



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



PITHIA and ICTP

Bruno Nava
ICTP

Brussels, 14 March 2023

What is ICTP?



The Abdus Salam International Centre for Theoretical Physics (ICTP) is world-class research and a successful model of international collaboration

What is ICTP?

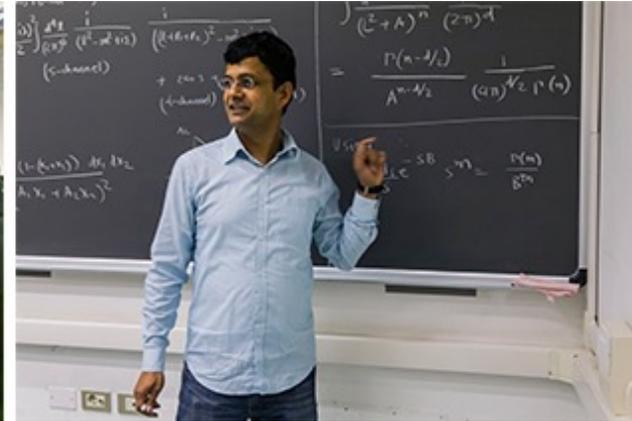
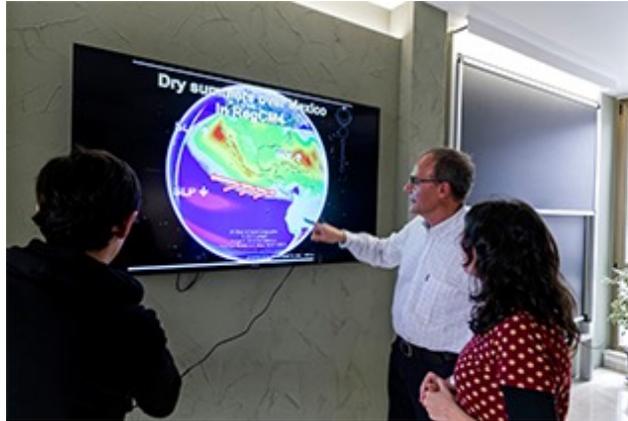


- Founded in 1964 by Nobel Laureate Abdus Salam to enhance international cooperation through science
- Combines world class research with a unique global mission of building science capacity in the developing world
- Governed by tripartite agreement between Italy, UNESCO and IAEA

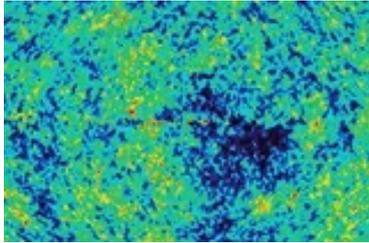
Research

Education

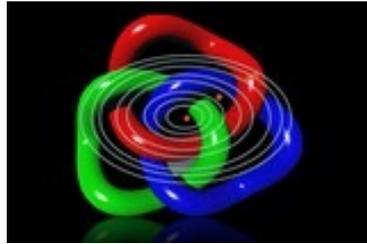
Outreach



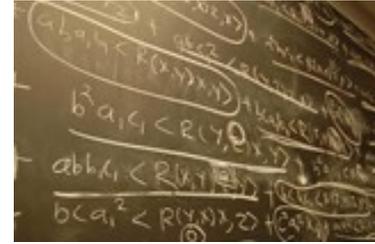
High Energy Cosmology and Astroparticle Physics



Condensed Matter and Statistical Physics



Mathematics



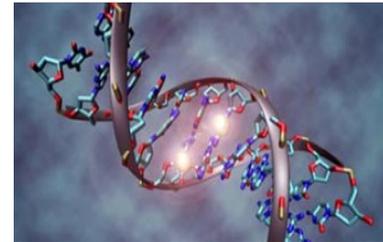
Science, Technology and Innovation



Earth System Physics



Quantitative Life Sciences



Also: Sustainable Energy
and High Performance
Computing

Nobel-worthy contributions

Research at ICTP and its partner institutes has contributed to 5 Nobels:

- **Physics Nobel 1979:** ICTP founder Abdus Salam
- **Nobel Peace Prize 2007:** ICTP's Earth System Physics scientist Filippo Giorgi's work with IPCC
- **Physics Nobel 2013:** ICTP's High Energy Physics section contributed to ATLAS discovery of Higgs Boson
- **Physics Nobel 2015:** Prize confirmed theory of solar neutrino oscillations co-developed by ICTP scientist Alexei Smirnov
- **Physics Nobel 2017:** gravitational wave detection by LIGO (ICTP-SAIFR collaborated)

ICTP degree programmes

- PhD in Physics (with University of Trieste)
- PhD in Physics and Mathematics (with SISSA)
- PhD in Earth Science and Fluid Mechanics (with University of Trieste)
- Masters in Medical Physics (with University of Trieste)
- Masters in High Performance Computing (with SISSA)
- Master of Complex Systems (with consortium of European universities)

ICTP's Postgraduate Diploma Programme: Preparing young scholars for PhD studies

Since 1991

- more than 1000 Diploma graduates
- more than 75% earned or working toward PhDs



ICTP's international conferences encourage “Brain Gain”

