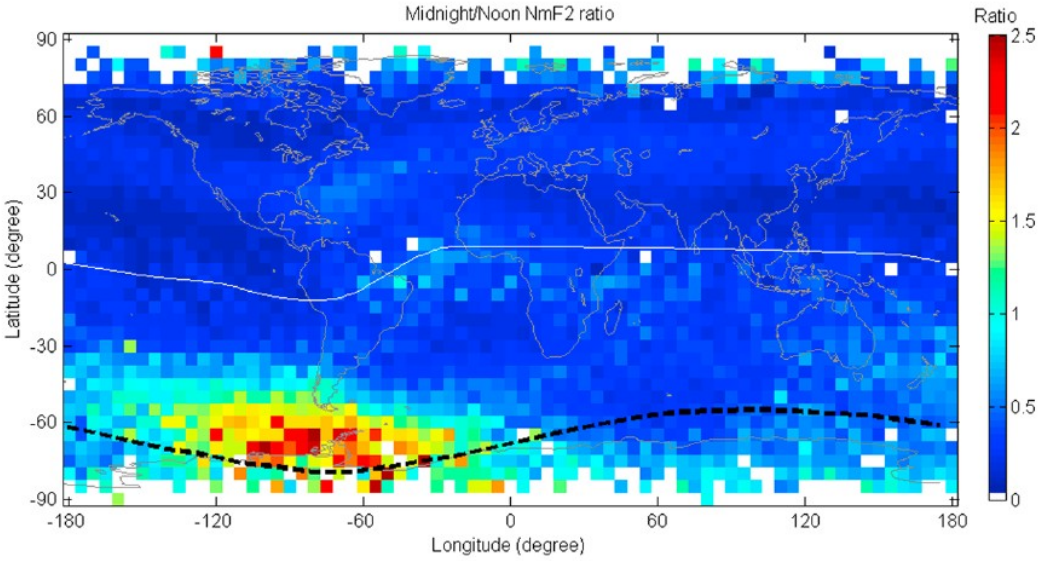


Satellite trajectory visualizations

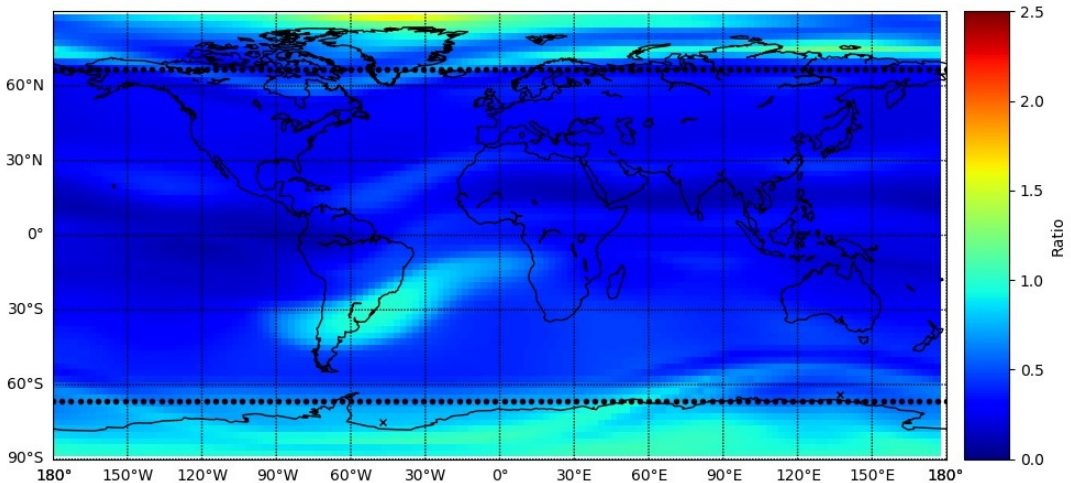


NPDE/WSA in NmF2

Richards et al. 2017
COSMIC NmF2 data,
January/December from
2007 to 2010



TIEGCM
simulation
for **SOLAR MIN**,
benchmark case,
December solstice



NPDE/WSA in NmF2 (cont'd)

