The Abdus Salam
International Centre
for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

GNSS related activities of the ICTP Telecommunications/ICT for development Laboratory

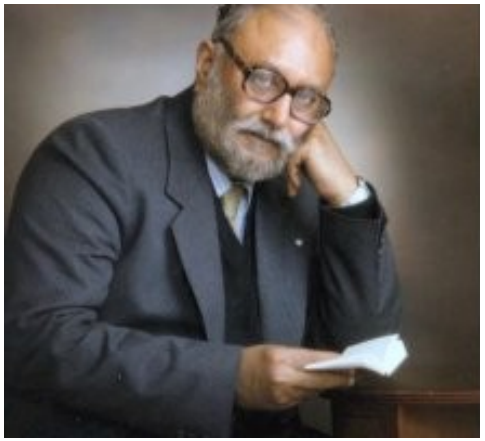
S. M. Radicella and B. Nava

Head, Telecommunications/ICT

For Development Laboratory (T/ICT4D)

About ICTP

- Was founded in 1964 by the late Nobel Laureate Abdus Salam.
- ICTP operates under a tripartite agreement between the Italian Government, the International Atomic Energy Agency (IAEA), and the United Nations Educational, Scientific and Cultural Organization (UNESCO).
- The agreement was ratified by an act of the Italian Parliament in January 1995.

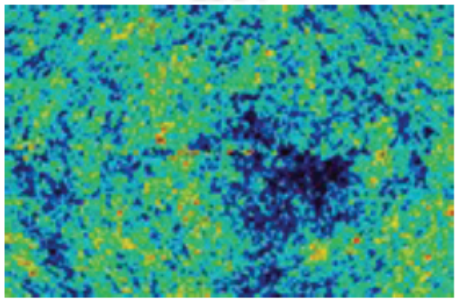


ICTP Mission

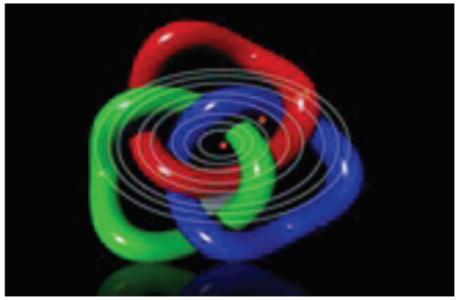
- To foster growth of advanced pure and applied physics and mathematics studies, especially in developing countries.
- To develop high-level scientific training programmes and encourage international scientific exchange.
- To conduct research at the highest international standards.

Research at ICTP

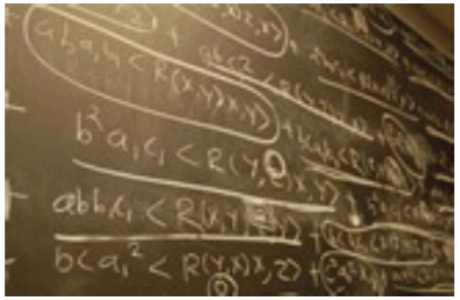
High Energy Cosmology and Astroparticle Physics
1964



Condensed Matters and Statistical Physics
1974



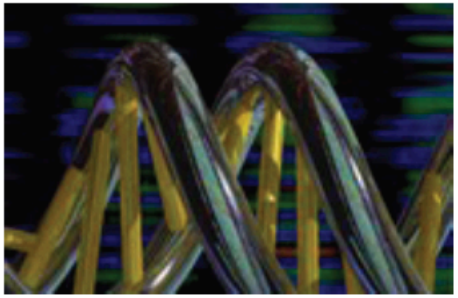
Mathematics
1986



Applied Physics
1990

Earth System Physics
1998

New areas
2011



- Telecommunications
- ICT4D
- Microprocessors...

