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


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SIRGAS

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# INTRODUCTION

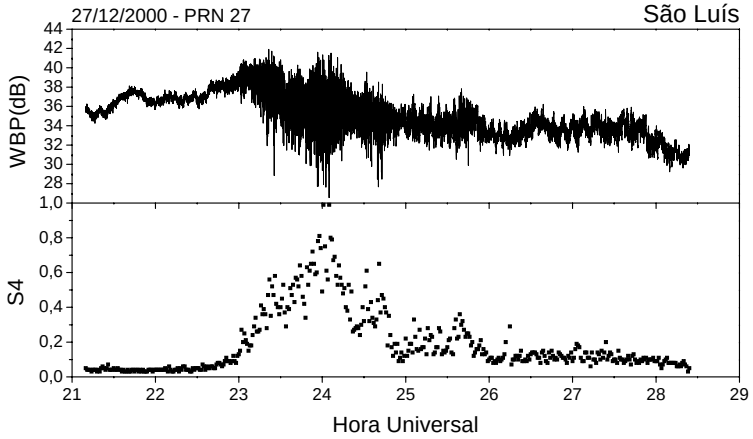
- SCINTEC is a project for monitoring and mapping the total electron content (TEC) and ionospheric scintillation in real time over the Brazilian territory.
- SCINTEC system provides data to a Relational Database Management System (RDBM-S).

www.inpe.br/scintec

# MOTIVATION

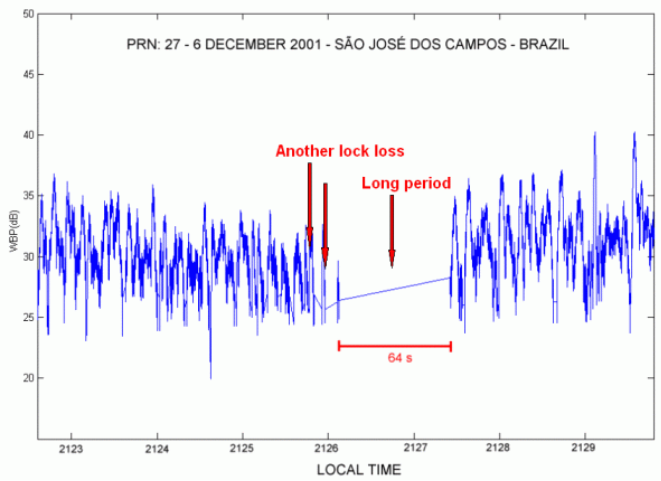
- Several studies have demonstrated that the equatorial ionospheric scintillations affects the performance of GPS receivers.

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

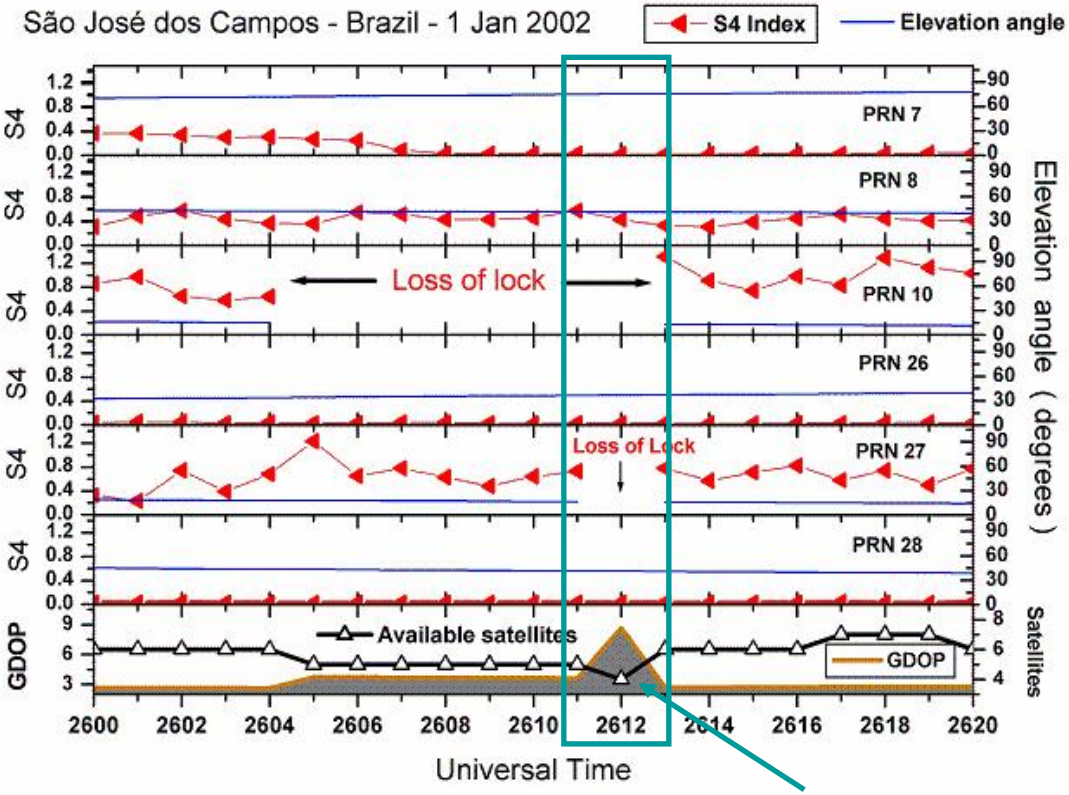


# MOTIVATION

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.



