

font=10.5

* ISWI Newsletter - Vol. 15 No. 006 15 June 2023 *
* Editor: George Maeda, georgemaeda3[at]gmail.com *
* Archive of back issues: ISWI Website <https://iswi-secretariat.org/> *
* Archive of all ISWI webinars: *
* <https://www.youtube.com/playlist?list=PLa0qa4cng0GF3cKuj6Yz5kqG1BQ-Akkhr> *

Reminder that the ISWI Website up and running:
<https://iswi-secretariat.org/>
It is the official archive of various ISWI functions.
For example, you can access all ISWI Newsletters
since 2009, when the website and the newsletter
started operations.

The website is managed by:
Dr. Kathleen Kraemer
Boston College, Institute for Scientific Research
Kenny Cottle Hall
885 Centre St.
Newton, MA 02459, United States
kathleen.kraemer[at]bc.edu

The newsletter is edited by:
George Maeda (currently employed by Ark Edge Space, Tokyo)
Permanent postal address:
P.O. Box 220534
Boston, MA, 02122 United States
georgemaeda3[at]gmail.com

Another reminder:
If you have any time-sensitive announcements for
our ISWI community, please send to me as quickly as
you can. It should be two months ahead of the event.
This newsletter aims to go out each month on the 15th.

Note:
Attached PDF files are now labelled with a red 3-digit
serial number on the first page of each file.

-- Editor.

CONTENTS OF THIS ISSUE:

- [01] ISWI Webinar
. Title: Solar Flares and Space Weather
. Speaker: Dr Lucia Kleint
- [02] Special Report:
. "ICTP-SCOSTEP-ISWI School and Workshop on the
. Predictability of the Solar-Terrestrial Coupling - PRESTO";
. 29 May - 2 June 2023, Abdus Salam International Center
. for Theoretical Physics, Trieste, Italy
- [03] SPACE WEATHER SUMMER SCHOOL: Physics and use of tools
. October 14-25 2024 ; Conakry, Guinea
- [04] The first space weather Phd from Pakistan:
. Title: "Ionospheric and magnetic changes
. induced by space weather at low and mid latitudes."
. MAY 31st 2023
- [05] Obituary for Professor Cyril Onwumechili of Nigeria.
. He participated in the IGY. Closely associated with
. Equatorial electrojets
- [06] First call for participants:
. "6th Asia-Oceania Space Weather Alliance (AOSWA) Workshop"

[07] "How Solar Wind Flows From the Sun Like Water From a Shower Head";
The Parker Solar Probe is providing NASA researchers with
insights into how the sun accelerates particles to a million
miles per hour. THE NEW YORK TIMES. 7th June 2023.

[01]-----

FROM: Maria Graciela Molina
DATE: Tue, Jun 6, 2023,
TO: ISWI community

Dear colleagues,

We are pleased to announce the next ISWI Seminar of 2023
by Dr Lucia Kleint scheduled for June 28th at
3 PM Central European Time (9 AM EDT; 6:30 PM IST).

This time the ISWI Seminar will be carried out under
the scope of the United Nations Workshop on the International
Space Weather Initiative: The Way Forward.

As usual, to register for this virtual seminar,
please send an email to: iswisupport@bc.edu
Please include "ISWI Seminar Registration" in the subject line.
There is a limit of 300 participants, so please register
your interest as soon as possible. The MS Teams link will
be sent to registered participants 2 days before the event.

Please remember that the seminars will be recorded.
The playlist with the previous seminars, which will also
include future sessions, can be accessed through the following link:
https://www.unoosa.org/oosa/en/ourwork/psa/bssi/iswi_webinars.html

Looking forward to meeting you in the next ISWI seminar!
With kind regards,

Graciela Molina
on behalf of the ISWI Seminar Committee

Title: Solar Flares and Space Weather
Speaker: Dr Lucia Kleint

Abstract:

Eruptions on the Sun, called solar flares, are extremely powerful. Their violent nature and influence on Earth were realized in 1859 when English astronomer R. Carrington suddenly saw an unexpected brightening on the Sun. Lasting only a few minutes on the Sun, the event was followed by intense space weather with auroras seen as far south as Hawaii, and by failures of telegraph systems, whose operators suffered from electric shocks. Research in flare physics has determined that the energy stored in the solar magnetic field is powering the eruptions. Particles accelerated during magnetic reconnection events precipitate into interplanetary space, but also towards the solar surface where they cause many observable phenomena, such as heating, mass motions, and emission in the whole electromagnetic spectrum. Large solar eruptions are the main causes of severe space weather events, which can affect satellites and communication. In this presentation, I will give a closer look on the origins of space weather and the current research on solar flares.

Dra. María Graciela Molina
Professor FACET -UNT
Researcher CONICET
Associated researcher INGV

Av. Independencia 1800, Tucumán - Argentina
Tel: +54-381-4364093 (ext. 7765)
gmolina@herrera.unt.edu.ar /
m.graciela.molina@gmail.com

Flyer is attached:
Flyer for June 2023 ISWI webinar.pdf
001

=====

[02]-----

"ICTP-SCOSTEP-ISWI School and Workshop on the
Predictability of the Solar-Terrestrial Coupling - PRESTO";
29 May - 2 June 2023, Abdus Salam International Center
for Theoretical Physics, Trieste, Italy

A special report by Dr Nat Gopalswamy.
See this pdf:
PRESTO report from Nat on 15-06-2023.pdf
002

[03]-----

First Announcement:

SPACE WEATHER SUMMER SCHOOL: Physics and use of tools
October 14-25 2024 ; Conakry, Guinea

See:
GUINEA_2024-avant-projet -english_02juin 2023.pdf
003

Submitted by:
Dr. AMORY-MAZAUDIER Christine (LPP/Polytechnic/UPMC/France)

[04]-----

Hi Georg:
Here it is the first PhD defended in Space Weather in Pakistan
sincerely, Christine

See:
PhD Waqar YOUNAS.pdf
004

Submitted by:
Dr. AMORY-MAZAUDIER Christine (LPP/Polytechnic/UPMC/France)

[05]-----

Dear Wiseman,

Greetings from Nigeria!

Find attached herewith a news item for the ISWI Newsletter.
It is an announcement of the exit of Professor Cyril Onwumechili,
a man whose name is synonymous with Equatorial electrojet.
He also participated in the International Geophysical Year (IGY)
as a scientist during 1957 - 1959. He made meaningful
contributions to our science of space weather.

Best regards,
Professor Babatunde Rabi
United Nations African Regional Centre
for Space Science and Technology Education - English
UN-ARCSSTE
Obafemi Awolowo University Campus, Ile Ife, Nigeria

See:

Tribute to Onwumechili.pdf
005

[06]-----

From: Mardina Abdullah
Date: Mon, 15 May 2023
Subject: [FIRST ANNOUNCEMENT] Call For Participants :
6th Asia-Oceania Space Weather Alliance (AOSWA) Workshop 2023
To: George Maeda

Dear Maeda-san,
Could you please circulate this information via the ISWI Newsletter?
FYI, we're LOC for AOSWA this year.

Thank you and best regards,
Mardina

=====

***** First Announcement
CALL FOR PARTICIPANTS

AOSWA 2023
6th Asia-Oceania Space Weather Alliance (AOSWA) Workshop
<http://www.ukm.my/aoswa/>
Bangi Resort Hotel, Selangor, Malaysia
9-11 October 2023

Dear Sir/Madam,
The Space Science Centre (ANGKASA), under the Institute of
Climate Change of Universiti Kebangsaan Malaysia (UKM),
is proud to host the 6th Asia-Oceania Space Weather Alliance
Workshop, which is technically supported by the National
Institute of Information and Communications Technology (NICT) of Japan.

The ultimate objective of this workshop is to encourage
cooperation and sharing information related to space weather
research and operation among all relevant parties.

IMPORTANT DATES:
Abstract Submission Deadline: 30 June 2023
Notification of Acceptance : 15 July 2023
Registration and payment deadline: 31 July 2023
The 6th AOSWA Workshop: 9-11 October 2023

Please visit our WEBSITE for registration, ABSTRACT submission,
and workshop details, or CONTACT US for further information.
Kindly forward this announcement to your colleagues and
accept our utmost appreciation for your assistance in this matter.

We look forward to hearing from you soon.

