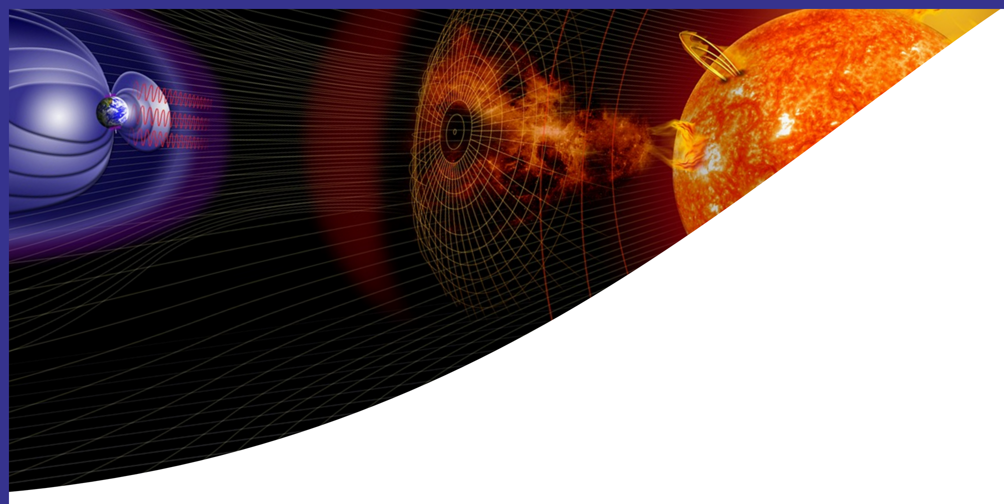

Performance Evaluation of a Data Assimilation Method Estimating the External Forcing of the I-T System

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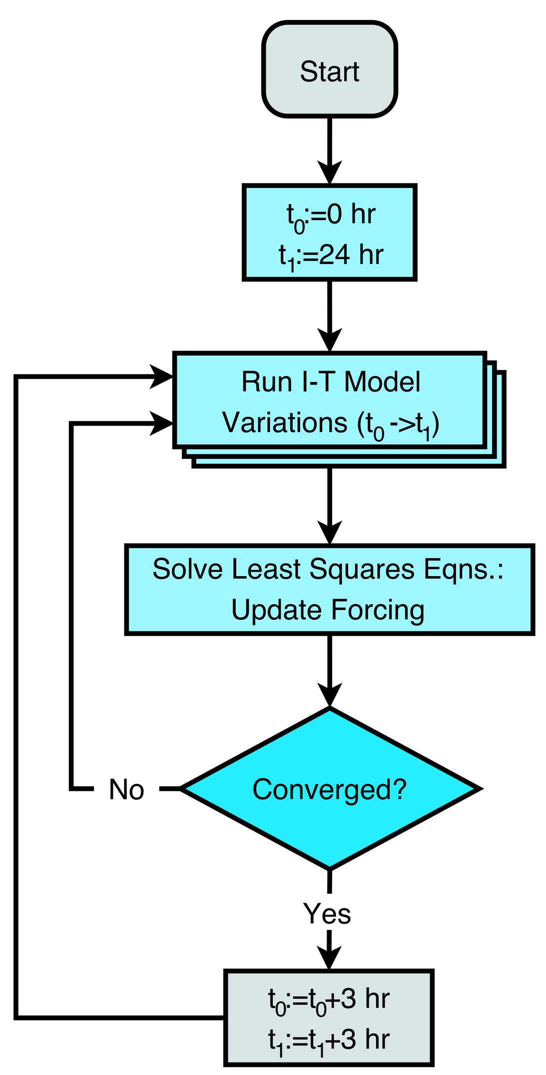
1. Introduction

- The Ionosphere-Thermosphere is a strongly driven dissipative system[6].
- Solar and geomagnetic inputs to the I-T system are not fully observed and are not fully captured in physics-based models. This uncertainty in the model forcing can introduce significant errors[6].
- We examine a data assimilation approach that estimates corrections to the $F_{10.7}$ and Kp input parameters, with the aim of improved agreement between multiple model outputs and data sources.

