The Abdus Salam
International Centre
for Theoretical Physics

Workshop on GNSS Data Application to Low Latitude Ionospheric Research

5 - 17 May 2013

ICTP, Trieste, Italy

PROGRAMME

Message from Directors

Sponsors

Lecturers' information

Programme

List of Participants

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A Message from the Directors

Global Navigation Satellite Systems (GNSS), including the Satellite Based Augmentation Systems (SBAS) are a space technology that can help socio-economic transformation and full integration of developing countries into the world economy. GNSS applications can be used to increase food security, manage natural resources, provide efficient emergency location services, improve surveying and mapping, and provide greater precision and safety in land, water and air navigation systems. It also has applications in numerous fields of scientific study including space weather, geophysics, geography, geology, ecology and biology. This workshop is designed with activities to give an in deep view particularly of science applications of GNSS technology, in particular ionospheric research in low latitude regions.

The workshop will be conducted under an international partnership between the International Centre for Theoretical Physics (ICTP) and Boston College with the participation of the European Space Agency. This workshop is primarily funded by ICTP and BC and European Space Agency. Additional funding from a number of institutions including the Institute of Navigation, the Federal Aviation Administration (FAA), the U.S. Air Force, the International Committee for GNSS, the International Union of Geodesy and Geophysics, and the European Office of US Air Force Research and Development (EOARD) Worldwide experts in GNSS have generously donated their time to participate in this workshop as lecturers.

The workshop will include formal lectures and hands-on practice in GNSS architecture, signal structure, hardware, state of the art applications and principally scientific exploration using GNSS. Participants are from 23 countries of Africa, Latin America and Asia. The lecturers have been recruited from the US, Europe, India and Africa and have a reputation for excellence in teaching and GNSS. This diverse collection of people will generate an environment for social understanding, international friendships and collaborations. Most importantly, it will represent an international group committed to facilitating the use of GNSS technology for ionospheric research in low latitues.

As we begin this intensive workshop, we sincerely thank you for your participation and look forward to working with you over the next two weeks. If we can be of assistance during the workshop, please let us know.

With best regards,

S. M. Radicella
International Centre for Theoretical Physics

Patricia H. Doherty
Boston College

Roberto Prieto Cerdeira
European Space Agency

About the ICTP _BC partnership

ICTP is an international organization operating under the aegis of two United Nations Agencies, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA) with a seat agreement with the Italian Government that finances most of its activities. ICTP's mission is to foster advanced studies and research, especially in developing countries. Their activities include theory and applications in all areas of the physical sciences.

Boston College, a Jesuit Catholic University in the United States, is committed to the highest standard of academic excellence and to uniting high academic achievement with service to others. Boston College is also dedicated to conducting nationally and internationally significant research that advances insight and understanding, enriches culture, and addresses pressing social needs. Research programs are extensive and include the use of GNSS for scientific exploration and air navigation applications.

The directors for this workshop have successfully joined forces in the past on scientific workshops related to navigation science using GNSS. In fact, this workshop is the third in a series of workshop dedicated to this topic. Recent collaborations also include directing the Workshop on the Future of Ionospheric Research for Satellite Navigation and Positioning: its Relevance for Developing Countries (December 2006, Trieste, Italy); participating in the G8-UNESCO World Forum on Education, Research and Innovation: New Partnerships for Sustainable Development (May 2007, Trieste, Italy); hosting two International Beacon Satellite Symposiums (October 2004, Trieste, IT; June 2007, Boston, MA), as scientific coordinators for the International Heliophysical Year (IHY) Space Weather Science and Education Workshop (Addis Ababa, Ethiopia, November 2007), and as international coordinators for the Nigerian National Meeting on GNSS Science and Applications, Abuja, Nigeria, 16-19 November 2009 and the Workshop on the Ionosphere and its Effects on GNSS Systems in Cairo/Alexandria, Egypt, 10-13 January 2010.

To formalize the cooperation between the ICTP and the Boston College both institutions signed a Memorandum of Understanding in July 28, 2009. By this document it was established a general framework within which academic and research collaboration could develop between the two institutions to promote GNSS science and technology programs in developing countries with particular emphasis on Africa.

We sincerely thank our sponsors for their generosity.

