Using Extreme Value Theory for Determining the Probability of Carrington-Like Solar Flares

Sean Elvidge*, Matthew J. Angling
SERENE, University of Birmingham, Birmingham, UK

1. Extended Abstract

In the popular press, solar flares have become synonymous with space weather events even though they do not directly cause most of the major space weather effects [1]. However, the magnitude of a flare usually provides an indication of the total amount of energy in a space weather event. Extreme space weather events (solar superstorms) are often compared to the Carrington event of 1859 [2]. The Carrington event is thought to be the largest observed space weather event in the last 200 years. The flare associated with the Carrington event has been estimated to be an X45 ± 5 (i.e. $45 \pm 5\times10^{-4}$ Wm-2) [3].

The tail of the distribution of solar flares has long been assumed to follow a simple power law. Previous work on space weather risk has been based on the assumption that the flare distribution follows such a law [4], [5]. However, such an approach can lead to overly "fat-tails" in the probability distribution function and thus to an under estimation of the return time of such events. This paper will investigate the use of extreme value theory (EVT) in reanalyzing the distribution of solar flares with the aim of better estimating space weather risk.

EVT provides advanced tools for estimating probability distribution functions. Such an approach avoids any starting assumption about the underlying distribution [6]. In the various branches of space weather, EVT has been used to investigate the distribution of the daily Aa index (a measure of the disturbance of the Earth's magnetic field) [7], disturbance storm time (Dst) index (an indication of the strength of the equatorial electrojet) [8], geomagnetic data (dH/dt where H is the horizontal geomagnetic component) [9] and relativistic electron fluxes [10]. However, no such analysis has been performed on solar flare data. As well as estimating the frequency of Carrington-like solar flares, the EVT results in this paper are compared with flare data from the Kepler space telescope mission to estimate once-in-a-millennium flare events.

2. References

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