SCOSTEP Scientific Committee on Solar-Terrestrial Physics
COURSE

# SCOSTEP/COURSE Newsletter

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Inside
## THE ISSUE



**Article 1:**

# 3D Map of Auroral Kilometric Radiation: SCOSTEP/PRESTO Database Construction

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Alexandra Ruth Fogg


Sudipta Kumar Hazra

Space Weather drives a broad range of affects throughout the Earth's space environment, and Auroral Kilometric Radiation (AKR) was first observed in the 1960s[1]. We present a three-dimensional visibility map of AKR, a phenomenon which is correlated with the aurorae. AKR is anisotropically beamed in a hollow cone: a single AKR source can only be observed along the edges of the cone.

The quasi-continuous AKR emission, refraction effects and the movement of the source region, generates a statistical *illumination zone* (where AKR may be observed) and *shadow zone* (where AKR is generally not observed)[4]. 10 years of Wind/WAVES observations are used here to map this illumination/shadow zone structure in 3D.

Previous work processed Wind/WAVES data removing solar emissions[5,6], and secondly generating a list of individual AKR events[2,3]. These observations are sorted into 3D cartesian (XYZ) and polar grids (Local Time/LT x geomagnetic latitude x radial distance). Note that if a given AKR event is observed across multiple spatial bins, the duration is split across the bins accordingly.

The normalised observation time is calculated per bin: the amount of time Wind spent observing AKR divided by the residence time (the time Wind spent in the bin, regardless of observations). The dimensionless "normalised" observation time is presented as a function of location in a cartesian grid in Fig. 1(a) and a polar grid in Fig. 1(b). Higher normalised observation times are observed on the nightside, although AKR is observed at all LTs[7]; bins with no AKR observations are not plotted.

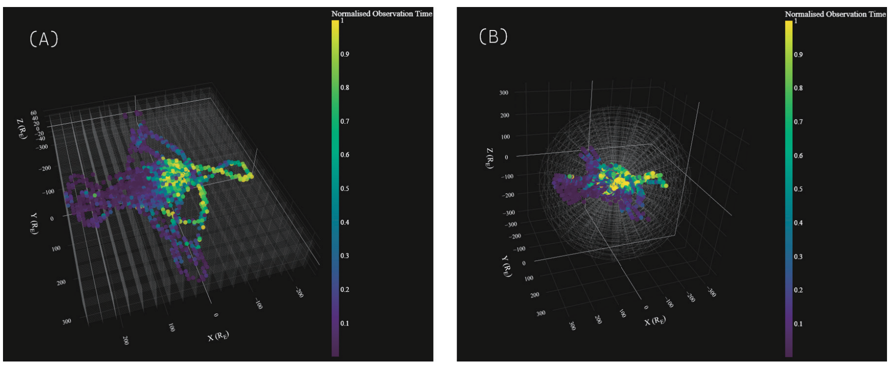


**Figure 1. Snapshots of 3D map of normalised AKR observation time binned in (a) cartesian grid, (b) polar grid. Cartesian bin width: 10x10x5 Earth Radii ($R_E \approx 6371$ km) in XYZ GSE. Polar grid bin width: 0.5 hr x 5° x 5 $R_E$ in LT x latitude x radial distance.**

Wind made a short transit through some bins in Fig. 1, but observed AKR continuously. These appear as normalised observation time of 1, despite a small sample. As a first approach, bins with normalised observation time equal to 1 are removed from the plots; these results are displayed in Fig. 2.

