



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

## **SCINTEC - The implementation of a system for monitoring and mapping of ionospheric scintillation and Total Electron Content in real time over Brazilian territory**

**Luiz Felipe C. de Rezende  
E. R. de Paula  
I. J. Kantor  
S. Stephany  
M. T. A. H. Muella  
P. M. Siqueira  
A.C. Neto  
Anderson P. Dutra**



**SIRGAS**

**26-29 May 2008 – Montevideo - Uruguay**



# INTRODUCTION

- SCINTEC is a project for monitoring and mapping the total electron content (TEC) and ionospheric scintillation in real time over the Brazilian territory.
- SCINTEC system provides data to a Relational Database Management System (RDBM-S).

[www.inpe.br/scintec](http://www.inpe.br/scintec)

Ministério da Ciência e Tecnologia

INPE INSTITUTO NACIONAL DE PESQUISAS ESPaciaIS

Coordenação Geral de Ciências Espaciais e Atmosféricas - CEA

**Divisão de Aeronomia - DAE**

**SCINTEC PROJECT**

Home Real Time Animation Scintillation DataBase Papers Related Links

SCINTEC is a software system created to monitor and generate real time maps of ionospheric scintillation and total electron content (TEC). SCINTEC is capable to assimilate ground-based GPS receiver data through the use of relational data base management system. SCINTEC also incorporates data mining and artificial intelligence tools to be used in ionospheric scintillation and magnetic storm predictions. All these resources are intended to be available on line on this WEB site.

SCINTEC is aimed to generate maps over the Brazilian territory. TEC maps over Brazil will be generated from International GNSS Service (IGS) and [Continuous Monitoring Brazilian Network \(RBMC\)](#) dual-frequency GPS receiver data network. The latter is managed by the Brazilian Institute of Geography and Statistics (IBGE).

SCINTEC will also be integrated with the Low-Latitude Ionosphere Sensor Network (LISN) in order to provide, for the scientific community, scintillation and TEC real time maps over South America. This is part of an extensive project of collaboration and interaction between American South Cone researchers.

SCINTEC has been developed by the INPE's GPS group and supported by [The State of São Paulo Research Foundation \(FAPESP\)](#), a research foundation sited at São Paulo state, Brazil.

Support

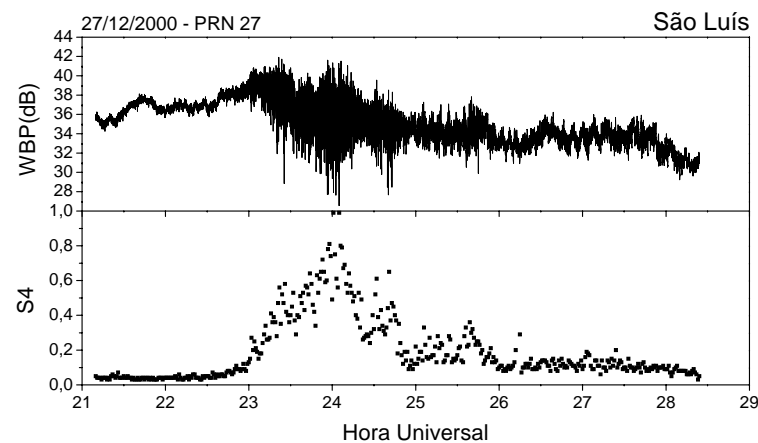
Concluído Internet



# MOTIVATION

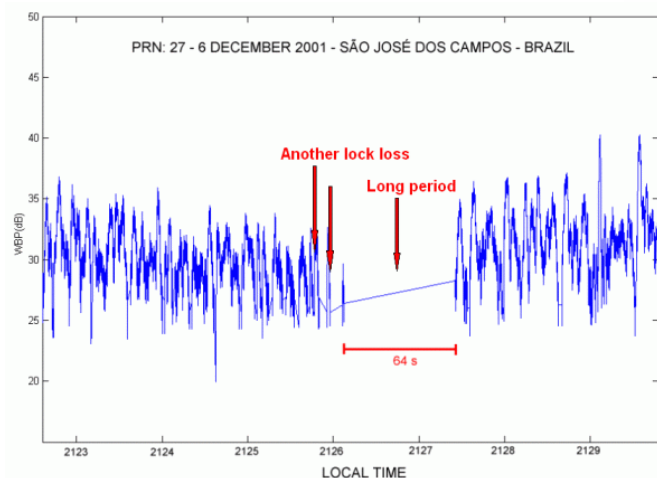
- Several studies have demonstrated that the equatorial ionospheric scintillations affects the performance of GPS receivers.

