Recent observations of Poynting flux made by the DMSP F-15 satellite have revealed a set of geomagnetic storm events (2004-2005) with anomalous, large energy deposition in narrow elongated crescents into the dayside thermosphere. The extreme energy input occurs within narrow ExB flow channels bounded by a highly localized (latitude) pair of oppositely directed field-aligned currents (FACs). Most of these events are associated with dominant in-the-ecliptic interplanetary magnetic field values, often, but not exclusively, while the IMF Bz is positive. An additional characteristic of these events is high speed solar wind. Using MHD models, observations, and data assimilation, we will show why such circumstances in the solar wind lead to localized energy deposition in the dayside high-latitude thermosphere. We will discuss the relation of these events to statistical patterns of Joule heating and neutral density upheaval.