- Provide training and skills to scientists from developing countries
- Organise more than 60 conferences/workshops each year
- Welcome up to 5000 scientists from 145 nations each year
- Attract an additional 1000-2000 scientists/year through hosted activities

ICTP-SCOSTEP-ISWI School and Workshop on the Predictability of the Solar-Terrestrial Coupling - PRESTO



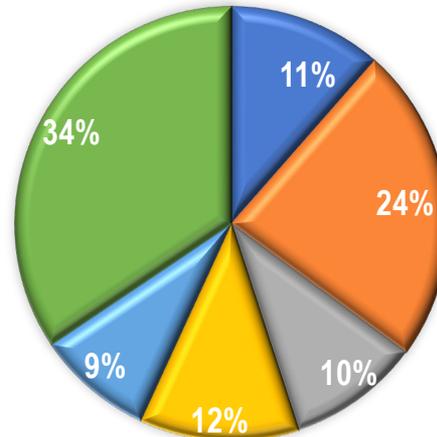
29 May - 2 June 2023
An ICTP Meeting
Trieste, Italy

Topics:

- Observations and modelling of solar eruptions, solar wind and SEPs from Sun through interplanetary space
- Prediction of solar transients, streams/SIRs and SEP from Sun to geospace
- Effect of space weather on the Earth's ionosphere, thermosphere, and magnetosphere
- Influence of the lower atmosphere on the mesosphere, thermosphere, and ionosphere
- Solar forcing specification and impacts on the atmosphere and climate
- Precipitating energetic particles and their effects on atmosphere
- Predictability of the solar cycle

ICTP visiting scientists: where do they come from?

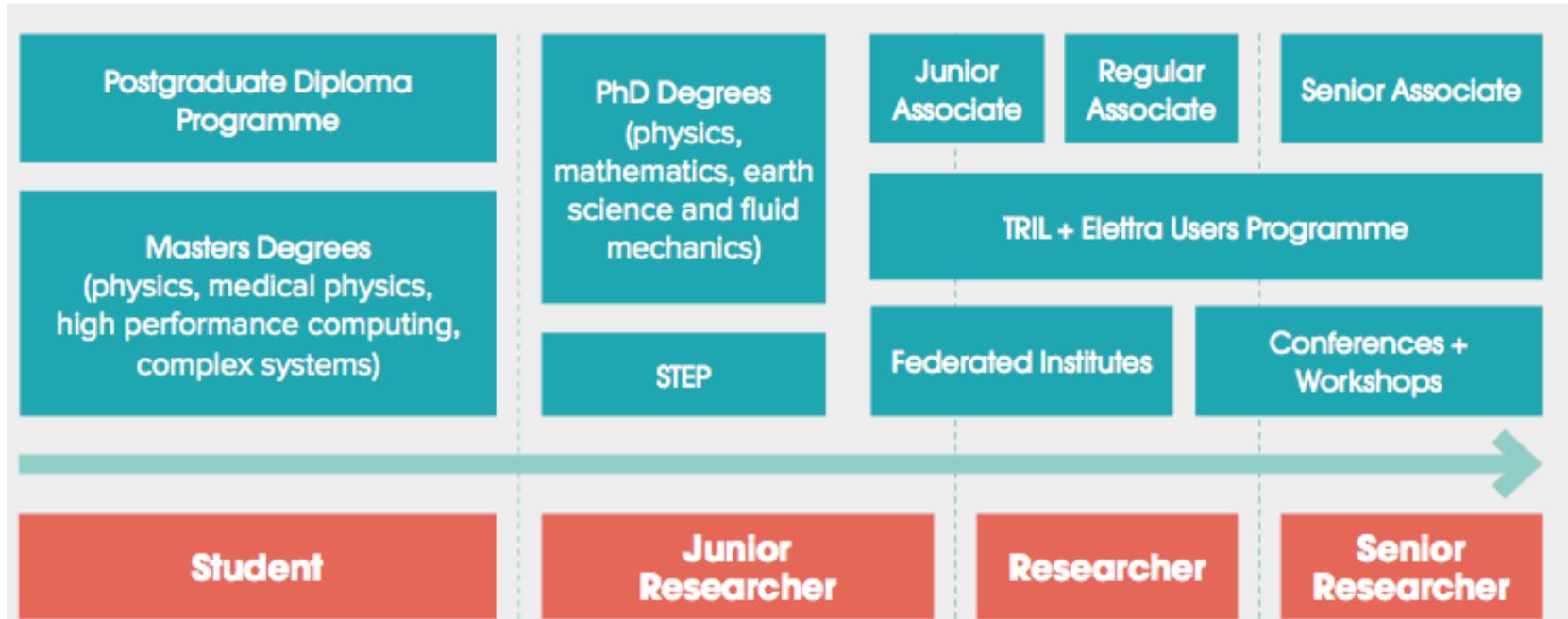
- More than 180,000 visits since 1970
- 188 countries represented
- In 2021, 30% of ICTP visiting scientists were women



