

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

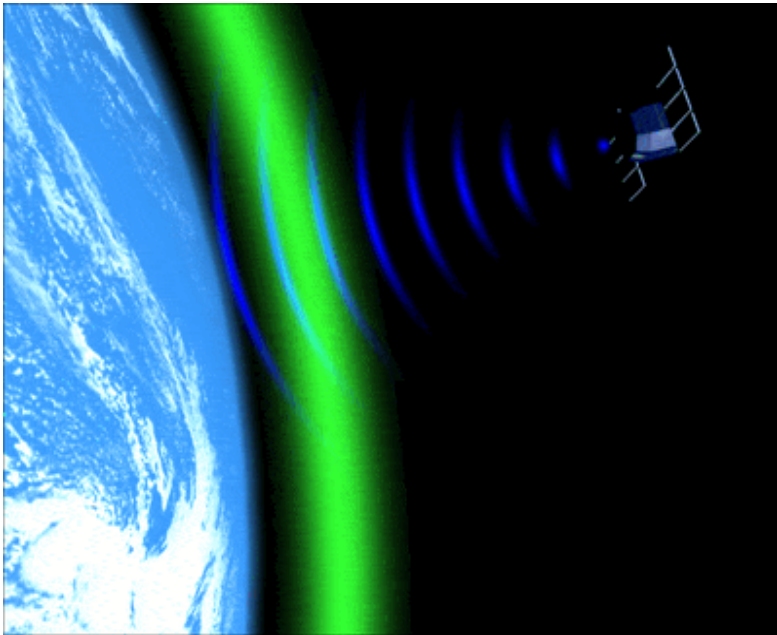
ESA-Alcantara

CIGALA-CALIBRA

TRANSMIT

ESPAS

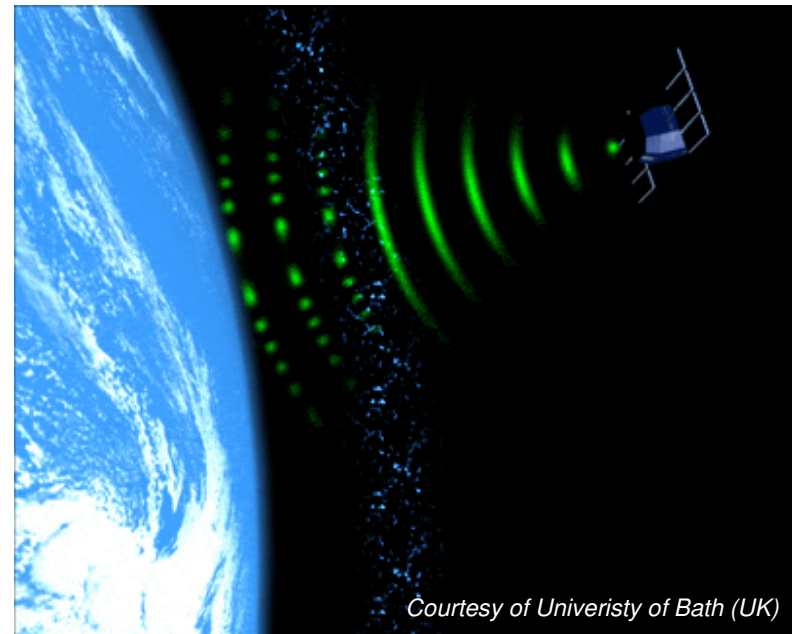
GNSS signal from Space to Earth: effects induced by the Ionosphere



Total Electron Content (TEC)



