# Panel on Observing Infrastructure

*South American Observing Infrastructure - Current status and the known or potential gaps in the area. Recommendations for future work. Suggestions for local priority needs for the global space weather enterprise.*

J.E.R.Costa - INPE – National Institute for Space Science
EMBRACE –Regional Warning Center in Brazil

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# Introduction

**First I will address the Space Weather issues as a matter of an operational center:**

- **It needs cooperation with real time capability (most of time).**
- **It will be restricted to products being used for monitoring/ forecasting space weather.**

- **The networks of sensors today in Latin America is mostly driven by science. They are now being used by SW operations through cooperation with existing projects.**
- **We have now in Latin America two Regional Warning Center (Brazil and Mexico) and we are talking to Argentina to organize their AWC (associate).**
- **Gaps in the network are being used for planning the investment of EMBRACE program or through international initiatives.**
- **I will present some conclusions and offer suggestions to overcome some of the main difficulties.**

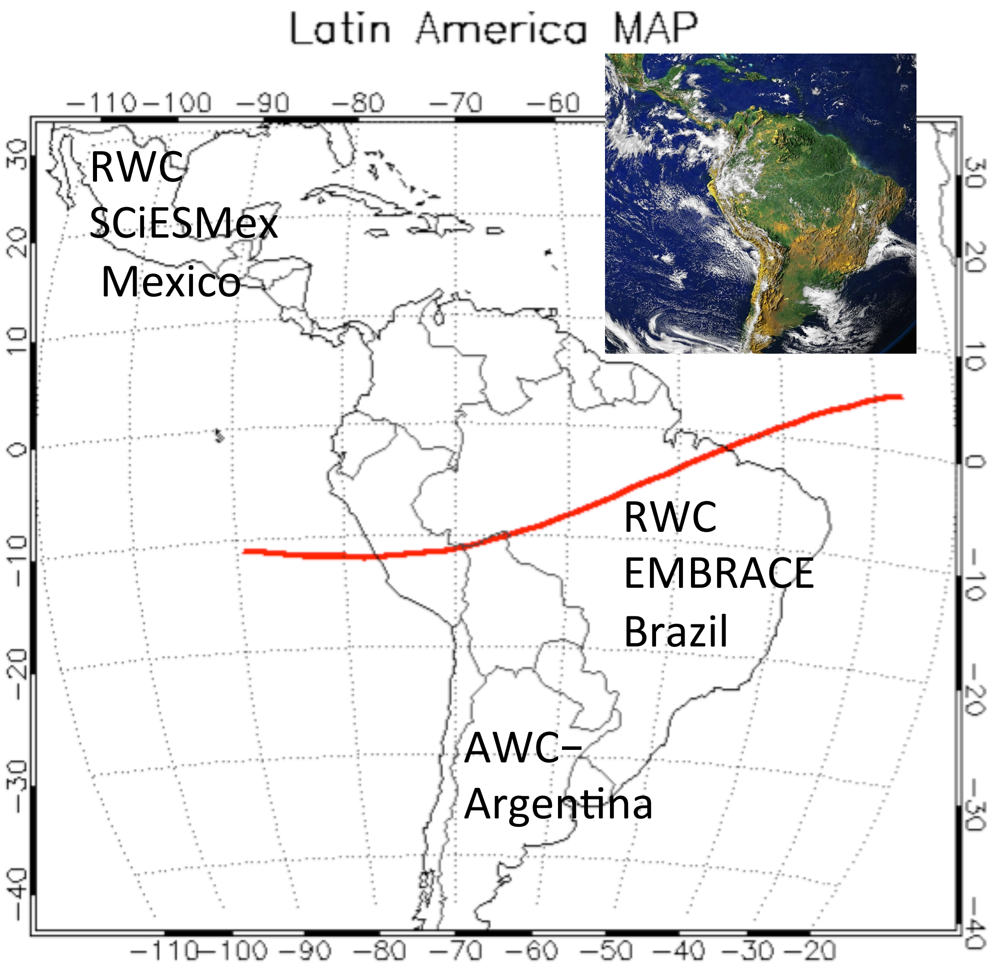


TABLE 1. Summary of the Scientific Networks/Facilities, operating in Latin America

| Group | Name(Acronym) | Origin (Year) | Objective of Investigation (Primary Objective) | Current Status (FO, PO, NO*) |
|---|---|---|---|---|
| Atm. | Embrace GlowNet | 1998 | Gravity Waves (85 km) and Plasma Bubbles (260 km) footprints signature and propagations | PO |
| Atm. | AAS | 1998 | Airglow in mesopause region | FO |
| Atm. | SARINET | 1999 | D-Region density variations and solar flares related effects | FO |
| Atm. | SAVNET | 2006 | D-Region (daytime) and E-Region (nighttime) density variations and solar flares related effects | FO |
| Atm. | NDMC | 1998 | Mesopause region and changing climate | FO |
| Atm. | RIOM-SMN | 2012 | Absorption in ionosphere | PO |
| Atm. | Schumann station | 2014 | Schumann resonance frequencies | FO |
| Atm. | Embrace DigiNet | 1990 | Bottom-side ionospheric profile measurements and upper-side ionospheric profile theoretical extrapolations, Maximum Usable Frequency from oblique HF ionospheric reflections | PO |
| Atm. | RBMC | 1996 | Total ionized atmosphere content and positioning for several purposes like geodynamics studies of the South American plate | FO |
| Atm. | Calibra | 2012 | Total ionized atmosphere content and positioning for several purposes like topographical and geodetic surveys, land management and offshore operations | PO |
| Mag. | Embrace MagNet | 2011 | Geomagnetic field variations and geomagnetic storm detections | PO |

Airglow imagers

Ionosondes

GNSS sensors

Magnetometers

Source: Denardini, et.al (2016): Review on space weather in Latin America-2, AdvSR, 58, p.1940.

