Status of the SIRGAS reference frame: recent developments and new challenges

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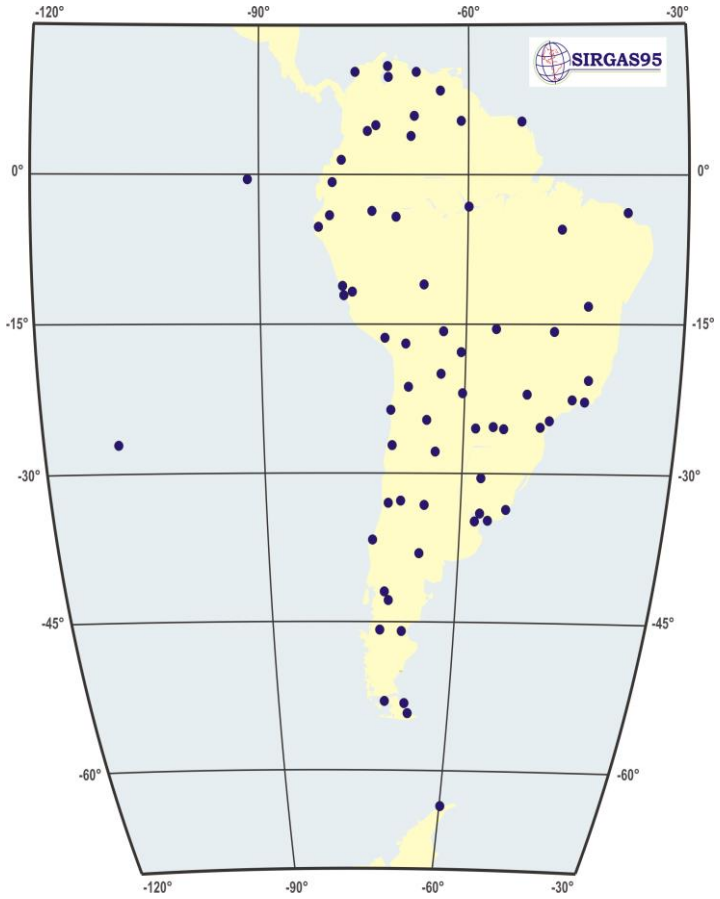
SIRGAS: Sistema de Referencia Geocéntrico para las Américas

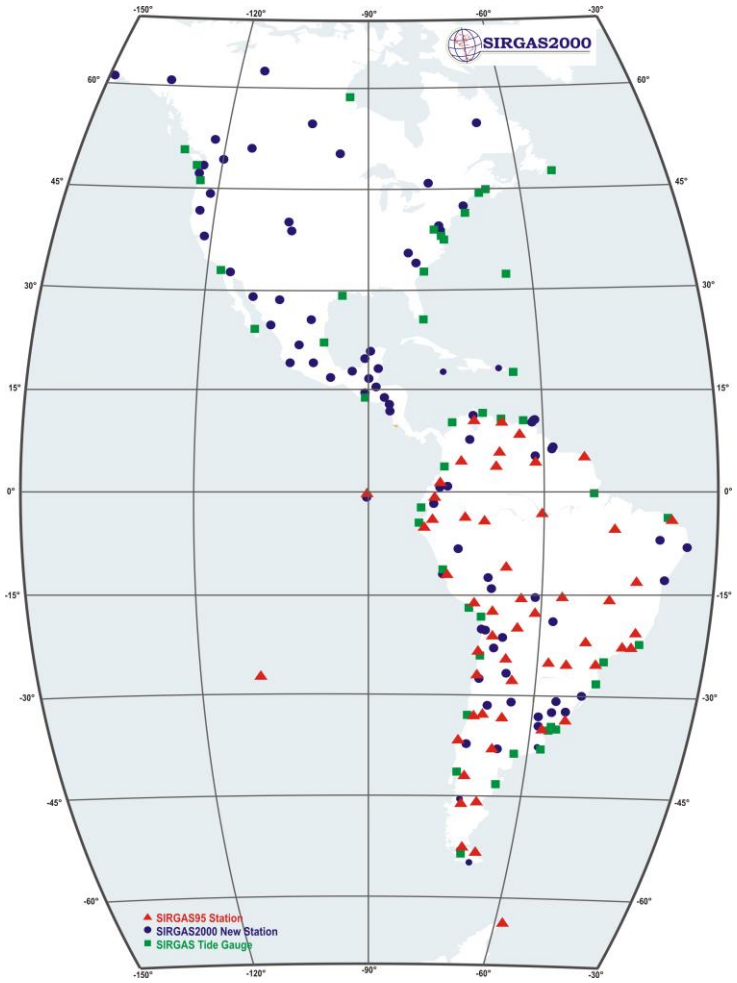
- Established in 1993
- Initiated by
  - International Association of Geodesy – IAG
  - Pan-American Institute for Geography and History – PAIGH
  - US Defence Mapping Agency – DMA (today NGA)
  - South American national mapping agencies
- Realised by a regional densification of the International Terrestrial Reference Frame (ITRF)
- Extended to a gravity field-related vertical reference system in 1998
  - Geopotential numbers referring to a common W_0 reference value

