THE ACHIEVEMENTS: 1993 - 2011

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IBGE - Brazil

United Nations International Meeting on the Applications of Global Navigation Satellite Systems, 13 December 2011, Vienna, Austria

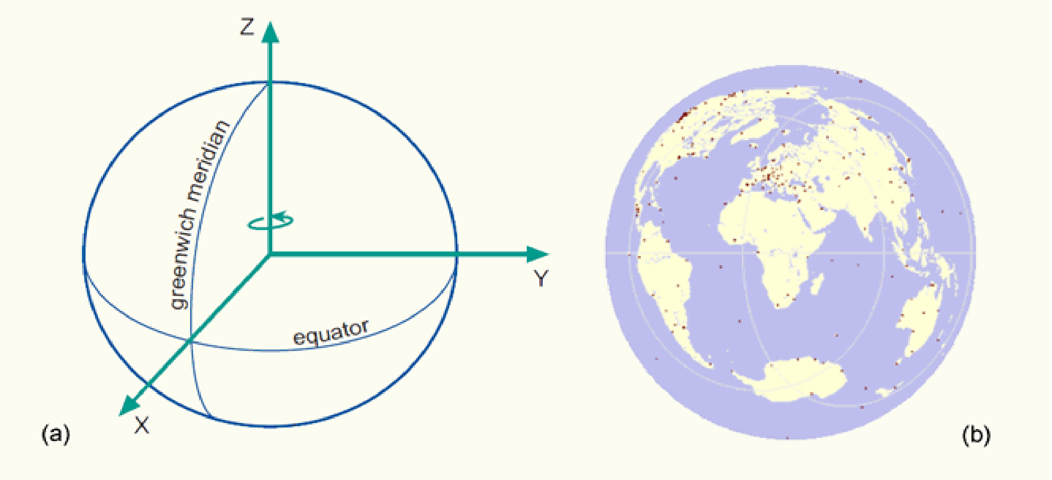
DEFINITION

SIRGAS stands for Geocentric Reference System for the Americas

IAG Sub Commission 1.3b

Working Group of the PAIGH Cartography Commission

- SIRGAS as a reference system is defined identical with the International Terrestrial Reference System (ITRS)
- SIRGAS as a reference frame is a regional densification of the International Terrestrial reference Frame (ITRF)



(a) The International Terrestrial Reference System (ITRS)
(b) The International Terrestrial Reference Frame (ITRF) visualized as a distributed set of ground control stations (represented by red points)

http://www.kartografie.nl

THE BEGINNIG

- SIRGAS was created during the International Conference for the Definition of a South American Geocentric Datum, held from October 4 to 7, 1993, in Asunción, Paraguay.

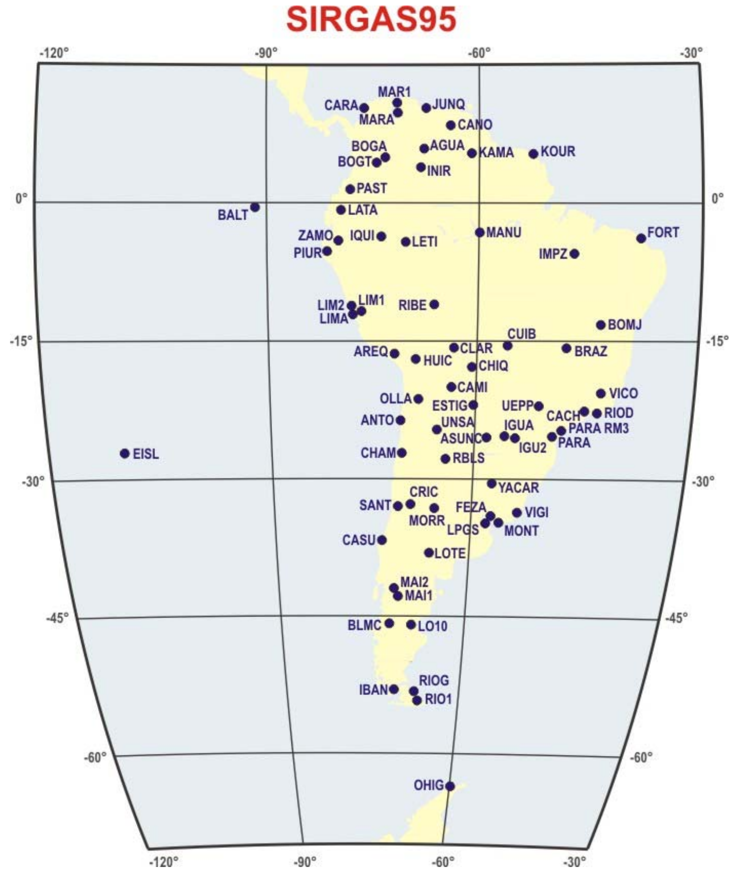
- The Conference was attended by delegations from the most of the of South American countries.

- The development of SIRGAS "Project" comprised the activities needed to the adoption on the continent of a reference network of accuracy compatible with the techniques of satellite positioning, especially those associated with the Global Positioning System (GPS).

THE FIRST CAMPAIGN: 1995

- Measurements from 00:00 (UT), may 26 to 24:00 (UT) June 04.
- 57 stations
- 30 institutions
- 11 countries
- 3 processing centres

Argentina	10
Bolivia	6
Brasil	11
Chile	7
Colombia	5
Ecuador	3
Guiana Fr.	1
Paraguay	2
Perú	4
Uruguay	3
Venezuela	5
Total	**57**



“An extremely well executed project”, Wolfgang Torge, XXI IUGG General Assembly, Boulder.

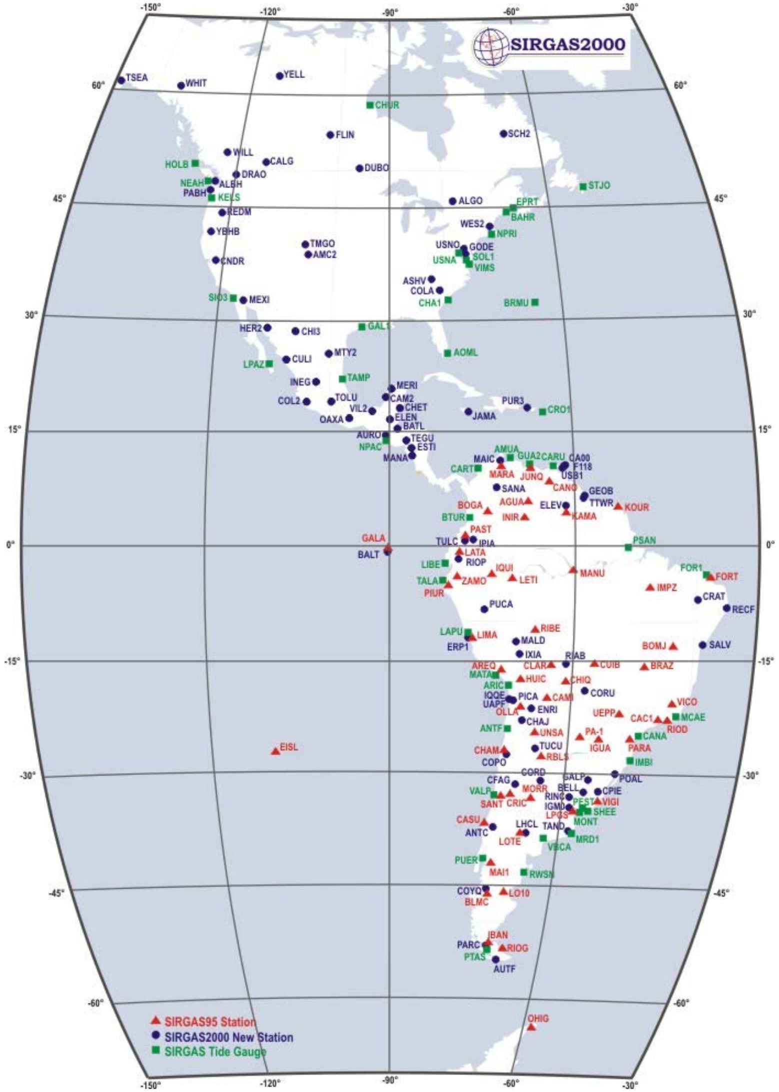
THE SECOND CAMPAIGN: 2000

SIRGAS
www.sirgas.org

- Measurements from 00:00 (UT), May 10 to 24:00 (UT), May 19.
- 184 stations
- 25 countries
- The 2005 campaign stations were re-occupied as well as national tide gauges and international connecting points

