SIRGAS: 25 years providing the geodetic infrastructure in Latin America

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Introduction

SIRGAS is the Geocentric Reference System for the Americas. It is realized by a regional densification of the International Terrestrial Reference Frame (ITRF). Besides the geometrical reference system, SIRGAS includes the definition and realization of a vertical reference system, based on ellipsoidal heights and geopotential numbers (referred to the global W_0 value). SIRGAS was created in 1993 during the International Conference for the Definition of a South American Geocentric Reference System held in Asuncion, Paraguay. This conference was promoted and supported by the International Association of Geodesy (IAG), the Pan-American Institute for Geography and History (PAIGH), and the US Defence Mapping Agency (DMA), today National Geospatial-Intelligence Agency (NGA).

Operational structure of SIRGAS

SIRGAS forms part of the Sub-commission 1.3 (Regional Reference Frames) of IAG Commission 1 (Reference Frames) and corresponds to a Working Group of the Cartography Commission of PAIGH. The administrative issues are managed by an Executive Committee, which depends on the Directing Council, main body of the organization. The official policies and recommendations of SIRGAS are approved and given by the Directing Council. Since this Council is composed by one representative of each member country, one of IAG and one of PAIGH, it is also in charge of communicating the SIRGAS recommendations to the national bodies responsible for the local geodetic reference systems. The scientific and technical activities are coordinated by the Working Groups in close cooperation with the Scientific Council and the IAG and PAIGH representatives (Fig. 1).

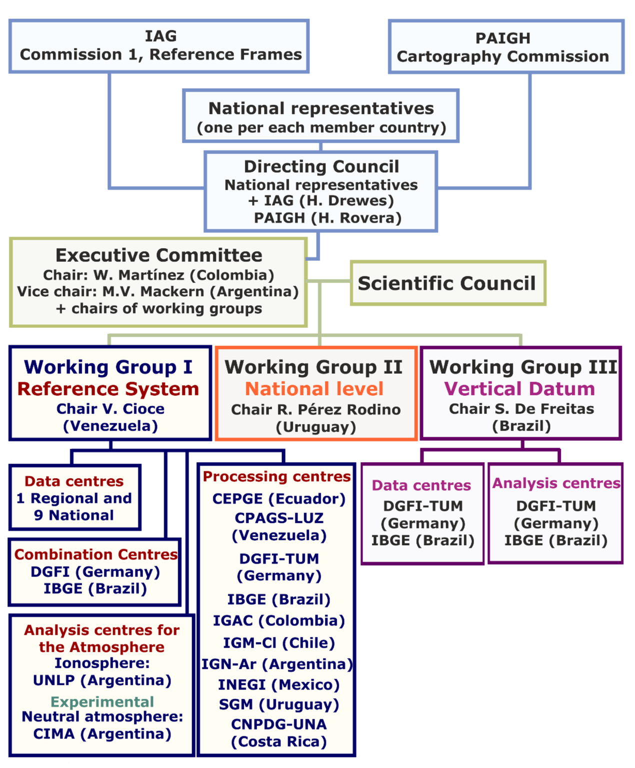

Fig. 1. SIRGAS structure: SIRGAS is a non-profit organization based on the voluntary contribution of over 50 self-funding agencies, universities, and research institutions; working together to provide the highest precision reference frame in Latin America.

SIRGAS Realizations

The first realization of SIRGAS (SIRGAS95) is a high-precision GPS network of 58 points distributed over South America and refers to ITRF94, epoch 1995.4. In 2000, this network was re-measured and extended to the Caribbean, Central and North American countries (Fig. 2). This second realization (SIRGAS2000) includes 184 GPS stations and refers to ITRF2000, epoch 2000.4. The original acronym of SIRGAS (Geocentric Reference System for South America) was changed in 2001 to Geocentric Reference System for the Americas, since the SIRGAS2000 GPS campaign was extended to North- and Central America, and the United Nations Organization, through its 7th Cartographic Conference for The Americas (New York, January 22 – 27, 2001), recommend to adopt SIRGAS as official reference system in all American countries.

The present realization of SIRGAS is given by a network of continuously operating GNSS stations distributed over Latin America called SIRGAS-CON (SIRGAS Continuously Operating Network). It comprises 533 stations: 67 belonging to the IGS global network, 339 tracking GLONASS, 79 tracking GALILEO, and 43 tracking BEIDOU (Fig. 3). GPS and GLONASS observations tracked at the SIRGAS stations are processed on a weekly basis by ten analysis centres to generate instantaneous weekly station positions aligned to the ITRF and multi-year (cumulative) reference frame solutions. The instantaneous weekly positions are especially useful when strong earthquakes cause co-seismic displacements or strong relaxation motions at the SIRGAS stations disabling the use of previous coordinates (Fig. 4). The multi-year solutions provide the most accurate and up-to-date SIRGAS station positions and velocities. They are used for the realization and maintenance of the SIRGAS reference frame between two releases of the ITRF (Fig. 5).