SIRGAS realisations

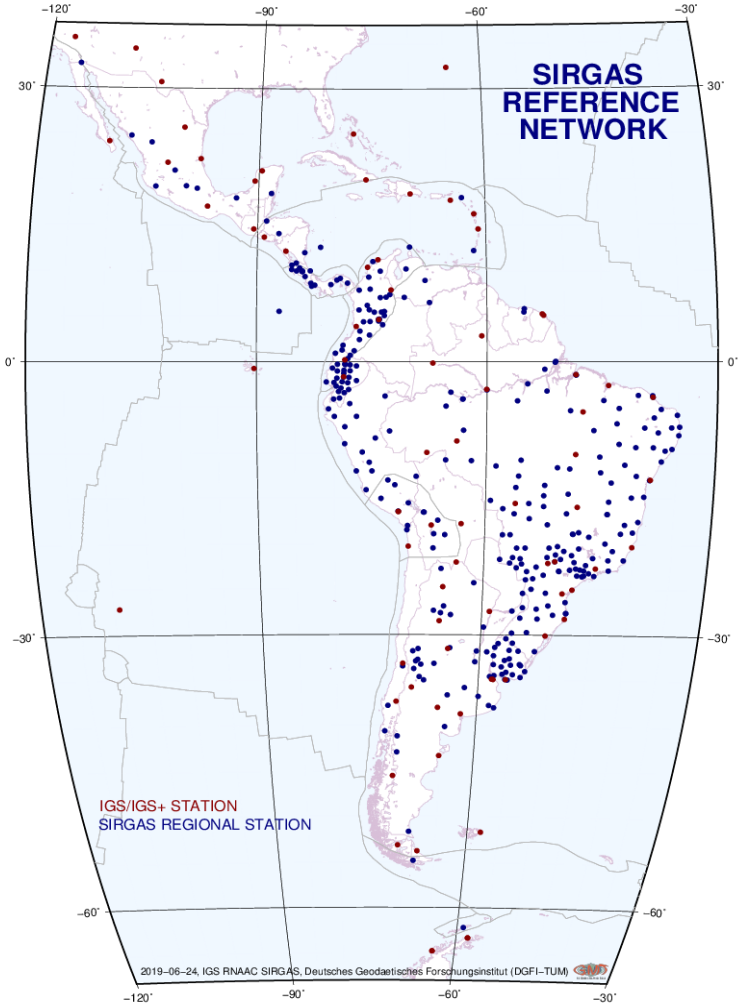
SIRGAS1995: ITRF94 1995.4
GPS campaign, 58 stations



SIRGAS2000: ITRF2000 2000.4
GPS campaign, 184 stations



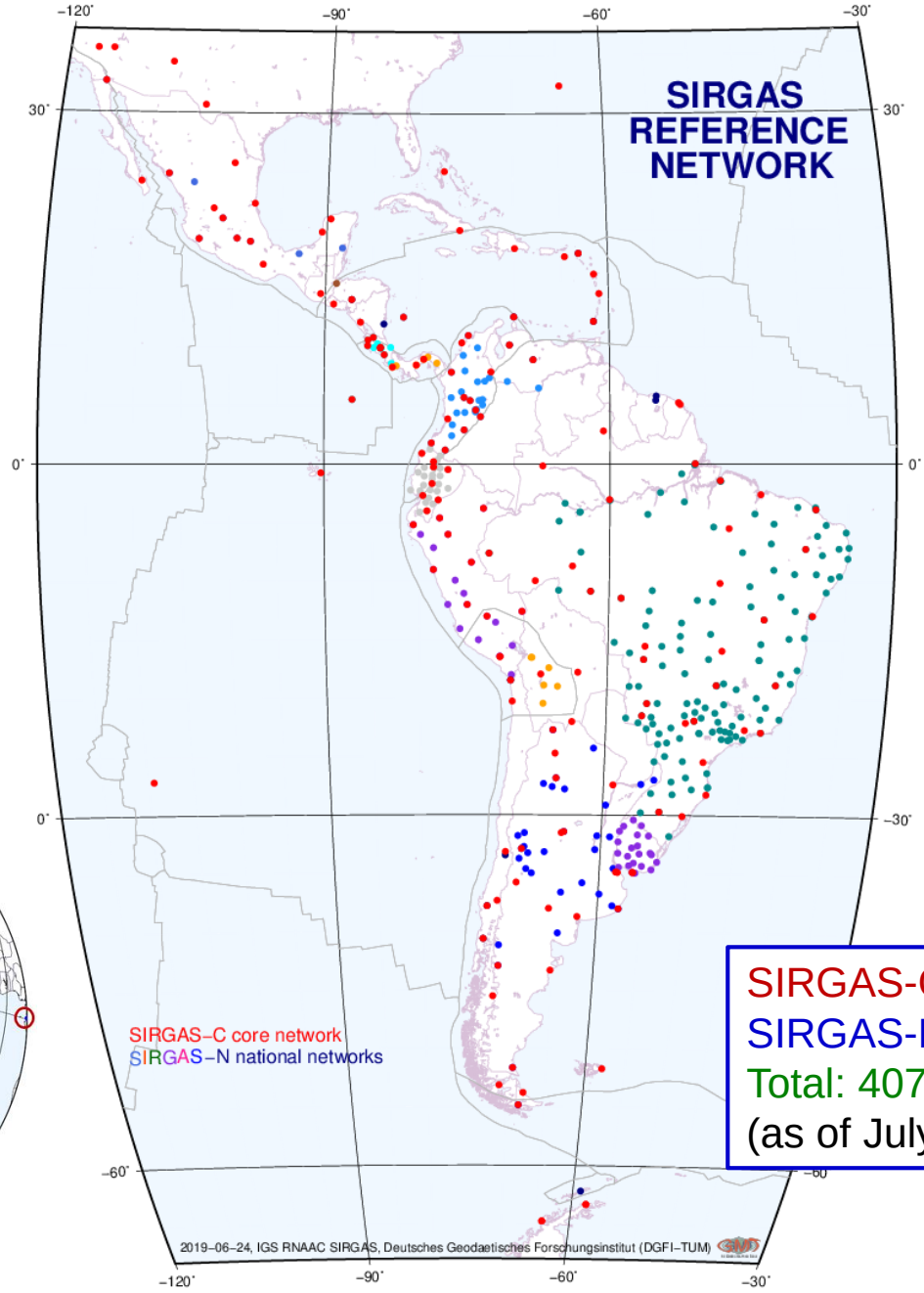
Today: ≈ 400 continuously operating
GNSS stations