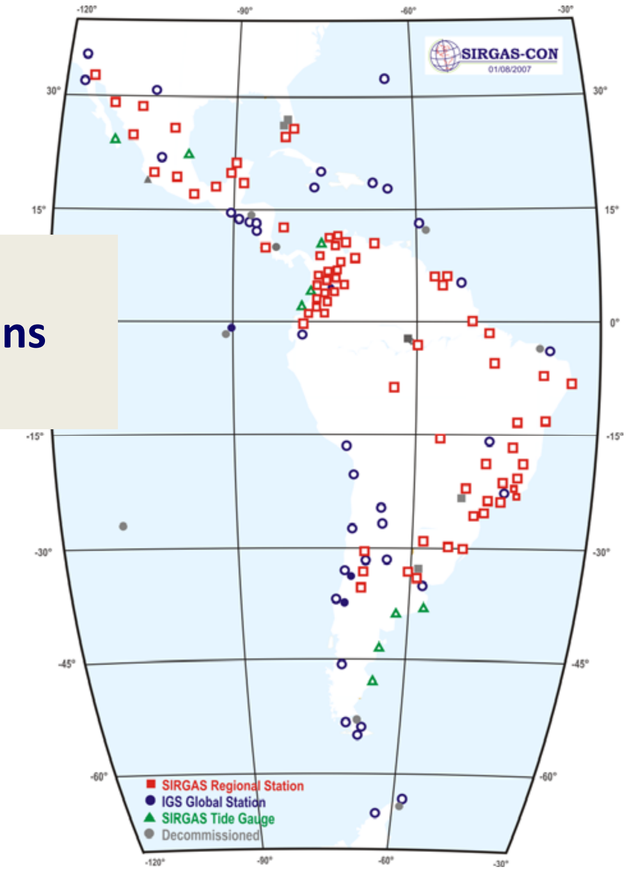
Table 1. Distribution and types of stations in the countries

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



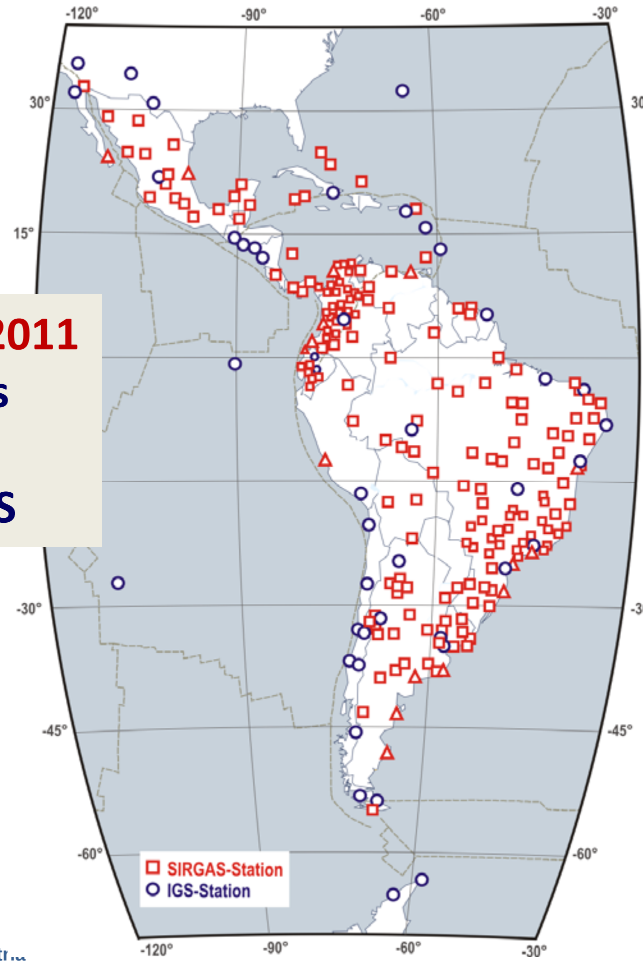
SIRGAS CON NETWORK (1/2)

After 2000, SIRGAS begun its realization by a network of continuously operating GNSS stations with precisely known positions (referred to an specific reference epoch) and their changes with time (station velocities). This SIRGAS Continuously Operating Network (**SIRGAS-CON**) is currently composed by about 250 permanently operating GNSS sites, 48 of them belonging to the global IGS network.



July 2007
149 stations
54 IGS

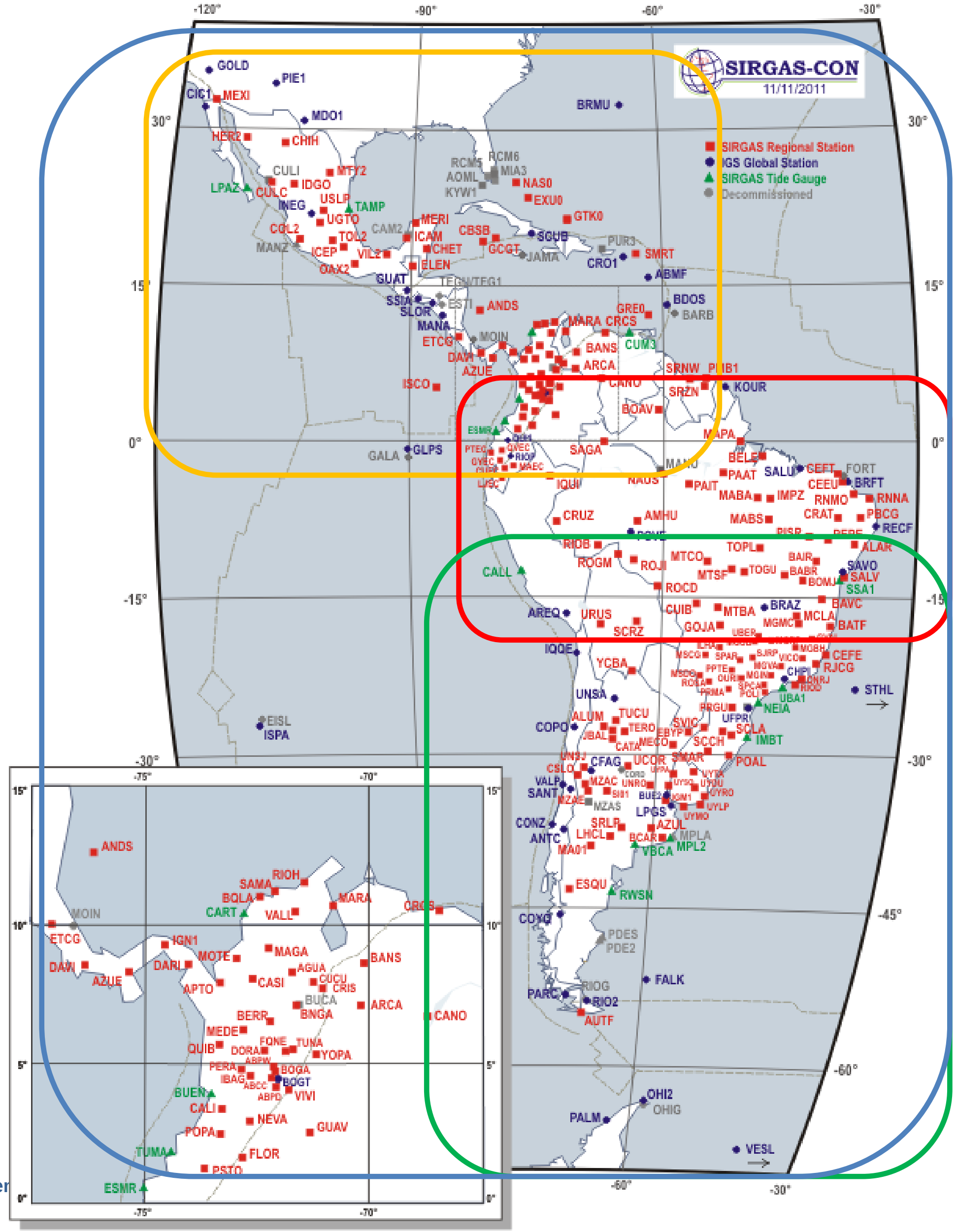
December 2011
250 stations
48 IGS
72 GLONASS



