EPN Tropospheric Products

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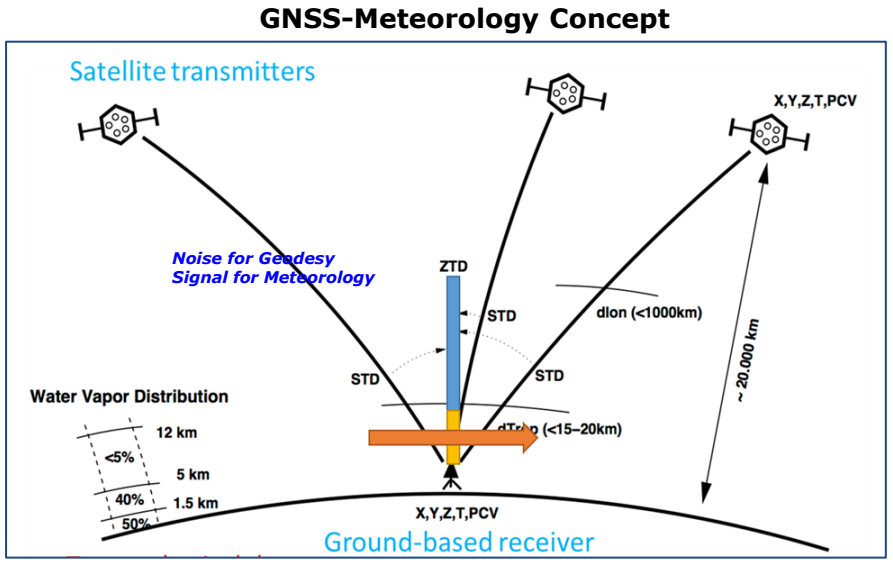
Outline

- Key Milestone in the EPN Tropospheric Product
- Operational Solution:
  - New EPN AC: GFZ - Potsdam
  - IWV added in the EPN combined product
  - Multi-year tropospheric solution
  - Status of the Transition to ITRF2020
- EPN ZTD data exploitation
- Summary and next steps

Key Milestones



- 2001: Special Project
- 2008: Routine Operation
- 2012: EPN-Repro1: 1996-2009
- 2014: Troposphere Analysis Coordinator moved from BKG to ASI/CGS
- 2017: EPN-Repro2: 1996-2014
- 2020: IWV added in the EPN combined products

  Solutions delivered in SINEX_TRO V2.0 format

Operational Solutions

- **Period**: GPS weeks 1825 – 2237
- **16** (+1) **ACs**: ASI, BEK, BEV, BKG, COE, IGE, IGN, GFZ, LPT, MUT, NKG, RGA, ROB, SGO, SUT, UPA, WUT
- **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 guarantees the reliability of the EPN products
- **GNSS SW:** EPOS.P8 (1 AC), GIPSYX (1 AC), GAMIT (1 AC), BERNESE (14 ACs)
- **Processing Options:** refer to 'Guidelines for EPN Analysis Centres'

