Session: National and Local Activities

Coordination of the GNSS networks in Spain

Working Group of the Specialized Commission for the Geodetic System (CESG)
Superior Geographic Council (Consejo Superior Geográfico - España)

Presented by: Jose A. Sánchez Sobrino, CESG Secretary, IGN

GNSS networks in Spain

- 2005-2009: deployment of regional GNSS public networks (14 in total)
- Purpose: RTK services.
- Some issues affecting stations:
  - No geodetic marks or choke ring antenas.
  - No IERS dome numbers, duplicated names, no IGS logs.
  - Some networks didn't publish RINEX files.
  - No standard RINEX naming or compression.
  - The most important: **no homogeneous or accurate coordinates for the stations.**
  - In general, poor coordination between IGN and regional networks or vicinity regions.

Specialized Commission of Geodetic System (CESG)

- Geographic Council (CSG), created by law 1545/2007.
- Some Commissions dependant of CSG; one of them, CESG (2011).
- A Working Group was created in 2012 in order to achieve 3 main goals:
  - To adopt ETRF2000 as conventional realization of ETRS89 for Spain, following EUREF recommendations.
  - To process in a continuous way the GNSS data in order to produce cumulative and homogeneous solutions.
  - To publish a common web portal with basic information about all public GNSS networks.
- The WG members were, basically, the network managers and it was divided in:
  - Web portal WG
  - Processing WG

Some achievements of the web portal WG

- IERS dome numbers for all stations and resolution of duplicated 4-char names.
- IGS logs in M3G for all stations.
- Publication of RINEX 2/3 files in public repositories, according to the RINEX naming standars.
- Sharing stations: real time data streams with vicinity regions and IGN<>regional networks.
- Homogenization of mountpoints naming.

Solución RTK	FORMATO							
	Bruto (leica, topcon, RT27, ...)	RTCM2.x	RTCM3.x	CMRx	CMR+	CMR	Leica	Leica4G
Punto simple *	PAML0	PAML2	PAML3	PALMX	PALM+	PALMC	PALML	PALMG
CERCANA	CERCANA0	CERCANA2	CERCANA3	CERCANAX	CERCANA+	CERCANAC	CERCANAL	CERCANAG
VRS	VRS0	VRS2	VRS3	VRSX	VRS+	VRSC	VRSL	VRSG
FKP	----	FKP2	FKP3	----	----	----	----	----
MAC ó MAX (MAC)	MAC0	----	MAC3	----	----	----	MACL	MACG
I-MAX (IMAX)	IMAX0	IMAX2	IMAX3	IMAXX	IMAX+	IMAXC	IMAXL	IMAXG

2017 – Mountpoints naming agreement

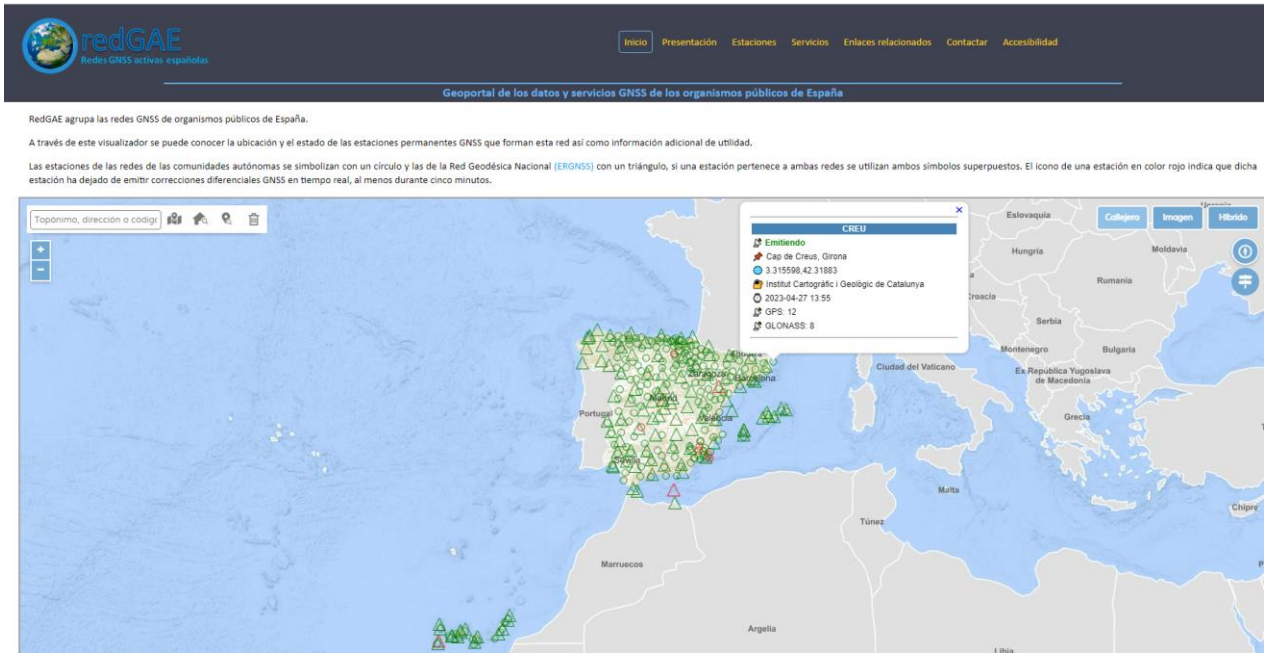
Solución RTK	FORMATO						
	Bruto (leica, topcon RT27,...)	RTCM3.x	CMRx	CMR+	CMR	Leica	Leica4G
Punto simple *	PAML0M	PAML3M	PAMLXM	PAML+M	PALMCM	PALMLM	PALMGM
CERCANA	CERCANA0M	CERCANA3M	CERCANAXM	CERCANA+M	CERCANACM	CERCANALM	CERCANAGM
VRS	VRS0M	VRS3M	VRSXM	VRS+M	VRSCM	VRSLM	VRSGM
FKP	----	FKP3M	----	----	----	----	----
MAC o MAX (MAC)		MAC3M	----	----	----	MACLM	MACGM
I-MAX (iMAX)	IMAX0M	IMAX3M	IMAXXM	IMAX+M	IMAXCM	IMAXLM	IMAXGM

