REFAG 2022
THESSALONIKI - GREECE

ETRS89 Realization and Maintenance in Spain

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Spanish Geodetic Reference System & background

Official Spanish Geodetic Reference System is defined by law 1071/2007:

15822 *REAL DECRETO 1071/2007, de 27 de julio, por el que se regula el sistema geodésico de referencia oficial en España.*

Iberian Peninsula – ETRS89 (European Terrestrial Reference System)

Canary Islands – REGCAN95

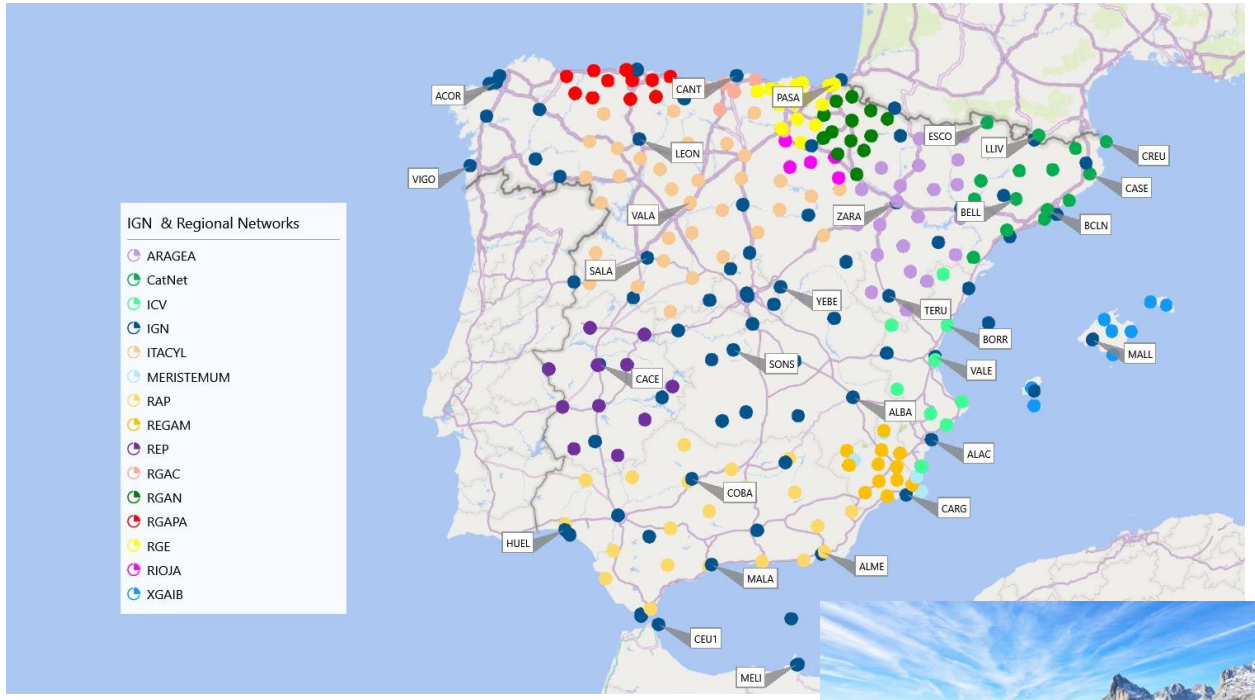
ETRS89 realization:

Relies on REGENTE passive network: 1.100 points.

Frame: ETRF96, IBERIA95 campaign, jointly with Portugal, EUREF98 resolutions.

Currently, access to ETRS89 through GNSS active networks.

Current status of GNSS public networks



Instituto Geográfico Nacional (IGN) – ERGNSS network.
Comunidad de Madrid – Red de estaciones GNSS de la Comunidad de Madrid (RGM)
Gobierno de Aragón – Instituto Geográfico de Aragón (ARAGEA).
Gobierno de Cantabria – Red Geodésica Activa de Cantabria (RGAC).
Gobierno de Euskadi – Red de Estaciones de Referencia GNSS de Euskadi (RGE).
Gobierno de La Rioja – Red de estaciones permanentes GNSS.
Gobierno de Navarra – Red Geodésica Activa de Navarra (RGAN).
Institut Cartogràfic i Geologic de Catalunya (ICGC) – CatNet.
Instituto Cartográfico de Valencia (ICV) – Red Geodésica Activa en Tiempo Real (ERVA).
Instituto de Estadística y Cartografía de Andalucía – Red Andaluza de Posicionamiento (RAP).
Instituto Tecnológico Agrario de Castilla-León (ITACYL) – Red GNSS Castilla y León.
Junta de Extremadura – Red Extremeña de Posicionamiento (REP).
Principado de Asturias – RGAPA.
Región de Murcia – Redes REGAM y Meristemum.
SITIBSA – Xarxa de Geodesia Activa de les Illes Balears (XGAIB).

Motivation

- Many of the frames/coordinates of permanent GNSS networks:
  - weren't consistent between each other nor in the same frame (ETRF05, ETRF00, ETRF??).
  - weren't observed in the same epoch nor covered same time span.
  - weren't homogeneously processed following guidelines (e.g. TWG).
  - aren't regularly updated (i.e. due to discontinuities or other changes in the network stations).

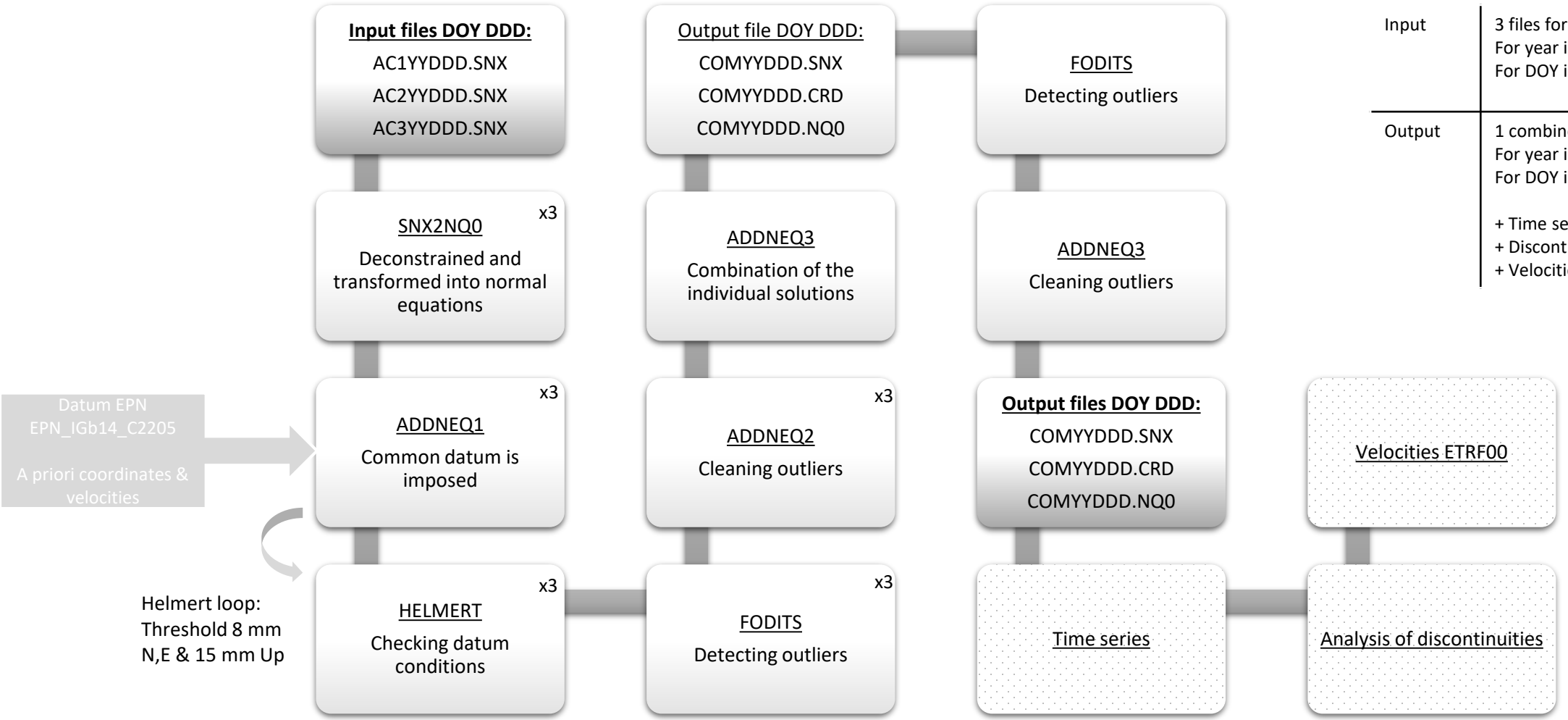
- As a result, the Specialized Commission on Geodetic System (Geographic Superior Council) decided to create a WG to harmonize and standardize an unique and common reference framework in ETRF00 for all public GNSS networks in Spain.

