The Significance of GNSS for Radio Science

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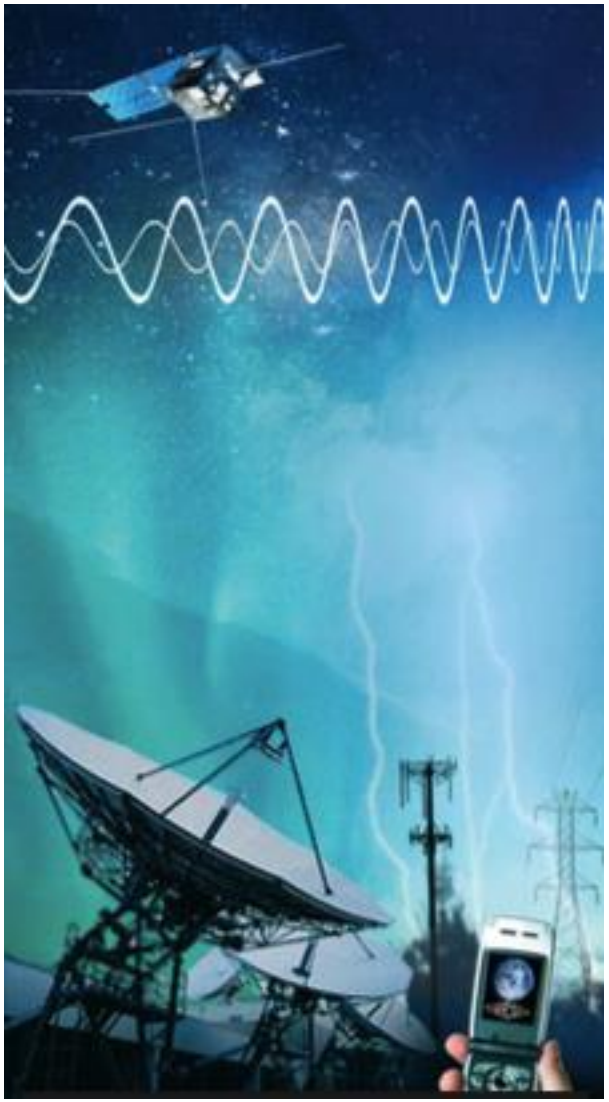
What is URSI?



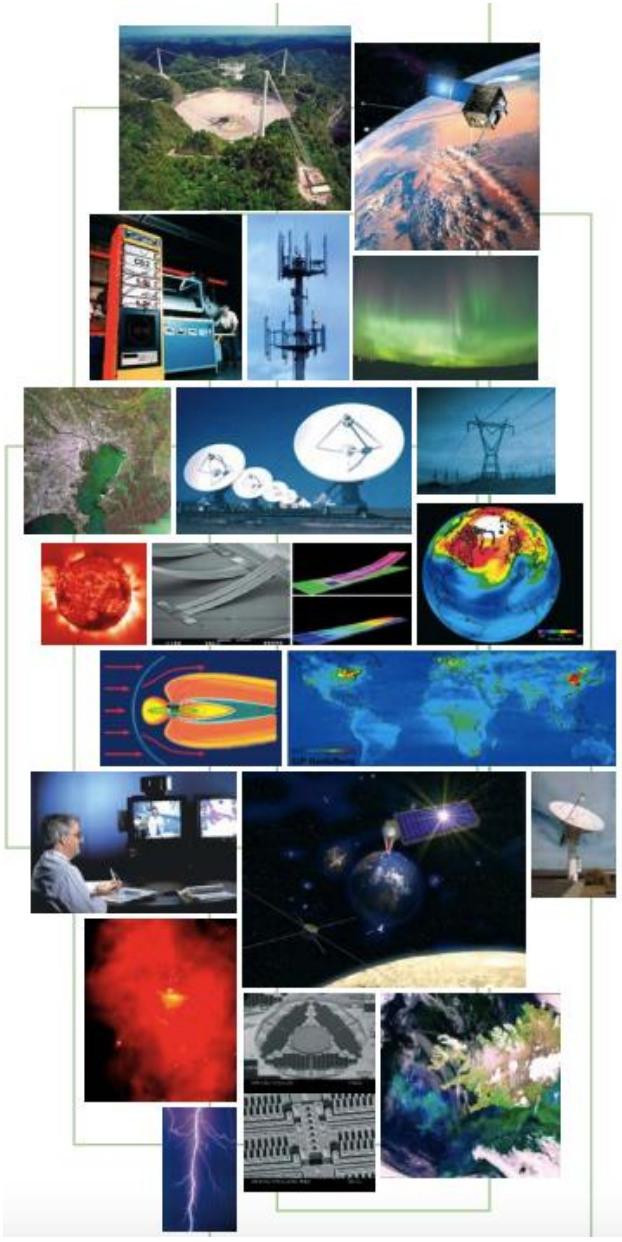
- Union Radio-Scientifique Internationale
- International Union of Radio Science
  - founded in 1919
  - a non-governmental and not-for-profit organization
  - operates under the auspices of the International Council for Science (ICSU).
- URSI stimulates and coordinates international radio science research
  - pure research
  - applied research (applications)