Sincerely,
Prof. Ir. Dr. Mardina Abdullah
Chair
Local Organizing Committee
6th Asia-Oceania Space Weather Alliance (AOSWA) Workshop
Space Science Centre (ANGKASA)
Institute of Climate Change
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor, Malaysia
E-mail: aoswa[at]ukm.edu.my

[07]-----

See:
Parker Solar Probe.pdf
006

*****[End of this issue of the ISWI Newsletter]*****

June 28th, 2023

3PM Central European Time
(9AM EDT; 6:30PM IST)

Solar Flares and Space Weather



Dr. Lucia Kleint

University of Bern

Eruptions on the Sun, called solar flares, are extremely powerful. Their violent nature and influence on Earth were realized in 1859 when English astronomer R. Carrington suddenly saw an unexpected brightening on the Sun. Lasting only a few minutes on the Sun, the event was followed by intense space weather with auroras seen as far south as Hawaii, and by failures of telegraph systems, whose operators suffered from electric shocks.

Research in flare physics has determined that the energy stored in the solar magnetic field is powering the eruptions. Particles accelerated during magnetic reconnection events precipitate into interplanetary space, but also towards the solar surface where they cause many observable phenomena, such as heating, mass motions, and emission in the whole electromagnetic spectrum. Large solar eruptions are the main causes of severe space weather events, which can affect satellites and communication. In this presentation, I will give a closer look on the origins of space weather and the current research on solar flares.



To get the webinar link,
you need to first register.

Put “ISWI Seminar Registration” in
the subject line.

001



ICTP-SCOSTEP-ISWI School

002

and

Workshop on the Predictability of the Solar-Terrestrial Coupling – PRESTO

29 May - 2 June 2023, Abdus Salam International Center for Theoretical Physics, Trieste, Italy

A joint workshop and school covering SCOSTEP and ISWI science topics were recently hosted by the Abdus Salam International Center for Theoretical Physics (ICTP), Trieste, Italy.

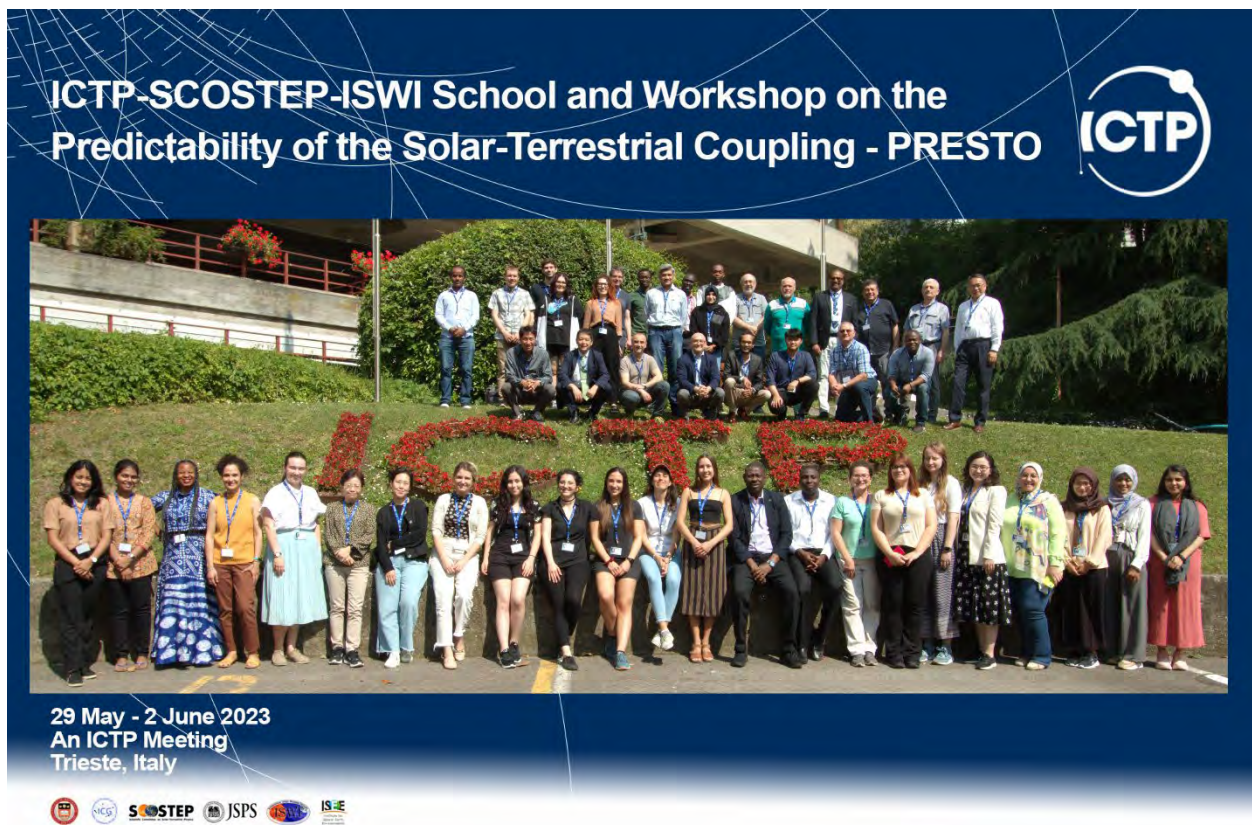


Figure 1. The Space Science School group photo.

ISWI/SCOSTEP School

The one-day capacity building activity held on 29 May 2023 is a key activity common to both ISWI and SCOSTEP. The school covered the following topics.

Extreme Space Weather Events (Nat Gopalswamy, NASA/GSFC)

An Introduction to Earth-affecting Solar Transients (Jie Zhang, GMU)

Magnetosphere dynamics in the MHD approximation and its connection to the auroral ionosphere (Kazuo Shiokawa)

Ionosphere variability at equatorial and low latitudes (Nicholas Pedatella, NCAR)

Fundamental Physics of Magnetohydrodynamic Processes in the Sun (Ramon Lopez, UT Arlington)

Solar influences on climate, with some statistics (Stergios Misios, Greece)

These one-hour lectures were designed to enable the students to better absorb the material presented during the workshop.

The PRESTO Workshop

The workshop focused on PRESTO (PREdictability of the variable Solar-Terrestrial cOupling), which is the current international science program of SCOTEP. PRESTO seeks to improve the predictability of energy flow in the integrated Sun-Earth system on various times scales from milliseconds to centuries by promoting international collaborative efforts. The sessions were designed to highlight the new results obtained under the PRESTO program.

The workshop included keynote talks, invited talks, contributed talks, poster presentations (including flash talks advertising poster). The workshop content was distributed into seven scientific sessions:

Session 1. Observations and modelling of solar eruptions, solar wind and SEPs from Sun through interplanetary space (conveners: Spiros Patsourakos Emilia Kilpua Allison Jaynes).

Session 2. Prediction of solar transients, streams/SIRs and SEP from Sun to geospace (Emilia Kilpua Spiros Patsourakos Allison Jaynes)

Session 3. Effect of Space Weather on the Earth's ionosphere, thermosphere, and magnetosphere (Duggirala Pallamraju Loren Chang Nick Pedatella)

Session 4. Influence of the lower atmosphere on the mesosphere, thermosphere, and ionosphere (Nick Pedatella Loren Chang Duggirala Pallamraju)

Session 5. Solar forcing specification and impacts on the atmosphere and climate (Stergios Misios Odele Coddington Jie Jiang)

Session 6. Precipitating energetic particles and their effects on atmosphere (Eugene Rozanov Odele Coddington Jie Jiang Stergios Misios)

Session 7. Predictability of the solar cycle (Jie Jiang Stergios Misios Odele Coddington).

Keynote speakers

Each day, the workshop started with a keynote speech last for an hour:

1. **Predictions and Current Progress of Solar Cycle 25.** W. D. PESNELL, NASA Goddard Space Flight Center, USA
2. **Space Weather Predictability** I. DAGLIS, University of Athens, Greece
3. **Atmosphere-Ionosphere coupling and its role in space weather** H. LIU, Kyushu University, Japan
4. **What do we know about the solar influence on the Earth's climate?** E. ROZANOV, PMOD/WRC, Switzerland

