



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA  
**INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS**

# **BRAZILIAN CONTRIBUTION TO THE LISN PROJECT (LOW-LATITUDE IONOSPHERIC SENSOR NETWORK)**

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**SIRGAS**

26-29 May 2008 – Montevideo - Uruguay



Over equatorial and low magnetic latitudes the GPS System is affected by the

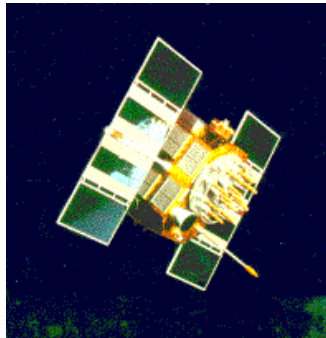
- TEC (Total Electron Content)
- ionospheric scintillation.

The TEC causes delay in the GPS signal while the scintillations can cause

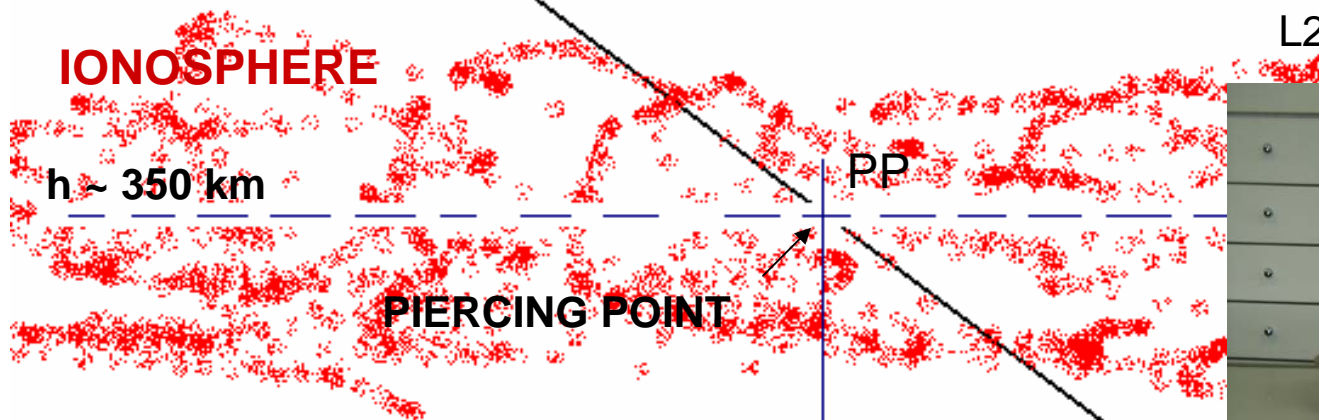
- loss-of-lock and
- positioning degradation.



# GLOBAL POSITIONING SYSTEM (GPS)



24 satellites  
20,200 km altitude  
12 hour period



L-band  
L1 = 1575.42 MHz  
L2 = 1227.60 MHz

The GPS system main purpose is to determine the position and velocity of a fixed or mobile object, placed over or near the earth surface, using the signals of 24 satellites on earth's orbit.



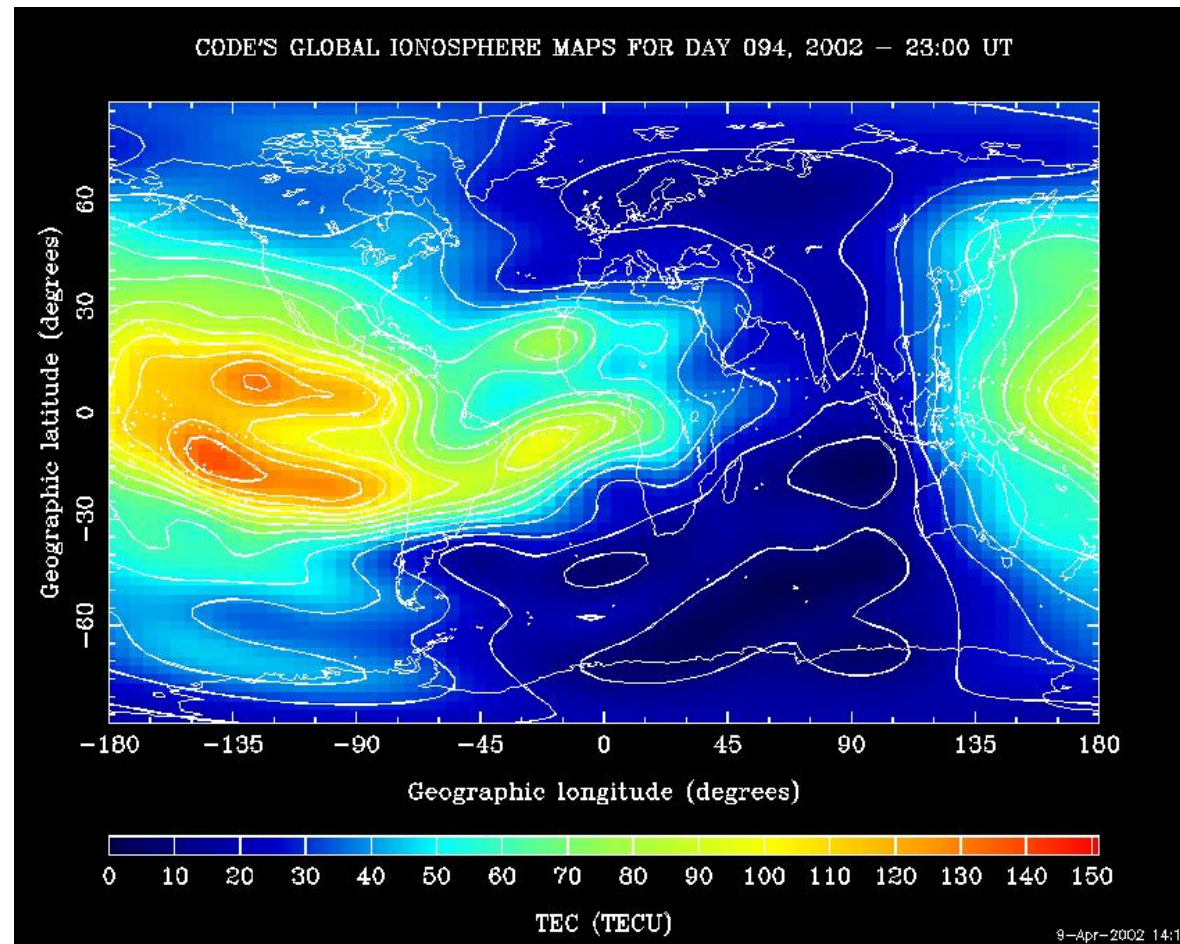


## TEC contour map of CODE's Global Ionospheric Map Geographic latitude and longitude. Day 094, 20:02 - 23:00 UT

The Total Electron Content (TEC) is the amount of free electrons along the path of the electromagnetic wave between each satellite and the receiver