May 8, 2023: 405 EPN stations

7 AC	6 AC	5 AC	4 AC	3 AC
0,5%	4%	37%	57%	2%
2	16	149	230	8

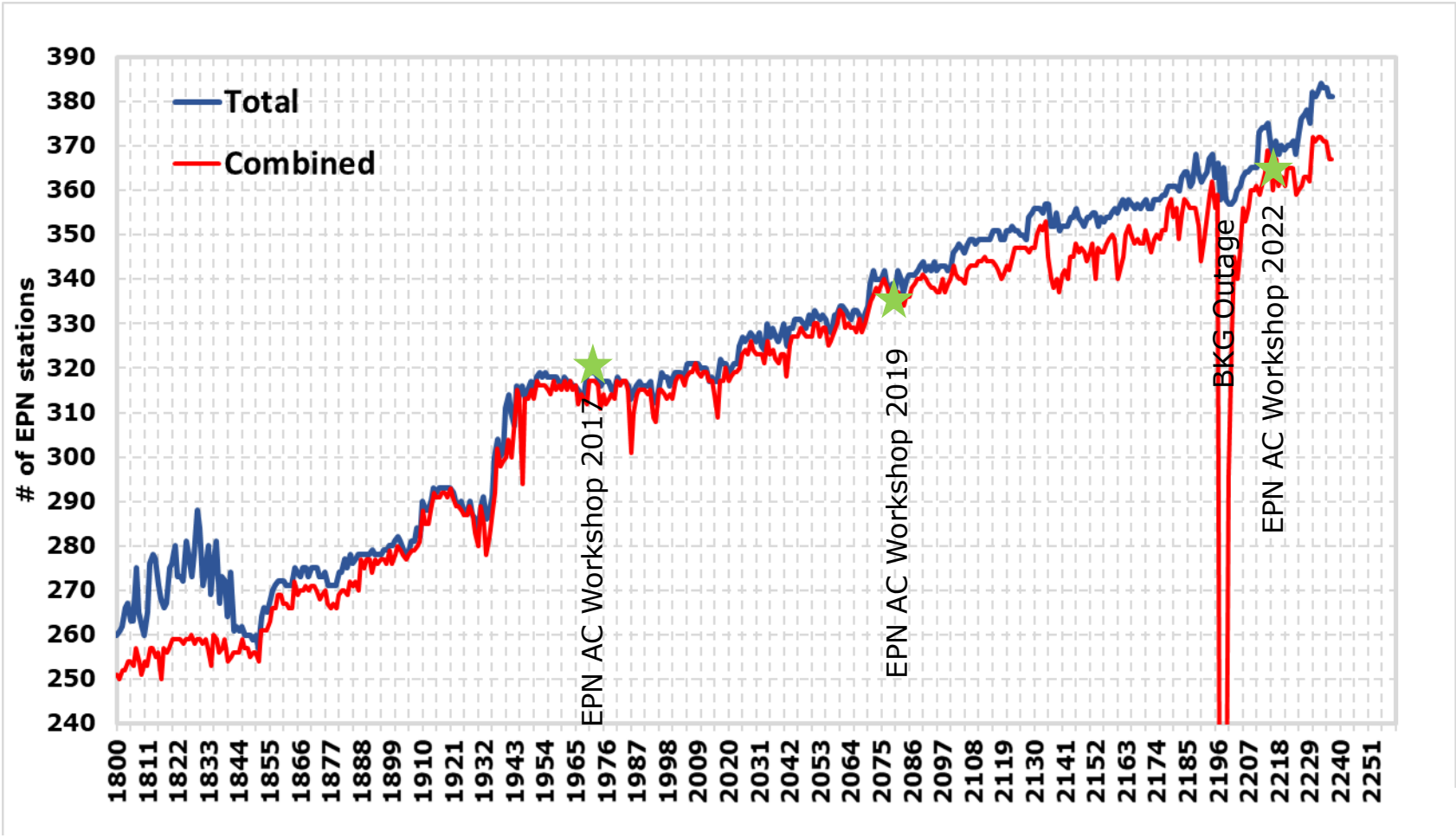
Operational Tropo Combination

Last Combined Solution: GPS week 2237:

Total Stations available 381

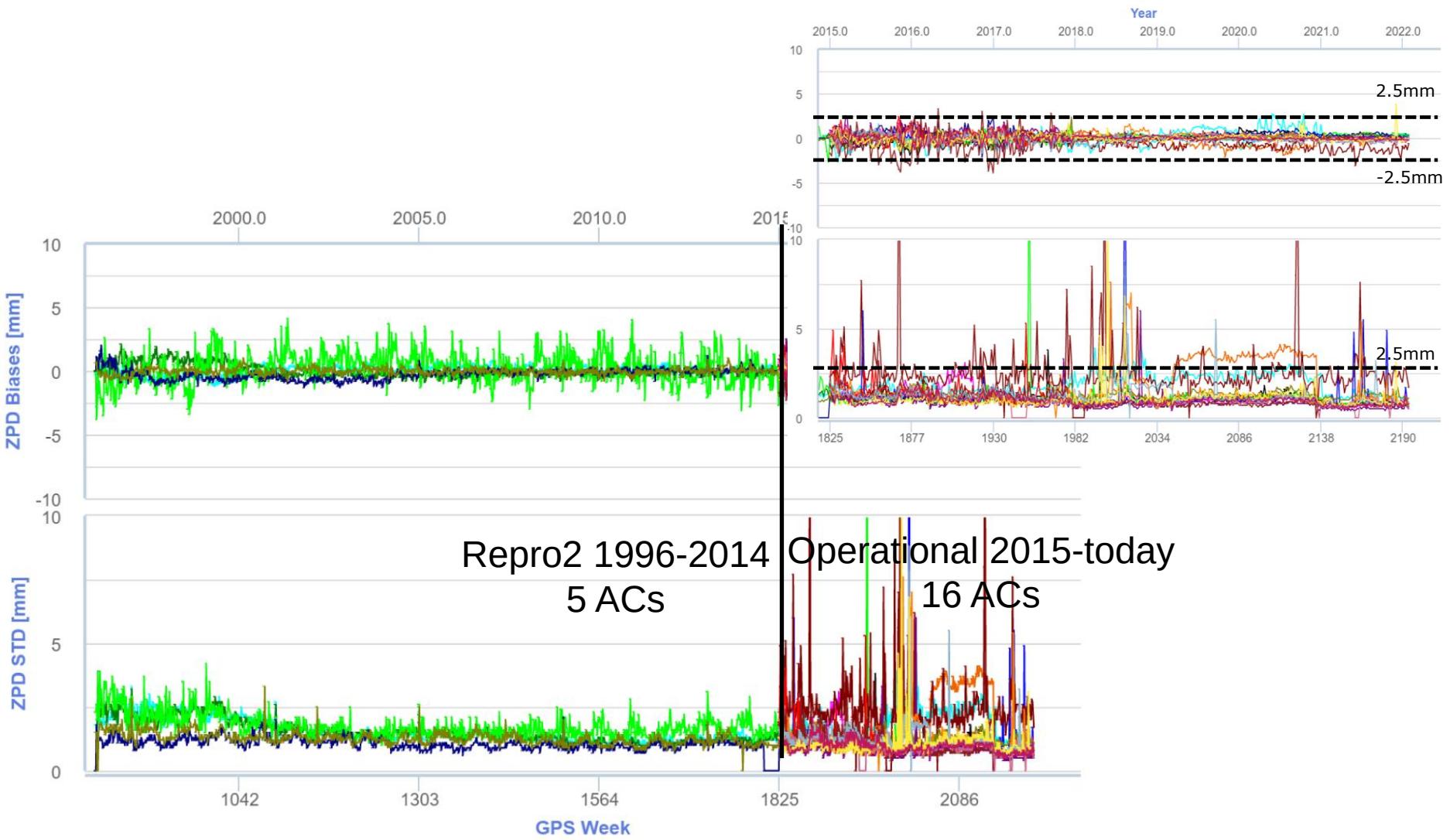
Combined Stations 367

→ One AC solution is not available



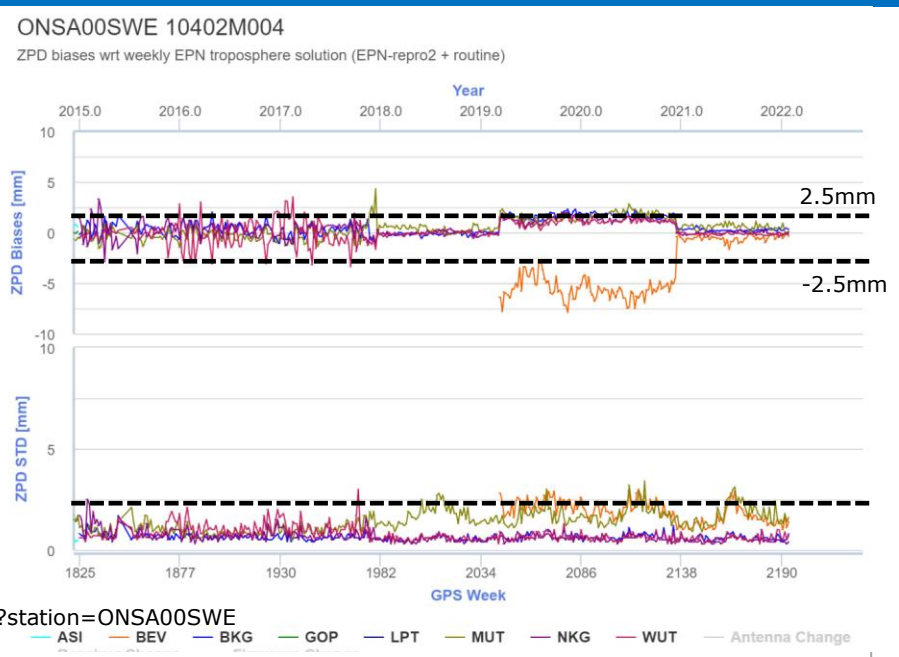
Operational Monitoring at AC level

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



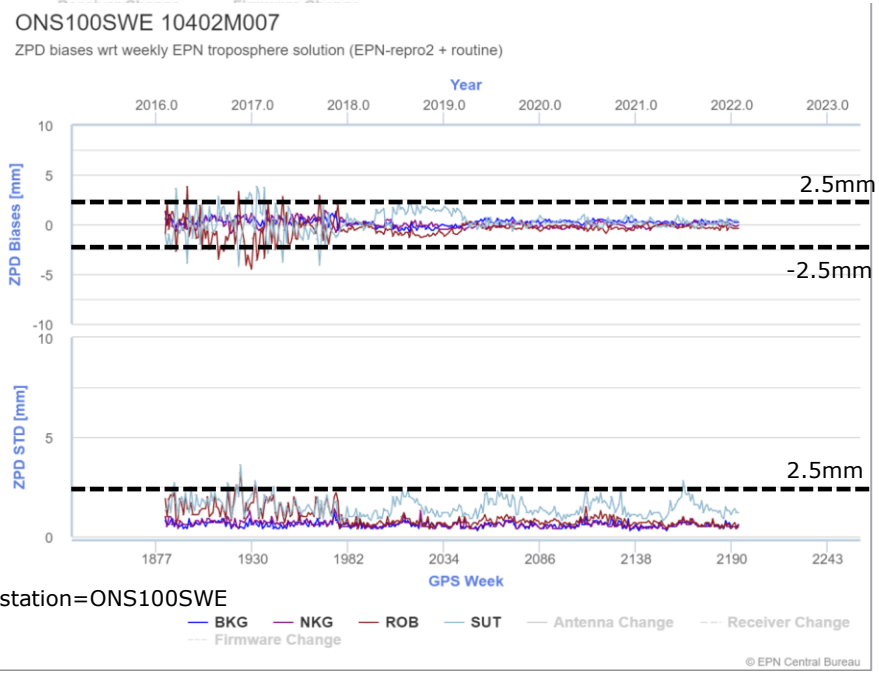
Operational Monitoring at Station level

ONSA: Analyzed by BKG, GFZ, MUT, NKG, WUT



http://www.epncb.oma.be/_productsservices/troposphere/zpd_biases_station.php?station=ONSA00SWE