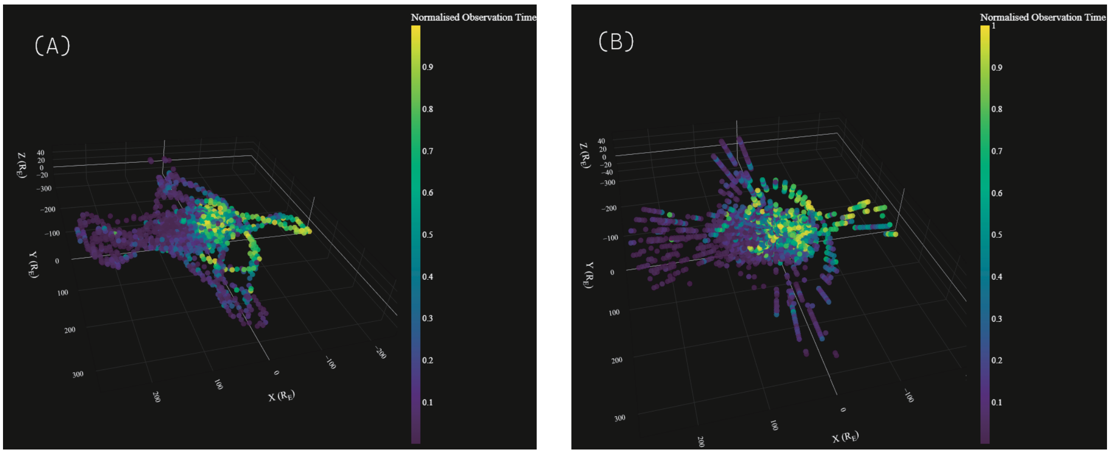


**Figure 2. As for Fig. 1, but with bins equal to 1 removed.**

Finally, it is important to highlight the versatility of the tool created. Figs. 1 and 2 are snapshots taken from an interactive .html file. In this file, the user can click and drag the grid to view from different angles, zoom in and out, and download an image. Fig. 3 shows a screenshot of the interface, highlighting the ability to hover over a bin and display its information.

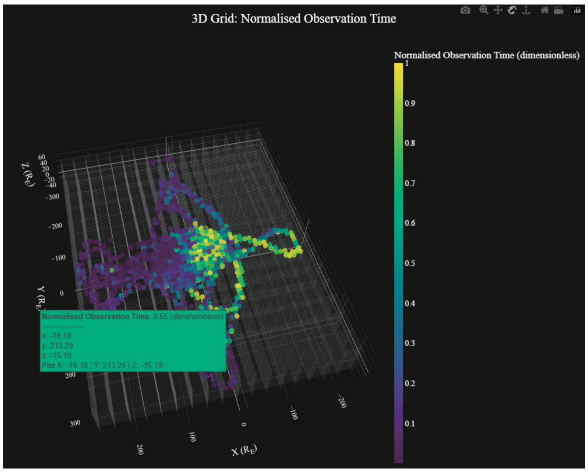


**Figure 3. Screenshot of interactive tool.**

This SCOSTEP grant enabled us to hire a paid intern to complete this project, which is ongoing. As the project continues, these interactive .html files will be hosted on the DIAS website[1]. We are also pursuing a modelling approach, which will allow a user to request a probability of observing AKR at a given location.

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[1] https://www.dias.ie/cosmicphysics/astrophysics/astro-research/astro-planetary-magnetospheres/

Highlight on Young Scientists 1:

# Assessing the Effectiveness of Low-Cost Magnetometers for Studying High-Latitude Current Systems

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Ankita ManjreKar

The ionosphere at high latitude is coupled with the magnetosphere through vertical field-aligned currents (FACs). Any change in solar wind or interplanetary magnetic field directly impacts the strength of FACs, which modulate ionospheric currents and generate magnetic field variations that can be recorded from ground magnetometers.

SECS, introduced by Amm [1997] and Amm and Viljanen [1999], provides a powerful tool for studying ionospheric currents. SECS uses ground magnetic field variations to reconstruct an equivalent current system. However, accurate reconstruction of ionospheric current system requires a dense magnetometer network.

Space Weather UnderGround (SWUG) is a program aimed at developing and deploying low-cost magnetometers across the Alaska region [Smith 2020]. Using the SECS method with synthetic current systems, we aimed to assess how effectively the existing Alaska magnetometer network, along with SWUG magnetometers, can capture high-latitude ionospheric currents.

Three ionospheric current systems were tested with 10 science quality magnetometers (GI and USGS) and 6–10 SWUG magnetometers. Synthetic magnetic field data is generated using the SECS grid and which is then used to reconstruct the initial current systems.

The results (Figure 2a–2b) show that Current System 1, which contains fewer small-scale structures, exhibits lower errors, while Current System 3, with more small-scale features, shows the highest RMSE. As the number of magnetometers increases, the RMSE decreases, demonstrating that improving spatial coverage significantly reduces reconstruction error.

However, since SWUG instruments are low-cost, their measurements may include larger uncertainties. To account for this, we add random errors to the SWUG measurements. For a network of 10 science-quality and 10 SWUG magnetometers, the RMSE remains nearly constant up to 20 nT error, beyond which it increases significantly (Figure 2c–2d). This shows that even low-cost magnetometers with measurement uncertainties up to 20 nT can still be useful for ionospheric studies.

