

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

S.M. Alves-Costa, L. Sánchez, D. Piñon, J.A. Tarrío-Mosquera, G. Guimarães, D. Gómez, H. Drewes, M.V. Mackern, E. Antokoletz, A.C.O.C de Matos, D. Blitzkow, A.L. da Silva, , J. Inzunza, D. España, O. Rodríguez, S. Rozas-Bornes, H. Guagni, G. González, O. Paucar-Llaja, J.M. Pampillón, A. Alvarez-Calderon



REFAG2022: Reference frames for applications in Geosciences  
Thessaloniki, Greece, October 17 - 20, 2022

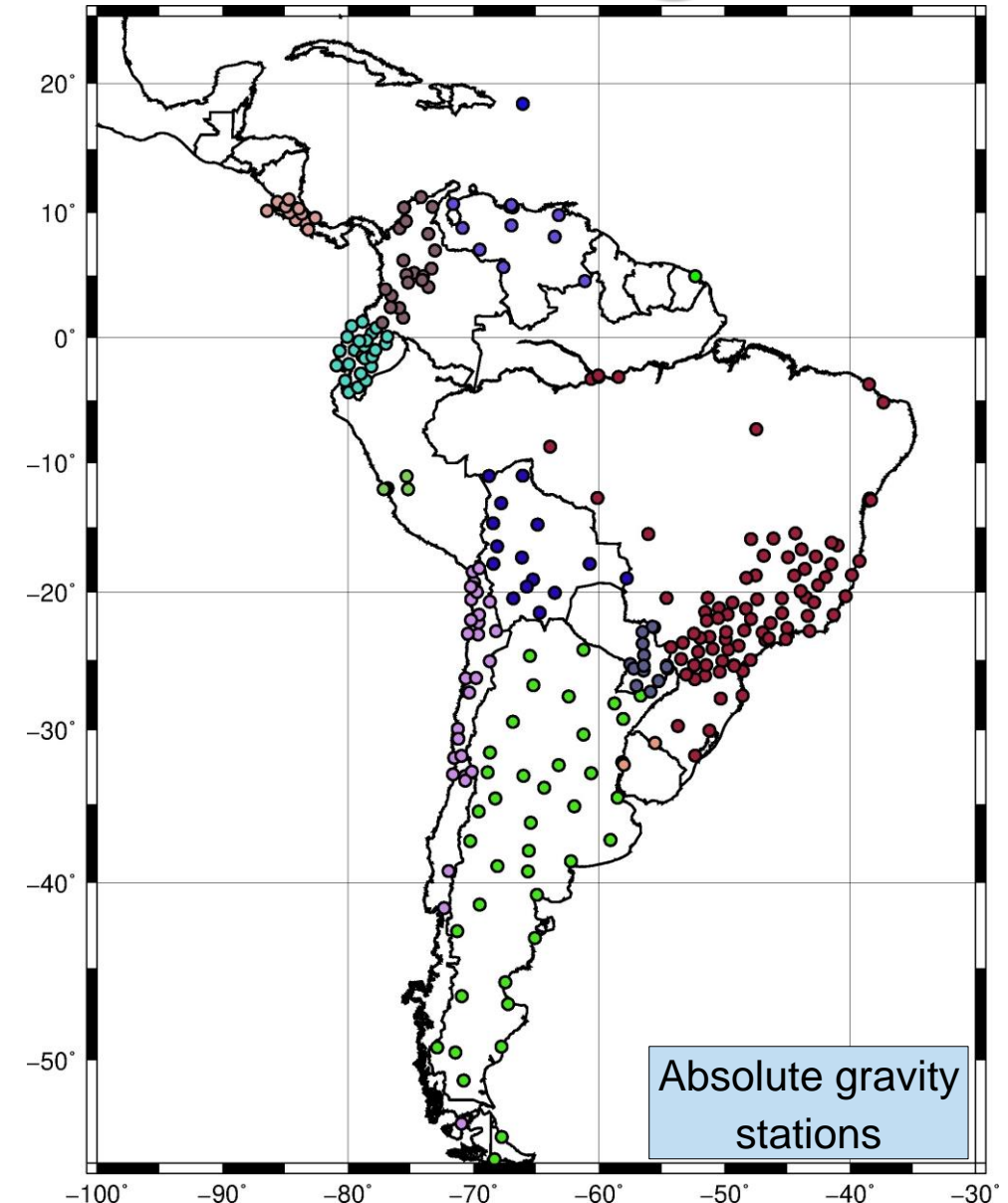
# Introduction



- 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**

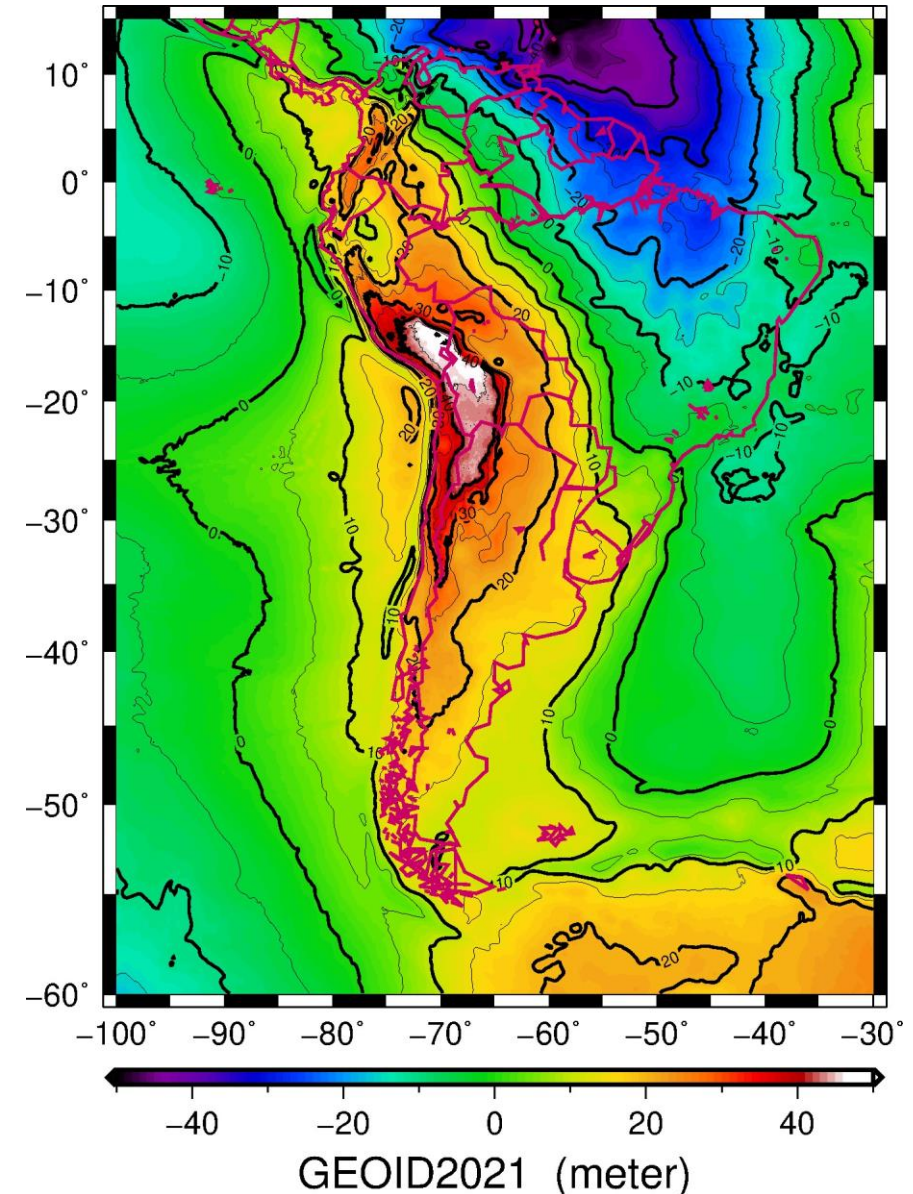
# Physical reference frame: Gravimetry

- **Objective:** To provide a modern reference standard for terrestrial gravimetry
- **Goal:** To establish a regional reference network of absolute gravity stations (as a densification of the future *International Terrestrial Gravity Reference Frame – ITGRF*)
- **On-going activities:**