- A call for participation was issued to all the public GNSS Network managers. The following ACs volunteered to participate in the ETRF2000 WG.

Processing options for each AC

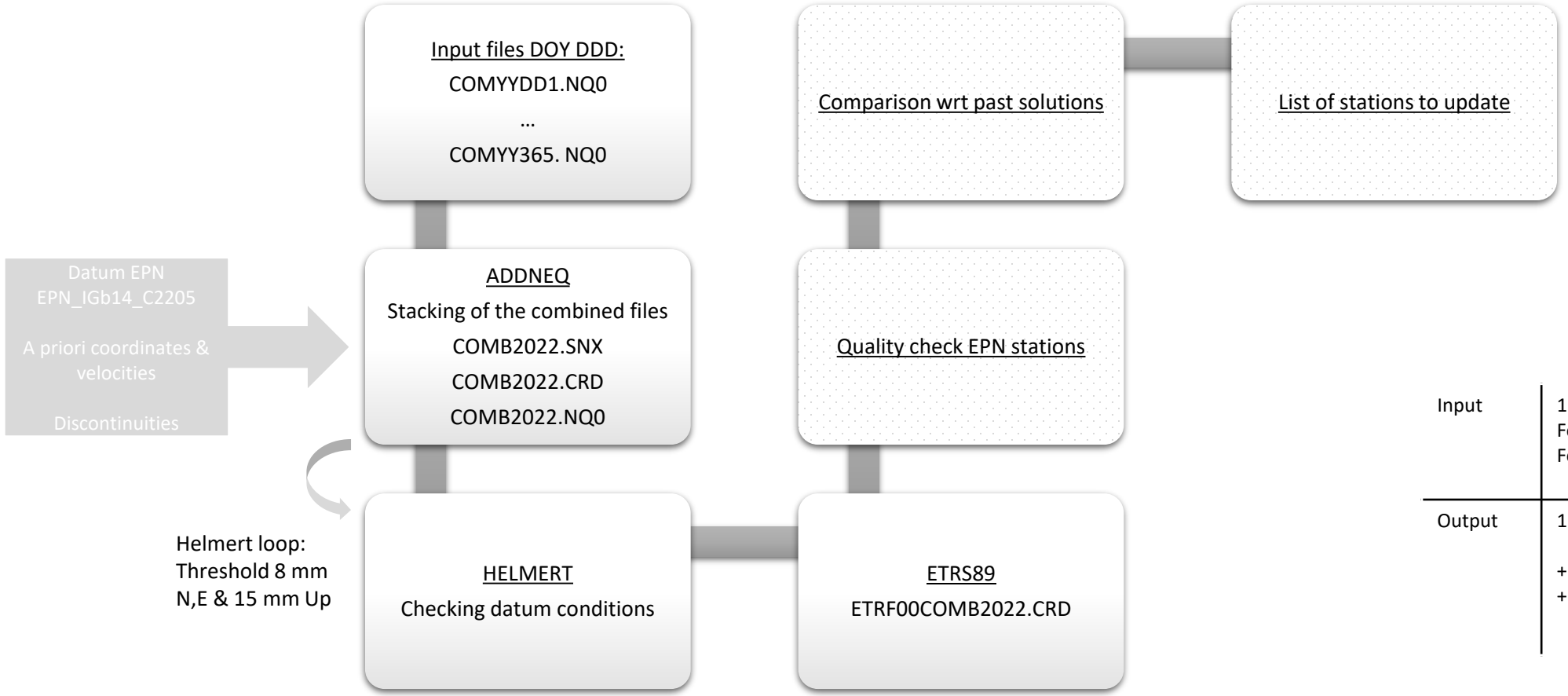
	IGN	ICGC	IECA	ITACYL
PERIOD SUBMITTED	2011 - 2022	2011 - 2019	2011 - 2017	2011-2022
EXPERIENCE	EUREF LAC since 2001, EPN-D, Repro1 & 2	Submitting a solution to EPN-D	Submitting a solution to EPN-D as a sub-net of ARA	Wide experience in GNSS processing
SOFTWARE	Bernese 5.2	Bernese 5.2	Bernese 5.2	GAMIT/GLOBK 10.71
SYSTEMS	GPS+GLONASS	GPS+GLONASS	GPS+GLONASS	GPS
SOLUTION TYPE	NETWORK	NETWORK	NETWORK	NETWORK
GNSS NETWORKS PROCESSED	Aragea, catnet, ergnss, erva, itacyl, meristemum, rap, regam, rep, rgac, rgan, rgapa, rge, rioja, xgaib	Aragea, catnet, ergnss, erva, meristemum, regam, rgan , rge	Ergnss, catnet, rap, rep, rgan, rgapa, rioja	Epn, itacyl
ORBITS	CODE	CODE	CODE	IGS
ANTENNAS	IGS14+IND. CALIB	IGS14+IND. CALIB	IGS08+IND. CALIB	IGS14+IND. CALIB
IERS	2010	2010	2010	Solid Earth tide IERS2003, Short period Earth Orientation: IERS: 2010
GRAV. MODEL	EGM08	EGM08	EGM08	EGM08
TROPOSPHERE	VMF (1h) + GRAD (6h)	VMF (1h) + GRAD (24h)	VMF (1h) + GRAD (24h)	VMF (1h) + GRAD (12h)
IONOSPHERE	CODE (HOY Included)	CODE (HOY Included)	CODE (HOY Included)	GMAP (2nd & 3th order) Magnetic field IGRF13
REF. FRAME	IGS	EPN	EPN	Igb14 orbits (loosely constrained)
OCEAN TIDES	FES2004	FES2004	FES2004	FES2004
ATM. TID. LOAD	YES	YES	YES	YES
ELEV. MASK	3	3	3	5

Combination. Step 1: daily combined SNX



Input	3 files for each AC For year in 2011..2022 For DOY in 001..365
Output	1 combined file (SNX, CRD, NQ0 formats) For year in 2011..2022 For DOY in 001..365 + Time series + Discontinuities + Velocities ETRF00