- Renewable energies
- Quantitative Biology
- High Performance Computing

Training activities

Schools, Workshops, conferences per year:

- ± 60 activities in campus,
- ± 25 activities in developing countries,

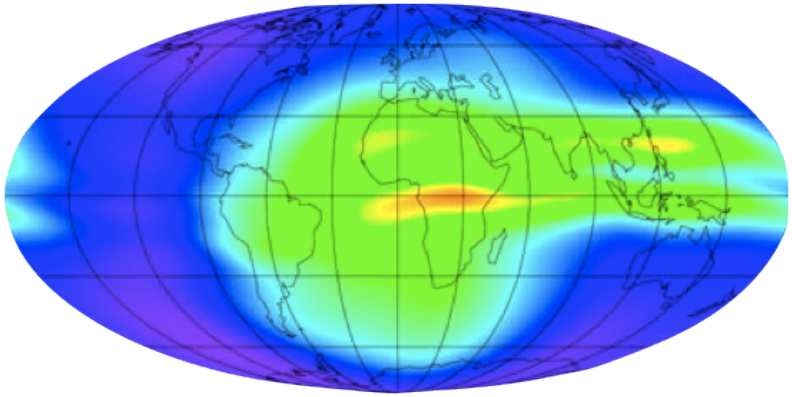
Visitors per year:

- ± 5000 (25% females)
- Average per month ± 500
- From ± 140 nations

The T/ICT4D (former ARPL)

- Ionospheric Radiopropagation (since 1990):

  research and training in ionospheric physics with application to GNSS science and technology

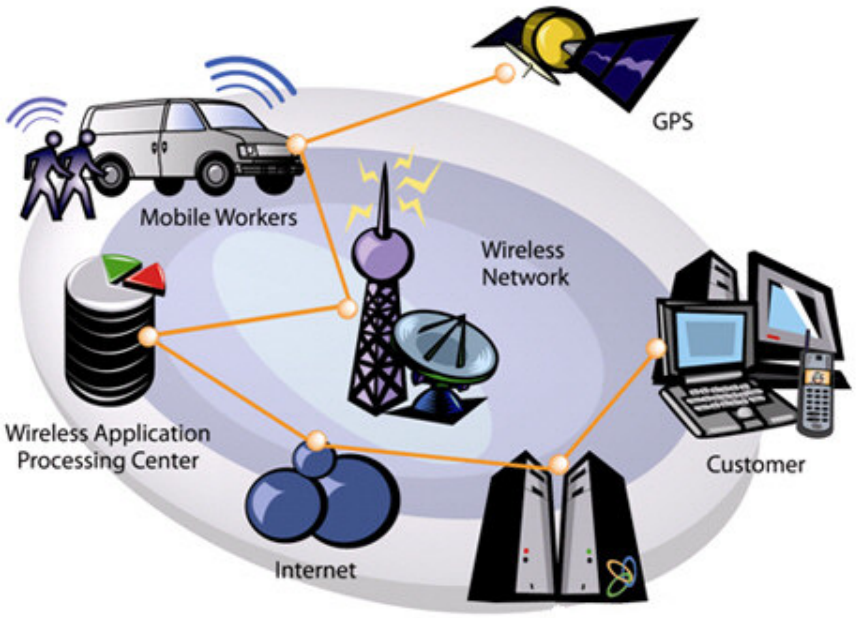


- Wireless communications (since 1995):

  research and training in Wireless ICT including Wireless Sensors Networks for Development and Internet of Things

Why this two sections together?

Today trend



Combined uses of GNSS (GPS, GLONASS, Galileo, Compass, etc.) and Information and Communication Technology (ICT):

Location Based Services

The early years

- **1990-1995: focused on development of ionospheric models (European COST actions) and support to existing ones (IRI model)**
- 1990: Di Giovanni-Radicella [DGR] model initiated modeling efforts.
- 1994-2004: Experts met yearly in IRI Task Force Activities at ICTP to discuss improvements of IRI model.
- 1995: modified DGR adopted in final product of Prediction and Restrospective Ionospheric Modelling (PRIME) COST action.
- 1995-1999: new family of models developed in collaboration with University of Graz, Austria, originally in the framework of COST actions and later related to **GNSS** operation.

