Project Details

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Selection Year: 2013
Program Element: Focused Science Topic

Topic: Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system

Project Title:
Global Thermospheric Wind Response to Geomagnetic Storms

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Summary:
Proposal summary of NASA LWS-FST proposal 2013

Global thermospheric wind response to geomagnetic storms

During geomagnetic storms high-latitude electric fields and auroral precipitation are greatly enhanced resulting in large amounts of energy and momentum being deposited into the thermosphere-ionosphere (T-I) system. One consequence of this energy and momentum deposition is that there are significant changes to the global thermospheric wind circulation and thus also a fundamental impact on the composition and dynamics of both the neutral and the ionized components of the T-I system. The changes of the global neutral wind circulation, and the way that they affect ionospheric variations under geomagnetically disturbed conditions, are poorly understood. Most previous studies have focused primarily on the storm-time changes of neutral winds at high latitudes. A full understanding of the behavior of the neutral winds on a global scale during and after geomagnetic storms is still lacking. In particular, the processes by which storm-time changes at high latitudes affect low and middle latitude T-I system are not fully understood.

Thus, we propose to study the changes in the global structures of neutral winds and their associated ionospheric variations during and after geomagnetic storms and the physical mechanisms that cause these changes. To perform this study the proposed research will address the following specific questions:

1) How do global neutral winds and the ionosphere change during storms?

2) How does storm strength or duration affect changes of global neutral wind circulation during storms?

3) How long does it take for the global wind system and the ionosphere to recover to its pre-storm state? What are the main factors that determine this recovery?

4) What are the processes that produce vertical shears in the horizontal winds during storms?

We will carry out numerical studies using a state-of-art coupled magnetosphere ionosphere thermosphere (CMIT) model and the thermosphere ionosphere electrodynamics global circulation model (TIEGCM) and diagnostically analyze model outputs to address these questions. We will also use existing archived wind data from DE-2, UARS/WINDII and CHAMP measurements to ensure the fidelity of our modeled winds by comparing model results with these wind observations. Ionospheric peak electron densities from the global network of ionosonde observations, global ionospheric total electron content maps from GPS observations, and CHAMP in situ electron density measurements will also be employed to study the storm-time wind effect on the ionosphere.

The proposed effort will directly address NASA announcement NNH13ZDA001N-LWS focused science topic 1.3.1 (d) Thermospheric wind dynamics during geomagnetic storms and their influence on the coupled magnetosphere-ionosphere-thermosphere system by investigating storm-time changes of the neutral winds, the associated ionospheric variations and the mechanisms by which these changes occur. It will enhance our understanding of the global-scale behavior of the coupled thermosphere and ionosphere system during and after geomagnetic storms, which directly relates to the Science Goals for the Next Decade #2: determine the dynamics and coupling of Earth s magnetosphere, ionosphere, and atmosphere and their

response to solar and terrestrial inputs in the recently released National Research Council s Decadal Survey report.

Publication References:

Summary: no summary

Reference: Wu, Qian; Noto, John; Kerr, Robert; Kapali, Sudha; Riccobono, Juanita; Wang, Wenbin; Talaat, Elsayed R.; (2014), First Palmer and Millstone Hill midlatitude conjugate observation of thermospheric winds, Journal of Geophysical Research: Space Physics, Volume 119, Issue 4, pp. 3016-3028, doi: 10.1002/2013JA019062

Summary: no summary

Reference: Lei, Jiuhou; Wang, Wenbin; Thayer, Jeffrey P.; Luan, Xiaoli; Dou, Xiankang; Burns, Alan G.; Solomon, Stanley C.; (2014), Simulations of the equatorial thermosphere anomaly: Geomagnetic activity modulation, Journal of Geophysical Research: Space Physics, Volume 119, Issue 8, pp. 6821-6832, doi: 10.1002/2014JA020152

Summary: no summary

Reference:
Liu, Jing; Wang, Wenbin; Burns, Alan; Solomon, Stanley C.; Zhang, Shunrong; Zhang, Yongliang; Huang, Chaosong; (2016), Relative importance of horizontal and vertical transports to the formation of ionospheric storm-enhanced density and polar tongue of ionization, Journal of Geophysical Research: Space Physics, Volume 121, Issue 8, pp. 8121-8133, doi: 10.1002/2016JA022882

Summary: no summary

Reference: Yue, Xinan; Wang, Wenbin; Lei, Jiuhou; Burns, Alan; Zhang, Yongliang; Wan, Weixing; Liu, Libo; Hu, Lianhuan; Zhao, Biqiang; Schreiner, William S.; (2016), Long-lasting negative ionospheric storm effects in low and middle latitudes during the recovery phase of the 17 March 2013 geomagnetic storm, Journal of Geophysical Research: Space Physics, Volume 121, Issue 9, pp. 9234-9249, doi: 10.1002/2016JA022984

Summary: no summary

Reference: Zhang, Shun-Rong; Erickson, Philip J.; Zhang, Yongliang; Wang, Wenbin; Huang, Chaosong; Coster, Anthea J.; Holt, John M.; Foster, John F.; Sulzer, Michael; Kerr, Robert; (2017), Observations of ion-neutral coupling associated with strong electrodynamic disturbances during the 2015 St. Patrick's Day storm, Journal of Geophysical Research: Space Physics, Volume 122, Issue 1, pp. 1314-1337, doi: 10.1002/2016JA023307

Summary: no summary

Reference: Wiltberger, M.; Merkin, V.; Zhang, B.; Toffoletto, F.; Oppenheim, M.; Wang, W.; Lyon, J. G.; Liu, J.; Dimant, Y.; Sitnov, M. I.; Stephens, G. K.; (2017), Effects of electrojet turbulence on a magnetosphere-ionosphere simulation of a geomagnetic storm, Journal of Geophysical Research: Space Physics, Volume 122, Issue 5, pp. 5008-5027, doi: 10.1002/2016JA023700