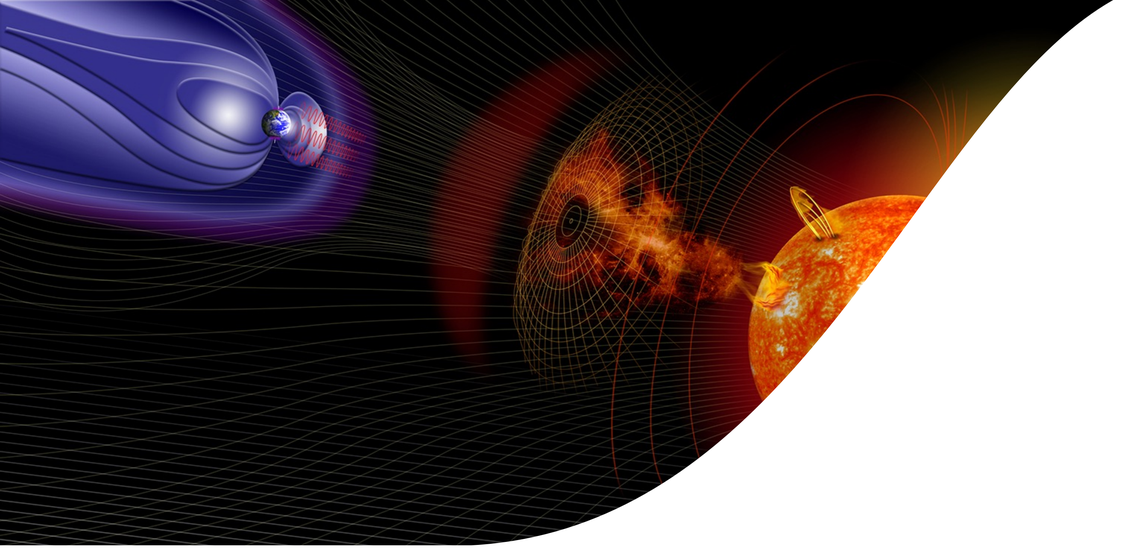

The Impact of Neutral-Atmosphere Data Assimilation with WAM-IPE on Global Ionosphere TEC Specification

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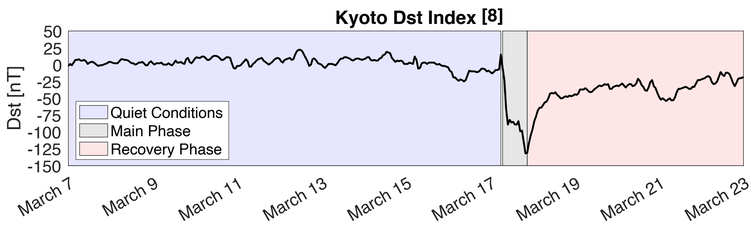
Motivation & Objectives

- Data assimilation (DA) techniques estimate corrections to computational models by comparing model output to observations[5].
- The DA scheme employed here compares satellite accelerometer-derived thermosphere mass density measurements with a global atmosphere-ionosphere model to make corrections to the model's external solar and geophysical drivers.
- This method has been previously demonstrated to improve neutral density specification[5,6].
- Here, we investigate the effects of the neutral-density DA on the modeled ionosphere.
- The modeled vertical total electron content (TEC) for the 2013 St. Patrick's Day geomagnetic storm is compared with TEC data from ground-based GNSS receivers.
- This is part of a larger effort to validate the neutral-plasma coupling of the model in preparation for assimilating ionospheric observables to improve the prediction of equatorial plasma irregularities.