• Scintillation occurs when a radio wave crosses the ionosphere and it suffers a distortion in phase and amplitude.

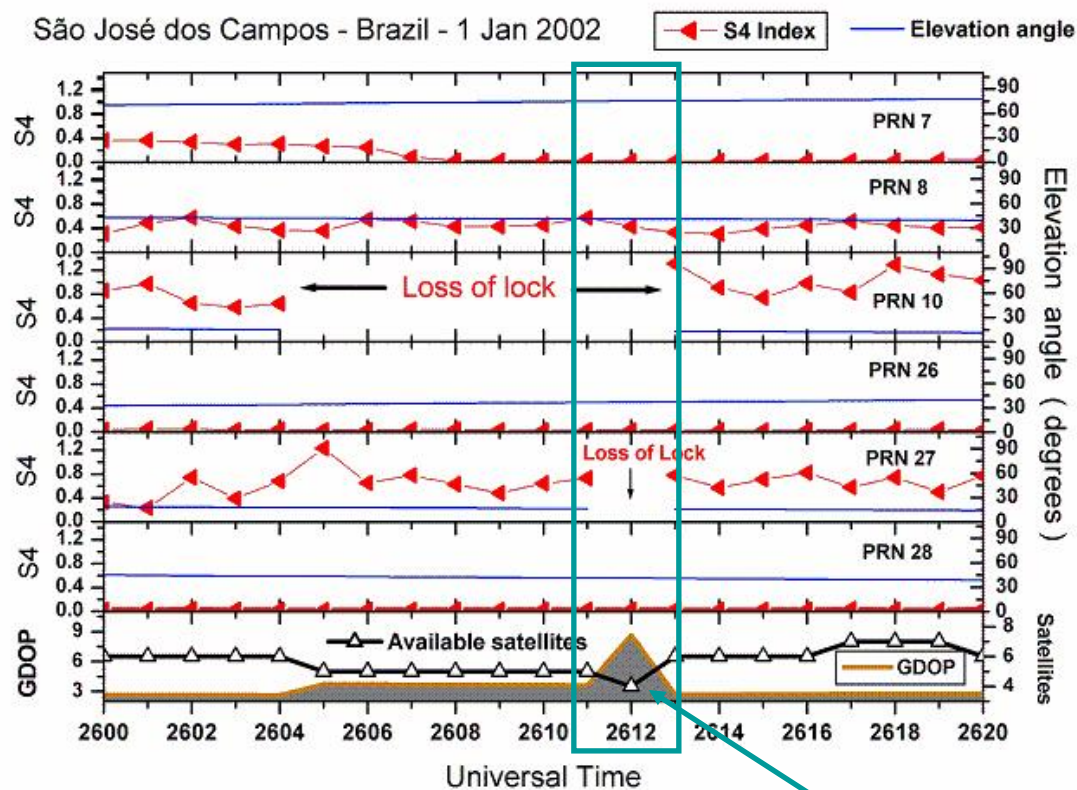


# MOTIVATION

Scintillation contributes to the loss of lock of the GPS receivers, decreasing the number of available satellites and consequently the possibility to get good satellite geometry in the sky.



**Loss of lock**





# SCINTEC (Scintillation & TEC) PROJECT

## OBJECTIVES:

- Mapping of plasma bubbles in real time available in the Internet (finalizing). Extend the mapping to the South America – integration with the LISN (Low Latitude Ionospheric Sensor Network)
- Using DM (Data Mining) to do prediction of the ionospheric scintillation.
- Implementation of the RDBMS (Relational Data Base Management System) with data of TEC and ionospheric scintillation.
- Through SQL (Structured query language ) to retrieve the data.
- Calculate the zonal velocity of the ionospheric irregularities.
- Analyze the effects of plasma irregularities in the TEC.
- Analyze the effects of the magnetic storms.
- Study the effects of the solar cycle and season.
- Analyze loss of lock in the GPS signal.
- Mapping of the TEC over the Brazilian territory.
- This project is supported by The State of São Paulo Research Foundation (FAPESP).