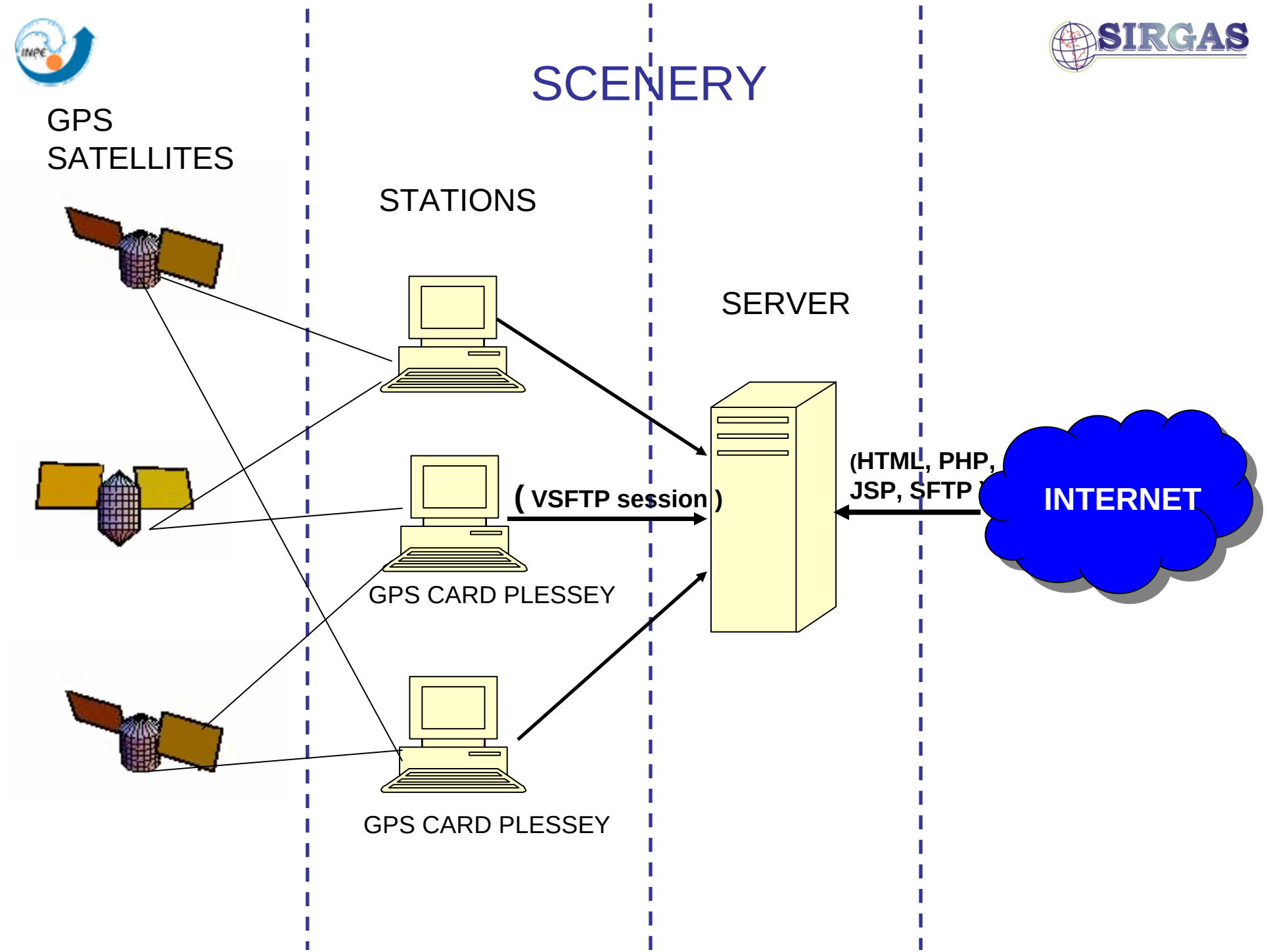

**Loss of lock**



# SCINTEC (Scintillation & TEC) PROJECT

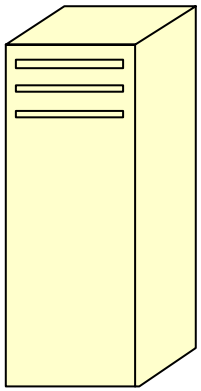
## OBJECTIVES:

- 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
(HTML, PHP,
JSP, SFTP
INTERNET
( VSFTP session )
GPS CARD PLESSEY
GPS CARD PLESSEY