Why is Radio Science important?

Radio Science encompasses the knowledge and study of all aspects of electromagnetic fields and waves.

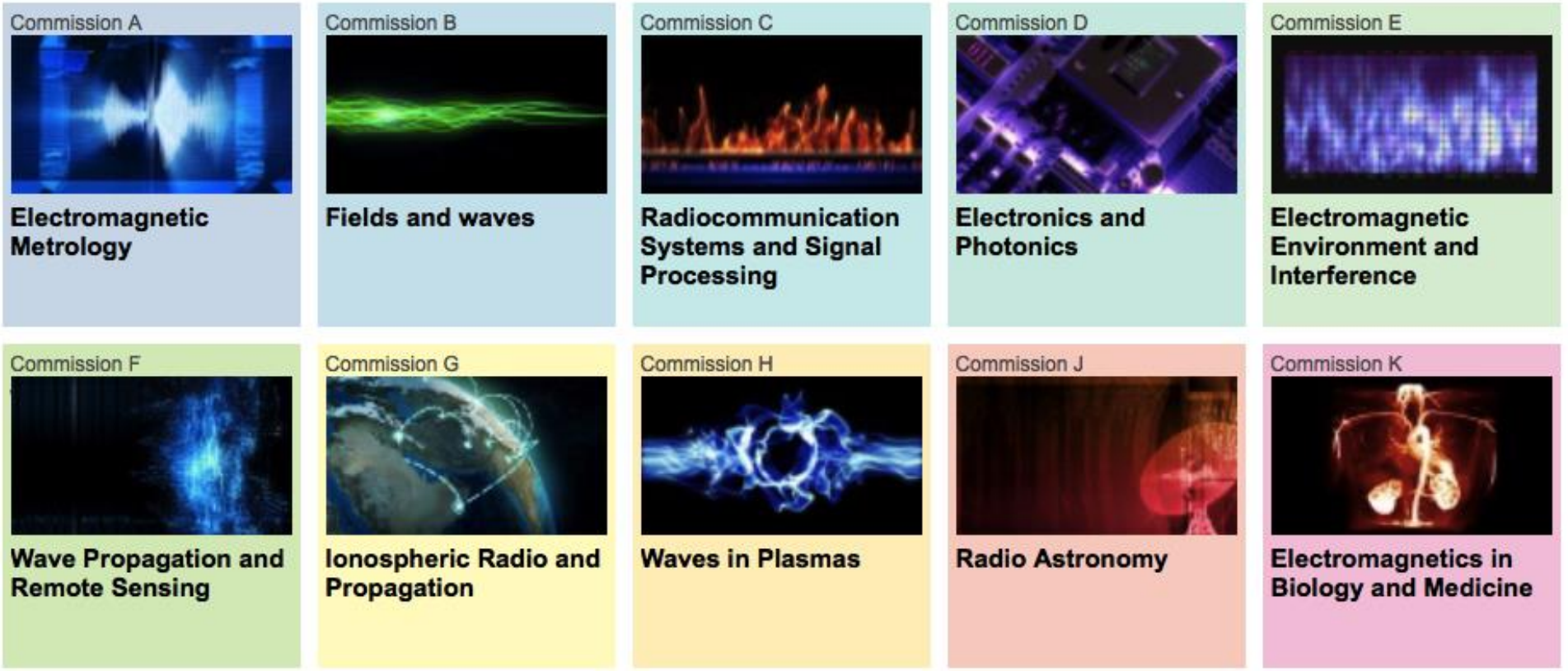
Measurements, models, and forecasting techniques pertinent to electromagnetic fields and waves including:

- antenna
- signals and systems
- the terrestrial and space environment
- remote sensing
- radio propagation problems in radio astronomy
- and many more



GNSS is central to many of these topics

URSI Scientific Commissions



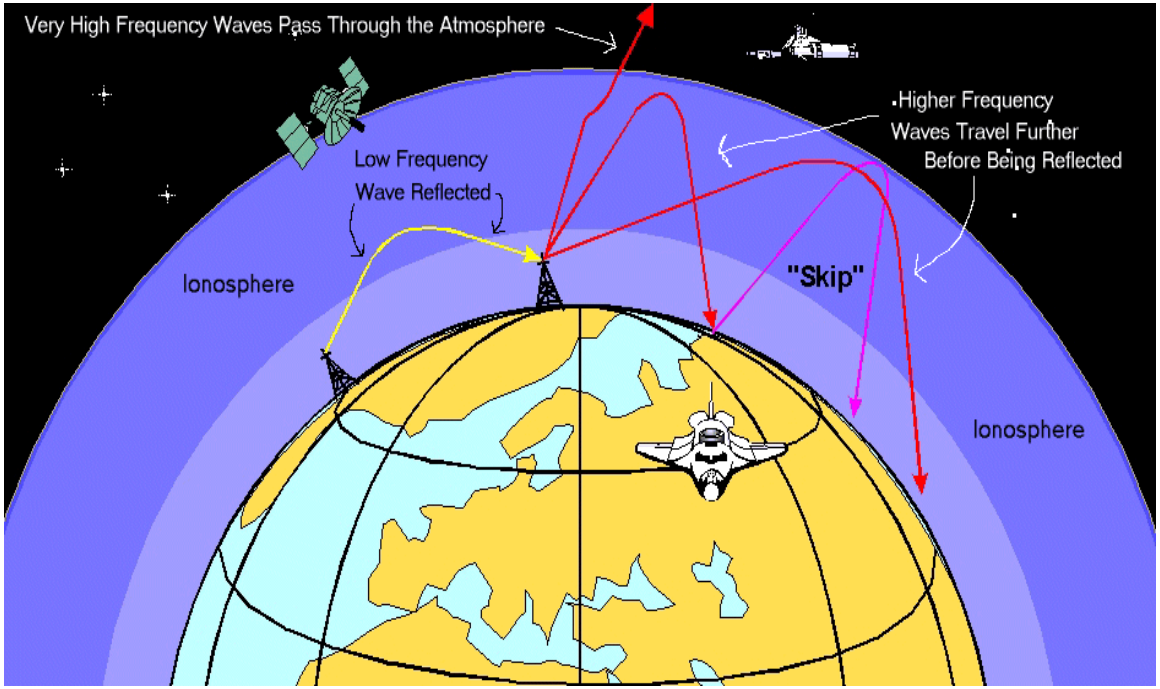
GNSS significantly relevant to at least 4 Commissions

- Commission F: Wave Propagation and Remote Sensing
- Commission G: Ionospheric Radio and Propagation --- Space Weather
- Commission H: Active Experiments in Space Plasmas
- Commission J: Radio Astronomy

Early Studies on Radio Waves

Revealed Ionospheric Properties

Region of the Earth's upper atmosphere with a high concentration of free ions and electrons

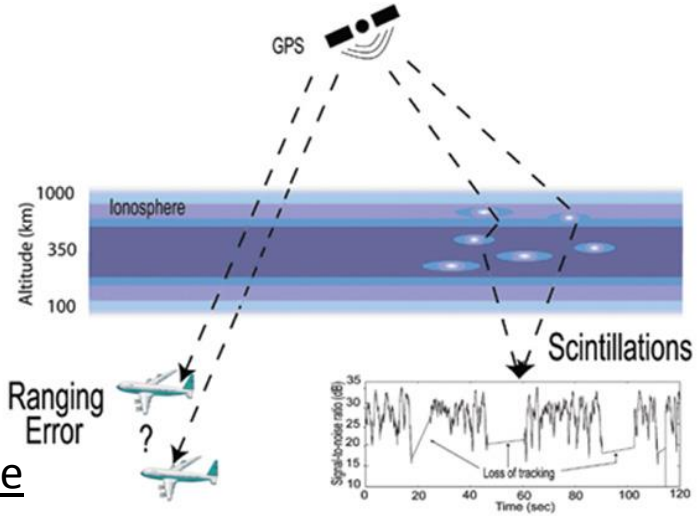


- **On frequencies below~30MHz, the ionosphere bends path traveled by the radio wave back toward earth, allowing long distance communication.**
- **At much higher frequencies, such as GNSS, radio waves passes right through the ionosphere.**
- **The speed of the signal is dependent on the density of electrons in the ionosphere.**