Delay



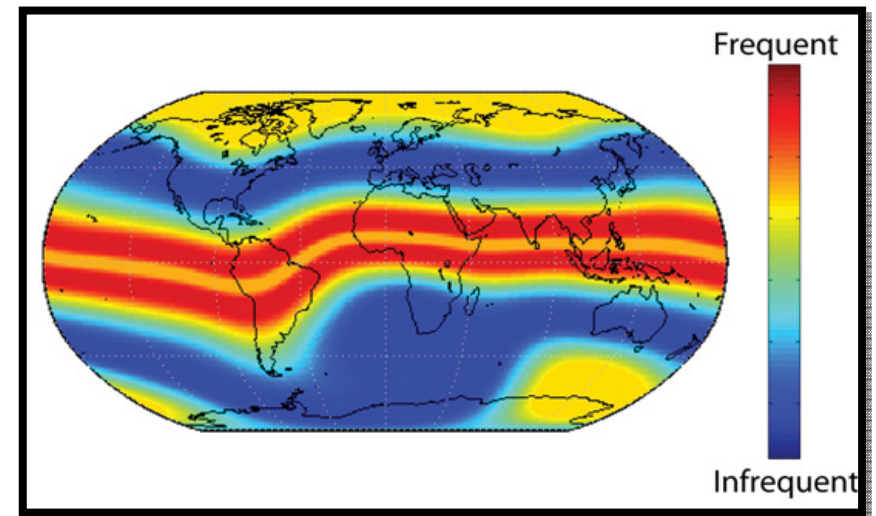
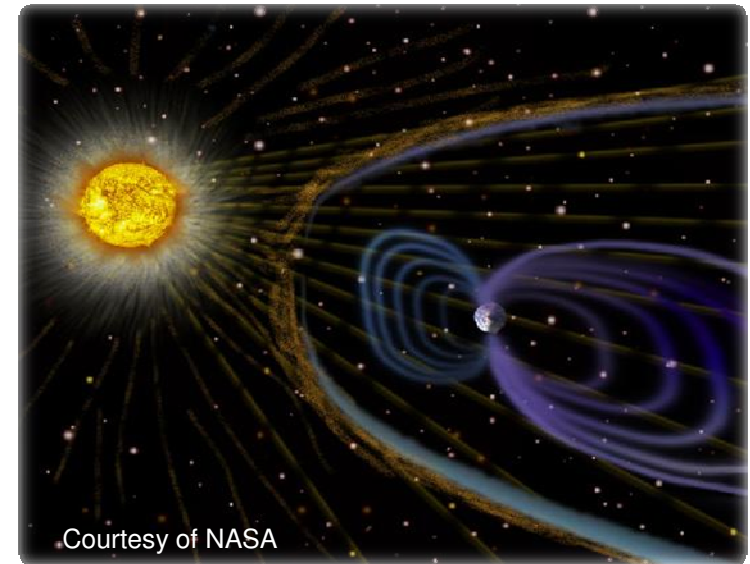
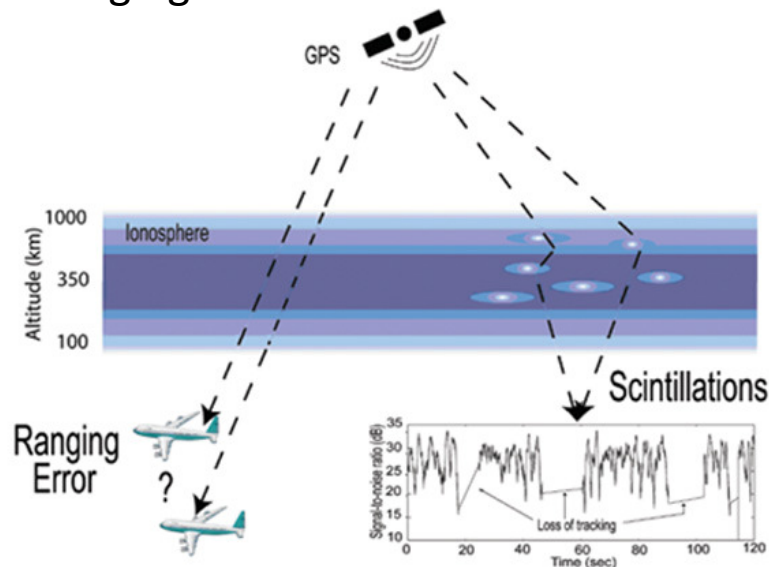
Turbulence



Scintillation (Scattering)

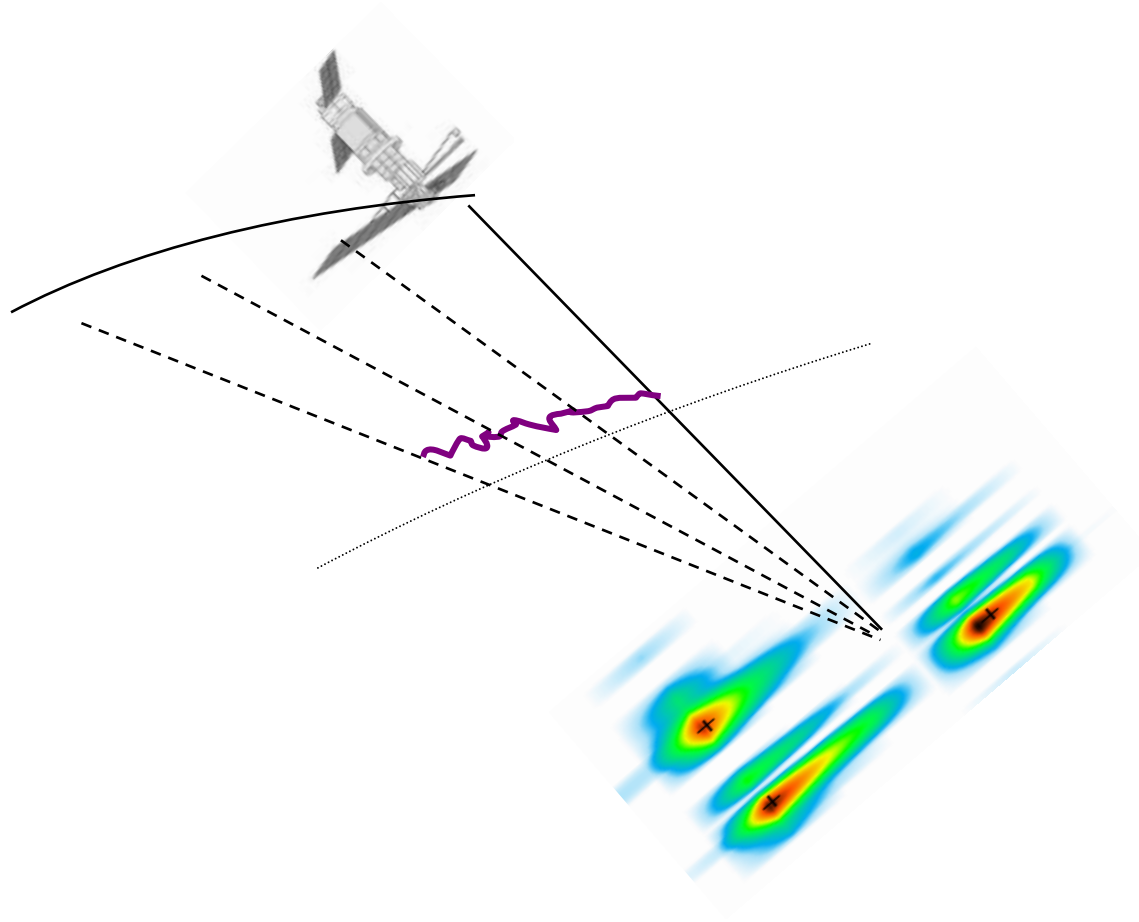
Why such effect?

