SIRGAS

THE SPATIAL REFERENCE FOR GEOMATICS IN THE AMERICAS

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Congreso Internacional Geomática Andina 2012
4 y 5 de junio, Bogotá, D. C., Colombia

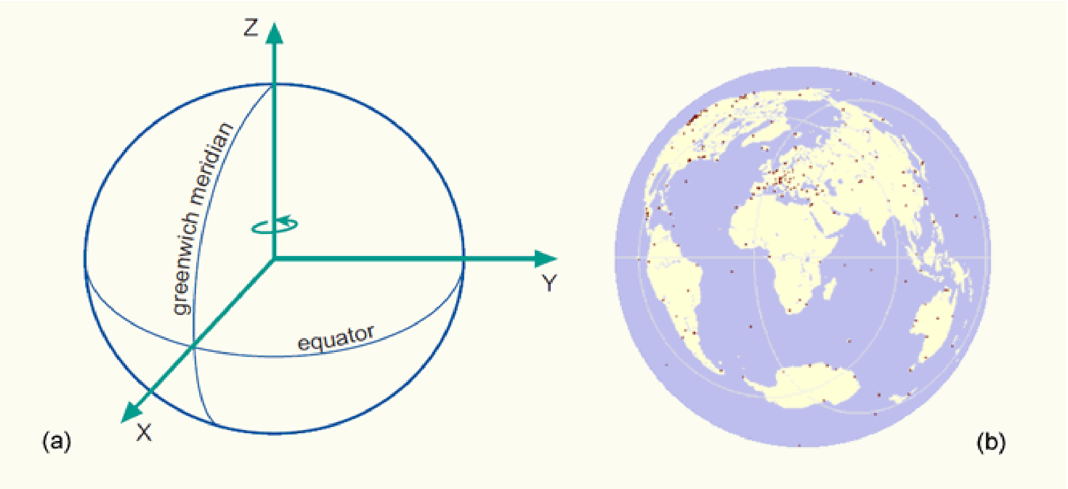
SIRGAS stands for Geocentric Reference System for the Americas

✓ **IAG Sub Commission 1.3b:** Reference Frames / Regional Reference Frames / South and Central America

✓ **Working Group of the PAIGH Cartography Commission**

- SIRGAS as a reference system is defined as identical with the International Terrestrial Reference System (ITRS)

- SIRGAS as a reference frame is a regional densification of the International Terrestrial reference Frame (ITRF)



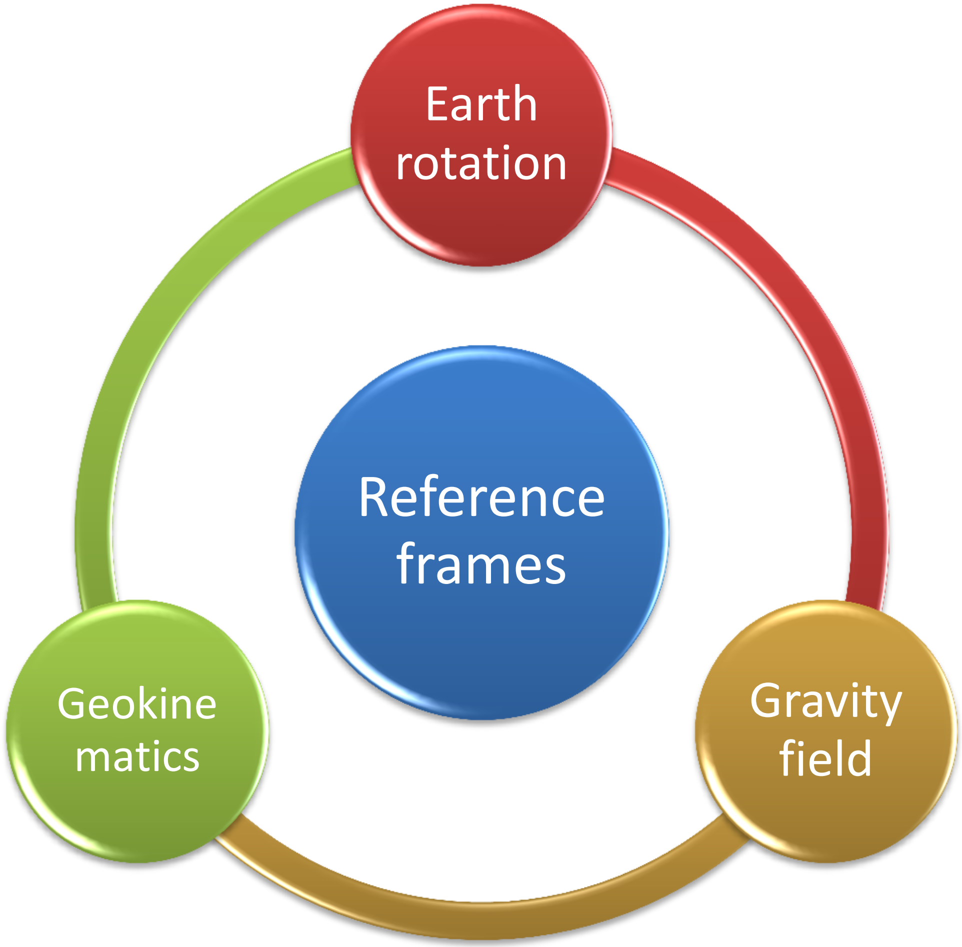
(a) The International Terrestrial Reference System (ITRS)

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

http://www.kartografie.nl

The science for measuring changes in the Earth System

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. NAP, 2010)



THE BEGINNIG

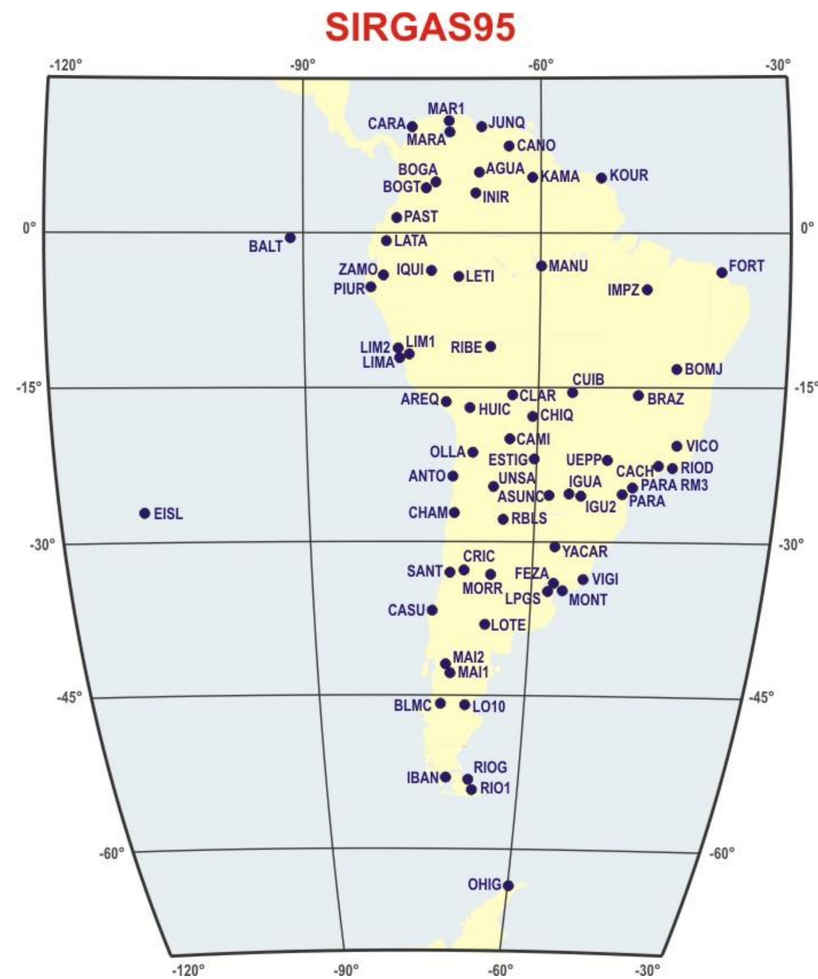
- SIRGAS was created during the International Conference for the Definition of a South American Geocentric Datum, held from October 4 to 7, 1993, in Asunción, Paraguay.

