

Report on the 2009 General Meeting of SIRGAS: Geocentric Reference System for the Americas

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SIRGAS (Sistema de Referencia Geocéntrico para las Américas) is responsible for the definition, realization, and maintenance of the 3D geocentric reference system for Latin America and the Caribbean, including a gravity field-related vertical reference system. This responsibility comprises: Determination and maintenance of a continental geocentric reference frame as a regional densification of the global ITRF; establishment of high-precise national geodetic reference networks as SIRGAS densification in the member countries; and definition/realization of a unified vertical reference system composed by physical and geometrical heights consistent world-wide.

SIRGAS is the backbone for all projects related to geo-spatial information in the region. It supports the development of practical applications such as land management, engineering projects, digital administration of geographical data, geospatial data infrastructures, etc., as well as a wide range of scientific applications such as the monitoring of Earth's crust deformations, vertical movements, sea level variations, atmospheric studies, observation and measuring of global change effects, etc.

SIRGAS is a component of the International Association of Geodesy (IAG) through the Commission 1 (Reference Frames), Sub commission 1.3 (Regional Reference Frames), being responsible for the Regional Reference Frame for South- and Central America (1.3b). SIRGAS is also a Working Group of the Cartographic Commission of the Pan American Institute for Geography and History (PAIGH).

Activities, advances, and new challenges of SIRGAS are reported, discussed, and re-oriented (if necessary) in the SIRGAS yearly meetings, which have been realized since 1993. The last one was carried out within the Scientific Assembly of the International Association of Geodesy (IAG) - "Geodesy for Planet Earth"-, held from August 31 to September 4, 2009 in Buenos Aires, Argentina. Since the scientific program of the Assembly covered all SIRGAS objectives, SIRGAS did not conduct a parallel meeting but all its contributions were submitted and presented at the different IAG Assembly sessions.

In about 30 oral presentations and 20 posters, the following SIRGAS issues were presented during the IAG Assembly:

- Densification, operational improvement, and analysis of the SIRGAS Continuously Operating Network (SIRGAS-CON);
- Atmospheric studies (troposphere + ionosphere) based on the SIRGAS infrastructure;
- Extension of SIRGAS in Central America and the Caribbean;
- National achievements by adopting and using SIRGAS as official reference frame;
- Advances in the definition and implementation of the SIRGAS vertical reference system within a global concept;
- GNSS applications in real time;
- Interaction SIRGAS - GGOS (Global Geodetic Observing System)

Most of the SIRGAS contributions were submitted to the proceedings for the IAG 2009 Scientific Assembly, which are planned to be part of the IAG Symposia Series. Additionally, a detailed report containing the oral presentations and posters is available, as usual, at the SIRGAS web site (www.sirgas.org).

Complementary to the scientific presentations, the Annual Meeting of the SIRGAS Executive Committee took place on September 1, 2009, covering the following themes:

- Report of SIRGAS President
 - Main activities achieved during the last year;
 - Changes in the Executive Committee (new National Representatives);
 - Participation of SIRGAS in international working groups and meetings;
 - Announcement of the SIRGAS 2010 General Meeting.

- Report of the SIRGAS Working Groups
 - SIRGAS-WGI (Reference System): New experimental processing centres, new multi year solution for the SIRGAS-CON network, atmospheric studies based on the SIRGAS infrastructure (SIRGAS-ION), coming activities;
 - SIRGAS-WGII (Geocentric Datum): New national densifications of SIRGAS, first IAG/PAIGH/SIRGAS School on Reference Systems, SIRGAS Real Time, integration of Central American and the Caribbean countries into SIRGAS, coming activities;
 - SIRGAS-GTIII (Vertical Datum): Towards geopotential numbers computation in a continental level, realization of the reference surface, coming activities.

- Availability and distribution of the SIRGAS products: SIRGAS in the Internet, maintenance of the SIRGAS web site, use of the SIRGAS products.

The main conclusions and recommendations of the SIRGAS 2009 General Meeting are:

1. The analysis strategy of the SIRGAS-CON network, based on the individual processing of one core network and three densification networks and their combination in a unified solution, demonstrated to be very efficient. The four SIRGAS Official Processing Centres (IGAC, Colombia; IBGE, Brazil; CIMA, Argentina; and DGFI, Germany) satisfy the administrative and quality processing requirements defined in the SIRGAS guidelines, which are consistent with the IGS and IERS standards. Their weekly solutions are at the same accuracy level with respect to each other and with respect to final weekly combinations.
2. The main SIRGAS-CON products (i.e. loosely constrained weekly solutions for the IGS polyhedron and weekly positions aligned to the IGS05) present a precision (internal consistency) of about $\pm 0,8$ mm for the horizontal position and $\pm 2,5$ mm for the vertical one, while the realization accuracy with respect to the IGS05 frame (external consistency) is about $\pm 1,5$ mm for the horizontal component and $\pm 3,8$ mm for the vertical one.
3. A new multi-annual solution, identified as SIR09P01, for the SIRGAS-CON network was released in June 2009. It covers all the weekly solutions provided by the SIRGAS Analysis Centres from January 2, 2000 (GPS week 1043) to January 3, 2009 (GPS week 1512). It is referred to IGS05 at 2005.0. The precision of its positions at the reference epoch is estimated to be better than ± 0.5 mm in the horizontal component and ± 0.9 mm in the vertical one. The precision of the linear velocities is about ± 0.8 mm/a. A loosely constrained version of this solution was delivered as the SIRGAS contribution to the IAG SC1.3 Working Group on Regional Dense Velocity Fields.
4. The availability of horizontal velocities in those regions which are not covered by SIRGAS-CON stations is strongly improved through the new Velocity Model for South America and the Caribbean (VEMOS 2009), which represents the continuous present-day deformation of the Earth's crust in the SIRGAS region. It is based on nearly 500 velocity stations observed in 13 GPS projects. The overall precision of the point velocities is better than ± 1 mm/a in South-North and about $\pm 1,5$ mm/a in West-East direction.
5. The SIRGAS-WGI outlined a conventional strategy to define the geodetic datum within the SIRGAS-CON weekly solutions. This strategy shall be applied by the SIRGAS Combination Centres (IBGE, Brazil, and DGFI, Germany) to generate weekly positions aligned to the IGS05 frame. The datum definition strategy is based on constraining the coordinates of the IGS05 stations to their positions calculated within the IGS weekly combinations (igsyyP~~www~~.snx). The applied constraint shall correspond to a weight inversely proportional to the internal variance of the GPS measurements. Explicitly, the application of linear velocities to obtain reference coordinates for the datum definition is not recommended by SIRGAS.
6. The requirement of redundancy in the processing of the SIRGAS-CON stations (each station processed by at least three analysis centres) is being faced by installing more SIRGAS Processing