  - Quality evaluation of existing absolute gravity stations
  - Identification of regional gaps and establishment of new stations
- **Challenges:**
  - Deployment of continuous measuring gravimeters (continuous monitoring of reference stations)
  - Comparison/calibration of the different absolute gravimeters used in the region



# Physical reference frame: Geoid modelling

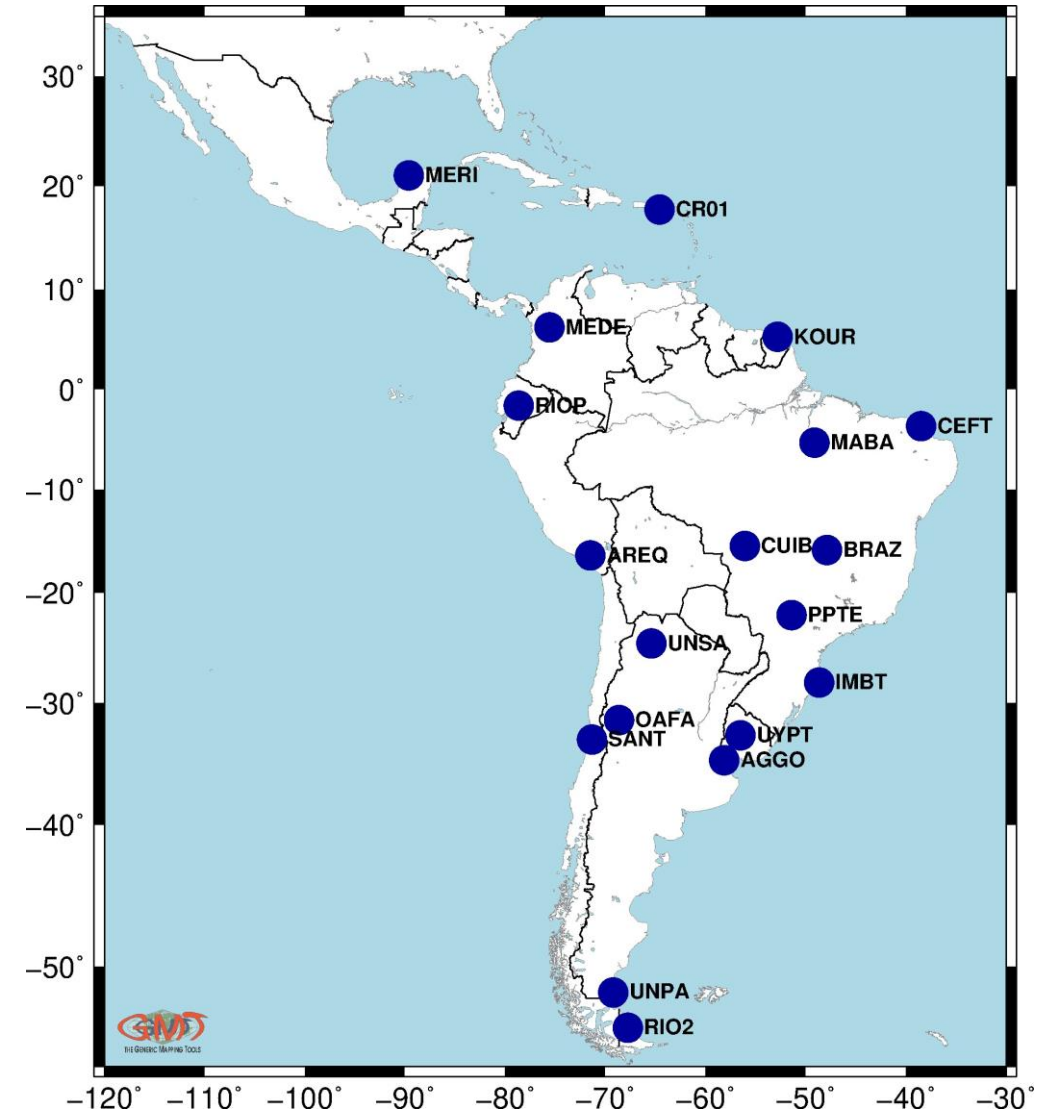
- **Objective:** To increase the accuracy of existing regional and national models and to promote the determination of national geoid models where they are missing
- **Goal:** To provide precise regional/national geoid models to support GNSS/levelling applications with high reliability
- **On-going activities:**
  - Comparison of existing national geoid models with the regional one
- **Challenges:**
  - To solve regional gravity data gaps
  - To identify sources of discrepancy between different geoid models
  - Quality assessment of geoid models





