# Guidelines for SIRGAS Analysis Centres

*Version 2.2. March 13, 2017*
*(Previous release: Version 2.1. August 1, 2013)*

*Changes/Additions*:

*March 2017:* the Centro Nacional de Procesamiento de datos GNSS, Universidad Nacional (Costa Rica) is included as an official SIRGAS processing centre. Some Internet links are updated. The IGS14 is added as current reference frame.
*August 2013*: The new IERS and IGS standards are included in the SIRGAS processing guidelines, the delivery of daily loosely constrained solutions in SINEX format together with the weekly ones is explicitly specified, the IGM of Chile is installed as an official processing centre, and the Centro Nacional de Procesamiento de datos GNSS, Universidad Nacional (Costa Rica) as an experimental one.
*July 2011*: CPAGS-LUZ: Centro de Procesamiento y Análisis GNSS SIRGAS del Laboratorio de Geodesia Física y Satelital de la Universidad del Zulia (Venezuela) changes to CPAGS-LUZ: Centro de Procesamiento y Análisis GNSS SIRGAS de la Universidad del Zulia (Venezuela)
*January, 2011:* IGN-Ar and INEGI are installed as Official SIRGAS Processing Centres.
*September, 2010:* The new SIRGAS FTP server is included.
*January, 2010:* CEPGE-Ec, SGM-Uy, and CPAGS-LUZ are installed as Official SIRGAS Processing Centres.
*October, 2009:* A standard strategy for the geodetic datum definition within the weekly solutions of the SIRGAS-CON network is specifically included.
*April, 2009*: The Laboratorio de Geodesia Física y Satelital de la Universidad del Zulia (LGFS-LUZ) and the Servicio Geográfico Militar of Uruguay (SGM-Uy) are added as new Experimental Processing Centres.
*January, 2009*: The Instituto Geográfico Militar de Ecuador (IGM-Ec) is added as a new Experimental Processing Centre.

*This document presents the guidelines for the SIRGAS Analysis Centres, i.e. Local Processing Centres, Experimental Processing Centres, and Combination Centres. It was prepared by the SIRGAS-WGI and complemented with suggestions sent by SIRGAS colleagues who carefully read its content. This support is highly appreciated.*

*In order to keep this document up-to-day, we thank you for sending comments, questions, and suggestions to Víctor Cioce, president of the SIRGAS-WGI: Reference System (vcioce@fing.luz.edu.ve).*

The SIRGAS Analysis Centres comprise the Processing Centres and the Combination Centres. The Processing Centres perform routine analysis of selected SIRGAS stations and generate loosely constrained daily and weekly solutions for station positions in SINEX (Software Independent Exchange) format. The individual (daily and weekly) solutions for the national reference networks (called SIRGAS-N) obtained by the Local Processing Centres are combined with the loosely constrained weekly solutions for the SIRGAS core network (called SIRGAS-C) computed by the IGS-RNAAC-SIR (IGS Regional Network Associate Analysis Centre for SIRGAS) (see *"Guidelines for the Coordination of the SIRGAS Continuously Operating Network (SIRGAS-CON)"*). The SIRGAS Combination Centres are responsible for combining the loosely constrained weekly solutions for the SIRGAS-N networks with the corresponding solution for the SIRGAS-C core network. The analysis strategy guarantees that each regional station is included in three individual solutions.

The present document describes the guidelines for the SIRGAS Processing and Combination Centres, including: a) required steps for becoming a new SIRGAS Processing Centre, b)

processing options, instructions, and schemes for processing and combination, and c) result submission, filenames description, and address to upload the analysis results.

**Structure of the SIRGAS-CON analysis**

Figure 1 presents the relationship between the SIRGAS Data Centres, the Processing Centres, and the Combination Centres, including the corresponding coordination and the final SIRGAS-CON products.

The activities related with the SIRGAS-CON issues are coordinated by the SIRGAS Working Group I (Reference System), President of which is also designated as the Network Coordinator or SIRGAS-CON Coordinator.