STRONG FREQUENCY DEPENDENCE

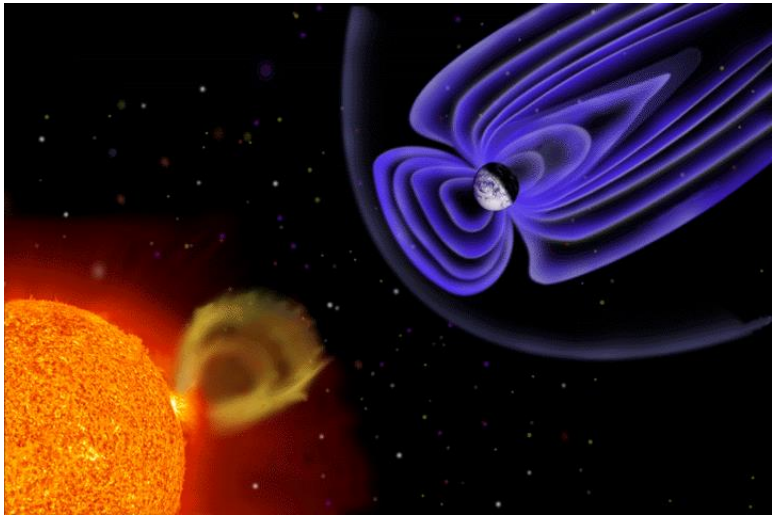
Ionospheric Effects on GNSS

- **Range Error - TEC**
  - Due to a change in the speed of the signal
    - Group Delay of the signal modulation (absolute range error)
    - Carrier Phase advance (relative range error)
  - Proportional to Total Electron Content
    - Range Error $= {}_{+/-} \frac{40.3\ TEC}{f^2}$
  - Varies from 1 to ~100m
- **Scintillation**
  - Due to rapid fluctuations in the amplitude and phase of the signal
  - May induce loss of lock – navigation errors
  - Rare at mid-latitudes
  - Can be severe after local sunset in the equatorial regions, especially near the peak of solar cycle
- **Other Effects**
  - Faraday Rotation, Absorption, Doppler Shift, Waveform Distortion and Refraction, Diffraction

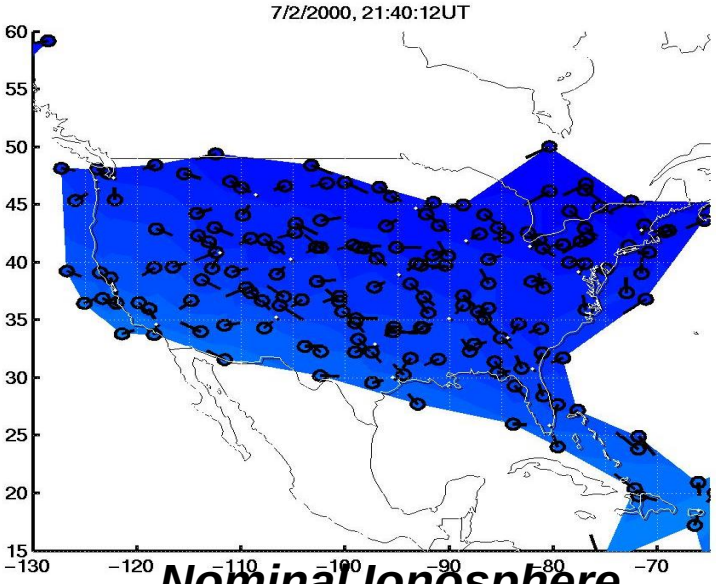


Varies with location, local time, season, geomagnetic and solar activity.

