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DEPARTAMENTO DE ENGENHARIA CARTOGRÁFICA

# **A Glimpse at Geodetic Activities in Latin America**

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GGOS Coordinating Board member-at-large

**GGOS Day 2016**

Harvard – Smithsonian Center for Astrophysics

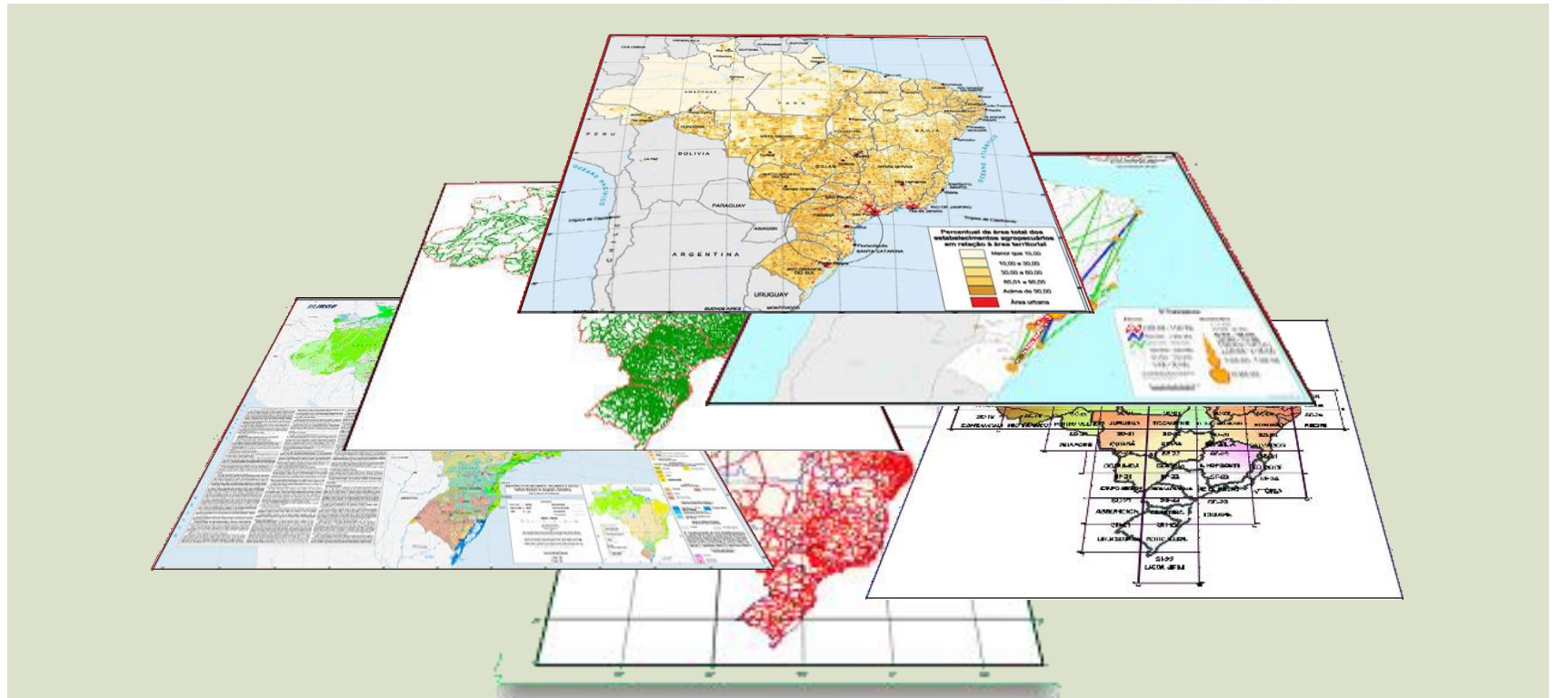
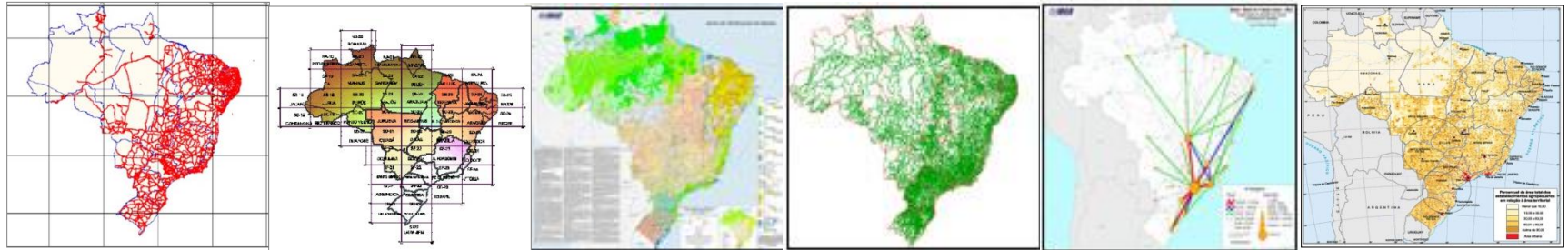
October 24-27, 2016



# Contents

- Introduction
- SIRGAS
- UN-GGIM: Americas
- Final remarks

# Geospatial Information layers



**Geodetic information corresponds to the basic layer of National Spatial Data Infrastructures, providing positional reference to any territorial component**

# Importance of a unified and precise Geodetic Reference System

Example: construction accident in São Paulo in 2001 when a GPS controlled machine hit a oil pipe due to the use of inconsistent reference systems

- 2,000 people had to leave their homes for 28h
- Highway blocked for 12hs
- Fortunately, no people injured





# SIRGAS – A multi-national initiative

## • Before SIRGAS

- ✓ South American countries adopted different reference systems causing problems to define borders, for mapping, etc.
  - PSAD56, SAD69, Bogotá, Yacaré, Campo Unchauspe
- ✓ Classical systems not accurate comparing to GNSS

## • Establishment of the SIRGAS Project

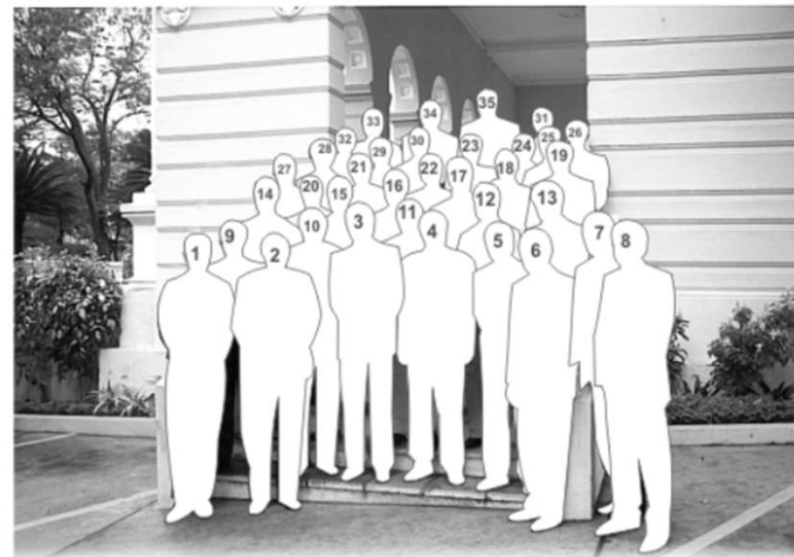
- ✓ Conference in October 1993, Asunción, Paraguay

