SIRGAS: the core geodetic infrastructure in Latin America and the Caribbean

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Earth and Environmental Sciences for Future Generations

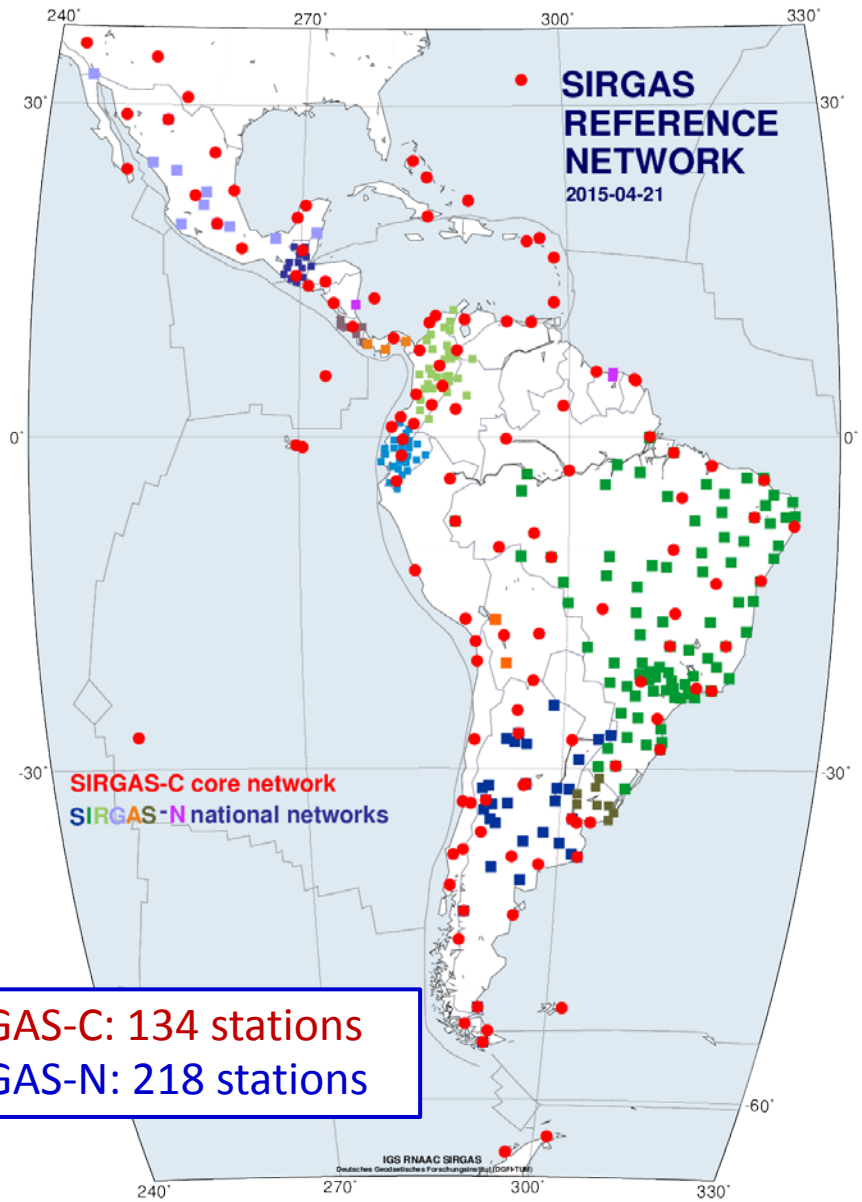
The SIRGAS Reference Frame

The SIRGAS Reference Frame comprises

- a continental reference network (SIRGAS-C) as the primary densification of the ITRF in the region; and
- national densifications (SIRGAS-N) of the continental reference frame.