- 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?

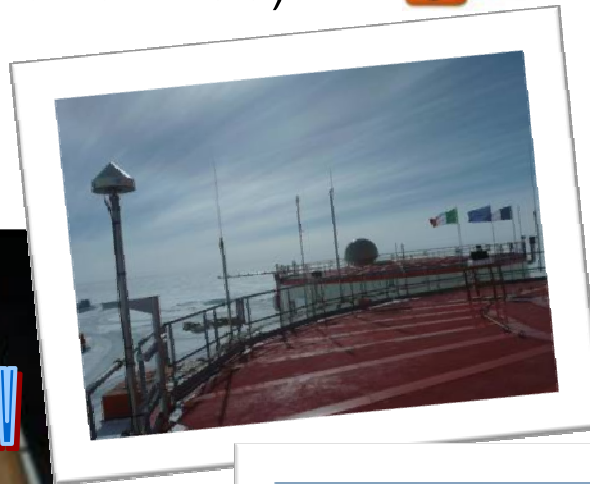


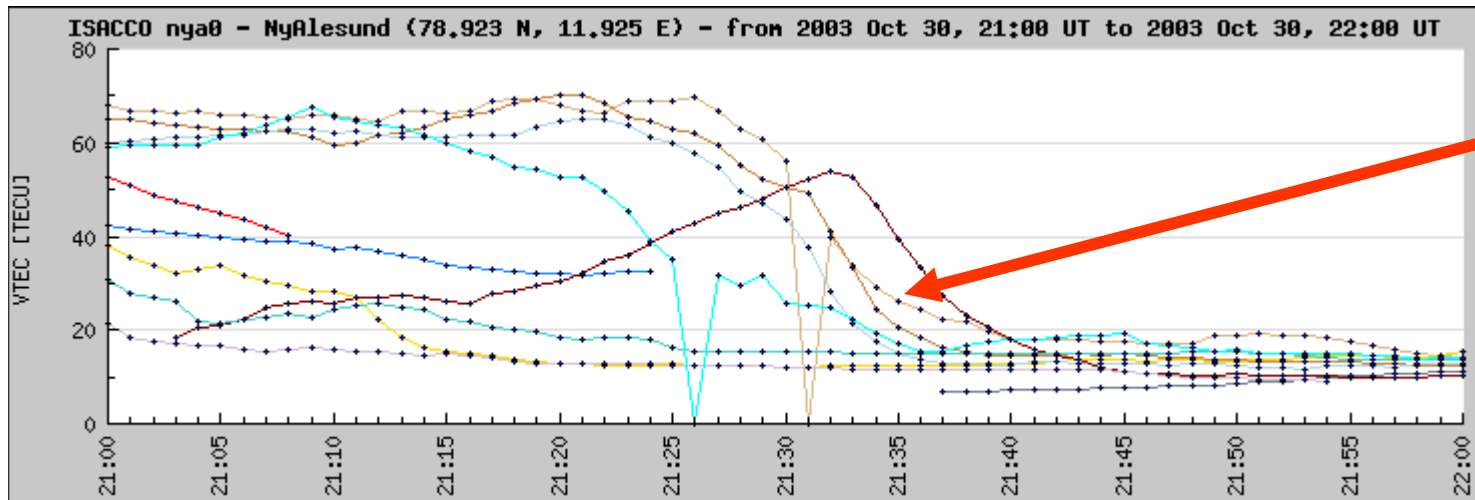
GNSS receivers for scintillation

High frequency sampling (50Hz)

