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SIRGAS: the geocentric reference frame of the Americas

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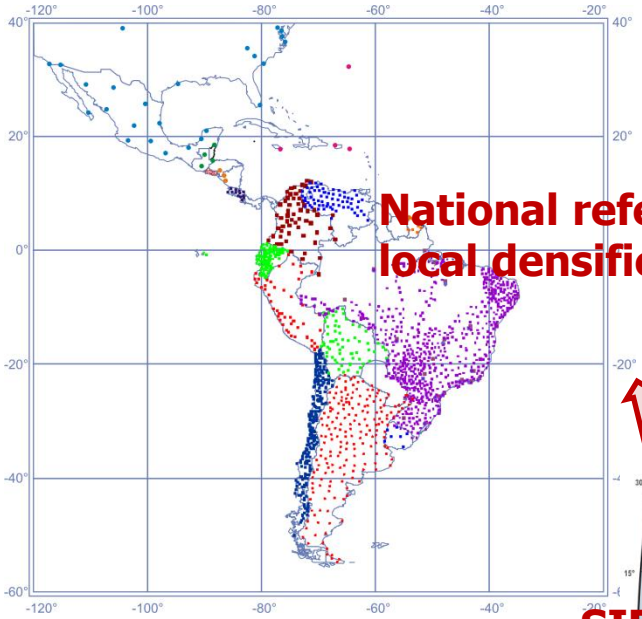
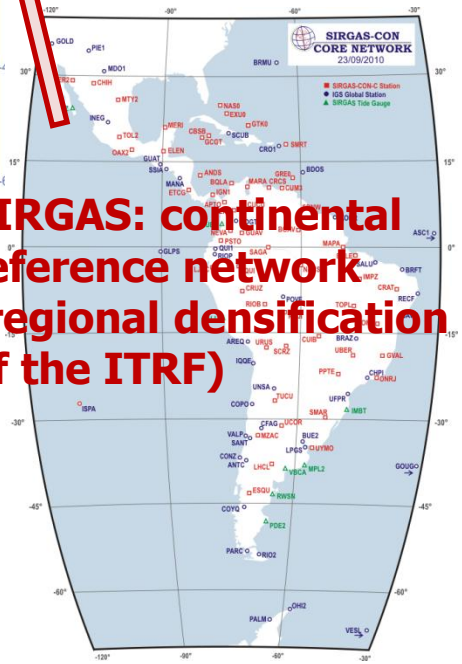
SIRGAS realization

The realization of SIRGAS is a densification of the ITRF

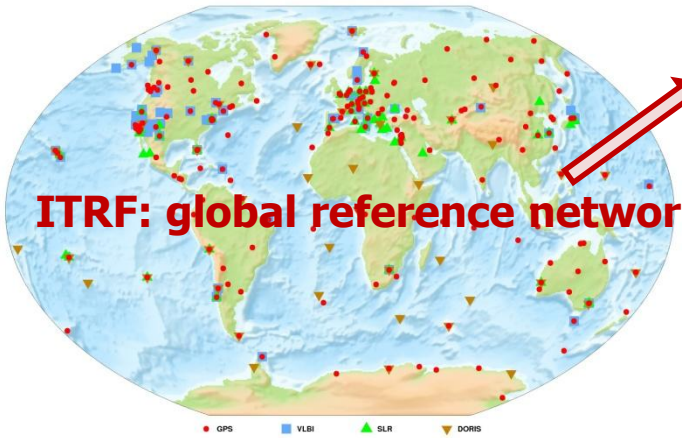
- to guarantee consistency between terrestrial reference stations and GNSS satellite orbits (provided by the IGS);
- to make the global reference frame available at national and local levels.



National reference networks: local densifications of SIRGAS



SIRGAS: continental reference network (regional densification of the ITRF)



ITRF: global reference network

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Continuous monitoring of the reference frame