$$TEC = \int_{receiver}^{satellite} N \cdot ds$$

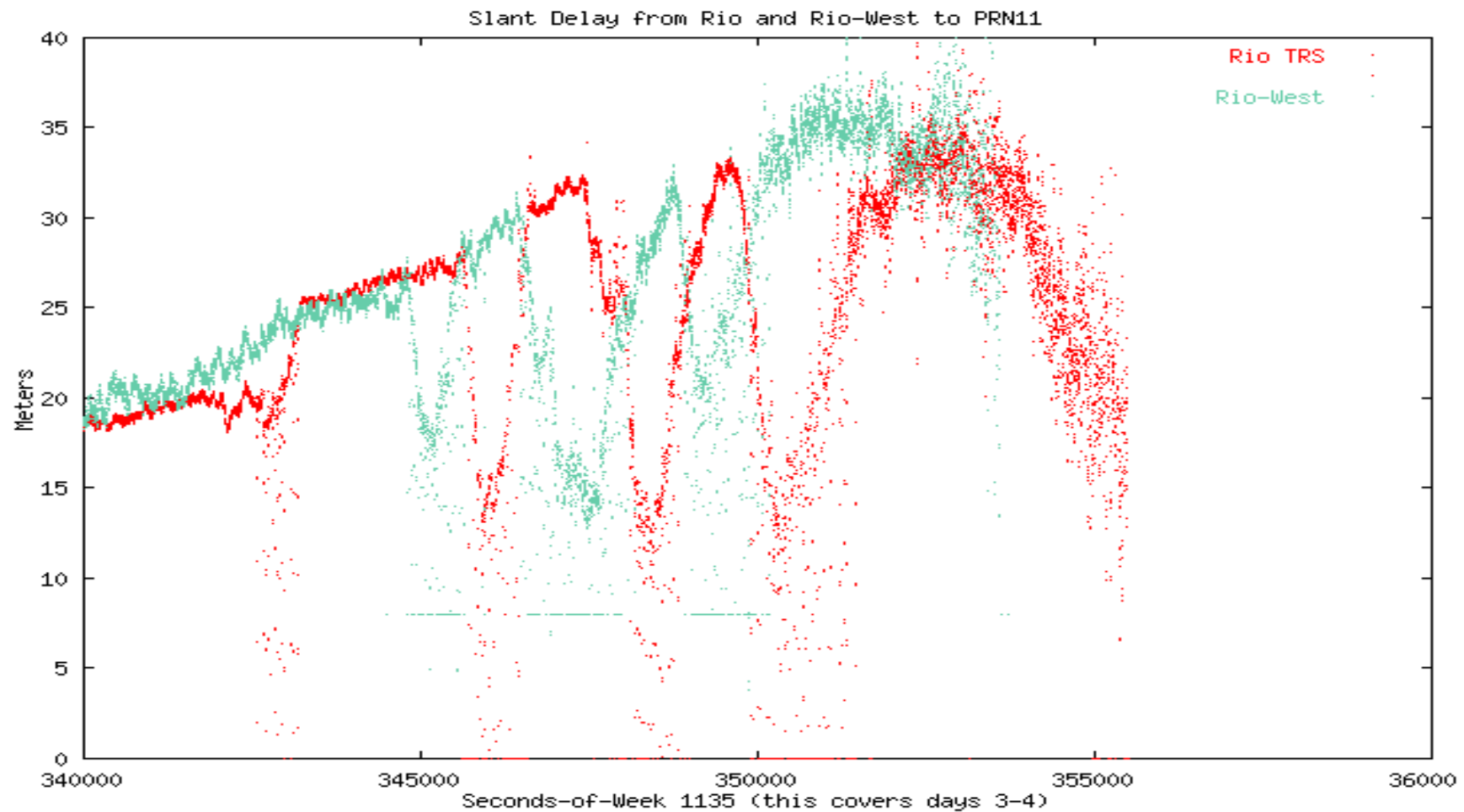
N is the electron density



# THE EFFECTS OF IONOSPHERIC IRREGULARITIES OVER TEC



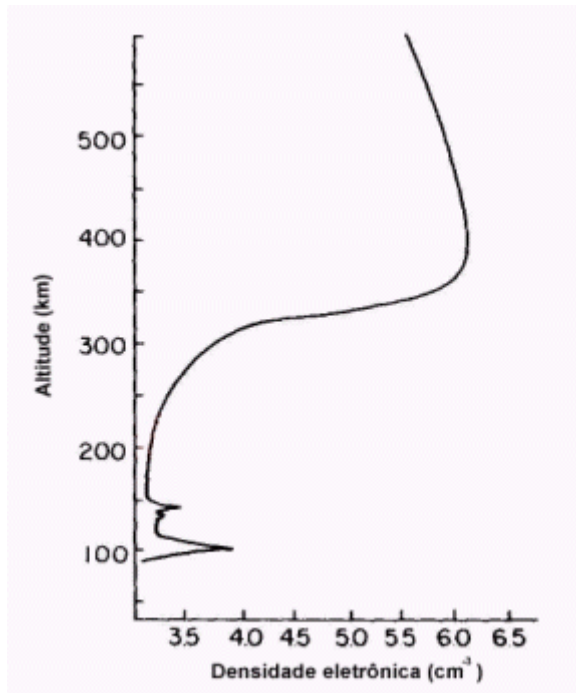
- IONOSPHERIC IRREGULARITIES CAUSE LARGE DEPLETION ON THE TOTAL ELECTRON CONTENT.



PLOT FROM TOM DEHEL ( FAA – FEDERAL AVIATION ADMINISTRATION – USA ), 2002

# IONOSPHERIC IRREGULARITY GENERATION MECHANISM

Rayleigh - Taylor (RT) instability Dungey (1956)



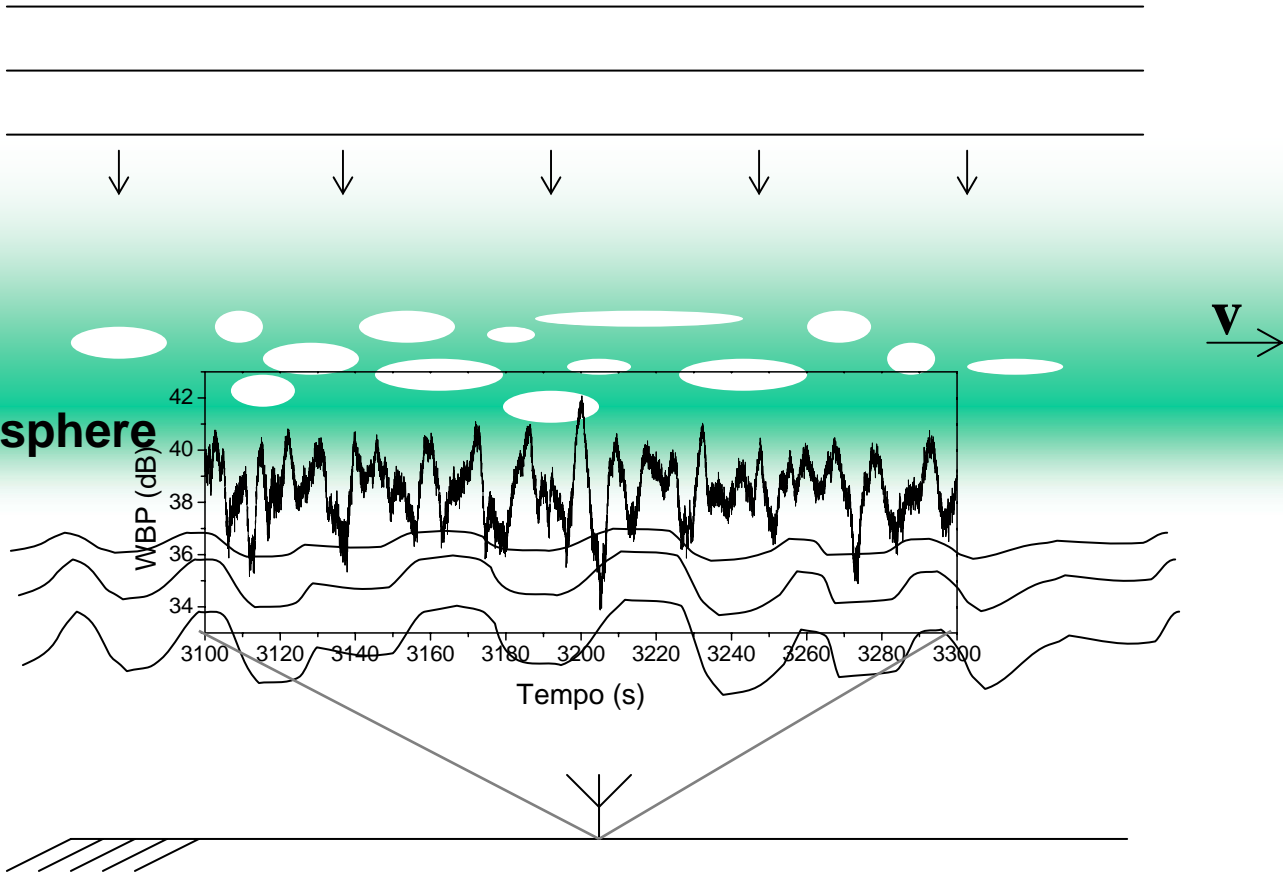
Kelley (1989, pag. e 122)