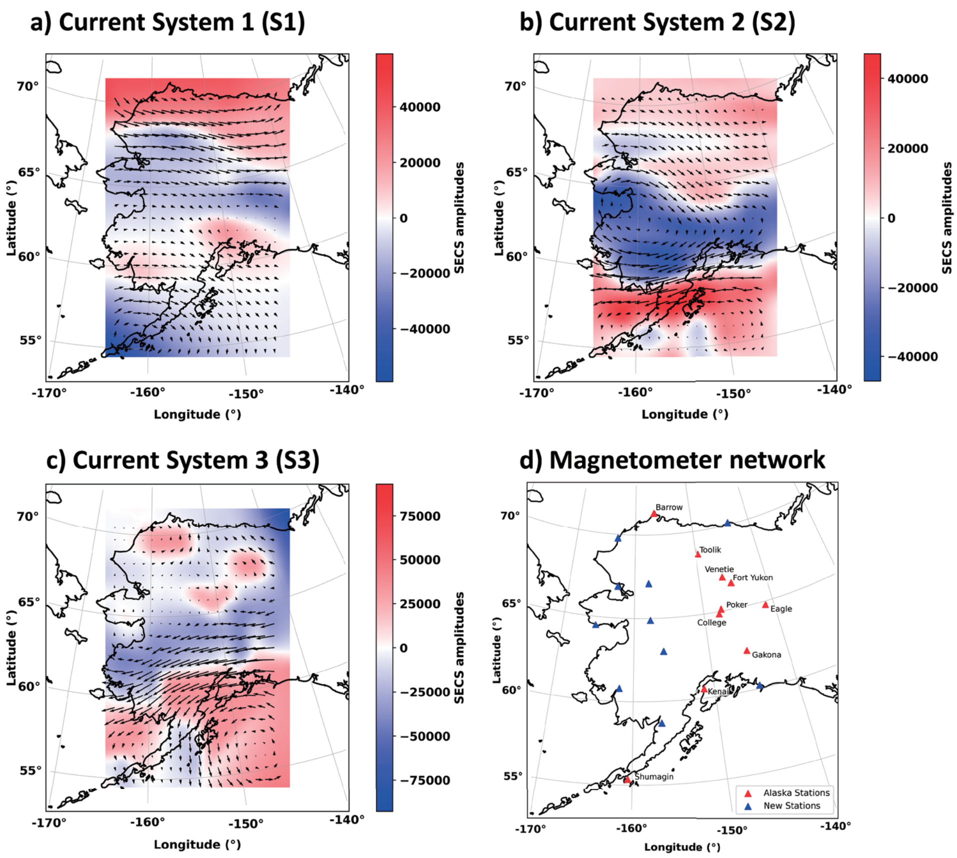


**Figure 1. The figure shows magnetometer network and three synthetic current systems.**

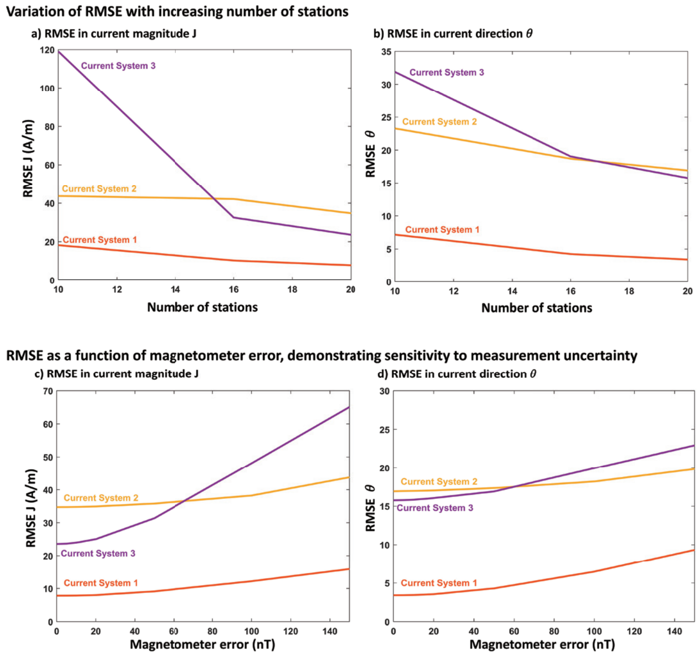


**Figure 2. RMSE in current magnitude J (A/m) and current direction θ as a function of the number of stations (Panels a and b) and magnetometer measurement error (Panels c and d).**

**Acknowledgement:**

I sincerely thank the SCOSTEP Visiting Scholar (SVS) program and NASA Goddard Space Flight Center for facilitating my visit to conduct this work. I am especially grateful to Dr. Hyunju Connor for her guidance, support, and valuable discussions throughout this study.

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Highlight on Young Scientists 2:

## Ionospheric Irregularity Detection from COSMIC Radio Occultation Data: A New Methodological Framework

Yushau Sulaiman

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Modeling ionospheric conditions and forecasting the occurrence of irregularities are major challenges in space weather research, especially in data-sparse regions. This research introduces the Radio Occultation Rate of Change of Electron Density (RORCED) index, a novel method of detecting electron density fluctuations using altitudinal profiles. Electron Density Profiles (EDPs) derived from Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) Radio Occultation (RO) data were analyzed when the peak height of the F2 layer (hmF2) fell within 3°×3°in latitudes and longitudes relative to the reference location (Habarulema et al., 2014). We used quiet-time geomagnetic observations and established a threshold of $2.5\times10^{3}cm^{-3}/km$ for Equatorial Spread F (ESF) identification over the Ilorin ionosonde location (8.5°N, 4.5°E), Nigeria.

