Istituto Nazionale di GEOFISICA e VULCANOLOGIA

The use of GNSS for Space Weather: the Italian case

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Outline

GNSS signal from Space to Earth

Delay and Scattering
Why such effects?
(solar wind / magnetosphere, ionosphere, perturbations, Scintillation)

How to monitor TEC and scintillation by GNSS?

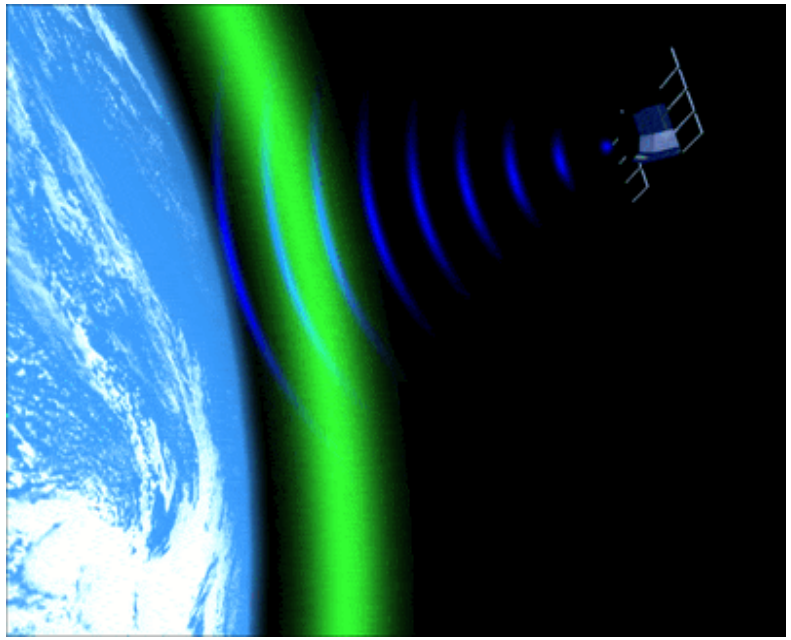
Monitoring technique
Scintillation effect example during the halloween storm at high latitude
Italian contribution to the international network

Remarks and technologic and scientific challenges

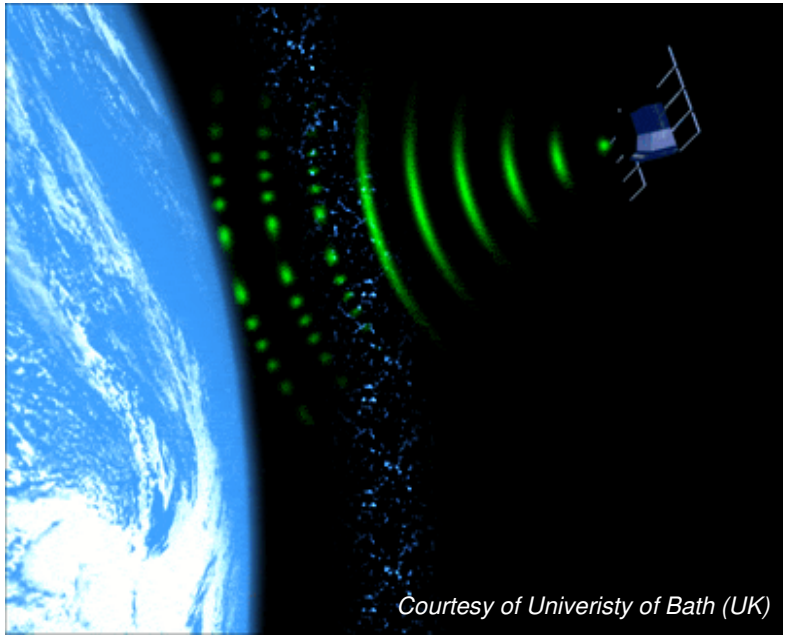
International project results

ESA-Alcantara
CIGALA-CALIBRA
TRANSMIT
ESPAS

GNSS signal from Space to Earth: effects induced by the Ionosphere



Total Electron Content (TEC)