The SIRGAS-CON network comprises:

a) One core network (SIRGAS-C), primary densification of ITRF in Latin America, with a good continental coverage and stabile site locations to ensure high long-term stability of the reference frame;

b) National reference networks (SIRGAS-N) improving the densification of the core network and providing accessibility to the reference frame at national and local levels. Both, the core network and the national networks satisfy the same characteristics and quality; and each station is processed by three analysis centres.
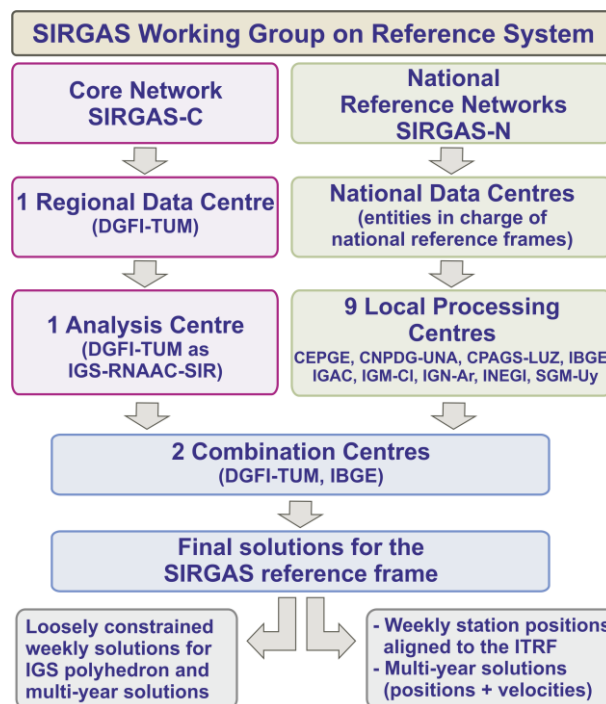


*Figure 1. Structure of the SIRGAS-CON analysis (March 2017).*

The observational data (RINEX files) of the SIRGAS stations belonging to the core network (SIRGAS-C) are collected and archived by the SIRGAS Regional Data Centre. The observational data of the SIRGAS-CON stations belonging to the national reference networks (SIRGAS-N) are collected and archived by the SIRGAS National Data Centres (see ***"Guidelines for the Coordination of the SIRGAS Continuously Operating Network***

*(SIRGAS-CON)")*. The SIRGAS-C network is processed by the IGS-RNAAC-SIR. The SIRGAS-N national networks are computed by the SIRGAS Local Processing Centres. The loosely constrained daily and weekly solutions delivered by the Local Processing Centres are combined with the loosely constrained solutions for the SIRGAS-C core network to obtain compatible station positions and velocities in a continental level. The final SIRGAS coordinates and velocities are provided through the web site www.sirgas.org. The delivered products are:

- loosely constrained weekly station positions in SINEX format to be included into the IGS polyhedron and for the computation of multiyear solutions;
- weekly station positions aligned to the ITRF for practical applications in Latin America;
- multiyear solutions (positions + velocities) for practical and scientific applications requiring time-dependent positioning.

**SIRGAS Analysis Centres**

**Local Processing Centres**: perform weekly computations of a specified set of SIRGAS-N stations. Their solutions are combined with the core network to provide the final SIRGAS-CON products. At present, they are:

- CEPGE: Centro de Procesamiento de datos GNSS del Ecuador, Instituto Geográfico Militar (Ecuador)
- CNPDG-UNA: Centro Nacional de Procesamiento de Datos GNSS, Universidad Nacional (Costa Rica)
- CPAGS-LUZ: Centro de Procesamiento y Análisis GNSS SIRGAS de la Universidad del Zulia (Venezuela)
- IBGE: Instituto Brasileiro de Geografia e Estatistica (Brazil)
- IGAC: Instituto Geográfico Agustín Codazzi (Colombia)
- IGM-Cl: Instituto Geográfico Militar (Chile)
- IGN-Ar: Instituto Geográfico Nacional (Argentina)
- INEGI: Instituto Nacional de Estadística y Geografía (Mexico)
- SGM-Uy: Servicio Geográfico Militar (Uruguay)