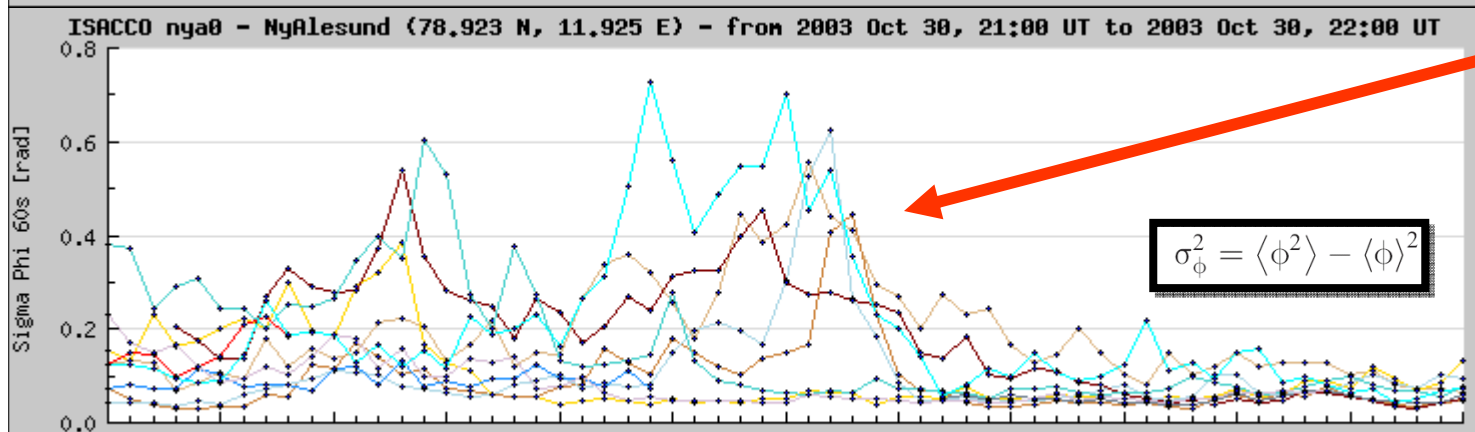
Multiple frequency

Multi constellation (GPS, GALILEO, GLONASS)

