



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA  
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS



# The contribution of the EMBRACE Brazilian Space Weather Monitoring Program to GNSS services

**Presenter:**

**André João Rypl**

**Head of the International Cooperation Office  
Brazilian Space Agency – AEB ([www.aeb.gov.br](http://www.aeb.gov.br))  
[andre.rypl@aeb.gov.br](mailto:andre.rypl@aeb.gov.br)**



- **Overview**
  - **Website information**
  - **Examples of reports**
    - **Android app**
  - **Other GNSS-related initiatives**
-



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



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA  
**AGÊNCIA ESPACIAL BRASILEIRA**



**PROGRAMA DE  
ESTUDO E  
MONITORAMENTO  
BRASILEIRO DO  
CLIMA  
ESPACIAL**



**(Brazilian Space Weather  
Survey and Monitoring  
Program)**



**Program was set up in 2007, operational in 2008**

**AIMS:**

- **Monitor and model space weather phenomena**
- **Raise awareness of space weather effects**
- **Provide real-time information / forecasts**
- **Anticipate and estimate space weather impacts on space- and land-based systems**
  
- **EMBRACE operates as a Regional Warning and Alert Center for Space Weather**
- **Member of International Space Environment Services (ISES)**



## **SOLUTIONS FOR**

- **GNSS systems**
  - **Precision agriculture**
  - **Flight safety / flight control**
  - **Oil rigs**
- **Defence**
- **Communications / broadcast systems**
- **Power grids / distribution systems**
- **Oil and natural gas pipelines**
- **Satellites**



## www.inpe.br

## www.inpe.br/climaespacial

Página Principal do INPE

http://www.inpe.br/ingles/index.php

Ministério da Ciência e Tecnologia

Search

**Space Weather**

News items:

- 15/04/2010 - Brazil and China set up policy for space data distribution
- 14/04/2010 - INPE's new supercomputer expands to 50 times the processing capacity
- 08/04/2010 - DETER confirms 208,2 km2 of deforestation in the Amazon state in the first two months

BRASIL Acesso à informação

Participe Serviços Legislação Canais

**EMBRACE**  
ESTUDO E MONITORAMENTO BRASILEIRO DO CLIMA ESPACIAL  
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Início Embrace Produtos Boletim Índices e Dados Workshops Glossário Contato

Último do dia: R0 G0 S0

Máximo do dia: R0 G0 S0

Último ocorrido: R1 G1 S0

A maior mancha solar dos últimos anos  
Responsável: Mc. Márcia Cuedes O início da semana do dia...

Fluxo de Raios-X

Fluxo Raios-X (GOES-15)  
Dados de 1 minuto - (18/11/2014)

Índice Ksa

Rede EMBRACE de Magnetômetros  
Índice Ksa - (18/11/2014)

O Sol (últimas 24h)



BRAZIL Information access Participate Services Legislation Information channels

Public Scientists Educators Media

## EMBRACE

ESTUDO E MONITORAMENTO BRASILEIRO DO CLIMA ESPACIAL  
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Home Embrace Products Bulletin Indices and Data Workshops Glossary Data Contact

Day's last			Day's max			Latest event		
GOES	MAG	UNAVAIABLE	GOES	MAG	UNAVAIABLE	GOES	MAG	UNAVAIABLE
NONE	R0	NONE	NONE	G0	NONE	R2	G1	S0

Furnas System for electricity and Cigré Brazil hosted the Workshop on the Geomagnetic Induced Currents effects on the Power Network

On April 05, 2016 the city of Rio de Janeiro hosted at the Furnas Hall, the Workshop on GIC to...

X-Ray Flux X-Ray Flux (GOES-14)

Ksa Index EMBRACE Magnetometers Network

Search

Daily Sun

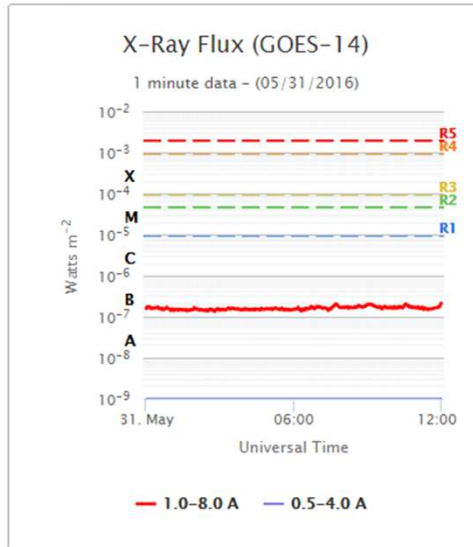


# Website

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



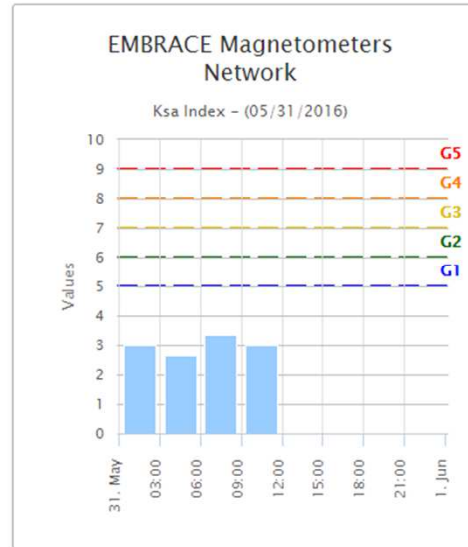
## X-Ray Flux



MINUTE 142th BRIEFING:  
 15/06/2015, 14H30



## Ksa Index



Information about the interruption of the Embrace / INPE web site services since last Sunday ( May, 17 )



Search

Daily Sun

Courtesy of NASA/SDO and the AIA, EVE, and HMI science teams. [More details.](#)