| | | | | |
|---|---|---|---|---|
| | **Magnetometers** | | | |
| Mag. | Intermagnet in Mexico | 2002 to 2012 | Geomagnetic field (absolute, variations), geomagnetic storm detections, long term secular changes and contribute to IGRF | PO |
| Mag. | Intermagnet in Argentina | 1991 | Geomagnetic field (absolute, variations), geomagnetic storm detections, long term secular changes and contribute to IGRF | FO |
| Mag. | SMN-LAS | 1961 | Geomagnetic Storms. South American Magnetic Anomaly. | FO |
| | **Cosmic Rays** | | | |
| I. M. | GMDN in Brazil | 2006 | Cosmic ray, ICMEs trough Forbush decrease | FO |
| I. M. | SciCRT-GMDN in Mexico | 2014 | Cosmic ray, ICMEs trough Forbush decrease | FO |
| I. M. | LAGO | 2011 | Cosmic ray, ICMEs trough Forbush decrease | PO |
| I. M. | Auger - Low energy modes | 2005 | Cosmic ray, ICMEs trough Forbush decrease | FO |
| I. M. | Cosmic Ray Observatory | 1999 | Cosmic ray, ICMEs trough Forbush decrease | FO |
| | **Interplanetary Scintillation** | | | |
| I. M. | MEXART | 2005 | tracking of solar wind disturbances using the interplanetary scintillation technique | FO |
| | **Solar observatories** | | | |
| Sun | Solar Submillimeter Telescope | 1999 | Active region | FO |
| Sun | Callisto-MEXART | 2015 | Solar radio burst | FO |
| Sun | Solar Neutron Telescope Network | 2004 | Solar energetic particles | FO |
| Sun | Itapetinga Radio | 1974 | Galactic and extra-galactic studies, solar physics specially the solar continuous emission and transition region monitoring | FO |
| Sun | Brazilian Decimetric Array | 2004 | Galactic and extra-galactic studies, high resolution solar physics | PO |
| Sun | Northeast Radio Space Observatory | 1993 | Geodetic studies as well as galactic and extra-galactic studies. | FO |

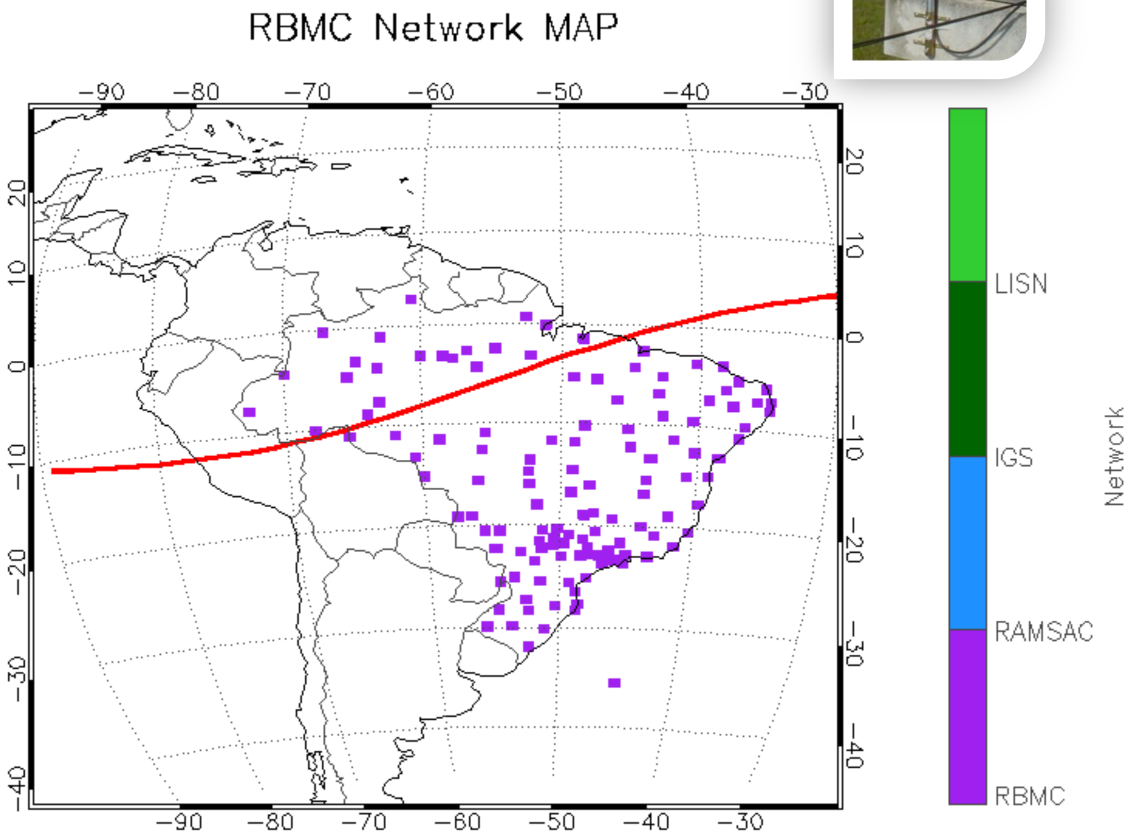
* FO = Fully operational, PO = Partially Operational, NO = Not Operational

Source: Denardini, et.al (2016): Review on space weather in Latin America-2, AdvSR, 58, p.1940.