Prof. Sandro M. Radicella is the Head of the Aeronomy and Radiopropagation Laboratory (ARPL) of the Abdus Salam International Centre for Theoretical Physics. He has published more than 130 papers in the fields of aeronomy and radiocommunications. The most important achievement of his recent scientific production is the development of models of vertical distribution of electronic density in the ionosphere in collaboration with colleagues from the ARPL and of the University of Graz, Austria. One of these models is being used by the European Space Agency in areas related to the use of GPS and the new GALILEO satellite system. He has organized a series of Colleges, Schools and Workshops, for participants mainly from developing countries, in the fields of Ionospheric Physics, Radiocommunications and Information and Communication Technology that he directs at the ICTP since 1989. He has been awarded in 2001 with the Doctor Honoris Causa degree from the University of Bucharest, Romania, and in 2005 with the Doctor of Science degree Honoris Causa from the Obafemi Awolowo University in Ile-Ife, Nigeria.

Ms. Patricia Doherty is Director and a senior scientist of the Institute for Scientific Research at Boston College. As director of the Institute, she oversees the activities of staff members working on a variety of innovative research projects. These projects include space weather studies, ionospheric effects on space-based systems, ionospheric measurement techniques, chemical reactions in space and magnetospheric physics. Patricia's research interests include GNSS as a space weather sensor; ionospheric effects on satellite-based augmentation systems; and promoting research and education in GNSS technology in developing countries. She holds offices as Executive Vice President of the Institute of Navigation and as the Chair of the Beacon Satellite Studies group under the International Union of Radio Scientists(URSI). Patricia was also recently elected a Fellow of the Institute of Navigation.

Mr. Roberto Prieto Cerdeira is a Propagation Engineer with the European Space Agency (ESA) in ESTEC, The Netherlands. He received his Telecommunications Engineering degree from the University of Vigo, Spain in 2002 and followed postgraduate studies on Space Science and Radioastronomy in Chalmers University of Technology (Gothenburg, Sweden). Since 2004, he has been with the Wave Interaction and Propagation Section in ESA/ESTEC where he is responsible of the activities related to radiowave propagation in the ionosphere and local environment for Global Navigation Satellite Systems (GNSS) and Satellite Mobile Communications. He actively participates in ITU-R Study Group 3, the SBAS-Iono group and the Network of Experts on Electromagnetic Wave Propagation (NoE-EWP). He is a member of IEEE and the Institute of Navigation (ION).

Dr. Bruno Nava is a permanent researcher at the Aeronomy and Radiopropagation Laboratory of the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. His main field of application is 3D ionospheric electron density modeling, with particular interest to model adaptation to experimental data. As a member of the Ionospheric Expert Team and of the Advisory Group on Ionosphere of the European Space Agency he has been involved in support activities related to EGNOS and GALILEO projects. He has also been involved in the European COST actions 251, 271 and, as co-leader of the working package "Data Ingestion and Assimilation in Ionospheric Models" he had an active role in the European COST action 296. At the present time, B.Nava's research efforts are addressed to radio occultation data inversion, with the participation to the ROSA (Radio Occultation Sounder for Atmosphere) project.

Prof. Fernando Quevedo is a Guatemalan physicist. He was appointed director of the Abdus Salam International Centre for Theoretical Physics (ICTP) in October 2009. Born in Costa Rica obtained his early education in Guatemala. He got his Ph.D. from the University of Texas at Austin in 1986 under the supervision of Nobel Laureate Steven Weinberg. Following a string of research appointments at CERN, Switzerland, McGill University in Canada, Institut de Physique in Neuchatel, Switzerland, and the Los Alamos National Laboratory, USA, as well as a brief term as professor of physics at the UNAM (Mexican National Autonomous University), Mexico, Prof. Quevedo joined the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK, in 1998, where he has been Professor of Theoretical Physics and Fellow of Gonville and Caius College. He has been awarded The Wolfson Merit Award, Dotorate Honoris Causa from Universidad de San Carlos de Guatemala and Universidad del Valle de Guatemala, John Solomon Guggenheim Foundation Fellowship and the 1998 ICTP Prize in High Energy Physics. He has authored more than 100 papers.

Dr. Katy Alazo Cuartas: Academic Education: 1989-1994. Physics B.Sc., Physics Faculty, University of La Habana, Cuba. Current Institution (Since 2000): Institute of Geophysics and Astronomy (IGA), Department of Space Geophysics, Ministry of Sciences, Technology and Environment, La Habana, Cuba. She has been involved in the research projects in her home institution, concerned with the study of the Variability of the Electronic Concentration Profile of the Ionosphere and the modeling of ionospheric parameters. In 2006, started Ph.D. studies related to GNSS applied to ionospheric research. 2007-2009 she has been a fellow in the ICTP Sandwich Training Educational Programme under the supervision of Prof. S.M. Radicella. and Dr. L. Ciraolo. She has been developing a software for GPS-TEC calibration based on the Method of Single Station Estimation of Arc Offsets and applying this to the TEC modeling in the Caribbean Region.