- The 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**



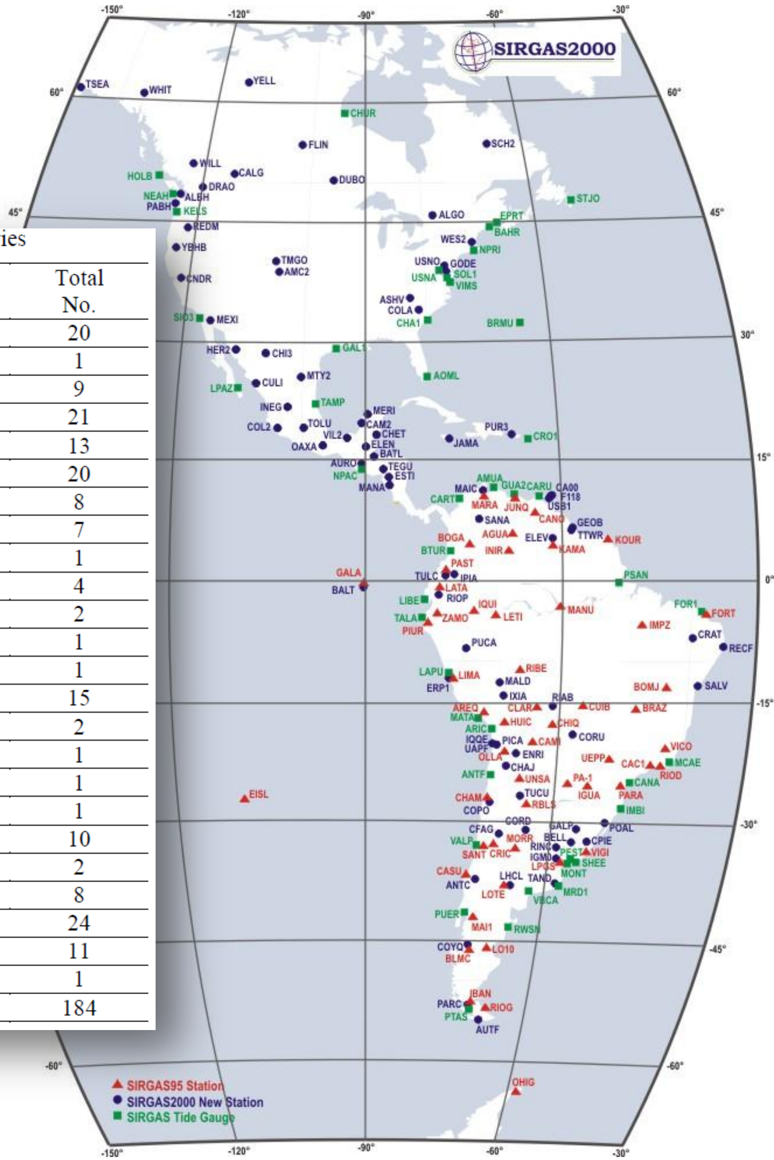
“***An extremely well executed project***”, Wolfgang Torge, XXI IUGG General Assembly, Boulder.

THE SECOND CAMPAIGN: 2000

- Measurements from 00:00 (UT), May 10 to 24:00 (UT), May 19.
- 184 stations
- 25 countries
- The SIRGAS 95 campaign stations were re-occupied as well as national tide gauges and international connecting points

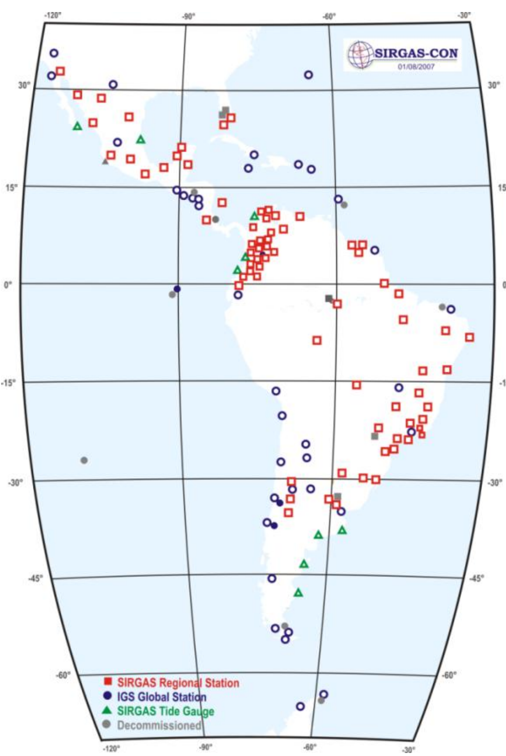
Table 1. Distribution and types of stations in the countries

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

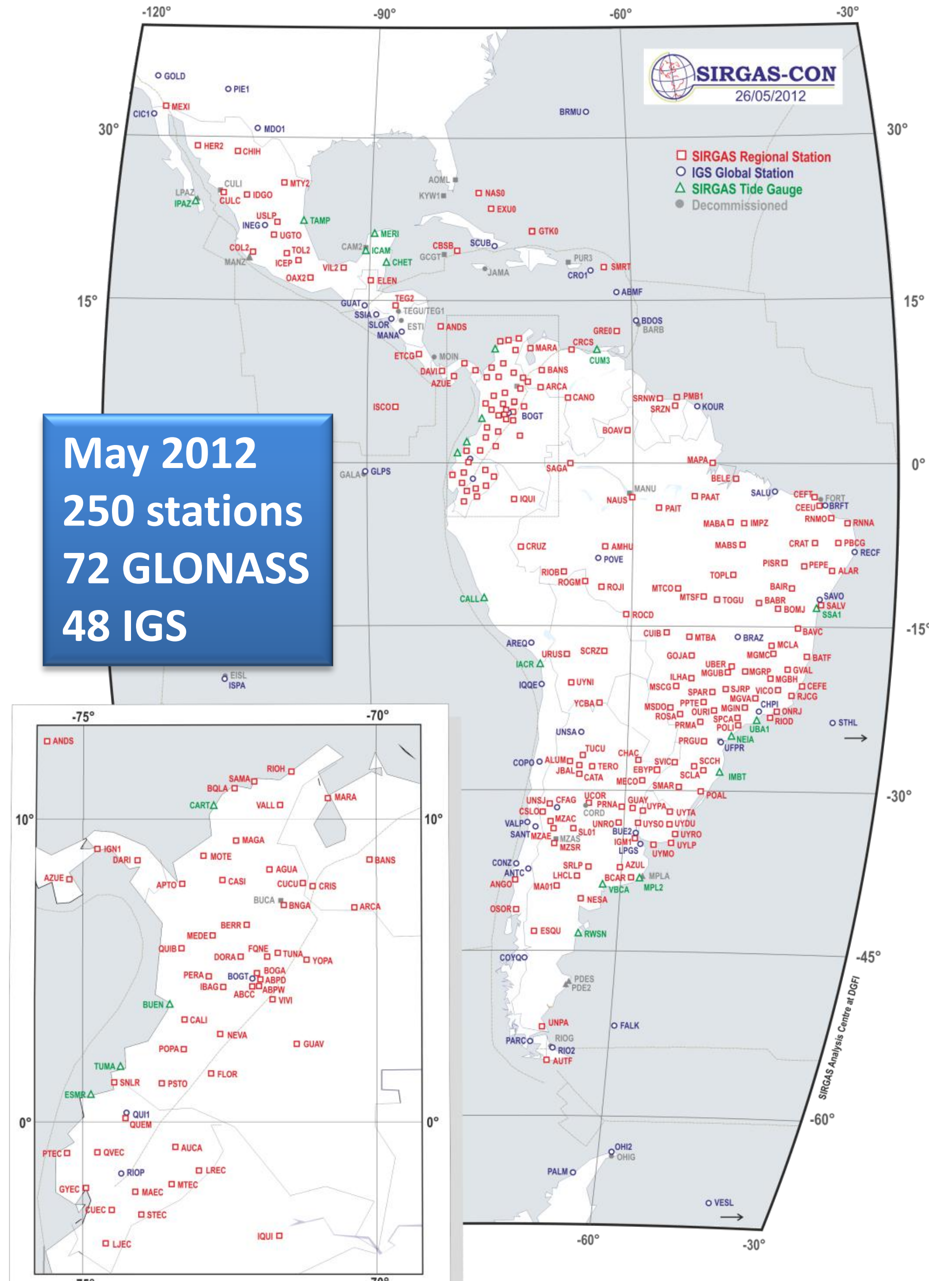


SIRGAS-CON NETWORK (1/2)

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.



