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# Introducing the INCT GNSS-NavAer

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& Equipe

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- INCT - General idea
- The GNSS NavAer Project;
- **GNSS NavAer Aims**;
- GNSS NavAer WPs;
- What have we done so far?
- Final Comments.

# INCT General Idea

- INCT in Portuguese is the acronym for Instituto Nacional de Ciência e Tecnologia, that means National Institute of Science and Technology.
- One of the largest program of Science and Technology in Brazil.
- The aim of INCT is very ambitious and has to involve groups of research in the frontier of Science and Technology considering strategic areas for the sustainable development of the country.

- Competitive science and technology at international level;
- It is expected that the development should be integrated with the industry for the benefits of the society.

- The last call was named INCT 16/2014.

# Thematic areas of the last call: 16/2014

- Tecnologias ambientais e mitigação de mudanças climáticas
- Biotecnologia e uso sustentável da biodiversidade
- Agricultura
- Saúde e fármacos
- Espaço, defesa e segurança nacional
- Desenvolvimento urbano
- Segurança pública
- Fontes alternativas de energias renováveis, biocombustíveis e bioenergia
- Nanotecnologia
- Pesquisa Nuclear
- Tecnologia da informação e comunicação
- **Controle e Gerenciamento de Tráfego Aéreo /Air traffic management and control**

# The GNSS NavAer Project

- It was submitted by researchers from UNESP PP, INPE, ITA and IAE and named as “GNSS Technology to Support Air Navigation”, whose short name is **GNSS NavAer,**
  - Now, researchers from PUC-Rio, UFRGS and IFESP-PE also are members.
  - It started in Jan 2017 with duration of 6 years.
-

# The problem to be tackled

- GNSS for aerial navigation constitutes a worldwide tendency in the present days and, in the future, it will be the main technology adopted for determination of airplanes positioning/navigation in all flight phases.

- SBAS (Satellite-based Augumentation System) and GBAS (Ground-based Augumentation System) will be the most demanding technologies on this context.

- However, in Brazil and other low latitude regions, the ionosphere poses serious problems during some periods:
  - a GNSS receiver may deteriorate the navigation, stop tracking few or even all satellites.

- Therefore, application of technologies based on GNSS for aviation and other real time applications over the Brazilian territory demands a deep evaluation of Ionospheric effects.

- The Brazilian authorities, after few tests at 2000's, decided not using SBAS - and directed actions to the development of GBAS.

- So, it can be highlighted the GBAS, which uses GNSS systems, transmitting corrections to improve the accuracy in determining the aircrafts position aiming at guiding it for a precise landing is very demanding for Brazilian authorities in the air navigation.

  - For GBAS - Integrity is of the main concern
    - It involves accuracy, availability, and continuity at high level of probability (defined by ICAO).
    - The Ionosphere in our region imposes several problems
      - Challenge for using in Safety of Life Applications

# GNSS NavAer Aims

**General Objective**

- To graduate human resources to develop researchers and to transfer knowledge to the society, in the area of atmosphere monitoring, especially with the aspects related to the ionosphere TEC (Total Electron Content) and IS (Ionospheric Scintillation) in the GNSS signal;

- To assess the GNSS applicability in the air navigation taking into account reliability and safety, within the Brazilian territory, as well as other real time applications;

# GNSS NavAer WPs

- **WP1 – Infrastructure, Human Resources, Internacionalization and Dissemination -**
  - Ampliação da rede de receptores GNSS e sua manutenção
  - Definição/Realização da Estrutura de TI e transmissão dos dados
  - Formação de Mestres e Doutores e Especialistas para dar suporte às demandas da navegação aérea;
  - Internationalization and Dissemination
- **WP2 - To research the ionospheric dynamics over the Brazilian territory, mainly the TEC and IS effects;**
- **WP3 - Analysis of equatorial and low latitude ionosphere over the GBAS operation;**

- **WP4 – Statistical modelling of the IS;**

- **WP5 - Ionospheric threat model development suitable for the GBAS operation in the Brazilian airspace;**

- **WP6 - Development of new GNSS positioning technics in the air navigation using the new GNSS signals;**

- **WP7 - Improvement of the GNSS receivers performances under IS in the equatorial ionization anomaly region;**

# What Have we done so far?

## General idea of the achievements will be provide next.

# Infrastructure

# The GNSS NavAer network

- **To Expand the CIGALA/CALIBRA Network from previous projects.**
- **GNSS (Septentrio PolaRx5s) receivers with CNPq funding.**
- **Extra receivers may be purchased with FAPESP funding.**