Bulletin

Sun

Posted in: 30/05/2016

There exist two active regions (NOAA 2548 and 2549) in the visible disk of the Sun. They are located near to the coordinates N14W78 and S14E03. The ac ... [Continue...](#)

Interplanetary Medium

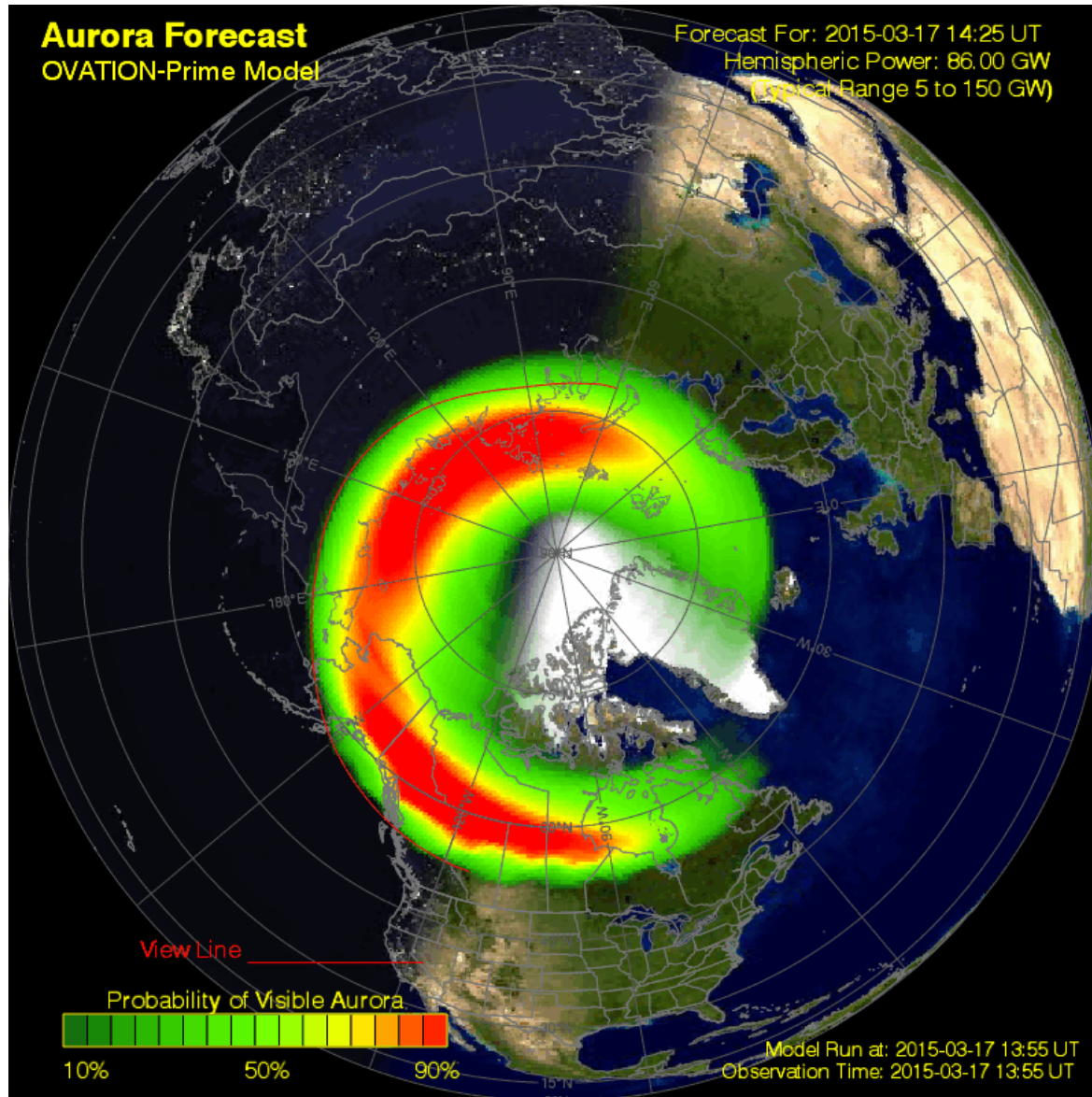
Posted in: 30/05/2016

After being disturbed between days 27 ad 29, the interplanetary medium has been calm on the last





# Storm on March 17 2015



**@ 11:14 AM BLT**

A G4 (Severe) geomagnetic storm was observed today at 07/1358 UTC (09:58 EDT). This is the response to a pair of CMEs leaving the Sun on 15 March.