Figure 1 shows the RORCED index compared with ionograms for ESF identification. Figure 1a illustrates that the RORCED index (top panel) surpasses the defined threshold (black dashed lines) during ESF events identified on ionograms (bottom panel). Figure 1b presents a similar illustration to Figure 1a, but for periods of minimal RORCED deviation and absence of ESF on ionograms.

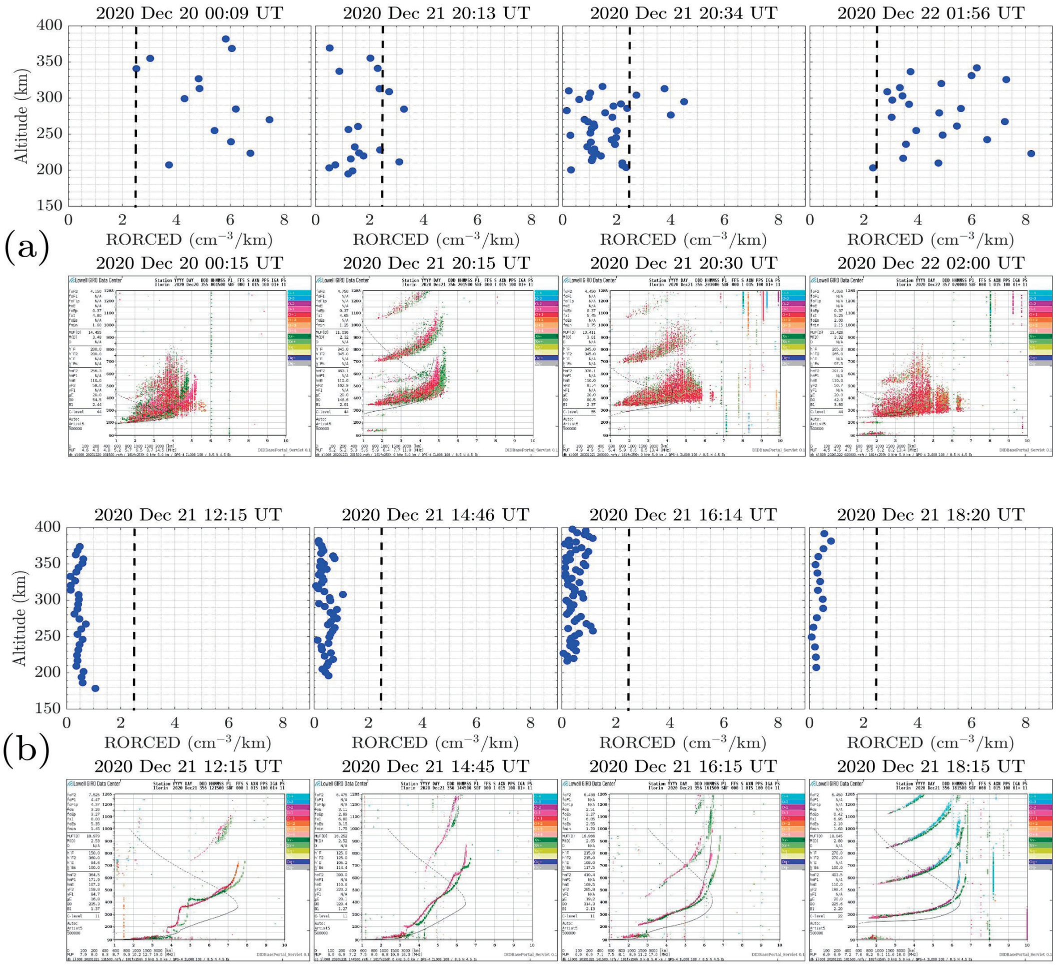


**Figure 1. Illustrations of the RORCED and ionograms matched for ESF identification over Ilorin ionosonde station for cases of ESF occurrence (a), and cases of no ESF occurrence (b). The black dashed lines indicate the threshold of 2.5×10$^{3}$cm$^{-3}$/km.**

To evaluate the performance of RORCED, we compared it with the Rate of Total Electron Content index (ROTI) derived from ground-based GNSS observations in the African region. Figure 2 presents the RORCED and ROTI indices over Malindi (MAL2; 2.99°S, 40.19°E), Addis Ababa (ADIS; 9.03°N, 38.76°E), Yamoussoukro (YKRO; 6.87°N, 5.24°W), and N'koltang (NKLG; 0.35°N, 9.67°E) GNSS stations. A ROTI threshold of 0.4 TECU/min (indicated by the horizontal blue dashed lines), as proposed by Oladipo et al. (2014), was used to identify the occurrences of irregularities. Panels (a-d) reveal that both indices exhibit similar diurnal patterns and consistently indicate the occurrence of plasma irregularities during postsunset and postmidnight periods. Although there are instances where RORCED exhibits higher peaks than ROTI or vice versa, it is evident that the two methods show agreement during periods when both indices remain steady or exhibit fluctuations.

