



Københavns Universitet

Signatures of cosmic-ray increase attributed to exceptional solar storms inferred from multiple cosmogenic radionuclide records

Mekhaldi, F.; Muscheler, R.; Adolphi, F.; Svensson, Anders; Aldahan, Ala; Possnert, G.; McConnell, J.R.; Sigl, M.; Welten, K.C.; Woodruff, T. E.

Published in:
Geophysical Research Abstracts

Publication date:
2014

Document Version
Early version, also known as pre-print

Citation for published version (APA):
Mekhaldi, F., Muscheler, R., Adolphi, F., Svensson, A., Aldahan, A., Possnert, G., ... Woodruff, T. E. (2014). Signatures of cosmic-ray increase attributed to exceptional solar storms inferred from multiple cosmogenic radionuclide records. Geophysical Research Abstracts, 16, 15977-2.



Signatures of cosmic-ray increase attributed to exceptional solar storms inferred from multiple cosmogenic radionuclide records

Florian Mekhaldi (1), Raimund Muscheler (1), Florian Adolphi (1), Anders Svensson (2), Ala Aldahan (3,4), Göran Possnert (5), Joseph R. McConnell (6), Michael Sigl (6), Kees C. Welten (7), and Thomas E. Woodruff (8)

(1) Department of Geology – Quaternary Sciences, Lund University, Sweden, (2) Center for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Denmark, (3) Department of Earth Sciences, Uppsala University, Sweden, (4) Department of Geology, United Arab Emirates University, Al Ain, UAE, (5) Tandem Laboratory, Uppsala University, Sweden, (6) Division of Hydrologic Sciences, Desert Research Institute, Reno, USA, (7) Space Sciences Laboratory, University of California, Berkeley, USA, (8) PRIME Laboratory, Purdue University, West Lafayette, USA

Miyake et al. (2012, 2013) discovered rapid increases of ^{14}C content in tree rings dated to AD 774-5 and AD 993-4 which they have attributed to cosmic-ray events. These extreme particle events have no counterparts in the instrumental record and have been tentatively associated with solar proton events, supernovae and short gamma-ray bursts, which have very different energy spectra. Cosmogenic radionuclides such as ^{14}C , ^{10}Be and ^{36}Cl arise from the interaction of cosmic rays with atmospheric nitrogen, oxygen and argon. These radio-isotopes are produced through different reaction pathways and vary with different energy dependencies of the production rate cross section. Owing to this, yield functions can be used to determine the energy level of incident particles. However, only ^{14}C has been measured at high resolution to quantify the energy and thus the origin of the outbursts. We present an annually resolved record of ^{10}Be from the NGRIP ice core for the two events. In addition, we also utilized the GRIP ice core ^{36}Cl record in our analysis.

Our results show that the differential production of cosmogenic ^{14}C , ^{10}Be and ^{36}Cl is consistent with a solar energy spectrum. Considering the notable increase in radionuclides, the solar storms would have had to be substantially greater than the largest recorded geomagnetic storm, the so-called Carrington event. This challenges our understanding of the sun's dynamics. Furthermore, the events could possibly be of interest for the investigation of potential cosmic ray-cloud linkages (Svensmark & Friis-Christensen, 1997). Alternatively, such outbursts of energetic particles have the potential to deplete atmospheric ozone and alter atmospheric circulation. Ultimately, the magnitude of such particle events draws attention to the perhaps underestimated potential of the sun to cause great damage to modern technologies.

References

- Miyake, F., Masuda, K. & Nakamura, T. Another rapid event in the carbon-14 content of tree rings. *Nature Communications* **4**:1748, DOI: 10.1038/ncomms2783 (2013).
- Miyake, F., Nagaya, K., Masuda, K. & Nakamura, T. A signature of cosmic-ray increase in AD 774–775 from tree rings in Japan. *Nature* **486**, 240-242, DOI: 10.1038/nature11123 (2012).
- Svensmark, H., & Friis-Christensen, E. Variation of cosmic ray flux and global cloud coverage — A missing link in solar-climate relationships. *J. Atmos. Sol., Terr. Phys.*, **59**, 225–1232, DOI: 10.1029/1998JD200091 (1997).