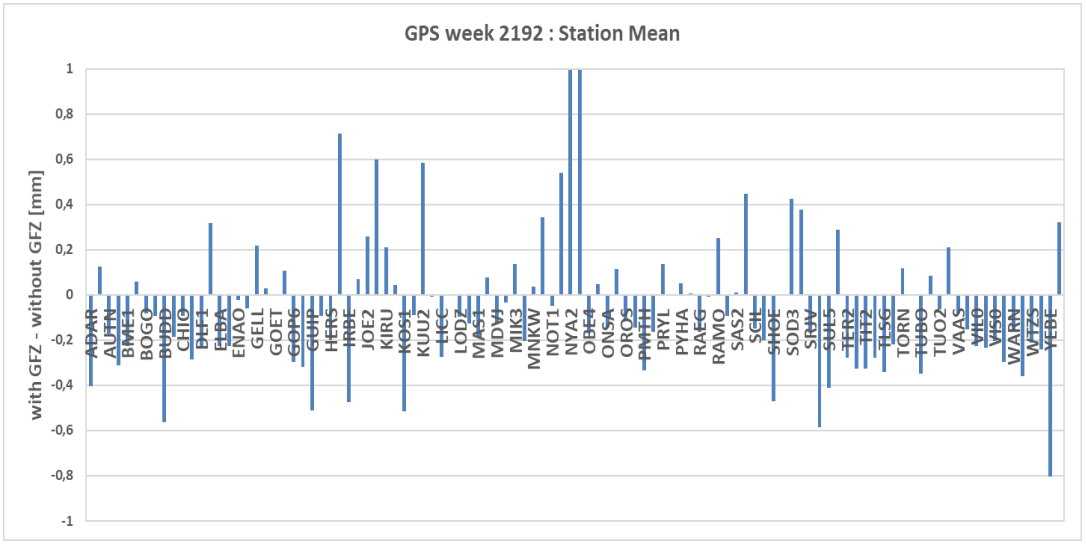
ONS1: Analyzed by BKG-NKG-ROB-SUT

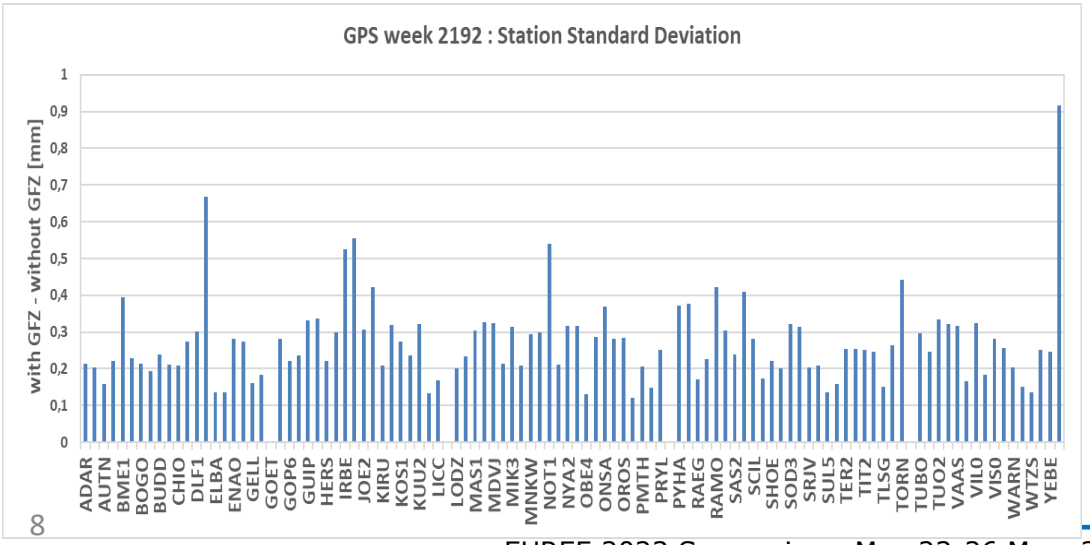


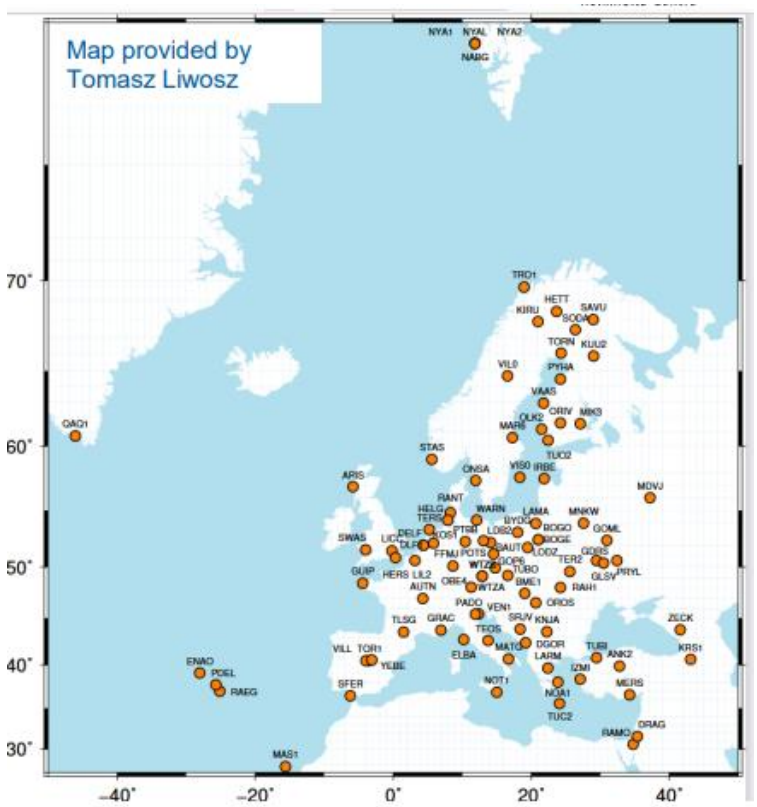
http://www.epncb.oma.be/_productsservices/troposphere/zpd_biases_station.php?station=ONS100SWE

New EPN AC: GFZ - Potsdam

- GFZ as upcoming EPN AC (repro + operational)
- EPOS.P8 will be used for GNSS processing







Operational ZTD to IWV Conversion

- **Input:** EPN ZTD combined values
- **Auxiliary Data:** ECMWF operational products available at:
  https://vmf.geo.tuwien.ac.at/trop_products/GRID/2.5x2/VMF1/STD_OP
  Linear interpolation in time, bilinear interpolation in space
- **Output:** EPN ZTD and IWV in SINEX_TRO_v2.0 from GPS week 2139 (21JAN03)