Combination. Step 2: stacking daily combined NEQ into an unique solution



Input	1 combined file For year in 2011..2022 For DOY in 001..365
Output	1 stacked file: coordinates and velocities ITRF + ERTF00 coordinates + List of stations to update

Original combination and updates

1st combination:

Period: [DOY 107 2011 – DOY 029 2017]

Epoch: 01-01-2017

Ref. frame: IGb08

Analysis Centres: 4

Finish date: ending 2017

2nd combination:

Period: 1st combination + [DOY 029 2017 - DOY 001 2020]

Epoch: 01-01-2020

Ref. frame: IGb08 + IGb14

Analysis Centres: 3

Finish date: ending 2020

3th combination: 303 stations

Period: 1st combination + 2nd combination + [DOY 001 2020 - DOY 001 2022]

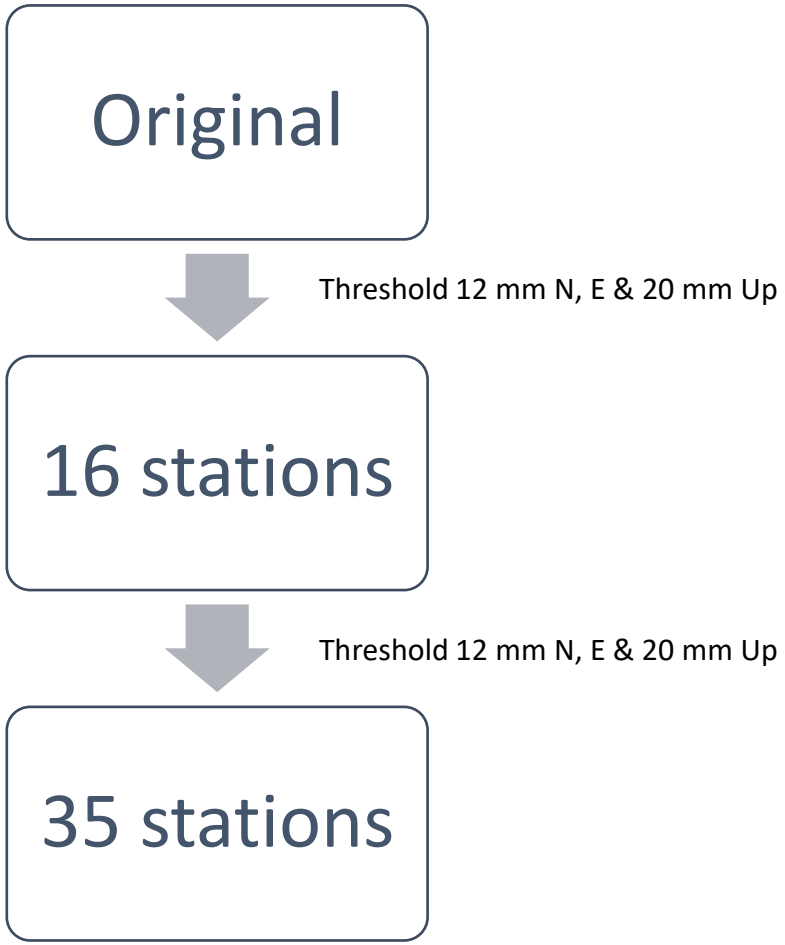
Epoch: 01-01-2022

Ref. frame: IGb08 + IGb14

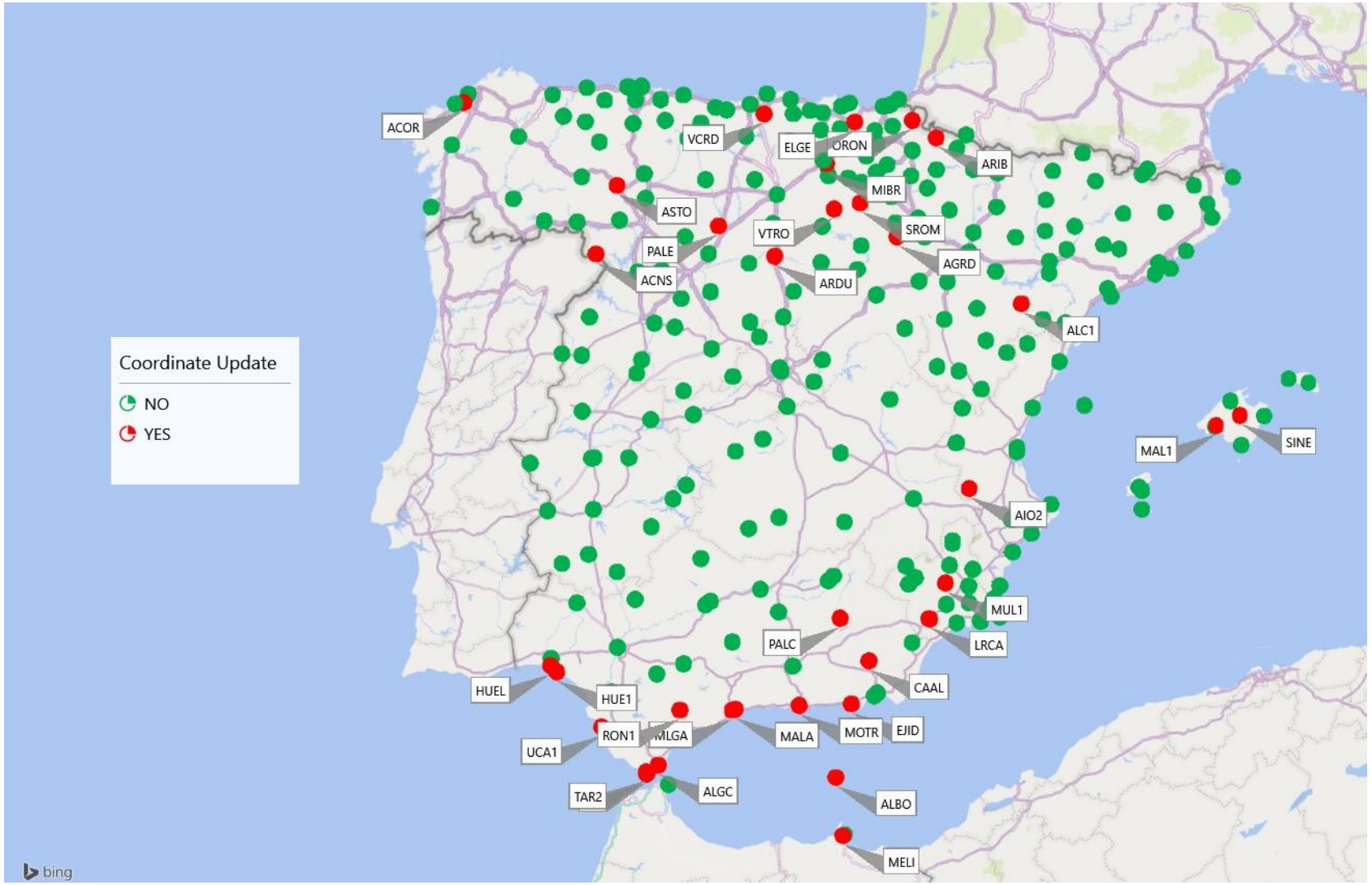
Analysis Centres: 2

Finish date: ending 2022

stations with update of their coordinates

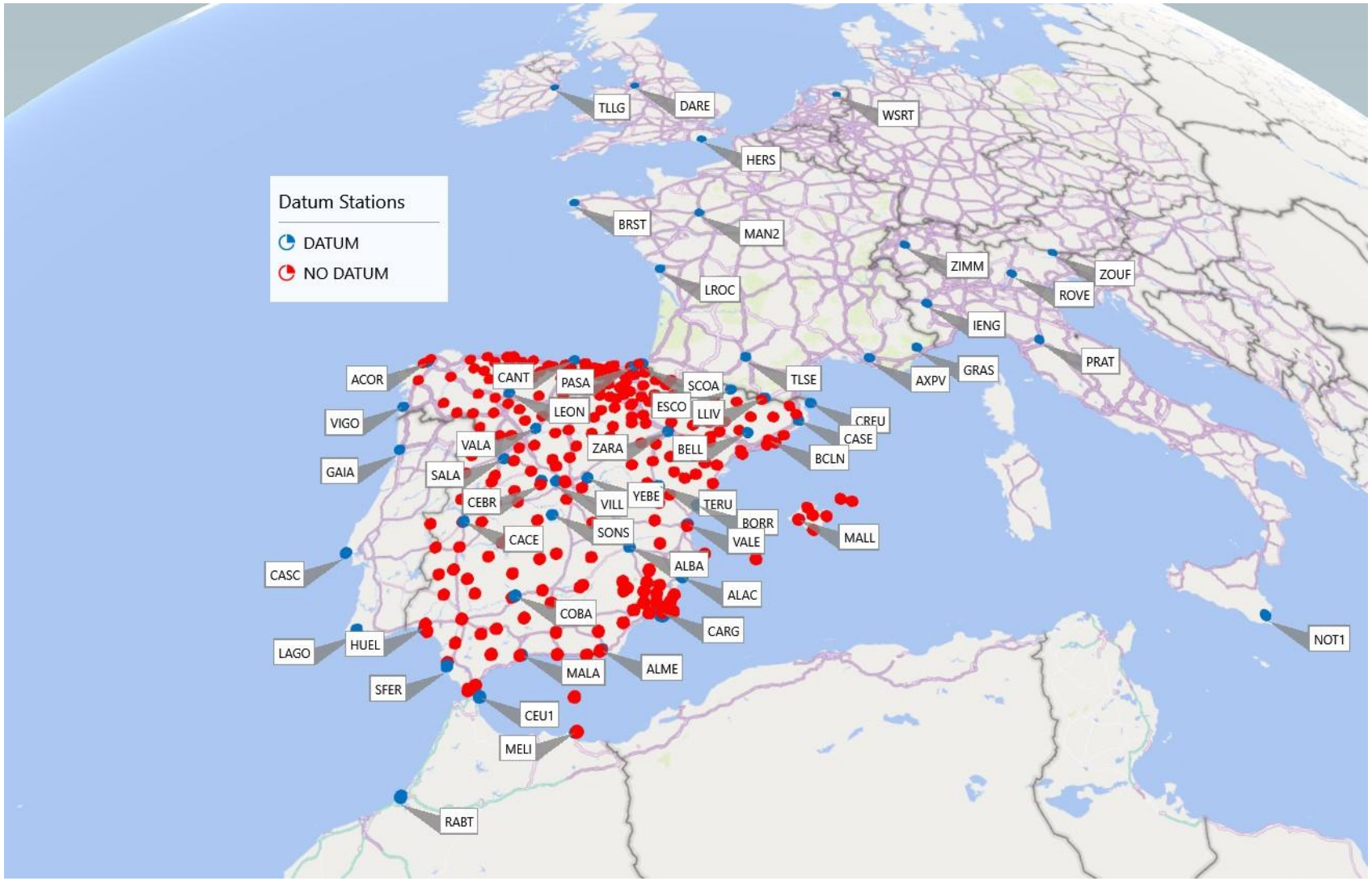


Coordinate update



3th combination
Data from 2011 to 2022
Ref. epoch 01.01.2022
Updated Stations = 35

Results (I): datum align. check (COMPAR)

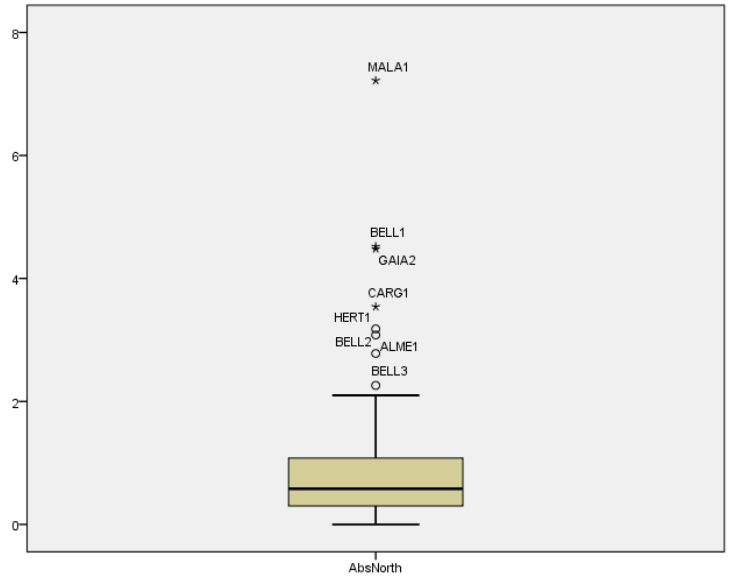


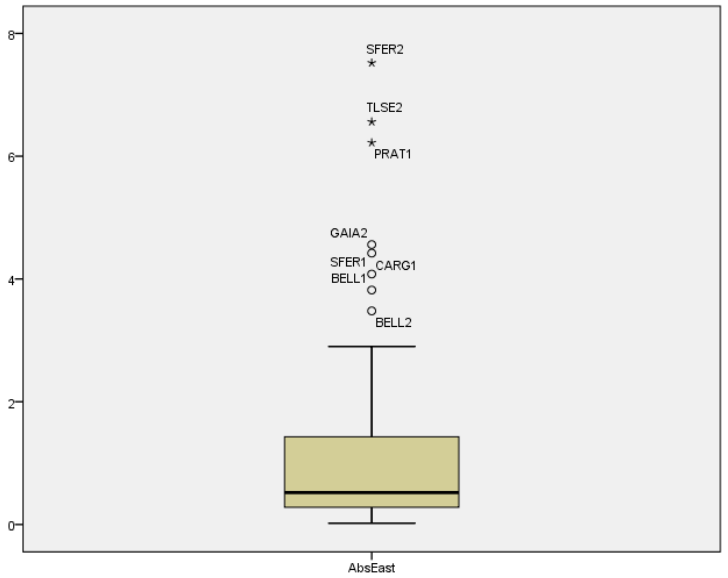
Datum Stations = 57
No datum Stations = 246

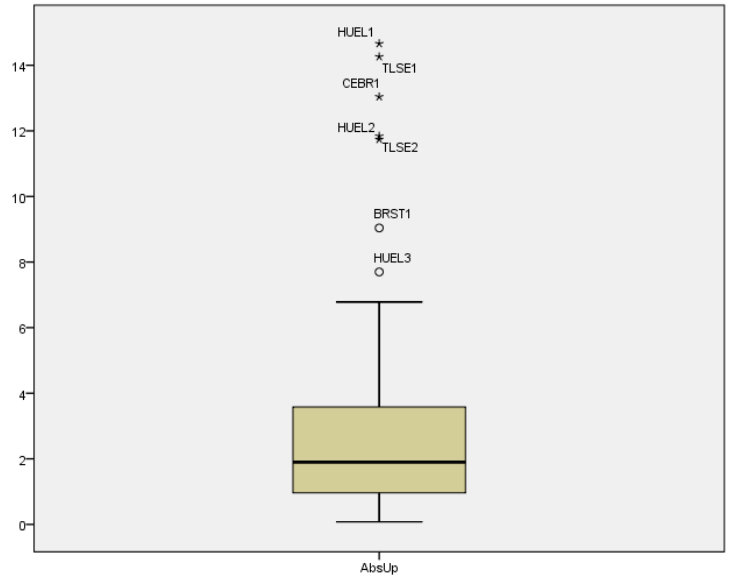
Results (I): datum align. check (COMPAR)

