The report of the EPN Analysis Centres Coordinator

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Overview

The report of the EPN Analysis Centre Coordinator (ACC) focuses on the activities related to EPN GNSS analysis during the last year.

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

- New guidelines for EPN analysis centres
- Status of AC and combined coordinate solutions
  - changes in combination strategy
- Status of EPN AC solutions in EPN reprocessing 3 project
- Summary and outlook

Update of guidelines for EPN Analysis Centres

With the switch from the IGb14 to IGS20 reference frame and standards, the guidelines for the EPN Analysis Centres had to be updated:

- the new guidelines were discussed after the last Symposium among EPN coordinators and ACs
- the document with the new guidelines was published on the EPN CB web page on July 31, 2023

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

Update of guidelines for EPN Analysis Centres

The new features in the EPN analysis include:

- the usage of a new reference framework: IGS20/igs20.atx (additional receiver calibrations allowed in the EPN)
- correction of antenna calibrations for antennas not oriented towards north
- exclusion of GNSS observations for which antenna corrections are missing
- the usage VMF3 for troposphere modelling (in place of VMF1)
- the usage of new ocean tide model: FES2014b (in place of FES2004)

Other changes in the guidelines include:

- the new recommendation to provide rapid troposphere parameters
- the usage of new API service provided by the EPN CB for station exclusions `https://epncb.oma.be/api/production/ExcludedStations/`
- new long filenames for AC products

Long filenames for EPN AC products – update

The long filenames for AC products were slightly corrected after the last Symposium. All EPN operational product filenames now contain the acronym EPN (previously OPS):

Final daily SINEX:	AAA0EPNFIN_YYYYDDD0000_01D_01D_SOL.SNX.gz
Final summary file:	AAA0EPNFIN_YYYYDDD0000_07D_07D_SUM.SUM.gz
Rapid SINEX:	AAA0EPNRAP_YYYYDDD0000_01D_01D_SOL.SNX.gz

This change allows to:

- better recognize the AC products created for the EPN
- avoid potential conflicts with products created by CODE and GFZ ACs for the IGS

The products with previous filenames (containing OPS) were renamed by the BKG and BEV data centers to the new filenames (containing EPN)

17 EPN Analysis Centres

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 Surveying, Austria
BKG	Bundesamt für Kartographie und Geodäsie, Germany
COD	Astronomical Institute, University of Bern, Switzerland
GFZ	GeoForschungsZentrum, Potsdam, Germany
IGE	Instituto Geográfico Nacional, Spain
IGN	L'Institut national de l'information géographique et forestière, France
LPT	Federal Office of Topography swisstopo, Switzerland
MUT	Military University of Technology, Poland
NKG	Nordic Geodetic Commision, Lantmäteriet, 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

Status of the IGS20 AC solutions (1/2)

- After the switch from IGb14 to IGS20 the creation of combined final solutions was stopped due to missing solutions from 5 ACs
- At the EUREF Symposium 2023 the ACs were urged to provide their solutions by July 1, 2023 (Resolution No. 3)
- In September 2023 15 (of 17) AC solutions were available and the creation of combined solutions could be resumed
  - two solutions (from IGN and RGA) were still missing
  - small changes to AC networks done, so that each station was processed by at least 3 ACs

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- Since week 2305 (March 10, 2024) the combined solutions have been based on 16 (of 17) AC solutions
  - the new solutions have been provided by the RGA AC (solutions for weeks 2238-2304 to be submitted soon)
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- Recombination of AC solutions since week 2238 is planned when all 17 AC solutions are available
  - some AC solutions that were corrected and resubmitted due to detected issues (e.g., noisy time-series, large position outliers, not all IGS20 standards applied) could be also included

EPN Analysis Centres characteristics

AC	Software	Solutions			No. of stations		GNSS[2]
					in 2024	change[1]	
ASI	GipsyX 2.1	Final	Rapid	NRT	120	+19/−1	GRE
BEK	Bernese 5.4	Final	Rapid	–	140	+6/−1	GRE
BEV	Bernese 5.4	Final	–	–	176	0/−1	GRE
BKG	Bernese 5.4	Final	Rapid	NRT	156	+1/ 0	GRE
COD	Bernese 5.5	Final	–	–	39	0/ 0	GRE
GFZ	EPOS.P8	Final	–	–	114	+1/ 0	GRE
IGE	Bernese 5.4	Final	Rapid	–	100	0/ 0	GRE
IGN	Bernese 5.4	–	–	–	62	0/ 0	–
LPT	Bernese 5.3	Final	Rapid	NRT	60	+1/ 0	GRE
MUT	GAMIT 10.71	Final	Rapid	–	158	+1/−1	GE
NKG	Bernese 5.4	Final	Rapid	–	108	+3/ 0	GRE
RGA	Bernese 5.4	Final	–	–	71	+3/−1	GRE
ROB	Bernese 5.4	Final	Rapid	–	114	0/ 0	GRE
SGO	Bernese 5.4	Final	Rapid	–	67	+3/ 0	GRE
SUT	Bernese 5.4	Final	Rapid	NRT	94	+10/ 0	GRE
UPA	Bernese 5.4	Final	Rapid	–	119	+16/−2	GRE
WUT	Bernese 5.4	Final	Rapid	–	156	+3/−1	GRE