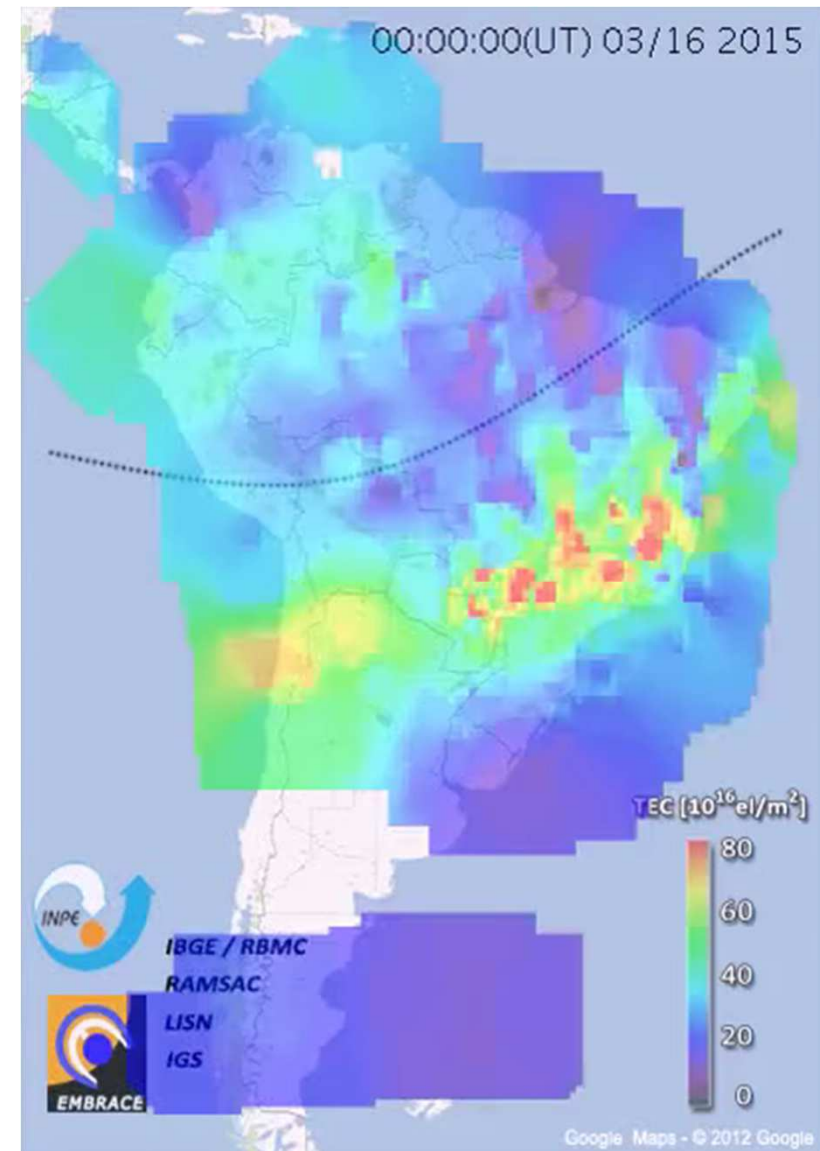
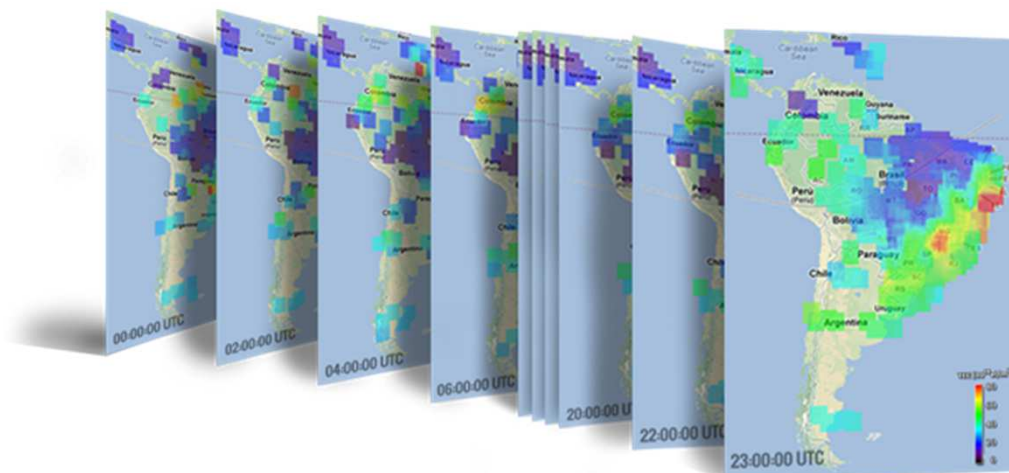
**@ 01:09 PM BLT**

The Embrace/INPE monitoring system detected a G3 level Magnetic Storm using the South American disturbance index Ksa.



## Total electron Content 16-18 March 2015

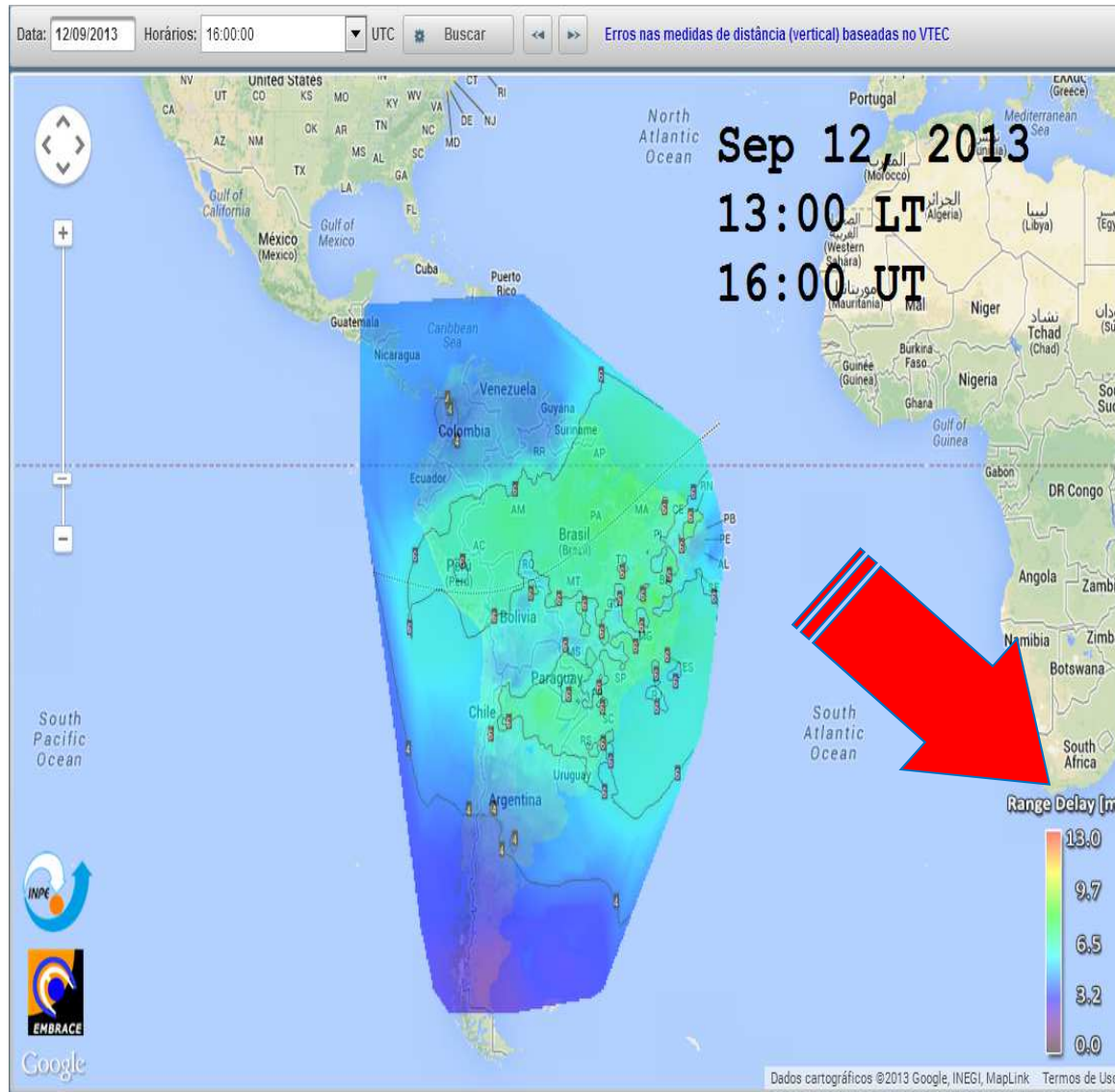
The TEC map is generated at Embrace/INPE every 10 minutes using GNSS signals received from more than 150 receptors over the whole of South America, specially those belonging to the following networks: RBMC-IBGE, RAMSAC, LISN, and IGS.





