



Training Activities on GNSS Science and Applications: The ICTP-Boston College Partnership



Yenca Migoya-Orué (ICTP), Sandro Radicella (ICTP) and Patricia Doherty (BC)



The Abdus Salam
**International Centre
for Theoretical Physics**



For 50 years, **the Abdus Salam International Centre for Theoretical Physics (ICTP)** has been a driving force behind global efforts to advance scientific expertise in the developing world.

Founded in 1964 by the Nobel Laureate **Abdus Salam**, ICTP seeks to accomplish its mission, which is to:

➤ Foster the growth of advanced studies and research in physical and mathematical sciences, especially in developing countries.

➤ To develop high-level scientific training programmes and encourage international scientific exchange.

➤ Conduct research at the highest international standards.



Boston College's Institute for Scientific Research (ISR)

Mission: Conduct ethical and innovative research in both experimental and theoretical aspects of space physics, space weather, space and plasma chemistry, solar-terrestrial research and ionospheric studies.

Through research and workshops, ISR also fosters the intellectual development of young scientists from around the world.



"Ever to excel"



Workshop on the Future of Ionospheric Research for Satellite Navigation and Positioning:
its Relevance for Developing Countries

Trieste, December 2006

The ICTP and ISR joined together to host a workshop for the first time in December 2006. The workshop was **on Satellite Navigation and Positioning and its Relevance for Developing Countries.**

Forty six scientists from sixteen countries from **Africa, the Americas, Asia and Europe** participated in the workshop.

The main conclusion of the meeting was the importance of providing **a series of workshop on different aspects of GNSS science and applications for the benefit of developing countries** with particular emphasis on the effects of the ionosphere on GNSS operations.

An International Partnership for Education in Satellite Navigation Science and Technology for Africa

To formalize the cooperation between the ICTP and the BC both institutions signed a **MoU** in **July 28, 2009**. By this document it was established a general framework to promote **GNSS** science and technology programs in developing countries with particular emphasis on **Africa**.



**Memorandum of Understanding
between**



**The Abdus Salam International Centre for Theoretical Physics
and
Boston College**

This MoU is entered into between Boston College, Chestnut Hill, MA, USA and the Abdus Salam International Centre for Theoretical Physics (ICTP) 34100 Trieste, Italy, hereinafter referred to as the “parties”.



Partnership Goals

- 1) To help build a knowledgeable GNSS African workforce
 - 2) To encourage the use of GNSS for societal and economic development and scientific exploration
- Conduct workshops for university professors, lecturers, graduate students
 - Provide equipment and training materials to collaborating universities
 - Provide opportunities and guidance for international scientific research collaborations within Africa and with developed nations for GNSS (space physics, space weather, applications)