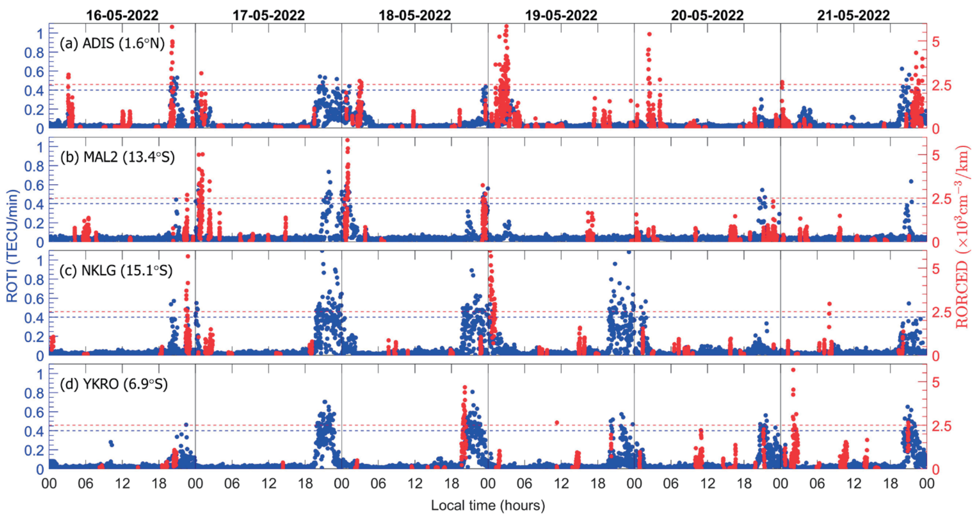


**Figure 2. Examples of plasma density irregularities detection by RORCED and ROTI indices over ADIS, MAL2, NKLG and YKRO GNSS stations. The red and blue dashed lines, respectively, indicate the thresholds for RORCED and ROTI.**

**Acknowledgments:**

The author gratefully acknowledge the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) for the opportunity provided through the SCOSTEP Visiting Scholar program, and the South African National Space Agency (SANSA) for hosting the research and providing essential resources. The author also extend sincere gratitude to Tshimangadzo Merline Matamba, John Bosco Habarulema, Daniel Okoh, Benjamin Wisdom Joshua, and Mustapha Abbas for their valuable contributions to this work.

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Highlight on Young Scientists 3:

# Characteristic behavior of SAR arc, STEVE and Red-Green arc during HILDCAA events

Ayushi Nema

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The Earth's upper atmosphere hosts faint but scientifically rich optical phenomena at subauroral latitudes: Stable Auroral Red (SAR) arcs, Strong Thermal Emission Velocity Enhancements (STEVE), and Red-Green (RG) auroral arcs, driven by magnetosphere-ionosphere (MI) coupling during geomagnetically active periods. This study presents the first statistical analysis of these phenomena during High-Intensity, Long-Duration, Continuous AE Activity (HILDCAA) events (Tsurutani and Gonzalez, 1987).

HILDCAA events are sustained geomagnetic activity periods driven by high-speed solar wind streams from coronal holes, maintaining moderate but continuous energy input into the MI system. Unlike geomagnetic storms, they provide a unique natural laboratory for studying subauroral dynamics under prolonged but moderate forcing. Using 630.0 nm all-sky imagers from the Optical Mesosphere Thermosphere Imager (OMTI) network (Shiokawa et al., 1999) at Athabasca, Kapuskasing (Canada) and Nyrölä (Finland), we analyzed a 9-year dataset (2011-2019). SAR arcs were identified by 630.0 nm emission equatorward of the auroral oval with no concurrent 557.7 nm enhancement, RG arcs by simultaneous enhancements in both wavelengths, and STEVE by its narrow bright structure and picket-fence pattern as shown in Figure 1 (a-f).