2022 – Mountpoints MSM naming agreement

Some achievements of the web portal WG (II)

- Web portal: REDGAE (https://redgae.ign.es)

- Information about:
  - Real time status of stations
  - Metadata (logs / datasheets)
  - Public services:
    - Real time casters
    - RINEX repositories
  - “Official” coordinates
  - Links, documents, contacts…
  - Next contents:
    - Time series & velocities
    - Discontinuities



Some achievements of the web portal WG (III)

redGAE
Redes GNSS activas españolas

Inicio | Presentación | Estaciones | Servicios | Enlaces relacionados | Contactar | Accesibilidad

Geoportal de los datos y servicios GNSS de los organismos públicos de España

Estaciones

Redes de estaciones permanentes activas GNSS en España

- ARAGEA: Red de Geodesia Activa de Aragón
- CATNET: Xarxa d'estacions permanentes GNSS de Catalunya

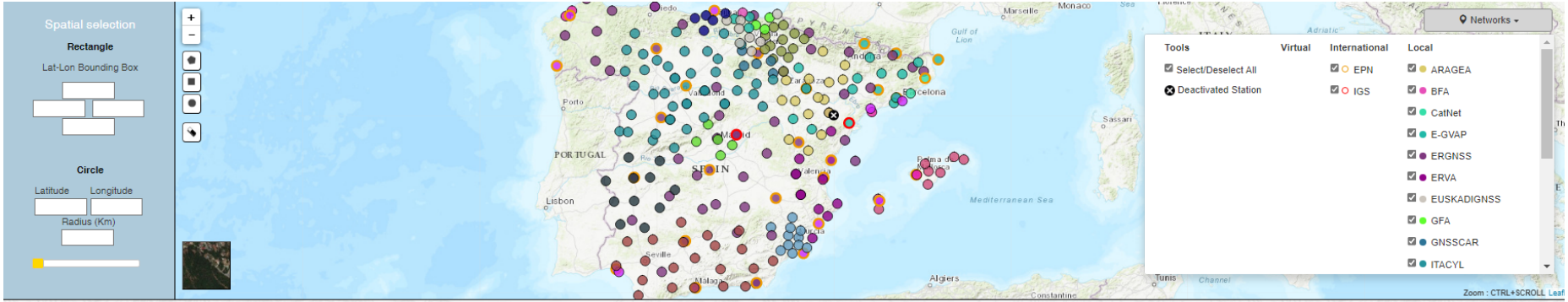
CATNET (Cataluña)

