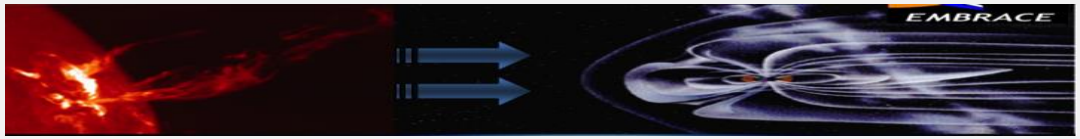


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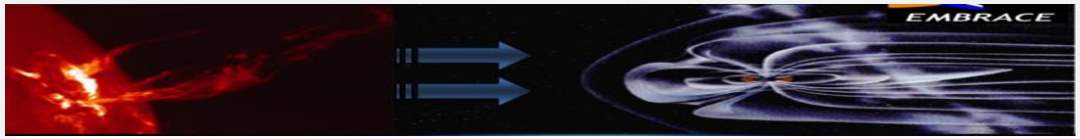
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS


# Brazilian Space Weather Program:

# EMBRACE

Presented by:
J.E.R.Costa

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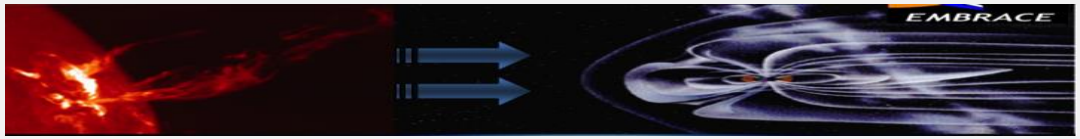
# Brazilian Studies and Monitoring of Space Weather

INAUGURATION YEAR

Space Weather Workshop – Boulder-CO
23-27 April, 2012






# OUR PLAN

The program has a focus on monitoring the regions of the
agnetic
of the
nization
radio
equatorial Ionosphere and the SAMA (South America Ma
Anomaly). The main concerns are to model peculiarities
Brazilian Ionosphere such as equatorial electrojet, the io
anomaly, the plasma bubbles and the consequences for
propagations

- Program started in 2008 with a four-year installation plan (plus one).
- EMBRACE is aimed to establish a “Space Weather Information and Prediction Centre”.
- Plans to establish and enhance INPE’s ground based monitoring systems.
- Ionospheric modeling with IT applications on the web for alerts, monitoring and predictions.

# ROUTE TO TODAY

Five year investment (2008-2012)

Instruments (2009..2012)

Building the Operation Center (2011)

Applications & Models (2011-…)

Assemblage & Progress (2012)

EMBRACE PROGRAM

South America Singularities

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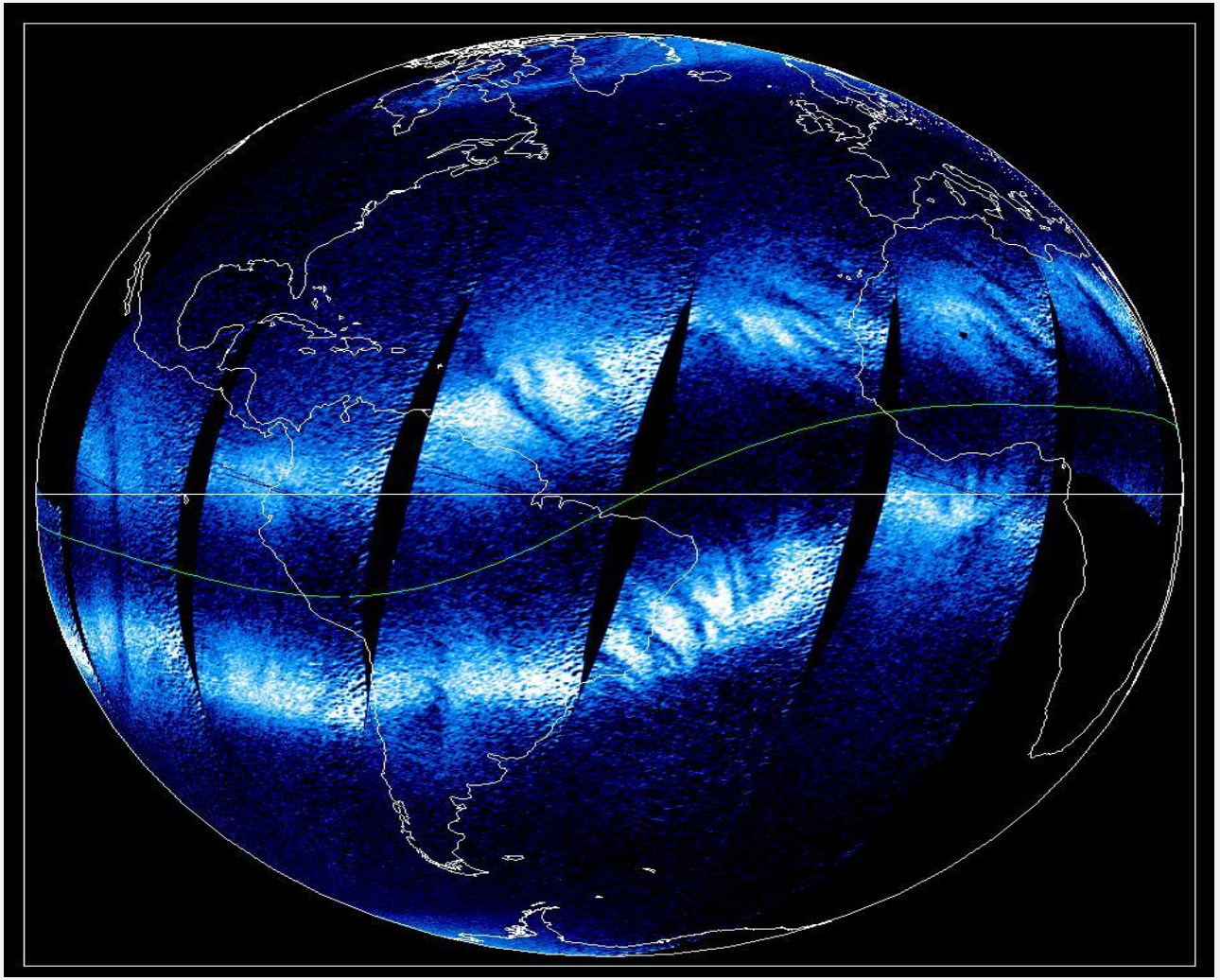
# EQUATORIAL ANOMALY AND PLASMA BUBBLES



Ionosphere Irregularities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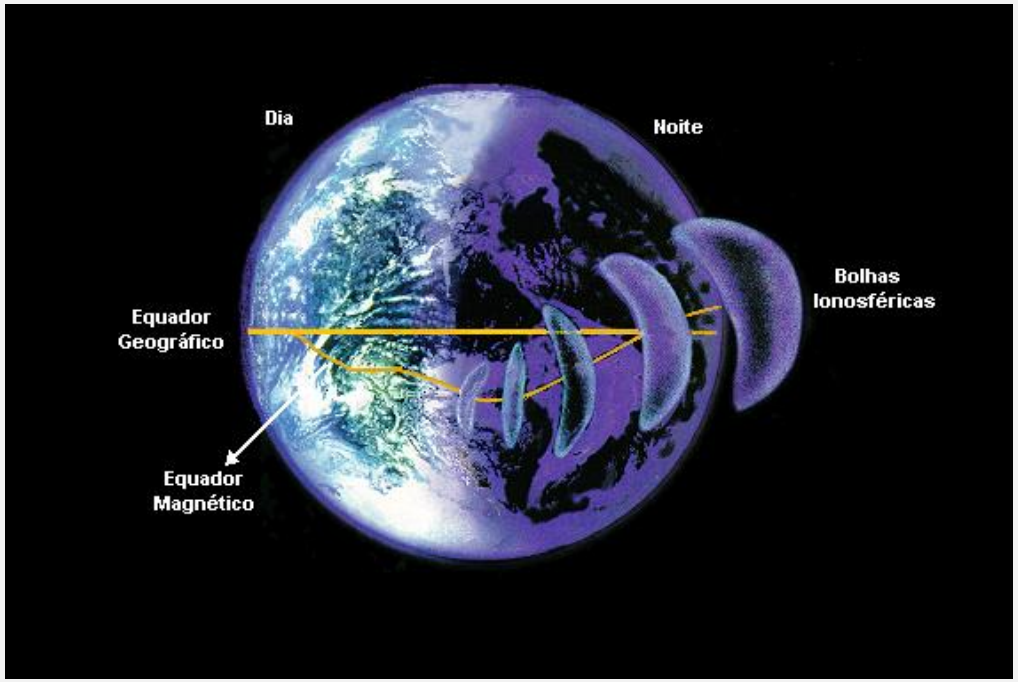
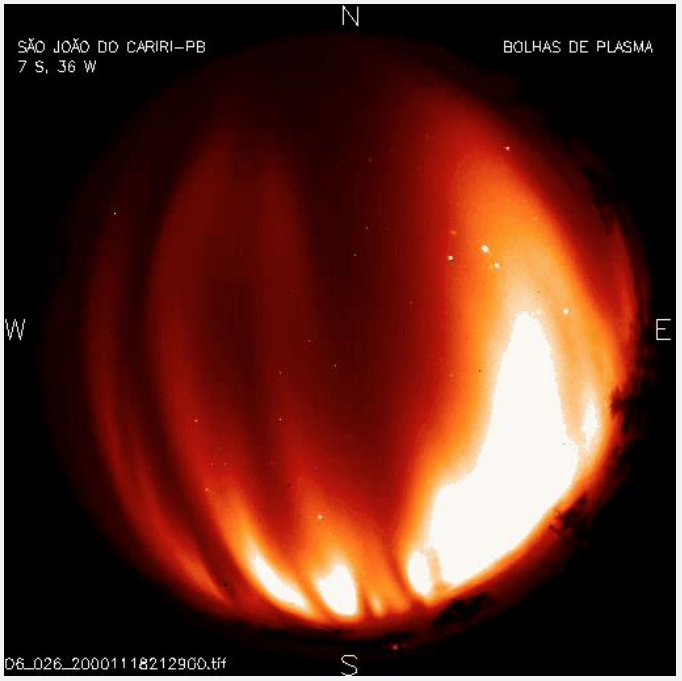
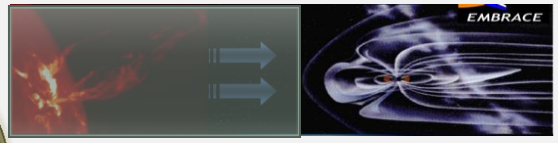
# EQUATORIAL PLASMA BUBBLES



South America Singularities

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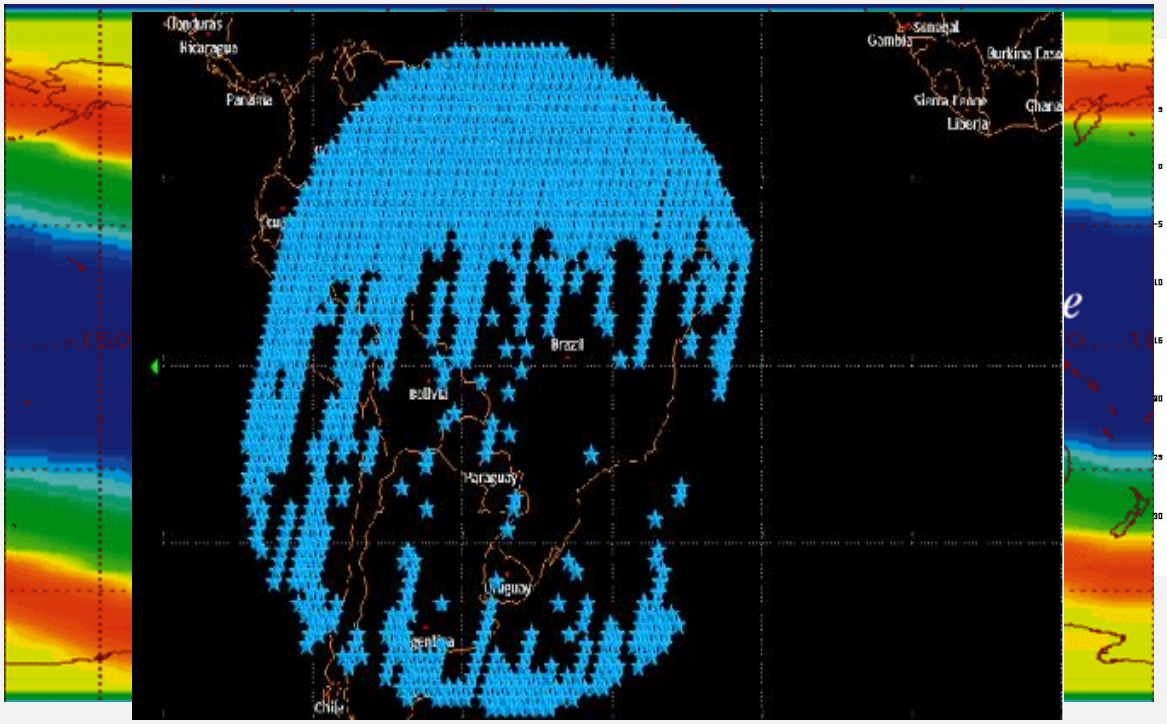
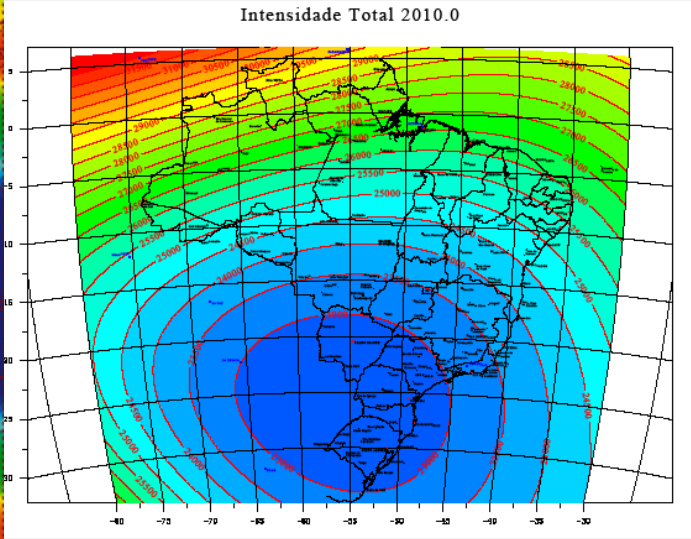
# SOUTH AMERICA MAGNETIC ANOMALY