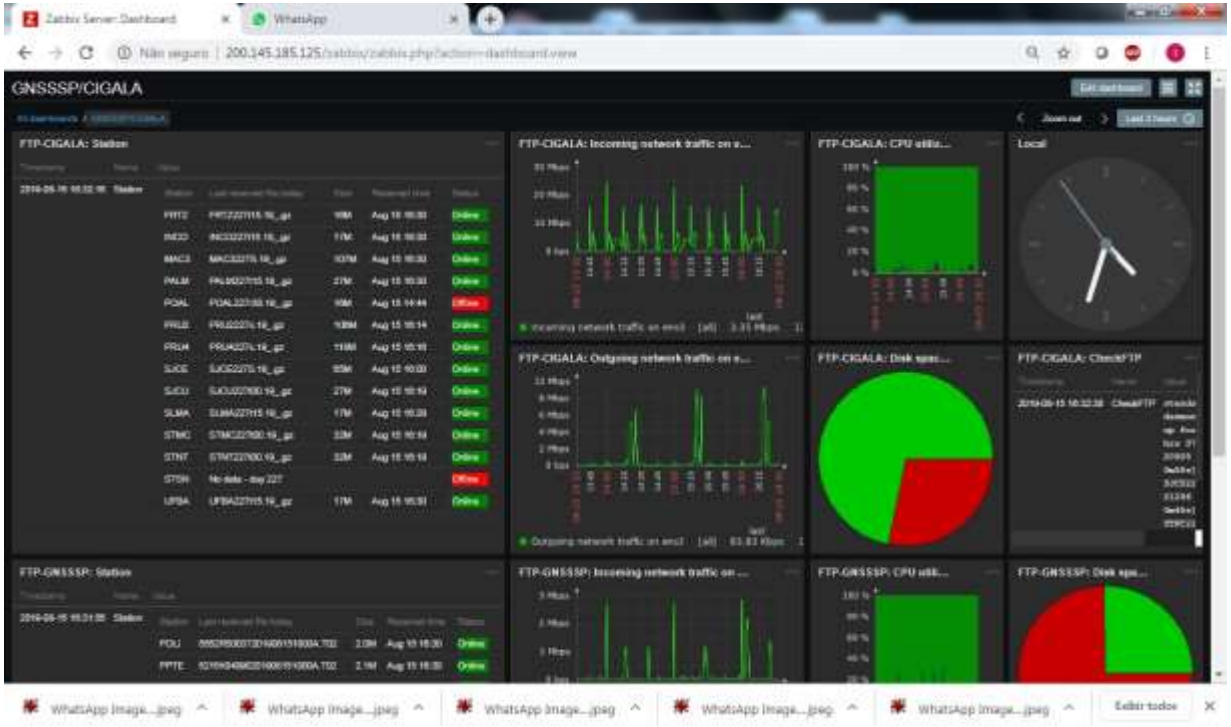
- **Multiconstellation (GPS / Glonass / Galieo e Beidou) e multifrequência (L1, L2 e L5);**
- **Allow 100 Hz (Code, phase and intensity) data collection;**
- **Provide ionosphere parameters like S4, sigma phi and others.**

# GNSS-NavAer network today

- 16 GNSS stations
- 03 under deployment
- 01 Simulator


**The stations are distributed in such way to have a very good sample of the IS occurrences in the Brazilian territory.**