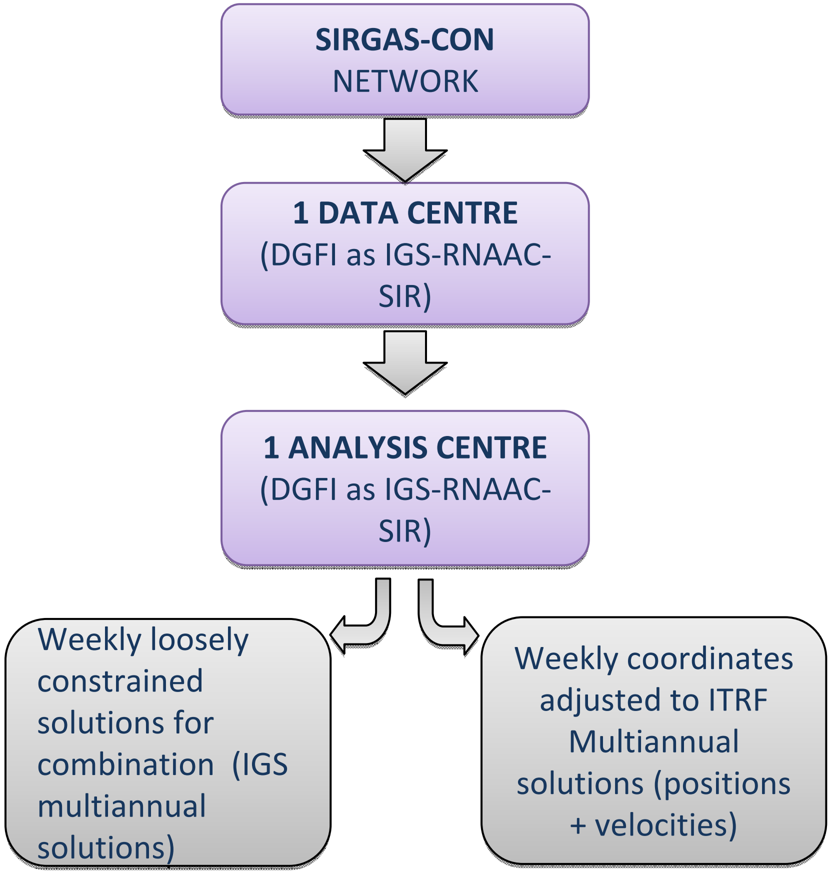
SIRGAS CON NETWORK (2/2)

- National reference frames in Latin America are part of SIRGAS CON.
- The core network (SIRGAS-CON-C) is the primary densification of ITRF in Latin America.
- Densification sub-networks (SIRGAS-CON-D) provide accessibility to the reference frame at local levels.
- Today,t here are three SIRGAS-CON-D sub-networks, but in the future, there shall be given so many SIRGAS-CON-D sub-networks as countries in the region.

