# Satellite Navigation and Technology for Africa

Joint Program between Boston College and the International Centre for Theoretical Physics, Trieste, Italy

Patricia H. Doherty and Sandro Radicella

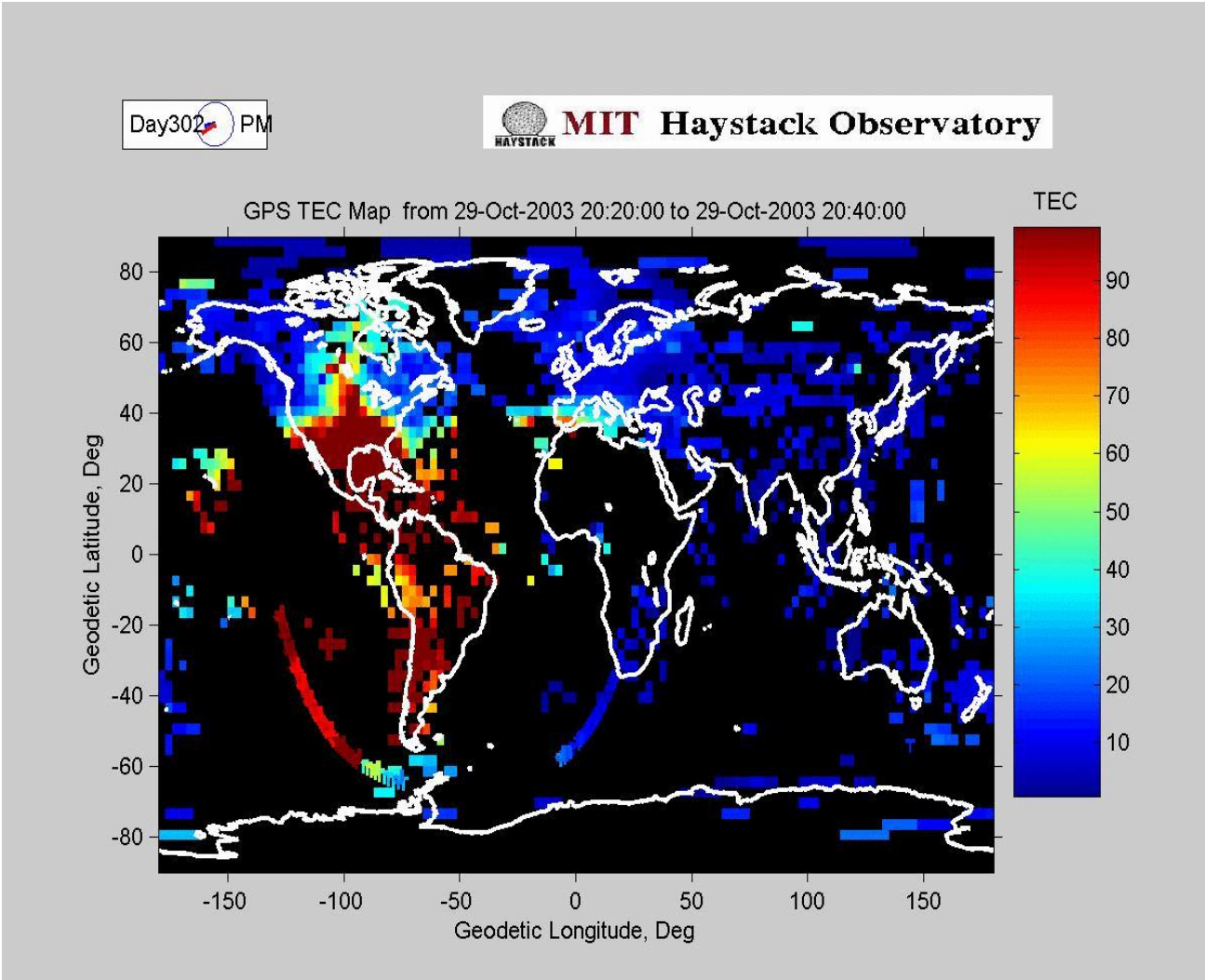

11th Meeting of Working Group C – ICG – 8 November 2016 – Sochi, Russia

# African Ionosphere was a Mystery

Global GPS derived ionospheric mapping during geomagnetic disturbances

Unattainable prior to GPS!