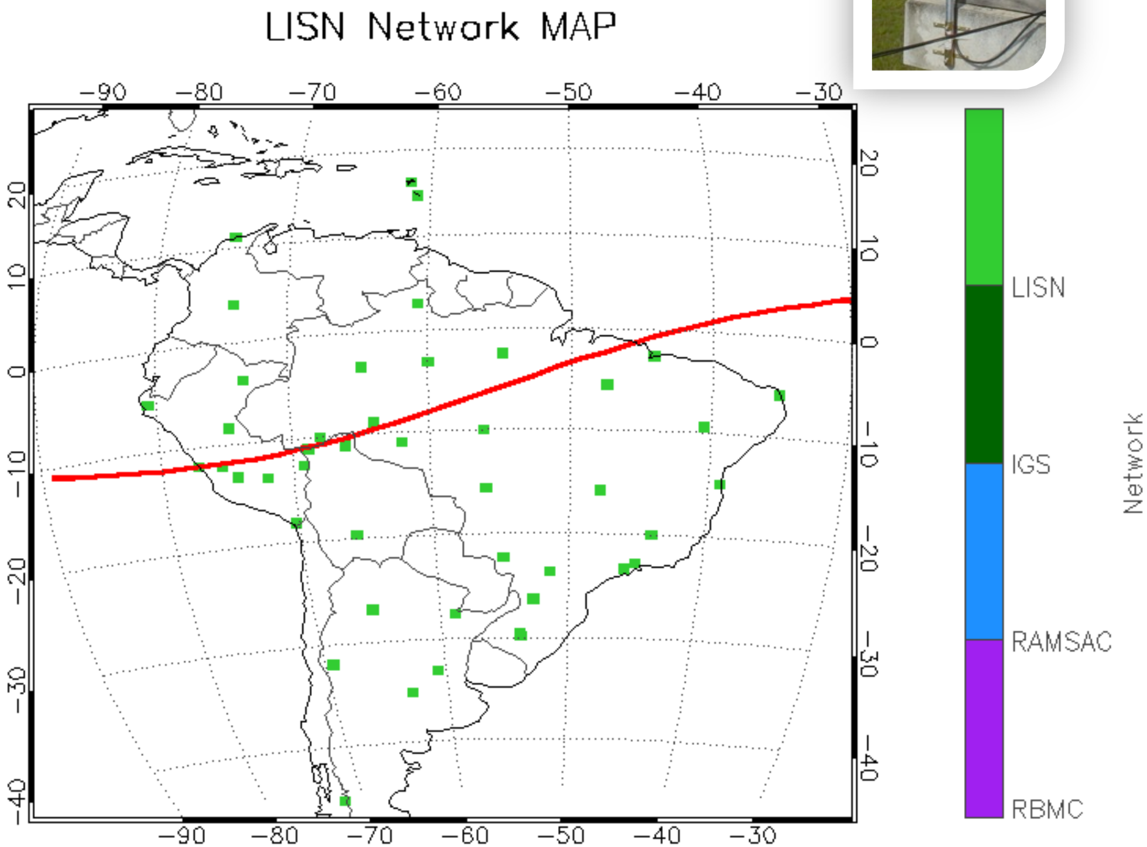
# GNSS Network for determinations of TEC

## Net: RBMC (RBMC -Brazilian Network for Continuous Monitoring of the GNSS Systems.)

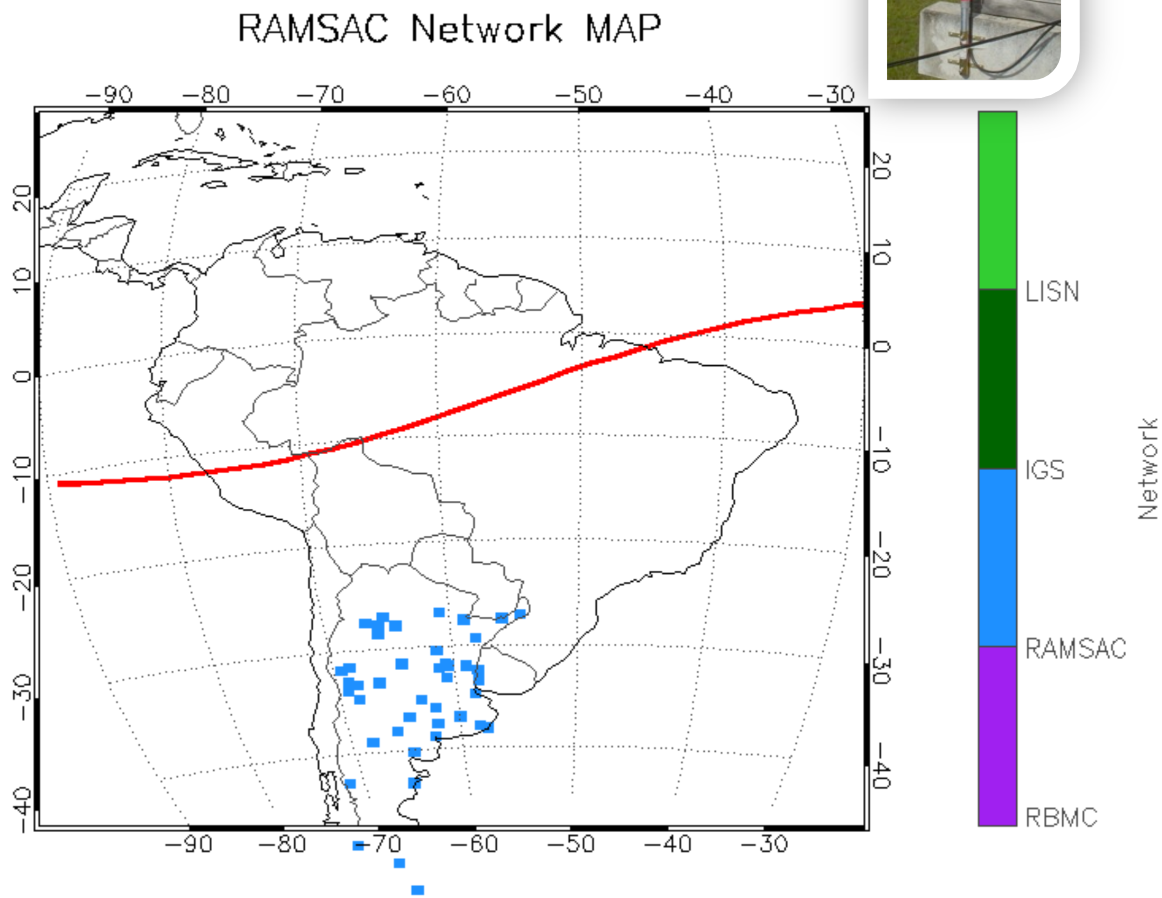
- The EMBRACE program does not own all the instruments used to complete the South America TEC map (now being extended to Latin America).
- A successful program of national and international cooperation was set to grant a denser GNSS network.
- In this example the Brazilian RBMC net.



