The switch from IGb14 to IGS20 in EPN GNSS analysis

Tomasz Liwosz

Warsaw University of Technology, Poland

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Introduction

- 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 is also consistent with IGS reprocessed solutions from years 1994-2020 (IGS repro3 project) computed for ITRF2020
- IGS switched from IGb14/igs14.atx to the IGS20/igs20.atx and repro3 standards starting with GPS week 2238, November 27, 2022 (IGSMAIL-8256)

IGS repro3 analysis standards

IGS repro3 processing standards include:

- processing of Galileo observations (in addition to GPS and GLONASS)
- the usage of new receiver antenna model
  - new multi-GNSS calibrations
  - taking into account receiver antenna misalignments from true north
  - the usage of GPS phase center corrections in place of missing corrections for other systems was not allowed
- GNSS satellite phase center offsets consistent with Galileo
- the usage of latest generation ocean tide loading model (e.g., FES2014b)
- the adoption of new pole models
  - new secular pole model (updated IERS convention)
  - new sub-daily pole tide model (Desai and Sibois, 2016)
- the adoption of new IGS naming convention for IGS products

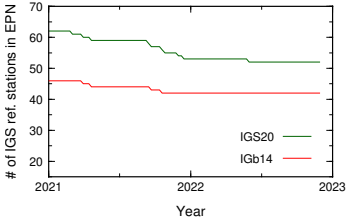
IGS20 reference frame files

IGS20 related files can be downloaded from the IGS RFC server at IGN:

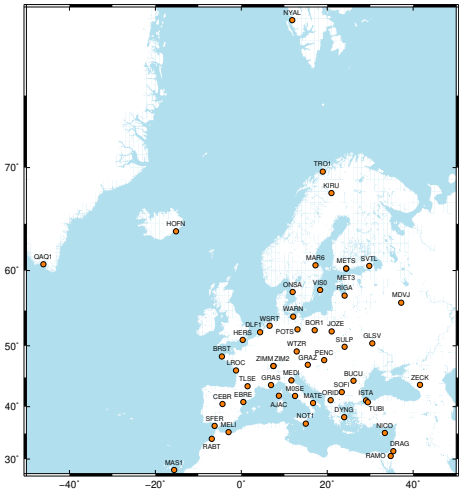
- station coordinates (at epoch 2015.0) and velocities
  - `ftp://ign-rf.ign.fr/pub/IGS20/IGS20.SNX.gz`
  - `ftp://ign-rf.ign.fr/pub/IGS20/IGS20.SSC`
- post seismic deformation (PSD) model (log, exp or exp+log):
  - `ftp://ign-rf.ign.fr/pub/IGS20/psd_IGS20.snx`
- discontinuity file:
  - `ftp://ign-rf.ign.fr/pub/discontinuities/soln_IGS20.snx`

IGS20 stations in EPN

- 74 EPN stations (62 active, 12 former) included in IGS20
- presently 52 usable EPN IGS20 stations (due to discontinuities)



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



52 EPN IGS20 stations

The igs20.atx model

- New IGS antenna model igs20.atx officially supports GPS, GLONASS and Galileo signals for receiver antennas
- Updated satellite phase center offsets (wrt. the ones used for the IGS repro3) to be consistent with the ITRF2020
- The IGS antenna model is available at:

  https://files.igs.org/pub/station/general/igs20.atx

Long product filenames in the IGS

New filenames for IGS repro3 and operational products expressed in IGS20 (`https://files.igs.org/pub/resource/guidelines/Guidelines_For_Long_Product_Filenames_in_the_IGS_v2.0.pdf`):

`AAAVPPPTTT_YYYYDDDHHMM_LEN_SMP_CNT.FMT[.gz]`

where:

`AAA`	analysis/combination center abbreviation
`V`	version/solution (0-9)
`PPP`	campaign/project specification (e.g. `OPS`, `R03`)
`TTT`	solution type identifier (e.g. `FIN`, `RAP`, `NRT`, `SNX`)
`YYYYDDDHHMM`	product intended nominal start epoch
`LEN`	product period (e.g. `01D`, `07D`)
`SMP`	temporal product sampling resolution (e.g. `01D`, `07D`)
`CNT`	content type (e.g. `CLK`, `CRD`, `ERP`, `GIM`, `ORB`, `SOL`, `TRO`)
`FMT`	file format (e.g. `CLK`, `ERP`, `INX`, `SNX`, `SP3`, `SUM`, `TRO`)

Examples of new names for IGS products

Examples for CODE IGS AC products (week 2238, day 0; 331 day of 2022) at:

`ftps://ftp.aiub.unibe.ch/CODE/2022/`

```
COD0OPSFIN_20223310000_01D_01D_ERP.ERP.gz
COD0OPSFIN_20223310000_01D_05M_ORB.SP3.gz
COD0OPSFIN_20223310000_01D_05S_CLK.CLK.gz
COD0OPSFIN_20223310000_01D_05S_OSB.BIA.gz
COD0OPSFIN_20223310000_01D_01H_GIM.ION.gz
```

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
- The EPN analysis centres workshop and EPN repro3 workshop were organized to discuss details concerning the switch to IGS20 and the upcoming EPN reprocessing project (minutes and presentations available at: `http://www.epncb.eu/_newseventslinks/workshops/EPNLACWS_2022/`)

Changes of processing options in EPN analysis

Processing option	Previous value	New value
Reference frame	IGb14	IGS20
Antenna model	`epn_14.atx` (inidiv. + IGS)	`igs20.atx` (+ exceptions)
Orbits and ERPs for final solutions	IGS, CODE rapid (with Galileo)	IGS AC (consistent 3 GNSS)
GNSS observations	GPS, GLONASS, Galileo	GPS, GLONASS, Galileo
Troposphere modelling	VMF1	VMF3 (VMF1 for EPN repro3)
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)

The new EPN receiver antenna model

With the switch from the IGb14 to IGS20, the receiver antenna model used in EPN was also changed.

- In years 2006-2022 the antenna model used in EPN consisted of individual calibrations completed by an IGS type mean antenna model
  - many individual calibrations without GLONASS or Galileo corrections
- For IGS20 analysis, the new EPN receiver antenna model (`epn_20.atx`) has been based almost exclusively on the IGS model – `igs20.atx`
  - better support for multi-GNSS signals
  - better consistency with IGS analysis
  - additional multi-GNSS calibrations in EPN model also allowed (for antennas not present in IGS model and not installed on IGS stations)
- The EPN antenna model is available at the EPN CB:
  - `ftp://ftp.epncb.oma.be/pub/station/general/epnc_20.atx` (additional calibrations wrt. `igs20.atx`; presently two calibrations included)
  - `ftp://ftp.epncb.oma.be/pub/station/general/epn_20.atx` (the merge of `epnc_20.atx` and current `igs20.atx`)

Antenna north misalignments for present EPN stations (February 2023)

No.	Station	Antenna type		Azimuth (°)	dN	dE (mm)	dU
1	ARA200SVN	LEIAR20	LEIM	1			
2	BBYS00SVK	TRM59800.00	NONE	180	4.1	6.5	−0.1
3	GANP00SVK	TRM59800.00	SCIS	311	0.3	1.2	−1.0
4	GSR100SVN	LEIAR20	LEIM	1			
5	JOEN00FIN	ASH700936A_M	SNOW	10			
6	KDA200SVN	LEIAR20	LEIM	1			
7	KHAR00UKR	NOV702GG	NONE	45			
8	KNJA00SRB	TRM41249.00	TZGD	102	1.0	−0.6	−0.2
9	KRAW00POL	ASH701945C_M	SNOW	180			
10	NPAZ00SRB	TRM115000.00	TZGD	90	−0.4	−0.9	−0.3
11	PZA200SVN	LEIAR20	LEIM	1			
12	SCIL00GBR	LEIAR10	NONE	−130	1.2	0.9	−2.2
13	SFER00ESP	LEIAR25	NONE	−145	5.7	6.5	0.4
14	SODA00FIN	AOAD/M_T	DUTD	9			
15	SVTL00RUS	JAVRINGANT_DM	JVDM	5			
16	UZHL00UKR	NOV702GG	NONE	180			
17	VAAS00FIN	ASH700936A_M	SNOW	5			
18	WUTH00NOR	SEPCHOKE_B3E6	SPKE	15			