# SERVER

SERVER

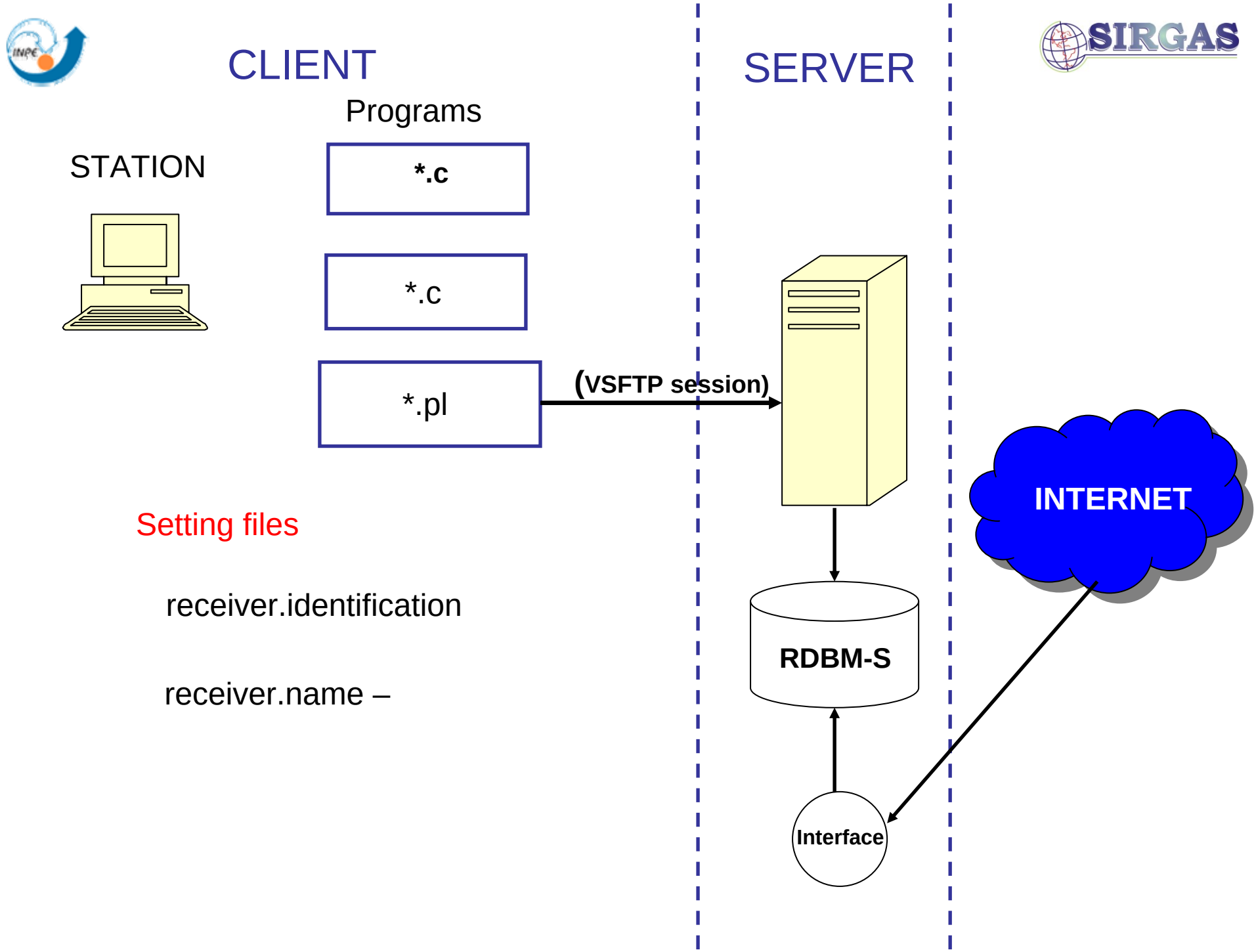


2 Processors Intel Xeon E5345 Quad Core - 2.33 GHz with 2X4MB of cache memory (1333 FSB).

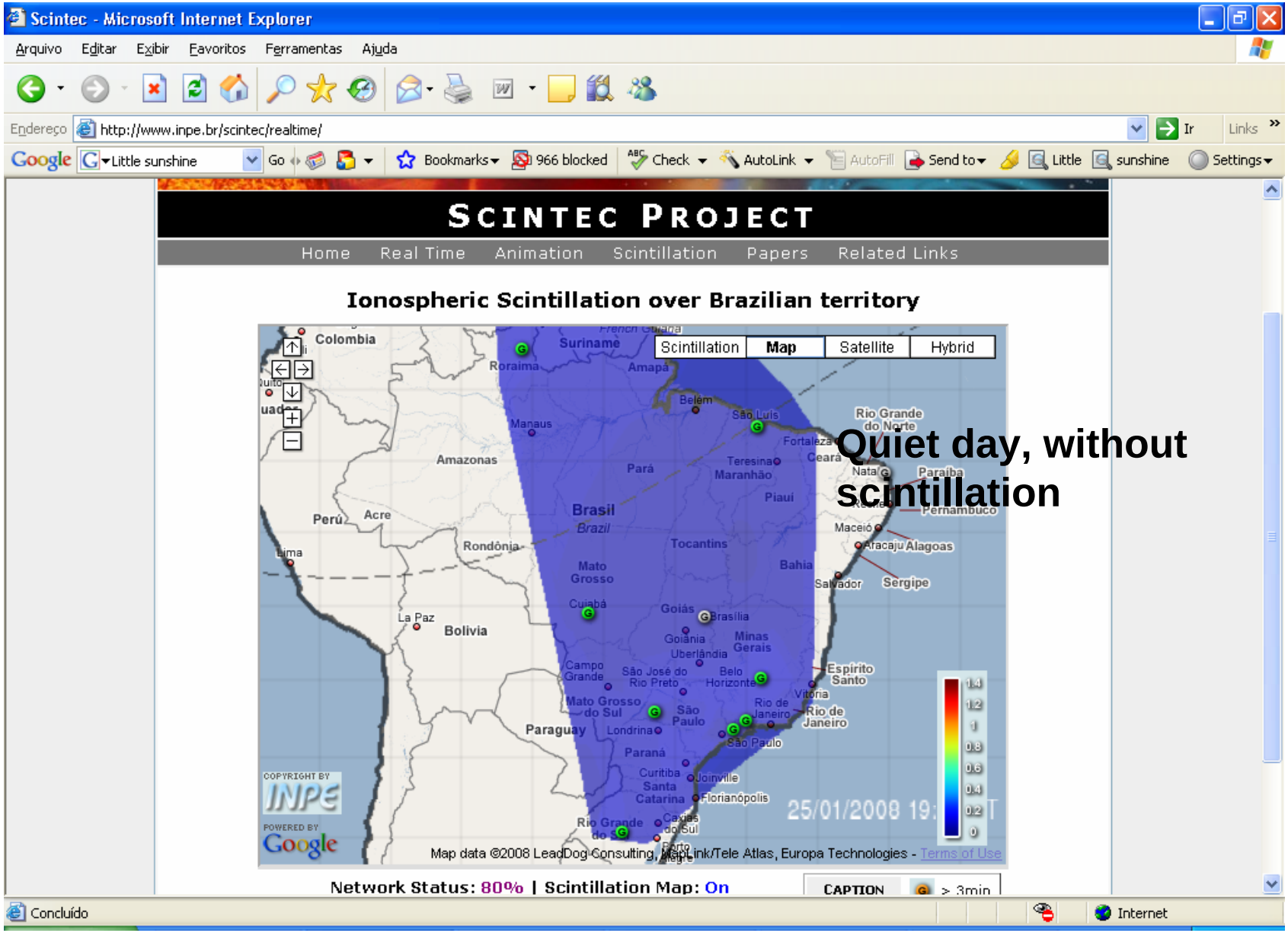
4 GB memory Fully Buffered Dimm (FBD) – DDR - 667 MHz (4x1 GB)

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

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


CLIENT
SERVER
SIRGAS
Programs
STATION
*.c
*.c
*.pl
(VSFTP session)
INTERNET
RDBM-S
Interface
Setting files
receiver.identification
receiver.name –