## • Objectives

- ✓ To define and establish a **geocentric reference system** for the continent
- ✓ To define and establish a geocentric datum
- ✓ To define and establish a unified **vertical datum**



(1) Robert Zebell (USA), (2) Knud Poder (Dinamarca), (3) Rubén Rodríguez (Argentina), (4) Wolfgang Torge (Alemania), (5) Muneendra Kumar (USA), (6) Lorenzo Centurión (Paraguay), (10) Ezequiel Pallejá (Argentina), (13) Sergio Bruni (Brasil), (14) Herve Fagard (Francia), (15) James Richardson (USA), (16) José Luis Caturfa (España), (17) Luiz Paulo Fortes (Brasil), (18) Michael Pinch (Canadá), (19) Benjamin Fernández (Colombia), (22) Hermann Drewes (Alemania), (23) Susana Arciniegas (Ecuador), (24) Alberto González (Colombia), (25) Oscar Cifuentes Zambrano (Chile), (26) Alfredo Stahlschmidt (Argentina), (27) Walter Subiza (Uruguay), (28) Edvaldo Fonseca Junior (Brasil), (29) Oscar Niño (Venezuela), (30) Eduardo Elinan (USA), (31) Jorge König (Argentina), (32) Melvin Hoyer (Venezuela), (33) José Napoleón Hernández (Venezuela), (34) Gunter Seeber (Alemania), (35) David Lehman (USA)

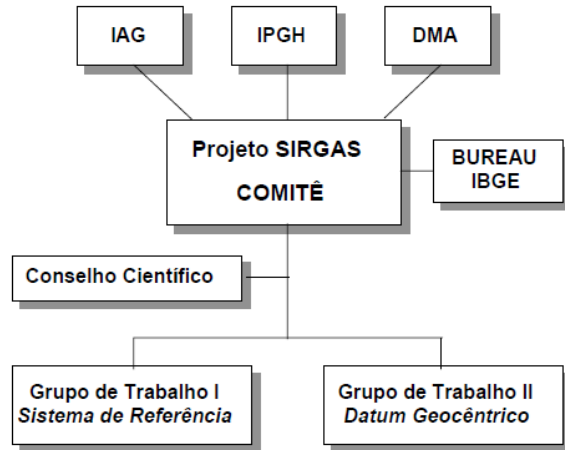


- “**South American Geocentric Reference System**” (1993-2001)
- “**Geocentric Reference System for the Americas**” (2001-...)
- IAG Subcomission 1.3b: Reference Frames / Regional Reference Frames / South and Central America
- PAIGH Working Group
- **SIRGAS**, as a reference system, is defined identically to the *International Terrestrial Reference System (ITRS)*
- **SIRGAS**, as a reference frame, is a regional densification of the *International Terrestrial Reference Frame (ITRF)*