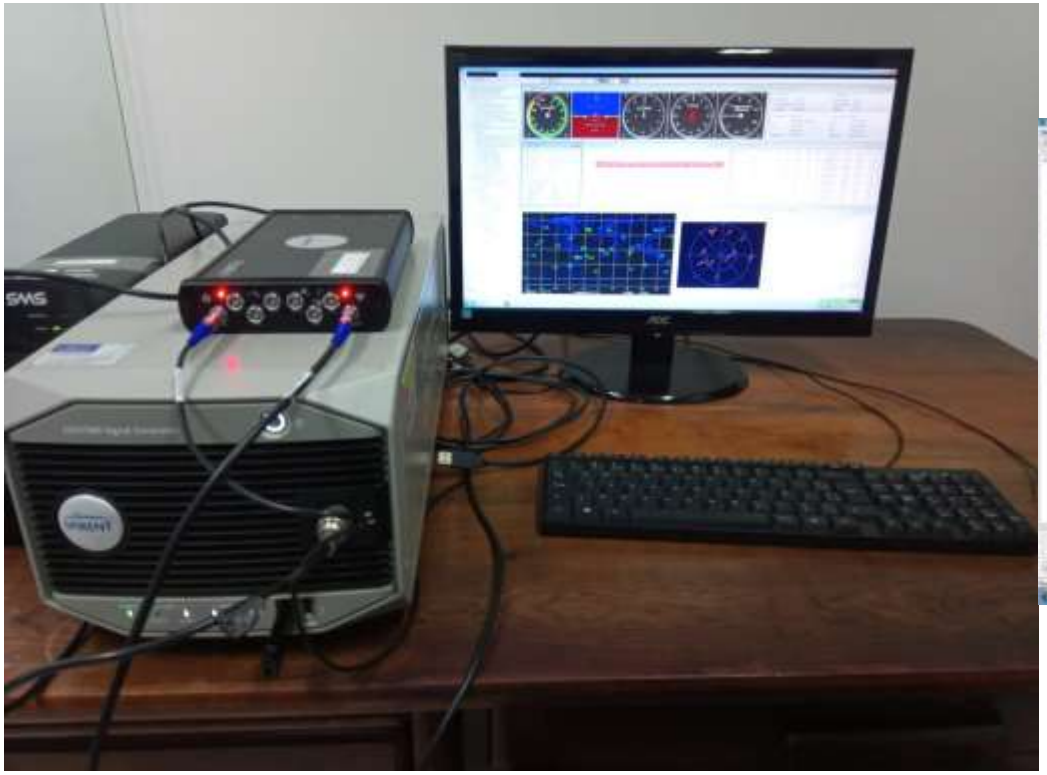
# Management of the network



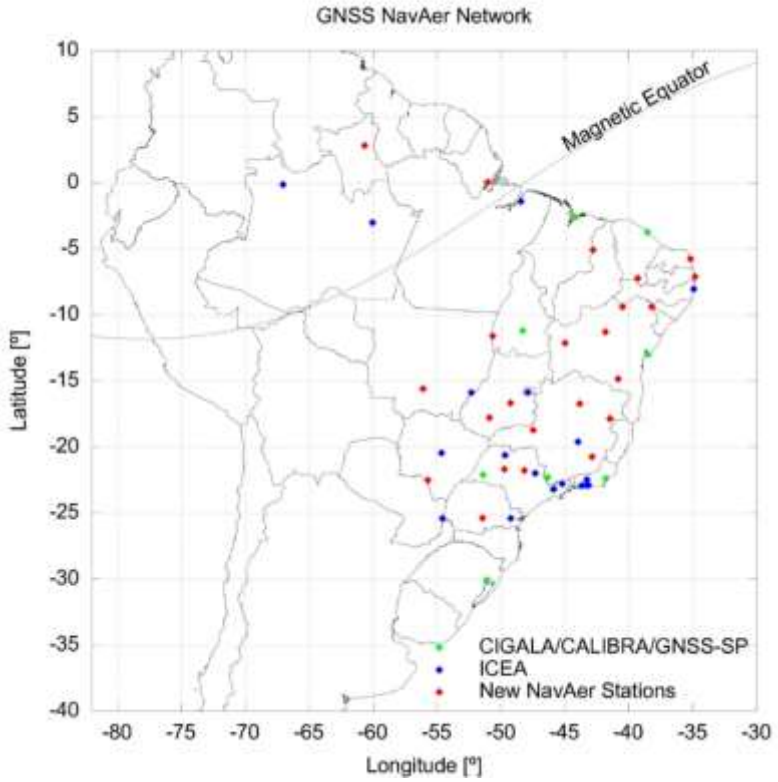


- A NTRIP Caster is available at Unesp.
- Raw data available every 15 min

# Spirent Simulator



# Future IS Monitoring network

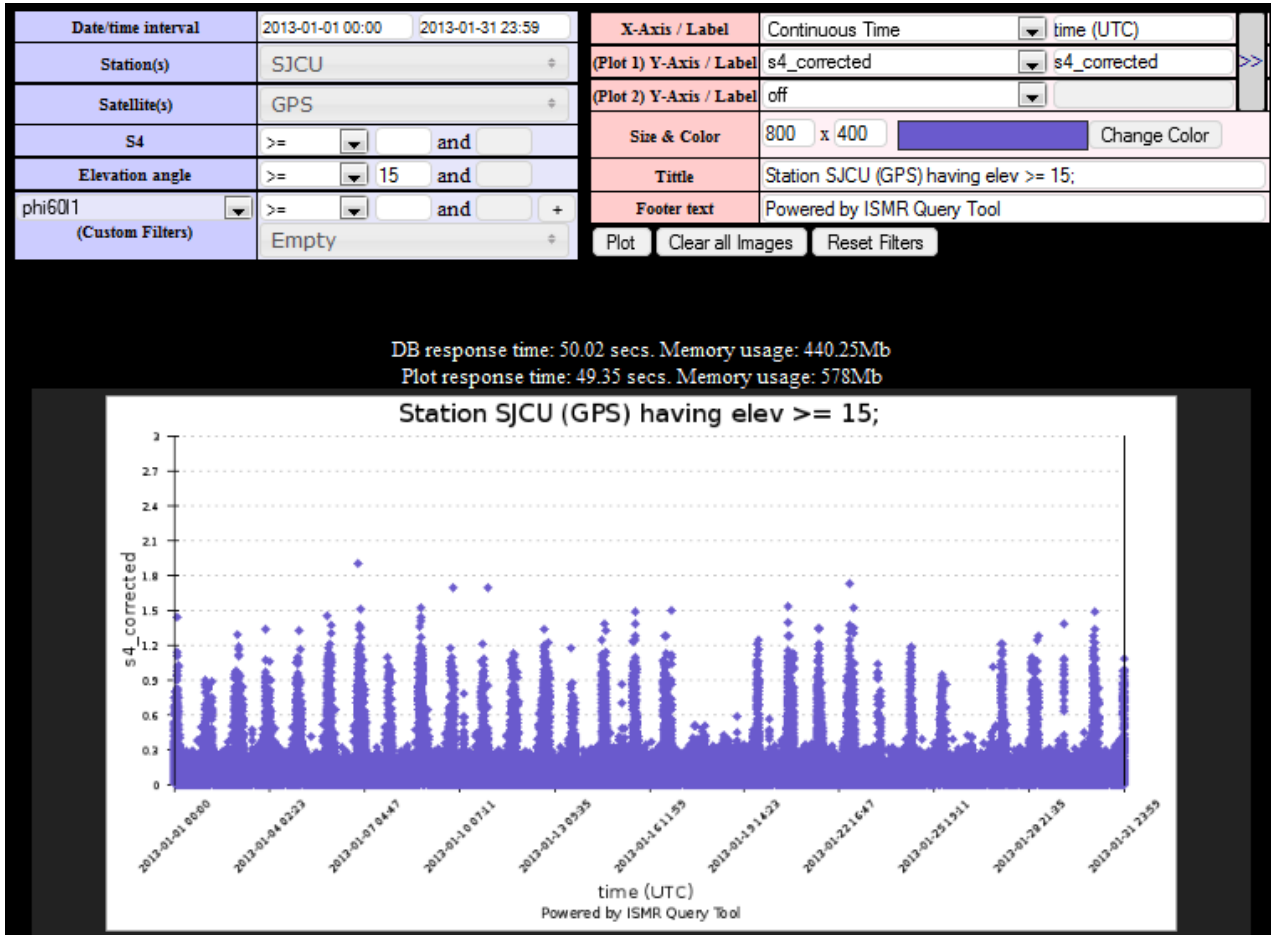