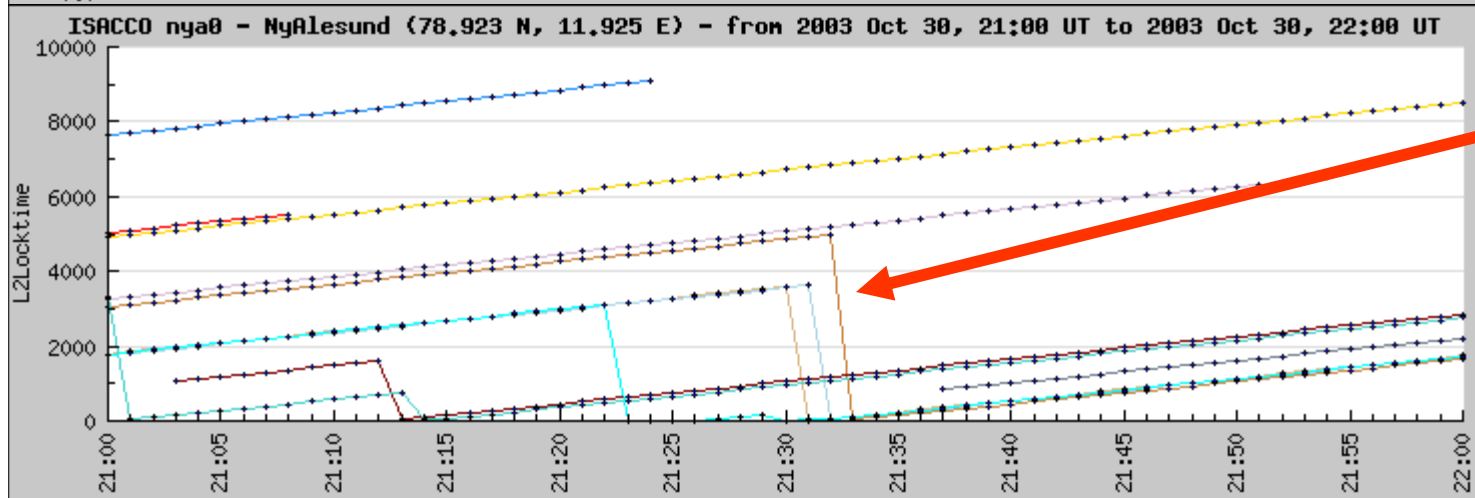




TEC
gradients



High level of
(phase) scintillations

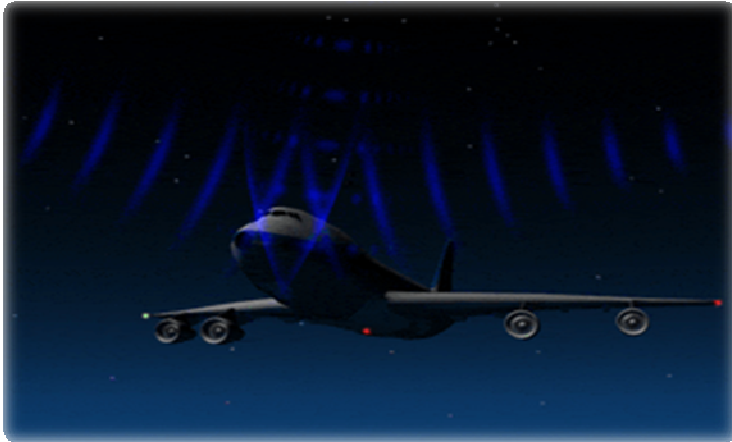


Loss of lock
on L2

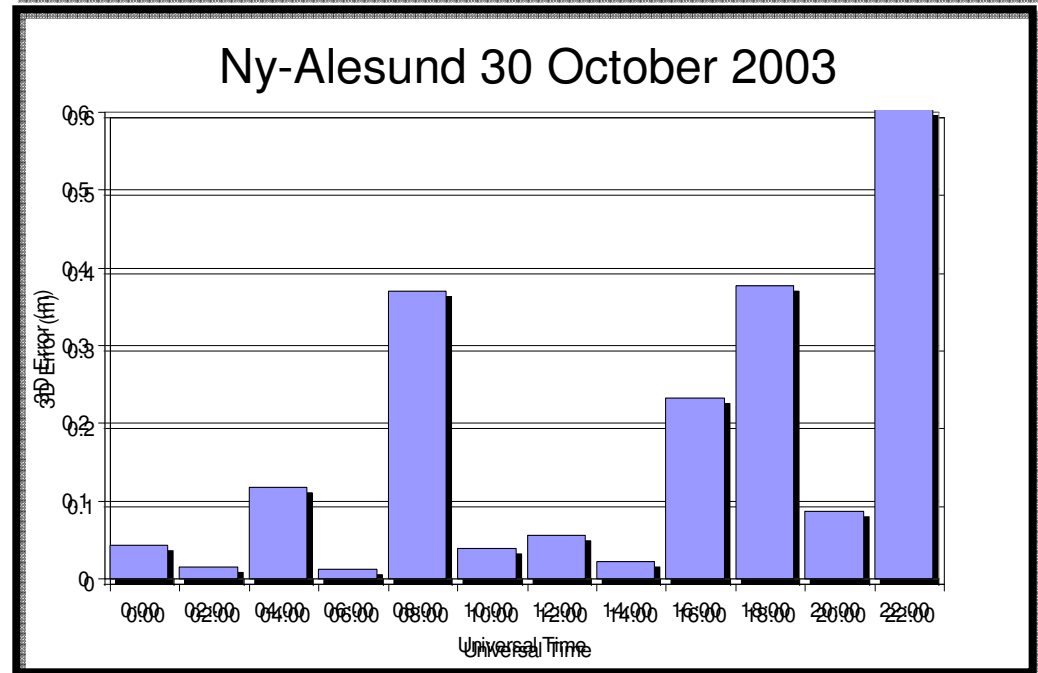
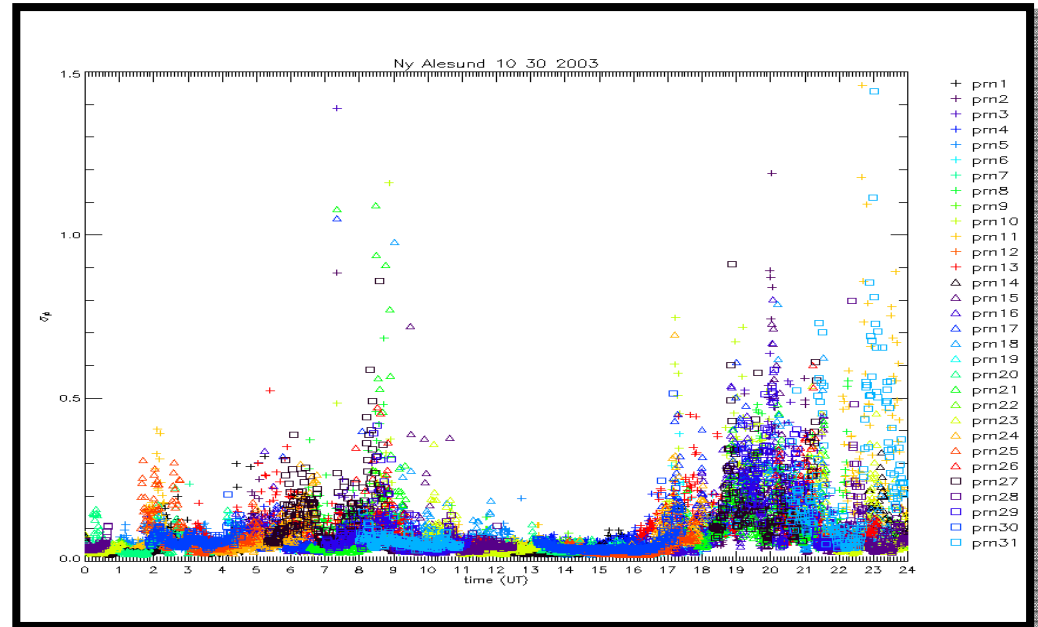
CONNECTION WITH
THE SATELLITE IS
LOST!

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)