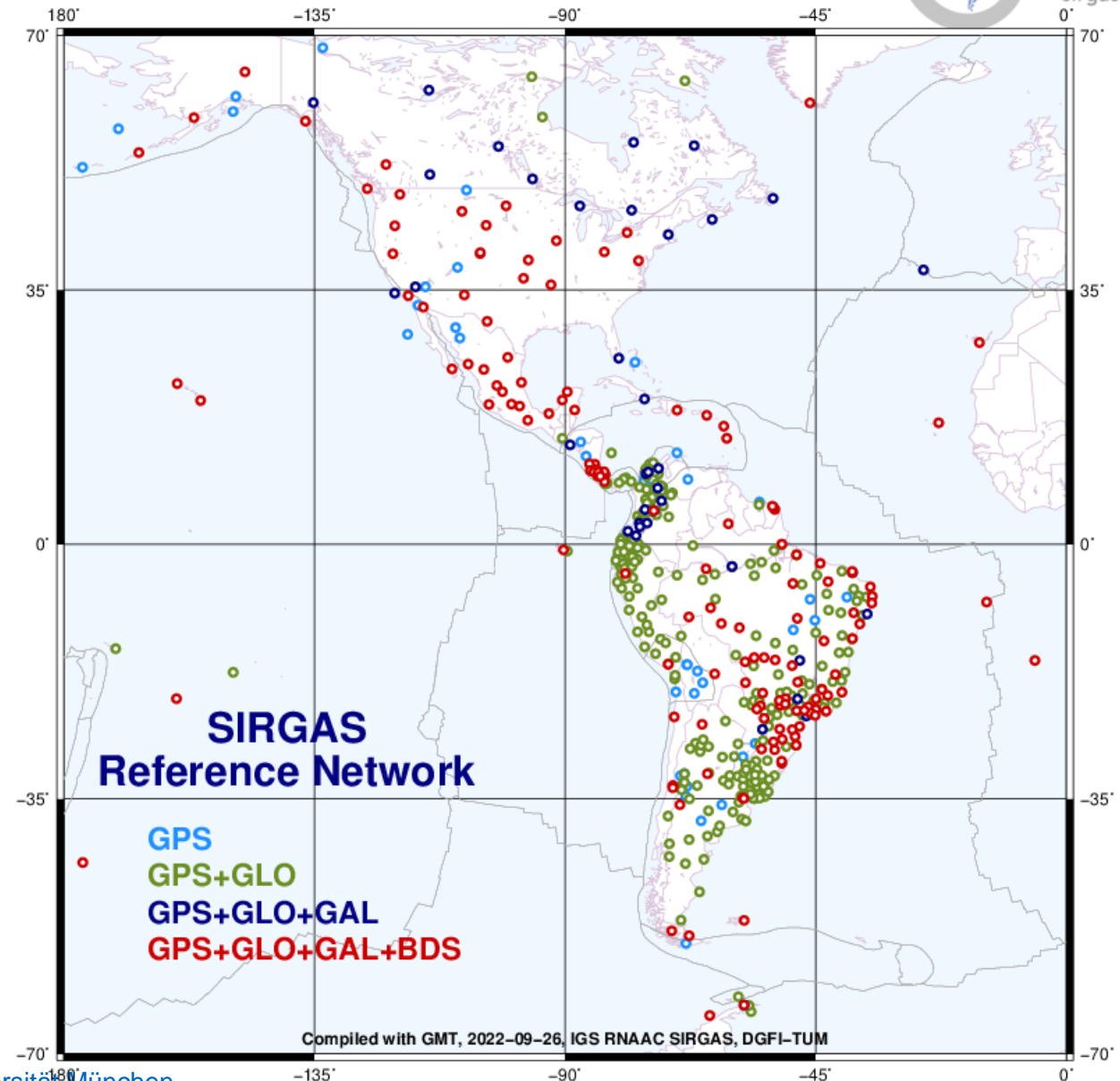
# Physical reference frame: Physical heights

- **Objective:** To provide a reference standard for the precise determination of physical heights
- **Goal:** To establish a regional densification of the global *International Height Reference Frame - IHRF*
- **On-going activities:**
  - Determination of potential coordinates at the Latin American IHRF stations
  - Selection of stations for national IHRF densifications
- **Challenges:**
  - Evaluation of discrepancies between different computation methods
  - Quality assessment in the determination of potential values

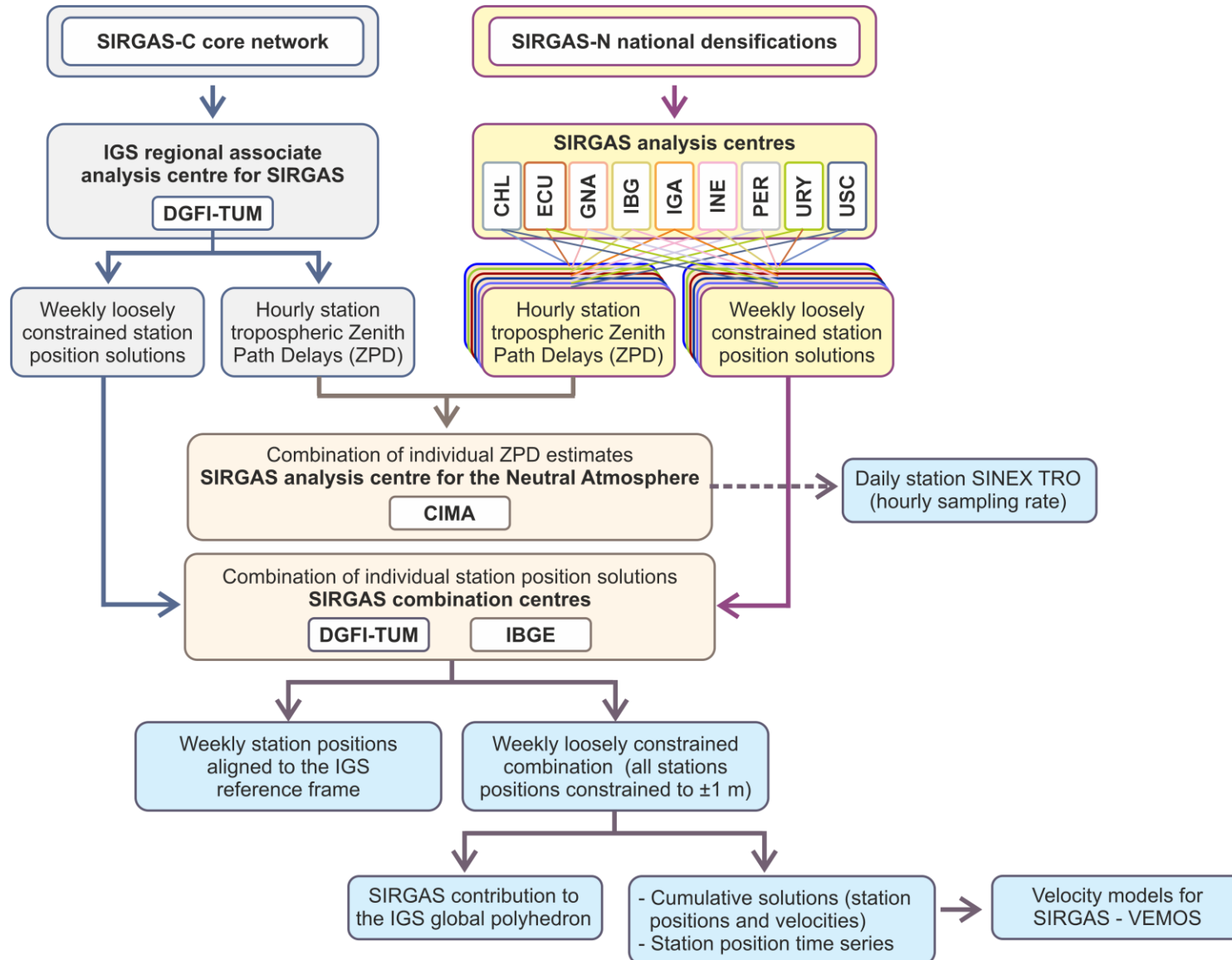


# Geocentric Reference Frame: Reference Network

- 493 stations (169 decommissioned)
  - 109 IGS stations
  - 384 regional stations
  - All tracking GPS
  - 440 tracking GLO
  - 194 tracking GAL
  - 151 tracking BDS

