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Radiocarbon in tree-rings reveals the solar 11-yr cycle over the last millennium

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The influence of solar variability on the Earth's climate is a major subject of interest for understanding past and predicting future climate changes. While the observational record of solar activity (e.g. sunspots) covers only the last about 400 yr, cosmogenic nuclides stored in tree rings (^{14}C) or ice cores (^{10}Be, ^{36}Cl) are used as proxies for solar activity and allow solar reconstructions reaching much further back in time [1-3]. Major drawbacks of cosmogenic nuclide based solar reconstructions are the presence of weather-induced noise (e.g. ^{10}Be in ice cores) or the low temporal resolution of long precisely dated records (^{14}C in tree rings). Here, we present a continuous, annually resolved ^{14}C record from precisely dated tree rings covering the past about 1'000 yr (969-1933 AD) comprising almost 1'300 highest-precision ^{14}C measurements. The annually resolved ^{14}C record adds significantly to the radiocarbon calibration curve[4], which has hitherto been based mainly on decay counting measurements. A multi box carbon cycle model is used to extract annual ^{14}C production changes from the tree ring data. The resulting high-resolution record of ^{14}C production is then used to reconstruct the solar modulation parameter over the last millennium. The comparison of solar modulation with global temperature provides evidence that low solar activity could have caused the temperature reduction during the Little Ice Age. The ^{14}C record further reveals for the first time the presence of the eleven-year solar cycle over the past 1'000 yr. The amplitude of this so called Schwabe cycle is found to correlate with the general level of the solar modulation with high amplitudes during periods of strong solar modulation and vice versa.

[1] Bard, E., Raisbeck, G., Yiou, F. & Jouzel, J. (2000) Solar irradiance during the last 1200 years based on cosmogenic nuclides. Tellus Series B-Chemical and Physical Meteorology 52, 985-992.

[2] Muscheler, R. et al. (2007) Solar activity during the last 1000 yr inferred from radionuclide records. Quaternary Science Reviews 26, 82-97.

[3] Usoskin, I.G. (2017) A history of solar activity over millennia, Living Rev. Sol. Phys. 14, 3.

[4] Reimer, P. J. et al. (2013) Intcal13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years Cal Bp. Radiocarbon 55, 1869-1887.