The BALEAR98 Project: final results

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Summary

During the week of 20th to 24th April 1998 **BALEAR98 campaign** was prepared, observed, and done between direct co-operation *Instituto Geográfico Nacional (IGN)* and *Servicio Geográfico del Ejército (SGE)*. The main objective of BALEAR98 is densification in the Balearic Archipelago of the *European Terrestrial Reference Frame 1989* (ETRF89) and precision improvement of GPS **EUREF89** campaign in the isles, establishing a high precision tridimensional geodetic network similar to **IBERIA95** in the Iberian Peninsula, of which two stations coincide with those of EUREF89. The campaign covers a network of 6 stations, 2 in Menorca, 2 en Mallorca y 2 in the Pitiusas. Processing was made using *Bernese GPS software, UNIX 4.0 Version*, including here final co-ordinates in the reference system ITRS96 epoch 1998.4 and reference frame ETRF89.

Simultaneously to BALEAR98, both institutions performed **REGENTE BALEARES** campaign, which consisted of 19 GPS stations observation (which included the 6 stations of BALEAR98) according to the whole established rules of REGENTE Project. The final processing and co-ordinate results in the same system and reference frame already mentioned was leaned in BALEAR98 obtained co-ordinates.

In the following week, two technicians of SGE, with support of an Spanish Air Forces helicopter, observed GPS of two stations in Columbrete Grande Island which, by this way, was perfectly linked to Balearic Islands.

In the campaign observations participated 3 officials of SGE and 10 Technical Engineers. Processing steps were carried out in "Área de Geodesia" facilities of IGN in Madrid by a mixed team of both institutions, being of mention the excellent collaboration showed by all participants.

BALEAR98 CAMPAIGN

1. Introduction

Results obtained in the Iberian Peninsula as well as in Balearic Archipelago, during EUREF89 campaign were not satisfactory enough, due to both a poor geometric orbital configuration at that time, as a result of small number of NAVSTAR vehicles, and to a high SLD receivers noise used. All this drove to IBERIA95 Project and BALEAR98 in order to improve quality of former results.

Early 1998, Servicio Geográfico del Ejército, SGE, and Instituto Geográfico Nacional, IGN, began contacts to resume a fruitful geodetic collaboration already shown in EUREF89, IBERIA95 and REGENTE 94 campaigns. The geodetic staff responsible for both institutions agreed in planning and carrying out together all GPS tasks in The Balearic Islands, keeping for SGE, due to logistic reasons, additional actions in Columbrete Grande Island. In March rules to choose stations were established, their monumentation and observation. Due to The excellent result reached in peninsular campaign IBERIA95, we decided to accept The same rules, adapted or adequate to The archipelago, in BALEAR98 project stations to be occupied:

Adequate distance between stations belonging to each island.

Stable and long life monumentation.

- Forced centering installed to remove related errors.
- GPS mark points with high precision levelling or located on sites where orthometric high precision heights can be easily obtainable.
- No broadcasting antennas neither obstacles near stations that could produce multipath effect.
- Stations are easily accessible and easily leveling.

During March 1998, a reconnaissance of selected points was made and The selected points were:

- Isle of Menorca:
  Point 61800 BAJOLÍ (ROI)
  Point 64715 BINIACH (ROI y EUREF89)
- Isle of Mallorca:
  Point 67067 MULETA (ROI)
  Point 72521 PORTO PETRO (ROI)
- Isle of IBIZA:
  Point 77263 FURNÁS (ROI)
- Isle of Formentera:
  Point 85000 MOLA (ROI y EUREF89)

Bad conditions of accessibility to *talayot* in which summit point CALA MANACOR (Mallorca) is placed advised not to take it into account, although it belonged to EUREF89 and The possibility to establish comparison between both campaigns.

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2. Observation

BALEAR98 GPS campaign was observed from 20th (110) to 24th (114) April de 1998, using six TRIMBLE 4000 SSE receivers and two antenna types, 4000 ST L1/l2 GEOD y TR GEOD L1/L2 GP.

