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Three dimensional GPS velocities and strain rate distribution in Colombia

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In Colombia, a continuous GPS network has been implemented by the GeoRED project of the Colombian Geological Survey since 2007, providing a valuable dataset to study the complex tectonics, seismic as well as volcanic activities due to interactions among three major plates (Caribbean plate, South American plate and Nazca plate) and two tectonic blocks (North Andean block and Panama-Choco block).

In this study, we conduct a new analysis of daily coordinates with the GAMIT/GLOBK software and we obtained time series of 84 GPS stations including those in surrounding countries under ITRF2014 for the period 2008-2017. Based on this coordinate solutions, we calculate average 3 dimensional velocities at GPS stations using HECTOR software (Bos et al, 2012). Horizontal and vertical velocities represent stable interseismic trends. We also calculate a strain rate distribution from this new velocity data using a method of Shen et al. (1996).

Horizontal velocities show consistency with the previous study by Mora-Paez et al. (2019). Horizontal velocities relative to the Caribbean plate show that a few coastal sites located at the NW border have no motion. This observation have two possible interpretations. One is that observed velocites represents long-term deformation and the boundary between the North Andean Block and the Caribbean plate is located further inland. The other interpretation is that the velocities represents a short term motion that should be accomodated in future earthquakes. Relative velocities also show that the significant contraction between Panama and North Andean Blocks. On the other hand, vertical velocities show a slight of coastal uplifts at a few mm/year decreasing to the north along the Colombia-Ecuador subduction zone which are consistent with the horizontal shortening, while at the Caribbean subduction zone, vertical velocities present subsidence at 2~5 mm/yr. Also, vertical velocities demonstrates there is no significant uplift faster than a few mm/yr in the northern Andean.

The strain rate distribution results show that a contractional regime localized in the Colombia-Ecuador and Caribbean subduction zones, as well as in the Panama-Colombia collision region is the main tectonic pattern with shortening rates between 60-80 nanostrain/yr. The orientation of the principal strain axes seems to be consistent with the global CMT solutions of earthquakes with moment magnitudes larger than Mw 5.0 shallower than 50 km depth. A smaller contraction signal (40 nanostrain/year) at the foothills of the Eastern cordillera is also obtained possibly related with thrust faulting and the uplift of the range. Significant shear strain (30-60 nanostrain/year) along the foothills of the Eastern cordillera validates the boundary between the South American plate and the North Andean block defined by Bird (2003) and it is consistent with the right lateral motion of the Algeciras fault.

Bird (2003), Geochem. Geophys. Geosys., 4(3), 1027.
Bos et al. (2012) J. Geod., 87, 351-360.
Mora-Paez et al. (2019), J. South Am. Earth Sci., 16, 76-91.
Shen et al. (1996), J. Geophys. Res., 101, 27957-27980.