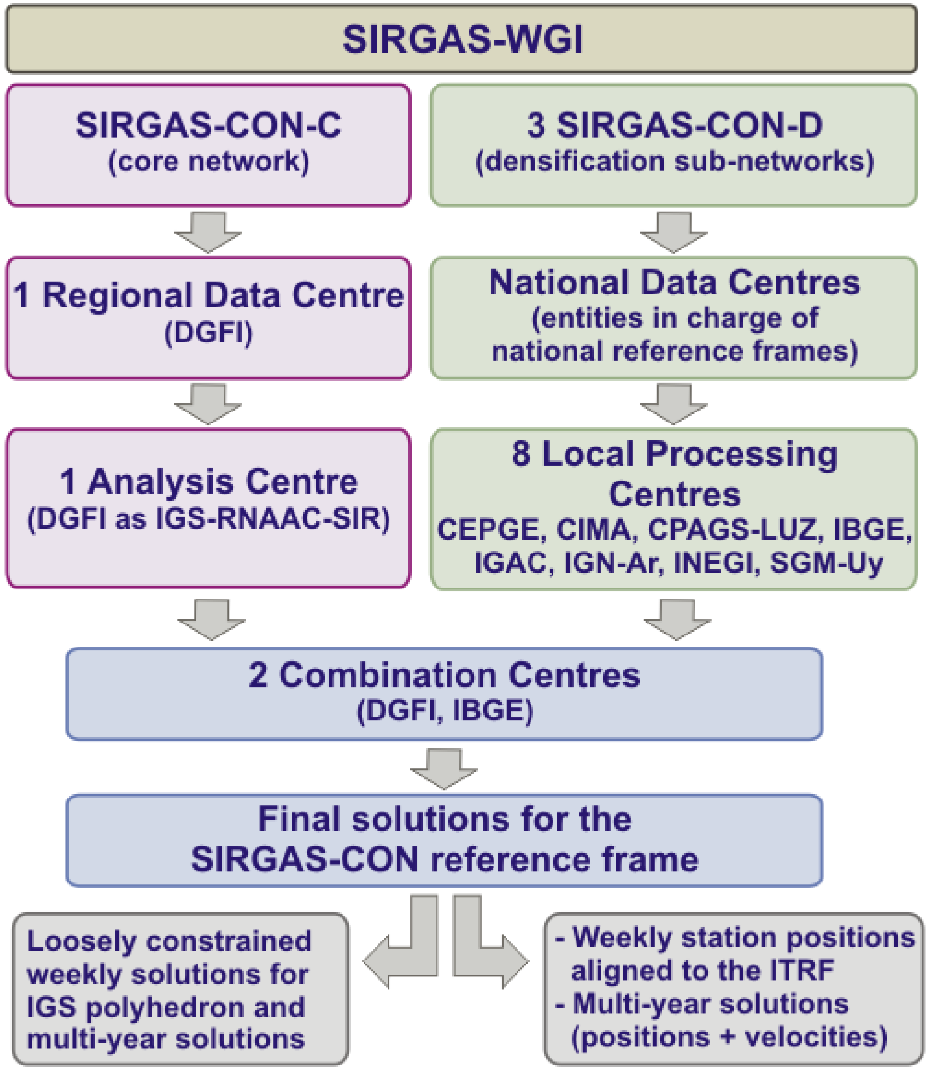
SIRGAS-CON



CHANGES IN DATA ANALYSIS



2007



2011

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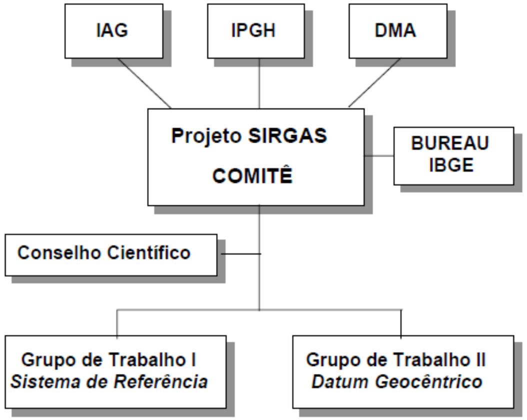
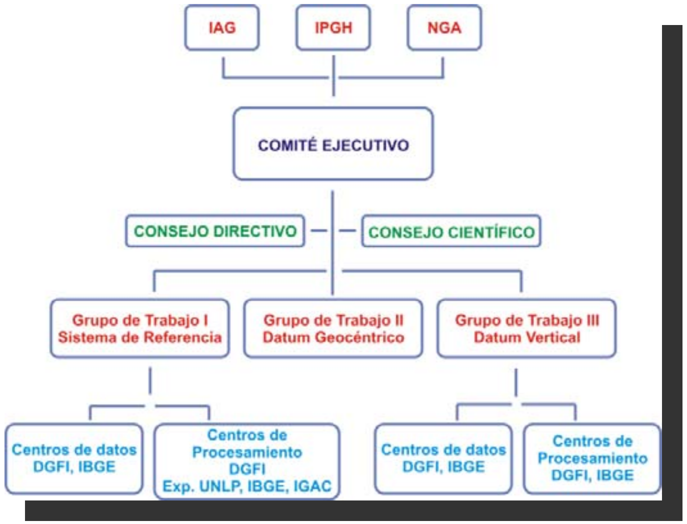
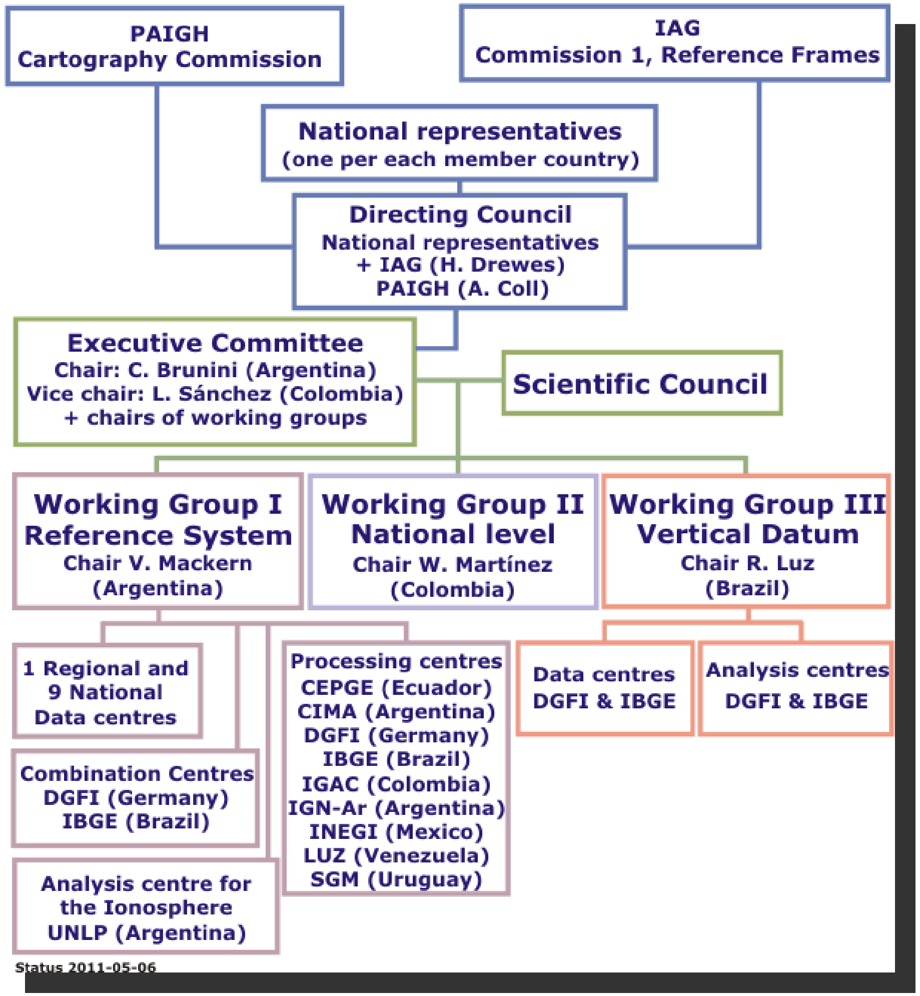
STRUCTURAL EVOLUTION



1993 – 1997



1997 -2011



2011…

PROCESSING

9 processing centres

CEPGE-Ec

CIMA-Ar

CPAGS-Ve

IBGE-Br

IGAC-Co

SGM-Uy

DGFI-De

IGN-Ar

INEGI-Mx

Officially since 2011-01-01

2 combination centres

IBGE-Br

DGFI-De

- Each station is processed by 3 centres
- 2 independent combinations
- Weekly coordinates:

σ = ±1,7 mm in N-E

σ = ±3,7 mm in h

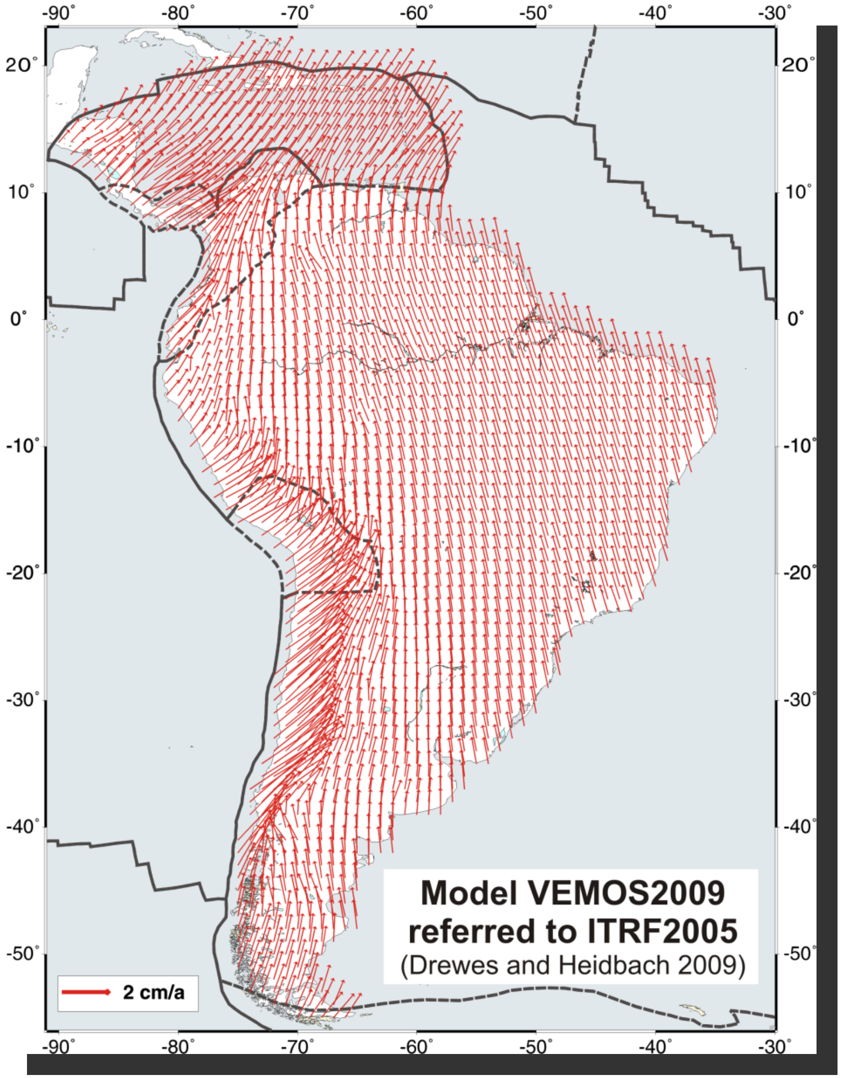
SIRGAS MEMBERS: 2011

International Association of Geodesy (IAG)