		Coordenadas en el sistema ETRS89												Red	
		Cartesianas Geocéntricas			Coordenadas geográficas			Coordenadas UTM							
Localización	Código IDN	X	Y	Z	Latitud(gg mm ss)	Longitud(gg mm ss)	h (elipsoidal)	X UTM	Y UTM	Huso	Ficha	Log	IGS	EUREF	ERGNSS
Les Avellanes, Lleida	AVEL 13440M001	4755888,266	62302,11	4236277,972	41 52 53,78356	0 45 1,91325 E	682,651	313354,14	4639077,946	31			☐	☐	☐
Bellmunt de Segarra, Barcelona	BELL 13431M001	4775849,626	116814,093	4213018,729	41 35 58,61516	1 24 4,0937 E	853,419	366757,089	4606557,994	31			☐	☑	☐
Beuda, Girona	BEUD 19404M001	4723447,299	220746,64	4267254,988	42 15 20,3108	2 40 32,61671 E	879,711	473252,214	4678211,383	31			☐	☐	☐
Cassà de la Selva, Girona	CASE 13494M001	4749772,755	240959,53	4236095,911	41 52 58,37991	2 54 15,00525 E	251,781	492048,895	4636777,465	31			☐	☑	☐
Cap de Creus, Girona	CREU 13432M001	4715420,543	273177,511	4271946,429	42 19 7,82158	3 18 56,15611 E	133,391	526006,282	4685225,799	31			☐	☑	☐
Roquetes, Tarragona	EBRE 13410M001	4833520,364	41536,83	4147461,291	40 49 15,18652	0 29 32,49183 E	107,792	288523,707	4521900,143	31			☑	☑	☐
Escornacrabes, Lleida	ESCO 13435M001	4696265,179	79978,225	4304244,75	42 41 36,86203	0 58 32,38653 E	2508,428	334179,222	4728774,238	31			☐	☑	☐
Begues, Barcelona	GARR 13489M001	4796983,793	160308,743	4187340,001	41 17 34,57599	1 54 50,52788 E	634,509	409073,572	4571845,439	31			☐	☐	☐
Lleida, Lleida	LLEI 13488M001	4774382,838	49690,068	4215084,8	41 37 45,4289	0 35 46,65278 E	254,324	299772,417	4611408,577	31			☐	☐	☐
Llivia, Girona	LLIV 13436M001	4709586,506	162244,344	4285914,025	42 28 41,24801	1 58 22,97366 E	1467,759	415589,533	4703374,936	31			☐	☑	☐
Mataro, Barcelona	MARE 13490M002	4777633,895	203108,985	4206595,149	41 31 42,39233	2 26 3,54804 E	86,764	452807,257	4597576,33	31			☐	☐	☐
Les Planes, Barcelona	PLAN 13442M001	4787329,036	166085,642	4197602,469	41 25 6,68906	1 59 13,0259 E	319,966	415341,731	4585714,121	31			☐	☐	☐
Reus, Tarragona	REUS 13491M001	4807314,339	98057,027	4176767,605	41 10 12,00596	1 10 6,69586 E	173,425	346363,188	4559245,89	31			☐	☐	☐
Sant Bartomeu del Grau, Barcelona	SBAR 13492M001	4745755,101	180181,135	4244588,952	41 58 48,38853	2 10 27,45508 E	937,895	431595,369	4647897,334	31			☐	☐	☐
Solsona, Lleida	SONA 13495M001	4746473,77	125685,293	4245468,293	41 59 32,04627	1 31 0,55813 E	755,482	377150,305	4649978,021	31			☐	☐	☐
Soriguera, Lleida	SORG 13493M001	4719087,743	93309,522	4277294,338	42 22 28,30604	1 7 57,89891 E	1284,481	346266,348	4693049,826	31			☐	☐	☐

- ERGNSS: Red de estaciones permanentes GNSS del IGN
- ERVA: Red de Estaciones de Referencia GNSS de Valencia
- GRAFCAN: Red de estaciones permanentes de Canarias
- ITACYL: Red de estaciones GNSS de Castilla y León
- MERISTEMUM: Red GNSS MERISTEMUM de Murcia

Some achievements of the web portal WG (IV)

- Inclusion of the networks in EPOS.
  - Spanish EPOS data node as a common repository > https://redgae-epos.ign.es/glasswebui/#/site
  - FTP > https servers



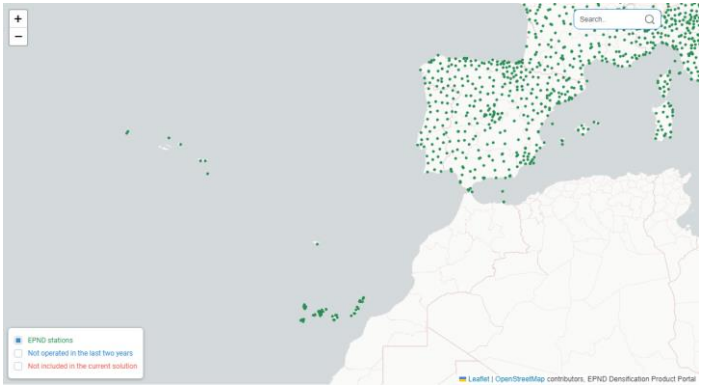
Marker	Site Name	Lat	Lon	Alt	Install Date	End Date	Country	State	City	Agency	Network
		greater than / less than	greater than / less than	greater than / less than	greater than / less than	greater than / less than					ex: epn,igs,... / inverse filter
ABAN00ESP	Abanilla	38.175	-1.054	207.620	2013-02-11 00:00:00		Spain	Región De Murcia	Parque De Bomberos De...	Comunidad Autónoma de...	E-GVAP & REGAM
ACAL00ESP	Los Alcázares	37.731	-0.861	67.590	2013-02-11 00:00:00		Spain	Región De Murcia	Parque De Bomberos De...	Comunidad Autónoma de...	E-GVAP & REGAM
ACIN00ESP	Albarracin	40.409	-1.437	1,177.850	2010-01-19 00:00:00		Spain	Teruel	Albarracín	Instituto Geografico de Ar...	ARAGEA
ACNS00ESP	Alcanices	41.700	-6.352	871.200	2008-02-14 00:00:00		Spain	Zamora	Alcanices	Instituto Tecnologico Agr...	E-GVAP & ERGNSS &
ACOR00ESP	A Coruna	43.364	-8.399	66.960	1998-03-06 10:10:00		Spain	A Coruna	A Coruna	Instituto Geografico Naci...	E-GVAP & EPN &
AGRD00ESP	Agreda	41.849	-1.931	1,010.800	2007-04-26 00:00:00		Spain	Soria	Agreda	Instituto Tecnologico Agr...	E-GVAP & ITACYL
AGUI00ESP	AGUIMES	27.904	-15.446	329.040	2009-12-14 00:00:00		Spain	Isla De Gran Canaria (La...	Aguimes	Cartográfica de Canarias,...	REPCAN
AIO200ESP	Ayora	39.061	-1.059	662.130	2019-10-03 00:00:00		Spain	Valencia	Ayora	Institut Cartogràfic Valencià	ERVA

