EPN Analysis Centres Coordinator Report

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EUREF Analysis Centres Workshop

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Outline

The EPN Analysis Centres Coordinator (ACC) combines and analyses GNSS coordinate solutions provided by 16 EPN Analysis Centres (AC).
The presentation focuses on:

1. Latest developments relevant for EPN GNSS data analysis
2. Recent activities of the ACC:
   - Combination and analysis of AC solutions including Galileo observations
   - Preliminary tests of analyzing the impact of adding global sites on EPN daily coordinate solutions

EPN Analysis Centres characteristics

AC	AC Description	Software	Solutions[1]			# sites
ASI	Centro di Geodesia Spaziale, Italy	GIPSY 6.2	F	R	U	72
BEK	Bavarian Academy of Sciences & Humanities, Germany	Bernese 5.2	F	R	–	104
BEV	Federal Office of Metrology and Surveing, Austria	Bernese 5.2	F	–	–	118
BKG	Bundesamt fuer Kartographie und Geodaesie, Germany	Bernese 5.2	F	R	U	124
COE	Center for Orbit Determination in Europe, Switzerland	Bernese 5.3	F	–	–	42
IGE	Instituto Geografico Nacional, Spain	Bernese 5.2	F	R	–	91
IGN	Institut Geographique National, France	Bernese 5.2	F	R	–	63
LPT	Federal Office of Topography swisstopo, Switzerland	Bernese 5.3	F	R	U	61
MUT	Military University of Technology, Poland	GAMIT/GLOBK	F	R	–	147
NKG	Nordic Geodetic Commision, Sweden	Bernese 5.2	F	–	–	98
RGA	Republic Geodetic Authority, Serbia	Bernese 5.2	F	–	–	55
ROB	Royal Observatory of Belgium, Belgium	Bernese 5.2	F	R	–	102
SGO	Lechner Knowledge Center, Hungary	Bernese 5.2	F	R	–	42
SUT	Slovak University of Technology, Slovakia	Bernese 5.2	F	–	–	59
UPA	University of Padova, Italy	Bernese 5.2	F	R	–	69
WUT	Warsaw University of Technology, Poland	Bernese 5.2	F	R	–	133

[1] Solutions: F – Final, R – Rapid, U – Ultra-rapid

Inclusion of new stations to EPN

Presently EPN consists of 342 stations. Since the last workshop:

- 28 new stations added,
- 7 stations removed,
- 6 stations proposed.

Distribution of stations wrt. the number of processing ACs:

#ACs	#sites	% of sites
3	71	20.8
4	207	60.5
5	61	17.8
6	3	0.9

AC	#new	#removed	#sites
ASI	20	1	72
BEK	8	1	104
BEV	17	0	118
BKG	7	0	124
COE	0	1	42
IGE	6	1	91
IGN	0	1	63
LPT	1	0	61
MUT	4	1	147
NKG	11	1	98
RGA	0	1	55
ROB	5	1	102
SGO	0	0	42
SUT	0	0	59
UPA	12	0	69
WUT	17	3	133

Proposed stations to EPN

- Presently there are 6 proposed stations to EPN

Antenna type	City	ACs	Ready
DGOR00MNE	Podgorica	ASI, BEV	
FFMJ00DEU	Frankfurt	BKG	*Yes*
MAT100ITA	Matera	ASI, BEV, BKG, LPT	
TIT200DEU	Titz	BKG	*Yes*
VAIN00LVA	Vainode	BEV, BKG, NKG	
YLDZ00TUR	Istanbul	ASI, BKG, OLG, SUT	

- Two stations are ready to be included: FFMJ00DEU, TIT200DEU,
- At least 2 ACs are still needed to process these stations.

