A link between high-speed solar wind streams and extratropical cyclones

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Databases of extratropical-cyclone tracks obtained from two meteorological reanalysis datasets are used in superposed epoch analysis of time series of solar wind plasma parameters and green-coronal emission line intensity. The time series are keyed to times of maximum growth of explosively developing extratropical cyclones during northern and southern winters. The new statistical evidence corroborates the previously published results (Prikryl et al., Ann. Geophys., 27, 1-30, 2009). This evidence shows that explosive extratropical cyclones tend to occur after arrivals of solar wind disturbances such as high-speed solar wind streams from coronal holes when large amplitude magneto-hydrodynamic waves couple to the magnetosphere-ionosphere system. These MHD waves modulate Joule heating and/or Lorentz forcing of the high-latitude thermosphere generating medium-scale atmospheric gravity waves. Ray tracing of aurorally-generated gravity waves show that the gravity waves propagate upward and downward through the atmosphere. Simulations of gravity wave propagation in a model atmosphere using the Transfer Function Model (TFM) (Mayr et al., Space Sci. Rev., 54, 297–375, 1990) show that propagating waves originating in the thermosphere can excite a spectrum of gravity waves in the lower atmosphere. At the tropospheric level, in spite of significantly reduced amplitudes, they can provide a lift of unstable air to release the moist symmetric instability thus initiating slantwise convection and forming cloud/precipitation bands (Prikryl et al., Ann. Geophys., 27, 31-57, 2009). The release of latent heat is known to provide energy for rapid development and intensification of extratropical cyclones.
Since 2009, Japan Meteorological Agency has archived detailed annual reports on calamitous severe weather events occurring nation-wide (http://www.jma.go.jp/jma/menu/menureport.html). The starting dates of the events attributed to low pressure systems are used as key times in the superposed epoch analysis of solar wind plasma parameters and green solar corona intensity. It is observed that the events of heavy rain or snow, strong wind and high ocean waves caused by low pressure storms, particularly in winter, tend to follow arrivals of high-speed solar wind. This is consistent with the statistical evidence based on the study of explosive extratropical cyclones in relation to solar wind.

Keywords: High-speed solar wind streams, Atmospheric gravity waves, Extratropical cyclones