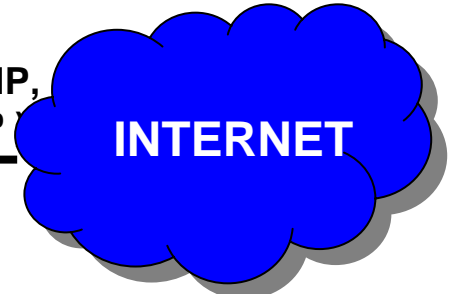
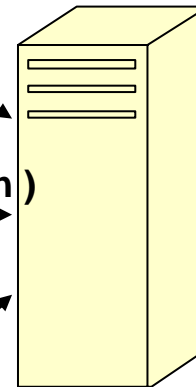
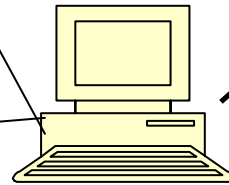
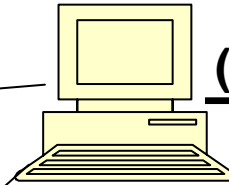
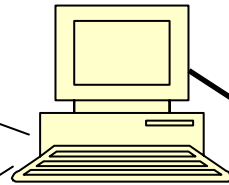
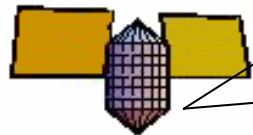


# SCENERY

GPS  
SATELLITES

STATIONS

SERVER



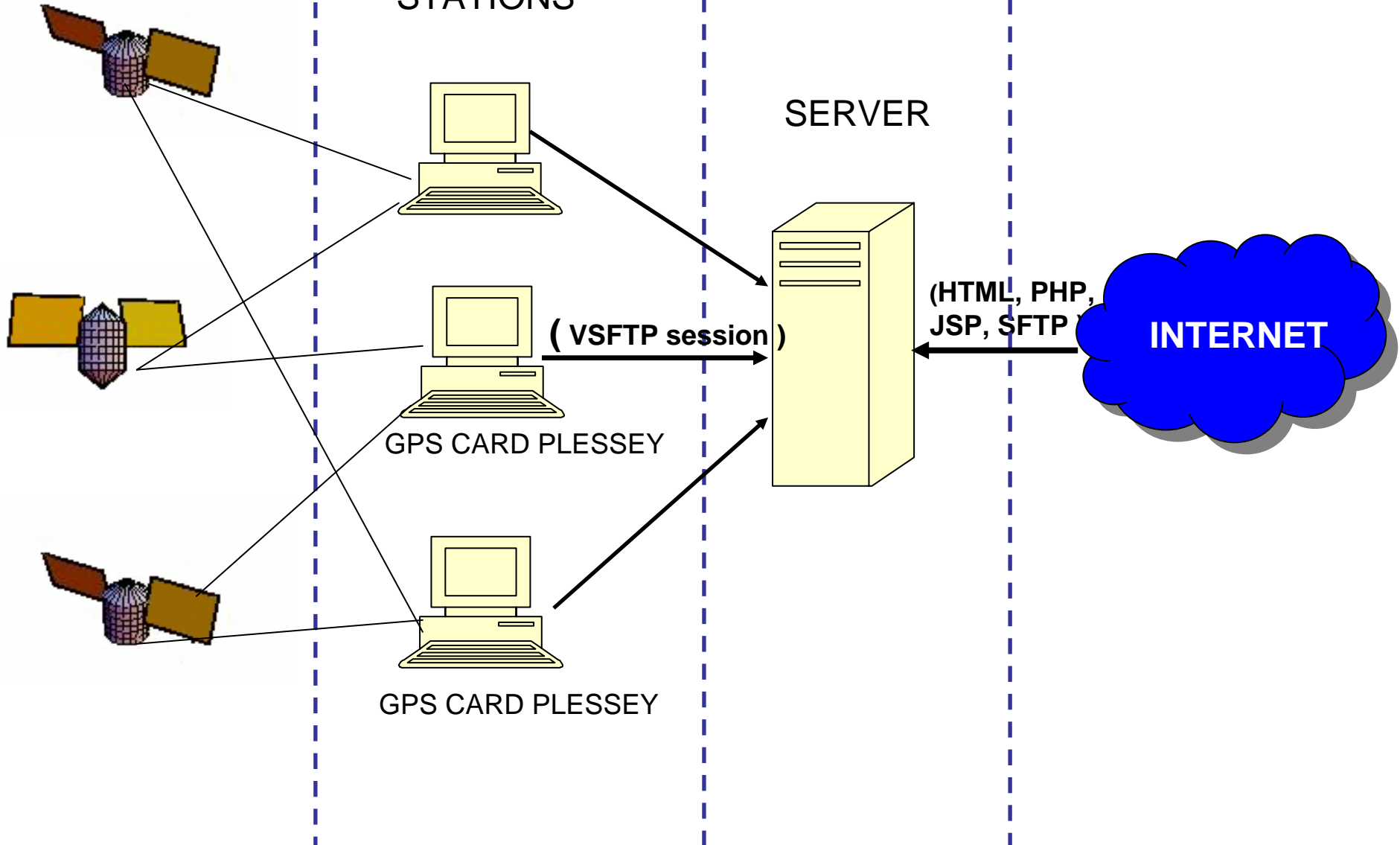
( VSFTP session )

