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The solar and interplanetary sources of great geomagnetic storms (Dst≤-200 nT) during solar cycle 23

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We group great geomagnetic storms (GGSs) into large geomagnetic stormsč-LGSs (-200nT ≤Dst<-300nT) and super geomagnetic stormsč-SGSs (Dst≤-300nT). An analysis of GGSs during solar cycle 23 shows that, of the 18 GGS (Dst≤-200nT) occurred during solar cycle 23, 12 are LGSs and 6 are SGSs. Of the 12 LGSs, 8 have a solar source located in the west hemisphere of the solar disk, and 4 have the solar sources in the east hemisphere of the solar disk, indicating an obvious asymmetrical distribution in longitude. LGSs have a solar source distributed between E18≤Lon≤W66 in longitude and S30≤Lat≤N20 in latitude, and SGSs between E18≤Lon≤W19 in longitude and S16≤Lat≤N22 in latitude, without showing an asymmetrical distribution in longitude. The study of IP sources of GGSs during solar cycle 23 has led us to believe that a sheath, or a magnetic cloud (MC), or the combination of a sheath , corotating interaction region (CIR) and MC, can result in a LGS. On the contrary, the IP sources of an SGS can only be a MC, or the combination of a sheath and a MC with MC playing a key role. CMEs' initial speed has poor correlation with GGSs for the events studied. In the given 18 SGSs, the south component of interplanetary (IP) magnetic field (B_s) is poorly correlated to the intensity of GGSs, the solar wind electric field (E_y) has much better correlation with the intensity of GGSs than B_s. The solar wind energy coupling function (ε) has the best correlation with the intensity of GGSs. Based on

the IP sources data of 18 SGSs, we have worked out the threshold values of three key IP parameters, namely B_s, E_y, and ε, to cause a GGS