



# GNSS for the Developing World: Collaborations for Scientific Exploration and Applications for Societal Benefits



**Patricia H. Doherty**  
***Institute for Scientific Research***  
***Boston College***

Space-Based Positioning Navigation and Timing  
National Advisory Board Meeting 20 November 2019. Cocoa Beach, Florida

# The Boston College/Abdus Salam International Centre for Theoretical Physics Collaboration and Outreach Workshops



## 2009 - the first joint activity



Satellite Navigation Science and Technology for Africa

23 March - 9 April 2009

ICTP, Trieste - Italy



International Committee on  
Global Navigation Satellite Systems





## G8-UNESCO World Forum on 'Education, Research and Innovation: New Partnership for Sustainable Development'

*(My introduction to the developing world...)*

Africa's Science and Technology Plan of Action (1) clearly states Africa's commitment to develop and use science and technology for socio-economic transformation and full integration into the world economy.



Global Navigation Satellite Systems (GNSS) are a space technology that can help meet that goal.

# GNSS Applications – Significant Benefits to the Developing World

- Increase food security
- Provide efficient emergency location services; disaster relief
- Improve mapping and surveying
- Wildlife conservation and natural resource management
- Provide greater precision and safety in land, sea and air navigation
- Scientific research and exploration – SPACE SCIENCE



Wildlife Conservation



Land Navigation



Precision Farming



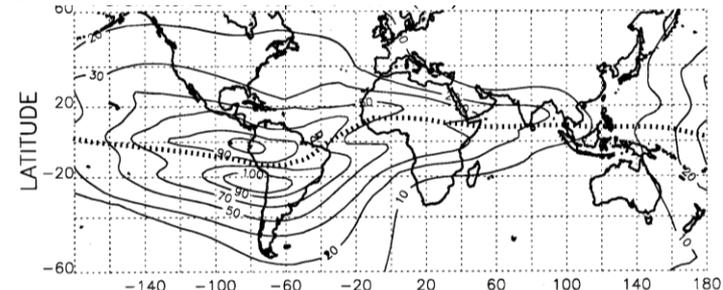
Water Navigation



Air Navigation



Disaster Relief



Scientific Exploration

# Initial 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 in land, sea and air navigation
  - Scientific research and exploration



International Committee on  
Global Navigation Satellite Systems





# 10 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
    - **Ionosphere, Space Weather**
  - Data acquisition, processing and analysis
  - Aviation Applications
  - Lego Robots Contest
  - Geocache Challenge
  - Android phones using GNSS





# 5<sup>th</sup> Workshop – 2014 Kigali, Rwanda

## African School on Space Science

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



# Themes have matured

## *GNSS, Navigation, Ionosphere, Space Weather*

2009: Satellite Navigation Science and Technology for Africa

2010: Satellite Navigation Science and Technology for Africa

2012: Science Applications of GNSS in Developing Countries

2013: GNSS Data Application to Low Latitude Ionospheric Research

2014: African School on Space Science, Rwanda

2015: Ionospheric Effects on SBAS and GBAS Applications at Low Latitudes

2016: The Use of Ionospheric GNSS Satellite Derived TEC for Navigation,  
Ionospheric and Space Weather Research

2017: Space Weather Effects on GNSS Operations

2018: Space Weather Effects on GNSS Operations at Low Latitudes

2019: Ionospheric Forecasting on GNSS Operations in Developing Countries:  
Findings and Challenges