Pan American Institute of Geography and Histrory (PAIGH)

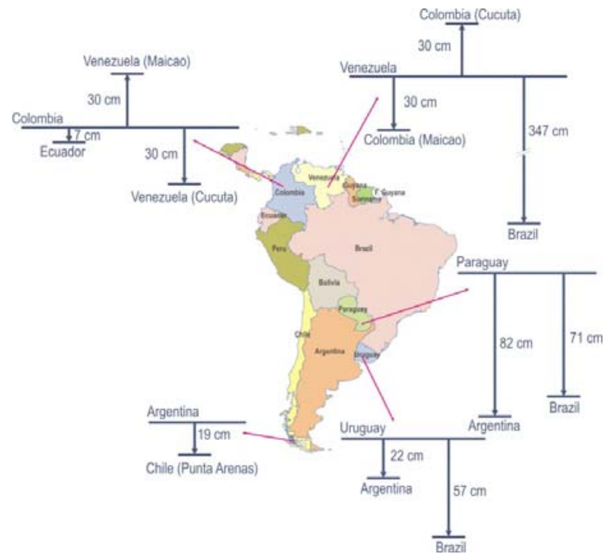
- Argentina
- Bolivia
- Brazil
- Canada
- Chile
- Colombia
- Costa Rica
- Ecuador
- El Salvador
- Guatemala
- Guyana
- Honduras
- Mexico
- Nicaragua
- Panama
- Paraguay
- Peru
- Uruguay
- Venezuela

VElocity MOdels SIRGAS



SIRGAS VERTICAL DATUM (1/2)

The **new SIRGAS vertical reference system** is based on a geometrical component that corresponds to ellipsoidal heights referred to the SIRGAS datum, and a physical component that is given in terms of geopotential quantities (W_0 as a reference level and geopotential numbers as primary coordinates). Its realization should:

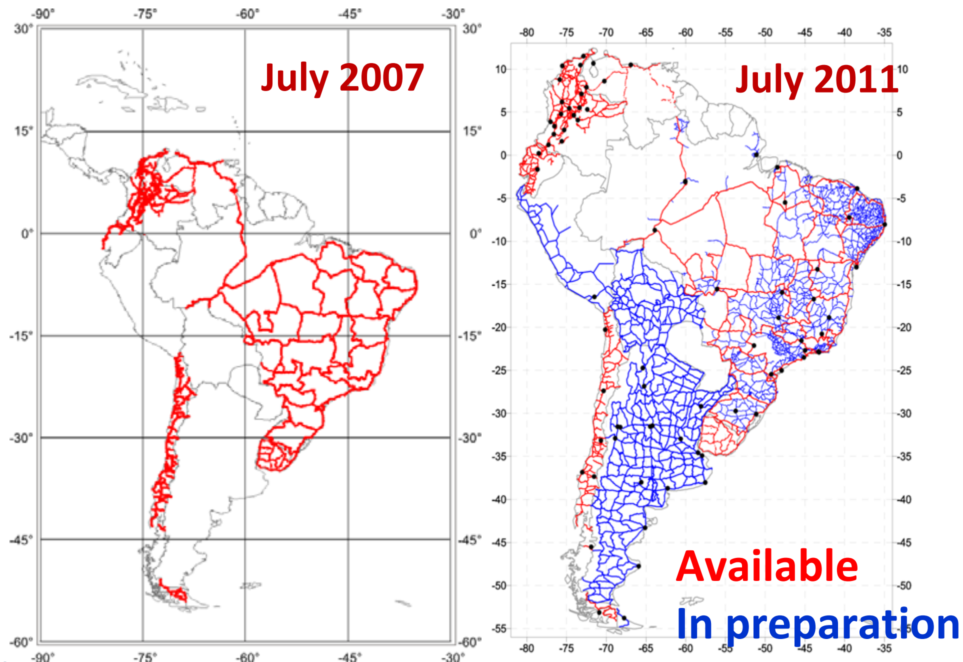


i) Refer to a unified global reference level W_0,

ii) Be given by proper physical heights (derived from spirit levelling in combination with gravity reductions), and

iii) Be associated to a specific reference epoch, i.e. it should consider the coordinate and referential changes with time.

The respective reference surface (geoid or quasigeoid) shall be determined in a common analysis over the whole continent.



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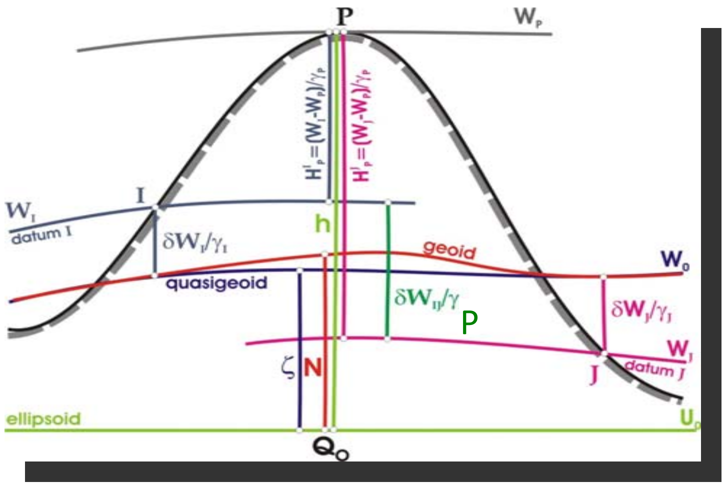
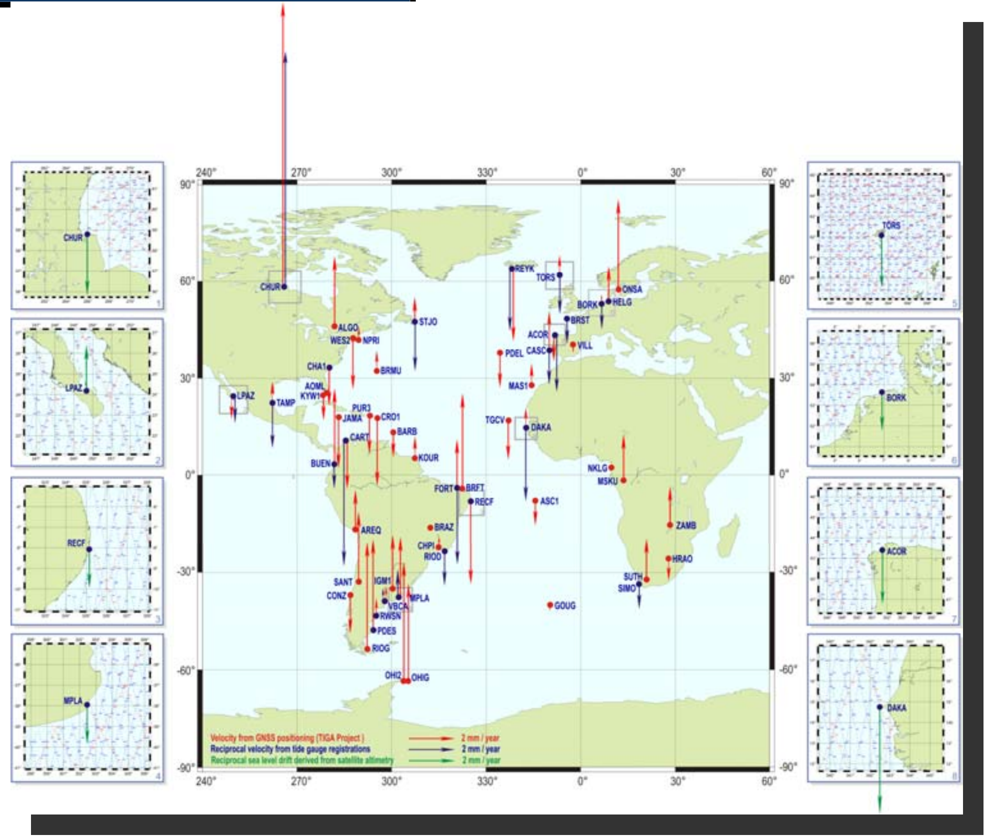
SIRGAS VERTICAL DATUM (2/2)