It guarantees

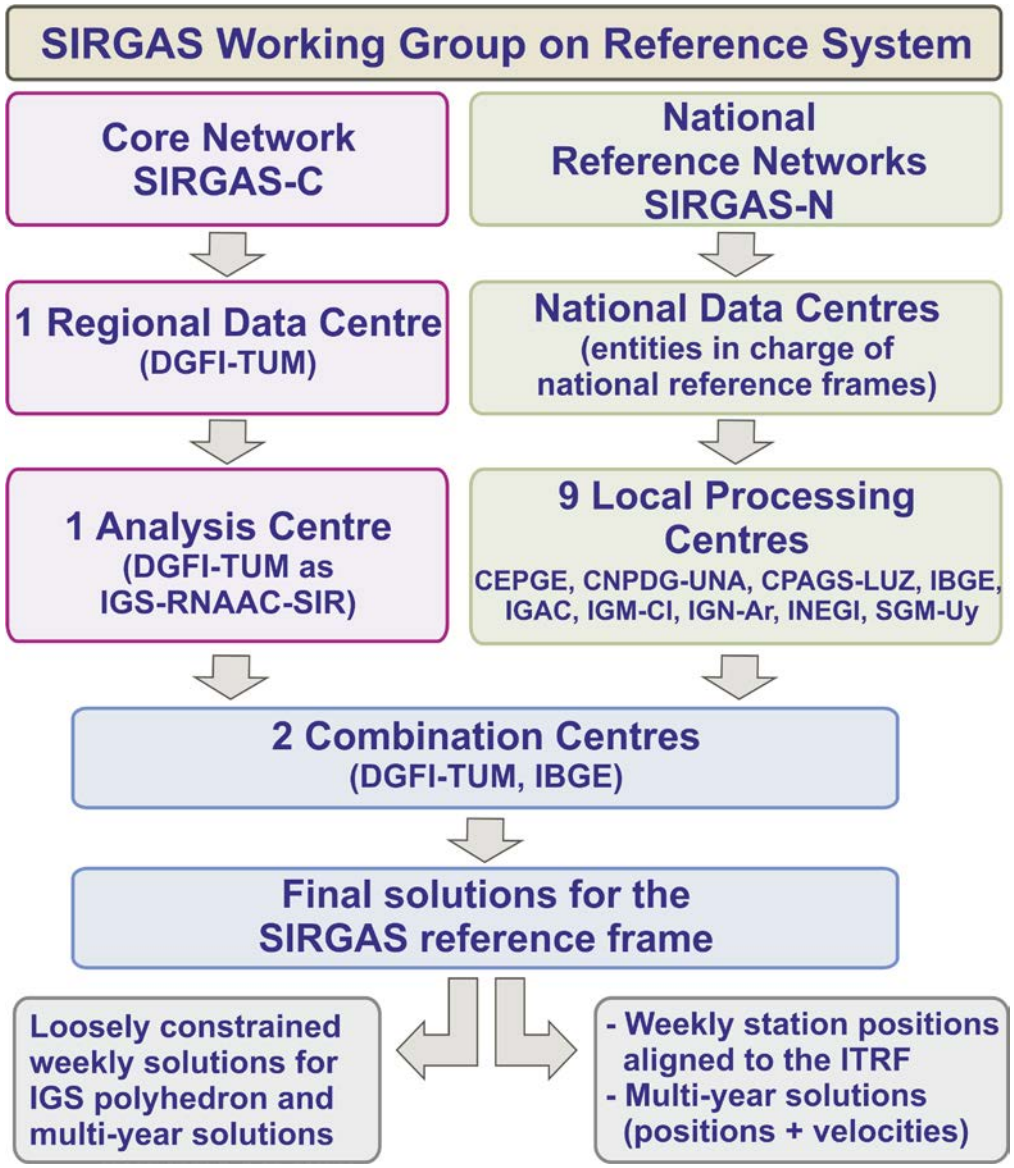
- accessibility to the global reference system at regional, national, and local levels and
- full consistency with the reference system of the (GNSS) satellite orbits.



SIRGAS-C: 134 stations
SIRGAS-N: 218 stations

The SIRGAS Reference Frame

- Each SIRGAS station is computed by three processing centres;
- The individual solutions are combined by the SIRGAS Combination Centres: IBGE (Brazil) and DGFI-TUM (Germany);
- Software:
  Argentina and Mexico
  → GAMIT/GlobK 10.5
  Brazil, Chile, Colombia, Costa Rica, Ecuador, Uruguay, Venezuela
  → Bernese GNSS Software 5.2