Richards et al. 2017
COSMIC NmF2 data,
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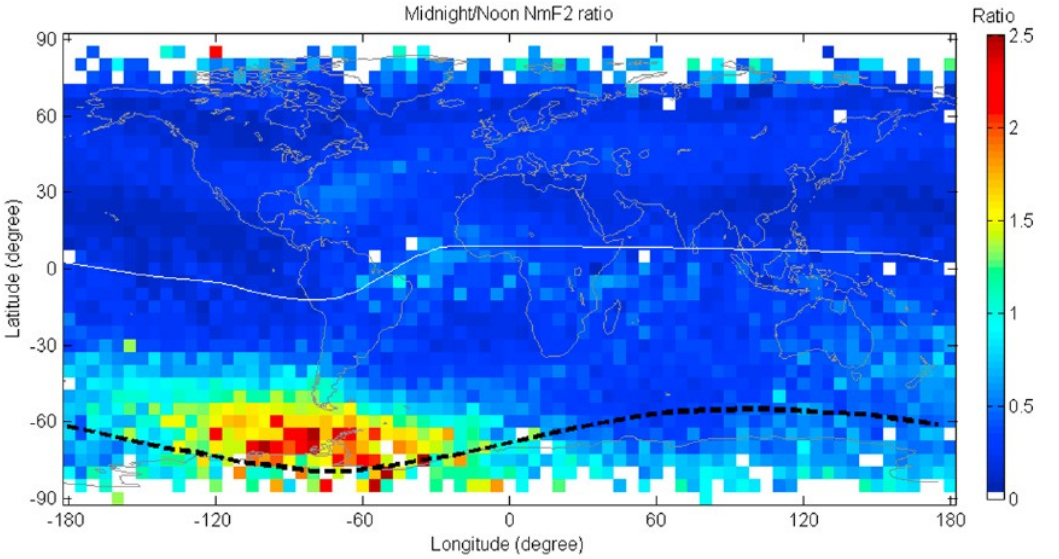