Determination of:

$$\delta W_i = W_0 - W_i \qquad \delta W_{ij} = W_j - W_i$$

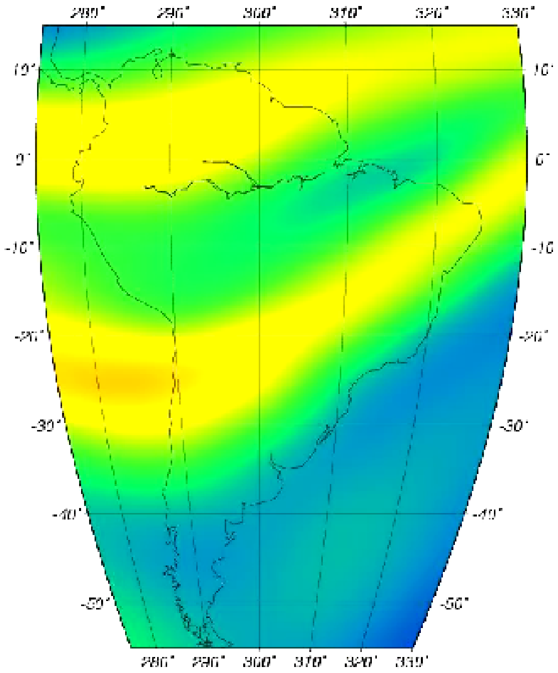
At:

-Reference tide gauges

- Areas around the tide gauges
- SIRGAS reference stations
- International connection points

Combined analysis of tidal records, satellite altimetry and GNSS positioning in order to unify the local vertical reference systems

ATMOSPHERIC RESEARCH

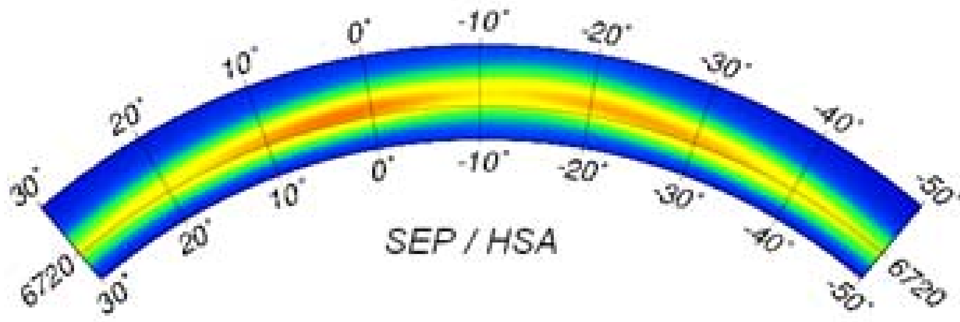


Evolution of the ionospheric model:

- 3-D representation of TEC and 4D of EC.

Applications for the projects:

- Augmentation Solution for the Caribbean, Central and South America (SACCSA) for ICAO.
- Low Ionosphere Sensor network;
- International Reference Ionosphere.

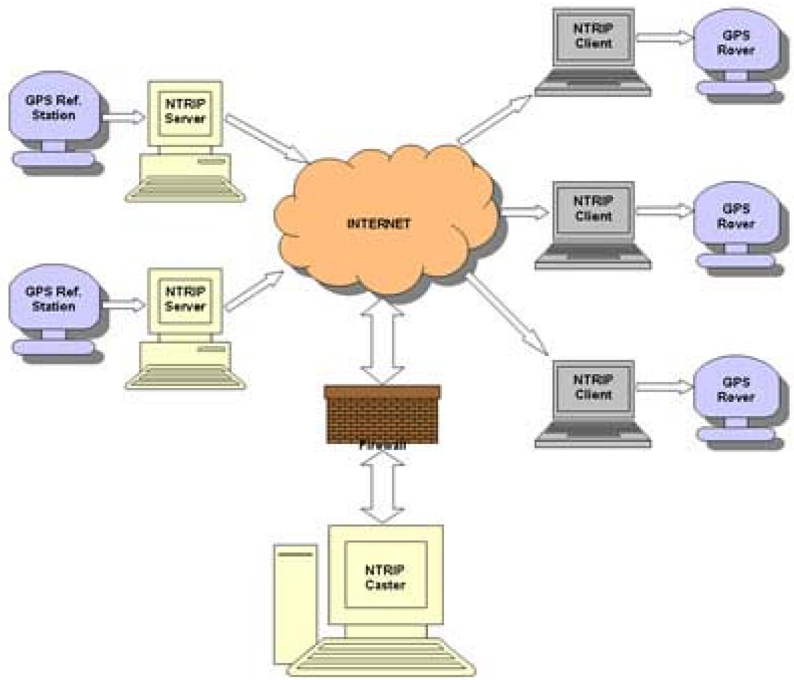


“Contribution to the Study of the Global Climatic Change and the Meteorological Prediction and the Space Weather: Argentina, Brazil, Colombia, Ecuador, Mexico, Venezuela and Uruguay under the guidance of Virginia Mackern (approved PAIGH in 2010);

REAL TIME

- Increasing number of stations that generate observations and corrections in real Time: installation of new casters and sharing of experiences that demonstrate the potential of the method, specially in Brazil, Uruguay, Argentina and Venezuela.

- At the beginning of 2011, the project "Evaluation of potential applications of NTRIP in SIRGAS" was presented to PAIGH with the participation of Uruguay, Argentina and Venezuela.



NEW SIRGAS GLONASS AND MoNoLin

SIRGAS Resolution 03, August 10, 2011:

- To establish the project SIRGAS-GLONASS ascribed to the WGI.
- To study the appropriate processing strategies for obtaining the best possible accuracies based on GLONASS positioning as a tool for the realization of the SIRGAS reference frame and to define the feasibility of its routine analysis in the same way as GPS.

Resolución SIRGAS 2011 No. 03 del 10 de agosto de 2011
sobre
El Proyecto SIRGAS-GLONASS

SIRGAS Resolution 04, August 10, 2011:

- To establish the project SIRGAS-MoNoLin ascribed to the WGI and WGII.
- To define the most appropriate strategy to include the non linear movements of the reference stations in the determination of their coordinates and, in consequence, to improve the kinematic representation of the reference frames that they integrate.