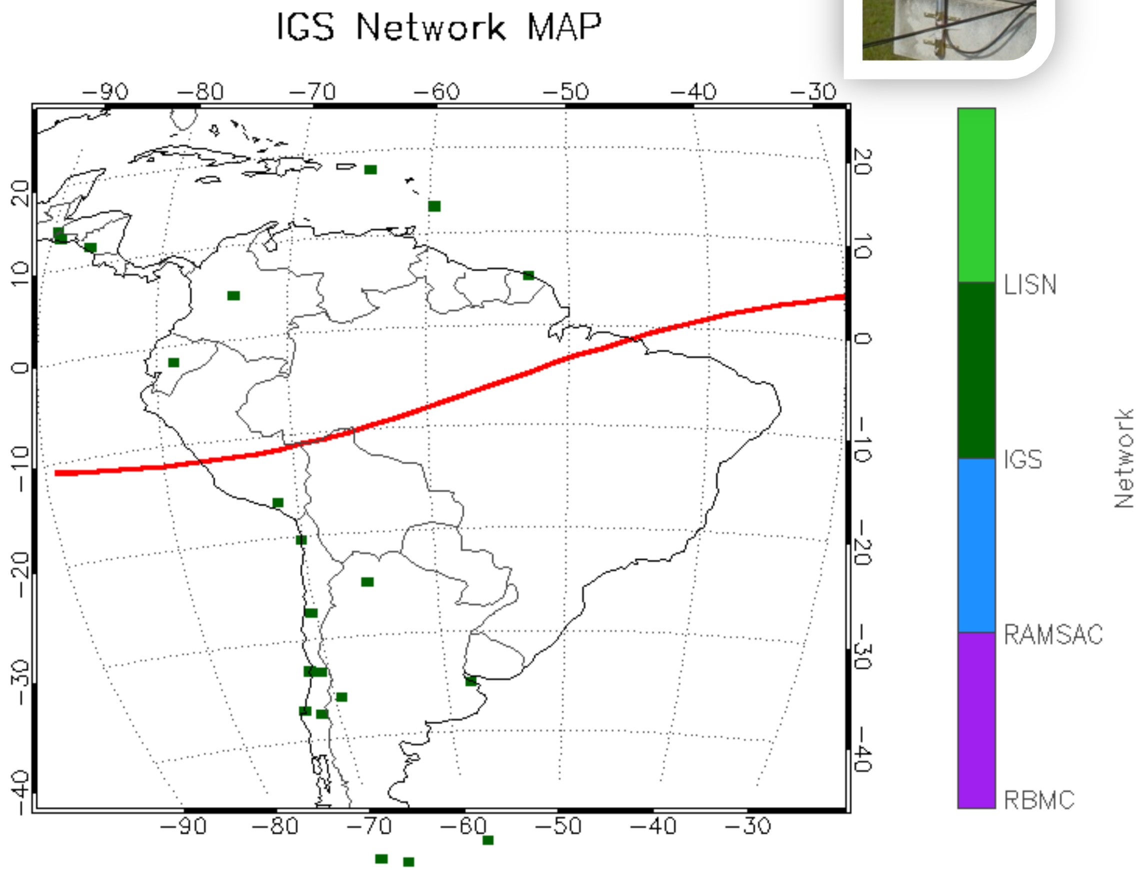
# GNSS Network for determinations of TEC
# Net: LISN – Boston College, USA