**IGS Regional Network Associate Analysis Centre for SIRGAS (IGS-RNAAC-SIR)**: weekly computes the SIRGAS-C core network and combines this network with the SIRGAS-N national networks. At present, it is operated by the

- *Deutsches Geodätisches Forschungsinstitut, Technische Universität München*, DGFI-TUM (Germany).

**Combination Centres**: are responsible for combining the loosely constrained weekly solutions for the SIRGAS-N national networks with the corresponding solution for the SIRGAS-C core network. At present, they are:

- *Instituto Brasileiro de Geografia e Estatistica*, IBGE (Brazil);
- *Deutsches Geodätisches Forschungsinstitut, Technische Universität München*, DGFI-TUM (Germany).

**Experimental Processing Centres**: are candidates to become SIRGAS Local Processing Centres. During a specified time period, they align their processing strategies to those required by SIRGAS and demonstrate their capacity for timely and continuously delivery of weekly

solutions. Once they satisfy these requirements, they are appointed as official processing centres. During the test period (at least one year), they process a set of SIRGAS-CON stations selected in accordance with the Network Coordinator, but their solutions are not included in the computation of the final SIRGAS-CON products.

## Instructions for Experimental Processing Centres

Each academic, governmental, or scientific organisation acting in any SIRGAS member country can become a SIRGAS Processing Centre. Interested organisations must be able to contribute to SIRGAS in a long-term basis, following specific guidelines, standards, and conventions to guarantee the permanent quality of the SIRGAS-CON products. To become a SIRGAS official processing centre, it is necessary to pass a test period, in which the accuracy of the computed solutions as well as operational aspects related with the punctuality and continuity on delivering the weekly solutions, the observance of SIRGAS guidelines, etc. are evaluated. Once the SIRGAS requirements are fulfilled by the candidate, it will be appointed as an official SIRGAS Local Processing Centre. It is necessary to make clear that the products generated by the processing centres (official or experimental) in the frame of SIRGAS are free-of-charge and available for everyone. This policy has to be accepted by new experimental processing centres.

Initial steps to become a SIRGAS Experimental Processing Centre

1. Contact the Network Coordinator with an official statement of desire to become an SIRGAS Experimental Processing Centre. It should specify name and address of the responsible. This statement must include a letter of support of the organization and a letter of agreement subscribed by the National Representative of his country in SIRGAS;

2. Include a proposal about the SIRGAS-CON stations you plan to process;

3. Describe the analysis software you will apply. It has to have the capacity to process the assigned SIRGAS-N network (or networks) and to fulfil the SIRGAS standards;

4. Suggest a 3-character identifier of your planned Experimental Processing Centre, for instance, IBG for "*Instituto Brasileiro de Geografia e Estatistica*";

5. Indicate a proposal for the first GPS week you plan to start the experiment.

Sub-network assignment

1. The Network Coordinator contacts the new Experimental Processing Centre after acceptance of the proposal by the SIRGAS Executive Committee;

2. The Network Coordinator assigns a sub-network to the new Experimental Processing Centre taking into account the stations included in its original proposal and the SIRGAS criteria about including the regional SIRGAS-CON stations in the same number of individual solutions. The SIRGAS Executive Committee participates in the final decision for the stations.

Evaluation Period for the Experimental Processing Centre

1. The Experimental Processing Centre starts with the experiment; it shall align its processing strategy to the SIRGAS standards and fulfil the operational requirements (see section ***"Instructions for Local Processing Centres"*** in this document). The test period is one year.

2. The SIRGAS Combination Centres routinely evaluate the weekly solutions delivered by the Experimental Processing Centre and prepare partial reports to the Network Coordinator. Based on these reports, the Network Coordinator indicates to the Experimental Processing Centre which aspects are to be improved.