[1] change of number of stations in AC networks since last Symposium

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

New step in combination procedure

- During working on the combination of AC solutions for weeks 2238-2276 several issues were noticed:
  - many large position outliers in several AC solutions (e.g., due to noisy or short data, software bugs)
  - large position offsets for stations (e.g., several Italian stations due to water in antenna)
- Direct combination revealed problems with reliable detection of position outliers
- Therefore, the combination procedure was slightly modified and the new step was added: before a combination of AC solutions, individual AC solutions are stacked into long-term solutions
  - the resulting position time series are analyzed and outliers are excluded (then the clean AC solutions are combined)
  - new strategy also helps to detect potential issues with individual AC solutions
  - the new step became part of regular operational combinations

New combination procedure

The basic steps of combination procedure:

1. Check AC SINEX files (i.e., the correctness of used receiver and antenna types, PCOs, antenna eccentricities, included/missing stations)
2. New step: Stack individual daily AC solutions into long-term solutions (CATREF software)
   - detect and exclude station position outliers
3. Combine daily AC solutions (Bernese GNSS Software)
   - detect and exclude station position outliers
4. Stack combined daily solutions into long-term solutions (Bernese GNSS Software/CATREF)
   - detect and exclude station position outliers

Example of position outliers

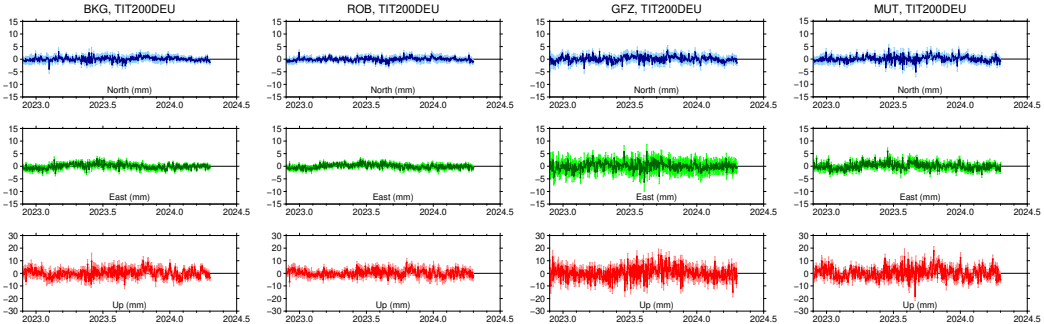
Position outliers detected in AC position time series during stacking of individual AC solutions (stage 'S') into long-term solutions are reported in daily and weekly summary reports. In table: Example from report `EUR0OPSSNX_20233540000_01D_01D_SUM.SUM`:

			Residuals (mm)		
Sol.	Stage	Station	North	East	Up
ASI	S	SART00ITA	0.0	-1.2	-52.0
ASI	S	TAR000ESP	-21.9	39.1	-37.6
BEK	S	SART00ITA	-1.2	-0.8	-52.7
BEV	S	ARJ600SWE	-5.3	3.9	-41.7
IGE	S	SART00ITA	-0.7	-0.2	-49.4
MUT	S	VIS600SWE	20.2	-0.8	-7.2
NKG	S	ARJ600SWE	-5.7	4.3	-45.4
SUT	S	MIKL00UKR	-76.4	-6.9	16.0
UPA	S	SART00ITA	-1.6	-1.1	-55.3
WUT	S	ARJ600SWE	-5.9	4.2	-45.2

- Note: the new reports (since GPS week 2238) contain 9-char station names (previously 4-char names were used)

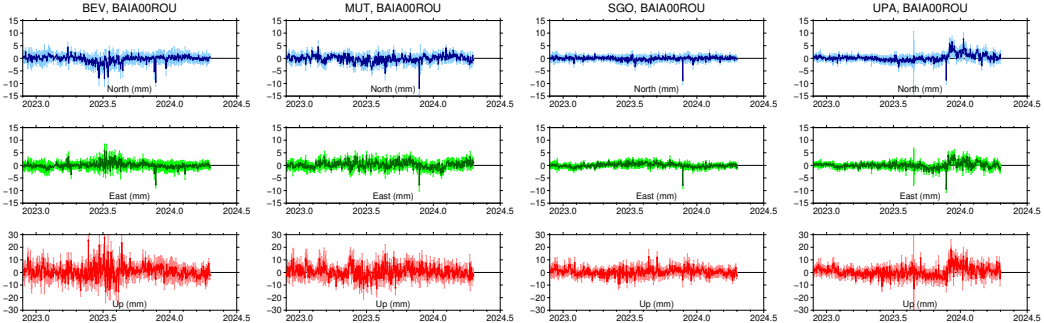
Example of AC residual position time series

