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Realizing ITRF-Consistent Continental Scale Geodetic Reference Frames Utilizing Inheritance of Seasonal Displacement Parameters

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Presentation Outline

Regional reference frames



GNSS polyhedron stacking



Impact of periodic terms in RF realization



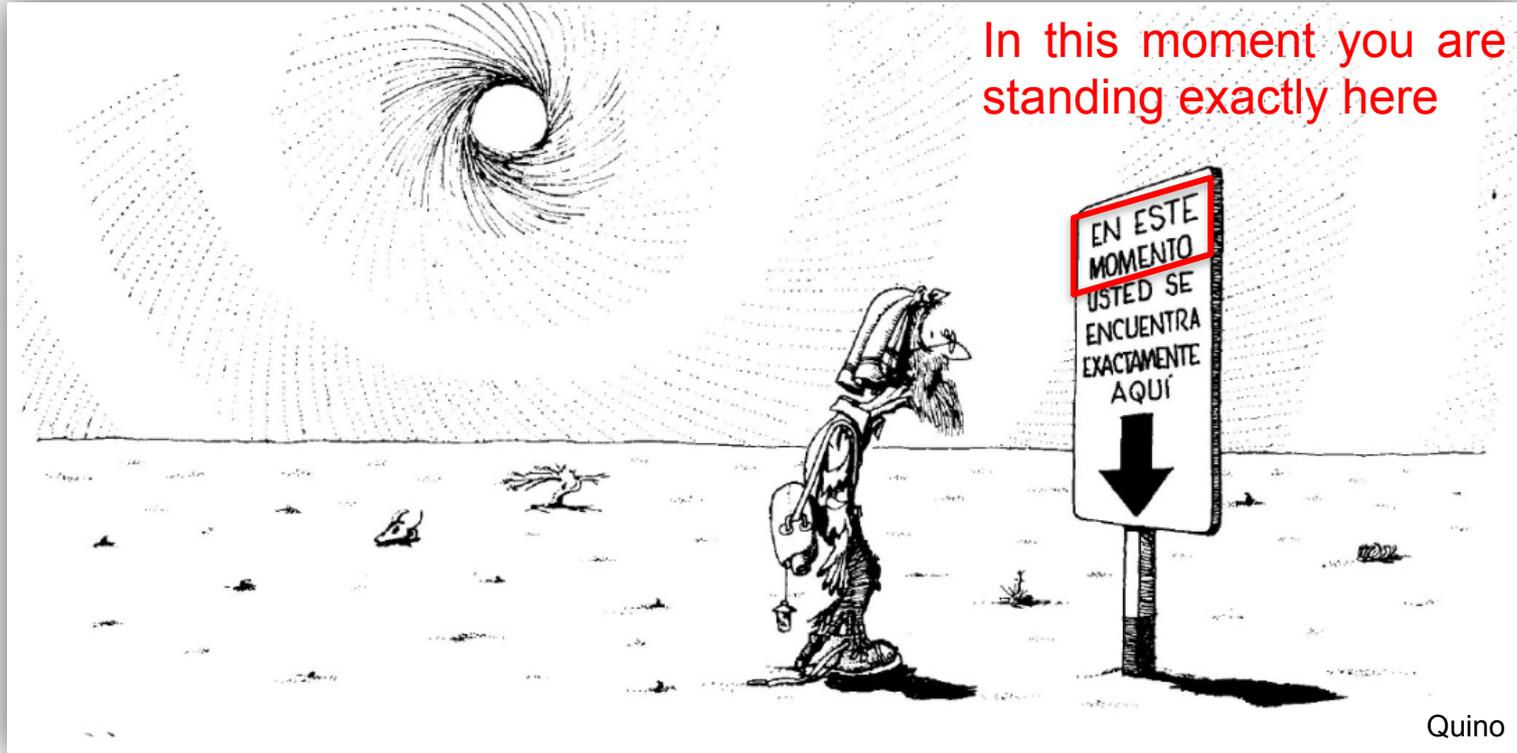
Inheritance of frequency space



Conclusions



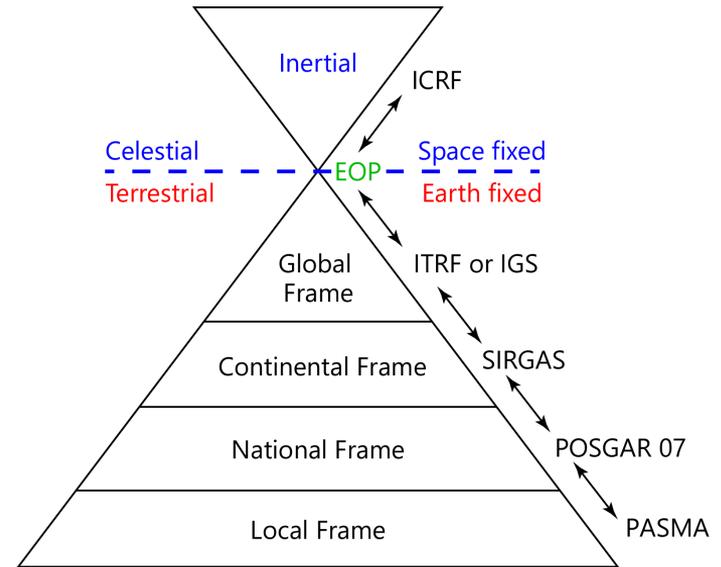
The importance of an accurate reference frame





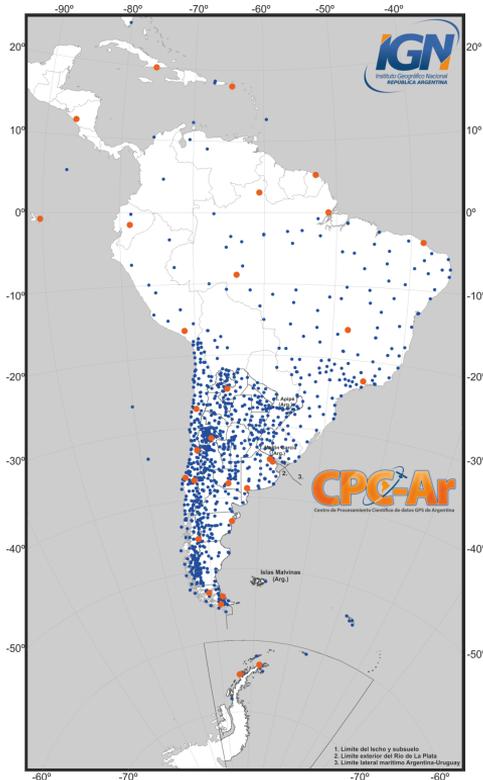
Regional reference frames

- A **densification** or an **implementation** of a primary reference frame (more later, see ISO 19161–1:2020).
- The densification is usually achieved through a Helmert transformation (H7 or H14) of the weekly or daily (preferred) solutions.
- The goal of to achieve the **maximum consistency** between the regional frame and the higher order frame.
- In other words, to obtain station coordinates without including the additional stations in the processing of the higher order frame.





POSGAR07b: an update of Argentina's reference frame



- Argentina's reference frame based on IGS14 and realized at the IGN.
- Realized using ~600 continuous stations (1998 – to present) and ~500 campaign or passive sites.
- GAMIT/GLOBK, IGS precise orbits, VMF1, and FES2014b.
- **DOES NOT** replace the official frame POSGAR07, it's only used internally at IGN and to access POSGAR07.



Maintaining POSGAR07's conventional epoch

1998.0

2006.632

POSGAR07c (IGS20)

2022.0

1998.0

2006.632

POSGAR07b (IGS14)

2019.5

2006.632

POSGAR07 (IGS05)

- At some point, a frame change will be inevitable!