## GEOMAGNETIC FIELD INTENSITY OVER SOUTH AMERICA




Courtesy of National Observatory, Brazil

Figure: Protons and electron flux greater than 0.5 MeV in low Earth orbit measured by the NASA/SAMPEX satellite.
SAMPEX (Solar Anomalous and Magnetospheric Particle Explorer)
(Source: www.aero.org)

SAMA region:

from 26,000 to 23,000 nT

in the last 100 years,

12 % of decrease

Regional Centre & Instruments Pipeline

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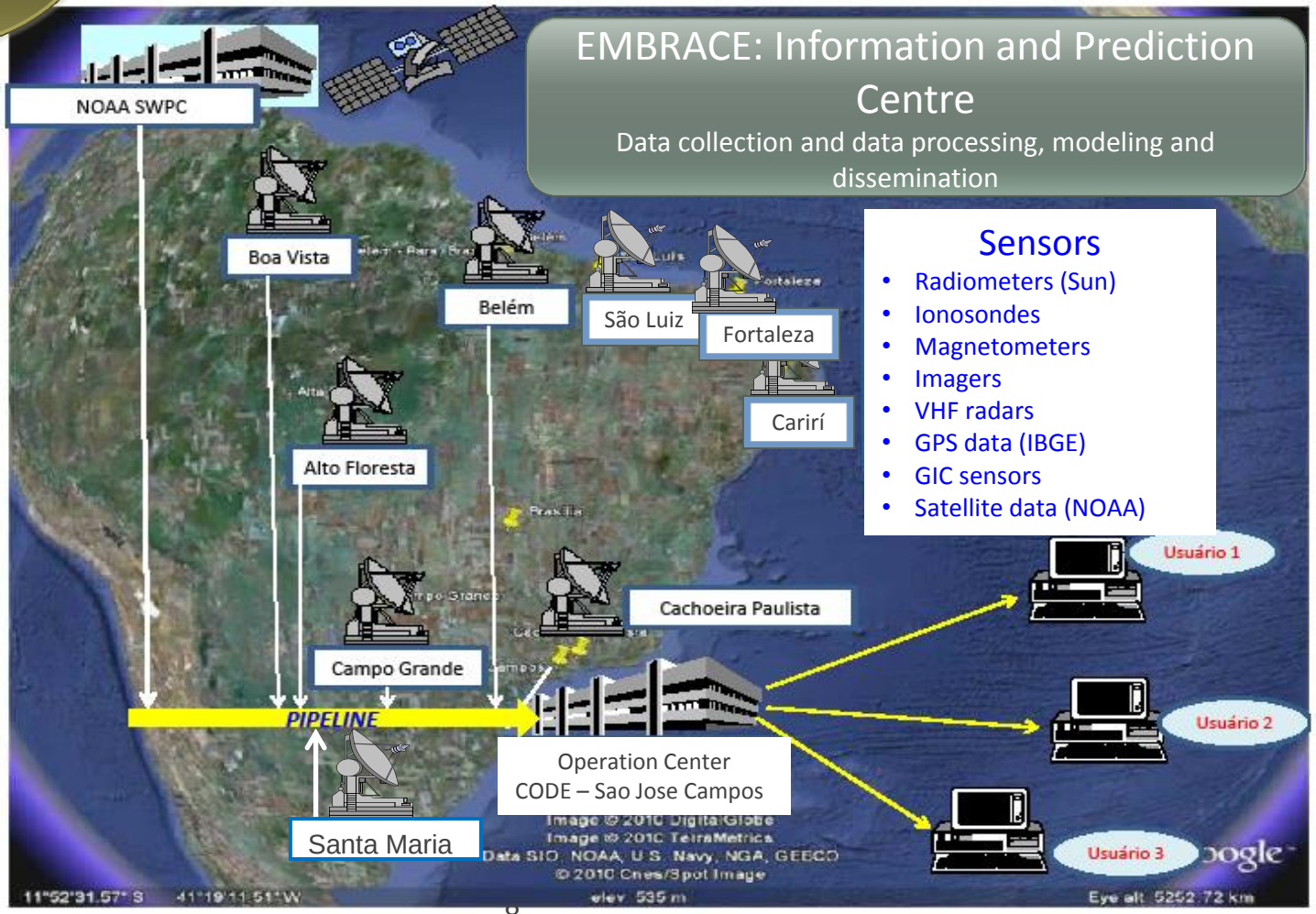
# EMBRACE'S DATA COLLECTION AND FLOW



Solar 10.7cm Images

Sun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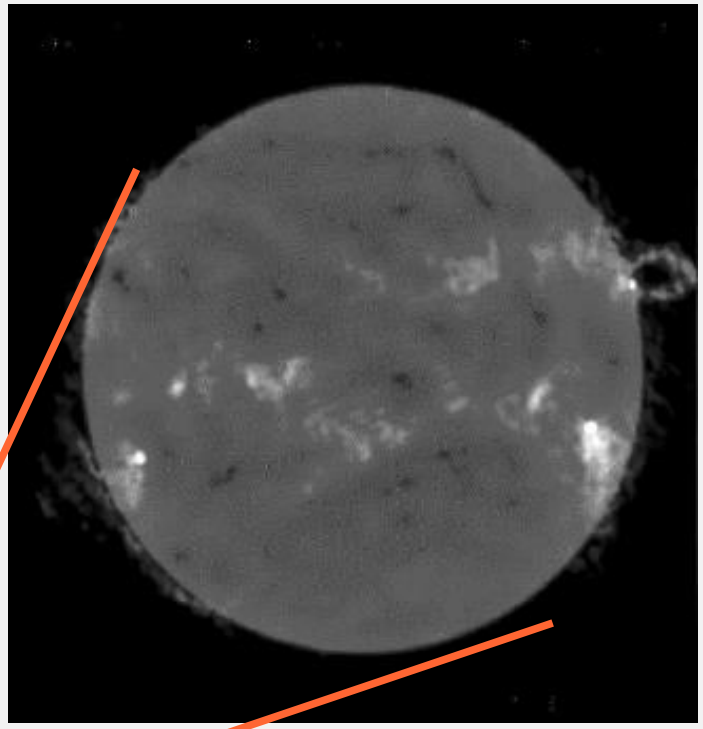
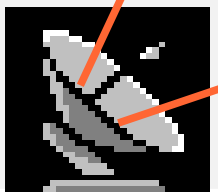
# FLUX DENSITY MEASUREMENTS

*Today radio emission at 10.7 cm (2.8 GHz) is spatially integrated and is the best solar activity index*

- *F10.7cm (**2.8 GHz**) measures the magnetic field organization of the active regions.*
- *BDA will make maps of the Sun from 1.2 à 1.7 GHz in future will observe **2.8 GHz.***
- *BDA operations will start late this year. EMBRACE will look forward changes in the atmosphere are more relevant*





Solar Radio Tasks

Sun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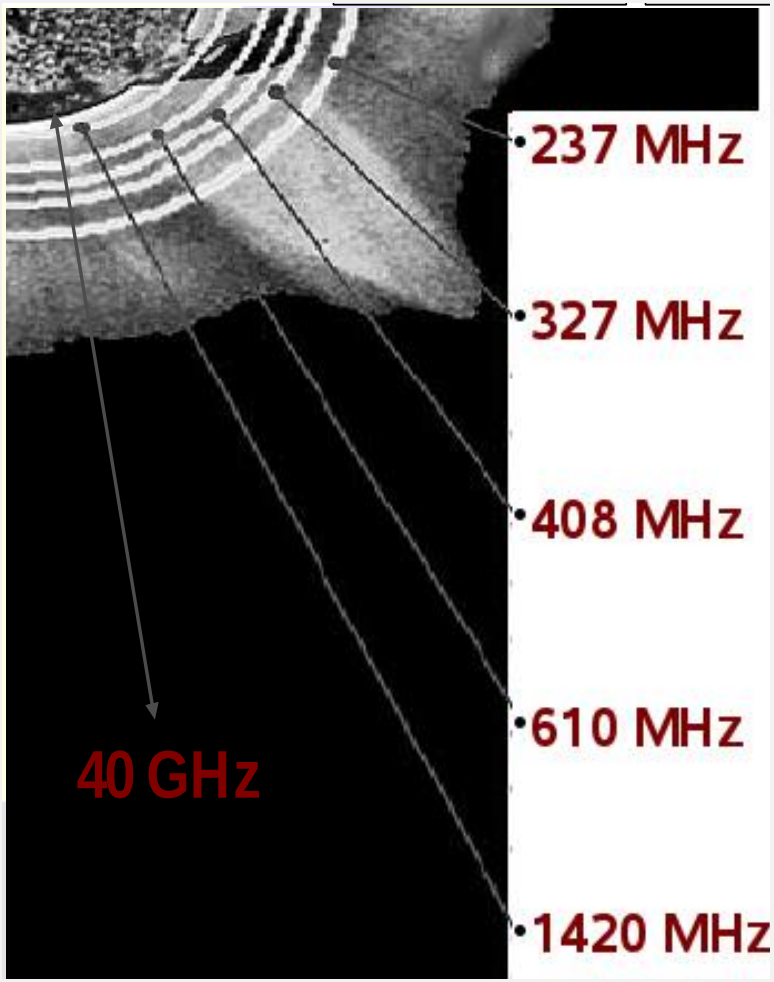
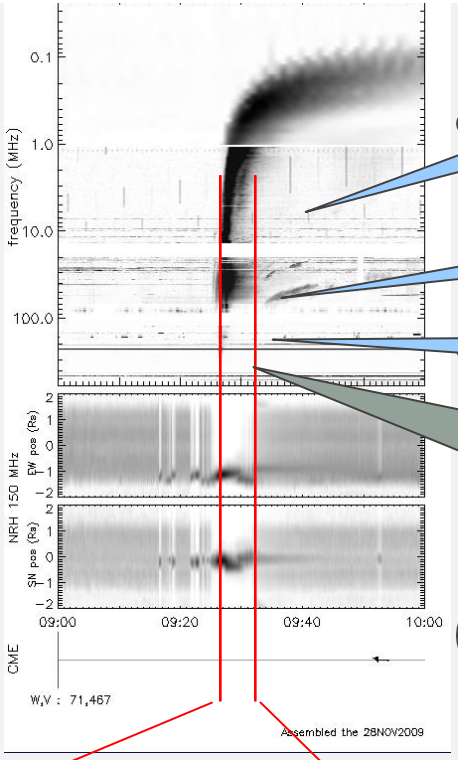
# SIGNATURE OF DYNAMICAL PHENOMENA