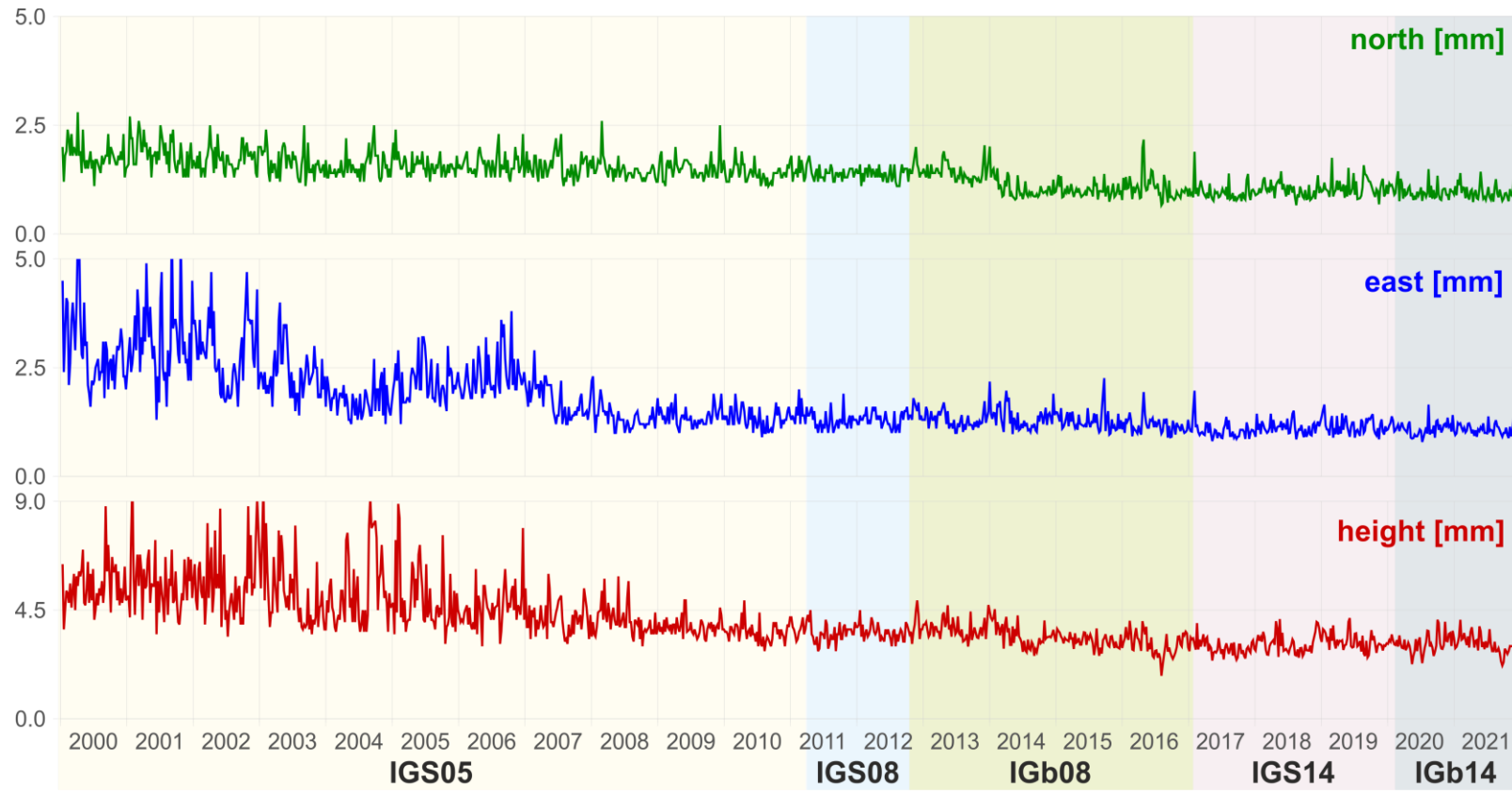


# Geocentric Reference Frame: Analysis and products



- Analysis
  - Ten GNSS analysis centres
  - 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 IGS reference frame
  - Cumulative solutions (station velocities, time series, post-seismic functions)
  - Velocity models VEMOS

