WHO CARES ABOUT WEAK GEOMAGNETIC STORMS?

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Although relativistic electron enhancements do occur together with geomagnetic storms, the size of the enhancements does not correlate with the size of the storms. Better correlations are found with parameters measuring substorm activity.

The earth magnetic field is subjected to continuous variations which are driven by the solar wind and the interplanetary magnetic field, IMF. These variations are known as magnetic activity and show different typical features. The most common type of activity are geomagnetic substorms whose most prominent signature are the brightening of the auroral arcs. Especially during periods of strong substorm activity it happens that a geomagnetic storm develops, which is characterized by the build up of a ring current. The ring current consists of ions in the 100 keV range which are trapped in the earth magnetic field and encircle the earth at a distance of typically 3 to 6 earth radii. These particles induce a southward oriented magnetic field, such that the geomagnetic field in the inner magnetosphere is reduced. In magnetograms recorded at the earth equator this shows up as typical dip which decreases to its minimum value within typically a day and then recovers over days back to its initial level. The size of a storm is measured by the disturbance storm-time index, Dst, which is the deviation of the magnetic field H-component at the earth equator compared to the quiescent state and is given in nT. According to the minimum Dst reached, magnetic storms are classified into the three classes weak ($-30<Dst_{min}$), moderate ($-30>Dst_{min}>-50$), and great ($Dst_{min}<-100$).

Geomagnetic activity can influence our life on earth in various manners. Telecommunication for example is altered by magnetic activity induced changes in the ionosphere and electric power systems can be knocked out by geomagnetically induced currents. The number of such effects normally increases with geomagnetic activity and are most severe during great magnetic storms. So one is most concerned about the large magnetic storms which threathen to break down critical systems.

Besides life on earth also space born systems can be effected by geomagnetic activity. Magnetic storms are normally associated with significant variations of the relativistic electrons trapped in the earth's outer radiation belt [1]. The initial magnetic field drop in the first phase of a magnetic storm is accompanied by a decrease of the electron fluxes, mainly due to betatron deceleration, but during the recovery of the magnetic field particle fluxes increase to levels which can be much higher than the prestorm value. These electron enhancements can cause failures in satellites.

Concluding by analogy it could be expected, that relativistic electron enhancements do also scale with the size of a magnetic storm which however is not the case. This is shown in the figure (left panel) where minimum Dst measured during a magnetic storm is plotted versus the > 1 MeV electron count rate increase measured with REM from PSI aboard the STRV-1b satellite in the outer radiation belt for 42 magnetic storms from 1995 to 1997. The correlation is obviously poor. There are moderate to great magnetic storms with only small enhancements but worth, also weak magnetic storms with large electron enhancements. Thus Dst is no good predictor for the size of the electron enhancements.

Better correlations are found with geomagnetic parameters measuring the substorm activity. For the investigated set of 42 magnetic storms the best correlation was found with Ap_{int}, which is the geomagnetic index Ap integrated between storm onset and the time the maximum electron rate was reached. Ap measures the averaged 3-hourly range of magnetic field variations at different geomagnetic observatories around the world. The results suggest that the acceleration process which produces the electron enhancements is linked with substorm activity and depends much less on the size of a magnetic storm.

So the answer to the question posed in the title of this report is: people who are concerned about the effects of charged particles in space should be aware that large relativistic electron fluxes can occur without associated large magnetic storm.

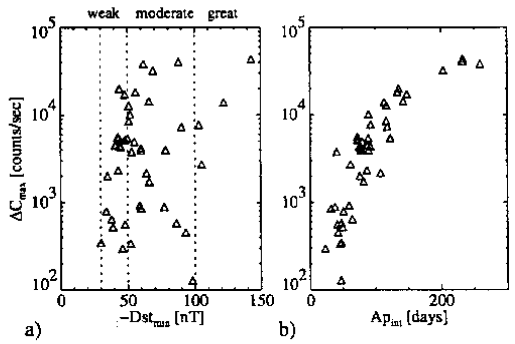

Fig. 1: Minimum Dst a) and integrated Ap b) versus electron count rate enhancement measured by REM in the earth's outer radiation belt for 42 magnetic storms from 1995 to 1997. There is obviously a much better correlation of the size of the electron enhancements with Ap_{int} than with Dst_{min}.

REFERENCE

[1] P. Bühler et al., PSI Annual Report 1997, Annex IIIA, p. 145 and 146.