# Seasonal effects in the weekly realization of the SIRGAS reference frame

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## Seasonal variations affecting regional networks

Usually, epoch solutions (daily, weekly, multi-year) of regional reference networks are aligned to the global reference frame (ITRF) using a set of fiducial stations with known positions and constant velocities. However, GNSS stations show significant seasonal position variations (mainly in the up component) resulting from a combination of geophysical loading and systematic errors. Ignoring these seasonal variations at reference stations can cause systematic errors in the datum realization, and the reference networks can significantly be deformed. These effects are larger in regional networks than in global ones, especially in zones with strong seasonal variations like the SIRGAS region (Fig. 1).

To evaluate the impact of seasonal variations in the weekly realization of the SIRGAS frame, free normal equations are solved applying two different sets of reference coordinates for the datum realization: the first set corresponds to the IGS05 positions at epoch 2000.0 extrapolated to the observation epoch using the ITRF2005 velocities (IGS05@2000 + VEL). The second set corresponds to the weekly positions determined for the IGS05 reference stations within the IGS weekly combination (igsyyPwwww.snx).

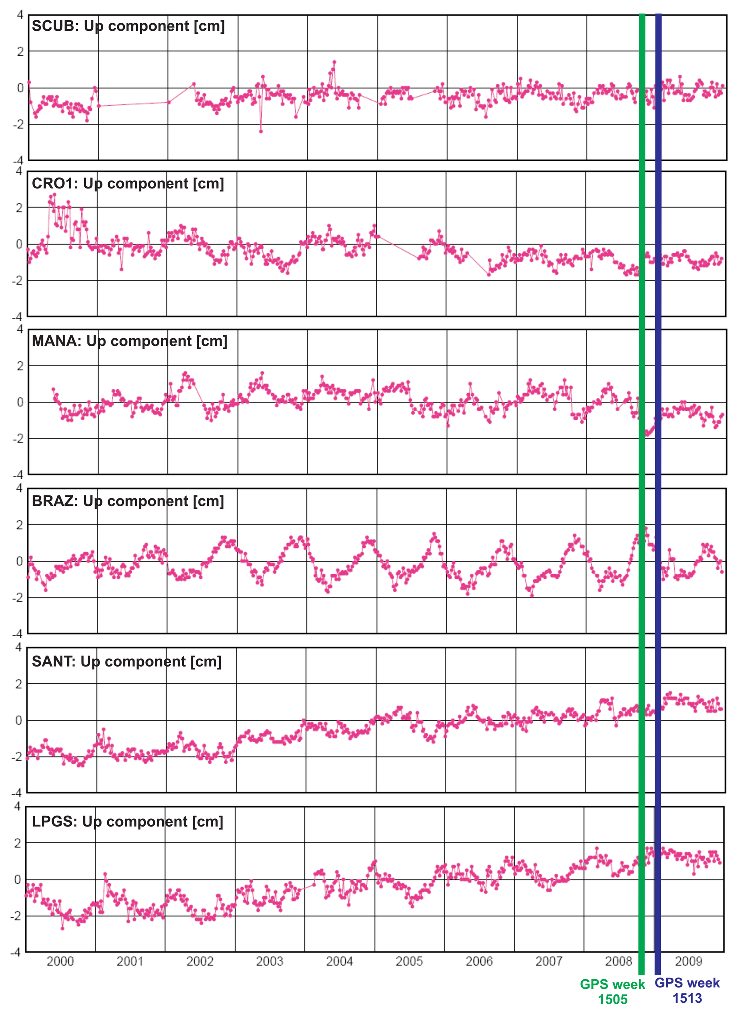

*Fig. 1. Time series for the up component of some IGS05 stations included in SIRGAS-CON (green and blue lines indicate the weeks represented in Fig. 2)*

## Results

Fig. 2 shows the residuals in the up component after a similarity transformation between the loosely constrained (non-deformed) solutions and those aligned to IGS05 for GPS weeks 1505 (2008-11-12) and 1513 (2009-01-07). It is evident that the network geometry of the loosely constrained solutions is always deformed, when the geodetic datum is realized. The deformation is especially large, if linear movements (constant velocities) at the reference stations are assumed.Mean RMS residuals for the period between January 2000 and January 2010 indicate that the largest distortions (more than 8 mm) appear at the fiducial points (Fig. 3); this is a consequence of constraining a seasonal signalby a linear trend.