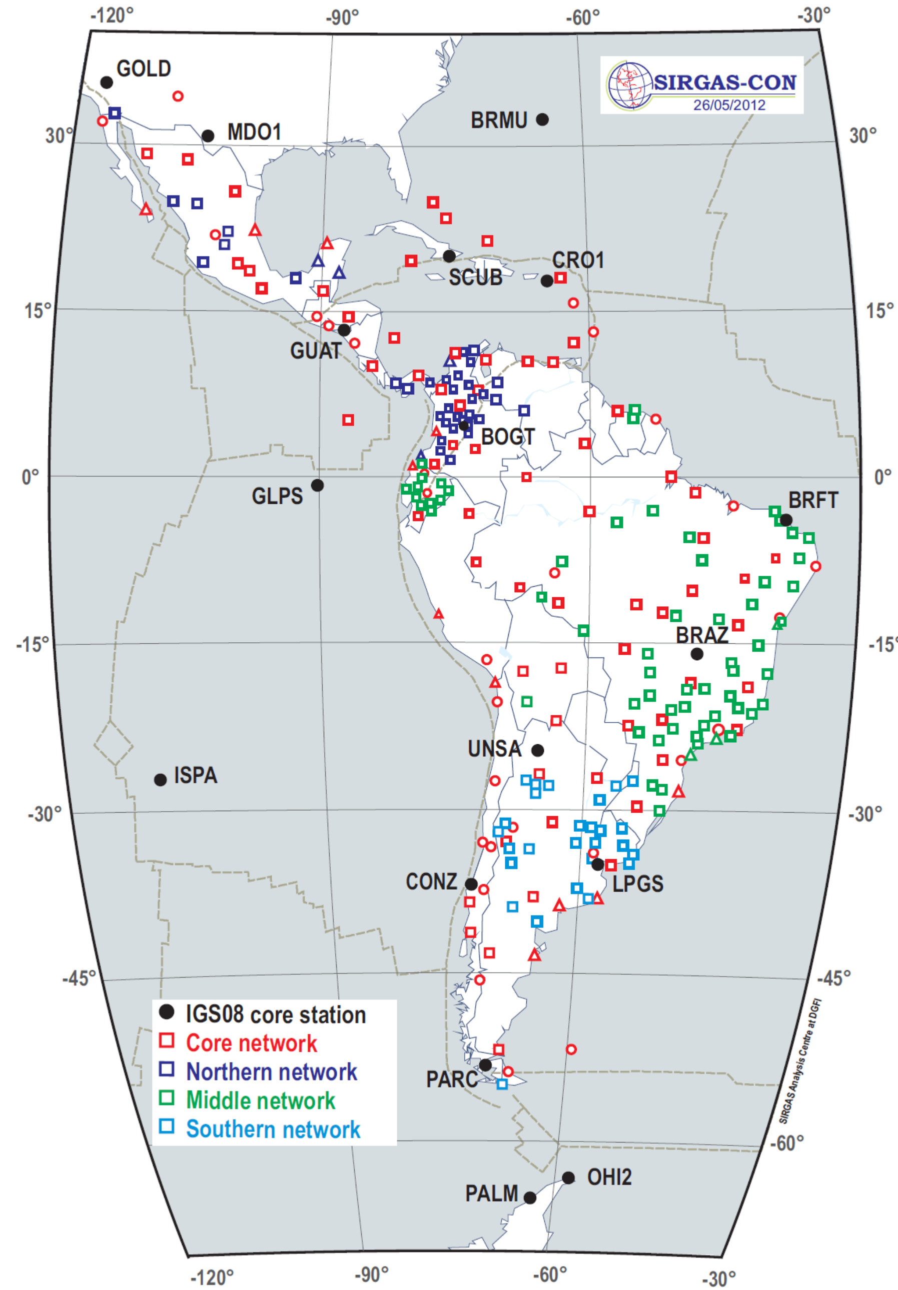
July 2007
149 stations
54 IGS



May 2012
250 stations
72 GLONASS
48 IGS

SIRGAS-CON NETWORK (2/2)

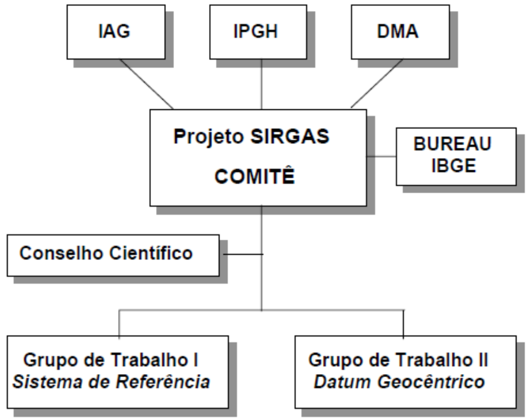
- National reference frames in Latin America are part of SIRGAS-CON.
- The core network (SIRGAS-CON-C) is the primary densification of ITRF in Latin America.
- Densification sub-networks (SIRGAS-CON-D) provide accessibility to the reference frame at local levels.
- Today, there are three SIRGAS-CON-D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