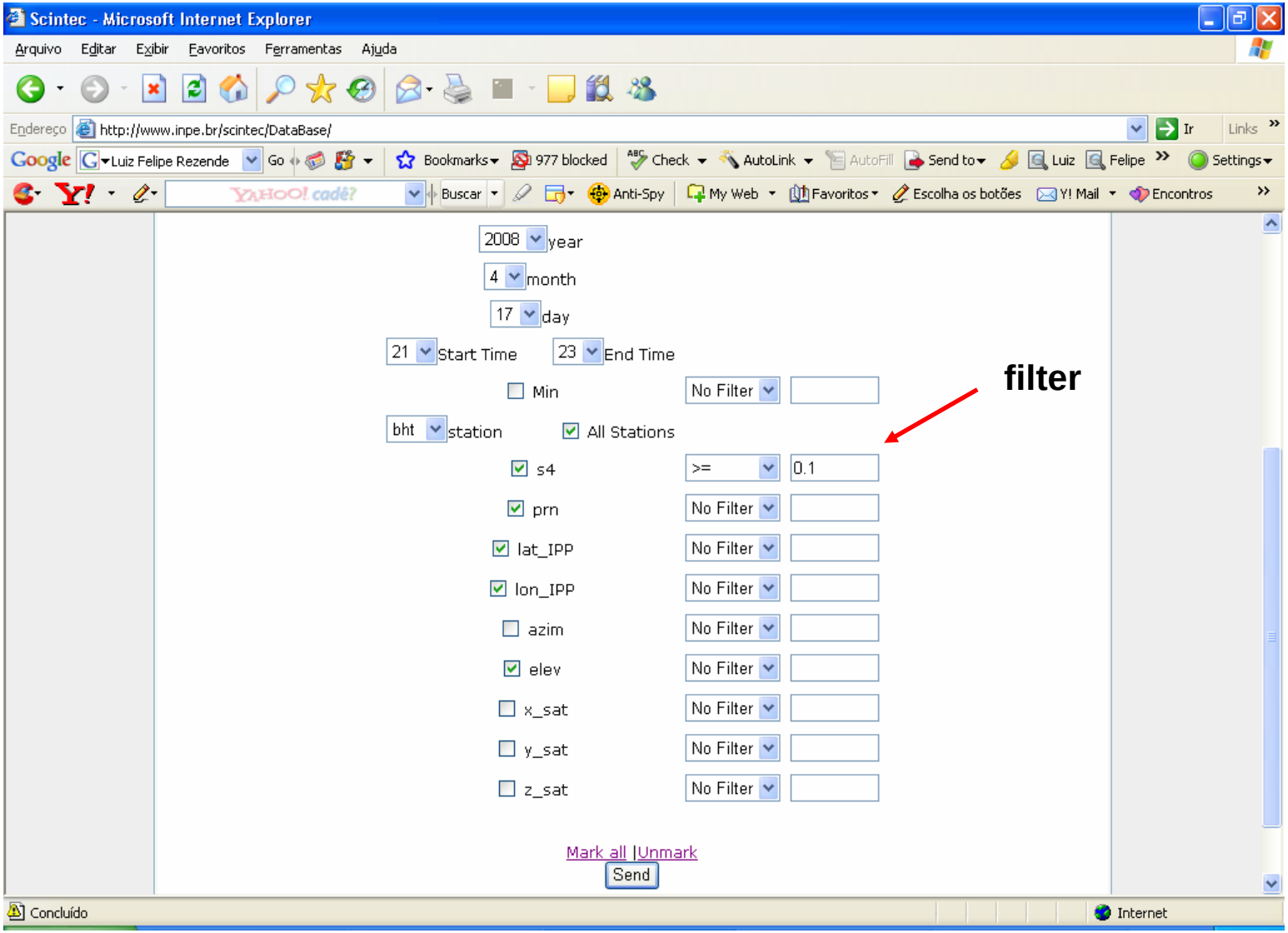
# SCINTEC – Real Time




**Quiet day, without scintillation**

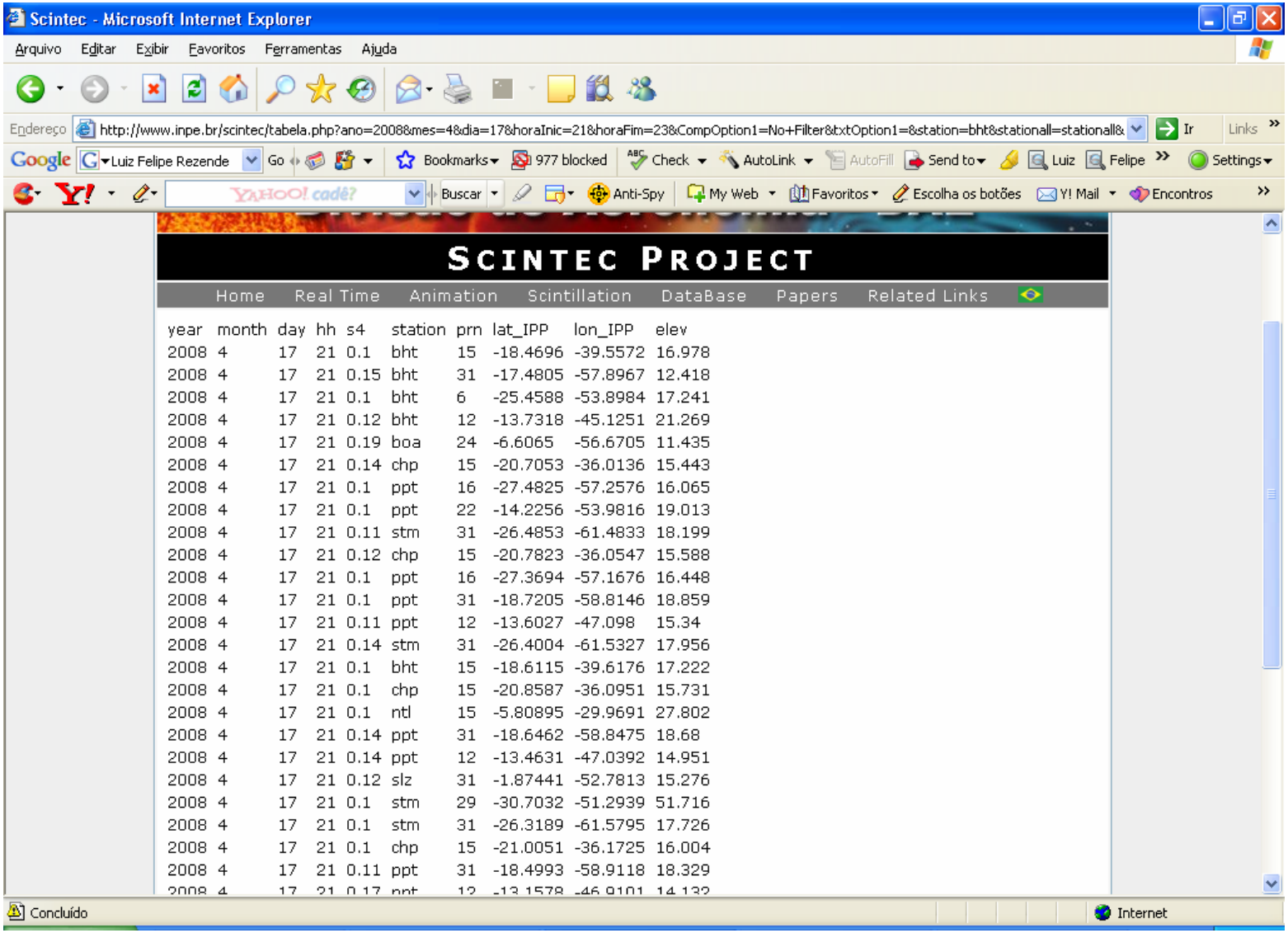
# Access to data

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



# Access to data

Results from query