Resolución SIRGAS 2011 No. 04 del 10 de agosto de 2011
sobre
El Proyecto MoNoLin: Incorporación de movimientos no lineales en marcos de referencia geodésicos

CAPACITY BUILDING

- Specialized courses for the establishment of the SIRGAS analysis centres
- Instituto Geográfico Militar de Ecuador, December 2008 and February 2011.CEPGE-IGM
- Servicio Geográfico Militar del Uruguay, March 2009

- SIRGAS Schools on Reference Systems
- First: Bogotá, July 2009, IGAC, 120 participants, 12 countries.
- Second: Lima, November 2010, IGN, 122 participants, 13 countries.
- Third: Heredia, August 2011, ETCG, 116 participants, 18 countries

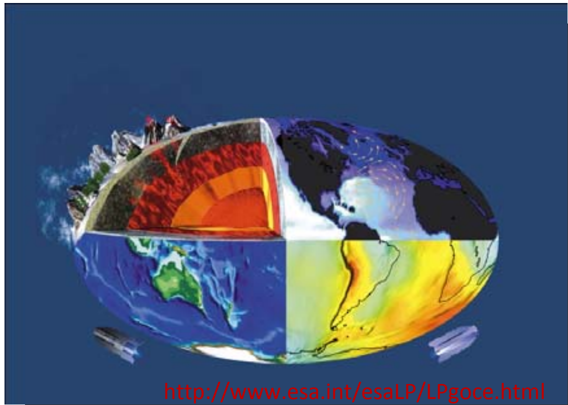
- SIRGAS Chapter in Advanced Course of Satellite Positioning: AECID
- Universidad Politécnica de Madrid, November 2009
- Montevideo , May 2010
- Universidad Politécnica de Madrid, November 2010

SIRGAS MEANS GEODESY

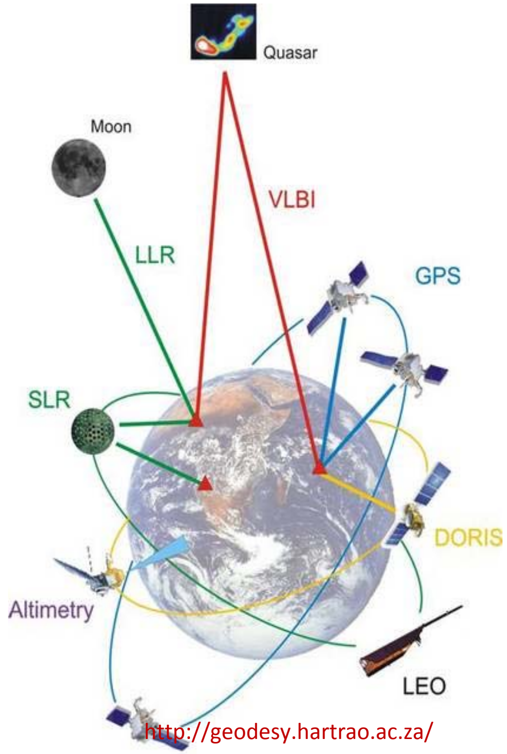
As the science of accurately measure and understand three fundamental properties of Earth: its geometric shape, its orientation in space, and its gravity field; and the changes of these properties with time (Precise Geodetic Infrastructure: National Requirements for a Shared Resource).

The science for measuring changes in the Earth System.

http://www.igp.ethz.ch/geometh/



http://www.esa.int/esaLP/LPgoce.html



http://geodesy.hartrao.ac.za/

SIRGAS provides the core data for the Americas Geospatial Data Infrastructure (Mackern, 2010)

SIRGAS MEANS INFRASTRUCTURE

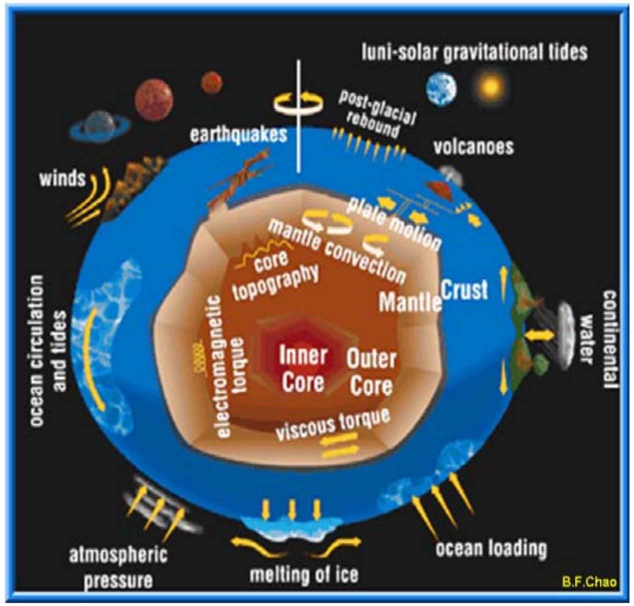
Geodetic infrastructure and observing systems:

As the set of human and technical resources devoted to the long-term definition, maintenance and modernization of a multipurpose continental network, which is a regional densification (realization) of the global International Terrestrial Reference Frame (ITRF). Systems can be set as components of the Infrastructure, oriented to the monitoring and study of different phenomena occurring in Earth System.

- “Global patterns of tectonic deformation
- Global patterns of all types of height changes
- Deformation due to the mass transfer between solid Earth, atmosphere, and hydrosphere including ice;
- Quantification of angular momentum exchange and mass transfer”

(Drewes, 2005)

http://ggos.gfz-potsdam.de/



http://www.agu.org/

SIRGAS MEANS EARTH SCIENCE

SIRGAS www.sirgas.org

- **Earth sciences.** As the contribution of geodetic science and techniques to the family of Earth sciences by sharing data, providing services and generating information that combined with those provided by different sources lead to a better comprehension of Earth.

SIRGAS - SISTEMA DE REFERENCIA GEOCÉNTRICO PARA LAS AMÉRICAS
www.sirgas.org

SIRGAS and the earthquake of February 27, 2010 in Chile

L. Sánchez, W. Seemüller, H. Drewes
Deutsches Geodätisches Forschungsinstitut (DGFI)
Munich, March 17th, 2010.

On 27 February 2010, at 06:34 UTC (03:34 local time) an earthquake (magnitude 8.8) shook the western part of Chile. The epicentre was located at 35.846°S and 72.719°W in a depth of about 35 km. In order to estimate the impact of this earthquake in the SIRGAS Reference Frame, daily station positions between February 21 and March 6, 2010 were computed for selected continuously operating SIRGAS stations. This processing includes IGS05 stations located in Europe, North America, Africa, and Antarctica as reference points (Fig. 1).

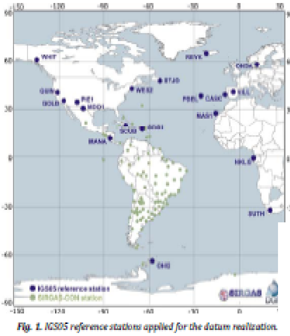


Fig. 1. IGS05 reference stations applied for the datum realization.