Out of 12 HILDCAA events, more than 90% were accompanied by at least one subauroral optical phenomenon, with 9 SAR arcs, 6 RG arcs, and 2 STEVE occurrences (as shown in Figure 2). The occurrence rate reaches ~45% during midnight hours, far exceeding previous studies (Yadav et al., 2022). Arc detachments predominantly occur in the pre-

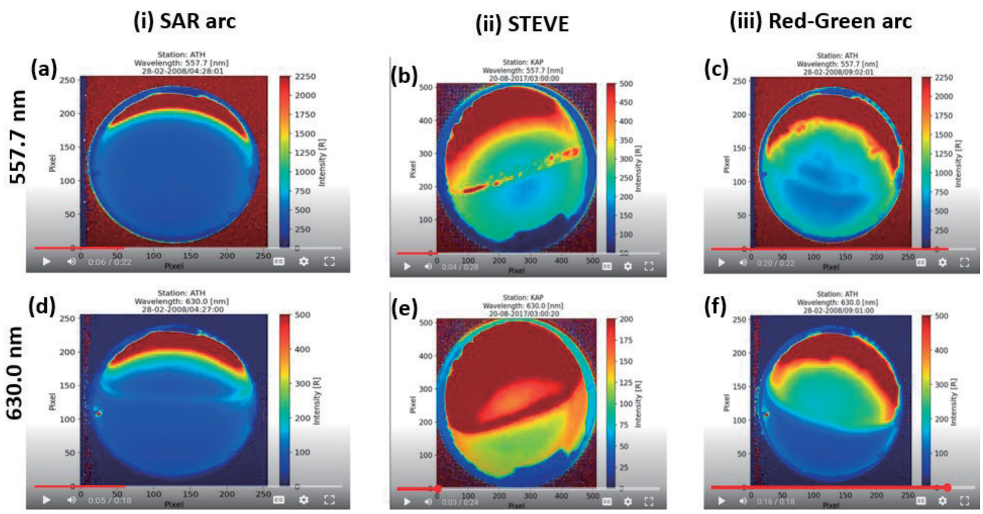


**Figure 1. Visual representation of SAR, STEVE and Red-Green arc at 557.7 nm and 630.0 nm wavelengths.**

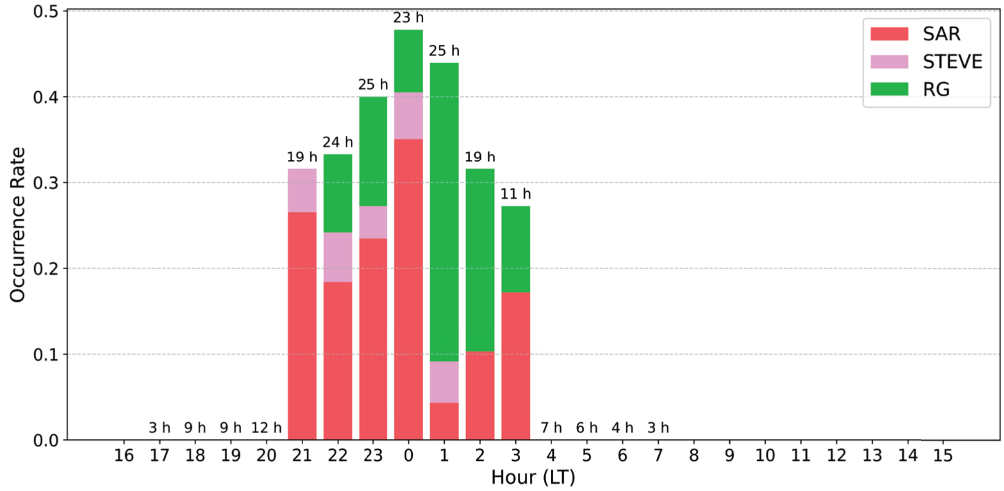


**Figure 2. Occurrence rate variation of SAR, STEVE and Red-Green arcs as a function of local time. Temporal distribution of each auroral event is shown along the bars with red color for SAR arc, purple for STEVE and green for Red-Green arc. The numbers above bars indicate the total hours of available image data with clear sky.**

midnight sector, consistent with ring current ion drift toward the dusk sector. The auroras occurring during HILDCAA events predominantly happen during midnight hours, suggesting local time significantly influences energy deposition mechanisms. This temporal preference is consistent with earlier statistical studies reporting that SAR arcs, STEVE, and RG arcs are most frequently observed near local midnight under moderate geomagnetic activity (Yadav et al., 2022). This establishes that HILDCAA-driven energy coupling creates highly favorable conditions for subauroral aurora formation, offering new insights into the interplay between solar wind streams, magnetospheric dynamics, and ionospheric responses.


