Occurrence statistics of intense geomagnetic storms

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The 45-year (1957-2001) database of Dst-index is analyzed for evaluating occurrence properties of geomagnetic storms. We focus on the intense and independent storm events, where the storm intensity (I_s; the minimum Dst in an event) is less than -100 nT and the storm waiting time (T_s; the interval between events at each Dst-minimum time) is longer than 48 hours. 321 events satisfy these criteria. Statistics of the storm parameters (I_s, T_s) in the data set suggest the following features.

(1) A stronger storm (I_s less than -250 nT) mostly follows the preceeding one within a short interval (less than 18 weeks), whereas a weaker one (I_s ˜-100 ˜-200 nT) has a large variance in T_s up to over one and a half year.
(2) The distributions of both I_s and T_s exhibit a power-law tail.
(3) The waiting time distribution (WTD) can be explicable in terms of a Poisson process with a time-varying rate $¥lambda(t)$.

The frequency of storm occurrences correlates well with the solar activity. A Poisson rate $¥lambda(t)$ is the expected frequency of events per unit time, so that $¥lambda(t)$ depends on the solar cycle. The rate $lambda$ (per 13 weeks) is $0.67 ¥pm 0.08$ in the weak phase, and $2.62 ¥pm 0.41$ in the active phase. The feature (3) above is also confirmed in the WTD of solar flares by Wheatland and Litvinenko (2002). They showed that the WTD have a power-law tail if the distribution of $¥lambda(t)$ has a power-law form. Therefore, the feature (2) and (3) are not inconsistent.

The value $lambda$ leads to the determination of the occurrence probability in the form of a Poisson distribution. For instance, we can estimate the probability that the intense storm will take place more than twice within the next one year. This idea can be applied to the evaluation of the storm occurrence in future. In the paper, we will also introduce the scheme of the long-term storm forecast in a long-term range.