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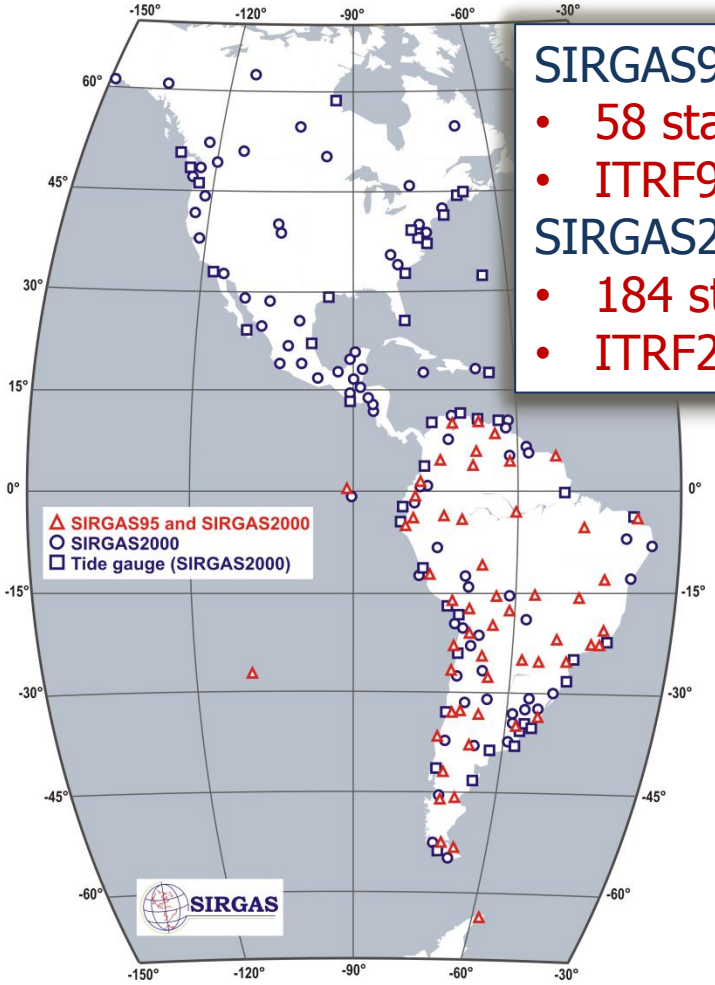
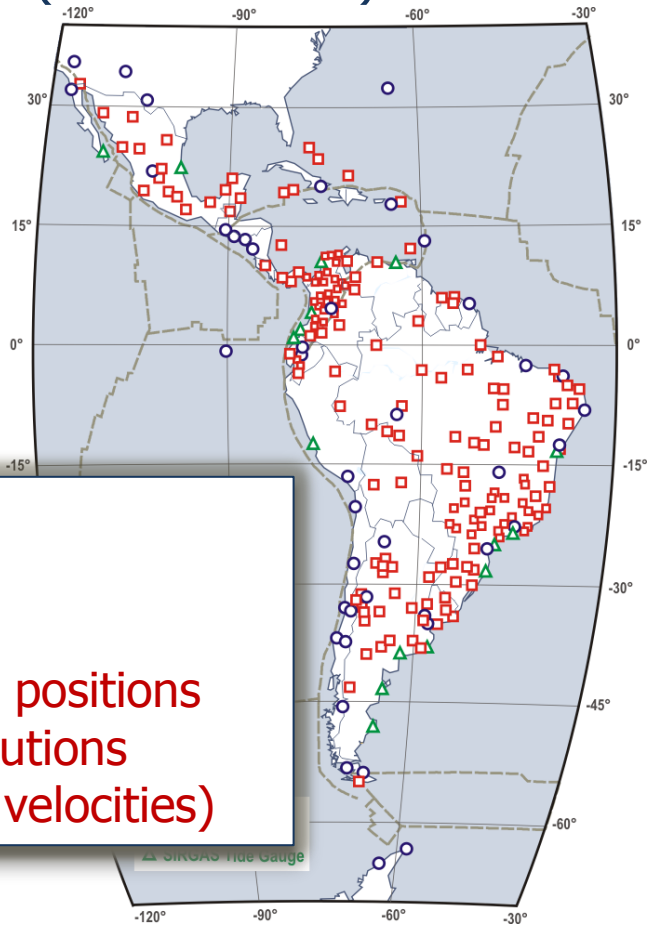
Before: Realization by means of GPS campaigns



SIRGAS95
- 58 stations
- ITRF94, 1995.4

SIRGAS2000
- 184 stations
- ITRF2000, 2000.4

Now: Realization by means of a continuously operating GNSS network (SIRGAS-CON)



SIRGAS-CON
- 237 stations
- Current ITRF
- Weekly station positions
- Cumulative solutions (positions and velocities)

DGFI IBGE

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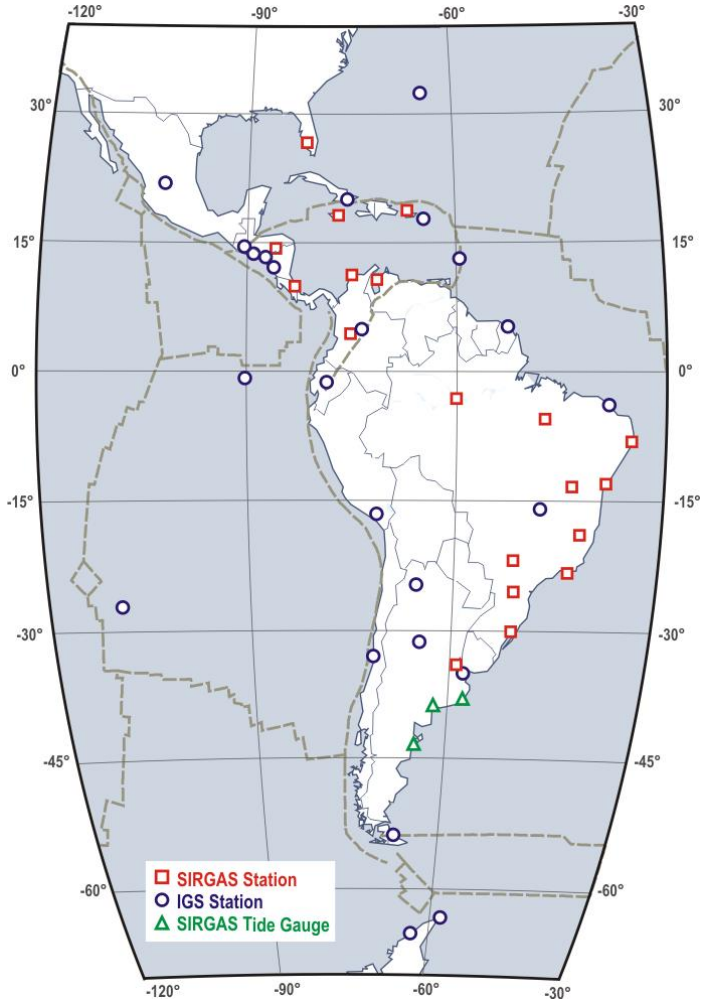
Geographical densification of the reference stations (1/2)

