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RESULTS FROM THREE GPS CAMPAIGNS IN TIERRA DEL FUEGO

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ABSTRACT

During January and February 1990, 1991 and 1992 an important collaboration took place between the Río Grande Astronomical Station (Estación Astronómica de Río Grande - EARG) and the Royal Institute and Observatory of the Spanish Navy (Real Instituto y Observatorio de la Armada de España - RIOA) .
Using RIOA GPS receivers a single base between one point in EARG (Río Grande) and another point located at the Centro Austral de Investigaciones Científicas (CADIC, Ushuaia) was measured several times.
Measured distances repetitivity is about 0.7 ppm (9 cm) and in components, 1 ppm. These results will permit the planning of an appropriate network to be measured with GPS which will contribute to the determination of crustal movements in the Tierra del Fuego region.

RESUMEN

En los meses de enero y febrero de los años 1990, 1991 y 1992 se realizó un trabajo de colaboración entre la Estación Astronómica Río Grande (EARG) y el Real Instituto y Observatorio de la Armada de España (RIOA).
Con posicionadores GPS pertecientes al grupo español se midió reiteradamente una misma base entre un punto situado en la EARG (Río Grande) y otro situado en el Centro Austral de Investigaciones Científicas (CADIC, Ushuaia).
La repetitividad de las distancias medidas es del orden de 0.7 ppm (unos 9 cm) y en componentes, de 1 ppm. Esto permitirá planificar una red apropiada en la región fueguina para la determinación de movimientos tectónicos utilizando GPS.

1. INTRODUCTION

The plate boundaries in the Tierra del Fuego and Antarctic regions are more or less established (Dalziel, 1984) but the real relative movements of these plates are still a problem to be solved. Modern geodetic tools such as GPS must play an important role to determine long term tectonic movements. In this study, a first attempt to establish a precise GPS baseline in Tierra del Fuego is discussed. An introduction to this work with more details about the structure of the region may be found in Brunini et al. (1990).

During January and February of the years 1990, 1991 y 1992 an important collaboration took place between the Río Grande Astronomical Station (Estación Astronómica de Río Grande - EARG) and the Royal Institute and Observatory of the Spanish Navy (Real Instituto y Observatorio de la Armada de España - RIOA).

The RIOA group operated GPS receivers during their Antarctic campaigns, while the EARG team operated one receiver on Tierra del Fuego island. Each year, for a few days, a single base between one point in EARG (Río Grande) and another point located at the Southern Scientific Research Center (Centro Austral de Investigaciones Científicas - CADIC, Ushuaia) was measured. Two double frequency receivers (TRIMBLE 4000 SLD) were used.

During the 1990 campaign, only L1 phase measurements were obtained from one of the receivers so no results will be shown for that period, although they are within the expected errors.

During the 1991 and 1992 campaigns several sessions of at least two hours each were observed. During 1992, a new baseline between one point located next to Fagnano lake (near EOLO building) and the point at CADIC, was measured for the first time.

2. SOFTWARE AND PROCESSING TECHNIQUES

Original raw data as recorded by the TRIMBLE receivers was converted into an ASCII file with reconstructed epochs, phases and ranges, using software developed at La Plata (Canosa, 1990). Observational data so reformatted was processed using the Berna University Software version 3.0 (Rothacher et al., 1988).

The strategy used for the reduction of the data, as suggested by the authors of the software, was the following:

1. Pseudo range measurements were processed to obtain clock parameters which are introduced into the data files used later in phase processing.

2. One orbital arc was calculated for each satellite adjusting all the broadcast ephemeris obtained during the observational period (typically two day long arcs were obtained). In this way, the orbital information used to process different sessions is homogeneous.

3. Data filtering and cycle slips repairing were carried out on the L1 and L2 phase observation files.

4. Final processing was done using phase double differences of the combination "L3" (ionosphere free linear combination).

5. For the ambiguity handling, a "sigma dependent" resolution was used. This strategy consists, in the first step, in calculating all the ambiguities and their associated errors as real numbers. If one integer is close enough to the obtained real value that is contained in interval I (I = real value plus or minus three times the formal error) then the ambiguity is said to be resolved. The integer value so obtained is no more an unknown quantity in the following iterations.

It is interesting to note here that ambiguity resolution is not guaranteed, especially in long baselines. In the case of EARG - CADIC baseline processing, final solutions adopted include several sessions in which some of the ambiguities remained as real values because no integers satisfied the condition established in 5.