SIRGAS reference network

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
- IGS stations: 69
- GLONASS: 335
- Galileo: 91
- Beidou: 58

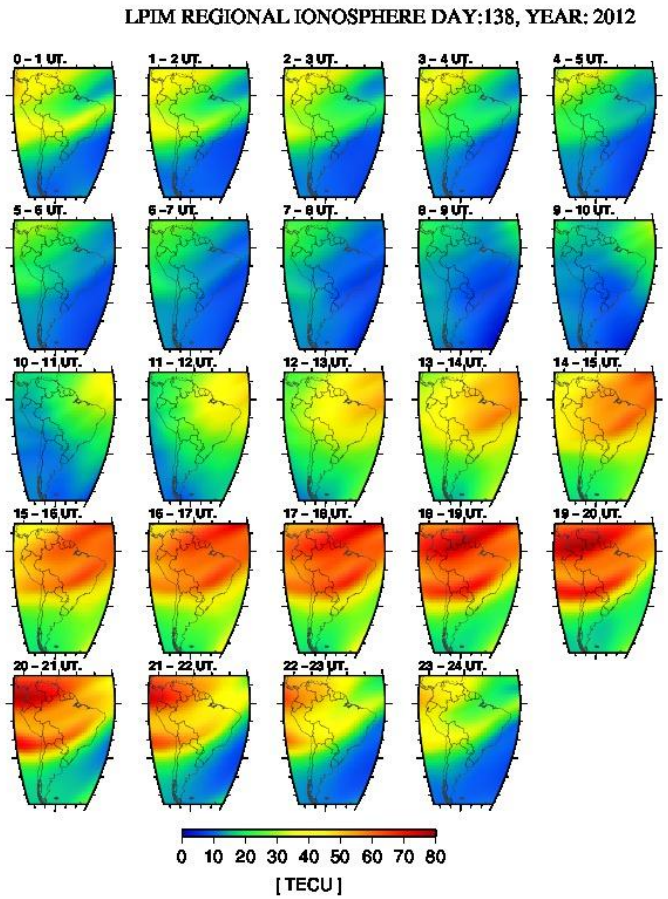


SIRGAS-C: 170 stations
SIRGAS-N: 237 stations
Total: 407 stations
(as of July 2019)

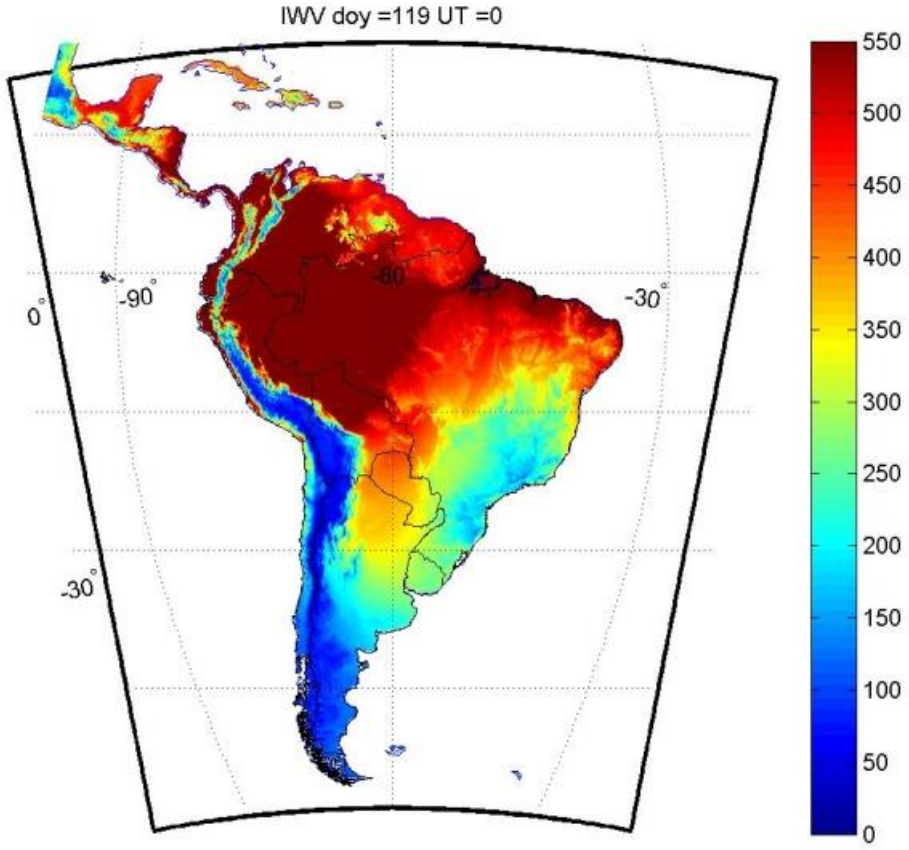
SIRGAS Reference Frame

Primary infrastructure for positioning, real-time applications, atmospheric studies, non-tidal loading deformation, etc.