New ANTEX file at EPN CB

- Recently, new individual antenna calibrations were provided to EPN for already used antennas,
- EPN CB prepared a new ANTEX file that allows for multiple individual calibrations for the same antennas (presently for 8 antennas)
  - important for backward compatibility, reprocessing

Antenna type	Serial number	# calibs	Installed at
LEIAR25.R3 LEIT	09050002	2	FFMJ00DEU, WARN00DEU
LEIAR25.R4 LEIT	10211013	2	HOFJ00DEU, AUBG00DEU
LEIAR25.R4 LEIT	10211018	2	LEIJ00DEU, HOFJ00DEU
LEIAR25.R4 LEIT	725058	2	RANT00DEU, DILL00DEU
LEIAR25.R4 LEIT	725266	2	DILL00DEU, GELL00DEU
LEIAR25.R4 LEIT	725267	2	BAUT00DEU, HOE200DEU
LEIAR25.R4 LEIT	725552	2	AUBG00DEU, RANT00DEU
LEIAR25.R4 LEIT	725559	2	WARN00DEU, HELG00DEU

New ANTEX file at EPN CB – example

An example for antenna LEIAR25.R4 LEIT, SN: 725552, installed at RANT00DEU and AUBG00DEU.

```
LEIAR25.R4      LEIT725552                                TYPE / SERIAL NO
ROBOT               Geo++ GmbH              1    2013-01-11METH / BY / # / DATE
     5.0                                                  DAZI
     0.0  90.0   5.0                                      ZEN1 / ZEN2 / DZEN
     4                                                    # OF FREQUENCIES
  2014    05    09    10    00    0.0000000               VALID FROM
  2018    06    05    10    00   59.9999999               VALID UNTIL
EPNC_RANT00DEU                                           SINEX CODE
```

```
LEIAR25.R4      LEIT725552                                TYPE / SERIAL NO
CHAMBER             IGG, Univ. Bonn         1    2018-08-23METH / BY / # / DATE
     5.0                                                  DAZI
     0.0  90.0   5.0                                      ZEN1 / ZEN2 / DZEN
    21                                                    # OF FREQUENCIES
  2018    11    27    10    00    0.0000000               VALID FROM
EPNC_AUBG00DEU                                           SINEX CODE
```

New ANTEX file in Bernese GNSS Software

- To use the new ANTEX file in Bernese GNSS Software, the software has to be updated (program `ATX2PCV.f90`, new routine `ANTCHK.f90`)
  - improvement B_96 (26-Feb-2019)
- Also, a new station information file (`STA-file`) has to be used with the new ANTEX file:

STATION NAME	...	FROM						TO						...	ANTENNA TYPE		ANTENNA SERIAL NBR	ANT #	...
**********	...	YYYY	MM	DD	HH	MM	SS	YYYY	MM	DD	HH	MM	SS	...	**********	**********	**********	******	...
AUBG 10913M001	...	2018	11	27	10	00	00	2099	12	31	00	00	00	...	LEIAR25.R4	LEIT	725552	25553	...
RANT 10914M001	...	2014	05	09	10	00	00	2016	07	10	12	00	00	...	LEIAR25.R4	LEIT	725552	25552	...
RANT 10914M001	...	2016	07	10	12	00	00	2017	06	02	08	30	00	...	LEIAR25.R4	LEIT	725552	25552	...
RANT 10914M001	...	2017	06	02	08	30	00	2018	06	05	10	00	00	...	LEIAR25.R4	LEIT	725552	25552	...

- The necessary STA-file also has been prepared by the EPN CB.

New ANTEX file at EPN CB

The new ANTEX and STA files have been prepared by the EPN CB and will be mantained in parallel (for a limited time) with the presently used files. (For how long the old files should be maintained?)

