SIRGAS: the geodetic reference frame for Latin America and the Caribbean

C. Brunini
UNLP, Argentina

L. Sánchez
DGFI, Germany

V. Mackern
UNCuyo, UJAM, Argentina

W. Martínez
IGAC, Colombia

R. Luz
IBGE, Brazil

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The realization of SIRGAS is a densification of the ITRF
- to guarantee consistency between terrestrial reference stations and GNSS satellite orbits (provided by the IGS);
- to make the global reference frame available at national and local levels.
Continuous monitoring of the reference frame

**Before:** Realization by means of GPS campaigns

**Now:** Realization by means of a continuously operating GNSS network (SIRGAS-CON)

- **SIRGAS95**
  - 58 stations
  - ITRF94, 1995.4

- **SIRGAS2000**
  - 184 stations
  - ITRF2000, 2000.4

- **SIRGAS-CON**
  - 237 stations
  - Current ITRF
  - Weekly station positions
  - Cumulative solutions (positions and velocities)
Geographical densification of the reference stations (1/2)

SIRGAS-CON in Sept. 2001
48 stations (24 IGS-stations)

SIRGAS-CON in Sept. 2010
237 stations (48 IGS-stations)
Number of SIRGAS-CON stations since 1995

- Improvement of the national reference frames by installing continuously operating GNSS stations (intensively since 2005);
- Integration of the national GNSS reference stations into the continental reference frame (SIRGAS-CON) for common processing and to guarantee consistency with the ITRF.
Redundancy in the analysis of the reference frame

**Before:** one processing centre, one network processed in one block. Each station processed once.

- SIRGAS-CON (one network)
  - 1 Data Centre (DGFI as IGS-RNAAC-SIR)
  - 1 Analysis Centre (DGFI as IGS-RNAAC-SIR)

  Loosely constrained weekly solutions for further combinations of the network (i.e. IGS polyhedron, multi-year solutions)

  - Weekly station positions aligned to the ITRF
  - Multi-year solutions (positions + velocities)

**Now:** 9 processing centres, 2 combination centres, one core network and many densification sub-networks (clusters). Each station processed by 3 analysis centres.

- SIRGAS-CON (core/continental network)
  - 1 Regional Data Centre (DGFI)
  - 1 Analysis Centre (DGFI as IGS-RNAAC-SIR)

- SIRGAS-CON-D (densification sub-networks)
  - National Data Centres (entities in charge of national reference frames)
  - 8 Local Processing Centres
    - CIMA (Argentina), IBGE (Brazil), IGAC (Colombia), IGM (Ecuador), SGM (Uruguay), LUZ (Venezuela), IGN (Argentina), INEGI (Mexico)

- 2 Combination Centres (DGFI, IBGE)

  Loosely constrained weekly solutions for further combinations of the network (i.e. IGS polyhedron, multi-year solutions)

  - Weekly station positions aligned to the ITRF
  - Multi-year solutions (positions + velocities)

Final solutions for the SIRGAS-CON reference frame (DGFI as IGS RNAAC SIR)

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Datum definition strategy and availability of weekly reference coordinates

Before: Reference station positions were transformed from a conventional reference epoch applying constant velocities: \( X(t_i) = X(t_0) + Vx(t_i - t_0) \)

Now: Reference positions are computed by aligning the weekly solutions of the SIRGAS frame to the same frame in which the GNSS orbits are computed, i.e. the IGS weekly solutions.

Discrepancies wrt loosely constrained solutions after applying different reference coordinates for the datum definition (GPS week 1504)
Reprocessing of the entire SIRGAS-CON network applying the reprocessed IGS products (IG1)

Every year cumulative (multi-year) solutions are computed to determine the kinematics of the SIRGAS reference frame.
Latest multi-year solution: SIR10P01

Time period: 02-01-2000 – 05-06-2010 (543 GPS weeks);
Stations: 183 (204 occupations);
Reference frame: ITF2008, epoch 2005.0;
Precision of positions at reference epoch: ±0,5 mm (hor), ±0,9 mm (up);
Precision of velocities: ±0,4 mm/a
Since July 2006, SIRGAS operates an Ionospheric Analysis Centre under the responsibility of La Plata National University, Argentina;

Hourly regional maps of vTEC are computed and delivered to the community.

They are applied for:

- validation of the International Reference Ionosphere (IRI);
- improvement of positioning with single-frequency GNSS receivers;
- feasibility studies for a SBAS in the region (supported by the International Civil Aviation Organization - ICAO).
16 countries of 18 SIRGAS member countries adopted SIRGAS as official reference frame, i.e. the SIRGAS continental network is extended through national densification networks.

Users of precise GNSS positioning refer to SIRGAS (or their densifications) by:

1. Introducing weekly station positions of the SIRGAS-CON stations as reference coordinates to process GNSS surveying;
2. Applying the velocities provided by the multi-year solutions to reduce new station positions to the conventional reference epoch defining the official reference frame.

\[ X(t_o) = X(t_i) - Vx(t_i - t_0) \]
1. Implementation of a real-time GNSS infrastructure using NTRIP;
2. Routine analysis of the GLONASS network;
3. Modelling of atmospheric loading to understand seasonal variations of station positions;
4. Realization of a unified vertical reference system within a global definition.