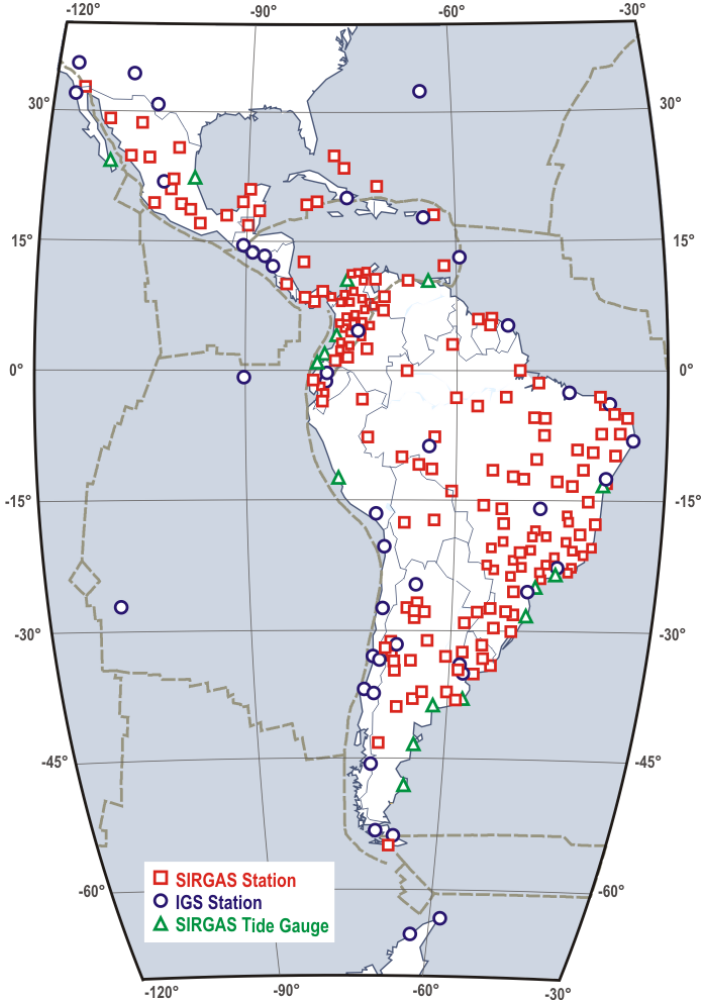
SIRGAS-CON in Sept. 2001

48 stations (24 IGS-stations)



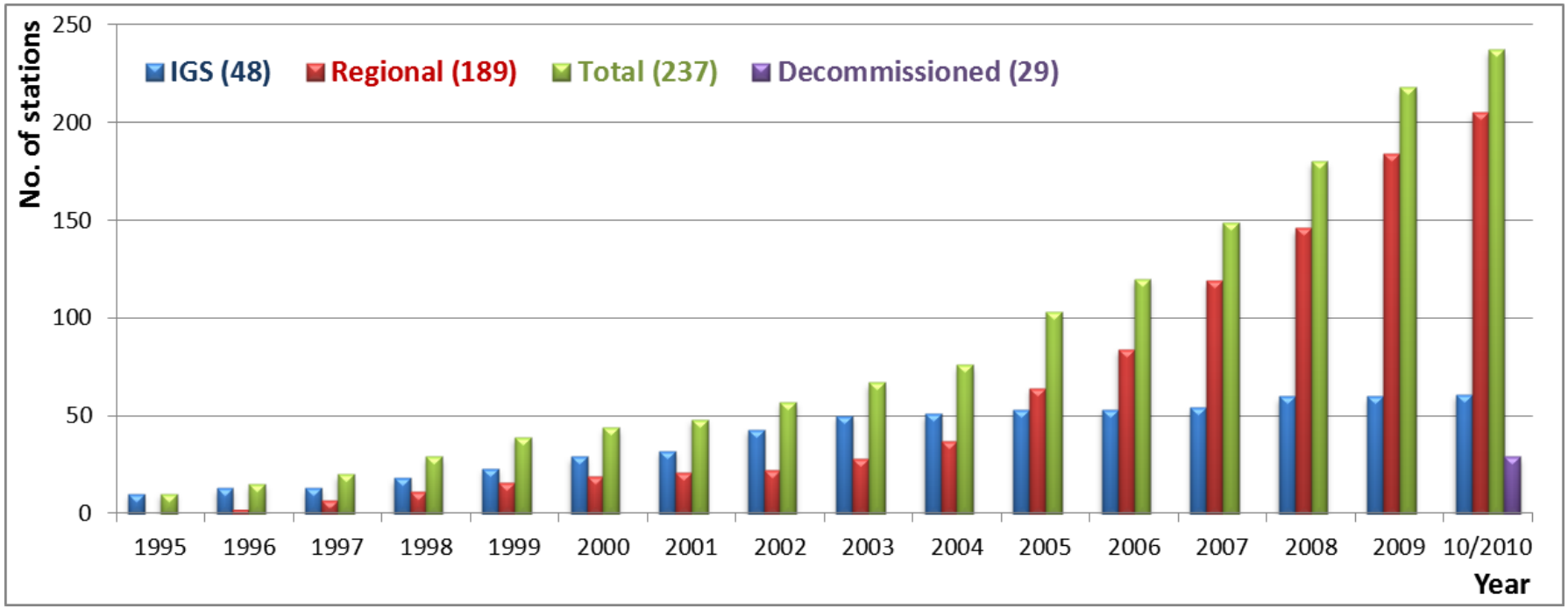
SIRGAS-CON in Sept. 2010

237 stations (48 IGS-stations)



Geographical densification of the reference stations (2/2)

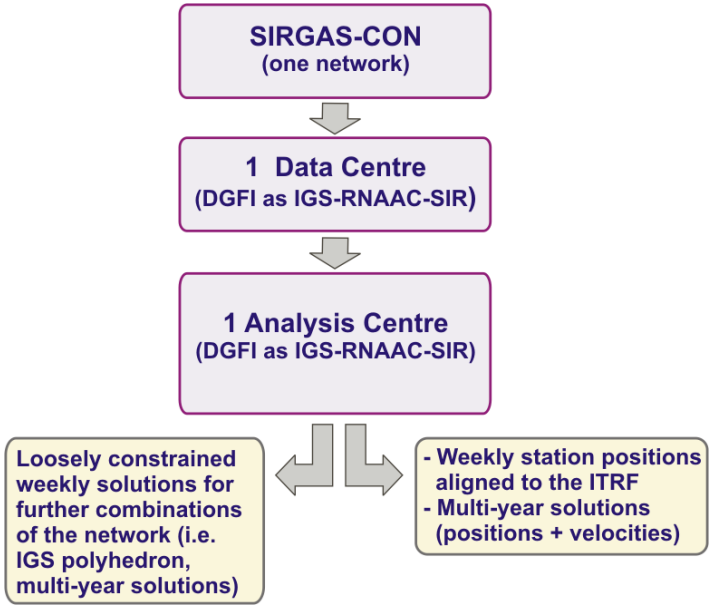
Number of SIRGAS-CON stations since 1995