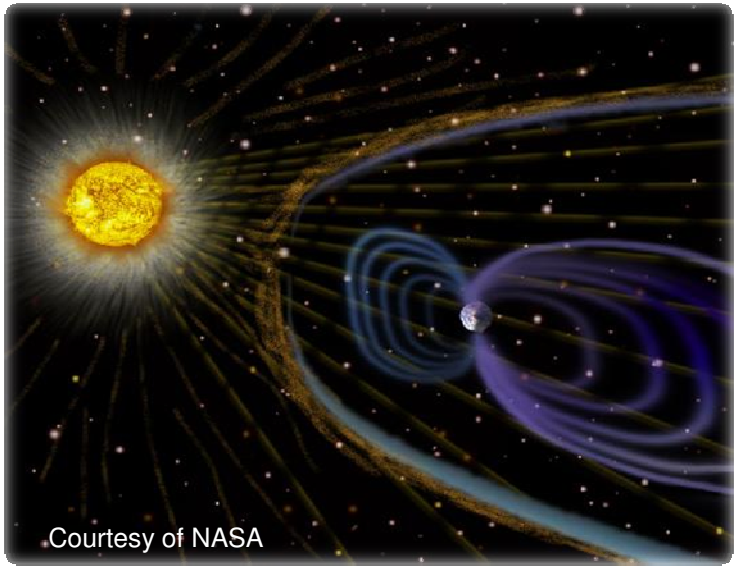
Turbulence

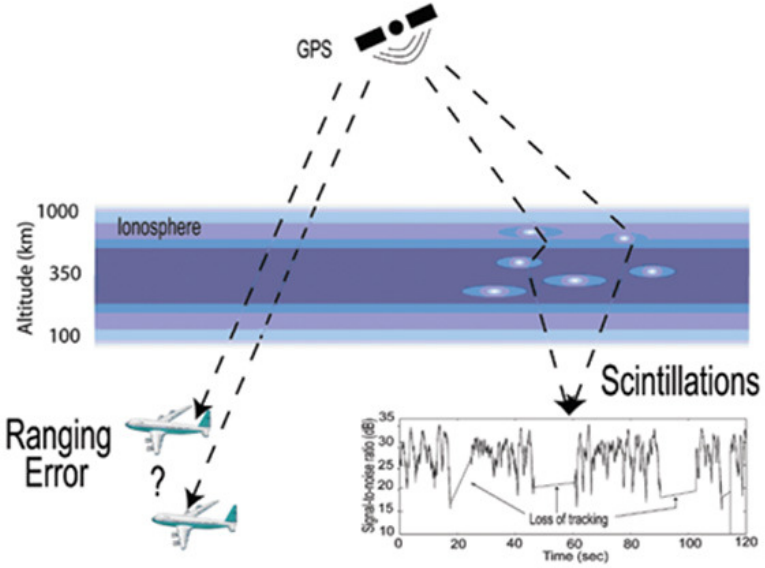
Delay

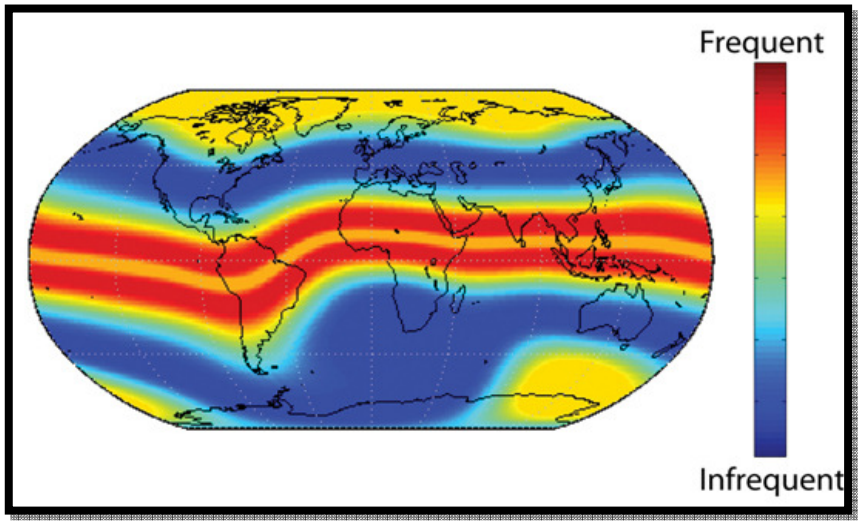
Scintillation (Scattering)

Why such effect?

- Solar Wind-Magnetosphere coupling causes turbulences of the ionosphere
  - Irregularities with scales in a large range (space and time)
  - Variation (+/-) of the ρ_{elec}
  - Random fluctuations of the refractive index
  - Distortion of the original wave front
- Diffraction effects on the transionospheric signals
  - Ranging errors – losses of lock

