Using Cascais GPS Permanent Station for geodynamic purposes.

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SUMMARY

Cascais GPS station, the first Portuguese Reference Station, is operating since March 1997. In September 1998 was accepted as an Euref station (nº 13909S001). Between October 1999 and January 2000, three new GPS stations were installed in Portugal: one in the Azores Islands – S. Miguel, another in Gaia, near Porto, on the Northwest coast of Portugal and the third one in Lagos, on the South coast. This last station is installed near a Tide Gauge, Lagos, and it could be very important for sea level control. The behaviour of these stations should be very useful for deducing or testing geodynamic models for the area, in particular the Açorean station as it is located near the triple junction zone of the American, African and Eurasian plates.

In Cascais, a five years time series of observations (24h a 30s), is giving us some time to deduce a pattern of behaviour for the station relatively to some other permanent stations. We have ourselves limited this study to two stations in Central Europe (Brussels and Zimmerwald) and to Maspalomas (African Plate) and S. Fernando (in Iberian Peninsula). Processing 2 days each two months, from May 1997 to April 2002, we will try to deduce the relative movements of Cascais within that period. We also introduce in this study, some of the new Portuguese GPS stations, especially the one in Azores. The observation period is still very short, about 2 years, to draw strong conclusions, but will be enough to shows up eventual existing tendencies.

Our strategy will be slightly different from the usual ones based upon the variation of the coordinates. We will monitor, instead, the variation of the distances in order to set us free of the referential constraints.

1. Introduction

The first Portuguese GPS Reference Station (CASC) was installed in Cascais, in May 1997, near the Cascais Tide Gauge. About 5 years of high quality data for that station are now available. This study is based upon the results of processing 2 consecutive days of GPS data, at 30s, each two months, connecting Cascais to some other EUREF stations (fig.1) chosen in the African and Eurasian plates. We will try to deduce relative movements between Cascais and those stations, within that period. By the end of 1999, our Institute installed 3 new Reference Stations, in Lagos (LAGO), in Ponta Delgada (PDEL), Açores, and in Gaia (GAIA) near Porto. We introduce, also, in this study, the first 2 years data from data stations. From a geodynamic point of view the PDEL station is the most important, because is located in the confluence of three tectonic plates, African, Eurasian and American. Although the observation

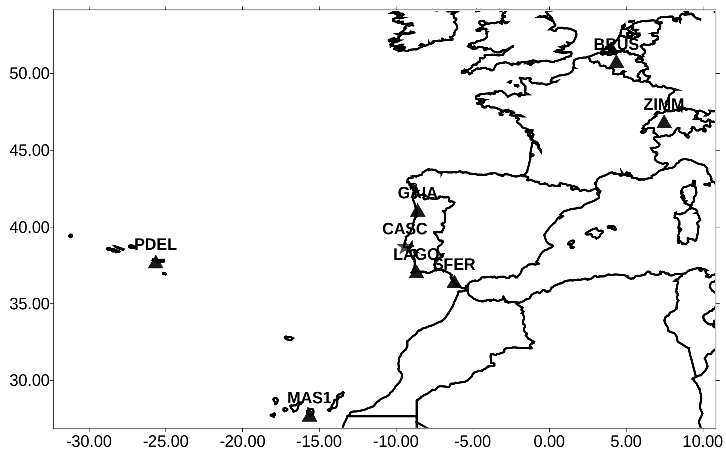

Fig.1- Distribution of the chosen stations

period is still very short, about 2 years, to draw strong conclusions. Maybe, will be enough to test the agreement with the accepted models for the area.

Our major concern will be, not deducing the displacement vectors, from the changes in the coordinates, but the variations of the distances.

Accordingly our strategy will be slightly different from the usual ones. We will compute the distances, instead of controlling the variation of the coordinates. The distances should be independent of the geodetic frame used, and so we will avoid some perturbing problems related to the change of the reference frame during that period.

2. Data and Epochs

The processed data consist in the GPS Rinex files (24h a 30s), two consecutive days, each two months. A two consecutive days period will cover a double full cycle on the most important parameters that causes the GPS observable to change. Each day was computed independently. The epoch value is the mean of this two days. An epoch each two month will provide, for the analysed time interval (97.05 to 2002.04), enough epochs.

3. Processing strategy

The GPS data was processed with Bernese 4.0 and 4.2 software, using precise orbits and the QIF (Quasi-Ionosphere Free) strategy for the ambiguity resolution.

For each epoch, the network was adjusted in Cartesian tridimensional coordinates in the ITRF96 reference frame. Brussels coordinates, a fiducial station of the EUREF network, were kept constraint to their ITRF96 values. Firstly, a daily solution for all the network was calculated obtaining normal equations that were combined together, year by year, by ADDNEQ subroutine, giving us the so called combined solution for these years.