# GNSS Network for determinations of TEC
# Net: RAMSAC - Argentina

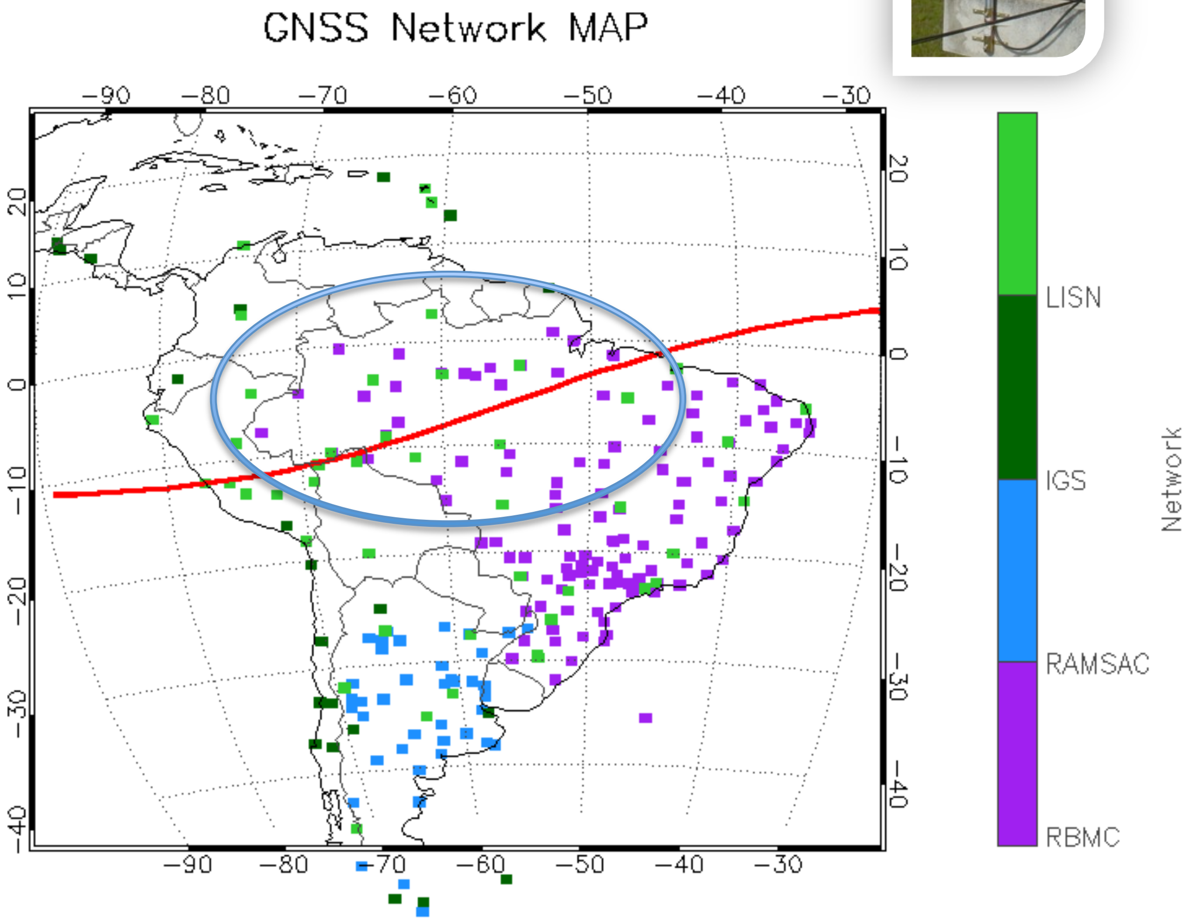


# GNSS Network for determinations of TEC
# Net: IGS - International



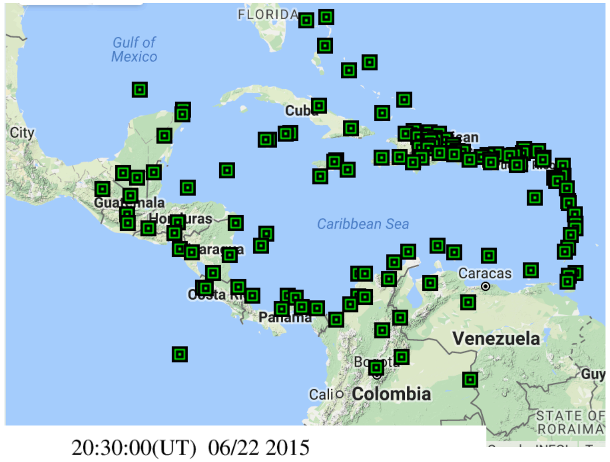
# GNSS Network for determinations of TEC
# Net: ALL NETWORKS

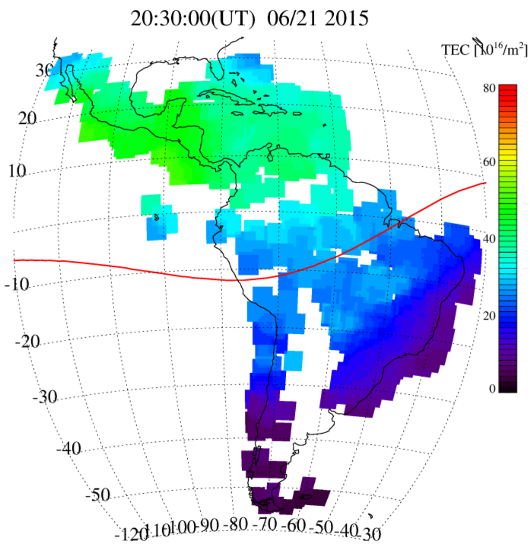
- Even including all sensors it is still a low density array.
- Mainly in the North of Amazon region and some neighbors countries .
- This map does not include Central America.

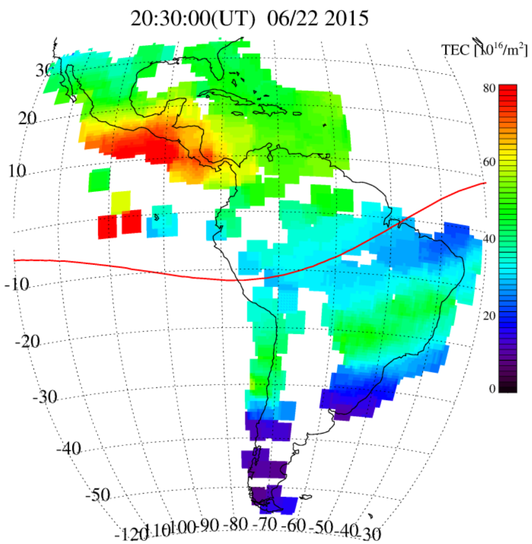


# GNSS Network for determinations of TEC Net: TLALOCNet-Mexico and COCONet-Central America

- The network is now being extended to whole Latin America including these two Networks.
- The gaps can be seen in the TEC maps.