Even though solutions based on the IGS weekly coordinates present large residuals (around 6 mm) at a few reference points, the deformation of the network geometry is much smaller than using IGS05@2000+VEL. Particularly, residuals larger than 8 mm disappear (Fig. 3b).

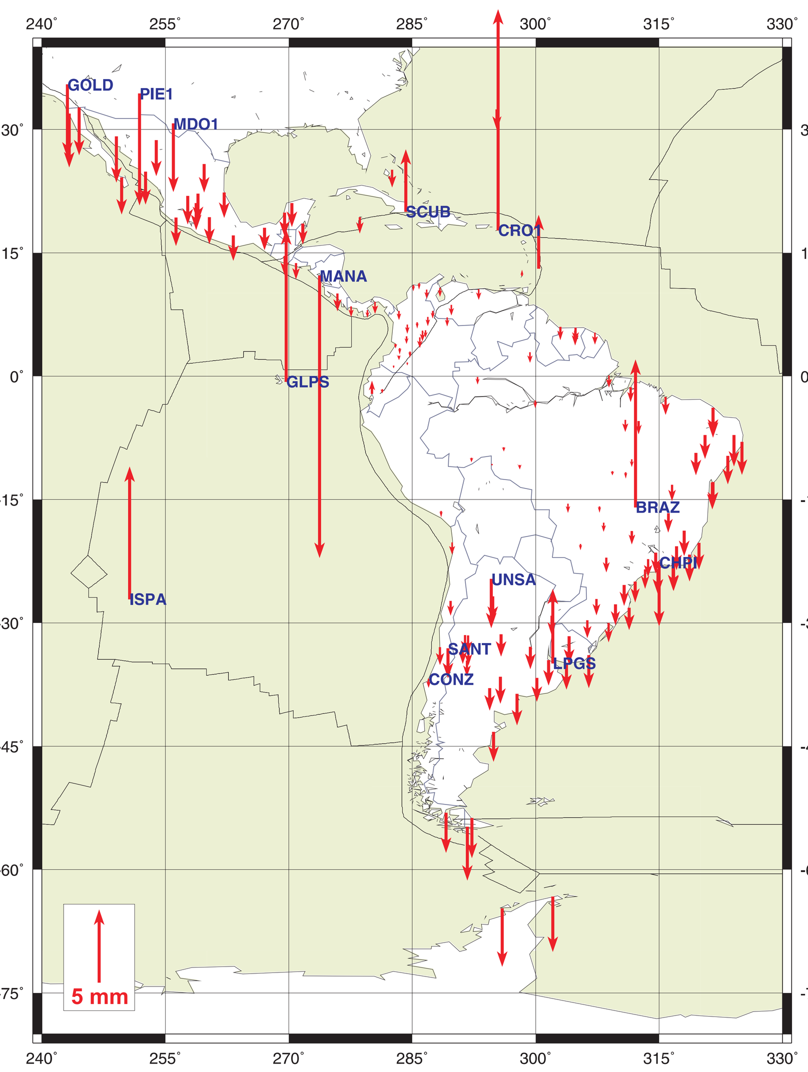

*Fig. 2a. Residuals in the up component after a similarity transformation between the loosely constrained solution and the solution aligned to the IGS05 using (IGS05@2000 + VEL) as reference coordinates for the GPS week 1505.*