# Geocentric Reference Frame: Analysis and products

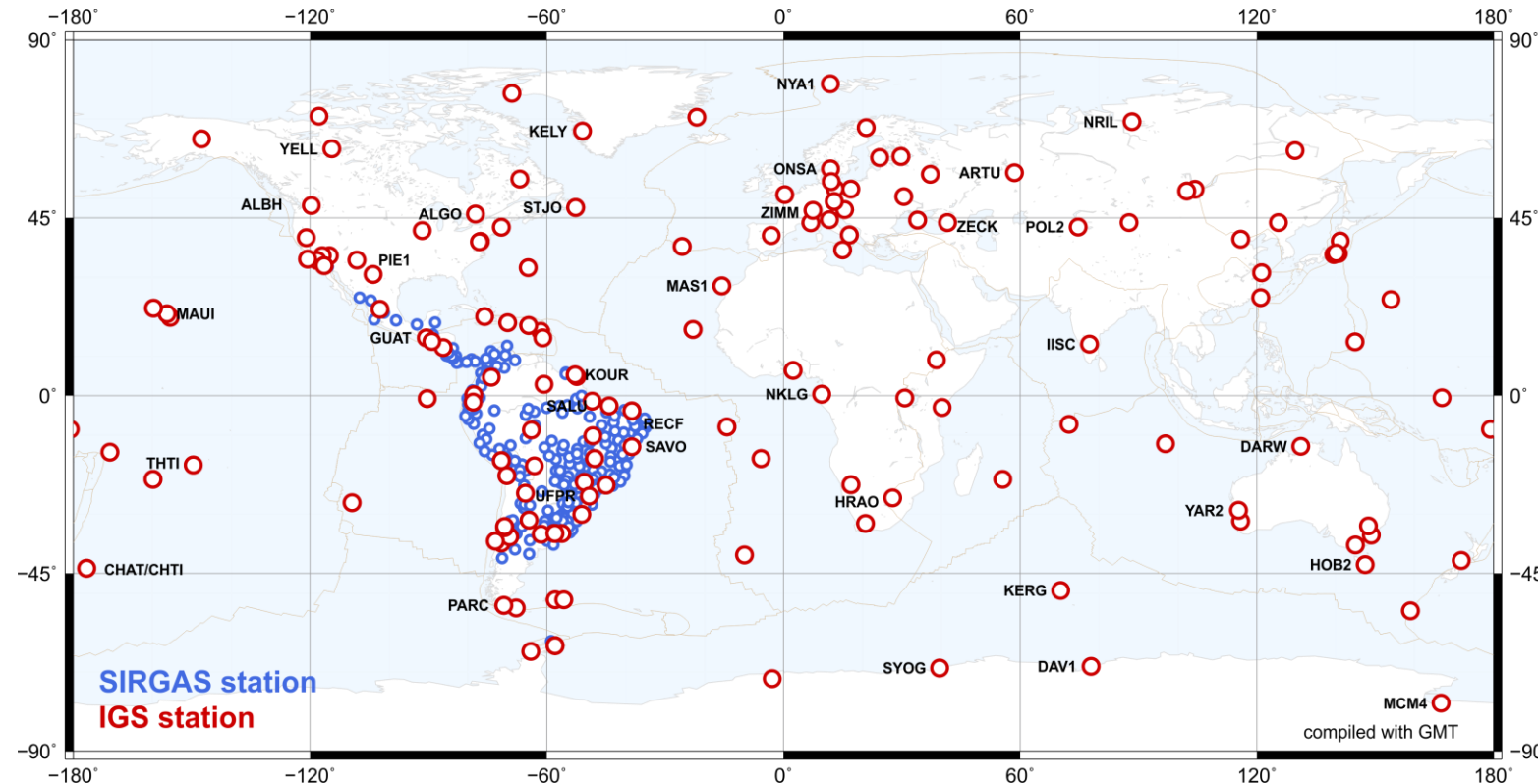


- Weekly station position repeatability in operational SIRGAS analysis
  - IGS05:  
N/E:  $\pm 2.8$  mm, h:  $\pm 6.0$  mm
  - IGS08/IGb08:  
N/E:  $\pm 1.8$  mm, h : 3.5 mm
  - IGS14/IGb14:  
N/E:  $\pm 0.8$  mm, h:  $\pm 2.6$  mm



# Geocentric Reference Frame: Second SIRGAS reprocessing

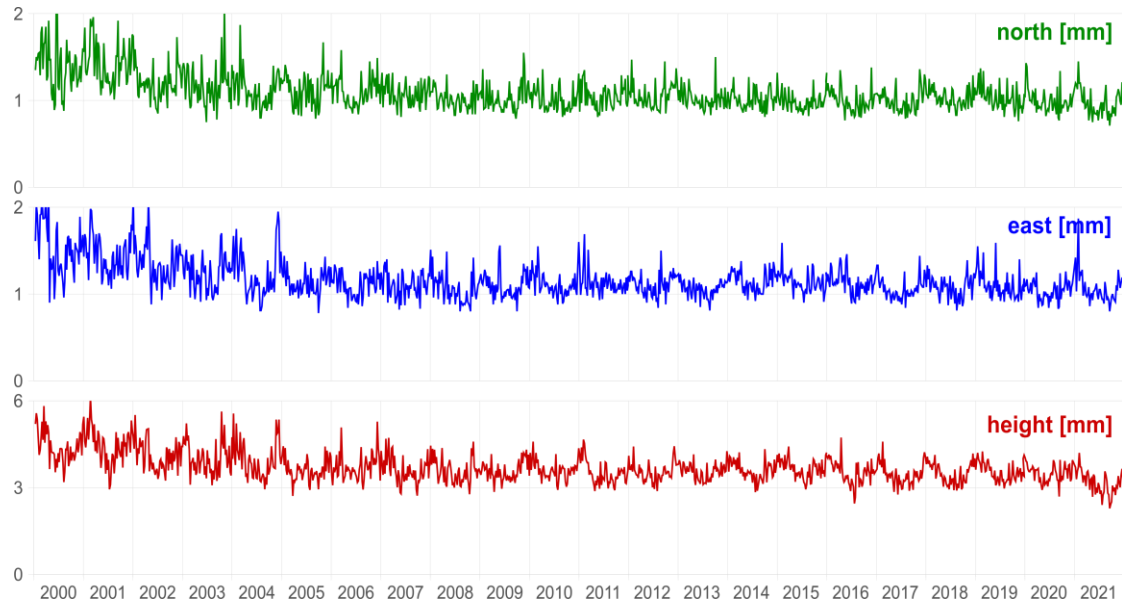
- Reanalysis of the historical SIRGAS GNSS data using a unified set of newest standards and conventions over the complete time span
- Reprocessing of SIRGAS data from January 2000 to December 2021
- 537 SIRGAS regional stations plus 128 IGS global stations (88 of them belonging to the IGS14/IGb14 reference frame)
- 2.6 million daily RINEX files processed
- IGS14/IGb14 reference frame: IGS and IG2 products (satellite orbits and clocks, EOPs) and phase centre variation model



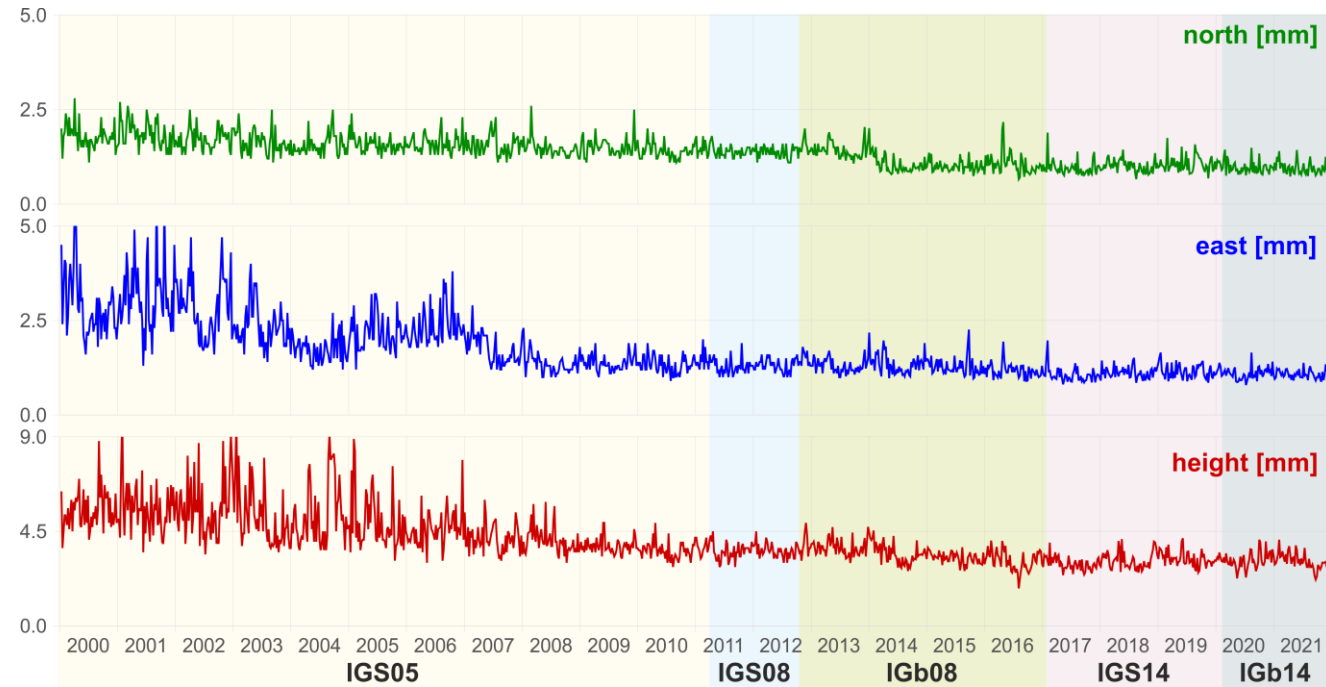
# Geocentric Reference Frame: Second SIRGAS reprocessing