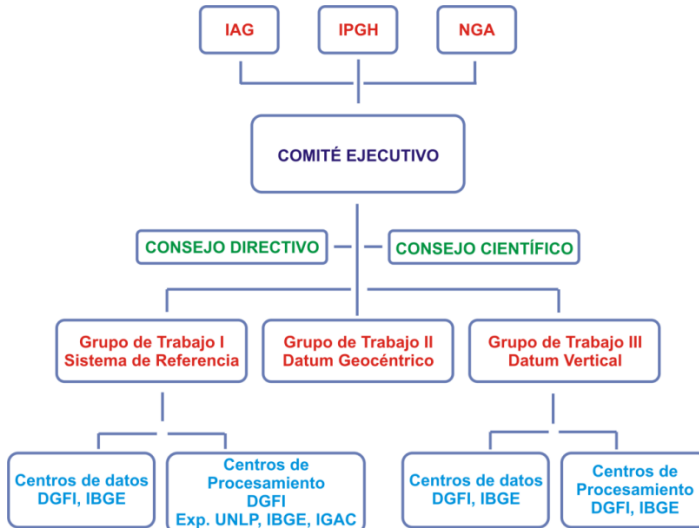


# SIRGAS Structures along the journey...

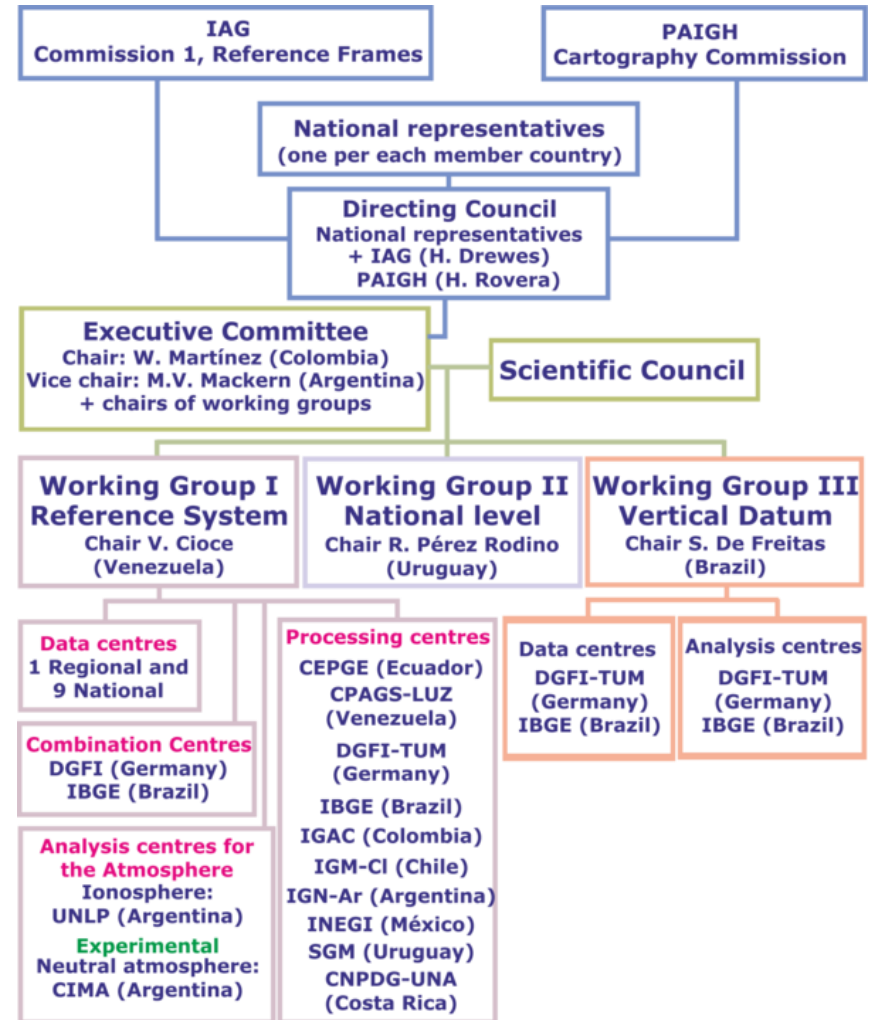
**1993 – 1997**



**1997 -2011**



**2011...**



Status 2015-11-21

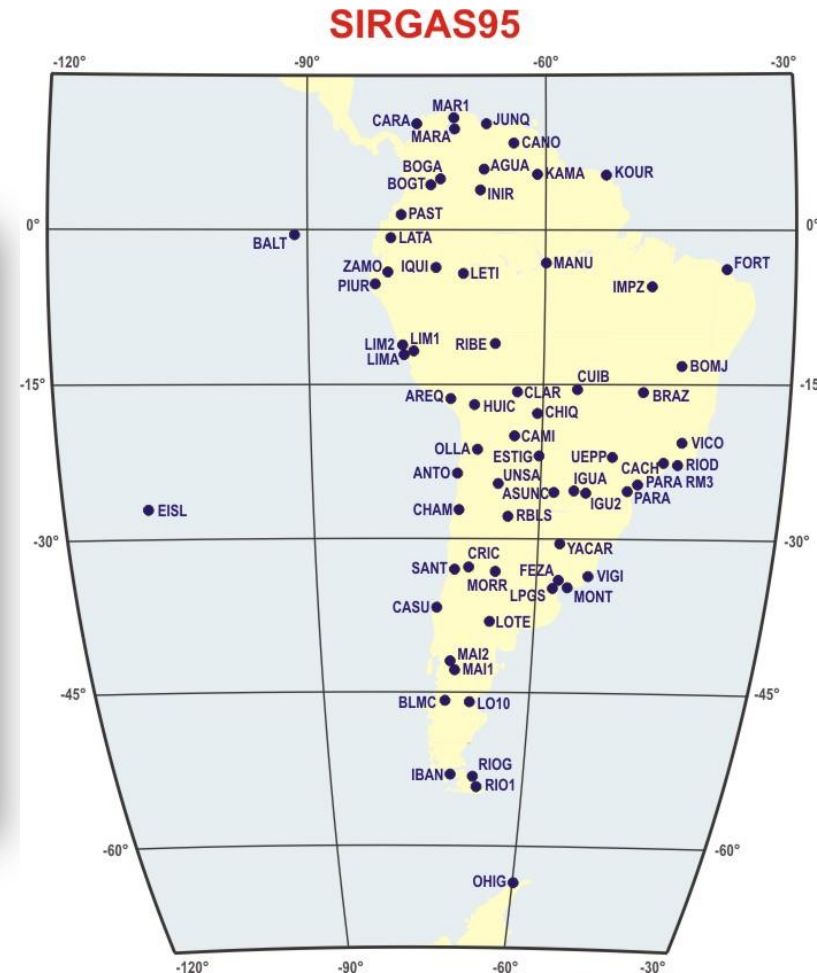
(source: [www.sirgas.org](http://www.sirgas.org))



# First SIRGAS Campaign (1995)

- From **May 26 1995, 00:00h (UTC)** to **June 4, 1995, 24:00hs (UTC)**
- 58 stations
- 30 institutions
- 11 countries
- 3 processing centres

Argentina	10
Bolivia	6
Brasil	11
Chile	8
Colombia	5
Ecuador	3
Guiana Fr.	1
Paraguay	2
Perú	4
Uruguay	3
Venezuela	5
<b>TOTAL</b>	<b>58</b>



(source: [www.sirgas.org](http://www.sirgas.org))

***“An extremely well executed project”***

Wolfgang Torge, President of IAG, XXI IUGG General Assembly 1995, Boulder



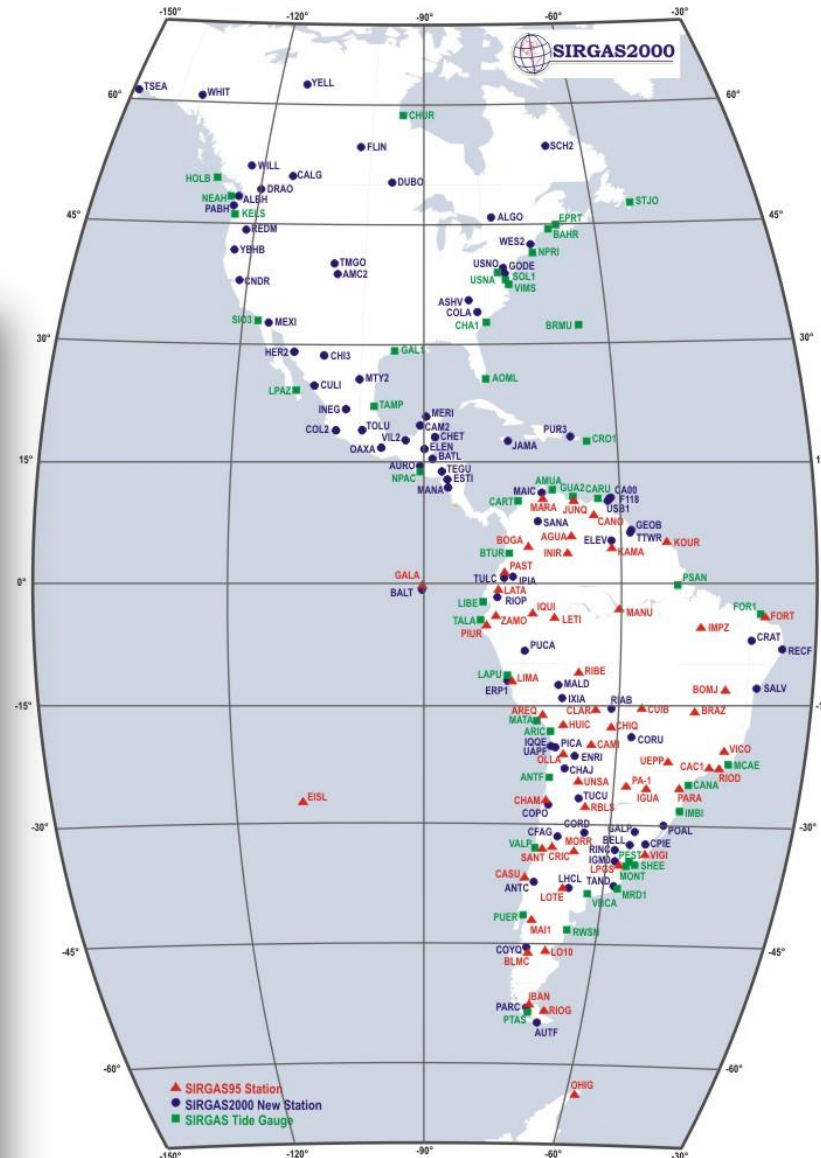


# Second SIRGAS Campaign (2000)

- From **May 10, 2000, 00:00h (UTC)** to **May 19, 2000, 24:00hs (UTC)**
- 184 stations
- 24 countries