# A Sample of Results

# ISMR Query Tool

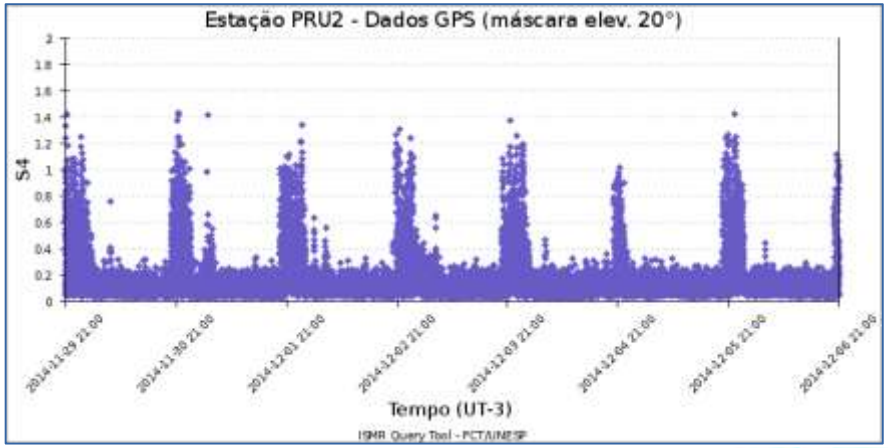
- The large numerosity of monitoring data motivated the development of a tool to support researchers in tasks related to characterization of scintillation occurrence