Some achievements of the web portal WG (V)

Network	Region	Nr files in data node	RINEX3 since
ARAGEA	Aragón	7.799	01/2022
CATNET	Cataluña	34.163	06/2017
ERGNSS	España	221.195	07/2016
ERVA	C. Valenciana	6.073	04/2016
GRAFCAN	Canarias	6.716	11/2022
ITACYL	Castilla-León	52.038	02/2018
RAP	Andalucía	9.906	05/2017
REGAM	Murcia	5.474	06/2022
REP	Extremadura	No data, no https	-
RGAC	Cantabria	1.717	02/2022
RGAN	Navarra	7.864	04/2021
RGAPA	Asturias	Still no EPOS	---
RGE	País Vasco	4.558	01/2022
Red GNSS Rioja	La Rioja	1.187	02/2022
Red GNSS Madrid	C. Madrid	6.006 (https IGN)	07/2016
XGAIB	Baleares	8.868 (https IGN)	

Data of GNSS networks in EPOS data node

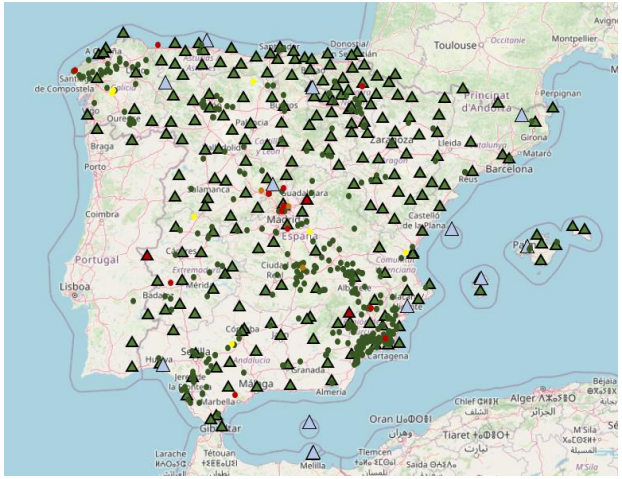
- This WG has been a good tool to harmonize and coordinate the GNSS networks: they contribute in all important projects, such as EPN-D, EPOS, E-GVAP…



EPN-D stations

Some achievements of the web portal WG (VI)

- Real Time Positioning Service (SPTR) at a national level in addition to RTK regional services.
  - 270 stations providing data streams: IGN & regional networks.
  - Multiconstellation and network solutions.
  - 13.000 users



Processing WG: Motivation

- Many of the frames/coordinates of regional 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 rigorous processing guidelines.
  - weren't regularly updated (i.e. due to discontinuities or other changes in the network stations).

