

Atmospheric Sounding at the European Permanent Network

Report of the Troposphere Coordinator

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- Galileo data in EPN troposphere products
- > Operational troposphere products:
 - EPN combined solution in SINEX_TRO v2.0
 - Cumulative Solution T2034 (1996-2018)



EUREF Symposium 2018: Resolution No 1

- The IAG Reference Frame Sub-commission for Europe (EUREF) *recognising* that Galileo is developing towards a fully deployed global navigation satellite system
- and further recognising the effort within the IGS MGEX working group to significantly improve the quality and availability of the Galileo orbits and noting the efforts and investment of station managers to install multi-GNSS stations and to establish the associated dataflows

encourages the analysis centres to build their capabilities for processing Galileo observations

however noting the analysis centre's requirement for Galileo specific receiver antenna calibrations

asks the EUREF community, GSA, ESA and the GNSS industry to support the IGS antenna working group in order to overcome the missing receiver antenna calibrations for Galileo signals.



Galileo in EPN troposphere product: Test Phase

- Test Phase: GPS week 2002-2043
- Operational combination is based on 16 ACs: ASI, BEK, BEV, BKG, COE, IGE, IGN, LPT, MUT, NKG, RGA, ROB, SGO, SUT, UPA, WUT
- > 3G (GPS+GLONASS+Galileo) Combination is based on the following ACs:

1. BEK → BEK_v3	since GPS week 2002
2. BKG → BKG_v3	since GPS week 2002
3. ROB \rightarrow ROB_v3	since GPS week 2002
4. UPA → UPA_v3	since GPS week 2014
5. IGE \rightarrow IGE_v3	since GPS week 2022
6. NKG → NKG_v3	since GPS week 2023
7. WUT \rightarrow WUT_v3	since GPS week 2027
8. SUT \rightarrow SUT_v3	since GPS week 2042

+ ASI, BEV, COE, IGN, MUT, RGA, SGO, SUT

LPT Multi-GNSS solution is ingested in both combinations.



3G Combination: Statistics

GPS week	# 3G AC	combined stations	stations with Galileo observations	combined stations with Galileo observations	%
2002	3	316	NA	NA	NA
2014	4	314	109	0	0%
2022	5	312	137	33	11%
2023	6	310	155	44	14%
2027	7	311	167	66	21%
2043	8	327	200	70	21%

- EPN is a **distributed processing**. The EPN stations are distributed among the AC in such a way that each station is analyzed by at least three AC:
 - this ensures the reliability of the EPN products,
 - but it turns out that also AC not submitting 3G solutions and stations not having Galileo observations could be affected.



Operational vs 3G Combination: AC with 3G

GPS week 2002-2043





Operational vs 3G Combination: AC without 3G

GPS week 2002-2043



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Operational vs 3G Combination: SBG200AUT

- > GPS week: 2002-2043
- Set to track: GPS+GLO+GAL+BDS
- Individual Calibration: G01, G02





Operational vs 3G Combination: ARJ600SWE

- > GPS week: 2002-2043
- Set to track: GPS+GLO+GAL+BDS+SBAS
- Individual Calibration: G01, G02, R01, R02





Operation vs 3G Combination: POTS00DEU

- > GPS week: 2002-2043
- Set to track: GPS+GLO+GAL+BDS+SBAS
- Individual Calibration: G01, G02, R01, R02, E01, E05



Operation vs 3GNSS Combination: USAL00ITA

- GPS week: 2002-2043
- Set to track: GPS+GLO+GAL+BDS+SBAS
- Mean Type Calibration



Mean ZTD difference

- > 41 weeks (2002 2043)
- Mean ZTD difference between operational and 3G combination
- > Only stations observing Galileo are shown



Standard deviation ZTD difference

- > 41 weeks (2002 2043)
- > STD ZTD difference between operational and 3G combination
- > Only stations observing Galileo are shown



Results for GPS week 2032 – Station statistics



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EPN troposphere product: Current Status

http://epncb.oma.be/_productsservices/troposphere/



Operational Combination

Total versus Combined Stations:

- EUREF Symposium 2018: 316 combined stations
- EUREF Symposium 2018: 329 combined stations



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IGS Workshop 2018 Recommendation:

To disseminate troposphere delay values, the IGS Tropo WG requests to adopt the **SINEX_TRO v2.0 format** *developed in the framework of the COST Action ES1206 'GNSS4SWEC'*

➢ GPS week 2034 (18DEC30-19JAN05)

✓ eur20347.tro/.tsu

✓ EUR00PEFIN_20183640000_07D_01H_TRO.TRO/.SUM



EPN cumulative solution ZTD Time Series

- Twice per year the EPN troposphere cumulative solution is updated.
- Last update T2034 (EUREF Mail 09779) covers the period 1996-2018.



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EPN cumulative solution: ZTD Monthly Mean





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EPN cumulative solution: Radiosonde





EPN cumulative solution: VLBI Radio Telescope



IVS-EUR								
	Bias [mm]	STD [mm]	DeltaH [m]	npts	data span			
MATE	0,8	16,8	7,7	6328	2002-2018			
MEDI	2,6	15,5	17,1	2086	2004-2018			
MSEL	2,2	16,2	17,8	1839	2004-2018			
NYA1	0,6	10,4	3,2	11224	2002-2018			
ONSA	3,2	20,1	13,7	2804	2002-2018			
SVTL	3,4	16,2	9,4	3452	2005-2018			
WTZR	1,1	15,3	3,1	16116	2002-2018			
YEBE	8,2	16,6	7,1	1995	2010-2018			
ZECK	2,1	17,3	8,8	3187	2006-2018			





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- The impact of Galileo observations on the combined product has been evaluated for a test phase of 41 weeks.
- The differences in the zenith path delays between the operational combined solution and the 3G combined solution are below 1 mm.
- Galileo observations are officially included in operational EPN products from GPS week 2044 on.
- Operational solutions are delivered in SINEX_TRO v2.0 from GPS week 2034 on.
- Tropospheric cumulative solution T2034 has been delivered and inter-compared.

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