# SCOSTEP/PRESTO NEWSLETTER

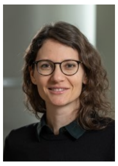
Vol. 35, April 2023

## Inside this issue

### Article 1:

# SOSMAG – Service Oriented Spacecraft Magnetometer on GEO-KOMPSAT-2A

David Fischer



Melanie Heil

Hans-Ulrich Auster

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The Service Oriented Spacecraft Magnetometer (SOSMAG) [1] is part of ESA's distributed Space Weather Sensor System (D3S), which has the task to provide accurate information for forecast/nowcast of space weather to infrastructure or satellite owners [Figure 1].

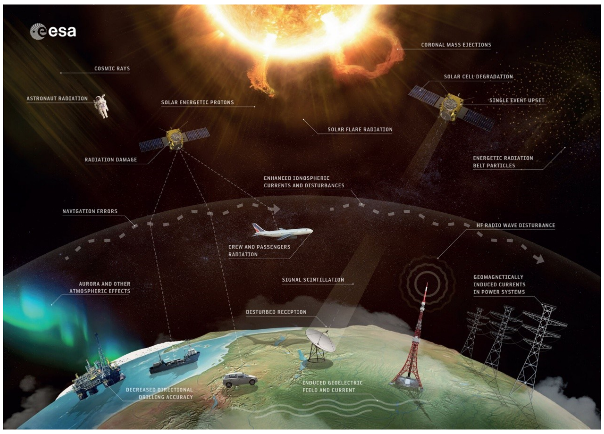


**Figure 1. Impact of Space Weather, ©ESA/Science Office, CC BY-SA 3.0 IGO.**

SOSMAG is a part of the Korean Space Environment Monitor (KSEM) on the Korean GEO-KOMPSAT-2A satellite, which was launched to geostationary orbit (128° E) in December 2018. The measurements of SOSMAG cover the previous gap of geostationary magnetic field measurements over Eastern Asia and complement the measurements of the GOES satellites above the American continent.

The SOSMAG instrument is designed to operate on a satellite without magnetic cleanliness program and employs two science-grade fluxgate sensors on a short boom and two additional anisotropic magnetoresistance sensors within the spacecraft body [Figure 2]. Data from all four sensors is combined mathematically to attenuate magnetic disturbances from the spacecraft [2]. This combination can be done using on-board or ground processing.

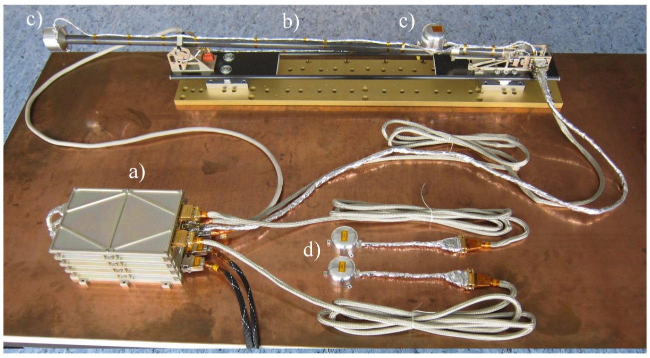


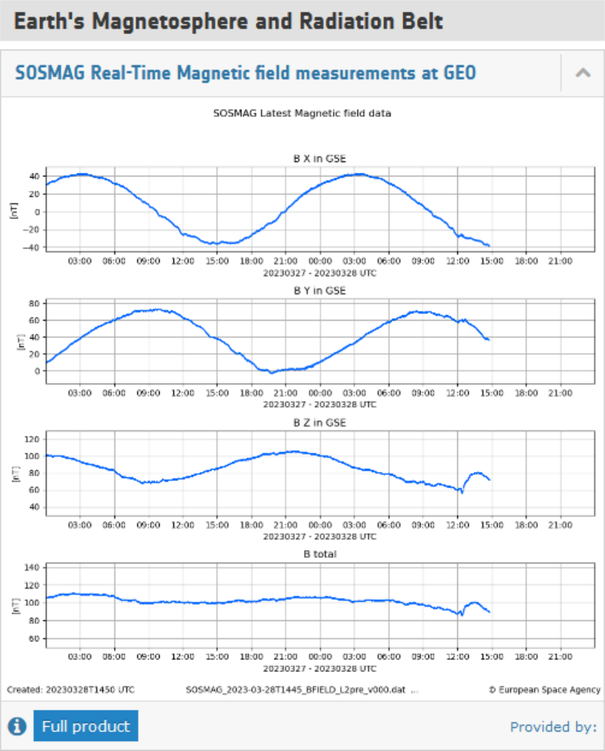
**Figure 2. SOSMAG qualification model with a) electronics box, b) boom with carbon fiber based interface plate, c) two fluxgate sensors mounted onto the boom and d) two anisotropic magnetoresistance sensors [1].**

The processed data from SOSMAG is available at ESA's Space Weather Service Network (SWE) [3] after free registration. Data is available with 3 different delays and qualities:

- Real-time data is provided with a delay of less than 5 minutes. It uses predetermined calibration and cleaning factors.
- Preliminary data is provided with a delay of less than 2 days. It is still calculated using predetermined calibration and cleaning factors, but possible gaps in real-time transmission and processing are closed.
- Final data is provided with a delay of 98 days. This data uses updated calibration and cleaning factors and provides the highest quality.