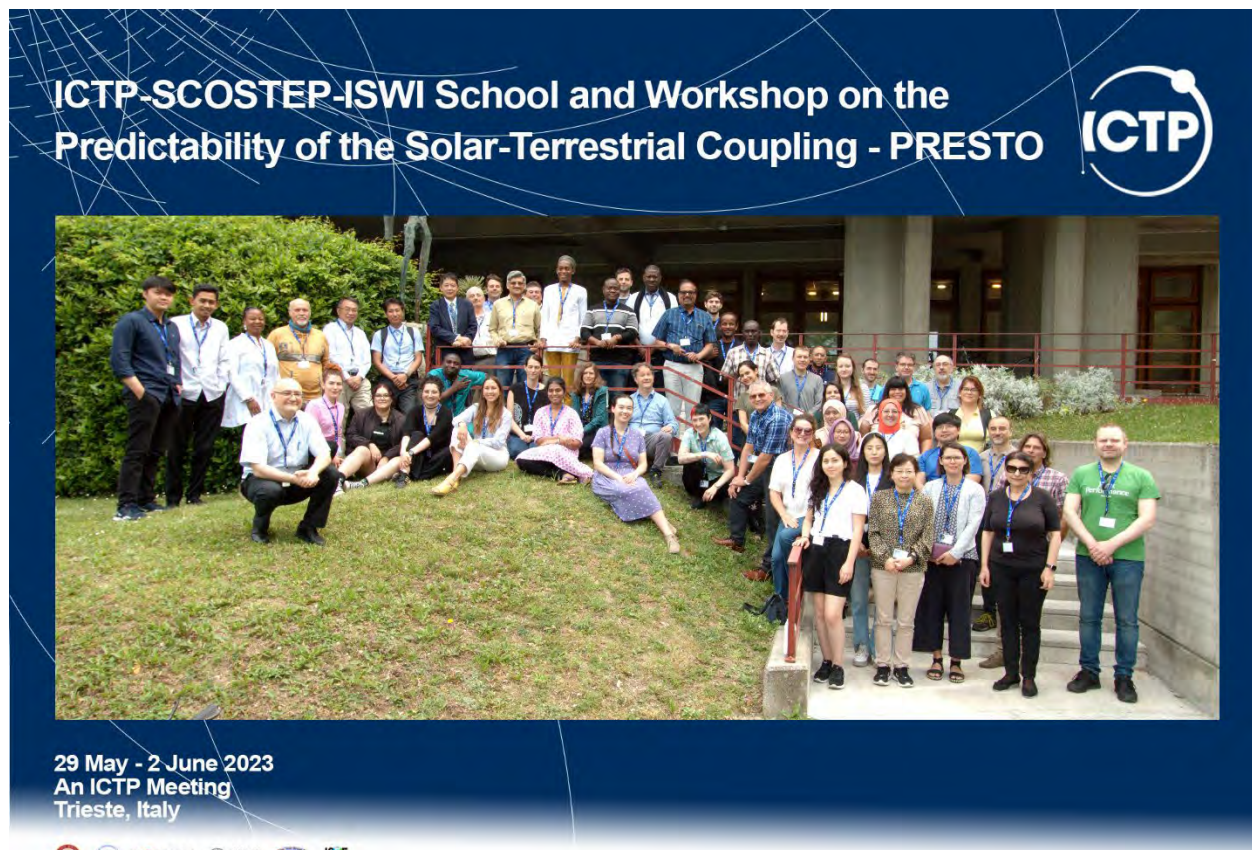


Figure 2. The PRESTO workshop group Photo.

The school/workshop activities were directed by:

Sharafat GADIMOVA (ICG/UNOOSA, Austria), Nat GOPALSWAMY (NASA, USA), Keith M. GROVES (Boston College, USA), Bruno NAVA (ICTP, Italy), Ramon LOPEZ (University of Texas at Arlington, USA), Kazuo SHIOKAWA (Nagoya University, Japan), Local Organiser: Bruno Nava (ICTP)

The school/workshop activities were co-sponsored by:

- The Scientific Committee on Solar Terrestrial Physics,
- The International Space Weather Initiative (ISWI),
- The International Committee on Global Navigation Satellite Systems,
- Japan Society for the Promotion of Science,
- ISEE Institute for Space-Earth Environmental Research, and
- Boston College

ISWI and SCOSTEP thank Monica Petronela Ancuta, Viktoriya Lvova, Adriana Pinto, who served in the School/Workshop secretariat to support the local organizer, Bruno Nava.

More details on the school and workshop can be found in:

<https://indico.ictp.it/event/10176>

Nat Gopalswamy

June 14, 2023

Received by ISWI Newsletter editor

G. Maeda on 15-June-2023

003



CRASTE-LF
affilié à l'ONU



SPACE WEATHER SUMMER SCHOOL

Physics and use of tools

October 14-25 2024

Conakry, Guinea

2024

Organized by

National Meteorological Agency
Directorate General for Innovation

With the support

International Space Weather Initiative (ISWI)

and

ICG (International Commission of GNSS)

Under the High Patronage of

The Minister of transport of the Republic of Guinea

Mr Félix LAMAHA

Summary

I.	Committees	page 3
II.	Introduction : The Objectives	page 4
III.	Motivations	page 5
IV.	Courses	page 7
V.	Budget and financing	page 8

I. The Committees

- Honorary Committee

Dr Diaka SIDIBE, Minister of Higher Education, Scientific Research and Innovation
of the Republic of Guinea, President

Madame Rose Pola PRICEMOU, Minister of planning and International cooperation
Vice-Président

- Organizing Committee

KOUROUMA Jean Moussa (ANM/Guinea), President
Innovation Department, Vice-President

Organizing Committee members

SYLLA Mabinty Bagui (ANM/Guinea)

DIALLO Ibrahima Sorry (ANM/Guinea)

BANGOURA Alhassane Denis (ANM/Guinea)

KOMAH Mohamed (Ministry of transport/Guinea)

MAOMOU Moriba 2 (ANM/Guinea)

BAH Ibrahima Mbemba (ANM/Guinea)

DIALLO Fatoumata Binta (ANM/Guinea)

CONTE Oumou (ANM/Guinea)

DIAWARA Finou (ANM/Guinea)

GUILAVOGUI David (ANM/Guinea)

DORE Souwala (ANM/Guinea)

Scientific Committee

LOUA René Tato President (ANM/Guinea)

GNABAHOU Allain Vice-President (MESRSI/Burkina Faso)

GAYE Idrissa Vice-President (University of Thiès/ Senegal,)

LAMAH Daniel (University of Kindia /Guinea)

AMORY-MAZAUDIER Christine (LPP/Polytechnic/UPMC/France)

ZAOURAR Naima (University Hari Boumediene/Algeria),

Faculty team

EMRAN Anas (University Mohammed V/Morocco)

FLEURY Rolland (IMT Atlantique, Brest /France)

KANTE Ibrahima Kalil (AGAC, Guinea)

KEITA Ibrahima (CERESCOR/Guinea)

OULARE Faya (UJNK/Guinea)

GRODJI Franck (University Houphouët Boigny/Côte d'Ivoire)

IBIASSY Geoffroy (University Marine Ngouabi/ Congo)

KAFANDO Pétronille (Université de Ouagadougou/Burkina Faso)

LECONTEL Olivier (LPP/France)

LE HUY Minh (Institut de géophysique de Hanoï /Vietnam)

MASSON Sophie (LPP/France)

PITOUT Frédéric (IRAP/ France)

KANTE Ibrahima Kalil (AGAC/Guinea)

SOULA Serge (University Paul Sabatier/France)

YAHIAI Yasmina (University Hari Boumediene/Algeria)

ZAOURAR Naima (Université Hari Boumediene/Algeria)

ZAKA Komenan (University Houphouët Boigny/ Côte d'Ivoire)

ZERBO Jean Louis (University Bobo Dioulasso/Burkina Faso)

II. INTRODUCTION

As part of the international ISWI (International Space Weather Initiative) project, in collaboration with GIRGEA, the 6th IMA (ISWI Maghreb Africa) school will be held in Conakry in October 2024.

The main aim of this school is to raise the level of expertise of students and professionals from the sub-region, enabling them to participate in and contribute to international projects. The two key points are :

- 1) Competence in the use of existing datasets and tools for terrestrial environmental studies; a large amount of environmental and geophysical data is available. The use of existing data is estimated at less than 10%. These data, using new technologies, knowledge of physical phenomena and various models, are the source of original scientific work.
- 2) The development and use, by Maghreb and West African scientists, of the results of studies combining environmental sciences and sustainable development by combining ground data with satellite data - e.g. for geophysical studies, telecommunications, positioning etc...

To achieve these objectives the courses will include:

- 1) A scientific part for understanding the measurements, information that can be extracted from the data and examples of applications in different fields.
- 2) A computer part on the algorithms used, their performance, and their installation.
- 3) Practical computer work for the use of algorithms and ground and satellite databases.
- 4) The use of models like TIEGCM, CTPIM, IRI, NeQuick, IGRF.
- 5) Presentations of information on new technologies used in this field such as Grid computing, Web services, databases

Therefore, we offer a school to use and discover :

- 1) All the possibilities of measurements from the ground network of GNSS stations, radar and other instruments located in Africa and around the world, as well as measurements available via Internet:
 - a. Studies of the ionosphere and the Sun's impact on the Earth's ionized environment (International Heliosphere Year and ISWI project);
 - b. Exploiting other instruments for development.
- 2) Geographic information systems to manage and visualize spatial data in all fields
- 3) The development of local databases and the use of existing databases via the Internet and an introduction to new technologies.