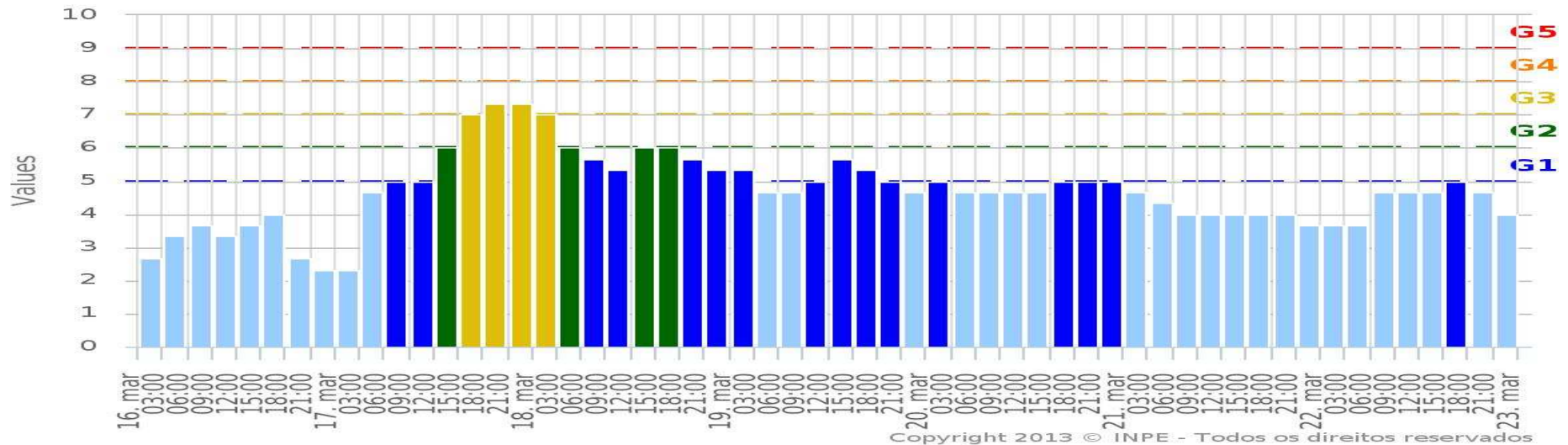


# TEC Map Error Map



## Rede EMBRACE de Magnetômetros

Índice Ksa - (16/03/2015 - 22/03/2015)



### G3 (Forte) - 7+



Evento ocorrido no período: 17/03/2015 18:00:00 a 17/03/2015 21:00:00

Efeito: Sistema elétrico: correções de voltagens podem ser necessárias, alarmes falsos iniciando algum equipamento de proteção. Operação de satélite: sobrecarga estática de superfície nos componentes podem ocorrer, pode ocorrer aumento do arrasto sobre os de baixa órbita, e correções podem ser necessárias para os problemas de orientação. Outros sistemas: podem ocorrer problemas intermitentes na navegação do satélite e navegação em baixa-frequência, comunicação em rádio HF pode ficar intermitente.

Medida: Ksa = 7

Frequência Amostral: 200 por ciclo (130 dias por ciclo)



The screenshot shows the EMBRACE website interface. At the top, it says 'Ministério da Ciência e Tecnologia' and 'EMBRACE Estudo e Monitoramento Brasileiro do Clima Espacial'. The navigation menu includes 'Página Inicial', 'CEA', 'IRPE', 'BOLETIM', and 'WORKSHOP'. The main content area is titled 'MONITORAMENTO EM TEMPO REAL' and features a 'Sol' image. Below this is 'IMAGENS DA ATIVIDADE SOLAR' with four panels labeled 'EIT 171', 'EIT 195', 'EIT 284', and 'EIT 284' showing different solar images. A 'Fonte: ESA e Nasa' link is provided. The 'INDICADOR DE ATIVIDADE SOLAR' section shows a line graph of the Solar Index (SI) from 1989-09-26 to 2009-09-26. The graph shows a significant increase in activity starting around 2000. At the bottom, there are sections for 'Meio Interplanetário', 'Campo Magnético', and 'Terra'. The footer contains copyright information for INPE.