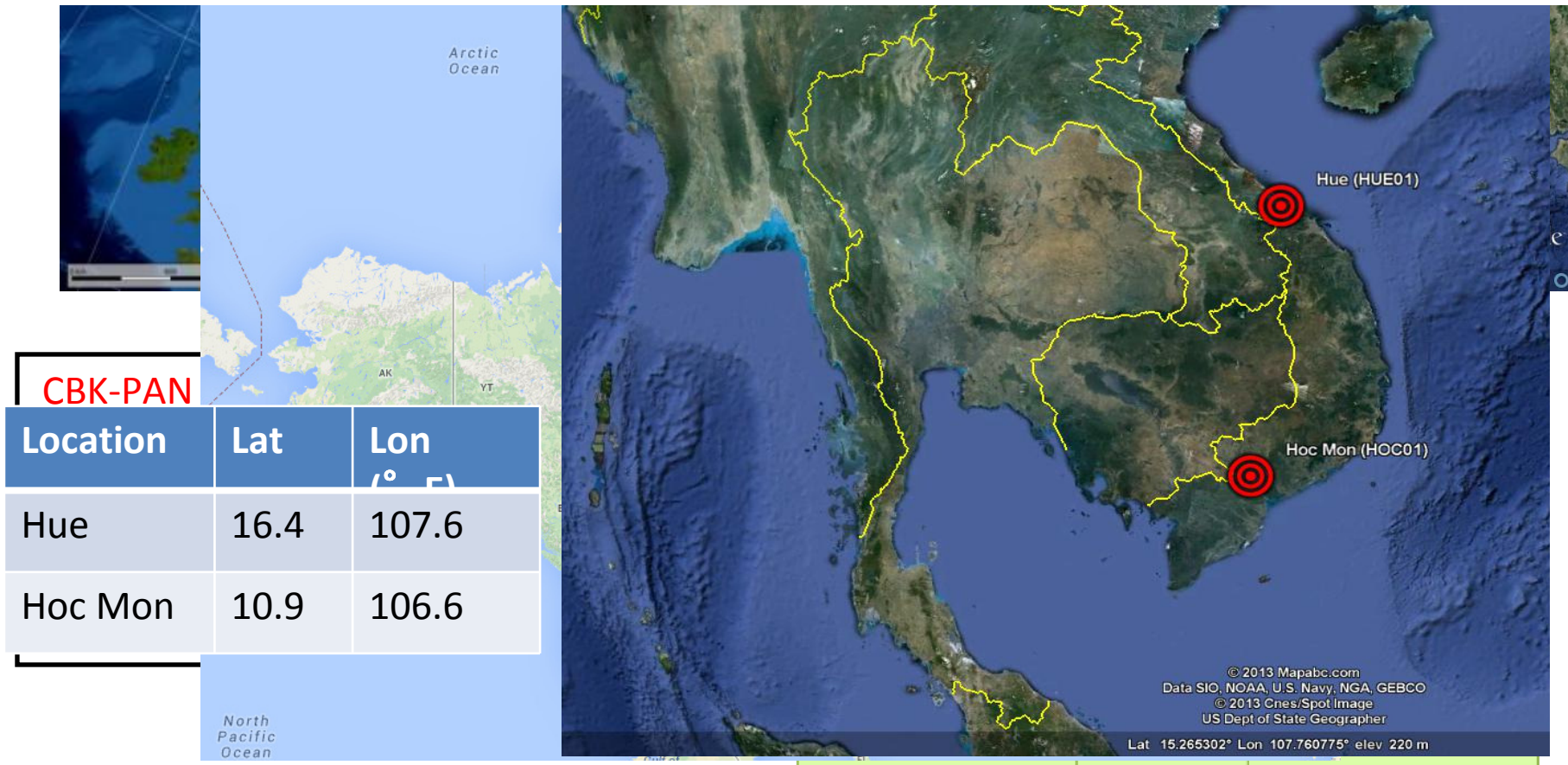


Data are accessible at the *electronic Space Weather upper atmosphere* website
eSWua
www.eSWua.ingv.it

