Report of the EPN Analysis Centres Coordinator

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Overview

The EPN Analysis Centres Coordinator (ACC) combines and analyses GNSS coordinate solutions computed by the EPN Analysis Centres (AC).

The presentation focuses on the activities of the ACC and changes relevant for EPN GNSS analysis since the last EUREF Symposium:

- updates in AC solutions
- changes in combined solutions
- updates in products and models used by ACs
- summary

Introduction – basic facts

- 16 EPN ACs regularly process GNSS data from $\sim$ 350 EPN stations (distributed processing)
  - processing RINEX 3 data mandatory since January 2021 (RINEX 2 no longer necessary if station submits RINEX 3 data)
- ACs may provide 3 types of solutions for their subnetworks of EPN stations (in SINEX format):
  - final weekly and daily (mandatory; delay up to 5 weeks)
  - rapid daily (recommended; delay up to 22 hours)
  - near-real time (recommended; delay: 1 hour)
- GNSS data processed according to the EPN analysis guidelines:

`https://www.epncb.eu/_documentation/guidelines/guidelines_analysis_centres.pdf`

EPN Analysis Centres description

AC	Agency
ASI	Centro di Geodesia Spaziale G. Colombo, Matera, Italy
BEK	Bavarian Academy of Sciences and Humanities, Germany
BEV	Federal Office of Metrology and Surveing, Austria
BKG	Bundesamt fuer Kartographie und Geodaesie, Germany
COE	Astronomical Institute, University of Bern, Switzerland
IGE	Instituto Geografico Nacional, Spain
IGN	Institut national de l'information geographique et forestiere, France
LPT	Federal Office of Topography swisstopo, Switzerland
MUT	Military University of Technology, Poland
NKG	Nordic Geodetic Commision, Sweden
RGA	Republic Geodetic Authority, Serbia
ROB	Royal Observatory of Belgium, Belgium
SGO	Lechner Knowledge Center, Hungary
SUT	Slovak University of Technology, Slovakia
UPA	University of Padova, Italy
WUT	Warsaw University of Technology, Poland

EPN Analysis Centres characteristics

AC	Software	Solutions			# sites	GNSS[1]
ASI	GipsyX 1.6	Final	Rapid	NRT	76	GRE
BEK	Bernese 5.2	Final	Rapid	–	110	GRE
BEV	Bernese 5.2	Final	–	–	130	GRE
BKG	Bernese 5.2	Final	Rapid	NRT	133	GRE
COE	Bernese 5.3	Final	–	–	40	GR
IGE	Bernese 5.2	Final	Rapid	–	91	GRE
IGN	Bernese 5.2	Final	Rapid	–	64	GR
LPT	Bernese 5.3	Final	Rapid	NRT	61	GRE
MUT	GAMIT 10.71	Final	–	–	148	GE
NKG	Bernese 5.2	Final	Rapid	–	100	GRE
RGA	Bernese 5.2	Final	–	–	53	GR
ROB	Bernese 5.2	Final	Rapid	–	108	GRE
SGO	Bernese 5.2	Final	Rapid	–	47	GRE
SUT	Bernese 5.2	Final	Rapid	NRT	58	GRE
UPA	Bernese 5.2	Final	Rapid	–	71	GRE
WUT	Bernese 5.2	Final	Rapid	–	138	GRE

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

- New rapid solution:
  - NKG (Oct. 2019)
- New NRT solution:
  - SUT (Apr. 2021)
- New ACs use Galileo:
  - SGO (Aug. 2020)
  - ASI (Jan. 2021)
- Number of ACs processing EPN stations:

#ACs	#sites	% of sites
3	88	24.3
4	210	58.0
5	60	16.6
6	4	1.1

Combined solutions

- AC solutions combined on a normal equation level using Bernese GNSS Software.

Details at: `https://epncb.eu/_productsservices/analysiscentres/CombinationStrategy.pdf`

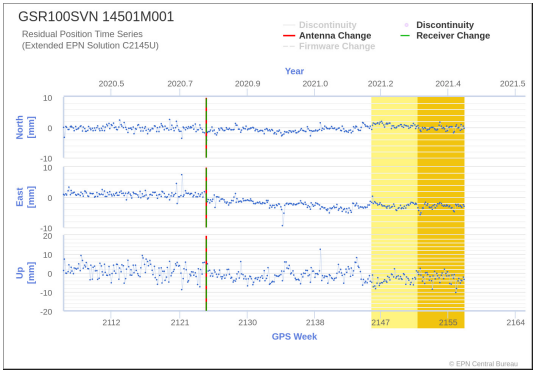
- Types of combined solutions and their usage:
  - final daily: the input for the EUREF cumulative solution computed by EPN Reference Frame Coordinator (Juliette Legrand)
  - rapid daily: station position monitoring (include $95 - 100\%$ of EPN stations)
  - near-real time: station position monitoring (include $\sim 47\%$ of EPN stations)
- Products available at BKG:

Final daily and weekly:
`ftp://igs.bkg.bund.de/EUREF/products/WWWWW/eurWWWW[0-7].[snx|crd|sum].Z`
Rapid:
`ftp://igs.bkg.bund.de/EUREF/products/WWWWW/eurWWWW[0-6]r.[snx|crd|sum].Z`
Near-real Time:
`ftp://igs.bkg.bund.de/EUREF/products/WWWWW/nrt[0-6]/eurWWWW[0-6]_[00-23].[snx|crd|sum].Z`

Rapid product

The product for station coordinate monitoring:

- interactive plots prepared at EPN CB
- relevant for ACs and ACC, station managers, other users



https://www.epncb.eu/_productsservices/timeseries/

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Near-real Time:
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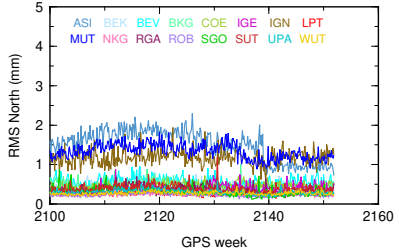
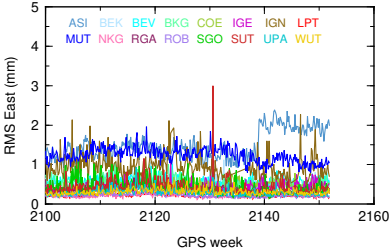
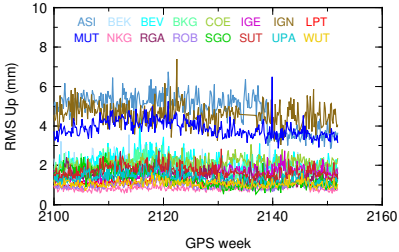
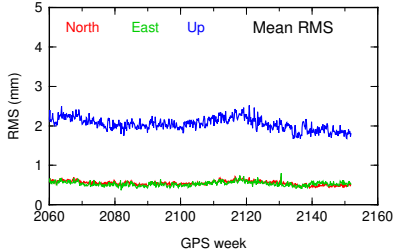
Combined solutions: AC solutions agreement

- RMSs of position residuals between each AC solution and combined solution





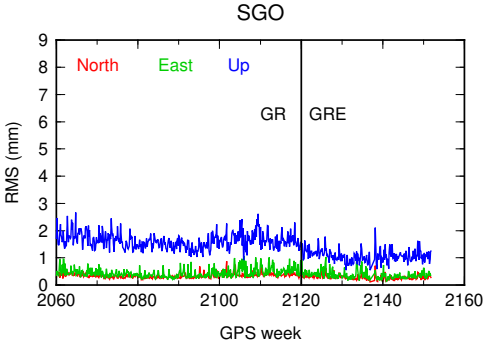




AC solutions: Galileo included in SGO and ASI solutions

Recently, two ACs started including Galileo in their final and rapid products:

1. SGO (Lechner Knowledge Center, Hungary), since week 2120 (August 23, 2020)



2. ASI (Centro di Geodesia Spaziale G. Colombo, Italy), since week 2139 (January 3, 2021)
   - switch to new software GipsyX

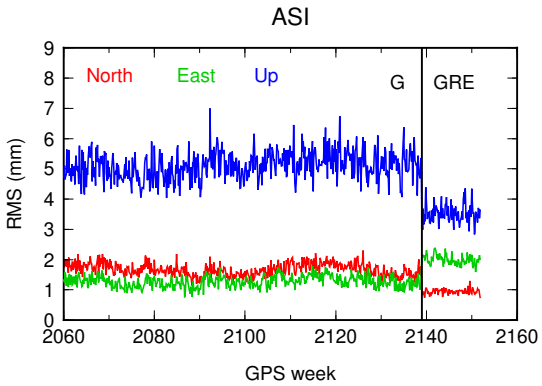
AC solutions: new ASI solutions with GipsyX

- Characteristics of new ASI solutions computed with GipsyX:
  - PPP solution
  - observations used: GPS, GLONASS, Galileo
  - no ambiguity fixing for the moment
  - full covariance matrix (correlated reference frame noise added)
- Before January 2021 ASI solutions were computed using GIPSY OASIS software
  - GPS only solution
  - ambiguities fixed
- Before the switch, both solutions were compared (combined) with the remaining ACs (comparison for week 2082):

		RMS (mm)		
Solution type	Software	N	E	U
ASI operational	GIPSY OASIS	1.61	1.10	4.58
ASI new	GipsyX	1.07	1.96	3.43

AC solutions: new ASI GipsyX solutions operational

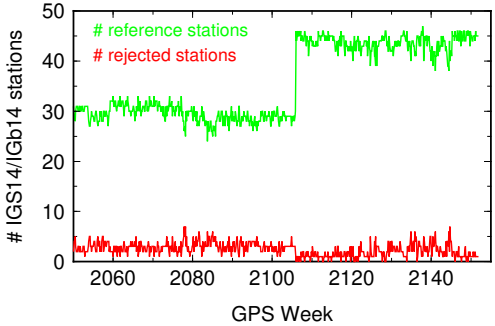
- RMSs of position residuals between ASI operational (final) solutions and the combined solutions
  - since week 2139 switch from GIPSY OASIS software (GPS-only) to GipsyX (GPS, GLONASS, Galileo)