An exemplary screenshot of the SWE portal is shown in Figure 3. Detailed information about SOSMAG data and its properties can be found at [4].

In addition to direct retrieval from the SWE portal, registered SWE users can also use PySPEDAS [5] as utility for data downloading. The SPEDAS team also provides daily overview plots [see Figure 4] that can be compared with data from magnetospheric missions easily [6].


Earth's Magnetosphere and Radiation Belt

SOSMAG Real-Time Magnetic field measurements at GEO

SOSMAG Latest Magnetic field data

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© European Space Agency

**Figure 3. SOSMAG Dashboard in the SWE Portal.**

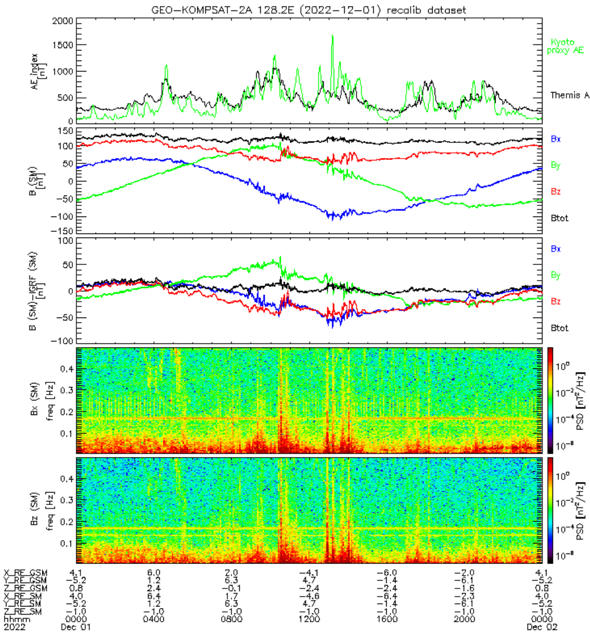

**Figure 4. SPEDAS Summary Plot.**

[1] Magnes, W.; Hillenmaier, O.; Auster, H.-U.; Brown, P.; Kraft, S.; Seon, J.; Delva, M.; et al. 'Space Weather Magnetometer Aboard GEO-KOMPSAT-2A'. Space Science Reviews, 216, 119 (2020). https://doi.org/10.1007/s11214-020-00742-2.

[2] Constantinescu, O. D.; Auster, H.-U.; Delva, M.; Hillenmaier, O.; Magnes, W.; and Plaschke, F. 'Principal Component Gradiometer Technique for Removal of Spacecraft-Generated Disturbances from Magnetic Field Data'. Geoscientific Instru-

mentation, Methods and Data Systems Discussions, 25 May 2020, 1–26. https://doi.org/10.5194/gi-2020-10.

[3] https://swe.ssa.esa.int/

[4] https://swe.ssa.esa.int/sosmag

[5] https://github.com/spedas/pyspedas

[6] http://themis.ssl.berkeley.edu/summary.php?year=2022&month=12&day=01&hour=0024&sumType=kompsat&type=sosmag

### Article 2:

# Development of Very Low Frequency (VLF) Radio Wave Database in Anchor University for Regional Advancement of Solar-Terrestrial Physics Research

**Victor U. J. Nwankwo**[1]
[1]Centre for Space Research (CESPAR), Anchor University, Lagos, Nigeria

Victor U. J. Nwankwo

The Earth’s atmosphere is dynamic and complex, characterised by temporal and spatial variability and significantly varies with time and location. This scenario makes multiregional deployment of scientific observational facilities (for atmospheric data acquisition) imperative, for better coverage and remote sensing of regions of interest. While the effort of many institutions in Africa is acknowledged in this regard, it is still worrisome that most parts of Africa (including Nigeria) lack adequate deployment of ground-based and space-borne observational facilities. Data shows that our regions are not well represented in the ongoing effort by the World Archive of Low-frequency data and observation (WALDO), and a limited or absence of global GNSS and digital ionosonde ground sites in most regions (see Fig 1). This underscores the need to embark on global deployment of more facilities and upgrade of the existing ones for a wider coverage, especially in the African continent [1].