Animação gentilmente cedida  
por C. M. Denardini

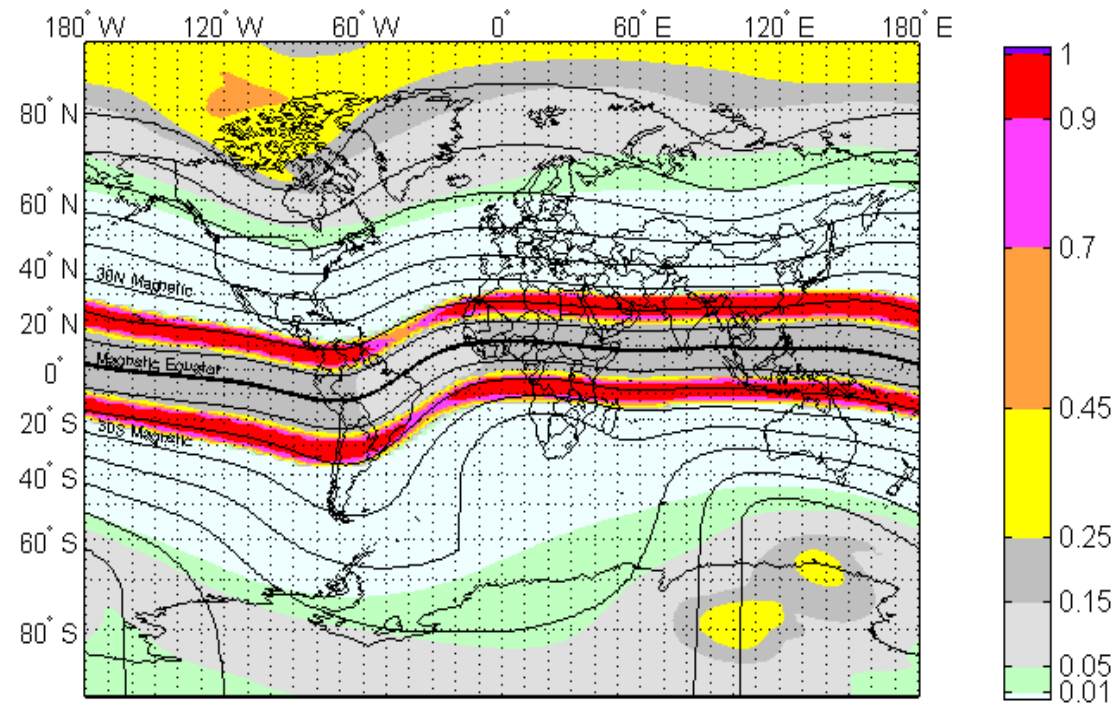
# IONOSPHERIC IRREGULARITY EFFECTS OVER THE GPS SIGNAL

▶ SCINTILLATION





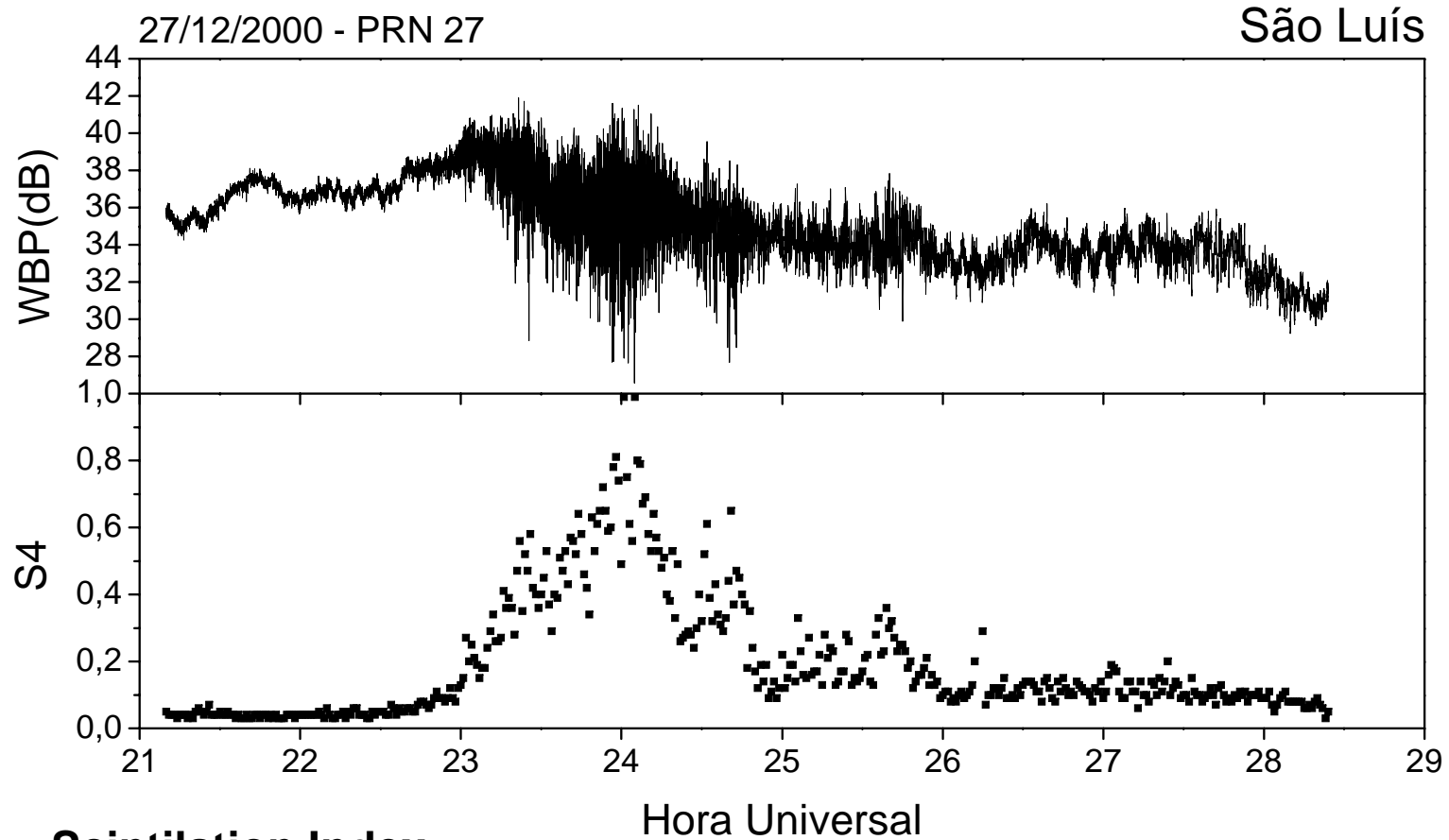
•THE EFFECTS ARE IN THE TROPICAL REGION ALL OVER THE WORLD WITH LARGEST INCIDENCE OF SCINTILLATIONS OVER BRAZIL ( LARGE MAGNETIC DECLINATION ).