	STATION	RECEIVER	TYPE	ANTENNA HEIGHT	EPOCHS	BEGIN	SESSIÓN	END	SESSIÓN
1	FURNAS	TRIMBLE	4000SSE	0.0450	1439	98-04-20	6:00:30	98-04-20	17:59:30
2	FURNAS	TRIMBLE	4000SSE	0.0450	1439	98-04-21	6:00:30	98-04-21	17:59:30
3	FURNAS	TRIMBLE	4000SSE	0.0450	1439	98-04-22	6:00:30	98-04-22	17:59:30
4	FURNAS	TRIMBLE	4000SSE	0.0450	1439	98-04-23	6:00:30	98-04-23	17:59:30
5	FURNAS	TRIMBLE	4000SSE	0.0450	1439	98-04-24	6:00:30	98-04-24	17:59:30
6	MOLA	TRIMBLE	4000SSE	0.0430	1438	98-04-20	6:01:00	98-04-20	17:59:30
7	MOLA	TRIMBLE	4000SSE	0.0430	1439	98-04-21	6:00:30	98-04-21	17:59:30
8	MOLA	TRIMBLE	4000SSE	0.0430	1439	98-04-22	6:00:30	98-04-22	17:59:30
9	MOLA	TRIMBLE	4000SSE	0.0430	1439	98-04-23	6:00:30	98-04-23	17:59:30
10	MOLA	TRIMBLE	4000SSE	0.0430	1439	98-04-24	6:00:30	98-04-24	17:59:30
11	MULETA	TRIMBLE	4000SSE	0.0430	1438	98-04-20	6:00:30	98-04-20	17:59:30
12	MULETA	TRIMBLE	4000SSE	0.0430	1438	98-04-21	6:01:00	98-04-21	17:59:30
13	MULETA	TRIMBLE	4000SSE	0.0430	1439	98-04-22	6:00:30	98-04-22	17:59:30
14	MULETA	TRIMBLE	4000SSE	0.0430	1439	98-04-23	6:00:30	98-04-23	17:59:30
15	MULETA	TRIMBLE	4000SSE	0.0430	1439	98-04-24	6:00:30	98-04-24	17:59:30
16	PORTO PETRO	TRIMBLE	4000SSE	0.0450	1439	98-04-20	6:00:30	98-04-20	17:59:30
17	PORTO PETRO	TRIMBLE	4000SSE	0.0450	1439	98-04-21	6:00:30	98-04-21	17:59:30
18	PORTO PETRO	TRIMBLE	4000SSE	0.0450	1430	98-04-22	6:05:00	98-04-22	17:59:30
19	PORTO PETRO	TRIMBLE	4000SSE	0.0450	1437	98-04-23	6:00:30	98-04-23	17:59:30
20	PORTO PETRO	TRIMBLE	4000SSE	0.0450	1439	98-04-24	6:00:30	98-04-24	17:59:30

Observations were simultaneously made during five consecutive days, each day 12 hours between approximately 07.00 and 19.00 UTC, every 30 seconds, observation mask of 15º above horizon and meteorological data every hour.

Antennas were oriented roughly to North direction trying to diminish phase centre errors due to satellite height variation.

3. Data processing

Calculus and adjustments were made in Processing facilities of "Área de Geodesia" of IGN by a mixed team, using *Bernese GPS software, UNIX 4.0 Version.* From raw data stored in receivers in TRIMBLE format, a previous conversion into RINEX format (*Receiver Independent Exchange Format*) was made, testing and introducing the convenient modifications in the antenna heights (accordingly with observation sheets) so that reference points and GPS markers were the correct ones. Later on a conversion to Bernese V3.0 format was made before processing. Bernese is installed in a SUNW-ULTRA1 workstation:

UltraSPARC 167mhz

RAM Physical Memory 128 Megabytes

Virtual Memory 355 Megabytes

SUNOS Release 5.5.1

UNIX System V Release 4.0 y Openwindows 5.5.1

Internal Disk 2.1 Gygabyte.

External Disk 5 Gygabytes

UNIX computer. It allows interchange of data between analysis centres as well as for international campaigns like EUVN, being RINEX format and Hatanaka and UNIX compression to easy this flow of information. Also this operating system has a higher process velocity for RAM is bigger and microprocessor velocity.

3.1 Processing strategy

a) Precise Ephemerides were used and Earth Rotation Parameters produced by *International GPS Service for Geodynamics* (IGS). From IGS orbits of GPS week number 954 in SP3 format expressed in ITRF-96 reference frame, tabular orbits were generated and finally standard orbits, which are introduced in Bernese software.

b) Reference Station co-ordinates in ITRF96 epoch 1997.0 were used in the same orbit reference frame, ITRF96

epoch 1997.0. These co-ordinates were translated into 1998.31 epoch, making use of IERS associate velocities (Web page Internet of IERS).

c) Processing of all co-ordinates with Bernese software epoch 1998.3.