2. Methods

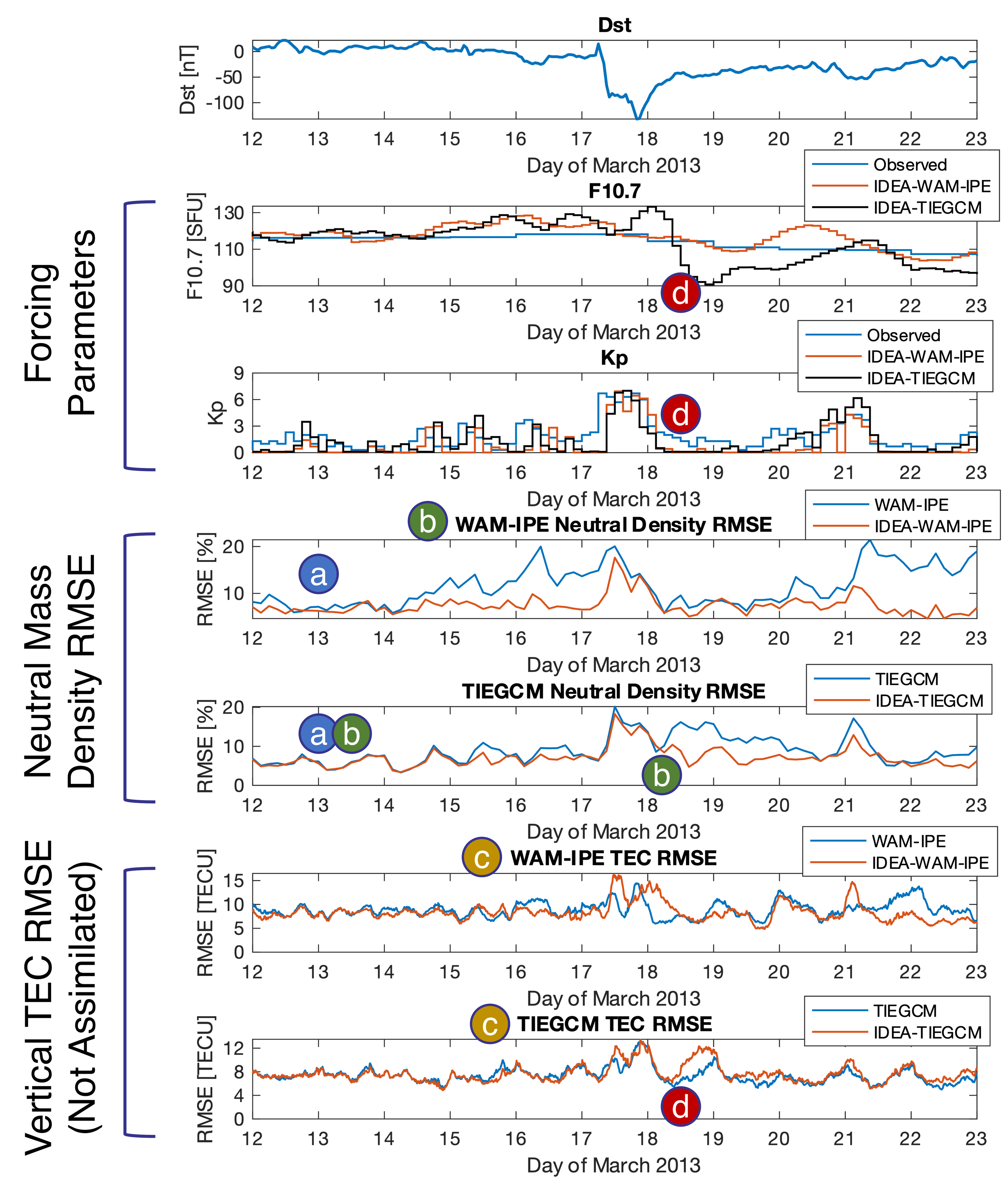
- This study employs the Iterative Driver Estimation and Assimilation (IDEA)[9] scheme, shown to the right. IDEA tests perturbations above and below an initial daily $F_{10.7}$ value and 3 most recent 3-hourly Kp values, then estimates the values that reduce model-data root-mean-square error (RMSE) the most.
- This technique provides sufficient time for the updated forcing to influence the model, without breaking the model's self-consistent physics.
- We assimilate the logarithm of mass densities derived from the accelerometer aboard the ESA GOCE mission[2] into the WAM-IPE[1,8] and TIEGCM[5] models.



$$RMSE = \sqrt{\frac{\sum_i^N (model_i - data_i)^2}{N}}$$

- The evaluated time period is March 12-23, 2013, which includes the arrival of a geomagnetic storm on March 17 at roughly 0530 UTC.
- Assimilative and free-running model outputs are compared with the assimilated neutral data as well as the CEDAR Madrigal Database GNSS vertical TEC data[3].

3. Results



4. Findings & Discussion

(a) Even without data assimilation, both models give very accurate thermosphere mass densities in the quiet period before this particular geomagnetic storm, with RMSE values below 10%.

(b) IDEA reduces the mass density RMS errors for nearly all times with WAM-IPE, and under geomagnetic disturbances with TIEGCM. The mass density RMSE of TIEGCM during quiet conditions is largely unchanged.