- in last 3 columns the effect of applying the antenna misalignment on position is shown (based on PPP analysis in Bernese 5.4, 1 week of data; no values: the effect was not computed)

Long filenames for EPN AC products

Following IGS, the long filenames were adopted for EPN products as well.
The filenames for EPN AC coordinate products will be as follows:

- daily product files (for day 331/2022):

  `AAA0OPSFIN_20223310000_01D_01D_SOL.SNX.gz`
  `AAA0OPSFIN_20223310000_01D_01D_SUM.SUM.gz`

- weekly product files (for week 2238; starts on day 331/2022):

  `AAA0OPSFIN_20223310000_07D_07D_SOL.SNX.gz`
  `AAA0OPSFIN_20223310000_07D_07D_SUM.SUM.gz`

  where: `AAA`: analysis centre acronym, `OPS`: operational product, `FIN`: final 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

Long names for EPN combined products

For EPN combined coordinate products, the new names are:

- daily:

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

- weekly:

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

  - `SNX` as a solution type in above examples means SINEX combination product

EPN Analysis Centres and used software

AC	Agency	Software[1]
ASI	Centro di Geodesia Spaziale G. Colombo, Matera, Italy	GipsyX 1.6
BEK	Bavarian Academy of Sciences and Humanities, Germany	Bernese 5.2
BEV	Federal Office of Metrology and Surveing, Austria	Bernese 5.2
BKG	Bundesamt für Kartographie und Geodäsie, Germany	Bernese 5.2
COE	Astronomical Institute, University of Bern, Switzerland	Bernese 5.5
GFZ[2]	GeoForschungsZentrum, Potsdam, Germany	EPOS.P8
IGE	Instituto Geográfico Nacional, Spain	Bernese 5.2
IGN	L'Institut national de l'information géographique et forestière, France	Bernese 5.2
LPT	Federal Office of Topography swisstopo, Switzerland	Bernese 5.3
MUT	Military University of Technology, Poland	GAMIT 10.71
NKG	Nordic Geodetic Commision, Lantmäteriet, Sweden	Bernese 5.2
RGA	Republic Geodetic Authority, Serbia	Bernese 5.2
ROB	Royal Observatory of Belgium, Belgium	Bernese 5.2
SGO	Lechner Knowledge Center, Hungary	Bernese 5.2
SUT	Slovak University of Technology, Slovakia	Bernese 5.2
UPA	University of Padova, Italy	Bernese 5.2
WUT	Warsaw University of Technology, Poland	Bernese 5.2

[1] Software used before the switch to the IGS20 (in orange: newer version of software available)
[2] New EPN analysis centre (since November 2022)

GNSS Software and new analysis standards

EPN Analysis Centres were asked to upgrade their software to the latest versions for best consistency with IGS20 standards:

- Bernese GNSS Software version 5.4 (some new features are not available in older version)
- GipsyX-2.1

Summary

- IGS switched to the new reference frame, IGS20, on 27 November 2022
- The switch to the IGS20 in EPN analysis in progress
  - details concernig processing strategy were finalized
  - for most EPN ACs the implemantation of the new IGS20 standards requires the upgrade of used software
  - first EPN and combined solutions computed in IGS20 expected in March
- EPN repro3 project to be started soon
  - the aim of the project is to consistently reanalyse EPN data from years 1996-2022 in IGS20 and according to the IGS repro3 standards