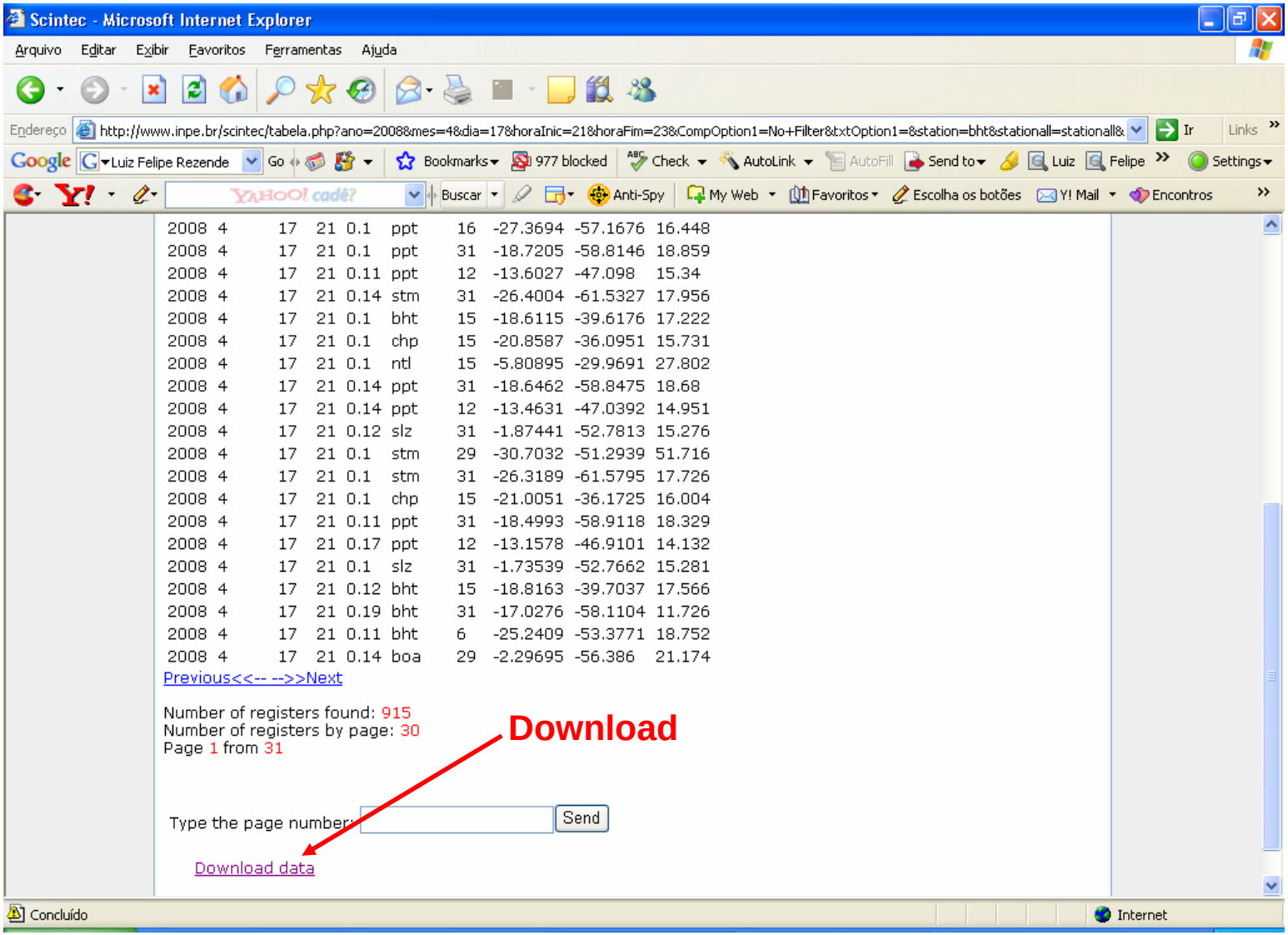

SCINTEC PROJECT

Home Real Time Animation Scintillation DataBase Papers Related Links

| year | month | day | hh | s4 | station | prn | 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 |

