Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

SIRGAS Reference Frame Products: weekly coordinates, multi-year solutions, surface kinematic models

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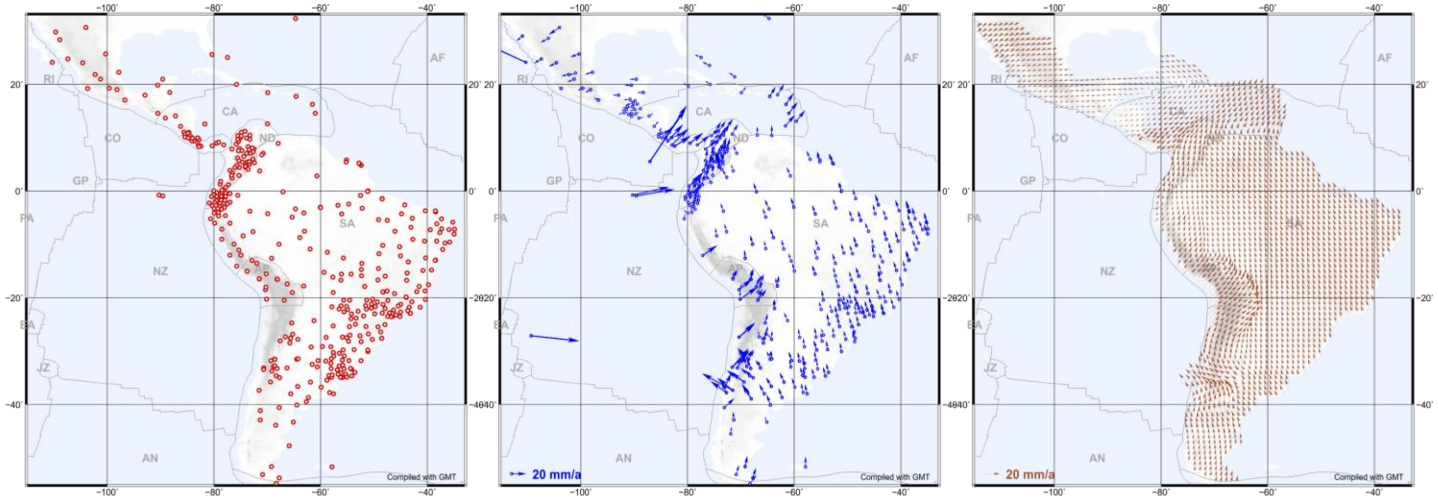


Virtual School on Geodesy, June 2025

Introduction

1993 – Objective: To establish a geocentric reference frame as ITRF densification in South America

1995 – First SIRGAS GPS campaign

1997 → Geocentric Reference System for **South America**: SIRGAS95 [54 stations, ITRF94, 1995.4]

2000 – Second SIRGAS GPS campaign: SIRGAS95 network plus stations in Central and North America

– UN Cartographic Conference for the Americas recommends to use SIRGAS for geo-referencing matters the Americas

2001 → Geocentric Reference System for **the Americas**: SIRGAS2000 [184 stations, ITRF2000, 2000.4]

2019 – *International Workshop for the Establishment of the GGRF in Latin America* recommends to extend the SIRGAS objectives to establish a unified physical reference frame for gravimetry, geoid and physical heights

– To support the activities of the *Working Group of the Geodetic Reference Framework for the Americas (GRFA)* of UN-GGIM-Americas

2020 → **Geodetic** Reference System for the Americas, including a physical reference frame for gravimetry, geoid and physical heights

SIRGAS Reference Frame Analysis at DGFI-TUM

1993 – 2005 → Conceptualisation, strategy for the realisation, coordination, data collection and data analysis of the two GPS campaigns for SIRGAS95 and SIRGAS2000

1996 – 2008 → Analysis of the SIRGAS Continuously Operating Stations until the first Latin American SIRGAS Analysis Centres were installed

2008 – 2023 → Operational analysis of the SIRGAS Core Network, responsibility transferred to the Latin American Analysis Centres

2008 – 2011 → Operational SIRGAS Combination Centre, responsibility transferred to IBGE, BR

2011 – … → SIRGAS Combination Centre for research purposes

2001 – 2022 → Operational computation of cumulative solutions (station positions and motions), responsibility transferred to the Latin American Analysis Centres

2001 – … → Computation of cumulative solutions and surface deformation models (VEMOS: velocity models for SIRGAS) for research purposes

2007 – 2021 → SIRGAS portal www.sirgas.org, new official SIRGAS web site https://sirgas.ipgh.org/

2021 – … → DGFI-TUM research results and products for SIRGAS at www.sirgas.org

SIRGAS Reference Network

495 stations (174 decommissioned), as of June 2025

→ 111 IGS stations

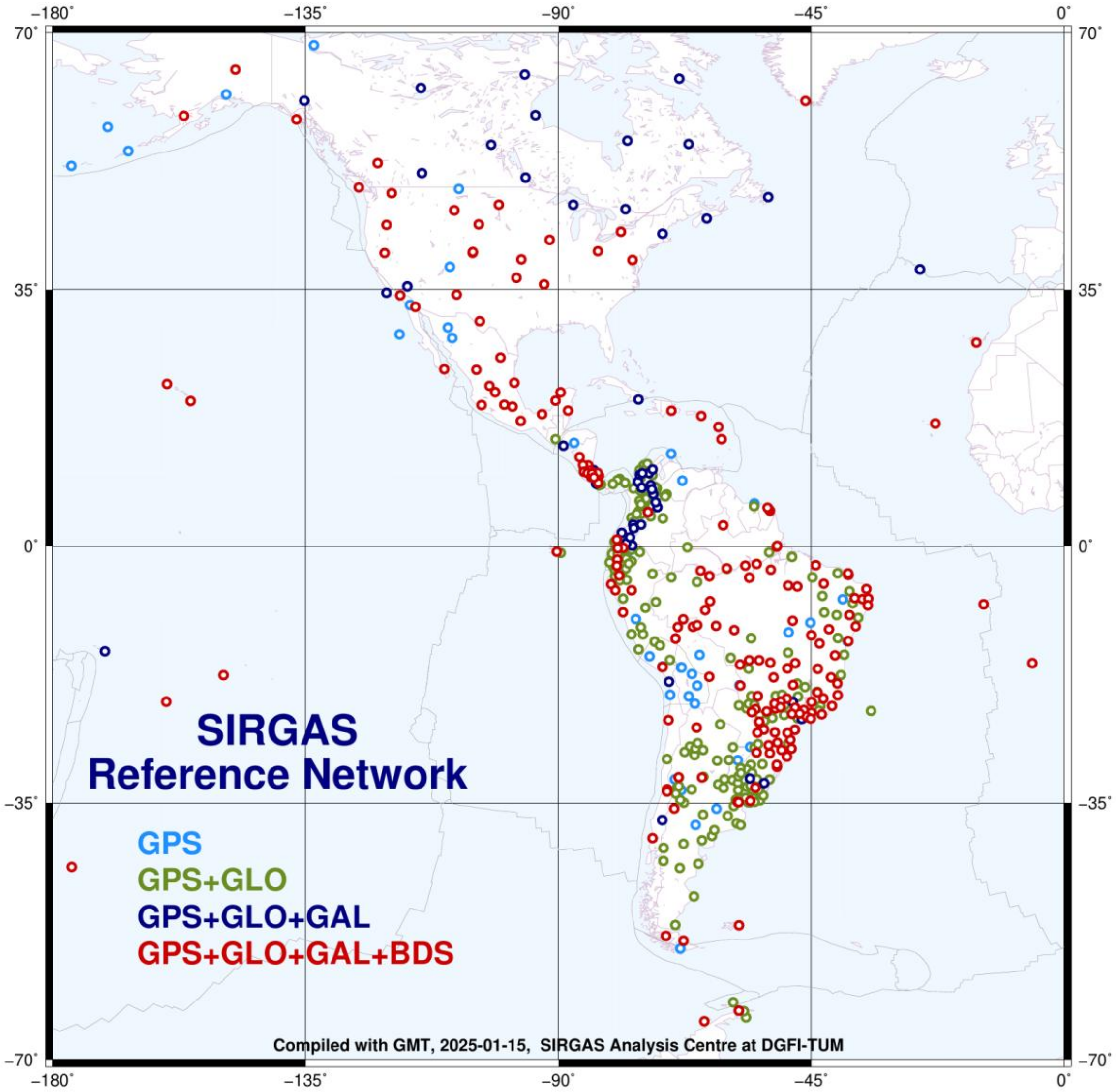
→ 384 regional stations

→ All tracking GPS

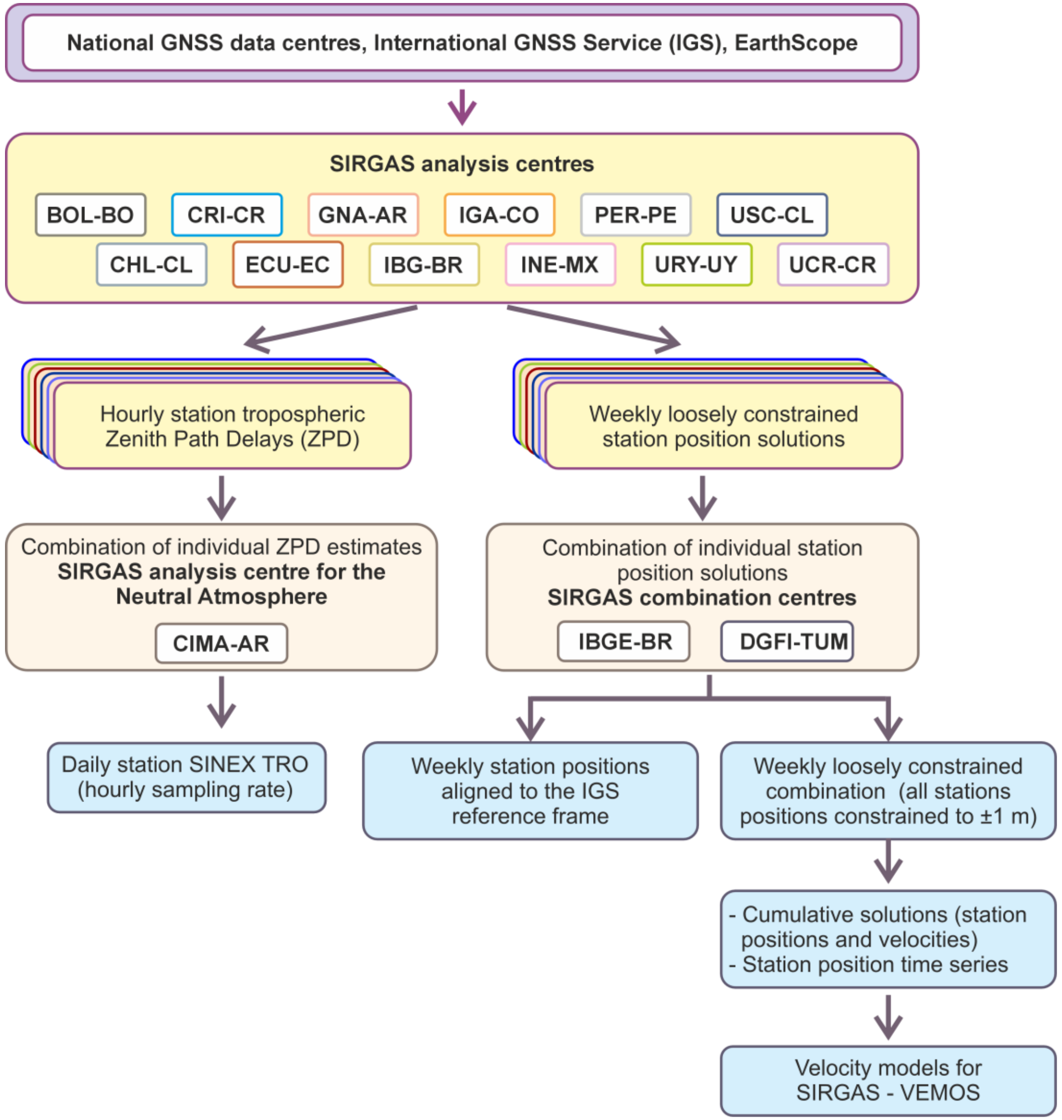
→ 445 tracking GLO

→ 247 tracking GAL

→ 197 tracking BDS

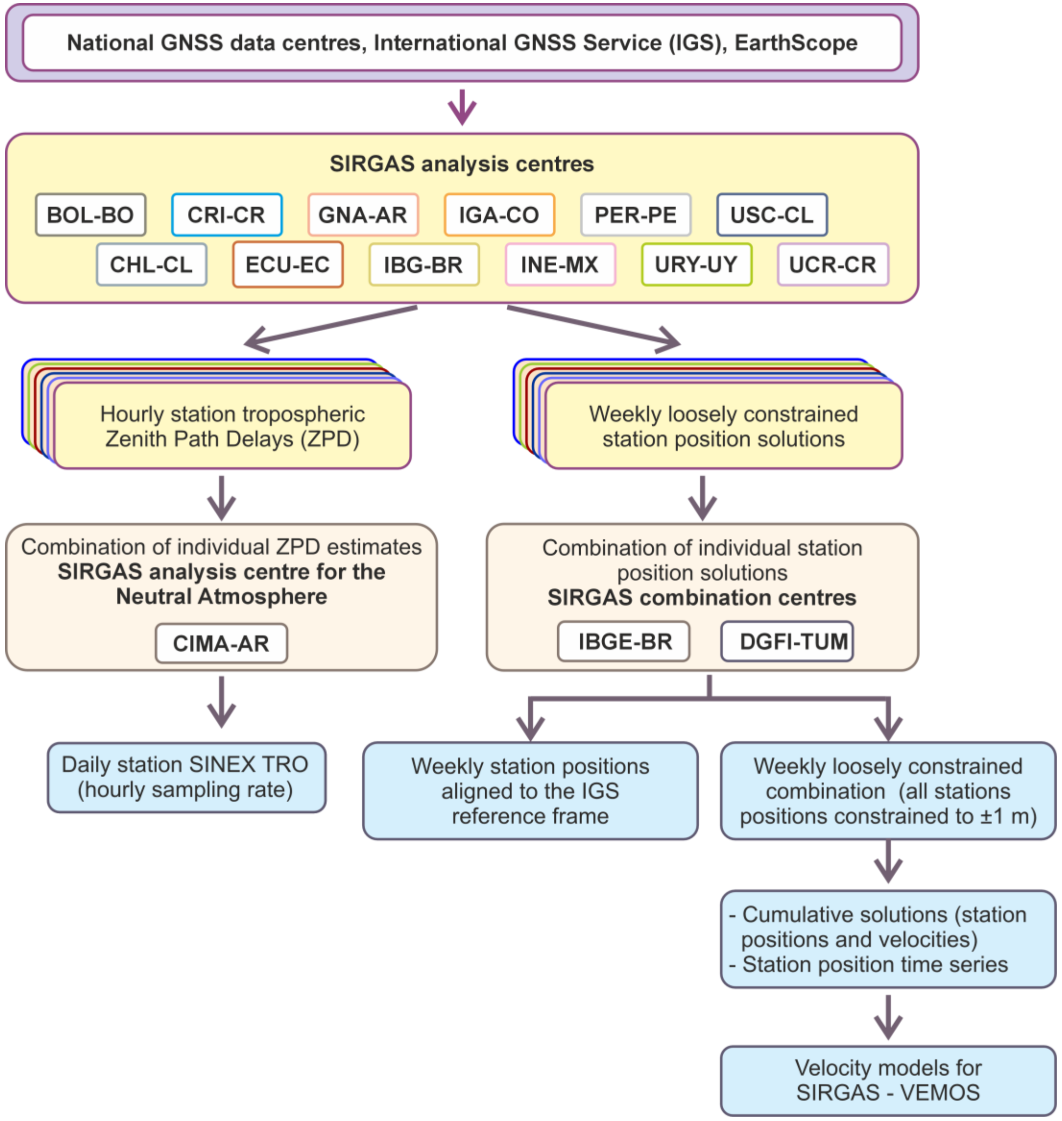


SIRGAS Reference Frame Analysis and Products



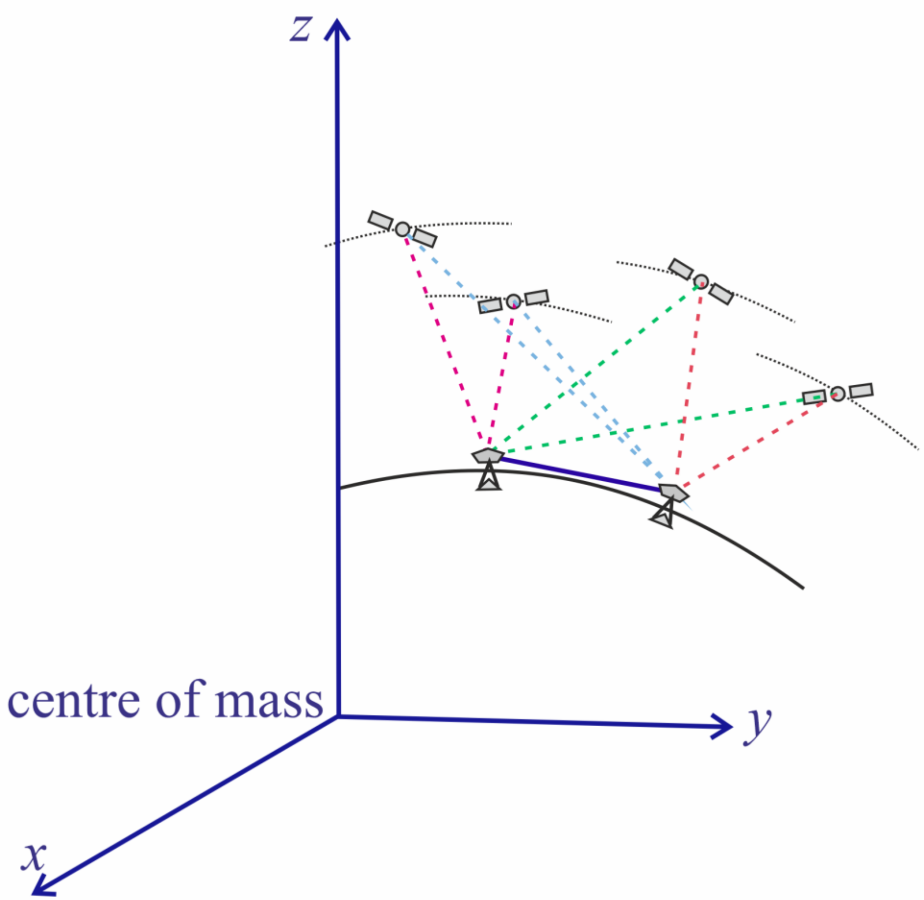
- Analysis
  - 12 GNSS analysis centres (8 Bernese Software, 4 Gamit [GNA, INE, PER, UCR])
  - Two GNSS combination centres
  - One analysis centre for the Neutral Atmosphere
- Products
  - Combined tropospheric Zenith Path Delays (hourly sampling rate)
  - Weekly station positions aligned to the ITRF
  - Cumulative solutions (station velocities, time series, post-seismic functions)
  - Velocity models VEMOS