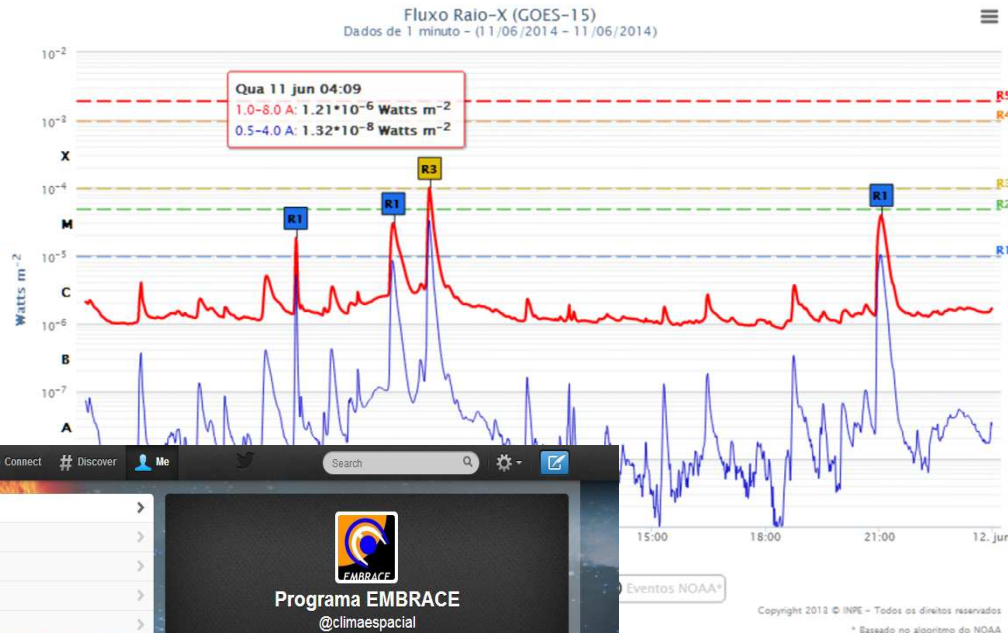
Solar Images

Solar Index





# Solar activity alerts



**@climaespacial**



## CLASS\_X

Clezio Marcos De Nardin,

O sistema de monitoramento do EMBRACE detectou um evento CLASS\_X através do instrumento GOES.

The monitoring system EMBRACE detected an CLASS\_X event through the instrument GOES.

### ALERTA RAIÓ-X GOES

**R3**

O sistema de detecção de eventos EMBRACE verificou a existência de flare classe X com nível de severidade R3 ocorrido em 11-06-2014 às 09:06:00 UTC.

Efeito de Severidade R3:  
HF Radio: Grande área de blackout em comunicação em rádio HF, perda de rádio contatos por aproximadamente uma hora na região iluminada.  
Navegação: Navegação em baixa frequência degradada por aproximadamente uma hora.

### X-RAY GOES ALERT

**R3**

The event detection system EMBRACE verified the existence of flare class X with severity level R3 occurred in 06-11-2014 at 09:06:00 UTC.

Effect Severity R3  
HF Radio: Large area blackout in HF radio communication, loss of radio contact for about an hour in the illuminated region.  
Navigation: Navigation in low frequency degraded for about an hour.

Esta é uma mensagem automática. Por favor não responda este email. Se precisar contatar-nos envie email para [contato.embrace@inpe.br](mailto:contato.embrace@inpe.br). This is an automated message. Please do not reply to this email. If you need to contact us please send email to [contato.embrace@inpe.br](mailto:contato.embrace@inpe.br).



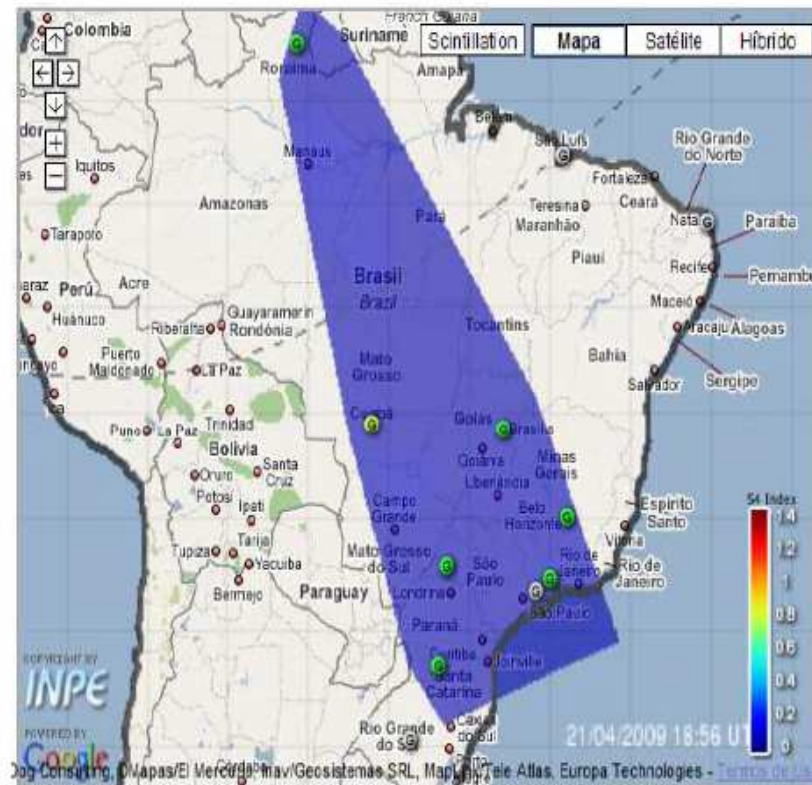
Visite nossa página no Facebook.  
Visit our page on Facebook.



Siga o EMBRACE no Twitter.  
Follow EMBRACE on Twitter.