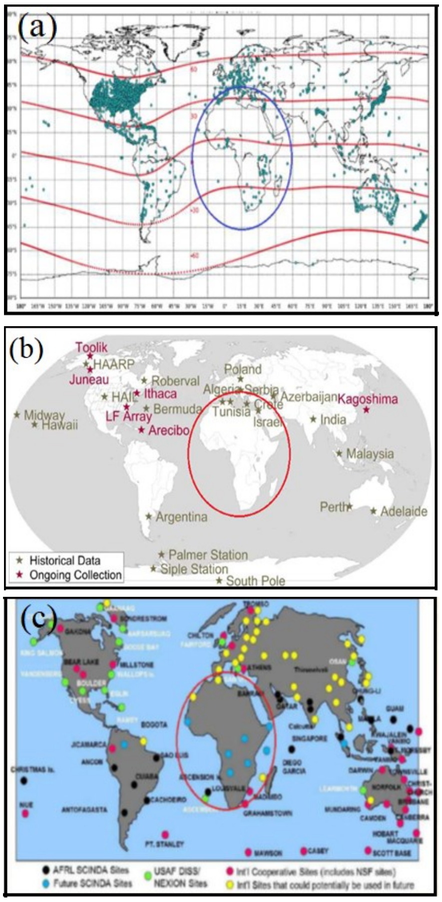

**Figure 1. (a) Map of Global GNSS ground-based sites used for processing total electron content (TEC) data [2] (b) VLF sites with data on or in queue from WALDO (Adapted from www.waldo.world) and (c) Sites for digital ionosonde sounding system (DISS), Next generation ionosonde (NEXION), scintillation network decision aid (SCINDA) [3].**

In 2018, Anchor University, Lagos (AUL) established the Space, Atmospheric Physics and Radio Wave Propagation Laboratory (AUL Space Lab) to (among other objectives) address the dearth of research data in our region through deployment of ground-based observational facilities and subsequently building regional and institutional database for advancing research in solar-terrestrial Physics, science and technology [4]. At inception, the AUL Space laboratory was a makeshift cubicle carved out of the Departmental office of Physics programme and housed the data capturing equipment with very limited space for researchers.

Data acquisition effectively began in 2019 using a multichannel very low frequency (VLF) radio waves Receiver (donated to the laboratory by the Indian Centre for Space Physics (ICSP) and Weather Station (measuring meteorological parameters). The VLF Receiver recorded time-variant amplitude of VLF radio waves from 4 transmitters at the time, including HWU (France), NWC (Australia), JJI (Japan) and VTX (India) (Fig 2). As the data accumulated over time, we saw the obvious need to properly process, store and subsequently retrieve the already acquired data, as well as make provision for a real-time data catalogue that will be publicly available for researchers and stakeholders in the field.