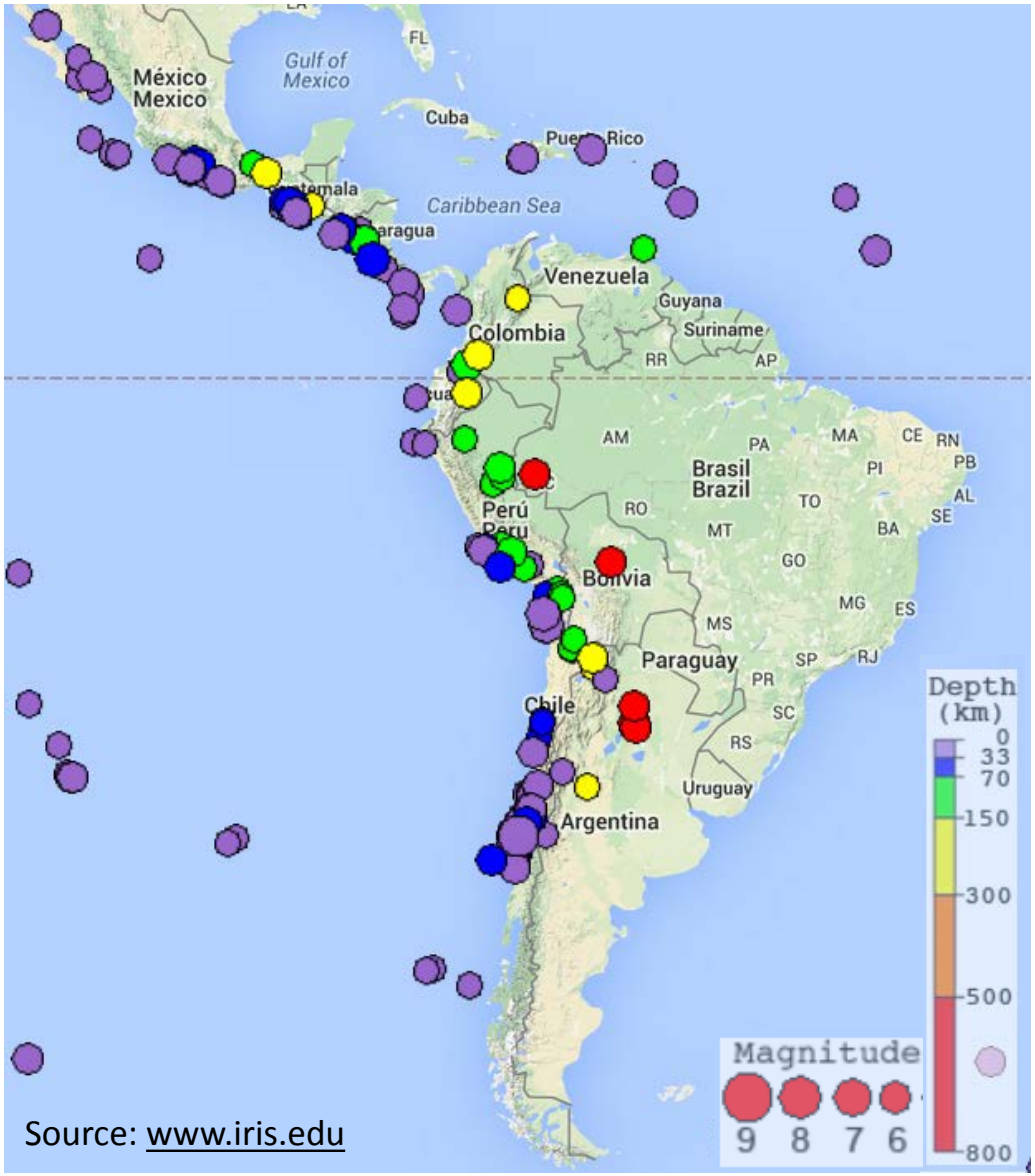
Main challenge: modelling reference frame deformations due to seismic events

Earthquakes in the SIRGAS Region from 2010-01-01 to 2015-06-17, with magnitudes from 6 to 10:

- Mw 8.0 – 8.8 : 2
- Mw 7.0 – 7.9 : 20
- Mw 6.0 – 6.9 : 124

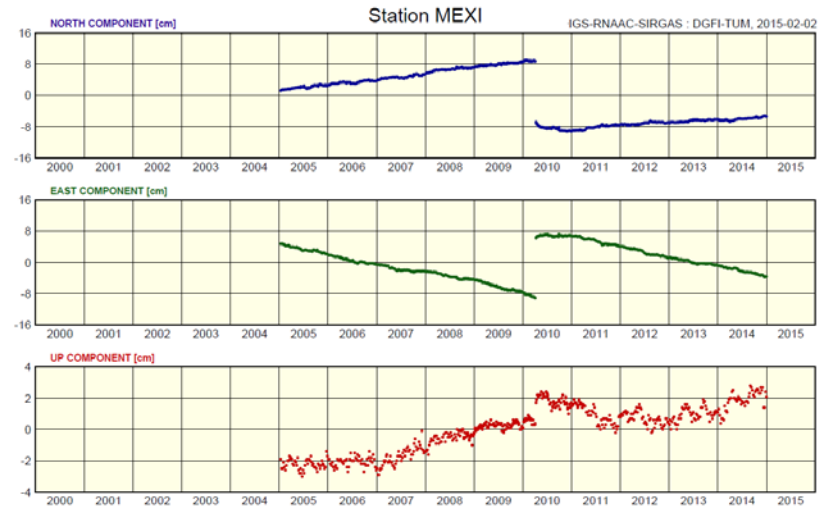
Source:

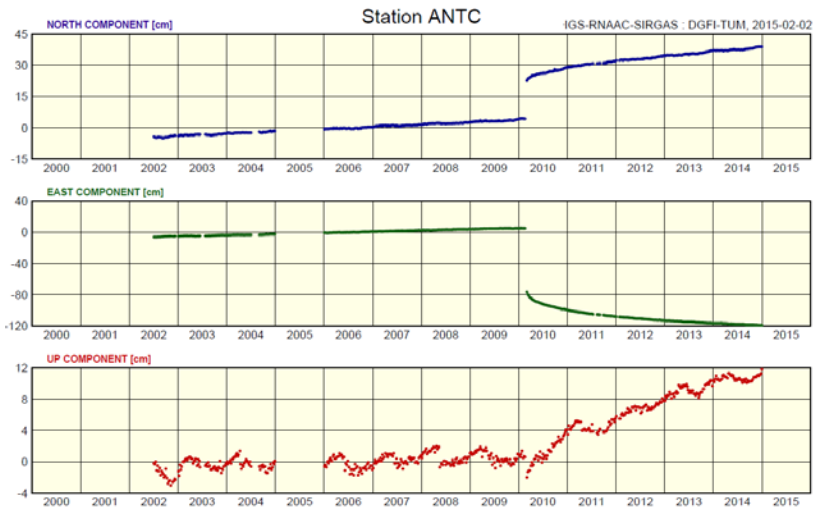
IRIS: Incorporated Research Institutions for Seismology, www.iris.edu