ZTD=ZHD+ZWD

↓

ZWD=ZTD-ZHD

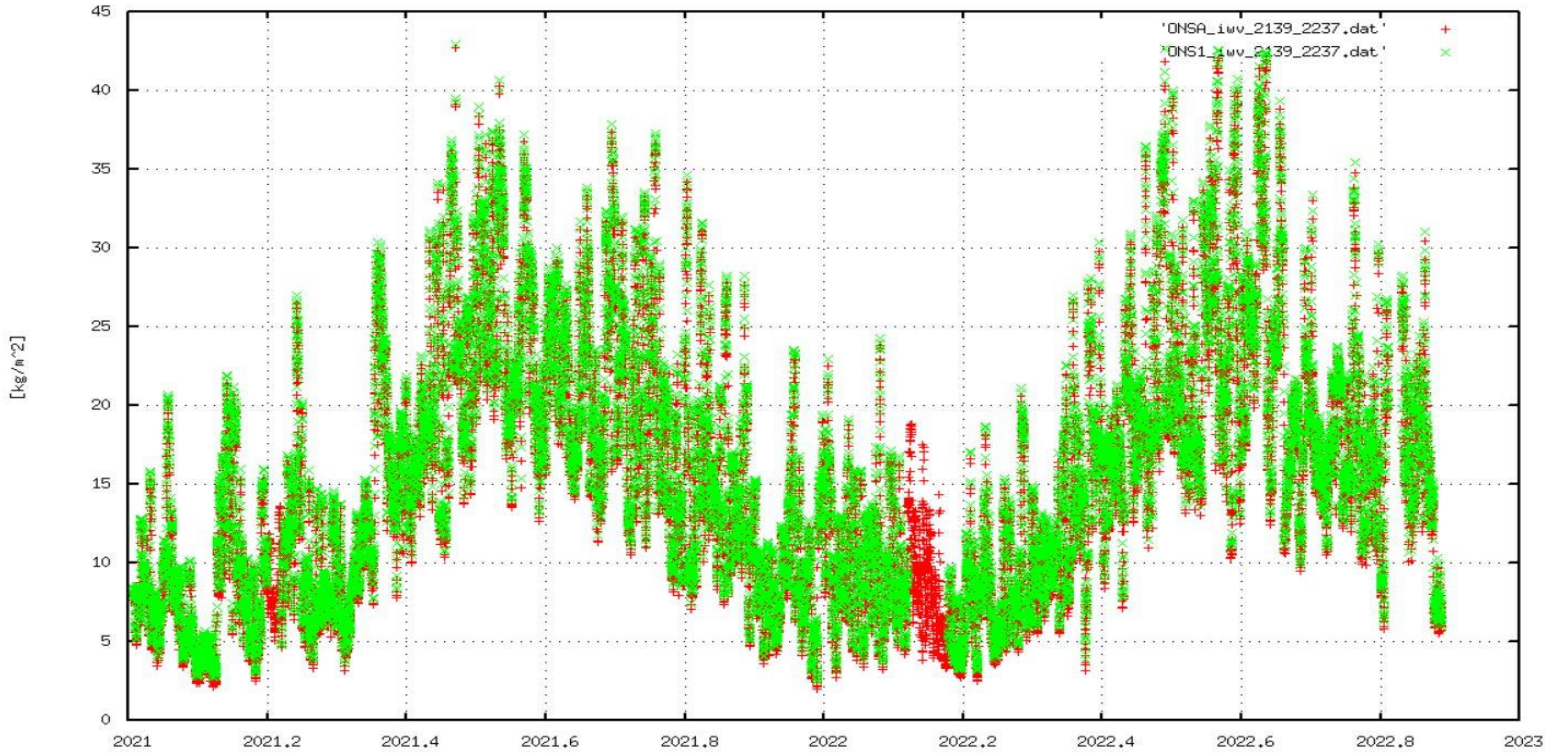
↓

IWV=K(T_m)* ZWD

→ $$ZHD = \frac{0.0022767 \cdot p}{1 - 0.00266 \cdot cos2\varphi - 0.00028 \cdot h}$$