The aim of this school is to develop data analysis in Africa, and thus make the most of numerous existing projects (IHY: International Heliophysical Year, ISWI: International Space Weather Initiative, etc.).

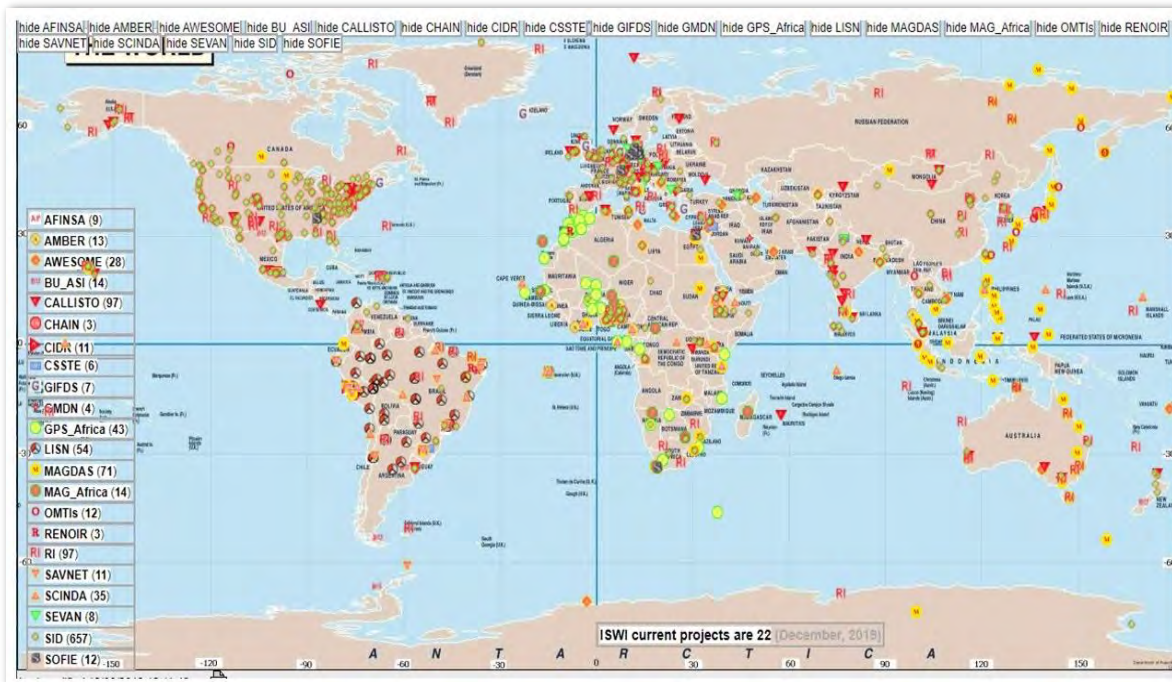
It will also provide an opportunity for researchers and scientists from the Maghreb and West Africa who wish to learn or acquire the skills to use existing datasets and tools related to Space Weather studies, to participate in and contribute to international projects.

The IMA schools also bring together young researchers from different Africa countries to forge lasting and fruitful collaborative relationships.

III. MOTIVATIONS

1 Instrument networks in Africa and worldwide

Following on from the International Heliophysical Year 2007-2009 project, the International Space Weather Initiative ISWI program (2010-2012) has continued to develop instrument networks on the African continent and worldwide, including networks of GNSS stations, magnetometers, radars, etc.... (See figure below from <http://www.iswi-secretariat.org>).



GIRGEA (Groupe International de Recherche en Géophysique Europe Afrique www.girgea.org) has been present in Africa for over 30 years, and has developed research teams in various countries in Africa (Algeria, Burkina Faso, Côte d'Ivoire, Egypt, Guinée, Morocco, DRC, Senegal, etc.) and Asia (Vietnam, Nepal, Pakistan, etc.).

In tropical and equatorial zones, it is necessary to know the contributions of the ionosphere (ionized layer surrounding the earth and located between 90 and 1000 km) and the atmosphere to the GNSS signal for numerous and diverse applications, as the crossing of these two media disturbs the signals received.

This school will focus on

- GPS applications to study the impact of the sun on the ionized layers of the atmosphere;
- Ocean-atmosphere interface and climate variability;
- Meteorological applications for sustainable development;
- GIS and remote sensing;
- EGNOS.

The adoption of information and communication technologies (ICT) and access to the Internet are booming in Africa, but because of their rapid growth worldwide, the digital divide between Africa and the rest of the world persists. So it's important to inform and train scientists and students about new database management techniques (creating and using existing ones): Data warehousing, data

mining, mass data analysis, etc. We need a better understanding Internet network monitoring methods, to check its evolution, and accessing computers and the computing grid to enable them to exploit their data, run their simulations, and collaborate with teams from all over the world.

2. Formation : ECOLE de METEOROLOGIE DE L'ESPACE

GIRGEA has already organized schools in Côte d'Ivoire (1995, 2017, 2022), Republic of Congo (2009), Egypt (2010), DRC (2011), Algeria (2013), Morocco (2011, 2014, 2015), Senegal (2019). All previous school reports can be found at www.girgea.org.

The schools aim to:

- 1) to introduce students to Sun-Earth relations and Space Meteorology with specialists from different disciplines (Sun physics, solar wind, magnetosphere, ionosphere, troposphere and internal and external magnetic field), to Ocean-atmosphere interaction.
- 2) analyze existing data from these different disciplines, using digital tools such as computing grids, data servers, the Internet and intensive computing resources,
- 3) develop student scientific mini-projects on a given event,
- 4) learn how to manage a project, write a thesis and publish scientific papers, and take part in national and international calls for tenders,
- 5) promote exchange and cooperation between students of different nationalities,
- 6) to publish in refereed journals, despite the sometimes difficult-to-find costs.

3. The project

The school is open to 40 participants from universities in west, central and east Africa and North Africa. Participants must already have a basic knowledge of computers and databases.

The aim of the school is to enable participants to :

- Master GPS handling and information gathering in the field;
- Master the use of GPS data according to their field of expertise and possible applications;
- Introduction to cartography and mastery of basic and advanced GIS functionalities using various standard software packages;
- Enhance knowledge of climate variability and ocean-atmosphere interaction;
- Promote synergy between GIS and GPS in different fields of application.

At the end of the course, participants should be able to:

For Space Weather

- Analyze solar activity and its impact on the Earth's environment and related systems.

For GNSS

- Know how to use a GPS (different instrument functions, installation);
- Quantify the various errors in positioning accuracy and analyze correction systems such as local differential GNSS or geostationary satellites,
- Exploit measurements on the ground or on board satellites/sondes for morphological studies of the atmosphere, ionosphere and geodesy,
- Analyze existing satellite navigation systems and their evolution;
- Know the different fields of application.

For SIG

- Build a geographic database (opening and creating layers, scanning, digitizing, structuring and organizing geographic data, modifying or deleting graphic objects, changing coordinates and manipulating projection systems, geo-referencing, integrating GPS points into an existing base map);
- Carry out thematic and spatial analyses (cartographic rendering);
- Know the equivalences between software (principles and terminology).

For GPS and GIS

- Know how to handle: recording, identifying, storing, searching for coordinates of points in the field, transferring points, etc. ... ;
- Know the databases of interest in the various fields covered;
- Know how to collect field data from a GPS and transfer it to a GIS.

For new technologies

- Know the calculation resources available and the underlying techniques,
- Know how to create databases and portals to access them,
- Technical support for network monitoring,
- Participate and collaborate in the global effort for new technologies.

Practical applications should be based on a variety of thematic data and concern areas of national interest.

An analysis of the targeted needs of the participants and their level will be made as soon as registration opens.

We recommend that registered students bring their own laptops.

Course content is generally provided at the end of each session.

Participants will include master's students, thesis students and staff from universities and other organizations requiring training upgrades.

IV. COURSES

-2 weeks of 40 hours spread over 10 days => ~ 80 hours

A detailed timetable will be proposed in November 2023

V. ESTIMATED BUDGET

As far as school funding is concerned, GIRGEA is a network with no permanent infrastructure, and only runs training schools as part of major projects with the help of various laboratories and international structures. The institutions of the professors taking part in the training contribute by covering the mobility of the teachers. The GIRGEA rules of procedure suggest that the country organizing the school should pay for the catering and accommodation of teachers and students. In keeping with the GIRGEA spirit of helping and sharing knowledge, teachers do not receive per diems. Half of the students attending the school are from the host country, and the other half come from Maghreb and West African countries.

Student tickets are paid for by various organizations (AUF, French embassies, PNST, CNRS, SCOSTEP, ICTP, ICG, EGNOS, Nagoya University etc.).