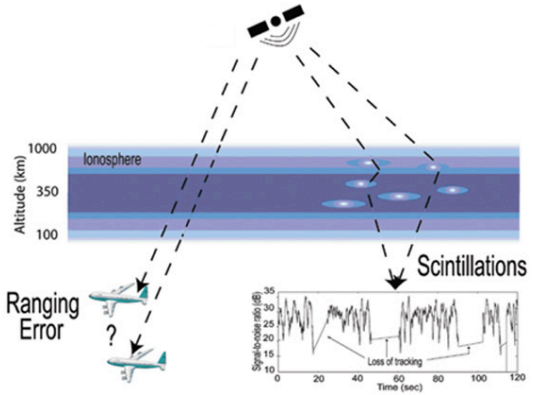
Focus on GNSS

The Laboratory coordinated the European **Ionospheric Experts Team** of **ESA** supporting **EGNOS** project.

The composition of the original team:

- **RIGAM:** Research Institute for Geophysics, Astrophysics and Meteorology, University of Graz, Austria
- **IFAC:** Istituto di Fisica Applicata 'Nello Carrara', Florence, Italy
- **DLR:** German Aerospace Center, Institute of Communications and Navigation, Neustrelitz, Germany
- **IEEA,** Soc. de Informatique, Electromagnetisme Electronique ed Analyse, Paris, France

Since 1990 the Laboratory is member of the **International SBAS-IONO Group**



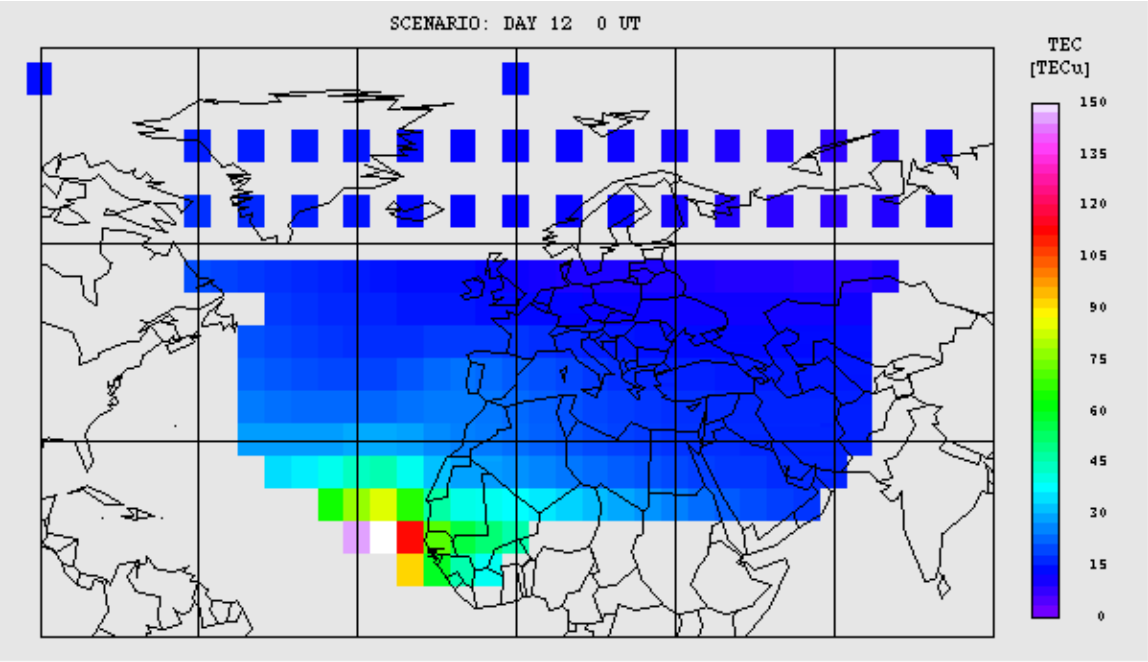
EGNOS

Focus on GNSS (cont.)