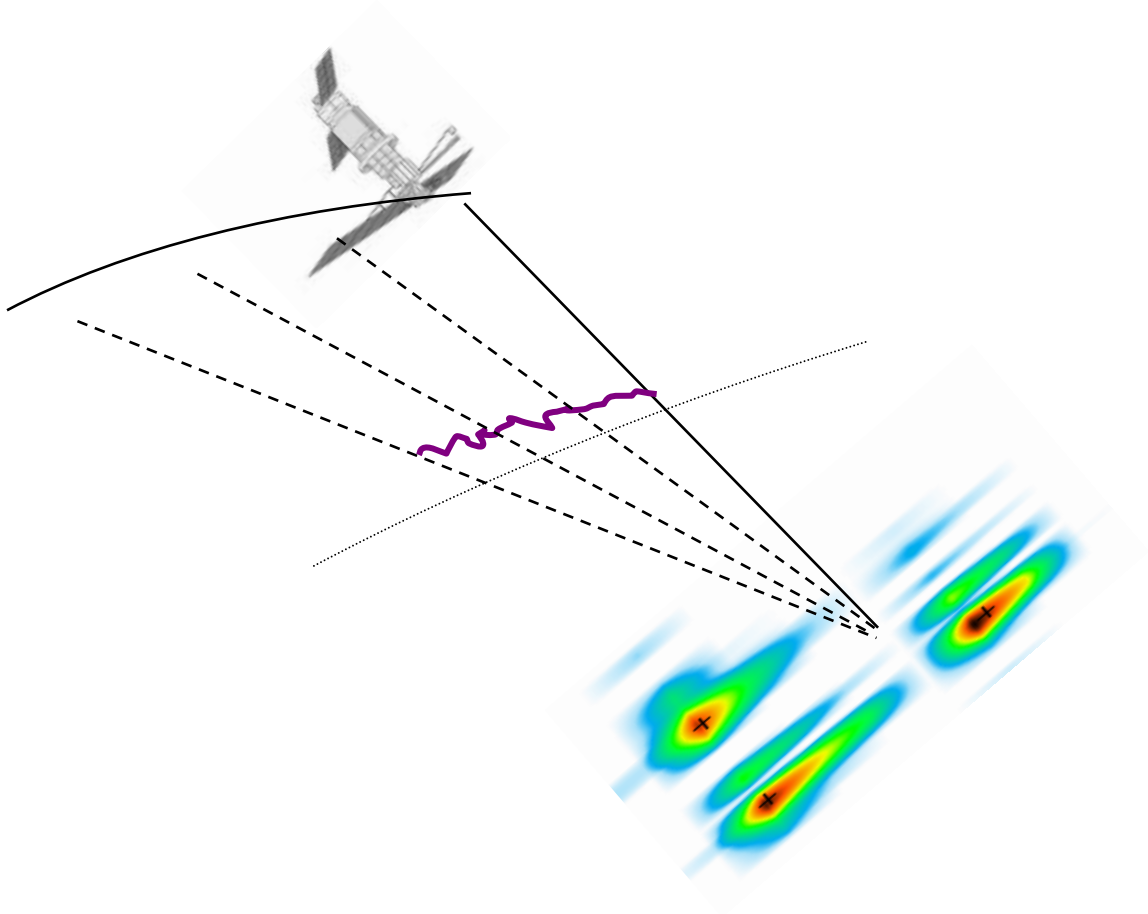






Global occurrence characteristics of scintillation (Courtesy of P. Kintner)

How to monitor TEC and scintillation by GNSS?