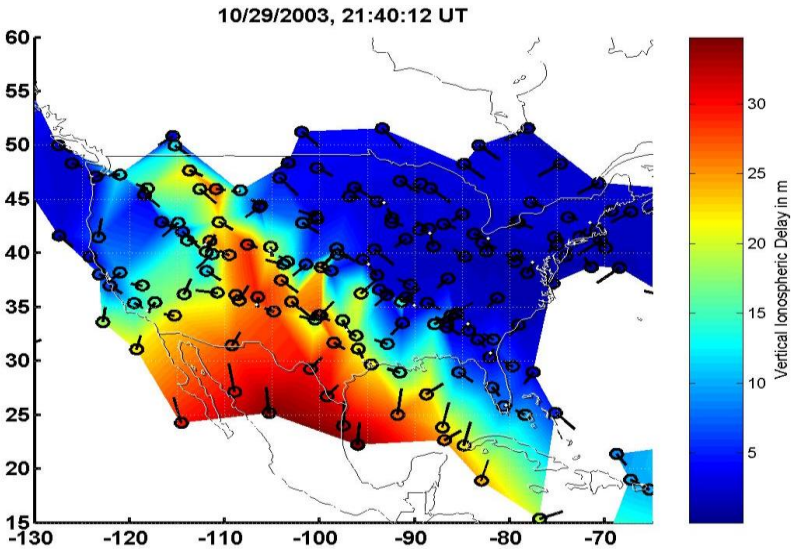
The Power of GNSS for Ionospheric and Space Weather Studies



Space weather refers to the environmental conditions in Earth's magnetosphere, ionosphere and thermosphere due to the Sun and the solar wind that can influence the functioning and reliability of spaceborne and ground-based systems and services or endanger property or human health.