Table 1. Distribution and types of stations in the countries

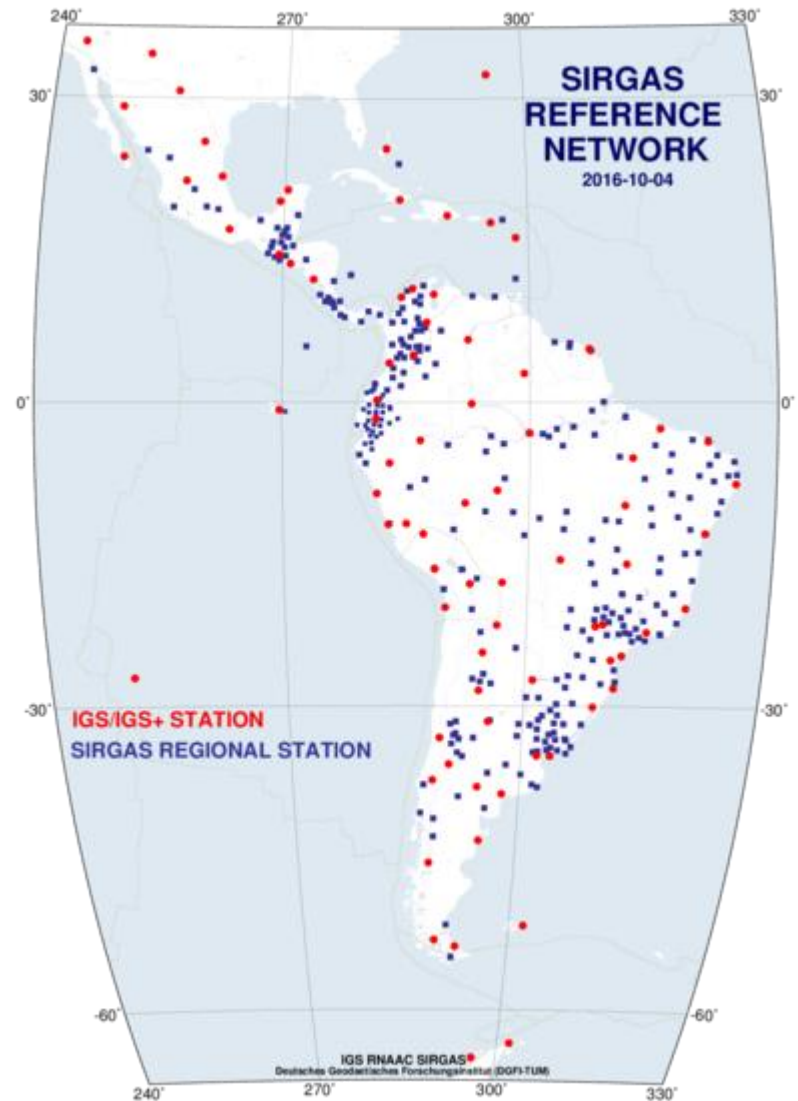
Country (Island)	SIRGAS 1995	New Site	Tide Gauge	Total No.
Argentina	10	7	3	20
Bermuda	-	-	1	1
Bolivia	6	3	-	9
Brazil	11	5	5	21
Canada	-	10	3	13
Chile	7	8	5	20
Colombia	5	2	1	8
Ecuador	3	3	1	7
Fr. Guiana	1	-	-	1
Guatemala	-	3	1	4
Guyana	-	2	-	2
Honduras	-	1	-	1
Jamaica	-	1	-	1
Mexico	-	13	2	15
Nicaragua	-	2	-	2
Paraguay	1	-	-	1
Puerto Rico	-	1	-	1
Saint Croix	-	-	1	1
Peru	4	3	3	10
Trinidad&Tobago	-	2	-	2
Uruguay	2	4	2	8
USA	-	12	12	24
Venezuela	5	3	3	11
Antarctica	1	-	-	1
Sum	56	85	43	184



(source: [www.sirgas.org](http://www.sirgas.org))

# SIRGAS-CON Network

- SIRGAS Continuous Operation Network
- GNSS stations with coordinates and velocities determined with very high accuracy (referred to a specific epoch)
- Oct 2016: ~400 stations, with 59 out of them belonging to IGS
- Monitors the SIRGAS frame



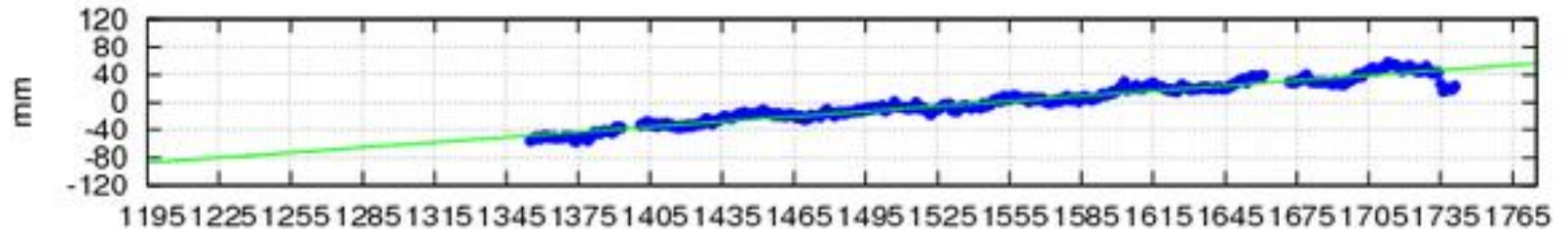
(source: [www.sirgas.org](http://www.sirgas.org))