ITRF96 coordinates epoch 1997.0 and velocities.ITRF96 coordinates epoch 1998.31

domes number	name	ID.	X Vx	Y Vy	Z Vz	X	Y	Z
12725M003	Cagliari	CAGL	4893378.948	772649.633	4004182.054	4893378.939	772649.650	4004182.064
12725M003			-0.007	0.0127	0.0079			
10002M006	Grasse	GRAS	4581691.023	556114.691	4389360.69	4581691.007	556114.716	4389360.699
10002M006			-0.012	0.0189	0.0106			
13410M001	Roquetes	EBRE	4833520.258	41536.952	4147461.441	4833520.241	41536.97	4147461.463
13410M001			-0.0126	0.0140	0.0169			
13406M001	Villafranca	VILL	4849833.799	-335049.18	4116014.831	4849833.79	-335049.15	4116014.847
13406M001			-0.0071	0.0188	0.0122			

3.2 Reference stations

Bearing in mind the closest IERS stations together with the shape of Balearic Archipelago, it was concluded that the optimal fiducial stations should be chosen among VILLAFRANCA (VILL), EBRO (EBRE), GRASSE (GRAS), and CAGLIARI (CAGL).

From early 1998, IGN installed a TRIMBLE 4000 Ssi receiver in the same place of EUVN97 campaign, Alicante tide gauge. The final objective was establishing a permanent GPS station at that point, connected to tide-gauge and by phone to IGN. Since 9.09.1999 ALAC GPS permanent station belongs to the EUREF Permanent Network.

Due to ALICANTE station (ALAC) collected data during the whole BALEAR98 campaign and bearing in mind that high precision coordinates from EUVN97 campaign (transformed to ETRF89) were available, a comparison in results is made in point 7.

3.3 Preprocessing

A rough initial solution from pseudo distances with L1 frequency C/A code data was performed to obtain adequate values for the receiver clock errors as well as approximate coordinates.

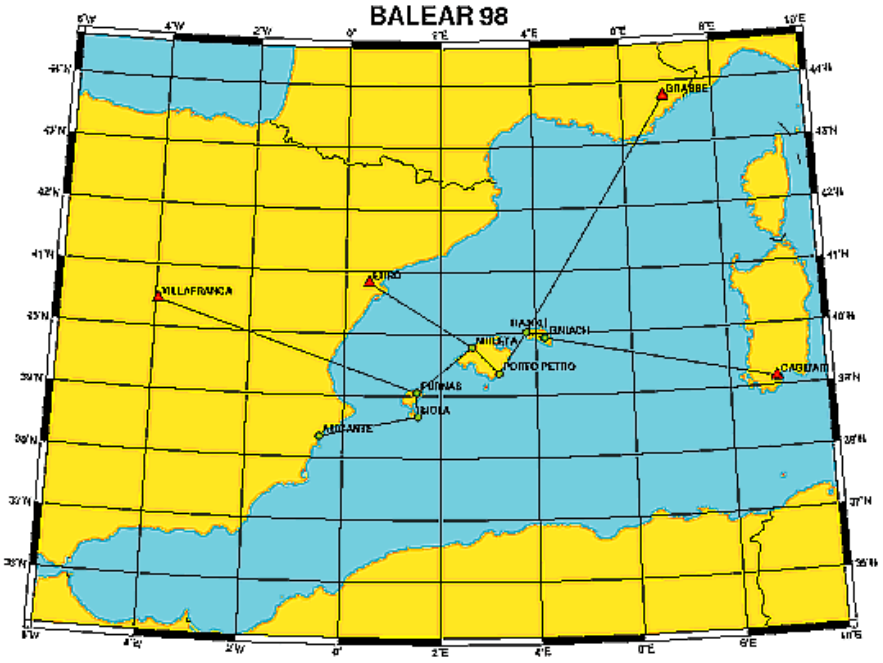
Satellite view of Balearic Islands.

For each day code and phase simple difference baselines were formed with the minimum path method. In this way, baseline configurations are shown in figure. Cycle slips were repaired or removed to get a good quality in the observations used for the final processing. Approximate coordinates were calculated as a first solution without fixing ambiguities to be introduced into the final step of calculation.

3.4 Free Network Solution

In order to derive an estimation about quality of data to be used, a four station network with reference stations was processed, keeping EBRE fixed. Comparing five day solutions, we could get an idea of the campaign data accuracy and reference stations.