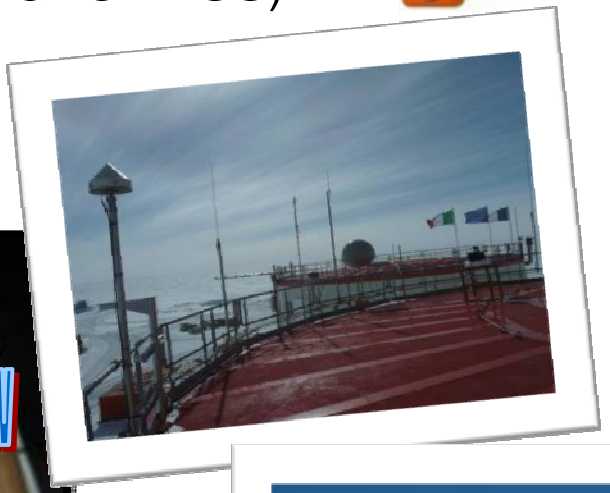


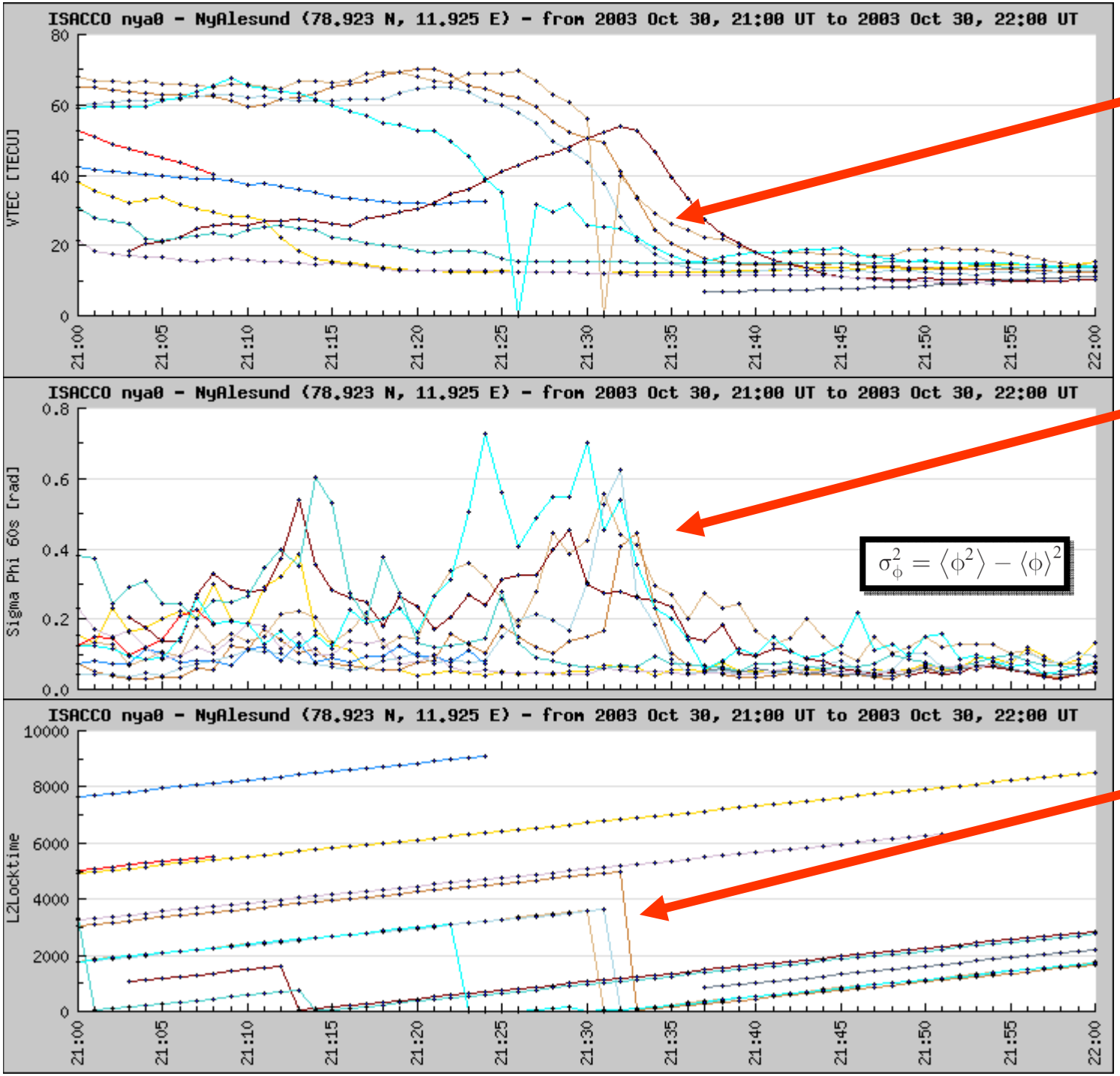
GNSS receivers for scintillation

High frequency sampling (50Hz)

Multiple frequency

Multi constellation (GPS, GALILEO, GLONASS)





TEC gradients

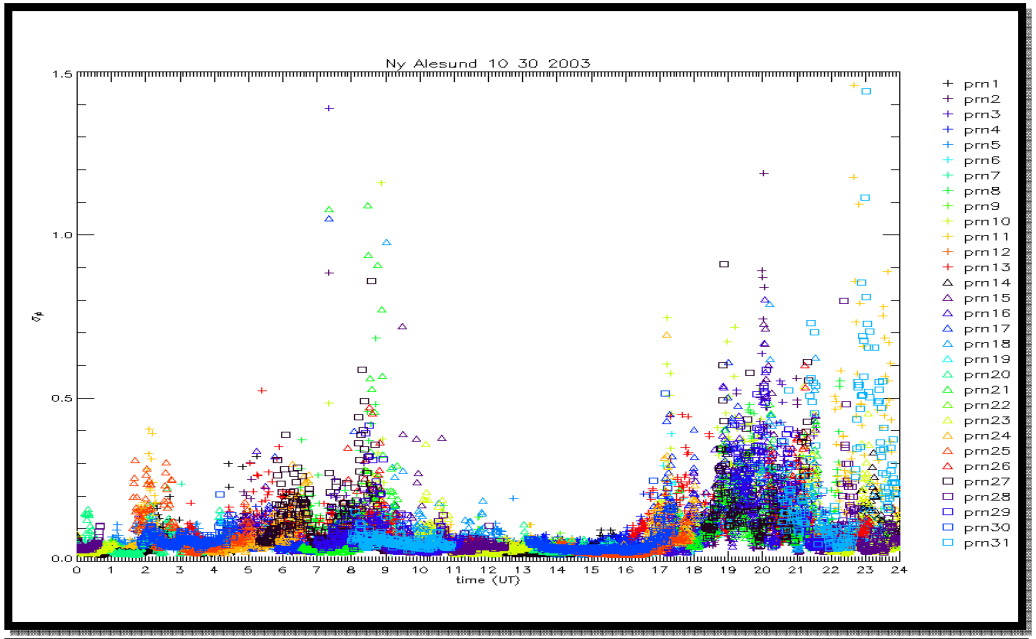
High level of (phase) scintillations

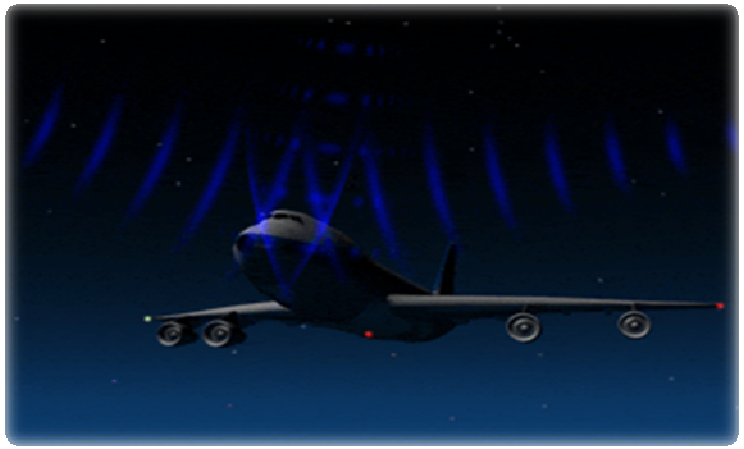
Loss of lock on L2

CONNECTION WITH THE SATELLITE IS LOST!