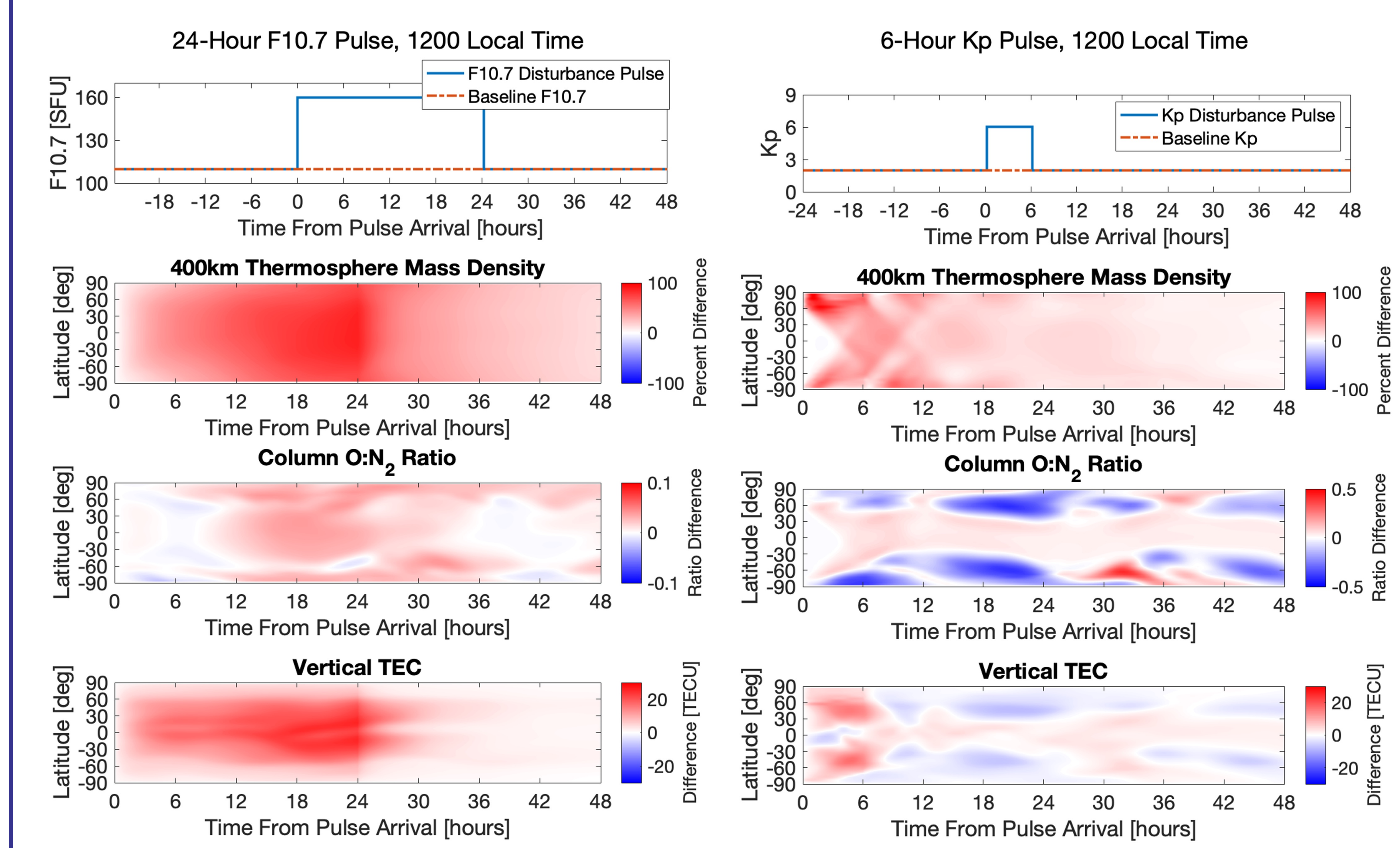
(c) The ionosphere TEC RMSE during quiet conditions shows negligible change with both models and fluctuates above and below the free-run values during disturbed conditions. This is likely because the forcing adjustments are made only to optimize the neutral mass density.

(d) Deficiencies in cooling following storm conditions[7] likely prompt IDEA to dramatically reduce the energy input of TIEGCM during the storm recovery. While this reduces the density error, the TEC RMSE increases significantly.

Thermosphere mass density at a constant altitude varies both with the motion of pressure surfaces and with changes in composition due to vertical winds[4]. Accelerometer density data alone does not contain information that allows the data assimilation engine to distinguish between these two mechanisms and adjust the model forcing accordingly. Adding data that contains composition information may increase the effectiveness of the data assimilation technique.

5. Ongoing Work

- Three runs of TIE-GCM have been conducted to examine the model's sensitivity to idealized step-function disturbances in $F_{10.7}$ and Kp.
- The results below show the change relative to the baseline run ($F_{10.7}$ = 110 SFU, Kp = 2) of observables in the model response to each disturbance.



- The column O/N_2 ratio shows greater orthogonality between the $F_{10.7}$ and Kp pulse responses than the corresponding responses in mass density.
- Assimilating column O/N_2 data alongside accelerometer densities may allow IDEA to better distinguish between $F_{10.7}$ and Kp adjustments while maintaining a realistic total energy input.

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Acknowledgments

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