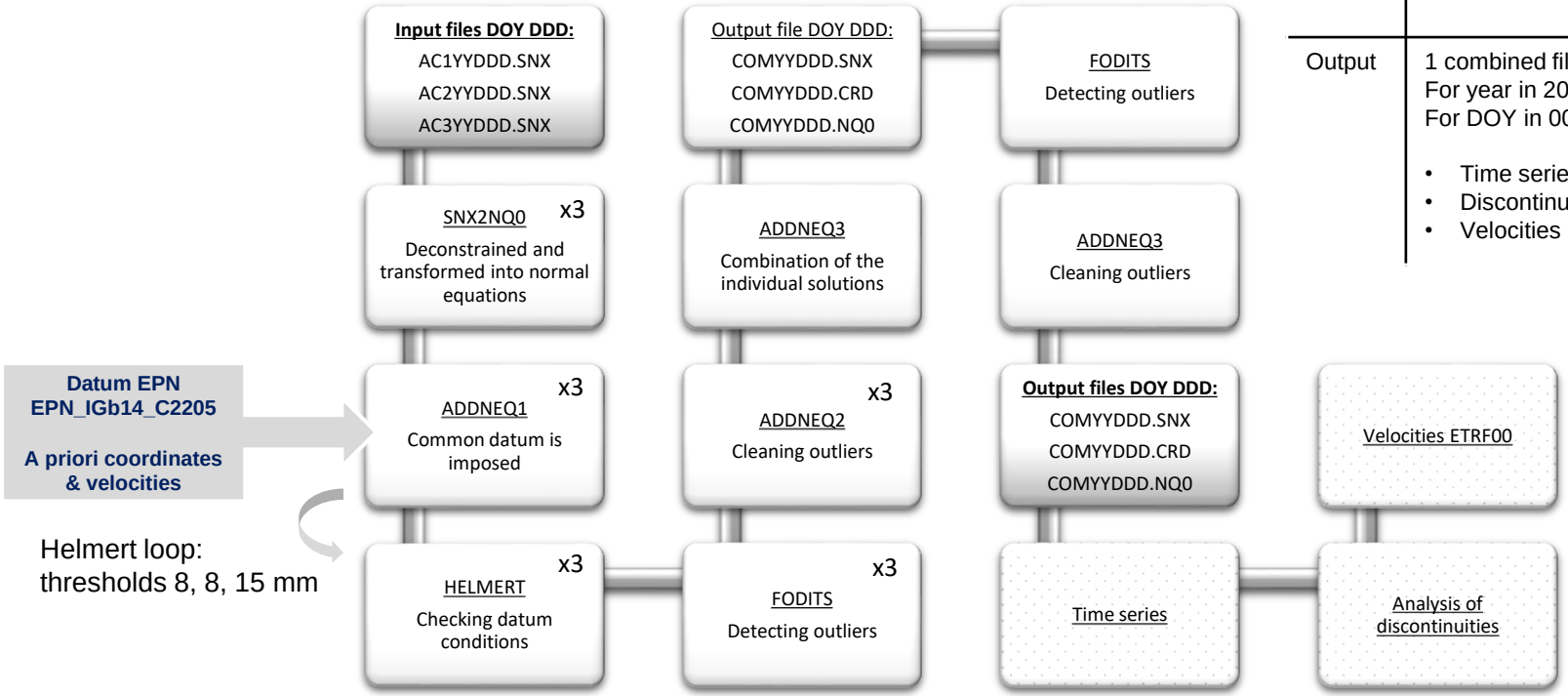
- A call for participation was issued to the WG. The following ACs volunteered to participate:
  - Institut Cartogràfic i Geològic de Catalunya (ICGC)
  - Instituto Tecnológico Agrario de Castilla-León (ITACYL)
  - Instituto Geográfico Nacional (IGN)
  - Instituto de Estadística y Cartografía de Andalucía (IECA)

Processing WG: ACs options

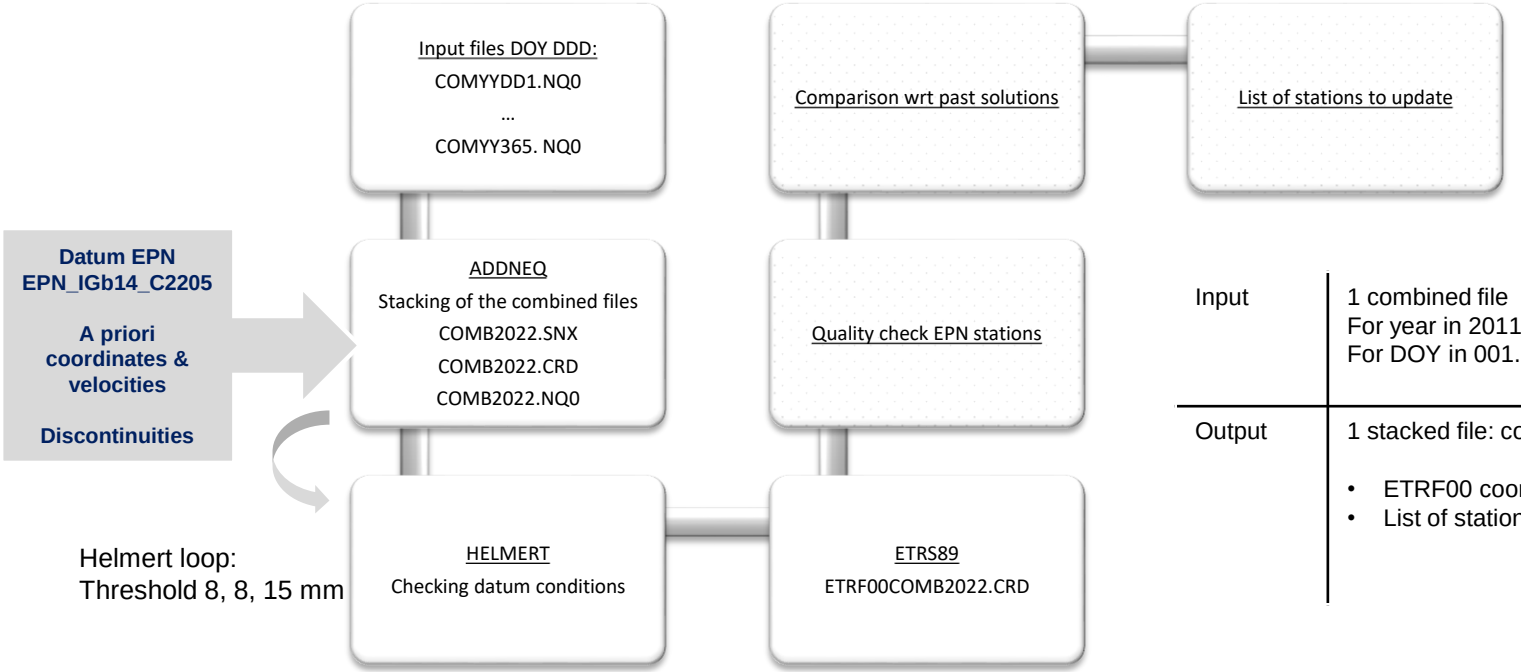
	IGN	ICGC	IECA	ITACYL
PERIOD SUBMITTED	2011 - 2022	2011 - 2019	2011 - 2017	2011-2022
EXPERIENCE	EUREF LAC since 2001, EPN-D, Repro1 & 2	Submitting a solution to EPN-D	Submitting a solution to EPN-D as a sub-net of ARA	Wide experience in GNSS processing
SOFTWARE	Bernese 5.2	Bernese 5.2	Bernese 5.2	GAMIT/GLOBK 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

