# Report of the Troposphere Coordinator



### **Rosa Pacione**

**Troposphere Coordinator** 



e-GEOS, ASI/CGS-Matera, Italy



### **EPN-Repro2** & Operational

#### http://www.epncb.oma.be/\_productsservices/sitezenithpathdelays/



### **Operational Tropo Products**

Main changes since the EPN AC Workshop 2017 in Brussels:

- GPS wk 1980: mapping function -> VMF1/ECMWF
- GPS wk 1980: tropo. grad. params in SINEX\_TRO
- GPS wk 2034: combined solution in SINEX\_TRO v2.0 format
- GPS wk 2044: switch to 3G (GPS + GLONASS + Galileo) solutions
- GPS wk xxxx: switch to RINEX3 data

AC	Agency	SW	# of stations	GNSS
ASI	Centro di Geodesia Spaziale, Italy	GIPSY OASIS II 6.2	72	G
BEK	Bavarian Accademy of Sciences and Humanities, Germany	Bernese 5.2	104	GRE
BEV	Federal Office of Metrology and Surveying Austria	Bernese 5.2	118	GRE
BGK	Bundesamt für Kartographie und Geodäsie, Germany	Bernese 5.2	124	GRE
COE	Centre for Orbit Determination in Europe, Switzerland	Bernese 5.2	42	GR
IGE	Istituto Geografico Natinal, Spain	Bernese 5.2	91	GRE
IGN	Institut Géographique National, France	Bernese 5.2	63	GR
LPT	Federal Office of Topography swisstopo, Switzerland	Bernese 5.2	61	GREC
MUT	Military University of Technology, Poland	GAMIT/GLOBK	147	G
NKG	Nordic Geodetic Commission, Sweeden	Bernese 5.2	98	GRE
RGA	Republic Geodetic Authority, Serbia	Bernese 5.2	55	GR
ROB	Royal Observatory of Belgium, Belgium	Bernese 5.2	102	GRE
SGO	Lechner Knowledge Center, Hungary	Bernese 5.2	42	GR
SUT	Slovak University of Technology, Slovakia	Bernese 5.2	59	GRE
UPA	University of Padua, Italy	Bernese 5.2	69	GRE
WUT	Warsaw University of Technology, Poland	Bernese 5.2	133	GRE
GNSS	G=GPS, R=GLONASS, E=Galileo, C=BeiDou			

# AC	GNSS
2	G
4	GR
9	GRE
1	GREC





- Mean troposphere zenith total delay (ZTD) difference between operational (GPS+GLONASS) and 3 GNSS (GPS+GLONASS+Galileo) combined solutions, and its standard deviation (bottom figure)
  42 weeks (GPS weeks 2002–2043) of ZTD solutions used
- Only stations observing Galileo are shown

*T. Liwosz, R. Pacione, E. Brockmann: Usage of Galileo in EUREF Permanent Network Data and Products, 7th International Colloquium on Scientific and Fundamental Aspects of GNSS, 4-6 September 2019, Zurich.* 



## **Operational Combination**

Total versus Combined Stations:

- EPN AC Workshop 2017: 315 combined stations
- EPN AC Workshop 2019: 328 combined stations



eurs

### Operational – AC Redundancy

Each of the EPN AC processes a subnetwork of the EPN. The EPN stations are distributed amongst the AC in such a way that each station is analyzed by at least three AC. This ensures the reliability of the EPN products.



October, 1° 2019: 345 EPN stations

	6 AC	5 AC	4 AC	3 AC
Station #	3	62	195	85
%	1%	18%	57%	25%

http://www.epncb.oma.be/\_productsservices/analysiscentres/dataprocessingdistribution.php



EPN Analysis Center Workshop, October 16-17, 2019, Warsaw Poland

### **Operational – AC Redundancy**

➢ 85 stations (i.e. 25%) are analyzed by 3 ACs



# EPN products in Regional Reanalysis



- SMHI is contracted to provide the Regional Reanalysis for Europe by the EU Copernicus Climate Change Service
- A high-resolution reanalysis from the early 1980's up to today
- GNSS Zenith Total Delay observations are planned to be used in the HARMONIE-ALADIN modelling system: EPN-Repro2
   + Operational
- White list of stations to be considered reliable selected on data availability
- Variational bias correction
- A 4-week test assimilation has shown that it works and the data give a reasonable and small positive impact.
  - Continuity is vital for reanalysis



EPN Analysis Center Workshop, October 16-17, 2019, Warsaw Poland

### **EPN-Repro2 & Operational**

#### http://www.epncb.oma.be/\_productsservices/sitezenithpathdelays/



### **Operational Products**

#### http://www.epncb.oma.be/\_productsservices/sitezenithpathdelays/



## Operational

#### http://www.epncb.oma.be/\_productsservices/sitezenithpathdelays/

Mean ZPD biases wrt weekly EPN troposphere solution

(EPN-repro2 + routine)





### Outlier detection – Example 1



### Outlier detection – Example 2

GPS wk 2043: BEV added GALILEO observations and switched from RNX2 to RNX3 RNX3 for CAG1 and NYA2 and RNX2 for KRS1 and MDVJ



### **Outlier detection – Example 3**

Potential outliers checked if the bias w.r.t. the mean exceeds **10 mm** 



2520

2500

GPS wk: 2066

'BADH bkg ztd dat 'BADH eur ztd.dat

'BADH ige ztd.dat 'BADH ign ztd.dat'

'BADH lpt ztd.dat'

### **Tropospheric Gradient Map**



EPN Analysis Center Workshop, October 16-17, 2019, Warsaw Poland

### Tropospheric Gradient Map - Bernese only

Epoch: 19AUG14, 12:00





## SINEX\_TRO v2.0 Format

Following IGS Workshop 2018 Recommendation the **EPN combined solution** is disseminated in **SINEX\_TRO v2.0 format** from GPS wk 2034 onward (http://twg.igs.org/documents/sinex\_tro\_v2.00.pdf)

- GPS week 2034 (18DEC30-19JAN05)
  - ✓ eur20347.tro/.tsu

✓ EUR00PEFIN\_20183640000\_07D\_01H\_TR0.TR0/.SUM

- De-coupled from SINEX -> metadata blocks became mandatory
- File naming convention according to IGS products
- 0 9-char SITE ID
- SITE/AC bias computed on daily basis
- Overall statistics with/without outliers in the SUMMARY file



E-GVAP



**E-GVAP** – The EIG EUMETNET GNSS Water Vapour Programme, Phases I-IV (2004-2023)

- EIG EUMETNET Project coordinating the near real-time delivery of data from ~3000 GPS sites delivering > 14M ZTDs pcm.
- Focus is on GPS-only hourly processing, delivering only ZTD in 90mins.
- **Operational assimilation** at a few European National Met Services, many others under testing.
- Use of E-GVAP ZTDs has proven **positive impact** on NWP forecast skill.
- Surface T and P used for conversion to Integrated Water Vapour (IWV).
- Active Quality Control (AQC) in place.
- MoUs in place with EUREF and EUPOS.



### E-GVAP combined vs EPN combined





- Status of the EPN operational tropo product
- EPN tropo product in European Reanalysis

### • **Continuity is vital for reanalysis**

- Tropospheric Gradients are a topic of research
- EPN combined solution is SINEX\_TRO v2.0 format

**Acknowledgment:** the EPN ACs for providing the solutions used for the combination as well as the GNSS site owners for the collection and distribution of GNSS rinex data. e-GEOS work is carried out under ASI contract 2017-I.0-R.0