- Since **2000** the laboratory was also involved in **GALILEO** system ionospheric issues through other European projects.

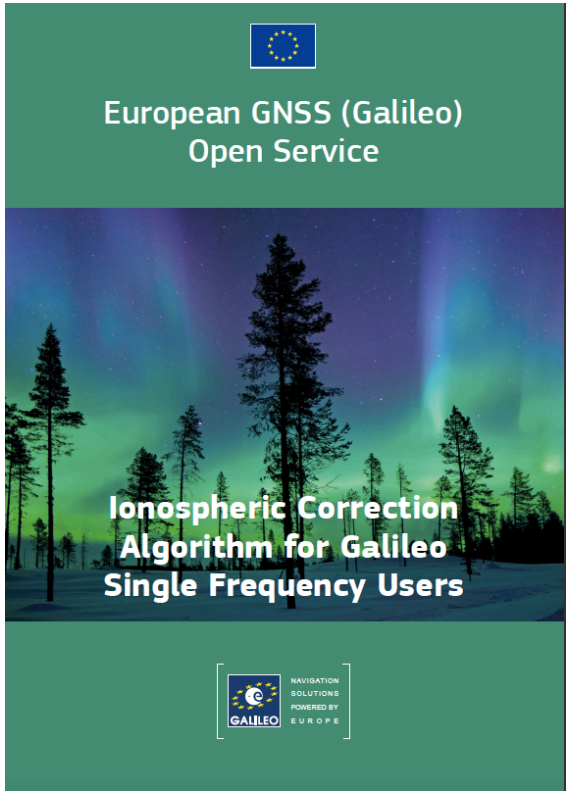
Focus on GNSS: **EGNOS**

One of the new ionospheric models, **NeQuick**, was used to generate “worst cases” ionospheric scenarios for the development and tuning of **EGNOS** algorithms.



Focus on GNSS: **GALILEO**

The European **GALILEO** system has adapted the **NeQuick** model for its single-frequency ionospheric correction algorithm.



The **EC** released the official document related to the use of the **NeQuick** model by **GALILEO.**

Acknowledgements

The *NeQuick* electron density model was developed by the Abdus Salam International Center of Theoretical Physics (ICTP) and the University of Graz. The adaptation of *NeQuick* for Galileo single-frequency ionospheric correction algorithm (*NeQuick G*) has been performed by the European Space Agency (ESA) involving the original authors and other European ionospheric scientists under various ESA contracts. The step-by-step algorithmic description of *NeQuick* for Galileo contained in this document has been a collaborative effort of ICTP, ESA and the European Commission, including JRC.

Focus on GNSS: NeQuick and ICG

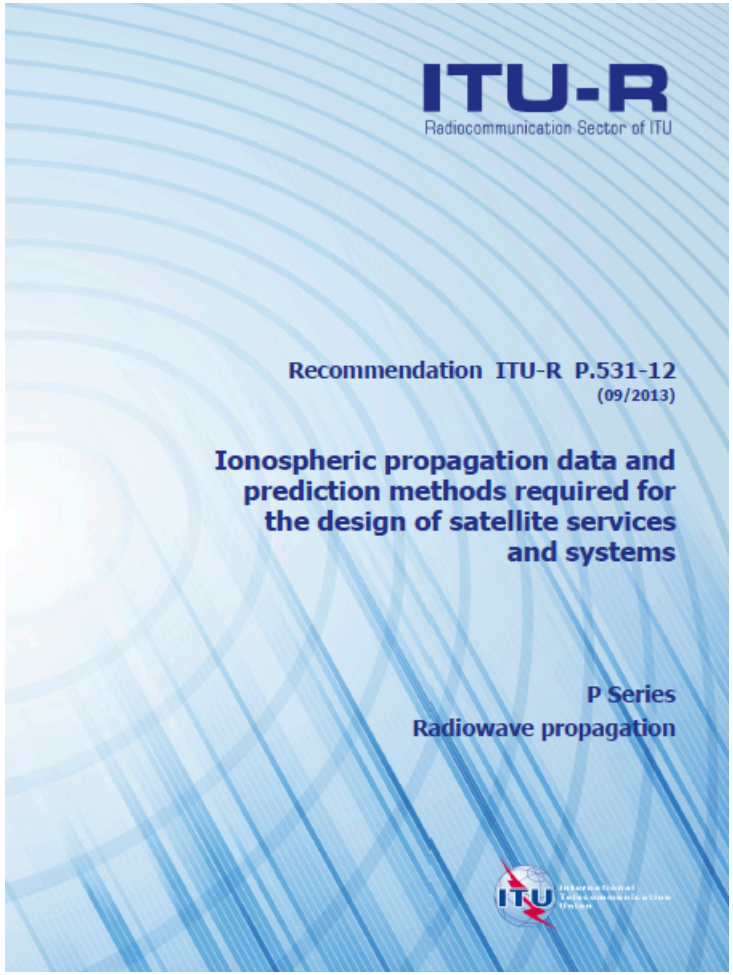
UNITED NATIONS
Office for Outer Space Affairs