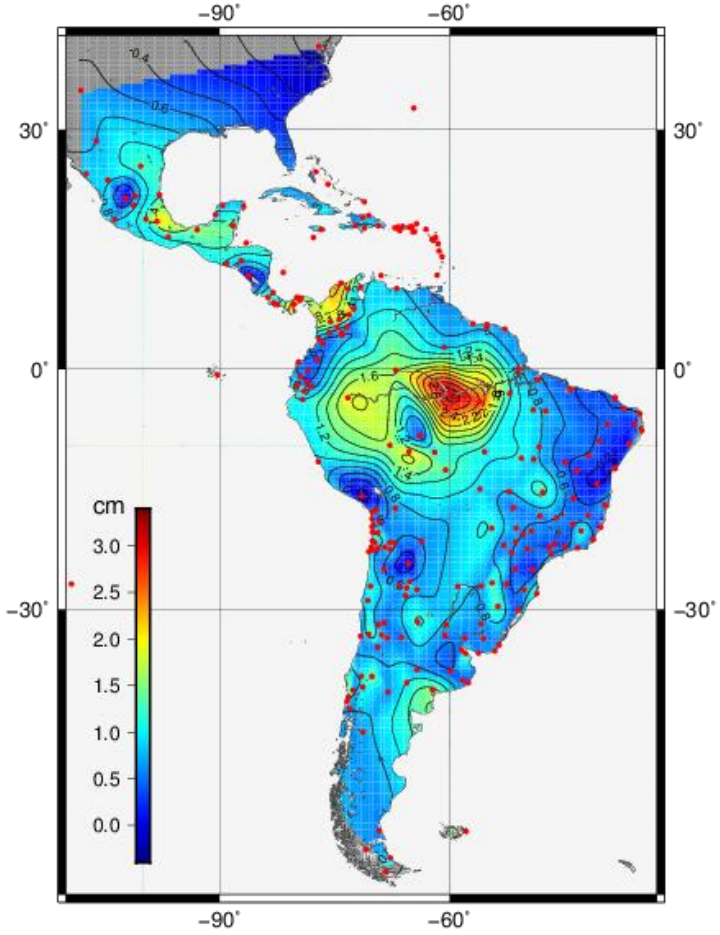
Daily maps of vertical total electron content (VTEC) (Brunini et al. 2010)



Daily maps of integrated water vapour (IWV) Mackern et al. (2019)



Non-tidal loading deformation modelling (Brunini et al. 2018)



Operational analysis of the SIRGAS Reference Frame

Nine processing centres:

IGM-Chile, CEPGE-Ecuador, IGN-Argentina, IBGE-Brazil, IGAC-Colombia, INEGI-Mexico, CPAGS-LUZ-Venezuela, SGM-Uruguay IGS RNAAC SIRGAS (DGFI-TUM) Germany

Two combination centres:

IBGE-Brazil, IGS RNAAC SIRGAS-Germany

Each SIRGAS station is computed by three processing centres following unified standards aligned to IERS and IGS

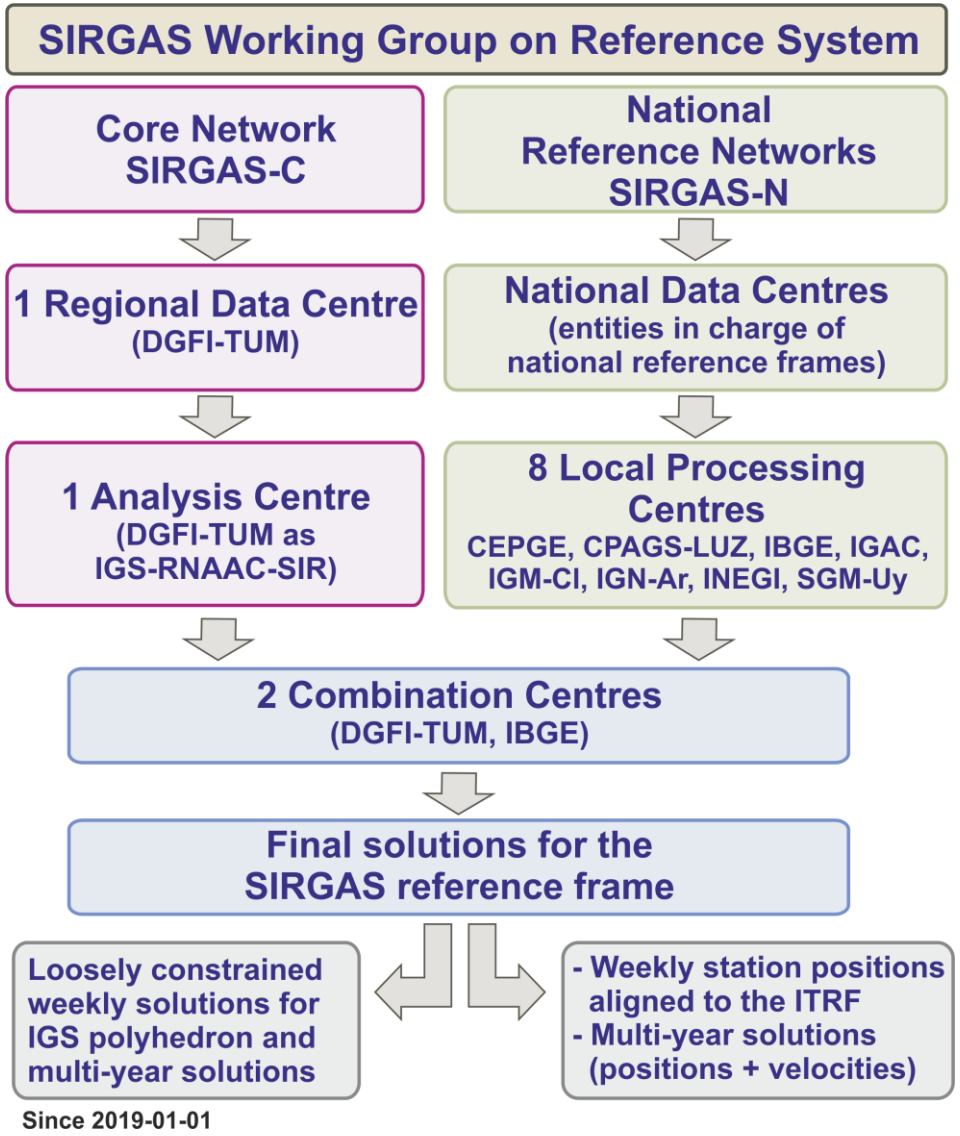
Software:

Argentina and Mexico

→ GAMIT/GlobK 10.5

Brazil, Chile, Colombia, Ecuador, Uruguay, Venezuela, IGS RNAAC SIRGAS

→ Bernese GNSS Software 5.2



SIRGAS coordinates

1) Weekly station positions aligned to the ITRF
   - based on the IGS operational products (satellite orbits, satellite clocks, EOPs) and IGS reference frame coordinates
   - especially useful when strong earthquakes cause co-seismic jumps or strong relaxation motions at the SIRGAS reference stations making the previous coordinates useless
   - precision (internal consistency) is about ±1.0 mm in the horizontal component and ±2.5 mm in the height
   - reliability (external accuracy) is about ±1.0 mm in the horizontal position and ±3.0 mm in the height.

2) Multiyear (cumulative) solutions providing station constant velocities and positions referring to a certain epoch
   - to maintain the SIRGAS reference frame between two releases of the ITRF
   - to monitor the kinematics of the reference frame.

Kinematics of the SIRGAS Reference Frame

SIR11P01: 2000.0 - 2010.1

ITRF2008, 2005.0, 230 stations

Accuracy positions
Hor.: ±1.5 mm, Vert.: ±2.4 mm

Accuracy velocities
H.: ±0.7 mm/a, V.: ±1.1 mm/a

SIR15P01: 2010.2 - 2015.2

IGb08, 2013.0, 456 stations

Accuracy positions
Hor.: ±0.8 mm, Vert.: ±3.5 mm

Accuracy velocities
H.: ±0.7 mm/a, V.: ±1.6 mm/a

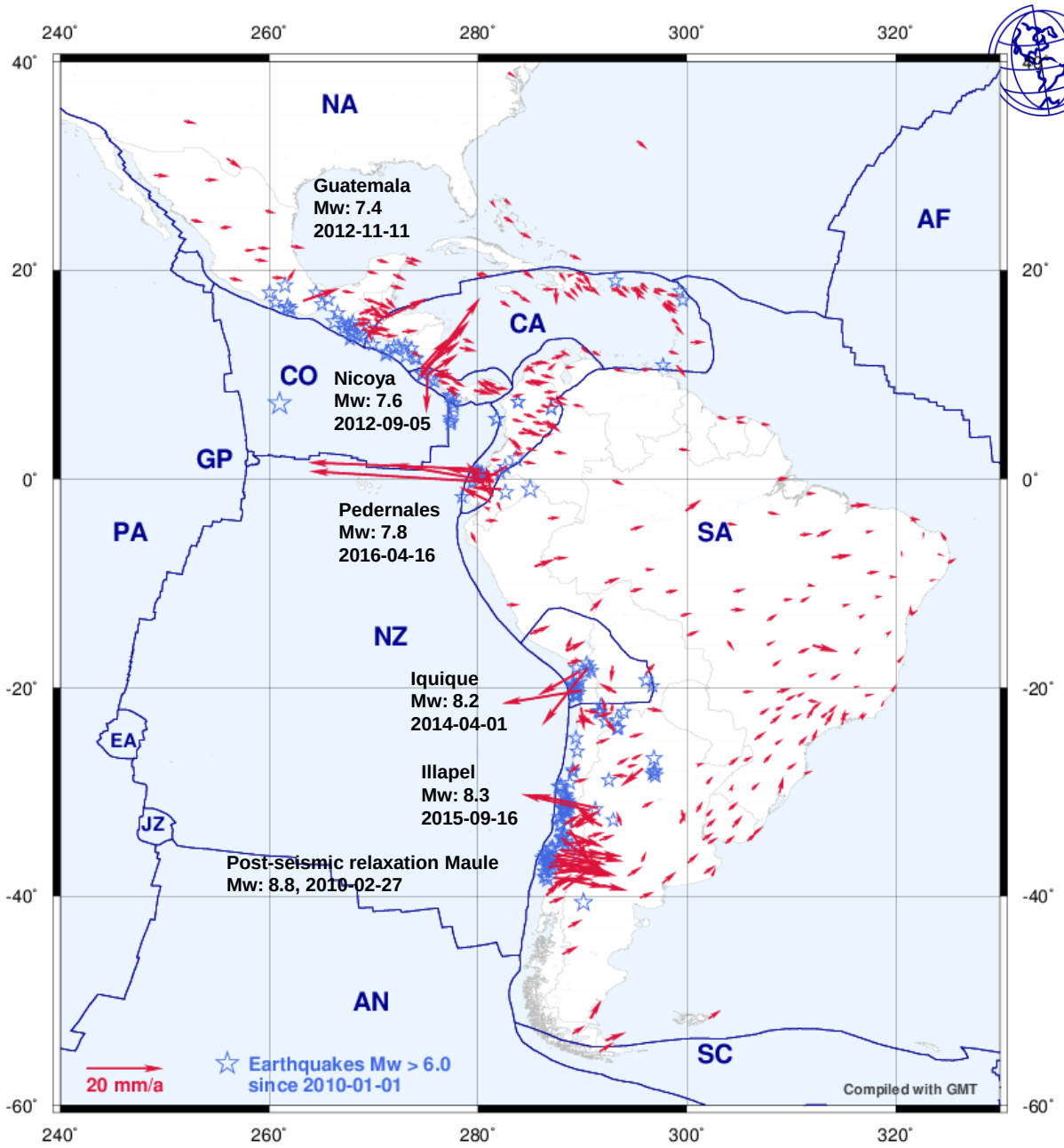
SIR17P01: 2011.2 - 2017.1

IGS14, 2015.0, 345 stations

Accuracy positions
Hor.: ±0.8 mm, Vert.: ±2.5 mm

Accuracy velocities
H.: ±0.7 mm/a, V.: ±1.1 mm/a

Changes in the station velocities due to strong earthquakes

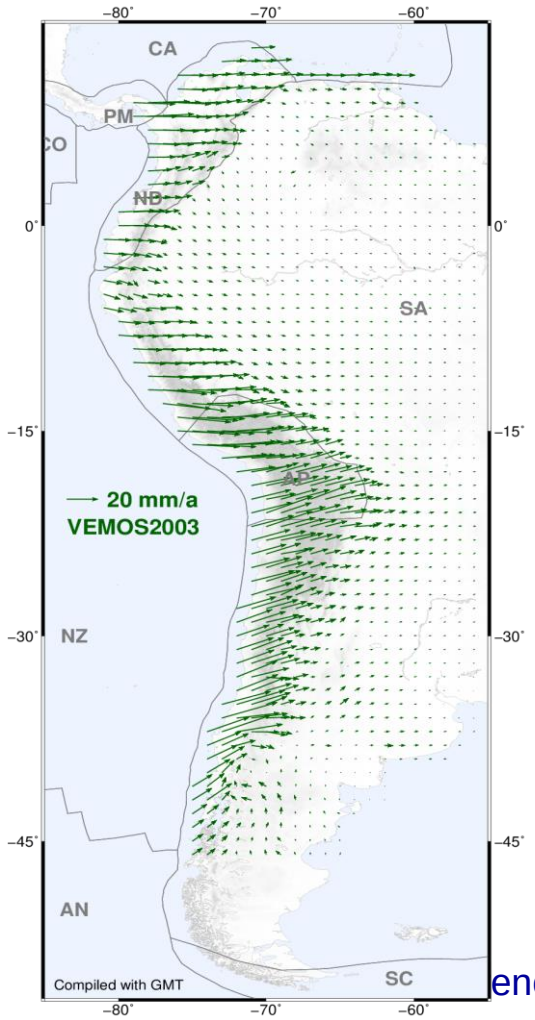


Comparison SIR15P01 and SIR17P01

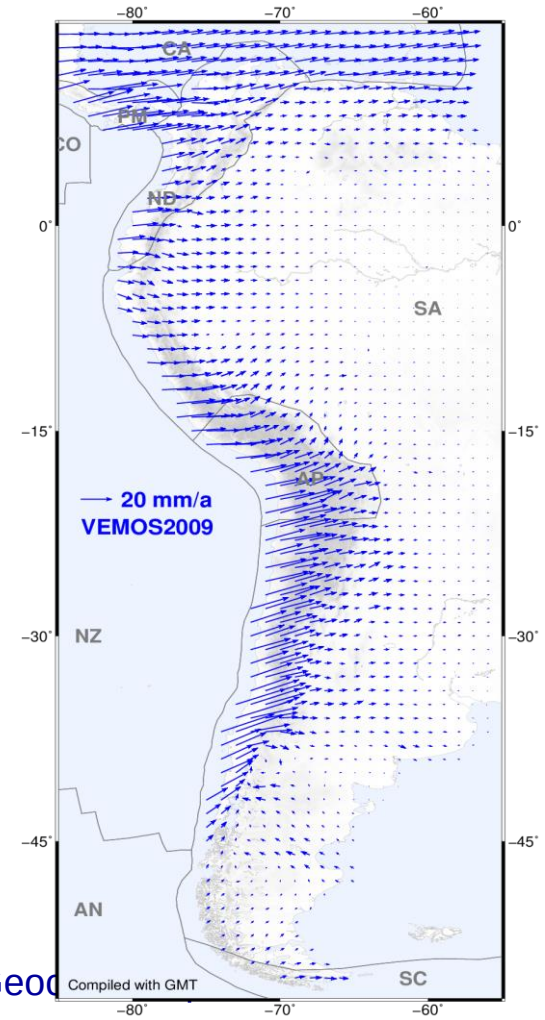
Geodetic surface deformation models for SIRGAS: VEMOS

Surface deformation models are regularly computed. New versions are released only when strong changes are detected.

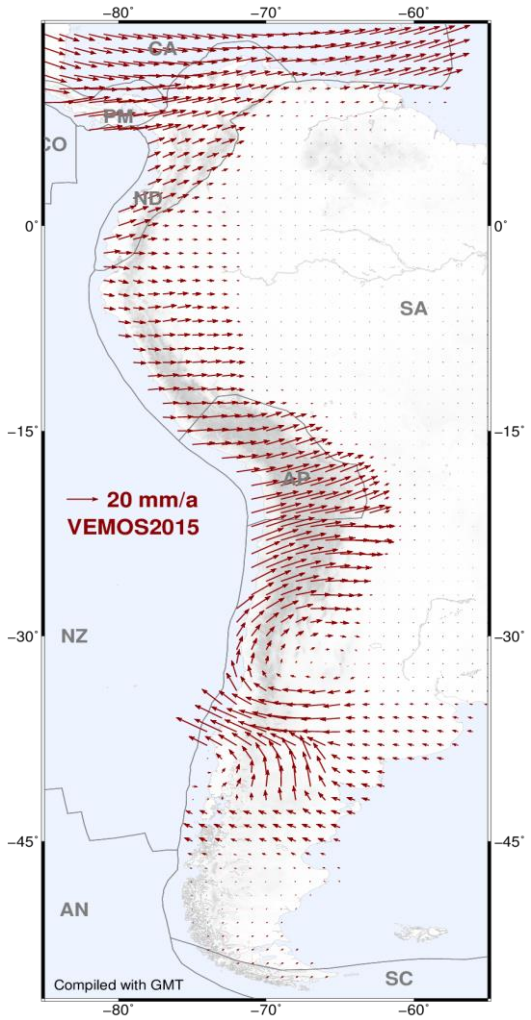
VEMOS2003
1993.0 to 2002.0
(Drewes & Heidbach, 2005)