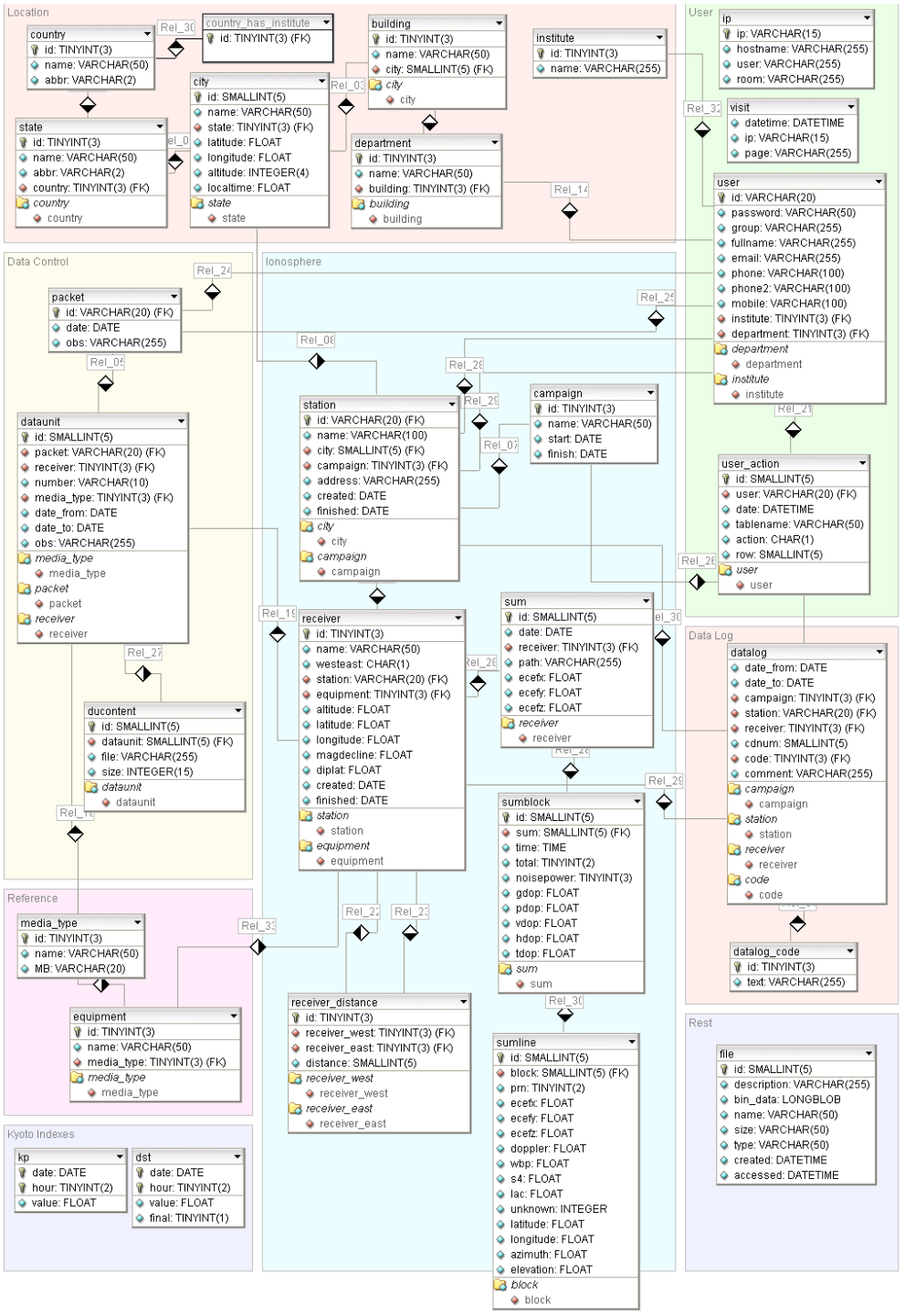
# Access to data

Download of the data of the query ( ASCII file )



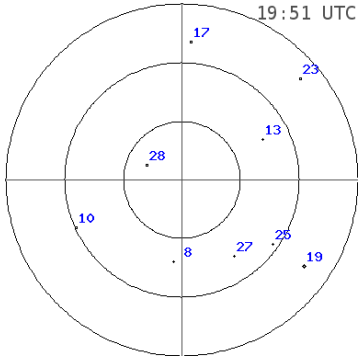
Relational Model of Data Base provides:

-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.