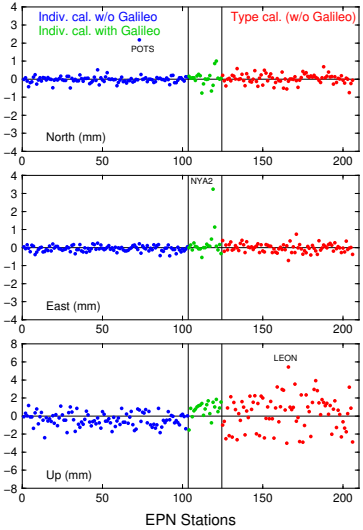
```
ftp://ftp.epncb.oma.be/pub/station/general/epnc_14_recalib.atx
ftp://ftp.epncb.oma.be/pub/station/general/epn_14_WWWW_recalib.atx
ftp://ftp.epncb.oma.be/pub/station/general/EUREF_recalib.STA

ftp://ftp.epncb.oma.be/pub/station/general/epnc_14.atx
ftp://ftp.epncb.oma.be/pub/station/general/epn_14_WWWW.atx
ftp://ftp.epncb.oma.be/pub/station/general/EUREF.STA
```

Galileo in operational solutions since GPS week 2044

AC	Software	Test phase (weeks)	GNSS[1]	Remark
ASI	Gipsy Oasis II 6.2		G	
BEK	Bernese 5.2	1975–2043	GRE	Galileo
BEV	Bernese 5.2		GRE	Galileo
BKG	Bernese 5.2	1965–2043	GRE	Galileo
COE	Bernese 5.3		GR	
IGE	Bernese 5.2	1975–2043	GRE	Galileo
IGN	Bernese 5.2		GR	
LPT	Bernese 5.3	1975–2043	GREC	Galileo
MUT	GAMIT/GLOBK		GE	Galileo
NKG	Bernese 5.2	2023–2043	GRE	Galileo
RGA	Bernese 5.2		GR	
ROB	Bernese 5.2	1960–2043	GRE	Galileo
SGO	Bernese 5.2		GR	
SUT	Bernese 5.2	2036–2043	GRE	Galileo
UPA	Bernese 5.2	1975–2043	GRE	Galileo
WUT	Bernese 5.2	2000–2043	GRE	Galileo

[1] GNSS: G – GPS, R – GLONASS, E – Galileo, C – Beidou

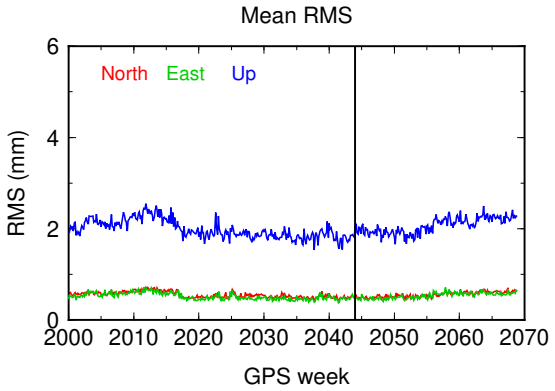
Impact of Galileo on station positions (test phase)



- Mean station position differences between combined solutions based on the 9 ACs test solutions (GPS+GLONASS+Galileo) and the operational solutions (GPS+GLONASS)
- Stations grouped according to the antenna calibration type
- 44 weeks (2000–2043) of daily solutions used for comparison
- Largest position differences were obtained for stations with type-mean calibrated antennas (especially for the up component)

RMS of AC residuals wrt. combination

- RMS of position differences between all individual AC solutions and the combined solution for north, east and vertical components.



Other relevant information for EPN ACs

- According to the new EPN station guidelines, since January 1, 2020 submission of RINEX 2 will be optional for stations submitting RINEX 3 data.
  - ACs that use only RINEX 2 for processing should switch to RINEX 3 as soon as possible.
- Since mid September, CODE IGS analysis centre has extended the rapid and ultra-rapid products from a two-system to a three-system processing: GPS, GLONASS, Galileo (see LAC-MAIL no. 2492 for details)
  - Galileo observations may be also included in EPN rapid (and ultra-rapid) products.

Comparison of EPN solutions with global solution

Following the GB action item, ACC started activities on the global extension of EPN.

