From solar eruptions to transformer saturations: following the chain of Sun-Earth connections

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Significant geomagnetically induced currents (GIC) in power systems produced during the geomagnetic storms are the hazardous impacts of the solar disturbances. These currents, flowing through the transformer windings, cause extra magnetization which can lead to harmonics generation, heating and, in extreme cases, to power blackout. In order to properly mitigate these detrimental effects, it is important to analyze the complete sequence of phenomena, from identification of the solar sources to the analysis of the impacts.

This presentation will review the most significant events in solar cycles 23 and 24, from its generation on the Sun, propagation through the interplanetary media, to the effects on the ground magnetic field and on power grids. It will show that while during solar cycle 23 the most of the geomagnetic storms and subsequent effects on power systems were resulting from coronal mass ejections (CMEs) often associated with significant flaring activity, current solar cycle 24 is quite different. During current solar cycle there were not many CMEs as obvious sources of geomagnetic storms so far, thus, the resulting GIC in general were not large, especially at low latitudes. Nevertheless, the lack of powerful flares and CMEs gives the opportunity to identify the geomagnetic disturbances and impacts on power grids of solar features which were less pronounced during strong cycles, such as disappearing filaments and high speed streams.

The largest events in each solar cycle will be presented as overview tables and their comparisons will be discussed. As well, detailed analysis will be done for several specific events when the recordings of the GIC and other power system parameters in North America show the presence of large GIC in power systems.