Lack of measurements and limited expertise in Africa




[Coster et al, 2003]

# Project Goals

- To help build a knowledgeable GNSS African workforce
- To encourage the use of GNSS for societal and economic development and scientific exploration
  - Increase food security; manage natural resources; wildlife conservation
  - Provide efficient emergency location services; disaster relief
  - Improve mapping and surveying
  - Provide greater precision and safety on land, sea and air navigation
  - Scientific research and exploration – Space Weather

International Committee on Global Navigation Satellite Systems

# 7 Workshops held since 2009

- Most held at the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy
- 2014 held in Kigali, Rwanda

- Curriculum
  - Fundamentals of GNSS
  - State of the Art GNSS Technologies
  - Scientific Exploration using GNSS
    - **Focus on space weather**
  - Aviation Applications
  - Data acquisition, processing and analysis
  - Lego Robots Contest
  - Geocache Challenge
  - Android phones using GNSS


# 5th Workshop – 2014 Kigali, Rwanda African School on Space Weather

GNSS applications and scientific exploration together with a greater focus on space science and how solar events can affect our technology on Earth – specifically GNSS.


# Increasing number of students and young scientists studying and using GNSS

(Many more applications than we can support)

# Increasing participation by women

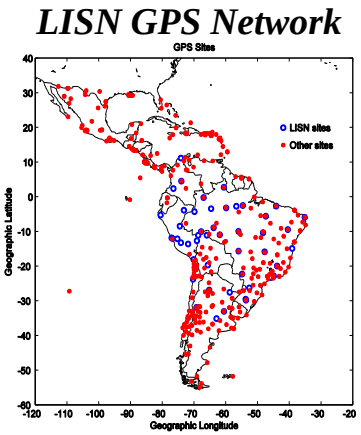
# Participants Appreciate ION Professionals