Local budget covered by Guinea

	Quantity	Description	P.U. (fr guinean)	Cost (fr guinean)	Cost (euros)
Supplies	100	Ballpoint pen with badge	50000	5 000 000	571
	100	Folder with flap	5000	500 000	82
	5	Carton of reams of paper	50000	250 000	55
T-shirts	100		150000	15 000 000	1 658
Restauration	1320 (60 pers.x11jx2)	Coffee break	15000	19 800 000	2 179
	660 (60 pers.x11j)	Lunch (startee/resistance/ mineral water/dessert/water in room)	250000	165 000 000	17 957
Transport / logistic	12j	Mini Bus vehicle rental	1000000	12 000 000	1 332
	11j	Conference room	1500000	16 500 000	1 821
Accommodat ion	240	(20 rooms with 2 beds for 12 nights)	900000	216 000 000	23 499
	240	(20 rooms with 1 bed for 12 nights)	1000000	240 000 000	26 106
Fees	20	Teachers (Dinner)	250000	5 000 000	571
	40	Auditors (Dinner)	250000	10 000 000	1 115
Excursions	2	Excursions	5000000	10 000 000	1 115
Media coverage	5	TV, Radio, online Press	3000000	15 000 000	1 658
Unforessen events	1		5000000	5 000 000	571
				735 050 000	80291

Air tickets for certain teachers paid for by their institution when the institution is able to pay for them.

Countries	Cost per unit (euros)	Number	Total cost (euros)
Algeria	300	3 /2	900
Burkina Faso	300	2	600
Côte d'Ivoire	300	2	600
France	750	7/6	5250
Morocco	1200	1	1200
DRC	300	1	300
Republic du Congo	300	1	300
Tunisia	500	1	500
Vietnam	1700	1	1700
Total		19	11350

Student air tickets (2 per participating country)

Country	Cost per unit (euros)	Number	Total cost (euros)
Algeria	300	2	600
Benin	200	2	400
Burkina Faso	450	2	900
Cameroon	600	2	1200
Morocco	1200	2	2400
Republic of Congo	838	2	1676
Democratic Republic of Congo	650	2	1300
Tchad	1400	2	2800
Rwanda	600	2	1200
Senegal	800	2	1600
Tunisia	500	2	1000
Total		20	15076



PhD Waqar YOUNAS

004

Title : *“Ionospheric and magnetic changes induced by space weather at low-and-mid-latitudes.”*

MAY 31st 2023

Quaid-I-Azam University, Islamabad, Pakistan



External rapporteurs

Dr Art RICHMOND, (*NCAR/USA*)

Dr Michel BLANC, (*IRAP/France*)

Co-supervisor

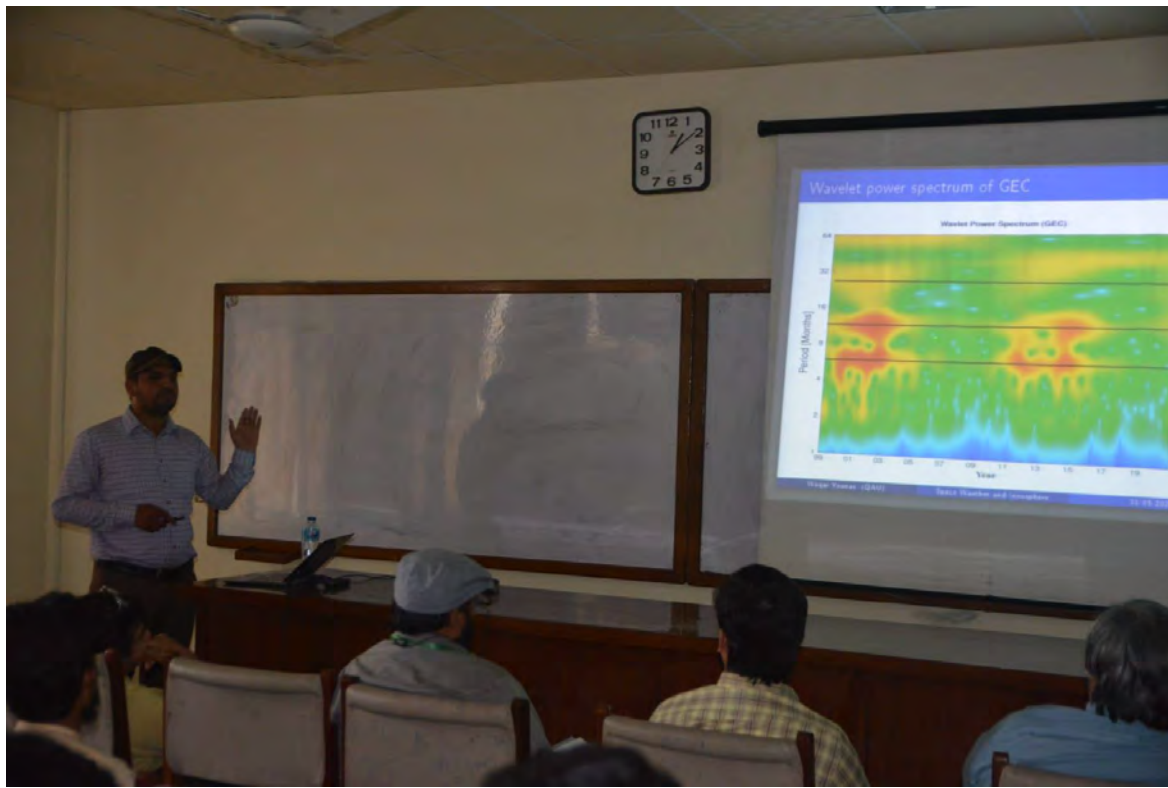
Dr Christine AMORY-MAZAUDIÉR

(*LPP/France*)

Dr Rolland FLEURY, (*IMT, France*)

From the left to the right : Waqar YOUNAS (Candidat), Dr Muhammad KAMRAN (Examiner 2), Dr Majid KHAN (Supervisor), Dr Aman ur REHMAN (Examiner 1) Dr Kashif SABEEH (President, Physics Department of QAU),

Papers included in the PhD

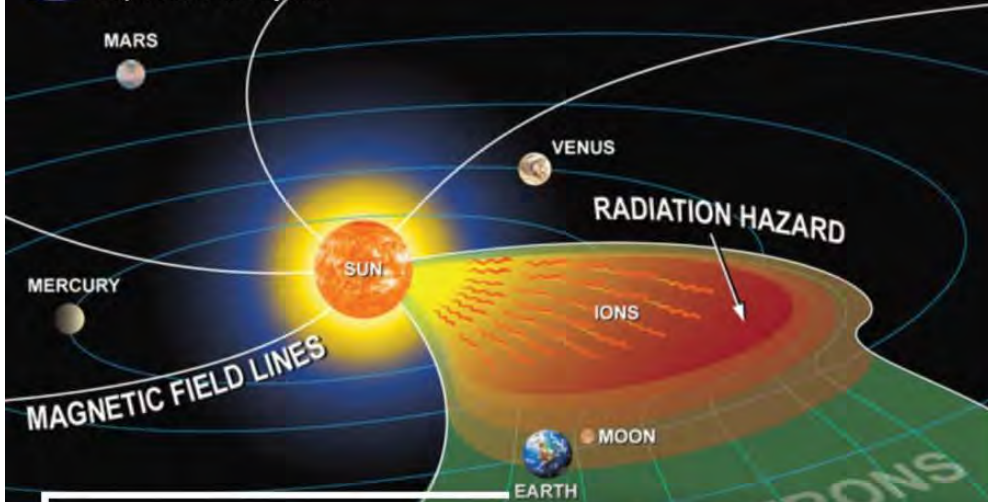


1. Younas, W., Amory-Mazaudier, C., Khan, M., Fleury, R. (2020). Ionospheric and Magnetic Signatures of a Space Weather Event on 25–29 August 2018: CME and HSSWs. *Journal of Geophysical Research: Space Physics*, 125(8). <https://doi.org/10.1029/2020ja027981>
2. Younas, W., Khan, M., Amory-Mazaudier, C., Amaechi, P. O., & Fleury, R. (2021). Middle and low latitudes hemispheric asymmetries in O/N2 and TEC during intense magnetic storms of Solar Cycle 24. *Advances in Space Research*. <https://doi.org/10.1016/j.asr.2021.10.027>



3. Younas, W., Amory-Mazaudier, C., Khan, M., & Le Huy, M. (2021). Magnetic Signatures of Ionospheric Disturbance Dynamo for CME and HSSWs Generated Storms. *Space Weather*, 19(9). <https://doi.org/10.1029/2021SW002825>
4. Younas, W., Amory-Mazaudier, C., Khan, M., & Amaechi, P. O. (2022, July). Climatology of global, hemispheric and regional electron content variations during the solar cycles 23 and 24. *Adv in Space Research*. <https://doi.org/10.1016/j.asr.2022.07.029> •

