Improved modelling for the SIRGAS reference frame computation

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New processing standards for the SIRGAS Reference Frame

The SIRGAS Reference Frame is presently composed of about 350 stations (Fig. 1) which are processed on a weekly basis by 10 analysis centres: CEPGE (Ecuador), CPAGS-LUZ (Venezuela), DGFI (Germany), IBGE (Brazil), IGAC (Colombia), IGM-Bo (Bolivia), IGM-Cl (Chile), IGN-Ar (Argentina), INEGI (Mexico), and SGM-Uy (Uruguay). The processing characteristics are generally based on the IERS Conventions and the IGS Guidelines; with the exception that for the individual SIRGAS solutions the satellite orbits and clocks as well as the Earth orientation parameters are fixed to the final weekly IGS values (SIRGAS does not compute these parameters). INEGI and IGN-Ar employ the software GAMIT/GLOBK (Herring et al. 2010); all other analysis centres use the Bernese GPS Software V. 5.2 (Dach et al. 2007, 2013). Since January 2014, the SIRGAS analysis centres apply the standards of the IERS Conventions 2010 (Petit and Luzum 2010) and the characteristics specified by the IGS for the second reprocessing of the IGS global network. The main changes with respect to the previous processing strategy are:

- Reference frame: IGS08/IGb08 (Rebischung et al. 2012);
- Antenna phase centre model: igs08.atx (Schmid 2011);
- Tropospheric zenith delay modelling based on the Vienna Mapping Function 1 (VMF1, Böhm et al. 2006) with a priori values (~dry part) from the gridded coefficients provided by J. Böhm at http://ggosatm.hg.tuwien.ac.at/DELAY/GRID/VMFG/ and refinement through the computation of partial derivatives with 2 h intervals within the network adjustment;
- Tidal corrections for solid Earth tides, permanent tide, and solid Earth pole tide as described by Petit and Luzum (2010). The ocean tidal loading is reduced with the FES2004 model (Letellier 2004) and the atmospheric tidal loading caused by the semidiurnal constituents S1 and S2 is reduced following the model of van Dam and Ray (2010). The reduction coefficients for the ocean tidal loading are provided by M.S. Bos and H.-G. Scherneck at http://holt.oso.chalmers.se/loading/. The reduction coefficients for the atmospheric tidal loading are provided by T. van Dam at http://geophy.uni.lu/ggfc-atmosphere/tide-loading-calculator.html;
- Non-tidal loadings like atmospheric pressure, ocean bottom pressure, or surface hydrology are not reduced.

At present, the SIRGAS analysis centres are reprocessing the daily normal equations backwards until January 1997 applying these new standards.

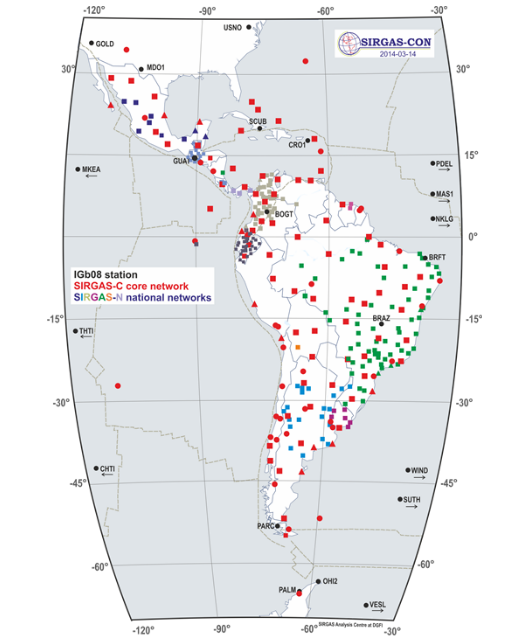

Fig. 1. SIRGAS reference network (as of March 2014).

Post-seismic kinematics of the SIRGAS Reference Frame

Based on reprocessed normal equations applying the updated standards, a new cumulative solution for the SIRGAS Reference Frame was computed covering a time span of four years starting two months after the strong earthquake in Chile in February 2010. Given that most of the ITRF stations in South America were affected by this earthquake, further stations located in Europe, Africa, Oceania and North America (Fig. 2) are now considered for the SIRGAS computations to increase the availability of fiducial points. The geodetic datum of the new cumulative solution is realised by applying not-net-rotation and not-net-translation conditions with respect to the IGb08 coordinates of the selected reference stations (Fig. 2). This procedure was carried out using the Bernese GNSS Software V.5.2 (Dach et al. 2007, 2013). The solution includes positions and velocities for 108 SIRGAS core stations referring to IGb08, epoch 2012.0. Its estimated precision is ±1.4 mm (horizontal) and ±2.5 mm (vertical) for the station positions at the reference epoch, and ±0.8 mm/yr (horizontal) and ±1.2 mm/yr (vertical) for the constant velocities. Stations showing very irregular post-seismic movements, like CONZ (Concepción, Chile) or ANTC (Antuco, Chile), are excluded because constant velocities (linear coordinate changes) are insufficient to model their behaviour (Fig. 3).