# Time series - NAUS (Manaus - Brazil)

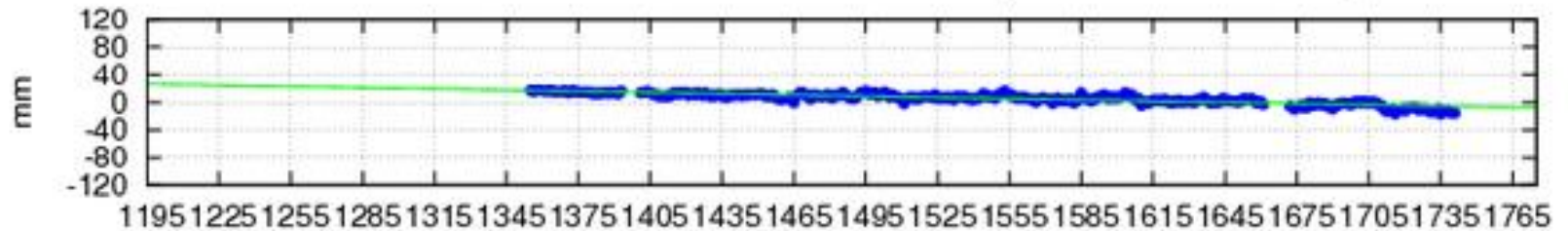


NAUS - Velocidade Planimetrica  $0.01333 \pm 0.00024$  m/ano

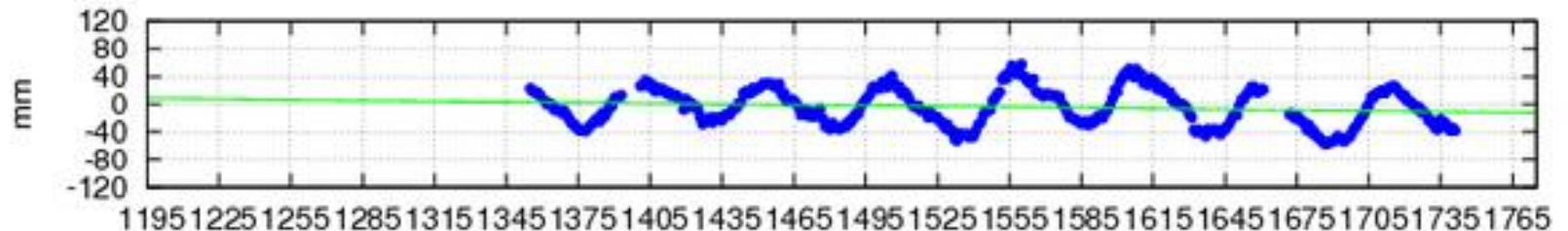
Norte - Coef =  $0.24837 \pm 0.00415$  mm/semana ( $0.01295 \pm 0.00022$  m/ano )



Leste - Coef =  $-0.06067 \pm 0.00187$  mm/semana ( $-0.00316 \pm 1e-04$  m/ano )

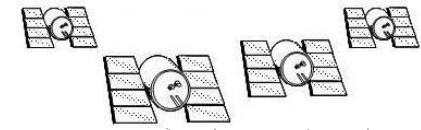
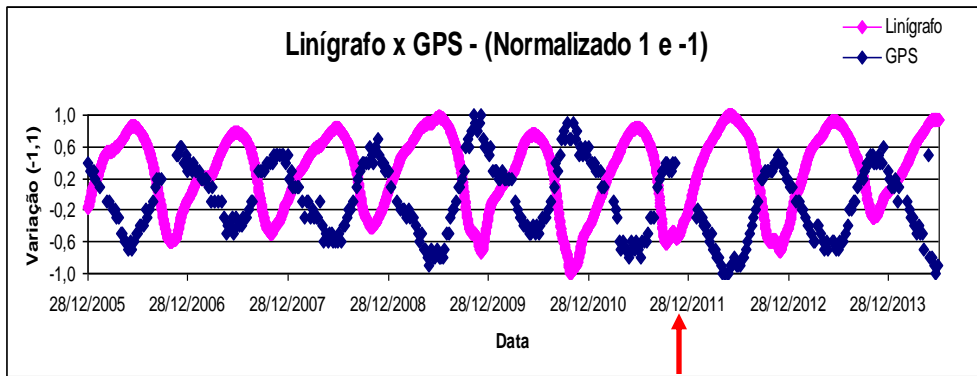


Altura - Coef =  $-0.03711 \pm 0.0113$  mm/semana ( $-0.00194 \pm 0.00059$  m/ano )