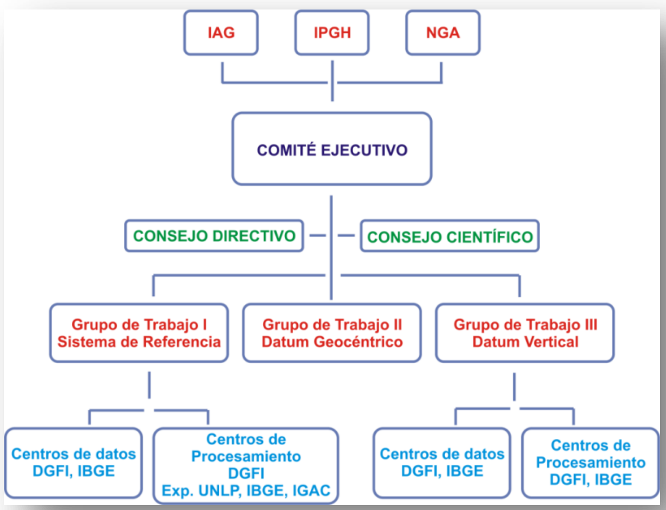
SIRGAS www.sirgas.org

STRUCTURE

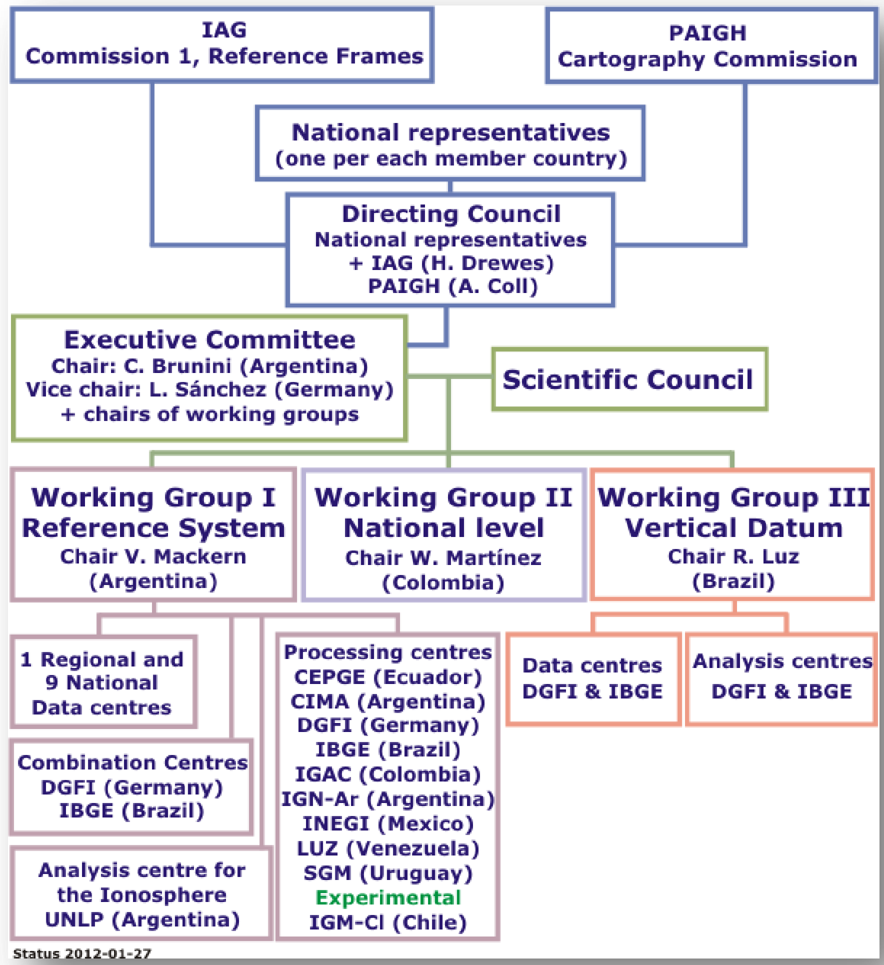
1993 – 1997



1997 -2011



2011…



DATA PROCESSING AND ANALYSIS

2007

SIRGAS-CON
NETWORK

↓

1 DATA CENTRE
(DGFI as IGS-RNAAC-SIR)

↓

1 ANALYSIS CENTRE
(DGFI as IGS-RNAAC-SIR)

- Weekly loosely constrained solutions for combination (IGS multiannual solutions)
- Weekly coordinates adjusted to ITRF Multiannual solutions (positions + velocities)

→

2012

SIRGAS-GTI

Red Continental SIRGAS-CON-C	3 subredes de densificación SIRGAS-CON-D
1 Centro Regional de Datos (DGFI)	Centros Nacionales de Datos (entidades encargadas de los marcos de referencia)
1 Centro de Procesamiento (DGFI como IGS-RNAAC-SIR)	8 Centros Locales de Procesamiento CEPGE, CIMA, CPAGS-LUZ, IBGE, IGAC, IGN-Ar, INEGI, SGM-Uy

↓

2 Centros de Combinación
(DGFI, IBGE)

↓

Soluciones finales para el marco de referencia SIRGAS-CON

- Soluciones semanales semilibres para el poliedro global del IGS y soluciones multianuales
- - Coordenadas semanales ajustadas al ITRF
  - Soluciones multianuales (posiciones y velocidades)

CENTRES

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

MEMBERS

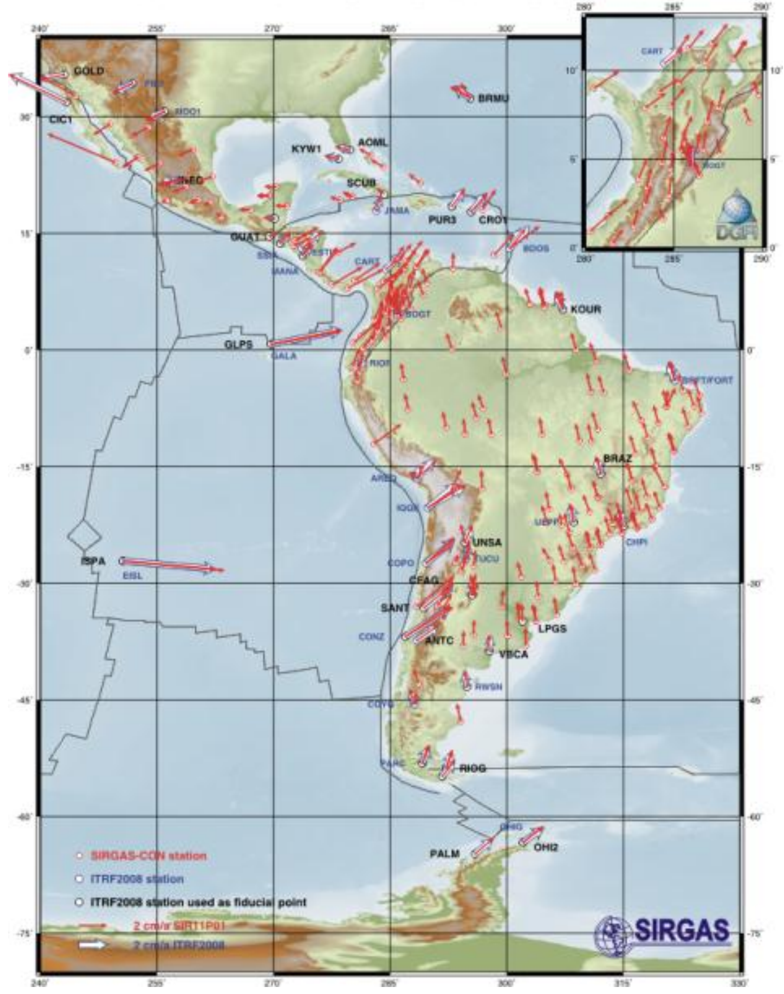
International Association of Geodesy (IAG)

Pan American Institute of Geography and History (PAIGH)