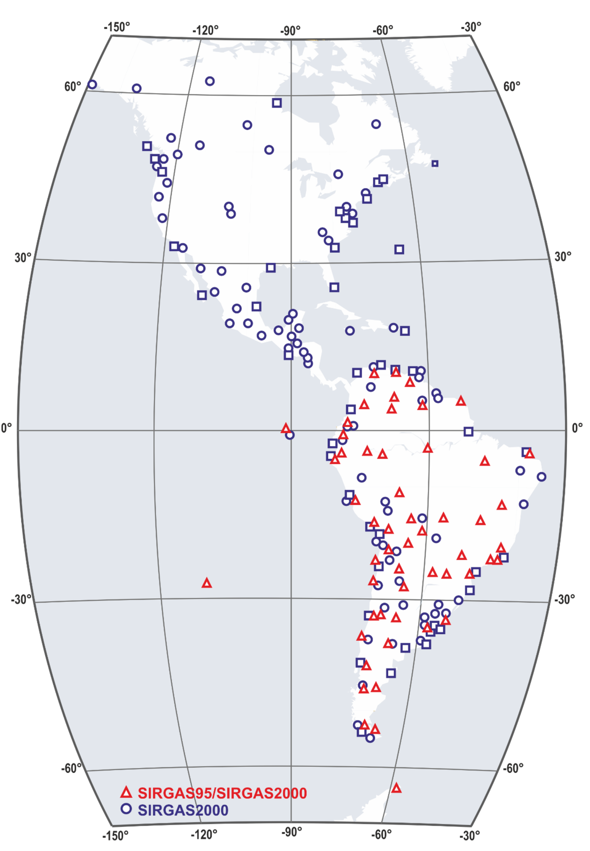

Fig. 2: SIRGAS reference frames SIRGAS95 and SIRGAS2000 (based on GPS campaigns in 1995 and 2000, respectively).

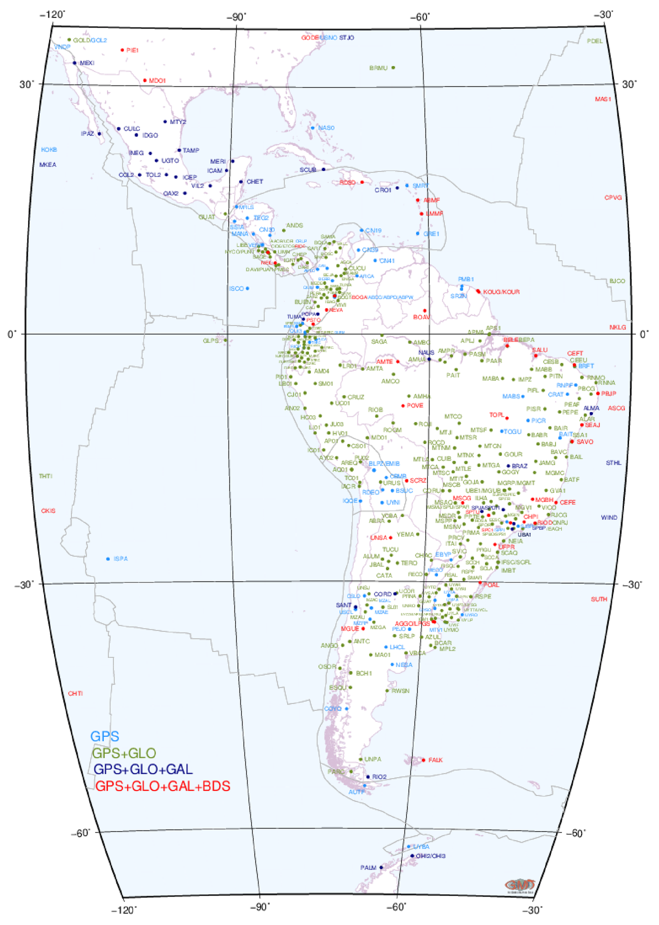

Fig. 3: Present SIRGAS reference frame: it comprises 533 continuously operating GNSS stations: 67 belonging to the IGS global network, 339 tracking GLONASS, 79 tracking GALILEO, and 43 tracking BEIDOU. 122 stations have been decommissioned, but they are included in the SIRGAS reprocessing campaigns.