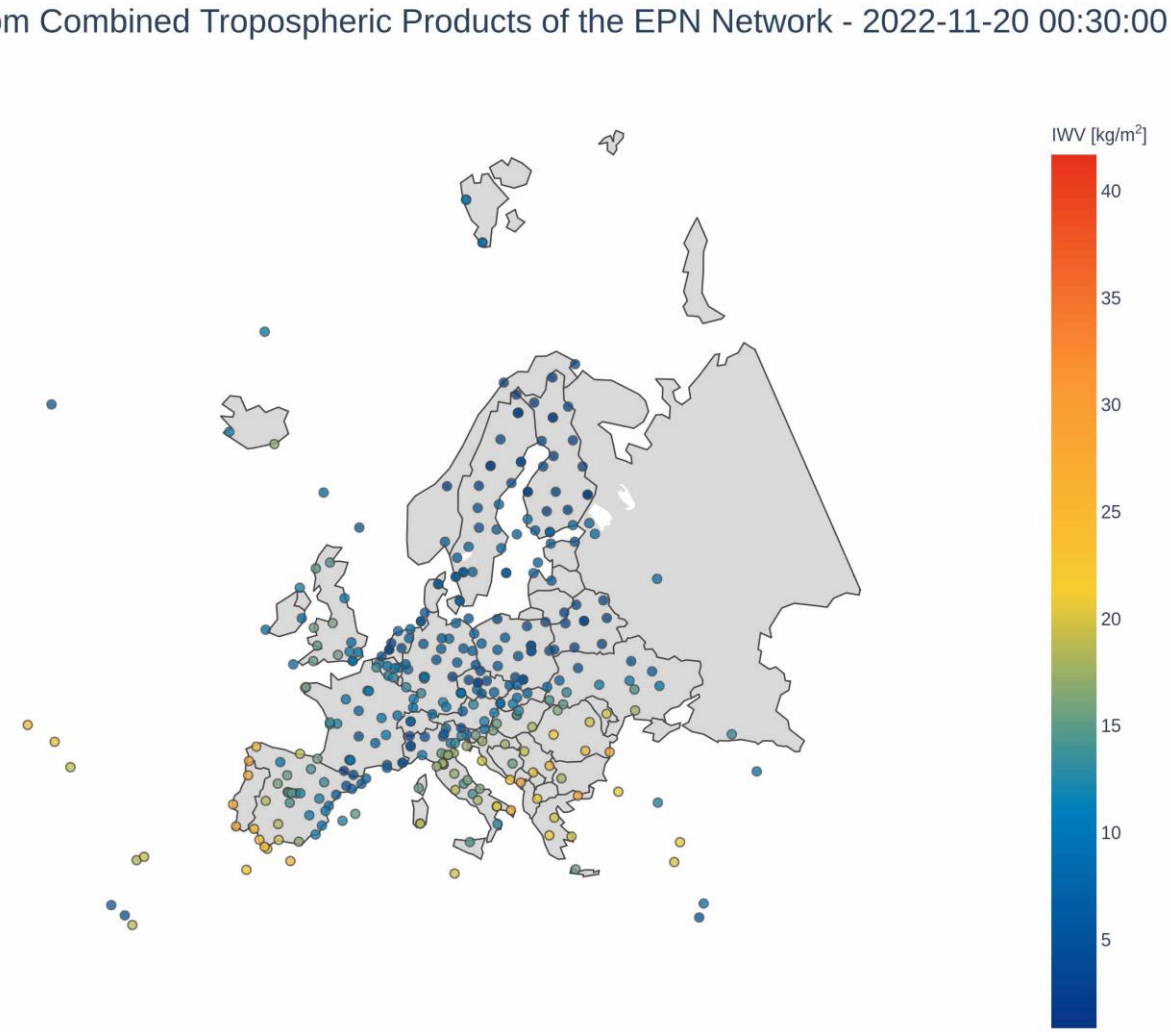
→ $$IWV = \frac{10^6}{R_v \left(k_2' + \frac{k_3}{T_m} \right)} ZWD \qquad T_m = \frac{\int_H^\infty e/T \, dh}{\int_H^\infty e/T^2 \, dh}$$

ONSA & ONS1 IWV Time series



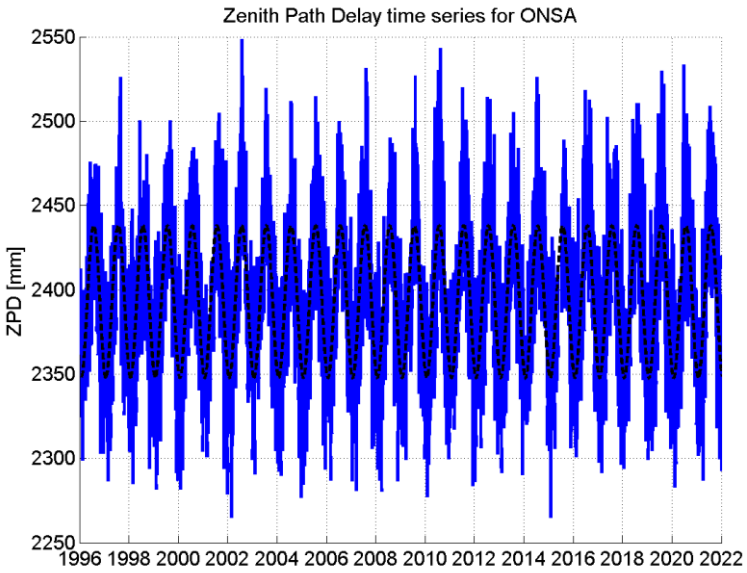
IVW Evolution at the EPN Stations

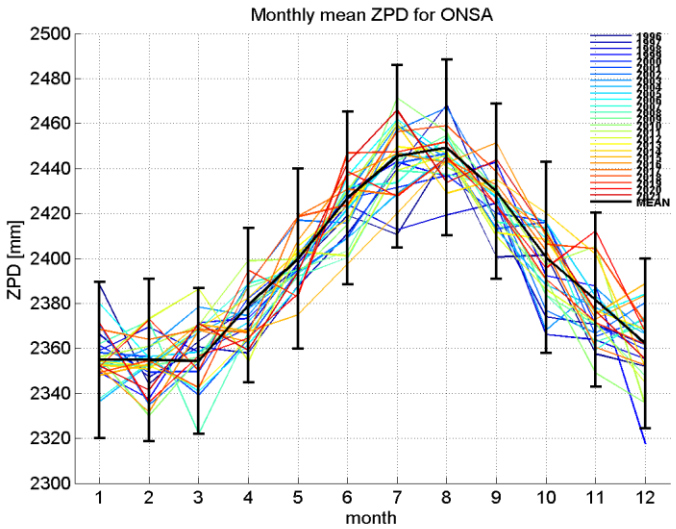
GPS week 2237 Nov 20-26, 2022



EPN multi-year tropo solution

http://www.epncb.oma.be/_productsservices/troposphere/zpd_timeseries_station.php?station=ONSA00SWE