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

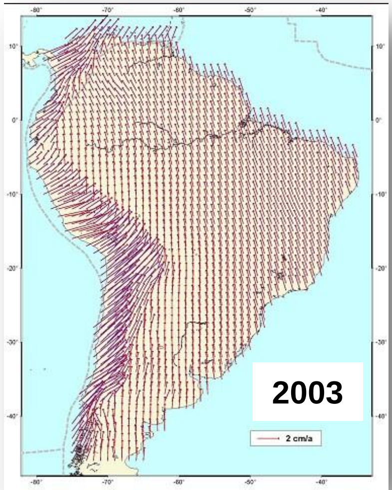
MULTI-ANNUAL SOLUTIONS

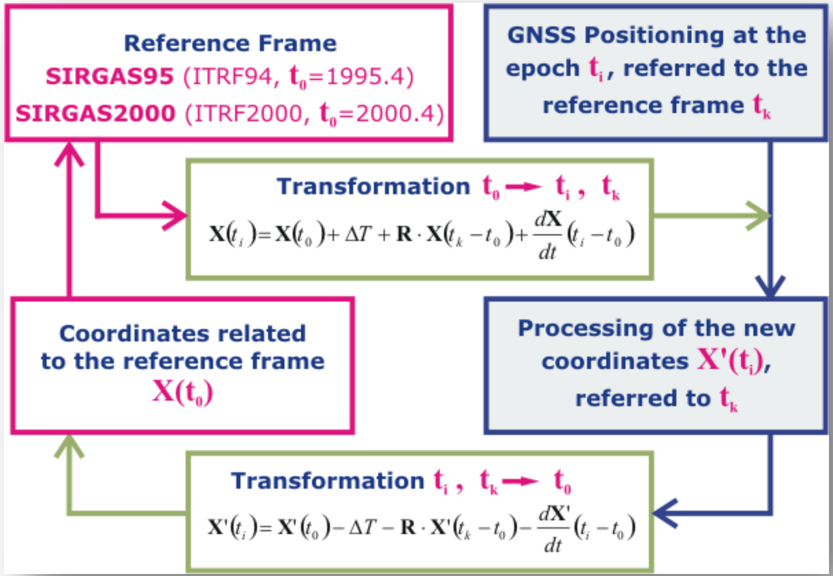
SIR11P01 horizontal velocities



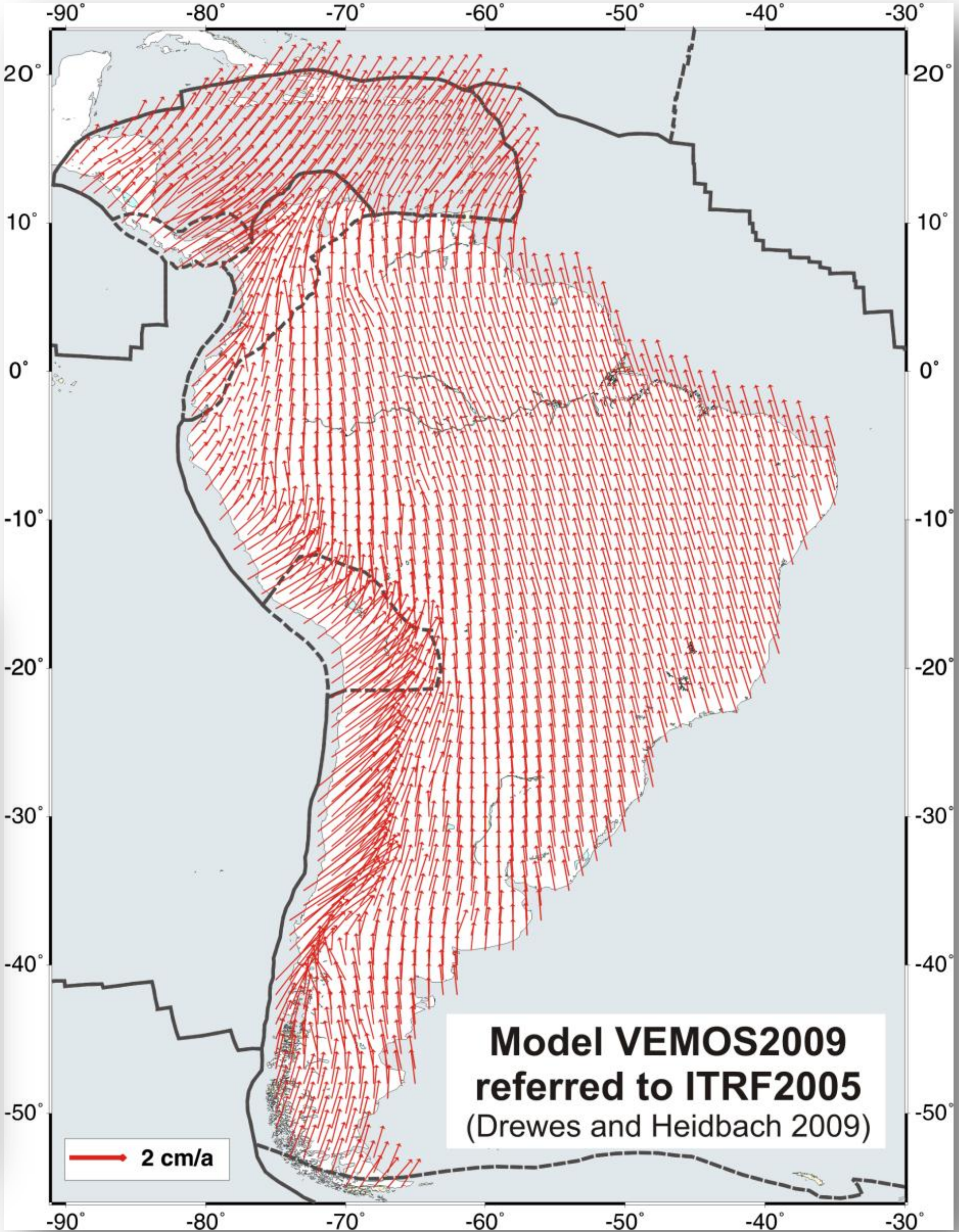
SIR11P01 vertical velocities

VELOCITY MODELS





Drewes, H. and O. Heidbach (2009).



VERTICAL DATUM

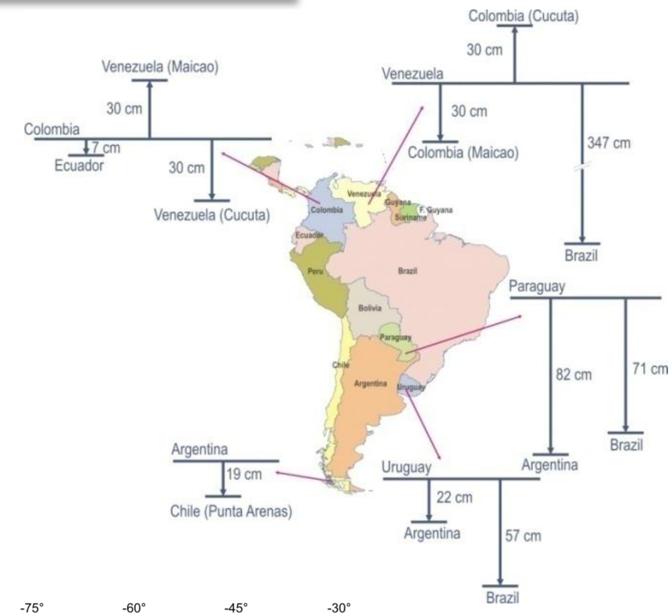
The **new SIRGAS vertical reference system** is based on a geometrical component that corresponds to ellipsoidal heights referred to the SIRGAS datum, and a physical component that is given in terms of geopotential quantities (W_0 as a reference level and geopotential numbers as primary coordinates).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

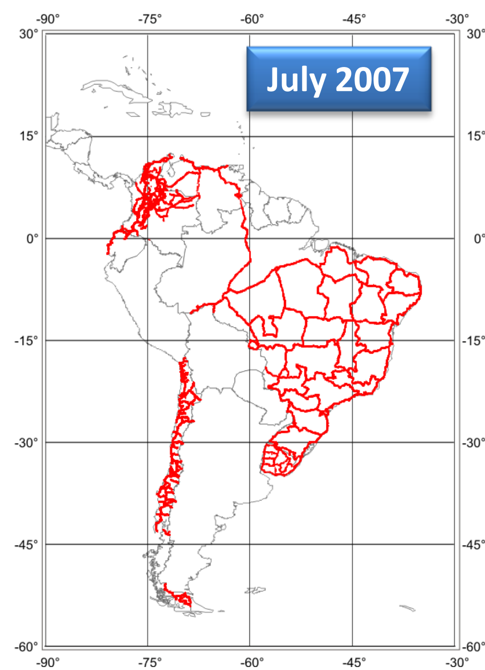
i) Refer to a unified global reference level W_0,

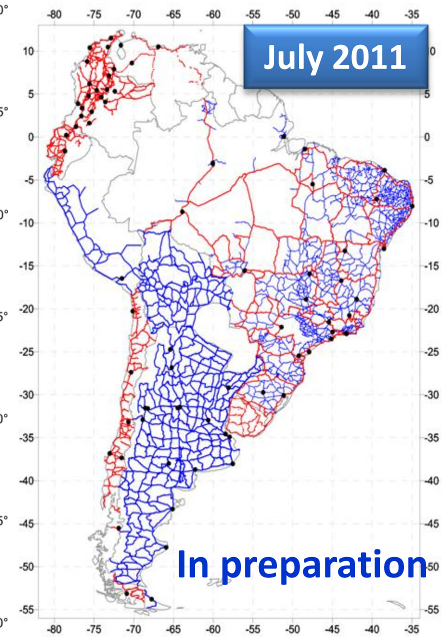
ii) Be given by proper physical heights (derived from spirit levelling in combination with gravity reductions), and

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

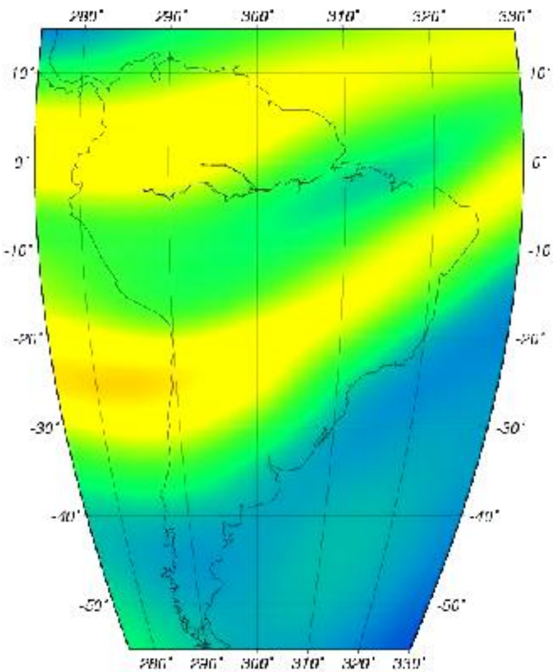
The respective reference surface (geoid or quasi-geoid) shall be determined in a common analysis over the whole continent.







ATMOSPHERIC RESEARCH

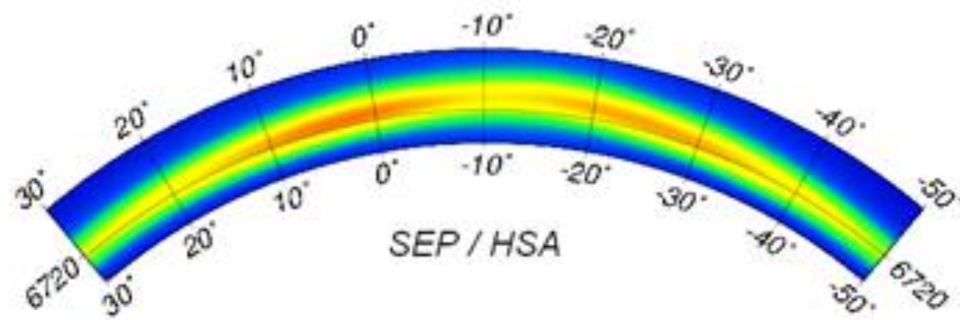


Evolution of the ionospheric model:

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.