# GPS Error – Ionospheric Scintillation

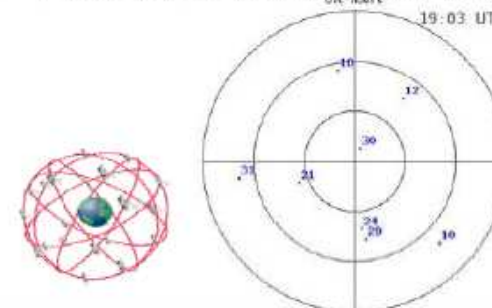
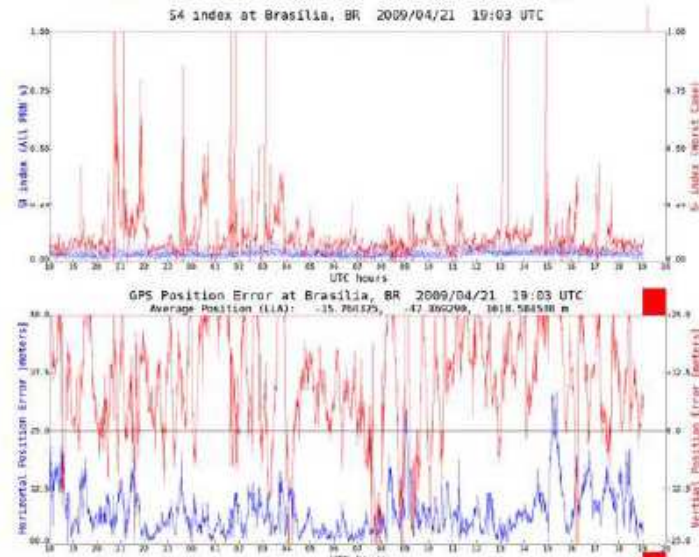


**Network Status: 64%** | **Scintillation Map: On**  
 Larger scintillation: 0.13 in the satellite 10 from Presidente Prudente, BR.  
 Put the mouse over the stations to get more informations or click to get scintillation plots, errors, azimuth and elevation angle.

CAPTION	Symbol	Meaning
> 3min	Orange circle	Scintillation duration
Online	Green circle	Station status
> 6min	Red circle	Scintillation duration
> 1min	Yellow circle	Scintillation duration
Offline	Grey circle	Station status

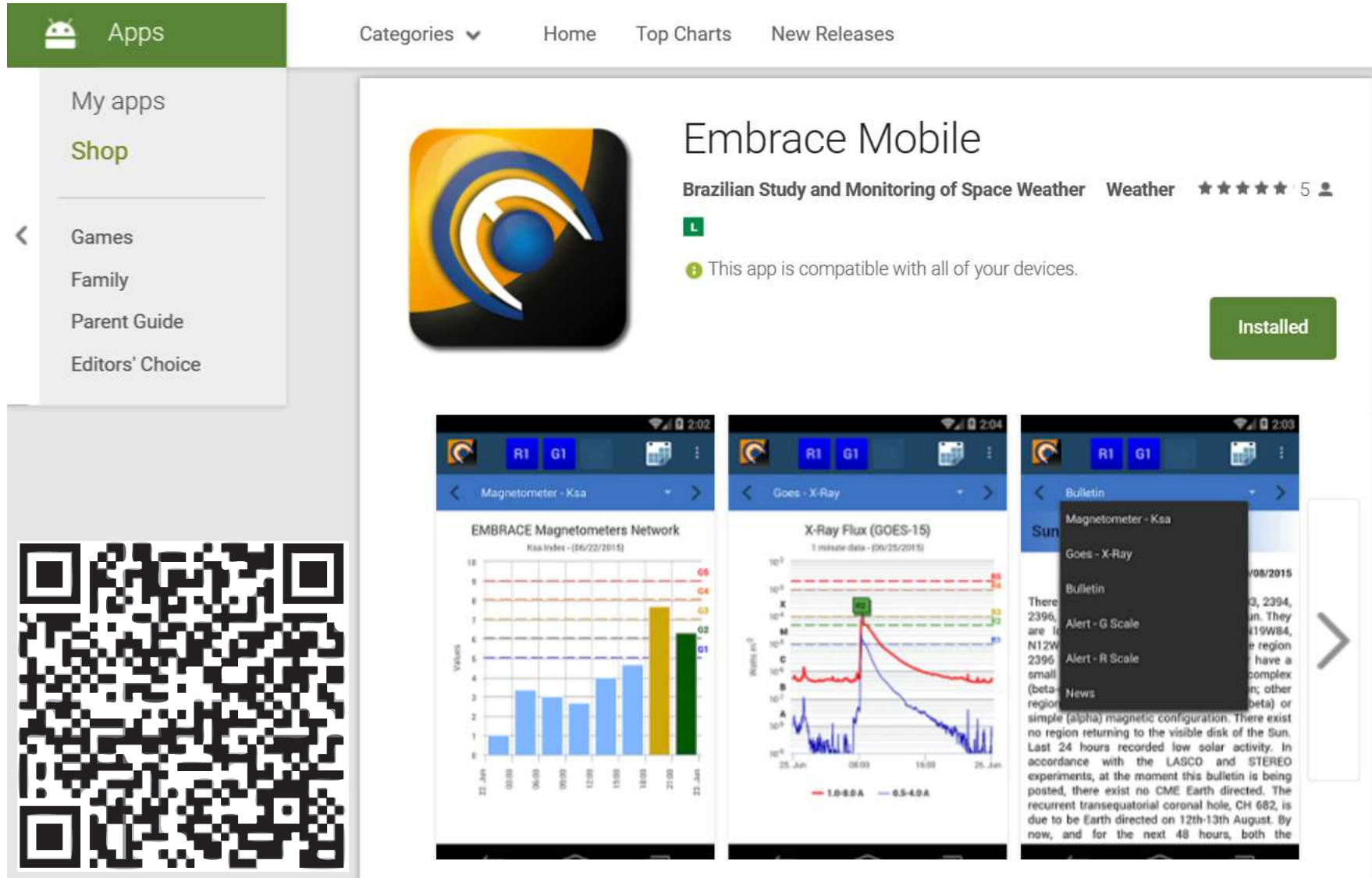
## Real Time Ionospheric Scintillation - BRASIL

