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Reconstruction of the extreme solar particle events registered in cosmogenic proxies

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Extreme solar particle events (ESPE) are a special class of solar energetic particle (SEP) events characterized by huge SEP fluxes, orders of magnitude greater than ever observed directly. The first event of this class, dated back to 774 AD, was found by Miyake and coworkers in 2012 in cosmogenic radiocarbon records in tree rings and identified as an ESPE. Today, four ESPEs are independently found and confirmed in different isotopes, and there are several more event candidates registered in radiocarbon that are awaiting confirmation in other cosmogenic proxies. In this work, we report a new method of the ESPE fluence reconstruction which simultaneously accounts for different cosmogenic-isotope datasets. For evaluations of the spectral shape of ESPEs, we used the recent reconstruction of strong SEP events registered by neutron monitors (GLE events), where GLEs SEP fluences were fitted with the combination of power-laws with exponential cutoffs. For each GLE we calculated the expected production/deposition of cosmogenic isotopes and then found (if that was possible) the scaling factor, which allows us to simultaneously fit all the available cosmogenic proxies signals for each ESPE. After that, we described the fluence for each of ESPEs with scaled fluences of separated GLEs, that allowed us to account for different SEP spectral shapes and hardnesses. The method also accounts for different sources of uncertainties (including changes in the geomagnetic field, the solar activity and measurement accuracy). In comparison to GLE #5 (23/02/1956), which was the hardest and the strongest directly registered GLE, ESPE events have a 30—70 times greater fluence making them strong manifestations of the solar activity.

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