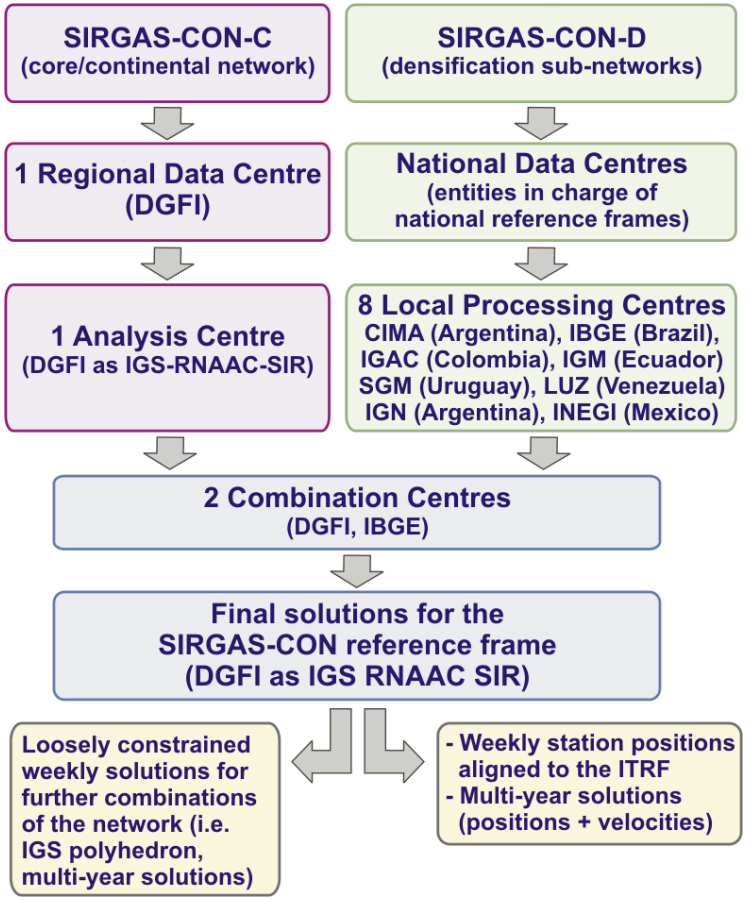
- Improvement of the national reference frames by installing continuously operating GNSS stations (intensively since 2005);
- Integration of the national GNSS reference stations into the continental reference frame (SIRGAS-CON) for common processing and to guarantee consistency with the ITRF.

Redundancy in the analysis of the reference frame

Before: one processing centre, one network processed in one block. Each station processed once.



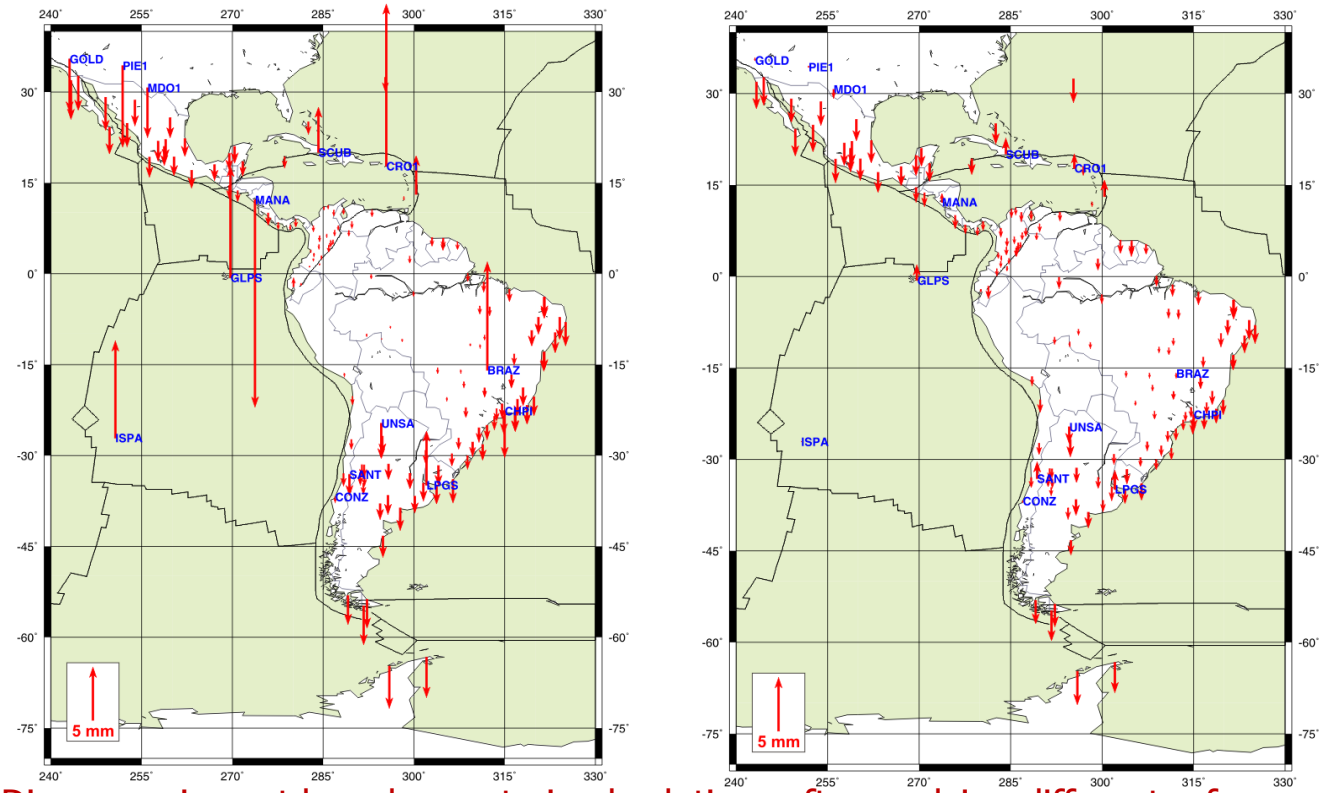
Now: 9 processing centres, 2 combination centres, one core network and many densification sub-networks (clusters). Each station processed by 3 analysis centres.