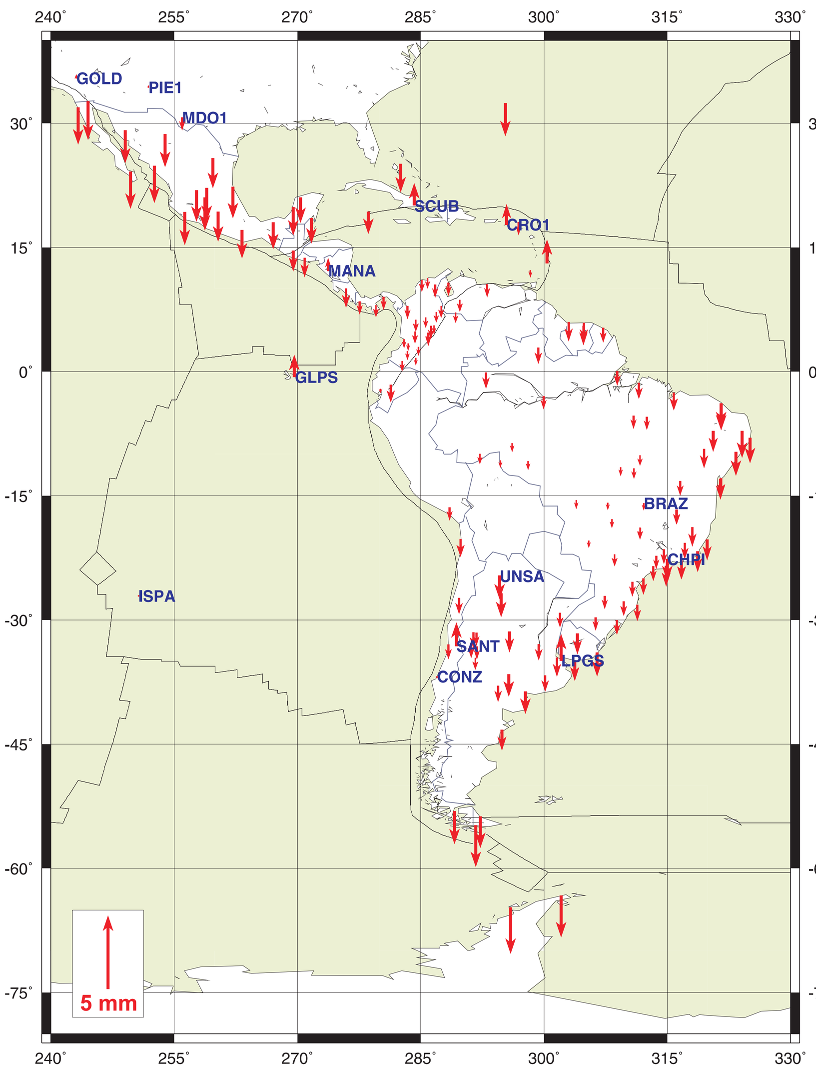

*Fig. 2b. Residuals in the up component after a similarity transformation between the loosely constrained solution and the solution aligned to the IGS05 using IGS weekly positions as reference coordinates for the GPS week 1505.*

