

2020 ISEE Award

Award Winners : Prof. Ilya G. Usoskin (team representative)

Dr. Stepan V. Poluianov

Title : Contribution to solar-terrestrial environmental research through international joint research on extreme solar particle events and their environmental and social impacts

Citation :

A rapid increase in carbon-14 in tree rings in 775 CE, discovered by the ISEE (Institute for Space-Earth Environmental Research) research team, had a massive impact on cosmogenic isotope research groups over the world, and various hypotheses to explain the event were proposed. Among them, Professor Ilya Usoskin quickly pointed out that an extreme solar energetic particle (SEP) event is the primary driver of the event. This hypothesis was confirmed later by many additional studies. In October 2018, he, together with Associate Professor Miyake from ISEE hosted an ISEE International Workshop “Extreme solar events: How hostile can the Sun be?” at Nagoya University and summarized the latest knowledge on extreme solar events together with 12 leading scientists from various scientific field. Then, the summary of the ISEE International Workshop was published as a book by the Institute of Physics (IOP).

Dr. S. Poluianov conducted an international joint research “Model of production-transport-deposition of cosmogenic isotopes over Antarctica with verification with experimental data (2019 ISEE International Joint Research Program)” with Associate Professor Kurita from ISEE. This joint research has led to the publication of a paper on a new three-dimensional production model of cosmogenic tritium (Poluianov et al, 2020).

The Oulu and ISEE team have jointly applied and received approval for an ISSI (International Space Science Institute, Bern, Switzerland) international team “Solar extreme events: Setting up a paradigm (2020-2022, leaders F. Miyake and I. Usoskin)”. This application has led to the development of new international joint research based on the ISEE joint research. Furthermore, the award winners advanced the studies discussed at the ISEE International Workshop and achieved numerous results. It is noteworthy that Prof. Usoskin et al. revisited the strongest directly observed SEP event on February 23, 1956, and evaluated the sensitivity of the indirect SEP detection method using cosmogenic nuclides (Usoskin et al. 2020).

As described earlier, Professor Usoskin and Dr. Poluianov have established a new paradigm for extreme events of space-earth environmental change that have not been considered before, through the ISEE International Workshop Program (2018) and the ISEE International Joint Research Program (2019). In addition, the award winners are working together with ISEE research team to develop new research fields on extreme solar particle events and their effects from the both space and earth scientific perspectives. These activities consist with the mission of ISEE that explores the space-earth environment. For these reasons, Professor Ilya Usoskin and Dr. Stepan Poluianov are the recipients of ISEE award 2020.

List of ISEE Joint Research Program activities and the related publications by the award winner:

- ISEE Joint Usage and Joint Research Program Activities
 - International Workshop (2018) “Extreme solar events: How hostile can the Sun be?” (I. Usoskin – organizer, S. Poluianov – participant, host – F. Miyake)
 - ISEE International Joint Research Program (2019) “Model of production-transport-deposition of cosmogenic isotopes over Antarctica with verification with experimental data” (S. Poluianov, host – N. Kurita)

- Related publications
 - Miyake, F., I. Usoskin, S. Poluianov (eds), *Extreme Solar Particle Storms: the hostile Sun*, IOP Publ., Bristol UK, 2019, doi: 10.1088/2514-3433/ab404a (book, ~350 pages).
 - Sukhodolov, T. I.G. Usoskin, E. Rozanov, ... F. Miyake, et al., Atmospheric impacts of the strongest known solar particle storm of 775 AD, *Sci. Rep.*, 7, 45257, 2017. doi: 10.1038/srep45257.
 - Usoskin, I.G. et al., Revisited Reference Solar Proton Event of 23 February 1956: Assessment of the Cosmogenic-Isotope Method Sensitivity to Extreme Solar Events, *J. Geophys. Res. (Space Phys.)*, 125, e2020JA027921, 2020, doi: 10.1029/2020JA027921.
 - Usoskin, I.G., et al. Revisited GLE database: Fluences of solar energetic particles as measured by the neutron-monitor network since 1956, *Astron. Astrophys.*, 640, A17, 2020, doi: 10.1051/0004-6361/202038272.
 - Poluianov, S., G. Kovaltsov, I. Usoskin, A new full 3D model of cosmogenic tritium ^3H production in the atmosphere (CRAC:3H), *J. Geophys. Res. Atmos.*, 125, e2020JD033147, 2020, doi: 10.1029/2020JD033147.

- Poluianov, S.V., G.A. Kovaltsov, A.L. Mishev and I.G. Usoskin, Production of cosmogenic isotopes ^7Be , ^{10}Be , ^{14}C , ^{22}Na , and ^{36}Cl in the atmosphere: Altitudinal profiles of yield functions, *J. Geophys. Res. Atmos.*, 121, 8125-8136, 2016, doi:10.1002/2016JD025034.
- Poluianov, S., G.A. Kovaltsov, I.G. Usoskin, Solar energetic particles and galactic cosmic rays over millions of years as inferred from data on cosmogenic ^{26}Al in lunar samples, *Astron. Astrophys.*, 618, A96, 2018, doi: 10.1051/0004-6361/201833561.
- Uusitalo, J. L. Arppe, T. Hackman, S. Helama, G. Kovaltsov, K. Mielikäinen, H. Mäkinen, P. Nöjd, V. Palonen, I. Usoskin, M. Oinonen, Solar superstorm of AD 774 recorded subannually by Arctic tree rings, *Nature Comm.*, 9, 3495, 2018, doi: 10.1038/s41467-018-05883-1.
- Usoskin, I.G. A history of solar activity over millennia, *Living Rev. Sol. Phys.* 14, 3, 2017 doi:10.1007/s41116-017-0006-9
- Usoskin, I.G., G.A. Kovaltsov, The carbon-14 spike in the 8th century was not caused by a cometary impact on Earth, *Icarus*, 260, 475-476, 2015.

Career summaries of the award winners:

Ilya G. Usoskin (Professor, University of Oulu) received his PhD in astrophysics in the A. F. Ioffe Physical-Technical Institute in 1995, and then, he was involved in the spaceborne astroparticle experiment AMS (Alpha Magnetic Spectrometer) at INFN Milano, Italy. Since 2000, he worked as the head of the Oulu Cosmic Ray Station at the University of Oulu in Finland. Since 2012, he has been a full professor of space physics at the University of Oulu. He served as the vice-director of the ReSoLVE (Research on SOLar Long-term Variability and Effects) Center of Excellence of the Academy of Finland in 2014–2019. The most honorable awards he has received are knighthood (first class knight) of the Order of the Lion of Finland (2013), and the Julius Bartels medal (2018) of the European Geosciences Union



Prof. Usoskin is an expert in solar activity as well as in the variability of cosmic rays and their atmospheric effects. He is one of the founders of the space climate research discipline. He has authored or co-authored more than 200 peer-reviewed research publication in the fields of solar and heliospheric physics, solar–terrestrial relations, and geophysics.

Stepan V. Poluianov (Senior Researcher, University of Oulu) received his PhD in space physics at University of Oulu in 2016. He is studying cosmic rays and their interaction with matter. He is involved in measurements of cosmic rays by neutron monitors in Finland and Antarctica. In 2019, he became a member of the AMS Collaboration, which runs the cosmic-ray experiment AMS-02 at the International Space Station. He has made significant contributions to developments of a universal and detailed model of cosmogenic nuclide production in the atmosphere, and a novel method for the estimation of solar energetic particle spectra from lunar rocks.