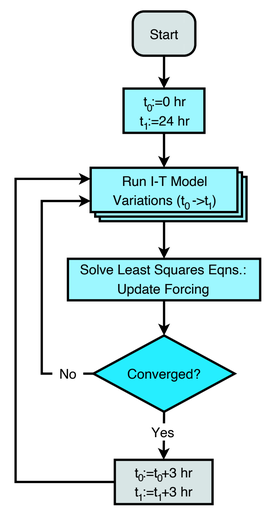
Test Case: 2013 St. Patrick's Day Storm



- The geomagnetic storm was caused by a coronal mass ejection emitted from the Sun on 2013-03-15 that arrived at Earth on 2013-03-17[9].
- This analysis extends from 2013-03-07 to 2013-03-23.

Data Assimilation: Neutral Atmosphere Mass Density

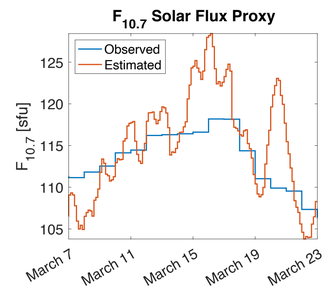
- Data source: Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) accelerometer mass densities[2].
- The IDEA data assimilation technique[5] (right) adjusts Kp and F10.7 inputs to align modeled neutral mass density with the corresponding data.

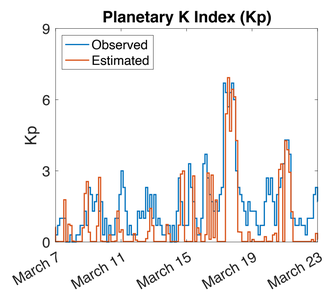


Sutton (2018)

Results & Discussion

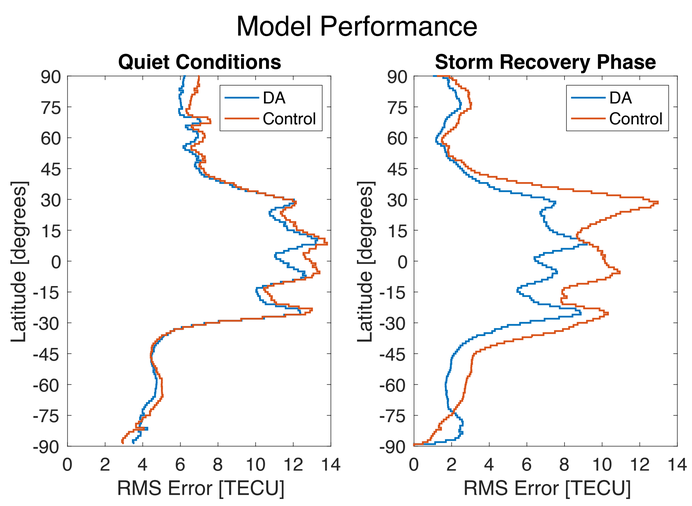
Estimated Drivers





- The DA-estimated solar and geomagnetic indices are not physically meaningful, given that they serve to correct for both model and driver errors.

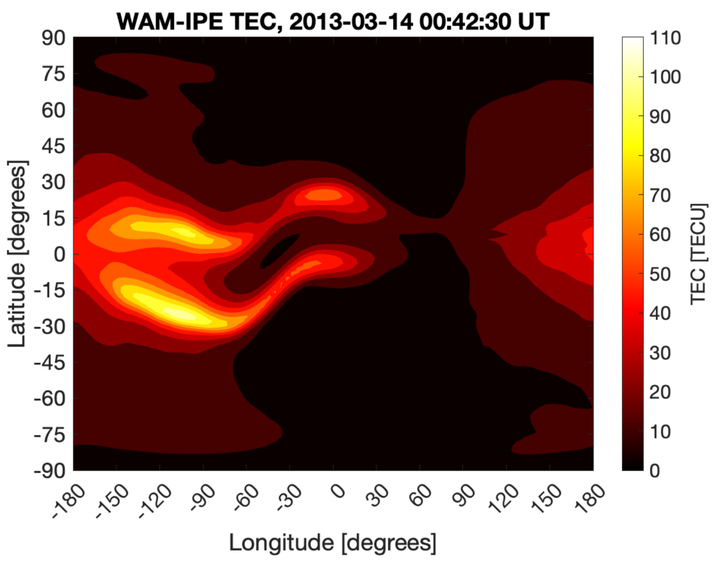
TEC Comparison: Multi-day RMSE by Latitude



