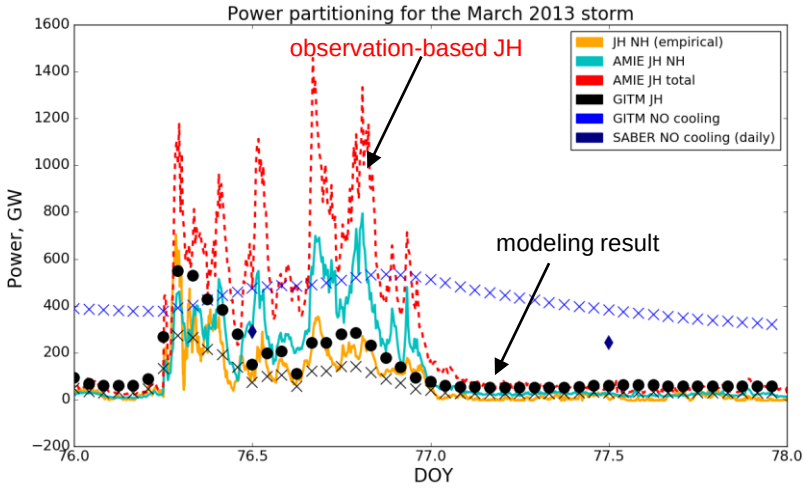
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Ionosphere-Thermosphere Energy Budget

Verkhoglyadova



GITM energy budget during 17–18 March 2013 storms versus observation-based estimates for the thermospheric cooling and the Joule heating (JH). Note variability in observation-based JH and modeling underestimation (black dots).

Verkhoglyadova, O. P., X. Meng, A. J. Mannucci, M. G.Mlynczak, L. A. Hunt, and G. Lu (2017), Ionosphere thermosphere energy budgets for the ICME storms of March 2013 and 2015 estimated with GITM and observational proxies, Space Weather, 15, doi:10.1002/ 2017SW001650

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Science Question: Energy budget is an important characteristic of the ionosphere-thermosphere (IT) system. In the paper we inter-compare and evaluate different available sources for estimation of energy terms, including a numerical model, empirical models, and direct satellite measurements. How well do empirical relationships represent the energy budget in specific geomagnetic storms? How well does global circulation modeling describe energy partitioning? How inter-consistent are these estimates?

Data & Results:

We utilize Global Ionosphere-Thermosphere Model (GITM) runs for two recent strong geomagnetic storms, March 2013 and March 2015. We focus on comparison of modeled energy/power partitioning and observation-derived energy estimates. We utilize NASA TIMED/SABER, NOAA/TIROS and DMSP data products and NASA OMNI database. Our study showed a reasonable agreement between GITM estimates of energy channels and observation-based estimates, and several shortcomings of the modeling.

Significance: Creating reliable forecast of the IT system is one of the main goals of the space weather discipline. Since energy is one of the most important and general parameters describing a system dynamics, we need to evaluate how accurately models can represent the IT energy budget and to find how to improve our forecasting models.

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Data Sources:
NASA TIMED/SABER http://saber.gats-inc.com; OMNI database (http://omniweb.gsfc.nasa.gov/form/omni_min.html); CEDAR Database at NCAR (http://cedarweb.vsp.ucar.edu/wiki/index.php/Main_Page) based on DMSP and NOAA/TIROS satellite measurements

Computer resources:
The computing resources at the NASA supercomputer Pleiades were provided by the NASA High-End Computing Program through the NASA Advanced Supercomputing Division at Ames Research Center. GITM was made available through the University of Michigan's Space Weather Modeling Framework.
The instant run facility of CCMC was used (https://ccmc.gsfc.nasa.gov/).

Technical Description of Figure:
GITM energy budget during 17–18 March 2013 versus observation-based estimates: GITM-estimated Joule heating (black crosses and black dots), thermospheric NO cooling (dark blue crosses) with daily averaged TIMED/SABER NO power (dark blue diamonds), empirical Joule heating in the Northern Hemisphere, and empirical AMIE estimates for the Northern Hemispheres (solid line) and for the whole globe (dashed line). Note variability in observation-based JH and modeling underestimation.

Scientific significance, societal relevance, and relationships to future missions:
We discuss challenges and discrepancies in estimating and global modeling of the ionosphere-thermosphere energy partitioning, especially Joule heating, during geomagnetic storms. This study evaluates current capabilities for estimating the IT energy budget during two recent storms. Our study showes a reasonable agreement between model and observation-based estimates, as well as possible model shortcomings which need to be addressed. Different definitions and estimates of Joule heating result in a major uncertainty in the total budget estimations. Effects of time variable high-latitude electric field may need to be included for more precise determination of thermospheric heating. Understanding energy budget and improving its estimates are important for the space weather forecasting efforts.