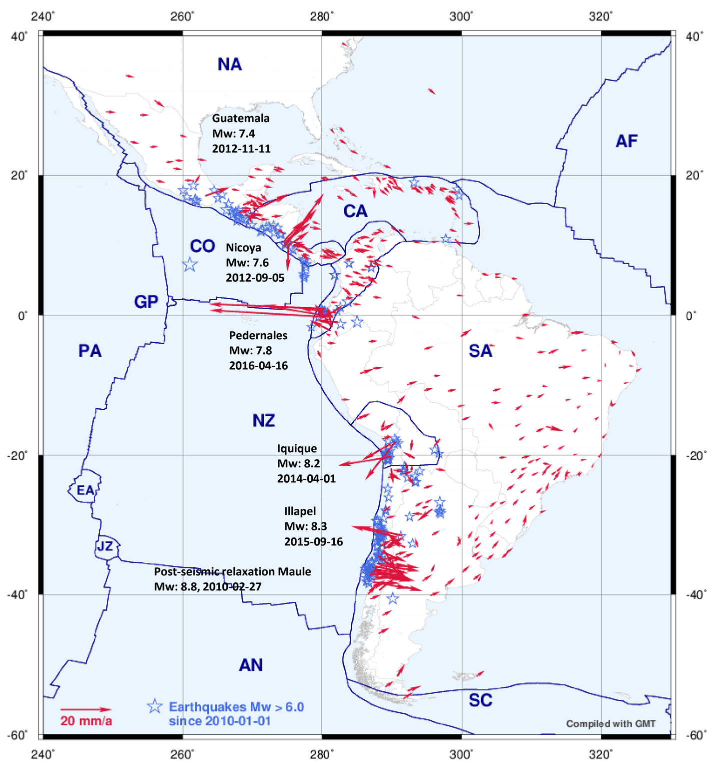

Fig. 4: Changes in the velocities of the SIRGAS stations caused by strong earthquakes since February 2010.