GPS CARD PLESSEY

GPS CARD PLESSEY

(HTML, PHP,  
JSP, SFTP)

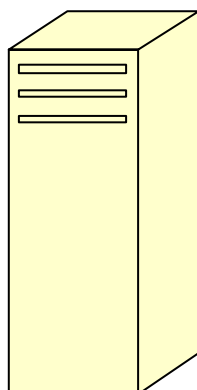
INTERNET





# SERVER

## SERVER



2 Processors Intel Xeon E5345 Quad Core - 2.33 GHz with 2X4MB of cache memory (1333 FSB).

4 GB memory Fully Buffered Dimm (FBD) – DDR - 667 MHz (4x1 GB)

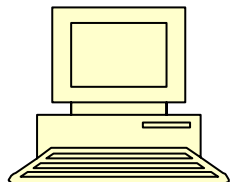
7 hard disks - 300GB SAS - 3.5" – 10,000 rpm

Red Hat Enterprise Linux ES 4.0 - support a EM64T (64 bits)



# CLIENT

STATION



Programs

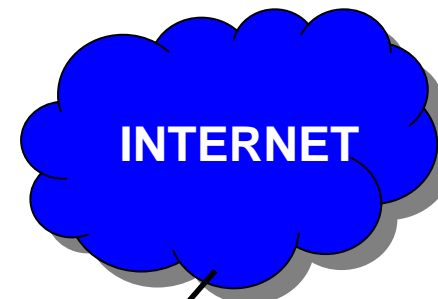
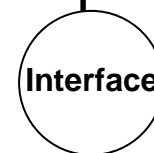
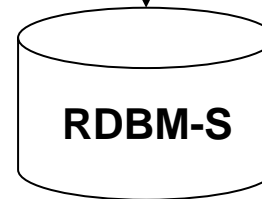
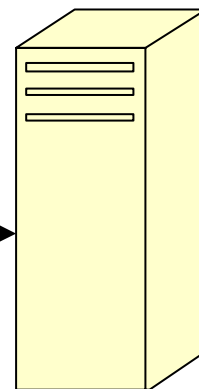
\*.c

\*.c

\*.pl

(VSFTP session)

# SERVER



Setting files

receiver.identification

receiver.name –







# SCINTEC – Real Time

Scintec - Microsoft Internet Explorer

Arquivo Editar Exibir Favoritos Ferramentas Ajuda

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

Google Little sunshine

## SCINTEC PROJECT

Home Real Time Animation Scintillation Papers Related Links

### Ionospheric Scintillation over Brazilian territory

Scintillation **Map** Satellite Hybrid

Quiet day, without scintillation

25/01/2008 19:00

Network Status: 80% | Scintillation Map: On

Concluído Internet



# Access to data

The system provides access to data base through graphic interface and Structured Query Language (SQL).