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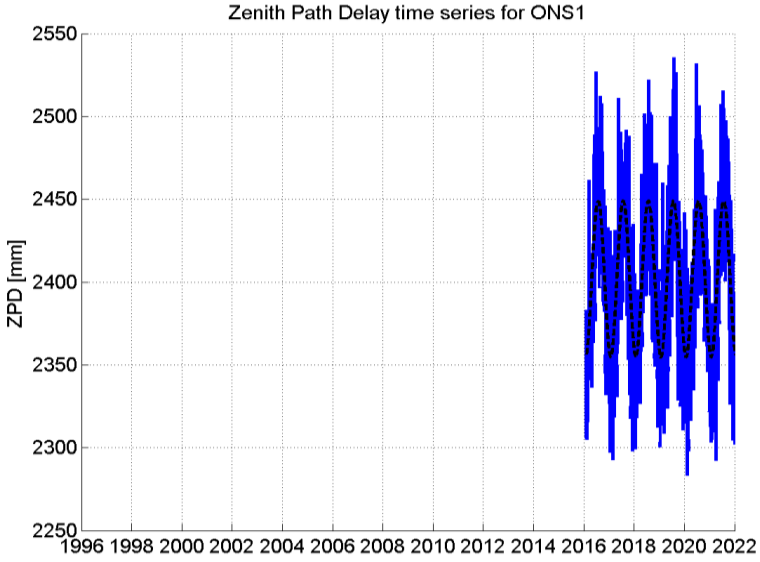
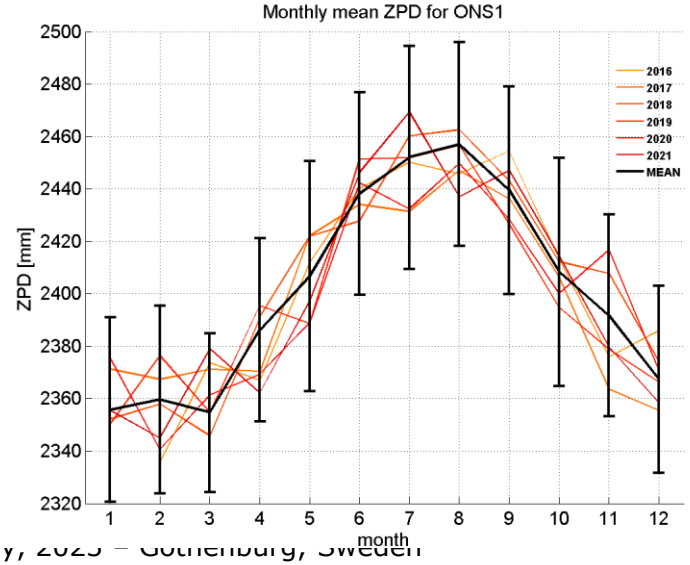
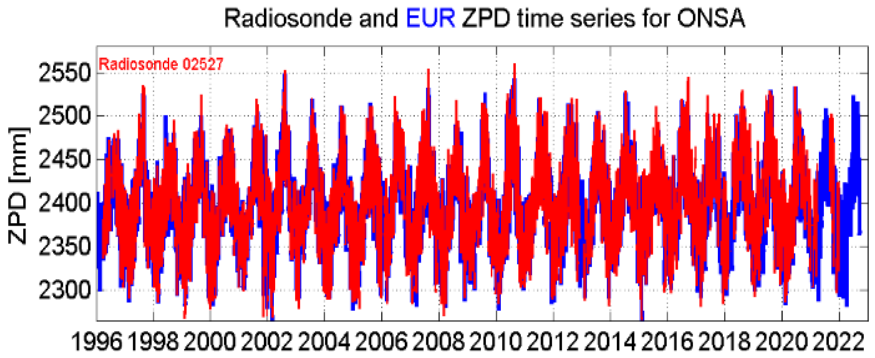
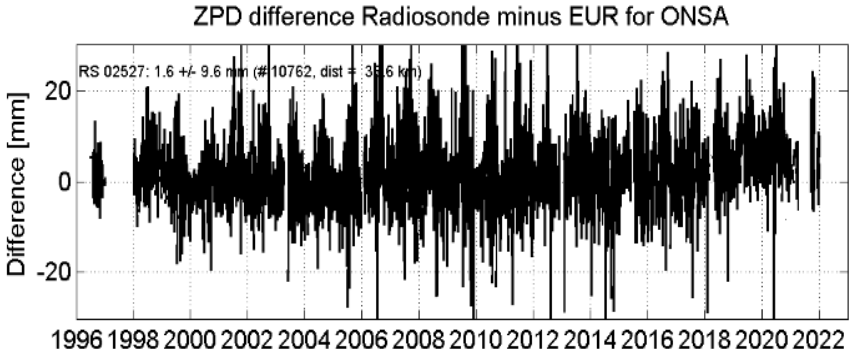