Datum definition strategy and availability of weekly reference coordinates

Before: Reference station positions were transformed from a conventional reference epoch applying constant velocities: $X(t_i) = X(t_0) + Vx(t_i - t_0)$

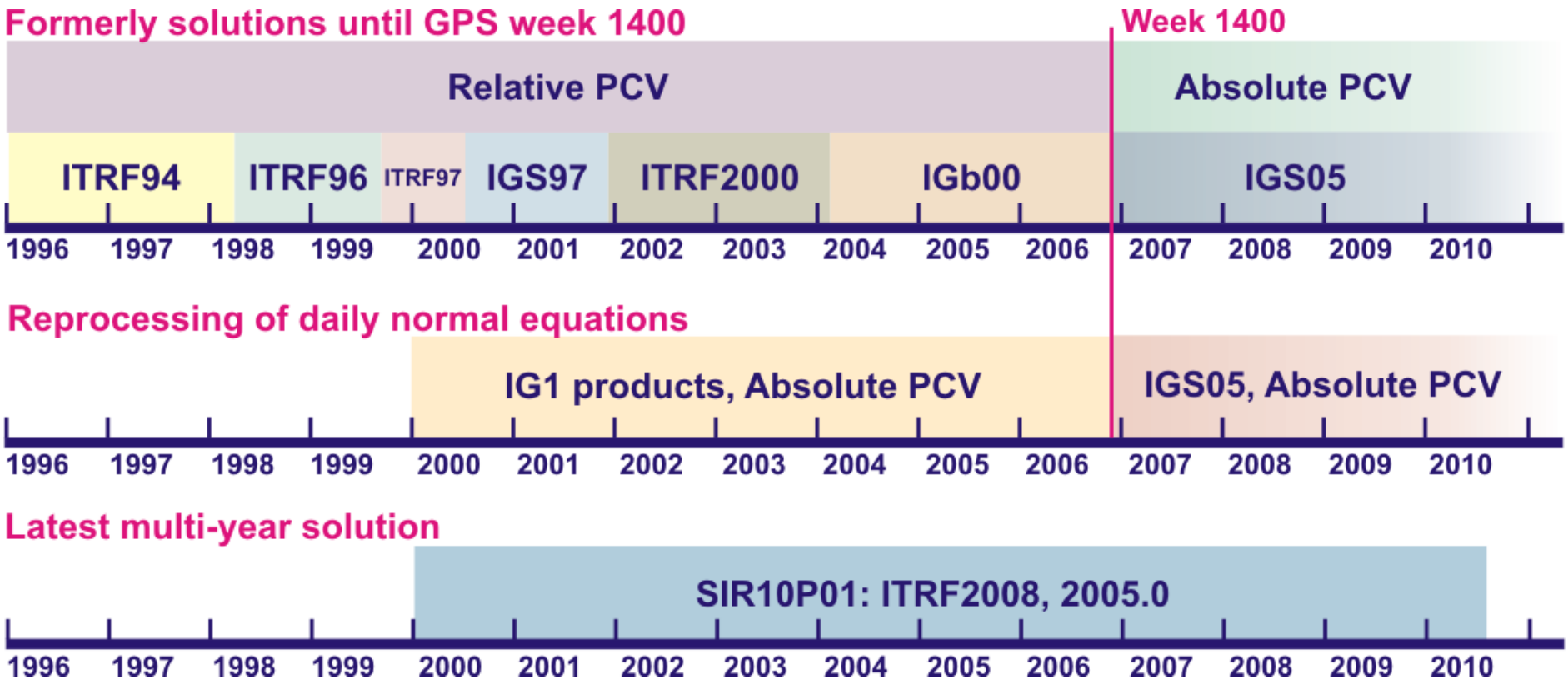
Now: Reference positions are computed by aligning the weekly solutions of the SIRGAS frame to the same frame in which the GNSS orbits are computed, i.e. the IGS weekly solutions.



Discrepancies wrt loosely constrained solutions after applying different reference coordinates for the datum definition (GPS week 1504)

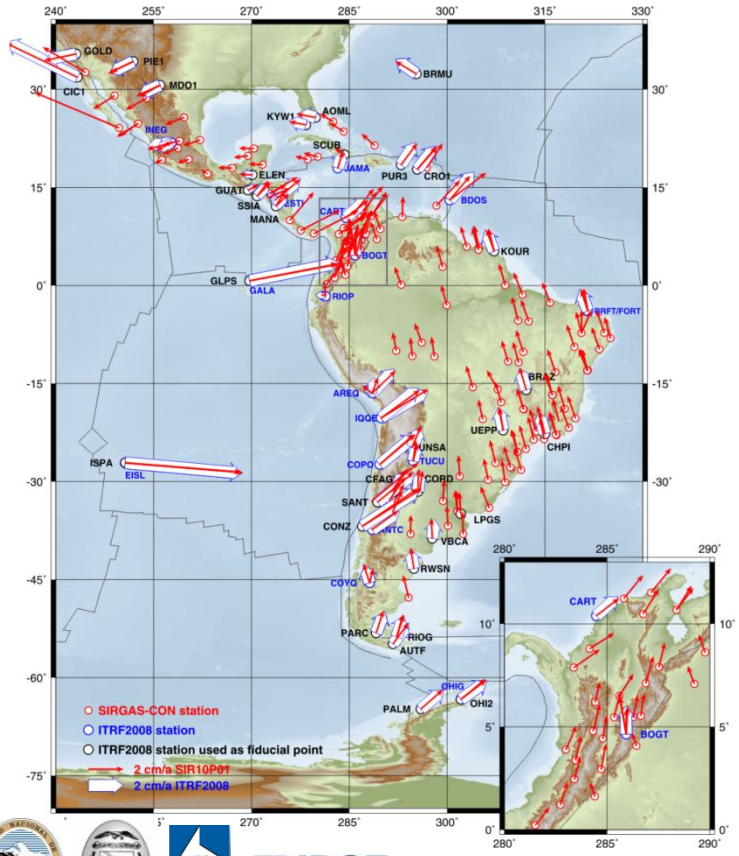
Reprocessing of the entire SIRGAS-CON network applying the reprocessed IGS products (IG1)