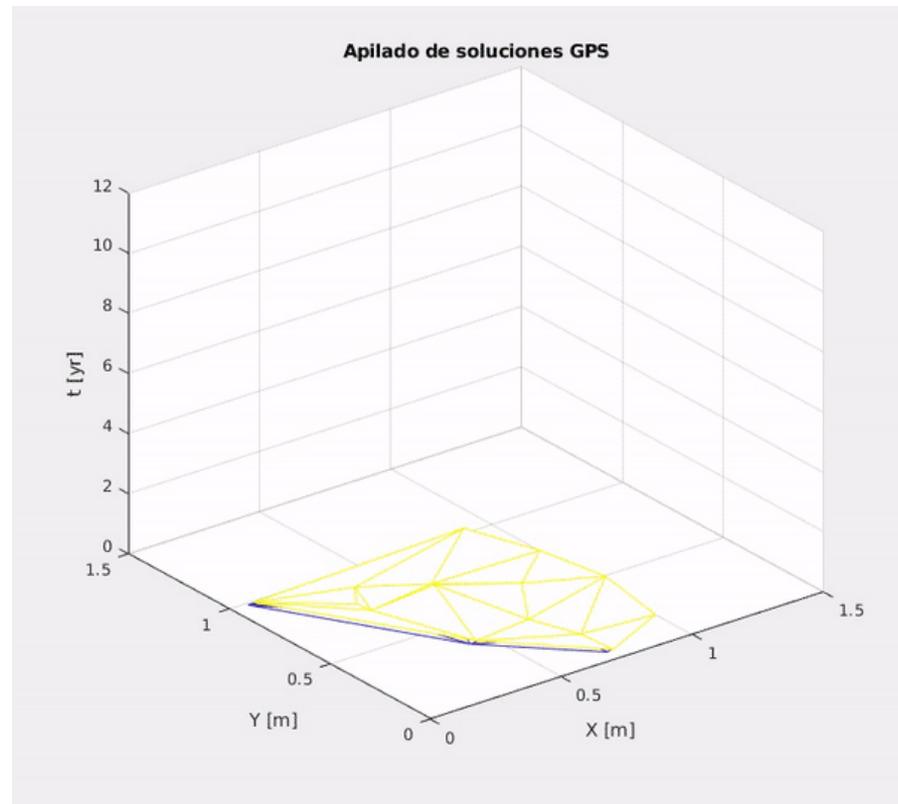


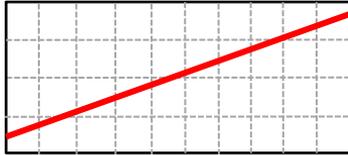
GNSS polyhedron stacking

- Traditional method: H7 o H14 alignment. Our method: **a regional stack of solutions**
- RMS minimization between solutions and frame trajectories
- This gives additional control over the determination of the frame

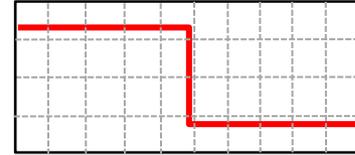
IMPORTANT!

- The main difference with “traditional” reference frames: the RF parameters are constantly updated → there are no parameters “extrapolations” after finalizing the frame determination (the frame is constantly being determined!)



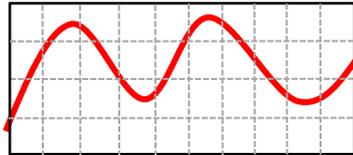


Constant velocity: tectonics

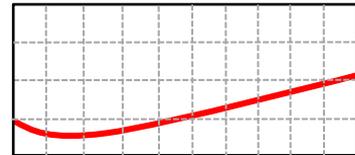


Jumps: earthquakes and antennas

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Periodic: annual and semi-annual