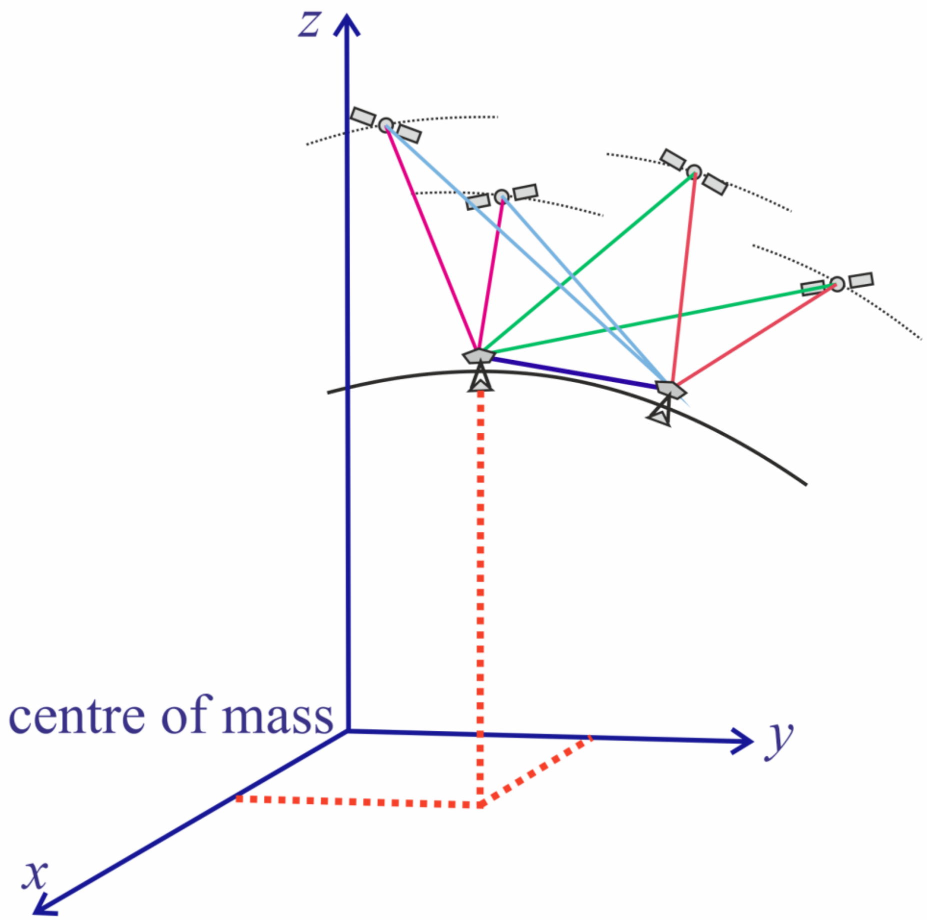
Operational analysis of the SIRGAS reference frame



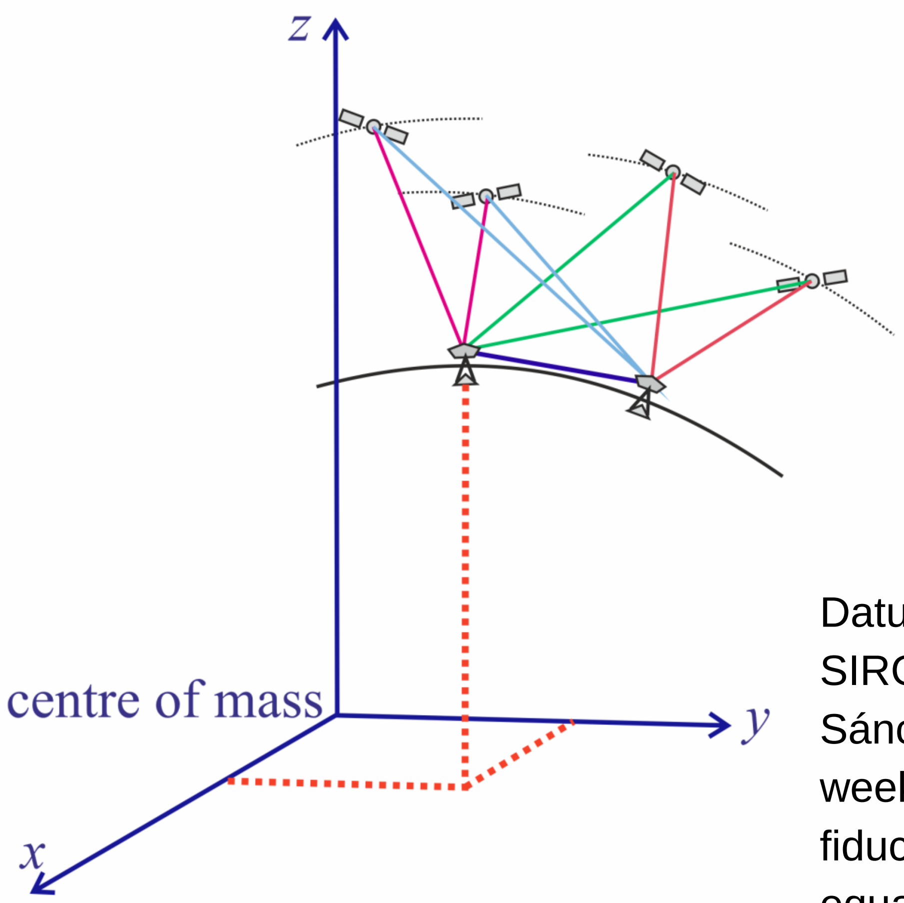
- 12 analysis centres
- Unified analysis standards according to the IERS (International Earth Rotation and Reference Systems Service) and the IGS (International GNSS Service)
- Satellite orbits, corrections to satellite clocks and Earth orientation parameters are fixed to the final weekly IGS values (SIRGAS does not compute these parameters)
- Each station in three individual solutions
- SIRGAS analysis centres deliver weekly loosely constrained solutions (positions for all stations are constrained to $\pm$1 m)

Operational analysis of the SIRGAS reference frame





Operational analysis of the SIRGAS reference frame



Coordinates of fiducial points have to be given

- in the same reference frame in which the satellite orbits are given (IGS reference frame)
- at the same epoch when the GNSS data is obtained

$$X(t) = X(t_0) + \dot{X}(t - t_0) + \delta X_{PSD}(t) + \delta X_f(t)$$

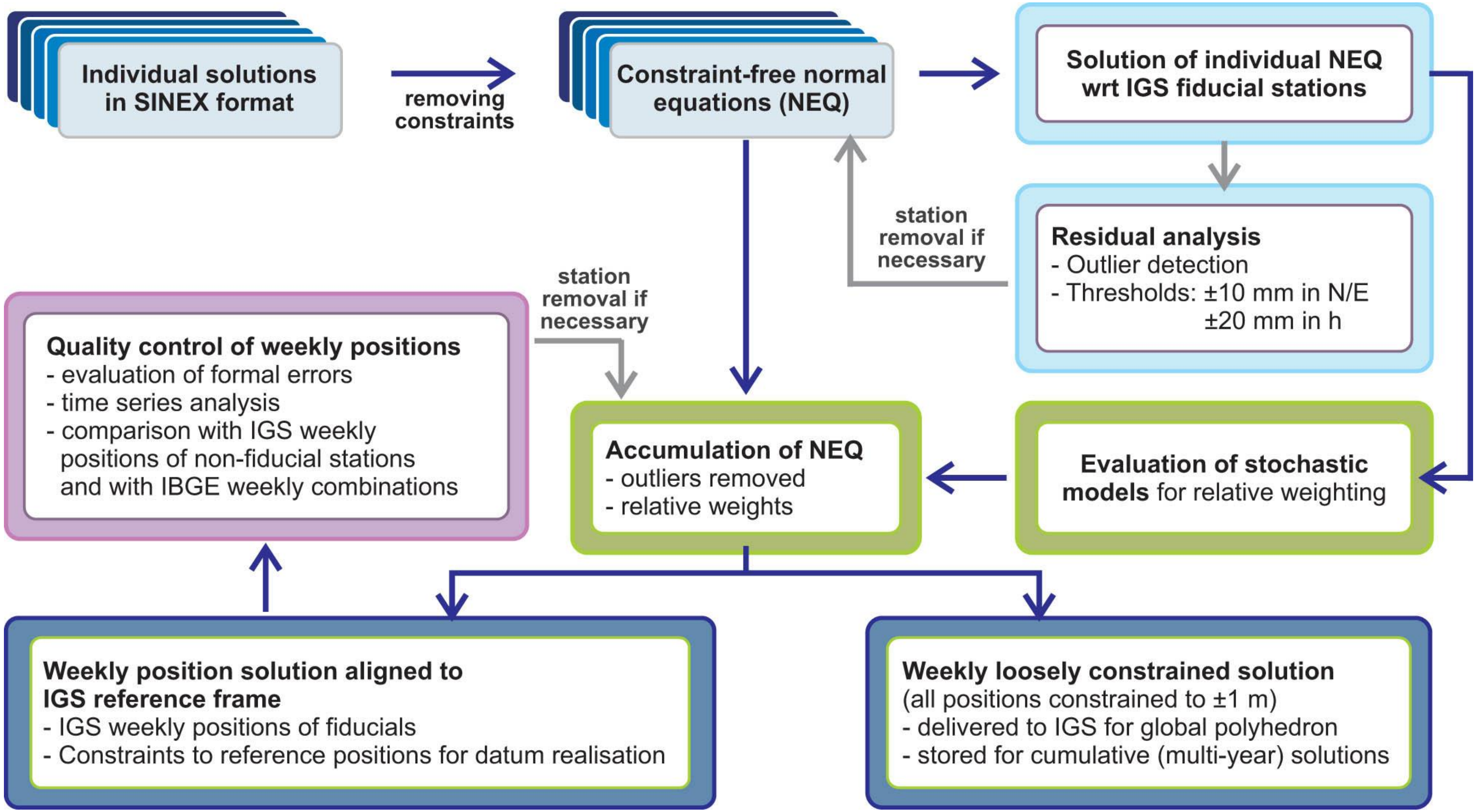
Datum definition in SIRGAS (Mackern and Sánchez, 2009): IGS weekly coordinates of IGS fiducial points with weights equal to the inverse of their standard deviations

Conventional realisation related to a secular centre of mass

log or exp

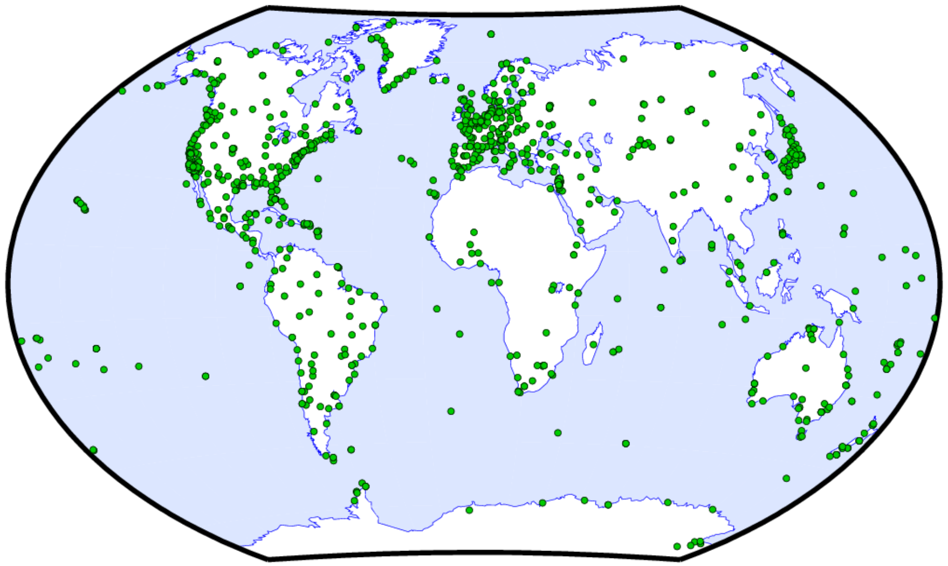
Mathematical approximation (harmonic functions) or non-tidal loading modelling

Weekly Station Coordinates (positions)

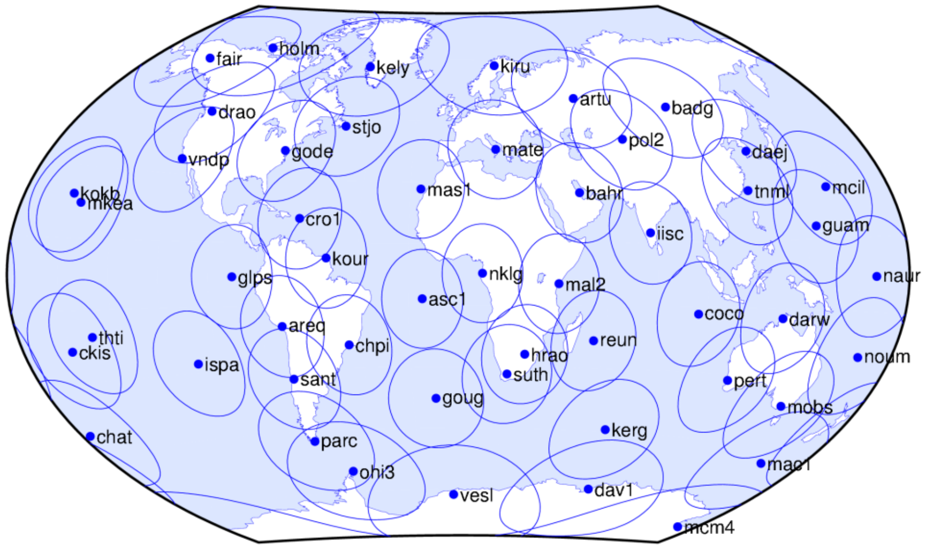


ITRF, IGS Reference Frame, SIRGAS

1) In the SIRGAS processing, the GNSS satellite orbits and clocks are introduced as known parameters. Consequently, the station coordinates refer to the same reference system/frame as the GNSS orbits.
2) As all GNSS stations included in the ITRF solutions do not present the same quality, the International GNSS Service (IGS) selects a set of globally distributed, stable ITRF GNSS sites to be used as the reference frame for the computation of the IGS final products (i.e. satellite orbits, satellite clock, Earth orientation parameters, corrections to the antenna phase centre variations (PCV)). This station selection is called IGS reference frame.