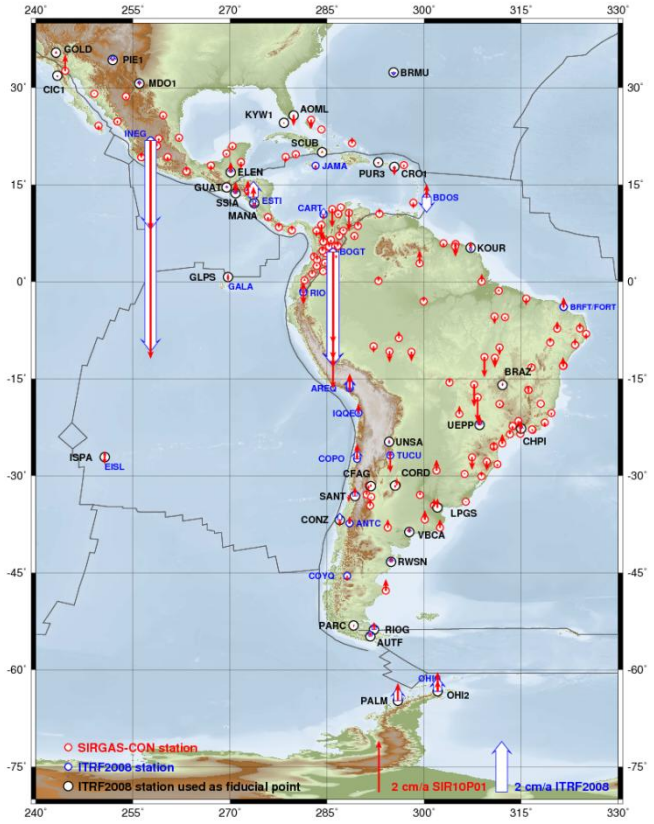
Every year cumulative (multi-year) solutions are computed to determine the kinematics of the SIRGAS reference frame.



Latest multi-year solution: SIR10P01

Time period: 02-01-2000 – 05-06-2010 (543 GPS weeks);
Stations: 183 (204 occupations);
Reference frame: ITF2008, epoch 2005.0;
Precision of positions at reference epoch: ±0,5 mm (hor), ±0,9 mm (vert.);
Precision of velocities: ±0,2 mm/a (hor), ±0,4 mm/a (vert.)





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Applicability of SIRGAS as reference frame

16 countries of 18 SIRGAS member countries adopted SIRGAS as official reference frame, i.e. the SIRGAS continental network is extended through national densification networks.

Users of precise GNSS positioning refer to SIRGAS (or their densifications) by:

1. Introducing weekly station positions of the SIRGAS-CON stations as reference coordinates to process GNSS surveying;
2. Applying the velocities provided by the multi-year solutions to reduce new station positions to the conventional reference epoch defining the official reference frame.

$$X(t_o) = X(t_i) - Vx(t_i - t_0)$$

Capacity building within SIRGAS

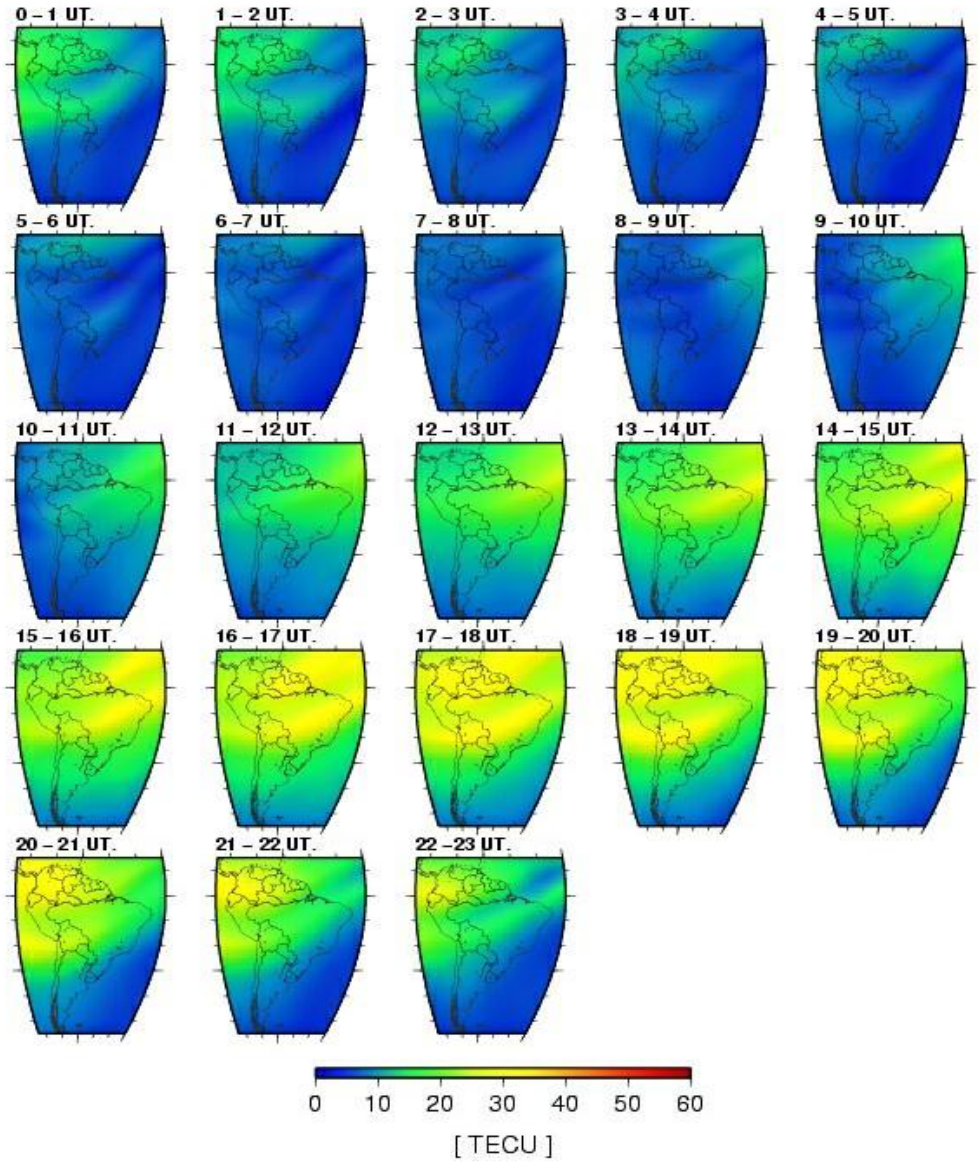
1. SIRGAS School on Reference Systems with support of the International Association of Geodesy (IAG) and the Pan-American Institute of Geography and History (PAIGH):
   - Bogotá, Colombia. July 2009, 120 participants, 12 countries
   - Lima, Peru. November 2010, 112 participants, 13 countries;
2. Advanced courses on GNSS analysis to establish and support SIRGAS Processing Centres operated by Latin American institutions (Colombia, Ecuador, Uruguay, Venezuela).