Semana GPS

# Time series – NAUS station height vs. river water level



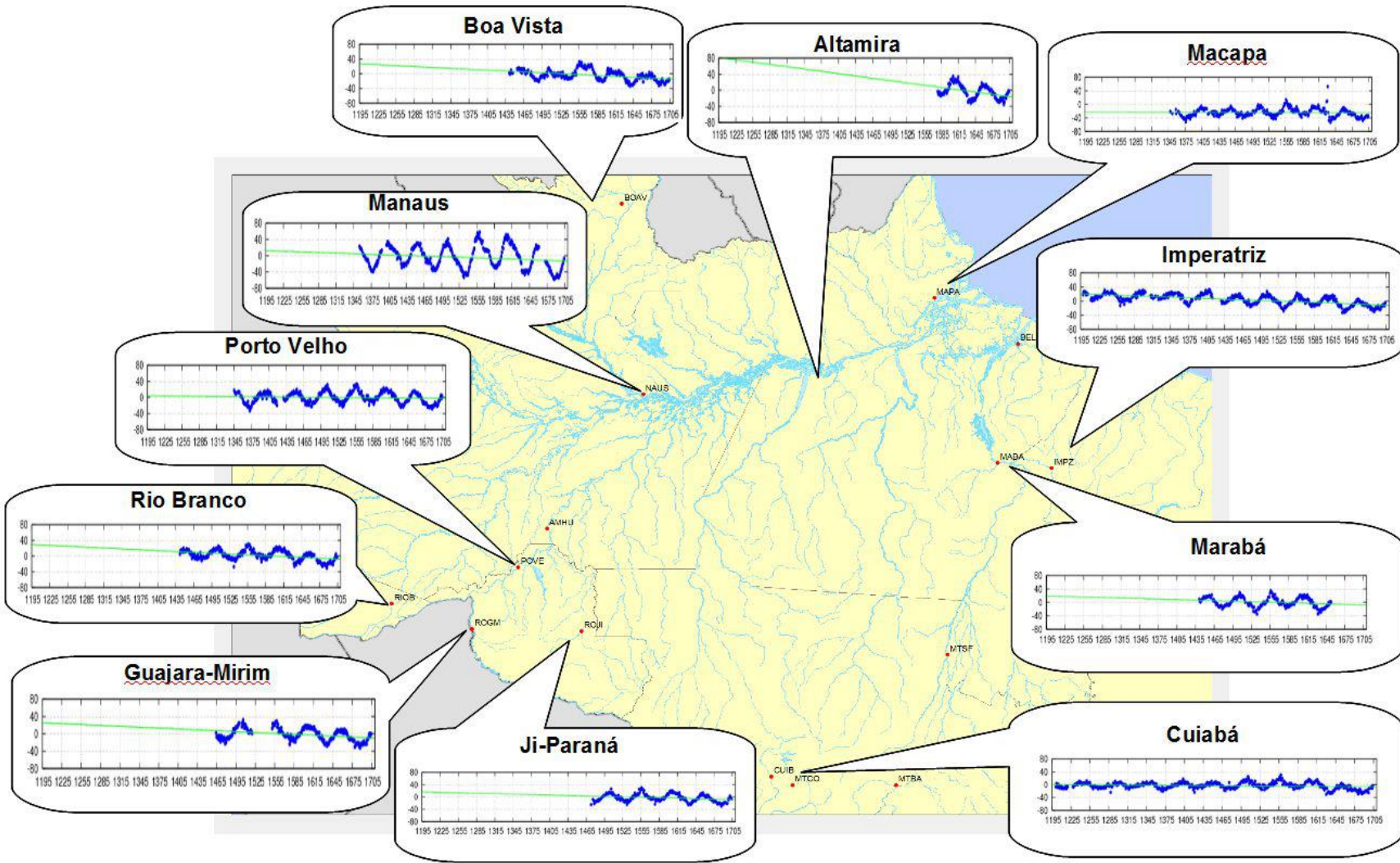
~ 13 km

$\Delta h$  (max) ~ 11 cm

$\Delta Z$  (max) ~ 16 m

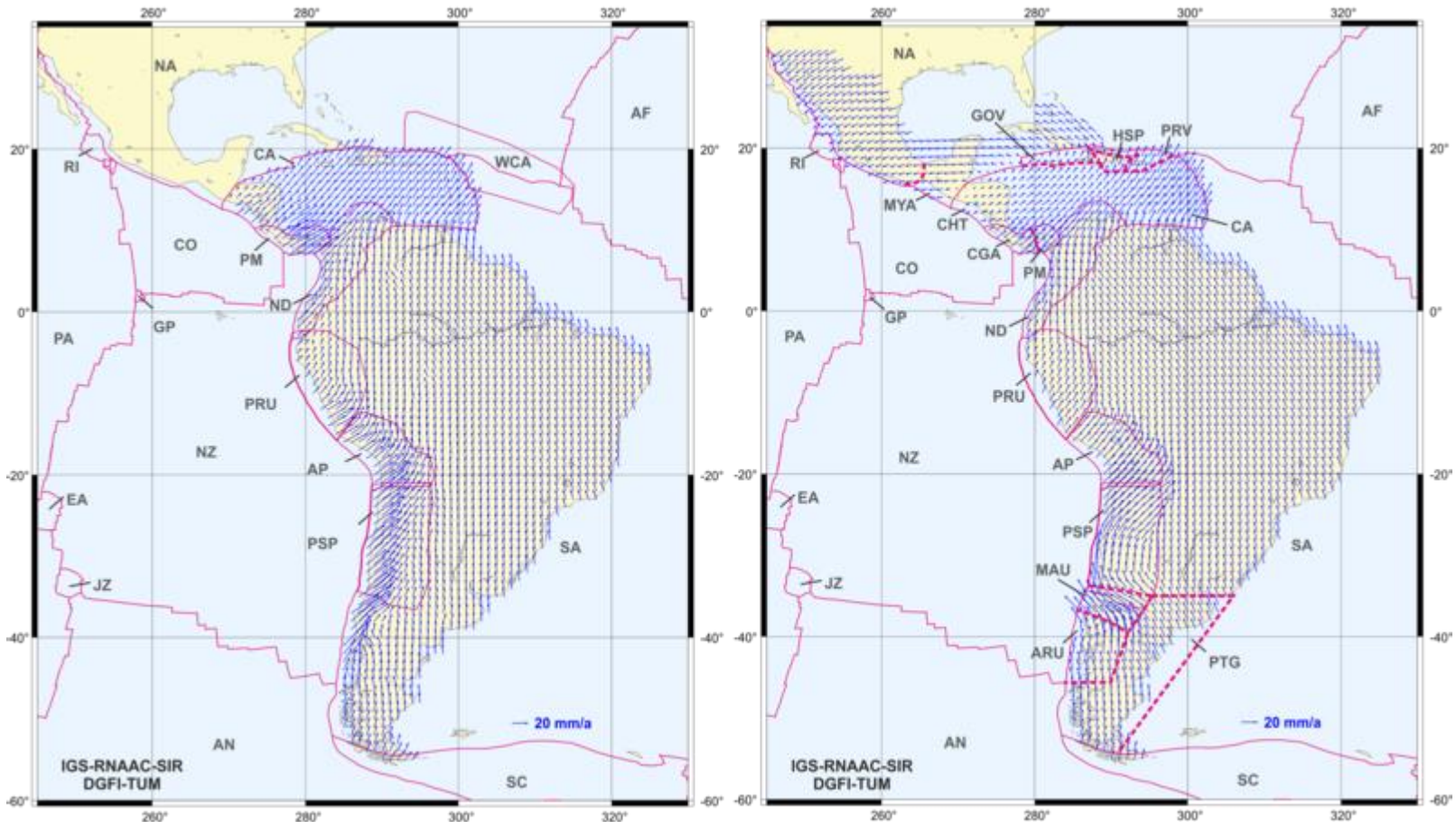
Bevis et al. *Seasonal fluctuations in the mass of the Amazon River system and Earth's elastic response*. Geophysical Research Letters, Vol. 32, L16308, pp. 1-4, 2005

# GNSS CORS heights in and around the Amazon



(source: [www.ibge.gov.br](http://www.ibge.gov.br))

# Velocity Models for South America and the Caribbean



VEMOS2009 (left) referred to the ITRF2005 (Drewes and Heidbach 2012), and VEMOS2015 (right) referred to IGb08 (Sánchez and Drewes 2016)

(source: [www.sirgas.org](http://www.sirgas.org))



# Adoption of a SIRGAS Reference Frame

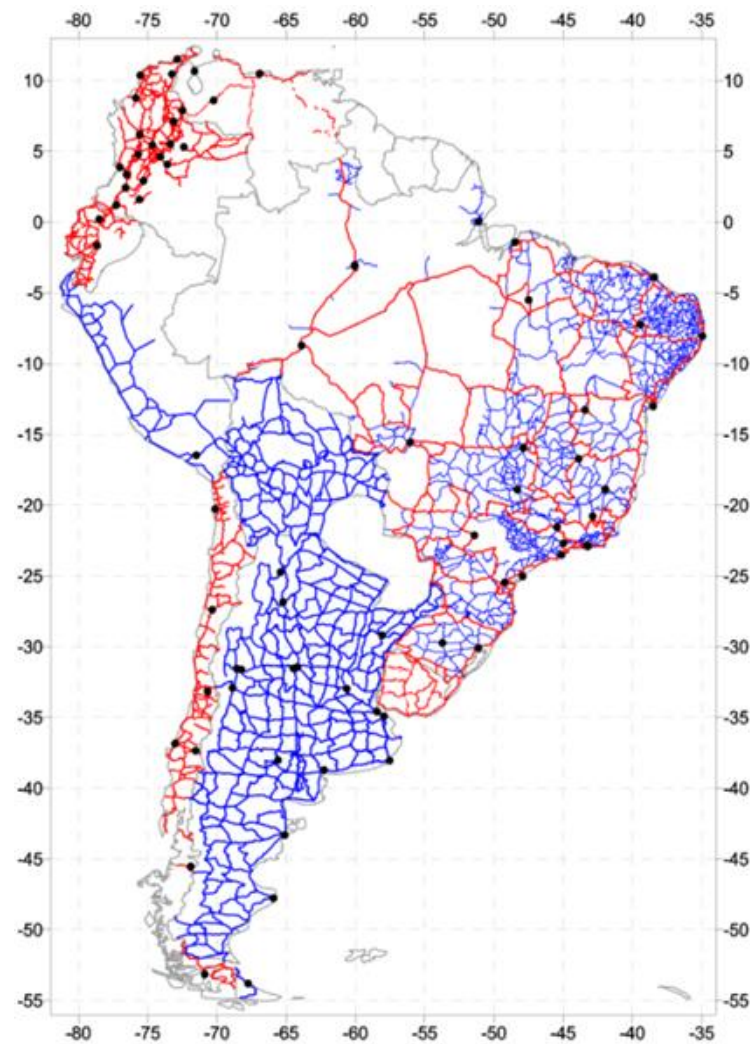
- **Resolution 4** of the **7<sup>th</sup> UNRCC-A** (2001) recommended the adoption of a SIRGAS-compatible reference frame by countries of the Americas
- **Resolution 7** of the **8<sup>th</sup> UNRCC-A** recommended the integration of Central America and Caribbean countries to SIRGAS
- SIRGAS supported the solution of **Ecuador and Peru boundary conflict** , the longest one in the Americas (since 1800s!)
- Currently: **20** member countries
  - South America: 12
  - Central America: 6
  - North America: 1
  - Caribbean: 1

