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Extreme Space Weather Events in the First Epochs of Lower Solar Activity Cycles

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Introduction

Based on the homogeneous series of the geomagnetic index Aa and taking into account the current scale of the intensity of disturbances in the near-Earth space and the scenario of solar cyclicity, the problem of the distribution of extreme and very strong magnetic storms with intensities (G5, G4) in the first cycles (12 and 24) of epochs of lowered solar activity was taken into consideration. It's possible that the sunspot and flare activity in solar cycle 12 was significantly higher than that in cycle 24 but significantly lower than in solar cycles of the epoch of increased solar activity. This is indicated by the significant decrease in the number of such events and active solar phenomena in the most recent cycle. The practically periodic fluctuations in the many manifestations of Solar Activity (SA), the full collection of observed, nonstationary processes in the Sun's atmosphere, are one of the Sun's most amazing characteristics. These occurrences lead to changes in the particle fluxes and electromagnetic wave ranges of the object's emission. Various observational metrics describe the SA level. The relative sunspot number (W), which R. Wolf initially developed in 1849 when a service was organized in Europe: daily sunspot measurements with one method at several observatories, is the index longest series. Science started to study the Sun as a result. Wolf also recovered the yearly mean values from 1700 and the monthly mean values from 1749 for this index.

It should be remembered that, up until 1849, this series was assembled from very patchy data collected by some European observers. Modern scholars were able to qualitatively extend this series until 1611 utilizing even more sparse data from individual telescopic views. The spectral characteristics of the reconstructed part (100 years) are completely different from reliable series, and it contains features and characteristics of individual cycles that have not been observed in a reliable series over 180 years, making the reliability of all of the reconstructed data incomparably lower than reliable series. The number of sunspots and other active structures seen on the Sun's visible disc changes regularly, nearly periodically, as a result of the SA cycles. The entire, physical SA cycle, which includes two 11-year cycles and an average period of 22 years, is connected to the dynamics of the solar magnetic field. A lower amplitude and an even number characterize the first cycle. Though it tends to get shorter, the mean time between large reliable cyclical changes is 10.81 years. Thus, the average cycle period for the seven solar cycles that occurred during the 20th century (15 cycles–19 cycles, 21 cycles, and 22 cycles) was 10.44 years. Currently, it is possible to ascertain the scenario of solar cyclicity, its traits and characteristics, and developmental laws for reliable (10 cycles–24 cycles) and conditionally trustworthy solar 8 cycles and 9 cycles) on a time scale of 180 years thanks to the statistics of sunspot observations. Unexpected consistency in the primary manifestations of the development of individual 11- and 22-year cycles is revealed by a dependable sequence of relative sunspot numbers.

From 1878 through 1933, the first epoch of decreased solar activity occurred (five solar cycles). At the time, however, observational data on the Sun were restricted to the Wolf numbers, the number and areas of sunspot

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groups, and information on variations in the geomagnetic field: the magnitude of the disturbance of the geomagnetic field at two mid-latitude geomagnetic observatories spaced across the hemispheres that continuously record the state of the Earth's magnetic field, as well as sudden short-term increases in the geomagnetic field. Despite this, it is still possible to infer, at least roughly, the characteristics of the SC flare activity and its geo effectiveness during the era of decreased SA from these findings. Only during the dawn of the space age did observations of the Sun and its impact on the NES become routine and comprehensive (SC 19, the early 1960s). The majority of our knowledge about active phenomena on the Sun and their impact on the NES is related to the epoch of increased SA (1944–1996) and the transitional period SC23 between epochs when almost all of the magnetic properties of the active phenomena on the Sun were preserved after the total magnetic field of the Sun was weakened (by more than two times).

Therefore, it was only possible to analyze the key features of the geo-effective activity of the first period of dropped SA, for both background and average values, in SC 24 (the first SC of the second epoch of lowered SA and in the present SC 25). Given that the Gnevyshev-Ol' rule was carefully adhered to within the epochs on a trustworthy series, the latter should be of average value, according to the scenarios of reliable SCs. Only during transitional times might violations of this norm be anticipated, as in SCs 22–23. Observations reveal that these two SCs deviated somewhat from the recognized pattern of SC growth and had rather unique properties. The implementation of highly geo-effective flare events that caused extreme magnetic storms in the NES was more conducive during the SC 12 rise branch than during the SC 24 rise branch, according to the application of homogeneous observational data and the use of a single system to estimate the intensity of disturbances in the NES for extreme (G5) and severe (G4) magnetic disturbances in the first cycles of epochs of lowered SA. Even powerful (G3) geomagnetic disturbances were not seen during the SC 24 rising branch. Even though the circumstances for the realization of the considered events were roughly equal across the declining branch, the first epoch of lower SA had a much higher number of them than the second.

The changes in the solar magnetic fields and the physical conditions they brought about in the interplanetary medium turned out to be far more profound than we had anticipated by the start of the second period of low SA. This leads to the preliminary conclusion that the fraction of medium-sized flare events with a complex structure, which occurs in relatively small active regions with a complex magnetic configuration, was marginally higher in the initial cycle of the first epoch of lowered SA than it is now, in the initial cycle of the second such epoch.