Nominal Ionosphere



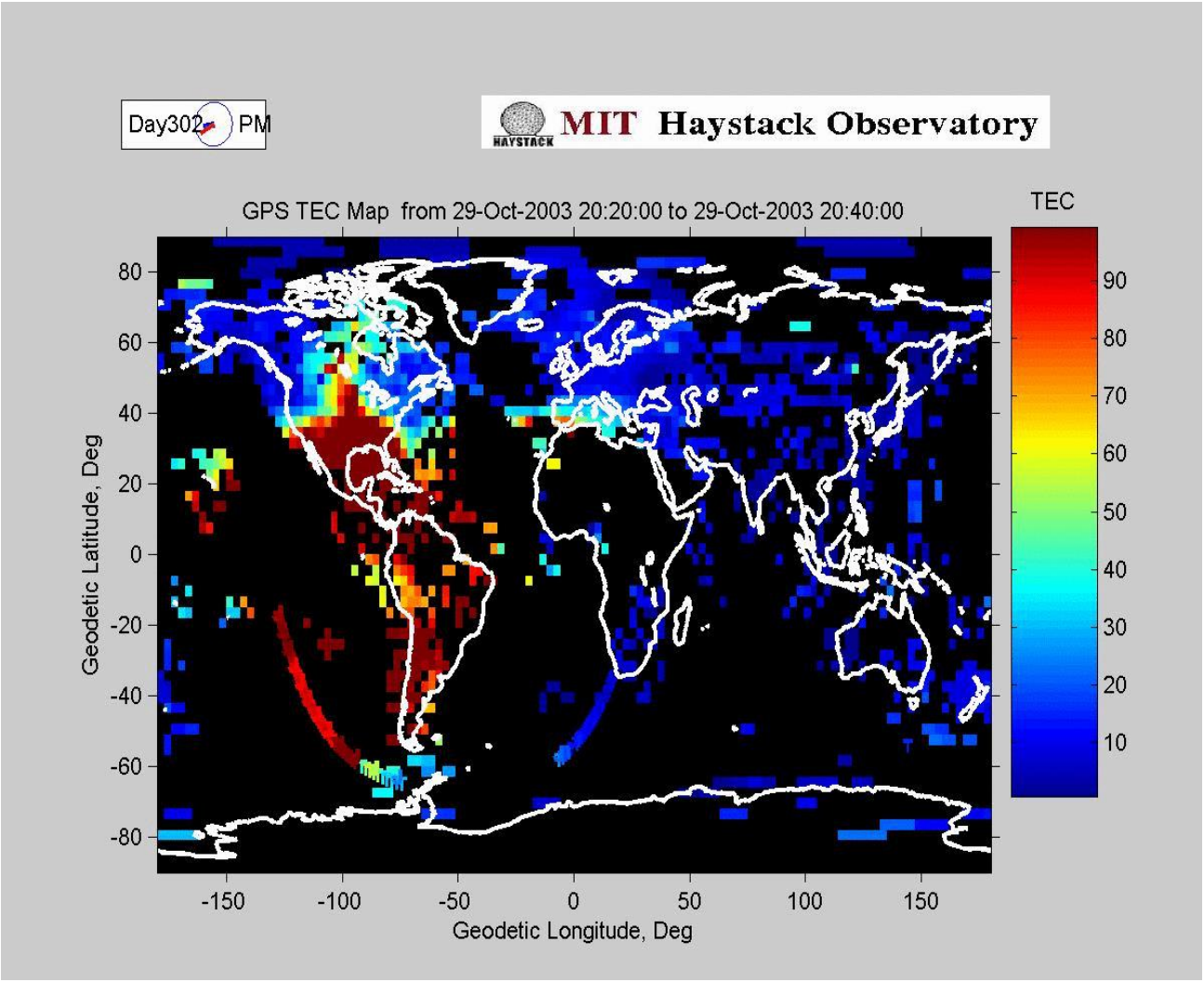
Disturbed Ionosphere

Figures courtesy of Seebany Datta-Barua

The Power of GNSS for Global Space Weather Studies

Global GPS derived ionospheric mapping during geomagnetic disturbances

Unattainable prior to GPS!

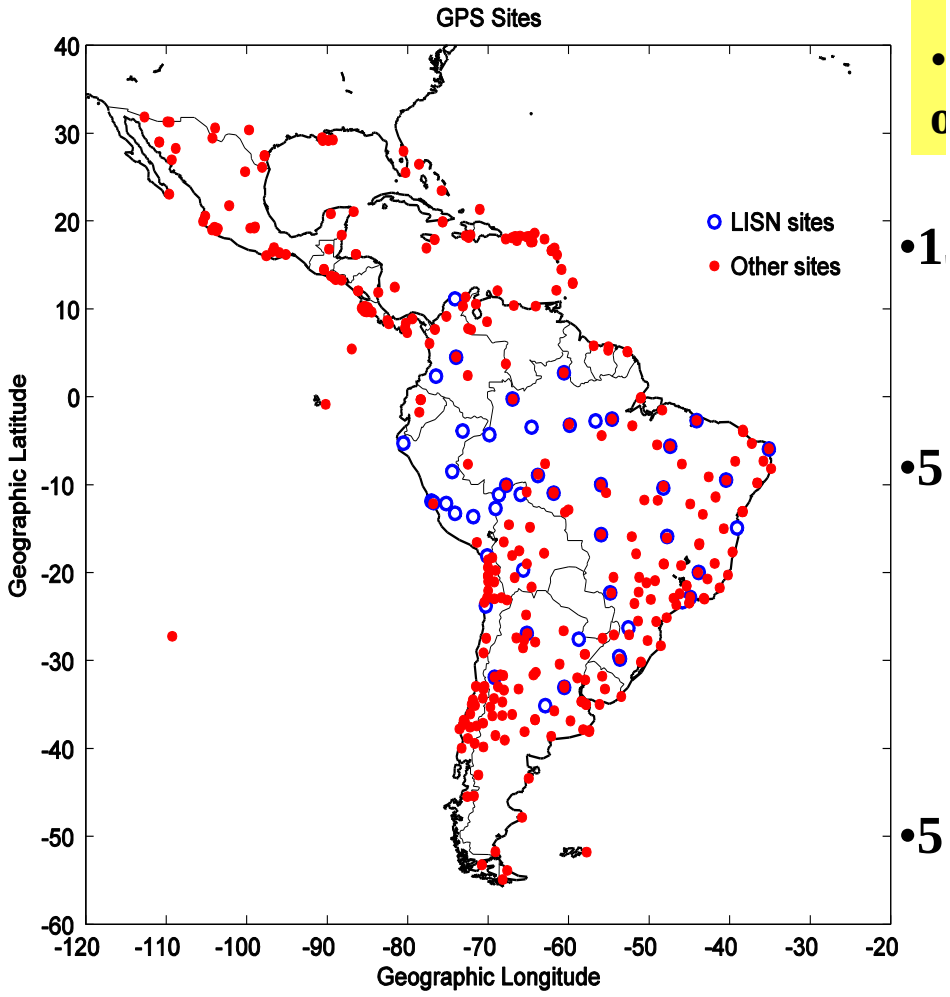


[Coster et al, 2003]