Country	National Reference Frame
Argentina	ITRF2005, epoch 2006.6
Bolivia	SIRGAS95, epoch 1995.4
Brazil	SIRGAS2000, epoch 2000.4
Chile	SIRGAS2000, epoch 2002.0
Colombia	SIRGAS95, epoch 1995.4
Costa Rica	ITRF2000, epoch 2005.8
Ecuador	SIRGAS95, epoch 1995.4
El Salvador	SIRGAS, epoch 2007.8
French Guyana	ITRF93, epoch 1995.0
Guatemala	SIRGAS
Mexico	ITRF2008, epoch 2010.0
Panama	SIRGAS2000, epoch 2000.0
Peru	SIRGAS95, epoch 1995.4
Uruguay	SIRGAS95, epoch 1995.4
Venezuela	SIRGAS95, epoch 1995.4

(source: [www.sirgas.org](http://www.sirgas.org))

# SIRGAS Vertical Reference System

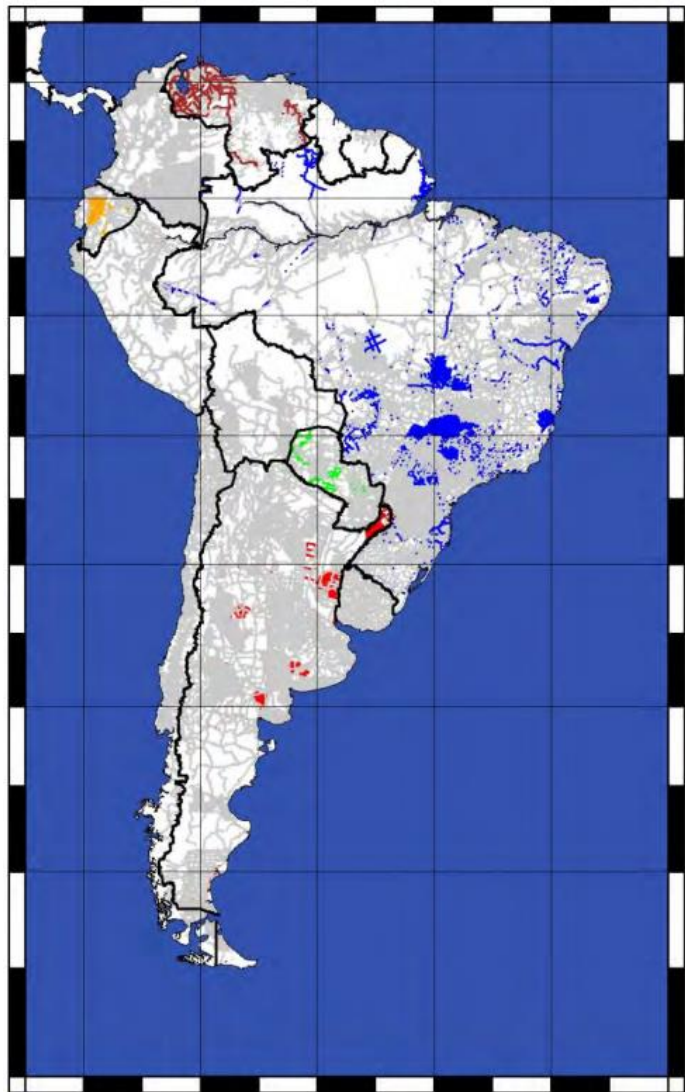
- Based on a **geometrical component** (SIRGAS ellipsoidal heights) and a **physical component** ( $W_0$  as a reference level and geopotential numbers as primary coordinates)
- It should refer to a unified global reference level  $W_0$
- Be given by proper **physical heights** (derived from spirit levelling in combination with gravity reductions)
- Be associated to a specific **reference epoch**
- Next activity: **SIRGAS WG III Workshop**, Nov 21-25, 2016, Quito, Ecuador



(source: Brunini et al. 2011, [www.sirgas.org](http://www.sirgas.org))



# Gravity Data and the Geoid



-80° -70° -60° -50° -40° -30°

**Colorful points represent recent surveys**

**Modelo geoidal  
(cuasi-geoide)  
en América del Sur**

**GEOID2015**

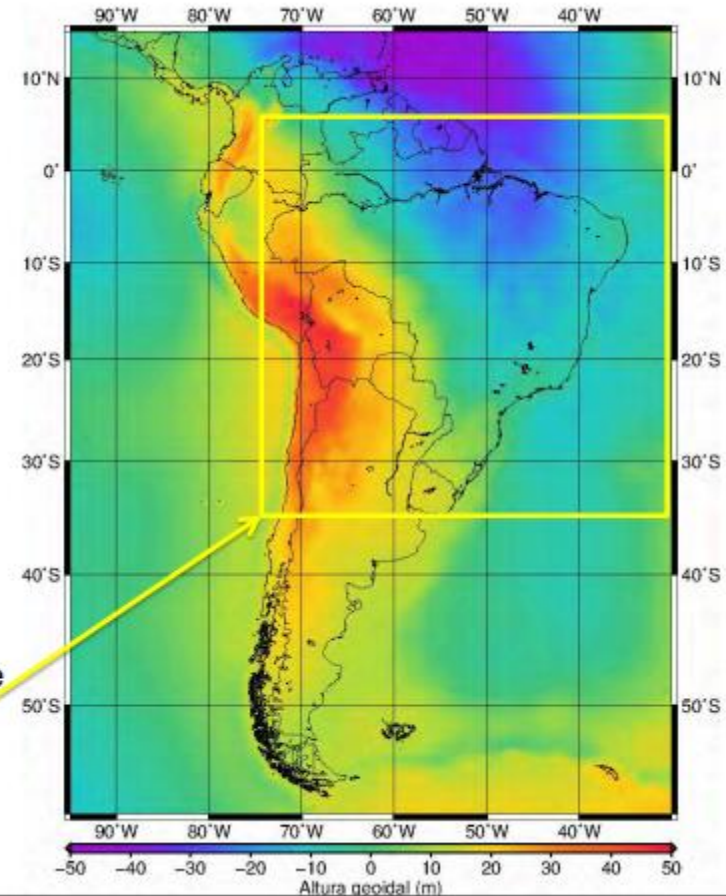
**Dimensión de la red  
5' x 5'**

**15° N y 57° S  
en latitude**

**95° W y 30° W  
en longitude**

International Service for the  
Geoid (ISG)