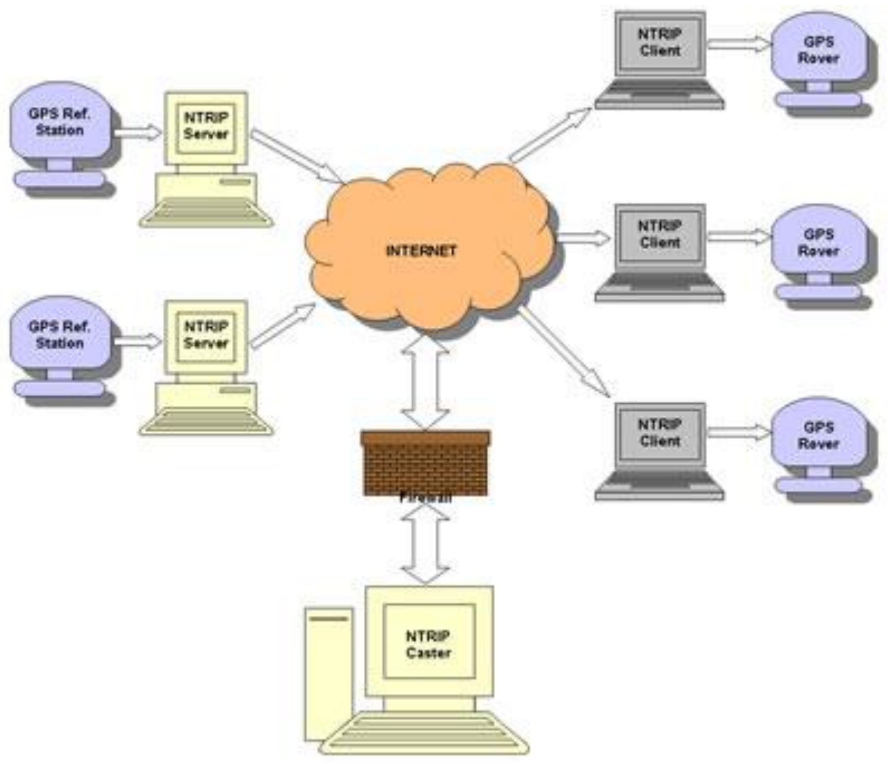


"Contribution to the Study of the Global Climatic Change and the Meteorological Prediction and the Space Weather: Argentina, Brazil, Colombia, Ecuador, Mexico, Venezuela and Uruguay" under the guidance of Virginia Mackern (approved PAIGH in 2010)

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 GLONASS AND MoNoLin

SIRGAS Resolution 03, August 10, 2011:

- To establish the project **SIRGAS-GLONASS** ascribed to the WG-I.
- 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

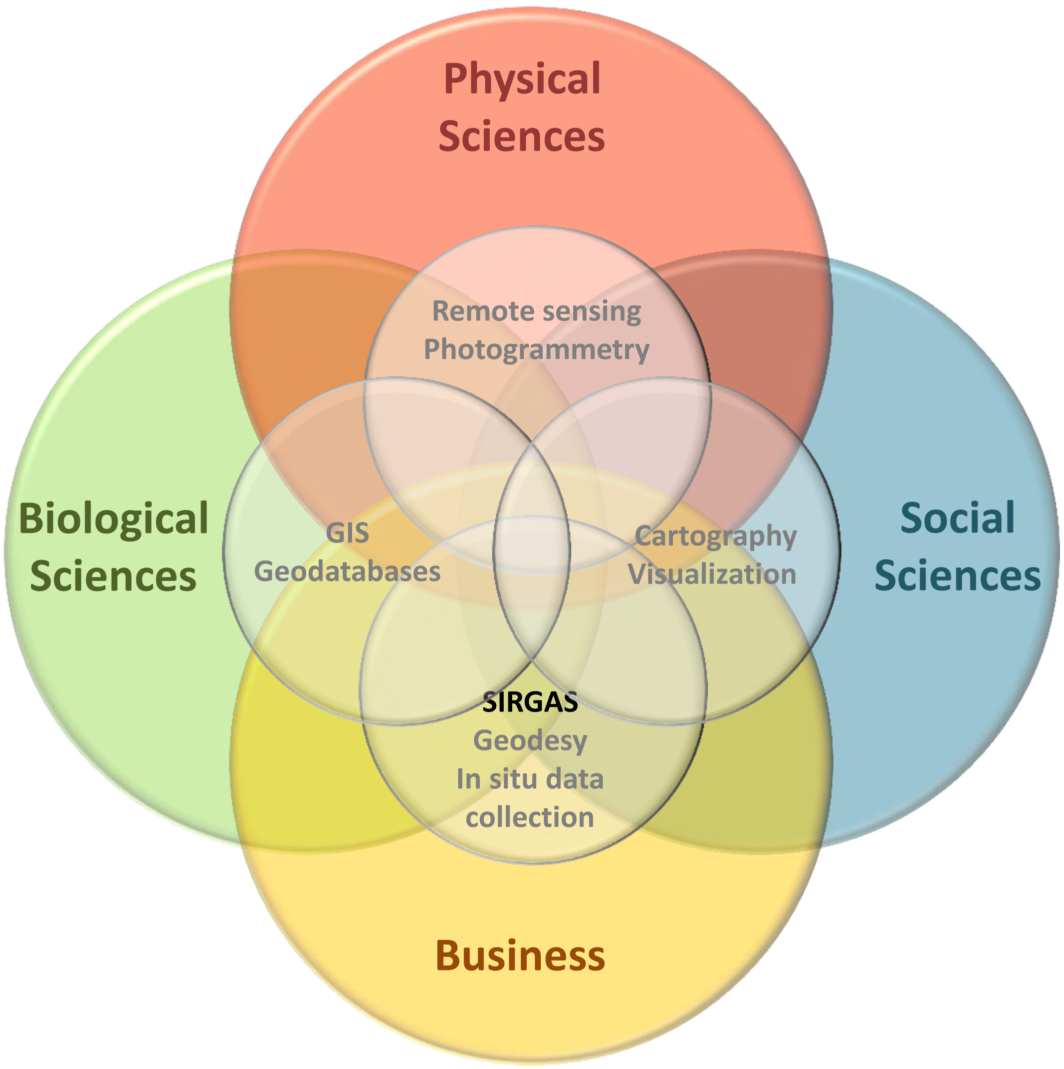
CAPACITY BUILDING

- 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

GEOMATICS

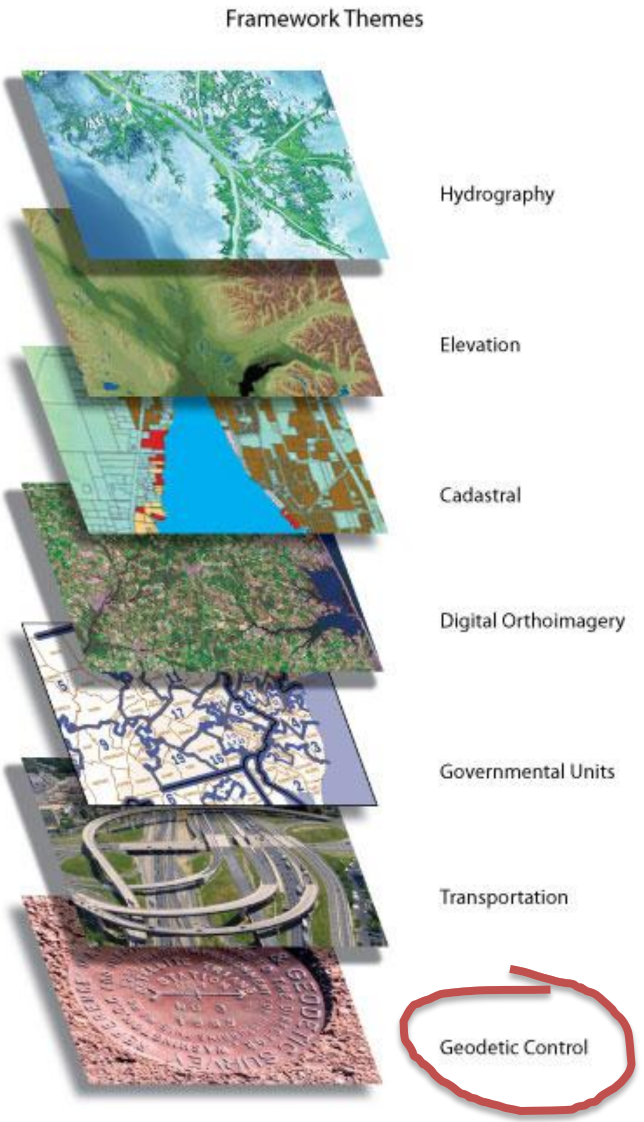


Adapted from: http://cast.uark.edu/home/research/geomatics.html

Spatial Data Infrastructures (SDI)