### Current GPS S4 Data Display - Brasilia, DF - Station A



# Android App

<https://play.google.com/store/apps/details?id=br.inpe.climaespacial.mobile>



The screenshot shows the Google Play Store page for the 'Embrace Mobile' app. The app is categorized as 'Weather' and has a 5-star rating from 5 users. It is marked as 'Installed'. The app icon features a stylized blue and yellow eye-like shape. Below the app title, there are three preview images showing the app's interface:

- Magnetometer - Ksa:** A bar chart titled 'EMBRACE Magnetometers Network' showing Ksa Index values from 22-Jan to 23-Jan. The y-axis is labeled 'Values' and ranges from 0 to 18. Horizontal dashed lines indicate alert levels: G5 (red), G4 (orange), G3 (yellow), G2 (green), and G1 (blue).
- Goes - X-Ray:** A line graph titled 'X-Ray Flux (GOES-15)' showing 1-minute data from 25-Jan to 26-Jan. The y-axis is labeled 'Watts m<sup>-2</sup>' on a logarithmic scale from 10<sup>-8</sup> to 10<sup>0</sup>. It shows two data series: 1.0-8.0 A (red) and 0.5-4.0 A (blue).
- Bulletin:** A text-based bulletin screen with a menu overlay. The menu items include: Magnetometer - Ksa, Goes - X-Ray, Bulletin, Alert - G Scale, Alert - R Scale, and News.

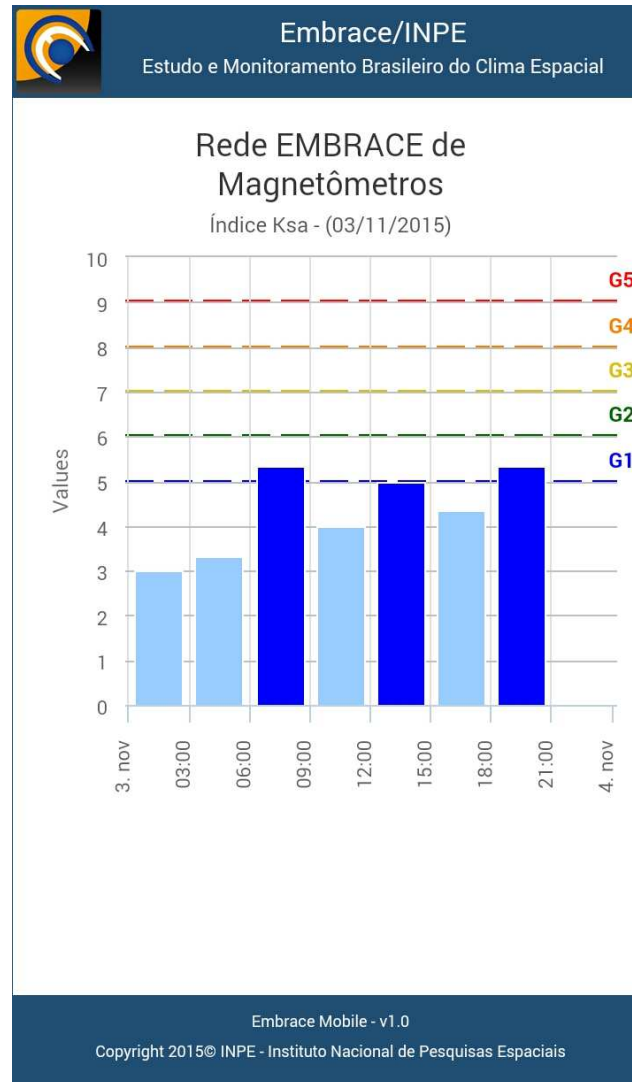
On the left side of the Play Store page, there is a sidebar menu with options: My apps, Shop, Games, Family, Parent Guide, and Editors' Choice. A QR code is located in the bottom left corner of the app's preview area.



## Embrace Mobile

New APP  
Embrace  
Mobile  
Google Play

SINCE  
JULY 2015



Embrace/INPE  
Estudo e Monitoramento Brasileiro do Clima Espacial

G1

03 nov 15 18:00  
 Instrumento  
**MAG**  
 Classe  
**KSA**

Evento ocorrido no período: 03/11/2015 18:00:00 a 03/11/2015 21:00:00

Efeito: Sistema elétrico: flutuações fracas na voltagem podem acontecer. Operação de satélite: possível impacto pequeno nas operações. Outros sistemas: animais migratórios são afetados neste nível e em níveis mais altos.

Medida: Kp = 5

Frequência Amostral: 1700 por ciclo (900 dias por ciclo)