Receivers, epochs observed and antenna heights are given in the table below.



station name	receiver type	antenna height	epochs	begin	session	end	session
CAGLIARI	ROGUE SNR-8100	0.0450	2877	98-04-20	0:00:00	98-04-20	23:59:00
CAGLIARI	ROGUE SNR-8100	0.0450	2879	98-04-21	0:00:00	98-04-21	23:59:00
CAGLIARI	ROGUE SNR-8100	0.0450	2879	98-04-22	0:00:00	98-04-22	23:59:00
CAGLIARI	ROGUE SNR-8100	0.0450	2879	98-04-23	0:00:00	98-04-23	23:59:00
CAGLIARI	ROGUE SNR-8100	0.0450	2879	98-04-24	0:00:00	98-04-24	23:59:00
EBRE	TRIMBLE 4000SSI	0.0000	2880	98-04-20	0:00:00	98-04-20	23:59:30
EBRE	TRIMBLE 4000SSI	0.0000	2880	98-04-21	0:00:00	98-04-21	23:59:30
EBRE	TRIMBLE 4000SSI	0.0000	2880	98-04-22	0:00:00	98-04-22	23:59:30
EBRE	TRIMBLE 4000SSI	0.0000	2880	98-04-23	0:00:00	98-04-23	23:59:30
EBRE	TRIMBLE 4000SSI	0.0000	2880	98-04-24	0:00:00	98-04-24	23:59:30
GRAS	ROGUE SNR-12 RM	0.0350	2863	98-04-20	0:00:00	98-04-20	23:59:30
GRAS	ROGUE SNR-12 RM	0.0350	2880	98-04-21	0:00:00	98-04-21	23:59:30
GRAS	ROGUE SNR-12 RM	0.0350	2880	98-04-22	0:00:00	98-04-22	23:59:30
GRAS	ROGUE SNR-12 RM	0.0350	2880	98-04-23	0:00:00	98-04-23	23:59:30
GRAS	ROGUE SNR-12 RM	0.0350	2880	98-04-24	0:00:00	98-04-24	23:59:30
SFER	TRIMBLE 4000SSE	16.260	2877	98-04-20	0:00:30	98-04-20	23:59:00
SFER	TRIMBLE 4000SSE	16.260	2878	98-04-21	0:00:30	98-04-21	23:59:00
SFER	TRIMBLE 4000SSE	16.260	2878	98-04-22	0:00:30	98-04-22	23:59:00
SFER	TRIMBLE 4000SSE	16.260	2877	98-04-23	0:00:30	98-04-23	23:59:00
SFER	TRIMBLE 4000SSE	16.260	2878	98-04-24	0:00:30	98-04-24	23:59:00
VILL	ROGUE SNR-8100	0.0437	2880	98-04-20	0:00:00	98-04-20	23:59:30
VILL	ROGUE SNR-8100	0.0437	2880	98-04-21	0:00:00	98-04-21	23:59:30
VILL	ROGUE SNR-8100	0.0437	2880	98-04-22	0:00:00	98-04-22	23:59:30
VILL	ROGUE SNR-8100	0.0437	2880	98-04-23	0:00:00	98-04-23	23:59:30
VILL	ROGUE SNR-8100	0.0437	2880	98-04-24	0:00:00	98-04-24	23:59:30

Comparison of station coordinates with respect to the combined solution in mm - unweighted rms of individual coordinate residuals									
NUM	STATION	#FIL	C	RMS	1	2	3	4	5
5	CAGLIARI	4	N	1.2	-1.3		1.4	-0.1	-0.6
			E	0.7	-0.2		0.2	1.1	0.4
			U	5.1	-4.7		1.7	6.4	-3.4
2	GRAS	5	N	2.5	-2.5	0.4	-1	4.1	-1.2
			E	2.3	-0.4	-2.9	0.5	3.3	-1.1
			U	3	-1.1	2.3	4.2	-3.4	1.2
4	VILL	5	N	1.8	-2.1	-0.2	-0.1	2.8	-0.2
			E	1.2	-0.1	0.5	-1.1	1.9	-0.7
			U	3.3	2.4	-5.4	1.7	-1.6	2

The mean square standard deviation of the coordinates of the three free stations, fixing EBRE, and derived from the repeatability of the five separate solutions and expressed in northings, eastings and heights (up) can be estimated to be:

rms(North) = 0.002 m. rms(East) = 0.001 m. rms(Up) = 0.004 m.

Unweighted rms values with respect to the combined solution in mm								
	#FIL	C	RMS	1	2	3	4	5
COMBINATION	5	N	1.5	2.0	0.3	1.0	2.9	0.8
		E	1.2	0.2	2.1	0.7	2.3	0.8
		U	3.0	3.1	4.1	2.8	4.3	2.4
		#STA	4	4	3	4	4	4
		FAC		4.31	4.86	4.11	3.85	3.47