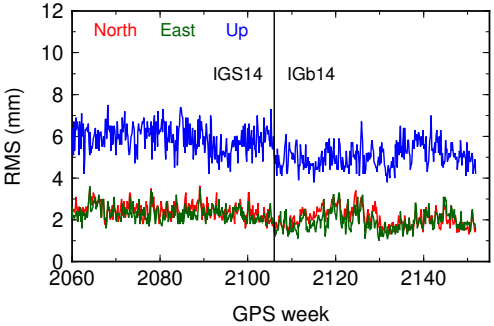


Combined solutions: switch to IGb14 reference frame

Starting with GPS week 2106 (May 17, 2020) all EPN combined solutions are aligned to the IGb14 reference frame (updated version of IGS14).

- left: number of stations used for alignment of EPN final daily solutions, and stations rejected (if residuals exceed 8/15 mm in horizontal/vertical components),
- right: RMS of residuals between IGS14/IGb14 and EPN combined final positions.





EPN Analysis Centres Workshop

The EPN Analysis Centres was held in Warsaw on October 16-17, 2019.

All workshops's presentations and recommendations are available at:
`http://www.epncb.eu/_newseventslinks/workshops/EPNLACWS_2019/`

AC Workshop decisions: using CODE rapid products in final analysis

Workshop decision

EPN ACs processing Galileo observations in final solutions should use CODE rapid products (satellite orbits and clocks, EOP) for GNSS analysis

- Before the workshop EPN ACs processing Galileo used CODE MGEX (*Multi-GNSS Experiment*) products
- At the workshop, CODE announced plans to change the IGS14 antenna model used for MGEX products to IGSr3 model prepared for IGS repro3,
  - the IGSr3 model not consistent with IGS14
- CODE MGEX products could no longer be used by EUREF ACs
- Necessary switch to CODE rapid products (3 GNSS solutions, consistent with IGS14)

R. Dach, A. Villiger, L. Prange *Recent developments within the IGS and at the CODE analysis centre*, `http://www.epncb.eu/_newseventslinks/workshops/EPNLACWS_2019/pdf/2.03_AC_beamer.pdf`

AC Workshop decisions: modification of EPN antenna model

Workshop decision

For new individual receiver antenna models provided to EPN after the workshop, only corrections for GPS L1/L2 and GLONASS L1/L2 are included in the EPN antenna model (`epnc_14.atx` and `epn_14.atx`). Models for antennas already included in EPN not changed!

Background

CODE IGS AC demonstrated that using satellite Galileo E5 calibrations for Galileo E5 observations affects the scale as it is realized by the GPS and GLONASS satellite antenna offsets based on the IGS14 reference frame.

- the inconsistency produces biases in station heights when using Galileo measurements,
- it was shown that the usage of receiver GPS L2 antenna corrections for Galileo E5 signal can compensate this effect,
- it was therefore recommended to use the IGS14 antenna model as it is and not include Galileo E5 calibrations.

New ANTEX file at EPN CB

- Since May 17, 2020 new ANTEX file used in EPN for GNSS analysis
- the new ANTEX file was prepared by EPN CB and includes repeated individual calibrations for the same antennas (presently for 12 antennas)
  - important for backward compatibility, reprocessing

Antenna type	Serial number	# calibs	Installed at following EPN stations
LEIAR25.R3 LEIT	09050002	2	FFMJ00DEU, WARN00DEU
LEIAR25.R3 LEIT	09390011	2	GELL00DEU, LEIJ00DEU
LEIAR25.R3 LEIT	10020025	3	FFMJ00DEU, HEL200DEU, BAUT00DEU
LEIAR25.R4 LEIT	10211013	2	HOFJ00DEU, AUBG00DEU
LEIAR25.R4 LEIT	10211018	2	LEIJ00DEU, HOFJ00DEU
LEIAR25.R4 LEIT	725057	2	KARL00DEU, GOR200DEU
LEIAR25.R4 LEIT	725058	2	DILL00DEU, LDB200DEU
LEIAR25.R4 LEIT	725072	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.

- example from ANTEX files: epn_14.atx and epnc_14.atx available at EPN CB

```
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
```

Third EPN Reprocessing

- Following IGS, EPN is going to do the third reprocessing of EPN data since January 1996
  - the data are going to be reanalysed in a consistent way, using latest models and methodology
- The activities will be coordinated by Christof Voelksen, the chairman of the EPN Reprocessing Working Group
  - the EPN ACs will be invited soon by the Chairman to participate in the project

Summary

- EPN ACs and ACC continued operational activities
- New ACs processing Galileo (ASI, SGO)
- New rapid (NKG) and NRT (SUT) solutions
- Modifications concerning Galileo processing
  - CODE rapid products used
  - Galileo E5 corrections not included in EPN antenna model
- New EPN antenna model with repeated calibrations implemented
- Reprocessing activities to be started soon

We thank EPN ACs for the efforts in providing GNSS solutions to EPN!