- Articles which are not included in this dissertation:
- 5. Younas, W., Khan, M., Amory-Mazaudier, C., & Amaechi, P. O. (2022, December 19). Ionospheric response to the coronal hole activity of August 2020: A global multi-instrumental overview. *Space Weather*. American Geophysical Union (AGU). <https://doi.org/10.1029/2022sw003176>
- 6. Khan, J., Younas, W., Khan, M., & Amory-Mazaudier, C. (2022). Climatology of O/N₂ Variations at Low- and Mid-Latitudes during Solar Cycles 23 and 24. *Atmosphere*. <https://doi.org/10.3390/atmos13101645>
- 7. Imtiaz, N., Younas, W., Khan, M. (2020). Response of the low- to midlatitude ionosphere to the geomagnetic storm of September 2017. *Annales Geophysicae*, 38(2), 359–372. <https://doi.org/10.5194/angeo-38-359-2020> v
- 8. Amaechi, P. O., Oyeyemi, E. O., Akala, A. O., Kaab, M., Younas, W., et al. (2021). Comparison of ionospheric anomalies over African equatorial/low-latitude region with IRI-2016 model predictions during the maximum phase of solar cycle 24. *Advances in Space Research*. <https://doi.org/10.1016/j.asr.2021.03.040>
- 9. Bolaji, O. S., et al., Younas, W. (2021). Storm Time Effects on Latitudinal Distribution of Ionospheric TEC in the American and Asian-Australian Sectors: August 25–26, 2018 Geomagnetic Storm. *Journal of Geophysical Research: Space Physics*, 126(8). <https://doi.org/10.1029/2020ja02906>



Introduction to SPACE PHYSICS

Short Summer Course

This course is specially designed for undergraduate students and those Master's students willing to pursue research in Space Physics and in particular Space Plasma.

Main Topics Include

- Introduction to the terrestrial environment
- Interplanetary medium
- Solar wind and its properties
- Space weather and its impact on our modern life

Course Duration: 18-29 July, 2022

Course Fee: 1,000 (For UW Students)

1,200 (For Outsiders)

+92 336 5108095 <http://uow.edu.pk/vas>



Speakers

Dr. Christine Amory-Mazaudier

UMPC, France

Mr. Waqar Younas

PhD Scholar, QAU

Mr. Muhammad Mudassar Abbasi

University of Wah (UW)

Organizers

Dr. Mattiullah

Chairperson- UW

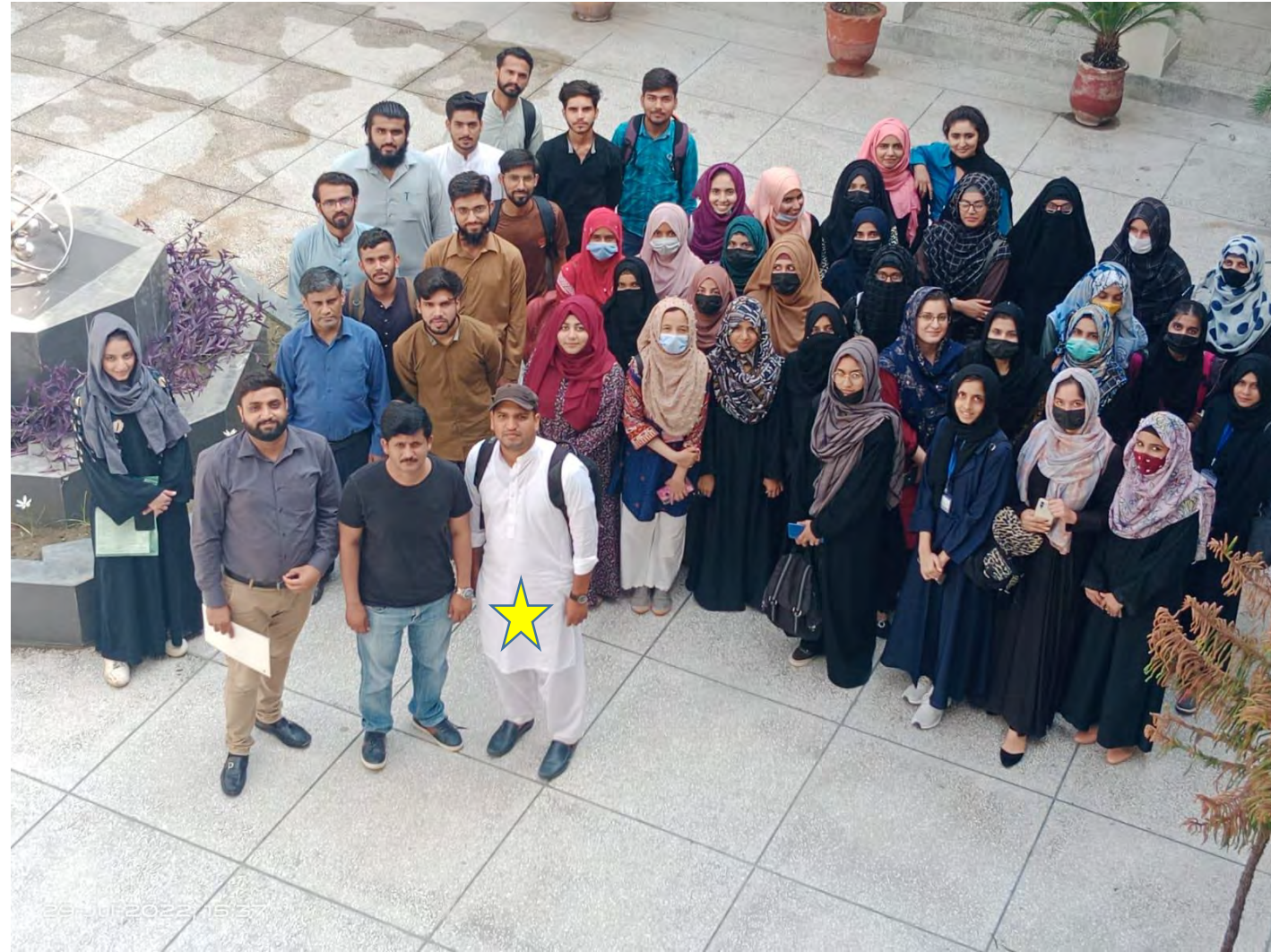
Mr. M. Mudassar Abbasi

Lecturer-UW

Mr. Muhammad Rizwan

Lecturer-UW

Wqar YOUNAS organized in July 2022 a workshop on the Introduction to Space Physics
Waqar YOUNAS is in the front



Exit of Professor Cyril Agodi Onwumechili (20 January 1932 – 16 May 2023)



005

Professor Cyril Agodi Onwumechili (1932-2023)

And so, the news of the passing away of Professor Cyril Agodi Onwumechili came to us with great impact such as in sudden commencement of a geomagnetic storm. The exit of this great and all-round scientist has further depleted the rank of distinguished scientists that have ever come out of Africa. I was privileged to meet him in person for the first time in 1992 when I was a Masters student at the University of Nigeria, Nsukka. It was my mentor and the leader of our space research group who in his characteristic ways of developing different aspects of space science that introduced me to him. He brought me under the supervision of the erudite scholar as he wanted me to learn the science of the geomagnetic phenomena from one of the best in the world. It has since paid off. The day I showed the first results from our plots of sequential variability of geomagnetic field to Prof Onwumechili in 1992 in his make shift lodge opposite IMT Enugu, where I often visit him, was a day I will never forget in my life. He sighted the hand drawn plots and while holding the graph sheets in his hands, danced with joy as if he was holding a baby. Really, a baby was born that very day. I am one of his scientific sons. I had privilege of being in his country home at Inyi, Enugu state, South-Eastern part of Nigeria. We were also with him when he was honoured with the honorary Doctor of Science degree by the University of Nigeria, Nsukka in 2000. He did not only teach me science, he gave me some lessons that border on university administration and culture as well. I found him highly inspiring, truthful, simple, humble, intelligent, creative, brilliant and humane.

Professor Cyril Agodi Onwumechili, born on 20 January 1932, hailed from Inyi (Enugu state, South Eastern part of Nigeria). He was educated at the King's College, Lagos 1944-1949; University College, Ibadan, (then a University of London affiliated College), 1949-1957; International Institute of Nuclear Science and Engineering, Argonne National Laboratory, operated by the University of Chicago, U S A, 1960. He held the following qualifications: B. Sc. General (London) in Pure and Applied Mathematics and Physics, 1953; B. Sc. Special (London) in Physics, 1954; Ph.D. (London) in Physics, 1958; Diploma in Administration and Operation of Nuclear Facilities, 1960. He also possessed honorary Doctor of Science (Hon. D.Sc.) of the following Institutions: University of Ife (now Obafemi Awolowo University), December, 1977; Enugu State University of Science & Technology, May, 1992; and University of Nigeria, Nsukka, April 2001.