Dr. Dieter Bilitza is an expert in ionospheric physics and the principal author of the International Reference Ionosphere (IRI), a widely-used model for the ionosphere that is undergoing registration as an ISO standard. He is a research professor at George Mason University's School of Physics, Astronomy, and Computational Science in Fairfax, Virginia and a chief scientist on the SESDA contract in NASA GSFC's Heliospheric Physics Laboratory. Dr Bilitza received his Diploma and PhD in physics from the Albert-Ludwig University in Freiburg, Germany. In his Doctoral Thesis he developed a theoretical model for the heat balance of the ionospheric plasma. At the Frauenhofer Institute for Space Research in Freiburg and later at NASA's Goddard Space Flight Center he used satellite and ground-based data to study ionospheric variability and its representation through mathematical functions. As Chief Scientist at NASA/GSFC's National Space Science Data Center (NSSDC) and Space Physics Data Facility (SPDF) his main responsibilities are archiving of non-solar space physics data from NASA's heliospheric satellite missions and access to these data and orbits through CDAWeb and SSCWeb/Tipsod. Dr. Bilitza has published 127 refereed papers in scientific journals (62 as lead author; G-Index: 25; H-Index: 14) and has served as editor for 20 issues of Advances in Space Research and 1 AIP book. He has contributed chapters to three books including Springer's Encyclopedia of Physics. His main science focus during the last year was the development and release of the 2012 version of the model, IRI-2012, that includes major improvements and several new parameters (e.g., auroral boundaries).

Dr. Christopher Bridgwood is a Research Analyst at the Institute for Scientific Research at Boston College. He has been involved in the development and maintenance of the AFRL-SCINDA network and operational Space Weather products for the Air Force Weather Agency (AFWA). His contributions include, but not limited to, analysis of real-time ionospheric scintillation data, developing software, technical support, and scientific studies. He has coauthored several papers pertaining to space weather. One of those papers received Best Paper Award at the International Ionospheric Effects Symposium, 2011. Chris has a B.S. in mathematics, M.S. in applied mathematics, and has taught mathematics at university level.

Dr. Luigi Ciraolo took his degree in Physics discussing a thesis on the measurement of electron temperature in the ionosphere by Langmuir probes. In the following five years, his main field of activity is Electronics, at the institutes "MARITELERADAR" of the Italian Navy and "Electronics and Telecommunications" of the University of Pisa. In 1969 he joins CNR (National Research Council, Italy) working in satellite geodesy, namely the design, realization and scientific use of a Doppler station for the Navy Navigation Satellite System (NNSS) in the framework of a cooperation with US organizations. He investigated the capabilities of software receivers, constructing one prototype for the reception of the VLF OMEGA navigation system. Starting the 90's, another prototype of software receiver for the NNSS was built, aimed to observe latitudinal behavior of Total Electron Content (TEC). Given the excellent results obtained, a chain of four stations for observations in the Mediterranean area was set up. At the same time the interest moved towards ionospheric use of Global Positioning System (GPS), mainly the problem of correcting the observed differential delays from biases and offsets to get TEC (Calibration or de-biasing). This has become now his main activity. He still attempts, despite his retirement, to reduce as much as possible the occurrence of negative TEC's from his procedures.

Dr. Anthea J. Coster (Ph.D. Rice) is a research scientist at the MIT Haystack Observatory where she directs numerous GPS projects. Her research interests include space weather effects, magnetosphere and ionosphere coupling, GPS positioning and measurement accuracy, and meteor detection and analysis. She has been working with GPS since 1985, and, together with her coworkers, she developed the first real-time ionospheric monitoring system based on GPS in 1991. Her GPS TEC maps were the first to illustrate that storm enhanced density (SED), one of the major sources of space weather at the mid-latitudes, occurs across large areas of the United States during geomagnetic storms. SEDs have now been detected over Europe, Japan, and Australia. She is a member of the Institute of Navigation, the American Geophysical Union, and the Union of Radio Science (U.R.S.I.). She is the past U.S. chair of commission G of U.R.S.I. and she served on the ION council from 2001-2006. More recently, she has served on the science steering committee of the U.S. National Science Foundation's Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR) program.