GNSS Applications for Africa

- 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



Wildlife Conservation



Land Navigation



Water Navigation



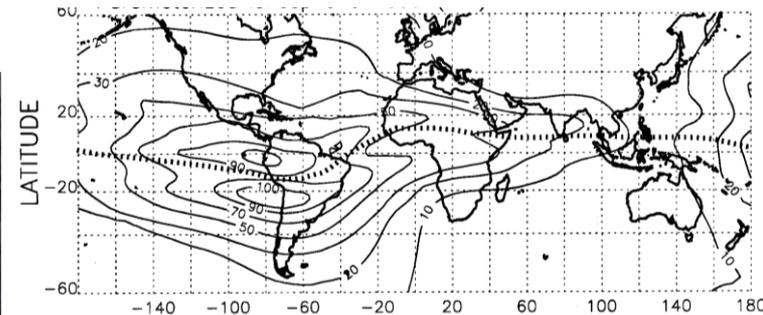
Disaster Relief



Precision Farming



Air Navigation



Scientific Exploration



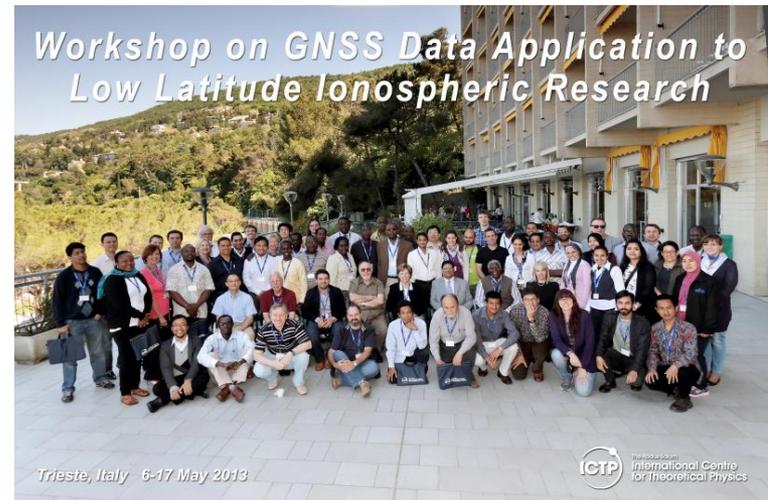
The ICTP-BC workshops series

2009, 23 March - 9 April; Satellite Navigation Science and Technology for Africa, **Trieste**, Directors: S.M. Radicella and P. Doherty

2010, 6 April - 23 April; Second Workshop on Satellite Navigation Science and Technology for Africa, **Trieste**, Directors: Patricia H. Doherty, Sandro M. Radicella.

2012, 11 April - 1 May; Workshop on Science Applications of GNSS in Developing Countries (11-27 April), followed by the: Seminar on Development and Use of the Ionospheric NeQuick Model (30 April-1 May), **Trieste**, Directors: S.M. Radicella, Patricia H. Doherty

2013, 6-17 May; Workshop on GNSS Data Application to Low Latitude Ionospheric Research, **Trieste**, Directors: S. M. Radicella, P. Doherty, R. Prieto, B. Nava



The ICTP-BC workshops series



2014, 30 June – 11 July; African School on Space Science: Related Applications and Awareness for Sustainable Development of the Region, **Kigali (Rwanda)**, Directors: C. Amory, P. Doherty, B. Nava, S. Radicella and J. Uwamahoro.

2015, 2-13 March; Workshop on Ionospheric Effects on SBAS and GBAS Applications at Low Latitudes, **Trieste**, Directors: S. M. Radicella, P. Doherty, B. Nava.

2016, 20 June - 24 June; Use of Ionospheric GNSS Satellite Derived Total Electron Content Data for Navigation, Ionospheric and Space Weather Research, **Trieste**. Directors: S.M. Radicella, P. Doherty, B. Nava.

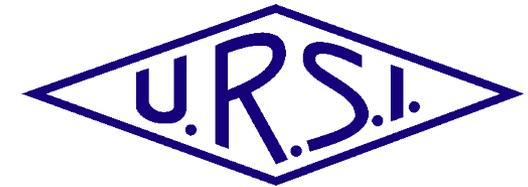
2017, 22 May – 2 June; Extended Workshop on Space Weather Effects on GNSS Operations, **Trieste**, Directors: S.M. Radicella, P. Doherty, B. Nava.



International Committee on
Global Navigation Satellite Systems



UNOOSA



Acknowledgements

The series of workshops were possible thanks to the sponsorship and financial support of several institutions. In particular, the contribution of the **ICG** allowed the participation of diverse developing country scientists to these activities.

The series of ICTP-BC workshops

Our lecturers are highly skilled professors, scientists, engineers and research associates from different prestigious Institutions around the world.

Lecturers and presenters are really **passionate** about topics.



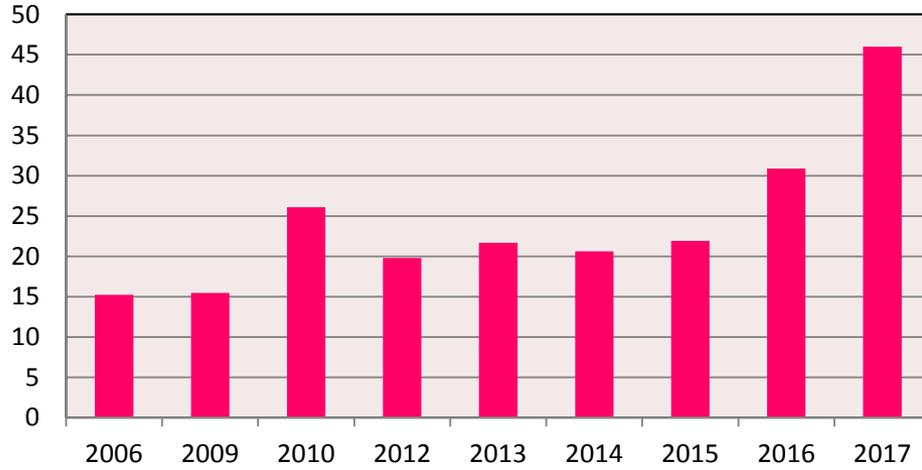


Workshops always provide an opportunity for “hands-on” or skill-based practice and learning.