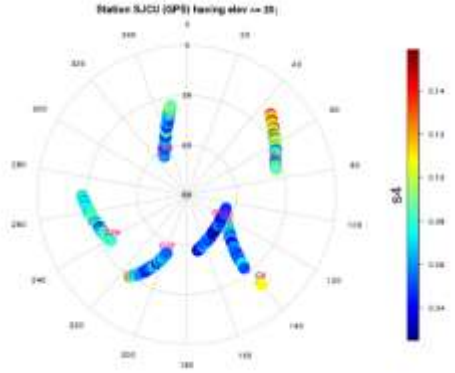
- Resources of ISMR Query Tool:
  - Support data analysis through data visualization and data mining
    - Data analysis with dynamic scatterplots, maps, interactive visualization and data mining algorithms
    - Users can explore the monitoring data (collected since 2011)
    - Users can also download the monitoring data to work locally

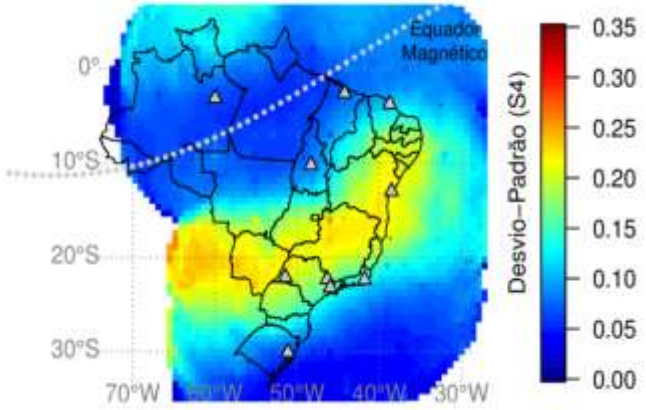
# ISMR Query Tool: example of user interface



# Sample features:
# Daily variation / Spatial Distribution



# Related Paper

Computers & Geosciences 104 (2017) 125–134

Contents lists available at ScienceDirect

Computers & Geosciences

journal homepage: www.elsevier.com/locate/cageo

## Visual exploration and analysis of ionospheric scintillation monitoring data: The ISMR Query Tool

Bruno César Vani [a,*], Milton Hirokazu Shimabukuro [b], João Francisco Galera Monico [c]

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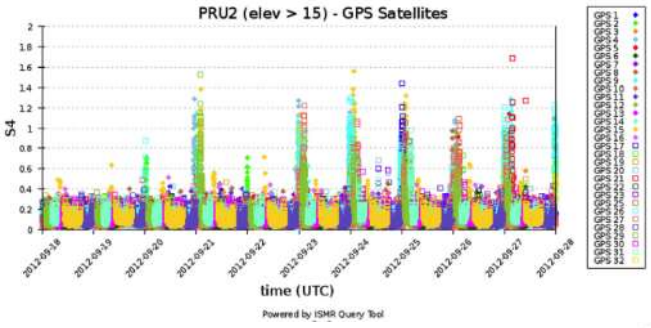
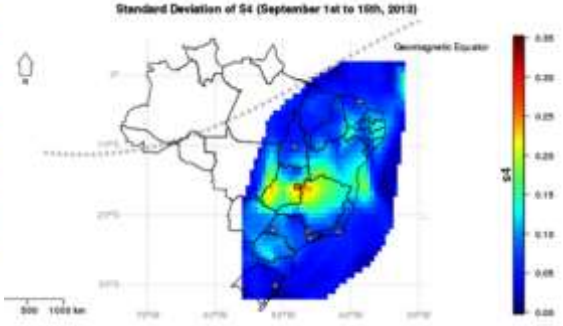
[c] Department of Cartography, Faculdade de Ciências e Tecnologia, UNESP – Universidade Estadual Paulista, Rua Roberto Simonsen, 305, 19060-900, P. Prudente, SP, Brazil