The distances between Cascais and the others stations were computed from these coordinates solutions for each epoch.

4. Network

Figure one illustrates the distribution of the stations used. The network is built in a star form, consisting in the connections between Cascais to the other stations.

Brussels and Zimmerwald were chosen due to the fact that are fiducial EUREF stations and are supposed to be in a stable part of the Eurasian plate, mainly Brussels. S. Fernando because is near the African plate boundary and is operating since many years. Maspalomas, on the African plate was an imperative choice, as well as Ponta Delgada, in Açores. This last location is very important indeed, because the detailed geodynamic behaviour of the triple junction zone is not yet well known. Several theories gives Ponta Delgada in the African plate, others in the Eurasian plate, there is no agreement.

5. Repeatabilities

For repeatability of a station we mean the r.m.s. error of the coordinates obtained for this station in each epoch, against the combined year solution. The coordinates were computed in the frame of ITRF96 reference system, using Brussels as a fiducial point.

A repeatability table is a tool for detecting some gross errors on the processed station. The amplitudes of the repeatabilities values are due to three main causes: the inner error of the processed GPS baseline; the short period relative movements of the stations and the eventual displacements itselfs.

The short period movements are caused mainly by earth tides, ocean and atmospheric loading effects, ionospheric and tropospheric refraction. The processing software is supposed to model these effects, but, obviously, not completely.

Analysing these results some conclusions can be drawn:

1- The maximum amplitude of the repeatability value is about 15 mm for the North and East component and 40 mm for the Up.
2- Cascais shows values lesser than 10mm for the North and East component and 20 mm for the up.
3- Maspalomas and S. Fernando have the greatest values, especially due to the lack of many observations.
4- This sets our limit of significance, for the distance variation between each of these stations and Cascais, on about 10 mm, i.e., only distance variations greater than 10 mm might have geodynamic meaning.

6. Distance variations

In this extended abstract it is not possible to present all the graphics that illustrates the variation of all the computed distances, between Cascais and the other stations.

So, we choose three graphics too illustrate the distance variations, CASC-BRUS (fig.2), CASC-MAS1 (fig.3) and CASC-PDEL (fig.4).

The differences were worked out from each epoch against the first day of epoch one. The straight line in each graph is the regression fit line for this data.

Analysing all the graphics we can draw some conclusions:

1- The amplitudes of the distance variations rise above the established significant limit in only two cases: Cascais to Mas1 and Cascais to Ponta Delgada. In all the other cases the distances variations have, according the repeatabilities, no significance.
2- Analysing fig.2 we can conclude that there are a slight tendency for decreasing this distance in about 1,2 mm/year ± 0.8 mm/year.

