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Mapping solar activity predicts extreme space weather

A regular clock correlating different solar activities provides, for the first time, a physical explanation for the observed cycle of solar activity.

BERN, SWITZERLAND – The variable nature of the solar cycle is a perplexing issue in solar physics with wide-ranging implications for space weather on the Earth impacting societal activities. Utilizing the Hilbert transform of sunspot numbers, former *ISSI Johannes Geiss* fellow Sandra Chapman from the University of Warwick in the UK together with co-author Thierry Dudok de Wit from the International Space Science Institute Bern in Switzerland and the University of Orléans in France have devised a method to synchronize the fluctuating 11-year Schwabe cycle to a simple, uniform clock. This innovative approach allows for the correlation of extreme space weather events, as indicated by the *aa* index (i.e., the longest continuous record of the magnetic field), with solar active region dynamics dating back to 1874.

Key findings reveal a pivotal transition point: when over 90% of solar active regions converge within approximately 15° of the solar equator, the occurrence of the most severe space weather events diminishes. This shift occurs from regions characterized by high gradients in solar differential rotation, capable of fueling coronal mass ejections, to areas where rotational dynamics remain relatively constant across latitudes.

Moreover, the study elucidates the onset of moderate space weather events, coinciding with 27-day solar rotation recurrences in the *aa* index. This correlation aligns with the relocation of solar active region centroids to within 15° of the solar equator, indicating stable and persistent source regions for high-speed solar streams.

These findings provide a compelling physical explanation for the observed two-component cycle of activity in the *aa* index, shedding light on the intricate relationship between solar dynamics and space weather phenomena. Such insights hold promise for enhancing our ability to predict and mitigate the societal impacts of extreme space weather events.

Chapman, S.C. and Dudok de Wit, T. (2024). A solar cycle clock for extreme space weather, Nature Scientific Reports, https://doi.org/10.1038/s41598-024-58960-5

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Note to the media

When reporting on this story, please mention the *ISSI Johannes Geiss* fellowship of Sandra Chapman.

Press release text by Fabio Crameri

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More information

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