# GPS SIGNAL SCINTILLATION

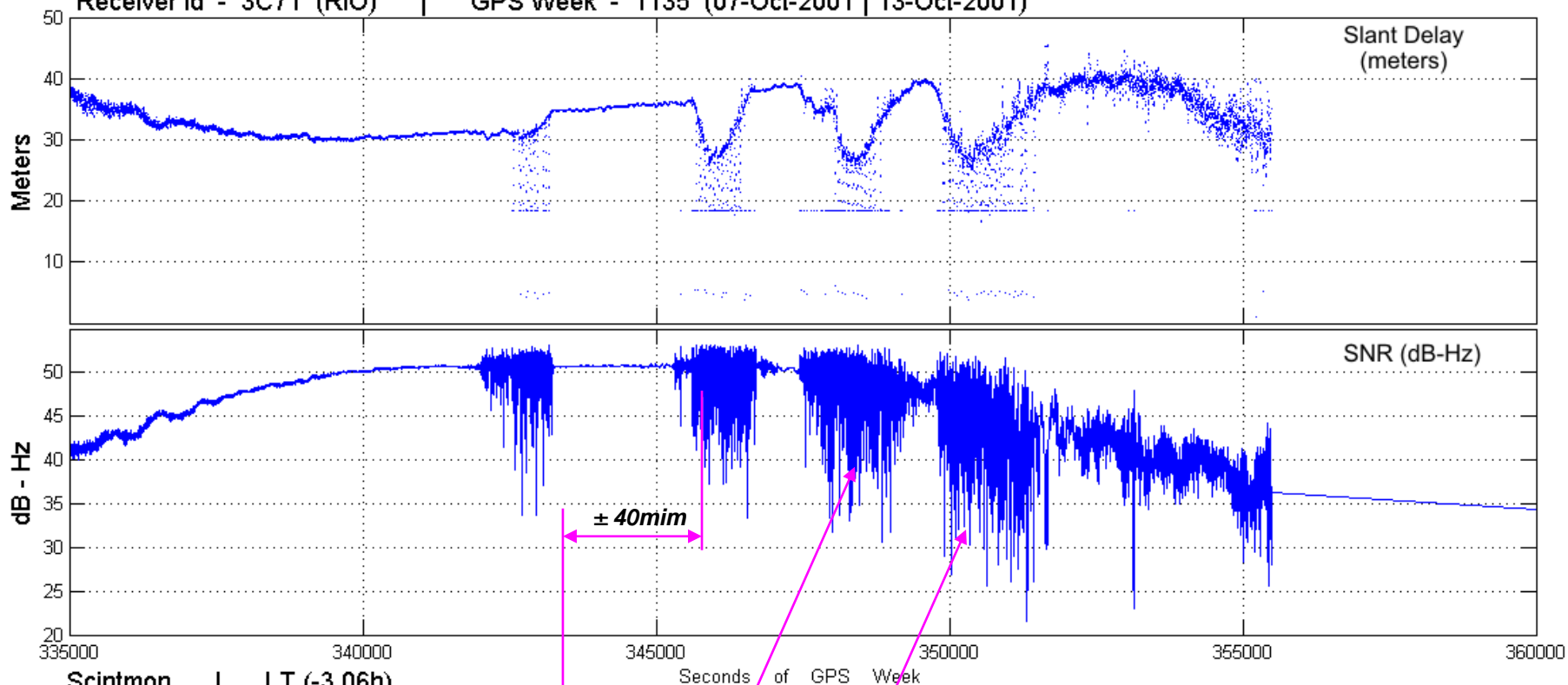


## Scintillation Index

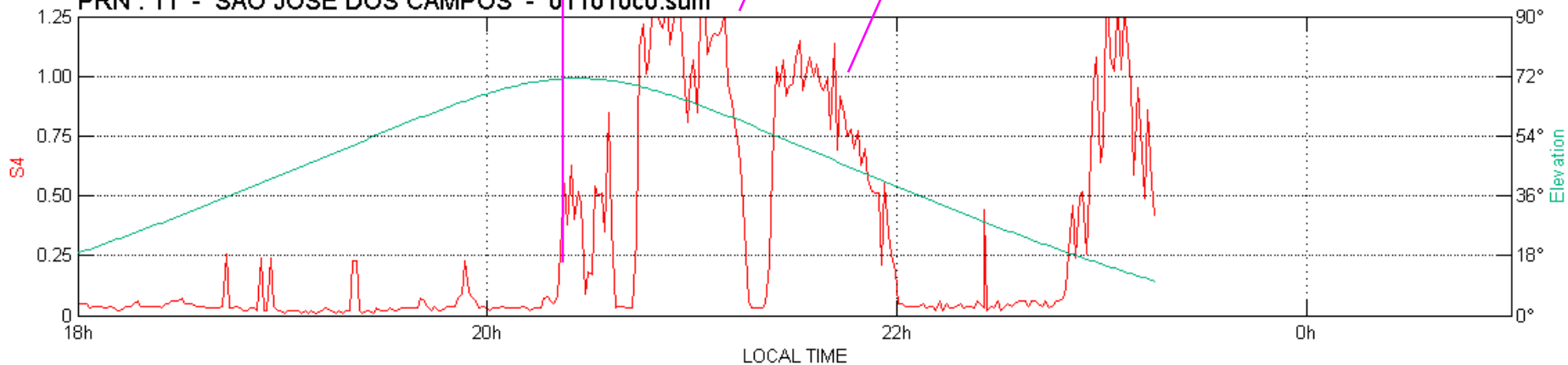
$$S_4^2 = \frac{\langle I^2 \rangle - \langle I \rangle^2}{\langle I \rangle^2}$$

# IRREGULARITY EFFECTS OVER SBAS (SPACE BASED AUGMENTATION SYSTEM) -TESTBED

TestBed | PRN - 11  
Receiver Id - 3C71 (RIO) | GPS Week - 1135 (07-Oct-2001 | 13-Oct-2001)