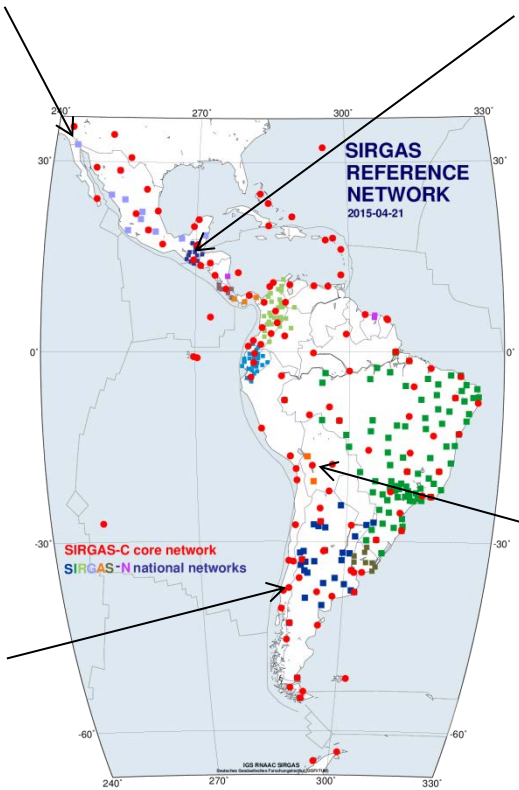


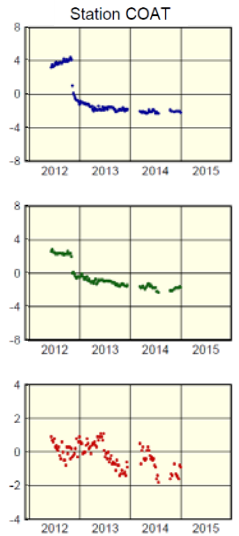
Seismic effects on reference station time series

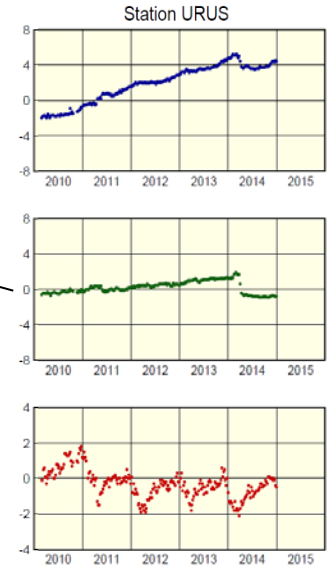
Strong earthquakes produce not only discontinuities in the station position time series, but also in the “usual” lineal movement of the stations:





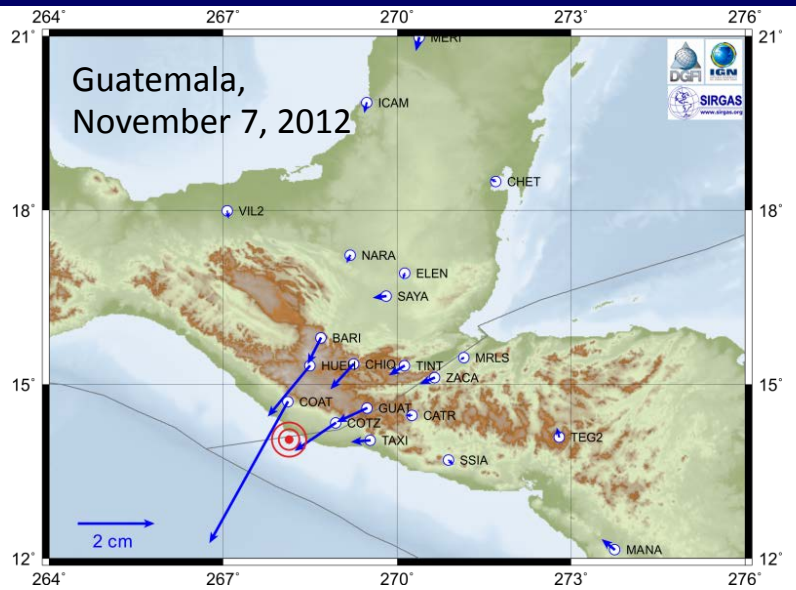


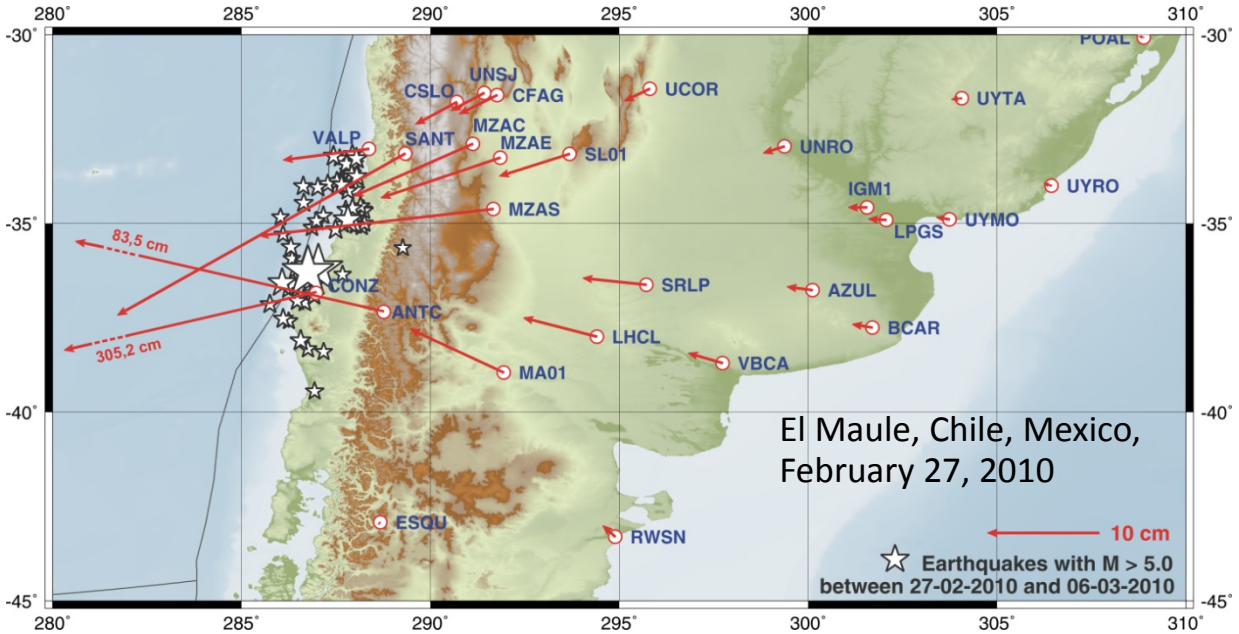




Inhomogeneous reference frame deformations

The caused deformations are not homogeneous along the reference frame and, therefore, the transformation between the pre-seismic and the post-seismic coordinates can not be carried out with the usual network transformations (like similarity or affine)