Ms. Susan Delay is a senior research analyst at the Institute for Scientific Research at Boston College. In this role, Susan develops software to access and analyze data from a number of ionospheric sensors including GNSS satellite receivers and data from the TOPEX and JASON satellites. Susan is also involved in studies involving atmospheric and ionospheric modeling and forecasting. Susan holds a degree in Mathematics from Trinity College in Washington, DC and a MS in Administration from Boston College.

Dr. Christopher J. Hegarty is a director with The MITRE Corporation where he has working primarily on aviation applications of GPS since 1992. He is the chair of RTCA's Program Management Committee, co-chair of RTCA Special Committee 159, and associate editor of NAVIGATION: The Journal of the Institute of Navigation. He was a co-recipient of the 1998 ION Early Achievement Award and the recipient of the 2005 ION Johannes Kepler Award. He served as ION President in 2008.

Dr. Vadym Paznukhov received his PhD in 2004 at the University of Massachusetts Lowell. His PhD dissertation was dedicated to developing new techniques for studying traveling ionospheric disturbances with the use of digital ionospheric instruments. After graduation, he worked at University of Massachusetts Lowell on ionospheric storm modeling, GPS TEC radio occultation validation, and instrument development for a space missions. Since 2010, Vadym has worked as a Research Scientist at Boston College where his concentration is studying equatorial ionosphere using measurements from global GPS receiver network. He is also actively involved in developing and conducting active ionospheric experiments using HF heating facilities (HAARP) as well as investigating magnetosphere-ionosphere interaction using THEMIS satellite data and ground based all sky cameras.

Ms. Gabriella Povero is the Head of Higher Education Unit in Satellite Navigation Research Area in Instituto Superiore Mario Boella, in Torino, Italy. She graduated in Electronic Engineering at Politecnico di Torino. Her interests are in GNSS receiver technologies and GNSS Education. She has been coordinating several research projects on GNSS with partners from South East Asia. She is vice-coordinator of the Specializing Master on Navigation and Related Applications at Politecnico di Torino

Dr. Sergey Pulinets is a Head of Laboratory, Fiodorov Institute of Applied Geophysics, Moscow, Russia. He has more than 35 years of experience in Space Plasma Physics, Physics of the Ionosphere, and Geophysics. Dr. Pulinets is a leader of an international team of scientists proposing the Lithosphere-Atmosphere-Ionosphere coupling concept related to seismo-tectonics, active faulting and earthquake processes. Dr. Pulinets is a co-convener of the American Geophysical Union, fellow of IUGG Inter Association Working Group on Electromagnetic Studies of Earthquakes and Volcanoes (EMSEV), correspondent member of International Radio Science Union (URSI), International Committee of Space Research (COSPAR), fellow of URSI/COSPAR International Reference Ionosphere (IRI) Working Group, fellow of United Physical Society of Russia, member of editorial board of Geomagnetism and Aeronomy journal.

Dr. Paluri Venkata Sri Rama Rao completed his bachelors and masters degrees with first class during 1960 and 1962 respectively and obtained his Ph.D degree in Space Physics in 1967. After serving as lecturer and associate professor he was promoted as professor in the year 1982. He also served as Registrar of Andhra University from 1990-1994. He retired as a professor in Physics in October 2000 and was later awarded the Emeritus Scientist Fellowship by CSIR, Govt. of India in which he served for five years. He is currently an honorary Professor in the Department of Physics, Andhra University guiding Ph.D students.
Prof. Rama Rao established and lead the group on satellite beacon studies of the ionosphere and worked extensively on the equatorial and low latitude ionospheric phenomena, particularly on the Total Electron Content and Scintillations. He has handled the pilot project on the feasibility studies of the Indian GAGAN programme using signals from the GPS

satellites through a network of 21 receiving stations spread over the Indian sub-continent. He has published over 150 research papers. He has produced more than 20 Ph.D degrees and most of his students occupied respectable positions in India and abroad.
He has been awarded UNESCO fellowship twice and worked at NOAA Laboratories, Boulder, Colarado in1976 with Prof. Ken Davies and at the Air Force Geophysics Labs, Bedford, Mass in 1982 with Prof. Jack Klobuchar. He has extensively travelled all over the globe and visited more than 40 countries during the past 4 decades and participated, chaired and conducted several National and International symposia. He is one of the the co-chairs of the URSI commission-G on satellite beacon studies for the past 18 years. He also served as Scientific Advisory Committee member of Space Physics Laboratory, VSSC, Indian Space Research Organization (ISRO) and Project Advisory Committee member, Department of Sience & Technology (DST), Govt. of India.