G1

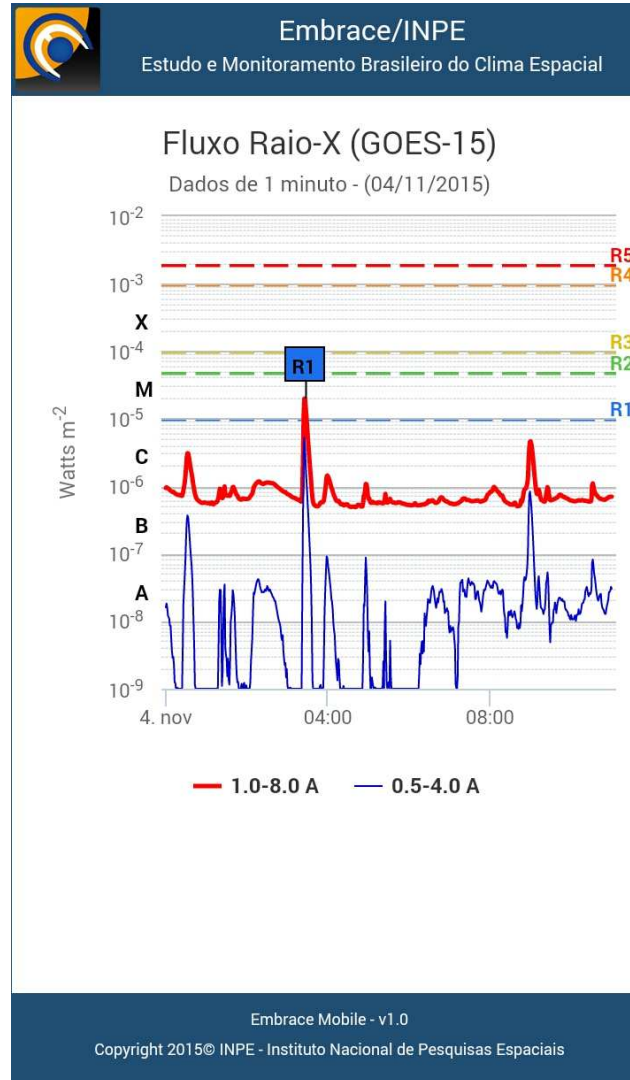
03 nov 15 12:00  
 Instrumento

Embrace Mobile - v1.0  
Copyright 2015© INPE - Instituto Nacional de Pesquisas Espaciais

## Embrace Mobile

New APP  
Embrace  
Mobile  
Google Play

**SINCE  
JULY 2015**



Embrace/INPE  
Estudo e Monitoramento Brasileiro do Clima Espacial

**R1** 04 nov 15 03:25  
Instrumento  
**GOES**  
Classe  
**CLASS\_M**

O sistema de monitoramento do Embrace/INPE detectou a existência de flare **CLASSE M** ( $1,98 \times 10^{-5.0}$  Watts m<sup>-2</sup>) com nível de severidade R1 ocorrido em 04-11-2015 às 03:25:00 UTC. Detalhes: [Clique aqui](#)

Efeito de Severidade R1:  
 HF Rádio: Completo blackout em HF (high frequency\*\*) no lado iluminado inteiro da Terra durando horas. Isto resulta em falta de contato com aviadores e marinheiros nestes setores.  
 Navegação: navegação em baixa frequência usado pela marinha e alguns sistemas de aviação experimenta falhas na área iluminada por horas, causando perda em posicionamento. Erros maiores em sistemas de navegação por satélites por horas na parte iluminada da Terra e que pode se propagar

Embrace Mobile - v1.0  
Copyright 2015© INPE - Instituto Nacional de Pesquisas Espaciais





# Other GNSS Initiatives



## **CIGALA (GALILEO)**

Concept for Ionospheric Scintillation Mitigation  
for Professional GNSS in Latin America (ended in 2012, but network is still active)

## **CALIBRA**

COUNTERING GNSS HIGH ACCURACY  
APPLICATIONS LIMITATIONS DUE TO IONOSPHERIC DISTURBANCES IN BRAZIL

New: GBAS aircraft landing system –  
modelling to adapt US parameters to Brazil

## **ISMR QUERY TOOL**

ISMR Query Tool allows users to perform queries and analysis  
on the CIGALA/CALIBRA ionospheric monitoring database

## CIGALA/CALIBRA website

The screenshot shows a web browser window displaying the CIGALA/CALIBRA website. The browser's address bar shows the URL `is-cigala-calibra.fct.unesp.br/is/index.php?lan=en`. The website has a blue navigation bar with the following menu items: HOME, Stations Network, CIGALA, CALIBRA, ISMR Query Tool, Publications, News, and Login. The main content area features a section for the **ISMR Query Tool**, which is described as a web software for analyzing ionospheric monitoring data. A diagram illustrates the data flow from GNSS Stations to a Central Facility, then to DUMS, and finally to the ISMR Query Tool accessible via the Internet to Users. A list of links includes 'Register / Contact' and 'Screenshots'. To the right, there is a section for **Precision Agriculture** with an image of a car and a person, and text explaining the challenges of using high-accuracy positioning systems like RTK 24/7 due to ionospheric scintillation. Below this is a 'Highlights' section containing a map of Brazil with a color-coded heatmap representing ionospheric scintillation data. A legend on the right of the map shows a color scale from 0 (blue) to 0.2 (red) in increments of 0.04. The browser's download bar at the bottom shows several files, including 'mbrazil.gif' and 'map-brazil-360x270-....gif'.

<http://is-cigala-calibra.fct.unesp.br/is/index.php?lan=en>

## GLONASS and Space Weather



**4 GLONASS CORRECTION STATIONS:**

**Recife (NE)**

**Brasília (center)**

**Santa Maria (South)**

**Precise point positioning studies**

## GLONASS at UnB – PPP Studies

The overall objective of the proposed research on Precise Point Positioning (PPP) is to assess the **impact of multi-constellations** instead of stand-alone (GPS or GLONASS) PPP solution around Brasilia. Data are extracted from the GNSS receiver of the One-Way Station (OWS) MSGLONAS, «Sazhen-TM-BIS» installed at University of Brasilia.

### **Future perspectives include:**

- Practical applications on HASP (high altitude student platform);
  - Onboard attitude determination;
  - Impact point prediction;
- High precision applications with UAVs and mobile robots.



Clezio M. De Nardin - [clezio.denardin@inpe.br](mailto:clezio.denardin@inpe.br)

INPE – EMBRACE

Renato Borges – [raborges07@hotmail.com](mailto:raborges07@hotmail.com)

UnB - PPP

João Francisco Galera Monico –

[galera@ftc.unesp.br](mailto:galera@ftc.unesp.br)

UNESP - CALIBRA