- Preliminary tests have been performed to analyse the impact of adding global stations on EPN daily coordinate solutions.

Comparison of EPN solutions with global solution

The following global solutions have been used for the creation of EPN global solution:

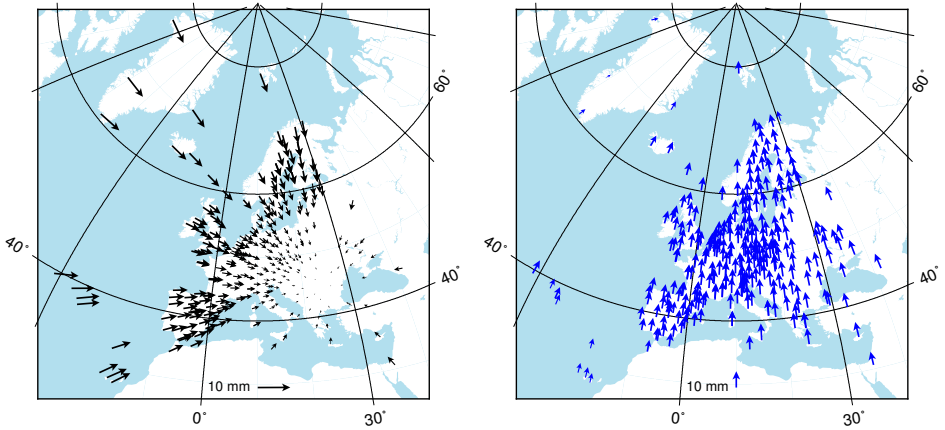
1. 1-day CODE global solution (1980–2043, 2050–2055),
2. operational IGN EPN AC solution (1980–2043, 2050–2055),
3. global solutions provided by IGE EPN AC (1990–1997),
4. global solutions provided by UPA EPN AC (2050–2055),
5. global solutions computed by WUT EPN AC (1980–2043, 2050–2055).

The global solutions were combined together with the EPN AC operational solutions for 72 weeks (1980–2043, 2050–2055).

- the differences between EPN operational (regional) and EPN global solutions were inspected

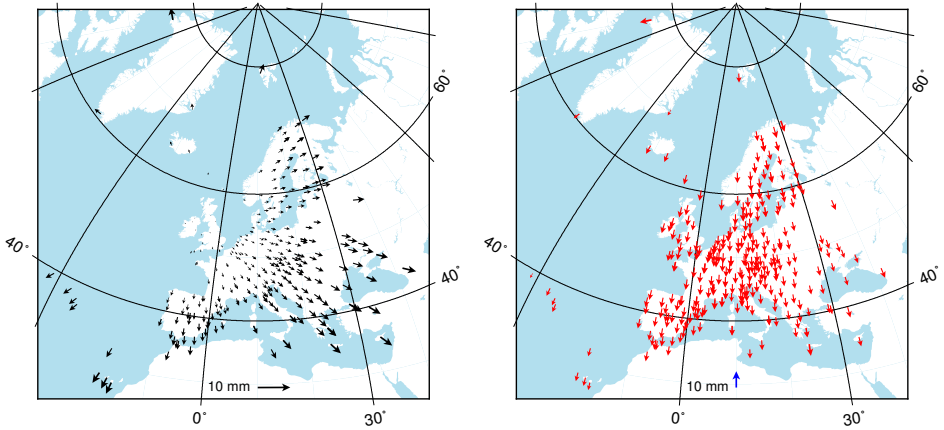
Direct comparison of EPN operational and EPN global solutions

Differences of positions between EPN operational solutions and EPN global solutions for week 1983, day 6

