Geophysical Research Abstracts
Vol. 13, EGU2011-2768, 2011
EGU General Assembly 2011

Aspects of modeling the high-latitude magnetosphere-ionosphere energy transfer

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The Earth's ionosphere and thermosphere form a complex coupled system. This system can be forced from the lower atmosphere mainly via different kinds of waves and tides. The signature of this forcing is very obvious during geomagnetically quiet times and especially under solar minimum conditions at low and mid-latitudes. However, the ionosphere is also forced from above, especially during geomagnetically disturbed times but also during geomagnetically quiet times. The effects of this forcing will be seen globally on different times scales in the thermospheric temperature, composition, density and winds. In general, global circulation models (GCMs) have been able to reproduce the general features of the global response to the magnetosphere-ionosphere coupling. However there is still a lot of uncertainty about how to quantify the spatial and temporal distribution of the energy input, and how to measure it. This limits our ability to develop predictive models.

The downward perturbation Poynting flux component is widely used as a measurement of the magnetosphere-ionosphere coupling, and it is assumed to represent the electromagnetic energy dissipation in the ionosphere. Simple examples show that the downward Poynting flux vector can over- or underestimate the electromagnetic energy dissipation in the ionosphere in regions of low or high conductance, respectively. To specify the high-latitude energy input for GCMs a self consistent empirical model of the high latitude magnetosphere-ionosphere energy transfer was developed based on Dynamics-Explorer 2 data. The model captures the average conditions for different seasons and IMF conditions. The influence of the electric field variability which is included in this model can increase the Joule heating up to 100%, making the magnitude of total Joule heating more comparable with the integrated Poynting flux, although the spatial distributions of the two can differ. The thermospheric response depends on both the horizontal and vertical distributions of energy input. With a simple example it can be shown that the upper-thermosphere density response to F-region heating is relatively strong and fast, while the same total E-region heating produces a much weaker initial response with a much longer decay time.