Professor Onwumechili worked as Professor at the following Universities: University of Ibadan, Nigeria, 1958 – 1966; University of Nigeria, Nsukka, Nigeria, 1966 – 1978; University of Alaska, Fairbanks, U S A (as Visiting Professor for one year), 1972; and University College of the University of Wales, Cardiff, U K (as Professor on Sabbatical for one year), 1987 –1988. Has served in the following capacities: Head of Department of Physics, for three separate tenures in University of Ibadan and

University of Nigeria, Nsukka. 1965-1966, 1966-1970, 1976-1978; Dean of the Faculty of Science, for four separate tenures in University of Ibadan and University of Nigeria, Nsukka. 1965-1966, 1970-1971, 1973-1976, 1978; Vice Chancellor, University of Ife, Nigeria, Jan. 1979 – Dec. 1982; (now Obafemi Awolowo University, Ile-Ife) and Vice Chancellor (President), Anambra State University of Technology, Enugu, Nigeria, Jan. 1983 – Dec. 1986 (when it consisted of Campuses that became the current Enugu State University of Science and Technology, Enugu; and Nnamdi Azikiwe University, Awka; and it gave birth to Campuses that became the current Ebonyi State University, Abakaliki and College of Medicine, Nnewi).

As a global scientist, he participated actively in the International Geophysical Year IGY (1957-1958). In his career, he established two and directed four geomagnetic observatories. He was a brilliant researcher who directed several research projects financed nationally and internationally; and supervised several successful Masters and Doctoral students. He was the first Editor-in-Chief of the Nigerian Journal of Science. He attended well over 100 international conferences and read papers in most of them.

Onwumechili published extensively for many decades from the late 1950s to early 2000s, his literary articles dominated the space of geomagnetic phenomena **with emphasis on 'equatorial electrojet'**. His name is synonymous with equatorial electrojet EEJ, a current that flows at an altitude of about 106 kilometers and within a narrow strip around the magnetic equator. His contributions have increased our understanding of EEJ. His continuous current distribution model enabled the estimation of the parameters of EEJ, counter equatorial electrojet CEJ, Solar Quiet daily Sq, and counter Solar Quiet daily CSq ionospheric currents from ground- and satellite/rocket data. This Onwumechili model which was first published in Nigerian Journal of Science in 1965 and later re-published in 1967 (in Onwumechili C.A. 1967. Geomagnetic Variations in the Equatorial Zone. Chapter III-2, Volume 1, 83 pp, in: Physics of Geomagnetic Phenomena, Edited by Matsushita S. and Campbell W.H., published by Academic Press, New York.) has continued to be relevant in contemporary research work. Global scientists are utilizing the models to generate parameters of EEJ in American, Indian, Africa and East Asian sectors. His 632-paged treatise **titled "The Equatorial Electrojet", published by Gordon & Breach Science Publishers, Amsterdam, has become the bible of 'Equatorial Electrojet'. The book is available from Taylor and Francis Group, United Kingdom.**

He also **published some good books on University Administration including the 'Cost Effectiveness and Efficiency in African Universities: Experience in Obafemi Awolowo University, Ife in Nigeria', a 227-paged book sponsored by Netherlands Government in 1993, under the Association of African Universities, Accra, Ghana. His biography titled "Coming A Long Way" was published in 2010 by King Printing Company, Lowell, Massachusetts, USA.**and

He served the Nigeria in several capacities and made meaningful contributions to the national development. He was a member of the Governing Councils of the following Institutions: University of Ibadan, 1967-1968; University of Nigeria, Nsukka, 1970-1973 and 1974-1976; Advanced College of Education, Uyo, 1975-1976; University of Ife, 1979-1982; and Anambra State University of Technology, Enugu, 1980-1983 and 1983-1986. He was a member of the following bodies: National Science Research Council of Nigeria, 1973-1976; National Science and Technology Development Agency of Nigeria, 1977-1980; and Panel of Experts that formulated guidelines for a comprehensive and integrated energy policy for Nigeria, 1984. He was a member of the following Commissions: Sixth Form Commission of the National Universities Commission to plan the introduction of Sixth Forms in Nigeria, 1966; Chairman of a Panel of Scientists to formulate and advise the East Central State Government on Agricultural Research, 1971; Visitation Panel commissioned by the Governor of the Western Region of Nigeria to assess the progress, and formulate plans for the future of University of Ife, 1974; Nigerian Energy Commission, 1989-1995; Board Member of National Universities Commission 2002 - 2005. He was the chairman of the following Governing Boards and Councils of the following institutions: PRODA, a Federal Industrial R and D Projects Institute, 1974-1978; Interim

Board of Adeyemi (Advanced) College of Education, Ondo, 1981-1982; the Institute of Agricultural Research and Training, Ibadan, 1979-1982; Industrial Development Centre, Enugu, 1983-1984; and the Anambra State University of Technology, Enugu, 1984-1985.

He was involved in several committee works of many international scientific organisations and activities, some of which are: Commonwealth Consultative Committee on Space Research, 1961-1966; Treasurer, West African Science Association 1961-1965; Manager, Journal of West African Science Association 1962-1967; International IQSY Committee 1963-1967, of International Council of Scientific Unions, as representative of Africa; Several Committees of International Association of Geomagnetism and Aeronomy; International Union of Geodesy and Geophysics; International Scientific Programmes Committee for the International Symposia on Equatorial Aeronomy, 1972-1990 and 1993-2000.

Also at global level, he served in the following capacities: Chairman, Panel of Experts from France, Nigeria, Philippines, Sweden, USSR and Venezuela to advise Secretary General of United Nations on the Plans and Nuclear Capability of South Africa, New York, July-August, 1980; member of the Executive Committee and Board of Trustees of the International Institute for Tropical Agriculture (IITA), 1980-1982; member of International Panel of Experts (ACSTD) advising the United Nations on Science and Technology for Development, 1981-1983; member of Consultative Panels of Experts to advise UNESCO on Higher Education, 1983 - 1984; member of United Nations CSTD Panel of Specialists on Human Resources Development for Planning, Management and Implementation of Science and Technology in Developing Countries, 1983; Vice President of the Association of African Universities, 1984-1989; Chairman of the Management Committee of **UNESCO's** African Network of Scientific and Technological Institutions (ANSTI), 1985-1989; Chairman of International Commission on Developing Countries for IAGA Sciences, 1991-1995; **Chairman, Scientific Committee of "Study Programme on Higher Education Management in Africa"** by Association of African Universities, 1993 to 2002.

Professor Onwumechili was widely travelled and has sojourned in well over 100 cities in all the continents of the world. Of scientific interest were his numerous scientific tours which include the commissioned extensive tour of the following: Educational and nuclear installations in Midwestern and Western USA, 1960; Educational and geophysical institutions in Germany, 1964; Nuclear and some agricultural institutions in France, 1979; and Nuclear reactor installations in USSR, 1974; and all Institutes on Space Research in India, 1991. He was also, at different time, a guest scientist to the following Academies of Sciences: Royal Society of Great Britain, London, 1979; French Academy of Sciences, Paris, 1979; Italian Academy of Sciences, Rome, 1982; Polish Academy of Sciences, Warsaw, 1982; and Bulgarian Academy of Sciences, Sofia, 1986.

Professor **Onwumechili's scientific exploits** were indeed universal and beyond boundaries. In 1964, he was Commissioned by UNESCO to give a series of lectures exploring the appropriate areas of investigation in preparation for the inauguration of the Equatorial Rocket Launching Site at Thumba in Southern India. In 1972, he was a consultant for three months to the Institute for Space Research (INPE), of the National Research Council of Brazil, Sao Jose dos Campos, to formulate and introduce projects, and train some Brazilians for research in a certain area of Geophysics. In 1987, he was a consultant for ten weeks to the United Nations Economic Commission for Africa, to formulate and submit a report on the establishment of African Energy Commission (ANEC). In 1988, He was at the Commonwealth Science Council, London, to prepare draft guidelines on Technology Assessment titled, **"Technology Assessment: Anticipating the Consequences of Technological Choices"**. He was a consultant to the Association of African Universities, in various periods of 1989-1991, on a World Bank sponsored project, **"Study on Cost Effectiveness and Efficiency in African Universities", with a view to** providing guidelines for the development of policies on Higher Education in Africa. Between May and June, 1992, he served as a consultant to United Nations Economic Commission for Africa on **"Experiences in the acquisition** and transfer of nuclear science and technology as applied to agricultural

production, food processing and preservation". In 1993, he was a consultant to the Association of African Universities, on **"Cost Effectiveness and Efficiency in African Universities, Phase II"**, sponsored by Netherlands Government. From 1993 to 2002 he led a project on Study Programme on Higher Education Management in Africa" as a consultant for the Association of African Universities.