IGS/GNSS stations in ITRF2014

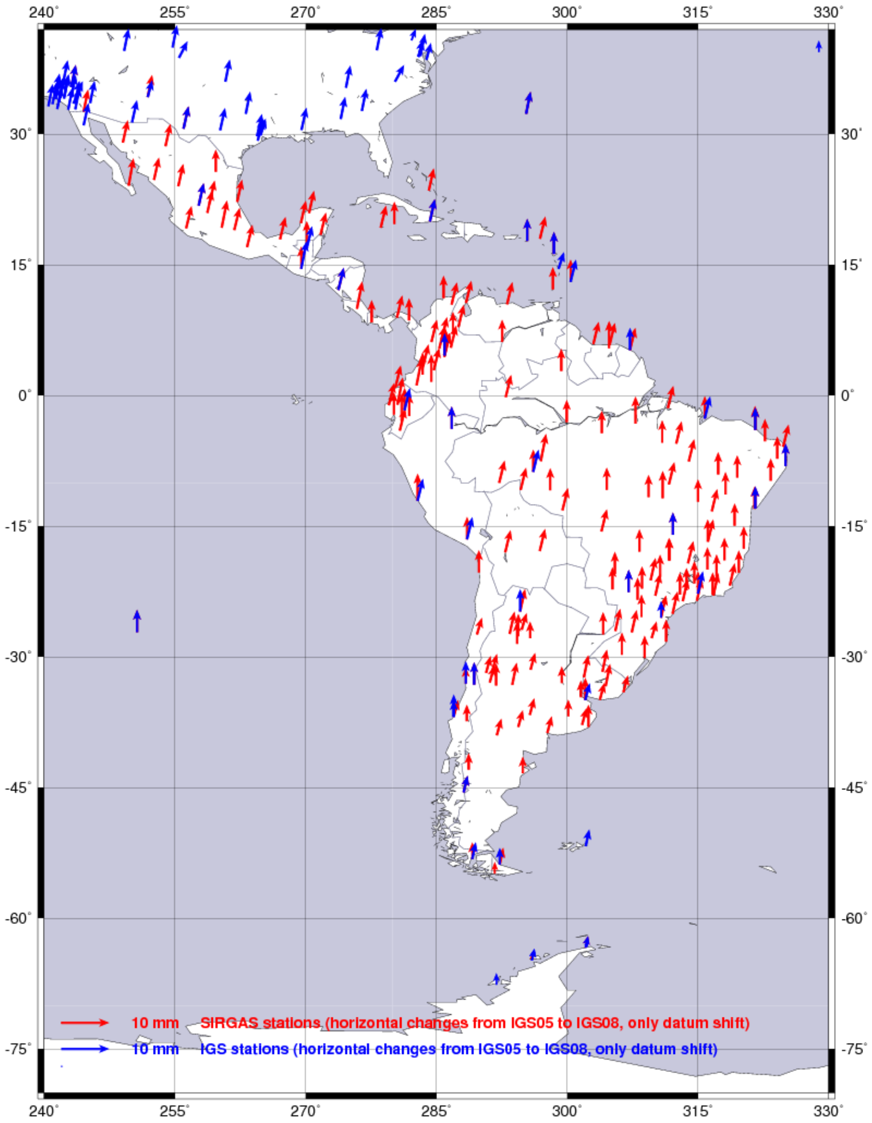


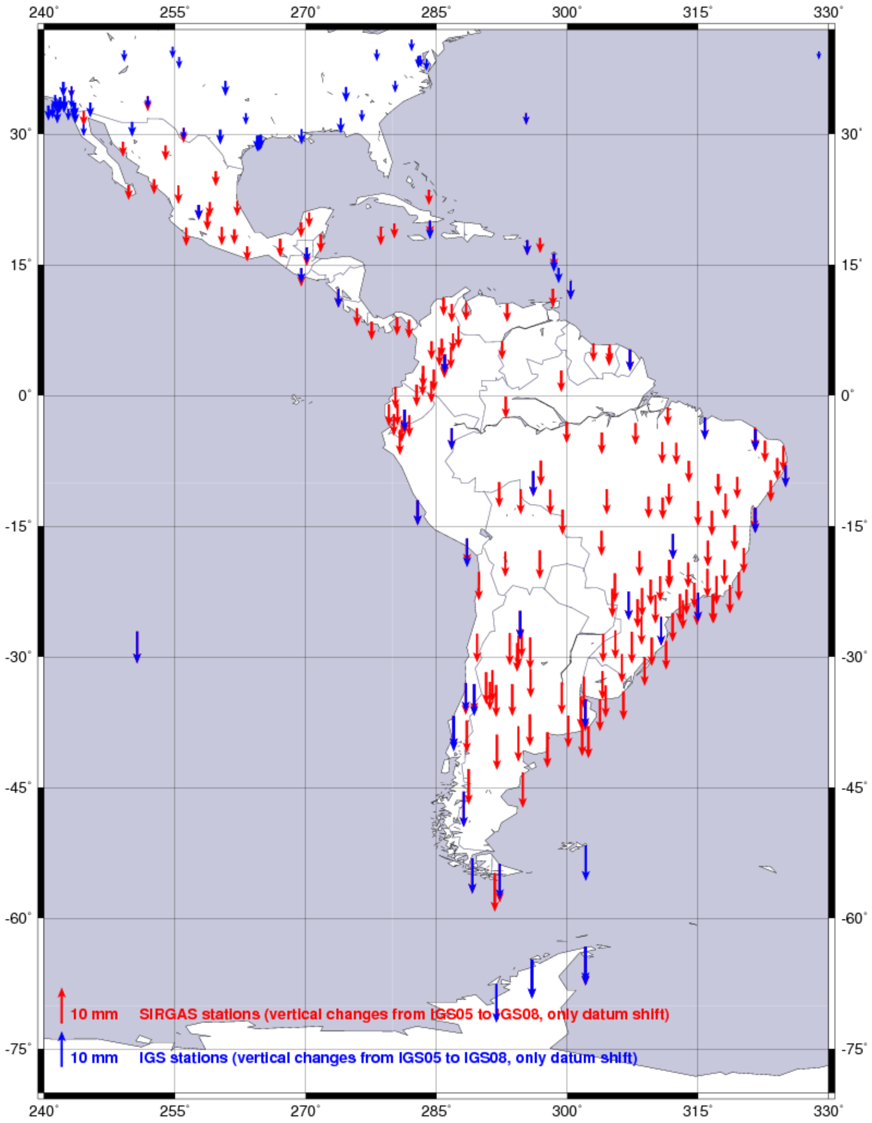
IGS14 reference (core) network

ITRF, IGS Reference Frame, SIRGAS

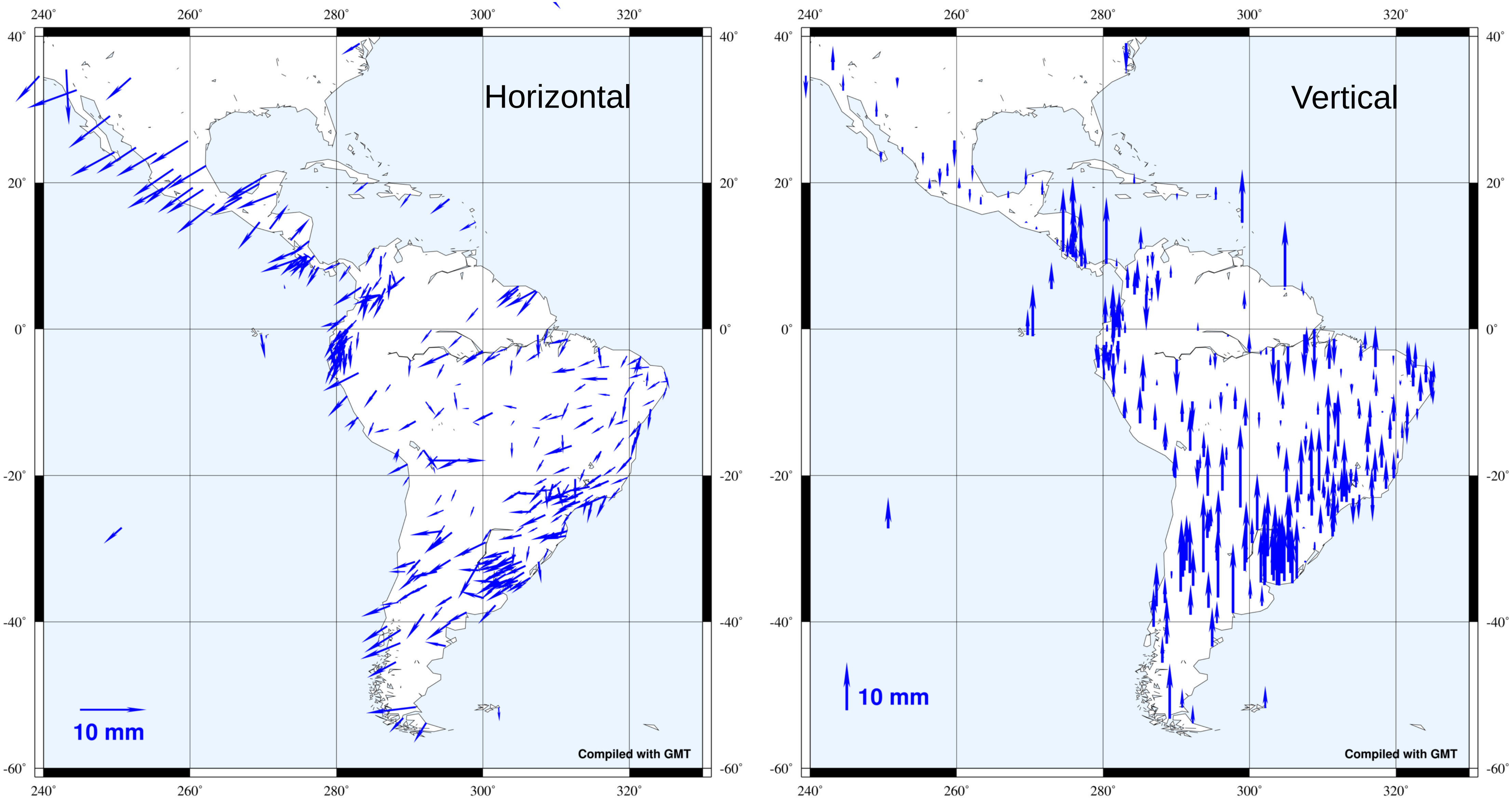
1) The publication of a new ITRF is quickly followed by the release of an updated IGS reference frame:
   - it includes station positions and velocities referring to the new ITRF and
   - new corrections for the antenna PCVs consistent with the new ITRF.
   - It is identified as the ITRF, but using IGS: ITRF2014 $\rightarrow$ IGS14
2) By refinement of an IGS reference frame (by adding/excluding stations or extending the time covered) and improved (better) version is released, i.e., IGS08 $\rightarrow$ IGb08.
3) In this way, the SIRGAS weekly solutions refer, for instance:
   - IGS05: 2006-11-05 thru 2011-04-16
   - IGS08/IGb08: 2011-04-17 thru 2017-01-28
   - IGS14/IGb14: 2017-01-29 thru 2022-11-26
   - IGS20: 2022-11-27 thru 2025-02-01
   - IGb20: since 2025-02-02
4) It is expected that the IGS reference frames are completely equivalent to the corresponding ITRF in orientation, translation and scale. In this way, the IGS final products can be considered to be nominally in the current ITRF.
5) However, the introduction of a new reference frame causes artificial changes (discontinuities) in the station positions.

From IGS05 to IGS08/IGb08





From IGS08/IGb08 to IGS14/IGb14



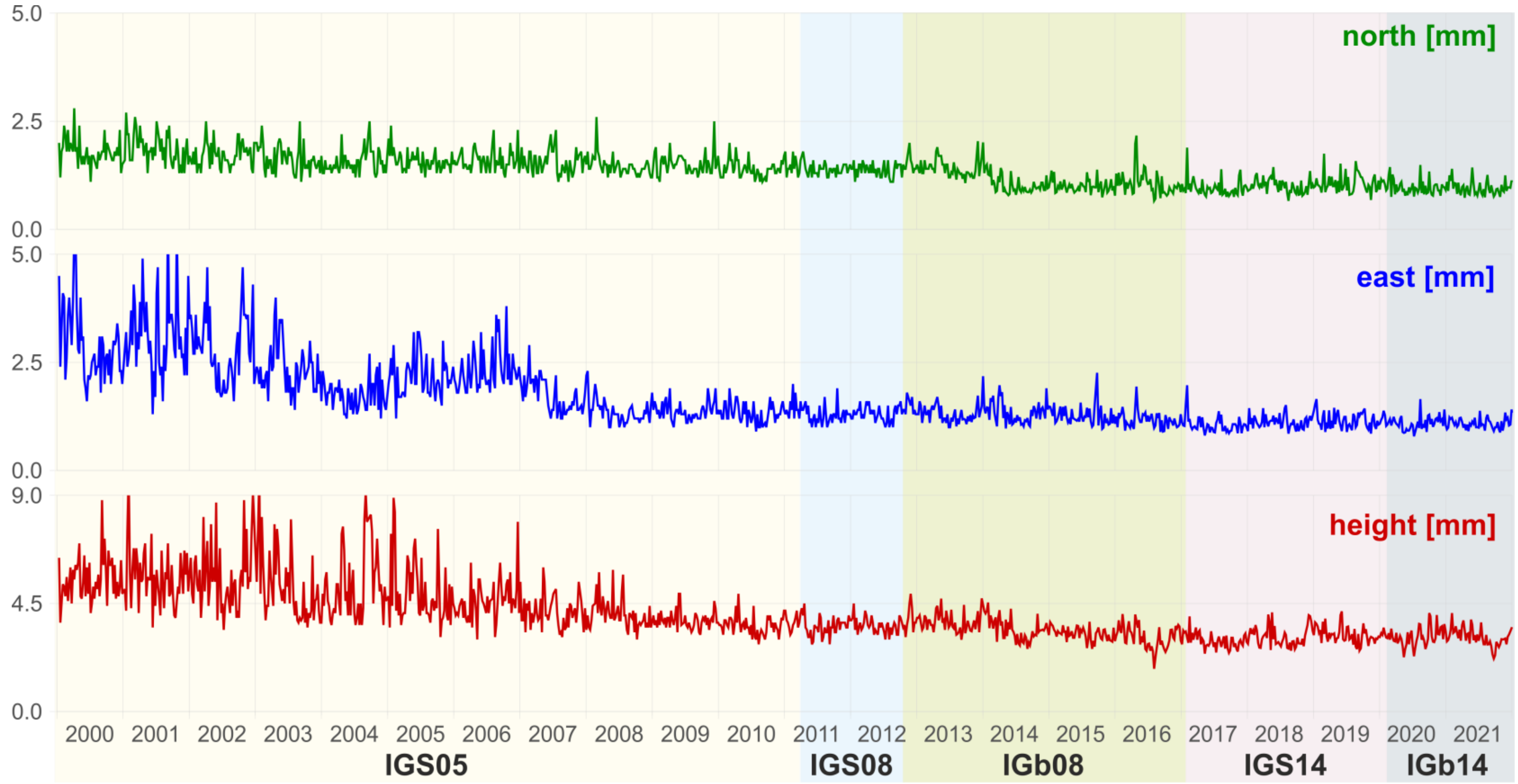
Reprocessing of the SIRGAS Reference Frame

1) Changing reference frame solutions and analysis standards may introduce spurious artefacts and systematics in the station position time series.

2) Therefore, to ensure reliability and long-term stability of geodetic reference frames, the historical geodetic data have to be reanalysed from time to time using a unified set of newest standards and conventions over the complete time span. In SIRGAS, two reprocessing campaigns have been performed so far:

   - **SIRGAS-Repro1 comprises GNSS data from 2000-01-02 to 2008-08-30** and its main objectives were to consider absolute corrections for the phase centre variations of the GNSS antennae and to refer station positions and velocities to the IGS05 reference frame. These reprocessed solutions are identified with SI1.
   - **SIRGAS-Repro2 comprises GNSS data from 2000-01-02 to 2022-01-01** and its main objectives were a quality evaluation of the SIRGAS GNSS historical data, a homogeneous analysis of all existing SIRGAS data, and to refer all weekly solutions to the IGS14/IGb14 reference frame. These reprocessed solutions are identified with SI2.

Comparison of weekly operational solutions and SIRGAS-Repro2



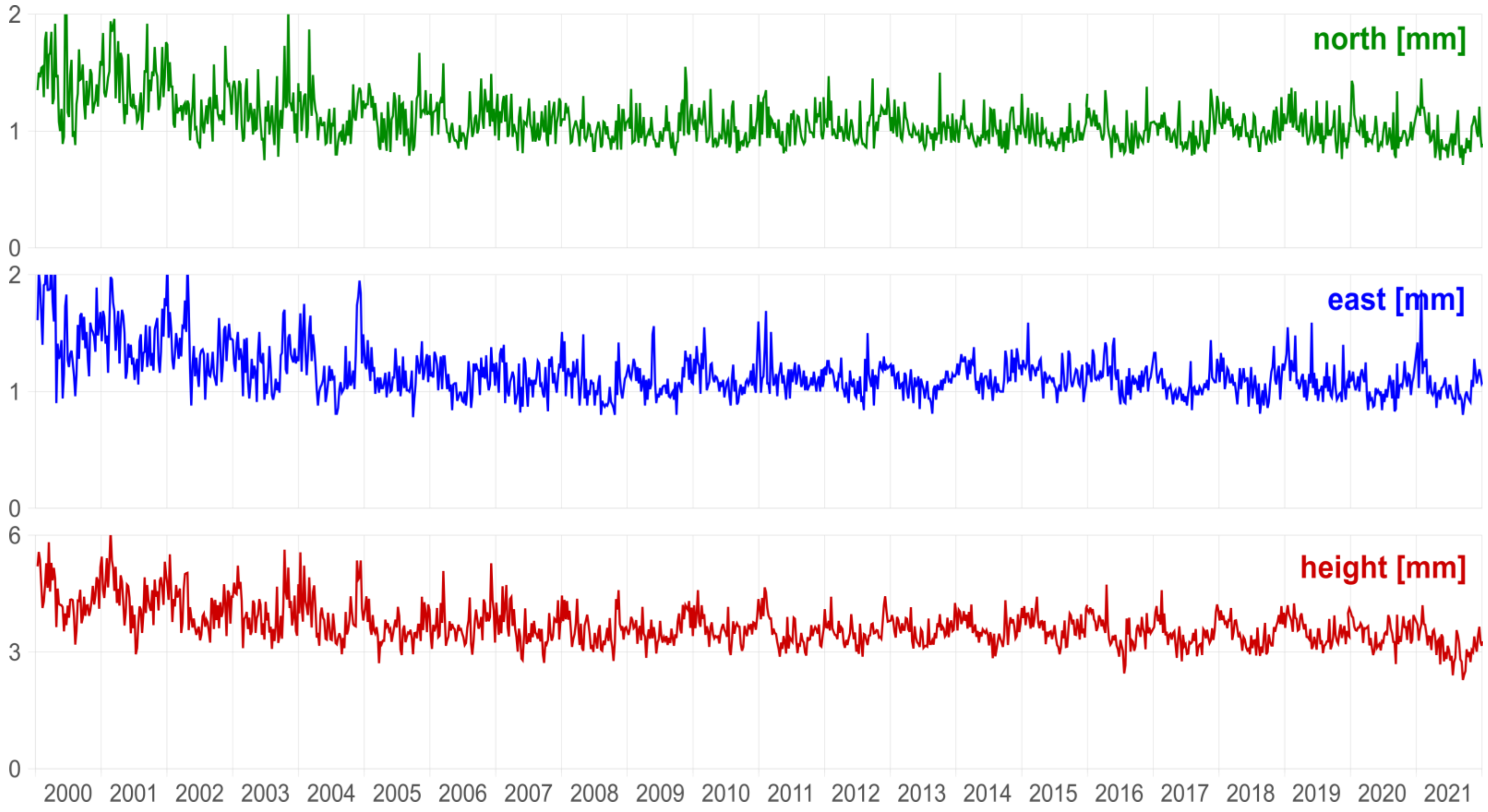
- Weekly station position repeatability in operational SIRGAS analysis
  - IGS05:

    N/E: ±2.8 mm, h: ±6.0 mm
  - IGS08/IGb08:

    N/E: ±1.8 mm, h : 3.5 mm
  - IGS14/IGb14:

    N/E: ±0.8 mm, h: ±2.6 mm

Comparison of weekly operational solutions and SIRGAS-Repro2



- Weekly station position repeatability in SIRGAS-Repro2
  - Before January 2017

    N/E: ±1.3 mm, h: ±3.8 mm
  - After January 2017

    N/E: ±0.8 mm, h: ±2.6 mm

Weekly Station Coordinates Availability at www.sirgas.org

Home
About SIRGAS
Realizations +
Stations +
Wee
XYZ
XYZ
Lat L

Weekly positions generated by DGFI-TUM for the SIRGAS stations

- Weekly XYZ positions sorted by GPS week

Home
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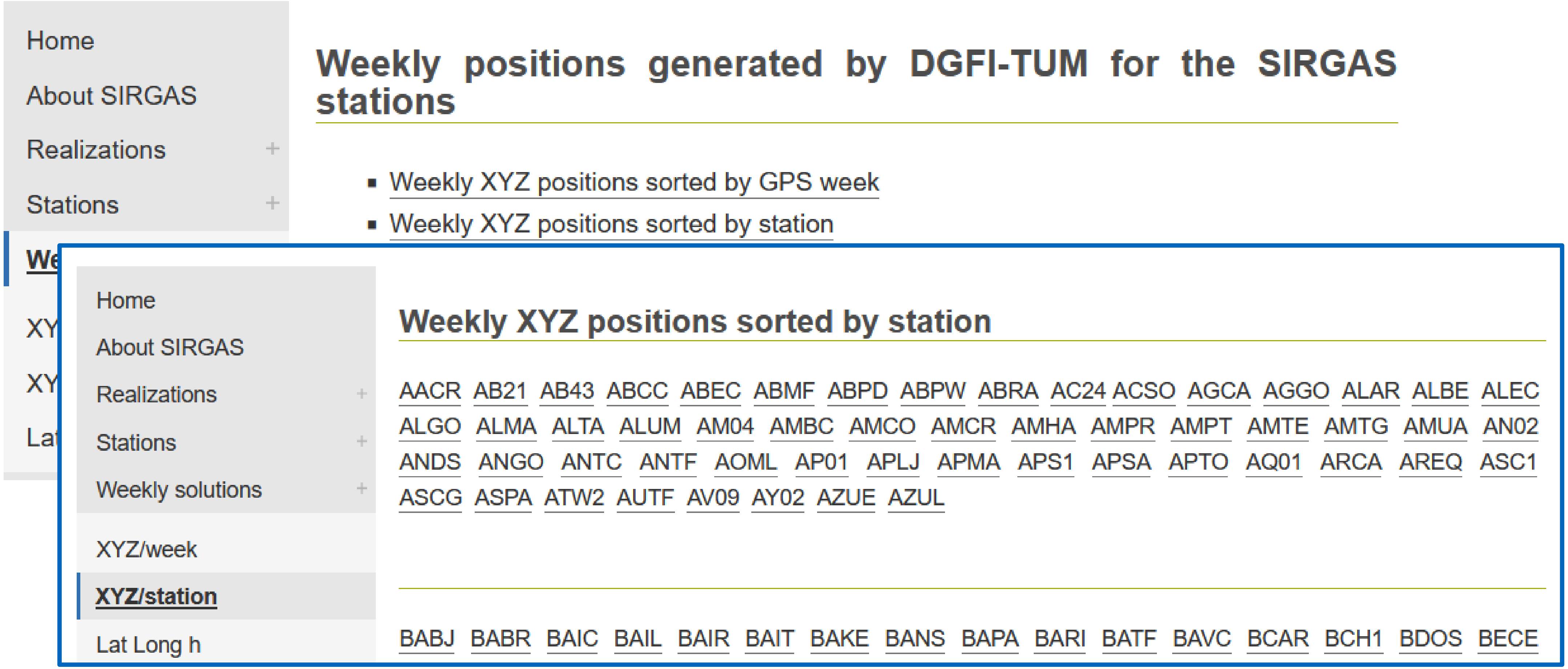
XYZ/week
XYZ/station
Lat Long h

Weekly XYZ positions

2025 | 2024 | 2023 | 2022 | 2021 | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 |
2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 |

2025-03-19 [2025.2137] week 2358
2025-03-12 [2025.1945] week 2357
2025-03-05 [2025.1753] week 2356
2025-02-26 [2025.1562] week 2355

Weekly Station Coordinates Availability at www.sirgas.org



Weekly Station Coordinates Availability at www.sirgas.org

SIRGAS sirgas.ipgh.org TUM

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- **Weekly solutions**
- XYZ/w
- XYZ/st
- Lat Lor

Weekly positions generated by DGFI-TUM for the SIRGAS stations

- Weekly XYZ positions sorted by GPS week
- Weekly XYZ positions sorted by station
- Weekly ellipsoidal positions sorted by station

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- About SIRGAS
- Realizations +
- Stations +
- Weekly solutions +
- XYZ/week
- XYZ/station
- **Lat Long h**

Weekly ellipsoidal positions sorted by station

AACR AB21 AB43 ABCC ABEC ABMF ABPD ABPW ABRA AC24 ACSO AGCA AGGO ALAR ALBE ALEC ALGO ALMA ALTA ALUM AM04 AMBC AMCO AMCR AMHA AMPR AMPT AMTE AMTG AMUA AN02 ANDS ANGO ANTC ANTF AOML AP01 APLJ APMA APS1 APSA APTO AQ01 ARCA AREQ ASC1 ASCG ASPA ATW2 AUTF AV09 AY02 AZUE AZUL

BABJ BABR BAIC BAIL BAIR BAIT BAKE BANS BAPA BARI BATF BAVC BCAR BCH1 BDOS BECE

Weekly Station Coordinates Availability at www.sirgas.org

```
sir25P2356.crd
Week 2356: SIRGAS sol aligned to IGb20 (igs25P2356)            15-APR-25 13:49
--------------------------------------------------------------------------------
LOCAL GEODETIC DATUM: IGb20              EPOCH: 2025-03-05 12:00:00

NUM  STATION NAME           X (M)          Y (M)          Z (M)     FLAG

  1  AACR 40612M001     644009.11918 -6251064.21840  1093781.03982    A
  5  AB21 49381M001   -3940203.83709  -229767.89118  4993529.80226    A
  6  AB43 49298M001   -2449678.94432 -2313243.00161  5397464.29829    A
  9  ABEC 42040M001    1257908.32637 -6254107.70953  -140325.13444    A
 10  ABMF 97103M001    2919785.83011 -5383744.90761  1774604.93529    A
 16  AC24 49239M001   -3051338.95606 -1317097.81985  5425614.08415    A
 18  AC58 49257M001   -3416996.34074  -589123.31147  5335363.33594    A
 24  AGCA 41907M001    1782547.12028 -6054787.89366   916299.64228    A
 25  AGGO 41596M001    2765120.88303 -4449248.44356 -3626403.65235    A
 30  ALAR 41653M001    5043729.68892 -3753105.65901 -1072966.75283    A
 31  ALBE 41943M001    1806735.02014 -6056493.15603   855562.64572    A
 34  ALEC 42029M001    1233231.85788 -6255435.58672  -243534.42660    A
 35  ALGO 40104M002     918129.05264 -4346071.34419  4561977.93182    W
 39  ALTA 47988M001    1694060.59586 -4281659.29669 -4399009.98611    A
 41  AM04 42255M001    1336684.42805 -6215846.81028  -507918.18957    A
 44  AMCO 41696M001    2652254.90179 -5775435.48206  -538086.87048    A
 46  AMHA 41646M002    2868133.06577 -5635932.94536  -828833.27772    A
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 52  AMTE 48091M001    2720483.55588 -5756956.97081  -369743.67672    A
 54  AMUA 48070M001    3182722.95465 -5516674.65518  -341716.81079    A
 55  AN02 42231M001    1252397.34618 -6172147.37286 -1005195.04856    A
 61  ANTC 41713S001    1608538.53286 -4816370.60954 -3847798.24098    A
 62  ANTF 41780M001    1958241.53320 -5505483.51431 -2548076.24093    A
 64  AP01 42226M001    1825836.76915 -5926941.62464 -1494699.87092    A
 65  APLJ 48076M001    3881011.60198 -5060684.05759   -90889.37069    A
 66  APMA 41629M002    4005474.09726 -4963530.91487     5201.14477    A
 69  APTO 41933S001    1460798.05551 -6147200.60974   868399.64295    A
 70  AQ01 42229M001    1941764.87591 -5805845.97426 -1792210.24696    A
```

```
File created on 2025-03-27

Contents:
Column 1: epoch in year.decimals
Column 2: civil date
Column 3: GPS week
Column 4: reference frame
Column 5: station id
Column 6: station domes number
Column 7: coordinate X in meters
Column 8: coordinate Y in meters
Column 9: coordinate Z in meters
Column 10: formal error of coordinate X (sigma_X) in meters
Column 11: formal error of coordinate Y (sigma_Y) in meters
Column 12: formal error of coordinate Z (sigma_Z) in meters

Discontinuities detected at this station:
  2017-03-23  Antenna change
  2017-09-15  Antenna change

------------------------------------------------------------------------------------------------------------------------
2000.0137 2000-01-05 1043 IGb14 AUTF 41515S001 1360918.80611 -3420457.88895 -5191175.24230 8.574e-05 1.556e-04 2.017e-04
2000.0328 2000-01-12 1044 IGb14 AUTF 41515S001 1360918.80492 -3420457.88854 -5191175.24168 8.664e-05 1.560e-04 2.017e-04
2000.0519 2000-01-19 1045 IGb14 AUTF 41515S001 1360918.80562 -3420457.88940 -5191175.23936 8.540e-05 1.557e-04 2.019e-04
2000.0710 2000-01-26 1046 IGb14 AUTF 41515S001 1360918.80670 -3420457.89026 -5191175.24419 8.930e-05 1.659e-04 2.234e-04
2000.0902 2000-02-02 1047 IGb14 AUTF 41515S001 1360918.80772 -3420457.88904 -5191175.24194 8.429e-05 1.520e-04 2.077e-04
2000.1093 2000-02-09 1048 IGb14 AUTF 41515S001 1360918.80813 -3420457.89117 -5191175.24459 8.173e-05 1.476e-04 1.959e-04
2000.1284 2000-02-16 1049 IGb14 AUTF 41515S001 1360918.80876 -3420457.88883 -5191175.23988 8.381e-05 1.494e-04 1.992e-04
2000.1475 2000-02-23 1050 IGb14 AUTF 41515S001 1360918.80907 -3420457.88990 -5191175.24205 8.496e-05 1.526e-04 1.995e-04
2000.1667 2000-03-01 1051 IGb14 AUTF 41515S001 1360918.80974 -3420457.88818 -5191175.24304 8.529e-05 1.527e-04 2.034e-04
2000.1858 2000-03-08 1052 IGb14 AUTF 41515S001 1360918.80837 -3420457.89337 -5191175.23930 9.015e-05 1.631e-04 2.141e-04
2000.2049 2000-03-15 1053 IGb14 AUTF 41515S001 1360918.80877 -3420457.89278 -5191175.24323 9.182e-05 1.609e-04 2.162e-04
```

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File created on 2025-03-27

Contents:
Column 1: epoch in year.decimals
Column 2: civil date
Column 3: GPS week
Column 4: reference frame
Column 5: station id
Column 6: station domes number
Column 7: latitude (PHI) in degrees.decimal
Column 8: longitude (LAMBDA) in degrees.decimal
Column 9: ellipsoidal height (h) in meters
Column 10: formal error of latitude (sigma_PHI) in degrees.decimal
Column 11: formal error of longitude (sigma_LAMBDA) in degrees.decimal
Column 12: formal error of ellipsoidal height (sigma_h) in meters

Discontinuities detected at this station:
  2017-03-23  Antenna change
  2017-09-15  Antenna change

------------------------------------------------------------------------------------------------------------------------
2000.0137 2000-01-05 1043 IGb14 AUTF 41515S001 -54.8395255950  291.6964323293   71.87778 0.151E-08 0.154E-08 0.186E-03
2000.0328 2000-01-12 1044 IGb14 AUTF 41515S001 -54.8395255978  291.6964323145   71.87680 0.151E-08 0.155E-08 0.186E-03
2000.0519 2000-01-19 1045 IGb14 AUTF 41515S001 -54.8395255781  291.6964323196   71.87551 0.151E-08 0.153E-08 0.186E-03
2000.0710 2000-01-26 1046 IGb14 AUTF 41515S001 -54.8395255943  291.6964323303   71.88015 0.164E-08 0.161E-08 0.204E-03
2000.0902 2000-02-02 1047 IGb14 AUTF 41515S001 -54.8395255882  291.6964323521   71.87788 0.151E-08 0.151E-08 0.189E-03
2000.1093 2000-02-09 1048 IGb14 AUTF 41515S001 -54.8395255862  291.6964323458   71.88127 0.145E-08 0.146E-08 0.179E-03
2000.1284 2000-02-16 1049 IGb14 AUTF 41515S001 -54.8395255761  291.6964323683   71.87630 0.147E-08 0.149E-08 0.182E-03
2000.1475 2000-02-23 1050 IGb14 AUTF 41515S001 -54.8395255792  291.6964323667   71.87872 0.149E-08 0.152E-08 0.183E-03
2000.1667 2000-03-01 1051 IGb14 AUTF 41515S001 -54.8395255942  291.6964323862   71.87875 0.150E-08 0.152E-08 0.186E-03
2000.1858 2000-03-08 1052 IGb14 AUTF 41515S001 -54.8395255432  291.6964323366   71.87818 0.159E-08 0.161E-08 0.197E-03
2000.2049 2000-03-15 1053 IGb14 AUTF 41515S001 -54.8395255665  291.6964323458   71.88116 0.159E-08 0.163E-08 0.198E-03
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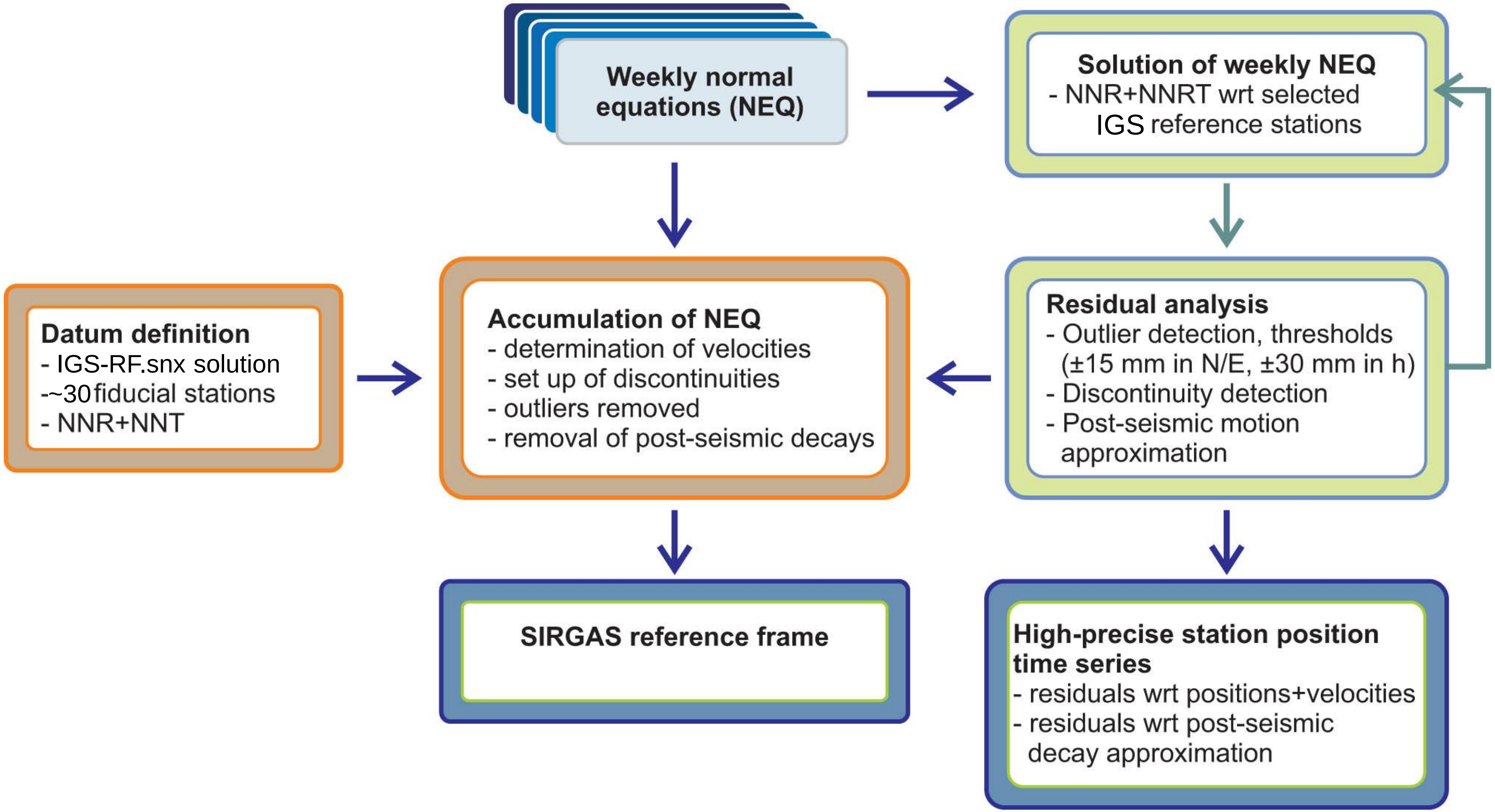
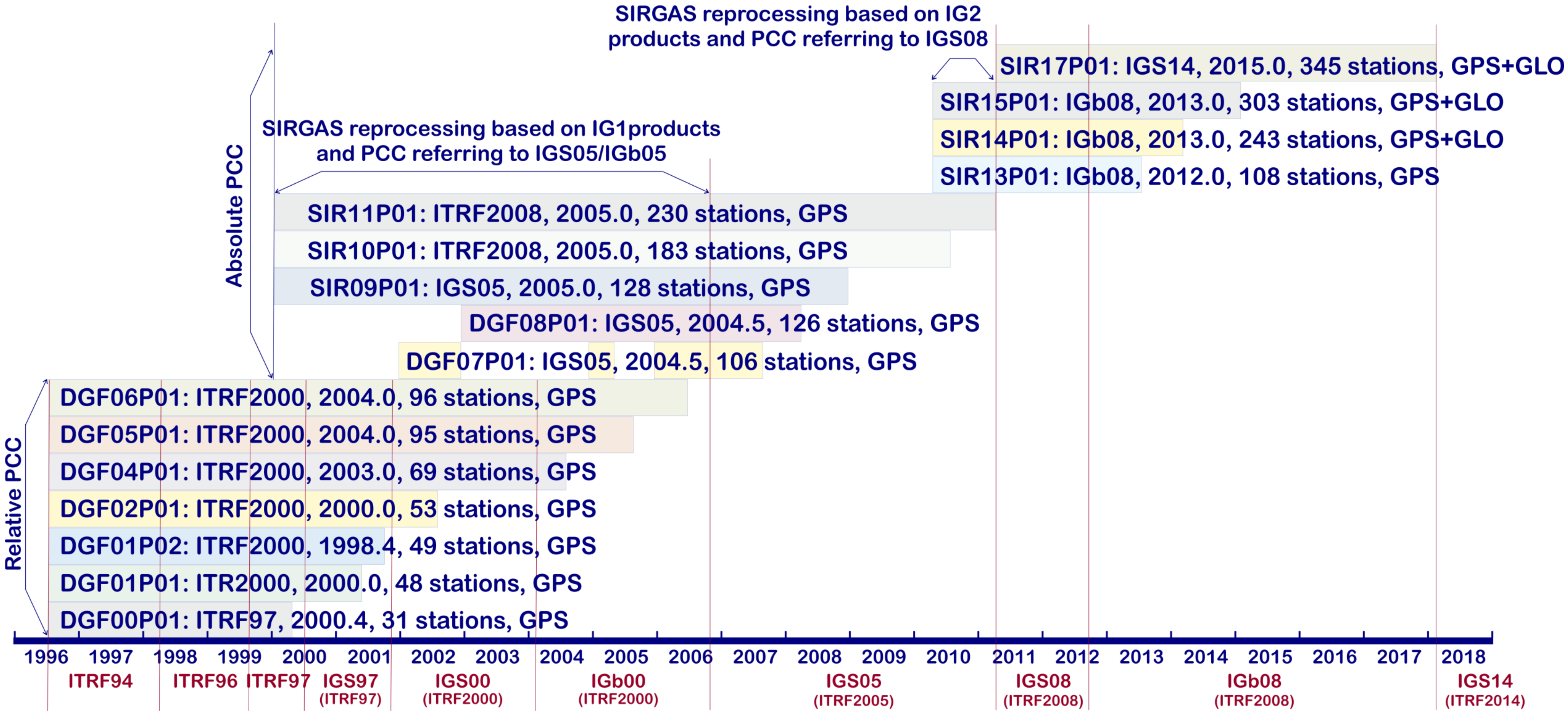
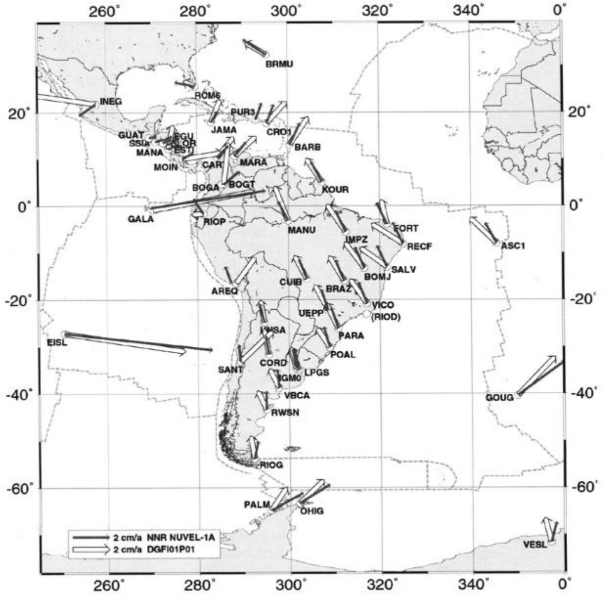
SIRGAS Cumulative (multi-year) Solutions