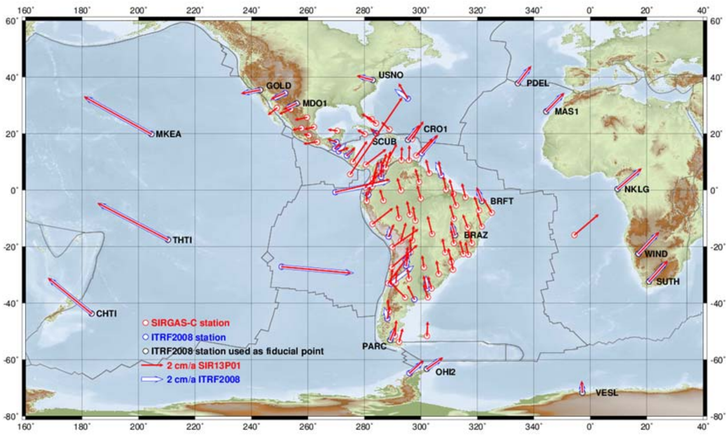

Fig. 2. Horizontal velocities of the post-seismic SIRGAS cumulative solution (stations with labels are fiducial points).

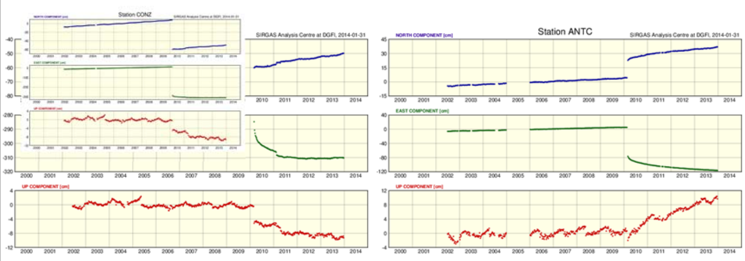

Fig. 3. Station position time series of CONZ (Concepción, Chile) and ANTC (Antuco, Chile).

Changes in the kinematics of the SIRGAS Reference Frame after the earthquake in February 2010 in Chile

Newly estimated station positions and velocities are compared with reference frames computed previous to the Chile earthquake, namely with ITRF2008 and the SIR10P01 cumulative SIRGAS solution for the year 2010 (covering the time span from January 2000 to January 2010). These comparisons show very large discrepancies (Fig. 4 and 5), in particular in the East component. Main reasons for this disagreement are:

- ITRF2008 and SIR10P01 do not reflect the effects (co-seismic and post-seismic movements) caused by the earthquake in February 2010 ;
- The weekly input solutions for ITRF2008 and SIR10P01 were computed with respect to the IGS05 frame, while the new solution is computed with respect to IGS08/IGb08;
- Troposphere effects in SIR10P01 and the new solution are modelled differently. Although the atmosphere parameters estimated within the network adjustment (~wet part) are very similar (some mm of discrepancy), the a priori zenith delay values (~dry part) differ by up to 5 cm, especially at stations located in the tropical region;
- The uncertainty of the station velocities reduces the reliability of the station positions in the new solution, since an extrapolation from 2012.0 (reference epoch) to 2005.0 (epoch for comparison with the other solutions) is necessary;
- The datum realisation in both SIRGAS solutions is based on different fiducial points. While the old solution includes reference stations located in Latin America only, the new solution comprises reference stations located far away.

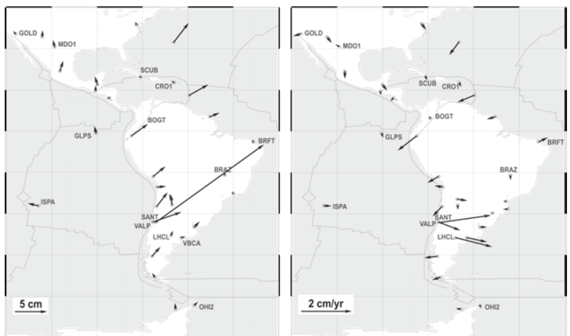

Fig. 4. Horizontal position difference vectors (left) and horizontal velocity difference vectors (right) between ITRF2008 and the post-seismic solution (all station coordinates refer to epoch 2005.0).

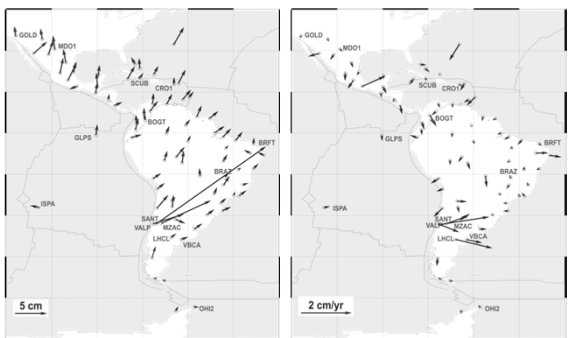

Fig. 5. Horizontal position difference vectors (left) and horizontal velocity difference vectors (right) between SIR10P01 (before the earthquake in February 2010) and the post-seismic solution (all station coordinates refer to epoch 2005.0).

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