- Station: TIT200DEU, ACs: BKG and ROB (Bernese), GFZ (EPOS.P8), MUT (GAMIT)



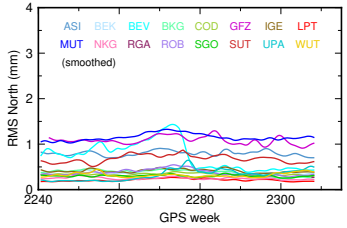
Example of AC residual position time series

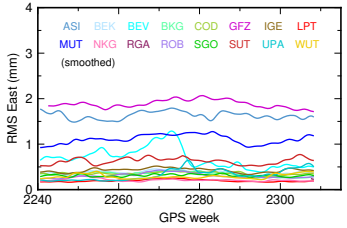
- Station: BAIA00ROU, ACs: BEV, MUT, SGO, UPA

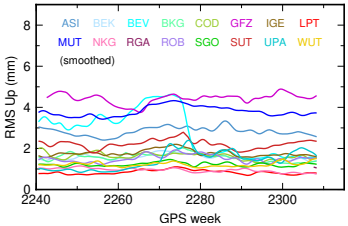


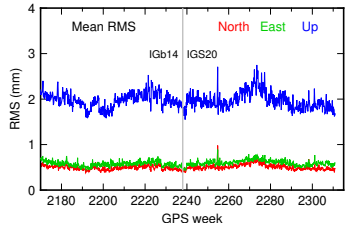
Combined solutions: AC solutions agreement

- RMSs of position residuals (smoothed) between each AC solution and combined solution (since GPS week 2238 to 2310)
- Bottom right: Mean RMS values (since GPS week 2170; including IGb14/IGS20 switch)









Status of EPN reprocessing 3 project

The goal of the EPN reprocessing 3 project is to reanalyse all GNSS data since January 1996 to November 2022 in the uniform reference frame (IGS20) and using consistent methodology (according to the new guidelines for EPN ACs). The project is conducted by the EPN Reprocessing Working group chaired by Christof Völksen

- 12 ACs participate in the EPN reprocessing 3 project: BEK, BKG, GFZ, IGE, IGN, MUT, NKG, ROB, SGO, SUT, UPA and WUT
  - AC networks were slightly modified, so that each station (active and former) would be processed by at least 3 ACs
  - benchmark test (for weeks 2236-2239) showed no significant position differences between repro3 and operational solutions
- The task of the ACC is to analyze and combine daily AC repro3 solutions
  - the same methodology will be used as in case of operational solutions (slide 11)
  - expected 9827 daily SINEX files from each AC

Initial checking of repro3 AC solutions

Several ACs already provided their solutions for testing[1]: BKG, IGE, IGN, NKG[2], MUT, SGO, SUT, UPA, WUT. Initial checking of AC solutions include:

1. checking of the content of SINEX files (receiver and antenna types, PCOs, antenna eccentricities, missing stations)
2. checking the quality of AC solutions (stacking of the individual AC daily solutions into long-term solutions, detection and exclusion of position outliers)

Main issues noticed:

- missing stations (mostly the former ones) in all AC solutions
  - reprocessing of the affected solutions necessary
- large position outliers (even few meters; can cause numerical problems, affect other stations in the network). All ACs are asked to check and clean their solutions before submission.

[1] SGO AC provided all solutions (1996-2022), while other ACs several years of solutions
[2] NKG solutions not yet checked

Present status of AC repro3 solutions

AC	Completed solutions	Remarks
BEK	2007-2022	all solutions expected by August
BKG	Parts of: 2017, 2019, 2020, 2022	correction of some solutions still necessary
GFZ	2001-2022	1996-2000 ready in June
IGE	6 years (2012-2014, 2020-2022)	4 years processed again (missing stations)
IGN	16 years (85-90%), 11 years (50%)	correction of some solutions still necessary
MUT	1996-2022	correction of some solutions still necessary
NKG	1996-2022	cleaning of solutions in progress
ROB	1996-2022	cleaning of solutions in progress
SGO	1996-2022	cleaning of solutions in progress
SUT	1996-2022	correction of some solutions still necessary
UPA	2019-2022	all solutions expected within a year
WUT	2008-2022	1996-2007 expected in June/July

Summary and outlook

- The creation of combined solutions in IGS20 was resumed in Autumn 2023
  - still not based on all AC solutions (16 of 17 solutions used)
  - recombination of AC solutions planned when all solutions available
- The new combination methodology implemented for operational and repro3 solutions
  - helps to detect issues with individual AC solutions
- New EPN analysis centres guidelines published
- The EPN reprocessing 3 project in progress
  - requires great effort from the ACs to create and validate their solutions
  - AC workshop proposed by Christof Völksen (in Autumn) to discuss the status of the project