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The major solar eruptive event in July 2012: Examining extreme space weather events

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A key goal for space weather studies is to define severe and extreme conditions that might plausibly afflict human technology. On 23 July 2012, solar active region 1520 ($\sim$141°W heliographic longitude) gave rise to a powerful coronal mass ejection (CME) with an initial speed that was determined to be 2500 ± 500 km/s. The eruption was directed away from Earth toward 125°W longitude. STEREO-A sensors detected the CME arrival only about 19 h later and made in situ measurements of the solar wind and interplanetary magnetic field. In this paper, we address the question of what would have happened if this powerful interplanetary event had been Earthward directed. Using a well-proven geomagnetic storm forecast model, we find that the 23–24 July event would certainly have produced a geomagnetic storm that was comparable to the largest events of the twentieth century (Dst ~ -500 nT). Using plausible assumptions about seasonal and time-of-day orientation of the Earth's magnetic dipole, the most extreme modeled value of storm-time disturbance would have been Dst $= {}^{-1}182$ nT. This is considerably larger than estimates for the famous Carrington storm of 1859. This finding has far reaching implications because it demonstrates that extreme space weather conditions such as those during March of 1989 or September of 1859 can happen even during a modest solar activity cycle such as the one presently underway. We argue that this extreme event should immediately be employed by the space weather community to model severe space weather effects on technological systems such as the electric power grid.