Thermospheric nitric oxide response to shock-led storms

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We present a multiyear superposed epoch study of the Sounding of the Atmosphere using Broadband Emission Radiometry nitric oxide (NO) emission data. NO is a trace constituent in the thermosphere that acts as cooling agent via infrared (IR) emissions. The NO cooling competes with storm time thermospheric heating resulting in a thermostat effect. Our study of nearly 200 events reveals that shock-led interplanetary coronal mass ejections (ICMEs) are prone to early and excessive thermospheric NO production and IR emissions. Excess NO emissions can arrest thermospheric expansion by cooling the thermosphere during intense storms. The strongest events curtail the interval of neutral density increase and produce a phenomenon known as thermospheric "overcooling." We use Defense Meteorological Satellite Program particle precipitation data to show that interplanetary shocks and their ICME drivers can more than double the fluxes of precipitating particles that are known to trigger the production of thermospheric NO. Coincident increases in Joule heating likely amplify the effect. In turn, NO emissions are more than double. For some events, there may be an additional factor of early NO production due to solar flares. Perhaps a more potent combination of solar wind events involves a series of ICMEs, especially if the interplanetary path has been "cleared" for the second or subsequent ICME. We discuss the roles and features of shock/sheath structures that allow the thermosphere to temper the effects of extreme storm time energy input. Shock-driven thermospheric NO IR cooling likely plays an important role in satellite drag forecasting challenges during extreme events.

Keywords: Thermospheric nitric oxide, Coronal mass ejections, Shock-led storms