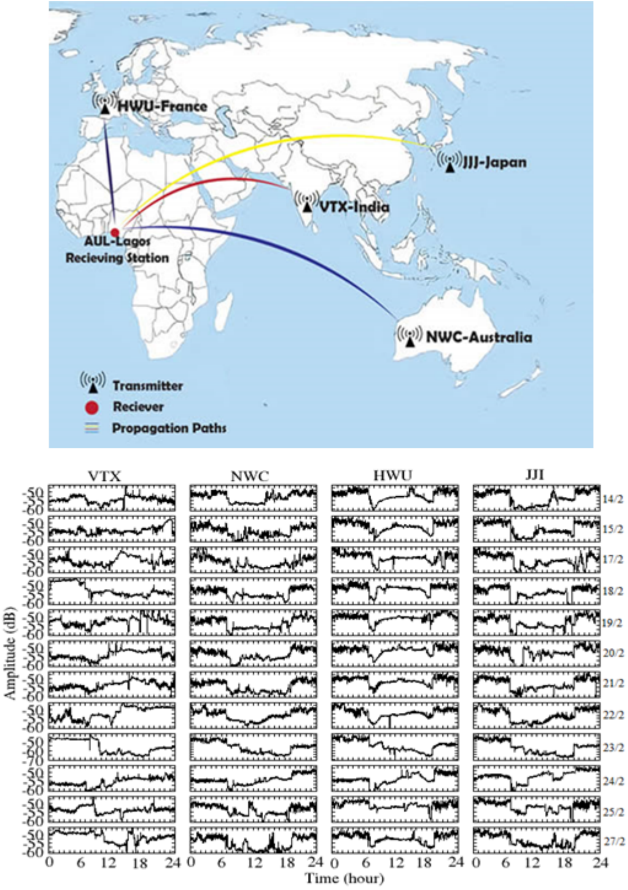

**Figure 2. Signal propagation paths and associated data received at AUL Space Lab.**

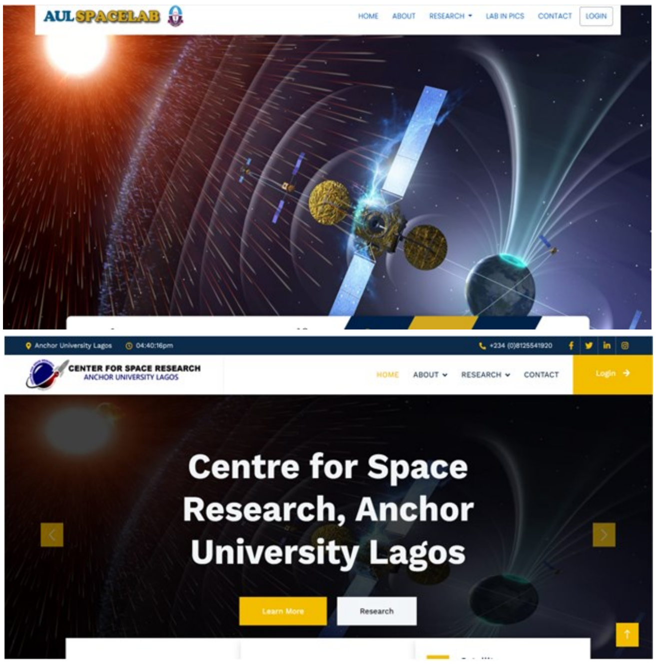

**Figure 3. An overview of AUL Space Lab and CESPAR homepage at [www.aulspacelab.space](www.aulspacelab.space) and [www.cespar.space](www.cespar.space).**

While this effort lasted, we experienced intervals of data gaps mainly due to moments of technical hitches and power outage, and eventual breakdown of the antenna of the only receiver at the time. It was on this premise that we successfully applied to the 2021 Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)/PRESTO Grant for creating database of solar-terrestrial data. We effectively utilized the grant to significantly progress and expand our laboratory to the capacity where we are now well-placed to pursue and meet the sole objectives of the laboratory. The outcome and/or product of the project include a successful archiving of VLF radio wave amplitude data that is now available for SCOSTEP community and other researchers on www.cespar.space (see webpage overview in Fig 3), and the acquisition of new VLF receivers that enabled us to resume data acquisition after a long break.

The impacts of the completed project include (i) better equipment and expansion of the recipient laboratory (AUL Space Lab), (ii) enhanced capacity to provide students and scholars with training and mentorship in solar-terrestrial physics (iii) upgrade of the recipient laboratory to Anchor University Center for Space Research (CESPER, see Fig 4) and (iv) increased visibility leading to scientific cooperation and/or collaboration with more institutions (more details in [4]).

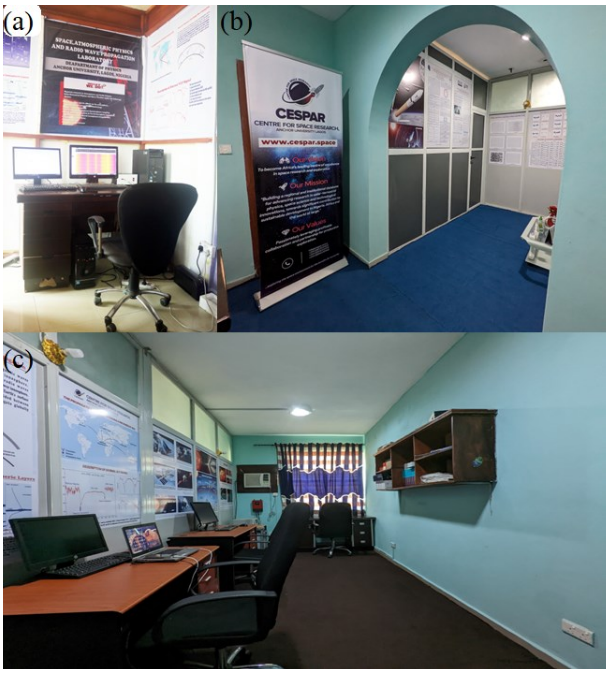

**Figure 4. (a) AUL Space Lab at inception (b & c) AUL Space Lab upgraded to Centre for Space Research (CESPAR).**

Acknowledgement: The AUL Space Lab team acknowledge and thank SCOSTEP and its management team for the SCOSTEP/PRESTO Grant that supported our effort. The following are also highly acknowledged for their unflinching support that made this achievement possible: The Vice Chancellor, Prof. Samuel O. Bamdele and members of Anchor University Management Team, the Dean of Faculty of Natural, Applied and Health Sciences (FNAHS), the AUL Space Lab Technical Crew, the Department of Physics (Anchor University), Prof. William Denig (SJCM, USA), Prof. S. K. Chakrabarti (ICSP, India), Prof. J-P

Raulin (CRAAM, Brazil), Prof. Caitriona Jackman and Prof. Peter Gallagher of DIAS, Ireland (DIAS Dunsink Observatory recently donated a Raspberry Pi magnetometer and VLF Receiver to support our effort), Prof O.O. Akinwnmi (AUL, Nigeria), Dr. O.E. Abe (Federal University, Oye Ekiti, Nigeria) and other colleagues too numerous to mention here.