Onwumechili was the 2nd President of the Nigerian Academy of Science, 1979-1981. Ownumechili, a Chartered Physicist, held fellowships of several scientific organisations. He was a Foundation Fellow of the Nigerian Academy of Science (FAS) (elected 1977), Science Association of Nigeria (FSAN) (elected 1974), the Nigerian Institute of Physics (FNIP) (elected 1993), and the African Geophysical Society (FAGS) (elected 2014). He was elected as a Fellow of British Institute of Physics (F.Inst.P) in 1969; Fellow of New York Academy of Sciences, 1982; Fellow of the African Academy of Sciences (FAAS), 1987; and Fellow of Third World Academy of Sciences, 1989; among others. As far back as 1968, Professor **Onwumechili's** biography was listed in **"World Who's Who in Science"**, by Marquis Publications. Thereafter, he has been listed in more than ten **"Who's Whos"** including: **"The International Who's Who"**, first in 1986-1987 by Europa Publications.

The reality is here with us that our distinguished Professor Cyril Agodi Onwumechili passed away on the 16th May 2023. He came in a solstice and left in another solstice. With his exit, Africa and indeed the whole world has lost a colossus. He lived a fulfilled life molding men and institutions all over the globe: He was a two-time former Vice Chancellor at two different Universities, a professor of professors, a former president of Nigerian Academy of Science, a professor without border, a global scientist, an embodiment of empowerment, foremost African geomagnetic physicist, an epitome of excellence, a mentor, a flavor of honour, an academic par excellence, an excellent administrator, an all-round scientist, a pioneer nuclear scientist, a pioneer physicist, a space scientist of repute. He started so early in life, bagged two Bachelor degrees in Mathematics and Physics before the age of 22; obtained his PhD degree at the age of 26 in 1958; and became a full Professor at the age of 30 in 1962. It is worthy of note that Onwumechili and one other person were the only two first Nigerian holders of Bachelor of Science in Physics to be ever produced by the now University of Ibadan in 1954. Though out of this world, we shall continue to live with him as we quote his published works in **literatures and bear him in our hearts. Then it is fulfilled of him, that "people like Professor Onwumechili don't die like others; rather they live on in the hearts of those that they have touched positively". Hence, he has become immortal of a sort. His relay batons are in several active hands. His labour has not been in vain. Just like many others who have benefited from him in life, I owe him eternal gratitude in many ways. Sleep on erudite Professor. Adieu Professor Cyril Agodi Onwumechili.**

Professor Babatunde Rabi,
United Nations African Regional Centre for Space Science and Technology Education – English
Obafemi Awolowo University Campus, Ile Ife, Nigeria
<https://www.unoosa.org/oosa/en/ourwork/psa/regional-centres/arcsste-e.html>
<https://arcsstee.org.ng/>
Email: tunderabiu2@gmail.com

How Solar Wind Flows From the Sun Like Water From a Shower Head

The Parker Solar Probe is providing NASA researchers with insights into how the sun accelerates particles to a million miles per hour.

006



By Kenneth Chang

June 7, 2023, 2:37 p.m. ET

Sign up for Science Times Get stories that capture the wonders of nature, the cosmos and the human body. [Get it sent to your inbox.](#)

High-speed particles spew out of the sun like water from a shower head, scientists reported on Wednesday.

Data from the Parker Space Probe, a NASA spacecraft that launched in 2018 and is now swooping in to gather readings of the sun's outer atmosphere, or corona, is providing clues about how the sun generates the solar wind — a million-miles-per-hour stream of electrons, protons and other charged particles rushing outward into the solar system.

The solar wind research ties into a mystery that has long perplexed scientists: Why is the corona, where temperatures soar to millions of degrees, so much hotter than the surface of the sun, which is a relatively cool 10,000 degrees Fahrenheit?

The Parker probe is named after Eugene N. Parker, a University of Chicago astrophysicist who first predicted the existence of the solar wind in 1958.

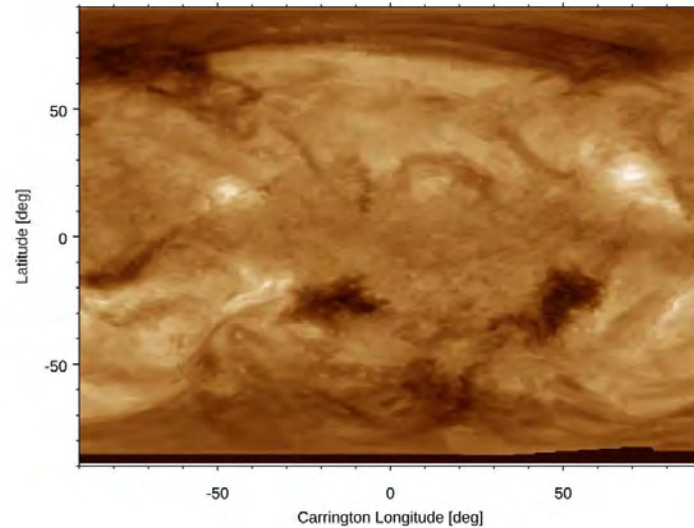
The sun has an atmosphere of tenuous gases that is dragged downward by gravity while pressure generated by fusion reactions within the sun pushes upward.

Overall, the forces balance so that the sun neither collapses nor blows apart. But the forces do not cancel perfectly everywhere, and Dr. Parker's calculations show how the sun can act like a leaky balloon.

"If you put enough pressure in the system," said Stuart Bale, a physicist at the University of California, Berkeley, "the atmosphere can escape. And as it escapes, it's becoming energized."

In a paper published on Wednesday in the journal *Nature*, Dr. Bale, who leads an instrument on the Parker Solar Probe that measures electric and magnetic fields in the solar wind, and his colleagues reported that the streams of solar wind match patterns of hot gases rising and cooler gases falling within the sun. This phenomenon of convection, essentially the same thing that occurs in a thunderstorm, produces up-and-down flows of hydrogen within the sun, and the pattern of flows — like thunderstorms packed next to one another — is known as supergranulation.

The convection of charged particles generates shifting magnetic fields that stretch until they snap and reconnect, releasing energy that contributes to the heating of the corona. That reconnection appears to accelerate the solar wind particles.



An extreme ultraviolet map of the solar corona showing the coronal hole (darker regions around -30 degrees latitude) that were sampled by the Parker Solar Probe. Within these coronal holes, flows in the solar atmosphere create intense, complex magnetic fields that annihilate and produce the pressure and energy to overcome solar gravity. Bale et al., Nature 2023

Earlier observations of the sun had already indicated that solar wind comes out of what are known as coronal holes, regions where the magnetic field continues far outward into space instead of wrapping around and coming back down at another point on the sun.

Imagine a simple bar magnet, which generates a magnetic field similar in shape to the one that surrounds Earth. At the poles, the magnetic fields go straight up and down; those are the coronal holes.

During the sun's quiet periods — solar activity varies on an 11-year cycle, from comparatively calm to hyperactive — the sun's magnetic field possesses this bar magnet configuration. When the Parker spacecraft launched, the sun was near its minimum.

But as the sun approaches the maximum of its cycle, when the magnetic field is in the throes of reversing direction, the structure of the field becomes more complex, and more coronal holes appear.

The Parker spacecraft's instruments detected that the solar wind was not uniform over coronal holes. Instead, the particles emerged in "microstreams," like jets from a shower head.

The space probe's sensors "started seeing that the solar wind had a huge amount of structure," said James Drake, a professor of physics at the University of Maryland and another author of the Nature paper.

The periodic pattern of the microstreams matched that of the supergranulation, suggesting that magnetic reconnection near the sun's surface plays a key role in the acceleration of the particles.

“I could figure out all the characteristics of reconnection,” Dr. Drake said. “I could figure out how much heating was going on. And once we figured out how much heating, I found out it was enough to power the wind.”

He added, “We didn’t have this before at all.”

Gary Zank, director of the Center for Space Plasma and Aeronomic Research at the University of Alabama in Huntsville, said the new results were “one crucial and important step in answering the puzzle of why the solar corona is a million degrees more hot compared to its very relatively cold surface.” Dr. Zank was not involved in the research, but he served as one of the scientists who reviewed the paper for Nature editors.

“It basically says, Here is the mechanism by which we can start to understand how that transfer of energy takes place,” Dr. Zank said.

Kenneth Chang has been at The Times since 2000, writing about physics, geology, chemistry, and the planets. Before becoming a science writer, he was a graduate student whose research involved the control of chaos. @kchangnyt