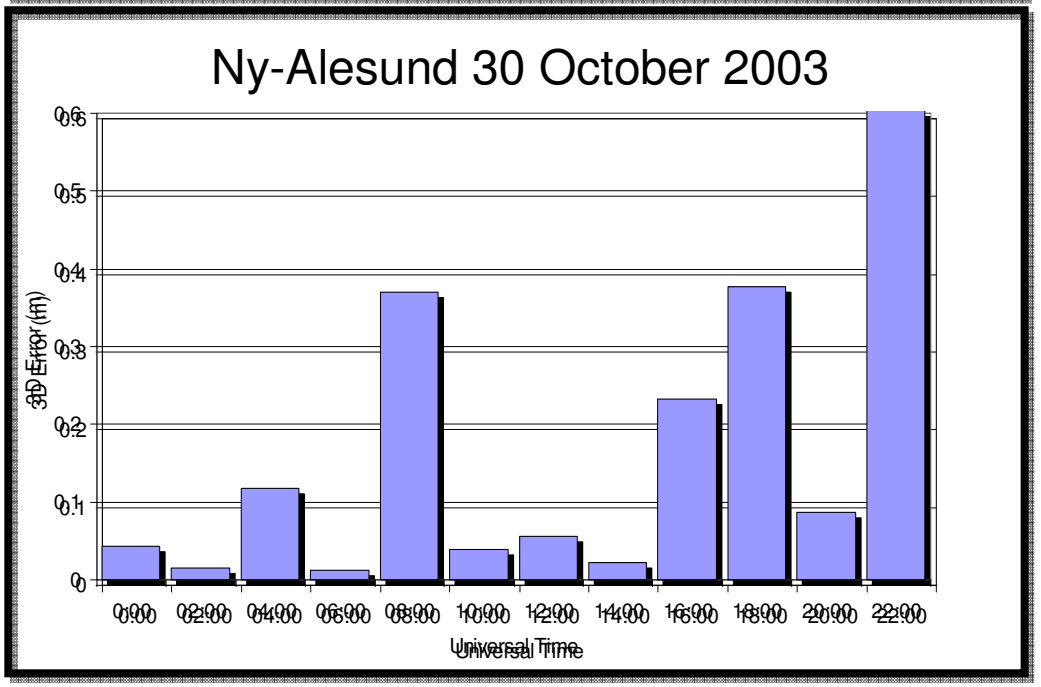
Loss of lock is not the only threat…

Scintillation





Positioning error



Italian network of Receivers

First receiver installed at Ny-Alesund (Svalbard) since 2003

Polar ionosphere

- Svalbard islands (3)
- Antarctica (4)

Mid latitude ionosphere

- Chania (Crete)
- Huelva (Spain) – stopped
- Huelva station moved to Lampedusa

Equatorial Ionosphere

- Tucuman (Argentina)