### Acknowledgements

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Meeting Report 1:

## ISWI–SCOSTEP International School on Space Weather (ISSW-2026)


S. Tulasi Ram

S. Tulasi Ram[1]
[1]Indian Institute of Geomagnetism, Mumbai, India

The ISWI–SCOSTEP International School on Space Weather (ISSW-2026) was held from 5–9 January 2026 at the Indian Institute of Geomagnetism (IIG), Mumbai, India. The school aimed to train Master's and Ph.D. students in understanding Sun–Earth interactions and various aspects of space weather, including solar-heliospheric processes, magnetospheric and ionospheric current systems, and their impacts on technology and society. Supported by organizations such as ISWI, SCOSTEP, ISRO, ANRF, and IIG, the program combined expert-led lectures with practical hands-on training sessions. Eleven leading scientists delivered lectures covering topics such as solar flares, coronal mass ejections, solar wind–magnetosphere interactions, and space weather effects like communication disruptions and satellite drag. A total of 70 participants attended the school, including 31 international participants from 18 countries and 50 Indian participants from 24 institutions. The program also conducted 42 hands-on sessions and provided financial and travel support to many participants, promoting global collaboration and capacity building in space weather research.


**Photo 1. Lecturers and Participants of ISWI-SCOSTEP International School on Space Weather (ISSW) - 2026.**

Meeting Report 2:

## 17th International Symposium on Equatorial Aeronomy


Claudia Stolle

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[1]Leibniz Institute of Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany

The 17th International Symposium on Equatorial Aeronomy (ISEA17, https://www.iap-kborn.de/isea17) was successfully held during February 9–13, 2026, in Liberia, Costa Rica, at the Campus of Universidad de Costa Rica. The conference brought together experts from the fields of atmosphere, ionosphere and magnetosphere science with particular focus on equatorial and low latitude aeronomy. The workshop welcomed 89 participants from 17 countries. The program included 100 presentations, thereof 12 invited talks, organized in sessions for large-scale variabilities, small-scale irregularities, vertical-atmosphere and atmosphere-ionosphere-magnetosphere coupling, recent advances in instrumentation/observations, and future trends and opportunities. A particular event was the panel discussion on opportunities from space traffic and for space sustainability in current research. This panel included scientific conference members and participants from the Secure World Foundation, ESA, and Space-X for fruitful sharing of perspectives. The symposium was enabled by sponsoring through SCOSTEP/PRESTO, COSPAR, ICTP, IUGG, NSF, and URSI. ISEA18 is expected in 3-4 years.

**Photo 1. Conference participants at the lecture hall in Liberia.**

Meeting Report 3:

# Workshop on Machine Learning applied to Space Weather and Global Navigation Satellite Systems

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[2]TSWC, Facultad de Ciencias Exactas y Tecnología, (FACET), Universidad Nacional de Tucumán (UNT), Argentina
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[5]STI Unit, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy
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Carolina Salas Matamoros


Maria Graciela Molina


Yenca Migoya Orué


Sharafat Gadimova

To advance the application of Machine Learning (ML) to Space Weather (SWx) and global navigation satellite systems (GNSS), and to initiate pilot projects and strengthen institutional collaboration across the Latin American region, a Workshop on machine learning applied to space weather and GNSS was held in San José from 16 to 20 February 2026 (https://www.unoosa.org/oosa/en/ourwork/icg/activities/2026/workshop_on_ml_gnss-2026.html). This workshop was co-organized and co-sponsored by the Space Research Center (CINESPA) of the University of Costa Rica, the United Nations Office for Outer Space Affairs (UNOOSA), the International Committee on GNSS (ICG), the Committee on Space Research (COSPAR), the Istituto Nazionale di Geofisica e Vulcanologia (INGV), and the Scientific Committee on Solar Terrestrial Physics (SCOSTEP), and by members of the Faculty of Exact Sciences and Technology (FACET) of the National University of Tucumán (UNT) and the Abdus Salam International Centre for Theoretical Physics (ICTP).


**Photo 1. Group photo.**

The workshop brought together more than 50 senior and early-career researchers from 18 countries, and covered introductions to Space Weather and the Ionosphere, Machine Learning techniques application to Space Weather, ionospheric modelling and forecasting, data processing and analysis, and GNSS-based applications. Moreover, hands-on sessions on ML applied to SWx datasets, along with a closing discussion on future steps, challenges, collaborations, and recommendations, completed the program.