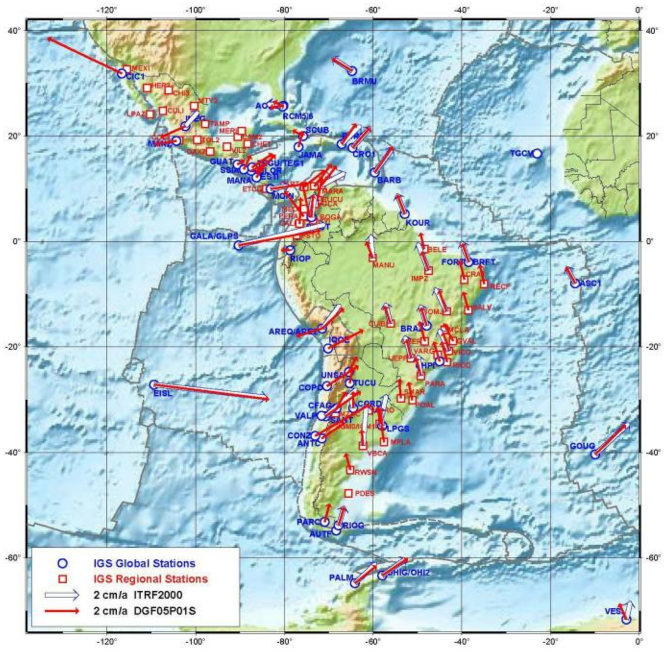
SIRGAS Cumulative (multi-year) Solutions



SIRGAS Cumulative (multi-year) Solutions



DGF00P01



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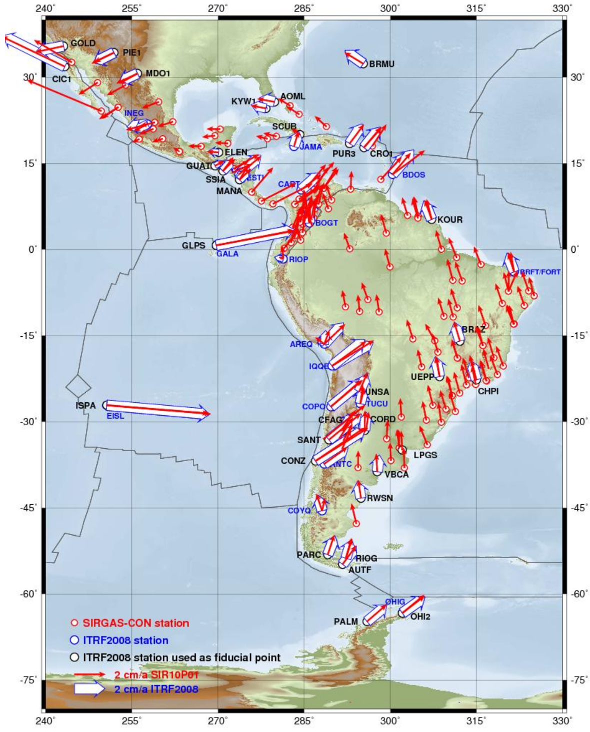
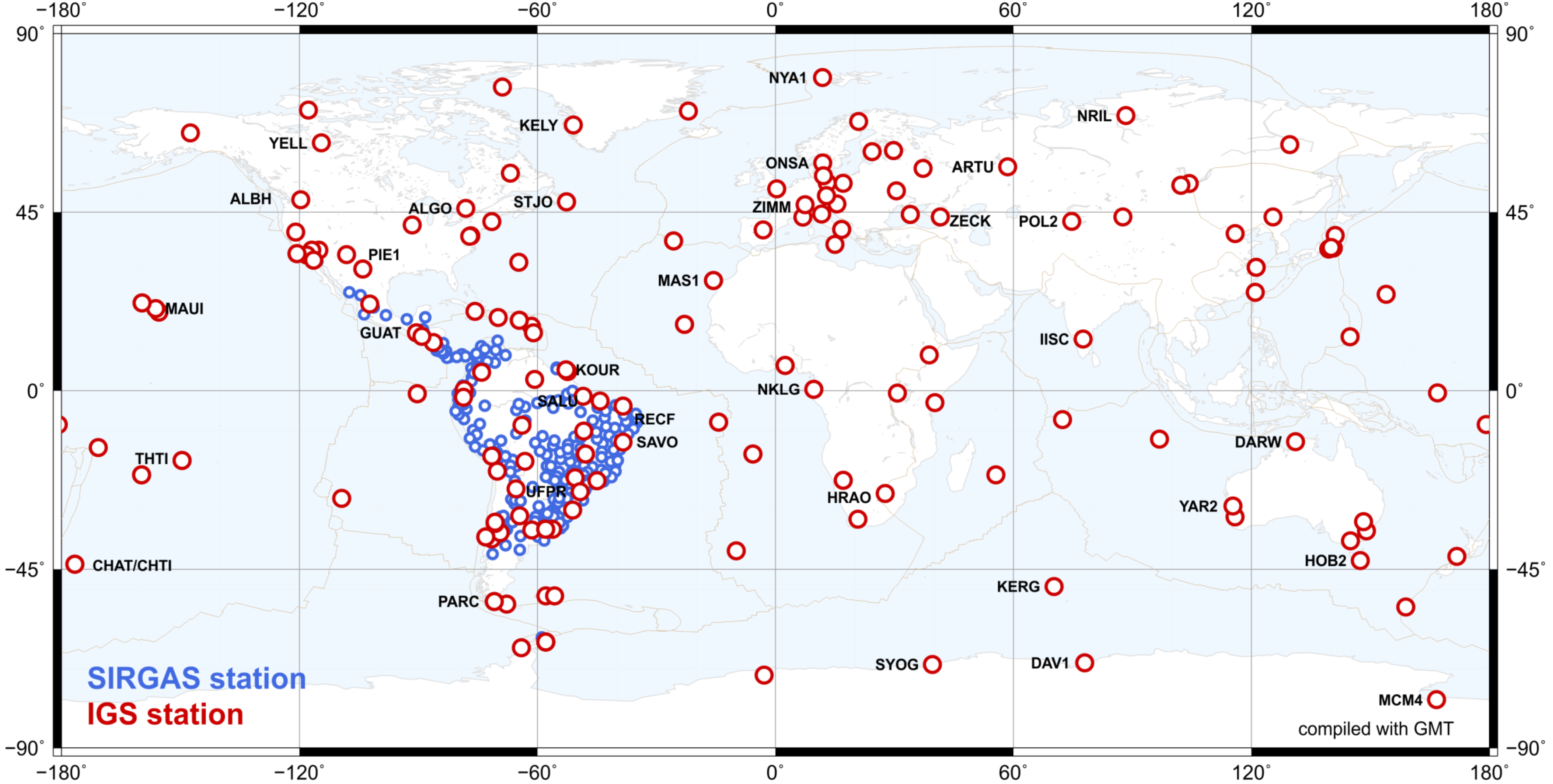


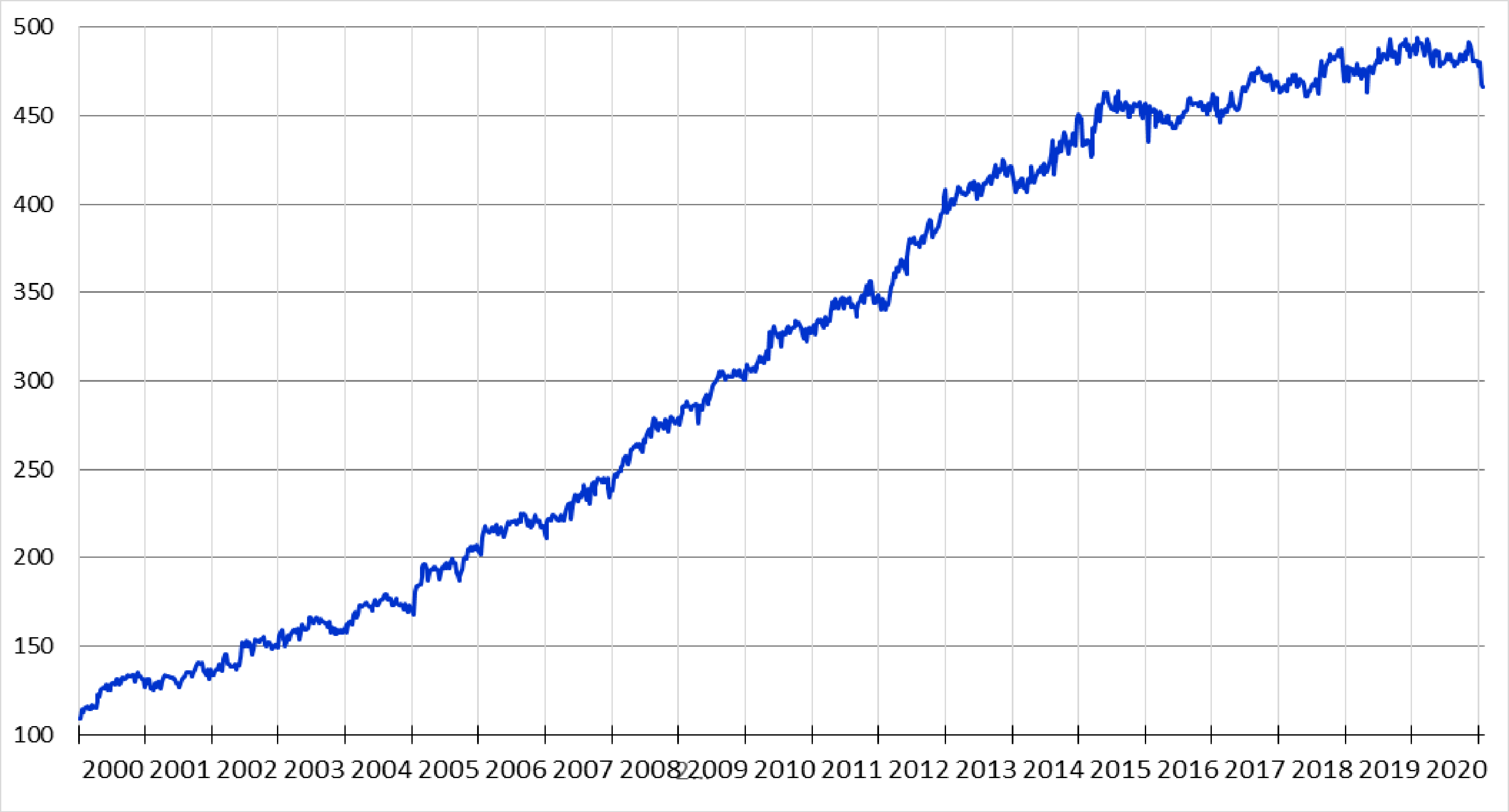
SIR10P01

SIR17P01

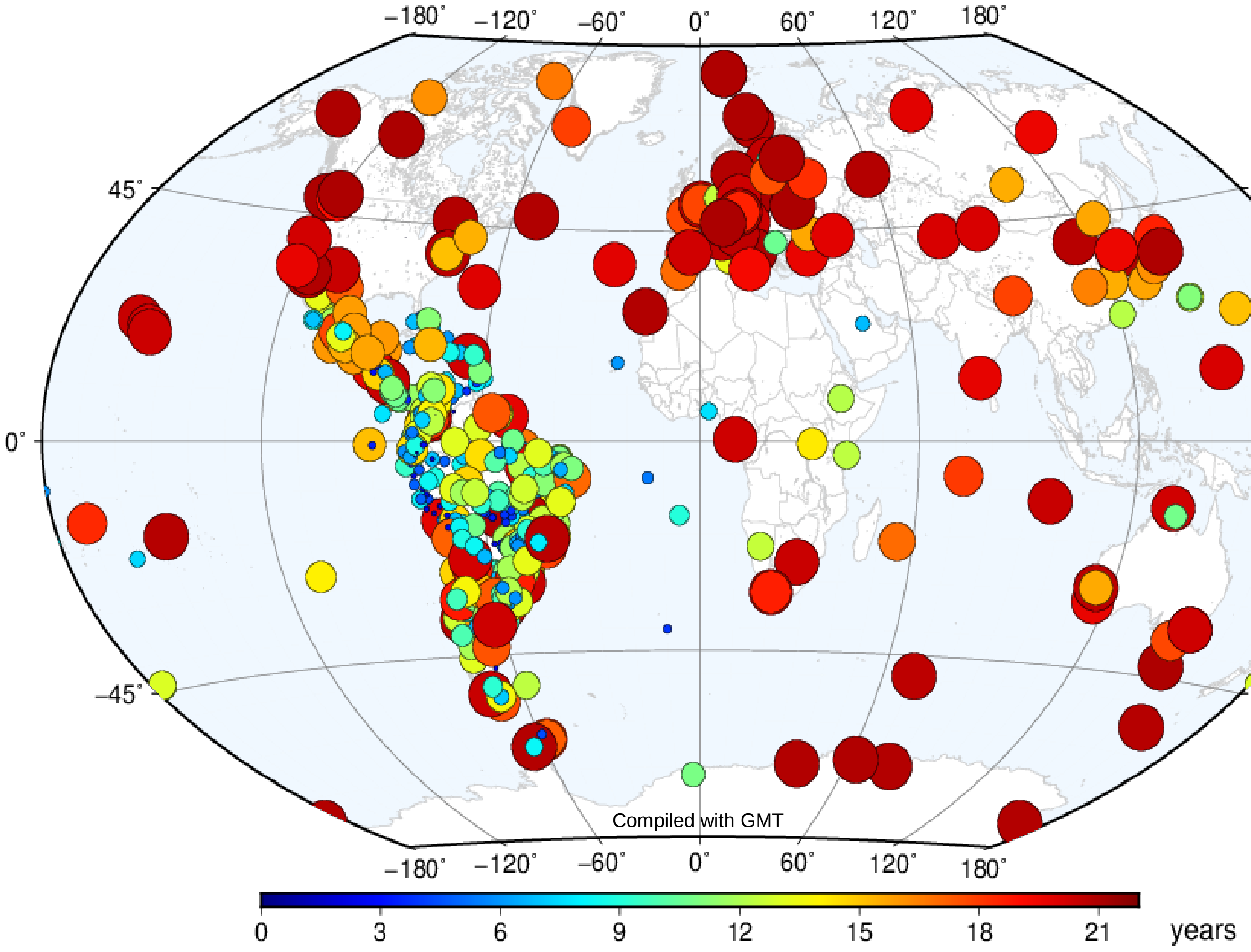
Latest reference frame solution – SIRGAS2022
SIRGAS-Repro2: 2000-01-02 thru 2022-04-30