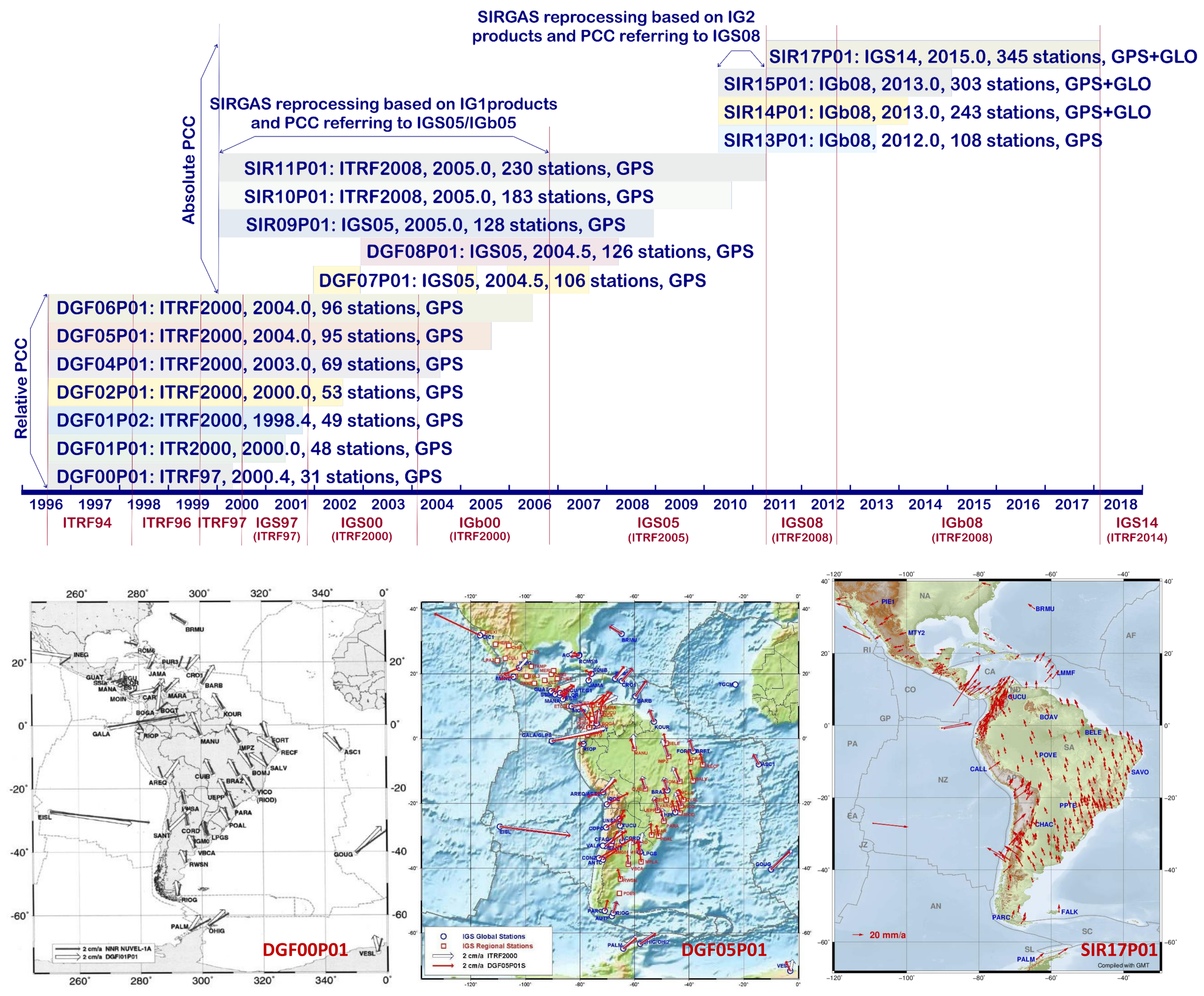

Fig. 5: Multi-year solutions computed for the SIRGAS reference frame. Coloured bars represent the time-span covered by each solution. The reference epoch for the station positions, the number of stations, the considered observations (GPS and GLONASS (GLO)) as well as the reference frame (ITRFyy/IGSyy) are shown. The figure also displays when relative or absolute corrections to the antenna phase centre variations (PCC) were applied, and which weekly solutions were reprocessed following the IGS reprocessing campaigns IG1 and IG2. The velocities of the multi-year solutions computed in 2000, 2005 and 2017 are shown as examples.

Surface deformation modelling within SIRGAS

As the western margin of Latin America is one of the seismically most active regions in the world, the maintenance of the SIRGAS frame implies the frequent computation of present-day (updated) surface deformation models to predict coordinate changes where no geodetic stations are installed. These models are called VEMOS (Velocity Model for SIRGAS) and have been computed in 2003 (data from May 1995 to Dec. 2001), 2009 (data from Jan. 2000 to Jun. 2009), 2015 (data from Mar. 2012 to Mar. 2015), and 2017 (data from Jan. 2014 to Jan. 2017). The comparison of these models makes evident that the present-day surface deformation in the SIRGAS region is highly influenced by the effects of major earthquakes (Fig. 6).

