REPORT ON THE SIRGAS-CON COMBINED SOLUTION, BY IBGE ANALYSIS CENTER

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INTRODUCTION

Since the SIRGAS2008 Meeting, the Instituto Brasileiro de Geografia e Estatística – IBGE supported the SIRGAS reference frame as Analysis Centre of the SIRGAS-CON (SIRGAS Continuously Observing Network). The official solutions started on week 1495 (August 31, 2008). Since then, 3 Local Processing Centres, CIMA, IBGE and IGAC are responsible to deliver weekly solutions that must be available 3 weeks after the date of observation.
The 3 Local Processing Centres are identified in this work as:
CIM : Instituto de Geodesia y Geodinámica de la Universidade Nacional de Cuyo IGG-CIMA, Argentina. This centre is in charge of processing SIRGAS-CON stations from the southern SIRGAS-CON sub-network.
IBG : Instituto Brasileiro de Geografia e Estatística(IBGE), Rio de Janeiro , Brasil. This centre is in charge of processing SIRGAS-CON stations from the central SIRGAS-CON sub-network.
IGA : Instituto Geográfico Agustín Codazzi (IGAC), Bogotá, Colombia. This centre is in charge of processing SIRGAS-CON stations from the northern SIRGAS-CON sub-network.
Deutsches Geodätisches Forschungsinstitut-DGFI, identified as SIR, process SIRGAS-CON data from a core sub-network which has stations in stable locations to ensure long-term stability of the reference frame.

At the same time, IBGE started the combination task of weekly solutions from Local Processing Centres and DGFI. One of IBGE Analysis Centre tasks is the combination of weekly solutions computed by each SIRGAS-CON Processing Centre and generate week solutions adjusted to the IGS05 reference frame. The combined solutions must be delivered 4 weeks after the date of observation. Results are available at IBGE FTP server in two types of weekly combined solutions: loosely constrained and constrained solutions.

For the combined solution presented in this work the coordinates of 182 stations were estimated using the IGS05 Reference Frame at epoch 2000,09 (GPS week 1513). The solutions provided by CIM, SIR, IBG and IGA span the period of week 1495 to 1531 (37 weeks, from October 2008 to May 2009), and are available as loosely constrained weekly solution (CCC*wwww*7.SNX).

Four combination strategies were evaluated using the minimum constraints approach, preserving the original characteristics of the weekly solutions and providing the alignment to the IGS05 reference frame. The procedures adopted for the combination and statistical analysis of results are presented as well.

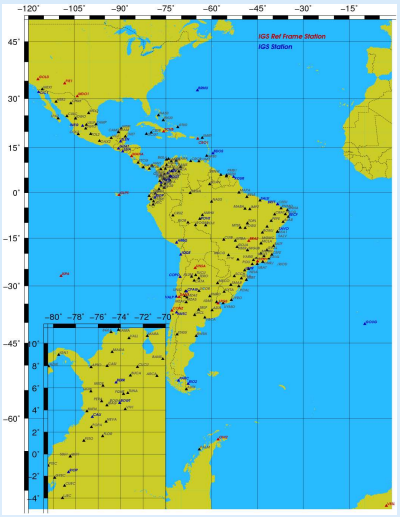


Fig. 1 – SIRGAS-COM Network, status may 2009

IBGE COMBINATION STRATEGY

The steps bellow describe the combination of weekly solutions provided by Processing Centres :

Step	
(1)	Constraints are removed from the weekly solutions of each Processing centre, using the free network solution strategy;
(2)	The free network solution of each processing centre is aligned to a set of stations that belong to IGS05 (2000.0) Reference network applying "no net rotation" and "no net translation" conditions. The IGS05 stations are: BRAZ, CHPI, CONZ, GOLD, ISPA, LPGS, MANA, MDO1, OHI2, PIE1, SANT, SCUB, UNSA and VESL.
(3)	The coordinates from step (2) of each processing centre are compared with IGS05 coordinates propagated to week epoch and between themselves to identify possible high residuals. The stations with residuals exceeding 10 mm in horizontal components and 20 mm in the vertical component will be analyzed and possibly removed from the solution. In the case of station exclusion the steps (1) and (2) will be repeated for the refinement of final solution and consequently the variance factor of the estimate.
(4)	The covariance matrix of each solution is scaled by the variance factor or scale factor.
(5)	The normal equations of each solution are combined to produce the loosely constrained weekly solution (IBG*wwww*S.SNX) applying a weight of 1 meter to all stations.
(6)	The normal equations of each solution are combined to produce the constrained solution (IBG*yyPwwww*.SNX) applying a weight of 1E-04 meters for IGS05 stations mentioned in step (2).
	Software: Bernese 5.0
	Available at: ftp://geoftp.ibge.gov.br/SIRGAS/Resultados/Combinacao/
	Solutions: loosely constrained weekly solutions (IBG*wwww*S.SNX) constrained weekly solutions (IBG*yyPwwww*.SNX)

EVALUATION OF NEW COMBINATION STRATEGIES FOR A PERIOD 1495 TO 1531

Four combination strategies were carried out for a period of 37 weeks (1495 to 1531 GPS week) in order to choose the best solution of SIRGAS-CON they are:

Strategy	Description	Reference of Coordinates
(1)	Minimum constraint conditions: the solution is aligned to a set of IGS stations, from IGS05 (IGS05_R.CRD) realization, applying the "no net rotation" and "no net translation" conditions.	IGS05_R.crd coordinates. propagated to week 1513, using IGS05_R.vel
(2)	Minimum constraint condition: Solution is aligned to a set of IGS stations, from IGS05 week (IGSyyPwwww.CRD) realization, applying the "no net rotation" and "no net translation" conditions.	IGS week solution 1513 (IGS09P1513.crd)
(3)	Constraint solution: constrain coordinates to a set of IGS05 stations to their a priori coordinates for geodetic datum definition. The strength of the constraints is 1E-06 m in all components.	IGS05_R.crd coordinates. propagated to week 1513, using IGS05_R.vel
(4)	Constraint solution: constrain coordinates of a selected set of IGS05 stations to their a priori coordinates for geodetic datum definition. The strength of the constraints is 1E-06 m in all components.	IGS week solution 1513 (IGS09P1513.crd)

RESULTS AND COMPARISON OF DIFFERENT STRATEGIES

Tables 1 and 2 present the transformation parameters between IGS05 and SIR solution, epoch 2009,02 (GSP week 1513) and the four combination strategies, in order to check the external fit of each solution to IGS05. As can be seen, rotation and scale are meaningless in these results; translations values are bigger in strategies (1) and (3).
Table 3 shows that the four strategies proposed have a good consistency with IGS and SIR solution, but bigger RMS were found in strategy (3).

Strategy	Tx(mm)	Ty(mm)	Tz(mm)	Rot_X(")	Rot_Y(")	Rot_Z(")	scl(mm/km)
(1)	-3.5	-4.2	7.4	-0.00005	-0.00005	-0.00016	0.0002
(2)	0.8	-1.6	5.4	-0.00003	-0.00005	-0.00013	0.0002
(3)	-6.1	-3.7	5.8	-0.00021	-0.00000	-0.00023	0.0002
(4)	-1.0	-1.4	2.9	-0.00009	-0.00002	-0.00005	0.0000

Table 1 – Transformation parameters between IGS05 weekly solution (week 1513) and each combination strategy.

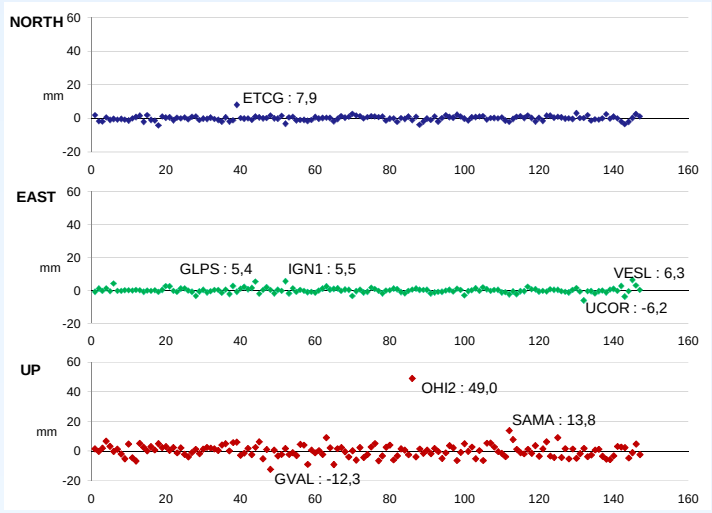
Strategy	Tx(mm)	Ty(mm)	Tz(mm)	Rot_X(")	Rot_Y(")	Rot_Z(")	scl(mm/km)
(1)	-0.4	-3.7	5.2	0.00000	0.00003	-0.00007	-0.0003
(2)	3.4	-1.3	3.2	0.00002	0.00004	-0.00005	-0.0003
(3)	-3.5	-2.4	3.0	- 0.00013	0.00006	-0.00015	-0.0001
(4)	1.2	-0.7	0.7	-0.00004	0.00006	0.00002	-0.0003

Table 2 – Transformation parameters between SIR weekly solution (week 1513) and each combination strategy.

	IGS			SIR		
Strategy	North (mm)	East (mm)	Up (mm)	North (mm)	East (mm)	Up (mm)
(1)	1.4	2.0	3.6	1.4	1.6	4.0
(2)	1.4	2.0	3.6	1.4	1.6	4.0
(3)	**3.1**	**2.2**	**6.2**	**1.9**	**1.6**	**4.6**
(4)	1.1	1.5	3.9	1.5	1.5	3.9

Table 3 – RMS of coordinate residuals between each combination strategy and week solution (1513) of IGS and SIR.

Residuals differences between solution (2) - Minimum constraint condition and SIR constrained weekly combination (SIR09P1513.crd)



CONCLUSIONS

The results were satisfactory even considering the small problems related to antenna/receiver identifications as well as related to antenna height.
It´s still necessary add more redundant solutions for as many stations as possible, especially those in the SIRGAS-CON network. Many SIRGAS-CON stations are still in only in one regional solution and therefore have no independent quality control check.
There are several strategies to integrate a regional solution in the global ITRF frame, having different impacts on the results influenced by the weighting, network configuration and quality of observations. Analyzing the four adjustment strategies shown in the results section, the free network solution with minimum constraints approach, allows the integration of the SIRGAS2000 network in the IGS05, keeping this way its internal and original consistency.