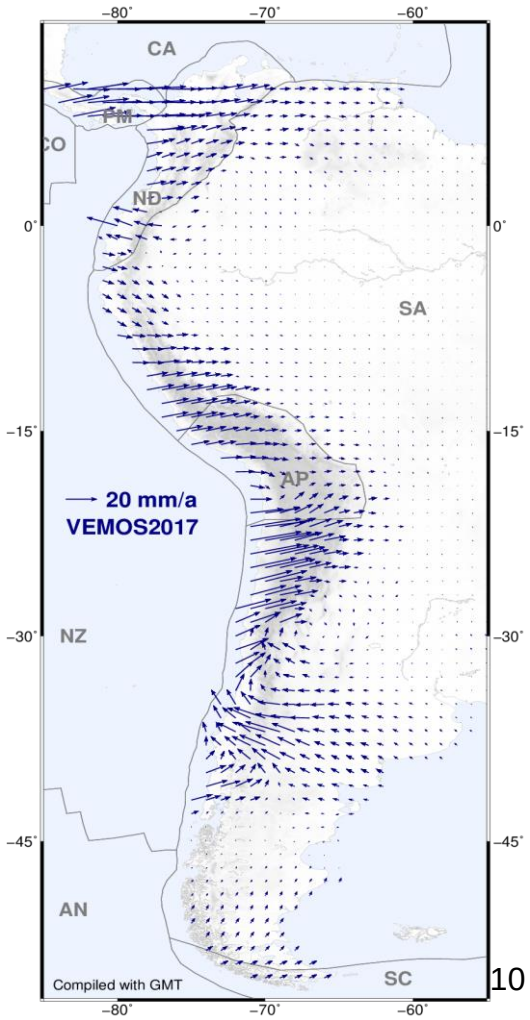
VEMOS2009
2000.0 to 2009.6
(Drewes & Heidbach, 2012)



VEMOS2015
2010.2 to 2015.2
(Sánchez & Drewes, 2016)



VEMOS2017
2014.0 to 2017.1
(Drewes & Sánchez, 2017)



Present shortcomings and outlook

- Large data gaps and frequent decommission of SIRGAS reference stations (138 since 1995) due to poor infrastructure (power failures, Internet unavailability, etc.).

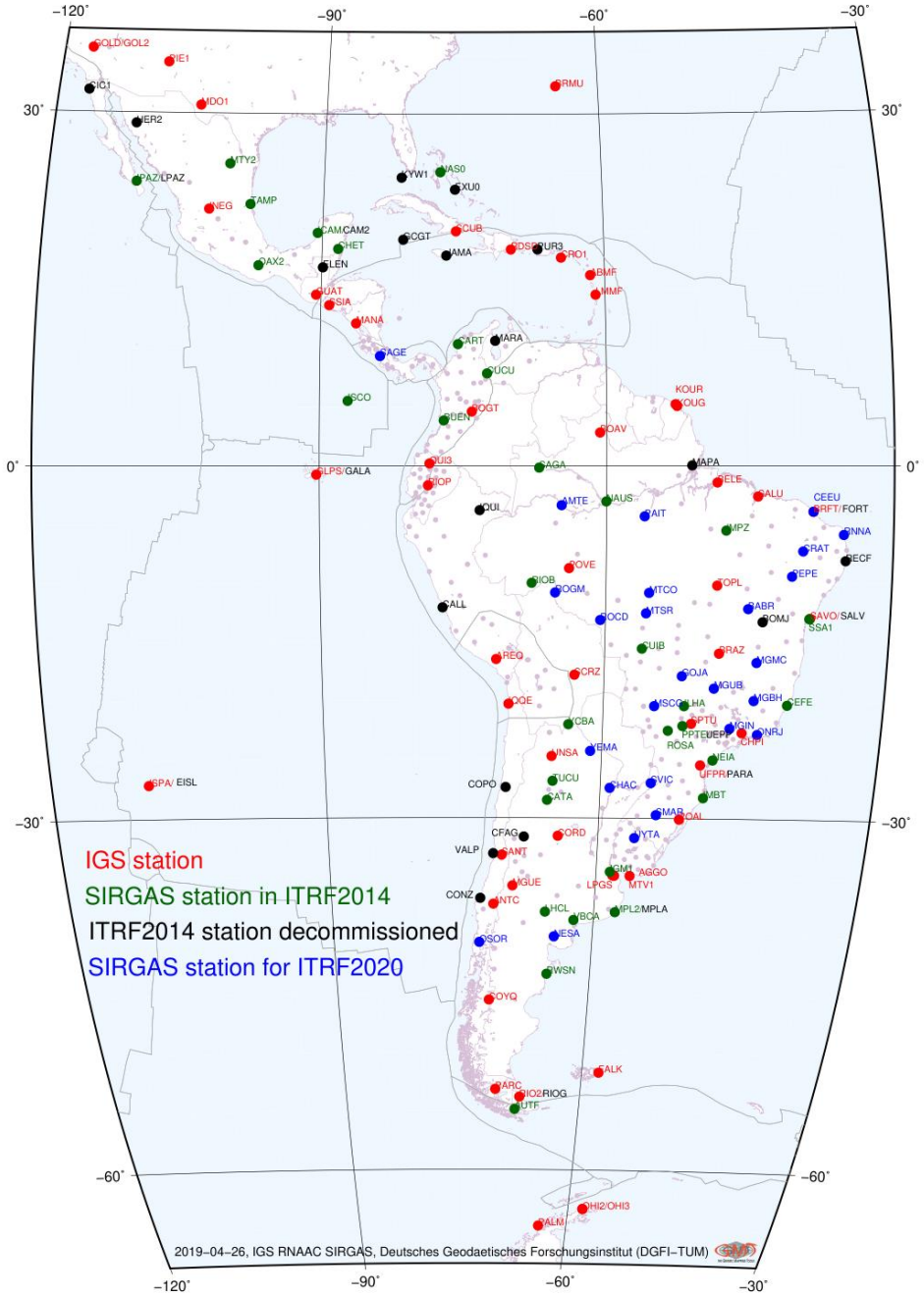
  → To ‘use’ the UN resolution on the GGRF as political argument to promote investment in geodetic infrastructure (Workshop for the implementation of the GGRF in Latin America, Buenos Aires, Sep 16 – 20, 2019, sponsored by the IUGG - 100th anniversary special grant program).