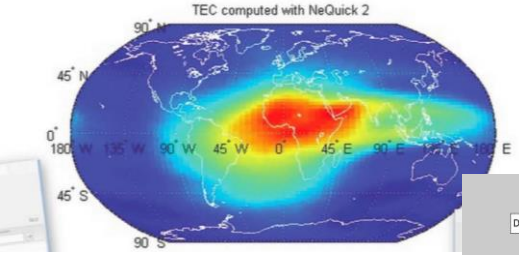
# Many opportunities for research

Improved imaging of the ionosphere over the equatorial region

- dense networks
- 3- tomographic reconstruction techniques

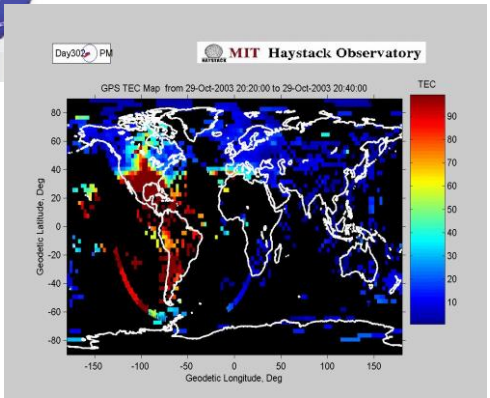



Longitudinal variability of space environment and equatorial spread-f



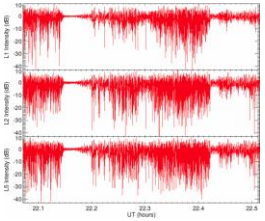

Improved modeling of space environment

Causes of spread –F

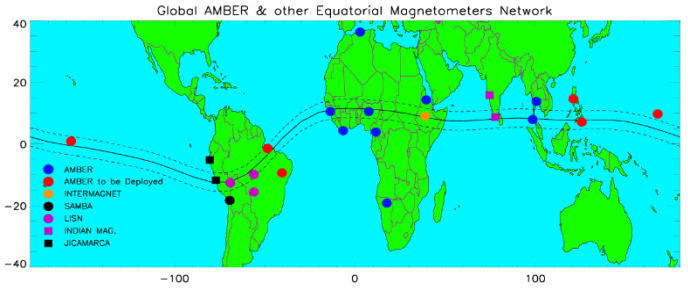



Effects of ionospheric effects on systems – navigation and communication systems

- Scintillation
- Ionospheric storms



Ionospheric rffects on augmentation systems



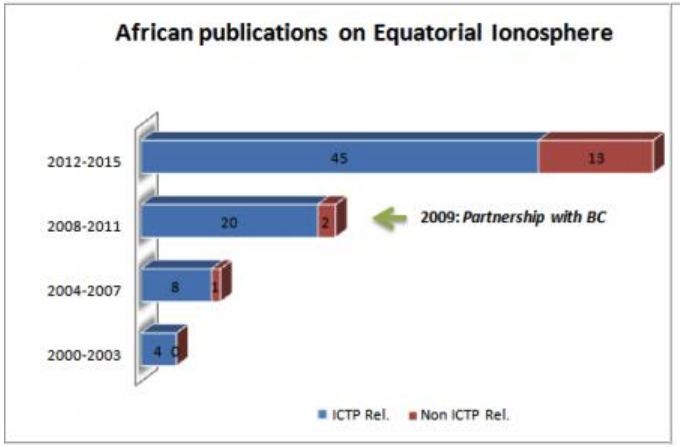

Studies of traveling ionospheric disturbance

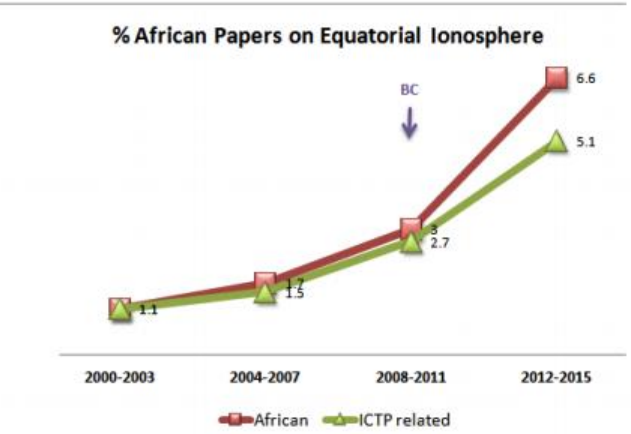
# Workshops Resulted in Sustainable Developments

- Regional workshops
- Government interest
- Infrastructure
- Scientific collaborations
- Programs of study
- New PhD level scientists using GNSS
- Increased publications

## A measure of impact in Africa

Papers published by African scientists working in Africa on "equatorial ionosphere" from World of Science website.




"ICTP Rel." means scientists related to ICTP having attended one or more training activities organized by ICTP and BC or having been ICTP associates or in other ICTP programs like STEP.