## DYNAMIC SPECTRUM



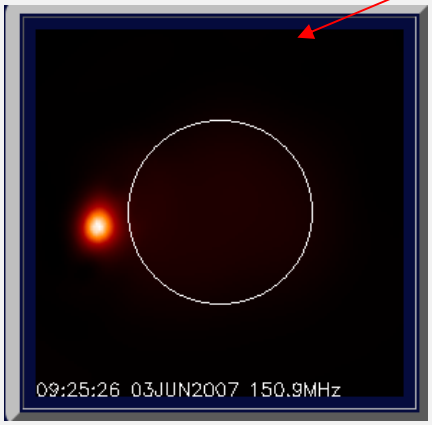

In space

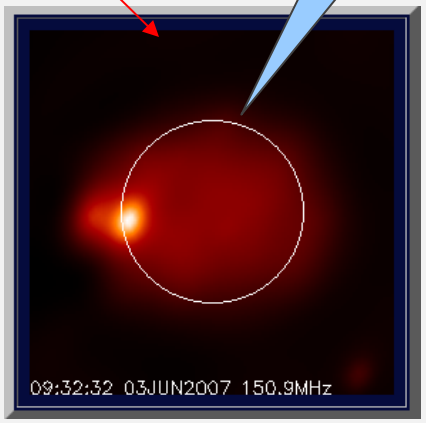
CALLISTO

BSS

SPECM

BDA



Solar Instruments Cachoeira Paulista

Sun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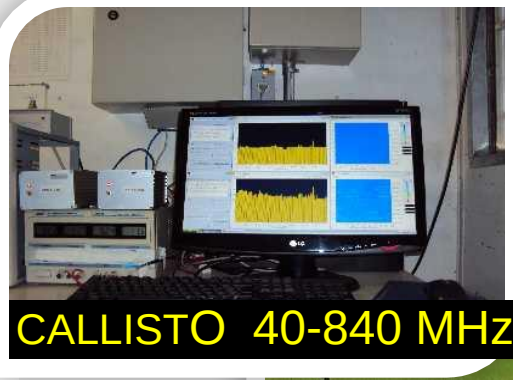
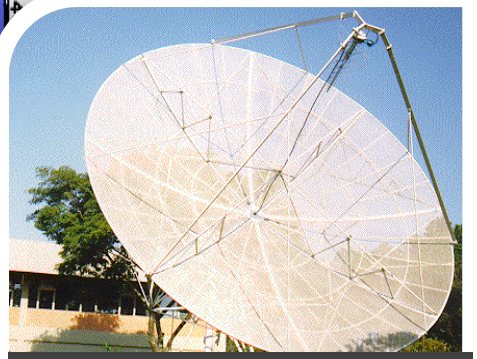
# SOLAR MONITORING

CALLISTO 40-840 MHz

BDA 1.2, 1.7, 2.8, and 5.6 GHz

**Cachoeira Paulista**



BSS 1.0 - 2.5 GHz

SPECM 1-40 GHz

Solar Instruments Atibaia

Sun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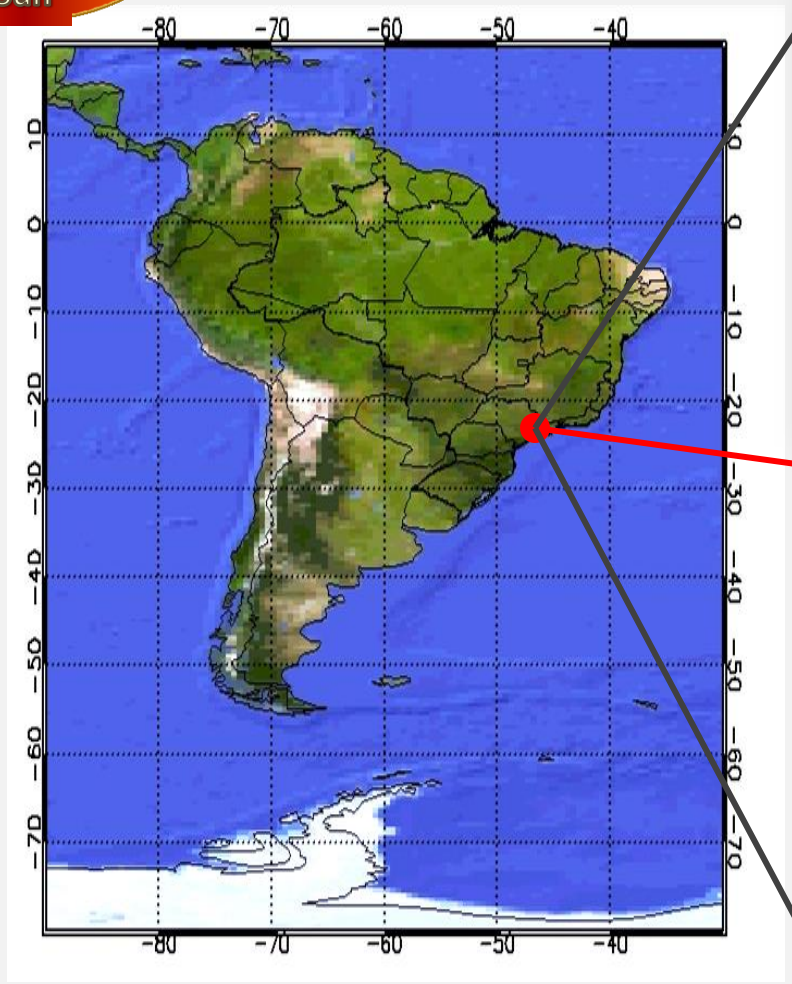
# SOLAR MONITORING





**Atibaia**


Solar Instrument SPUA

Sun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# SOLAR MONITORING

## ALERT SYSTEM: SPUA

### 12GHz

No Flares for now

SPUA Operation Mode: Sun Tracking

Solar Patrol Un-phased Array (SPUA)

Search Data:

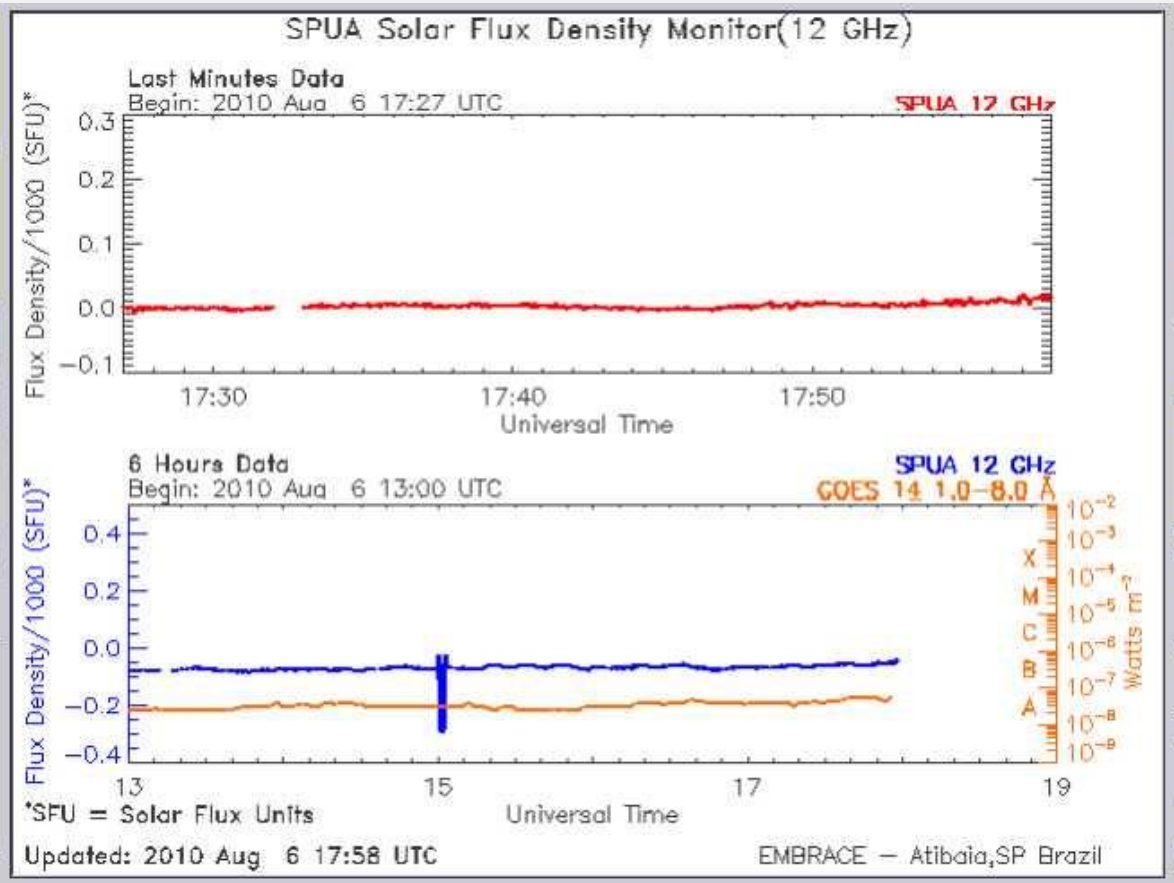
August

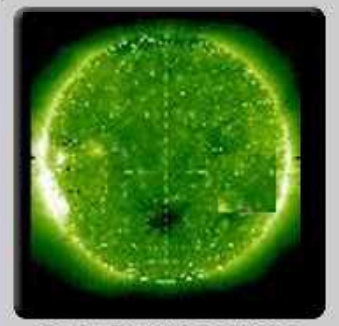
06

2010

Ok

Best View: 1024 x 768 pixels



Solar Burst Locations
(external source maps)

Last Burst
Heliographic Coordinates:

The observed flux density time profile at 12 GHz with **0.1 s** resolution is calibrated in **Solar Flux Units (SFU)** above the solar background.

The observing period is about **11:00 to 20:00 UTC**.

Automatic **calibrations** are done at **12:00, 15:00 and 18:00 UTC**.

Earlier today

This page updates dynamically every minute

Tomorrow

Solar Instrument SPUA

Sun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# SOLAR MONITORING

## ALERT SYSTEM: SPUA

NOW BURSTING

SPUA Operation Mode: Sun Tracking

Solar Patrol Un-phased Array (SPUA)

Search Data:

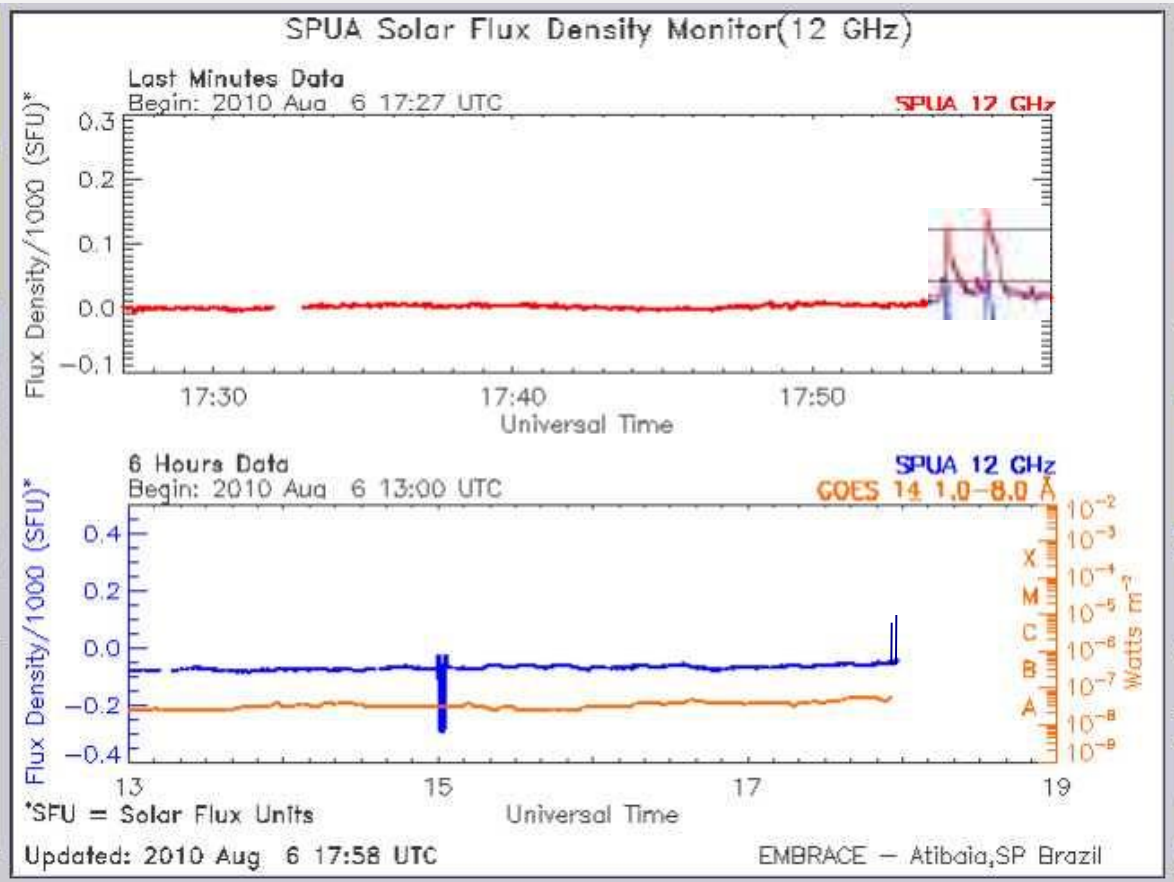
August

06

2010

Ok

Best View: 1024 x 768 pixels




Solar Burst Locations
(external source maps)

Last Burst
Heliographic Coordinates:
S 14 W 40

The observed flux density time profile at 12 GHz with **0.1 s** resolution is calibrated in **Solar Flux Units (SFU)** above the solar background.