Dr. John F. Raquet is an Associate Professor of Electrical Engineering at the AirForce Institute of Technology (AFIT), where he is also the Director of the Advanced Navigation Technology (ANT) Center. The ANT Center consists of 22 faculty members, 5 staff members, and over 40 students working to solve a wide variety of navigation problems. Dr. Raquet directly supervises the research of 6-10 MS and PhD students, and he is also responsible for teaching all of the GPS-related classes at AFIT. He has a multidisciplinary background, teaching in an electrical engineering department but having degrees in geomatics engineering (PhD, University of Calgary, 1998), aero/astro engineering (SM, Massachusetts Institute of Technology, 1991), and astronautical engineering (BS, US Air Force Academy, 1989). He has published over 100 navigation-related conference and journal papers and taught 26 navigation short courses to a number of different organizations. Dr. Raquet has been an active participant in the Institute of Navigation, and he has served as a session chair, program chair, track chair, and general chair of ION conferences, and on the ION Council as Central Region Vice President, Eastern Region Vice President, and Outreach Chair. He received the 2002 Institute of Navigation Early Achievement Award, the 1994 International Test and Evaluation Association (ITEA) Time-Space Position Instrumentation Data Collection and Electro-Optic Test and Evaluation Award, and the 1989 John von Neumann Award (presented to the top cadet in the Astronautical Engineering Department at the US Air Force Academy).

Dr. Charles L. Rino received his B.S. and M.S. degrees in electrical engineering from UC Berkeley in 1965 and 1966. He received his Ph.D. in information and computer science from UC San Diego in 1970. He conducted research in radio propagation and ionospheric physics at SRI International from 1970 until 1986 when he joined Mission Research Corporation as a Chief Scientist. In October 1987 he joined Vista Research as a Staff Scientist and later served as Vice President until he retired in 2009 and founded Rino Consulting.
In 1989 he was elected IEEE Fellow for contributions in wave propagation and ionospheric physics. He is principal author on over 50 papers on ionospheric physics, radio propagation, and surface scatter. His IEEE Press book *The Theory of Scintillation with Applications in Remote Sensing* was published in 2011.
Rino Consulting has conducted independent and contract research since 2009. Research supported by AFRL has led to invited papers presented at the 2010 Beacon Symposium (Barcelona, Spain), the 2011 Ionospheric Effects Symposium (Arlington, VA), and the 2012 National Radio Sciences Meeting (Boulder, Colorado).
In April 2013 Dr. Rino became a Visiting Scholar at Boston College.
Recent research activity has included:

Development of high-resolution digital receiver data processing for full bandwidth complex data.

- Three dimensional propagation simulations using equatorial plume simulations (Preliminary results published in Radio Science)
- Development of wavelet-based processing for data segmentation and spectral analysis for non- stationary structure
- Use of fractional Brownian motion model for simulation of equatorial plume structure
- Automated analysis of high-resolution it-situ F-region ionosphere structure

A paper entitled *Spherical Wave and Plane Wave Propagators* was published publication in the February 2013 issue of Antennas and Propagation Magazine. Current research activity can be found on the Rino Consulting website:
http\\www.chuckrino.com\wordpress

Dr. Julian Rose was awarded his PhD in 2011, from the University of Bath. His work involved using ionospheric imaging to improve the accuracy of GPS positioning and timing. In 2010 he was awarded the Westminster Medal at the Houses of Parliament for his research. Since then Julian has been continuing his work with ionospheric imaging and is involved in a CubeSat project with the UK Space Agency and also works on the plasmasphere. Most recently Julian has led the second Alcantara Study on Africa.

Dr. Luca Spogli has a PhD in high energy physics from University of Rome (Roma 3) and since 2008 he is in the Upper Atmosphere Physics group of the Instituto Nazionale di Geofisica e Vulcanologia in Rome, Italy. His main interests concern ionospheric dynamics at high, low and mid-latitude by means of GNSS observations and modelling.