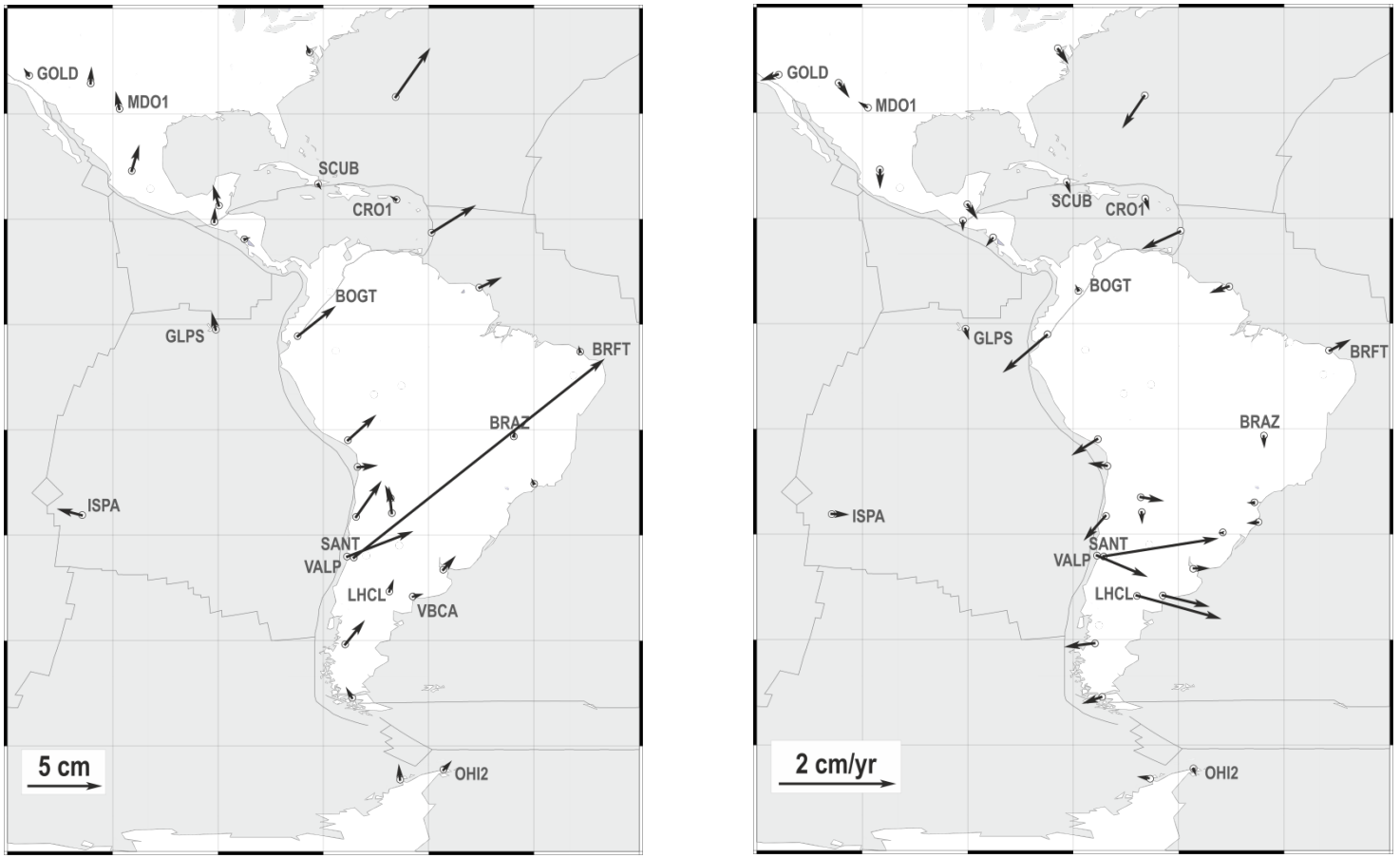




Co-seismic displacements in Chile/Argentina (Feb. 2010) and Guatemala (Nov. 2012)

Pre-seismic reference frame solutions are useless in the affected regions

Seismic deformations in the SIRGAS region make the existing ITRF solutions unusable and ITRF updates (re-computations) take too long.



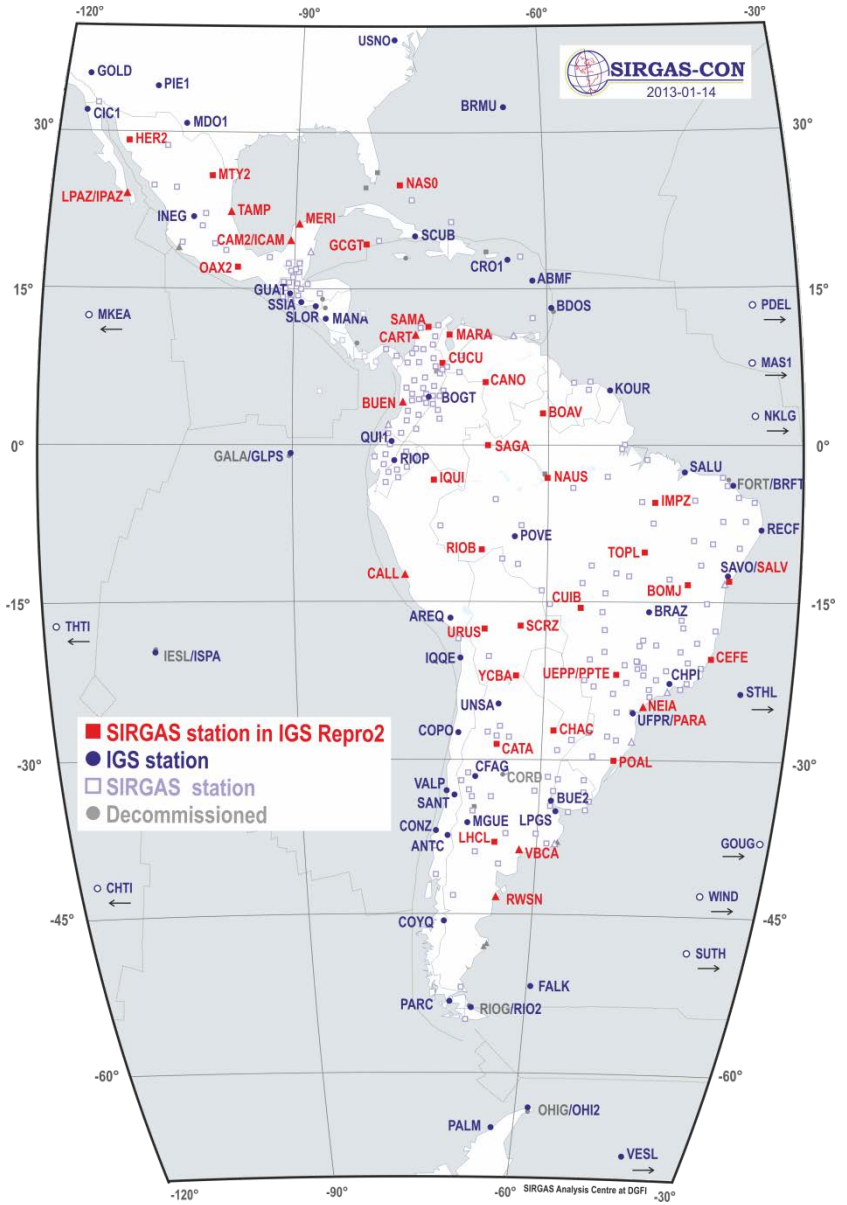
Horizontal position difference vectors (left) and horizontal velocity difference vectors (right) between the ITRF2008 and a SIRGAS post-seismic cumulative solution.