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Earlier today

This page updates dynamically every minute

Tomorrow

Solar Instrument CALLISTO

Sun


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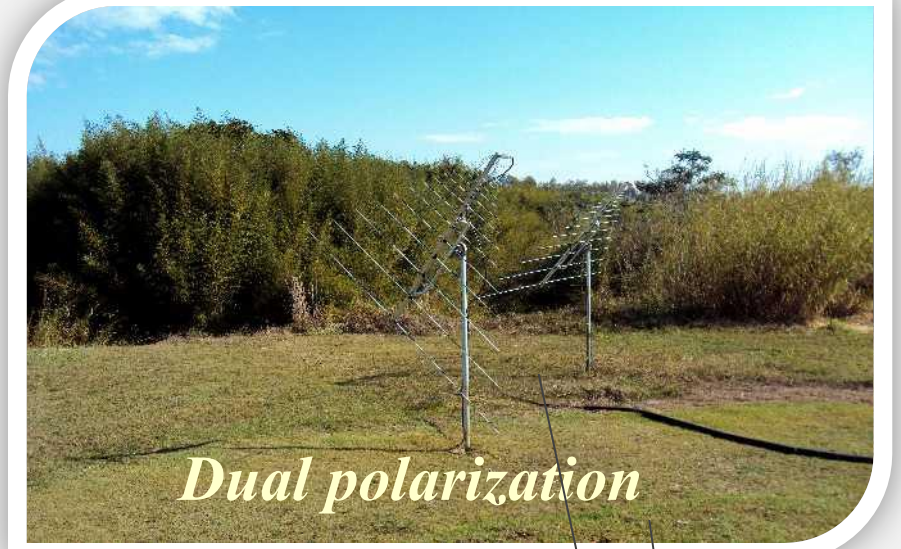
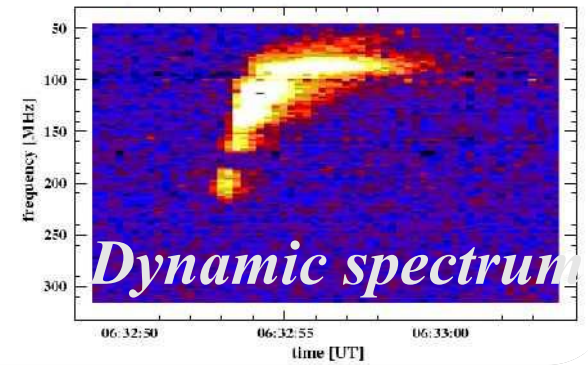
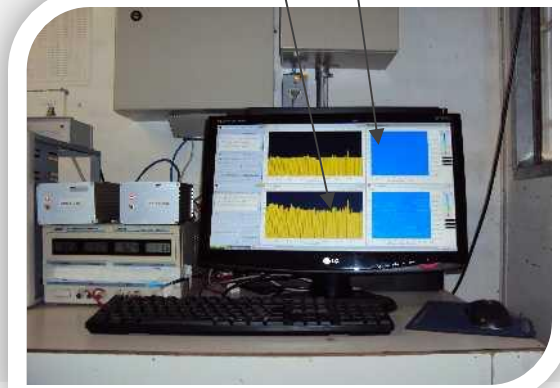
# SOLAR MONITORING




40-840MHz



Solar Instrument BSS

Sun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# SOLAR MONITORING

**Feed 1-2.5GHz**

Control Room

Receiver

Solar Instrument SPECM

Sun


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# SOLAR MONITORING

- Ultra High Band under Construction

- feed 1-18GHz

- feed 26-40GHz


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Solar Instrument BDA

Sun

# SOLAR MONITORING

Correlator

Feed & Preamp
1.2-1.7GHz

Receivers

Optical connections

Solar
Ground Based
Observatories


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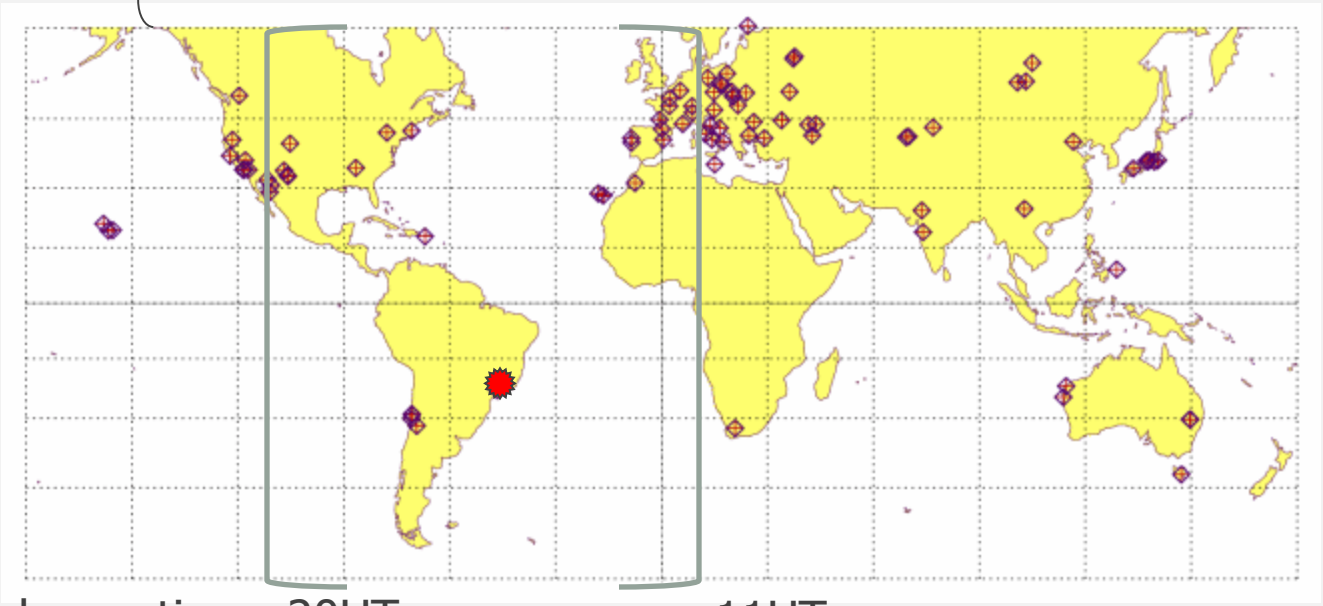
# SOLAR MONITORING

- SPECM (1-40 GHz, HPBW:0.6-10º)
- BSS (1-2.7 GHz, HPBW:1.0-1.2º)
- BDA (1-6 GHz , HPBW:0.6-1 arcmin)
- Itapetinga (22, 48 GHz , HPBW: 4, 2 arcmin)

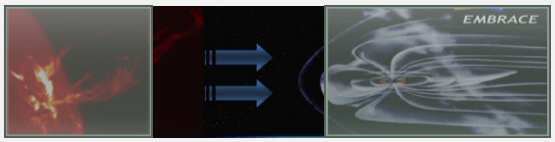


EMBRACE observation ~20UT ← ~11UT

http://www.arcetri.astro.it/~kreardon/EGSO/gbo/

I.M.
Instrument
Muon

I.M.

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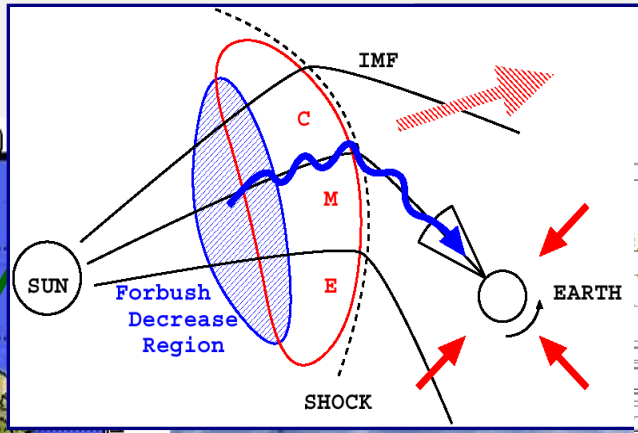
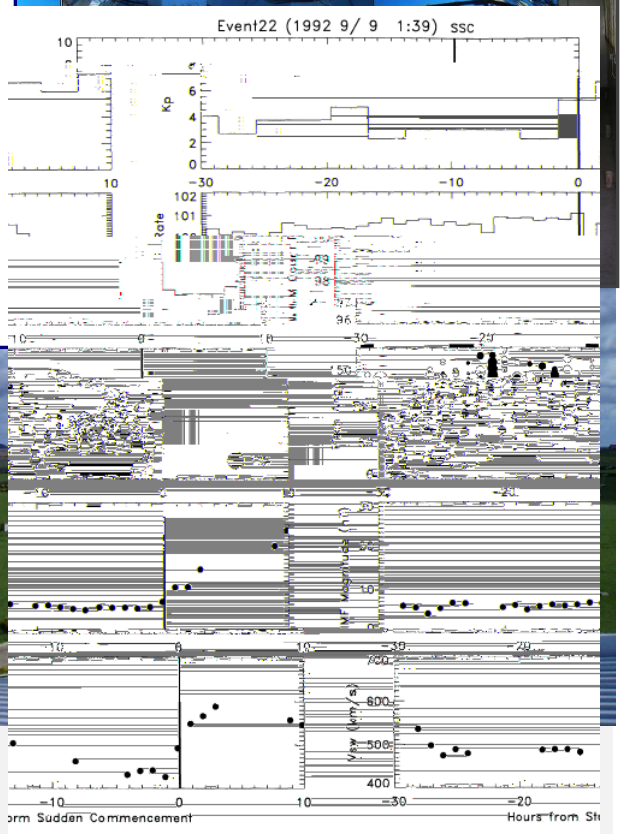
# COSMIC RAY MONITORING BY MUON DETECTOR TO PREDICT MAGNETIC STORM IN 6-8 HOURS





Munakata etal, JGR.2000

**São Martinho da Serra**
**Santa Maria** *(S29, W53)*

Magnetosphere
Instrument
Magnetormeter

Ionosphere&Earth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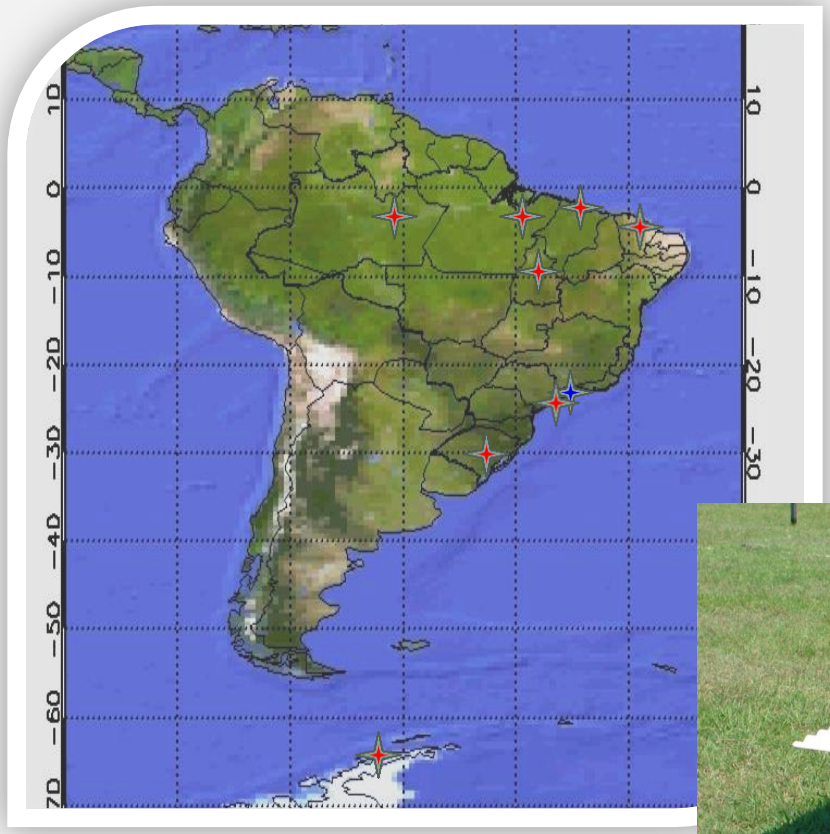
# MAGNETOMETERS NETWORK



- BLM ( 01°26'28" S, 48°26'40" W )
- MAN ( 02°54'52" S, 59°59'40" W )
- SLZ ( 02°35'36" S, 44°12'43" W )
- EUS ( 03°52'48" S, 38°25'28" W )
- PAL ( 10°17'50" S, 48°21'41" W )
- CXP ( 22°42'07" S, 45°00'52" W )
- SJC ( 23°12'38" S, 45°57'23" W )
- SMS ( 29°26'36" S, 53°49'22" W )
- FRZ ( 62°05'06" S, 58°24'12" W )