- Africa
- Asia
- Latin America
- Eastern Europe
- North America
- Western Europe

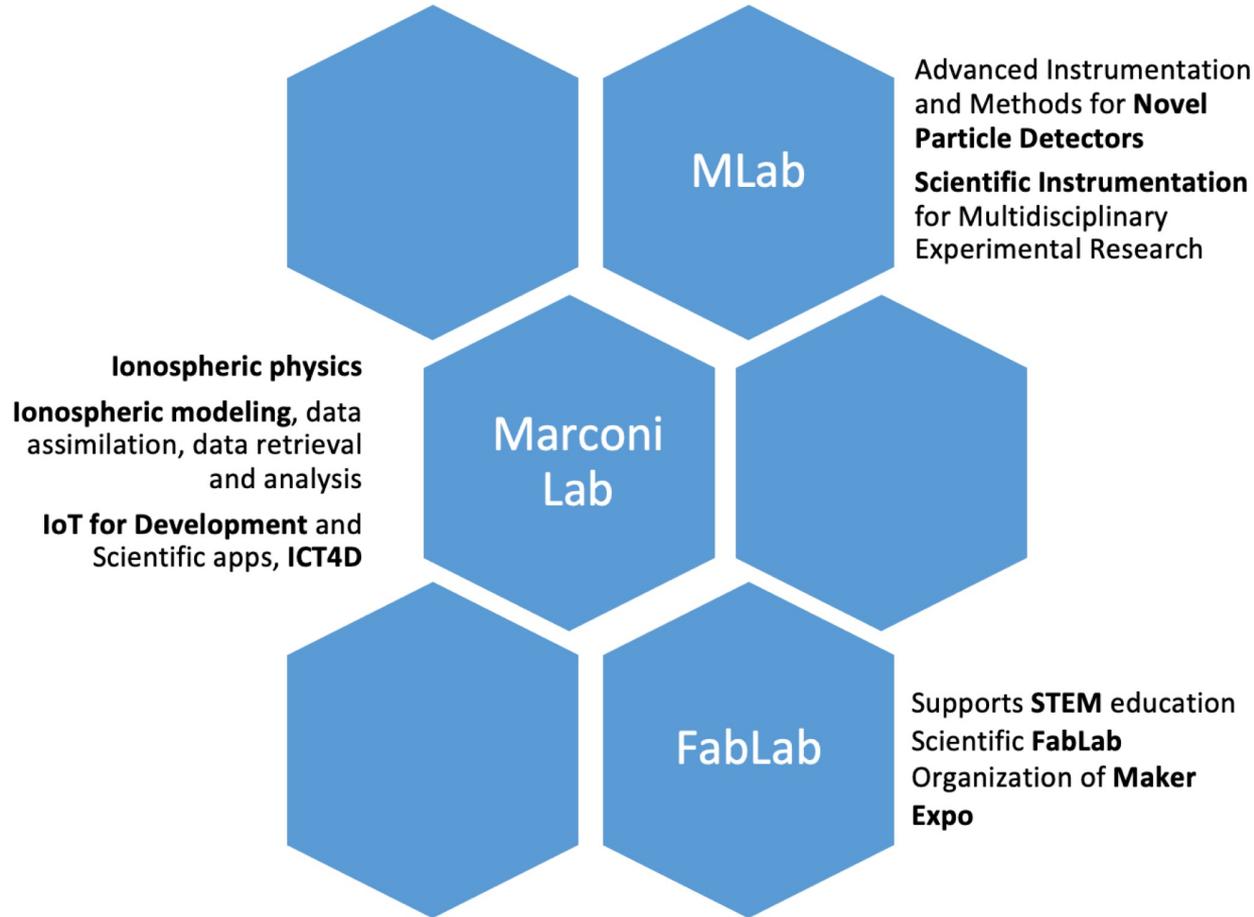


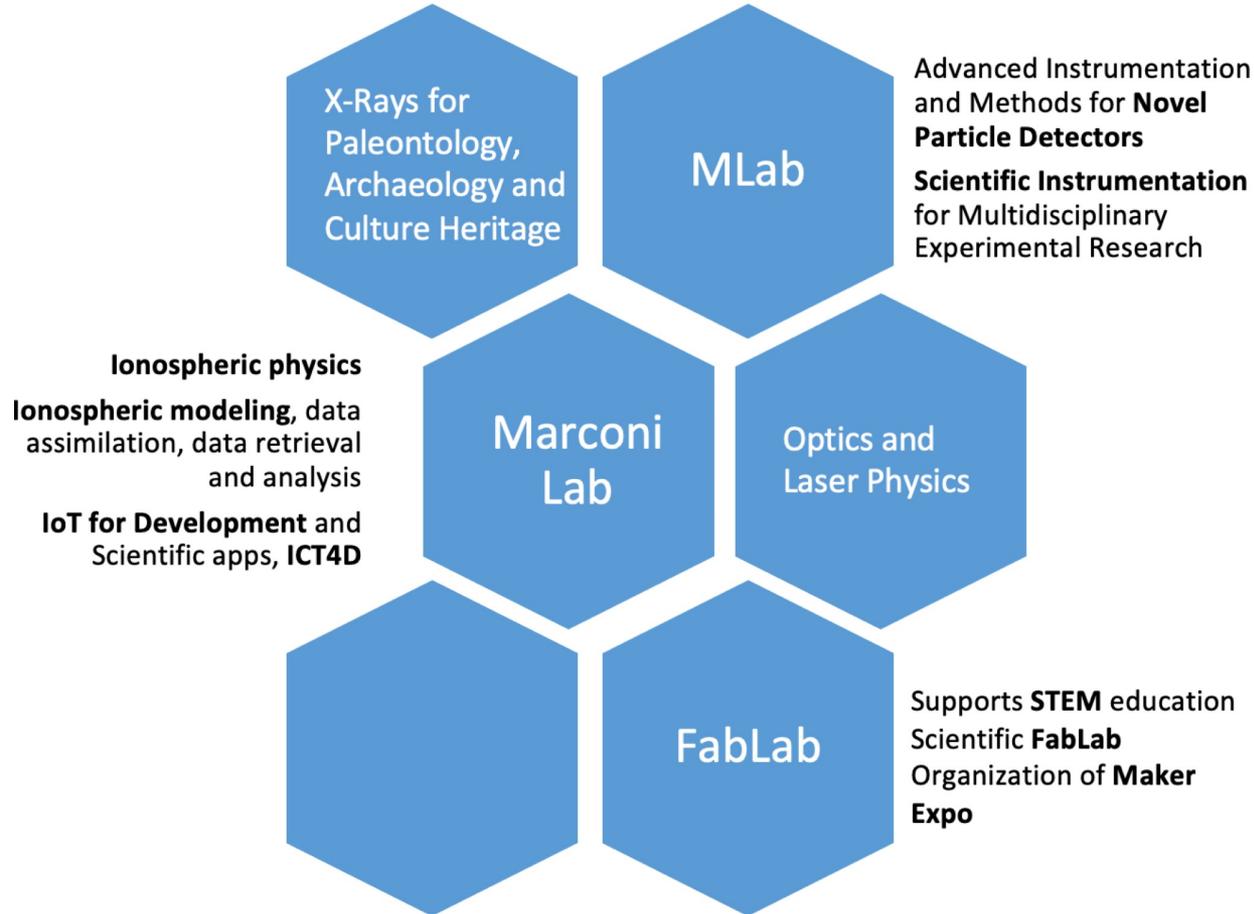
ICTP training programmes: Supporting scientists in all stages of their careers



ICTP has a long tradition of scientific capacity building in developing countries

- Office of External Activities
- Partner Institutes (Brazil, China, Mexico, Rwanda)