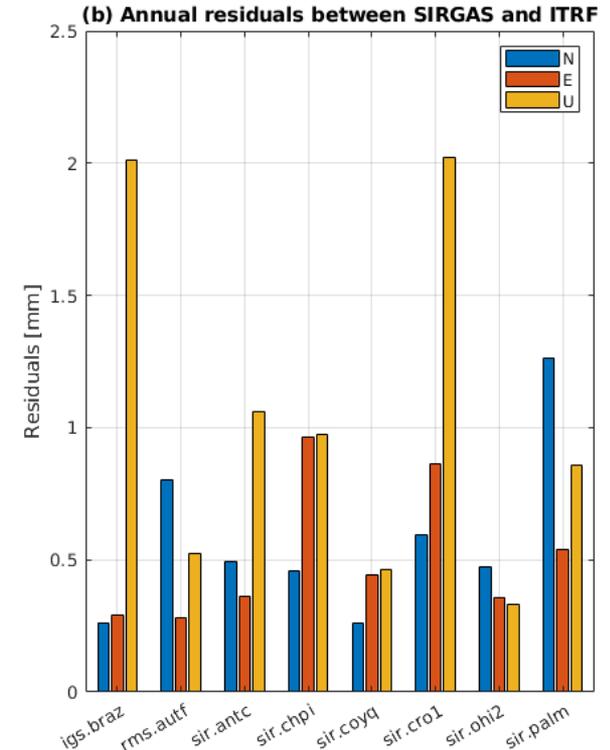
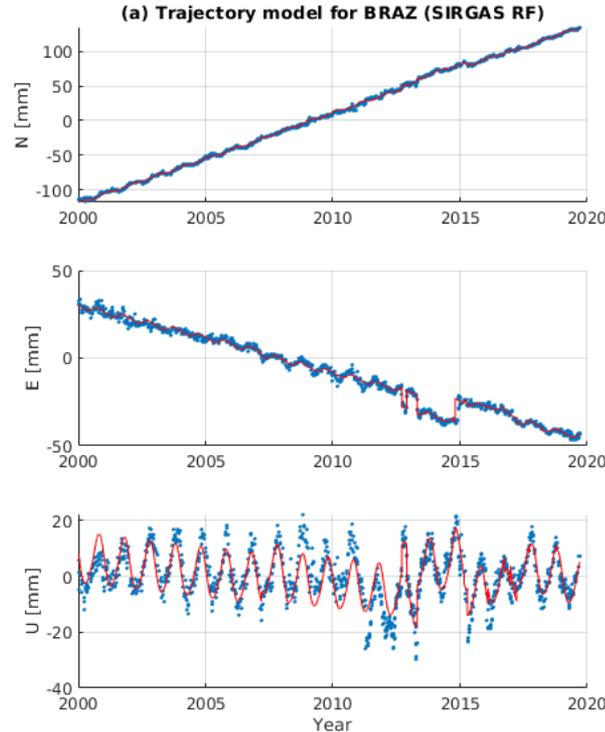


Logarithmic: viscous relaxation, afterslip



The impact of periodic terms (SIRGAS-CON vs ITRF 2014)

- The common-mode periodic terms are not “cancelled” on a regional solution
- This is well proven! → see for example Zou, R., Freymueller, J. T., Ding, K., Yang, S., & Wang, Q. (2014)