Abs. differences between combination and EPN coordinates (EPN_IGb14_C2205) in datum stations. North, East and Up components

mm







AbsNorth (mm)

Mean		,8798
95% Confidence Interval for Mean	Lower Bound	,6824
	Upper Bound	1,0773
Median		,5800
Variance		1,102
Std. Deviation		1,04976
Minimum		,00
Maximum		7,22

AbsEast (mm)

Mean		1,1083
95% Confidence Interval for Mean	Lower Bound	,8512
	Upper Bound	1,3654
Median		,5200
Variance		1,869
Std. Deviation		1,36700
Minimum		,02
Maximum		7,52

AbsUp (mm)

Mean		2,7897
95% Confidence Interval for Mean	Lower Bound	2,2471
	Upper Bound	3,3324
Median		1,9000
Variance		8,322
Std. Deviation		2,88486
Minimum		,08
Maximum		14,66

Results (I): datum align. check (HELMERT)

Residuals of the helmert transformation (NNR) wrt EPN cumulative solution in datum stations. North, East, Up components.

NUM	NAME	FLG	RESIDUALS IN MILLIMETERS		
1	ACOR 13434M00101	W W	-1.89	1.13	0.15
1	ACOR 13434M00102	W W	-0.72	0.48	-0.82
2	ALAC 13433M001I1	W W	-0.49	0.04	0.91
2	ALAC 13433M001I2	W W	0.79	-0.44	0.42
3	ALBA 13452M00101	W W	0.20	2.54	0.36
3	ALBA 13452M00102	W W	0.02	0.43	1.28
4	ALME 13437M00101	W W	-3.08	-2.17	5.37
4	ALME 13437M00102	W W	-0.60	-0.34	3.44
4	ALME 13437M00103	W W	0.67	-0.07	0.93
5	AXPV 10057M001	W W	0.64	0.25	-0.58
6	BCLN 13412M001	W W	-0.30	-1.28	-0.41
7	BELL 13431M00101	W W	-4.52	-3.83	0.59
7	BELL 13431M00102	W W	-2.77	-3.47	-4.14
7	BELL 13431M00103	W W	-2.27	-2.41	1.89
7	BELL 13431M00104	W W	-0.08	-0.29	0.70
8	BORR 13480M00101	W W	-0.09	-1.28	1.62
8	BORR 13480M00102	W W	1.65	-1.89	0.82
8	BORR 13480M001I3	W W	-0.66	0.61	-3.01
8	BORR 13480M001I4	W W	0.28	-1.41	1.21
9	BRST 10004M00401	W W	-0.80	1.72	-9.05
9	BRST 10004M00402	W W	-0.52	0.72	1.53
10	CACE 13447M001	W W	0.89	0.13	-0.52
11	CANT 13438M00101	W W	-1.60	1.42	-0.47
11	CANT 13438M001I2	W W	-0.34	-0.51	-1.32
11	CANT 13438M001I3	W W	-0.22	0.06	0.08
12	CARG 19412M001I1	W W	3.54	-4.43	-4.53
12	CARG 19412M001I2	W W	1.20	-1.31	-2.78
13	CASC 13909S00101	W W	-0.30	-0.39	3.24
13	CASC 13909S00102	W W	0.66	0.49	5.01
13	CASC 13909S00103	W W	0.85	-0.08	4.06
14	CASE 13494M00102	W W	-0.12	-1.06	-1.35
15	CEBR 13408M00101	W W	1.65	1.06	13.03
15	CEBR 13408M00102	W W	-0.14	-0.68	3.11
16	CEU1 13449M00201	W W	-0.96	1.53	3.85
16	CEU1 13449M00202	W W	-0.44	1.84	1.18
16	CEU1 13449M00203	W W	-0.33	1.00	3.75
16	CEU1 13449M00204	W W	1.13	0.57	2.56
17	COBA 13453M00101	W W	-0.31	1.58	-3.45
17	COBA 13453M00102	W W	1.22	0.27	-2.24
18	CREU 13432M00101	W W	-0.72	-2.13	-5.25
18	CREU 13432M00102	W W	-0.43	-0.13	-0.91
19	DARE 13208S00103	W W	-0.37	0.21	0.48
19	DARE 13208S001I2	W W	-1.02	0.51	1.32
21	ESCO 13435M00101	W W	-0.10	0.55	-5.10
21	ESCO 13435M00102	W W	0.13	0.41	-2.18
22	GAIA 13902M00102	W W	-4.48	-4.57	5.01
22	GAIA 13902M00103	W W	-1.01	0.41	4.20
22	GAIA 13902M00104	W W	0.21	0.26	1.01
22	GAIA 13902M00105	W W	-0.02	0.21	2.36
23	GRAS 10002M006	W W	0.33	-0.28	-1.63
24	HERS 13212M007	W W	-1.04	-0.52	1.12
25	HERT 13212M01001	W W	-3.19	1.70	3.05
25	HERT 13212M01002	W W	-0.36	-0.63	2.64
26	HUEL 13451M00101	W W	0.51	2.57	-14.67
26	HUEL 13451M00102	W W	0.05	2.41	-11.74
26	HUEL 13451M00103	W W	1.05	2.90	-7.71
27	IENG 12724S00101	W W	0.56	0.71	-0.98
27	IENG 12724S00102	W W	-0.66	-0.41	0.76
28	LAGO 13903M00101	W W	1.57	-2.52	1.98
28	LAGO 13903M00103	W W	1.19	0.18	3.81
28	LAGO 13903M00104	W W	0.64	0.06	4.20
29	LEON 13475M001	W W	-0.23	-0.53	6.09
30	LLIV 13436M00101	W W	-0.08	2.16	3.71
30	LLIV 13436M00102	W W	-0.25	0.05	2.24
31	LROC 10023M00101	W W	0.53	0.37	2.95
31	LROC 10023M00102	W W	-0.50	-1.11	-0.13
34	MALA 13443M00101	W W	7.22	-1.49	1.75
34	MALA 13443M00102	W W	-0.58	0.96	0.77
35	MALL 13444M001	W W	0.41	-0.21	-1.69
36	MAN2 10091M00202	W W	-0.80	0.43	0.74
37	MELI 19379M001	W W	0.48	-0.34	1.38
38	NOT1 12717M00401	W W	2.04	1.83	4.74
38	NOT1 12717M00402	W W	1.31	1.11	-2.30
38	NOT1 12717M00403	W W	1.15	0.47	-2.00
39	PASA 19351S00103	W W	-0.38	-0.27	-3.00
40	PRAT 12760M00101	W W	-0.22	6.21	-1.20
40	PRAT 12760M00102	W W	0.30	2.12	-0.34
40	PRAT 12760M00103	W W	-0.33	0.39	3.16
40	PRAT 12760M00104	W W	-0.36	0.63	2.85
41	RABT 35001M002	W W	0.50	0.02	-5.74
42	ROVE 12774M001	W W	-0.09	-0.44	0.29
43	SALA 13469M001	W W	0.21	-0.13	2.19
44	SCOA 10088M002	W W	-1.20	0.23	0.07
45	SFER 13402M00401	W W	0.72	-4.09	-5.96
45	SFER 13402M00402	W W	-1.94	-7.53	-6.16
45	SFER 13402M00403	W W	1.21	-0.13	1.31
47	SONS 13446M00101	W W	0.70	0.50	0.17
47	SONS 13446M00102	W W	-0.29	-0.42	-2.09
48	TERU 13487M00101	W W	0.40	0.65	-0.34
48	TERU 13487M00104	W W	0.50	-0.68	-1.90
48	TERU 13487M001I2	W W	1.55	1.34	4.44
48	TERU 13487M001I3	W W	-0.65	-0.48	-0.63
49	TLLG 13630M001	W W	-1.10	1.17	1.59
51	TLSE 10003M00901	W W	0.88	0.29	-14.27
51	TLSE 10003M00902	W W	-2.11	6.55	-11.85
51	TLSE 10003M009I4	W W	1.63	0.96	2.19
51	TLSE 10003M009I5	W W	0.09	-0.05	-2.29
52	VALA 13463M002I1	W W	-0.65	-0.14	1.73
52	VALA 13463M002I2	W W	-0.04	0.36	2.66
53	VALE 13439M001	W W	0.00	-0.30	0.07
54	VIGO 13450M00101	W W	-0.81	1.44	-1.81
54	VIGO 13450M00102	W W	-0.30	1.14	-1.15
54	VIGO 13450M00103	W W	-0.08	-0.11	1.69
55	VILL 13406M00101	W W	1.03	-1.98	6.78
55	VILL 13406M00102	W W	0.12	0.09	1.71
56	WSRT 13506M005I2	W W	1.47	-0.02	-1.59
57	YEBE 13420M00101	W W	0.64	0.34	2.30
57	YEBE 13420M00102	W W	0.36	-0.86	-2.39
58	ZARA 13462M001	W W	0.13	0.05	-1.43
59	ZIMM 14001M004	W W	-0.13	0.02	1.56
60	ZOUF 12763M001	W W	0.33	0.26	-0.35