3. At the end of the test period, the Network Coordinator, in accordance with the SIRGAS Executive Committee, indicates if the Experimental Processing Centre is able to be an official SIRGAS Local Processing Centre, or if it is necessary to extend the test period.

4. Before becoming an official SIRGAS Processing Centre, the organization supporting the operation of the Experimental Processing Centre must address a letter of compromise to SIRGAS ensuring the continuity of this support and the observance of the SIRGAS requirements.

**Instructions for Local Processing Centres**

The SIRGAS Local Processing Centres calculate first daily solutions for stations coordinates of the assigned set of SIRGAS stations and following combine those to a weekly solution. Both, daily and weekly solutions must be written in SINEX format. These SINEX files shall contain the station coordinate solutions and the corresponding co-variances matrixes. In order to avoid problems concerning the reduction of constraints, loosely constrained normal solutions should be provided. All constraints have to be reported in the SINEX files, i.e. the statistical information (e.g., number of observations, number of unknowns, variance factor, etc.) necessary for combining at the normal equation level has to be included. In the following, the minimal requirements for the processing strategy are listed:

General processing options

1. Observing sampling rate: 30 sec;

2. Elevation cut-off angle: 3°;

3. Observation weighting: Apply elevation dependent weighting to the observations. Local Processing Centres which can not use an elevation dependent weighting scheme are advised to continue using a 15° elevation cut off angle;

4. Computations and results shall be given in GPS time;

5. If in any processing step a global gravity model is required, the EGM2008[1] model shall be applied;

6. Satellite orbits, satellite clock offsets, and Earth orientation parameters should be fixed to the combined IGS solutions. They are available at http://www.igs.org/products/data;

7. Updated absolute calibration values for the antenna phase centre corrections, including the elevation- and azimuth-dependent values, published by the IGS must be applied. They are available at ftp://igs.org/pub/station/general/pcv_archive/. The combination of

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[1] Pavlis N-K., S.A. Holmes, S.C. Kenyon, J.K. Factor (2012). The development of the Earth Gravitational Model 2008 (EGM2008). J Geophys Res 117:B04406. DOI: 10.1029/2011JB008916.

antenna with radome must strictly be taken into account. The station information applied for processing must exactly coincide with the station information contained in the site log files. They are available at ftp://ftp.sirgas.org/pub/gps/DGF/station/log;

8.  Calibration values for the Z-component of the satellite positions must be applied. These values are included in the same PCV file containing the calibration values for the GNSS antennae (ftp://igs.org/pub/station/general/pcv_archive/);

9.  Tidal displacements: The periodic site movements due to ocean tide loading shall be introduced applying the most recent FES[2] ocean tide model. The corresponding values are provided by M.S. Bos and H.-G. Scherneck at http://holt.oso.chalmers.se/loading/. The selection for the option "*Do you want to correct your loading values for the motion?*" is NO, because SIRGAS utilizes the final IGS products, and they already include this correction;

10. Atmospheric loading: Tidal effects produced by the S1 and S2 components must be reduced following the Dam and Rey[3] (2010) model. The corresponding correction coefficients can be obtained at http://geophy.uni.lu/ggfc-atmosphere/tide-loading-calculator.html;

11. Non-tidal loading effects shall **not** be reduced! These effects can be better modelled if they are included in the station position time series.

12. Tropospheric refraction: The zenith delay due to the tropospheric refraction (wet part) shall be estimated at a 2-hours interval within the network adjustment, i.e. twelve daily corrections per station shall be computed. The Vienna Mapping Function (VMF) must be applied as *a-priori* model for the dry component and as mapping function for the estimation of the tropospheric parameters. The corresponding coefficients in global grids of 15° with time intervals of six hours are available at http://ggosatm.hg.tuwien.ac.at/DELAY/GRID/VMFG/. It is recommended to include the estimation of vertical gradients;

13. It is recommended to fix the phase ambiguities to integer numbers in the final solution;

14. The processing characteristics that have not been explicitly mentioned are left to the discretion of each Local Processing Centre:

15. The processing centres are requested to generate a brief report in text format describing those stations that are not included in the weekly solution, e.g. because the RINEX are not available, bad quality of the measurements, etc. This report must be named with the extension .REP.

