PROCEEDINGS OF SCIENCE

Investigation of extreme solar events in the 19th century from tree-ring ^{14}C data

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Cosmogenic nuclides, such as ^{14}C from tree rings and ^{10}Be and ^{36}Cl from ice cores, are good proxies for past extreme solar energetic particle (SEP) events. After a discovery of the extreme SEP event in 774 CE by cosmogenic nuclide data, several candidates for extreme SEP events have been reported, including ca. 993 CE, 660 BCE, and 7176 BCE. Magnitudes of these SEP events have been estimated to be tens of times larger than the largest SEP event on record (GLE #5 in 1956). Whereas a survey of such extreme SEP events is ongoing, identifying intermediate-sized SEP events that bridge the gap between smaller event detected by modern observations and extreme events detected by cosmogenic nuclides has not progressed sufficiently, primarily due to uncertainties in cosmogenic nuclide data. In this study, we measured ^{14}C concentrations in Alaskan tree samples (Sitka spruce) for the period from 1844 to 1876, to investigate potential ^{14}C increases corresponding to solar events such as the Carrington solar flare/geomagnetic superstorm in 1859 and geomagnetic superstorm in 1872. We analyzed both early and late wood samples to suppress potential seasonal effects on ^{14}C concentrations due to atmospheric transport. Our findings indicate no significant difference in ^{14}C levels between early and late wood in our Alaskan tree samples, suggesting either a shorter wood formation than typical or the use of stored carbon for wood formation. Overall, our measured data show no significant ^{14}C increase throughout the entire measurement period. This result provides an upper limit of annual integrated SEP fluence (F_{200}) during this period as approximately 1×10^9 [/cm^2]. These findings have been published in Miyake et al. 2023.

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Reference

[1] F. Miyake, M. Hakozaki, H. Hayakawa, N. Nakano, & L. Wacker, *No signature of extreme solar energetic particle events in high-precision ^{14}C data from the Alaskan tree for 1844–1876 CE., J. Space Weather Space Clim.* **13**, 31 (2023), https://doi.org/10.1051/swsc/2023030.