Data are accessible at the *electronic Space Weather upper atmosphere* website

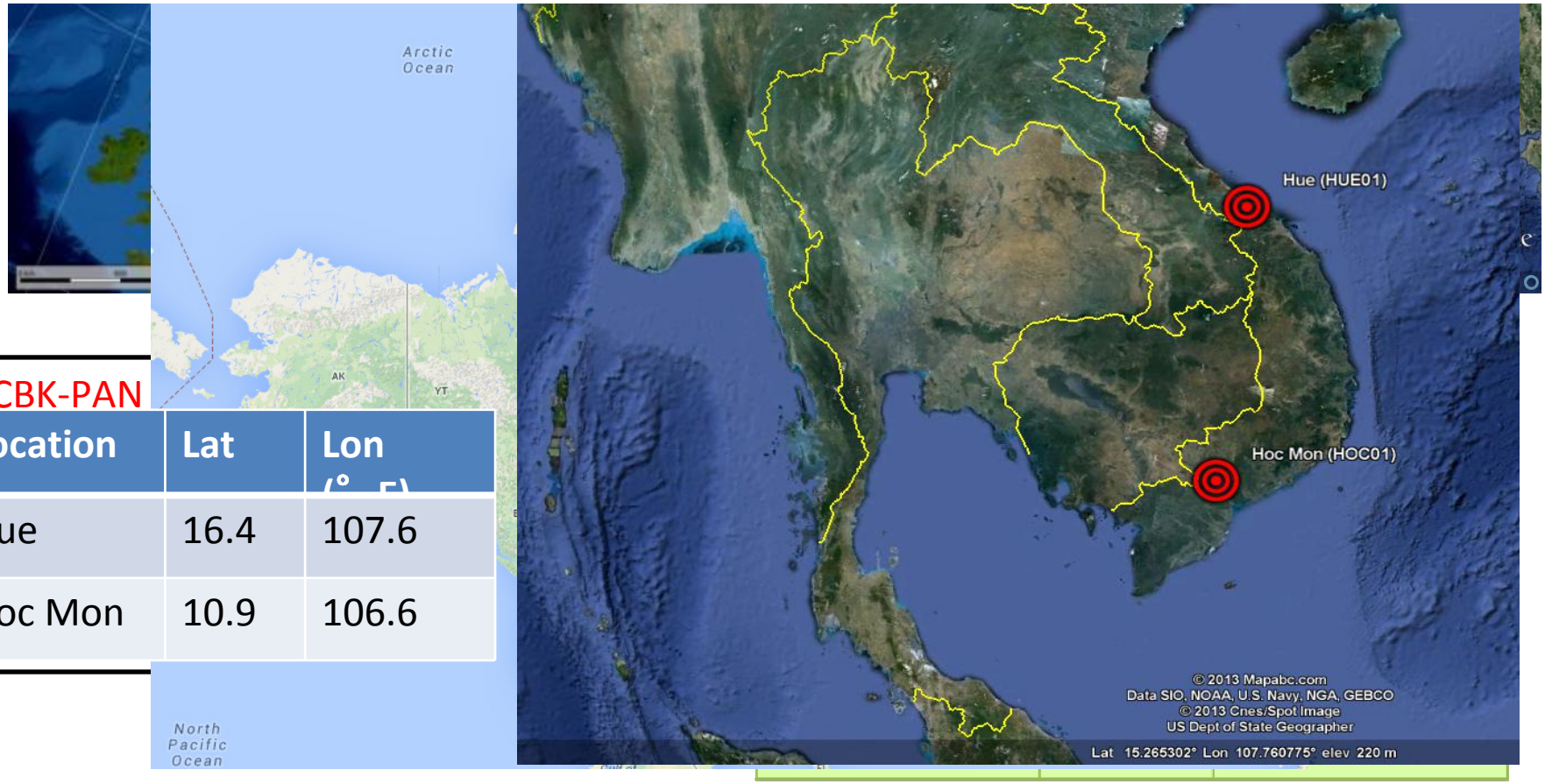
eSWua

www.eSWua.ingv.it

International network partners

Institute of Electronics and Telecommunications of Rennes (IETR) -University of Rennes

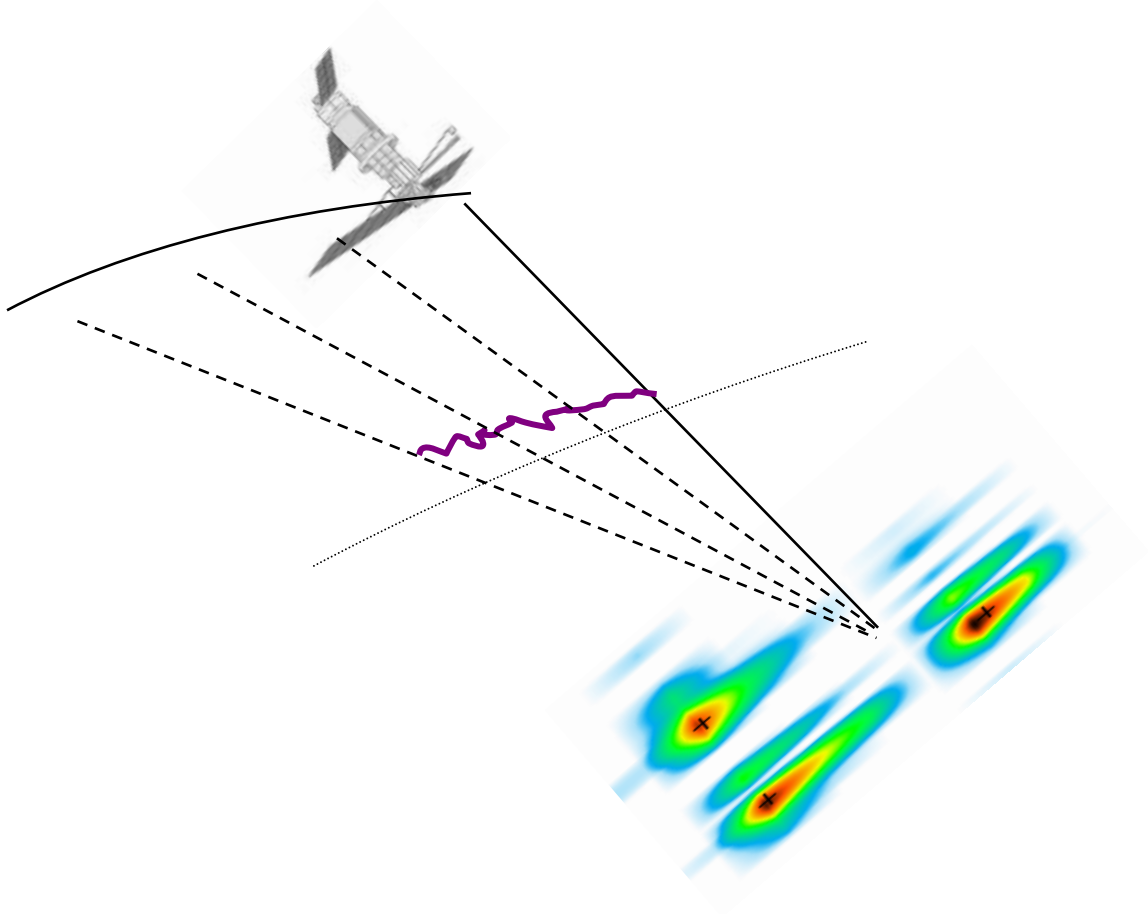
Vietnam Academy of Science and Technology (VAST), Institute of Geophysics