Unweighted rms values of the comparison between the solutions in mm								
	FIL	C		1	2	3	4	
	2	N		2.5				
		E		1.8				
		U		6.0				
		#STA		3				
	3	N		2.1	1.0			
		E		0.8	2.7			
		U		4.8	5.1			
		#STA		4	3			
	4	N		4.8	3.4	3.5		
		E		2.5	4.5	2.4		
		U		6.9	4.8	5.5		
		#STA		4	3	4		
	5	N		1.4	1.2	1.2	3.5	
		E		0.6	1.5	1.0	2.9	
		U		1.5	5.2	3.4	6.6	
		#STA		4	3	4	4	

The daily GPS baseline lengths repeatability between the reference sites are given in table

station 1	station 2	length about km	RMS ppm	RMS m	1 m	2 m	days 3 differences to the mean value m	4 m	5 m
GRASS	*EBRE*	621.87	0.005	0.0028	-0.0015	-0.0022	0.0002	0.0048	-0.0014
GRASS	*VILL*	969.94	0.002	0.0019	0.0001	-0.003	0.0019	0.0013	-0.0003
GRASS	*CAGL*	540.74	0.005	0.0024	-0.0013		-0.0021	0.0034	-0.0001
EBRE	*VILL*	378.25	0.004	0.0014	0.0005	-0.0005	0.0013	-0.0022	0.0008
EBRE	*CAGL*	747.42	0.001	0.0007	-0.0005		-0.0005	0.0011	0.0000
VILL	*CAGL*	1114.18	0.001	0.0008	-0.0007		0.0009	-0.0007	0.0006

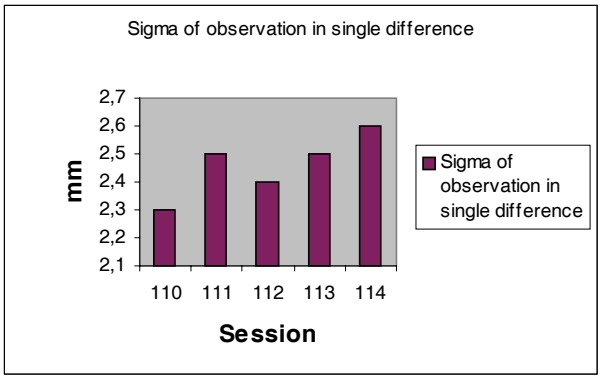
The accuracy of baseline length repeatabilities between the reference stations is better than 0.005 ppm. for distances of about 350 and 1100 km.

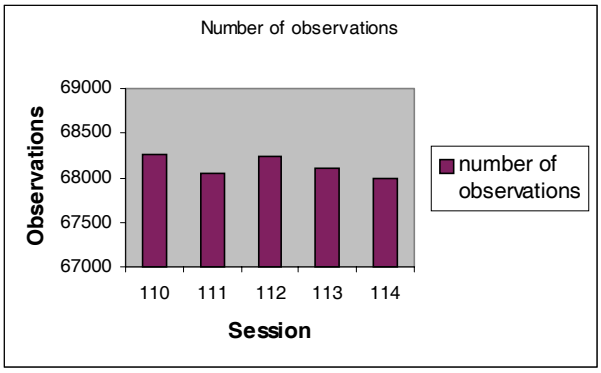
station	DX DN	DY DE	DZ DU
GRASS	0.018 0.019	0.002 -0.001	-0.011 0.007
CAGL	0.005 0.012	0.013 0.012	-0.010 -0.003
VILL	0.001 0.009	0.010 0.010	-0.012 -0.008

We could also estimate the actual accuracy comparing to initial IGS reference coordinates. Thus, differences in local (NEU) and geocentric (XYZ) systems are shown in table.