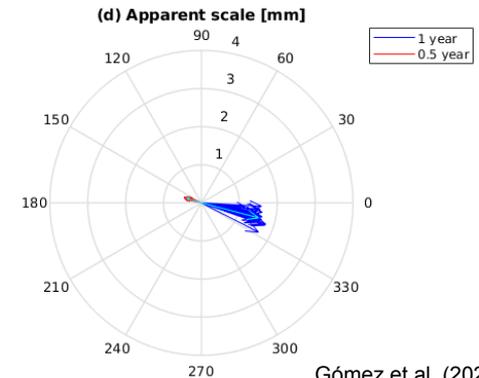
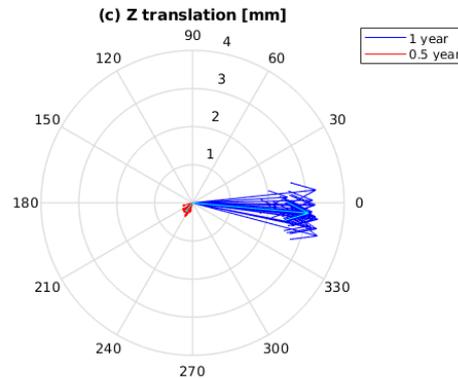
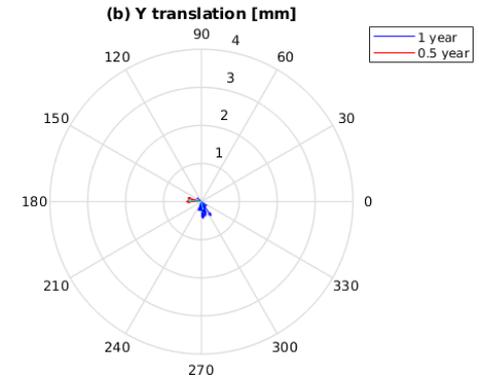
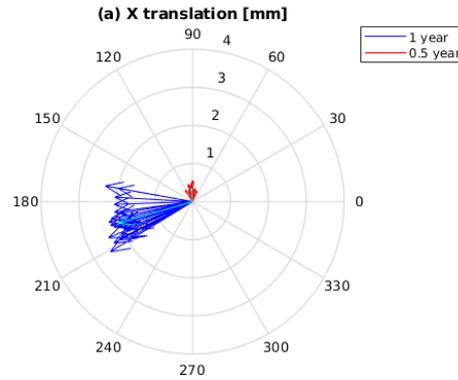
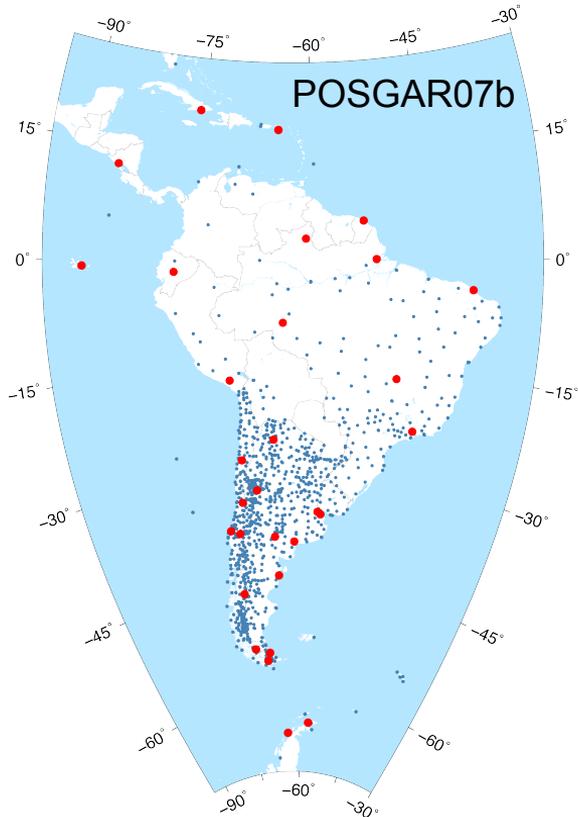


A solution to the problem: *inheritance*

- A differential solution is not sensitive to any “absolute” station displacement, including periodic ones
- In other words, relative periodic changes between stations are captured, but **all “common” periodic changes are lost!**
- One example: the earth’s center of mass variation with respect to the crust
- A child (or secondary) frame can inherit the “frequency space parameters” to solve this additional datum deficiency