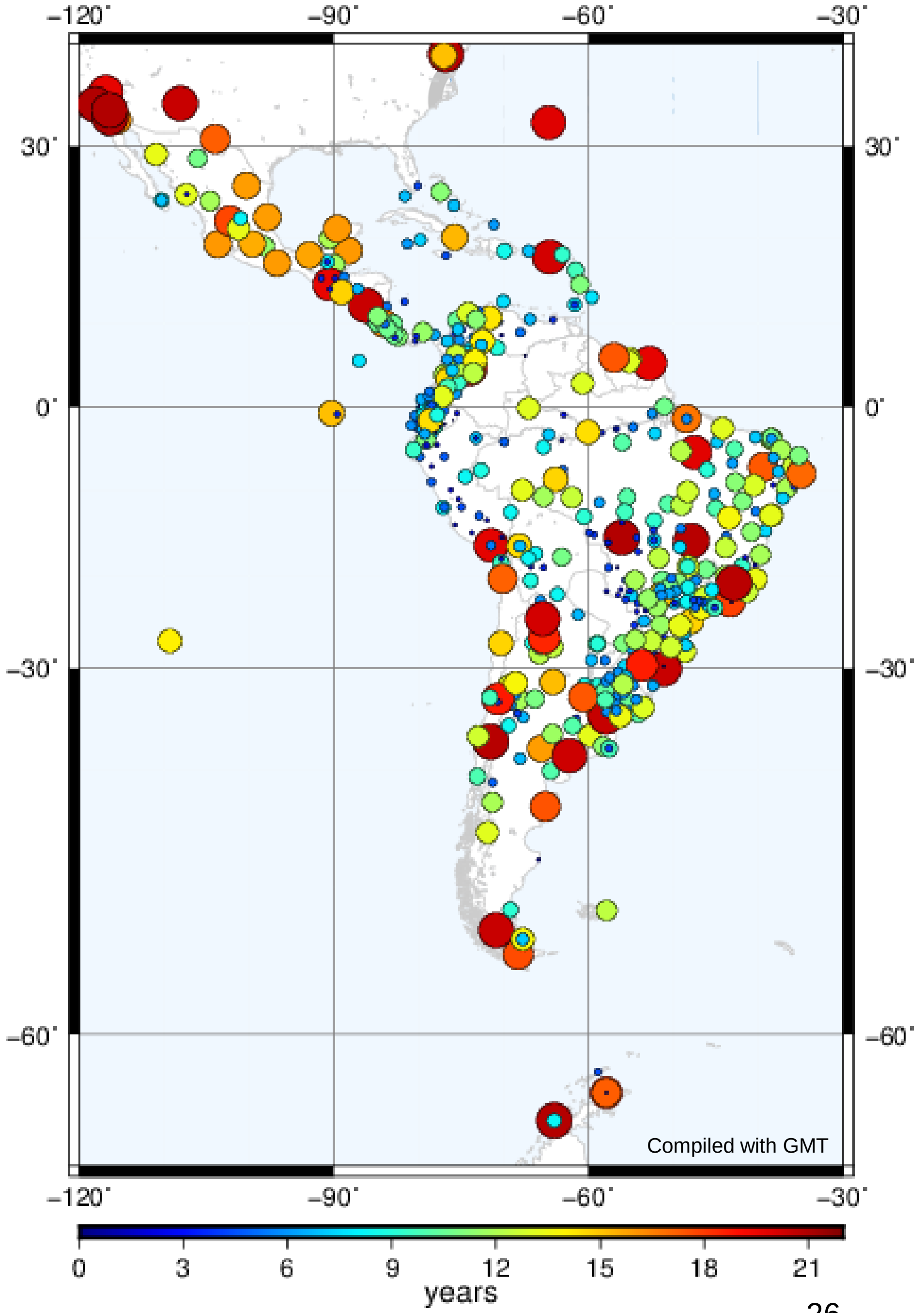


SIRGAS-Repro2: Stations per year

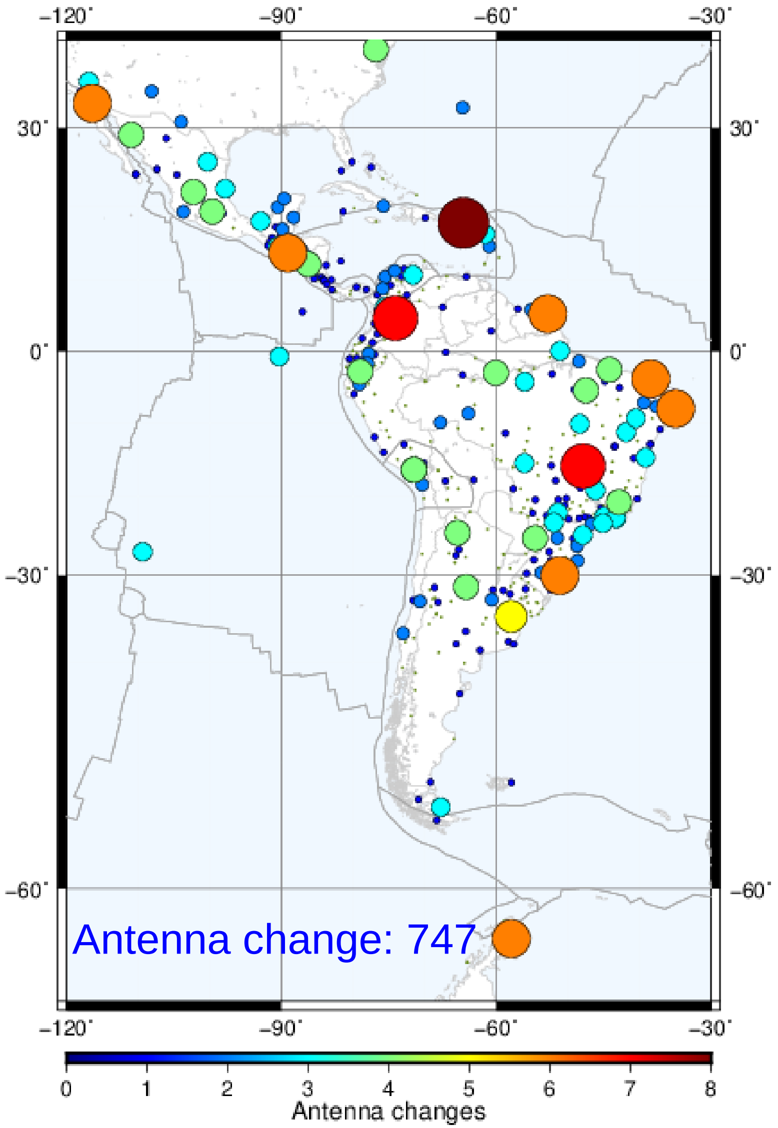


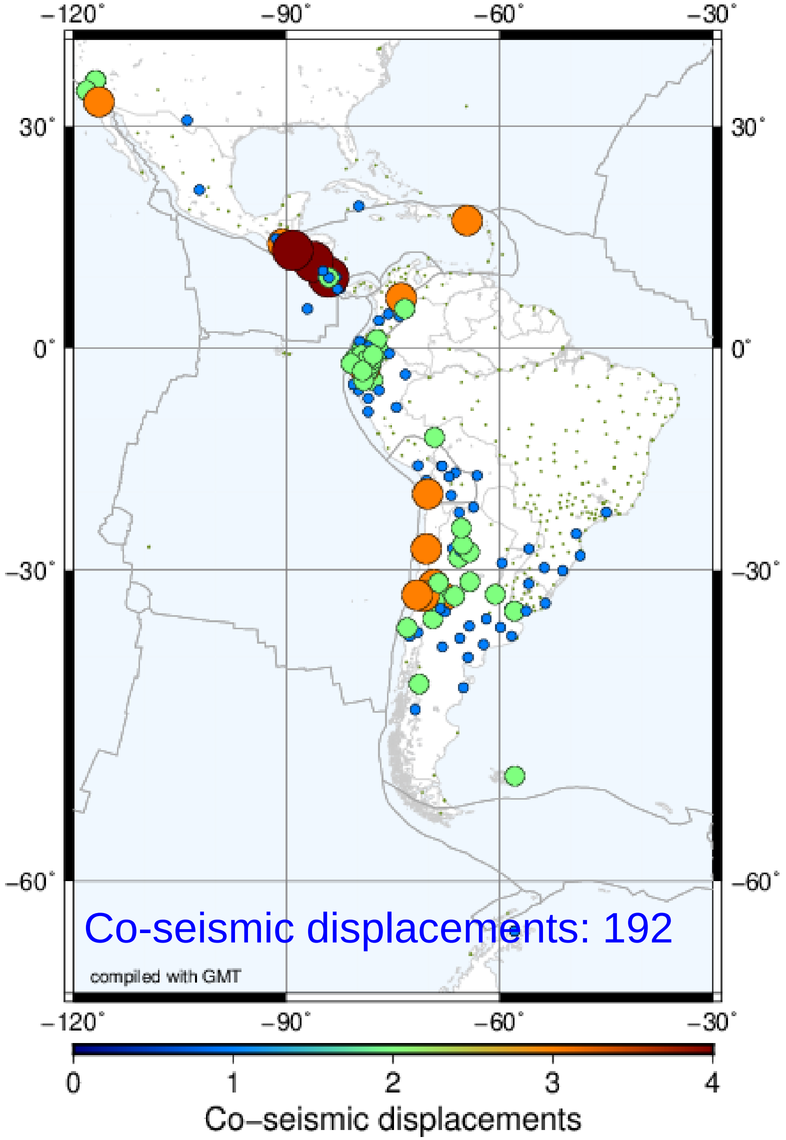
SIRGAS-Repro2: Years per station

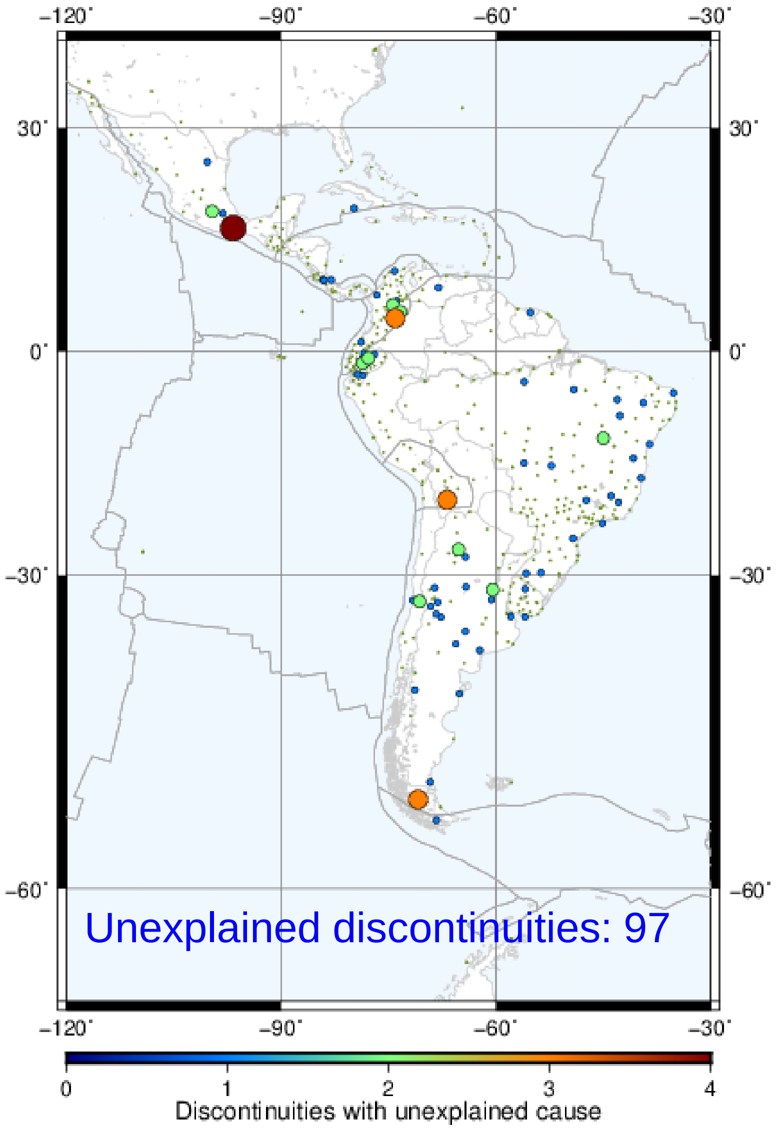




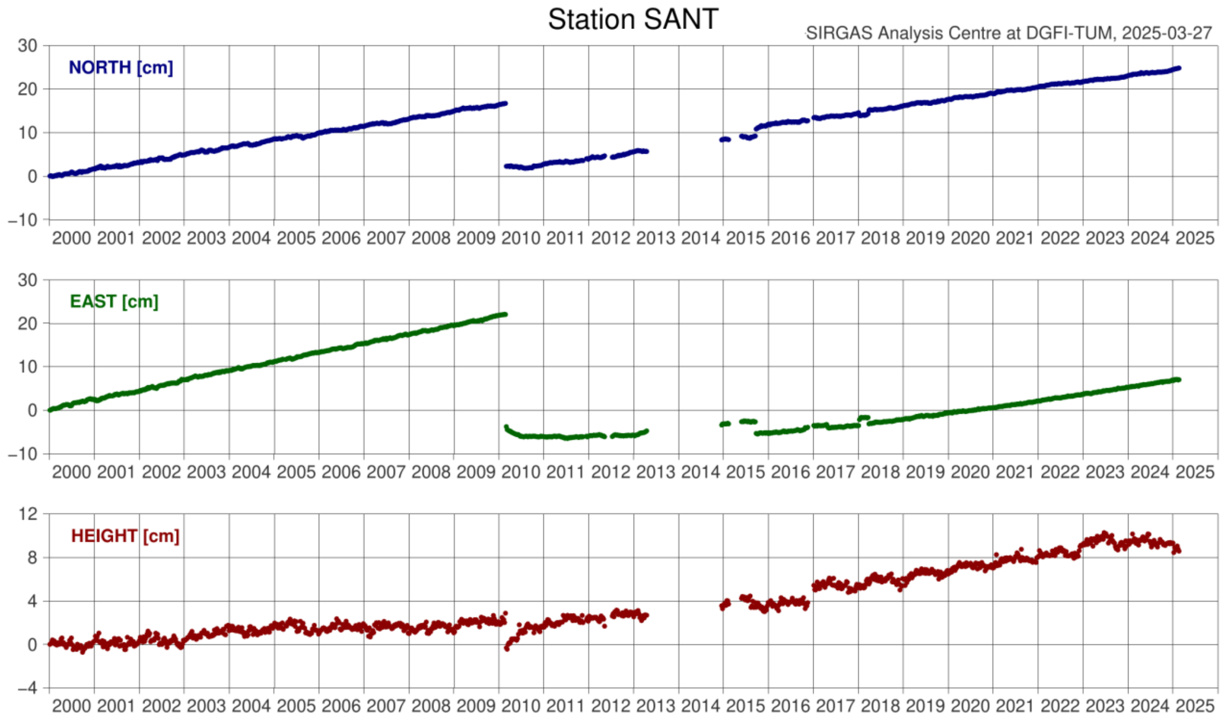
SIRGAS-Repro2: Discontinuities (1389 occupations)