ICG International Committee on Global Navigation Satellite Systems

ICG Working Groups: Working Group B recommendations

- **NeQuick Ionospheric Model**
  - ***To distribute to the Service Providers and Users the document providing the detailed description of the Nequick algorithm implemented in Galileo for the correction of the ionospheric error in single frequency users;***
  - ***For the Service Providers and interested users participating in the ICG, to assess the performance and usability of a Nequick ionospheric correction algorithm for the single frequency users similar to the one adopted by Galileo in view of its expected good performance compared with other models, i.e. at low latitudes***

Focus on GNSS: NeQuick and ITU



"For estimating the TEC, either a procedure based on the International Reference Ionosphere (IRI-2012) or a more flexible procedure, also suitable for slant TEC evaluation and based on NeQuick2 v.P531-12 are available."

Focus on GNSS: **Partnership with BC**

Partnership with the **ISR** of **Boston College** (USA) to promote and support GNSS related R&D in Africa (workshops and academic support including instruments).

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

Patricia H. Doherty
Boston College
and
Sandro M. Radicella
Abdus Salam International Centre for Theoretical Physics

NASA International Space Weather Initiative

Morocco - November 2009

Focus on GNSS: **TRAINING**

After the first steps in 2006 with the Workshop on the Future of Ionospheric Research for Satellite Navigation and Positioning: its Relevance for Developing Countries, the partnership with Boston College in **2009**, and the collaboration established with **ICG**, a series of training Workshops has been carried out in Trieste and in Africa.

- 2009 > Trieste and Abuja (Nigeria)
- 2010 > Trieste Cairo/Alexandria (Egypt)
- 2010 > Nairobi (Kenya)
- 2012 > Trieste
- 2013 > Trieste
- 2014 > Kigali (Rwanda)
- 2015 > Trieste

Focus on GNSS: **TREGA Project**

The **European Commission** has signed a ***Contribution Agreement*** with **ICTP** to carry out the project "***Training on EGNOS-GNSS in Africa (TREGA)***" aimed to provide technical assistance, capacity building at different levels and provision and use of test equipment for the implementation of **GNSS/EGNOS in Sub-Saharan Africa**.

Training on EGNOS-GNSS in Africa (TREGA)

The Abdus Salam International Centre for Theoretical Physics
A project implemented by ICTP

Funded by the European Union

Focus on GNSS: **TREGA Project** (cont.)

In the ***Appropriateness of ICTP*** note that justified the **EC** assignment to **ICTP** it is written:

"**The specific knowledge of the institute, and its experience in training people from developing countries, put this organization in a unique position for the participation in the project.**"

and:

"**The Aeronomy and Radiopropagation Laboratory of ICTP has a long-standing experience in training in the field of GNSS. It has also organized in the past a series of Workshops on Satellite Navigation Science and Technology for Africa.**"

THANK YOU FOR YOUR ATTENTION