Dr. Frank Van Graas is a Fritz J. and Dolores H. Russ Professor of Electrical Engineering and Principal Investigator with the Avionics Engineering Center at Ohio University. He served as the Institute of Navigation Executive Branch Science and Technology Policy Fellow in the Space Communication and Navigation Office at NASA Headquarters during the 2008-2009 academic year. He has been involved with GNSS research since 1984. Frank is a Past President of the ION (98-99) and currently serves as the ION Treasurer. Frank is also the Director of the Consortium of Ohio Universities on Navigation and Timekeeping. He has authored or co-authored over 150 technical publications including 40 journal papers and two patents. In 1996, he received the Johannes Kepler Award for "sustained and significant contributions to satellite navigation" from the Satellite Division of the ION. He is a Fellow of the ION and also received the ION Colonel Thomas L. Thurlow, Distinguished Service and Burka awards. In 2011, he received the John Ruth Avionics Award from the American Institute of Aeronautics and Astronautics.

Dr. Todd Walter received his B.S. in physics from Rensselaer Polytechnic Institute and his Ph.D. from Stanford University in 1993. He is currently a senior research engineer at Stanford University. He is a co-chair of the FAA's WAAS Integrity Performance Panel focused on the implementation of WAAS. His current activities include defining future architectures to provide aircraft guidance and working with the FAA on the implementation of dual-frequency WAAS. Key early contributions include: prototype development proving the feasibility of WAAS, significant contribution to WAAS MOPS, and design of integrity algorithms for WAAS. He is a fellow of the ION and serves as its president.

Dr. Endawoke Yizengaw was born and raised in small town of northwestern Ethiopia known as Amber. He received the B.Sc. degree in applied physics from Addis Ababa University, Ethiopia, in 1994, the M.Sc. degrees in atmospheric sciences from Tromso University, Norway, in 1998, and PhD degree in space science from La Trobe University, Australia, in 2004. He spent two years, from 2004 to 2006, as a postdoctoral researcher at the Institute of Geophysics and Planetary Physics (IGPP) of University of California Los Angeles (UCLA), where he won the 2006 Chancellor's Award for best Postdoctoral Researchers. From 2006 to 2009, he was a Research Faculty with IGPP of UCLA. Since July 2009 he has been a senior research scientist with the Institute for Scientific Research of Boston College in Boston, MA. He has been a Principal or Co-investigator in several interdisciplinary projects, primarily deploying ground-based instruments which includes AMBER project that comprises five magnetometers deployed in Africa. He is the author or coauthor of over 40 professional publications, of which more than 30 are in peer-reviewed scientific journals. His research interests include space weather, magnetosphere-ionosphere coupling, equatorial ionospheric electrodynamics, and ground- and space-based GPS tomography. His research is mainly focused on combining information from a variety of ground- and space-based instruments to understand ionospheric irregularities that affect the navigation and communication systems

The Abdus Salam International Centre for Theoretical Physics

Workshop on GNSS Data Application to Low Latitude Ionospheric Research

Organizer(s): S.M. Radicella (ICTP), P. Doherty (Boston College), R. Prieto (European Space Agency). ICTP Local Organizer: B. Nava
Trieste - Italy, 06 - 17 May 2013

Venue: Adriatico Guest House Giambiagi Lecture Hall

Programme

PART 1 - BASICS OF GNSS (Room:Adriatico Guest House Giambiagi Lecture Hall)

6 May 2013

09:00 - 12:00 (Room: Adriatico Guest House - Giambiagi Lecture Hall Area (Lower Level 1))
Registration and Administrative Formalities
All those attending the activity are required to complete online registration.

12:00 - 14:00 --- Lunch ---

14:00 - 15:30 **Opening Ceremony**
Talks by: F. Quevedo (Director, ICTP), S. Radicella (ICTP), P. Doherty (Boston College), R. Prieto-Cerdeira (ESA/ESTEC), S. Gadimova (UNOOSA-ICG)

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:00 **B. Rabiu** / *National Space Research and Development Agency, NASRDA, Abuja, Nigeria*
GNSS in Africa: Trends of Applications and Prospects

Tuesday - Fundamentals of GNSS (Room:Adriatico Guest House Giambiagi Lecture Hall)

7 May 2013

08:30 - 09:00 **P. Doherty, S.M. Radicella**
The workshop programme

09:00 - 10:30 **C. Hegarty** / *MITRE Corporation*
Fundamentals of GNSS

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 13:00 **C. Hegarty** / *MITRE Corporation*
GPS Measurements and Error Sources