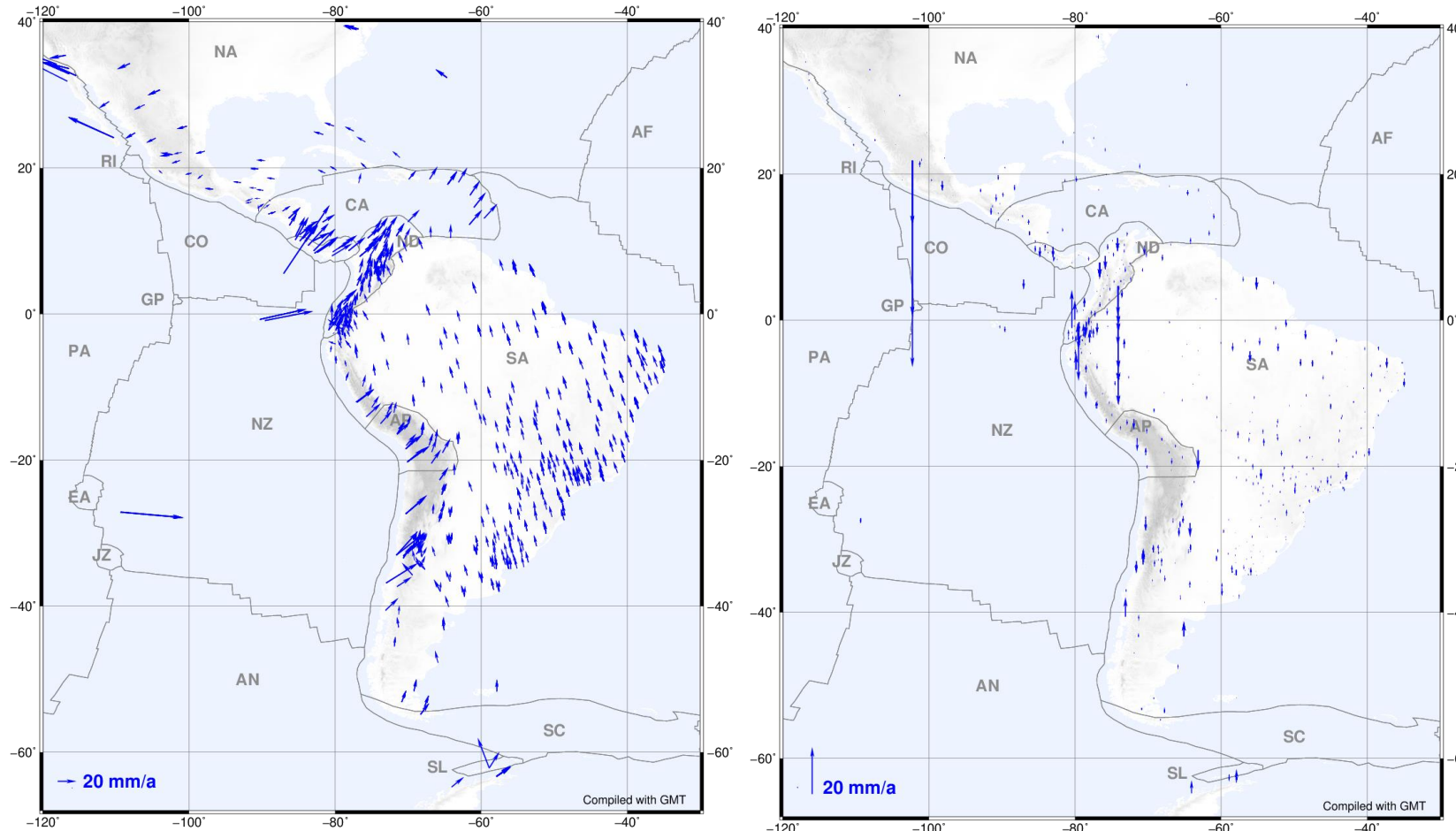
## Weekly station position repeatability in SIRGAS-Repro2