Session	X	Y	Z	D	H	amb. res.
1991:						
61/4	5.61	4.63	9.46	8.91	4.76	3/0
61/5	5.36	4.39	9.32	9.12	4.46	3/1
61/6	5.75	4.46	9.36	8.87	4.62	3/3
61/7	5.43	4.62	9.57	9.08	4.81	3/3
62/1	5.29	4.77	9.51	9.02	4.81	3/3
62/2	5.62	4.67	9.58	8.94	4.88	5/3
62/4	5.48	4.55	9.44	9.02	4.68	3/1
62/5	5.49	4.48	9.39	9.03	4.60	3/2
1992:						
67/1	5.49	4.52	9.46	9.04	4.68	5/1
67/2	5.44	4.77	9.31	8.83	4.67	5/5
averages	5.50	4.59	9.44	8.99	4.70	
standard deviations	0.13	0.13	0.10	0.09	0.12	

Table I. *CADIC GPS point coordinates. Results of individual sessions, averages and standard deviations.*

3. RESULTS AND COMMENTS

The results of all the sessions processed are presented in table 1. The first column indicates the date and session (an arbitrary designation); for example, in the first row, 61 is the day of the year, and 4 is the session number. Columns two, three and four show the last digits of the coordinates x, y, z respectively, in meters. Columns five and six show the last digits of the length of the baseline and the ellipsoidal height respectively. The last column shows the number of ambiguities and the number of those which have been resolved, for example, the first row 3/0 indicates that there were 3 ambiguities, but after processing none of them could be resolved. This means that the adopted solution for the session has 3 real values for the ambiguities. The last two rows show the column averages and standard deviations, respectively.

The results shown in table I are CADIC (Ushuaia) coordinates which are the unknowns of the problem because EARG (Rio Grande) coordinates have been adopted as the origin of the baseline. However, these adopted coordinates play a major role in the solution of the baseline parameters, because they remain fixed in the computation and this implies that they are supposed to be well known.

There are two important concepts related to the adopted origin. The first one is obvious; if the coordinates of the origin are changed, those on the other extreme of the baseline change too (but not exactly in the same way!). In this case, if another set of coordinates is adopted for EARG fundamental point, the coordinates in table I will also change.

The second point to stress is that a change in the origin is not exactly transferred to the unknown point coordinates. All the free parameters of the baseline computation (3 coordinates and ambiguities) will be affected by the change in the origin. It is usually accepted that the accuracy of 1ppm in the relative coordinates of the extremes of a baseline is only possible if the origin is known with an accuracy of a few meters.

The adopted coordinates of the fixed point at EARG were obtained during the 1984 MERIT Doppler Campaign (Perdomo R. and Del Cogliano D., 1988). They were obtained from doppler measurements to the TRANSIT System satellites. These coordinates were transformed to WGS84 using the parameters published in the Department of Defense World Geodetic System 1984 (1987). The single point position obtained directly from GPS measurements coincide with the transformed doppler position within the estimated errors.

The adopted coordinates for the point called EARG GPS1 in the WGS84 system are the following:

X = 1429883.76
Y = -3495363.41
Z = -5122690.40

and the estimated accuracy is 3 meters.

A DORIS beacon has been operating continuously at EARG since 1989. The absolute position of this beacon will contribute in the near future to upgrading the absolute position of the point EARG GPS1.

The coordinates of the CADIC point, obtained as the simple average of the individual values shown in table I are the following:

X = 1360235.50
Y = -3422364.59
Z = -5190059.44

D = 121318.99

where D is the distance between the two points.

As the results in table I show, measured distances repetitivity is about 0.7 ppm (9 cm standard deviation) and for the components X, Y, Z, repetitivity is 1 ppm. It is interesting to note that this is also the same order of magnitude for the ellipsoidal height (12 cm standard deviation). These results give realistic estimations of the real errors of these determinations.

So, using the methodology and equipment here mentioned, it would be possible to measure distances of 50 km with errors of 3 cm. This error can be lowered if a network containing several points is measured and adjusted. It seems evident that the next step is the design of a network to be measured with GPS, with points situated at lower distances and with a geographic distribution appropriate to the determination of all the components of the eventual crustal movements in the Tierra del Fuego region.

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