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 **C. Hegarty** / *MITRE Corporation*
GNSS Systems: Modernized GPS, GALILEO, GLONASS, COMPASS, IRNSS and QZSS

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:00 **ICTP/BC Team**
Introduction to Laboratory Work

20:30 - 22:30 (Room: Adriatico Guest House Cafeteria)
--- Welcome Dinner ---

Wednesday - Fundamentals of GNSS (Room:Adriatico Guest House Giambiagi Lecture Hall)

8 May 2013

09:00 - 10:30 **J. Raquet** / *AFIT*
The Navigation Solution

10:30 - 11:00 --- Coffee Break ---

11:00 - 13:00 **J. Raquet** / *AFIT*
The Navigation Solution (continued)

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 **F. Van Graas** / *Ohio University*
Differential GPS

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 16:30 **F. Van Graas** / *Ohio University*
Differential GPS (continued)

16:30 - 17:30 **J. Raquet** / *AFIT*
Differential GNSS Positioning Demo

Thursday - Applications of GNSS (Room:Adriatico Guest House Giambiagi Lecture Hall)

9 May 2013

08:30 - 10:00 **J. Raquet** / *AFIT*
Kalman filtering for GNSS

10:00 - 10:30 **F. Van Graas** / *Ohio University*
Inertial Navigation Systems

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 12:00 **F. Van Graas** / *Ohio University*
Inertial Navigation Systems (continued)

12:00 - 13:00 **F. Van Graas** / *Ohio University*
Kalman Filtering and Inertial Navigation Demo

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 **T. Walter** / *Stanford University*
GNSS and Aviation Applications

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:00 **T. Walter** / *Stanford University*
GNSS and Aviation Applications (continued)

PART 2 - SPACE WEATHER AND IONOSPHERIC EXPLORATION USING GNSS

Friday - The Alcantara Initiative (Room:Adriatico Guest House Giambiagi Lecture Hall)

10 May 2013

08:30 - 09:30 **D. Bilitza** / *George Mason University*
The International Reference Ionosphere

09:30 - 10:00 **A. Galvez** / *ESA/HQ*
ESA General Studies Programme and the Alcantara Initiative

10:00 - 10:30 **R. Prieto-Cerdeira** / *ESA/ESTEC*
The Alcantara Initiative: Ionospheric Ground Based Monitoring Networks in Low-Latitude Regions

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 11:40 **ICTP**
Alcantara:Low-latitude ionosphere in Africa 1

11:40 - 12:20 **ISMB**
Alcantara: Low-latitude ionosphere in Southeast Asia and Pacific

12:20 - 13:00 **INGV**
Alcantara: Low-latitude ionosphere in South-America

13:00 - 14:00 --- Lunch ---

14:00 - 14:30 **University of Bath**
Alcantara: Low-latitude ionosphere in Africa 2

14:30 - 15:30 **Panel Discussion**

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:00 **R. Prieto-Cerdeira** / *ESA/ESTEC*
Modeling and Simulation of Environmental Effects on GNSS

Monday - The Ionosphere (Room:Adriatico Guest House Giambiagi Lecture Hall)

13 May 2013

08:30 - 09:30 **S. Radicella** / *ICTP*
The Ionosphere

09:30 - 10:30 **Paluri V.S. Rama Rao** / *Andhra University*
The Low-Latitude Ionosphere: Genesis of the Equatorial Electrojet and its Control on the Equatorial Ionization Anomaly

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 12:00 **V. Paznukhov** / *Boston College*
Longitudinal Differences in Low-Latititude Ionosphere

12:00 - 13:00 **L. Ciraolo** / *ICTP*
TEC estimation from GNSS observations

13:00 - 14:00 --- Lunch ---

14:00 - 14:30 **P. Doherty** / *Boston College*
Ionospheric Effects on GNSS

14:30 - 15:15 **S. Delay** / *Boston College*
GNSS Data Processing

15:15 - 16:00 **L. Ciraolo** / *ICTP*
GNSS Data Processing

16:00 - 16:30 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:30 - 18:00 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
GNSS Data Processing

Tuesday - Space Weather (Room:Adriatico Guest House Giambiagi Lecture Hall)

14 May 2013

08:30 - 09:30 **E. Yizengaw** / *Boston College*
Introduction to Space Weather and its Impact on Our Daily Lives

09:30 - 10:30 **A. Coster** / *MIT*
Low-Latitude Response to Geomagnetic Storms

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 12:00 **C. Rino** / *Boston College*
Ionospheric Irregularities and Scintillation