2008 year  
4 month  
17 day  
21 Start Time 23 End Time  
 Min  
bht station  All Stations  
 s4   
 prn   
 lat\_IPP   
 lon\_IPP   
 azim   
 elev   
 x\_sat   
 y\_sat   
 z\_sat   
[Mark all](#) [Unmark](#)

**filter**



# Access to data

## Results from query

Scintec - Microsoft Internet Explorer

Arquivo Editar Exibir Favoritos Ferramentas Ajuda

Endereço <http://www.inpe.br/scintec/tabela.php?ano=2008&mes=4&dia=17&horaInic=21&horaFim=23&CompOption1=No+Filter&txtOption1=&station=bht&stationall=stationall&> Ir Links >>

Google Luiz Felipe Rezende Go Bookmarks 977 blocked Check AutoLink AutoFill Send to Luiz Felipe Settings

Y! YAHOO! cadê? Buscar Anti-Spy My Web Favoritos Escolha os botões Y! Mail Encontros

### SCINTEC PROJECT

Home Real Time Animation Scintillation DataBase Papers Related Links

year	month	day	hh	s4	station	pm	lat_IPP	lon_IPP	elev
2008	4	17	21	0.1	bht	15	-18.4696	-39.5572	16.978
2008	4	17	21	0.15	bht	31	-17.4805	-57.8967	12.418
2008	4	17	21	0.1	bht	6	-25.4588	-53.8984	17.241
2008	4	17	21	0.12	bht	12	-13.7318	-45.1251	21.269
2008	4	17	21	0.19	boa	24	-6.6065	-56.6705	11.435
2008	4	17	21	0.14	chp	15	-20.7053	-36.0136	15.443
2008	4	17	21	0.1	ppt	16	-27.4825	-57.2576	16.065
2008	4	17	21	0.1	ppt	22	-14.2256	-53.9816	19.013
2008	4	17	21	0.11	stm	31	-26.4853	-61.4833	18.199
2008	4	17	21	0.12	chp	15	-20.7823	-36.0547	15.588
2008	4	17	21	0.1	ppt	16	-27.3694	-57.1676	16.448
2008	4	17	21	0.1	ppt	31	-18.7205	-58.8146	18.859
2008	4	17	21	0.11	ppt	12	-13.6027	-47.098	15.34
2008	4	17	21	0.14	stm	31	-26.4004	-61.5327	17.956
2008	4	17	21	0.1	bht	15	-18.6115	-39.6176	17.222
2008	4	17	21	0.1	chp	15	-20.8587	-36.0951	15.731
2008	4	17	21	0.1	ntl	15	-5.80895	-29.9691	27.802
2008	4	17	21	0.14	ppt	31	-18.6462	-58.8475	18.68
2008	4	17	21	0.14	ppt	12	-13.4631	-47.0392	14.951
2008	4	17	21	0.12	slz	31	-1.87441	-52.7813	15.276
2008	4	17	21	0.1	stm	29	-30.7032	-51.2939	51.716
2008	4	17	21	0.1	stm	31	-26.3189	-61.5795	17.726
2008	4	17	21	0.1	chp	15	-21.0051	-36.1725	16.004
2008	4	17	21	0.11	ppt	31	-18.4993	-58.9118	18.329
2008	4	17	21	0.17	ppt	12	-13.1578	-46.9101	14.132

Concluído Internet



# Access to data

## Download of the data of the query ( ASCII file )

The screenshot shows a Microsoft Internet Explorer browser window displaying a data table from the INPE website. The table contains 20 rows of data with columns for year, month, day, time, station code, and three numerical values. Below the table, there are navigation links and summary statistics.

2008	4	17	21	0.1	ppt	16	-27.3694	-57.1676	16.448
2008	4	17	21	0.1	ppt	31	-18.7205	-58.8146	18.859
2008	4	17	21	0.11	ppt	12	-13.6027	-47.098	15.34
2008	4	17	21	0.14	stm	31	-26.4004	-61.5327	17.956
2008	4	17	21	0.1	bht	15	-18.6115	-39.6176	17.222
2008	4	17	21	0.1	chp	15	-20.8587	-36.0951	15.731
2008	4	17	21	0.1	ntl	15	-5.80895	-29.9691	27.802
2008	4	17	21	0.14	ppt	31	-18.6462	-58.8475	18.68
2008	4	17	21	0.14	ppt	12	-13.4631	-47.0392	14.951
2008	4	17	21	0.12	slz	31	-1.87441	-52.7813	15.276
2008	4	17	21	0.1	stm	29	-30.7032	-51.2939	51.716
2008	4	17	21	0.1	stm	31	-26.3189	-61.5795	17.726
2008	4	17	21	0.1	chp	15	-21.0051	-36.1725	16.004
2008	4	17	21	0.11	ppt	31	-18.4993	-58.9118	18.329
2008	4	17	21	0.17	ppt	12	-13.1578	-46.9101	14.132
2008	4	17	21	0.1	slz	31	-1.73539	-52.7662	15.281
2008	4	17	21	0.12	bht	15	-18.8163	-39.7037	17.566
2008	4	17	21	0.19	bht	31	-17.0276	-58.1104	11.726
2008	4	17	21	0.11	bht	6	-25.2409	-53.3771	18.752
2008	4	17	21	0.14	boa	29	-2.29695	-56.386	21.174