- IGS stations with large time series (installed in the 1990s and early 2000s) have been decommissioned without replacement.

  → Joint effort with P. Rebischung and B. Garayt (IGS Reference Frame Coordination) to include additional SIRGAS stations in the IGS reprocessing campaigns.

SIRGAS stations in IGS-Repro1 (ITRF2014) and IGS-Repro2 (ITRF2020)

to increase the number of fiducial points



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- Multiyear solutions as well as the inferred deformation models represent the mean displacements (deformation) along the defined periods (VEMOS2009: 2010.0 to 2009.6; VEMOS2015: 2010.2 to 2015.2; VEMOS2017: 2014.0 to 2017.1); co-seismic and post-seismic not considered.

  → Implementation of prediction approaches to model co-seismic and post-seismic effects based on the weekly position solutions.

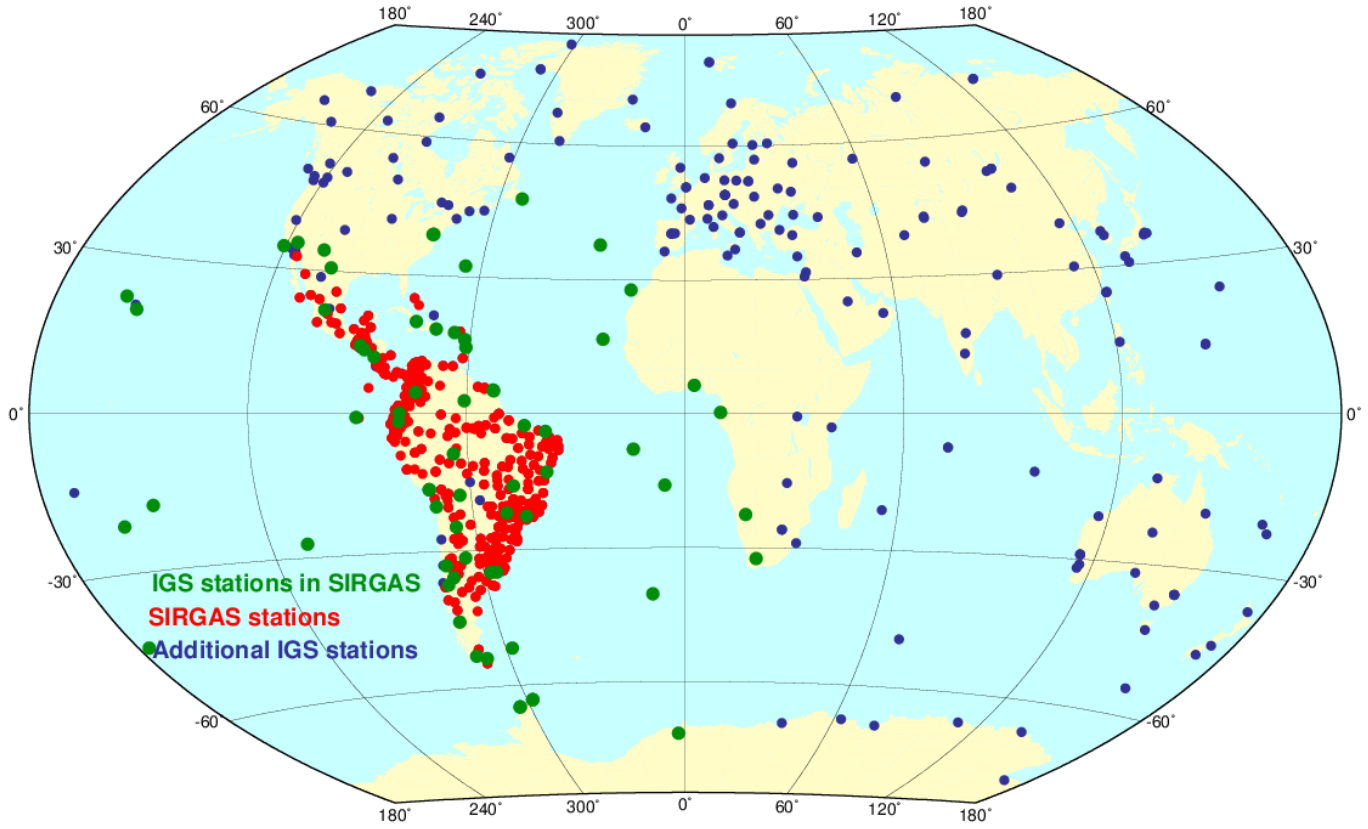
Present shortcomings and outlook

- Weekly and multiyear solutions refer to IGS05/IGb05, IGS08/IGb08 and IGS14 (no reprocessing of historical data in IGS08/IGb08)

  → Reprocessing in IGS14 (1997.0 – 2017.1)

- SIRGAS is a GNSS-based reference frame. Earthquakes, non-loading effects and local effects mislead the geocenter realisation

  → Strategies for the combination of SIRGAS weekly NEQ with SLR and VLBI NEQ.



Acknowledgements

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