SIRGAS data are…

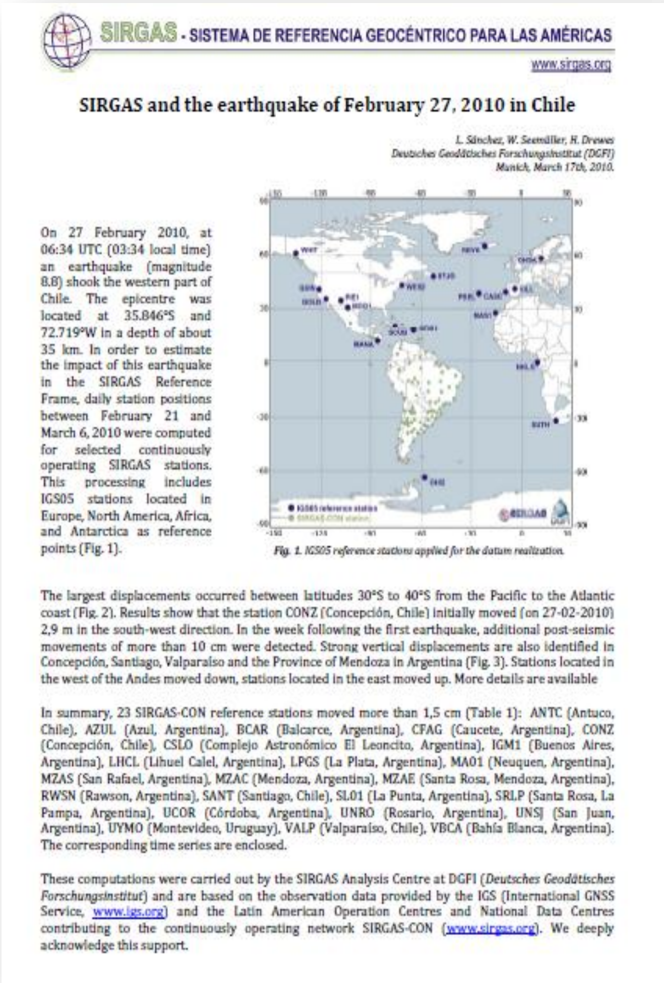
- The most basic theme in the SDI's of the Americas
- The basis for spatial data standardization
- The space-time link among data sets and information
- The common language for data sharing, interoperability and compatibility



http://www.fgdc.gov/library/whitepapers-reports/

EARTH SCIENCE

- 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.

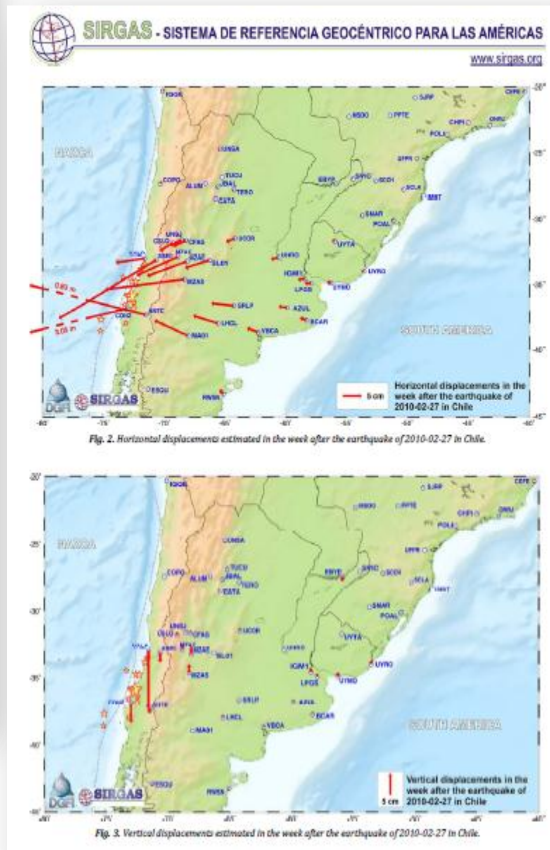
On 27 February 2010, at 06:34 UTC (03:34 local time) an earthquake (magnitude 8.8) shook the western part of Chile. The epicentre was located at 35.846°S and 72.719°W in a depth of about 35 km. In order to estimate the impact of this earthquake in the SIRGAS Reference Frame, daily station positions between 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 Atlantic coast (Fig. 2). Results show that the station CONZ (Concepción, Chile) initially moved (on 27-02-2010) 2,9 m in the south-west direction. In the week following the first earthquake, additional post-seismic movements of more than 10 cm were detected. Strong vertical displacements are also identified in Concepción, Santiago, Valparaíso and the Province of Mendoza in Argentina (Fig. 3). Stations located in the west of the Andes moved down, stations located in the east moved up. More details are available

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

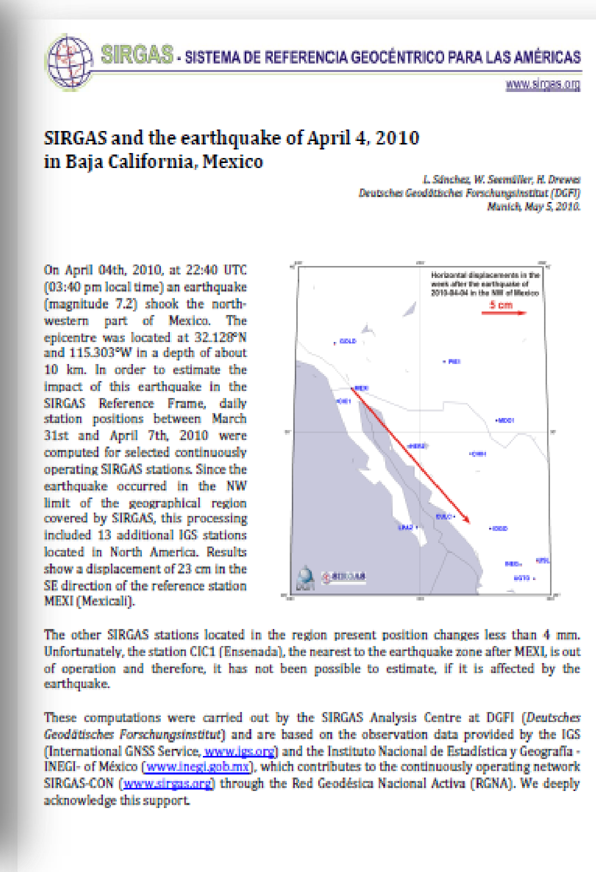
These computations were carried out by the SIRGAS Analysis Centre at DGFI (*Deutsches Geodätisches Forschungsinstitut*) and are based on the observation data provided by the IGS (International GNSS Service, www.igs.org) and the Latin American Operation Centres and National Data Centres contributing to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



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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.