[Previous<<-- -->>Next](#)

Number of registers found: 915  
Number of registers by page: 30  
Page 1 from 31

Type the page number:

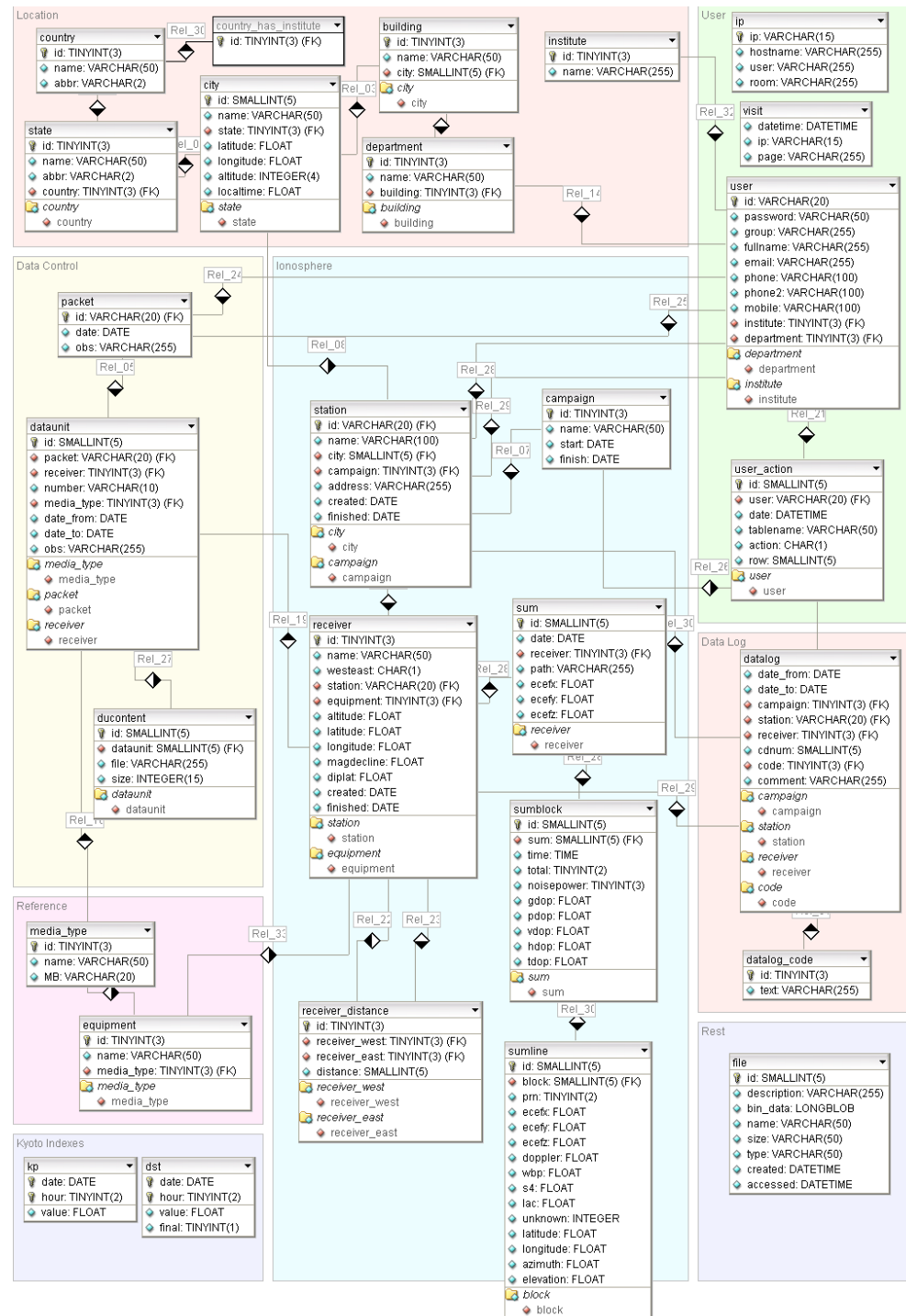
[Download data](#)