Scintmon | LT (-3.06h)  
PRN : 11 - SAO JOSE DOS CAMPOS - 011010c0.sum

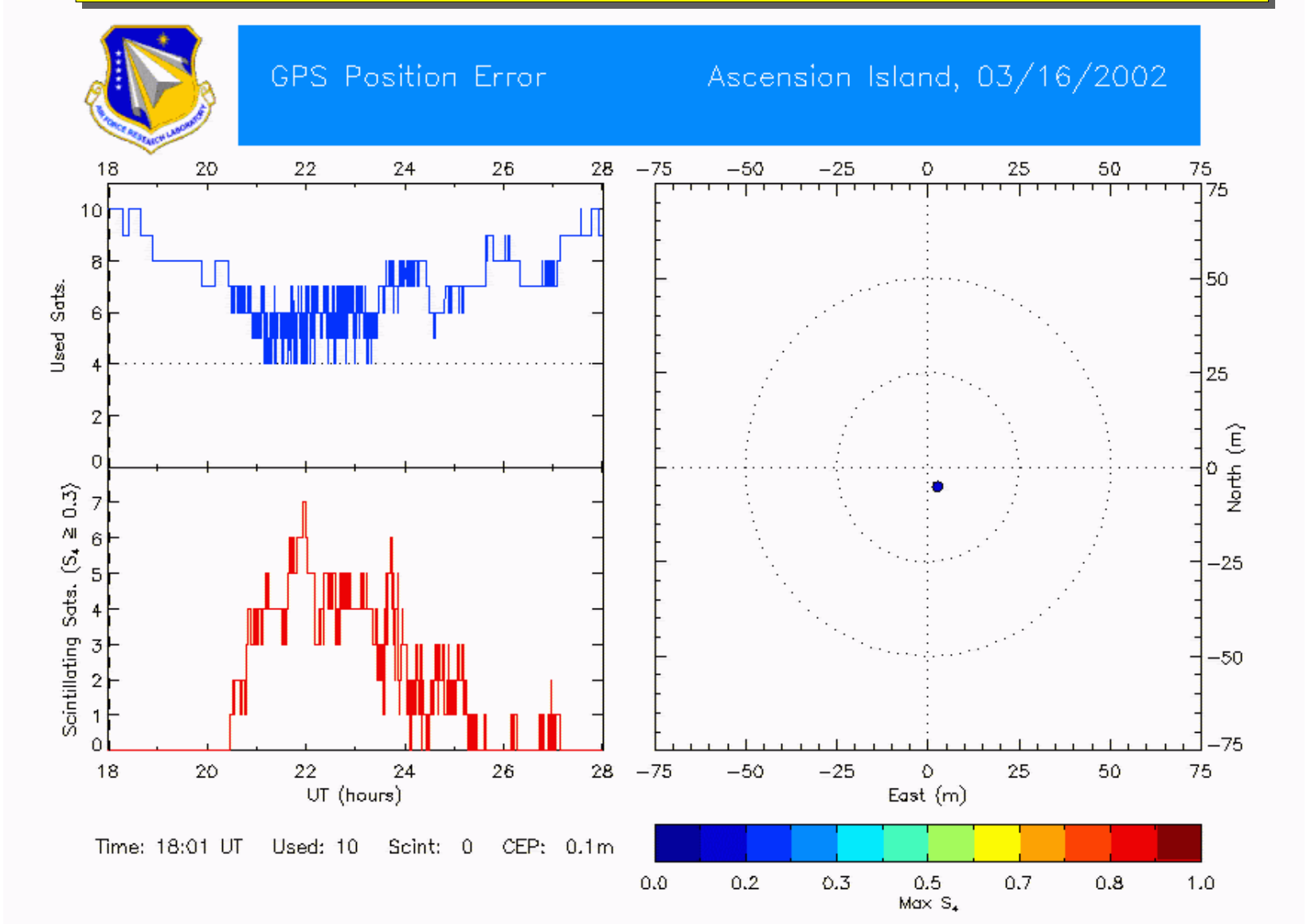




# IONOSPHERIC IRREGULARITY EFFECT OVER GPS POSITIONING ERRORS



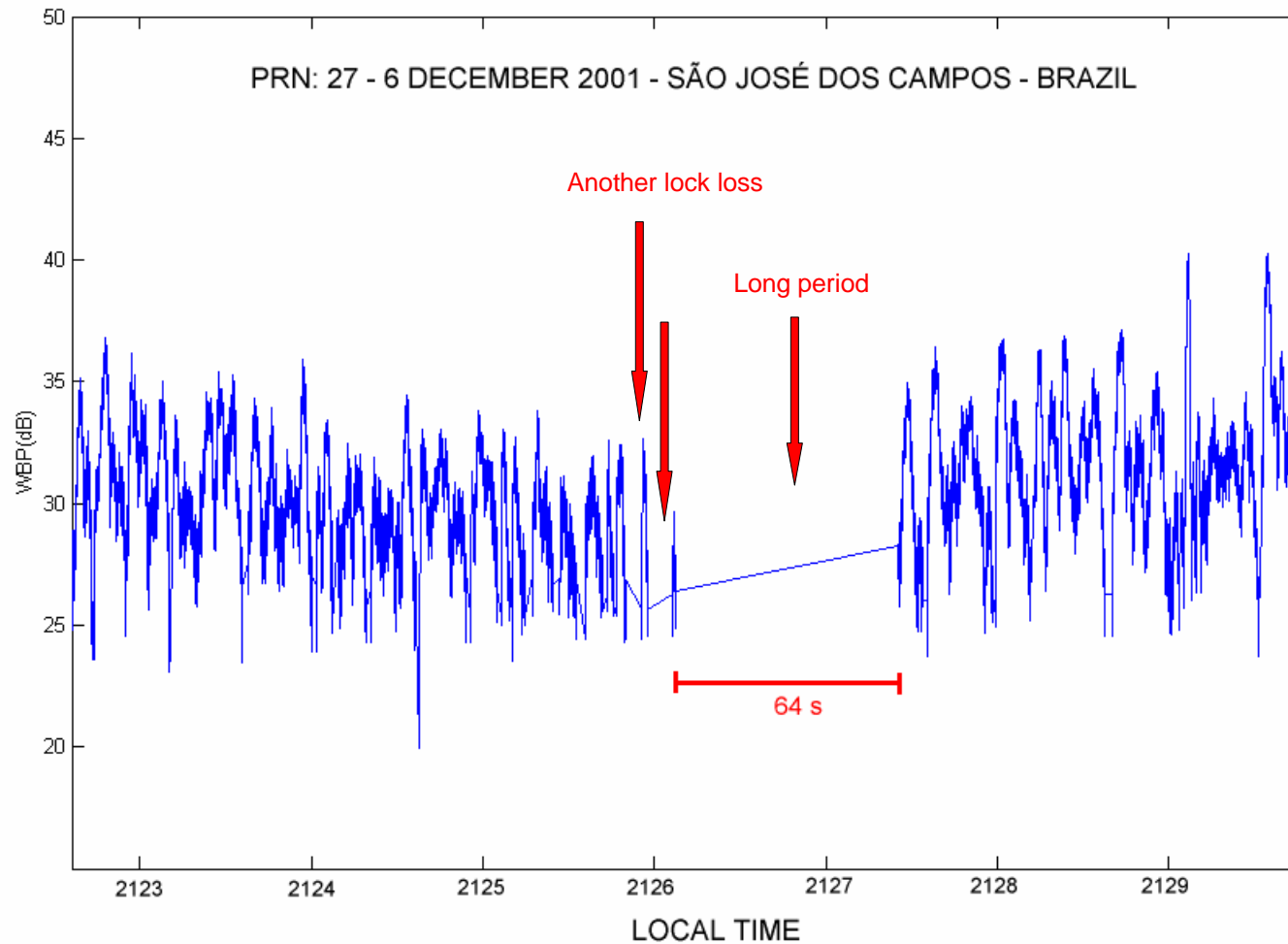
**Scintillation can cause rapid fluctuations in GPS position fix**