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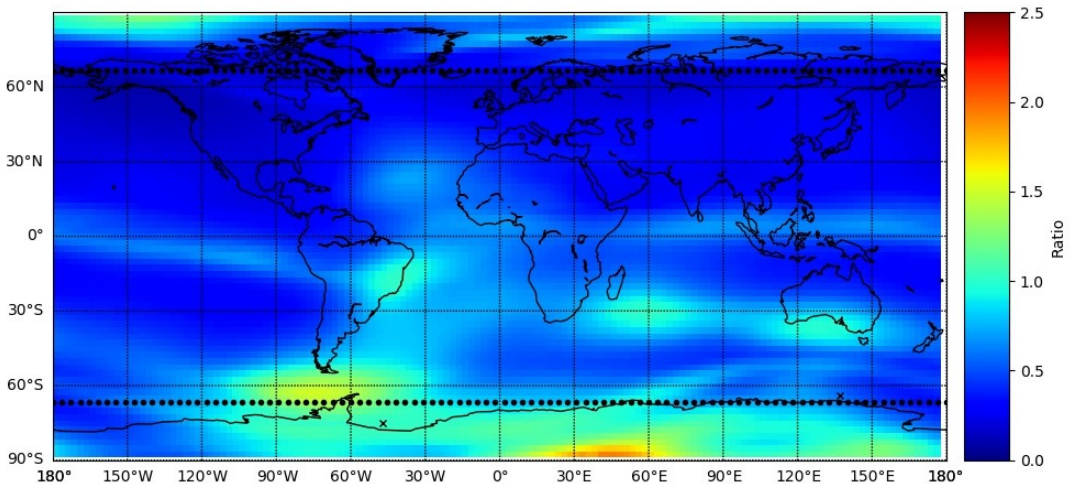
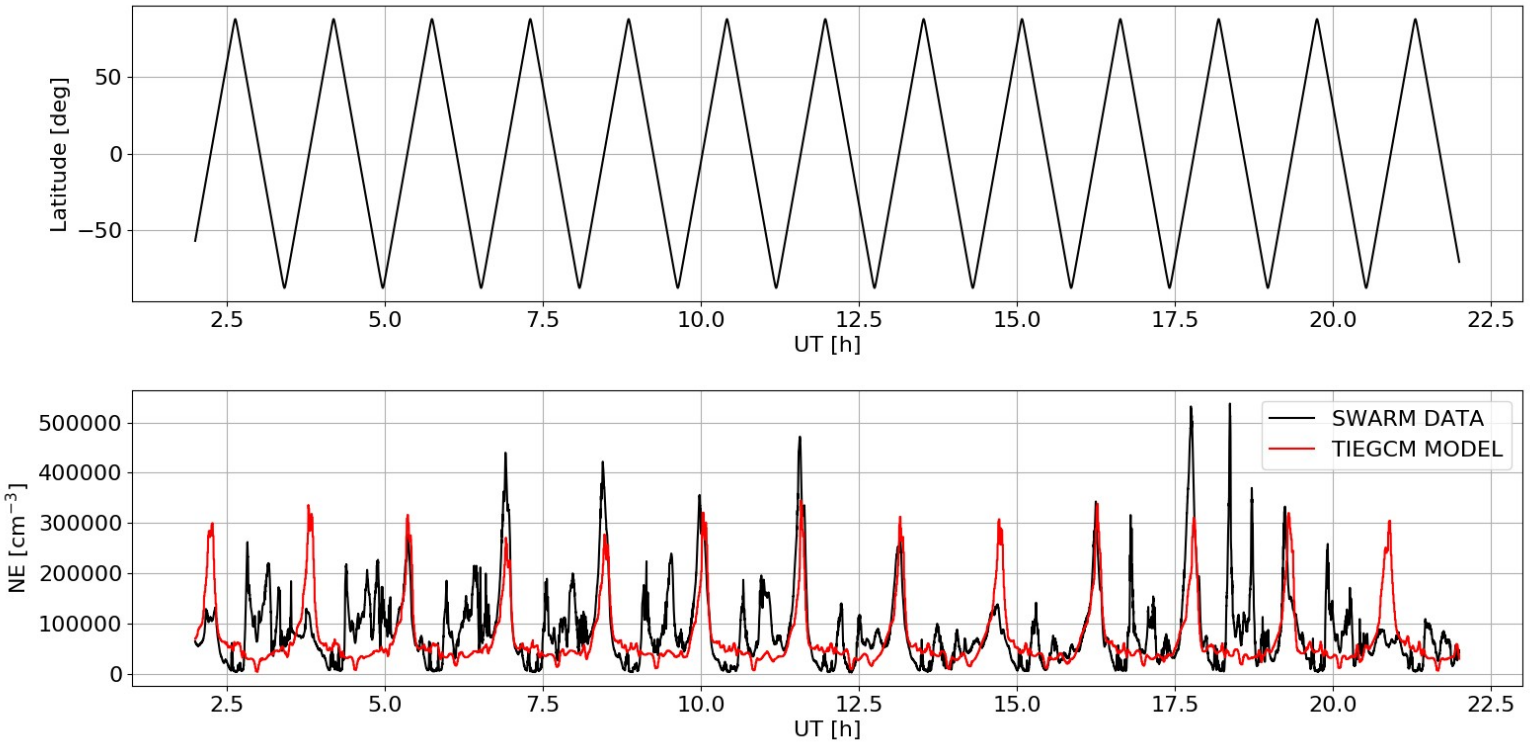
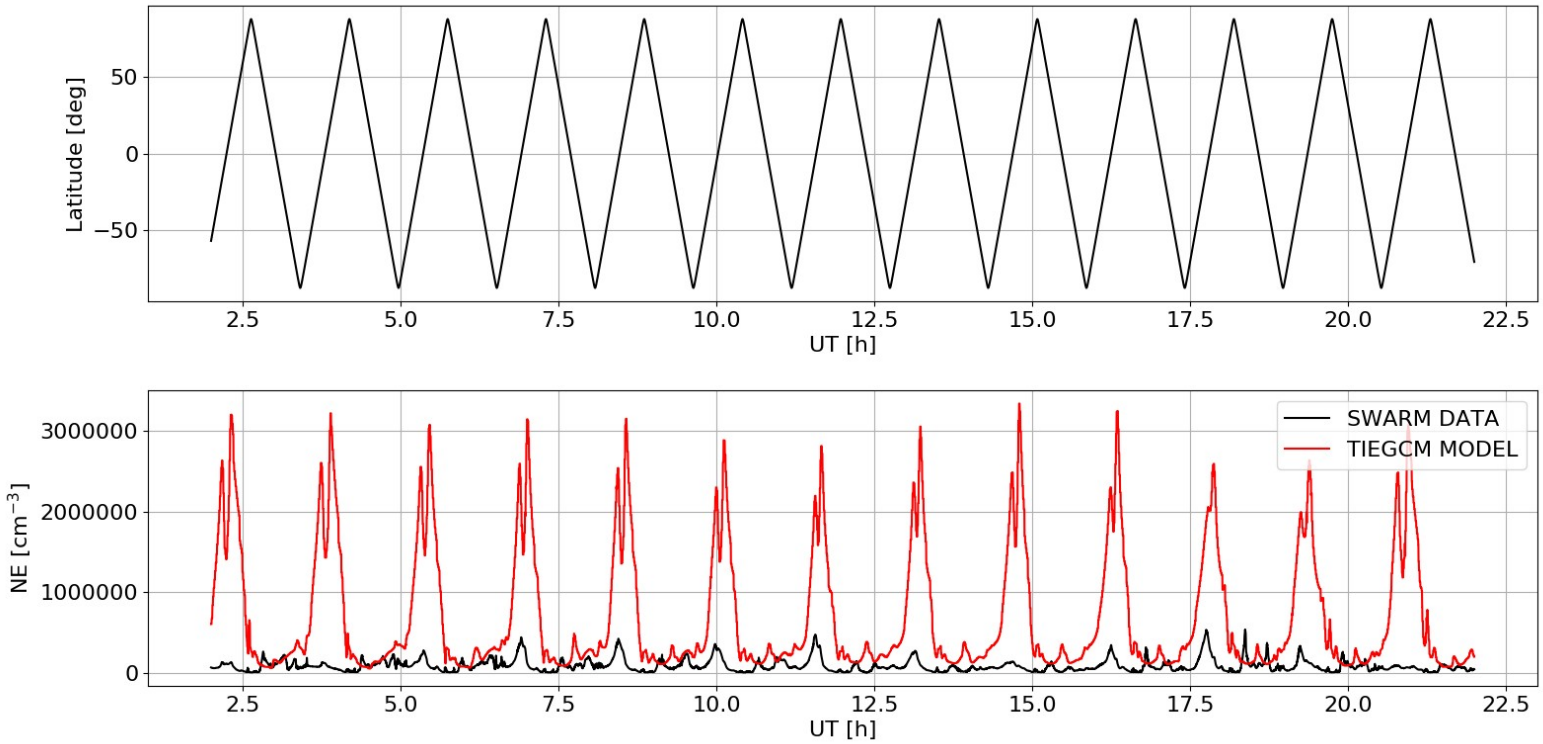


Swarm vs. TIEGCM, electron density, solar min



Swarm A data: 2018-12-24
TIEGCM model: 2002-12-24 (benchmark case: December solstice, **SOLAR MIN**)

Swarm vs. TIEGCM, electron density, solar max



Swarm A data: 2018-12-24
TIEGCM model: 2002-12-24 (benchmark case: December solstice, **SOLAR MAX**)

Summary

The project investigated ionospheric dynamics “around” TIEGCM reference (benchmark) cases. Recommendations:

- long-run simulation starting from a benchmark case in 2002 and driven by real time series characterizing the solar UV and the state of the magnetosphere (or equivalently solar wind conditions)
- direct comparison of TIEGCM solution with satellite measurements using the long run as a proper basis
- tracking down physical processes responsible for generation of NPDE/WSA, e.g., testing if it is related to transport processes by ExB drift or neutral wind
- using machine learning techniques for understanding discrepancies between the modeling results and satellite measurements