- Physics Without Frontiers
- Digital Fabrication & Science Dissemination





MARCONI LAB: WIRELESS AND IOT



Wireless Connectivity for Science and Development



Low-cost Weather Stations

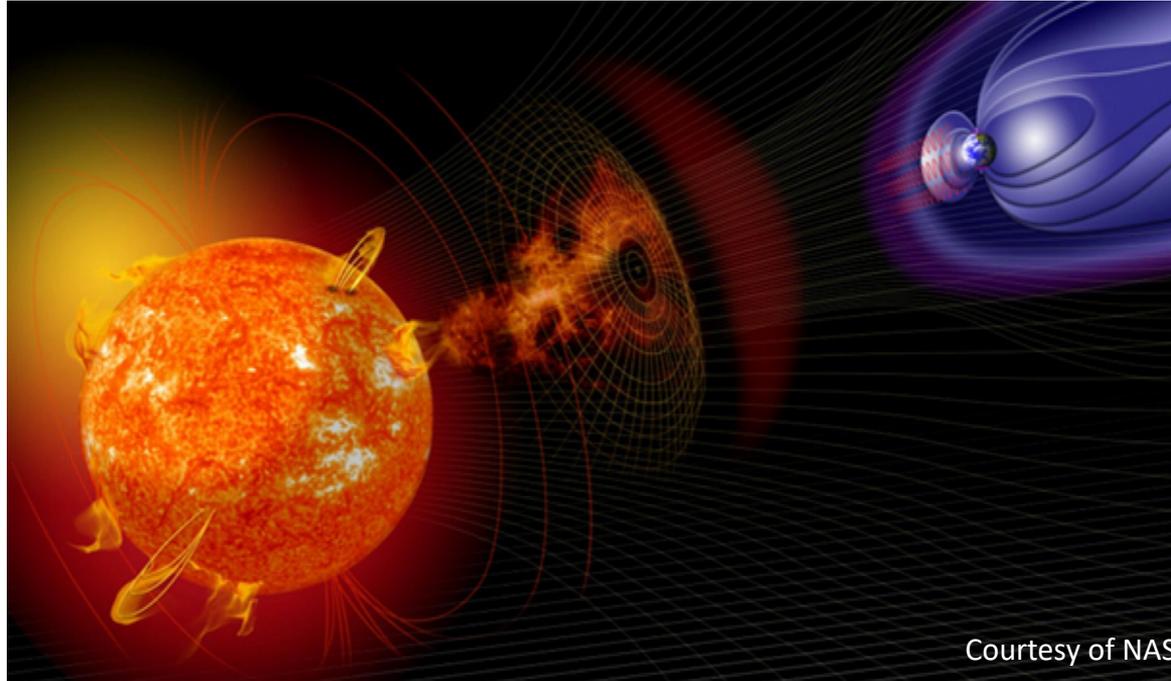


MARCONI LAB: IONOSPHERIC RESEARCH



The Ionospheric Team carries out research on the near-Earth plasma environment, with particular focus on space weather phenomena.