Fiducial points outside the SIRGAS Region

- Most of the ITRF stations in South America are affected by the earthquake in Chile in February 2010;
- Therefore, stations located in Europe, Africa, Oceania and North America are now included in the routine SIRGAS computations to increase the availability of fiducial points.

More ITRF stations in the SIRGAS Region

- 40 SIRGAS regional stations are now included in the routine weekly analysis of the IGS network since June 2012;
- Historical data remitted to the IGS for incorporation in the Second IGS Reprocessing;
- Next ITRF (2014) will contain these 40 stations;
- Advantages:
  - ✓ More fiducial stations in the SIRGAS region, but also,
  - ✓ A better global distribution of the ITRF stations.



SIR15P01: a post-seismic cumulative SIRGAS solution

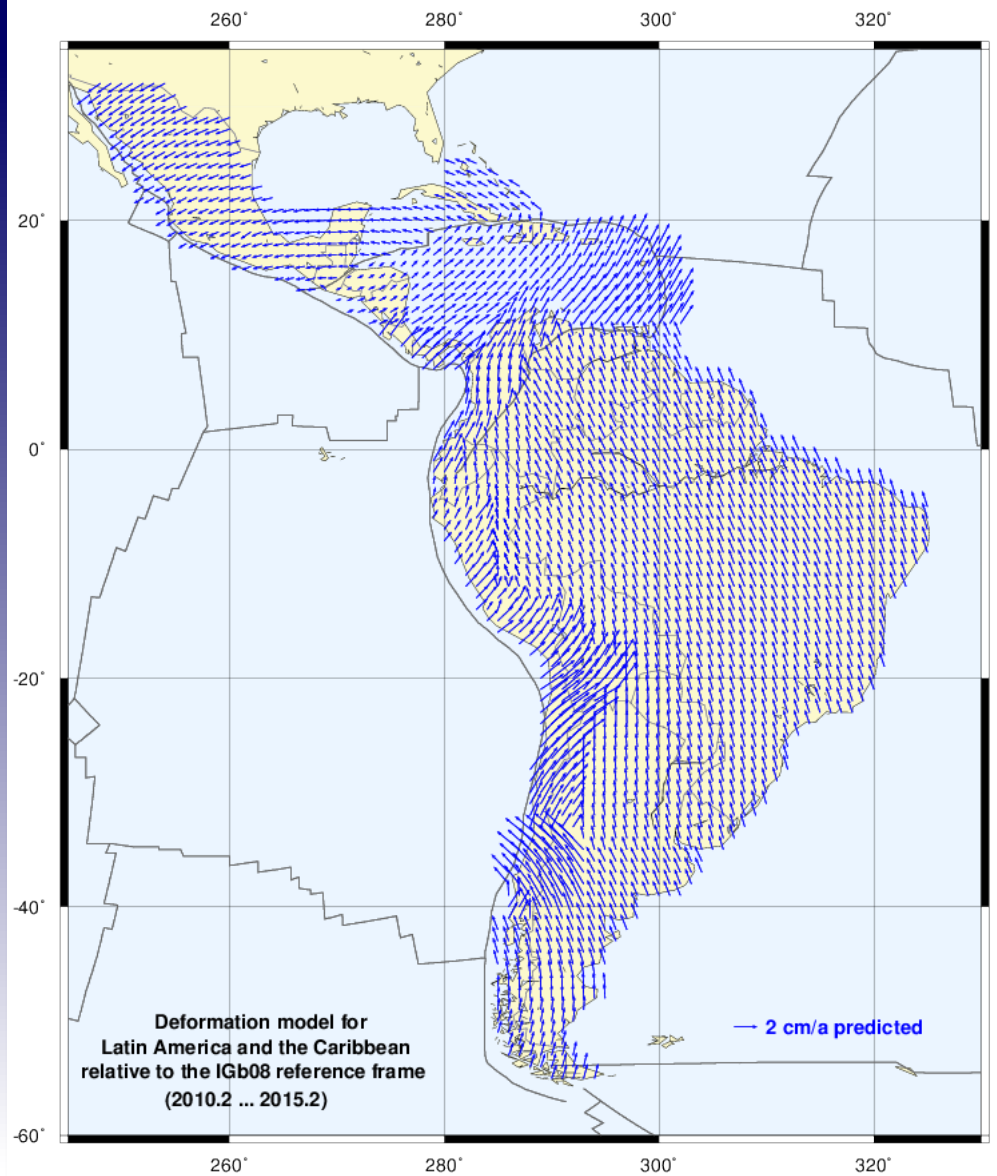
- Recomputed weekly normal equations applying new IGS/IERS standards;
- Time span: 2010.2 - 2015.2;
- 303 stations;
- Frame: IGb08, 2013.0
- Accuracy:

