Name of research institute or organization:

ETH Zürich, Labor für Ionenstrahlphysik (LIP)

Title of project:

^{7}Be, ^{10}Be and ^{36}Cl in monthly precipitation

Project leader and team:

Dr. Christof Vockenhuber, project leader
Dr. Marcus Christl
Alfred Lück

Project description:

Since 1998 the cosmogenic radionuclides ^{7}Be, ^{10}Be and ^{36}Cl have been measured in precipitation with monthly resolution at two locations in Switzerland, in Dübendorf (elevation 440 m a.s.l.) and Jungfraujoch (3580 m a.s.l.). These nuclides are continuously produced by the interaction of cosmic rays with the atmosphere and removed from the atmosphere by precipitation. Due to the long half-life of ^{10}Be (1.4 million years) concentrations of ^{10}Be can be measured in natural archives such as ice sheets and sediments with accelerator mass spectrometry (AMS), allowing to reconstruct the cosmic ray intensity for many millennia. The ^{7}Be is produced about twice as much as ^{10}Be in a similar way, however decays quickly due to its short half-life (53.2 days). Because of the very different half-lives of the two Be isotopes, the measured ratio provides an interesting tool for the study of the atmospheric transport processes.

The situation for ^{36}Cl (half-life of 0.3 million years) is similar, however since there is only one radionuclide, the interpretation of the data is more complex. ^{36}Cl is produced by spallation of Ar, then reduced to HCl and transported around the globe and finally deposited by precipitation.

Both ^{10}Be and ^{36}Cl have relatively short mean residence times (1-2 years) in the atmosphere compared to the other important cosmogenic radionuclide ^{14}C, which is well mixed in the atmosphere as CO_2. Thus they provide a more direct signal of changes in the cosmic ray intensities as they occur during strong cosmic events like large solar flares or short gamma ray bursts. Such an event was recently found in the year 775 AD in ^{14}C tree ring data.

The long-lived radionuclides ^{10}Be and ^{36}Cl are measured by AMS at the Laboratory of Ion Beam Physics at ETH Zurich, while the short-lived ^{7}Be is measured by gamma-ray spectroscopy with a Ge-detector at EAWAG. The unique dataset with monthly resolution and spanning now over almost two solar cycles allows to investigate seasonality as well as trends over several years to decades.

References:

[1] U. Heikkilä, J. Beer, and V. Alfimov, Beryllium-10 and beryllium-7 in precipitation in Dübendorf (440 m) and at Jungfraujoch (3580 m), Switzerland (1998–2005), J. Geophys. Res., 113 (2008) D11104

[2] F. Mekhaldi, R. Muscheler, F. Adolphi, A. Aldahan, J. Beer, J. R. McConnell, G. Possnert, M. Sigl, A. Svensson, H.-A. Synal, K. C. Welten, and T. E. Woodruff, Multiradionuclide evidence for the solar origin of the cosmic-ray events of ad 774/5 and 993/4, Nature Communications, 6 (2015) 8611

Key words:
^{10}Be, ^{7}Be, ^{36}Cl, long-term cosmic ray record, atmospheric transport processes, solar energetic particles, gamma ray bursts

Address:
Laboratory of Ion Beam Physics
ETH Zurich
HPK G31
Otto-Stern-Weg 5
CH-8093 Zurich

Contacts:
Dr. Christof Vockenhuber
Tel.: +41 44 633 3885
Fax: +41 44 633 3885
e-mail: vockenhuber@phys.ethz.ch
URL: http://www.ams.ethz.ch