## Weekly station position repeatability in SIRGAS operational



# Geocentric Reference Frame: SIRGAS2022

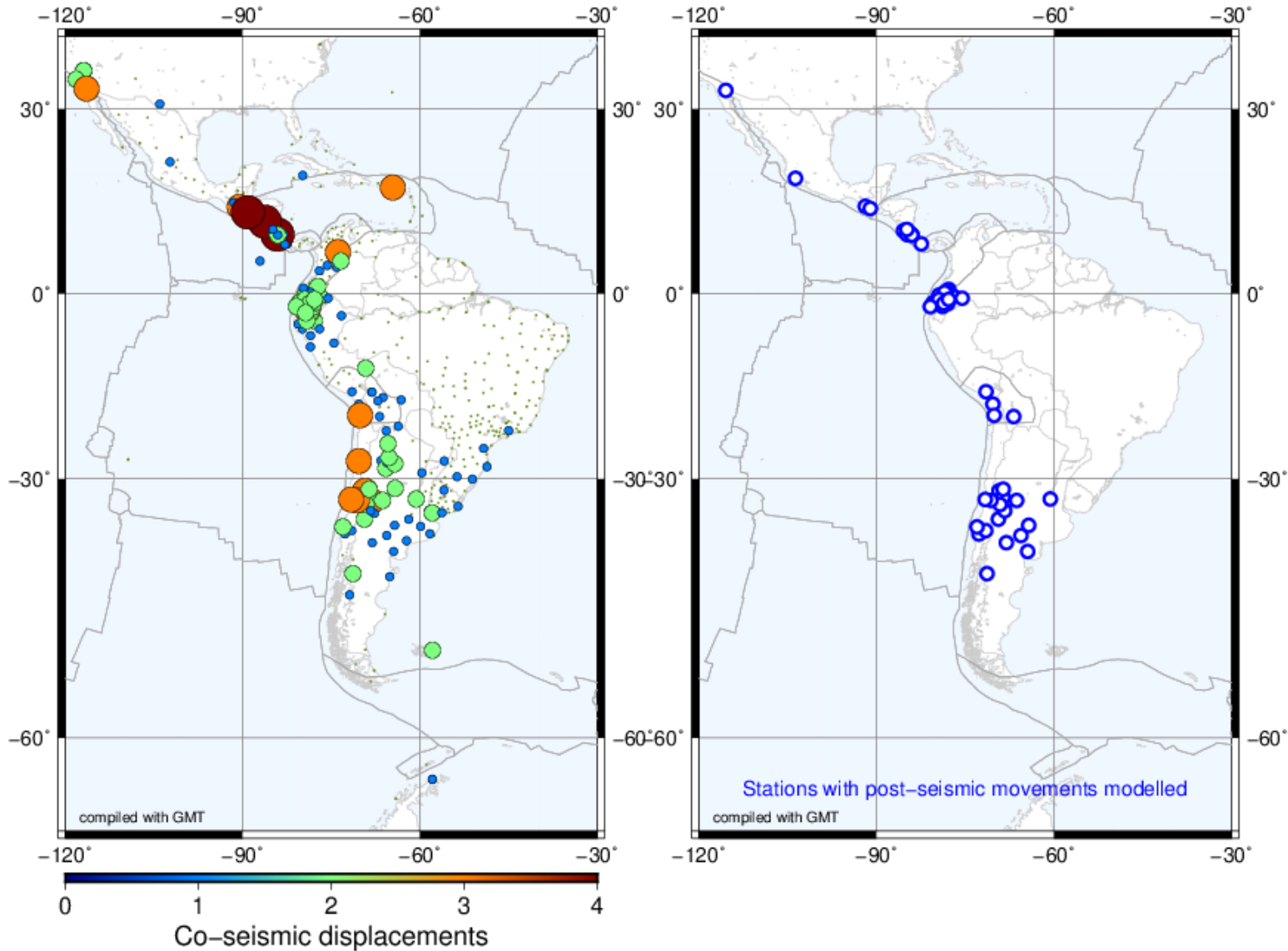


- Newest reference frame solution
- From Jan 2000 to April 2022 (update every 6 months)
- SIRGAS-Repro2 in IGB14 (Jan 2000 – Dec 2021) + operational SIRGAS solutions in IGB14 (since Jan 2022)
- 587 stations with 1389 occupations
- IGB14, 2015.0

- Accuracy

- Positions at reference epoch: N/E:  $\pm 0.8$  mm, h :  $\pm 1.4$  mm
- Velocities: N/E:  $\pm 0.6$  mm/year, h:  $\pm 1.0$  mm/year

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

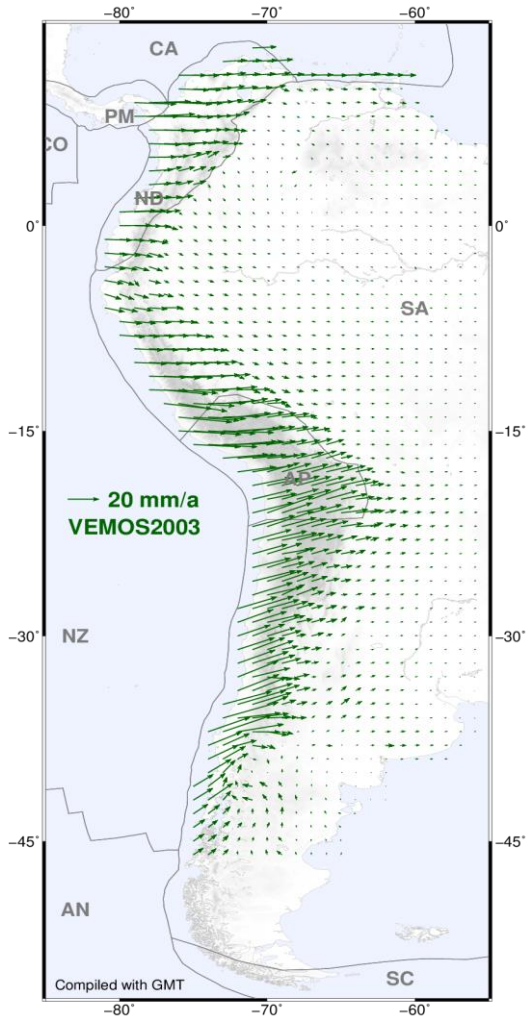


- SIRGAS2022
  - 21% of the discontinuities correspond to co-seismic displacements
  - 62 post-seismic functions