Ionosphere
Instrument
Ionosonde

Ionosphere&Earth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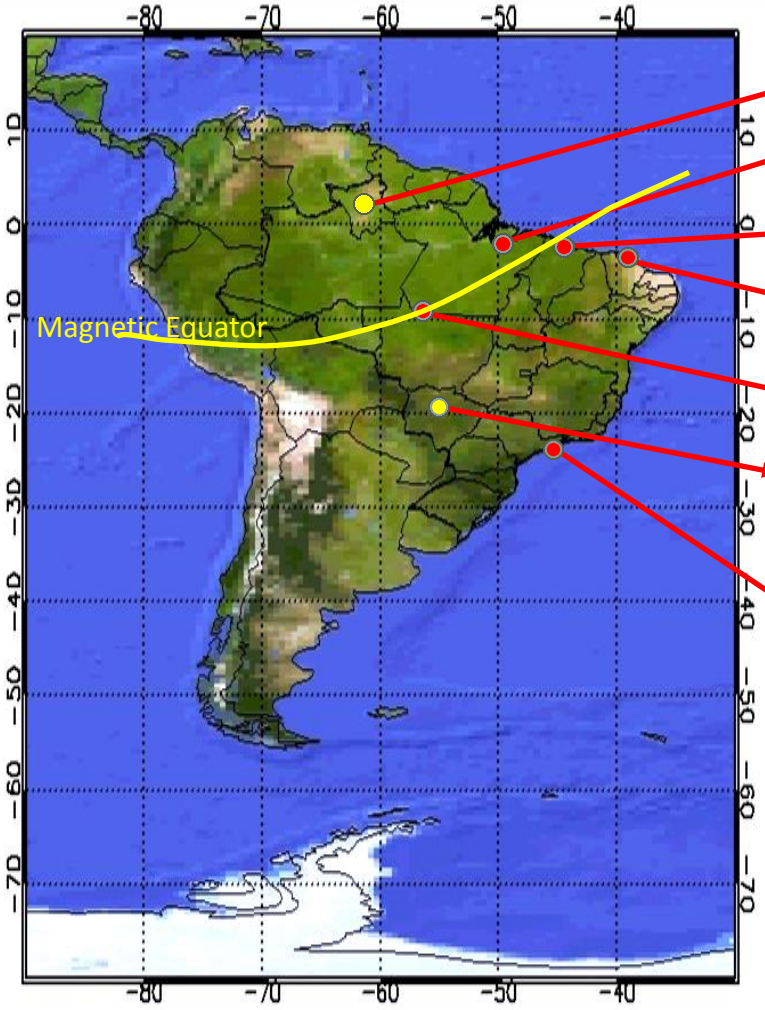
# IONOSONDES




- Boa Vista
- Belém
- São Luiz
- Fortaleza
- Alta Floresta
- Campo Grande
- Cachoeira Paulista

Installed & Working

To be installed

Ionosphere
Instrument
Ionosonde

Ionosphere&Earth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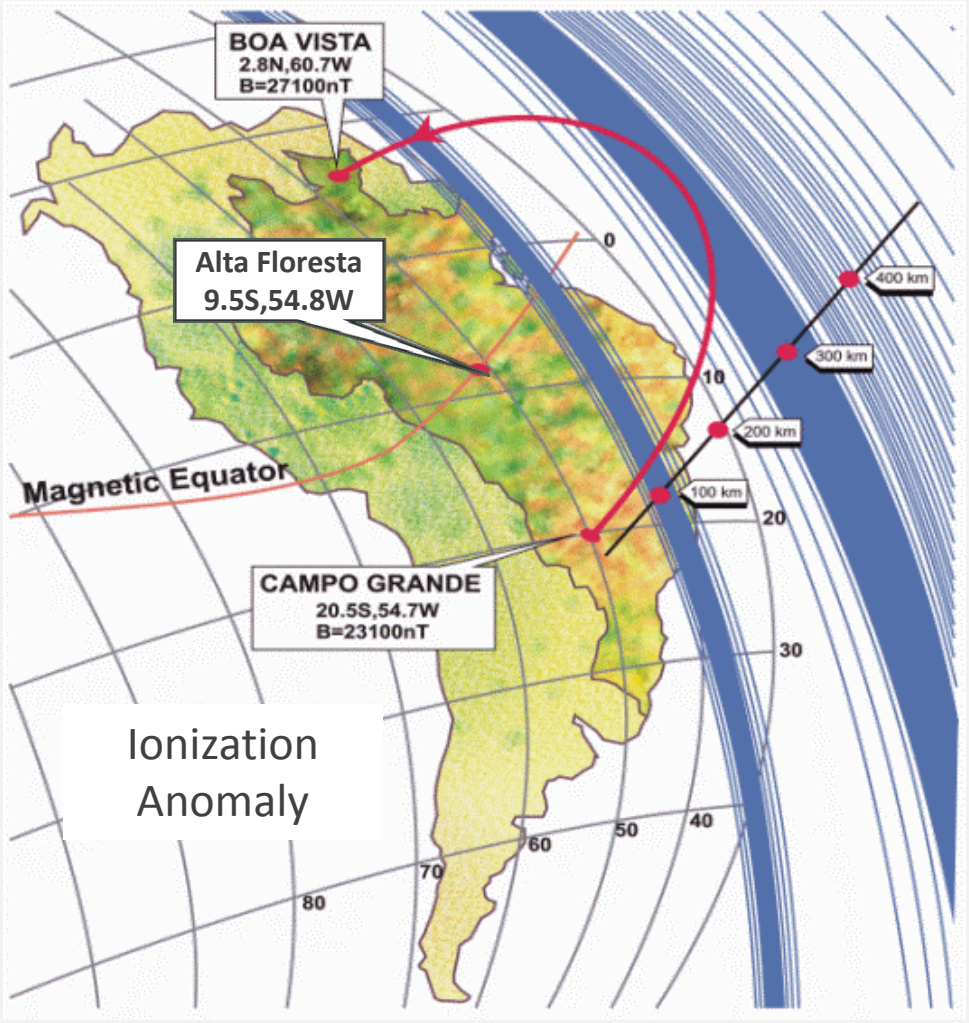
# CONJUGATE POINTS



Ionosphere Instrument GPS

Ionosphere&Earth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# GPS RECEIVERS FOR SCINTILLATION MONITORING




## LISN / NSF

Alta Floresta-MT
Belo Horizonte-MG
Boa Vista-RR
Brasília-DF
Cuiabá-MT
Dourados-MS
Ilhéus-BA
Imperatriz-MA
Natal-RN
Parintins-AM
Petrolina-PE
Porto Velho-RO
Rio Branco-AC
Santa Maria-RS
São Luís-MA
São José dos Campos-SP
Santarém-PA
Tefé-AM

## SCINTEC

Belem-PA
Belo Horizonte-MG
Boa Vista-RR
Brasilia-DF
Cachoeira Paulista-SP
Cuiabá-MT
Manaus-AM
Natal-RN
Palmas-PR
Presidente Prudente-SP
Santa Maria-RS
São João do Cariri-PB
São José dos Campos-SP
São Luís-MA
Tefé-AM

Ionosphere Instrument GPS

Ionosphere&Earth


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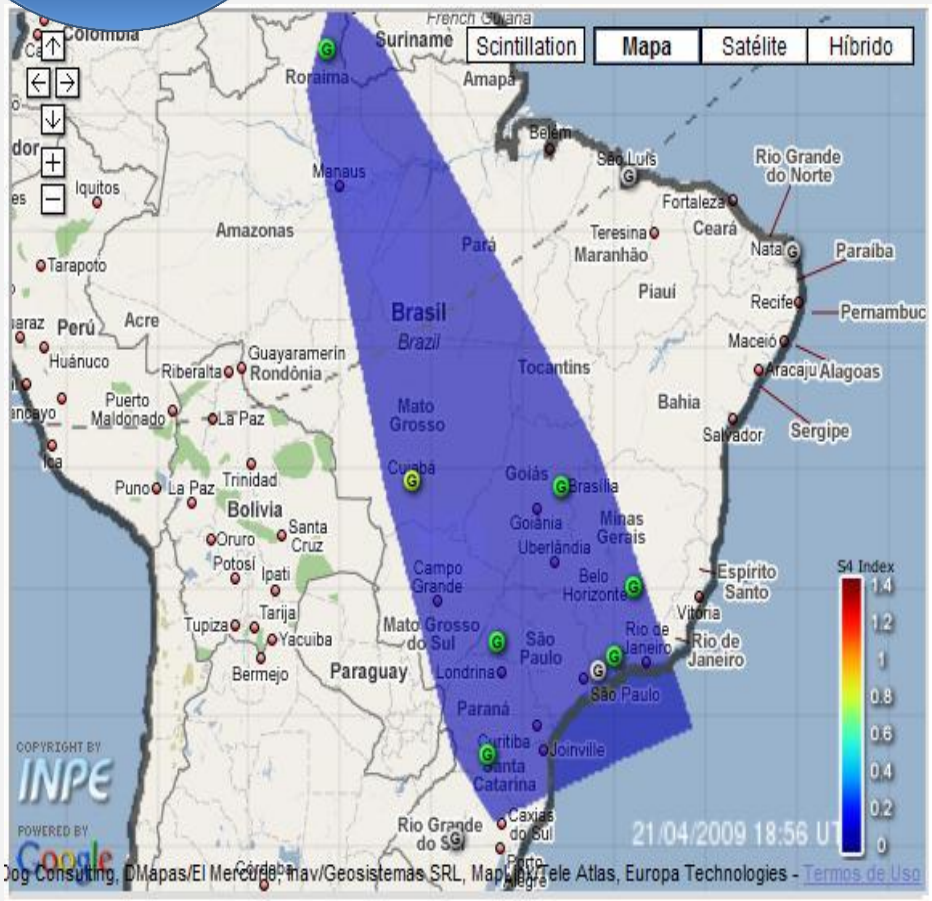
# S4 AND POSITIONING ERROR RANGES

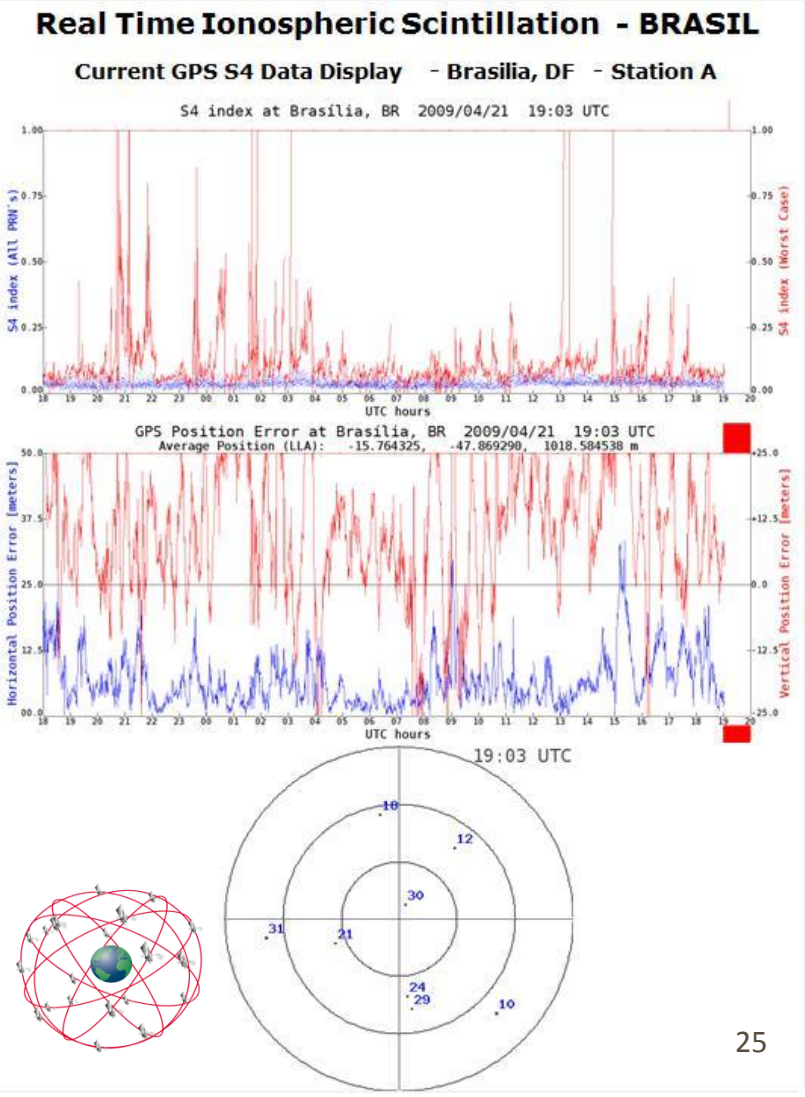



**Network Status: 64% | Scintillation Map: On**

Larger scintillation: 0.13 in the satellite 10 from Presidente Prudente, BR.