Datum selection:

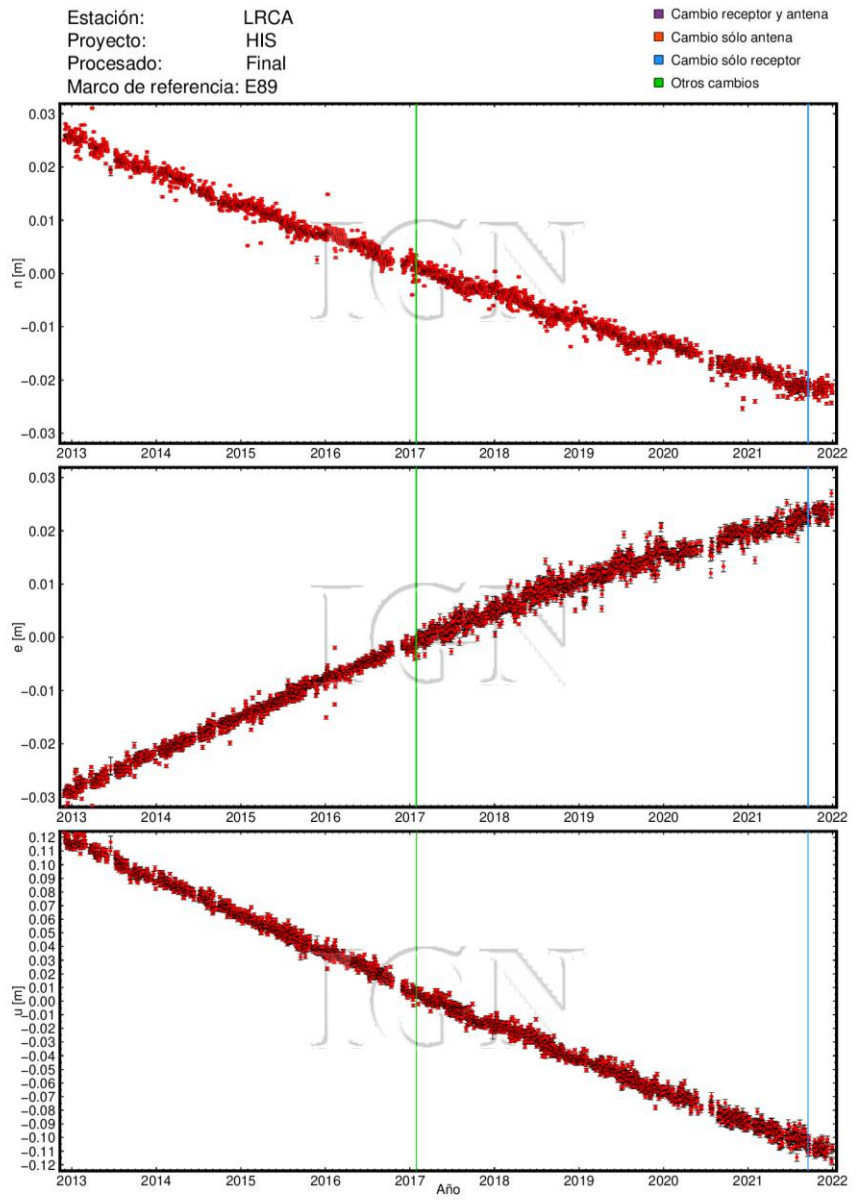
- 7-parameter transformation using all datum stations.
- Stations with residuals exceeding the threshold of 8 mm in horizontal components or 15 mm in the vertical component are eliminated from the datum.
- The combination process is repeated until no datum station coordinate residuals exceeding the mentioned threshold are detected.

RMS OF TRANSFORMATION :	2.66 MM		
TRANSLATION IN X :	-6.42	+- 0.25	MM
TRANSLATION IN Y :	-3.43	+- 0.25	MM
TRANSLATION IN Z :	-8.04	+- 0.25	MM

