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Detection of solar proton events by using radiocarbon in tree-rings

Nicolas Brehm[1], Marcus Christl[1], Hans-Arno Synal[1], Raimund Muscheler[2], Florian Adolphi[3], Alex Bayliss[4], Timothy Knowles[5], Emanuelle Casanova[6], Kurt Nicolussi[7], and Lukas Wacker[1]

[1]ETH Zürich, Physics, IPA, Switzerland (nbrehm@phys.ethz.ch)
[2]Climate and Environmental Physics, Physics Institute & Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
[3]Department of Geology, Lund University , Lund, Sweden
[4]Historic England, Cannon Bridge House, London, UK
[5]BRAMS, University of Bristol, Bristol, UK
[6]School of Chemistry, University of BristoBristol, UK
[7]Institute of Geography, University of Innsbruck, Innsbruck, Austria

Our Sun erratically expels large amounts of energetic particles into the interplanetary space and towards Earth, which can be observed as so-called solar proton events (SPE). A strong SPE might cause major damage to satellites and could even disrupt transformers at the ground[1]. This rises the questions how often strong SPEs occur. Since direct observations of SPEs are limited to the last decades, cosmogenic radionuclides can be used to detect such events further back in time. The production rate of cosmogenic nuclides, such as radiocarbon, is primarily dependent on the incoming flux of highly energetic galactic cosmic rays (GCR). Under normal conditions, the Sun's magnetic field carried by the (low energy) solar protons shields us from (high energy) GCRs, resulting in a lower production of cosmogenic radionuclides when the Sun is active. During a SPE, however, the sudden and drastic increase of high the energy solar protons themselves may lead to an elevated production of cosmogenic radionuclides on Earth. Only recently, such sharp increases in cosmogenic nuclide production occurring within less than one year have been detected in several radionuclide records (^{10}Be, ^{36}Cl, ^{14}C) from ice core and tree ring records, and have been attributed to SPEs[2,3].

Until now, only three SPE could confidently be detected in cosmogenic radionuclide records[1,4,5]. The reason for this is a general lack of accurately dated and annually resolved radionuclide records and/or the strong dampening of the production signal e.g. by the carbon cycle. To find and identify such events we measured radiocarbon in tree ring records at annual resolution with accelerator mass spectrometry (AMS). In this new, accurately dated and annually resolved ^{14}C record spanning the past about 1000 yr we found several new candidates for SPEs. Their timing and amplitude in terms of cosmogenic nuclide production was characterized by using a global carbon cycle box model. Once unambiguously identified such spiked production increases recorded in the absolutely dated tree ring record have a great potential to be used as a global tool to synchronize other not well dated (climate) records with cosmogenic radionuclides (e.g. ^{10}Be, ^{36}Cl).

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