# African Success Stories – just a few of many

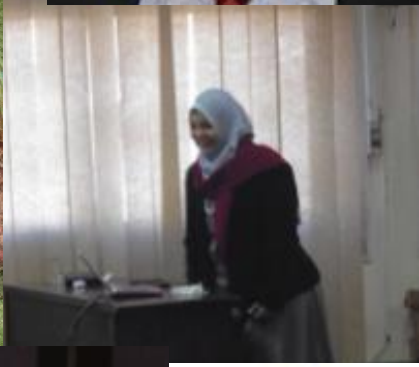
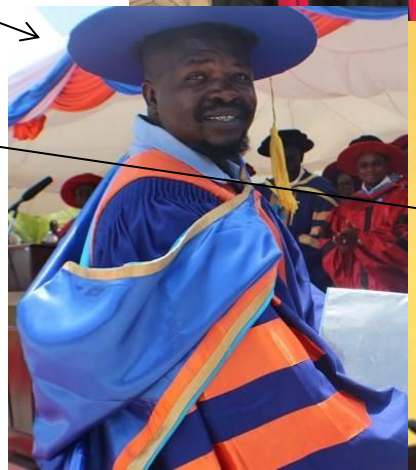
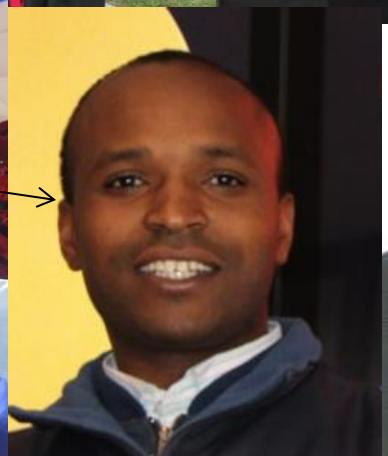
Dr. Babatunde Rabiu
Director NASDRA
President, **African Geophysical Society**
Recently delivered the 70th inaugural lecture at Federal University of Technology, Akure

Dr. Baylie Damtie
President Bahir Dar University
Dr. Melesseuw Nigussie
Bahir Dar University – first PhD recipient

Recent PhDs
**Dr. Joseph Olwendo, Kenya**
Dr. Amira Shimeis, Egypt
Dr. Ibrahim Salem, Egypt
**Dr. John Bosco Habarulema, Uganda**
Dr. Daniel Okoh, Nigeria
Dr. Patrick Sibanda, Zambia
Mr. Olalekan Adekunle Isioye, Nigeria
- Student paper award at ION GNSS+

And others…




# What's Next for the Satellite and Navigation Technology for Africa Program?

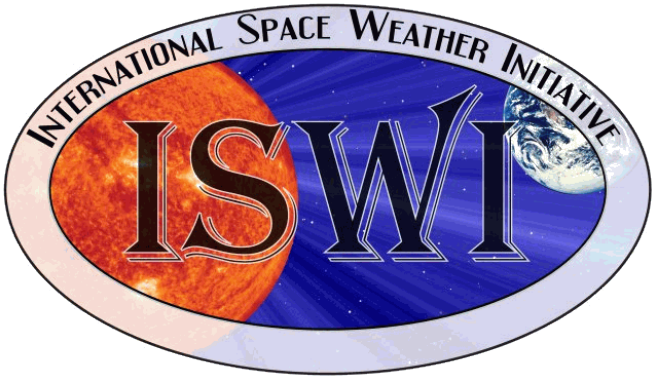
***Reflecting on the future***
***Looking for new ideas***
***Expansion to other nations***


***Next workshop planned for May 22 - June 2, 2017***
***ICTP, Trieste, Italy***
***Focus will be on Space Weather Effects on GNSS Operations***