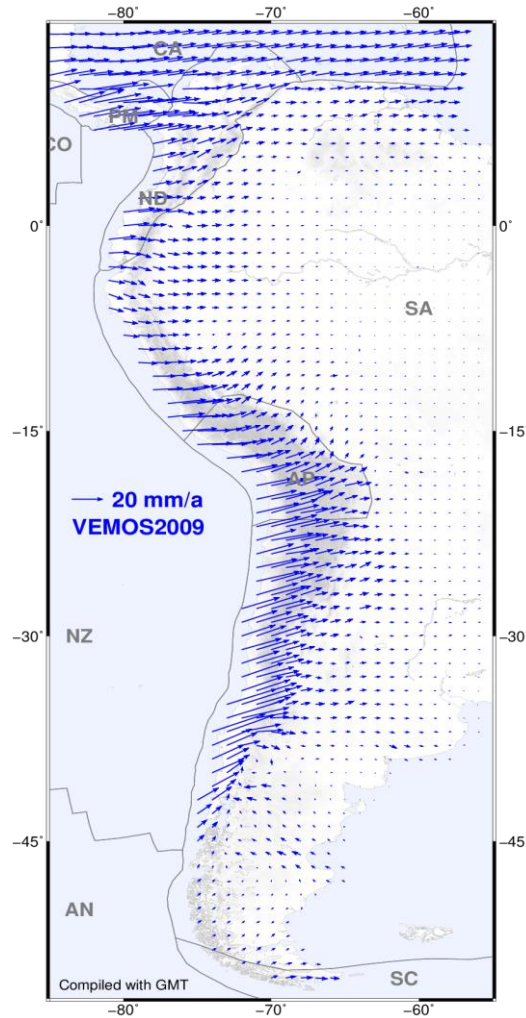


# Velocity model for SIRGAS: VEMOS (relative to South American plate)

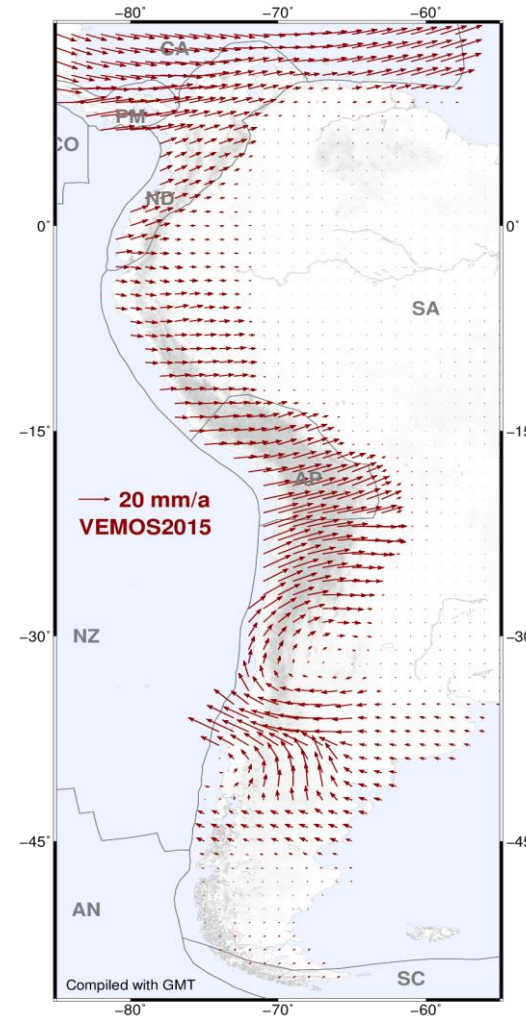
1993.0 to 2002.0



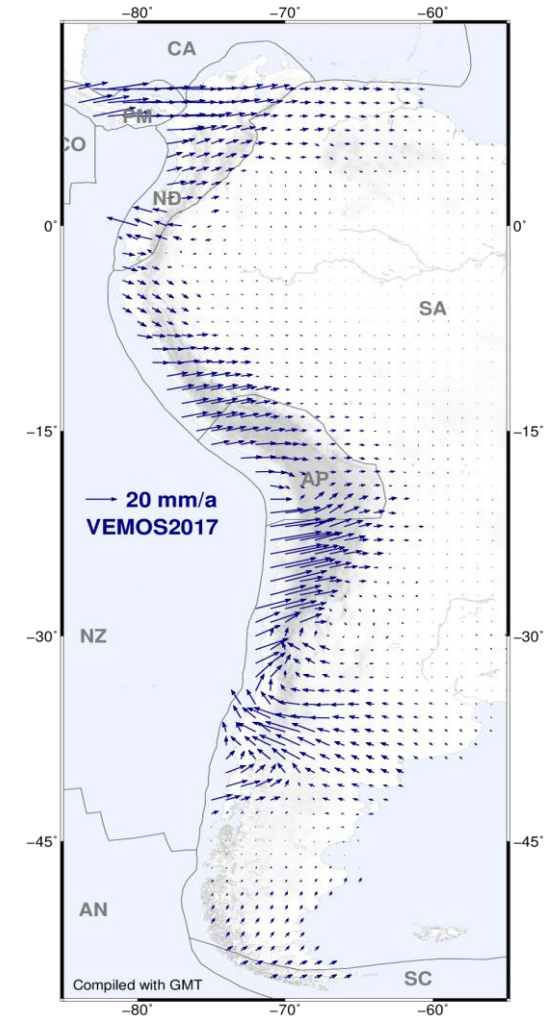
2000.0 to 2009.6



2010.2 to 2015.2



2014.0 to 2017.1



# Organisational infrastructure



Extern

**UN-GGIM:Américas**  
Geodetic Reference Framework for the Americas (GRFA) Working Group

**IUGG**  
International Association of Geodesy

SC 1.3b: Reference frames, South and Central America  
SC 2.4b: Gravity and Geoid in South America

**Pan-American Institute for Geography and History**  
Working group of the Cartography Commission



Intern

**Directing Council**

- IAG
- PAIGH
- 22 member countries
- Observers

**Scientific council**

**Executive Committee**

- President (S. Costa, Brazil)
- Vice-president (F. Arpe, Argentina)
- Three working groups
  - **Geometric reference frame** (J. Tarrío, Chile)
  - **Physical reference frame** (G. Guaimarães, Brazil)
  - **National duties** (D. Gómez, USA)



# Recent training and capacity building



Frequent *on-line* workshops, webinars

- 6 in 2020
- 4 in 2021
- 10 in 2022

**Taller sobre Sistemas de Referencia**  
 Profesor: Hermann Drewes  
 del 7 al 11 de febrero de 2022  
 Hora UTC: 02:00

07/02 Sistemas de coordenadas y sistemas de referencia  
 08/02 Sistema de referencia celeste, rebajón y marcos  
 09/02 Sistema y marco de referencia terrestre  
 10/02 Marcos de referencia regional y modelación de deformaciones  
 11/02 Referencia en la práctica

SIRGAS IAG TUM

**TALLER: SISTEMAS DE ALTURAS Y GRAVEDAD**  
 02 al 06 de Mayo de 2022 - 2:00 pm (UTC 0)

02/5	Laura Sánchez Technische Universität München - TUM/Alemania	Sistema internacional de alturas: definición (IHRF), realización (IHRF), estado actual
03/5	Gabriel do N. Guimarães Universidade Federal de Uberlândia - UFU/Brasil	Estado del IHRF en la región SIRGAS
04/5	Denizar Blizkow Centro de Estudios de Geodesia - CEGES/Brasil Ana Cristina O. C. de Matos Comissão Nacional de Altimetria, Gravimetria e Nivelamento - COMCNA/Argentina	Gravimetria y Geoida en la región SIRGAS
05/5	Ezequiel D. Antokoletz Universidad Nacional de La Plata - UNLP/Argentina Comisión Nacional de Altimetria, Gravimetria y Nivelamento - COMCNA/Argentina	Definición del Sistema de Referencia Internacional de Gravedad (IGRS) y su materialización
06/5	Roberto T. Luz Instituto Brasileiro de Geografia e Estatística - IBGE/Brasil	Nivelación, números geopotenciales y la evaluación y propagación del IHRF

El Taller será dictado en idioma español, y transmitido simultáneamente por el canal de YouTube de SIRGAS.

**WORKSHOP: Installation and Operation of permanent GNSS stations.**  
 How to include them in the SIRGAS-CON Network?

26/08	Amor Zoro IBGE/Brasil	Steps and details on the installation of a permanent GNSS station
29/08	Sonilo Costa IBGE/Brasil	Basic steps about receivers configuration
30/08	Jose Antonio Somo Universidad de Santiago de Chile - UACH Jesús María Álvarez Universidad de Santiago de Chile - UACH	Evaluation of data and metadata from GNSS stations Procedure for the inclusion of stations in the SIRGAS-CON Network
31/08	Laura Sánchez Technische Universität München - TUM	Inclusion of SIRGAS-CON stations in the IGS (products and reference network)

at 2:00 pm (UTC 0), for one hour every day

SIRGAS UNAVCO IBGE TUM

The Workshop will also be broadcast simultaneously on the SIRGAS YouTube channel and channel and will be available simultaneous translation ENG-ESP-ESP-ENG

Back to face-to-face...



Determination of precise geodetic reference frames using the scientific software for GNSS processing GAMIT-GLOBK, Costa Rica, July 2022

# Acknowledgements



The SIRGAS activities are possible thanks to the voluntary support of more than two hundred colleagues contributing to the working groups, to capacity building activities, operating GNSS stations, operating SIRGAS Analysis Centres, ... This support and that provided by the International Association of Geodesy (IAG) and the Pan-American Institute for Geography and History (PAIGH) to the geodetic reference activities in the SIRGAS region are highly appreciated.

More details at

<https://sirgas.ipgh.org/>

**Social Media** : @SirgasAmericas



SIRGAS 2022 Symposium

<https://sirgas.ipgh.org/simposio/en/home-2/>  
Santiago de Chile, November 7 to 9, 2022