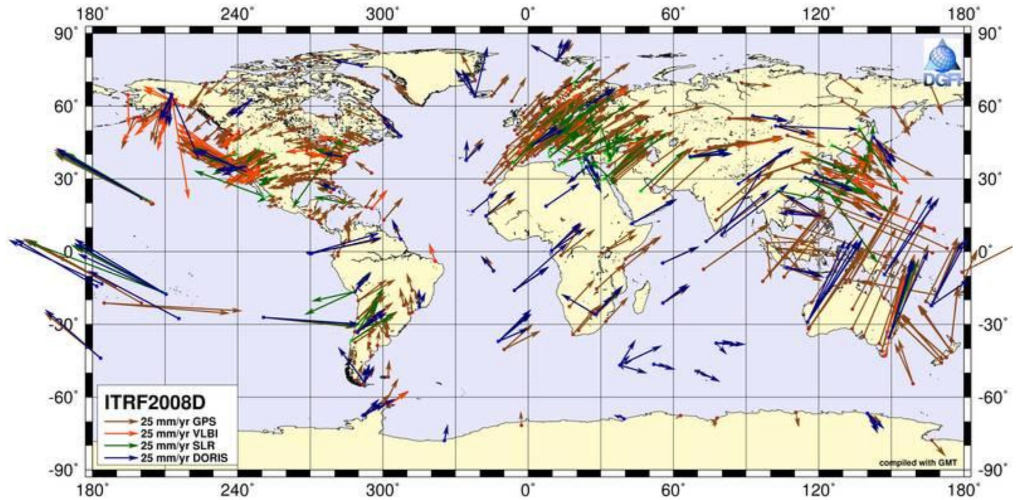
IN THE PRACTICE: DEFINITIONS

- Working on a SIRGAS basis, implies the use of the ITRF

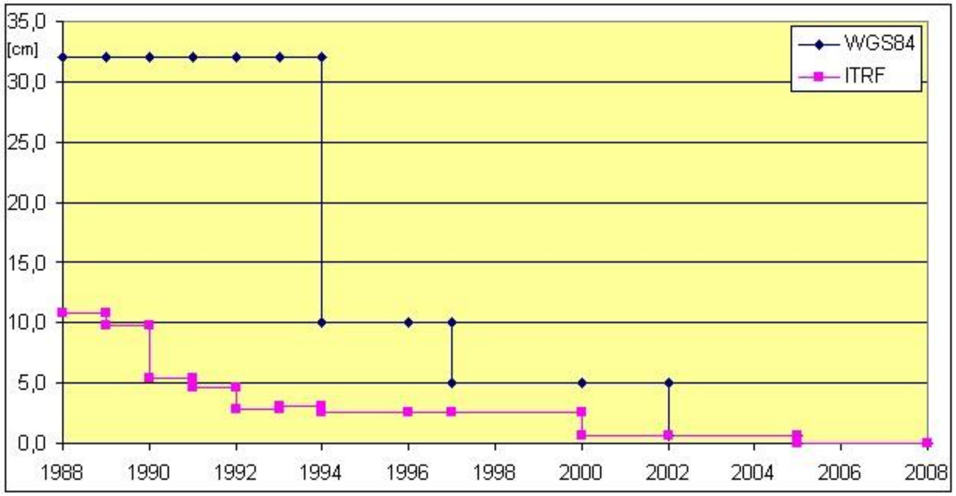
- World Geodetic System WGS84 was adjusted to ITRF and, nowadays they are equivalent.

- The practical use of SIRGAS involves a referencing to the International Terrestrial Reference Frame (ITRF).

- SIRGAS, ITRF and WGS84 are equivalent



http://www.dgfi.badw.de/index.php?id=2



- At present, member countries are implementing strategies to adopt the last version: ITRF08. GPS broadcasted information is compatible with it.

Country	Name	Datum	Reference epoch
Argentina	POSGAR	ITRF2005	2006,6
Bolivia	MARGEN	SIRGAS95	1995,4
Brazil	SIRGAS2000	SIRGAS2000	2000,4
Chile	SIRGAS-CHILE	SIRGAS2000	2002
Colombia	MAGNA-SIRGAS	SIRGAS95	1995,4
Costa Rica	CR05	ITRF2000	2005,8
Ecuador	RED BÁSICA	SIRGAS95	1995,4
El Salvador	SIRGAS ES-2007	SIRGAS-ES2007	2007,8
French Guyana	RGFG	ITRF93	1995
Mexico	RGNA	ITRF92	1988
Panama		ITRF2000	2000
Peru	PERU96	SIRGAS95	1995,4
Uruguay	SIRGAS-ROU-98	SIRGAS95	1995,4
Venezuela	SIRGAS-REGVEN	SIRGAS95	1995,4

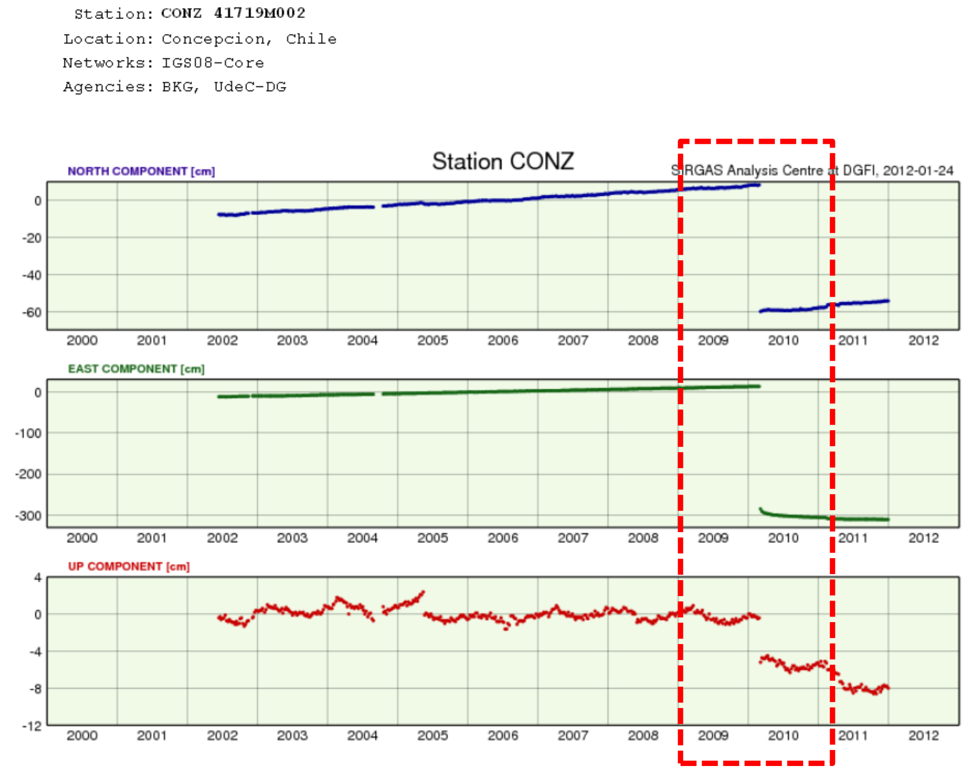
IN THE PRACTICE: ACCURATE SURVEYING

- A georreferencing process must be adequately linked to SIRGAS. It means, the use of continuous and/or passive stations in order to get accurate positions for engineering, surveying, among others.

- The use of VEMOS 2009 to refer the survey to a national reference frame in a space-time context. Constant velocities and deformation models can not reflect the effect of earthquakes (leaps) on stations coordinates. Linear velocities in these cases are useless. So…

- The use of the last set of coordinates released by SIRGAS is recommended (http://www.sirgas.org/index.php?id=153&L=2)

- Coordinates of control points in former national local datums can be transformed to SIRGAS, but accuracies will be low. Instead, points must be measured using SIRGAS base stations.



IN THE PRACTICE: MAPPING AND CADASTRE

- Satellite imagery is normally referred to ITRF (WGS84). In consequence, it is recommended that local ground control be made linked to SIRGAS.
- Maps elaborated using a former national datum should be transformed to SIRGAS. The inverse process decreases the accuracy and quality of results. SIRGAS countries have computed national transformation parameters. Even so, in the most of cases, global transformation parameters are valid for mapping purposes.
- GNSS measurements do not eliminate the electro-optical surveys. They are complementary processes: GNSS establishes the datum, and EDM´s gets detailed information, mainly in places where satellite signals are not available and/or no practical.
- Field measured positions, after a survey like traverses or GNSS accurate positioning have their own accuracies. They cannot be “mixed” with a cartographic product assuming full compatibility. Usually, errors in a map are, by far, greater than those of control points.
- Plane (projected) coordinates of control points can be assumed with the same accuracy than original geocentric Cartesian or geographic coordinates. This is valid if the SIRGAS frame is used for both data sets. This process is called conversion; different than transformation, which implies a shift between reference frames.
- Natural features must be avoided as reference for parcel delimitations. Instead, SIRGAS coordinates are recommended. Even if they change with time, areas normally keep their dimension.

Thank you very much