

*[Geophysical Research Letters]*

Supporting Information for

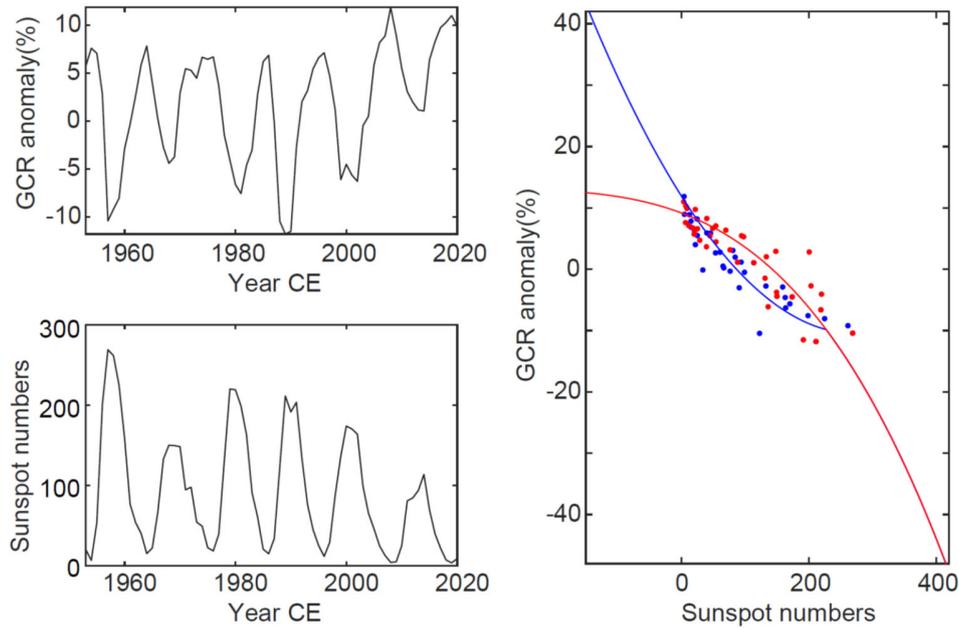
**[Recurrent large-scale solar proton events before the onset of the Wolf grand solar minimum]**

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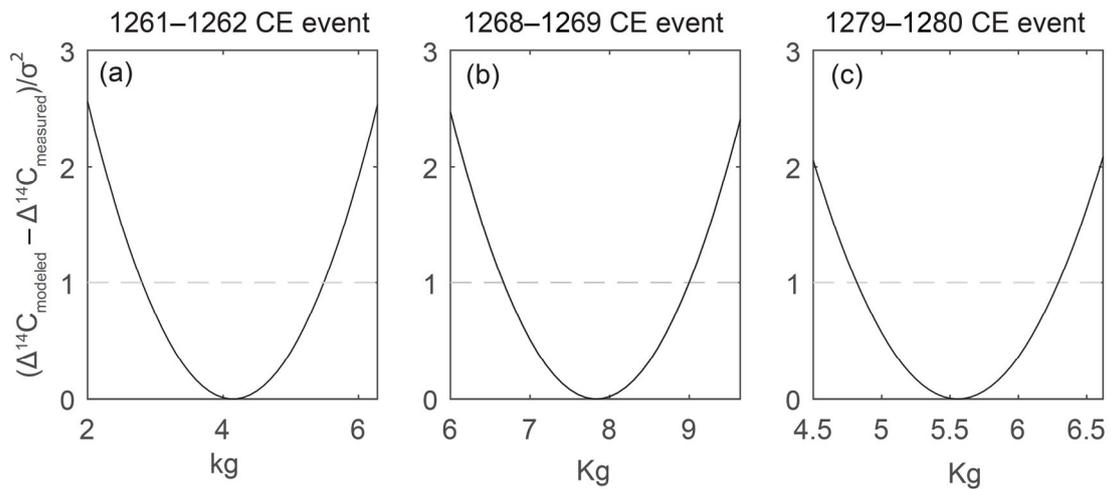
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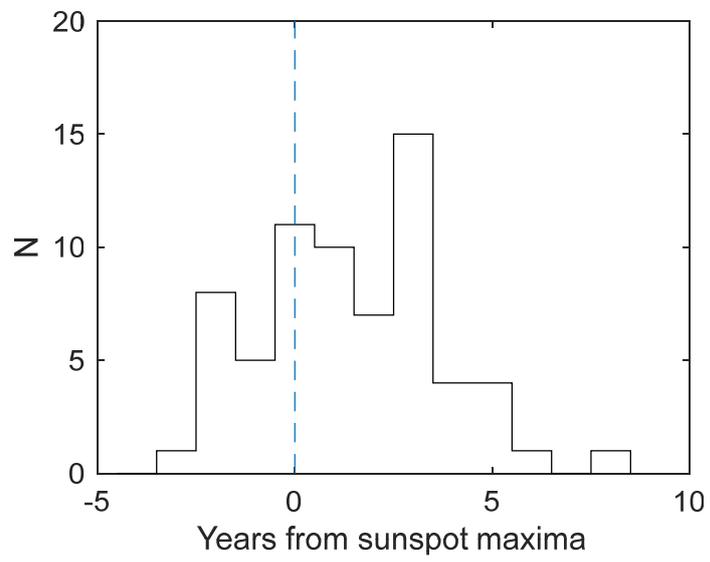
Figures S1 to S3



**Figure S1.** (a) Variation of galactic cosmic rays as monitored by the neutron monitors in Climax and Oulu stations. (b) Sunspot data from the World Data Center SILSO, Royal Observatory of Belgium, Brussels. (c) Comparison between the cosmic-ray flux and the sunspot numbers for the phases polarity of solar dipole magnetic field is positive (red dots) and negative (blue dots). The red and blue curves are the simple approximation and their extrapolation for sunspot numbers above 270 and below 0.



**Figure S2.** Comparison between the modeled and measured carbon-14 content for (a) 1261–1262 CE event, (b) 1268–1269 CE event, and (c) 1279–1280 CE event, for the cases carbon-14 was injected into the carbon cycle model within the ranges shown on the horizontal axes.



**Figure S3.** Solar cycle dependence of the number of ground level enhancements since 1956 CE.