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High resolution 36Cl measurements from polar ice cores - Implication as a proxy for solar forcing and solar storms detection

Content

In addition to acting as an external forcing of climate, the Sun routinely unleashes solar storms towards Earth in the form of energetic particles (SEP) and electromagnetic plasma. When large enough, solar storms can significantly impair our spacecraft and electronic infrastructures on the ground. However, the record of instrumental observations for SEPs and sunspots number only dates to the 1950s and 17^{th} century, respectively. To address the need for a more comprehensive time perspective on solar activity and solar storms, we can use cosmogenic radionuclides such as ^{10}Be and ^{36}Cl in ice cores. Radionuclides are mostly produced in the atmosphere by the high-energy interactions between atmospheric constituents and galactic cosmic rays, the influx of which is modulated by the fluctuating magnetic fields of the Sun and the Earth. As a result, radionuclides can embed, in part, the signal of solar activity. In addition, extreme solar storms can cause a large enhancement in atmospheric production rate and thereby, in ice-core concentrations of radionuclides. This holds particularly true for ^{36}Cl whose production is significantly more enhanced by SEPs, relative to ^{10}Be. Unfortunately, ^{36}Cl measurements require more ice and are therefore generally of coarser resolution and more uncertain. Here we present a new continuous record of ^{36}Cl from the NGRIP ice core reaching the end of the 14^{th} century. The highly resolved nature of our measurements together with a combined ^{10}Be and ^{36}Cl analysis allow us to link several intervals with ^{10}Be excess concentrations to volcanic eruptions. In addition, the new record shows several periods when ^{36}Cl excess concentrations coincide with known auroral sightings at unusual latitudes which may point to extreme solar storm event candidates. We complement the discussion around the most promising of these potential events with additional ^{36}Cl measurements from NEEM, EGRIP, and Bryan Coast. Finally, we also discuss the first annually resolved post-bomb peak ^{36}Cl measurements from the NEEM ice core. These new ^{36}Cl measurements show promise to improve both solar activity reconstructions and our assessment of the occurrence rate of extreme solar storms. However, their interpretation remains challenging.

Primary author: MEKHALDI, Florian (British Antarctic Survey | Dept. of Geology, Lund University, Sweden)

Co-authors: BEER, Jürg (EAWAG Swiss Federal Institute of Aquatic Science and Technology); ALDAHAN, Ala (Dept. of Geosciences, United Arab Emirates University); SYNAL, Hans-Arno (Laboratory of Ion Beam Physics, ETH Zürich); VOCKENHUBER, Christof (Laboratory of Ion Beam Physics, ETH Zürich); THOMAS, Liz (British Antarctic Survey); MUSCHELER, Raimund (Department of Geology, Lund University, Lund, Sweden)

Presenter: MEKHALDI, Florian (British Antarctic Survey | Dept. of Geology, Lund University, Sweden)

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