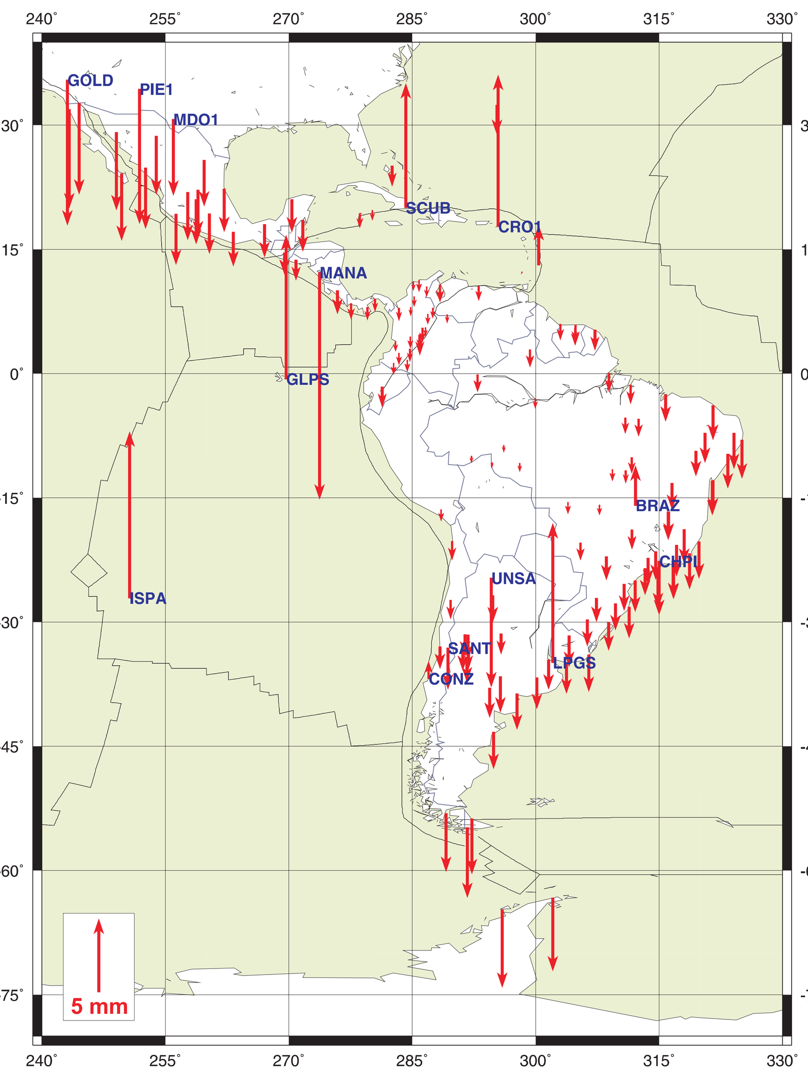

*Fig. 2c. Residuals in the up component after a similarity transformation between the loosely constrained solution and the solution aligned to the IGS05 using (IGS05@2000 + VEL) as reference coordinates for the GPS week 1513.*