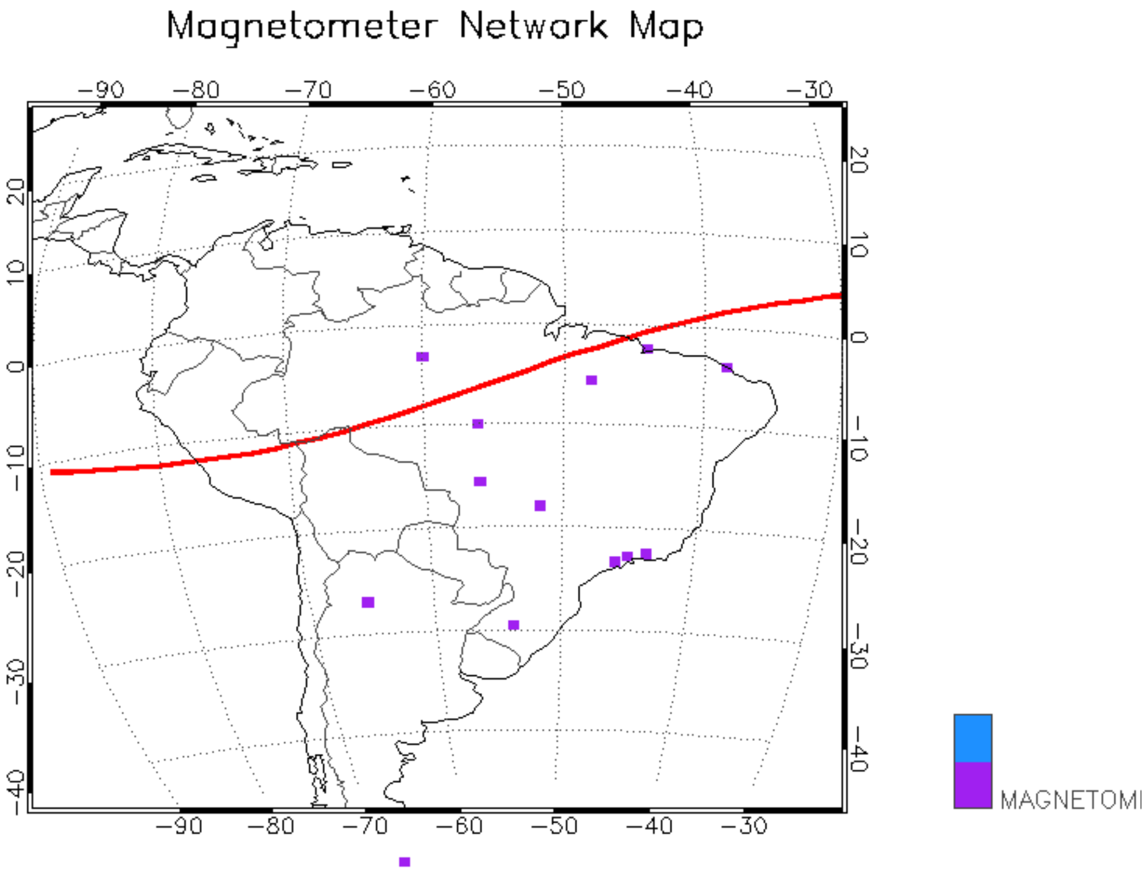



# Magnetometer Network

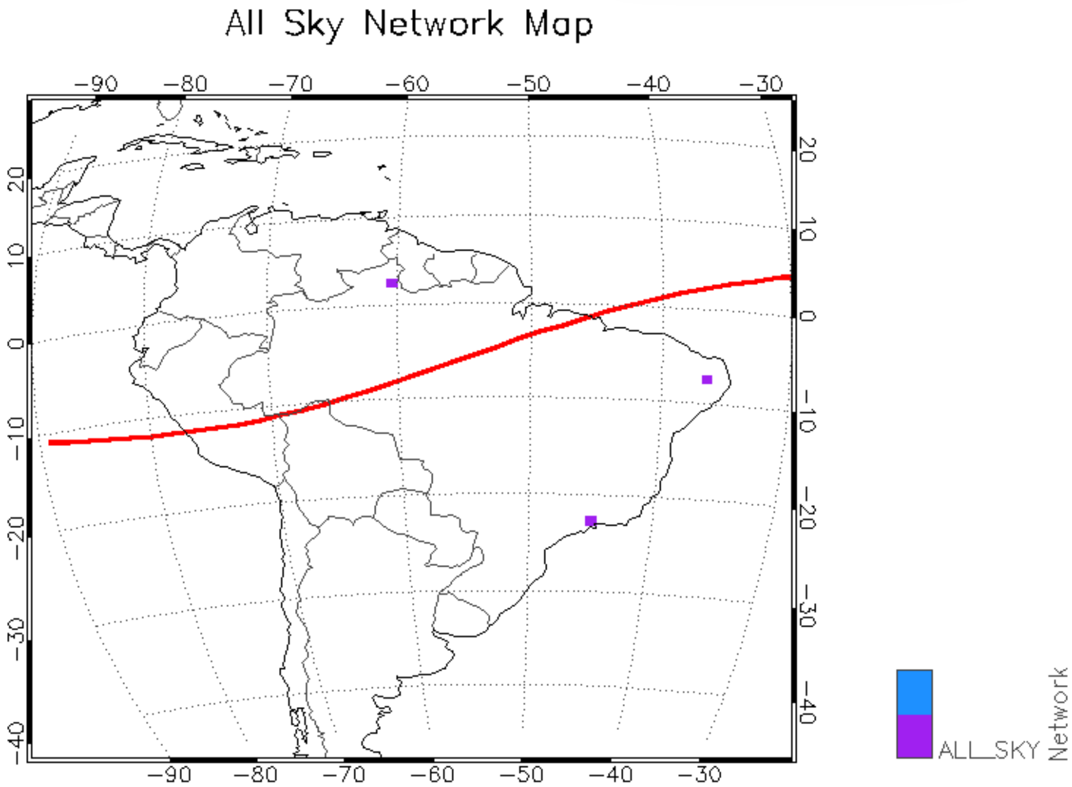
## Net: EMBRACE

- A low density network
- Although the magnetometers are cross-calibrated some of them are noisy due to electrical devices near.
- As the Magnetic Equator has moved to the West there is no magnetometer under the Equatorial Electro Jet.
- EEJ may amplifies the geomagnetic variations that give origin to the GIC. Need to have more focus on research.