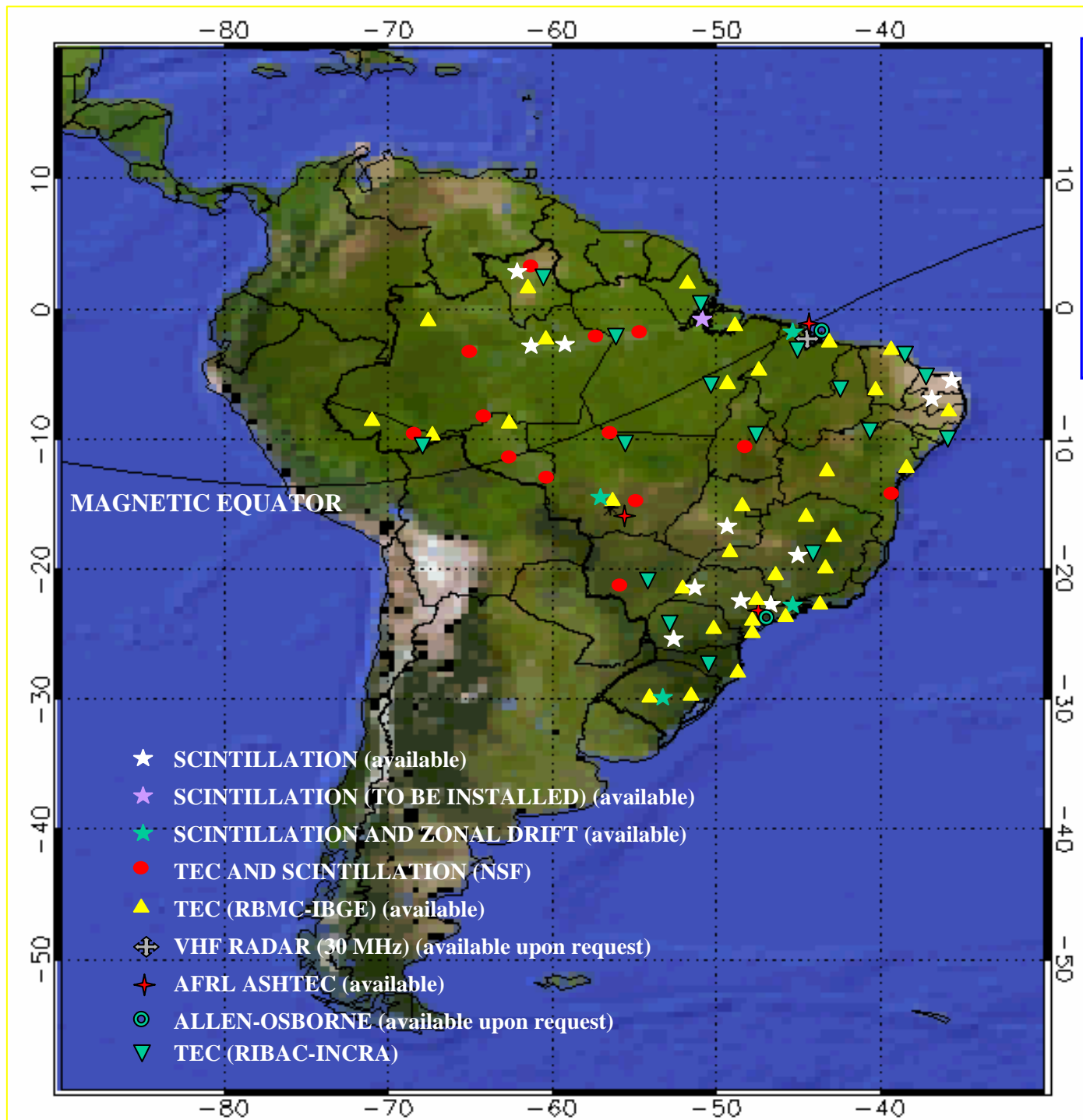


(Su. Basu et al., GRL, 2005)



# IONOSPHERIC IRREGULARITY EFFECTS OVER GPS LOSS OF LOCK





## Summary of GPS Stations in Brazil:

GPS receiving stations in Brazil (INPE, IBGE and LISN/NSF, INCRA)

★ ★ SINGLE FREQUENCY

- LISN/NSF receivers:  
 (C. Valladares)  
 (LISN PROJECT)  
 provide TEC AND S4
- Vilhena
  - Porto Velho
  - Rio Branco
  - Parintins
  - Tefé
  - Boa Vista
  - Dourados
  - Santarém
  - Alta Floresta
  - Ilhéus
  - Cuiabá
  - São José dos Campos
  - Ji-Paraná
  - Palmas



To study and understand these ionospheric effects it is necessary a network of ionospheric observing stations, like the LISN project,

LISN will provide a nowcast of the state of the South American Low-latitude ionosphere in terms of

- TEC,
- TEC depletions,
- scintillations,
- bottomside F and E-region densities and a
- short-term regional forecast of the onset of ESF.

# LISN Web Page

<http://jro.igp.gob.pe/subwebs/lisn/>

## LOW-LATITUDE IONOSPHERIC SENSOR NETWORK

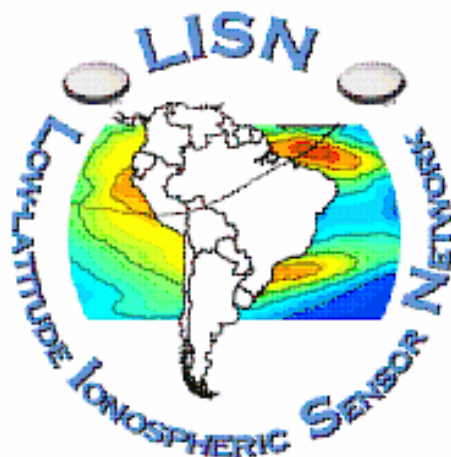
[Home](#)

[About LISN](#)

[Equipment](#)

[Stations](#)

[Other](#)



[LISN Workshop Aug. 2007 - Taller de Trabajo LISN Ago. 2007](#)

[LISN Workshop Gallery - Galería de Fotos](#)

Telecommunications play an important role in science and technology world-wide. This field has its own phenomena that need to be explained, and that is the challenge for LISN.

LISN, as a permanent array of the newest geophysical instruments in South America, closely coordinate as a "distributed observatory". Our main focus is on complex and extreme state of disturbance that take place in the magnetical-equatorial ionosphere nearly every day after sunset, and on the ionosphere-thermosphere-electrodynamics (ITE) system that constantly controls the dynamics of the plasma density, creating the proper conditions to initiate plasma turbulence.

Known and studied for seven decades, the equatorial Spread F (ESF) phenomena are now held responsible for causing high-technology (GPS) navigation and communication failures that depend on inter-hemispheric link. Enough is known and understood about this region and its process to show conclusively that nothing less than a meteorological approach to detailed and comprehensive observations, integrated closely with assimilative modeling, can lead to physical understanding and the imperatives of practical forecasting and nowcasting.

### Stations



[All Stations](#)

[Peru](#)

[Brazil](#)



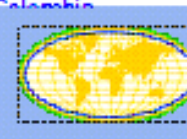
[Argentina](#)