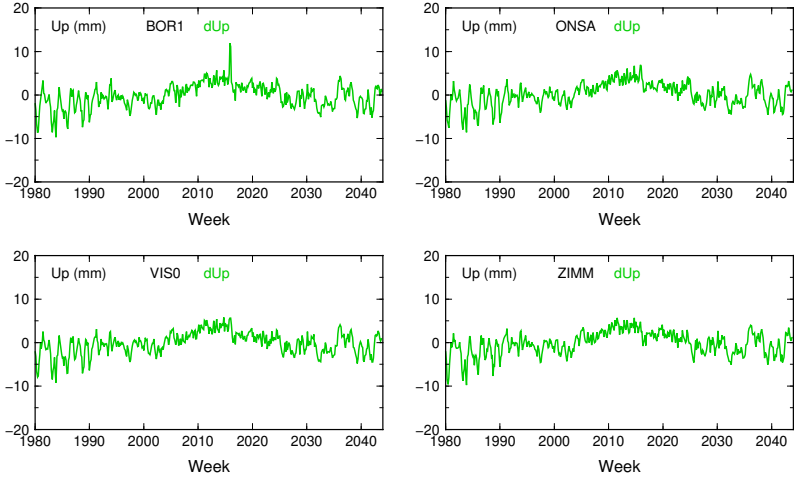


Direct comparison of EPN operational and EPN global solutions

Differences of positions between EPN combined operational solutions and EPN global solutions for week 2014, day 5

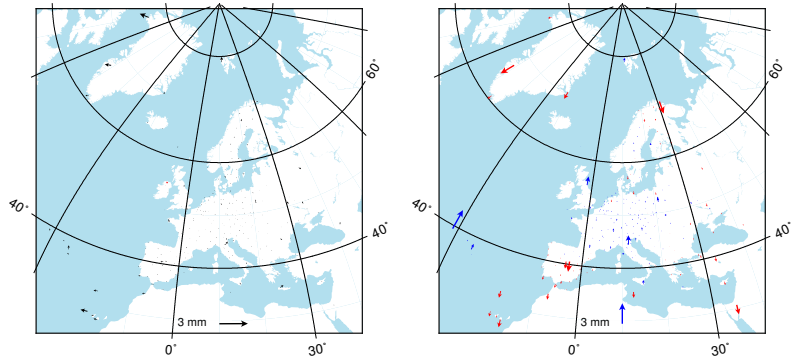


Examples of difference time series: up component



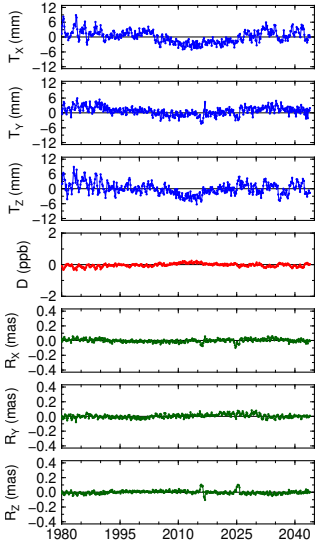
EPN vs. EPN global: 7-parameter transformation

Differences of positions between EPN combined operational solutions and EPN global solutions after 7-parameter transformation (3 translations, 3 rotations and scale) for week 1983, day 6



RMS North: 0.09 mm, RMS East: 0.09 mm, RMS Up: 0.38 mm

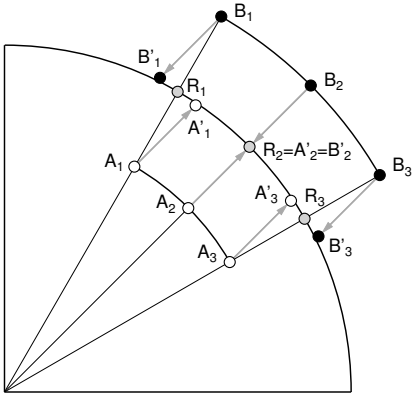
EPN vs. EPN global: transformation parameters, RMS of pos. residuals



- Mean RMSs (over 64 weeks) of station position residuals between EPN operational and EPN global after 3-, 6-, and 7-parameter transformation:

Transformation parameters	North (mm)	East (mm)	Up (mm)
3T	0.14	0.14	0.51
3T, 3R	0.14	0.13	0.47
3T, 3R, S	0.11	0.11	0.47

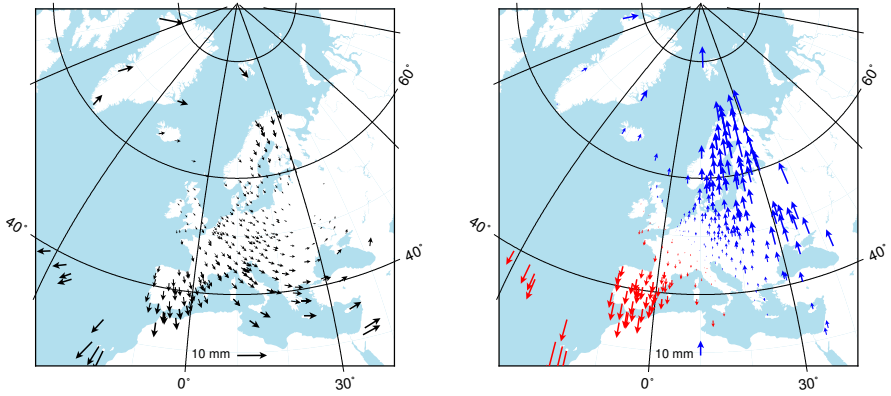
Loading effects



- R_1, R_2, R_3 – mean positions (reference, e.g., ITRF)
- A_1, A_2, A_3 – positions of sites during maximum load
- B_1, B_2, B_3 – positions of sites during minimum load
- A'_1, A'_2, A'_3, B'_1, B'_2, B'_3 – positions of points after transformation to reference positions using translations only

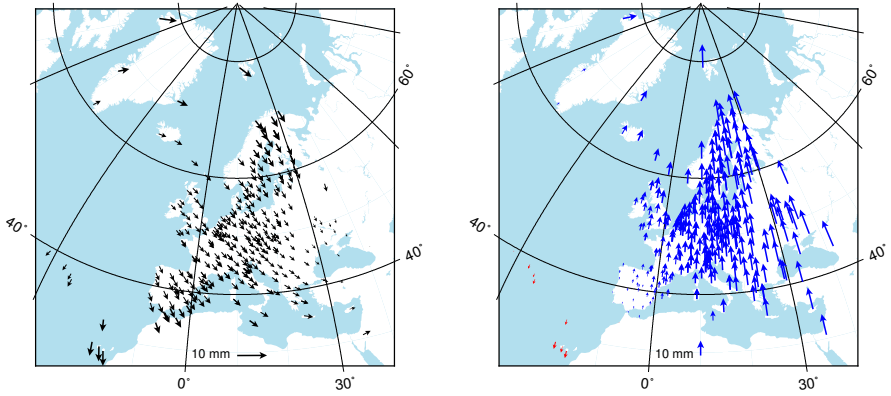
Transformed EPN solutions vs. EPN global

Differences of positions between transformed EPN solution (to IGS14 using 7-parameters) and EPN global solution for week 1990, day 3

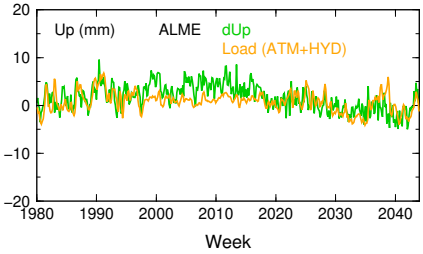


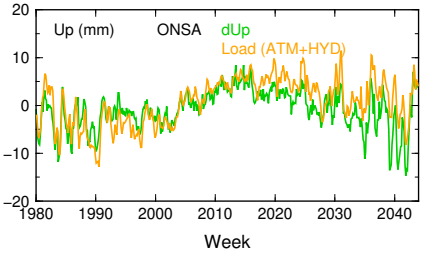
Transformed EPN solutions vs. EPN global