**Download**



## Relational Model of Data Base provides:

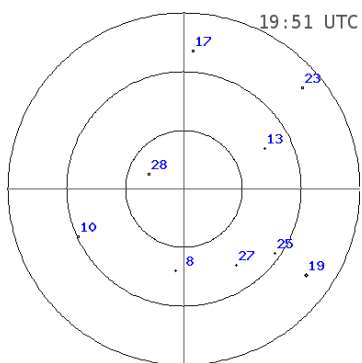
- Tables of data (scintillation and TEC);
- Metadata;
- Profile of users, collaborators, institutions;
- Table of equipments, stations;
- Magnetic indices (Kp, Dst );
- Solar flux ( F10.7);
- Campaigns.



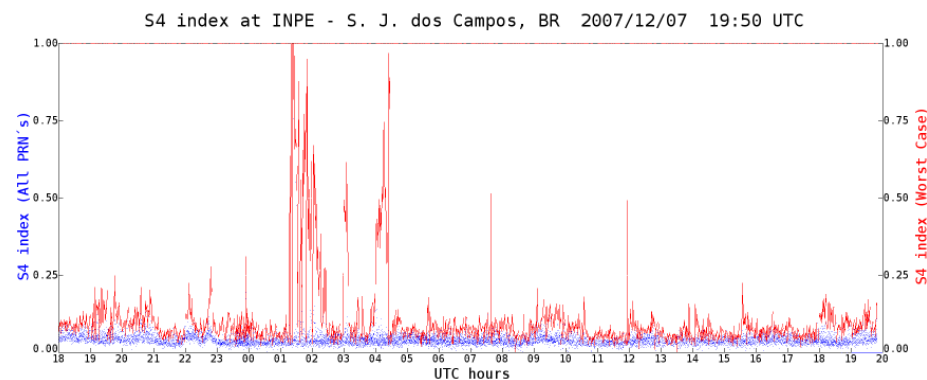


# PLOTS

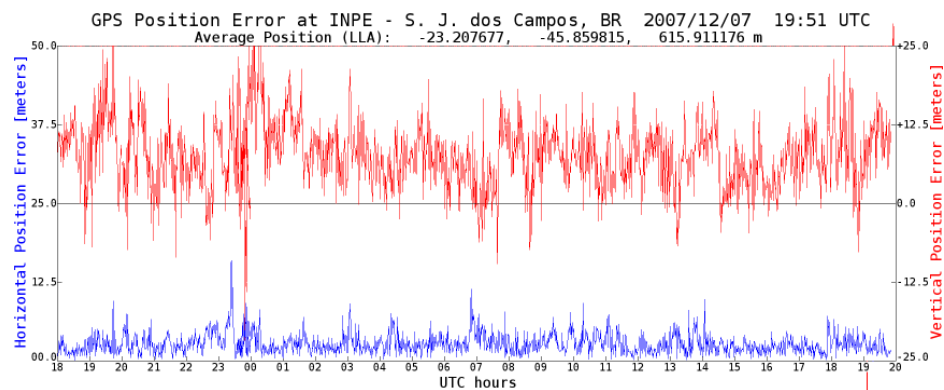
## Azimuth/Elevation angle



## Scintillation



## Positioning

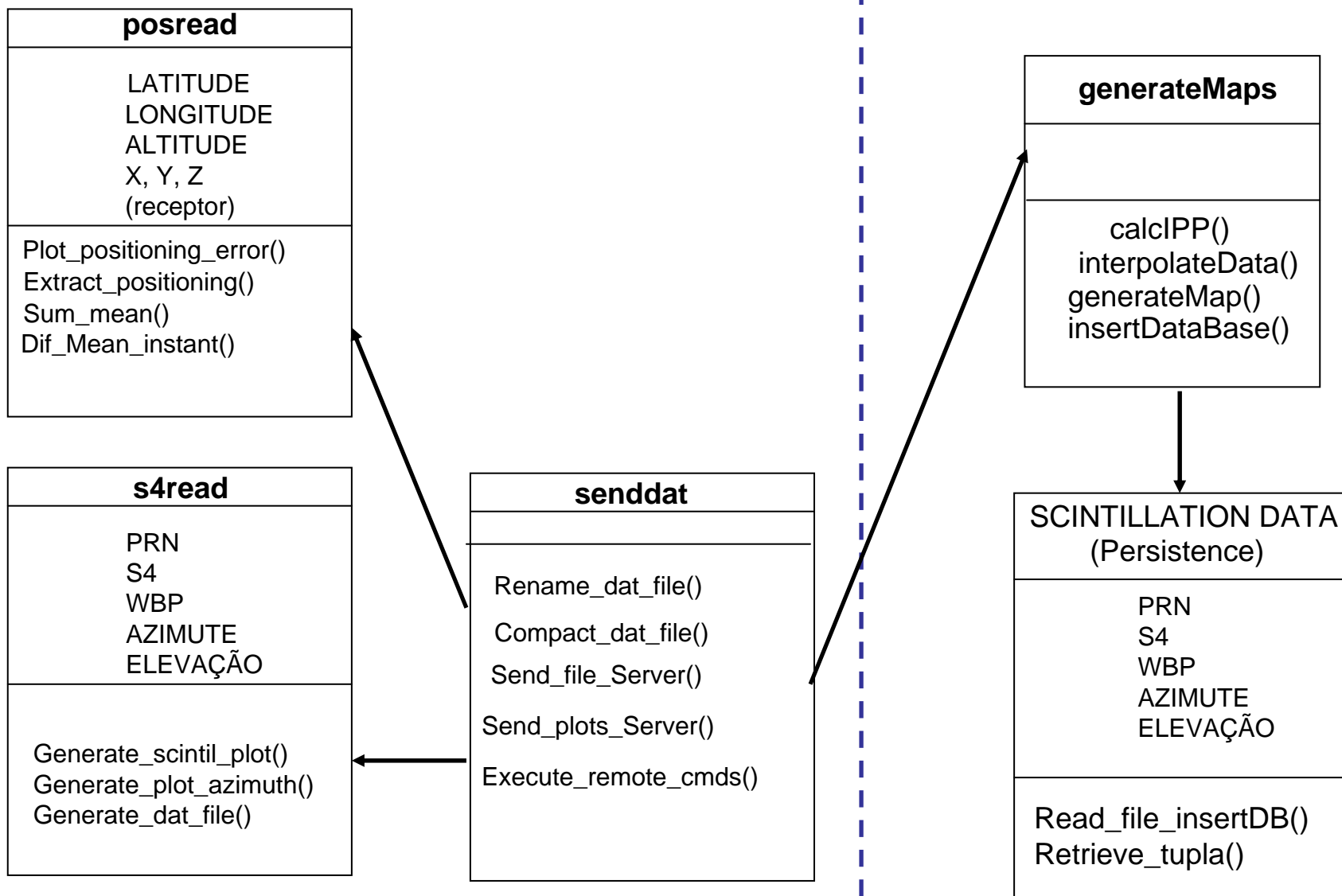




## STATION



## SERVER





# CONCLUSION

- The system is working well, but performance can be improved with more support staff and better hardware.
- This innovative project will contribute to Space Weather forecast and, besides its scientific purposes, will provide informations about the Ionosphere to eventual users of GPS receivers.





# NEXT STEPS

- TEC mapping in RT (real time); calculation of relative and absolute TEC.
  - Ionospheric scintillation modelling.
  - TEC modelling.
- The SCINTEC system will integrate the Low-Latitude Ionospheric Sensor Network (LISN) data to provide scintillation and TEC maps over South America and to get a better resolution over Brazil.
- Prediction of the scintillation using Data Mining techniques.
- Calculate the zonal velocity of the ionospheric irregularities.
- Analyze the effects of plasma irregularities in the TEC.
- Analyze the effects of the magnetic storms.
- Study the effects of the solar cycle and season.