- Ionospheric Modelling
- Data Assimilation
- Radio Occultation



Ionospheric Modelling

- The NeQuick 2 is an ionospheric electron density model developed at the former ARPL of ICTP, Trieste, Italy, in collaboration with Institute for Geophysics, Astrophysics and Meteorology of the University of Graz, Austria.
- It is a quick-run empirical model particularly designed for trans-ionospheric propagation applications, conceived to reproduce the median behavior of the ionosphere.

NeQuick 2 Web Model

Computation and plotting of slant electron density profile and total electron content

Endpoints Coordinates

Lower endpoint: Latitude °N Longitude °E Height km

Higher endpoint: Latitude °N Longitude °E Height km

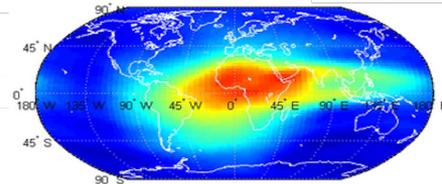
Satellite data: Azimuth °N Elevation ° Height km

Date and Time

Year(YYYY) Month January Day(DD) 15 Time Universal

Solar Activity

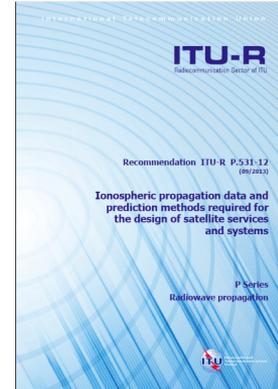
- R12 (source: NOAA-NGDC)
- Daily Solar Radio Flux (source: NOAA-NGDC)
- User Input Solar index type R12 Value *
- ITU-R compliant *