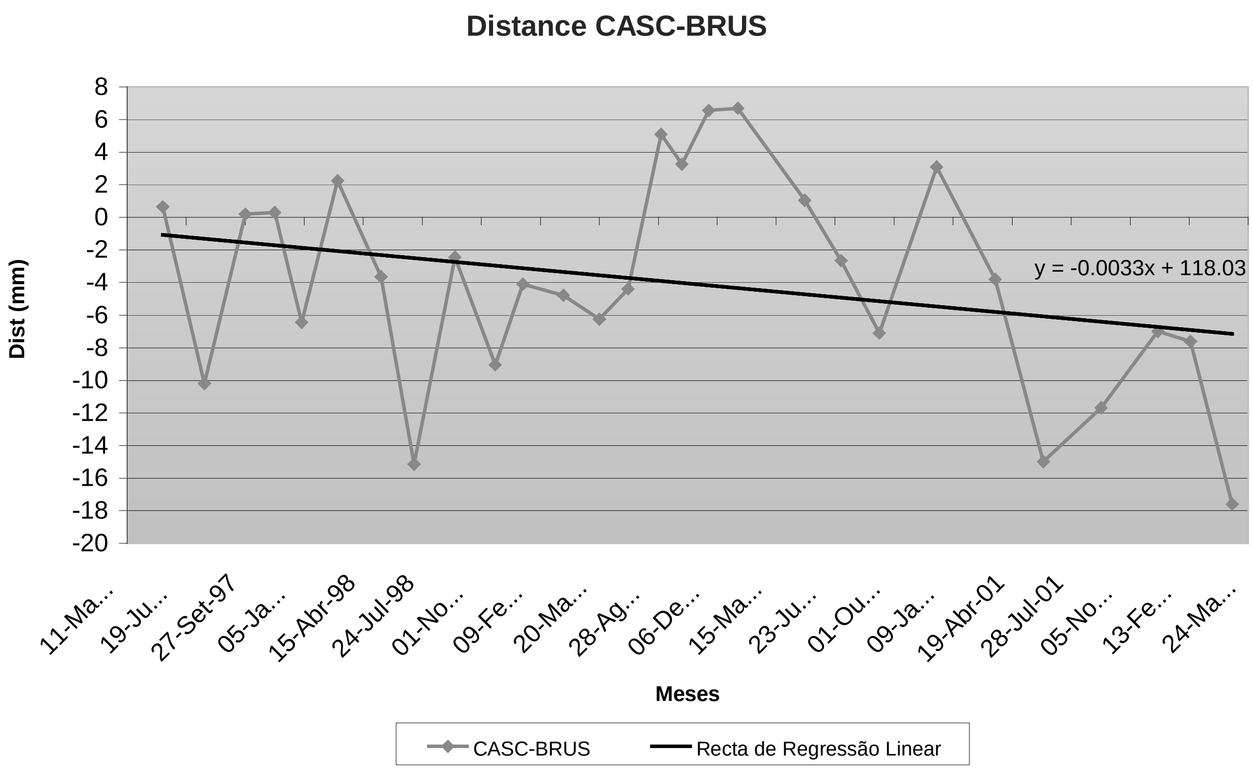

Fig.2 – Distance Cascais-Brussels

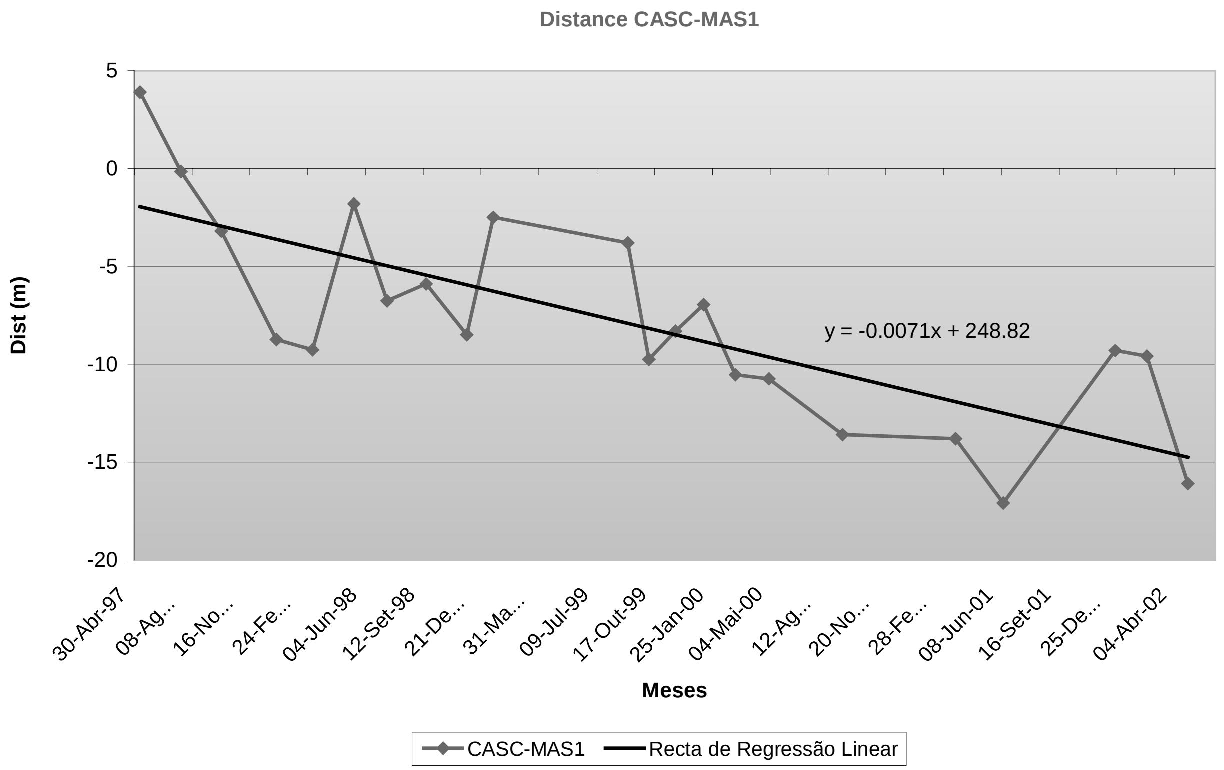

Fig.3 – Distance Casc-Mas1

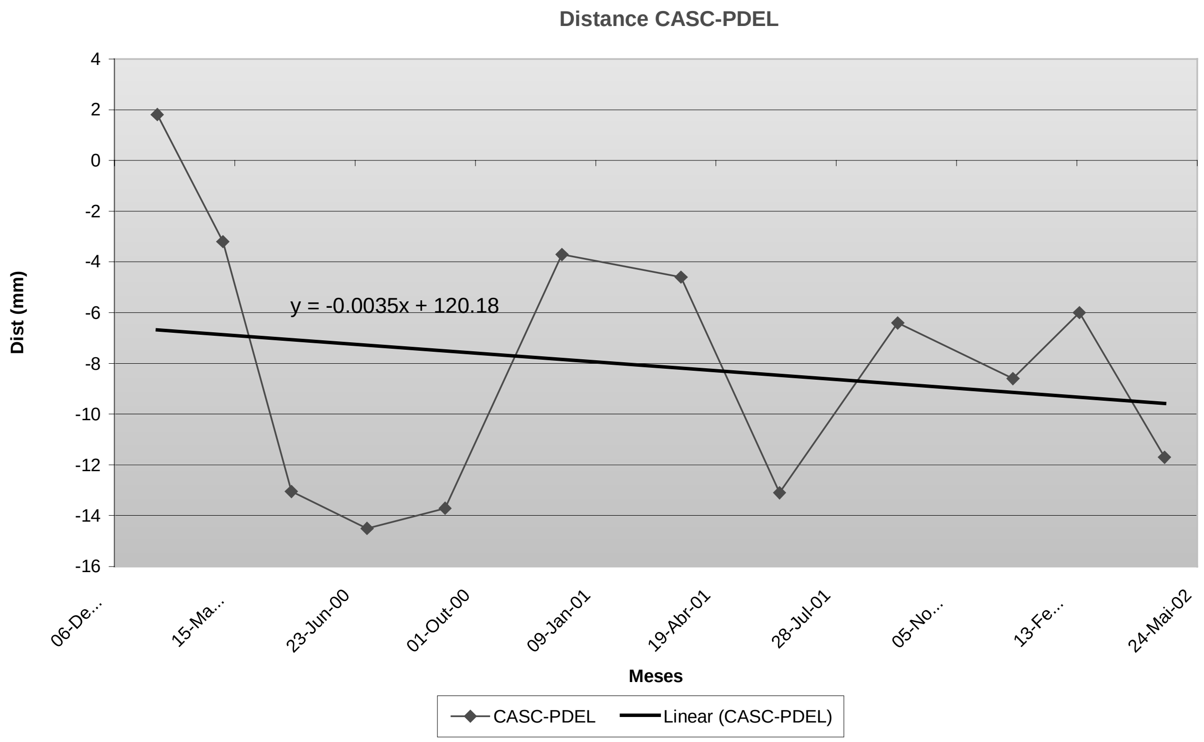

Fig.4 – Distance Casc-PDEL

3- For the distance CASC-MAS1 we have a decrease of 2,6 mm/year ± 0,5 mm/year this values indicates some statistical meaning (the value is greater than the RMS) that confirms the distance variation.

4- For CASC-PDEL, Despite the short time interval (2 years), we have a strong shortening of the distance CASC-PDEL, 1,7 mm/year ± 2,0 mm/year, although, this value is not very significantly because the RMS is bigger than the distance variation.

5- Statistically, the distance variation values obtained for the other distances are not significantly.

7. Comparison with NUVEL-1A model

From NUVEL model we deduced a broad model for the expected annual variation of the distance in order to make a comparison with the observed values.

1º- We deduced the velocities of all the stations, based in the plate motion of the model.

2º - The relative velocities between CASC and all the other stations were determined.

So, based in the model we have the annual variation of the distances that allow us a direct comparison with the observed values.

The table presents the velocities values deduced from the model.

Stations (A, B)	A (mm/year) (projected)	B (mm/year) (projected)	Nuvel ΔV (mm/year)	Signal
CASC-BRUS	22,96	23,44	0,48 (0,4)	+ (-)