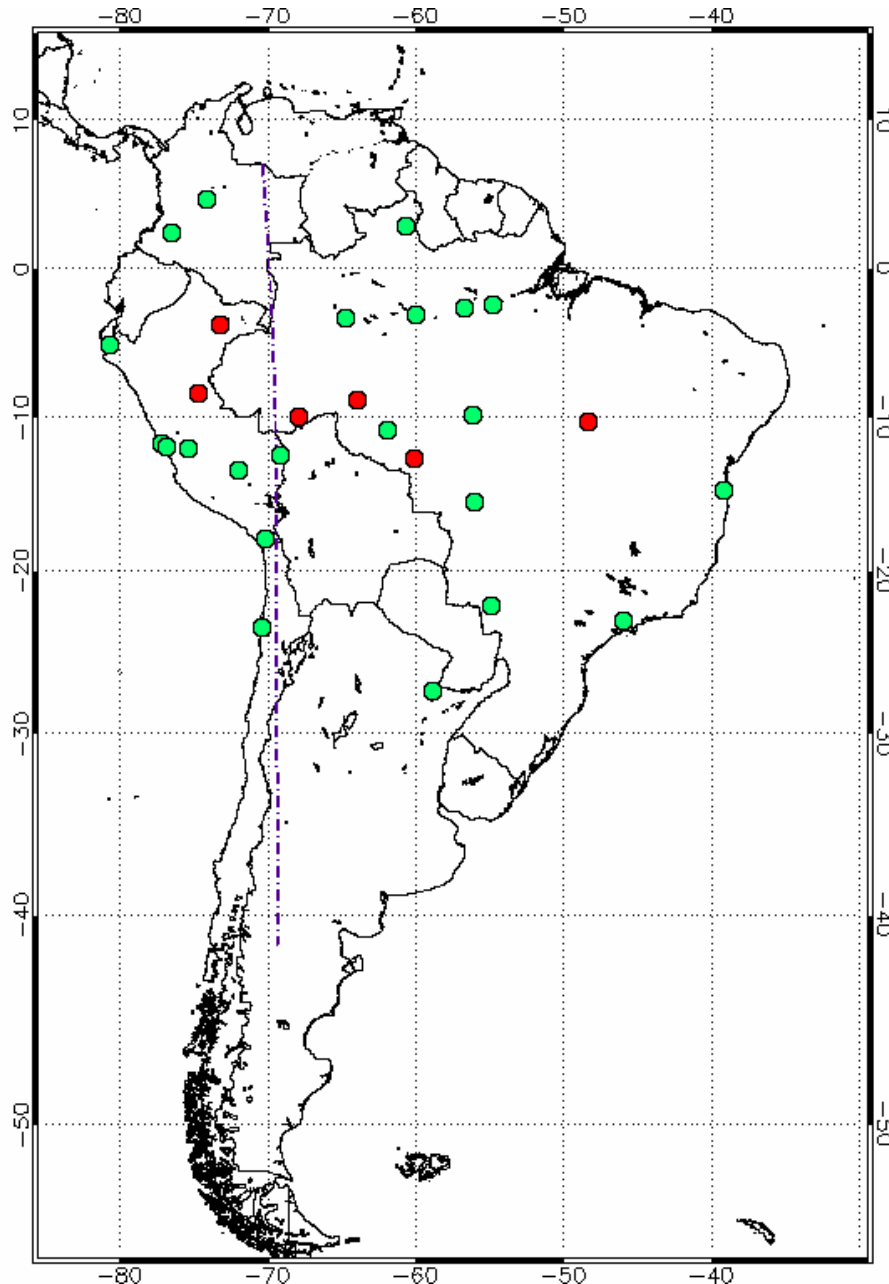
[Chile](#)



[Bolivia](#)

[Colombia](#)





## GPS stations in South America

LISN, proposed the installation about 50 stations of GPS, distributed in South America, this stations will be administered by Instituto Geofísico del Perú, located at aprox.  $12^{\circ}\text{S}$ ,  $75^{\circ}\text{W}$ , will be having a Central Server. The server have this principal function to monitoring, storage and distribution of information to the different users. At the map, green color, show the active stations and the red color the inactive stations.





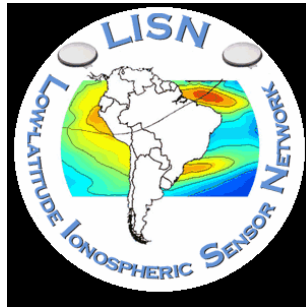
In the Brazilian territory  
15 LISN receivers were installed.

These GPS receivers are providing data  
that are being recorded at the main server at

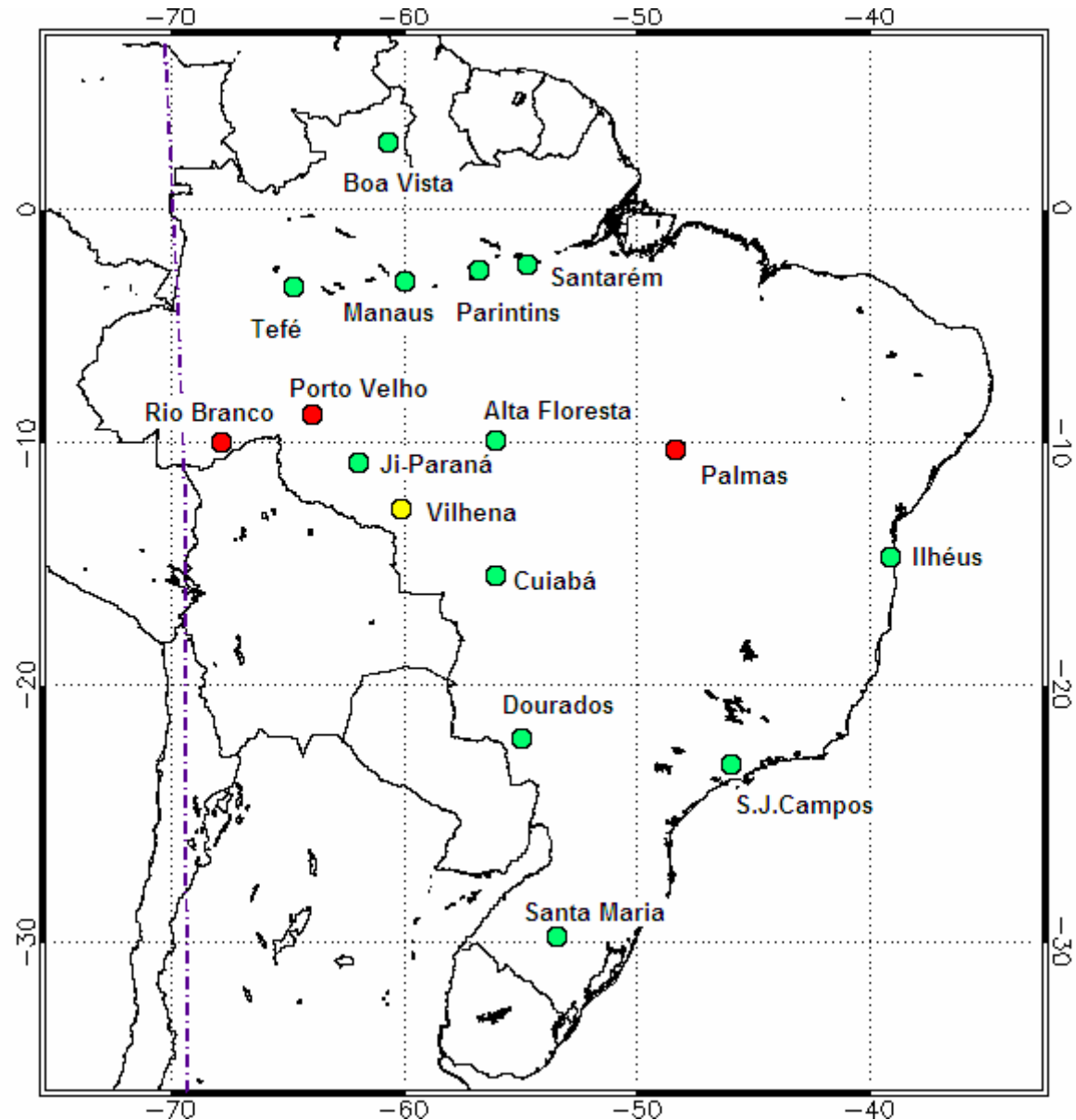
- Boston College and at
- São Jose dos Campos, Brazil.