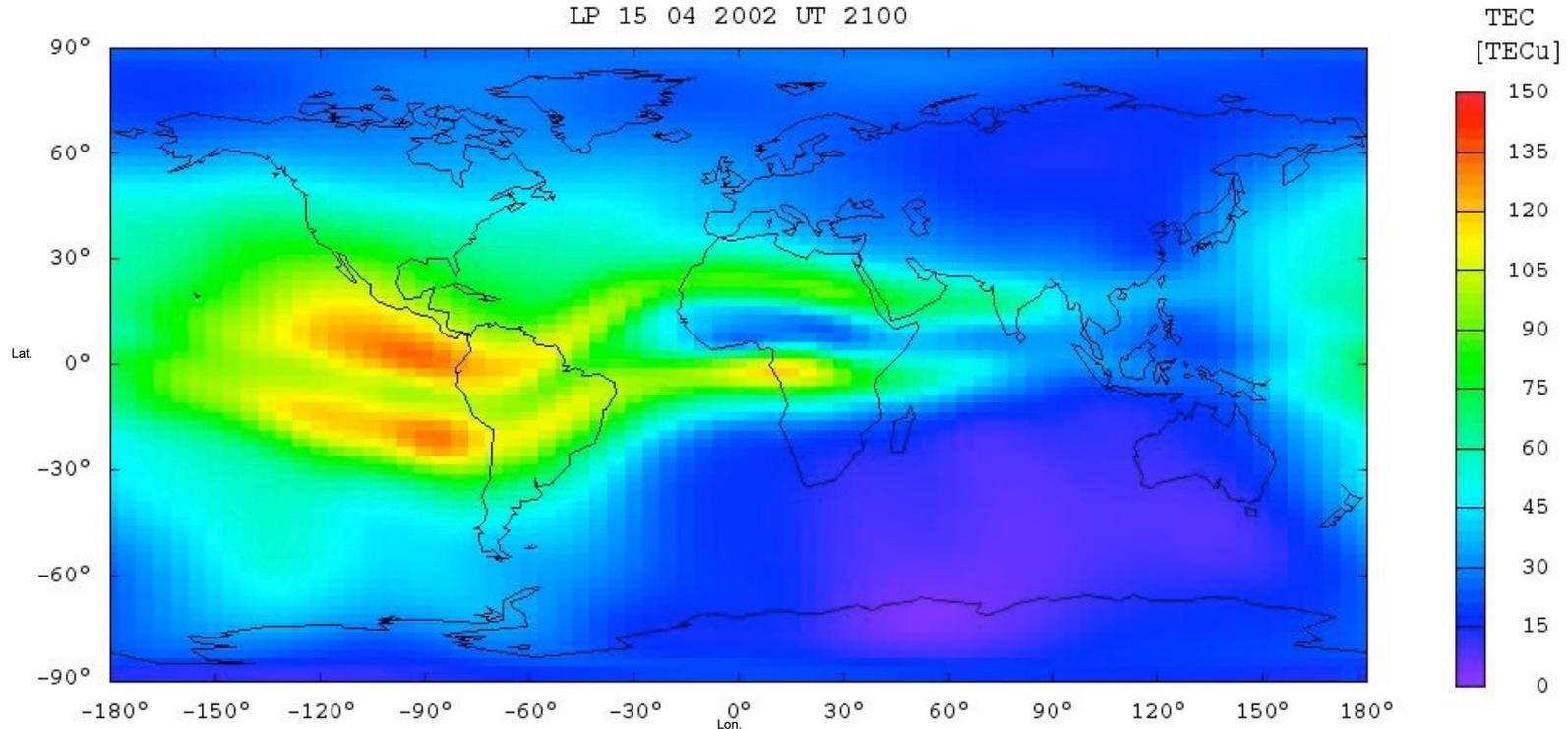


*For R12: [0 to 150]; for F10.7: [63 to 193] F.U.

Warning! Not respecting the limits could lead to undefined electron density values! (ITU-R P.1239 recommendation)

- The NeQuick (v1) has been adopted by Recommendation ITU-R P. 531 as a procedure for estimating TEC.
- Subsequently, the NeQuick 2 has substituted the NeQuick (v1) and it is the one currently recommended by ITU (ITU-R Recommendation P.531-12).
- A specific version of NeQuick (NeQuick G, implemented by ESA) has been adopted as Galileo Single-Frequency Ionospheric Correction Algorithm and its performance has been confirmed during In-Orbit Validation.
- ESA has also included NeQuick 2 in to Space Environment Information System.

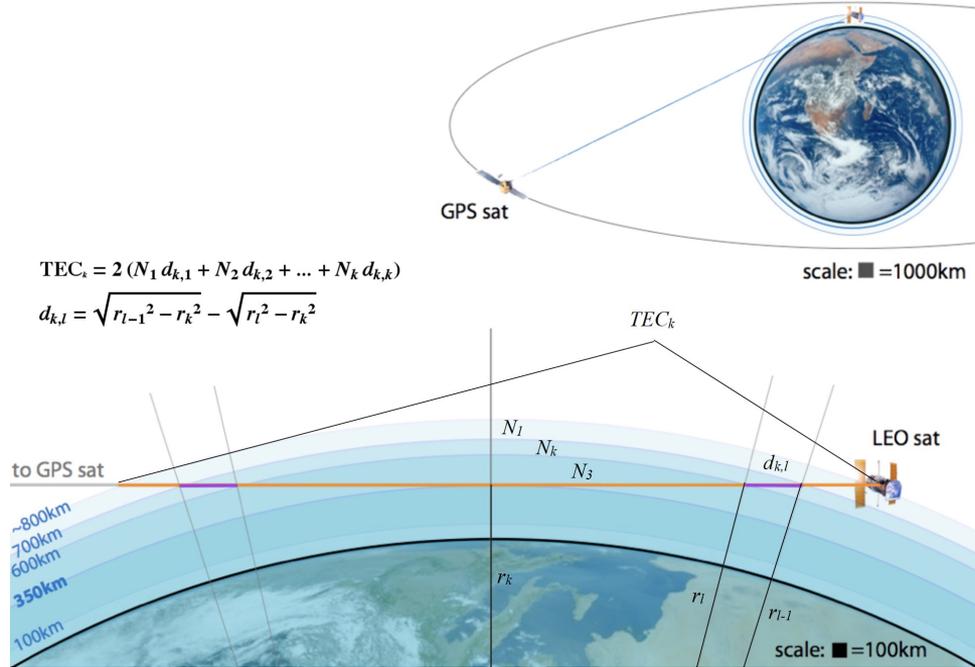




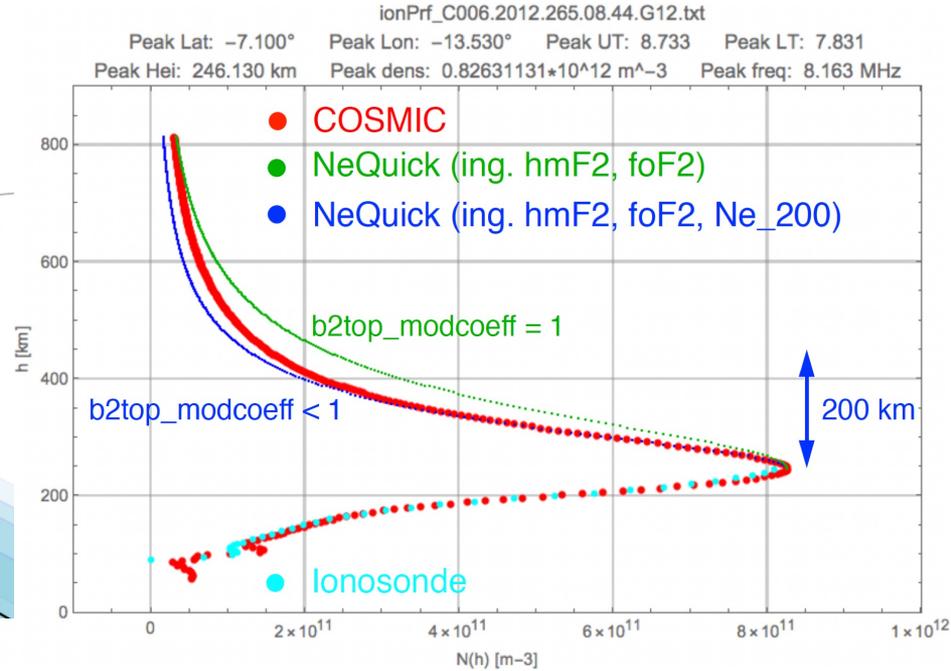
Vertical TEC map obtained from ground-based GNSS-derived data

