



Promoting Space Sustainability

Implementation of the Guidelines for the Long-term Sustainability (LTS) of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space

Operational Case Studies

I. Short description of the outer space activity

The Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) is a thematic organization of the International Science Council (ISC) and a permanent observer at the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). SCOSTEP runs international interdisciplinary scientific programs that lasts 4-5 years and promotes solar-terrestrial physics research by providing the necessary scientific framework for international collaboration. The solar-terrestrial physics is essentially important for sustainable use of outer space by providing knowledges and predictability of solar and magnetospheric/ionospheric disturbances and their consequences, e.g., on radiation hazards and GNSS positioning. One of the main tasks of SCOSTEP is to develop capacity building of solar-terrestrial physics research, which fits well with the LTS Guideline C. This document introduces various capacity building activities that have been and are going to be carried out by SCOSTEP. Some detailed descriptions of these activities are provided by Amory-Mazaudier et al. (2021) and at <https://scostep.org/>.

International Space Science Schools: In collaboration with the International Space Weather Initiative (ISWI) of UN-COPUOS under UNOOSA, SCOSTEP organizes International Space Science Schools and Workshops. The school and workshops consist of lectures and hands-on training activities for university students and early-career scientists. The past schools and workshops with ISWI were held in Kenya (2013), Peru (2014), India (2016, photo in **Figure 1**), and Azerbaijan (2018). The next one will be held as the Iberian Space Science Summer School (Portugal, online, <https://www.i4s-iberian-space-science-summer-school.com/>) in July 26-30, 2021. SCOSTEP's previous program VarSITI (Variability of the Sun and Its Terrestrial Impact, 2014-2018, <http://www.varsiti.org/>) also supported several schools on solar-terrestrial physics at Nigeria (2015, 2017), Indonesia (2015, 2018), and Russia (2017) (Shiokawa and Georgieva, 2021).



Figure 1. Group photo of the SCOSTEP-ISWI International School on Space Science held at Sangli Maharashtra, India, on 7-17 November 2016 with 74 graduate students from 14 countries (China, Egypt, Ethiopia, India, Indonesia, Ivory Coast, Kenya, Korea, Nigeria, Philippines, Rwanda, Thailand, Uganda, and Vietnam).

School Grants: SCOSTEP also supports organizers of the schools related to the solar-terrestrial physics by providing small supporting grants (<https://scostep.org/capacity-building/>). The grants can be used to cover travel expenses, costs for visa application, accommodation and per diem of selected participants, registration fee waivers, and costs for online schools. SCOSTEP also endorses lecturers of the schools based on the SCOSTEP Science Disciplinary Representatives, National Adherents and other SCOSTEP-related officers.

Online Capacity Building Lecture Series: Since 2020, face-to-face school activities has been restricted due to COVID-19. Thus, SCOSTEP has started online capacity building lecture series in 2021 (<https://scostep.org/capacity-building-lectures/>). This online lecture series provide both basic background and introductions to the latest scientific topics of solar-terrestrial physics to students and early-career scientists of all countries. The topics of the lectures so far were as follows.

1. "Motivation for soft X-ray imaging and plans for the STORM global imaging mission" by David G. Sibeck (USA) on January 22, 2021,
2. "Processing of electric and magnetic signals onboard the THEMIS spacecraft and applications of polarization analysis" by Ulrich Taubenschuss (Czech Republic) on March 5, 2021,
3. "Machine-learning based reconstruction of the inner magnetosphere" by Jacob Bortnik (USA) on March 29, 2021,
4. "An overview of the Sun's structure, and a closer look at solar magnetism and activity" by Alphonse C. Sterling (USA) on April 29, 2021, and

5. “The variable geospace environment and our radio wave based modern society: basic concepts of ionosphere and recent research problems at high latitudes” by Esa Turunen (Finland) on May 31, 2021.

SCOSTEP Visiting Scholar (SVS) Programme: The SCOSTEP Visiting Scholar programme (SVS) has been operating since 2015 (<https://scostep.org/svs/>). This programme provides graduate students with opportunity of training at well-established solar-terrestrial physics laboratories over periods of between one and three months. The training helps the students to advance their career in solar-terrestrial physics using the techniques and skills they learned during the training. SCOSTEP provides the airfare, while the host laboratory provides the living expenses. SCOSTEP has funded 4 to more than 10 scholars every year mostly from developing countries. Currently, more than 10 laboratories in the world are registered as the hosts of the SVS programme. Some students who joined the SVS programme have already been assigned in academic positions in their home countries.

