Geophysical Research Abstracts
Vol. 20, EGU2018-11519-2, 2018
EGU General Assembly 2018

Mid-latitude cyclones and storms in the context of solar wind-magnetosphere-ionosphere-atmosphere coupling

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Wilcox effect, a relation between solar wind magnetic sector boundary structure and mid-latitude upper tropospheric vorticity [1], was confirmed [2] pointing to a possibility that coupling between the solar wind and the Earth's magnetosphere, and ultimately the ionized and neutral atmosphere, can influence development of tropospheric weather. Recent results [3,4] that support such link are summarized and corroborated to show further evidence that explosive extratropical cyclones, significant snowstorms, windstorms and heavy rain, particularly if caused by intensifying low pressure systems in winter, tend to follow arrivals of high-speed solar wind streams from coronal holes or coronal mass ejections. Large amplitude magneto-hydrodynamic waves couple to the magnetosphere-ionosphere-atmosphere (MIA) system generating medium-scale atmospheric gravity waves in the lower thermosphere at high latitudes. These gravity waves propagate upward and downward, and can be ducted in the lower atmosphere over long distances. Simulations of gravity wave propagation in model atmosphere using the Transfer Function Model [5] show that propagating waves originating in the thermosphere can excite a spectrum of gravity waves in the lower atmosphere. In spite of significantly reduced amplitudes but subject to amplification upon reflection in the upper troposphere, these gravity waves can trigger/release instabilities, moist symmetric instability in particular, to initiate convection. The latent heat release leads to intensification of storms. Explosive extratropical cyclone tracks obtained from the meteorological reanalysis datasets and significant weather events in Canada, Slovakia, Japan, Australia, and the eastern USA, are examined in the context of solar wind coupling to the MIA system using the superposed epoch analysis. These results suggest that vertical coupling in the atmosphere exerts downward control from solar wind to the lower atmospheric levels influencing tropospheric weather development.

References

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