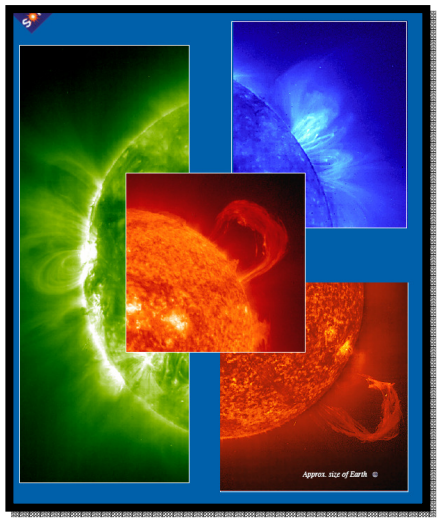


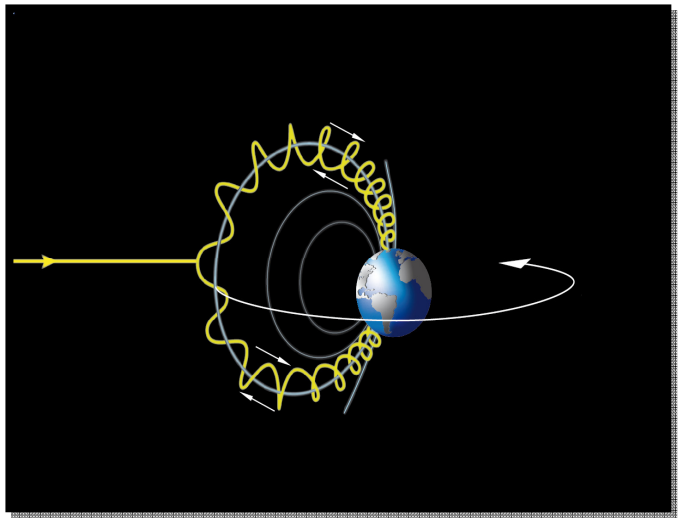
CBK-PAN

Location	Lat	Lon (° E)
Hue	16.4	107.6
Hoc Mon	10.9	106.6

Remarks and technologic and scientific challenges

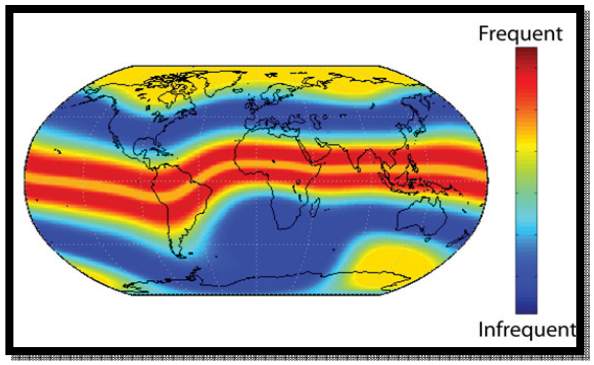






REMARKS

•Space Weather can affect significantly the Navigational and Positioning satellite systems
•This problem has limited the expansion of the GNSS market in mission-critical high-precision applications, such as air, rail and marine transport and even autonomous machinery in areas as agriculture.
•Ionospheric GNSS receivers are reliable, low cost and robust systems able to monitor the Space Weather effects in the ionosphere
•There is a need for a new generation of researchers, trained with ionospheric and Space Weather expertise directly connected to their GNSS knowledge.



TECHNOLOGIC AND SCIENTIFIC CHALLENGES

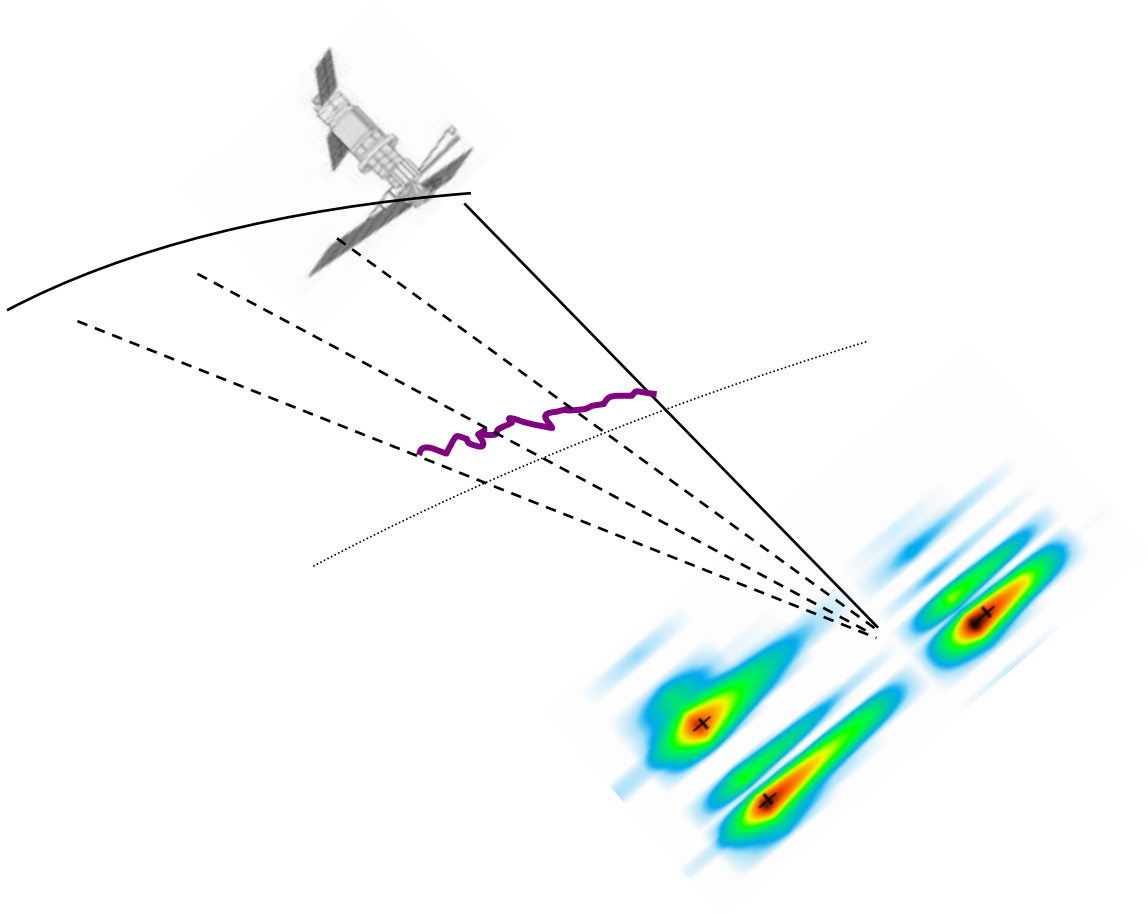
•Advance the physical modelling of the underlying processes associated with the ionospheric plasma environment and the knowledge of its influences on human activities