4. Constrained solution

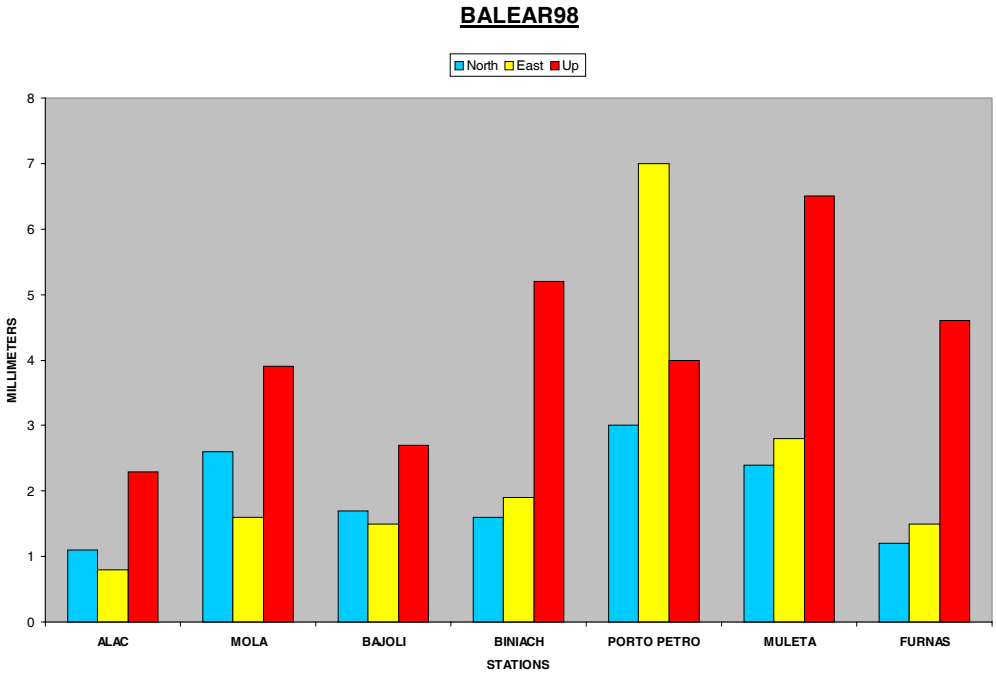
Final Constrained solution was obtained being fixed the five reference station coordinates, resulting a solution for each day of the campaign. The number of observations for each day and the standard deviation of each solution in single differences is shown in the next two tables. We can see that the greater the number of observations is, the smaller is sigma.





list of RMS values					
file	RMS (single difference)	#OBS	#PAR (ORIG.)	#PAR (SOLVED)	MJD
1	0.0023	68265	111	99	50923.50000
2	0.0035	68045	119	99	50924.50000
3	0.0024	68246	116	99	50925.50000
4	0.0025	68098	118	99	50926.50000
5	0.0026	67995	114	99	50927.50000
	0.0030	340649	446	363	50925.50000

Ambiguities were fixed baseline by baseline through QIF algorithm ("Quasi Ionosphere Free Ambiguity Resolution", Bernese Manual V4.0) using L1 and L2 phase measurements. Around 90 percent of ambiguities were fixed. Final solution was performed with L3 double differences. In this last step tropospheric delay parameters every two hours are introduced (six per session and station) based in standard tropospheric Saastamoinen model.



Comparison of station coordinates with respect to the combined solution in mm
- unweighted rms of individual coordinate residuals

station	#FIL	C	RMS	1	2	3	4	5
ALAC	5	N	1.1	0.5	0.3	-1.8	-0.8	0.9
		E	0.8	-0.6	0.7	-1.4	-0.3	-0.3
		U	2.3	-0.2	2.4	1.3	-2.4	-3.0
MOLA	5	N	2.6	0.3	1.9	-3.7	-1.6	2.4
		E	1.6	-0.1	-1.3	-2.1	0.2	1.9
		U	3.9	-0.2	5.0	-2.6	2.0	-4.9
BAJOLI	5	N	1.7	1.7	-2.5	0.0	-1.2	1.3
		E	1.5	-0.8	-1.1	0.7	-1.4	2.1
		U	2.7	-3.0	0.7	-0.1	4.1	-1.8
BINIACH	5	N	1.6	1.7	1.2	-1.1	-2.1	-0.6
		E	1.9	-1.3	-2.5	1.1	0.0	2.3
		U	5.2	-2.2	0.2	-2.2	8.5	-5.1
PORTO PETRO	5	N	3.0	1.4	1.4	2.2	-5.2	-0.9
		E	7.0	-5.6	-6.2	6.7	8.2	-3.5
		U	4.0	1.7	4.8	-2.7	-5.4	0.8
MULETA	5	N	2.4	-2.9	-2.0	-0.1	2.0	2.4
		E	2.8	-3.5	-1.7	0.2	-0.3	4.1
		U	6.5	9.9	1.6	-7.6	-2.9	-0.9
FURNAS	5	N	1.2	-1.5	1.3	0.6	-1.3	0.1
		E	1.5	0.1	-1.7	-1.8	0.4	1.5
		U	4.6	3.0	0.7	-2.4	4.9	-6.6

Unweighted rms values with respect to the combined solution in mm
Total number of stations: 11

	#FIL	C	RMS	1	2	3	4	5
COMBINATION	5	N	2.2	2.3	2.0	2.4	2.7	2.1
		E	2.6	2.6	2.6	2.8	3.0	2.5
		U	3.1	3.5	2.4	2.9	4.0	3.3
		#STA	11	11	11	11	11	11
		FAC		5.85	5.38	5.49	5.34	4.99

Outlier detection using the mean repeatability rms of each component detection level (residuum/rms): 3.00