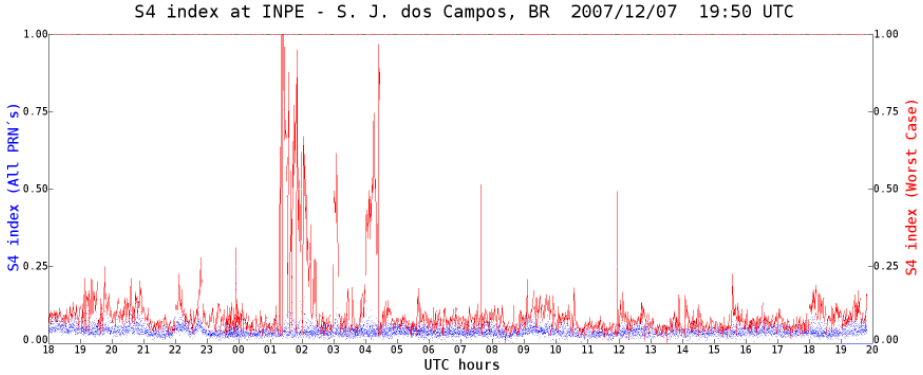


# PLOTS

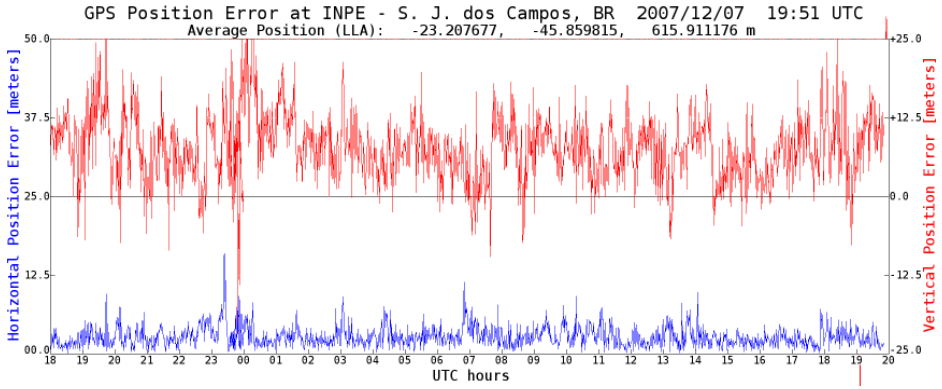
## Azimuth/Elevation angle

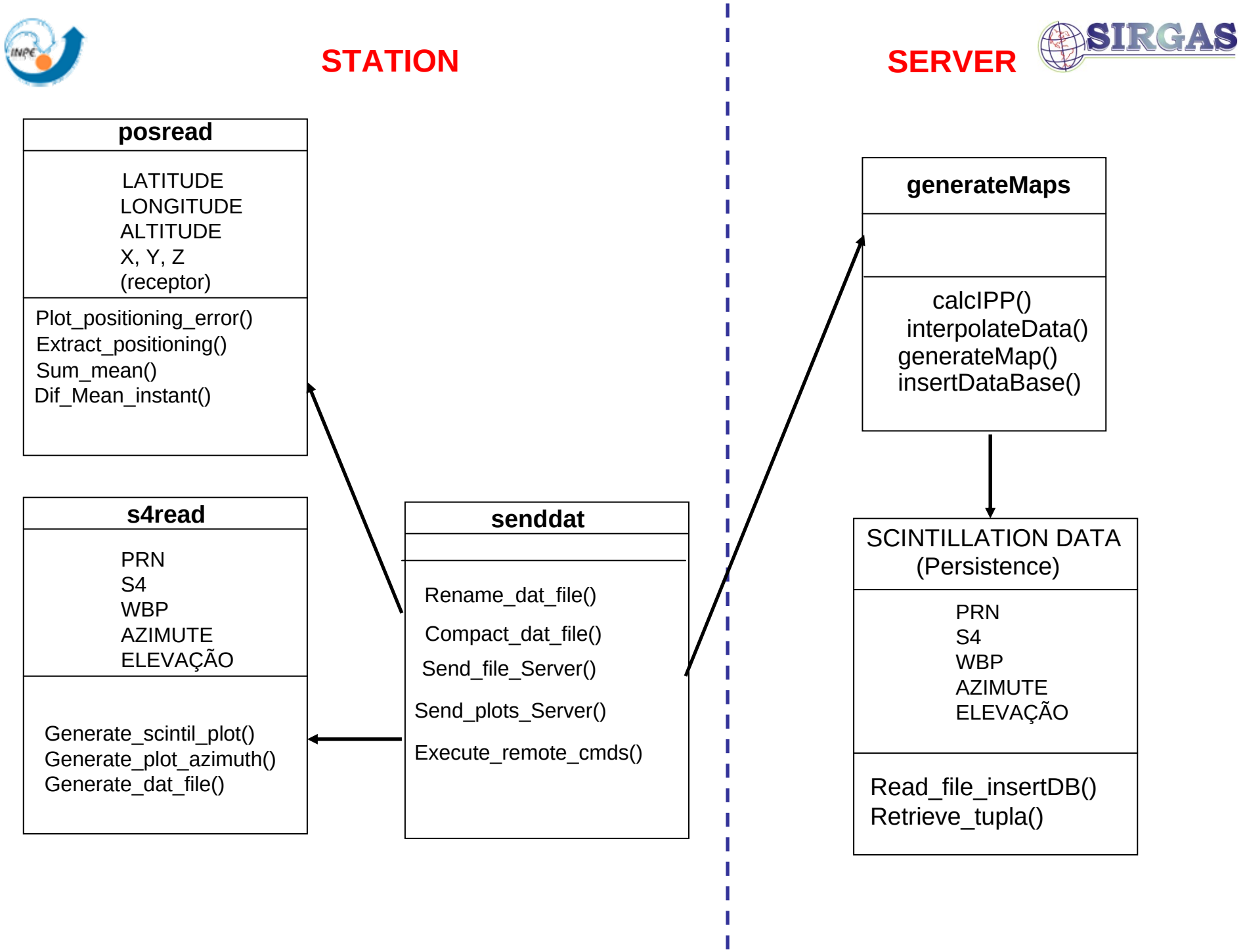



## Scintillation




## Positioning




STATION
SERVER
SIRGAS
posread
LATITUDE
LONGITUDE
ALTITUDE
X, Y, Z
(receptor)
Plot_positioning_error()
Extract_positioning()
Sum_mean()
Dif_Mean_instant()
s4read
PRN
S4
WBP
AZIMUTE
ELEVAÇÃO
Generate_scintil_plot()
Generate_plot_azimuth()
Generate_dat_file()
senddat
Rename_dat_file()
Compact_dat_file()
Send_file_Server()
Send_plots_Server()
Execute_remote_cmds()
generateMaps
calcIPP()
interpolateData()
generateMap()
insertDataBase()
SCINTILLATION DATA
(Persistence)
PRN
S4
WBP
AZIMUTE
ELEVAÇÃO
Read_file_insertDB()
Retrieve_tupla()

# 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 integrated 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.