# Mitigation of Scintillation Effects on Precise Point Positioning

- the methods, such as PPP and RTK, can performance of high precise positioning During strong scintillation, be harshly deteriorated (if not properly modeled);
- T
  ir
  lo
  d
  p
- R
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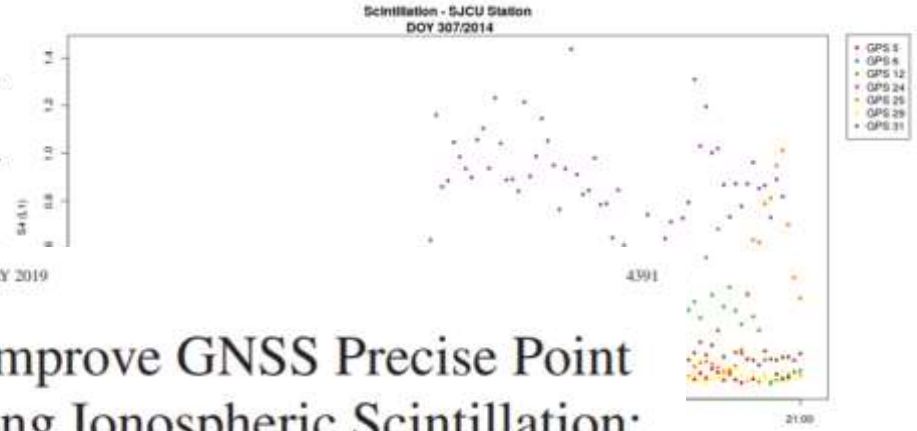
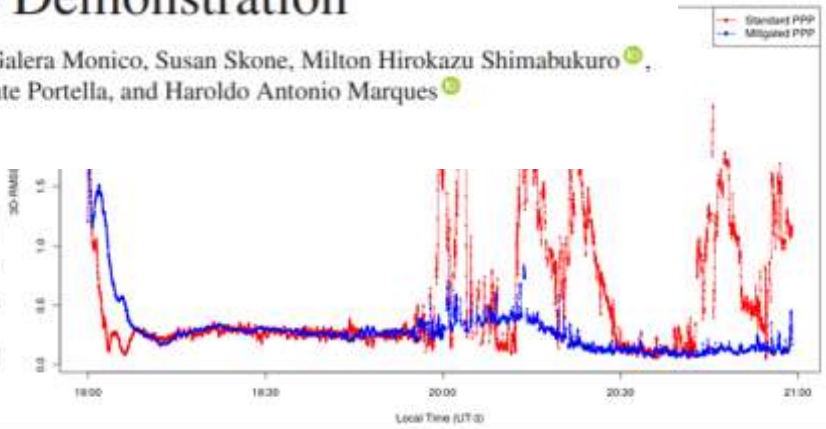
  expected level;
- Recent research on mitigation applied to PPP reached improvements up to 80% in the positioning accuracy during strong scintillation in relation to the standard PPP.




IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 68, NO. 5, MAY 2019 4391

## A Novel Approach to Improve GNSS Precise Point Positioning During Strong Ionospheric Scintillation: Theory and Demonstration

Bruno Cesar Vani, Biagio Forte, Joao Francisco Galera Monico, Susan Skone, Milton Hirokazu Shimabukuro, Alison de Oliveira Moraes, Igor Ponte Portella, and Haroldo Antonio Marques

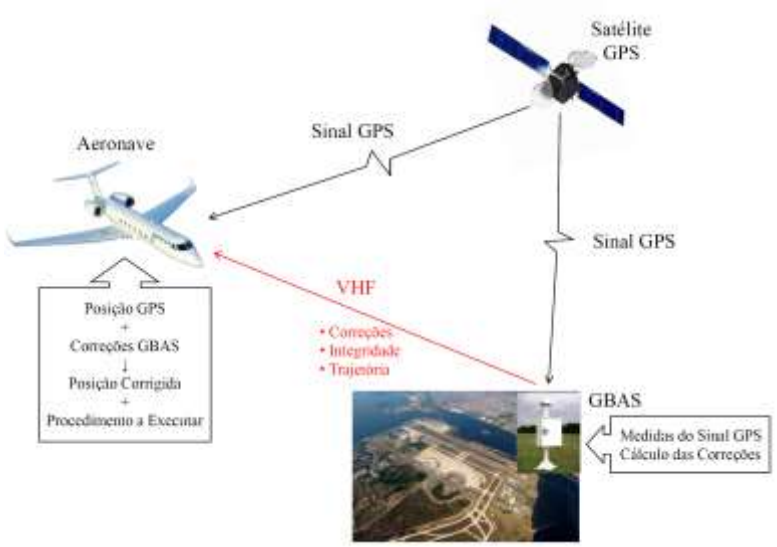


# Investigation of GBAS Risk Model

- Pereira (2018) computed a great number of ionospheric gradients for all available GNSS stations in Brazil since 2000, and estimated the integrity parameter $\sigma_{vig}$ (vertical ionospheric gradient) in the post processing mode.