***Planning a workshop in Africa in 2018***

***Seeking sponsorship and participation***

# International Space Weather Initiative

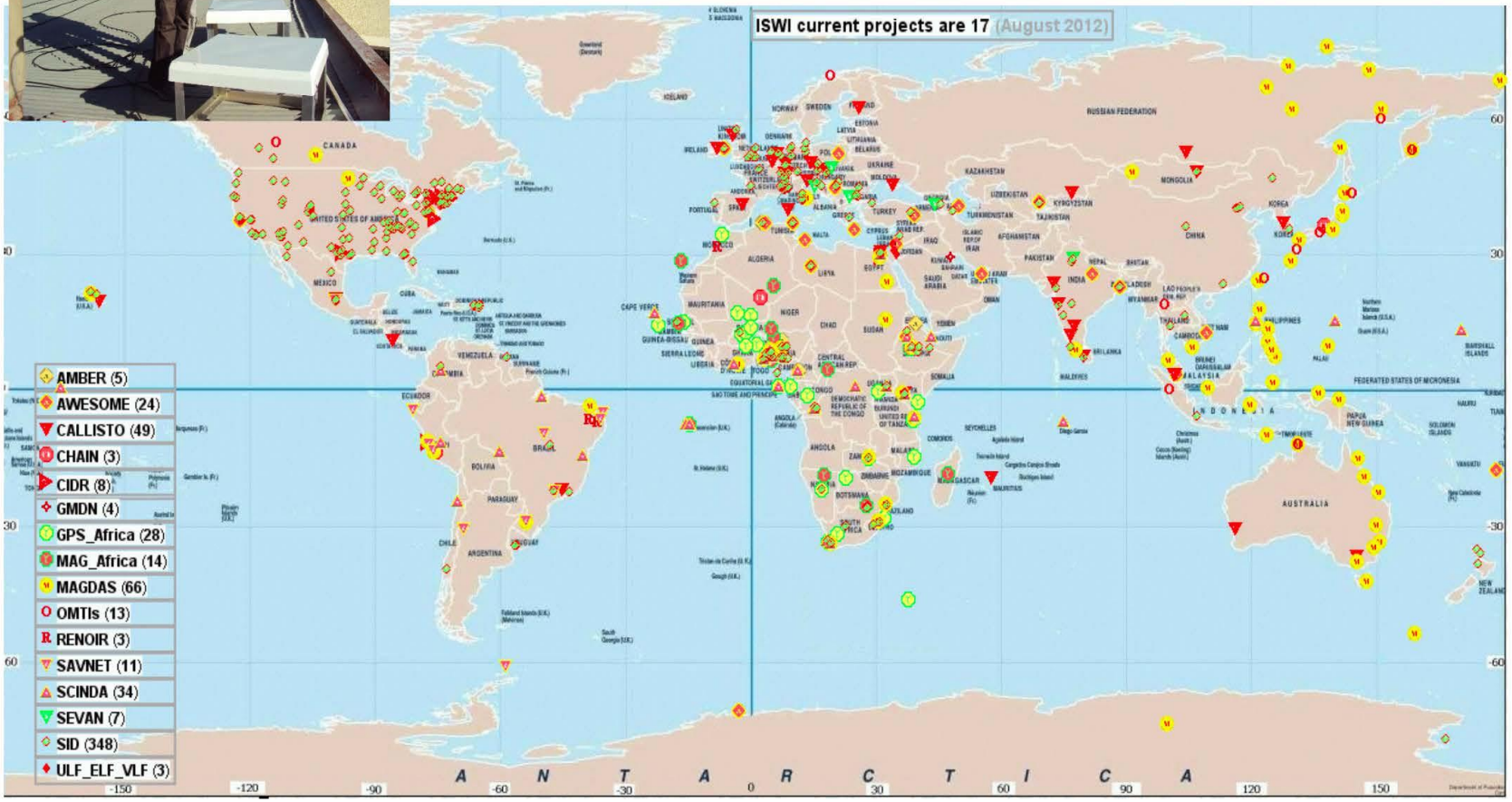



The goal of ISWI is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather.  This includes instrumentation, data analysis, modeling, education, training and public outreach.