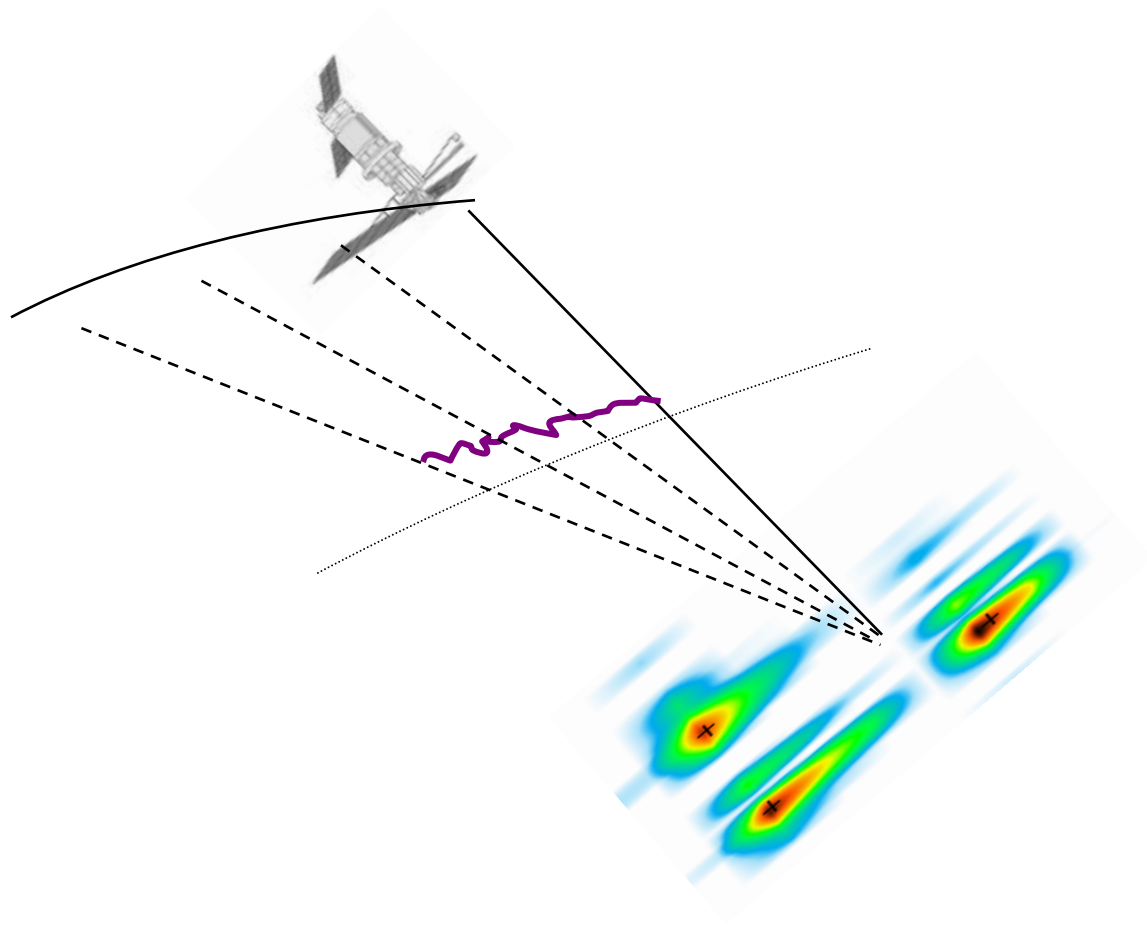


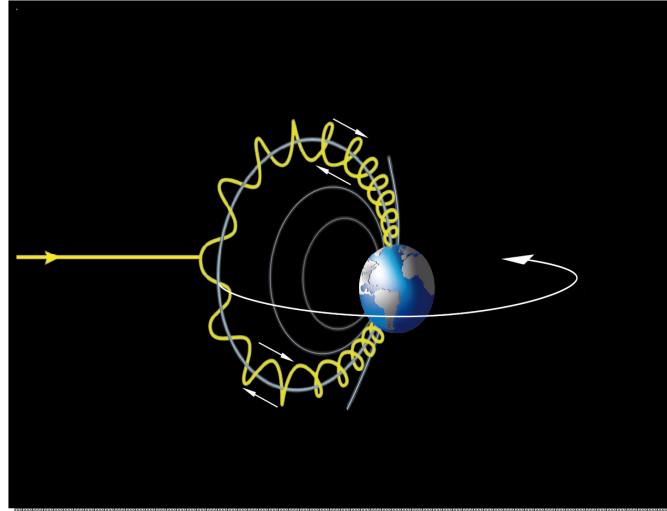
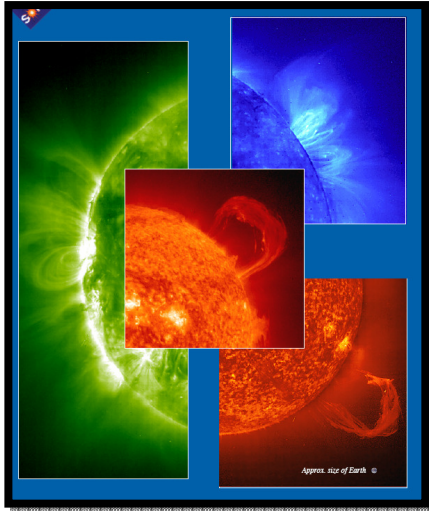
**Institute of Electronics and Telecommunications of Rennes (IETR)
-University of Rennes**

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



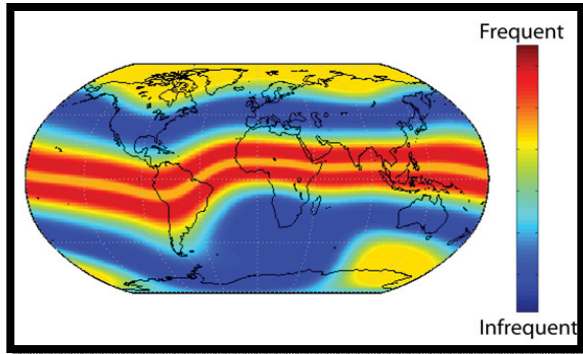
Remarks and technologic and scientific challenges