We provide GNSS TEC Calibration online

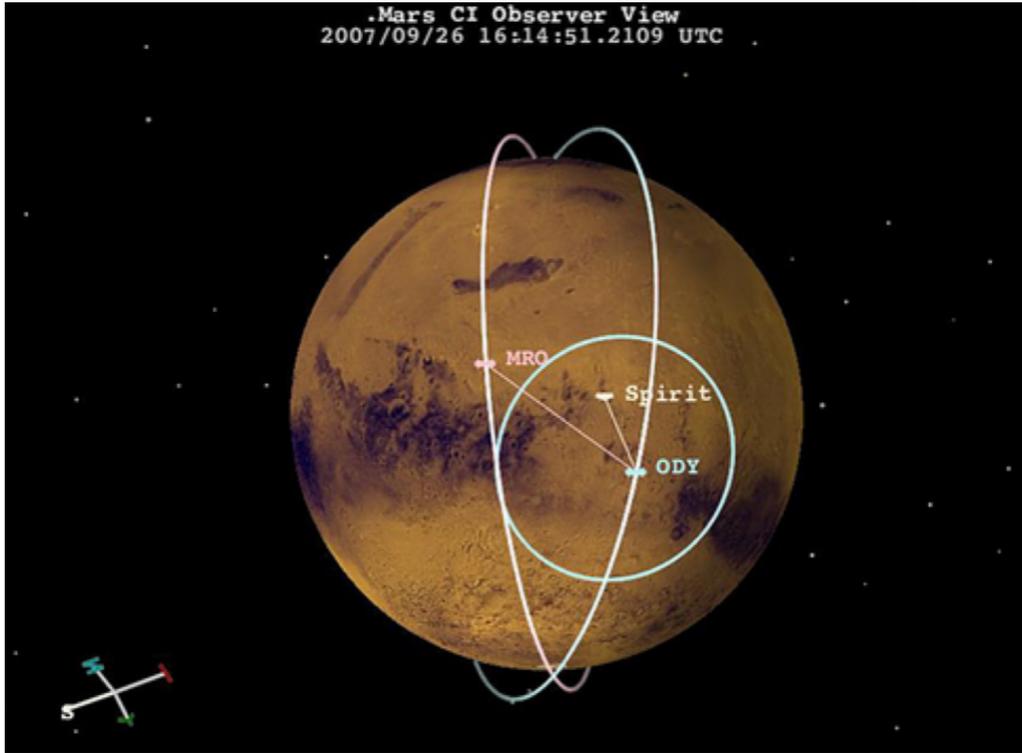
Radio Occultation



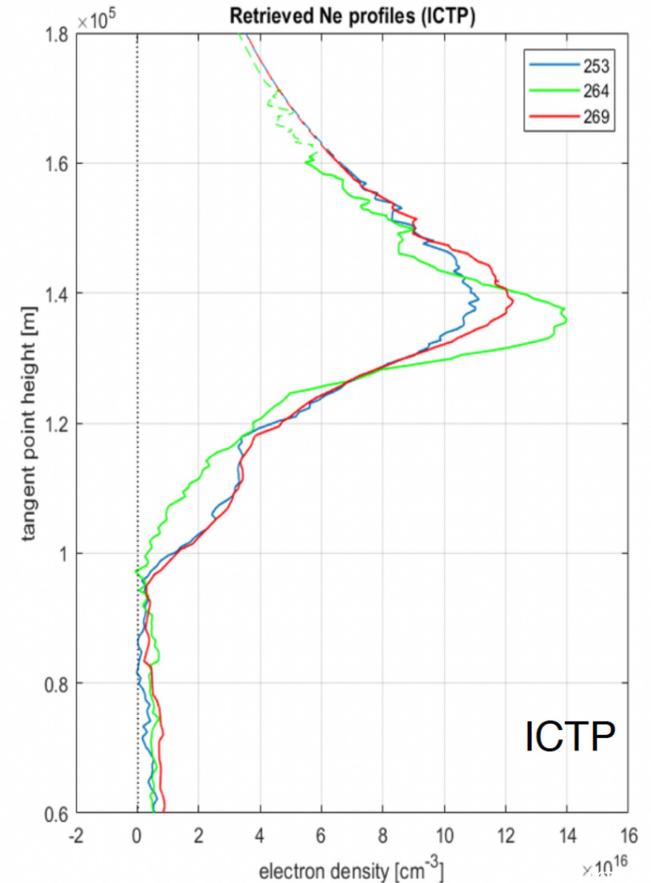
Radio Occultation (RO) geometry (GPS-LEO)