	N	E	U
RMS / COMPONENT	1.37	1.76	4.02
MEAN	-0.02	0.03	-0.01
MIN	-4.52	-7.53	-14.67
MAX	7.22	6.55	13.03

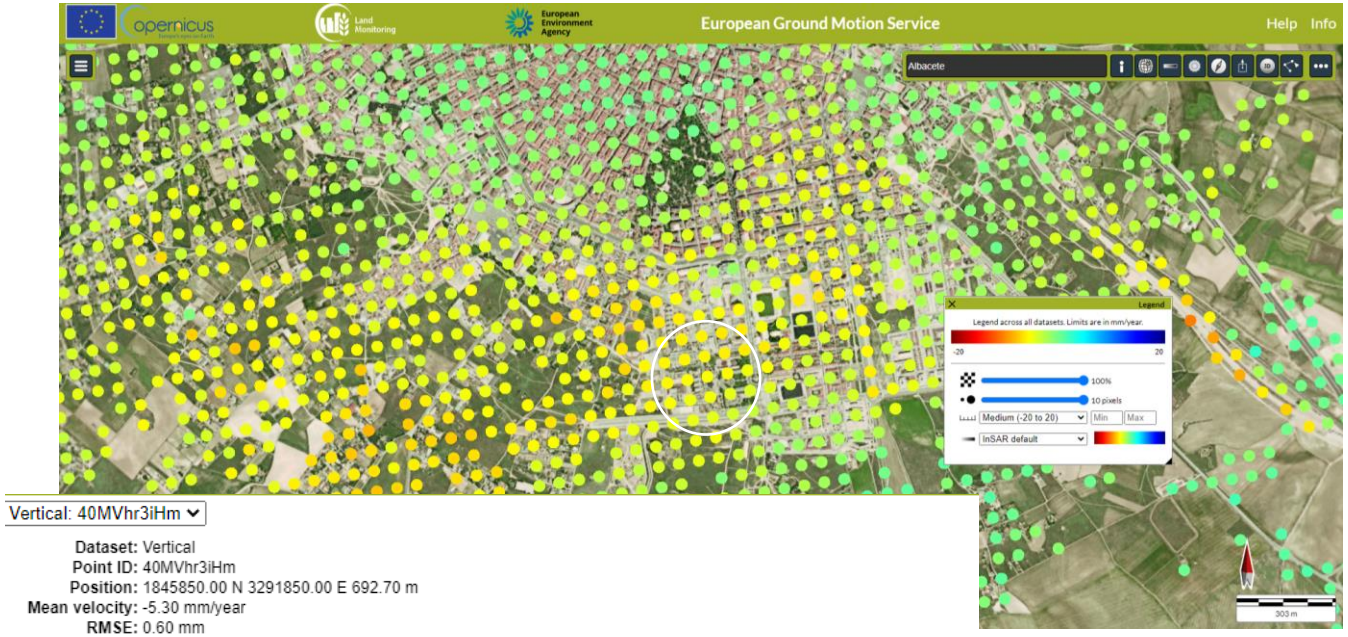
Results (II): Time Series

GNSS ~-25.6 mm/y
EGMS ~ -24.3 mm/y



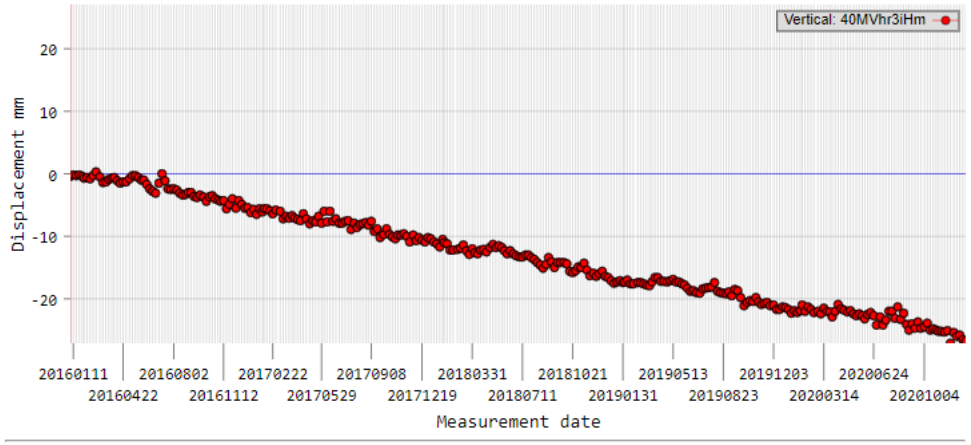
GNSS time serie

Results (II): Time Series

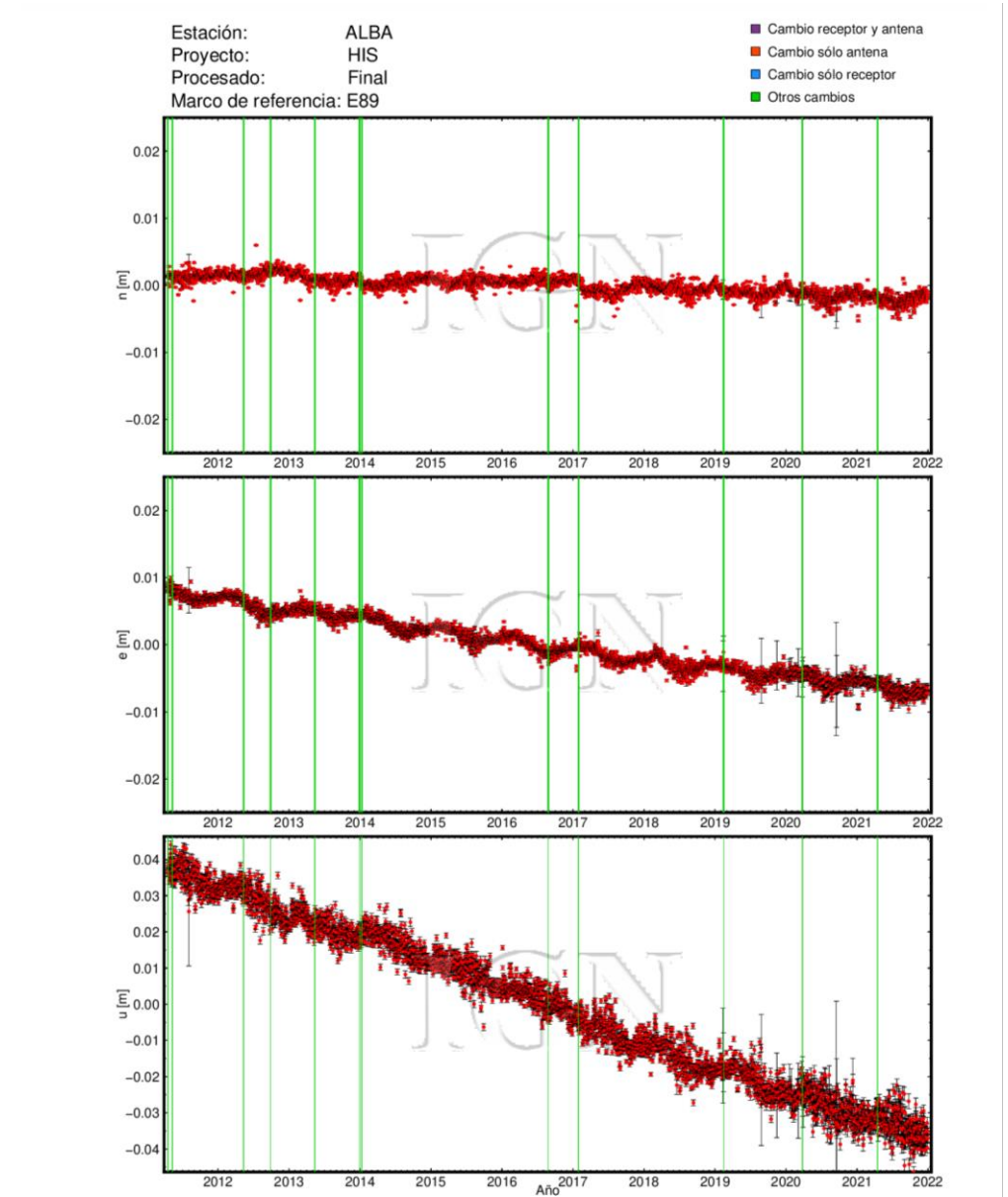


Vertical: 40MVhr3iHm

Dataset: Vertical
Point ID: 40MVhr3iHm
Position: 1845850.00 N 3291850.00 E 692.70 m
Mean velocity: -5.30 mm/year
RMSE: 0.60 mm