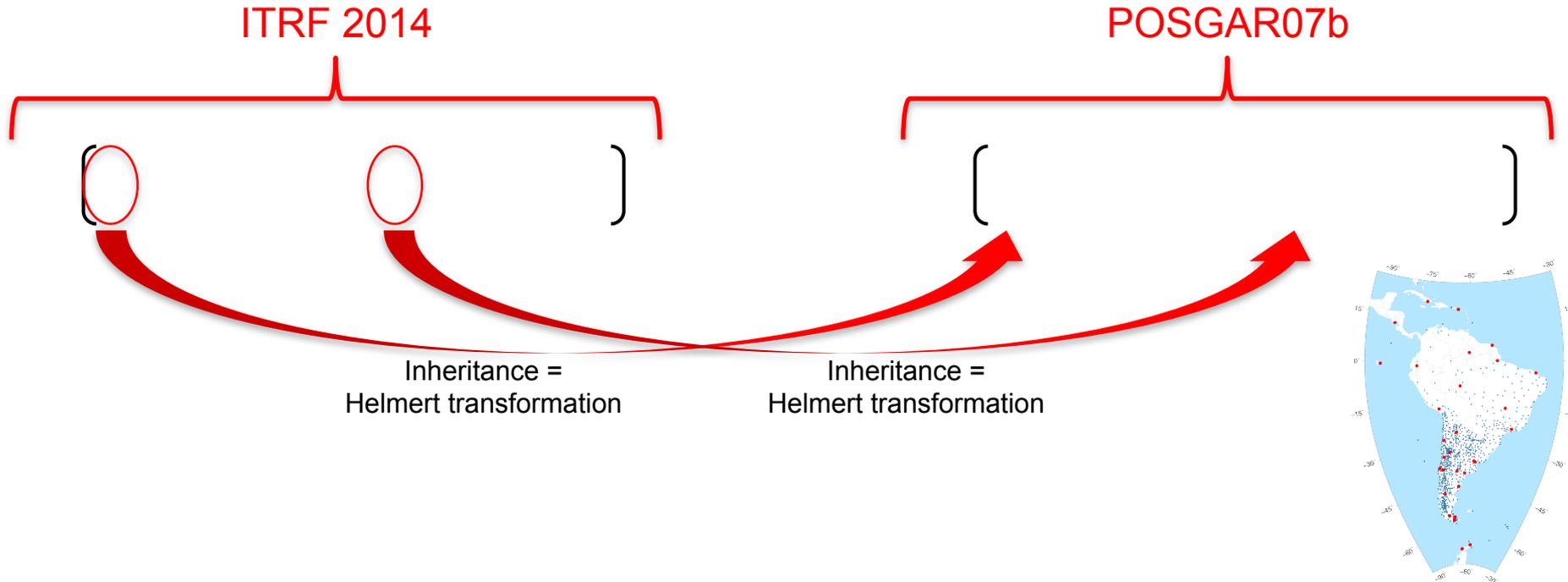


Quantifying ITRF's common mode in the region of interest





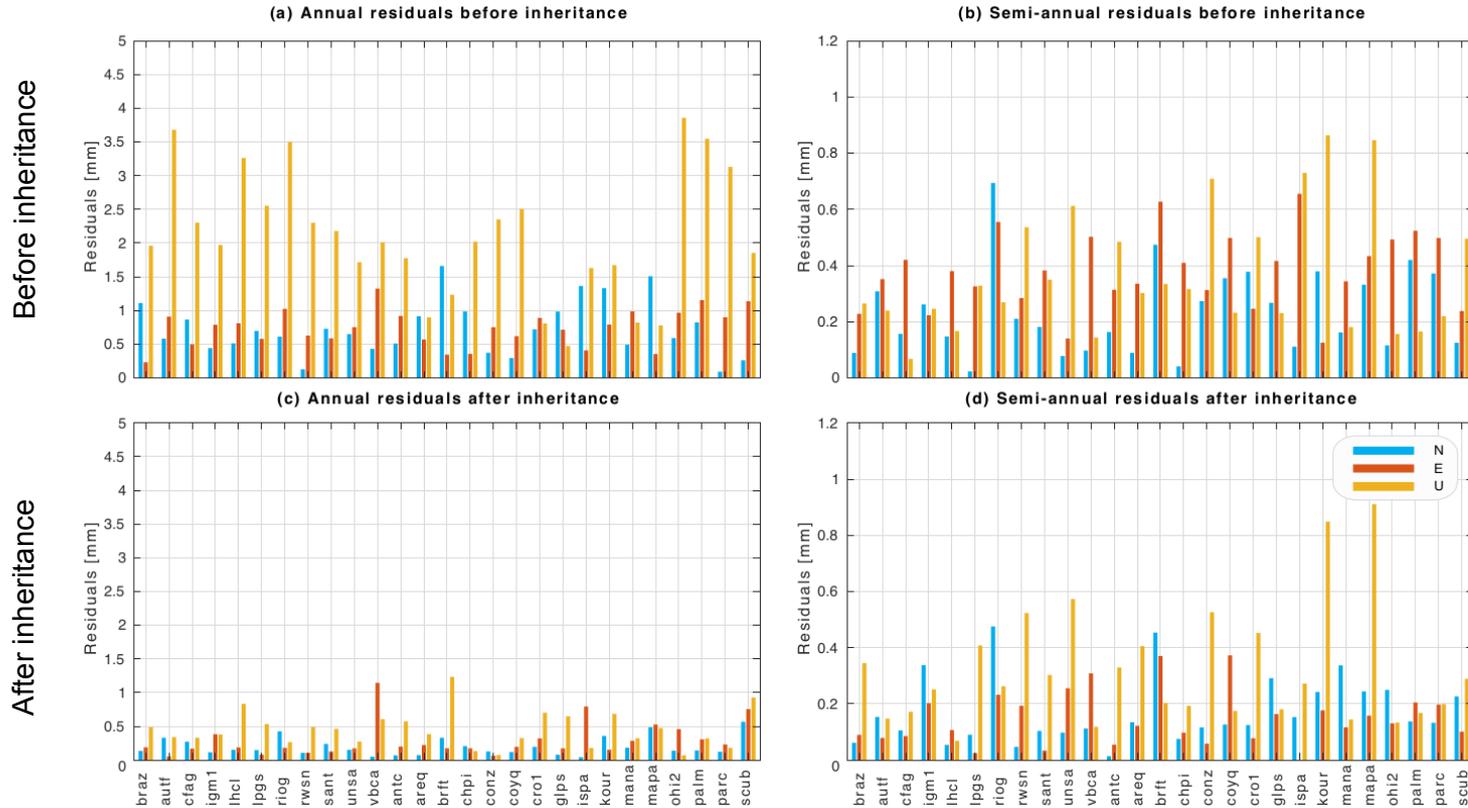
Inheritance or, if you prefer, frequency space alignment