Put the mouse over the stations to get more informations or click to get scintillation plots, errors, azimuth and elevation angle.

| CAPTION | |
|---|---|
| Online | > 3min |
| > 1min | > 6min |
| | Offline |



Ionosphere Instrument GPS

Ionosphere&Earth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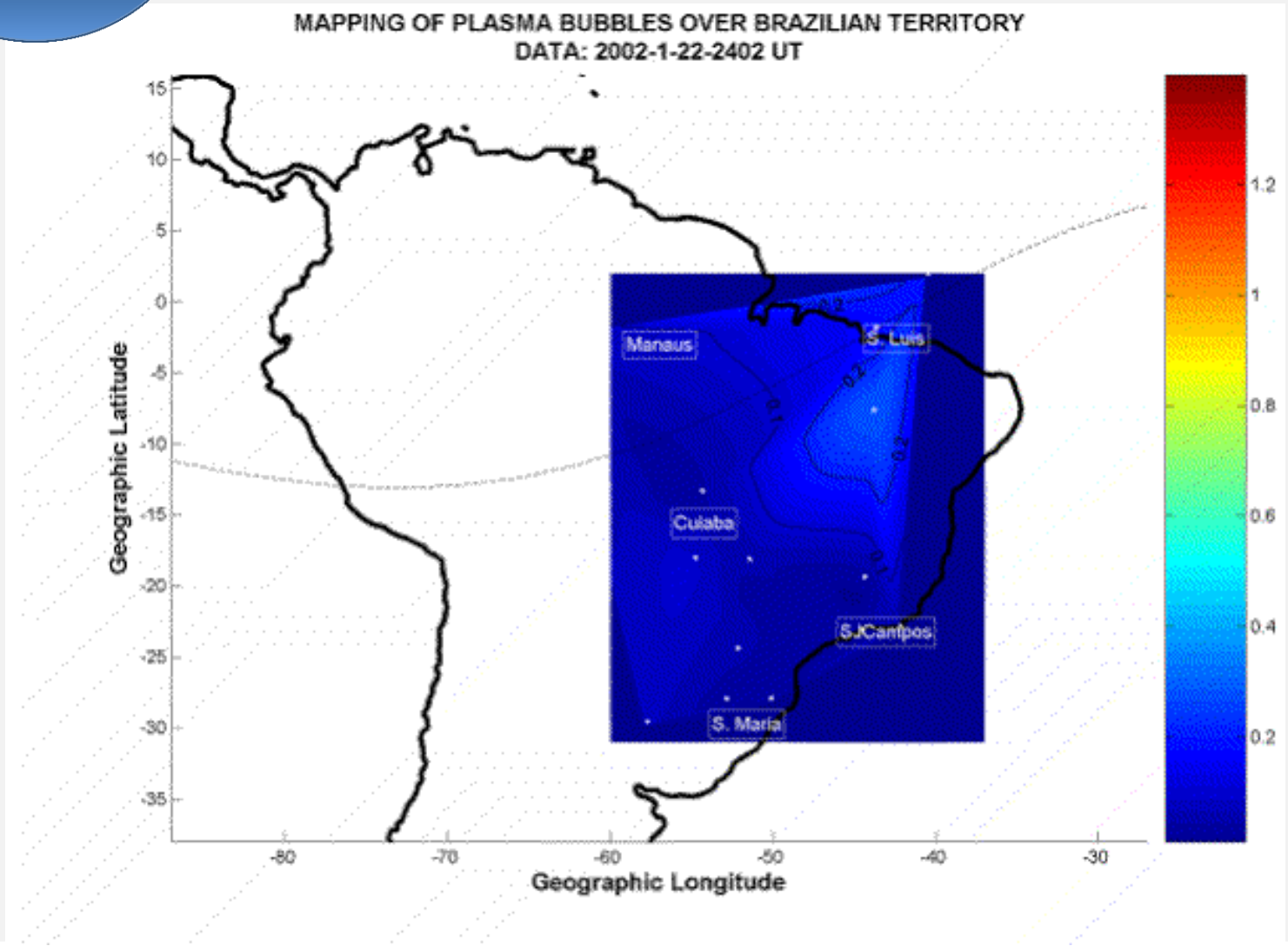
# IONOSPHERE SCINTILLATION MAP OVER BRAZIL



Ionosphere Instrument GPS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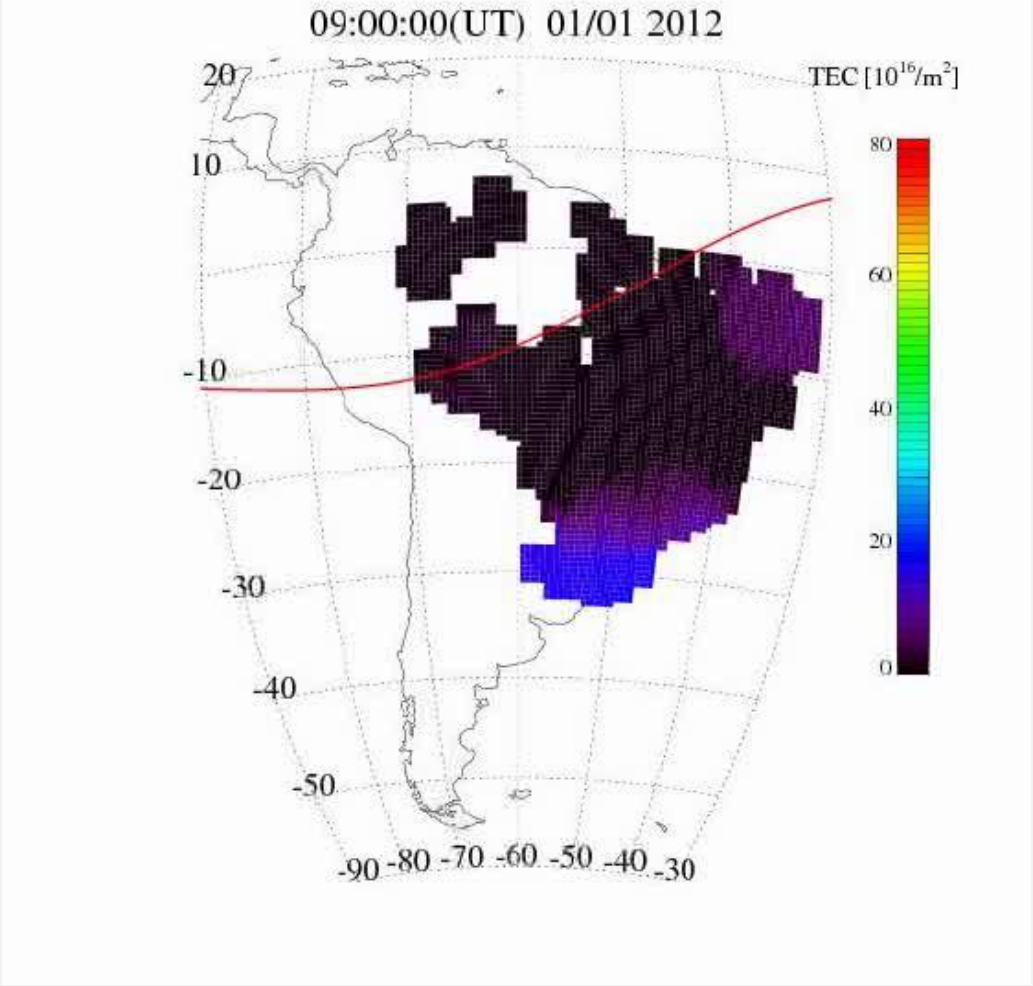
# GPSTEC MAPPING: 24 HOURS

## 2012 January 01, 9:00 – 02, 9:00 UT (24 hours)




IBGE RINEX data file
TEC Mapping code by STEL Nagoya University (Y. Otsuka)

Sheffield Ionosphere Model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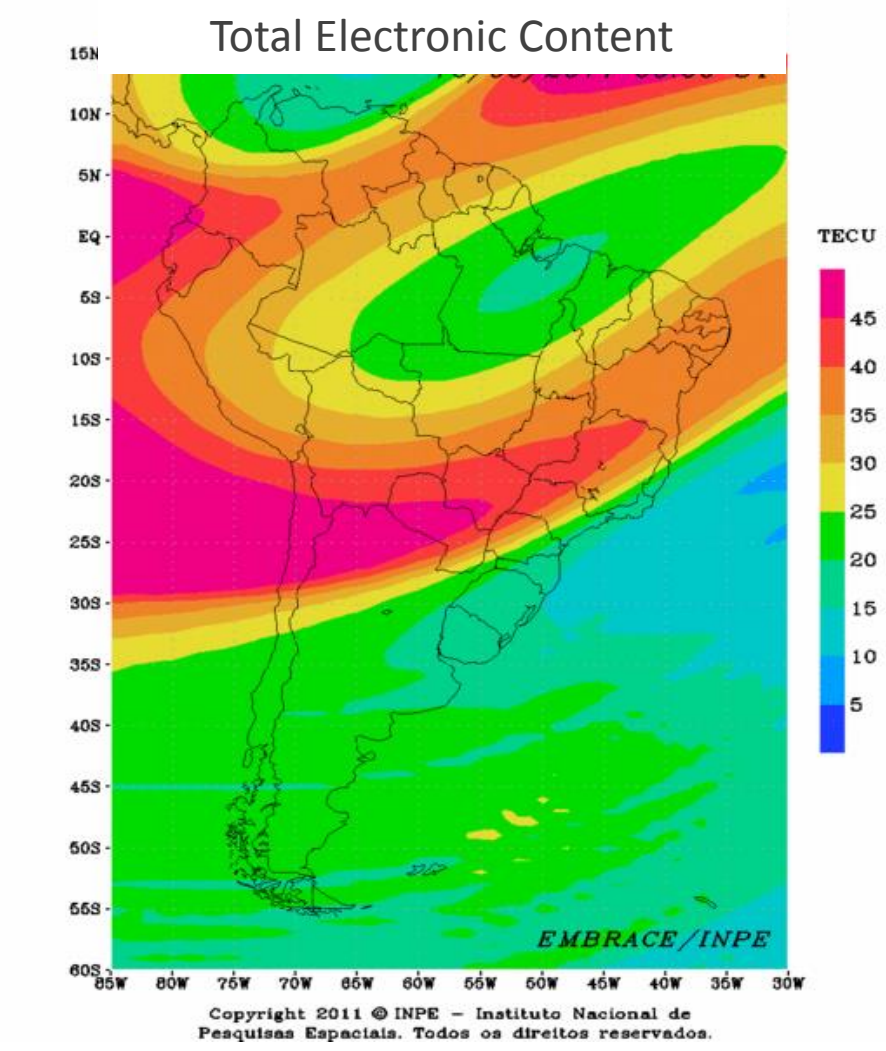
# SUPIM – IONOSPHERE MODEL




**This simulation were obtained from the SUPIM (Sheffield University Plasmasphere Ionosphere Model), a co-development of the Aeronomy Division of the CEA/INPE with the University of Sheffield and with the computational improvements by the Computer Lab for Space Weather at the SSO/INPE and by the Computer Lab for Mathematical and Science at the ETE/INPE.**

Sheffield Ionosphere Model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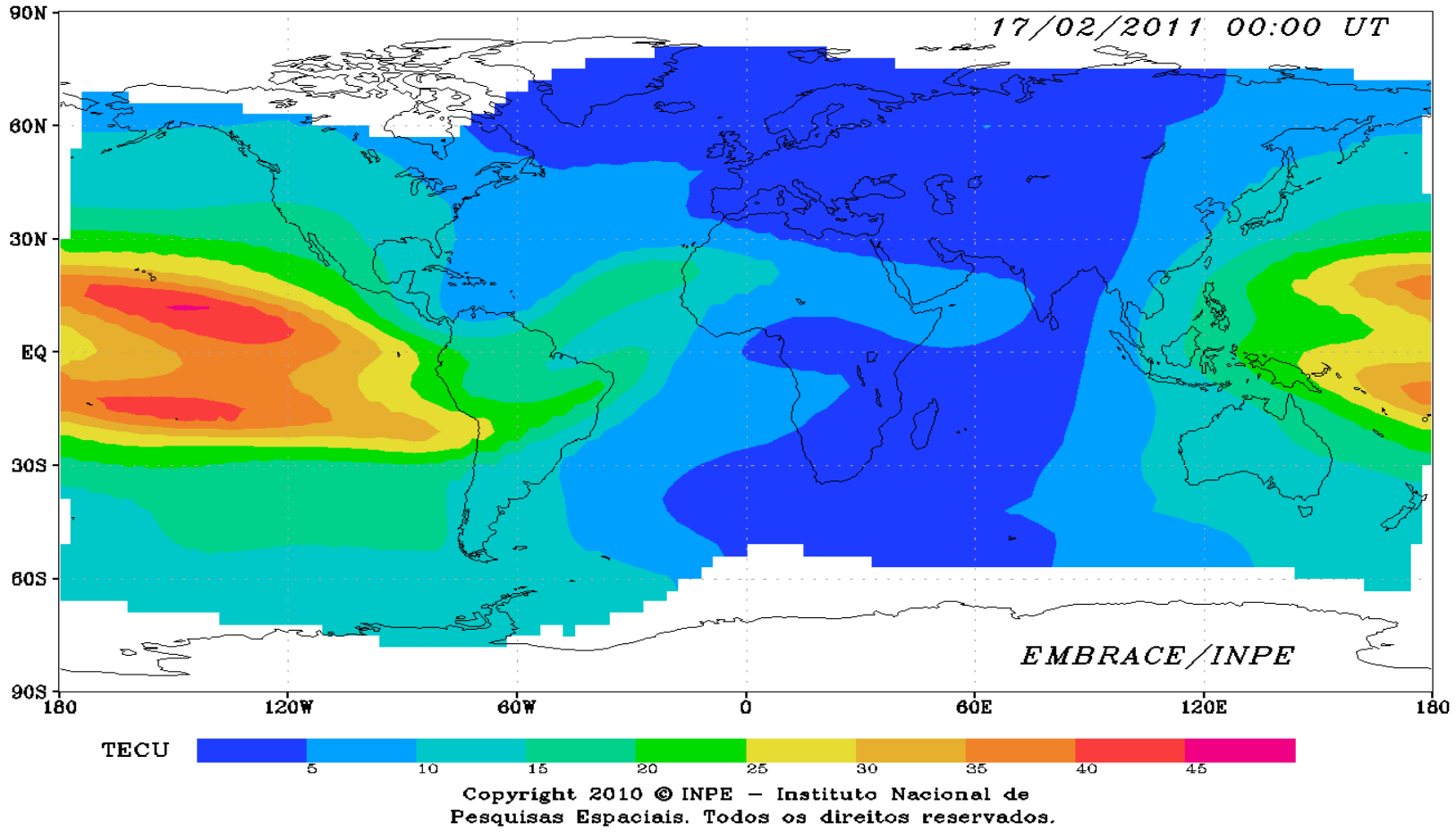
# GLOBAL MODEL