North: 0.007, east: 0.008, up: 0.009 (m)

file	station	component	residuum(m)	RMS(M)	MS*FAC(M)
4	PORTO PETRO	E	0.0082	0.0001	0.0007

Unweighted rms values of the comparison between the solutions in mm
Total number of stations: 11

	FIL	C		1	2	3	4	
	2	N		1.8				
		E		1.1				
		U		3.7				
		#STA		11				
	3	N		2.1	2.3			
		E		4.3	4.4			
		U		6.1	4.6			
		#STA		11	11			
	4	N		3.1	3.1	2.7		
		E		4.5	4.7	1.4		
		U		6.3	5.0	5.0		
		#STA		11	11	11		
	5	N		2.2	2.1	2.5	2.3	
		E		3.0	3.1	3.9	4.2	
		U		5.0	4.9	3.3	6.7	
		#STA		11	11	11	11	

The mean square standard deviation of the coordinates of the all stations derived from the repeatability of the five separate solutions and expressed in northings, eastings and heights (up) can be estimated to be:

rms(North) = 0.002 m. rms(East) = 0.002 m. rms(Up) = 0.004 m

5. Conversion to ETRS89

Final computation result is a coordinate list in ITRF96 epoch 1998.3. Transformation to ETRS89 epoch 1989.0 system is made by (Boucher, Altamini IERS internet site):

$$\underline{X}(S0) = \underline{X}(S1) + \underline{T}(S1) + \underline{R}\,\underline{X}(S1)\,\Delta t$$

where:

$\underline{X}(S0)$: coordinates in ETRS89 epoch 1998.3

$\underline{X}(S1)$: coordinates in ITRF96 epoch 1998.3

$\underline{T}(S1)$: shifts T1, T2, T3 based on global transformation from ITRF96 to ITRF89 including scale factor with:

T1 = 0.041 m. T2 = 0.041 m. T3 = -0.049 m.

R: rotation back to epoch 1989.0 due to European plate motion with NNR-NUVEL1A motion model or with individual velocities in ITRF96 (in "/y):

R1 = 0.0002 R2 = 0.0005 R3 = -0.00065

Δt: 9.3 years, time difference between 1998.3 and 1989.0 epochs.

The ITRF96 global combination has been made bearing in mind that the reference frame definition (origin, scale, orientation and time evolution) of the combination is achieved in such a way that ITRF96 is in the same system as the ITRF94 ("Report on ITRF96 data analysis", Boucher). For this reason, T-shifts and R-rotations are the same as in ITRF94.

6. Conclusions

Final coordinates for BALEAR98 show a good quality if we look at repeatabilities and comparing with reference station coordinates. The coordinate accuracy obtained for the final solution, as a result of five daily solution combination, can be estimated as being about 1cm. at the epoch of observation. BALEAR98 final coordinates are shown in the following tables:

Solution taking ALAC as reference station (fixed).

station	X96	Y96	Z96	X89	*Y89*	*Z89*
ALAC	5009051.290	-42072.344	3935057.626	5009051.418	-42072.485	3935057.464
EBRO	4833520.241	41536.970	4147461.463	4833520.377	41536.832	4147461.305
CAGL	4893378.939	772649.650	4004182.064	4893379.093	772649.511	4004181.912
GRAS	4581691.007	556114.716	4389360.699	4581691.164	556114.583	4389360.552
VILL	4849833.790	-335049.152	4116014.847	4849833.914	-335049.291	4116014.686
BAJOLI	4880684.421	324042.760	4079709.644	4880684.563	324042.621	4079709.488
BINIACH	4885022.039	357217.205	4071910.951	4885022.182	357217.066	4071910.795
FURNAS	4958328.569	131167.220	3997077.239	4958328.704	131167.079	3997077.079
MOLA	4985004.410	133639.192	3963556.001	4985004.544	133639.051	3963555.840
MULETA	4903034.481	228715.234	4059680.198	4903034.620	228715.094	4059680.040
PORTO PETRO	4930662.746	276987.508	4022967.642	4930662.886	276987.368	4022967.484