The Power of GNSS for Low-latitude Research

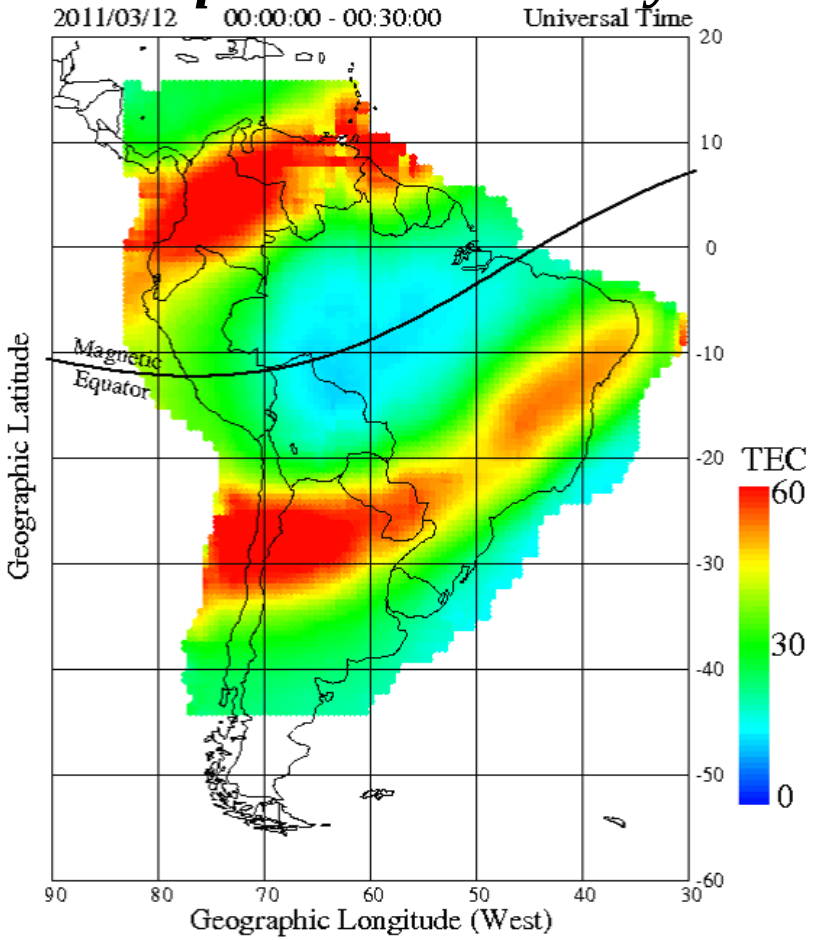
The Low-latitude Ionospheric Sensor Network (LISN)

LISN GPS Network



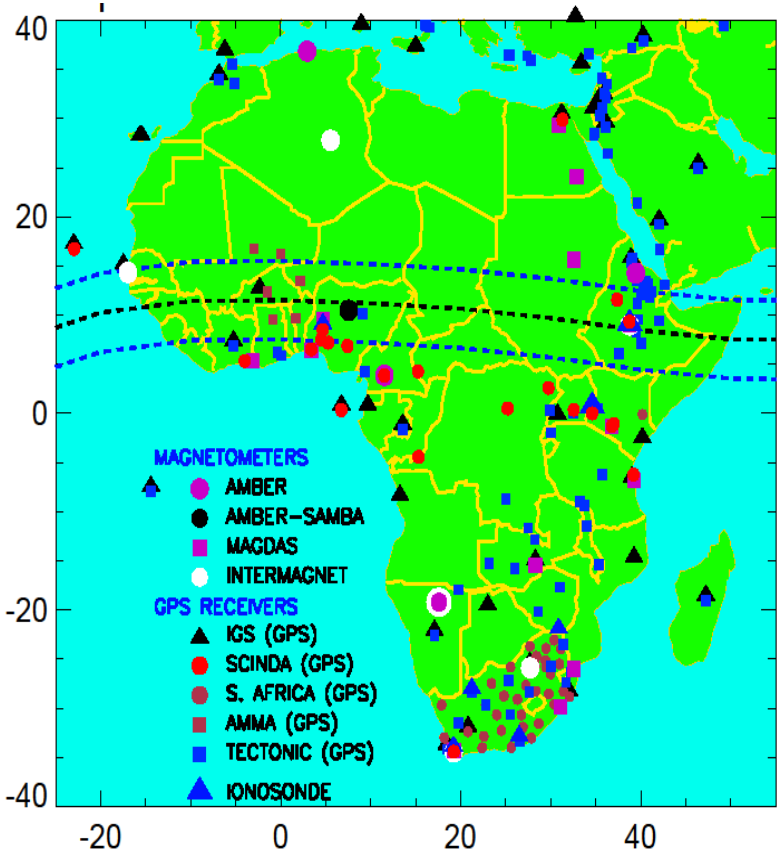
Development and Decay of the Equatorial Anomaly