$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(TEC_i^{data} - TEC_i^{model})^2}{N}}$$

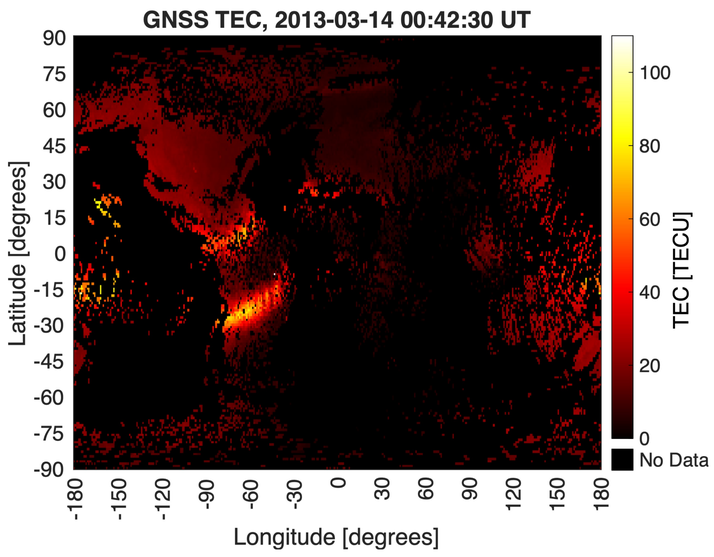
- The DA generally provides a small improvement in TEC, with the most significant changes during the period of geomagnetic storm influence and at low- to mid-latitudes near the equatorial ionization anomaly.
- Neutral densities, temperatures, and winds from WAM are passed to IPE. Correcting the neutral atmosphere via DA appears to partially translate to corrections in the modeled ionosphere electron density.
- Testing over more time periods is needed.

Model: WAM-IPE



- The Whole Atmosphere Model[1] - Ionosphere Plasmasphere Electrodynamics[4] (WAM-IPE) is a global, coupled general circulation model.
- Altitudes: Surface to ~500 km (neutral atmosphere) and 90 km to 10,000 km (plasma/electrodynamics)
- IPE takes its required neutral inputs from WAM.

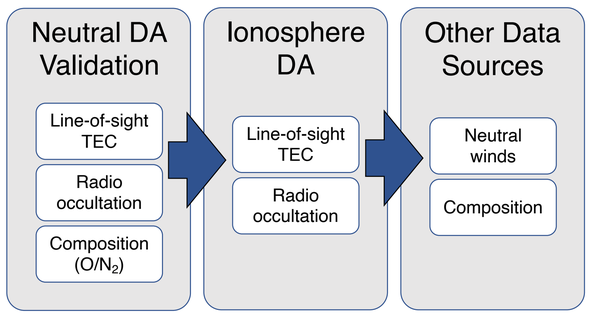
Ionosphere Observations: TEC



- Data source: CEDAR Madrigal Database World-Wide GNSS Receiver Network vertical total electron content[3].
- The vertical TEC maps assume a shell ionosphere at 350km altitude[7], with TECs at the pierce point binned to 1×1 degrees in latitude and longitude.

Findings & Ongoing Work

- The results are preliminary, but suggest that assimilation of neutral density data with the IDEA technique can modestly improve TEC specification, most significantly when geomagnetic storm influences are present.
- Using ionosphere observations which incorporate fewer assumptions, such as line-of-sight TEC data, will provide a more conclusive test.
- This data assimilation method is currently limited to a nowcast. Physically-reasonable drivers become important when extending the driver corrections to the future to provide a model forecast.
- More diverse data for assimilation will likely be necessary for instability predictions. The process to implement this is outlined to the right:



Acknowledgments

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