**References:**

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2. Verkhoglyadova et al., (2016). Solar wind driving of ionosphere-thermosphere responses in three storms near St. Patrick's Day in 2012, 2013, and 2015. J. Geophy. Res.: Space Physics, 121 (9), 8900-8923.
3. OFCMS Report, 2013. Report on space weather observing systems: current capabilities and requirements for next decade. NSWPC Joint Action Group for Space Environment Gap Analysis, USA.
4. CESPAR, 2022. Our Journey to Space, ValuePlus Inc., Lagos, Nigeria, https://www.cespar.space/doc/bulletin.pdf.

### Article 3:

# Atmospheric Electricity Measurments at the Villum Research Station

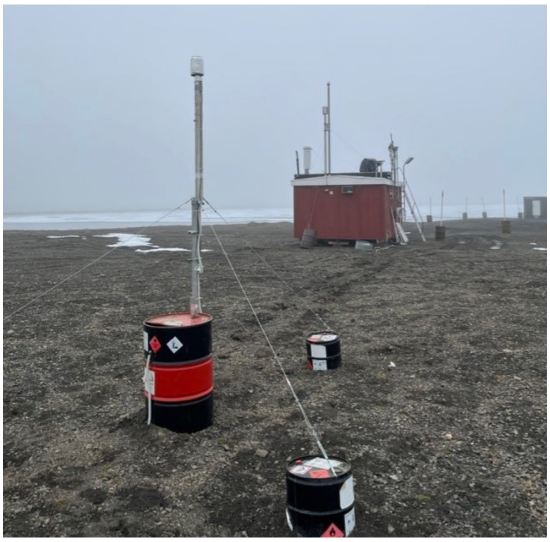
Stergios Misios

**Stergios Misios**[1]
[1]National Observatory of Athens, Athens, Greece

Clouds play a vital role on weather and climate, affecting precipitation and Earth's radiation budget. Nonetheless, the processes that govern their microphysical properties and feedbacks are far from understood. The majority of observational and all climate modelling studies assume a neutral environment, when studying cloud variations and cloud-aerosol interactions, hence neglecting altogether one key property of the atmosphere: electric charges. High energy cosmic rays of galactic and solar origin, natural radioactivity, lighting in thunderstorms and electrified shower clouds, produce ion clusters and charge the whole atmosphere causing a ubiquitous potential difference between the ionosphere and the surface (Williams and Mareev 2014). This Global Electric Circuit (GEC) allows the flow of charges to the surface in the fair-weather (undisturbed) regions of the globe.

Theory suggests that current-flow through a stratiform cloud will cause accumulation of space charge on the cloud edges, with charge transferred to cloud droplets and aerosol particles, with potential influences on cloud microphysics that in turn may affect cloud droplet size distributions, precipitation, lifetime, and radiative properties. If this is the case, it is reasonable to assume that charge-cloud processes cause tangible changes in atmospheric thermal stratification and radiation and as a consequence on the entire energy budget. Recent progress has provided some observational evidence for charge effects on clouds, relating cloud-base height with diurnal variations of GEC (Harrison and Ambaum 2013; Nicoll and Harrison 2016; Harrison et al. 2020). However, an experimental confirmation of charge-cloud interactions is a challenging task, because it requires quality-controlled concurrent measurements of GEC and cloud properties in fair-weather conditions not only at the surface but in clouds as well.

In August 2022, we installed a Chilworth JCI 131-electric field mill at the Villum Research Station (VRS) at Station Nord/Greenland (81.36 N, see Picture 1) to provide continuous measurements of potential gradient at ground level to characterize GEC variations. Our measurements will be part of the global atmospheric electricity monitoring network for climate and geophysical research (Nicoll et al. 2019). The station is also equipped with a Vaisala CL51 ceilometer, which gives information about overlaying layers of clouds and aerosols and an Airel NAIS aerosol spectrometer, which measures the mobility distribution of the ions. Different radiometers (e.g pyranometer) will allow us to quantify charge-cloud signatures on the surface energy budget. The particular meteorological conditions (e.g. negligible diurnal variability during polar night) that facilitate excellent GEC measurements and the frequent presence of liquid-phase layered clouds, make VRS an ideal location to study charge-cloud processes and their climatic signature (Harrison and Nicoll 2018). Observational results will ultimately improve the parameterization and refine the modeling of GEC-related processes.



**Picture 1. The Chilworth JCI 131 next to the Flygers hut, Greenland.**

Figure 1 shows raw hourly Potential Gradient time series at the VRS for August 2022. The mean PG is about 69 V/m and is enhanced considerably during snowstorms. As there is no direct communication to the instrument, the data are retrieved infrequently, every time scientists visit VRS, with the latest checkout in Dec 2022.