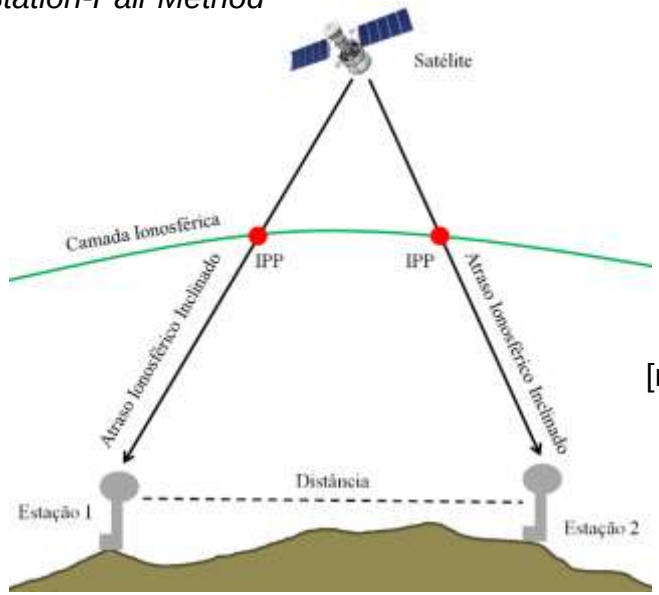
- It provided way to investigate the usability of the CONUS model for GBAS in Brazil.

# GBAS - GIG Airport

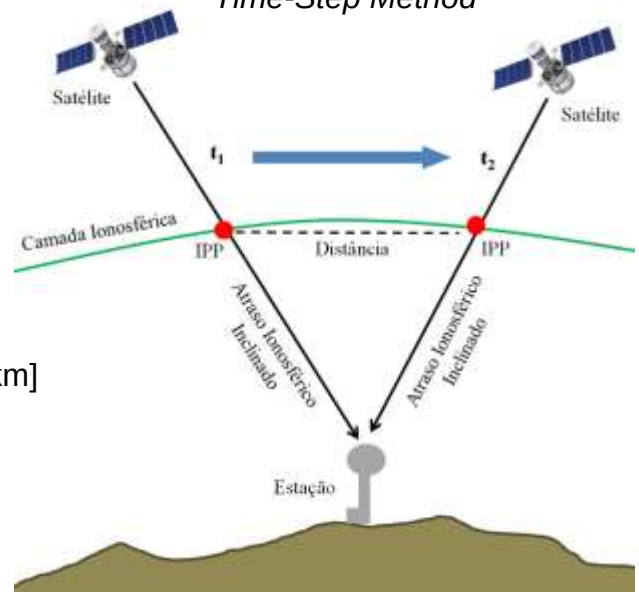



# Iono Gradient computation

*Station-Pair Method*




*Time-Step Method*




[mm/km]

$$g^s = \frac{\left|I^s_{r1} - I^s_{r2}\right|}{D_{r1r2}} \qquad I^s_r = \frac{\Phi^s_{rL1} - \Phi^s_{rL2}}{\gamma - 1} - \frac{c}{\gamma - 1}\left(DCB_r + DCB^s\right) - \frac{N^s_{rL1} - N^s_{rL2}}{\gamma - 1} \qquad g^s = \frac{\left|I^s_{rt_1} - I^s_{rt_2}\right|}{D_{IPPt1t2}}$$

- Cada par de estações: uma estação GBAS e uma aeronave.
- Influenciado pelo DCB dos receptores.
- Ideal: LB em torno de 40 a 100 km e pares orientados paralelamente ao equador magnético.

- Aumento da amostragem de gradientes.
- Gradientes com distâncias menores.
- Arquitetura não intuitiva.
- DCB do satélite e receptor eliminado... Entretanto, tem-se a decorrelação temporal.

# Ionospheric Parameters for GBAS Threat Models

- 307 days between the years 2000 and 2006 (RBMC data);
- Data: GPS (L1/L2 and L1/L5), GLONASS (L1/L2) and Galileo (L1/L5); and
- Gradients from carrier phase and smoothed pseudorange to find the time windows feasible of using GBAS

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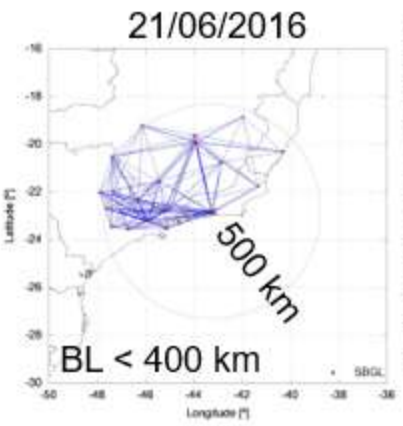
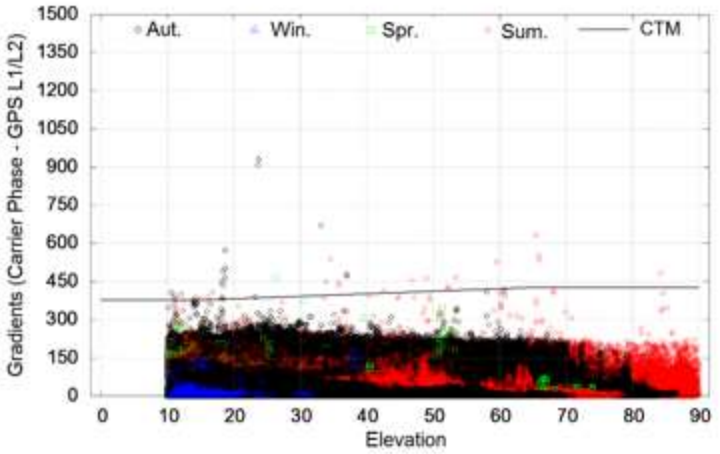
Rio de Janeiro International Airport (SBGL/GIG)