SCOSTEP/VarSITI Database and Data Analysis Tools: Solar-terrestrial physics requires various different datasets to understand complicated sun-earth connection. Students often have difficulty to find appropriate data and their handling tools for their study. Therefore, SCOSTEP’s VarSITI program compiled a list of international databases and data analysis tools of solar-terrestrial physics, particularly for use of early-career scientists and students in developing countries. The database list is available at <http://www.varsiti.org/>.

SCOSTEP Comic Books: SCOSTEP distributes comic books designed to introduce several topics in Solar-Terrestrial Physics to the public, particularly for children. The comic books were originally written by Hayanon (<https://www.hayanon.jp>) in Japanese with a coordination by the Seibundo Shinkosha Publishing Co., Ltd and Prof. Yosuke Kamide at the Solar-Terrestrial Environment Laboratory (currently Institute for Space-Earth Environmental Research) of Nagoya University in Japan. Under the SCOSTEP’s CAWSES programme (Climate and Weather of the Sun-Earth System, 2004-2008), SCOSTEP has provided bubble version (without text) of this comic series and encouraged scientists in the world to translate them into their own languages. Currently the comic books have been translated into English, French, Czech, German, Hindi, Italian, Japanese, Korean, Russian, Spanish, Tamil, and Urdu. These comic books in various languages are accessible at the SCOSTEP website: <https://scostep.org/space-science-comic-books/>.

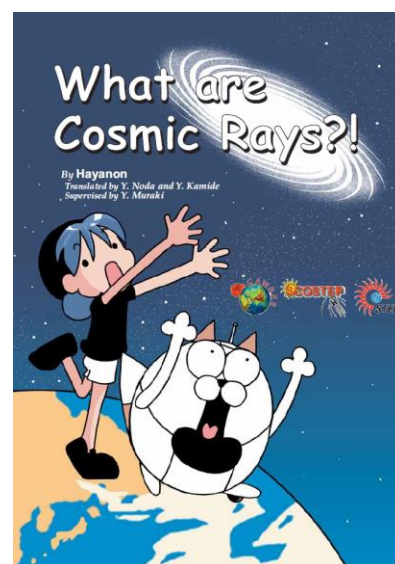


Figure 2. An example of the comic book of solar-terrestrial physics.

References:

Amory-Mazaudier C, Radicella S, Doherty P, Gadimova S, Fleury R, et al. 2021. Development of research capacities in space weather: a successful international cooperation. *J. Space Weather Space Clim.*11, 28. <https://doi.org/10.1051/swsc/2021006>.

Shiokawa, K. and K. Georgieva, A review of the SCOSTEP's 5-year scientific program VarSITI—Variability of the Sun and Its Terrestrial Impact, *Progress in Earth and Planetary Science* (2021) 8:21, <https://doi.org/10.1186/s40645-021-00410-1>

II. Connection with the LTS Guidelines

The above capacity building activities by SCOSTEP fits well with the LTS Guidelines C. International cooperation, capacity-building and awareness, particularly for Guideline C.3 Promote and support capacity-building. The guideline says that the international intergovernmental organizations with experience in space activities should encourage and support capacity-building in developing countries with emerging space programmes. The schools, online lecture series, visiting scholar program for students, construction of the list of databases and data analysis tools, and translation of space science comic books into various languages, all carried out by SCOSTEP, will develop capacity building in solar-terrestrial physics, particularly in developing countries. The solar-terrestrial physics is a key science to provide knowledges necessary to the safe and sustainable use of our space, for example, variability of radiation belt electron fluxes and ionospheric plasma densities. These knowledges are essential to avoid radiation hazards in space and positioning error of the Global Navigation Satellite System (GNSS).

III. Lessons learned

The capacity building activity never ends. SCOSTEP has organized international schools on space sciences at various countries almost every year. These schools provide precious opportunity for students from different countries to know each other and to communicate world-class scientists which is known only in scientific journals. Construction of database and data analysis tools also helps students in developing counties to touch the latest data of outer space. The SVS program has provided opportunities for students to visit well-established laboratories. Students in SVS program can make a good relationship with established scientists in these laboratories and expand their research during and after the program. SCOSTEP's comic books stimulate children to learn about outer space. These activities should be continued under the international framework in all countries in order to support capacity building in solar-terrestrial physics for long-term sustainability of outer space.