Processing schedule

1.  Download from Operational Centres (OC) or National Data Centres (NDC) all observation files in RINEX format corresponding to your SIRGAS-N network (or networks) for the period of the GPS week you are going to process. The data of the IGS stations included in your sub-network are available at the IGS data centres (see http://kb.igs.org/hc/en-us/articles/202054393-IGS-FTP-Sites);

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[2] Letellier T. (2004). Etude des ondes de marée sur les plateux continentaux. Thèse doctorale, Université de Toulouse III, Ecole Doctorale des Sciences de l'Univers, de l'Environnement et de l'Espace, 237 p.
[3] van Dam, T. and R. Ray, 2010, Updated October 2010. S1 and S2 Atmospheric Tide Loading Effects for Geodetic Applications.

2. Download the final IGS orbits and Earth Rotation Parameters (ERP) from an IGS data centre (see http://www.igs.org/products/data). They are available 13 days after the observation date;

3. Compute daily solutions as soon as the final IGS orbits become available;

4. The parameters are the station positions; i.e., troposphere and ambiguity parameters must be pre-eliminated in the daily solutions;

5. Generate a weekly solution (combination of the seven daily solutions) of the station positions;

6. Write the resulting station positions and co-variances (correlation coefficients) into a SINEX file for both, the daily and the weekly solutions;

7. Daily and weekly solutions should be datum free (loosely constrained), i.e. *a-priori* $\sigma$ for station positions should be $\sigma = \pm 1$ m. If it is not possible to generate loosely constrained weekly solutions, the corresponding SINEX files have to contain all *a-priori* constraints;

8. The SINEX files shall be compressed with ".gz" and named as follows:
cccwwww7.SNX (ccc = Local Processing Centre identifier, wwww = gpsweek) for the weekly SINEX coordinate files;
cccwwww0.SNX for the first day of the week;
cccwwww1.SNX for the second day of the week and so on.

   For example, IBG14650.SNX.gz, IBG14651.SNX.gz, IBG14652.SNX.gz, IBG14653.SNX.gz, IBG14654.SNX.gz, IBG14655.SNX.gz, IBG14656.SNX.gz and IBG14657.SNX are the daily and weekly IBGE solutions for the GPS week 1465. The identifiers for the existing Processing Centres are:

| Identifier | Processing centre |
|---|---|
| CHL | Instituto Geográfico Militar de Chile |
| DGF | Deutsches Geodätisches Forschungsinstitut, Technische Universität München |
| ECU | Centro de Procesamiento de datos GNSS del Ecuador, Instituto Geográfico Militar |
| GNA | Instituto Geográfico Nacional de Argentina |
| IBG | Instituto Brasileiro de Geografia e Estatistica |
| IGA | Instituto Geográfico Agustín Codazzi |
| INE | Instituto Nacional de Estadística, Geografía e Informática |
| LUZ | Centro de Procesamiento y Análisis GNSS SIRGAS de la Universidad del Zulia |
| UNA | Centro Nacional de Procesamiento de Datos GNSS, Universidad Nacional |
| URY | Servicio Geográfico Militar del Uruguay |

9. Submit, within the three weeks following the observation date, your daily and weekly solutions (in SINEX format) compressed with ".gz" to the IGS-RNAAC-SIR. For login and account information please contact the IGS-RNAAC-SIR responsible (Laura Sánchez lm.sanchez@tum.de);

10. The SINEX files generated by the Processing Centres have to include complete information for the statistic block in the SINEX file header, i.e. number of observations, number of unknowns, number of degrees of freedom, sampling interval (seconds), phase

measurement sigma, and variance factor. (Please see description at https://www.iers.org/IERS/EN/Organization/AnalysisCoordinator/SinexFormat/sinex.html). In the same way, the stations included in the SINEX file have to completely be identified by 4-char code and domes number.

