

Statistical analysis on how CME and SIR/CIR events effect the geomagnetic activity and the Earth's thermosphere

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In order to estimate the impact of different types of solar wind on the geomagnetic activity and the neutral density in the Earth's thermosphere, we present a comprehensive statistical analysis based on interplanetary coronal mass ejections (ICME) covering the time range from July 2003 - 2016 and stream interaction as well as corotating interaction regions (SIR/CIR) from July 2003 – December 2009. In general, geomagnetic storms induced by CIR are characterized by lower energy input compared to ICME induced storms but a significantly longer duration time due to a long-term negative B_z component in the magnetic cloud region.

Regarding the time of occurrence of ICME events, we rely on the catalogue maintained by Richardson and Cane. For the period of investigation more than 250 Earth-directed CME events are listed. All of them have been measured in situ by plasma and field instruments on board the ACE spacecraft. The arrival times of SIRs/CIRs are taken from the catalogue maintained by Lan Jian based on ACE and Wind in-situ measurements. From this list, we extracted 98 SIR/CIR events, from which the minimum B_z component is determined within a time window of 36 hours starting at the arrival of the SIR/CIR (same procedure as for ICMEs). Accordingly, the peak in Earth's neutral density is determined in the same time window. The densities itself are estimated by using accelerometer measurements collected by the Gravity Recovery And Climate Experiment (GRACE) satellites and subsequently related to various geomagnetic indices (e.g. SYM-H, Polar cap, a-indices, ...) as well as characteristic CME parameters like the impact speed, the southward magnetic field strength B_z and resultant derivatives.

We find high correlations ($cc=0.9$) between the CME characteristic (except the impact speed) and the thermospheric density enhancements as well as with most of the geomagnetic indices. However, considering only weaker ICME events (B_z up to -20nT) a lower correlation must be conceded. The same holds true for SIR/CIR events, as both cover compressed sheath regions with turbulent magnetic field. The absolute density increases for SIR/CIR induced storms is in the order of $1.7\text{E}-12\text{kg/m}^3$ for B_z values ranging from -4 to -19nT , with a related correlation coefficient of -0.41 .