REMARKS

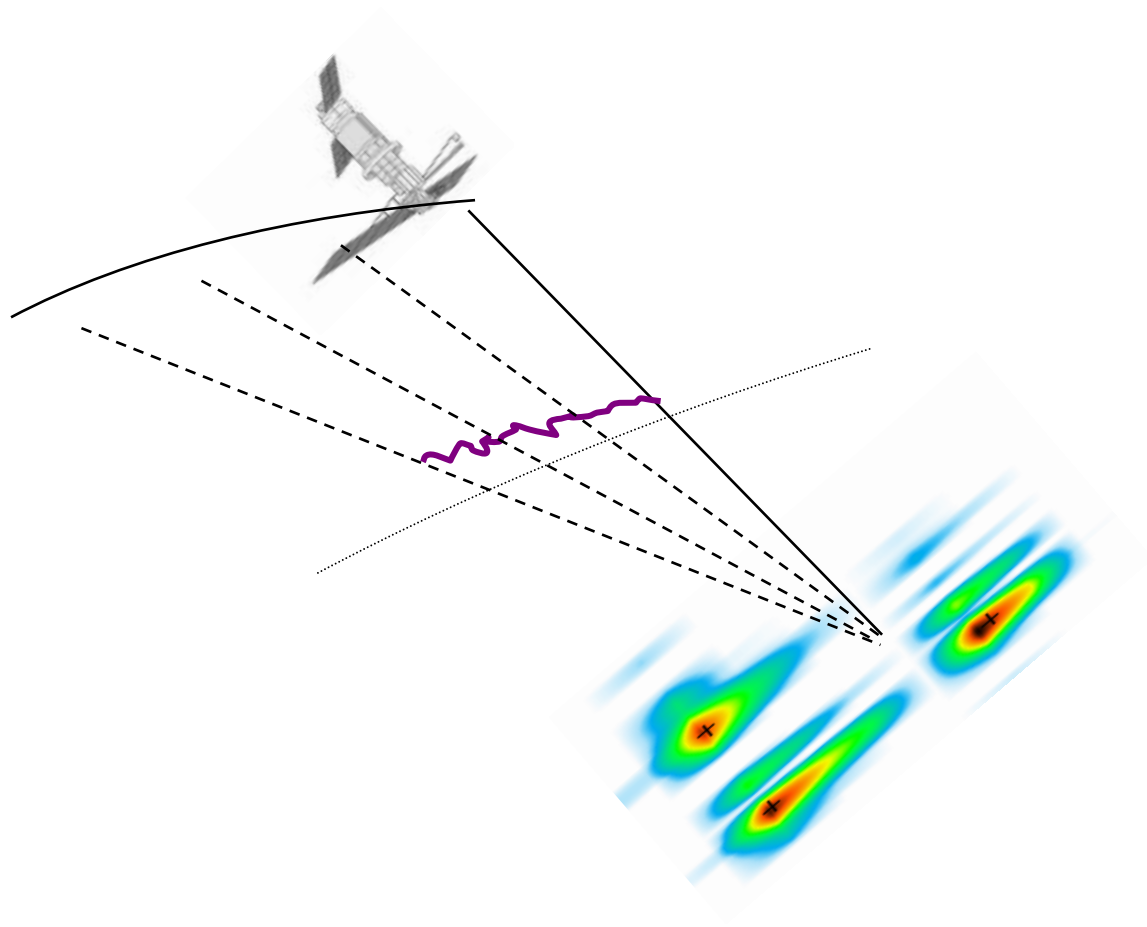
- Space Weather can affect significantly the Navigational and Positioning satellite systems
- This problem has limited the expansion of the GNSS market in mission-critical high-precision applications, such as air, rail and marine transport and even autonomous machinery in areas as agriculture.
- Ionospheric 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 Ionosphere Over South America

GINESTRA

Ground-based Ionosphere monitoring
NEtworks in SouthEast Asia: a survey

MEDSTEC

Towards Mapping of Electron Density,
Scintillation and Total Electron
Content



WHO

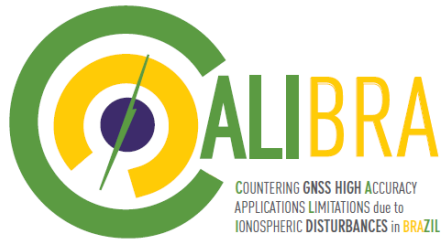


WITH



UNIVERSIDAD NACIONAL
DE TUCUMÁN
FIDES IN TERRA AD SIDERA VISUS

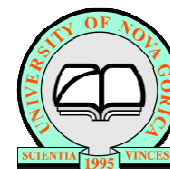
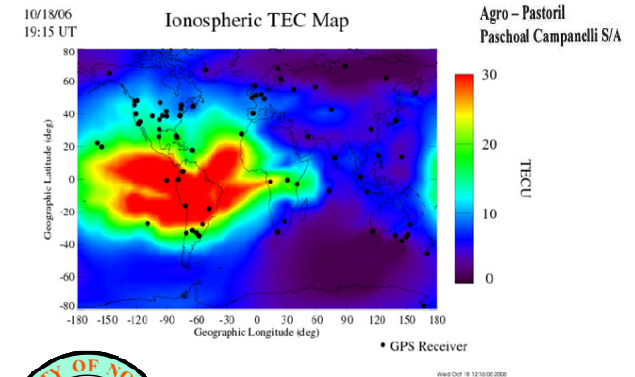




CALIBRA: Countering GNSS high Accuracy applications Limitation due to ionospheric disturbance in BRAzil FP7–GALILEO–2011–GSA–1a



- 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

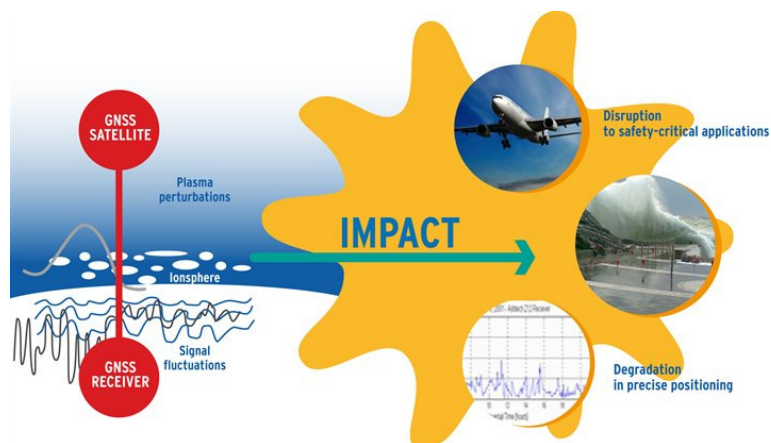


TRANSMIT

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



Near-Earth space data infrastructure for e-science

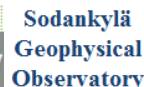
A platform to integrate heterogeneous data from earth's thermosphere, ionosphere, plasmasphere & magnetosphere

- 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, magnetometers 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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