RO-derived (from COSMIC satellite) and NeQuick-derived electron density profiles



Mutual Radio Occultation geometry over Mars



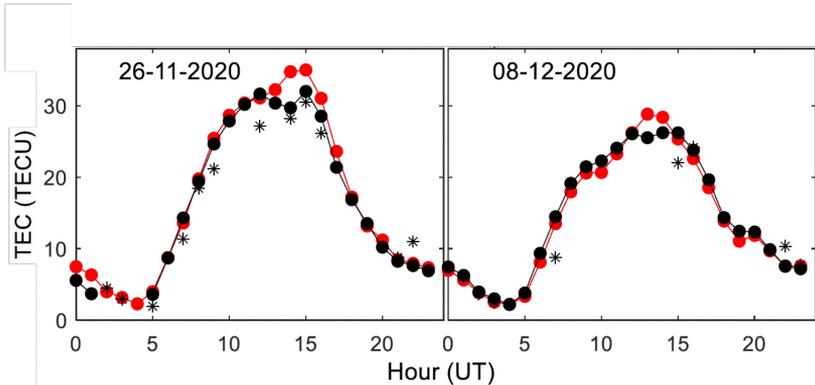


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Volume 68, Issue 9, 1 November 2021, Pages 3835-3845

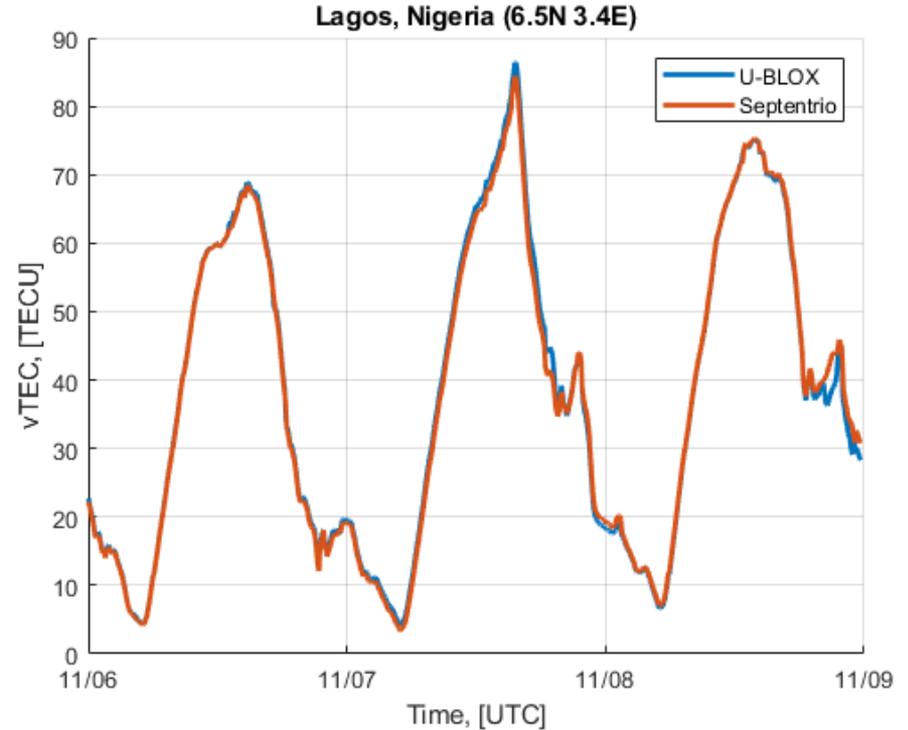


New results of ionospheric total electron content measurements from a low-cost global navigation satellite system receiver and comparisons with other data sources

Daniel Okoh ^{a, b, 2, 3}, Aderonke Obafaye ^a, Babatunde Rabiu ^{a, b}, Gopi Seemala ^c, Anton Kashcheyev ^d, Bruno Nava ^e



TEC derived from a low-cost GNSS receiver and COSMIC RO TEC for Abuja on 26 Nov and 8 Dec 2020



TEC derived from a low and a high-cost GNSS receiver for Lagos on 6-9 Nov 2022



International Committee on Global Navigation Satellite Systems (ICG): Annual Meeting

The Working Group C (of ICG) on Information Dissemination and Capacity Building has recommended:

to establish the project team within the WG-C to implement prototype systems to explore the possibilities of using low-cost receivers for space weather monitoring.

Possible actions in connection with PITHIA Project:

- Registration of the NeQuick model
- Participation to PITHIA/ICTP training activities
- TNA Projects for ICTP young researchers
- Low-cost instrumentation deployment

Thank you!