The report of the EPN Analysis Centres Coordinator

The switch from IGb14 to IGS20 in EPN GNSS analysis

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Overview

The report of the EUREF Permanent Network (EPN) Analysis Centre Coordinator (ACC) focuses on the activities related to EPN GNSS analysis, as well as Analysis Centres' (AC) and combined solutions during the last year.

The EPN ACC combines and analyses GNSS coordinate solutions computed by the EPN ACs.

- New EPN analysis centre
- Switch to IGS20 and new IGS standards in EPN GNSS analysis
  - updates in processing strategy
- Status of AC and combined coordinate solutions
- Summary and outlook

GeoForschungsZentrum (GFZ) – new EPN analysis centre

GeoForschungsZentrum, Germany (GFZ) become a new EPN analysis centre. GFZ is also one of the IGS ACs.

GFZ EPN AC will contribute with:

- operational solutions since GPS week 2238
- repro3 solutions

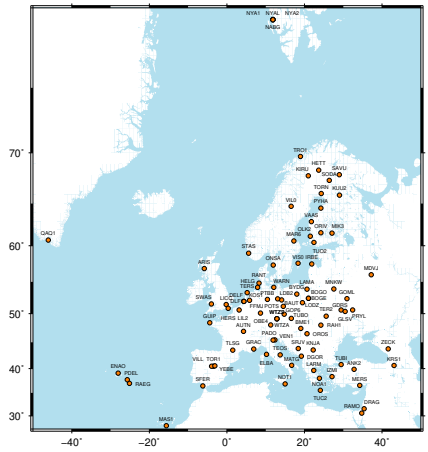
Subnetwork of EPN stations:

- 114 stations selected

Software used:

- EPOS.P8 developed at GFZ

More information on GNSS analysis at GFZ and used software will be given by Benjamin Männel in Session 3 on Thursday



Stations selected for GFZ network

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 Surveing, 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

Introduction of new IGS reference framework

- On July 26, 2022, the International GNSS Service (IGS) published a new terrestrial reference frame, IGS20, and new antenna model (igs20.atx) to be used for the generation of its products (IGSMAIL-8238)
  - IGS20 is consistent with the ITRF2020 (published in April 2022)
  - `igs20.atx` officially supports GPS, GLONASS and Galileo signals
- IGS switched from IGb14/igs14.atx to the IGS20/igs20.atx and repro3 standards starting with GPS week 2238, November 27, 2022 (IGSMAIL-8256)

IGS20 files

Positions and velocities:	`ftp://ign-rf.ign.fr/pub/IGS20/IGS20.SNX.gz`
PSD model:	`ftp://ign-rf.ign.fr/pub/IGS20/psd_IGS20.snx`
Discontinuities:	`ftp://ign-rf.ign.fr/pub/IGS20/soln_IGS20.snx`
Antenna model:	`https://files.igs.org/pub/station/general/igs20.atx`

Overview of IGS repro3 analysis standards

IGS repro3 processing standards include:

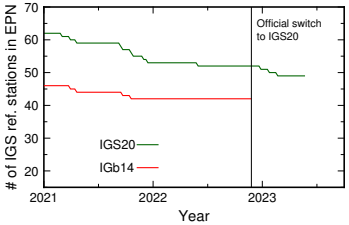
- processing of GPS, GLONASS and Galileo (new) observations
- the usage of new antenna model
  - multi-GNSS calibrations for receiver antennas
- taking into account receiver antenna misalignments from true north
- the usage of GPS phase centre corrections in place of missing corrections for other systems not allowed
- the usage of latest generation ocean tide loading model (e.g., FES2014b)
- the adoption of new pole models
  - new secular pole model (updated IERS 2010 convention)
  - new sub-daily pole tide model (Desai and Sibois)
- the adoption of new IGS naming convention for IGS products