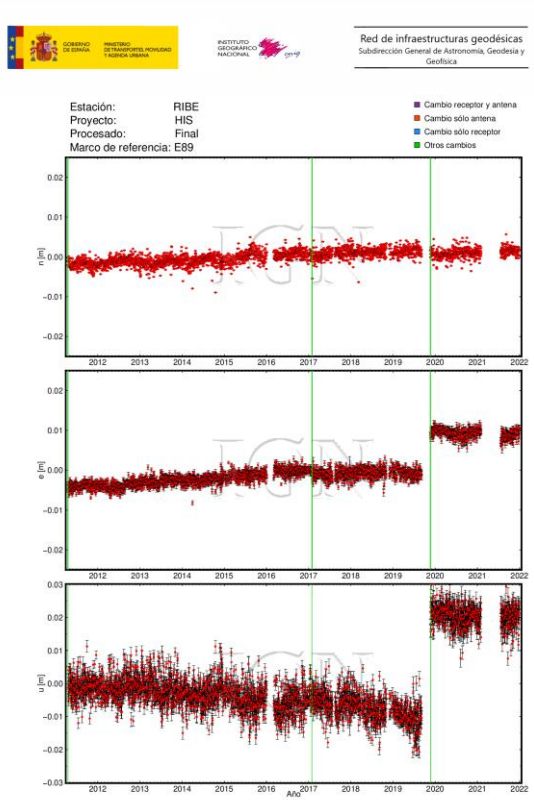


GNSS ~-7.1 mm/y
EGMS ~-5.3 mm/y

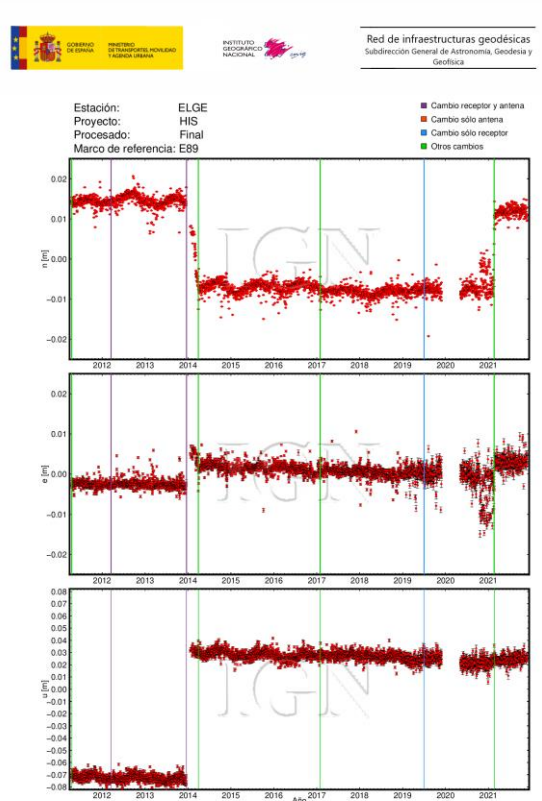


Results (III): Discontinuities

- Discontinuities are agreed between all the AC.
- The cause is not always known.



RIBE



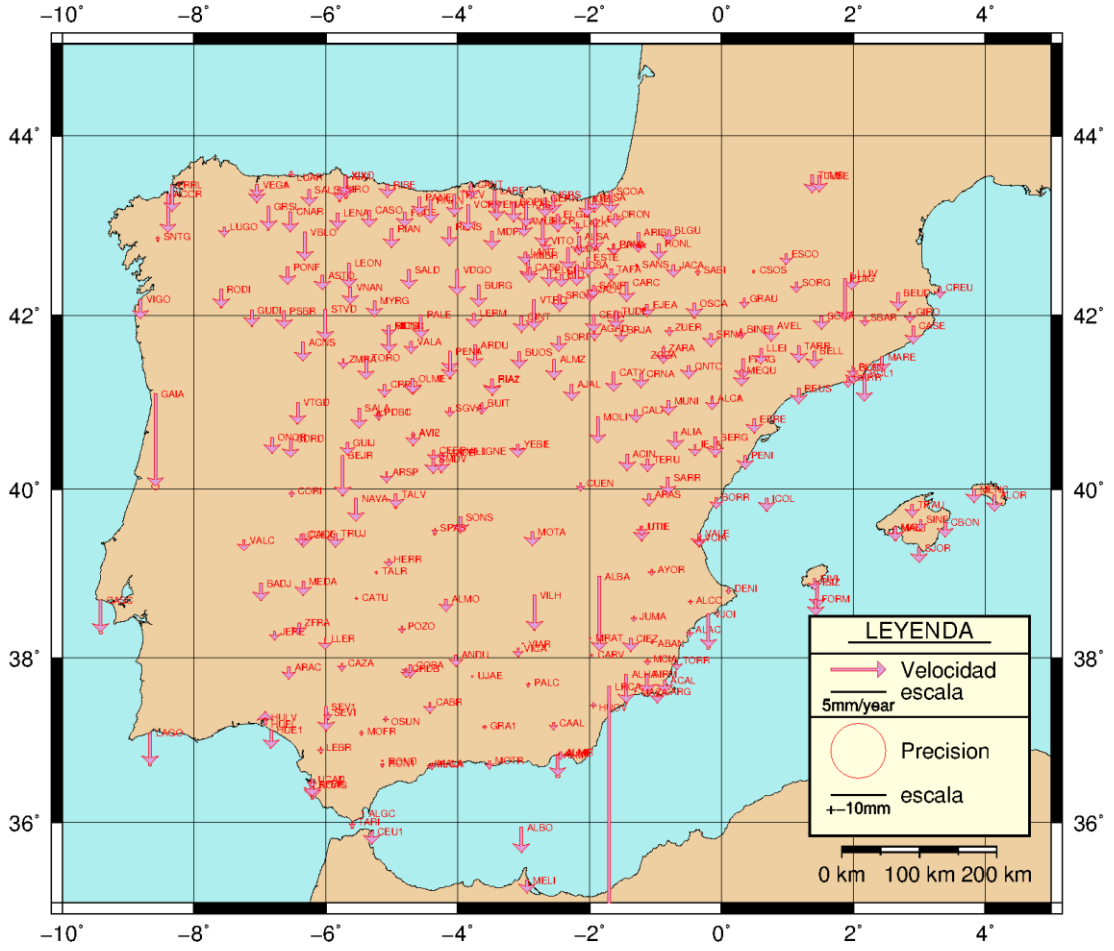
ELGE. Change in monumentation

- Software (FODITS, BSW5.2) + visual inspection of the time series.
- Datum stations: EPN discontinuities (C2205)

Results (IV): ERTF00 velocities

Horizontal ETRF00 velocities (N,E)

Vertical ETRF00 velocities (Up)



Software: CATS 3.1.2. Data from 2011 to 2022. West displacement in the Southern Spain stations.

Conclusions

- A new set of ETRF00 coordinates has been estimated for all the stations of Spanish GNSS public networks. As well as other products: discontinuities, time series, velocities…
- It will constitute the ETRF00 frame in the country.
- Consistent with EPN products, homogeneously processed, same time span…
- The resulting update of coordinates is going to be implemented as soon as posible in all the networks (national & regional).
- Almost all stations are integrated in EPN-D with up-to-date logsheets and IERS domes numbers.

Future works

- Apply for validation by the EUREF GB.
- Continuous processing already underway by ICGC, IGN, ITACYL.
- Periodically updating of coordinates in case of exceeding the specific threshold.
- Permanently monitoring the stations and report of inconsistencies to the station managers.

REFAG 2022
THESSALONIKI - GREECE

Thank you very much!
Ευχαριστώ πολύ

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