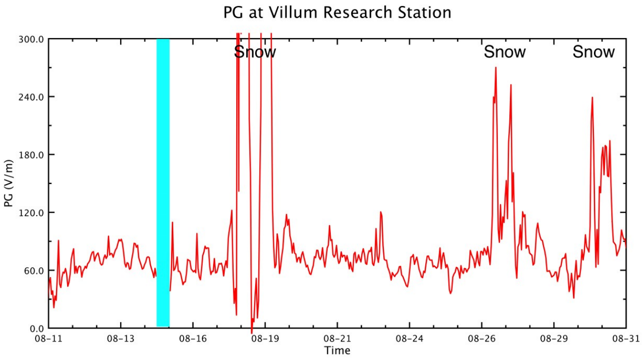


**Figure 1. Potential gradient time series for August 2022. Cyan box shows a power failure. Peaks of PG correspond to snowstorms.**

One key challenge in operating an instrument in the harsh Arctic environment is the heat insulation to prevent ice build up. The JCI-131 is particularly prone to environmental conditions because of the rotating plate, which can break when ice accumulates at the head in the case of long power failures (Our instrument broke during the testing phase). We have isolated the instrument with two flexible silicon heating pads and their performance was examined by taking measurements at the NCSR Demokritos ACTRIS station, Mt Helmos, Greece (2315 m asl) during the winter 2021/2022.

The project (https://isaaffik.org/projects/view/atmospheric-electricity-measurments-at-the-villum-research-station?iri=%2Fapi%2Fprojects%2F20b6ba86-26e5-43f5-8651-552d2d3e5801) brings together expertise in space-climate (Physics, Astronomy and Geoscience, Uni. Aarhus), aerosol and clouds theory and measurements at VRS (Env. Science, Uni. Aarhus), atmospheric electricity measurements, instrumentation and modeling (National Observatory of Athens, Greece) to assess the climatic relevance of GEC through influencing layered clouds. The JCI-131 has been purchased by the Villum Experiment project “Environmental consequences of solar cosmic rays ” and is planned to operate at VRS for 2 years at least. We acknowledge the SCOSTEP-PRESTO Grant for campaigns and Marie Skłodowska-Curie Action “Electric Volcano” for the financial support to visit VRS and the testing phase at Mt. Helmos. Scientific and logistic support at different stages of the project was given by: J. Skafte, K. Mortensen, M.F. Knudsen, Aarhus, K. Eleftheriadis and P. Fetfatzis NCSR Demokritos, A. Gourzelas, V. Daskalopoulou, G. Katoufas, V. Amiridis.

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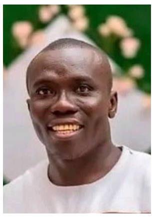
Williams, Earle, and Eugene Mareev. 2014. 'Recent progress on the global electrical circuit', Atmospheric Research, 135-136: 208-27.

### Highlight on Young Scientists 1:

# Ionospheric Plasma Fluctuation Response to Space Weather events over the Equatorial and Low Latitude Region



Patrick Essein

**Patrick Essein[1], Francis Nkrumah[1] and Moses Jojo Eghan[1]**
[1]University of Cape Coast, Department of Physics, Cape Coast, Ghana

## Introduction

As space technology becomes increasingly vital in our contemporary lives, we become more susceptible to space weather changes and interactions. The availability and application of these technologies are therefore influenced by ionospheric "weather," and the prediction of ionospheric conditions continues to be challenging because of limitations in the consistent observations of key parameters including plasma fluctuations (Essien et al., 2021).

On the 17th of March 2015, a strong (~50 nT) compression occurred, indicative of a shock reaching the magnetosphere, resulting geomagnetic storm with an index of -223 nT, indicating the generation of a strong ring current followed by a slow, long-lasting ring current during the recovery phase.

We estimated the detrended Total Electronic Content (dTEC) using data from GNSS receivers (Otsuka et al., 2013, Figueiredo et al., 2018, Essien et al., 2021). Figure 1 shows the dTEC profile of GPS PRN 23 observed by a receiver in Accra (5.60° N, 0.19° W). There are fluctuations between 08:00 and 09:30 UT, and the intensity gradually reduced.

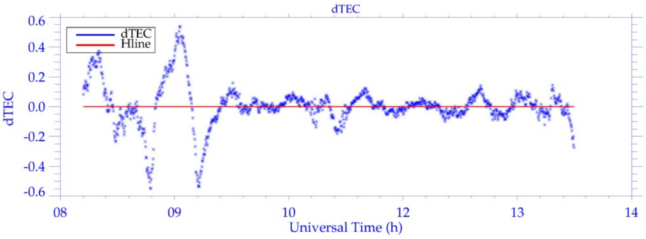


**Figure 1. dTEC profile over Accra on 17th March 2015.**

Series of dTEC maps of South American regions were used to create keograms as shown in Figure 3. The wavelength, period, phase velocity and propagation direction are 633.5 km, 34.5 min, 306.0 m/s, and 309.5o. Consistent observation on the September 2017 and August 2008 storms revealed the ionospheric plasma fluctuations.

