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

In this moment you are standing exactly here

Quino
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 o 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.

![Diagram of reference frames](image)
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

<table>
<thead>
<tr>
<th>Year</th>
<th>Epoch</th>
<th>Frame</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998.0</td>
<td>2006.632</td>
<td>POSGAR07c (IGS20)</td>
<td>2022.0</td>
</tr>
<tr>
<td>1998.0</td>
<td>2006.632</td>
<td>POSGAR07b (IGS14)</td>
<td>2019.5</td>
</tr>
<tr>
<td></td>
<td>2006.632</td>
<td>POSGAR07 (IGS05)</td>
<td></td>
</tr>
</tbody>
</table>

• 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

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)

Gómez et al. (2022)
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

Gómez et al. (2022)
Inheritance or, if you prefer, frequency space alignment

Using the $N$ common stations between ITRF 2014 and POSGAR07b.
Frequency space inheritance on POSGAR07b

(a) Annual residuals before inheritance

(b) Semi-annual residuals before inheritance

(c) Annual residuals after inheritance

(d) Semi-annual residuals after inheritance

Gómez et al. (2022)
Inheritance of position and velocity space parameters of POSGAR07b

- Position residuals between ITRF 2014 (POSGAR07b's conventional epoch, 2006.632) 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.

Gómez et al. (2022)
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

Smalley et al. (in preparation)
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.
¿Preguntas?
Questions?

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