Using the N common stations between ITRF 2014 y POSGAR07b



Frequency space inheritance on POSGAR07b

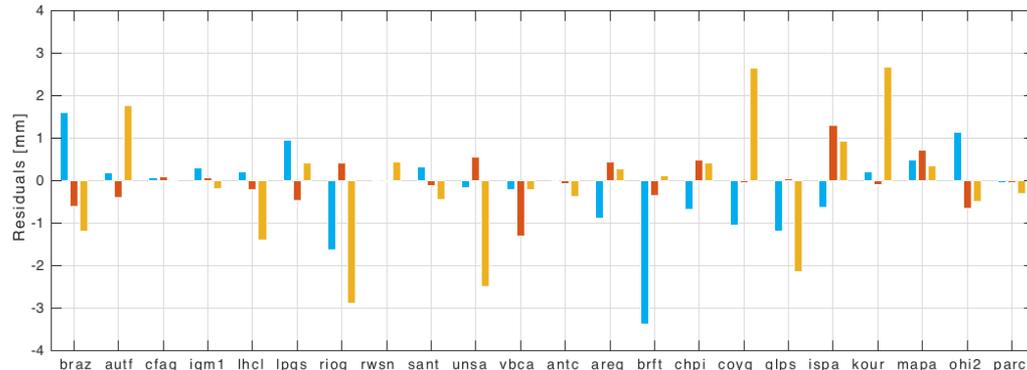




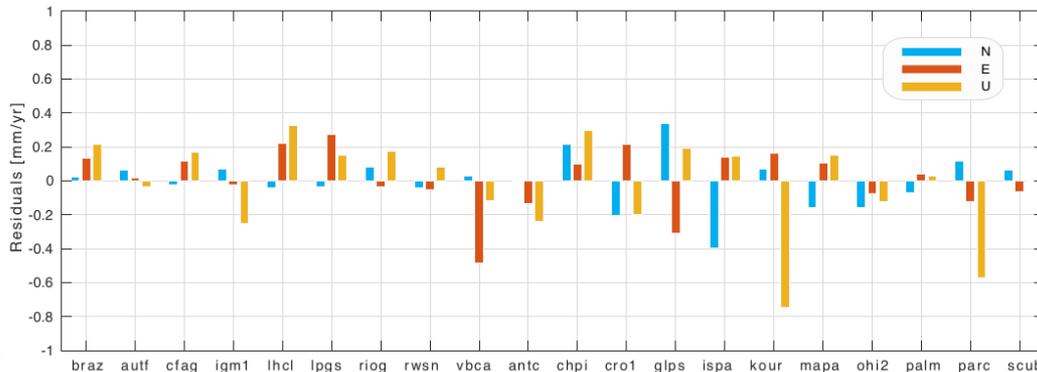
Inheritance of position and velocity space parameters of POSGAR07b

- Position residuals between ITRF 2014 (POSGAR07b's conventional epoch, 2006.632) y and velocity residuals.
- WRMS misfit of the position space parameters was 1 mm.
- WRMS misfit of the velocity space parameters was 0.2 mm/yr.
- Major differences between ITRF 2014 and POSGAR07b are due to processing differences, not model problems.