The largest displacements occurred between latitudes 30°S to 40°S from the Pacific to the coast (Fig. 2). Results show that the station CONZ (Concepción, Chile) initially moved (on 27-(2,9 m in the south-west direction. In the week following the first earthquake, additional pos movements of more than 10 cm were detected. Strong vertical displacements are also ide Concepción, Santiago, Valparaíso and the Province of Mendoza in Argentina (Fig. 3). Stations l the west of the Andes moved down, stations located in the east moved up. More details are ava

In summary, 23 SIRGAS-CON reference stations moved more than 1,5 cm (Table 1): ANTC Chile), AZUL (Azul, Argentina), BCAR (Balcarce, Argentina), CFAG (Caucete, Argentina (Concepción, Chile), CSLO (Complejo Astronómico El Leoncito, Argentina), IGM1 (Buen Argentina), LHCL (Lihuel Calel, Argentina), LPGS (La Plata, Argentina), MA01 (Neuquen, Ar MZAS (San Rafael, Argentina), MZAC (Mendoza, Argentina), MZAE (Santa Rosa, Mendoza, Ar RWSN (Rawson, Argentina), SANT (Santiago, Chile), SL01 (La Punta, Argentina), SRLP (Santa Pampa, Argentina), UCOR (Córdoba, Argentina), UNRO (Rosario, Argentina), UNSJ (S Argentina), UYMO (Montevideo, Uruguay), VALP (Valparaíso, Chile), VBCA (Bahía Blanca, Ar The corresponding time series are enclosed.

These computations were carried out by the SIRGAS Analysis Centre at DGFI (*Deutsches Geo Forschungsinstitut*) and are based on the observation data provided by the IGS (Internatio Service, www.igs.org) and the Latin American Operation Centres and National Data contributing to the continuously operating network SIRGAS-CON (www.sirgas.org). W acknowledge this support.

SIRGAS - SISTEMA DE REFERENCIA GEOCÉNTRICO PARA LAS AMÉRICAS
www.sirgas.org

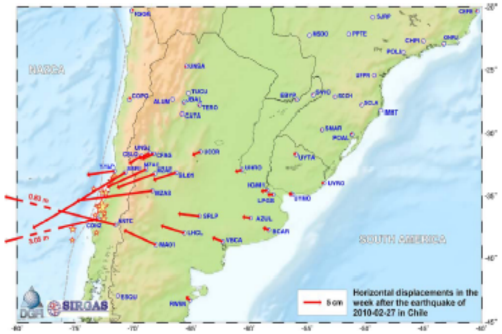


Fig. 2. Horizontal displacements estimated in the week after the earthquake of 2010-02-27 in Chile.

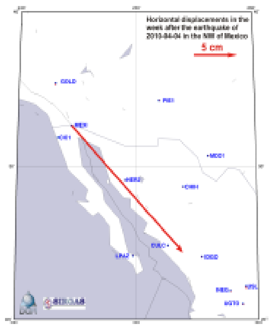
Fig. 3. Vertical displacements estimated in the week after the earthquake of 2010-02-27 in Chile.

SIRGAS - SISTEMA DE REFERENCIA GEOCÉNTRICO PARA LAS AMÉRICAS
www.sirgas.org

SIRGAS and the earthquake of April 4, 2010 in Baja California, Mexico

L. Sánchez, W. Seemüller, H. Drewes
Deutsches Geodätisches Forschungsinstitut (DGFI)
Munich, May 5, 2010.

On April 04th, 2010, at 22:40 UTC (03:40 pm local time) an earthquake (magnitude 7.2) shook the north-western part of Mexico. The epicentre was located at 32.128°N and 115.303°W in a depth of about 10 km. In order to estimate the impact of this earthquake in the SIRGAS Reference Frame, daily station positions between March 31st and April 7th, 2010 were computed for selected continuously operating SIRGAS stations. Since the earthquake occurred in the NW limit of the geographical region covered by SIRGAS, this processing included 13 additional IGS stations located in North America. Results show a displacement of 23 cm in the SE direction of the reference station MEXI (Mexicali).

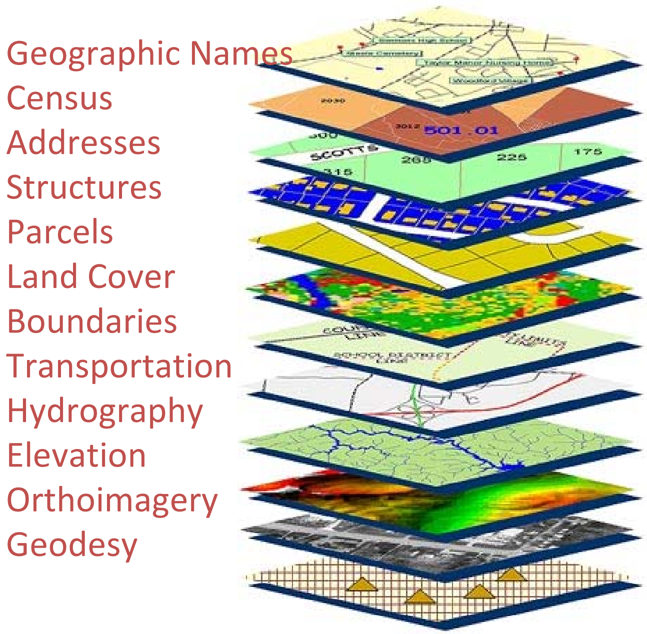


The other SIRGAS stations located in the region present position changes less than 4 mm. Unfortunately, the station CIC1 (Ensenada), the nearest to the earthquake zone after MEXI, is out of operation and therefore, it has not been possible to estimate, if it is affected by the earthquake.

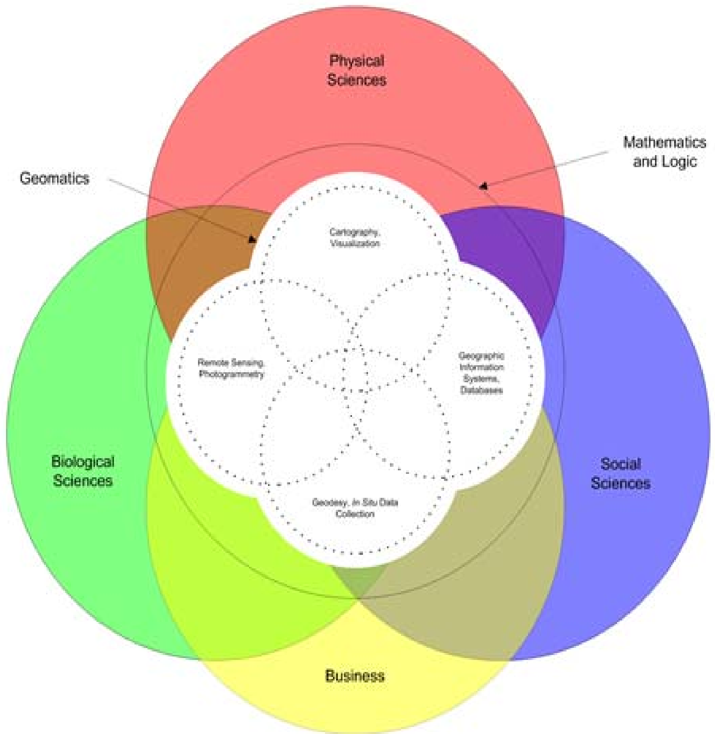
These computations were carried out by the SIRGAS Analysis Centre at DGFI (*Deutsches Geodätisches Forschungsinstitut*) and are based on the observation data provided by the IGS (International GNSS Service, www.igs.org) and the Instituto Nacional de Estadística y Geografía -INEGI- of México (www.inegi.gob.mx), which contributes to the continuously operating network SIRGAS-CON (www.sirgas.org) through the Red Geodésica Nacional Activa (RGNA). We deeply acknowledge this support.

SIRGAS MEANS: SOCIAL BENEFITS

- Social benefits. As a practical application focused on solving problems derived from natural hazards, global change and the social evolution itself. It is related to all the elements, variables and processes that can be located by geopositioning. This covers, by far, the most of the human activities and their relation with the environment.



http://www.techlines.ky.gov/



http://cast.uark.edu/home/research/geomatics.html

Thank you very much.