Ionospheric models of high-resolution

- Since July 2006, SIRGAS operates an Ionospheric Analysis Centre under the responsibility of La Plata National University, Argentina;
- Hourly regional maps of vTEC are computed and delivered to the community.

They are applied for:

- validation of the International Reference Ionosphere (IRI);
- improvement of positioning with single-frequency GNSS receivers;
- feasibility studies for a SBAS in the region (supported by the International Civil Aviation Organization - ICAO).



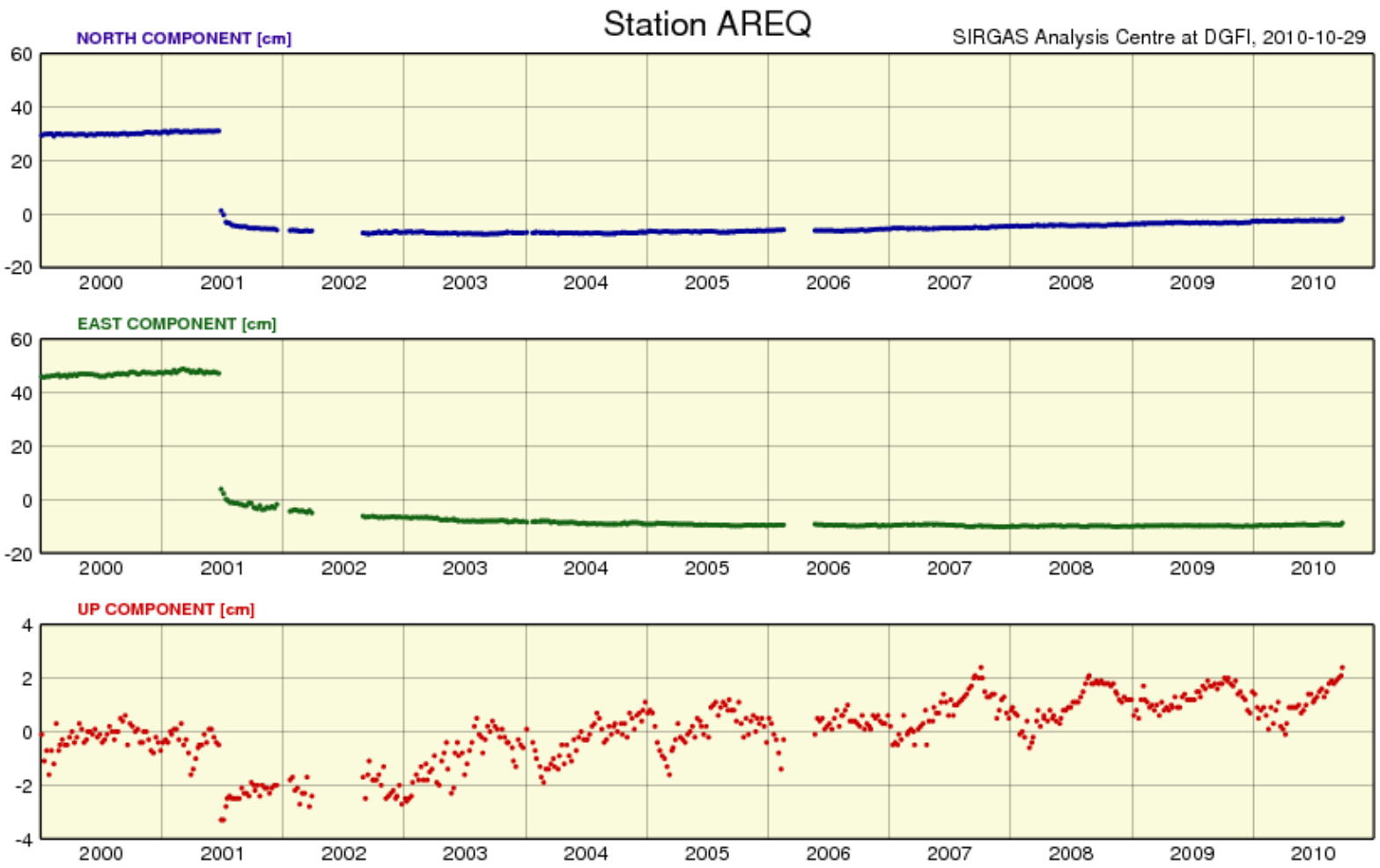
On-going activities

1. Implementation of a real-time GNSS infrastructure using NTRIP;
2. Routine analysis of the GLONASS network;
3. Modelling of atmospheric loading to understand seasonal variations of station positions;
4. Realization of a unified vertical reference system within a global definition;
5. Biggest challenge: to model the frame deformations due to seismic events.