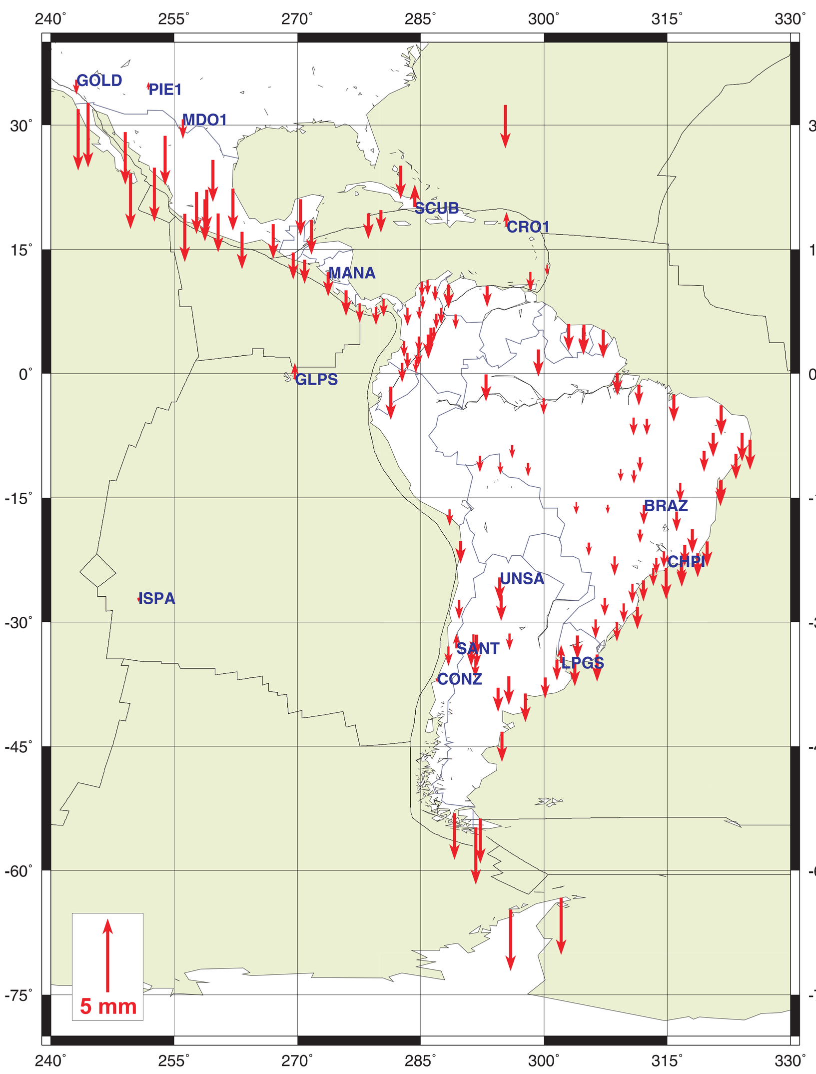

*Fig. 2d. Residuals in the up component after a similarity transformation between the loosely constrained solution and the solution aligned to the IGS05 using IGS weekly positions as reference coordinates for the GPS week 1513.*

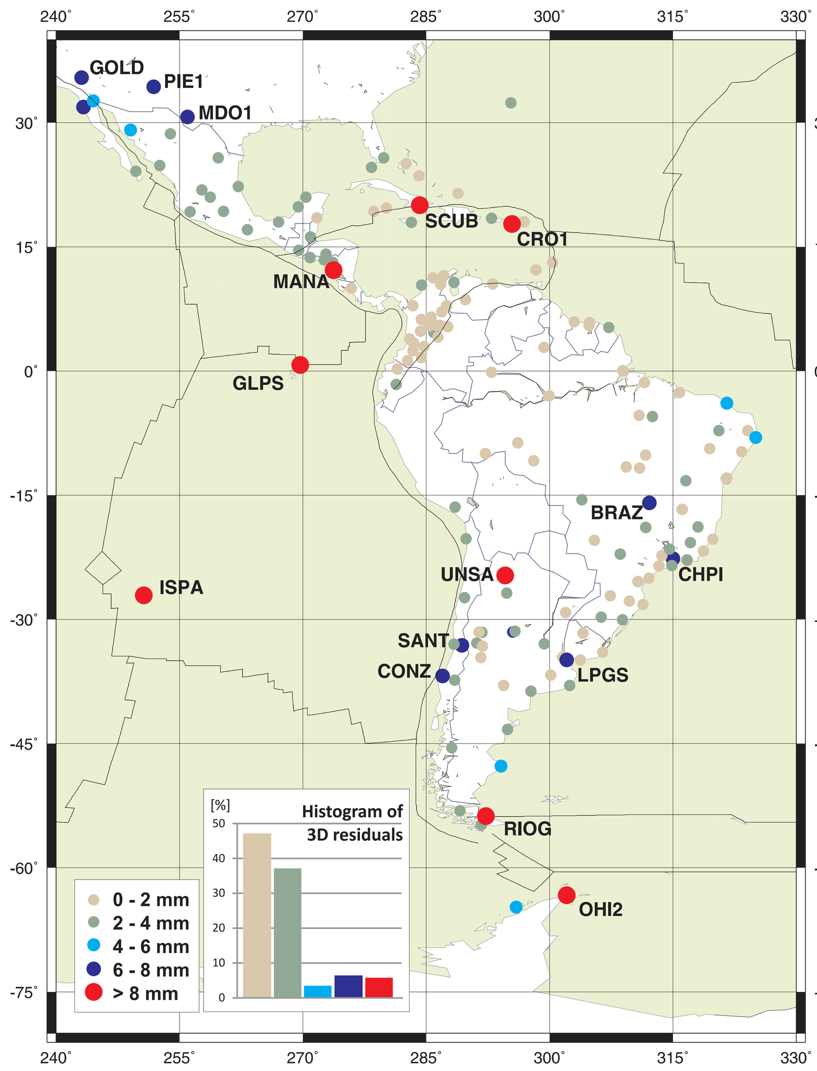

*Fig. 3a. 3D residuals after comparing the loosely constrained (non-deformed) weekly solutions with the weekly solutions aligned to the IGS05 using (IGS05@2000 + VEL). Mean RMS values for the period between January 2000 and January 2010.*