•Develop new techniques to detect and monitor space weather threats, with the introduction of new prediction and forecasting models, mitigation tools and improved system design

•Establish a real time system to monitor the ionosphere, capable of providing useful assistance to users, which exploits all available resources and adds value for worldwide services and products

•Incorporate solutions to this system that respond to all end user needs and that are applicable in all geographical regions of interest (polar, high and mid-latitudes, equatorial region).

International efforts to tackle the problem



GINESTRA – MIMOSA - MEDSTEC

COMPETENCE SURVEYS WITHIN THE ESA ALCANTARA INITIATIVES

MImOSA

Monitoring **I**onosphere **O**ver **S**outh **A**merica

GINESTRA

Ground-based **I**onosphere monitoring **NE**tworks in **S**outhes**T**e**R**n **A**sia: a survey

MEDSTEC

Towards **M**apping of **E**lectron **D**ensity, **S**cintillation and **T**otal **E**lectron **C**ontent

WHO

WITH

INGV

ISMB Istituto Superiore Mario Boella

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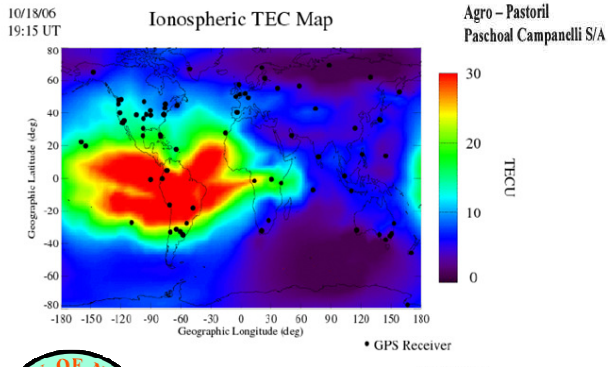
SOUTH AFRICAN NATIONAL SPACE AGENCY

CALIBRA: Countering GNSS high Accuracy applications LImitation due to ionospheric disturbance in BRAzil
FP7–GALILEO–2011–GSA–1a

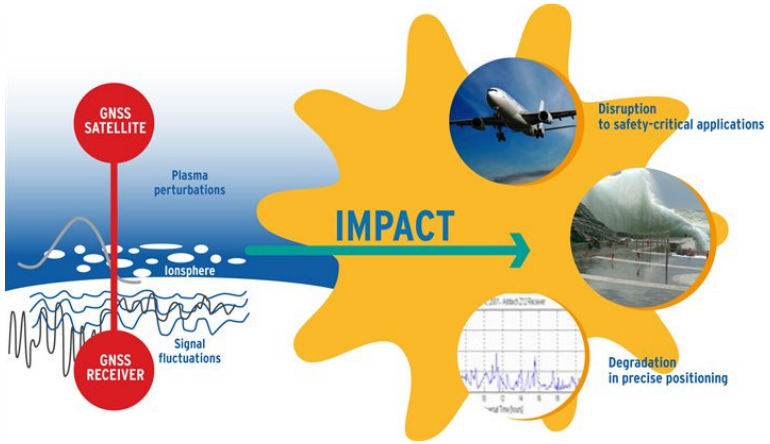
- CALIBRA builds on the outcomes of CIGALA
- Mitigate impact of ionospheric disturbances
  - Scintillation
  - TEC variations
- Focus on high accuracy GNSS positioning techniques
  - Better than 10cm
- Address applications in Brazil
- Devise commercially applicable solutions
- Implementation at receiver level
- Provide reassurance for users of GNSS at low latitudes



TRANSMIT

TRAINING RESEARCH AND APPLICATIONS NETWORK TO SUPPORT THE MITIGATION OF IONOSPHERIC THREATS

An FP7 Marie Curie Initial Training Network. The project addresses in particular ionospheric threats to Global Navigation Satellite Systems (GNSS) and related applications, in areas such as civil aviation, marine navigation and land transportation. TRANSMIT is a 4-year project and involves the recruitment of 16 young researchers across its partners



The University of Nottingham
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TRANSMIT Coordinator

espas
near earth space data infrastructure for e-science

SEVENTH FRAMEWORK PROGRAMME

Near-Earth space data infrastructure for e-science

A platform to integrate heterogeneous data from earth's thermosphere, ionosphere, plasmasphere & magnetosphere

- Supports the systematic exploration of multipoint measurements from the near-Earth space through homogenised access to multi-instrument data
- Provides access to 40+ datasets from : Cluster, EISCAT, GIRO, DIAS, SWACI, CHAMP, SuperDARN, FPI, magmetometers INGV, SGO, DTU, IMAGE, TGO, IMAGE/RPI, ACE, SOHO, PROBA2, NOAA/POES, etc.
- Supports data visualization, search, statistics, modelling

ESPAS User Interface is accessible through
http://www.espas-fp7.eu
Final ESPAS release: in April 2015

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