ISWI was a follow-on to the International Heliophysical Year (IHY)

IHY (2007-2008) – to understand planetary environments
ISWI (2009-present) – focusing on space weather

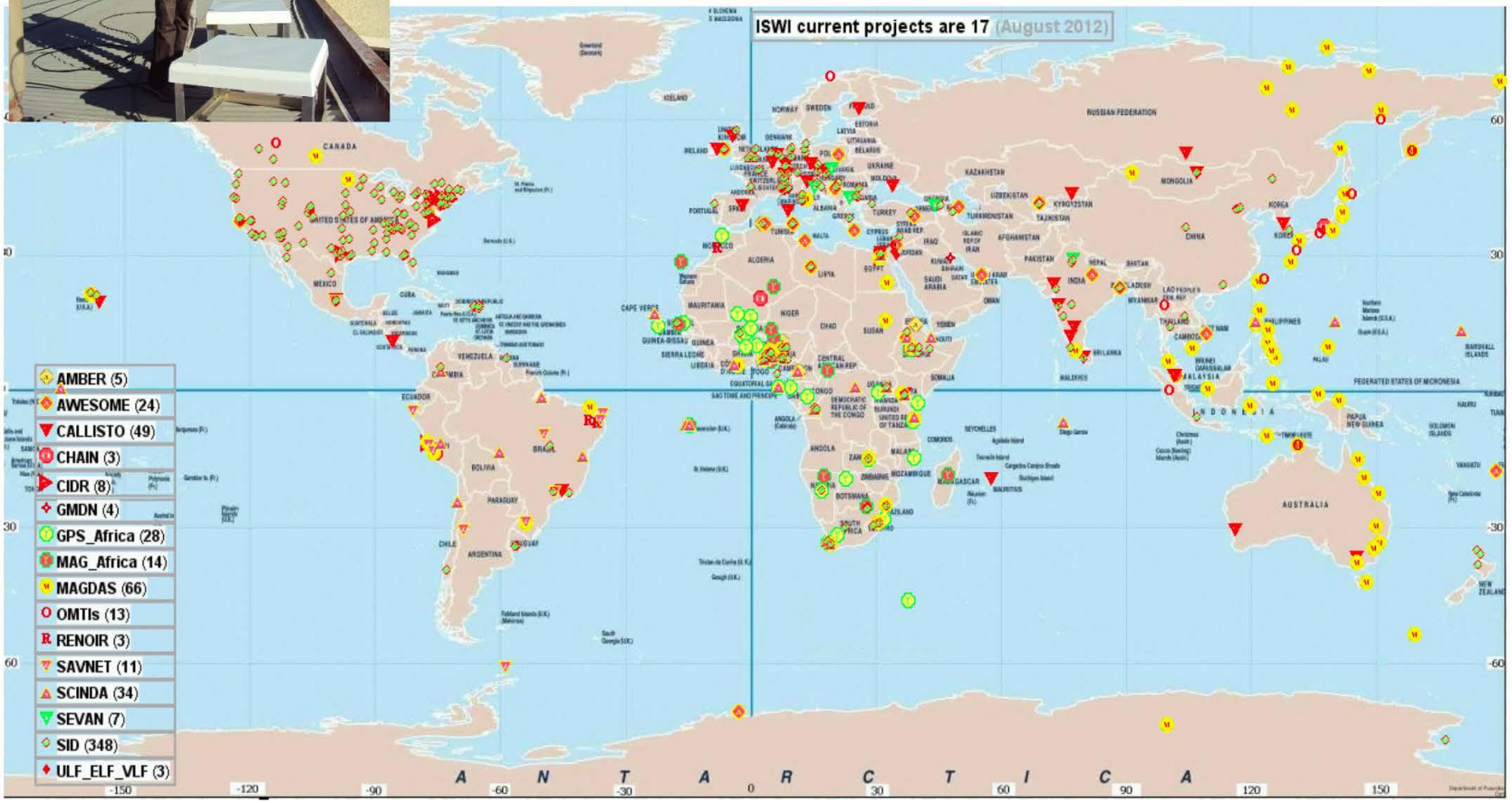
# IHY/ISWI Instrument Sites




17 projects – GPS, Scintillation, Magnetometers, Sudden Ionospheric Disturbance monitors, H-aplha imaging systems, incoherent doppler receivers, ionospheric flare detection systems, ULF/ELF/VLF networks, and more

Courtesy, N. Gopalswamy, NASA

# IHY/ISWI Instrument Sites




Scientists from developed and developing nations work together.
Students and faculty participate at all levels of the instrument project and science.
Data gaps are closed due to deployment at crucial locations.
Heavy focus on Africa, with added opportunities for training.