Centres hosted by Latin American institutions. In this year, three Experimental Centres started operations: Instituto Geográfico Militar of Ecuador (IGM, Ecuador), Laboratorio de Geodesia Física y Satelital at the Universidad del Zulia (LGFS-LUZ), and Servicio Geográfico Militar of Uruguay (SGM, Uruguay). Once they pass a validation period of one year, they become official processing centres and their weekly solutions will be included in the generation of the SIRGAS-CON official products.

7. Until now, the SIRGAS Analysis Centres process GPS data only. Since the number of GLONASS stations is increasing in the SIRGAS region, the SIRGAS-WGI initiates the routine processing of GLONASS observations in a weekly basis. All GLONASS stations will be analysed as an individual network, loosely constrained solutions of which will be combined with the similar solutions generated for the other SIRGAS-CON sub-networks. The analysis of the GLONASS data will be carried out by the Processing Centre CIMA (Argentina).
8. Two additional national networks were integrated into SIRGAS improving the accessibility of this continental frame at national level. In Argentina: Posiciones Geodésicas Argentinas (POSGAR07) refers to the ITRF2005, epoch 2006.6. The datum definition was realized by means of the multi-year solution DGF108P01 for the SIRGAS-CON network. The corresponding analysis was carried out by the Instituto Geográfico Nacional of Argentina using the software GAMIT-GLOBAL K. In El Salvador: The frame SIRGAS-ES2007.8 (SIRGAS El Salvador 2007.8) refers to the IGS05, epoch 2007.8. The datum definition is given by constraining the weekly coordinates of the SIRGAS-CON network at the observation epoch. The analysis was carried out by the Deutsches Geodätisches Forschungsinstitut using the Bernese Software.
9. Different capacity building tools have been implemented in the member countries with the purpose of supporting the adequate realization and use of SIRGAS as reference frame. One of the most successful is the IAG/PAIGH/SIRGAS School on Reference Systems, which aims to provide the attendant with theoretical concepts needed for the appropriate production and use of fundamental geodetic data. The first edition of this school was held in Bogotá (Colombia), from July 13 to 17, 2009 with 120 participants representing 12 countries of Latin America and the Caribbean. The next school will be carried out together with the SIRGAS 2010 General Meeting in Lima, Peru.
10. The SIRGAS Real Time (SIRGAS-RT) project was established in the SIRGAS 2008 General Meeting (May 2008). Its main objective is to evaluate the possibility of providing near real time corrections for GNSS positioning based on the SIRGAS-CON stations. After one year, Brazil, Uruguay, and Venezuela, who are applying the NTRIP tool, show significant advances in this topic, and the SIRGAS-WGII will continue promoting the development of similar studies in the other SIRGAS countries.
11. The routine production of vTEC maps for South America by the Universidad Nacional de la Plata (Argentina) as SIRGAS Ionosphere Analysis Centre provides control and improvement for different kind of projects such as the International Reference Ionosphere (IRI) over South America, positioning with single-frequency GPS receivers, and the feasibility of computing ionospheric corrections for a satellite based augmentation system (SBAS) for the region.
12. Regarding the definition and realization of a unified vertical reference system for SIRGAS, it should be mentioned that the Latin American countries continue preparing the levelling data to be processed in a continent-wide adjustment. The SIRGAS-WGIII analyses at present geopotential numbers of Colombia, Venezuela, Brazil, Ecuador, Uruguay, Argentina, and Chile. Bolivia, Peru, and Paraguay will provide the corresponding data in the next future.

Thanks to a kind invitation of the Instituto Geográfico Nacional of Peru, the SIRGAS 2010 General Meeting will be held in November 2010 in Lima, in the frame of the 42 Annual Meeting of the Directing Council of PAIGH.

SIRGAS deeply acknowledges the financial support given by IAG, PAIGH, and IUGG (International Union of Geodesy and Geophysics) for facilitating the attendance to the IAG Assembly of many SIRGAS colleagues. In total 9 SIRGAS scientists received grants for travel costs, daily expenses, and registration fee.