TOTAL ELECTRON CONTENT



Sheffield Ionosphere Model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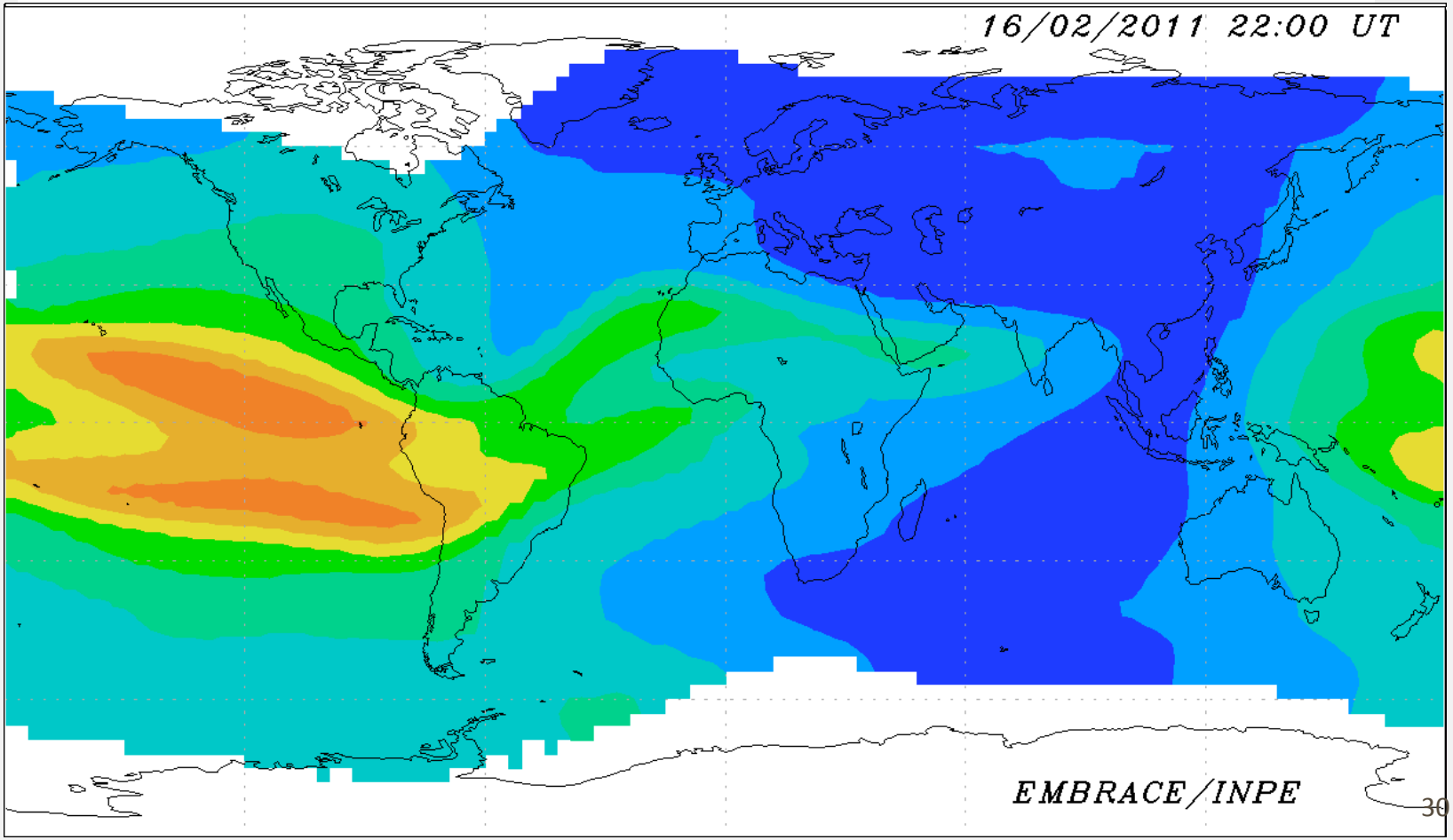
# COMPARING MODELS

TOTAL ELECTRON CONTENT



GIC Instrument FURNAS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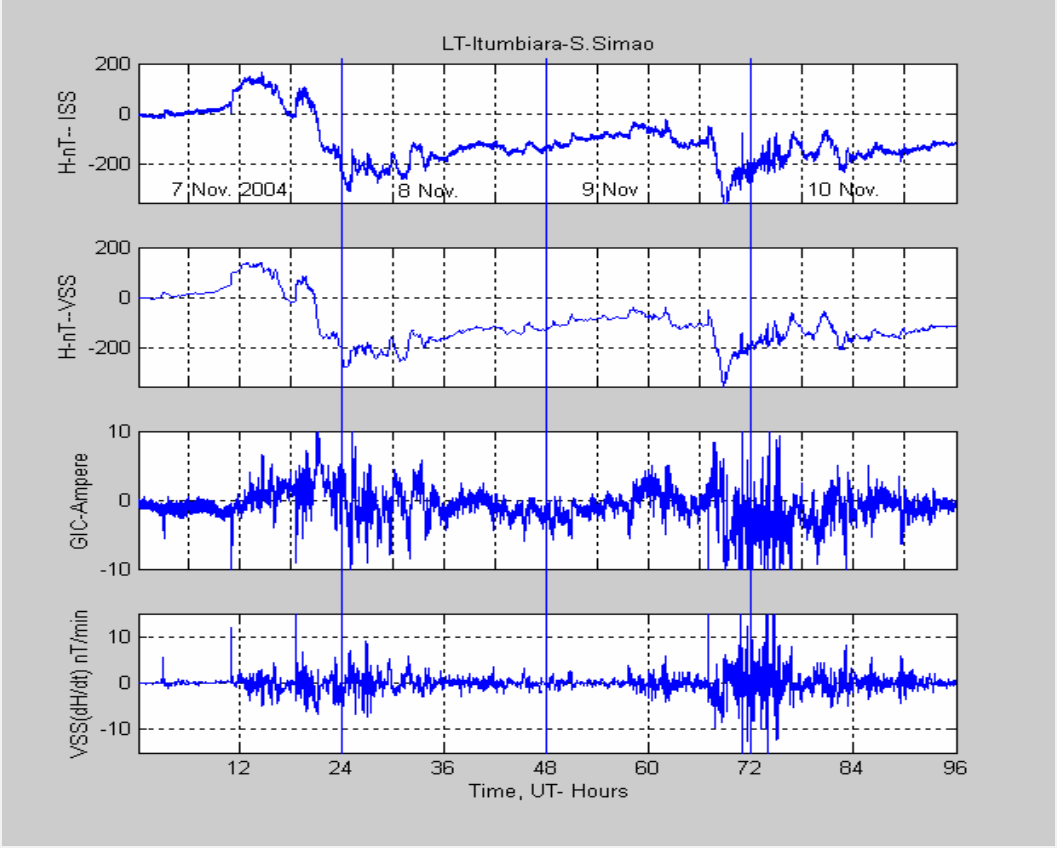
# GIC DETECTED IN FURNAS DURING THE GEOMAGNETIC STORM:




- Magnetic variations under the power line similar to the nearest Observatory in Vassouras (RJ)
- GIC measured correlated to the derivative dB/dt em Vassouras (RJ)

**EMBRACE Building**
**CODE:Operation Center Demísio Simões**

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# INAUGURATION YEAR


**www.inpe.br/spaceweather**

EMBRACE in WMO

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# WMO SPACE WEATHER WEB SITE

From Brazilian Space weather information and prediction center to WMO Space weather center: GPSTEC map and scintilation map over Brazil.

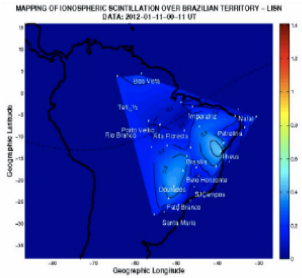
1. Ionospheric total electron content over Brazil: http://www.inpe.br/climaespacial/wmo/iTec.php

2. Ionospheric scintillation map over Brazil: http://www.inpe.br/climaespacial/wmo/iLisn.php

**INPE EMBRACE Space Weather Information and Prediction Center**

**Ionospheric Scintillation S4 Index Products**

**Scintillation S4 Index over Brazil**




**Product Desciption:**

GNSS signal scintillation monitored by ground-based receivers (LISN network). The map displays location of the receivers, near realtime S4 index. The movie shows 2-D plot of ionospheric scintillation during the evening to night time period of the previous day, represented by the S4 index, that impact telecommunication systems and GNSS signal availability.

**Target Users:**

Key product users include industries relying on high-accuracy GNSS positioning: surface and air navigation systems, agriculture, surveying, construction, drilling, and scientific users

Link to Map of Scintillation S4 Index over Brazil
Link to Video of Scintillation S4 Index over Brazil

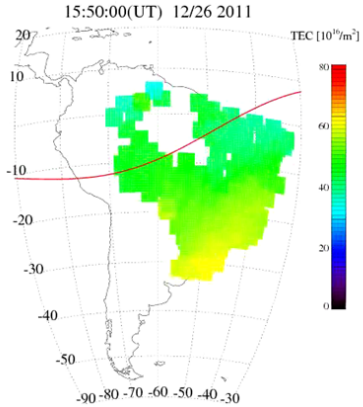
**Cadence**: 10 min.

**Data Source**: Ground-based GPS receivers

**INPE EMBRACE Space Weather Information and Prediction Center**

**Ionospheric Total Electron Content Products**

**Total Electron Content over Brazil**




**Product Desciption:**

This ionospheric product provides a measurement of the ionospheric total electron content (TEC) over Brazil. It is designed to estimate the signal delay for single and dual frequency GNSS applications. The map over South America displays TEC in color shade. The movie shows temporal variation of TEC from 00:00 UT to 24:00 UT of the previous day with the time interval of 10 minutes.It was produced under collaboration of STEL (Nagoya University), Kyoto University, NICT, Japan, and IBGE, Brazil.

**Target Users:**

Key product users include industries relying on high-accuracy GNSS positioning: agriculture, surveying, construction, drilling, and scientific users.

Link to Video of Total Electron Content over Brazil

Public Outreach

WORKSHOP DO PROGRAMA DE CLIMA ESPACIAL DO INPE COM USUÁRIOS

Auditório Fernando de Mendonça - INPE, 20 de outubro de 2011

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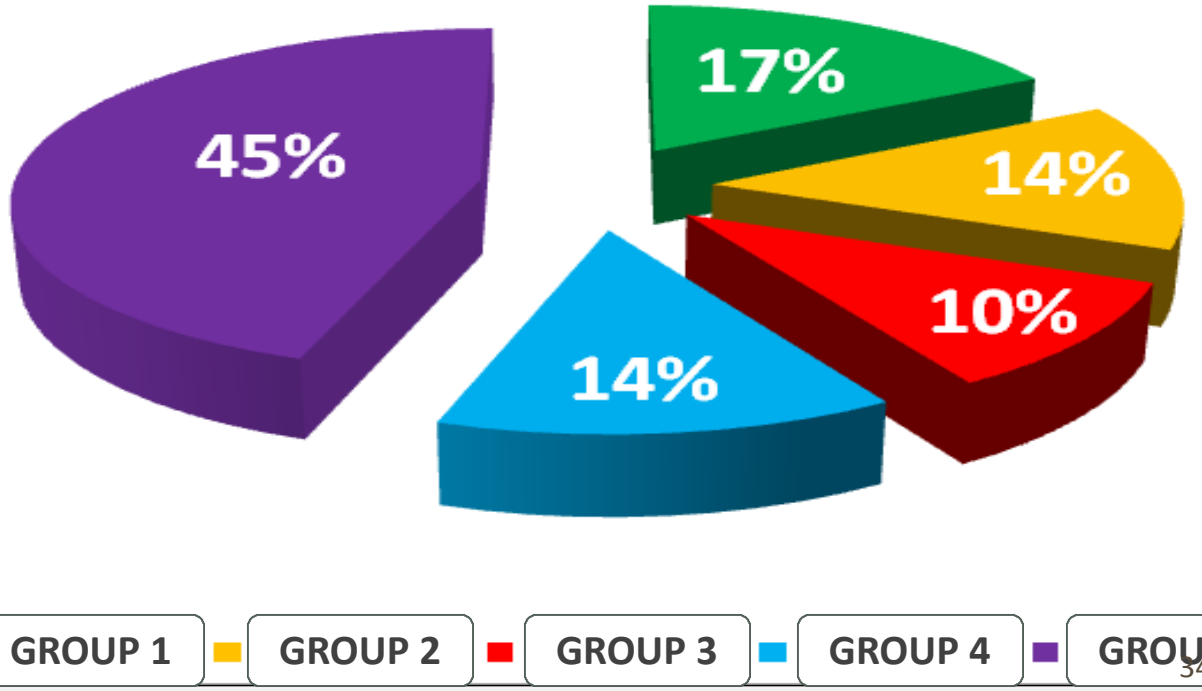
# EMBRACE WORKSHOP PARTICIPANTS

| GROUP | AREA/ENTERPRISE |
|---|---|
| Group 1 | GNSS USERS |
| Group 2 | TELECOMMUNICATIONS |
| Group 3 | SURFACE TECHNOLOGY |
| Group 4 | SATELLITE OPERATIONS |
| Group 5 | SCIENCE |



