

Detailed Analysis of Solar Data Related to Historical Extreme Geomagnetic Storms: 1868 – 2010 - DTU Orbit (09/11/2017)

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An analysis of historical Sun–Earth connection events in the context of the most extreme space weather events of the last ~ 150 years is presented. To identify the key factors leading to these extreme events, a sample of the most important geomagnetic storms was selected based mainly on the well-known aa index and on geomagnetic parameters described in the accompanying paper (Vennerstrøm et al., Solar Phys. in this issue, 2016, hereafter Paper I). This part of the analysis focuses on associating and characterizing the active regions (sunspot groups) that are most likely linked to these major geomagnetic storms. For this purpose, we used detailed sunspot catalogs as well as solar images and drawings from 1868 to 2010. We have systematically collected the most pertinent sunspot parameters back to 1868, gathering and digitizing solar drawings from different sources such as the Greenwich archives, and extracting the missing sunspot parameters. We present a detailed statistical analysis of the active region parameters (sunspots, flares) relative to the geomagnetic parameters developed in Paper I. In accordance with previous studies, but focusing on a much larger statistical sample, we find that the level of the geomagnetic storm is highly correlated to the size of the active regions at the time of the flare and correlated with the size of the flare itself. We also show that the origin at the Sun is most often a complex active region that is also most of the time close to the central meridian when the event is identified at the Sun. Because we are dealing with *extremely severe storms*, and not the usual *severe storm* sample, there is also a strong correlation between the size of the linked active region, the estimated transit speed, and the level of the geomagnetic event. In addition, we confirm that the geomagnetic events studied here and the associated events at the Sun present a low probability of occurring at low sunspot number value and are associated mainly with the maximum and descending part of the solar cycle.

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