(a) Coordinate space residuals

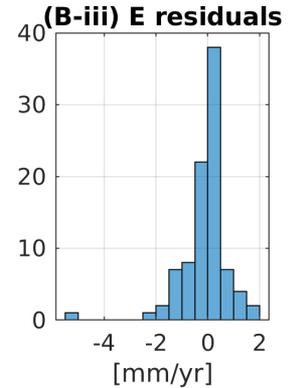
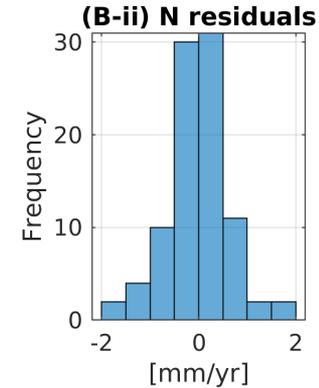
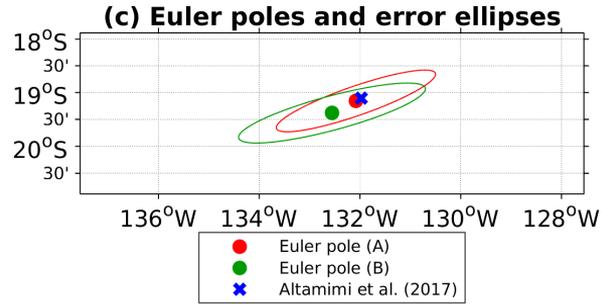
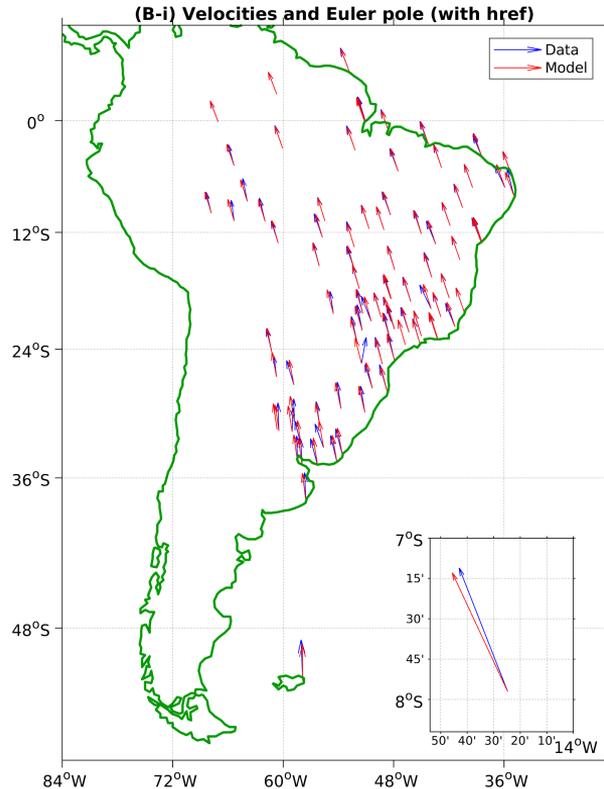


(b) Velocity space residuals





External coordinates: fixed South America frame



- Euler vector solution for South America is almost identical (numerically) and statistically equal to *Altamimi et al. (2017)*
- This showcases the accuracy of the external coordinates of POSGAR07b



Conclusions

- The earth is a dynamic system, and all geodynamic effects must be taken into account if we want to determine precise coordinates.
- With the improvement of the precision of GNSS, we need to take into account more model terms.
- The proposed methodology can be extended to other spaces (position, velocity, and frequency) to increase the consistency between the primary and secondary frame.
- A natural and immediate extension is “postseismic space” which would allow a secondary frame to inherit the postseismic parameters of the stations in a primary frame.



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**¿Preguntas?
Questions?**

**¡Muchas gracias por la atención!
Thank you for your attention!**