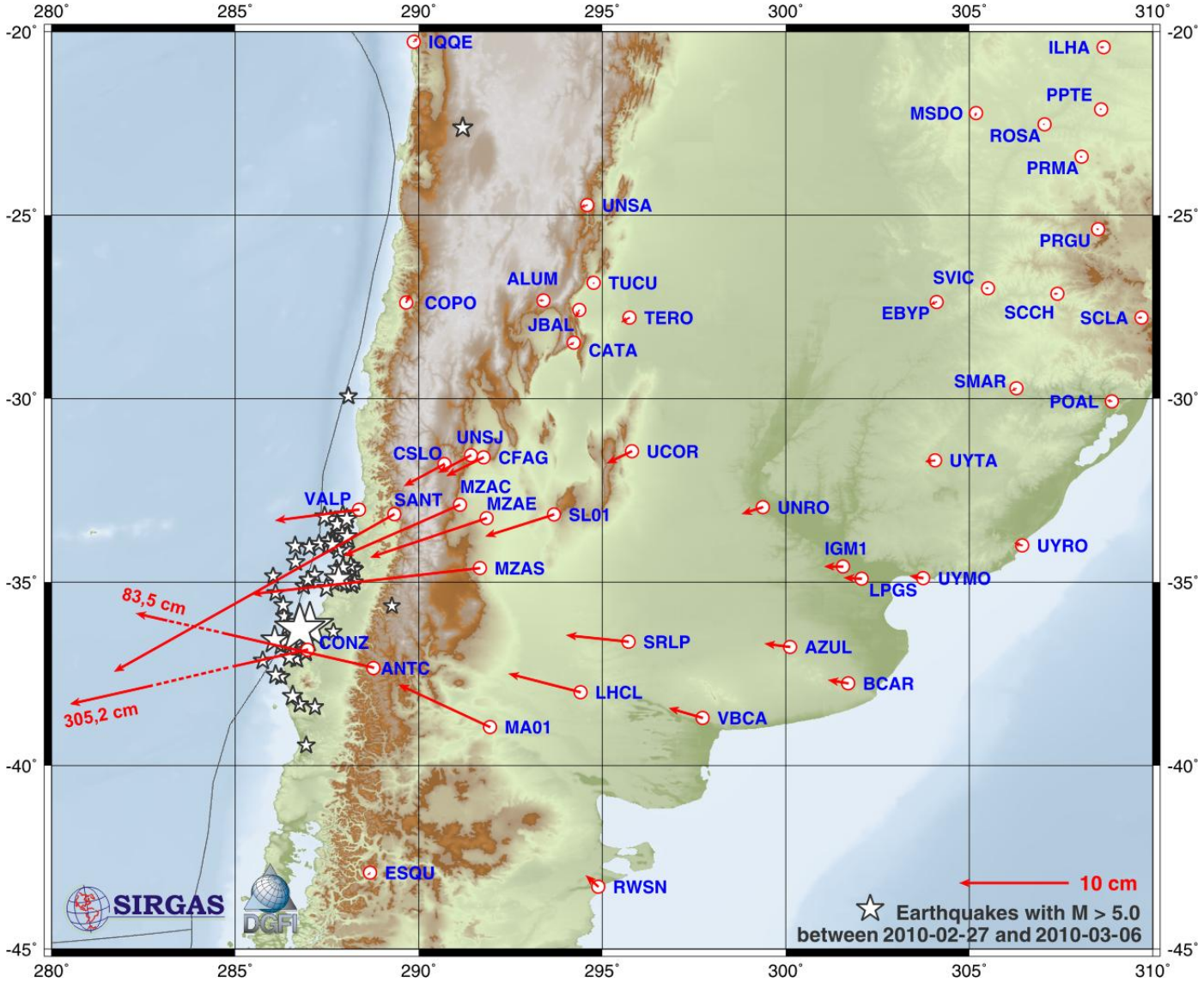
Impact of seismic events on the SIRGAS reference frame

Location	Date	M	Coordinate Change	Affected Stations
Mexicali, Mexico	2010-04-04	7,2	23 cm	MEXI
Chile	2010-02-27	8,8	1 cm - 3 m	See Fig. 2
Costa Rica	2008-01-08	6,1	2 cm	ETCG
Martinique	2007-11-29	7,4	1 cm	BDOS, GTK0
Copiapo, Chile	2006-04-30	5,3	2 cm	COPO
Tarapaca, Chile	2005-06-13	7,9	6 cm	IQQE
Managua, Nicaragua	2004-10-09	6,9	1 cm	MANA
Arequipa, Peru	2001-06-23	7,9	61 cm	AREQ

Impact of seismic events on the SIRGAS reference frame



Impact of seismic events on the SIRGAS reference frame



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Recommendations

1. To improve the national reference frames by installing more continuously operating GNSS stations in order to precisely monitor possible deformations;
2. The reference networks composed by non-continuously operating stations must be replaced as far as possible by continuously operating stations. If this is not possible, they have to be re-measured immediately after a strong seism;
3. The transformation between the pre-seismic and the post-seismic frame realizations must be based on a deformation model derived from discrete (weekly) station positions. The Helmert transformation cannot be applied;
4. In precise positioning, users have to apply epoch (weekly or monthly) positions as reference coordinates instead of those derived from a reference epoch and velocities.