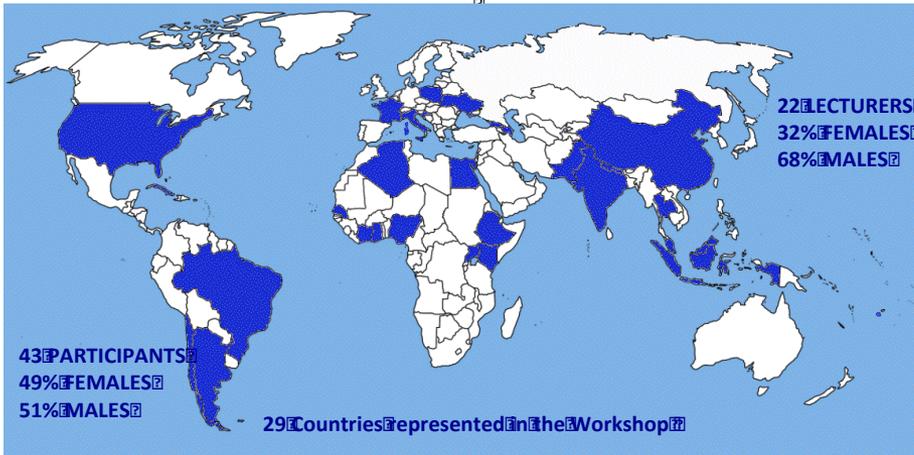
## **Significant Relevance for PNT**



# Geographical Area Extended



Workshop on Space Weather Effects on  
GNSS Operations at Low Latitudes  
The Abdus Salam ICTP  
Trieste - Italy, 23 April - 4 May 2018

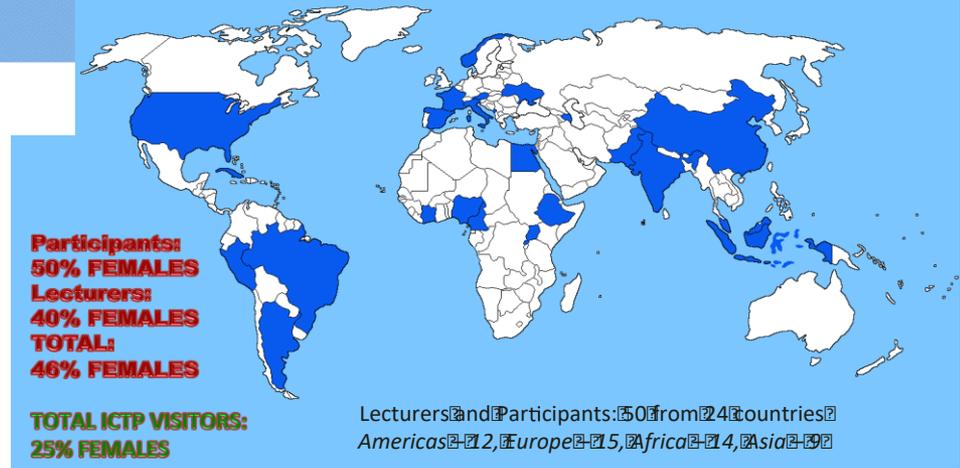


WELCOME

2017 – 24 countries

2018 - 29 countries  
2019 +Mexico

EXTENDED WORKSHOP ON SPACE WEATHER EFFECTS  
ON GNSS OPERATIONS  
The Abdus Salam ICTP, Trieste, Italy, 22 May - 2 June 2017



The Abdus Salam  
International Centre  
for Theoretical Physics



BOSTON COLLEGE

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

(Many more applications than we can support)