Switch to the IGS20 in EPN analysis

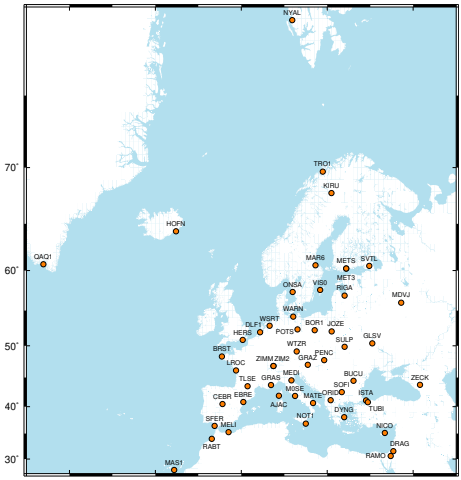
- To be consistent with IGS products expressed in IGS20, the EUREF Permanent Network (EPN) decided to switch to the IGS20/igs20.atx framework and new IGS repro3 standards at the same time as the IGS
- Several on-line meetings were organized, including the EPN analysis centres workshop and EPN repro3 workshop, to discuss details concerning the switch to IGS20 and the upcoming EPN reprocessing project (minutes and presentations from both workshops available at: `http://www.epncb.eu/_newseventslinks/workshops/EPNLACWS_2022/`)

IGS20 stations in EPN

- 74 EPN stations (62 active, 12 former) included in IGS20
- presently 49 usable EPN IGS20 stations (due to discontinuities)



- 3 stations with PSD model (ISTA00TUR, REYK00ISL, TUBI00TUR)



Present EPN IGS20 stations

The new EPN receiver antenna model

With the switch from the IGb14 to IGS20, the new EPN receiver antenna was adopted.

- In the new model, the individual calibrations (used in EPN in years 2006-2022) were not included
  - many individual calibrations without GLONASS or Galileo corrections
- The new EPN receiver antenna model (`epn_20.atx`) is based almost exclusively on IGS model (`igs20.atx`)
  - better support for multi-GNSS signals
  - better consistency with IGS analysis
- The EPN model may also contain additional multi-GNSS calibrations (`epnc_20.atx`) for antennas that are not present in the IGS model and are not installed on IGS stations
  - currently two calibrations are included in `epnc_20.atx` (`LEIAR25.R3_BEVA`, `TPSCR.G5_OSOS`)

Receiver antenna misalignments towards true north

Receiver antenna misalignments are taken into account in EPN IGS20 analysis.

Presently antenna misalignments occur on 23 EPN stations:

ARA20OSVN BBYS0OSVK GANP0OSVK GARI0OITA GJML0OSRB GSR10OSVN JOEN0OFIN KDA20OSVN KHAR0OUKR KNJA0OSRB KRAW0OPOL NPAZ0OSRB PLND0OSRB PZA20OSVN SCIL0OGBR SFER0OESP SID000SRB SODA0OFIN SUB000SRB SVTL0ORUS UZHL0OUKR VAAS0OFIN WUTH0ONOR

Effect of antenna misalignaments on station positions (examples):

Station	Antenna type		Azimuth (°)	dN	dE (mm)	dU
BBYS0OSVK	TRM59800.00	NONE	180	4.1	6.5	−0.1
GANP0OSVK	TRM59800.00	SCIS	311	0.3	1.2	−1.0
GARI0OITA	TPSCR.G3	TPSH	40	−0.8	1.4	1.1
KNJA0OSRB	TRM41249.00	TZGD	102	1.0	−0.6	−0.2
NPAZ0OSRB	TRM115000.00	TZGD	90	−0.4	−0.9	−0.3
SCIL0OGBR	LEIAR10	NONE	−130	1.2	0.9	−2.2
SFER0OESP	LEIAR25	NONE	−145	5.7	6.5	0.4

- the effect of the antenna misalignment on positions computed using Bernese 5.4 (PPP, 1 week of data)

IGS long filename convention for EPN AC products

IGS long filenames were adopted for all EPN coordinate products (final, rapid, NRT). The filenames for EPN AC coordinate products are as follows:

Final daily SINEX:	`AAA0OPSFIN_YYYYDDD0000_01D_01D_SOL.SNX.gz`
Final weekly SINEX:	`AAA0OPSFIN_YYYYDDD0000_07D_07D_SOL.SNX.gz`
Final summary:	`AAA0OPSFIN_YYYYDDD0000_07D_07D_SUM.SUM.gz`
Rapid SINEX:	`AAA0OPSRAP_YYYYDDD0000_01D_01D_SOL.SNX.gz`

where: `AAA`: analysis centre acronym, `OPS`: operational product, `FIN`/`RAP`: final/rapid product, `YYYYDDD0000`: start epoch of the product, first `01D`/`07D`: product length, second `01D`/`07D`: product resolution, `SOL`: solution with covariance or normal equation matrix, `SNX`: SINEX format, `SUM`: summary AC files

Details on new IGS filename convention can be found at:

`https://files.igs.org/pub/resource/guidelines/Guidelines_For_Long_Product_Filenames_in_the_IGS_v2.0.pdf`

Long names for EPN combined products

For EPN combined coordinate products the new names are:

- final daily:

  `EUR0OPSSNX_YYYYDDD0000_01D_01D_SOL.SNX.gz, [old name: eurWWWWD.snx.Z]`
  `EUR0OPSSNX_YYYYDDD0000_01D_01D_SUM.SUM.gz`

- final weekly:

  `EUR0OPSSNX_YYYYDDD0000_07D_07D_SOL.SNX.gz, [old name: eurWWWW7.snx.Z]`
  `EUR0OPSSNX_YYYYDDD0000_07D_07D_SUM.SUM.gz`

  - For final solutions `SNX` used as solution type (instead of `FIN` as for AC files)

- rapid daily:

  `EUR0OPSRAP_YYYYDDD0000_01D_01D_SOL.SNX.gz, [old name: eurWWWWDr.snx.Z]`
  `EUR0OPSRAP_YYYYDDD0000_01D_01D_SUM.SUM.gz`

The usage of VMF3 in operational analysis

With the switch to the IGS20, it was also decided to use the new troposphere mapping function, VMF3 (in place of VMF1 [1]) in EPN operational analysis:

- VMF3 is a refined and more accurate version of VMF1
- recommended for highest precision applications (improvement for the height component)
- VMF3 is used by CODE IGS AC in operational IGS20 analysis (VMF1 used for IGS repro3)

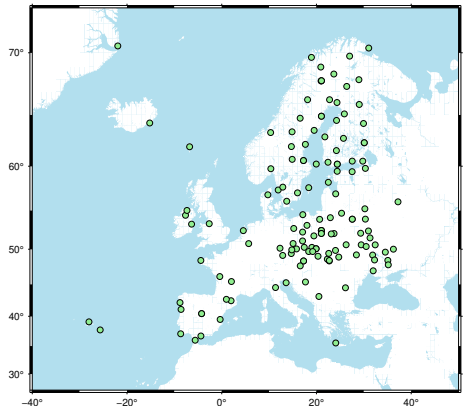
VMF3 grids can be accessed from TU Wien at:

`https://vmf.geo.tuwien.ac.at/trop_products/GRID/1x1/VMF3/VMF3_OP/`

[1] VMF1 is still accepted if VMF3 is not available in the processing software

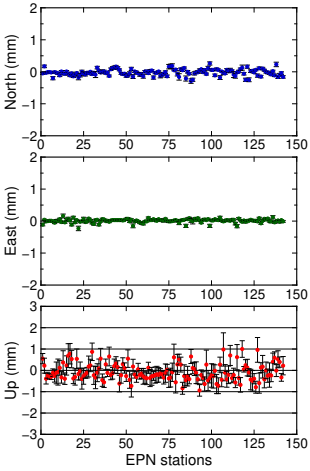
Comparison of VMF1 and VMF3 position solutions

- Bernese GNSS Software 5.4
- IGS20 standards applied
- two weeks of data (2238, 2239)
- ∼140 sites (WUT AC subnetwork)



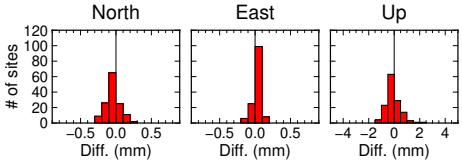
Comaprison of VMF1 and VMF3 solutions – results

- Mean station position differences over 2 weeks

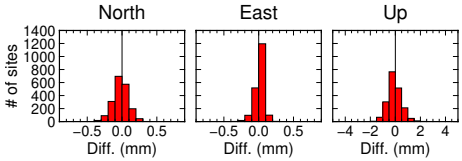


Histograms of daily station position differences:

- example for 1 day



- all 14 days



Changes of processing options in EPN analysis – summary

Processing option	Previous value	New value
Reference frame	IGb14	IGS20
Antenna model	`epn_14.atx` (inidiv. + IGS)	`igs20.atx` (+ EPN exceptions)
GNSS observations	GPS, GLONASS, Galileo	GPS, GLONASS, Galileo[2]
Orbits and ERPs for final solutions	IGS, CODE rapid (with Galileo)	Consistent 3 GNSS (e.g., CODE, GFZ)
Troposphere modelling	VMF1	VMF3
Antenna misalignment from north	not considered	corrected
Missing system-specific receiver antenna corrections	GPS PCO/PCV values used	GNSS observations not used in analysis
Ocean tide loading model	FES2004	FES2014b
Atmospheric tidal loading	recommended	not recommended
Product filenames	short	long (new IGS convention)

[2] Galileo officially supported by the IGS

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For most of the ACs, the implementation of the new IGS standards required upgrade of used software to the latest versions, e.g.:

- Bernese GNSS Software version 5.4 (used by 14 ACs)
- GipsyX-2.1 (used by 1 AC)

[2] Galileo officially supported by the IGS

New files/information related to EPN analysis at the EPN CB

- EPN antenna model (maintained at MUT):

```
ftp://ftp.epncb.oma.be/pub/station/general/epnc_20.atx
ftp://ftp.epncb.oma.be/pub/station/general/epn_20.atx
```

- FES2014b model for station displacements (maintained at EPN CB):

```
ftp://ftp.epncb.oma.be/pub/station/general/FES_2014b.BLQ
```

- Bernese GNSS Software 5.4 station information file consistent with `epn_20.atx` (created and maintained at WUT):

```
ftp://ftp.epncb.oma.be/pub/station/general/EUREF54_20.STA
```

- API for the excluded stations (discontinuation of 'excluded' files):

```
https://epncb.oma.be/api/production/ExcludedStations/
```

Status of AC solutions in IGS20

Presently 13 ACs provide final solutions in IGS20:

- 1 solution computed in older version (5.2) of Bernese GNSS Software (not all new standards can be applied)

Four ACs do not provide solutions in IGS20:

- late obtainment of Bernese GNSS Software 5.4
- lack of time, manpower, etc.

AC	Software	IGS20 Solutions (GPS weeks)	# of sites
ASI	GipsyX 2.1	2238-2259	98
BEK	Bernese 5.4	2238-2259	133
BEV	Bernese 5.4	2238-2258	177
BKG		not available	153
COD	Bernese 5.5	2238-2260	39
GFZ	EPOS.P8	2238-2258	114
IGE	Bernese 5.4	2238-2259	99
IGN		not available	62
LPT	Bernese 5.3	2238-2260	59
MUT	GAMIT 10.71	2238,2258	159
NKG	Bernese 5.4	2238,2259	104
RGA	Bernese 5.2	2238-2246	64
ROB	Bernese 5.4	2238-2260	113
SGO		not available	64
SUT		not available	81
UPA	Bernese 5.4	2238-2259	101
WUT	Bernese 5.4	2238-2249	153

Status of AC and combined solutions

The final combined solutions in IGS20 not yet available:

- due to missing AC solutions, 20-25% of EPN stations processed by only 1 or 2 ACs (each station should be included in at least 3 solutions)

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In order to not further delay the submission of the combined products and monitoring of EPN stations, it was agreed at the GB meeting to:

1. choose the deadline for providing final solutions by the ACs
2. start computing and providing combined products using available solutions
   - stations not processed by 3 ACs to be redistributed to the networks of contributing ACs

Summary

- New EPN Analysis Centre at the GFZ
- The switch to the IGS20 in EPN analysis in progress
  - details concernig processing strategy finalized
  - still several ACs not ready to provide solutions according to IGS20 standards
  - EPN combined solutions in IGS20 not yet provided
    - to be started created despite missing solutions
- The guidelines for EPN Analysis Centres consistent with the present analysis strategy will be published after the Symposium