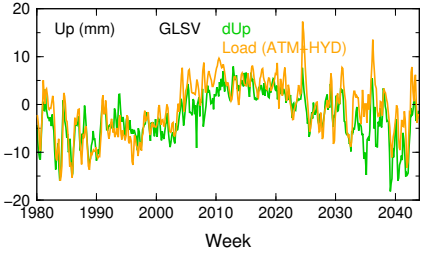
Differences of positions between transformed EPN solution (to IGS14 using 7-parameters) and EPN global solution for week 1983, day 6

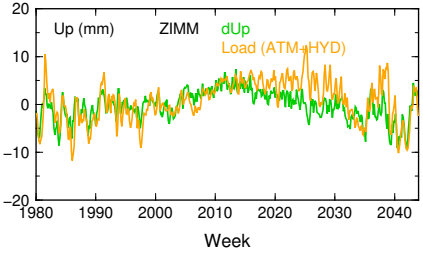


Comparison of difference time series to loading



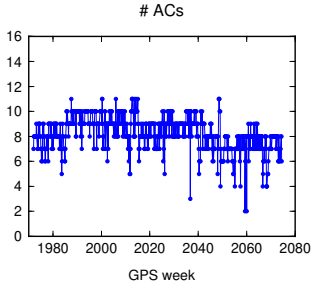


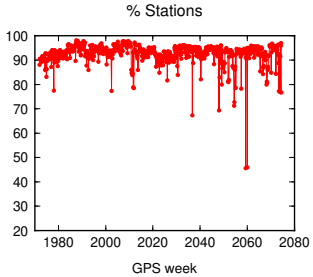


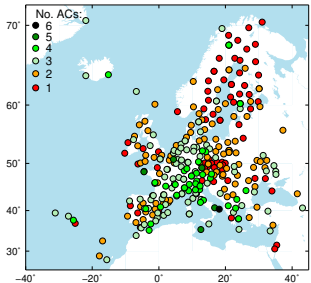


Rapid product

- up to 11 ACs contribute
- ∼90% stations included in rapid combined solutions
- ∼20% stations processed by 1 AC and ∼35% by 2 ACs only



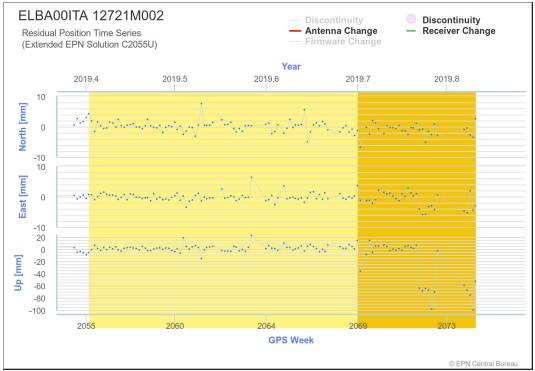




Rapid product

The product is useful for coordinate monitoring and for outlier identification:

- relevant for ACs, ACC, station managers
- more ACs are asked to start submitting rapid solutions to increase the redundancy and number of stations in combined solutions.



www.epncb.eu/_productsservices/timeseries/

Summary

- Galileo observations have been officially included in EPN final daily coordinate solutions since GPS week 2044 (March 10, 2019)
  - since mid September, because of new three sytem CODE products, Galileo observations may be used also in EPN rapid and ultra-rapid processings
- Analysis centres are asked to:
  - use the new EPN ANTEX file (with multiple antenna calibrations). (For how long the old files should be maintained?)
  - switch to RINEX3 processing (if not already done); since new year, RINEX 2 data may not be available for some stations
- The activities on the analysis of the impact global sites on EPN daily coordinate solutions have been started
  - How do we proceed?
  - Are more ACs interested to join these activities?