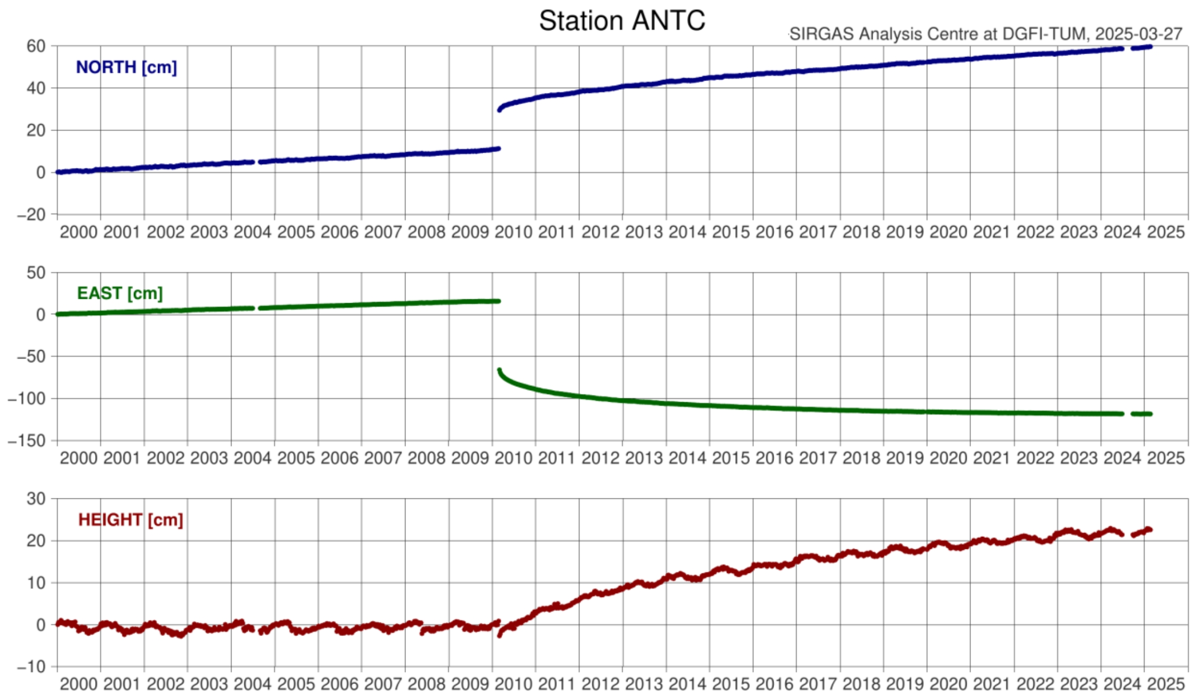






Present challenge: handling of co- and post-seismic effects



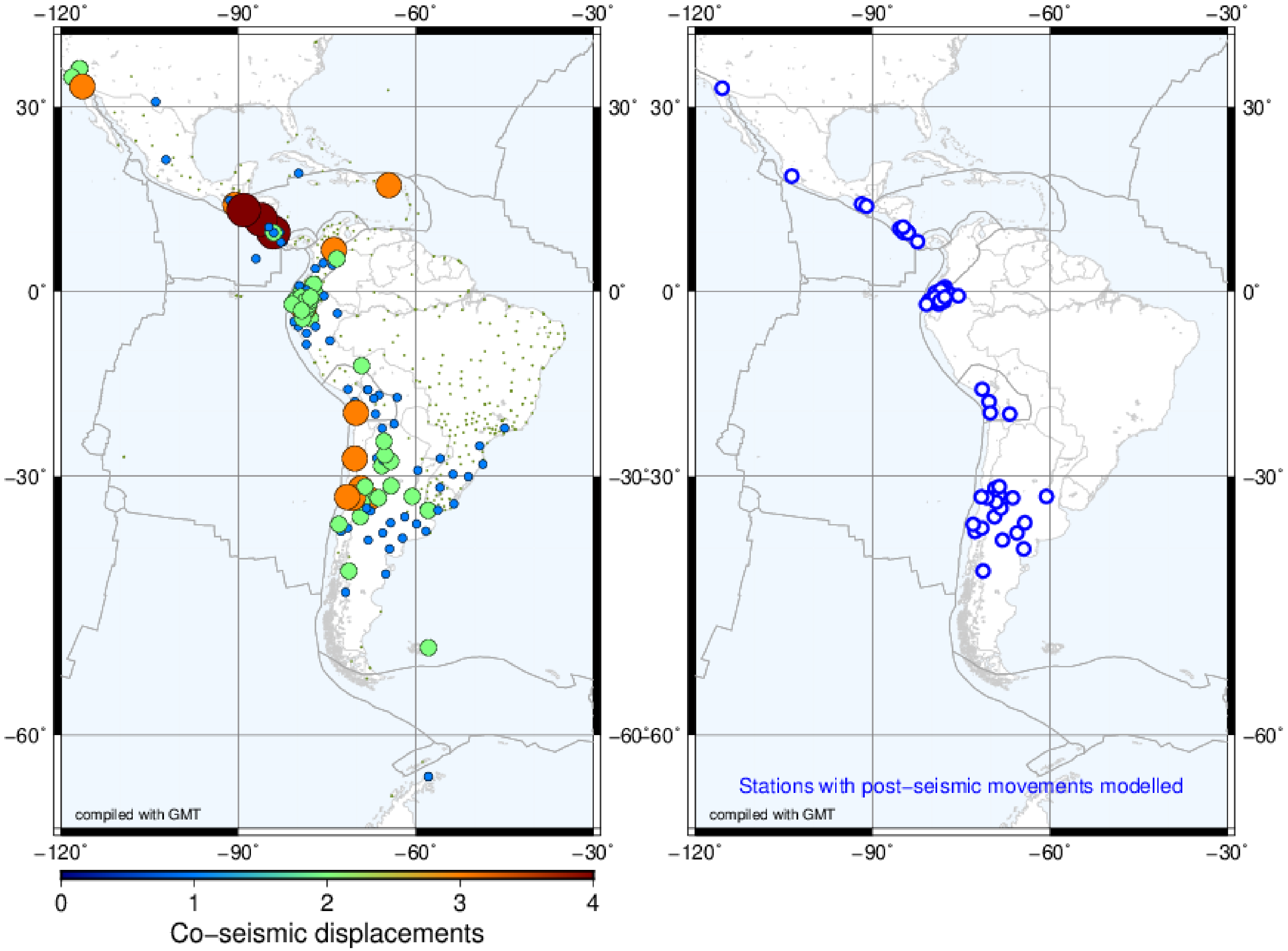


$$\delta x_{PSD}(t) = A_i \cdot \log\left(1 + \frac{\Delta t}{\tau_i}\right) + A_e \cdot \left(1 - \exp\left(-\frac{\Delta t}{\tau_i}\right)\right)$$

$$\delta x_{PSD}(t) = \sum_{i=1}^{2} A_i \cdot \log\left(1 + \frac{\Delta t}{\tau_i}\right)$$

A : amplitude
τ: duration post-seismic effect
Δt: time difference with respect to the time of occurrence of the earthquake

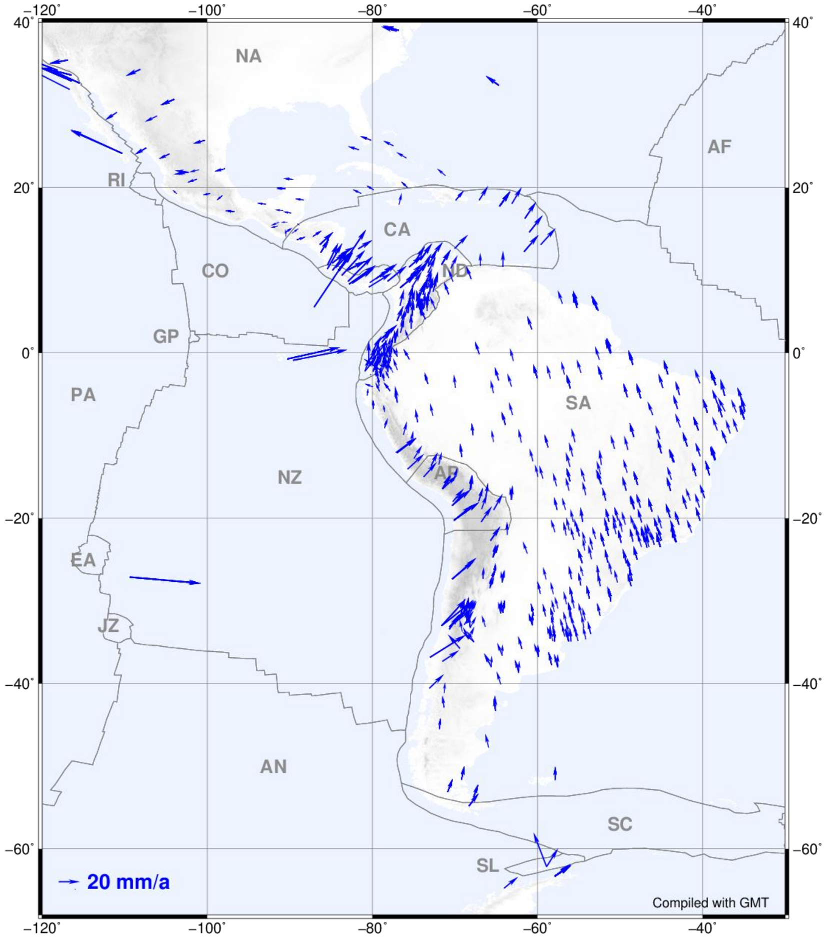
Present challenge: handling of co- and post-seismic effects

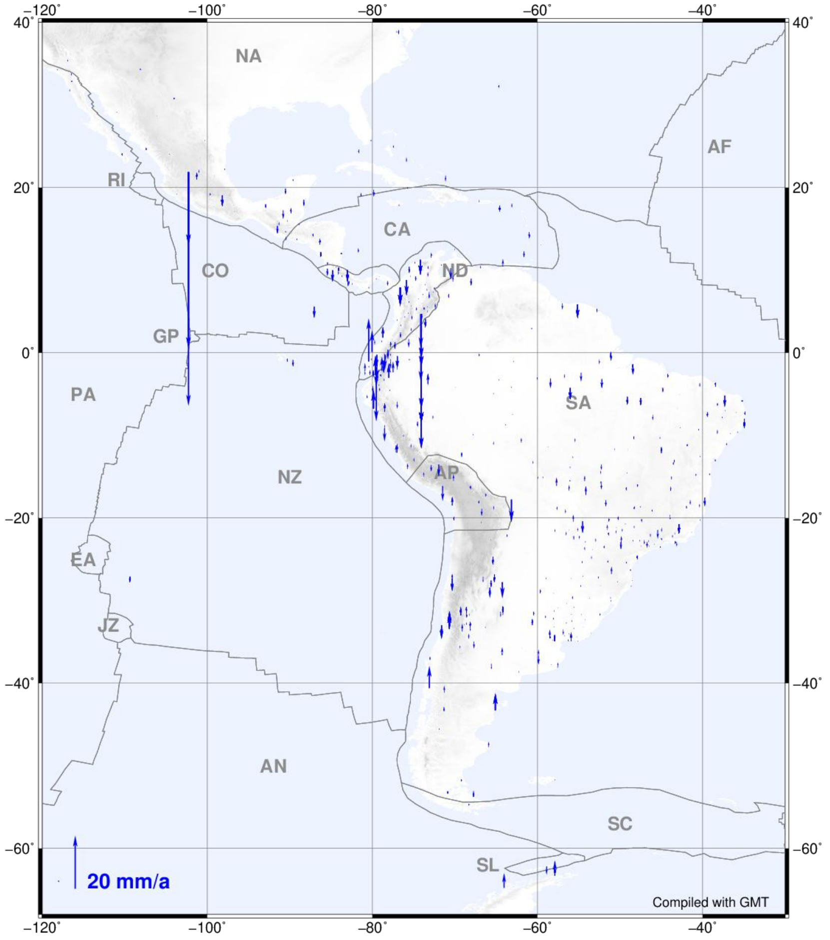


SIRGAS2022

- 21% of the discontinuities correspond to co-seismic displacements
- 62 post-seismic functions
- Coefficients of these functions change when time increases
- The seismic effects of different earthquakes are superimposed, requiring several approximation functions for the same station at very short time intervals

SIRGAS2022 Reference Frame Solution





- Newest reference frame solution
- From Jan 2000 to April 2022 (update every 6 months)
- SIRGAS-Repro2 in IGb14 (Jan 2000 – Dec 2021) + operational SIRGAS solutions in IGb14 (since Jan 2022)
- 587 stations with 1389 occupations
- IGb14, 2015.0

- Accuracy
  - Positions at reference epoch: N/E: ±0.8 mm, h : ±1.4 mm
  - Velocities: N/E: ±0.6 mm/year, h: ±1.0 mm/year

SIRGAS multi-year solutions
Availability at www.sirgas.org

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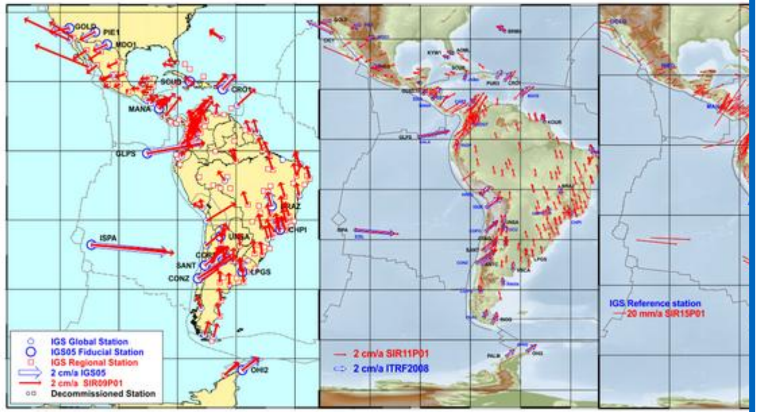
- Realizations +
- Stations +
- Weekly solutions +
- **Multi-year solutions**
- VEMOS velocity model +
- Publications
- Presentations
- Updates



SIRGAS multi-year solutions

The SIRGAS multi-year solutions provide the most accurate and up-to-
They are used for the realization and maintenance of the SIRGAS re
ITRF. While a new ITRF release is published more or less every five y
solutions are updated every one or two years. The combined adjustme
Bernese GNSS Software V5.2 and it is based on the loosely constraine
the IGS RNAAC SIRGAS to the IGS Analysis Centres. The compu
discontinuities due to episodic events such as co-seismic displacemen
to set up the appropriate parameters in the adjustment. The station po
velocities are estimated by aligning the SIRGAS reference frame to sele
SIRGAS multi-year solutions released so far are:

SIRGAS2022

- Aligned to IGS14/IGb14, epoch 2015.0
- Time span: 2000-01-02 thru 2022-04-30
- 587 stations with 1389 occupations
- GPS and GLONASS observations
- Based on the SIRGAS-Repro2 normal equation series, see https://www.sirgas.org/archive/gps/SIRGAS/REPRO2
- Station positions, stations velocities and SNX file available at https://www.sirgas.org/archive/gps/SIRGAS/SIRGAS2022
- More information in Sánchez L., Drewes H., Kehm A., Seitz M. (2022). SIRGAS reference frame analysis at DGFI-TUM. Journal of Geodetic Science, 12(1), 92–119, https://doi.org/10.1515/jogs-2022-0138

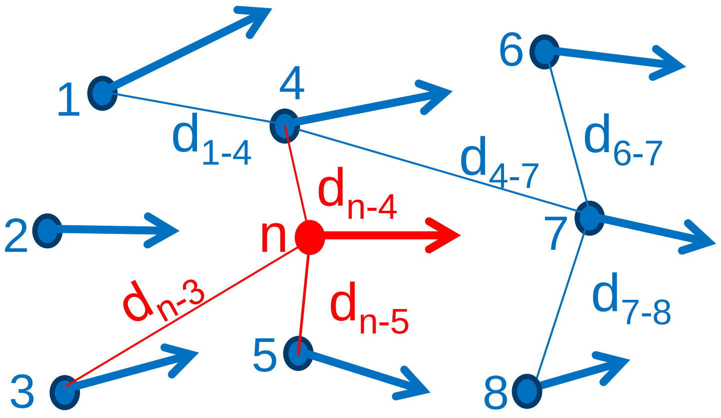
SIR17P01

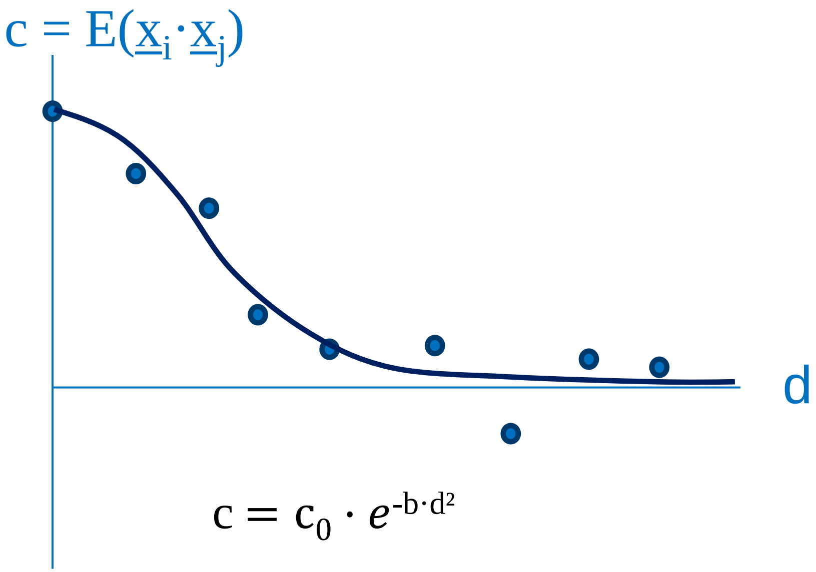
- Aligned to IGS14, epoch 2015.0
- Time span: 2011-04-17 thru 2017-01-28
- 345 stations
- GPS and GLONASS observations
- Absolute phase centre corrections
- This cumulative solution has been made consistent with the phase centre corrections referring to the IGS14 (model igs14.atx)
- This is achieved by applying the station-specific estimates published by the IGS for the IGS stations and by inferring the correction to the regional SIRGAS stations according to the latitude-dependent phase centre correction models also recommended by the IGS
- More information in *Sánchez L., Drewes H.* (2020): **SIRGAS 2017 reference frame realization SIR17P01**, open access, doi 10.1594/PANGAEA.912349, in supplement to: *Sánchez L., Drewes H.* (2020). Geodetic monitoring of the variable surface deformation in Latin America. International Association of Geodesy Symposia Series, Vol 152 , doi: 10.1007/1345_2020_91.