**MAPGEO2015**



**GEOID2015**

(source: Blitzkow et. al., 2015, [www.sirgas.org/index.php?id=240](http://www.sirgas.org/index.php?id=240))

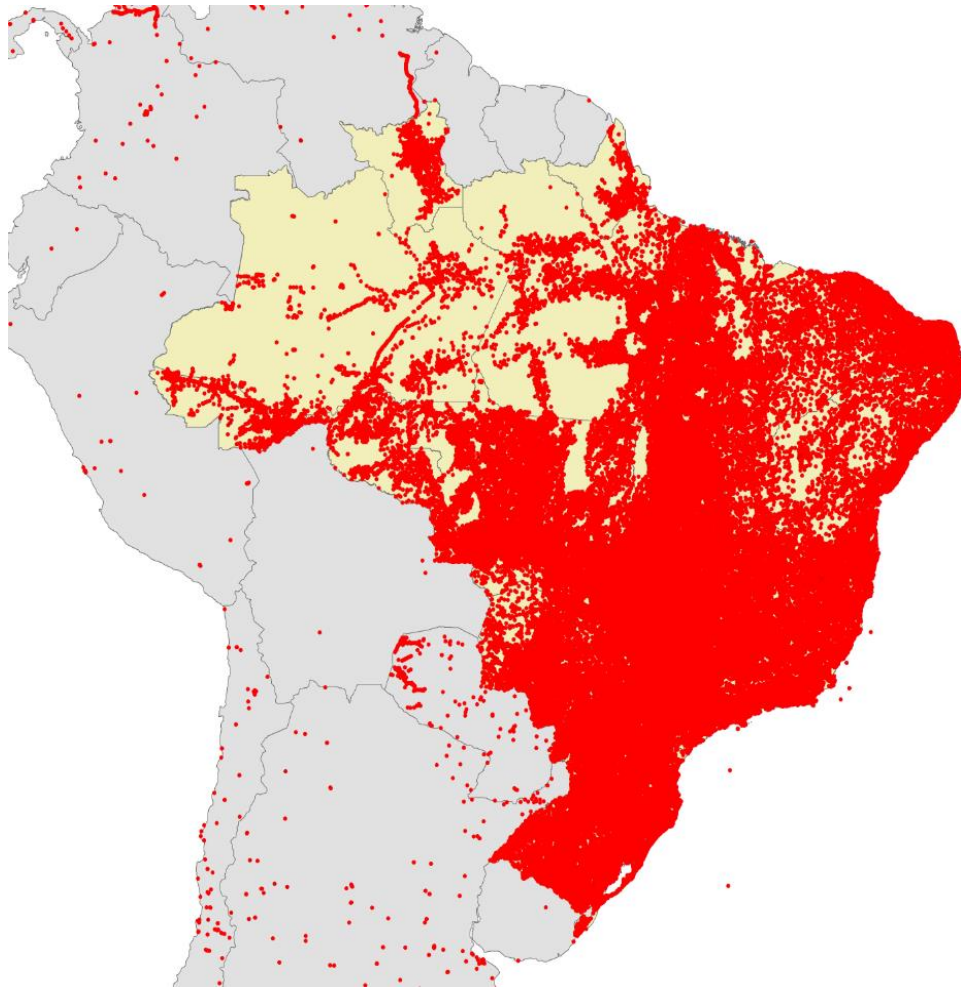
# Other SIRGAS Activities

- **Ionospheric analysis**
  - Universidad Nacional de La Plata (Argentina), official SIRGAS Analysis Centre for the Ionosphere, produces maps of vertical total electron content for the region
- **SIRGAS in Real Time (SIRGAS-RT)**
  - Assessment of SIRGAS capabilities for distributing GNSS corrections and associated data in real time using NTRIP (Networked Transport of RTCM via Internet Protocol) or other similar methods
- **Capacity building in the region**
  - Based on many SIRGAS schools, workshops, simposia, ...
  - SIRGAS 2016 Symposium: Nov 16-18, Quito, Ecuador
- **Combining geodetic techniques (SLR and VLBI) to optimize reference system realization in Latin America**
  - Capacity building project approved by PAIGH
  - Workshop to be held in 2017



Laser Ranging and VLBI Stations  
(source: adapted from [ilrs.gsfc.nasa.gov](http://ilrs.gsfc.nasa.gov) & [ivsc.gsfc.nasa.gov](http://ivsc.gsfc.nasa.gov))

# IBGE-PPP Service (Brazil)



Spatial distribution of IBGE-PPP results  
(source: IBGE)

- In operation since April 2009
- Uses CSRS-PPP tool, developed by [Geodetic Survey Division](#) of Natural Resources Canada (NRCan)
- Horizontal coordinates referred to SIRGAS2000 – propagated to 2000.4 using SIRGAS Velocity Model – VEMOS2009
- GPS static and kinematic results available 2:30 hs after of survey
- GPS&GLONASS results 36 hs after of survey
- ~15,000 processed stations per month



# UN-GGIM: Americas

- United Nations Global Geospatial Information Management (UN-GGIM) Sub-committee for the Americas
  - Formerly PC-IDEA: Permanent Committee on Geospatial Data Infrastructure for the Americas
  - Working Groups
    - Standards and Technical Specifications
    - Integration of Statistical and Geospatial Information
    - Access and Use of Geospatial Information in Disaster Risk Reduction and Climate Change
    - Regional Coordination and Cooperation (focused on the Caribbean)
    - Promotion and Assessment of Spatial Data Infrastructures (SDI)
- Institutional links in the region
  - PAIGH - PC-IDEA – SIRGAS Joint Action Plan 2013-2015
  - PAIGH – UN-GGIM Americas – SIRGAS Joint Action Plan 2016-2020

... both “to expedite the development of spatial data infrastructure of the Americas”

More information on [www.cp-idea.org](http://www.cp-idea.org)



# Final Remarks

- SIRGAS established a very connected network of institutions and people across Latin America ⇒ **its most valuable asset!**
- UN General Assembly Resolution of Feb 26, 2015 on “**Global Geodetic Reference Frame for Sustainable Development**”
  - **First in history** in the area of geospatial information!
  - Acknowledges the importance of a **coordinated global approach** for Geodesy
  - **Proposes a multilateral cooperation in Geodesy**, including geospatial **data sharing**, **capacity building in developing countries** and the establishment of **international standards and specifications**
  - Totally aligned with the efforts carried out in the scope of **SIRGAS** since 1993 towards the modernization and unification of the Geodetic Reference System of the Americas
- Establishment of a permanent **UN-GGIM Sub-Committee on Geodesy** at the UN-GGIM sixth session in New York last August

This scenario represents a unique opportunity for **IAG/GGOS** to foster its activities - globally and regionally!