# Upcoming meetings related to SCOSTEP

| Conference | Date | Location | Contact Information |
|---|---|---|---|
| ESPD Summer School 2026 | Apr. 27-May 1, 2026 | Dubrovnik, Croatia | https://oh.geof.unizg.hr/index.php/en/meetings/espd-school-2026 |
| 13th TREND Workshop | May 18-22, 2026 | Beijing, China | https://trends2026.casconf.cn/ |
| SCOSTEP's 16th Quadrennial Solar-Terrestrial Physics (STP-16) Symposium | Jun. 1-5, 2026 | Thessaloniki, Greece | https://scostep.org/events/stp-symposia/ |
| 18th Workshop "Solar Influences on the Magnetosphere, Ionosphere and Atmosphere" (SIMIA18) | Jun. 8-12, 2026 | Primorsko, Bulgaria | https://www.spaceclimate.bas.bg/ws-sozopol/ |
| Space Climate 10 Symposium | Jun. 9-12, 2026 | Åland/Ahvenanmaa, Finland | https://cosmicrays.oulu.fi/space_climate2026/ |
| 7th IMAOC School | Jun. 15-26, 2026 | Tunis, Tunisia | |
| 46th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events | Aug. 1-9, 2026 | Florence, Italy | https://www.cospar2026.org/ |
| SCAR Open Science Conference | Aug. 8-19, 2026 | Oslo Norway | https://scar2026.org/ |
| International Colloquium on Equatorial and Low Latitude Ionosphere (ICELLI) | Aug. 31-Sep. 4, 2026 | Ibadan, Oyo State, Nigeria | https://nspee.org/icelli/ |
| VERSIM 2026 Workshop | Sep. 7-11, 2026<br>Summer School:<br>Sep. 3-5, 2026 | Sopron, Hungary | https://versim2026.epss.hu/ |
| Data Science Training for Space Weather and Ionospheric Research | Sep. 25-29, 2026 | Arua, Uganda | |
| First Workshop on Sun and Space Weather | Sep. 28-Oct. 2, 2026 | Antalya, Turkey | https://sasw.akdeniz.edu.tr/tr/home-16264 |
| Alliance Meeting | Oct. 2026 | Rome, Italy | |
| The XXIst IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing | Oct. 25-30, 2026 | Ishioka, Japan | https://kakioka2026.org/ |
| Sun-Earth connection through stellar analogs | Nov. 1-4, 2026 | Graz, Austria | |
| 10th HEPPA-SOLARIS Workshop | Jan. 11-15, 2027 | Dunedin, New Zealand | https://www.solarisheppa.kit.edu/ |

Please send the information of upcoming meetings to the newsletter editors.

Announcement 1:

# The 63rd STSC Meeting of UNCOPUOS and the ISWI Steering Committee Meeting

Kazuo Shiokawa

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[1]Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Nagoya, Japan

SCOSTEP is a permanent observer of the United Nations Committee on Peaceful Uses of Outer Space (UNCOUOS). UNCOPUOS holds the Scientific and Technical Subcommittee (STSC) meeting every year in February, where SCOSTEP has made activity reports. The 63rd STSC meeting of UNCOPUOS took place on 2-13 February 2026 at the Vienna International Centre, Austria. At this STSC meeting, I made a 10-min technical presentation on 5 February 2026 to introduce updates of the activities of SCOSTEP, including the initiation activities of the new COURSE program (2026-2030) as well as SCOSTEP's capacity building and outreach activities (SVS, school, online lectures, and comic books). Details of this STSC meeting can be found at https://www.unoosa.org/oosa/en/ourwork/copuos/stsc/2026/index.html.

During this STSC meeting, the International Space Weather Initiative (ISWI) of UNCOPUOS held a steering committee meeting on 4-5 February 2026. Coordination of the international space weather schools organized by ISWI and the SCOSTEP's capacity building activities are discussed. Details of ISWI activities can be found at https://iswi-secretariat.org/.


**Photo 1. A photo at the SCOSTEP presentation during the UNCOPUOS STSC.**

The purpose of the SCOSTEP/COURSE newsletter is to promote communication among scientists related to solar-terrestrial physics and the SCOSTEP's COURSE program.

**The editors would like to ask you to submit the following articles to the SCOSTEP/COURSE newsletter.**

Our newsletter has five categories of the articles:

1. Articles— Each article has a maximum of 500 words length and four figures/photos (at least two figures/photos). With the writer's approval, the small face photo will be also added. On campaign, ground observations, satellite observations, modeling, etc.
2. Meeting reports—Each meeting report has a maximum of 150 words length and one photo from the meeting. With the writer's approval, the small face photo will be also added. On workshop/conference/ symposium report related to SCOSTEP/COURSE
3. Highlights on young scientists— Each highlight has a maximum of 300 words length and two figures. With the writer's approval, the small face photo will be also added. On the young scientist's own work related to SCOSTEP/COURSE
4. Announcement— Each announcement has a maximum of 200 words length. Announcements of campaign, workshop, etc.
5. Meeting schedule

Category 3 (Highlights on young scientists) helps both young scientists and SCOSTEP/COURSE members to know each other. Please contact the editors if you know any recommended young scientists who are willing to write an article on this category.

**To Submit an Article**

Articles/figures/photos can be emailed to the Newsletter Secretary, Ms. Mai Asakura (asakura_at_isee.nagoya-u.ac.jp). If you have any questions or problem, please do not hesitate to ask us.

**Subscription - SCOSTEP mailing list**

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