Step 1: Combination of daily SNX

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



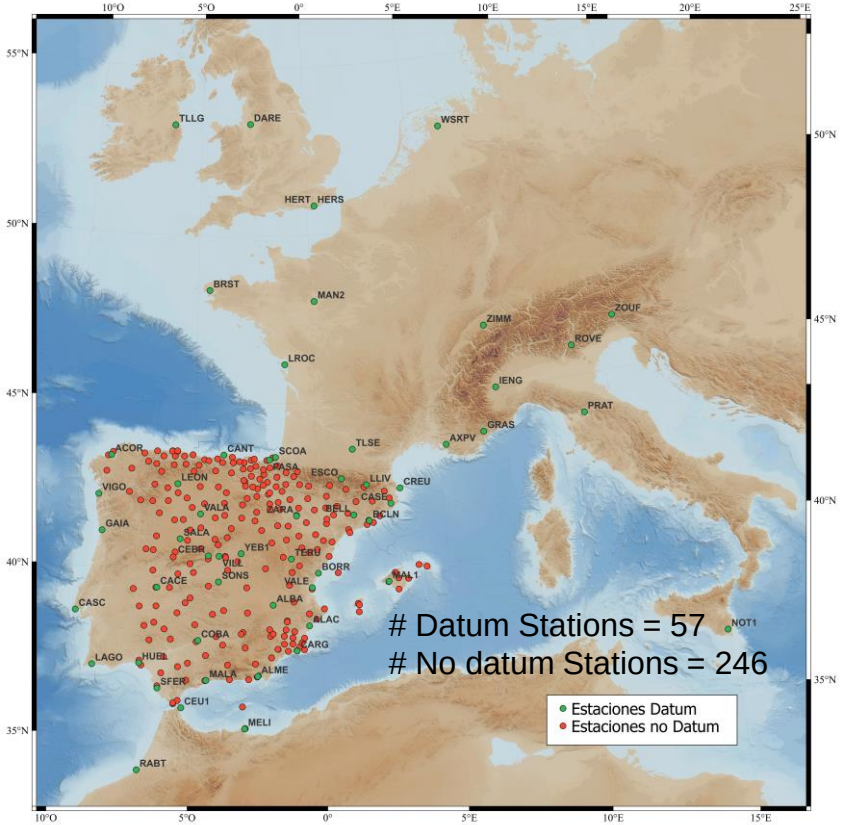
Step 2: stacking daily combined NEQ into an unique solution



(12, 12, 20 mm) for updating “oficial” CRD

Input	1 combined file For year in 2011..2022 For DOY in 001..365
Output	1 stacked file: coordinates and velocities ITRF • ETRF00 coordinates • List of stations to update

Datum alignement check



AbsNorth	Mean		0,87
	95% Confidence Interval for Mean	Lower Bound	0,68
		Upper Bound	1,07
	Median		0,58
	Variance		1,10
	Std. Deviation		1,04
	Minimum		0,00
	Maximum		7,22
AbsEast	Mean		1,10
	95% Confidence Interval for Mean	Lower Bound	0,85
		Upper Bound	1,36
	Median		0,52
	Variance		1,86
	Std. Deviation		1,36
	Minimum		0,02
	Maximum		7,52
AbsUp	Mean		2,78
	95% Confidence Interval for Mean	Lower Bound	2,24
		Upper Bound	3,33
	Median		1,90
	Variance		8,32
	Std. Deviation		2,88
	Minimum		0,08
	Maximum		14,66

Abs. differences between combination and EPN coordinates (EPN_IGb14_C2205) in datum stations. NEU components