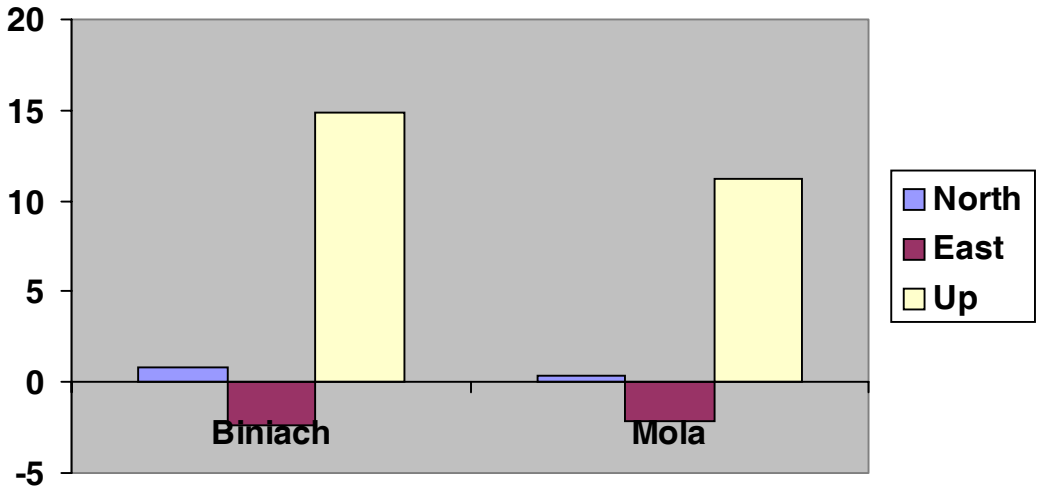
Final solution taking ALAC as non-fixed station.

STATION	X96	Y96	Z96	X89	Y89	Z89
EBRE	**4833520.241**	**41536.970**	**4147461.463**	4833520.377	41536.832	4147461.305
CAGL	4893378.939	772649.650	4004182.064	4893379.093	772649.511	4004181.912
GRAS	4581691.007	556114.716	4389360.699	4581691.164	556114.583	4389360.552
VILL	4849833.790	-335049.152	4116014.847	4849833.914	-335049.291	4116014.686
ALAC	5009051.279	-42072.326	3935057.640	5009051.408	-42072.468	3935057.478
BAJOLI	4880684.422	324042.764	4079709.650	4880684.564	324042.625	4079709.494
BINIACH	4885022.040	357217.208	4071910.958	4885022.183	357217.069	4071910.801
FURNAS	4958328.569	131167.225	3997077.246	4958328.704	131167.084	3997077.086
MOLA	4985004.409	133639.198	3963556.007	4985004.543	133639.056	3963555.847
MULETA	4903034.482	228715.238	4059680.204	4903034.621	228715.098	4059680.046
PORTO PETRO	4930662.746	276987.512	4022967.648	4930662.886	276987.372	4022967.491

7. Comparison to other campaigns

Stations BINIACH and MOLA took part in EUREF89 as numbers 79 and 81, respectively. Comparison of EUREF89 and BALEAR98 co-ordinates (reduced to ETRS89) is shown in the following table. Vector points from EUREF89 reference to GPS mark.

STA	X(m)	Y(m)	Z(m)	N (m)	E (m)	U (m)
BINIACH	0.111	-0.013	0.108	0.013	-0.021	0.154
MOLA	0.084	-0.014	0.080	0.010	-0.016	0.115



Station ALAC (which belongs since 9.09.1999 to EUREF Permanent Network) took also part in EUVN97 campaign. At the campaign observation time ALAC was not an official permanent station, for this reason it has remain non-fixed in the processing. Nowadays there is no velocity field for ALAC, but in the table below the results of BALEAR98 compared to EUVN campaign are shown, as well as compared to the EUREF WEEK solutions 1030, 1045, and 1060. A decrease in the X and Y velocity field, an increase in the Z coordinate is put up.

ALAC solution		X	Y	Z	DX	DY	DZ
EUVN97	ETRF96 epoch 1997.4	5009051.290	-42072.344	3935057.626			
BALEAR98	ETRF96 epoch 1998.31	5009051.279	-42072.326	3935057.640	-0.011	0.018	0.014
EUREF 1030 WEEK	ITRF97 (1999:279:43184m)	5009051.265	-42072.294	3935057.649	0.014	-0.032	-0.009
EUREF 1045 WEEK	ITRF97 (2000:019:43184m)	5009051.258	-42072.293	3935057.649	0.021	-0.033	-0.009
EUREF 1060 WEEK	ITRF97 (2000:124:43184m)	5009051.246	-42072.287	3935057.649	0.033	-0.039	-0.009

Differences to BALEAR98

In the table below it is shown the comparison between EUVN97 and BALEAR98 in ETRF89, once each solution is reduced from its own observation epoch to the reference epoch ETRF89.

ALAC solution		X	Y	Z
EUVN97	ETRF89	5009051.410	-42072.467	3935057.475
BALEAR98	ETRF89	5009051.408	-42072.468	3935057.478
Differences to BALEAR98		-0.002	-0.001	0.003

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