**Instructions for Combination Centres**

The SIRGAS Combination Centres are responsible for combining the loosely constrained weekly solutions generated by the Local Processing Centres for the SIRGAS-N national networks with the corresponding solution provided by the IGS-RNAAC-SIR for the SIRGAS-C core network. Starting the fourth week after the observation date, the weekly solutions of the Local Processing Centres shall be available for combination. If any solution is not available on time, it will be not included in the weekly combination. The combination scheme corresponds with:

1. Review of the available solutions concerning their SINEX format and the suitability for combination of unconstrained normal equations. For this purpose, it is necessary to remove the *a-priori* datum constraints which are included in the individual solutions;

2. Renaming of stations, if 4-char codes or Domes number do not coincide with the IERS Domes number data bank (ftp://igs-rf.ign.fr/pub/DOMES/codomes.snx);

3. Comparing station positions between the individual solutions as given in the submitted SINEX files to detect large discrepancies between the individual solutions;

4. Determination of relative weighting factors (also called re-scaling factors) between the individual solutions to compensate possible differences in the stochastic models. This can be performed by aligning the individual solutions to the same fiducial stations, i.e. the ITRF;

5. Identification of large outliers in the station positions and reduction of the corresponding stations before combination. It can be performed by the generation of time series and by comparing the individual solutions with each other and with the SIRGAS-C core solution;

6. Combination of the individual normal equations and residual analysis of the coordinate repeatability to identify new outliers. This and the two previous steps are iterative until a final combination is accepted;

7. Comparison of the individual solutions with the combined one and preparation of a report with the main results (transformation parameters, mean standard deviations, un-weighted RMS, residuals) to be made available together with the results of the combination;

8. Inform to the Network Coordinator about station irregularities or analysis inconveniences that show up at the combination level;

9. Generation of the following products:

   - A loosely constrained weekly solution (unconstrained normal equations for later computations);

   - A constrained weekly solution (station positions aligned to the ITRF values and cofactor matrix for internal control);

10. The filenames to be used are:

>    *cccwwwws. SNX, .CRD, .SUM*    Combined loosely constrained solution
>
>    *cccyyPwwww.snx, .crd, .sum*    Combined constrained weekly solution

being:

>    *ccc*: Combination Centre identifier
>    *wwww*: GPS week
>    *yy*: 2-digit year

For instance, the weekly solutions generated by IBGE for the GPS week 1465 are: ibg08P1465.snx (constrained weekly solution) and IBG1465S.SNX (loosely constrained weekly solution).

The IGS-RNAAC-SIR products use the same nomenclature with SIR as identifier.

11. Submission of the combined products to the IGS-RNAAC-SIR within the four weeks following the observation date. For login and account information please contact the IGS-RNAAC-SIR responsible (Laura Sánchez, lm.sanchez@tum.de).

**Guideline for the geodetic datum definition within the weekly solutions of the SIRGAS-CON network** (defined at the SIRGAS 2009 General Meeting, Buenos Aires, Argentina, September 1, 2009)

1. The IGS reference frame stations existing in the SIRGAS region shall be introduced as fiducial stations. At present, they correspond to the IGS14 stations;

2. As reference coordinates for the fiducial stations shall be introduced the station positions determined within the IGS weekly combinations (igs*yy*P*wwww*.snx, *yy* = year, *wwww* = GPS week). The application of constant velocities to extrapolate station positions from a given reference epoch is explicitly not recommended:

3. The a-priori standard deviation assigned to the reference coordinates within the network adjustment shall correspond to the standard deviations for station positions determined by the processing software. If the Bernese software is applied, ±1E-04 m shall be used.

4. This guideline will be updated when a new ITRF solution is available.