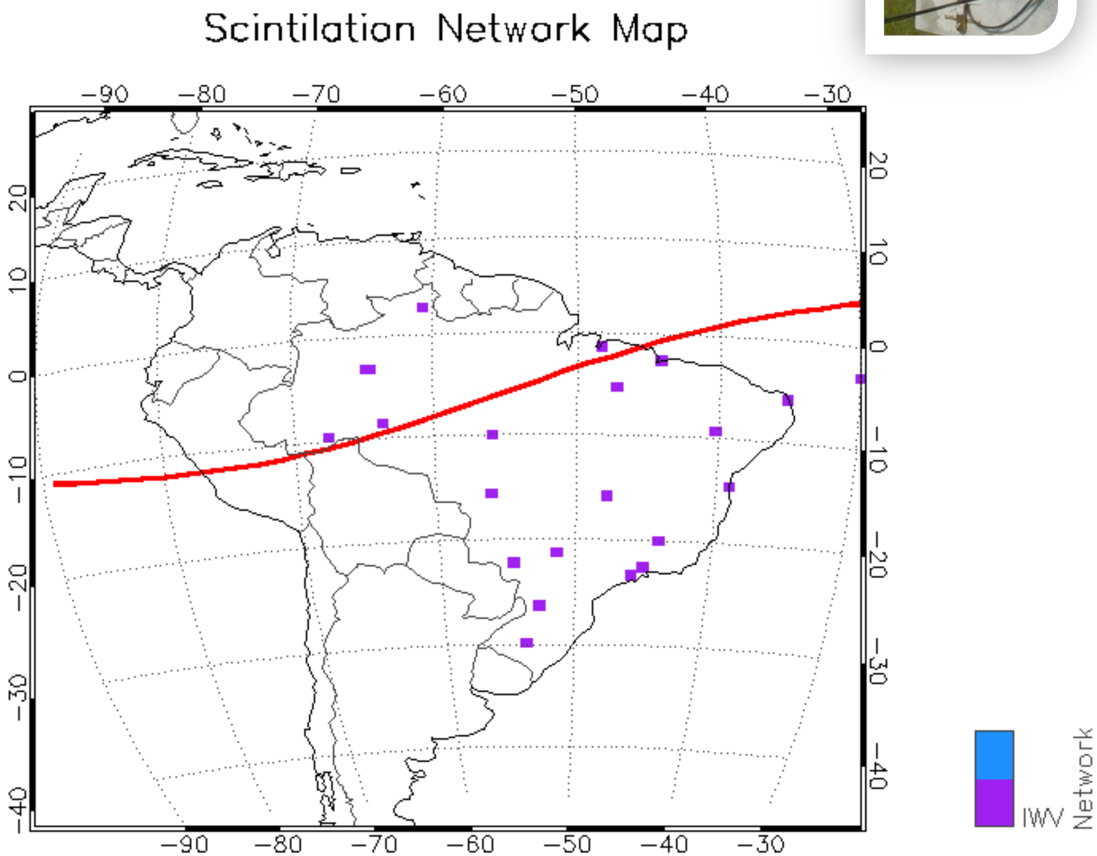
# Airglow Network
# Net: EMBRACE

- Low density network.
- Very important for the plasma bubble monitoring.
- Suffers from adequate sites without light pollution, clear sky and infrastructure.
- Need investment in F-P interferometer to understand better the plasma irregularity called plasma bubble.
- Two F-P were acquired to measure thermospheric winds and temperature (EMBRACE).
- Initial discussion with **Dr. Qian Wu -NCAR** (2 FPI) to be part of a North_South network.
- Initial discussion with **Dra. Hsieh, Syau-Yun** (John Hopkins) (4 All-Sky) to be deployed in Brazil



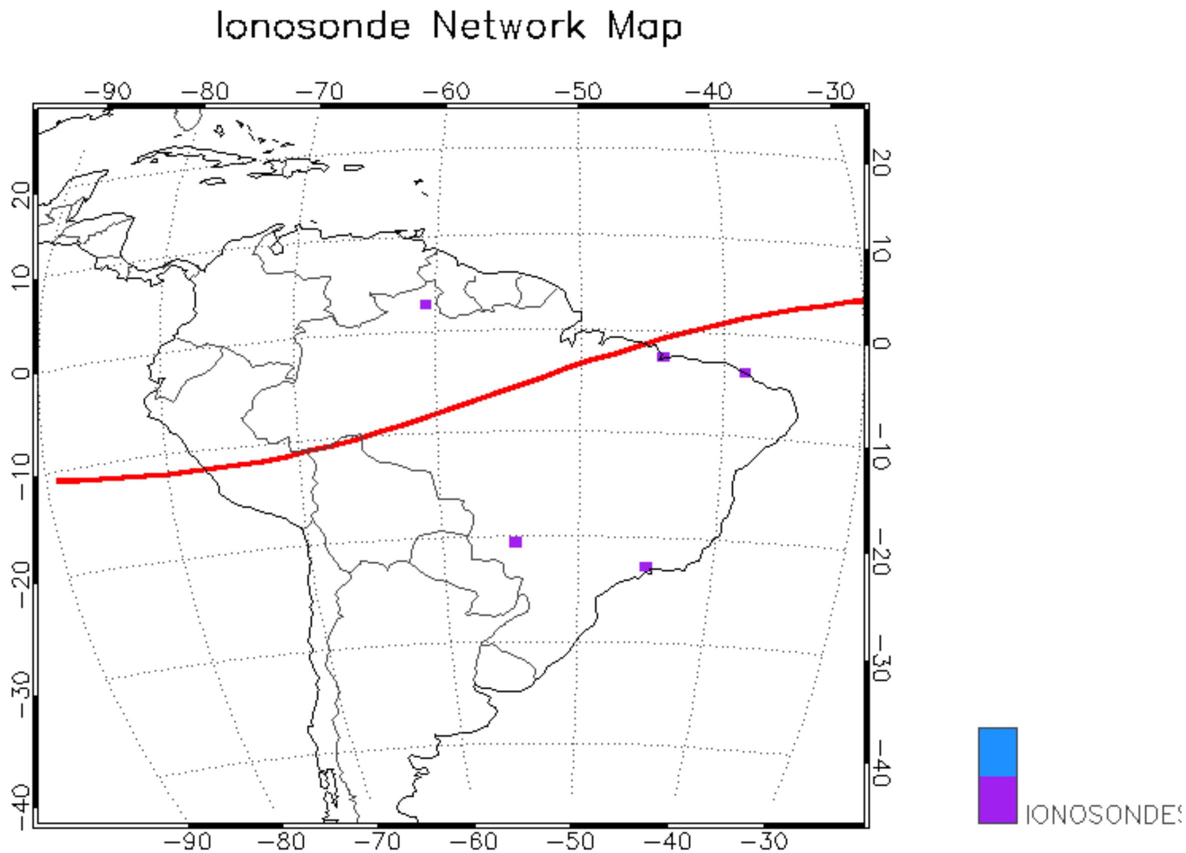
# GNSS Network with S4 index
# Net: EMBRACE

- Low density network.
- Very important for monitoring disturbance in radio wave propagation (index S4, others).
- The full network suffers from old GNSS receivers without capability to measure scintillations.



# Ionosonde Network
# Net: EMBRACE

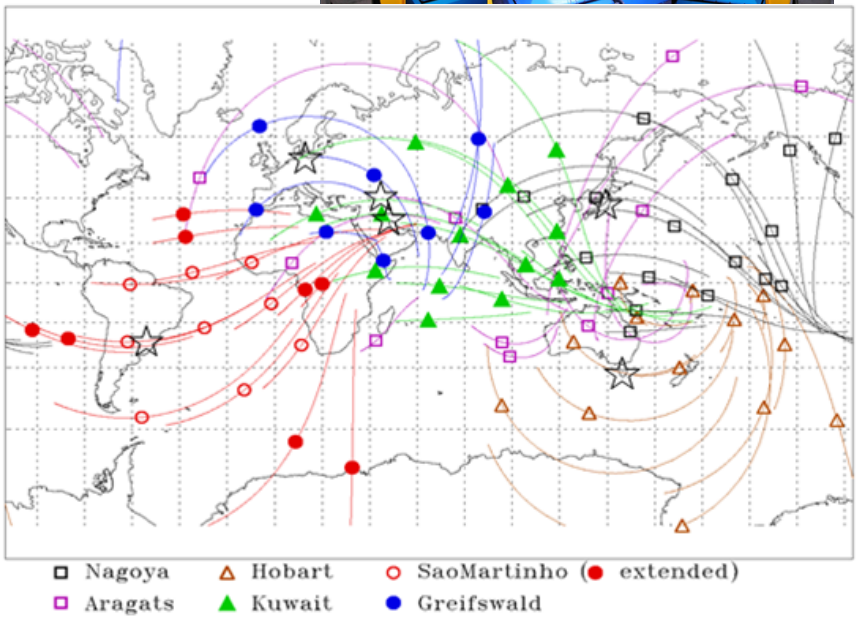
- Low density network.
- Need Ionosondes at the crest of the anomaly.
- Lack of local technical/scientific training to stimulate the partnership in planned strategic sites.