Surface kinematic models inferred from multi-year solutions

- **Input data** — Precise station velocities from reference frame multi-year solutions
- **Remove plate motions** — Removal of plate tectonic motions from the input (observed) velocities to obtain deformation vectors
- **Tectonic settings from Seismology** — Correlation between deformation vectors and tectonic/deformation features described by Seismology
- **LSC prediction** — Interpolation of the residual velocities to a regular grid using a geodetic Least Squares Collocation approach (LSC)
- **Deformation model**
- **Restore plate motions** — Addition of plate motions to the interpolated residual velocities
- **Velocity (kinematics) surface model**

Modelling of deformations based on the geodetic Least Squares Collocation approach (LSC)





2D-vector prediction:

$\underline{\mathbf{v}}_{pred} = \underline{\mathbf{C}}_{new}^{T}\, \underline{\mathbf{C}}_{obs}^{-1}\, \underline{\mathbf{v}}_{obs}$

$\underline{\mathbf{v}}_{pred}$ = predicted velocities (v_N, v_E) in a regular grid

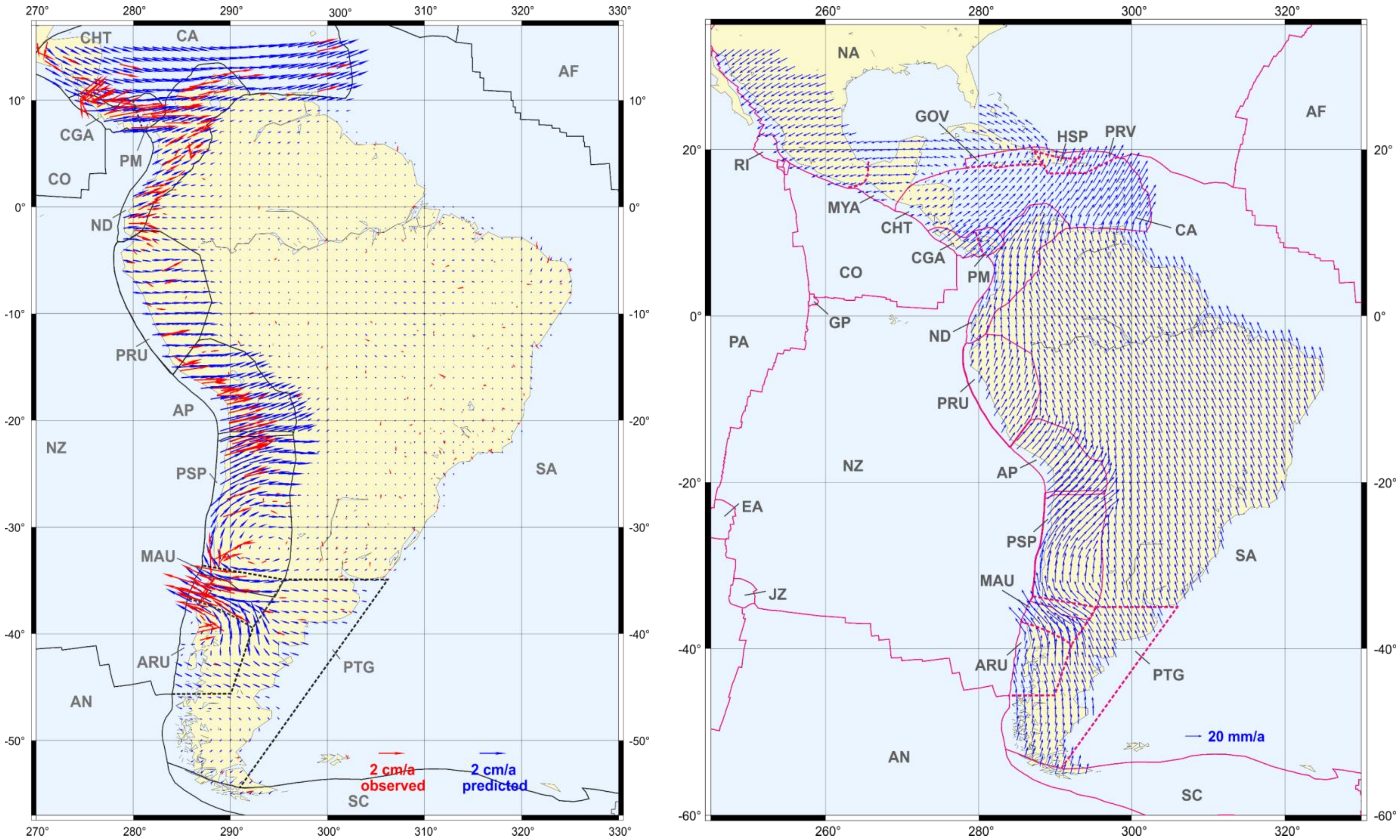
$\underline{\mathbf{v}}_{obs}$ = observed velocities (v_N, v_E) in geodetic stations

$\underline{\mathbf{C}}_{new}$= correlation matrix between predicted and observed vectors

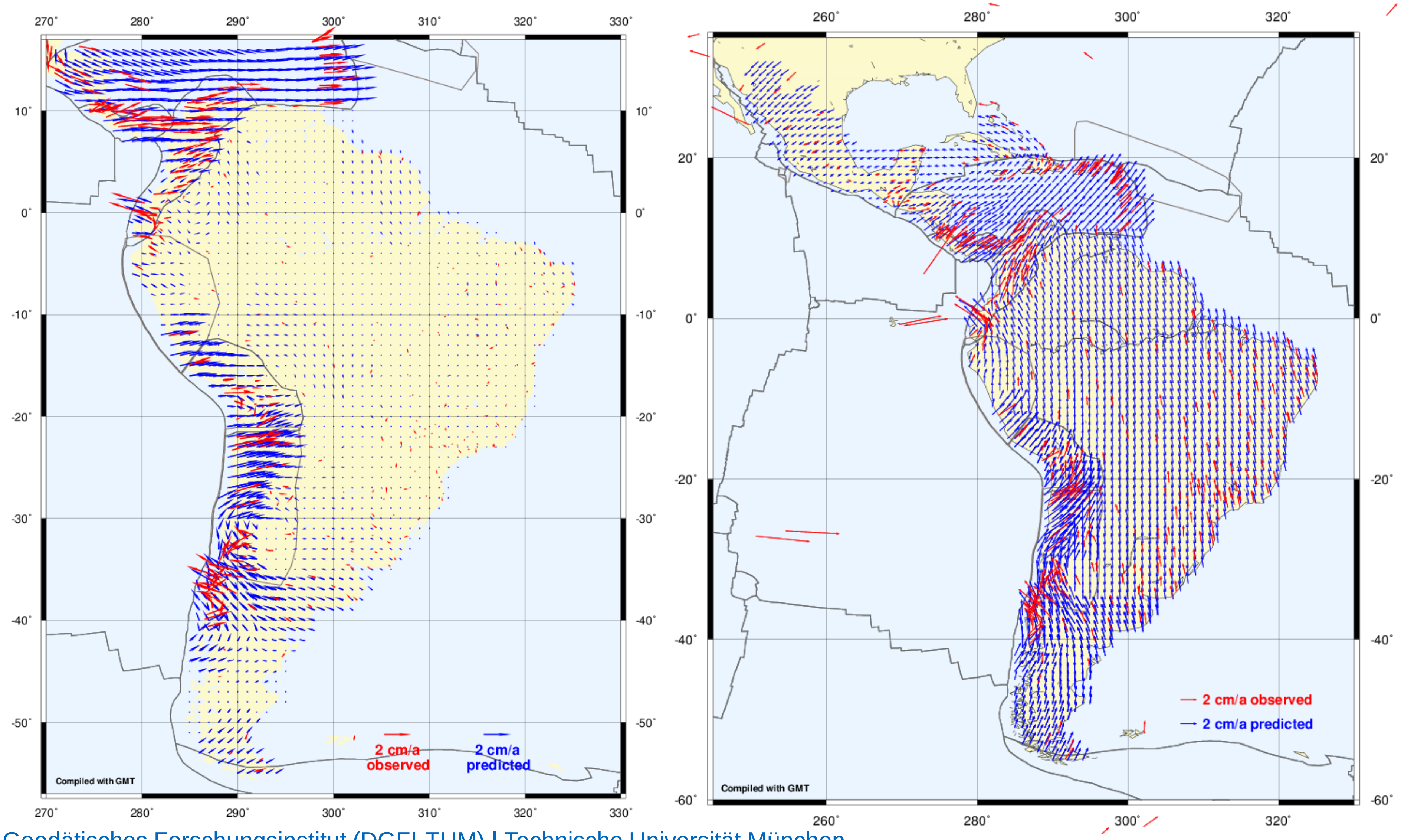
$\underline{\mathbf{C}}_{obs}$= correlation matrix between observed vectors (C_{NN}, C_{EE}, C_{NE})

$\underline{\mathbf{C}}$ matrices are built from empirical isotropic, stationary covariance functions.

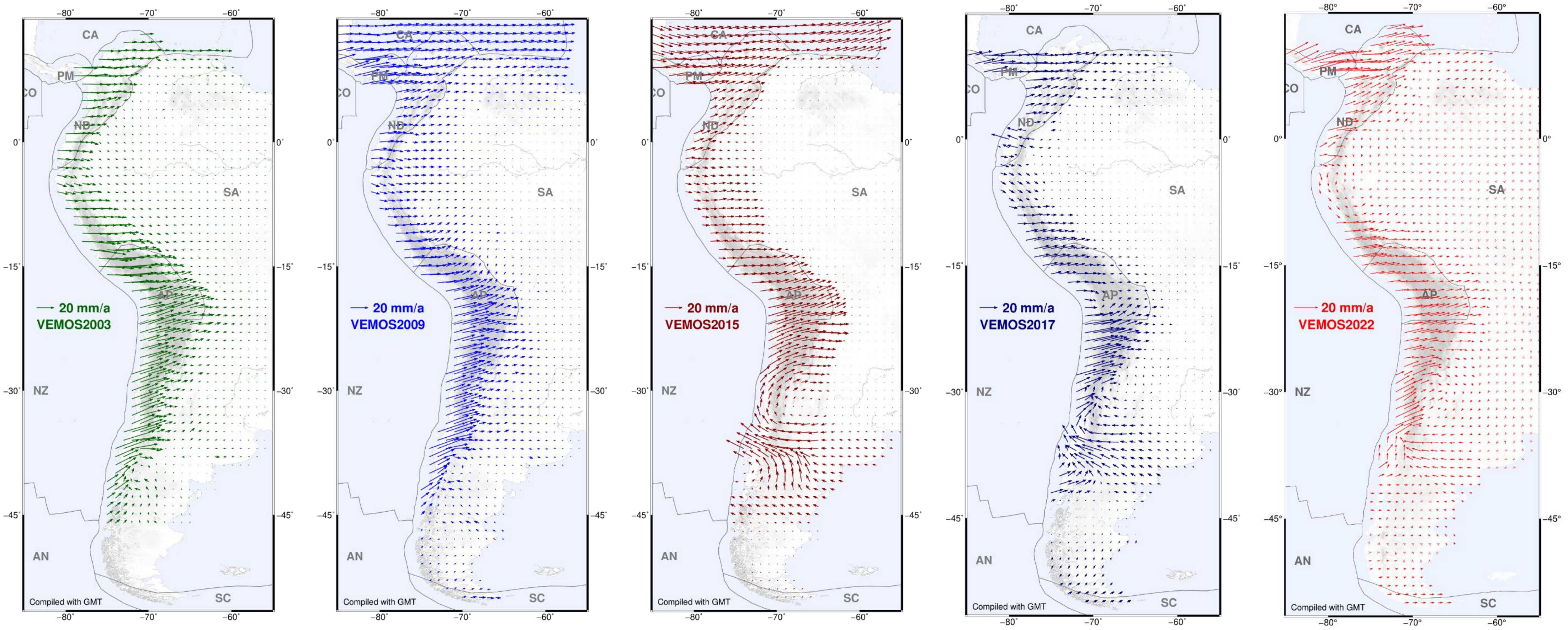
Surface kinematics and deformation model within 5 years after the 2010 Maule earthquake: VEMOS2015 (2010.2 ... 2015.2)



Surface kinematics and deformation model from January 2014 to January 2017: VEMOS2017



Sequence of surface deformation models in SIRGAS



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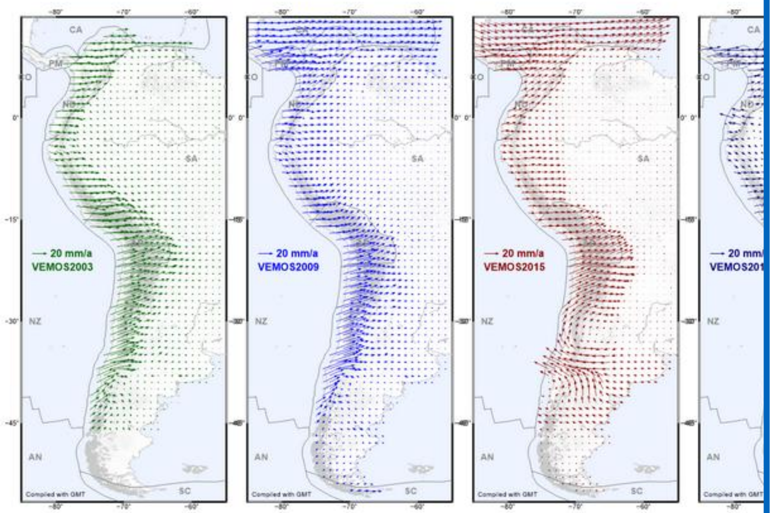
- Home
- About SIRGAS
- Realizations +
- Stations +
- Weekly solutions +
- Multi-year solutions
- **VEMOS velocity model**
- Using velocities in GNSS
- Publications
- Presentations
- Updates



VEMOS: Velocity model for SIRGAS

The GNSS data processing requires the reference station positions in the s
observation epoch as the satellite orbits. The weekly station positions of
Stations (SIRGAS-CON network) satisfy these requirements and therefo
SIRGAS-CON stations with their weekly positions as reference points for pre
region. If the reference points in a GNSS positioning are not continuously ope
weekly positions are not available), it is necessary to translate the reference
applying the so-called velocities. It is desirable that the velocities of refere

VEMOS2022 [download in txt format]

VEMOS2022 is based on the pointwise station velocities determined in the **SIRGAS2022 reference frame solution** and was computed using the same methods as the previous VEMOS2017 and VEMOS2015 models. **VEMOS2022** covers the period from **February 1, 2017 to April 30, 2022** and its average uncertainty is assessed to be ±0.8 mm/a in the north-south direction and ±1.3 mm/a in the east-west direction. When using VEMOS2017, please always quote the following citation:

> *Drewes H., Seitz M., Sánchez L.* (2024). **Realisation of the Non-Rotating Terrestrial Reference Frame by an Actual Plate Kinematic and Crustal Deformation Model (APKIM2020)**. International Association of Geodesy Symposia, https://doi.org/10.1007/1345_2024_276.

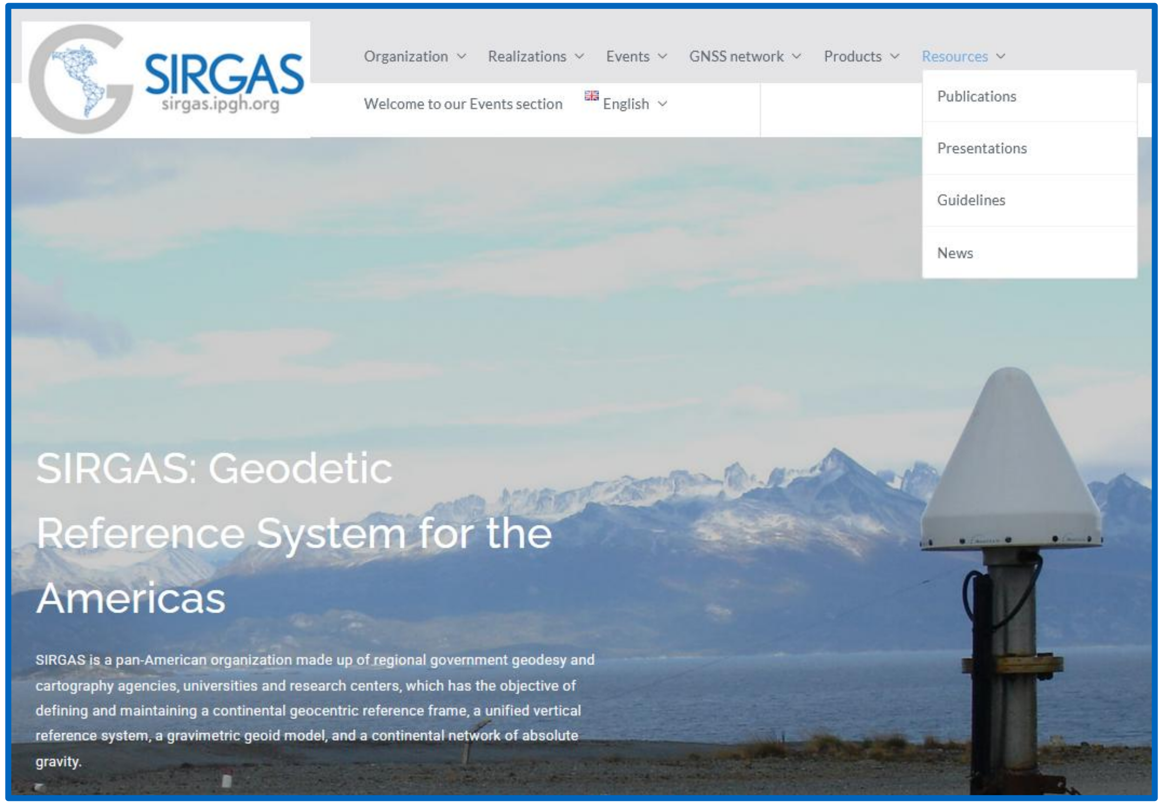
VEMOS2017 [download in txt format]

VEMOS2017 was derived from pointwise station velocities inferred at **515 geodetic sites from January 1, 2014 to January 28, 2017** using a geodetic least-squares collocation approach with empirically determined covariance functions. **VEMOS2017** describes the present-day deformation in Latin America and the Caribbean and continues the surface-kinematics model represented by VEMOS2015, which is valid from March 14, 2010 to April 11, 2015. VEMOS2017 covers the region from 120°W, 55°S to 35°W, 32°N with a spatial resolution of 1° x 1°. The average uncertainty of VEMOS2017 is assessed to be ±1.0 mm/a in the north-south direction and ±1.7 mm/a in the east-west direction. The maximum uncertainty values (up to ±15 mm/a) occur at the zones affected by recent strong earthquakes (in the Maule area, the northern part of Chile, Ecuador and Costa Rica). The best uncertainty values (about ±0.1 mm/a) result in the stable eastern part of the South American plate. When using **VEMOS2017**, please always quote the following **citation**:

> *Drewes H. and Sánchez L.* (2020): **Velocity model for SIRGAS 2017: VEMOS2017**, doi: 10.1594/PANGAEA.912350, Technische Universitaet Muenchen, Deutsches Geodaetisches Forschungsinstitut (DGFI-TUM), IGS RNAAC SIRGAS, supplement to:

Further reading

https://sirgas.ipgh.org



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