# Increasing participation by women

45% in 2018, 49% in 2019



17 women from 14 countries – May 2017

# Hands-On Laboratories

Precision Farming



GNSS Rx/Measurements



Cell Phones for GNSS



Mapping/Surveying

# Small Group Projects

## Typically on Positioning under Space Weather Events

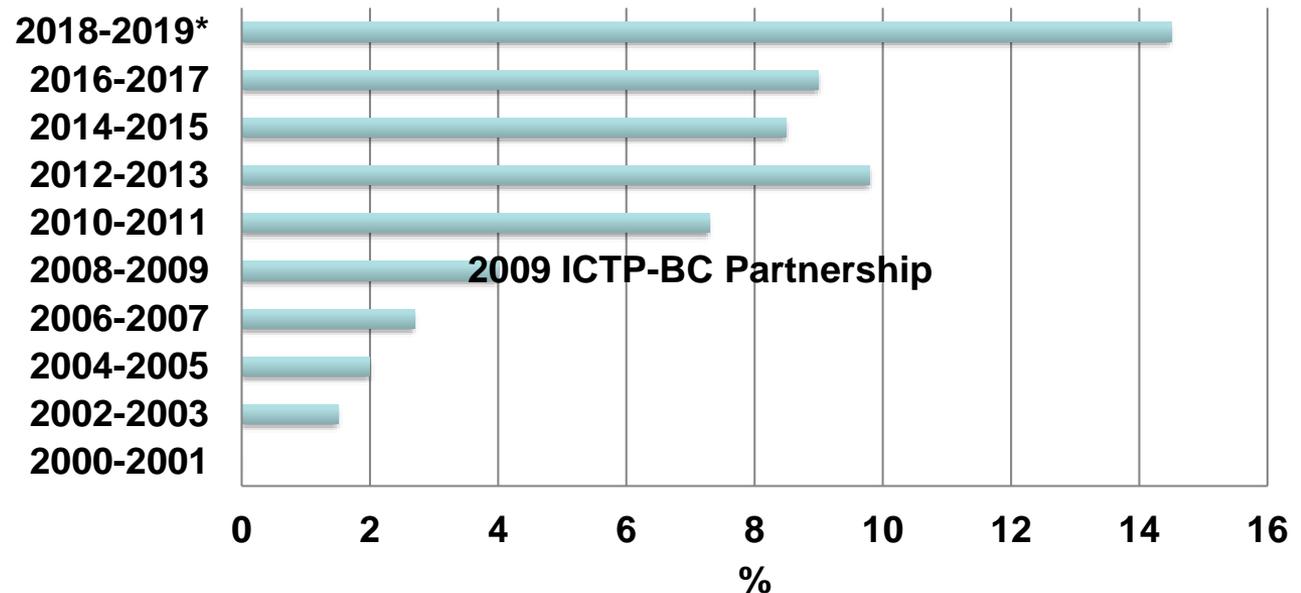


# Workshops Resulted in Sustainable Developments

## Measuring the Impact

- Regional workshops
- Government interest
- Infrastructure
- Scientific collaborations
- Academic programs
- New PhD level scientists using GNSS
- Increased publications

**% of the Total number of papers published on "equatorial ionosphere" by African scientists (first author African working in Africa) (source Web of Science Core Collection)**



**From 2010 to May 2019: 86% of the papers written by African scientists trained through ICTP-BC partnership activities**

# African Success Stories – just a few of many

Dr. Babatunde Rabi

Director NASDRA

1<sup>st</sup> President, **African Geophysical Society**

Delivered the 70<sup>th</sup> inaugural lecture  
at Federal University of Technology, Akure



Dr. Baylie Damtie

Former President Bahir Dar University

President Kepler University, Rwanda



Dr. Melessew Nigussie

Bahir Dar University – first PhD recipient

ICTP STEP Program // AGU Award Winner

Dr. Andrew Akala, Nigeria

BC Fullbright Scholar // AGU Award Winner

PhDs Awarded to former participants

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

And others...





# What's next?



## 2020 - African Workshop on GNSS and Space Weather

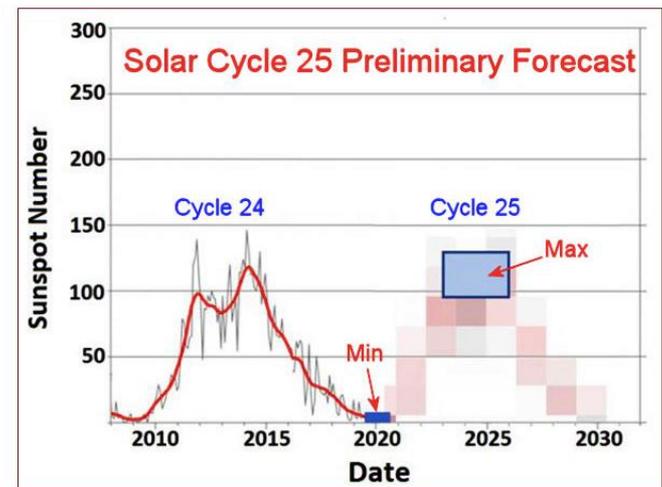
October 5-16, 2020

UN Affiliated Regional Centre for Space Science and  
Technology Education, Rabat, Morocco



**Provide updated knowledge on GNSS status, operations and applications. Tutorials on ionospheric and space weather research using GNSS.**

Workshop expected to gain regional interest. Increased participation by African young scientists and students.



# Participants Appreciate PNT Professionals



# Thanks for your attention!

Please join us in a future workshop supporting the next generation of GNSS knowledgeable scientists in the developing world.

Patricia H. Doherty  
Boston College  
[Patricia.Doherty@bc.edu](mailto:Patricia.Doherty@bc.edu)  
<http://www.bc.edu/isr>



Thanks to our collaborators and sponsors:



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