It is obvious that the characteristics of the ionospheric fluctuations observed during the storm day and recovery phase days are similar to the MSTIDs observed by Figueirido et al. (2018) and Essien et al. (2021) in the equatorial and low latitude region.

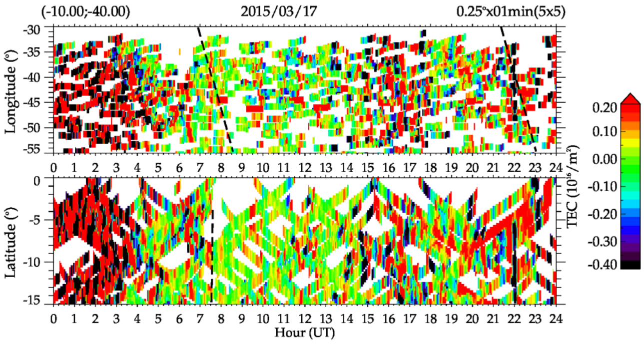


**Figure 2. Keograms created from the series dTEC maps on March 17th, 2015; longitudinal (top) and latitudinal (bottom). The black dashed lines indicate the dawn and dusk solar terminator.**

## Reference:

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3. Otsuka, et al., (2013). GPS observations of MSTIDs over Europe. In Annales Geophysicae (Vol. 31, No. 2, pp. 163-172). Copernicus GmbH.

Highlight on Young Scientists 2:

# Improving the Arrival Time Estimates of Coronal Mass Ejections by Using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data, and Machine Learning

Talwinder Singh

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The arrival time prediction of Coronal mass ejections (CMEs) is an area of active research. Many methods with varying levels of complexity have been developed to predict CME arrival. However, the mean absolute error (MAE) of predictions remains above 12 hours, even with the increasing complexity of methods.

We have developed a new method for CME arrival time prediction that uses magnetohydrodynamic simulations involving data-constrained flux-rope-based CMEs, which are introduced in a data-driven solar wind background (Singh et al., 2023). The CME model was explained in detail in Singh at al. (2022.) We found that, for 6 CMEs we studied, the MAE in arrival time was ~8 hours.

We further managed to improve our arrival time predictions by using ensemble modeling and comparing the ensemble solutions with STEREO-A&B heliospheric imager data. This was done by using our simulations to create synthetic J-maps and comparing them with J-maps created from HI observations (See Figure 1). Two machine learning (ML) methods, the lasso regression and (LR) neural networks (NNs), were used for this comparison. Using LR, we could reduce the MAE to ~4 hours. NNs made it possible to reduce the MAE to ~5 hours for the cases when HI data from both STEREO-A&B were available. Interestingly, NNs can provide similar MAE when only the STEREO-A data is used, which is encouraging since only STEREO B is currently not operational. Our methods also resulted in very encouraging values of standard deviation (precision) of arrival time.

Our methods demonstrate significant improvements in the CME arrival time predictions. Our work highlights the importance of using ML techniques in combination with data-constrained magnetohydrodynamic modeling to improve space weather predictions.