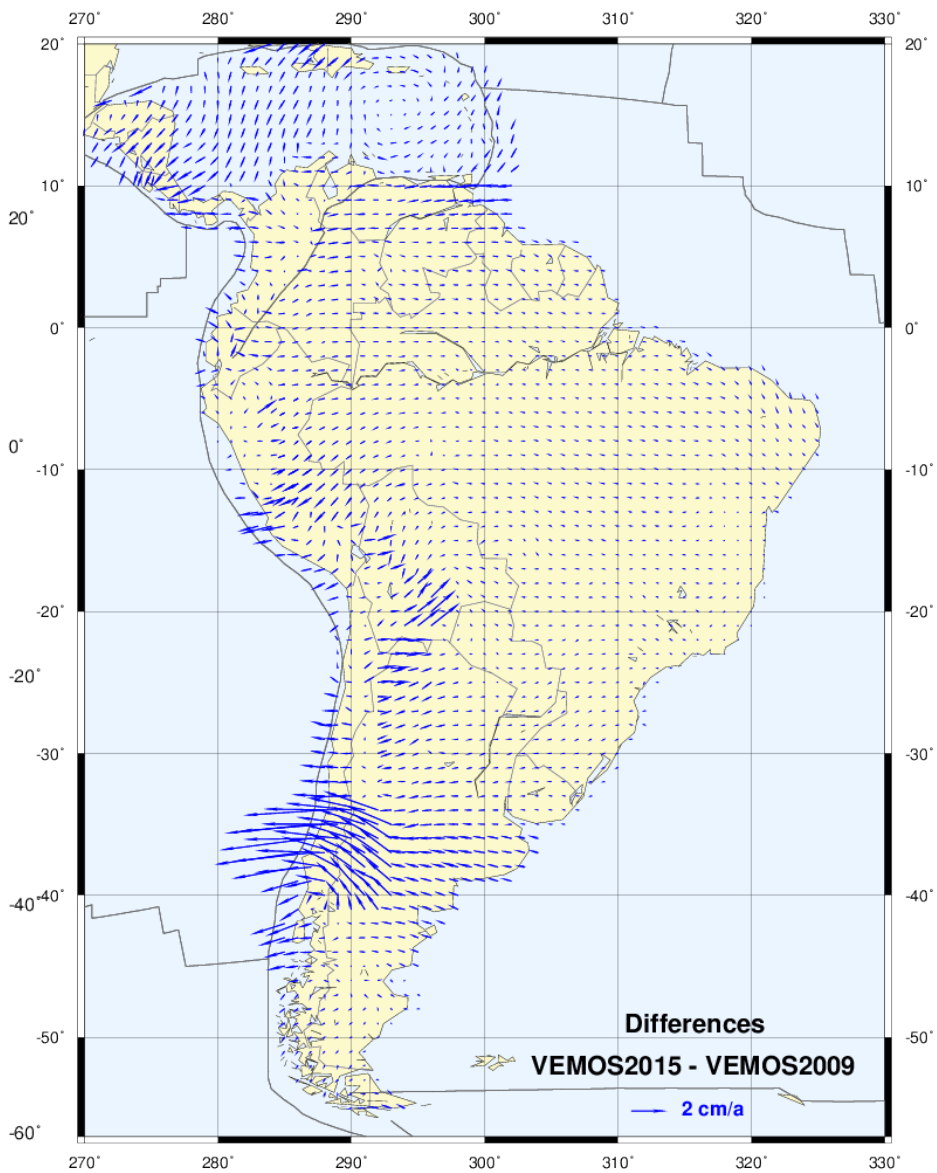
  Pos.: N - E = ±1,8 mm
  h = ±3,5 mm
  Vel.: N - E = ±1,0 mm/a
  h = ±1,2 mm/a

Densification of estimated velocities in the SIRGAS Region

- Processing of 135 additional stations (no SIRGAS stations) for the computation of a post-seismic SIRGAS deformation model;
- Additional data provided by UNAVCO and NGS.

Post-seismic deformation model VEMOS2015 and its comparison with the pre-seismic model VEMOS2009





On-going activities

- Second reprocessing of the entire SIRGAS reference frame:
  - ✓ New computation of daily normal equations from January 1, 1997 until December 31, 2013
  - ✓ Following the new geodetic standards outlined by the IERS and the IGS
  - ✓ Including GLONASS measurements;
- Computation of co-seismic deformation models derived from discrete (weekly) station positions to incorporate seismic discontinuities in the computation of the reference frame;
- These models shall be the basis for the transformation of geospatial information referring to the pre-seismic coordinates (specially in official maters like legal borders, cadastre, land management, etc.).
- Modelling of seasonal movements at the combination level of the weekly solutions.

Acknowledgments

- The results described in this presentation are a consequence of a **successful international geodetic cooperation** possible thanks to the active participation of more than **50 Latin American and Caribbean colleagues and institutions**, who not only make the measurements of the stations available, but also operate SIRGAS Analysis Centres, and execute projects to continue improving the reference frame. **This cooperation is highly recognized**.

- We also thank for the strong support provided by the **International Association of Geodesy** (IAG), the **Pan-American Institute for Geography and History** (PAIGH) and the **International Union of Geodesy and Geophysics** (IUGG).

- More details about SIRGAS in **www.sirgas.org**.