Courtesy, N. Gopalswamy, NASA

# IHY/ISWI Meetings &Schools

2007: IHY/SCINDA Africa Workshop, Addis Ababa, Ethiopia
2009: IHY/SCINDA Africa Workshop, Livingstone, Zambia

2010: **First UN/ESA/NASA/JAXA Workshop on ISWI**, Helwan, Egypt
2011: Rabat, Morocco; Kinshasa, Democratic Republic of the Congo
High Tatras, Slovakia; Lagos, Nigeria
**UN/Nigeria Workshop on ISWI, Abuja, Nigeria**
2012: Los Alamos, USA
ISWI/MAGDAS School on Space Science, Bandung, Indonesia
**UN/Ecuador Workshop on ISWI, Quito, Ecuador**
2013: MAGDAS School, Abidjan, Cote d'Ivoire
ISWI/SCOSTEP School, Nairobi, Kenya
School for Young Astronomers, Jatinangor, Indonesia
First ISWI School of Maghreb, Bab Ezzouar, Algeria
2014: SCOSTEP/ISWI International School on Space Science, Lima, Peru
2015: Space Weather School in Maghreb, Rabaat, Morocco
**UN/Japan Workshop on Space Weather, Fukuoka, Japan**
2016: SCOSTEP/ISWI School on Space Science, Sangli, Inda (next week)

**2017: UN/US Workshop on Space Weather, BOSTON!!! – 31 July – 4 August**

**4. Secretariat:** Solar Physics Laboratory, NASA/GSFC, Greenbelt, MD 20771, USA

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Shing Fung (Director for Data Coordination) NASA/GSFC

George Maeda (ISWI Newsletter Editor), Kyushu University, Japan

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www.iswi-secretariat.org

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**About ISWI Newsletter:**

It is scheduled to be published throughout the ISWI period, 2010 through 2012, by SERC (Space Environment Research Center) of Kyushu University, Japan. The publisher is Professor K. Yumoto (also Director of SERC) and the editor is George Maeda, who is a member of his SERC staff. This newsletter was requested by Prof. Hans Haubold (United Nations Program on Space Applications) (click here UN PSA archive). His letter is a beautifully concise statement about the mission of ISWI - where it came from and where it is to go.

Read more about this Newsletter

The number of subscribers is **477** (April 02, 2016) (details).

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(International Space Weather Initiative)
Newsletter

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**Four issues of the Newsletter were published in 2009. See the list**

**One hundred and nine issues of the Newsletter were published in 2010 See the list**

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**Hundred thirty-one issues of the Newsletter were published in 2012. See the list**

**One hundred twenty-six issues of the Newsletter were published in 2013 See the list**

**Forty-eight issues of the Newsletter have been published in 2014. See the list**

**Nineteen issues of the Newsletter was published in 2015. See the list**

**Eighteen issues of the Newsletter was published in 2016. See the list**

**GNSS is an enabling technology that can make major contributions to economic growth and societal betterment.**

- **BC/ICTP program promotes the use of GNSS for scientific applications and space weather in developing countries.**
- **ISWI program encourages space weather research and training using multiple space weather sensors including GNSS.**
- **Both programs offer many opportunities for capacity building and information dissemination**

GPS III Satellite (www.gps.gov)

# UPCOMING OPPORTUNITIES

ISWI School, Sangli, India
November 14-18, 2016

URSI/ICTP School on Radio Physics, Trieste, IT
March 27-31, 2017

BC/ICTP Workshop on Space Weather, Trieste, IT
May 22-June 2, 2017

UN/US Space Weather Workshop, Boston, USA
July 31 – August 4, 2017

ICG International Committee on Global Navigation Satellite Systems

# Thank you for your attention!

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