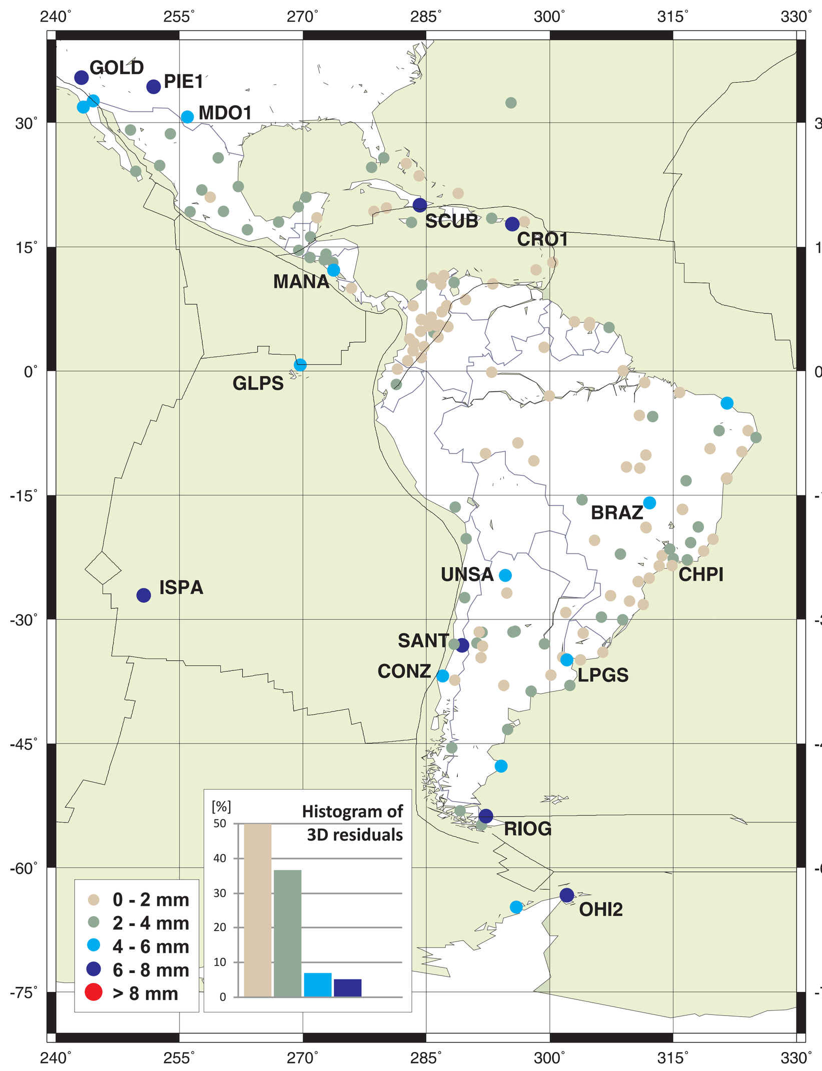

*Fig. 3b. 3D residuals after comparing the loosely constrained (non-deformed) weekly solutions with the weekly solutions aligned to the IGS05 using IGS weekly positions. Mean RMS values for the period between January 2000 and January 2010.*

## Conclusions

The use of constant velocities to extrapolate reference positions (ignoring seasonal effects) may cause errors on station coordinates (especially in the up component) as large as 20 mm (Fig. 2a, 2b). Applying IGS weekly positions for the weekly datum realization (as it is done by the SIRGAS combination centres) ensures a better compatibility between those networks and the GNSS orbits, allowing users to exploit the full precision of the GNSS measurements.

SIRGAS provides the backbone for implementing applications associated to geo-referenced data such as geodynamics, engineering, land management, data infrastructures, etc. These applications need coordinates compatible in time and with long-term stability, i.e. all station positions referring to the observation epoch shall be reduced to a conventional (reference) epoch with high precision. Using constant velocities generates a lack of precision.

In consequence, to support the adequate application of SIRGAS as reference frame in Latin America, different procedures to transform station positions between different epochs is presently under consideration within the SIRGAS community. Particular complexities have to be analyzed in those countries whose fundamental networks were severally affected by recent earthquakes (Chile, Argentina, and Mexico).

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