CASC-MAS1	22,54	22,75	0,2 (3,4)	- (-)
CASC-ZIMM	24,1	24,1	0 (0,9)	(-)
CASC-PDEL	15,79	13,78	2,0 (3,0)	+ (-)

Our distance variations agrees with the Nuvel1A model, although our velocities are greater than the model velocities, except for Casc-Pdel and Casc-Mas1.

According to the NUVELL model no significant variation should be expected for this distance, if it belongs to the Eurasian plate. If it stays in the African plate we should expect an expansion, instead of the observed shortening. Nevertheless the shortening could be explained, even with the African hypothesis, according to some local geodynamic models, but not the high-observed rate.

Relative to Casc-Mas1 our velocity is much greater than the model velocity, although in the same direction.

8. Geodynamic interpretation of the results

1. The most striking result is the shortening of the CASC-PDEL distance. This must be confirmed in the near future, but, if confirmed, it carries some evidence for the proposed model of an existing subduction zone along the Portuguese West Atlantic coast (António Ribeiro, 1996), assuming that Ponta Delgada is in Eurasia.
2. The tendency for the shortening of Cascais-Maspalomas distance fit in the known tectonic plate dynamics.
3. The fact that no significant variations were observed in the other distances, shows that the NW part of the Eurasian plate is stable.

References:

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