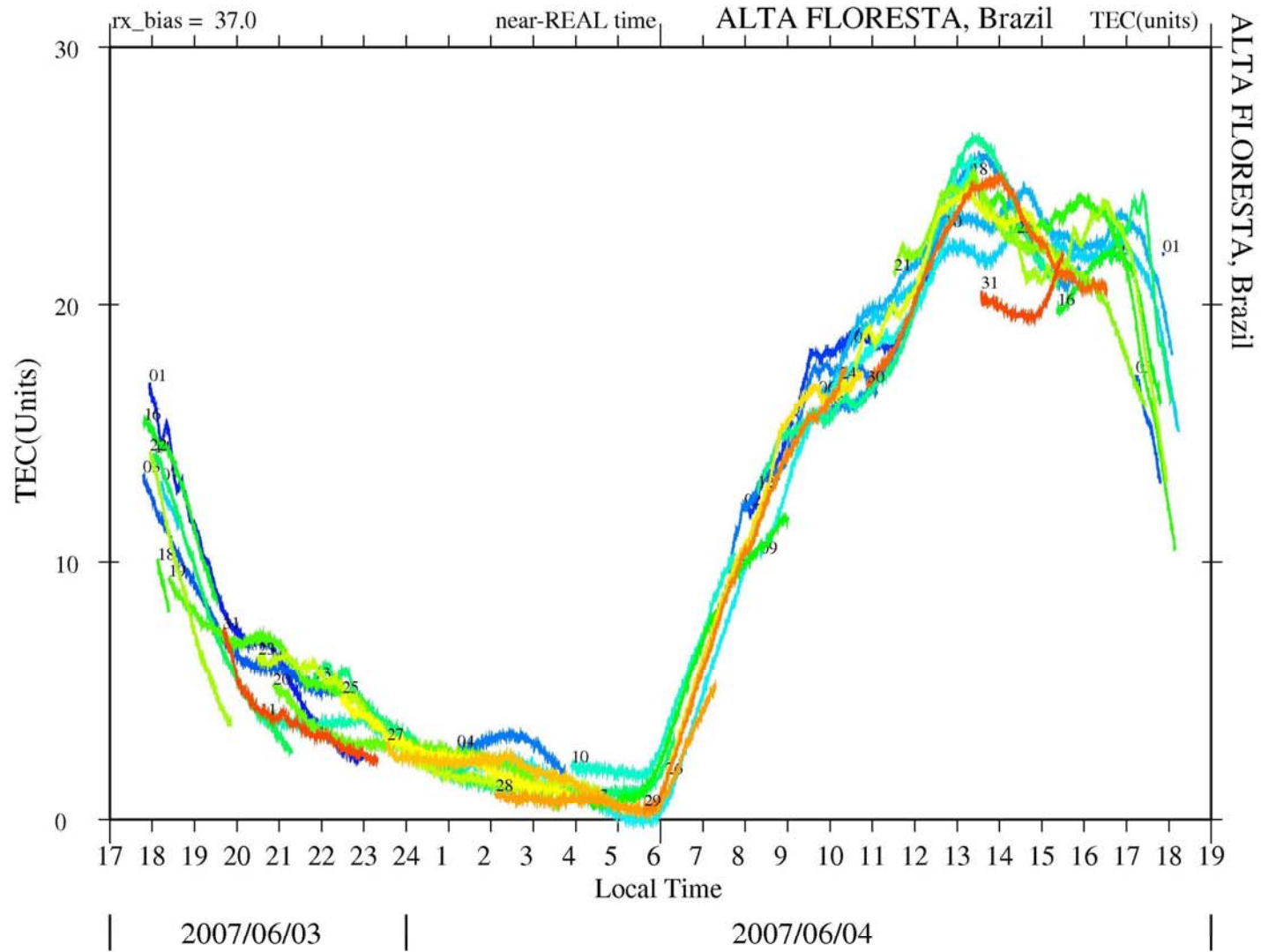
# LISN - Low-latitude Ionospheric Sensor Network



- Alta Floresta
- Boa Vista
- Cuiabá
- Dourados
- Ilhéus
- Ji-Paraná
- Manaus
- Parintins
- S.J.Campos
- Santa Maria
- Santarém
- Tefé
  
- Palmas
- Porto Velho
- Rio Branco
  
- Vilhena



# LISN - Low-latitude Ionospheric Sensor Network

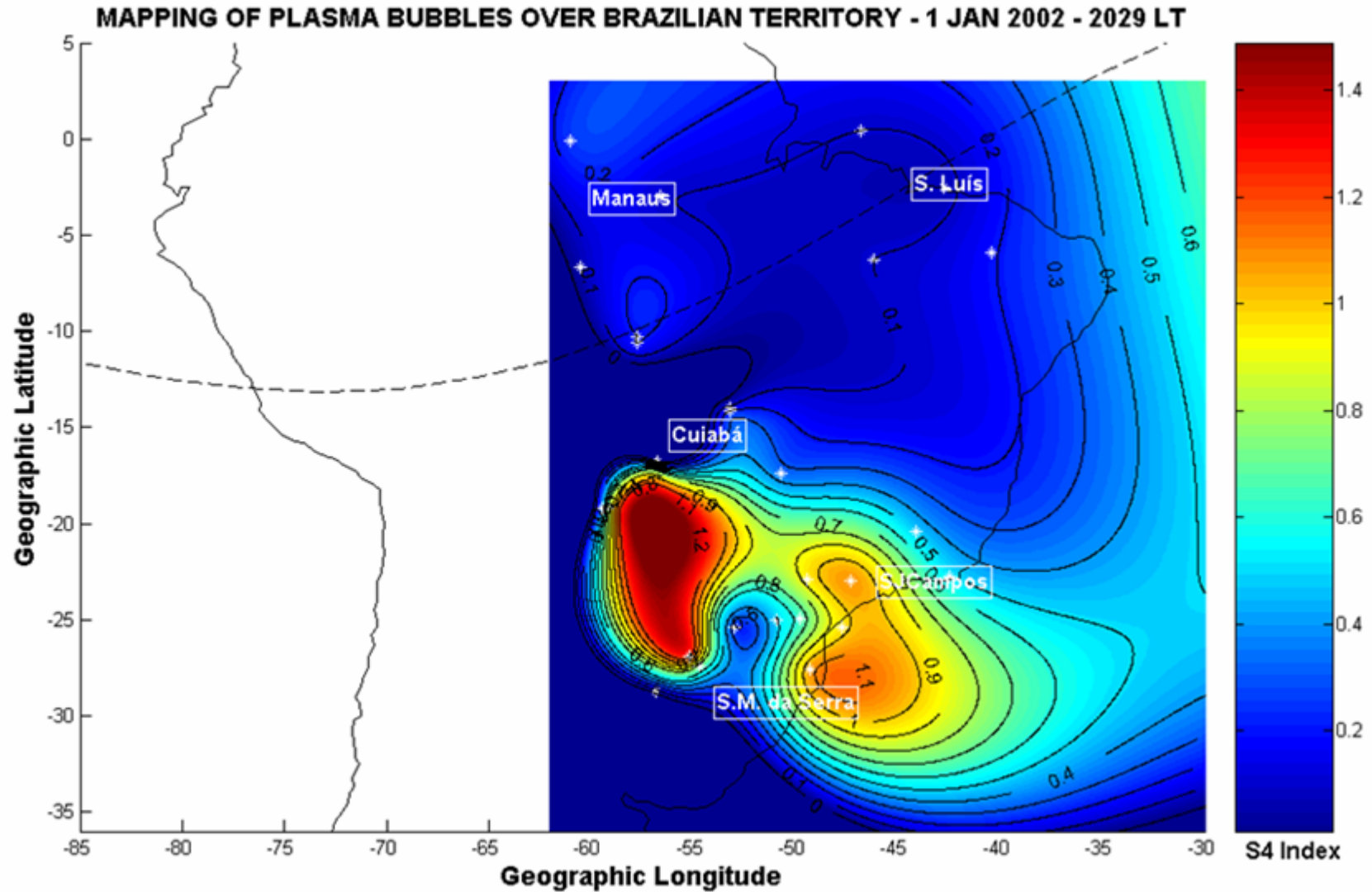




The LISN scintillation data, represented by the S4 scintillation index is going to complement the SCINTEC (Scintillation and TEC Monitoring) System that provides a real time scintillation map over Brazil.



# SCINTEC PROJECT <http://www.inpe.br/scintec/>





# SCINTEC PROJECT

Address of the site:

<http://www.inpe.br/scintec/>



The LISN TEC is going to be used:

to study the low latitude electrodynamics and  
to develop an ionospheric model which will  
be used:

- for Scientific Research,
- for Navigation and Positioning and
- Geodetic purposes