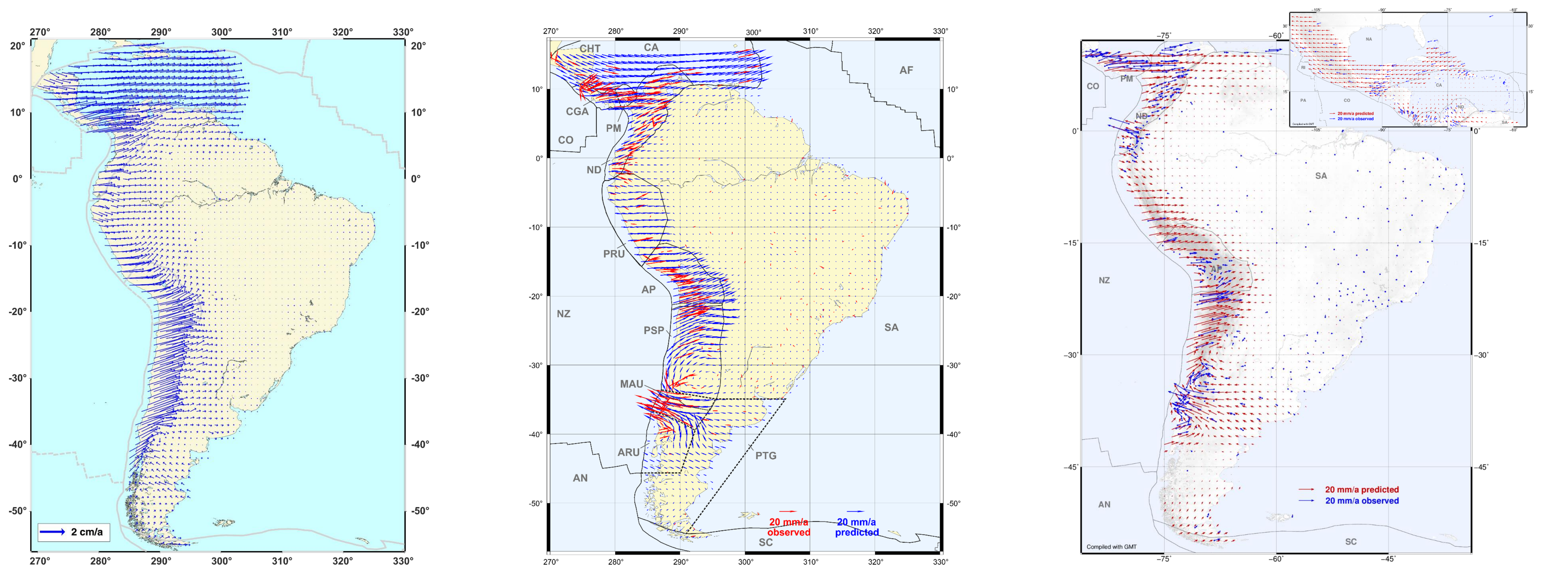

Fig. 6: Surface deformation models relative to the South American plate: VEMOS2009 (left) valid from 2000.0 to 2009.6; VEMOS2015 (centre) valid from 2012.2 to 2015.2; VEMOS2017 (right) valid from 2014.0 to 2017.1.

SIRGAS vertical reference system

The definition of the new SIRGAS vertical reference system is identical with the definition of the International Height Reference System (IHRS) given by the IAG Resolution No. 1, 2015. Its realization is planed to be a regional densification of the International Height Reference Frame (IHRF), Fig. 7. The geometrical component corresponds to ellipsoidal heights referred to the SIRGAS reference frame. The physical component is given in terms of geopotential quantities (W_0 as a reference level and geopotential numbers as primary coordinates). The realization of the new reference system includes the transformation of the existing height systems (Fig.8) to the new one.

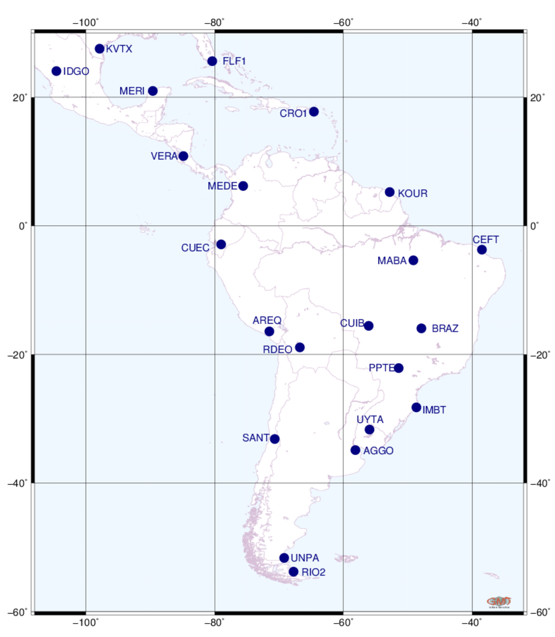

Fig. 7. Stations of the International Height Reference Frame (IHRF) in Latin America.

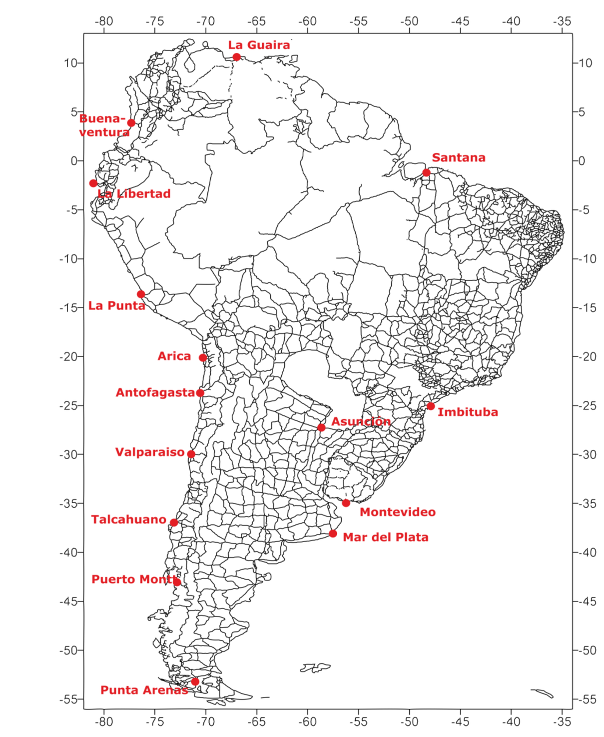

Fig. 8. Reference tide gauges and vertical networks of the existing height systems in South America.

Further reading

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