Cumulative solutions obtained by the processing WG

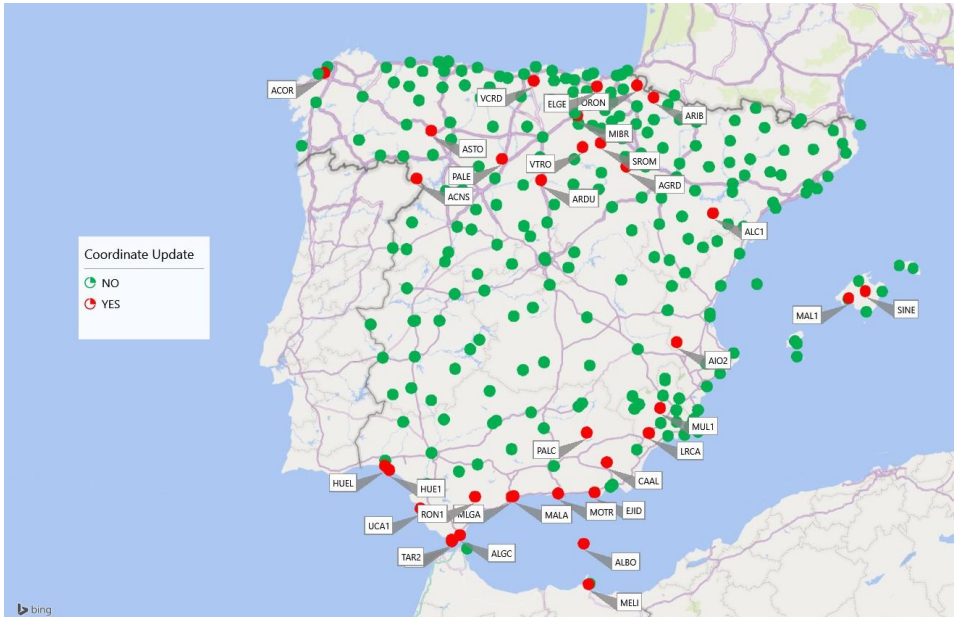
- 1st combination:
  Period: [DOY 107 2011 – DOY 029 2017]
  Epoch: 01-01-2017
  Ref. frame: IGb08
  Analysis Centres: 4
  Finish date: ending 2017
  271 stations

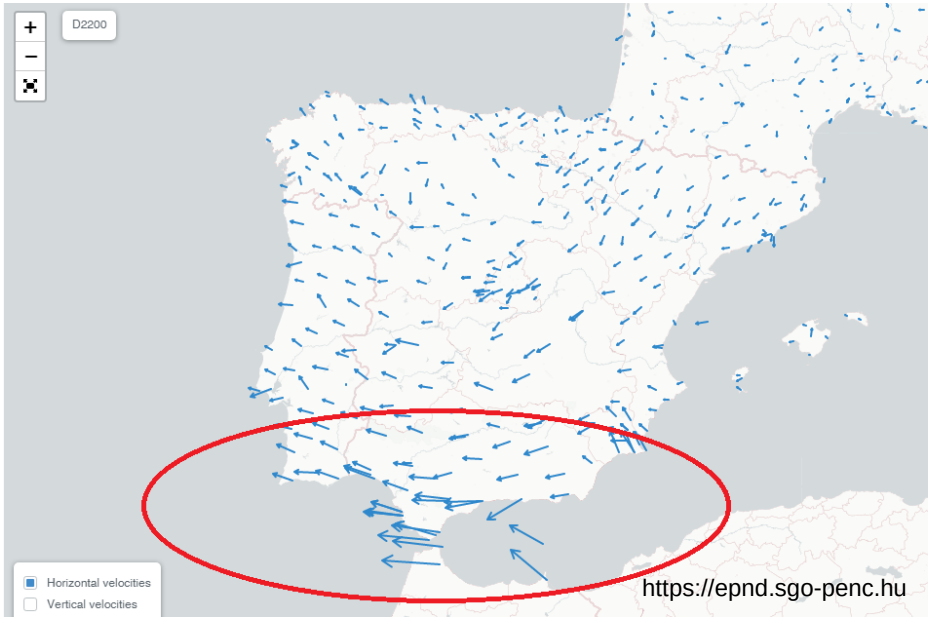
- 2nd combination:
  Period: 1st combination + [DOY 029 2017 - DOY 001 2020]
  Epoch: 01-01-2020
  Ref. frame: IGb08 + IGb14
  Analysis Centres: 3
  Finish date: ending 2020
  310 stations

- 3th combination:
  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
  303 stations