- To address key questions about the physics
- •1
- •5
- •5



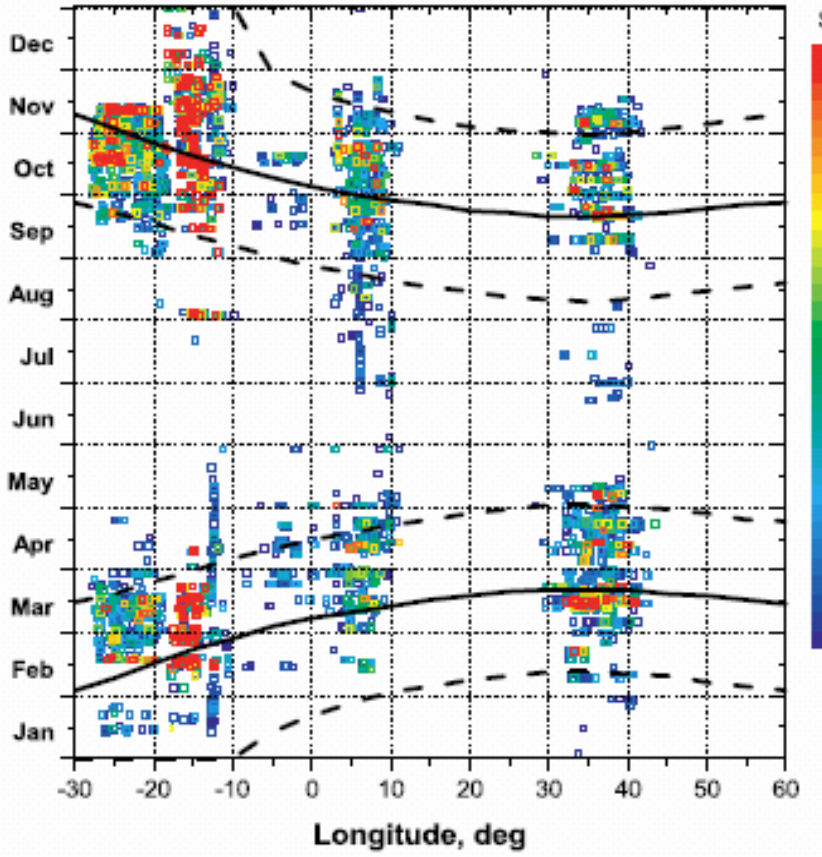
- Measure Vertical plasma drifts

The Power of GNSS for Research in Africa



data obtained from these facilities are being used to improve our understanding of global space weather as it affects the performance of GNSS

Scintillations



The African ionosphere was a mystery before GNSS.

URSI Publications

www.ursi.org/en/publications_rsb.asp

Published by AGU; Sponsored by URSI; indexed by IEEE-Xplore

URSI Meetings

- Flagship Meetings
  - Year 1: General Assembly and Scientific Symposium (GASS)
  - Year 2: Atlantic Radio Science Meeting (AT-RASC)
  - Year 3: Asia Pacific Radio Science Meeting (AP-RASC)
  - Year 1: GASS
- Commission specific meetings
- Supports international meetings
- National meetings

Summary

- The International Union of Radio Science stimulates and coordinates international studies using Radio Waves
- GNSS has been a significant source of information for URSI relevant studies
- Getting even better with multi-constellations and signals
- URSI appreciates status as an ICG observer

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