Laboratory sessions include demonstration of methods of practical application like GNSS data acquisition, analysis, robotics, precision farming, surveying, analyzing atmospheric and ionospheric data and signal structure.

The ICTP-BC workshops series

% Total Women's participation per year



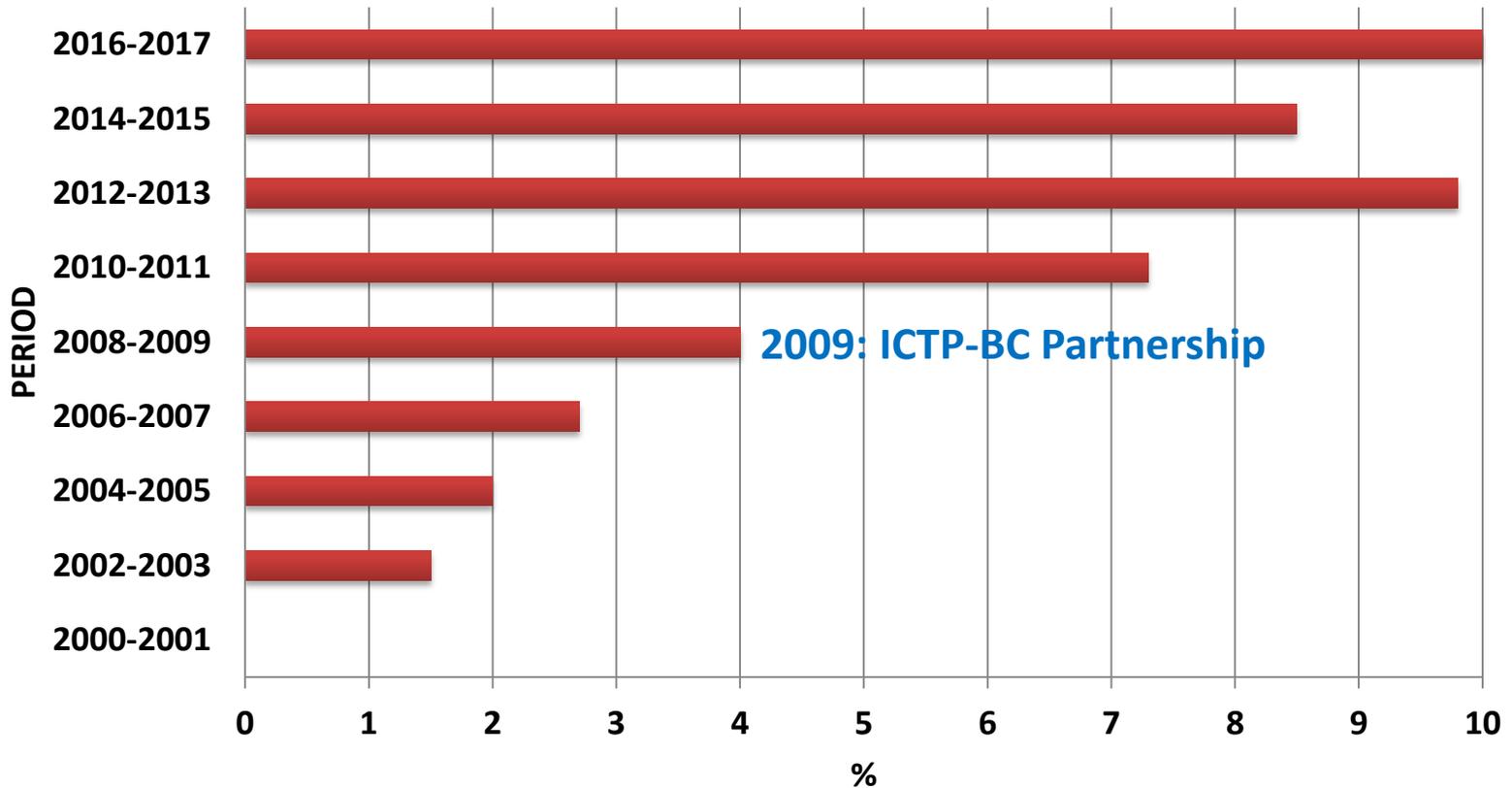
Women's Dinner at Trieste, 2016

Through our workshops we successfully trained more than **400 participants**.

In average there were **72 participants** (lecturers included) in each workshop.

We continue to empower women participation in our activities.