Threshold for updating CRDs:
12, 12, 20 mm

Update of coordinates

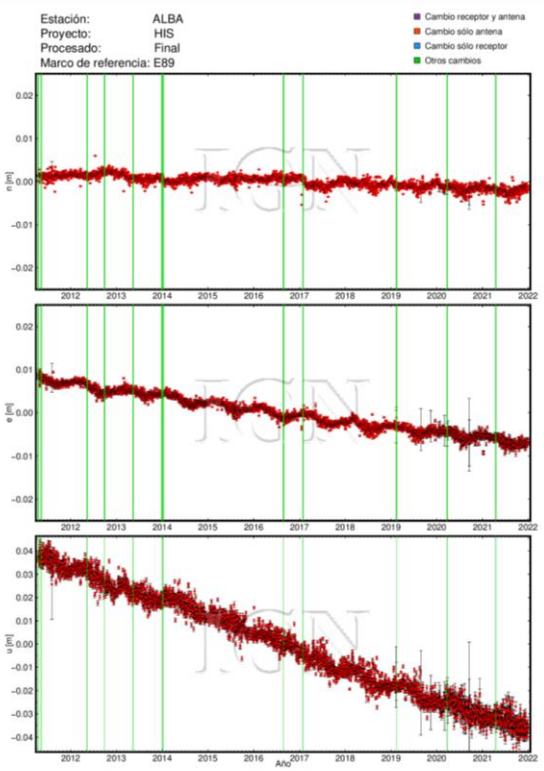


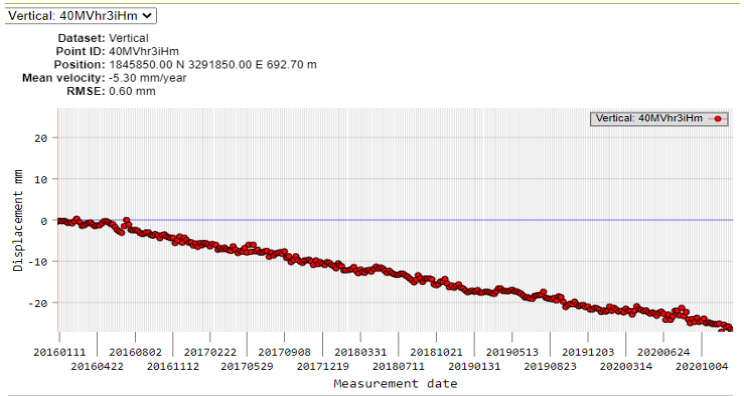


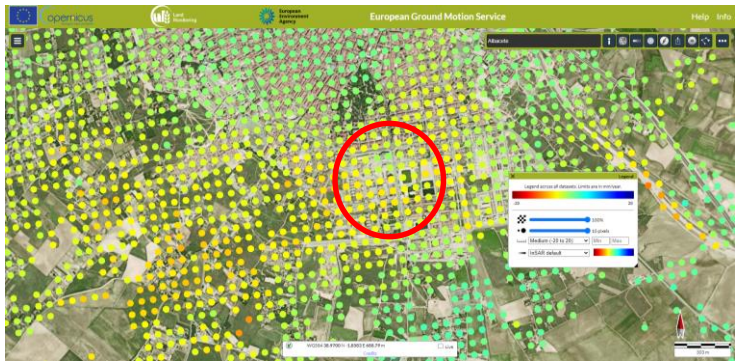
3th combination: Data from 2011 to 2022
Ref. epoch 2022,0
Updated Stations = 35

Changes in coordinates dues to:
- North: change of antenas
- South: ETRF00 velocities towards W (2-3 mm/yr)

Products: CRDs, time series, discontinuities, velocities (I)

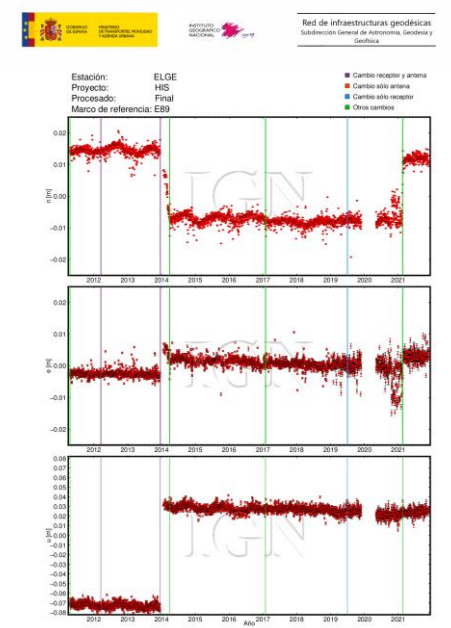






Up velocities
GNSS ~-7.1 mm/y
EGMS ~-5.3 mm/y

Products: CRDs, time series, discontinuities, velocities (II)



Discontinuities:
FODITS + time series inspection + EPN disc.

Hz velocities 2011-2022 (CATS 3.1.2)
West displacement in the southern región 2-3 mm/yr
Full agreement with EPN-D

Conclusions

- The WG has been demonstrated a good tool to harmonize and organize all the public GNSS networks: unique and updated geodetic reference frame, data, metadata, services…
- Thanks to this coordination, regional Spanish stations are integrated in the most important projects in Europe, such as EPN-D, EPOS or E-GVAP.
- There is a common web portal (https://redgae.ign.es) and RINEX repository (EPOS data node).
- There is a national RTK service (SPTR) as the result of a good cooperation between all the GNSS public networks (IGN + regional).
- The cumulative solutions produced by the WG constitutes the ETRF00 reference frame in the country, consistent with EPN products, homogeneously processed, same time span…
- An historical Repro is already on-going, which also will be sent to EPN-D.

Thank you for your attention

Working Group of the Specialized Commission for the Geodetic System (CESG)
Superior Geographic Council (Consejo Superior Geográfico - España)