Time and Elevation Window Exceptions (L1/L2), Carrier Phase

| Brazilian International Airports | Seasons | | | |
|---|---|---|---|---|
| | Autumn | Winter | Spring | Summer |
| Sao Paulo (SBGR/GRU) | 22h-05h UT | - | 22h-05h UT | 22h-05h UT |
| Rio de Janeiro (SBGL/GIG) | elev 10°- 37° | - | 23h-24h UT | 21h-24h UT |
| Brasilia (SBBR/BSB) | 22h-04h UT | - | 22h-02h UT | 22h-03h UT |
| Porto Alegre (SBPA/POA) | - | - | - | - |
| Recife (SBRF/REC) | - | - | - | 21h-24h UT |

**GBAS was not certified in Brazil due to Ion Scintillation.**

# Final Comments

- GNSS NavAer is under development and with several challenges;
- Support from FAPESP, CNPq and CAPES;
- Assessment of all INCTs will occur on 19 and 20th nov 2019;
- Several results are already available;
- Integration with SIRGAS may be feasible.

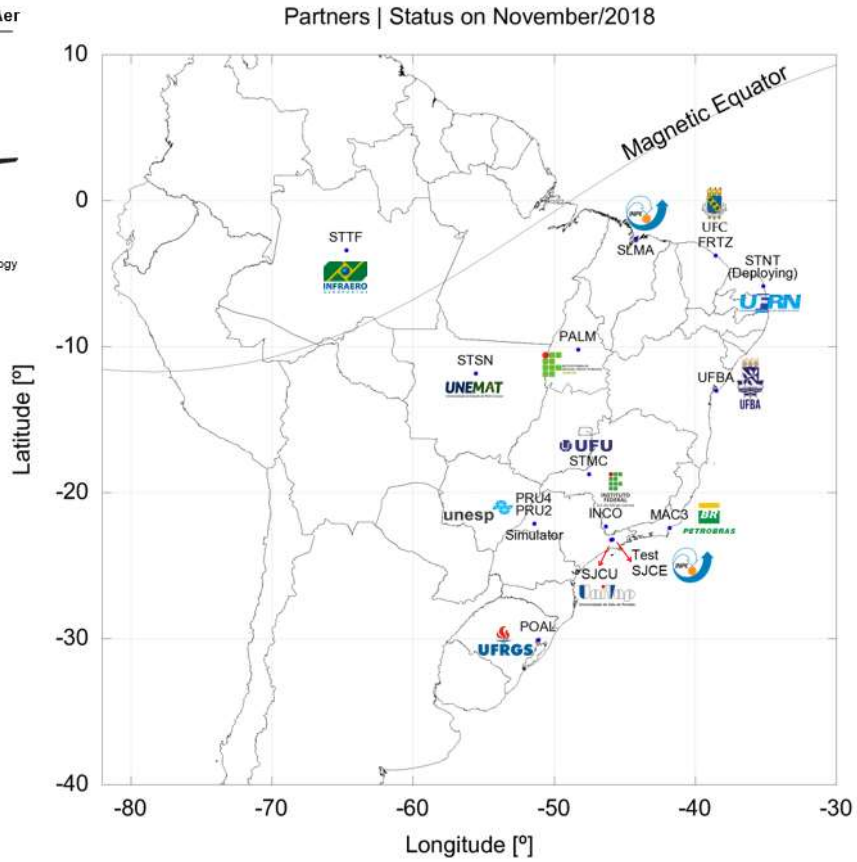
To follow GNSS NavAer go to:

http://inct-gnss-navaer.fct.unesp.br/pt/

# INCT GNSS-NavAer Network

I Workshop INCT GNSS-NavAer

National Institute of Science and Technology for GNSS in Support of Air Navigation

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