Public Outreach

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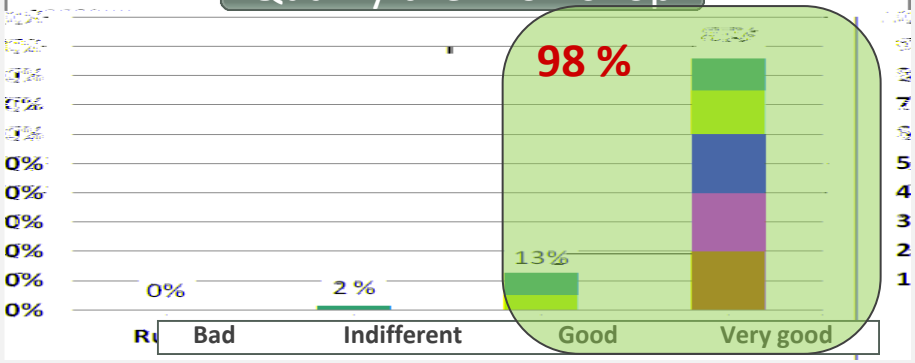
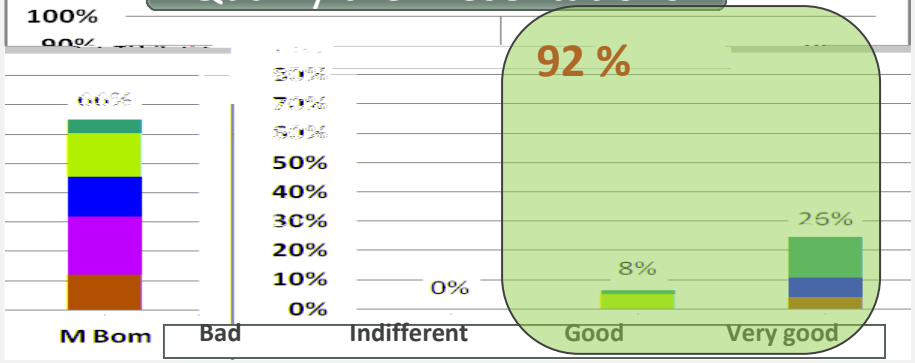
# WORKSHOP ANALYSIS

Courtesy:
Dr. Clezio DeNardin

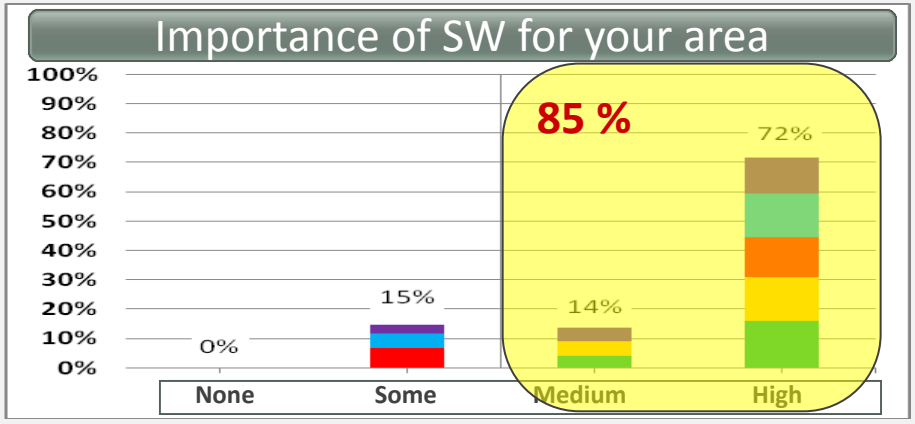
## Qualify the Workshop



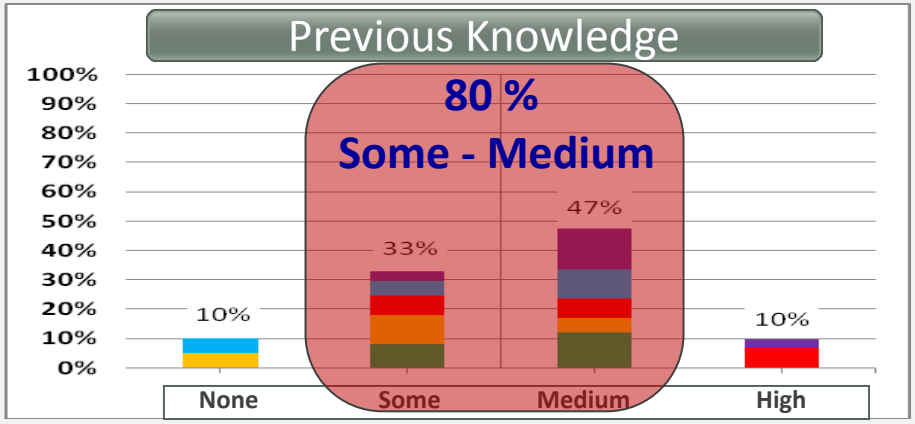

## Qualify the Presentations




## Importance of SW for your area




## Previous Knowledge



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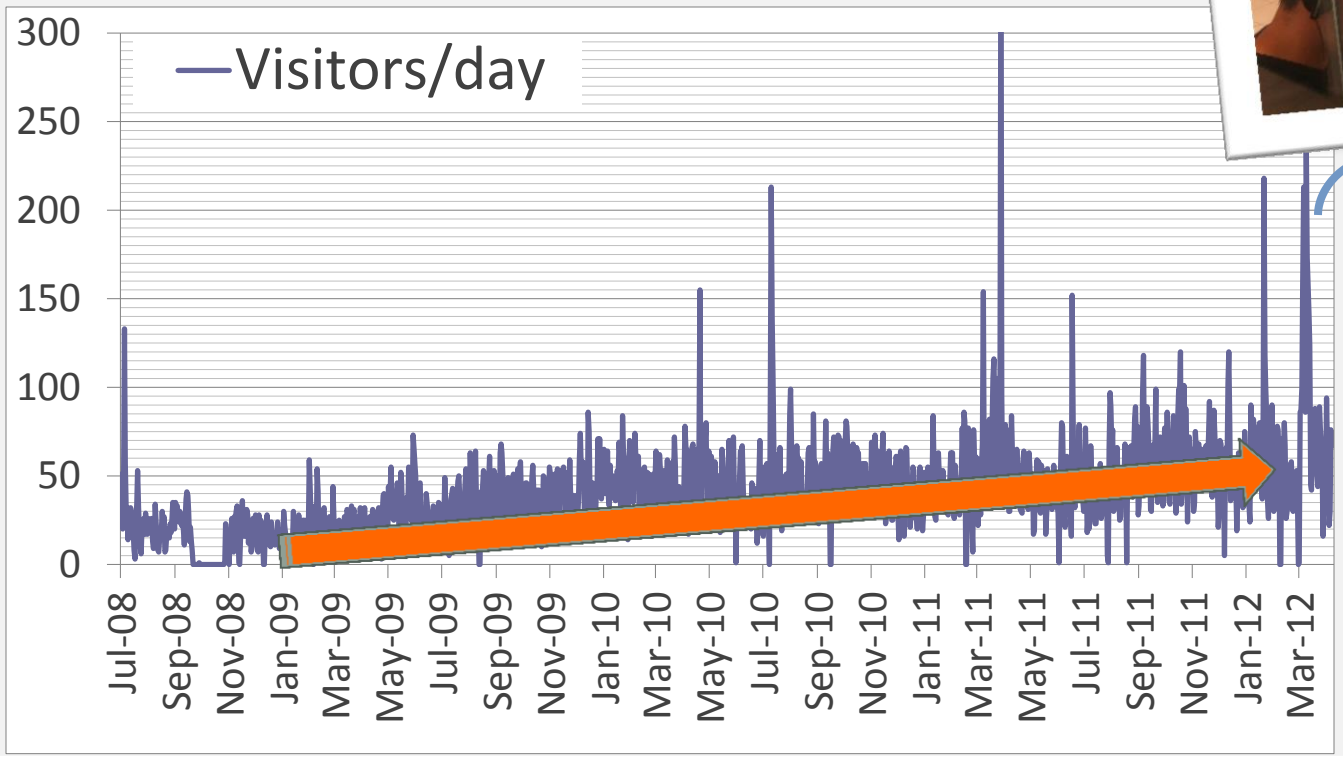
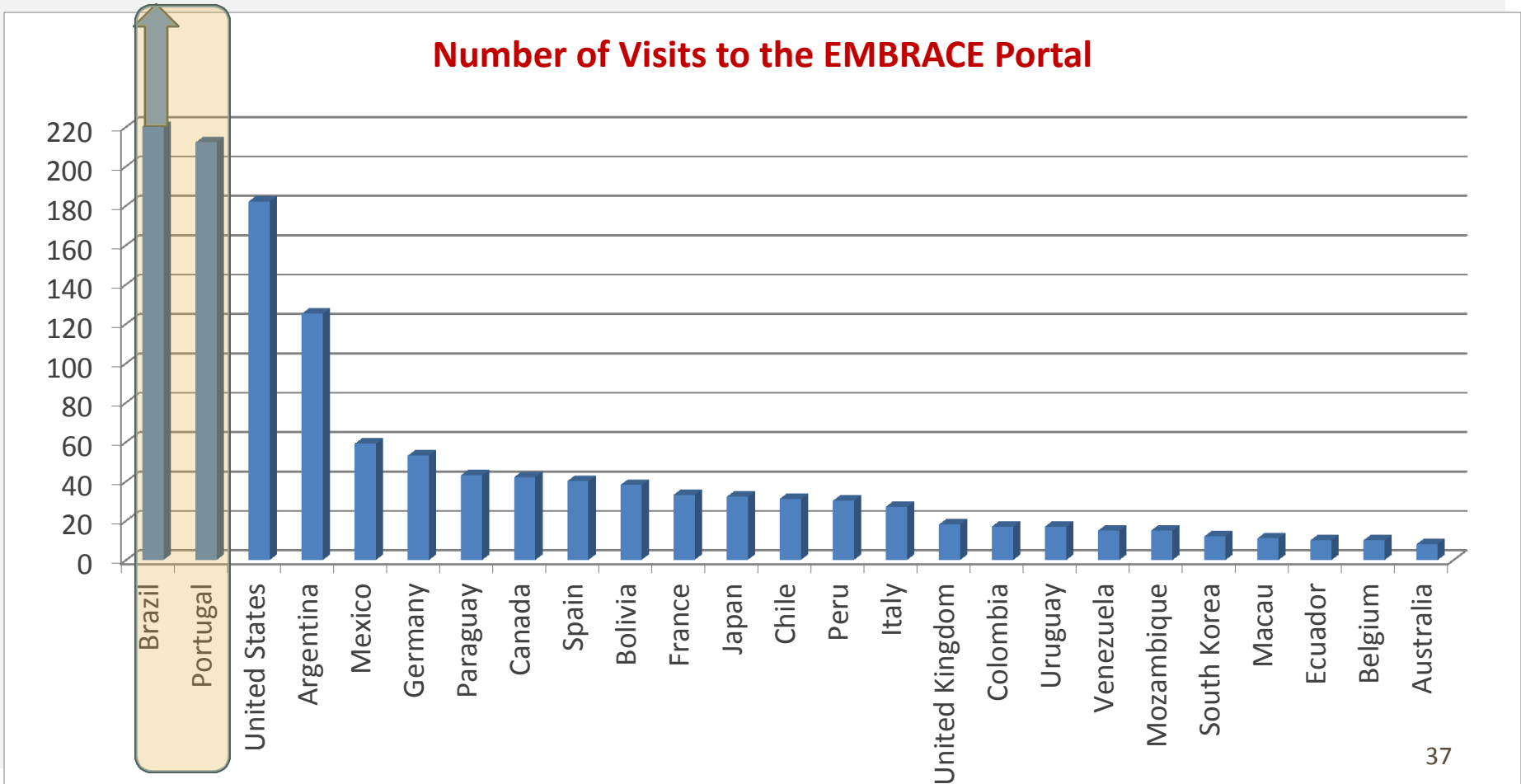
# EMBRACE'S VISIBILITY



Public Outreach

# EMBRACE'S VISIBILITY BY COUNTRIES

18,143



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# CONTACT US – THANK YOU

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