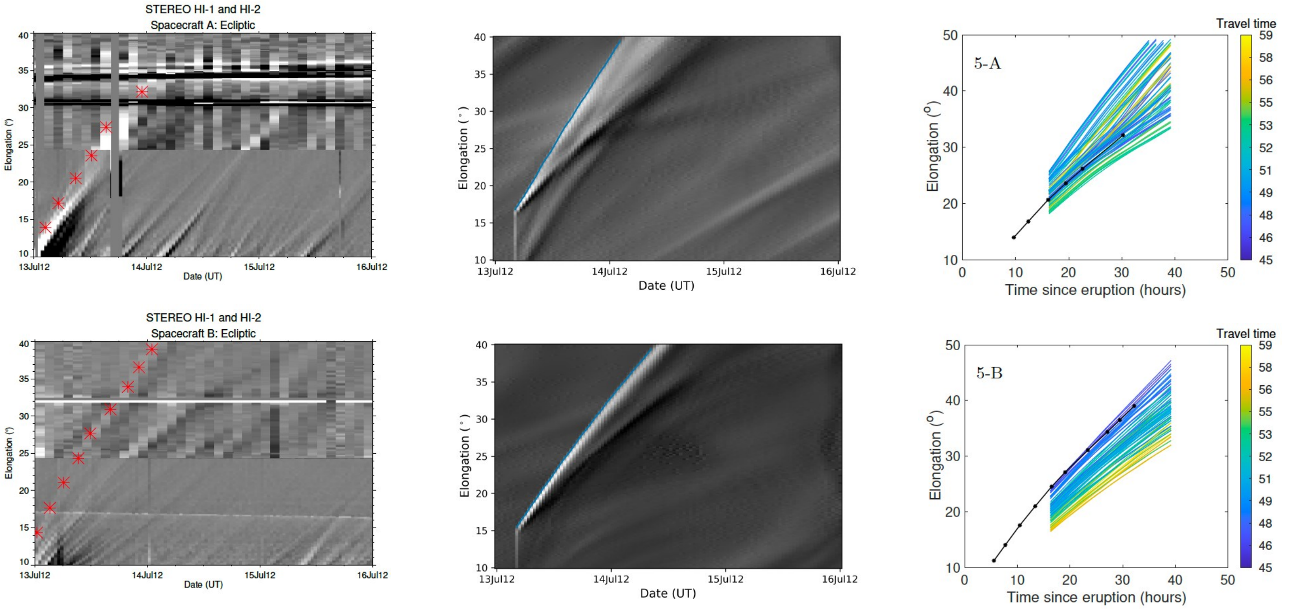

**Figure 1. Left panels: J-maps created using HI1 and HI2 data from STEREO-A (top) and STEREO-B (bottom) showing the 12 July 2012 CME. The tracked CME front is shown with red symbols in both J-maps. Middle panels: Synthetic J-maps created from the simulation of the seed ensemble member for the 12 July 2012 CME from STEREO-A (top) and STEREO-B (bottom) vantage point. The CME front is traced with the blue line. Right panels: The time-elongation data extracted from the J-maps by tracing the CME fronts in observed J-map (black line) and synthetic J-maps for all ensemble members (colored according to the travel time in hours from eruption to Earth impact). The top panel is for STEREO-A and the bottom panel is for STEREO-B.**

**References:**

Singh, T., Kim, T. K., Pogorelov, N. V., and Arge, C. N. (2022). Ensemble simulations of the 2012 July 12 coronal mass ejection with the constant-turn flux rope model. The Astrophysical Journal, 933(2):123.

Singh, T., Benson, B., Raza, S. A. Z., Kim, T. K., Pogorelov, N. V., Smith, W. P., and Arge, C. N. (2023). Improving the Arrival Time Estimates of Coronal Mass Ejections by Using Magneto- hydrodynamic Ensemble Modeling, Heliospheric Imager data, and Machine Learning. arXiv e-prints, page arXiv:2302.05588.

## Upcoming meetings related to SCOSTEP

| Conference | Date | Location | Contact Information |
|---|---|---|---|
| PRESTO Workshop & School | May 29-Jun. 2, 2023 | Trieste, Italy | https://indico.ictp.it/event/10176 |
| The 16th Hellenic Astronomical Conference | Jun. 25-28, 2023 | Athens, Greece | https://helas.gr/conf/2023/ |
| IUGG 2023 | Jul. 11-20, 2023 | Berlin, Germany | https://www.iugg2023berlin.org/ |
| The AGATA Kick-off meeting | Jul.12, 2023 | Germany | www.scar.org/science/agata/home |
| XXXVth URSI General Assembly and Scientific Symposium | Aug. 19-26, 2023 | Sapporo, Japan | https://www.ursi-gass2023.jp/ |
| International Conference on Space weather and Technology Applications | Aug. 21-23, 2023 | Lusaka, Zambia | |
| International Colloquium on Equatorial and Low Latitude Ionosphere (ICELLI 2023) | Sep. 4-8, 2023 | Ilorin, Nigeria | https://arcsstee.org.ng/colloq2023/ |
| Multi-instrumental and model investigation of the high-speed solar wind streams effect on the coupled ionosphere-plasmasphere system | October, 2023 | Prague, Czech Republic | |
| Space Weather and Upper Atmospheric Data analysis Training Workshop for East African Community | Oct. 2-6, 2023 | Arua, Uganda | |
| The 2023 Sun-Climate Symposium | Oct. 16-20, 2023 | Flagstaff, AZ, USA | |
| The European Space Weather Week (ESWW) | Nov. 20-24, 2023 | Toulouse, France | http://esww2023.irap.omp.eu/ |
| AGU Fall Meeting 2023 | Dec. 11-15, 2023 | San Francisco, CA, USA | https://www.agu.org/fall-meeting |
| 45th COSPAR Scientific Assembly | Jul. 13-21, 2024 | Busan, South Korea | https://www.cospar2024.org/ |
| XXXII IAU General Assembly | Aug. 5-16, 2024 | Cape Town, South Africa | https://www.iau.org/science/meetings/future/symposia/ |
| 11th SCAR Open Science Conference | Aug. 19-23, 2024 | Pucon, Chile | |

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

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

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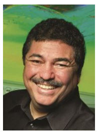

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