Solar wind influence on tropospheric weather through atmospheric vertical coupling

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A link between solar wind magnetic sector boundary structure and mid-latitude upper tropospheric vorticity discovered in the 1970s (Wilcox et al., Science, 180, 185-186, 1973) was later confirmed and physical mechanisms proposed (Tinsley et al., J. Geophys. Res., 106(D23), 1994; Prikryl et al., Ann. Geophys., 27, 1-57, 2009). To further emphasize their importance we investigate the occurrence of mid-latitude severe weather in the context of solar wind coupling to the magnetosphere-ionosphere-atmosphere (MIA) system. It is observed that significant snowstorms, windstorms and heavy rain, particularly if caused by low pressure systems in winter, tend to follow arrivals of high-speed solar wind. Previously published statistical evidence that explosive extratropical cyclones in the northern hemisphere tend to occur after arrivals of high-speed solar wind streams from coronal holes (Prikryl et al., J. Atmos. Sol.-Terr. Phys., 149, 219–231, 2016) is corroborated for the southern hemisphere. The leading edge of high-speed solar wind streams is a locus of large-amplitude magneto-hydrodynamic waves that modulate Joule heating and/or Lorentz forcing of the high-latitude lower thermosphere generating medium-scale atmospheric gravity waves that propagate upward and downward through the atmosphere. Simulations of gravity wave propagation in a model atmosphere using the Transfer Function Model (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. In spite of significantly reduced amplitudes but subject to amplification upon reflection in the upper troposphere, these gravity waves can provide a lift of unstable air to release instabilities in the troposphere thus initiating convection to form cloud/precipitation bands. It is primarily the energy provided by release of latent heat that leads to intensification of storms. These results indicate that vertical coupling in the atmosphere exerts downward control from solar wind to the lower atmospheric levels influencing tropospheric weather development.

Keywords: Atmospheric gravity wave, Severe weather, Extratropical cyclone, High-speed solar wind, Co-rotating interaction region, Solar wind coupling to the magnetosphere-ionosphere-atmosphere