% of the Total N° of papers published on "Equatorial Ionosphere", by African scientists
(source: Web of Science Core Collection)



Papers with first author being African scientist working in Africa.
80% of the papers published from 2010 to 2017 are by scientists that had participated in the training done under the ICTP-BC Partnership.

Workshop on Space Weather Effects on GNSS Operations at Low Latitudes



23 April - 4 May 2018
Trieste, Italy

Further information:
<http://indico.ictp.it/event/8304/>
www.ictp.it

Space weather is the variation in Sun energy emissions, solar wind, magnetosphere, ionosphere and thermosphere, which can influence the performance and reliability of a variety of space borne and ground-based technological systems. As such, space weather is recognised as the cause of significant errors experienced by Global Satellite Navigation Systems (GNSS), Satellite Based Augmentation Systems (SBAS) and their users.

Description:

GNSS or SBAS signals, propagating from a satellite to the user receiver, pass through the ionosphere where they are subject to the damaging effects of space weather. Under these conditions pseudo range errors and signal availability can occur receiver level or ground. The effects are critical at low latitudes where most of the developing countries are located.

The workshop will give theoretical and practical training on the physics of space weather and its main effects on the GNSS operations, with particular emphasis on the low latitudes ionospheric perturbations related to space weather.

Topics:

- Impact of the ICTP/ICTP/UCI Boston College (US) joint training activities on GNSS science and applications in developing countries (including Nigeria, Cote d'Ivoire, Ethiopia, Argentina and Malaysia)
- Introduction to satellite navigation and positioning, and the importance of satellite navigation for developing countries;
- GNSS systems and operations;
- Introduction to space weather;
- Continuous and transient ionospheric energy transfer from the Earth;
- Ionospheric and its response to space weather, with particular attention to low latitudes;
- Space weather effects on GNSS operations;
- Computer laboratory exercises on the use of space weather data for GNSS research and applications.

How to apply:

Online application:
<http://indico.ictp.it/event/8304/>

Female scientists are encouraged to apply.

Grants:

A limited number of grants are available to support the attendance of selected participants, with priority given to participants from developing countries. There is no registration fee.

Directors:

P. DOHERTY, *IB, Boston College*
S. M. RADICELLA, *ICTP*
B. NAVA, *ICTP*

Local Organizer:

B. NAVA, *ICTP*

Deadline:

1 February 2018

10° Workshop

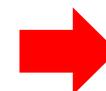
23 April – 4 May 2018
Trieste, Italy

Directors:

P. Doherty
S. Radicella
B. Nava

Participants: 44 (45% Women)

10 African countries
9 Asian/Oceanian
4 South American
2 European



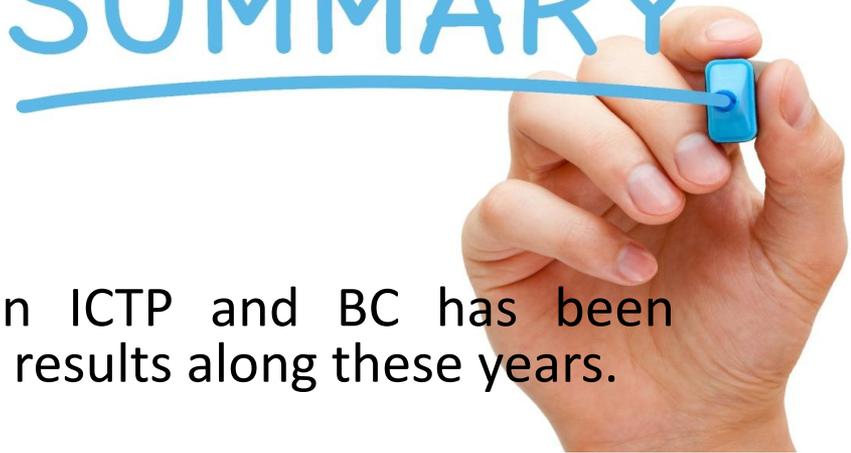
www.ictp.it



ICG International Commission on Global Geodesy and Earth System



SUMMARY



- An International partnership between ICTP and BC has been established in 2009 with very successful results along these years.
- The ICTP-BC partnership is helping to build a knowledgeable GNSS workforce and encouraging in the use of GNSS for socio-economic benefits and scientific exploration.
- A series of training activities have been organized in Trieste and Africa and their curricula include formal lectures with hands-on practice in GNSS.
- Our workshops benefit from long time collaboration with other research institutions, projects and colleagues around the world over years.

Thanks for you attention!



Muchas Gracias!



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