12:00 - 13:00 **S. Pulinets** / *Space Research Institute, Moscow*
Ionospheric Effects of Seismic Activity

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
A. J. Coster / *MIT*
The Madrigal Database
For half of the participants
Laboratory Project, BC-ICTP Team, Introduction 01h30'
Lecture for half the participants in Giambiagi Lecture Hall

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:30 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
A. J. Coster / *MIT*
The Madrigal Database
For half of the participants
Laboratory Project, BC-ICTP Team, Introduction 01h30'
Lecture for half the participants in Giambiagi Lecture Hall

Wednesday - Complementary Measurements (Room:Adriatico Guest House Giambiagi Lecture Hall)

15 May 2013

08:30 - 09:30 **E. Yizengaw** / *Boston College*
AMBER Magnetometers Network and Longitudinal Differences of Equatorial Electrodynamics and Ionospheric Vertical Density Distribution

09:30 - 10:30 **V. Paznukhov** / *Boston College*
Introduction to Ionosondes

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 11:30 **P. Doherty** / *Boston College*
The Low-latitude Ionospheric Sensor Network: A multi-instrument real-time ionospheric laboratory

11:30 - 12:30 **P. Doherty** / *Boston College*
Update on SCINDA activities

12:30 - 13:00 **C. Bridgwood** / *Boston College*
SCINDA operations

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
Laboratory Project, BC-ICTP Team
For half the participants

GPS Receiver Demonstration (C. Bridgwood) 01h30'

On the AGH Terrace, weather permitting, with half of the participants

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:30 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
E. Yizengaw / *Boston College*
Estimating Drift Velocity with Magnetometers
For half the participants

Ionosonde Data (V. Paznukhov) 01h30'

In Giambiagi Lecture Hall

Thursday - Ionospheric Modeling (Room:Adriatico Guest House Giambiagi Lecture Hall)

16 May 2013

09:00 - 09:45 **Y. Migoya Orué** / *ICTP*
NeQuick Model

09:45 - 10:30 **B. Nava** / *ICTP*
Radio-occultation for ionospheric studies

10:30 - 11:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

11:00 - 12:00 **B. Nava** / *ICTP*
Data Assimilation in Ionospheric Models

12:00 - 13:00 **S. Radicella** / *ICTP*
Electron Density Models: Present Trends and Validation Issues

13:00 - 14:00 --- Lunch ---

14:00 - 15:30 (Room: Adriatico Guest House - Eklund Informatics Lab (Lower Level 1))
Laboratory Project, BC-ICTP Team
Half of the participants

GPS Receiver Demonstration (C. Bridgwood) 01h30'

On the AGH Terrace, weather permitting, with half of the participants

15:30 - 16:00 (Room: Adriatico Guest House (Terrace))
--- Coffee Break ---

16:00 - 17:30 **E. Yizengaw** / *Boston College*
Laboratory-Accessing Space Weather Information

19:30 - 22:30 --- Final Dinner (ICTP/BC) ---

Friday - Closing Discussions and Closing Ceremony (Room:Adriatico Guest House Giambiagi Lecture Hall)

17 May 2013

08:30 - 08:50	**J.O. Adeniyi** / *University of Ilorin, Nigeria* **Ionospheric irregularities over Ilorin**
08:50 - 09:00	**P. Doherty** / *Boston College* **Geocache Wrap up**
09:00 - 09:15	**Laboratory Project - Team 1 Results**
09:15 - 09:30	**Team 2 Results**
09:30 - 09:45	**Team 3 Results**
09:45 - 10:00	**Team 4 Results**
10:00 - 10:15	**Team 5 Results**
10:15 - 10:30	**Team 6 Results**
10:30 - 11:00	(Room: Adriatico Guest House (Terrace)) --- Coffee Break ---
11:00 - 11:15	**Team 7 Results**
11:15 - 11:30	**Katy Alazo** / *ICTP* **Laboratory Projects - Wrap up**
11:30 - 12:15	**Open Discussion: The Future - Where do we go from here?**
12:15 - 13:15	**Closing Remarks and Distribution of Certificates of Participation**

The Abdus Salam
International Centre
for Theoretical Physics

Activity SMR: **2458**

Workshop on GNSS Data Application to Low Latitude Ionospheric Research

6 May 2013 - 17 May 2013
Trieste - ITALY

Final List of Participants

Total Number of Visitors: 83

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