# Other Networks

## EMBRACE-Brazil

A muon detector part of the Global Muon Detector Network –GMDN
Shinshu University




1)Nagoya, Japan; 2)Hobart, Australia; 3)City of Kuwait, Kwait; 4)São Martinho da Serra, Brazil

## SCiESMEX-Mexico

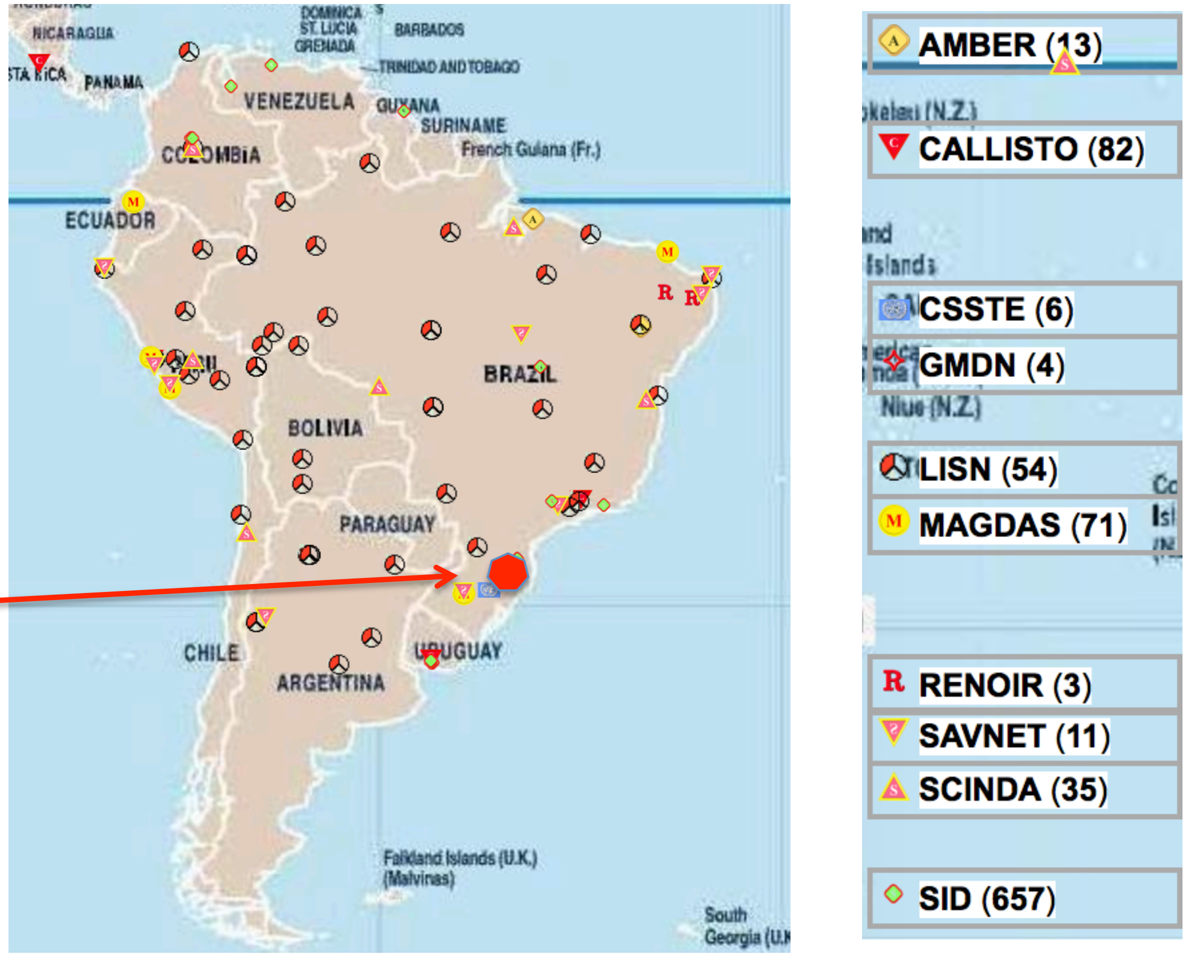
A radiotelescope MEXART, an array of 4096 dipoles operating at 140 MHz to track solar wind large-scale disturbances using the interplanetary scintillation technique.

Source: Mejia-Ambriz et.al, Solar Phys (2010) 265: 309–320

# ISWI Network

The majority of the ISWI instruments in the South America are in the LISN network.

**ISWI in Brazil** (48) *AMBER(2), CALLISTO(2), CSSTE(1), GMDN(1), LISN(22), MAGDAS(2), RENOIR(2), SAVNET(6), SCINDA(3), SID(7)*




## NSSC - International Meridian Circle Project.

- Ionosonde(1)
- Magnetometer(1)
- GNSS (1)
- All Sky (1)

# Conclusions

- **The cooperation among existent research groups** must be within association with an Operational Center for SW (RWC) and follow an operational approach:
  - The Operational Center (e.g. RWC) commit **to monitor the pipeline** of the instrument data to report quickly to the PI of instruments any interruption. Assuring an efficient duty cycle.
  - The Operational Center commit to **organize a data bank and promptly release** the information.
  - The Operational Center may **offer some technical support** for the instrument maintenance when needed (not always possible).
  - Initiatives to deploy instruments such as ISWI should always **use the support of an Operational Center** to be responsible for the instrument operation.
- International initiatives should work hard for the **creation of data banks of data from ground and space based instruments in data servers around the world** to enable the Operational Centers to collect data directly from the **data servers**.
- Foment **open data police**.
- In strategic areas **foment local technical/scientific training** to stimulate the partnership and assure continuity of the instrument operation. Training through capacity building schools.
- Offer **technical support scholarships**.