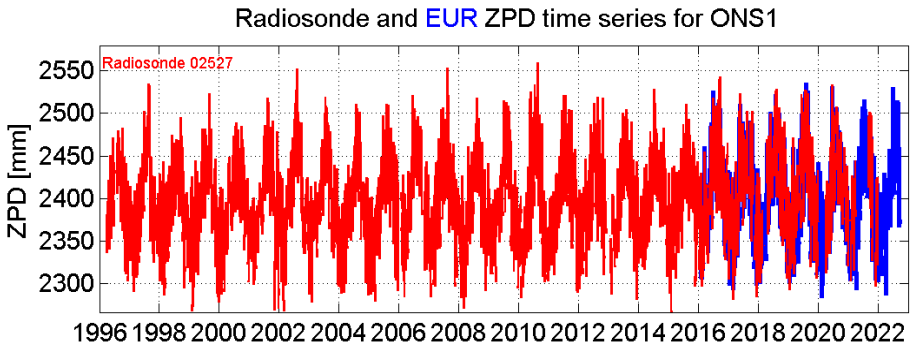


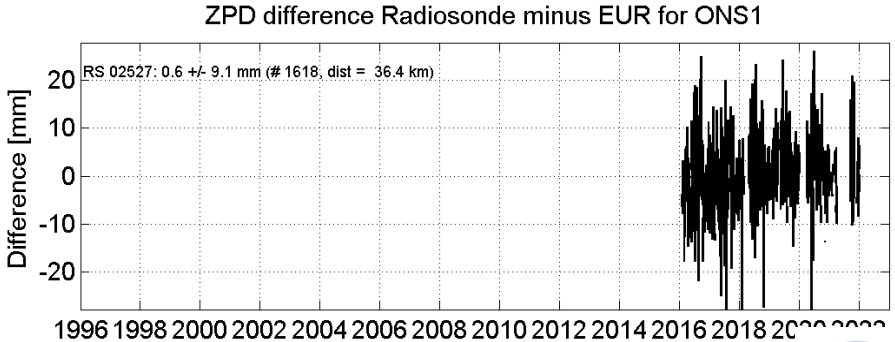
GNSS and RS EPN multi-year tropo solution

http://www.epncb.oma.be/_productsservices/troposphere/zpd_radiosondes_station.php?station=ONSA00SWE







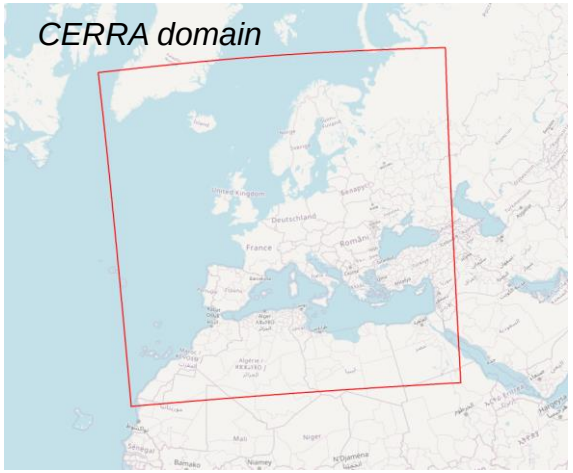


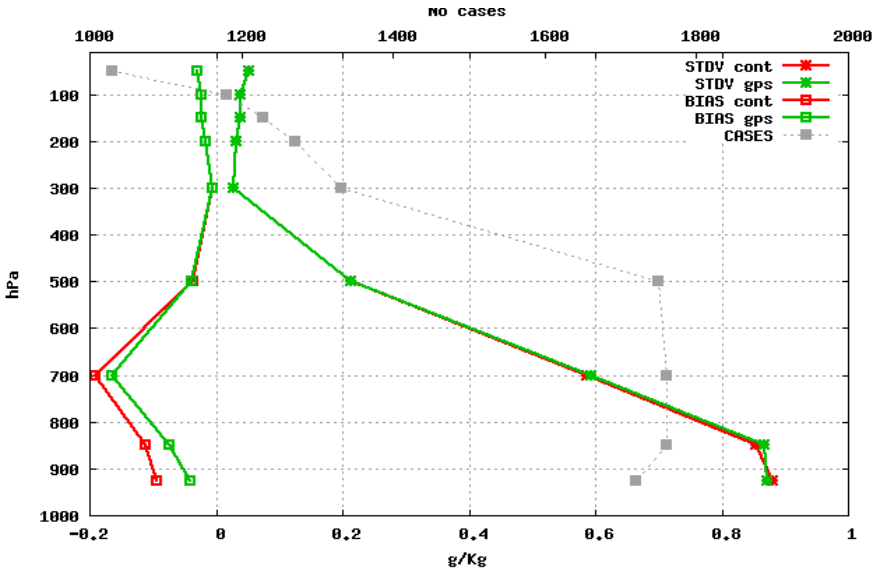
http://www.epncb.oma.be/_productsservices/troposphere/zpd_radiosondes_station.php?station=ONS100SWE

EPN ZTD in the Copernicus Regional Re-Analysis (CERRA)

CERRA:

- 5.5 km horizontal resolution, 1080x1080 grid points
- 106 vertical levels with model top at 1 hPa
- Run from 1984-2021
- 3Dvar assimilation system with a 3 hour cycling
- Includes conventional observations, satellite radiances, Scatterometers, AMV, GNSS-RO and **EPN GNSS-ZTD**

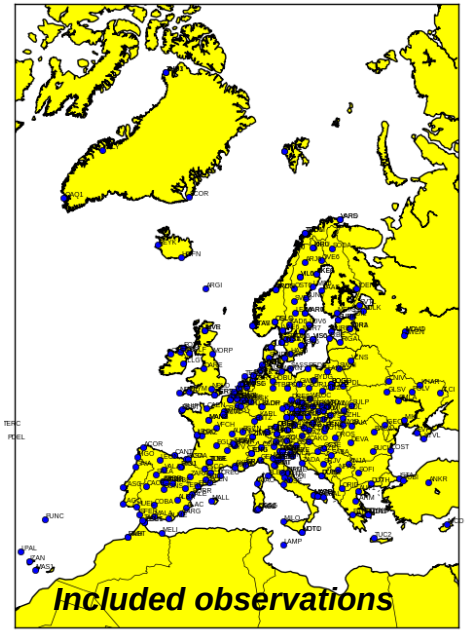




Red – Control run with no GNSS-ZTD
Green – Same run with GNSS-ZTD

Verification of specific humidity against radiosondes:

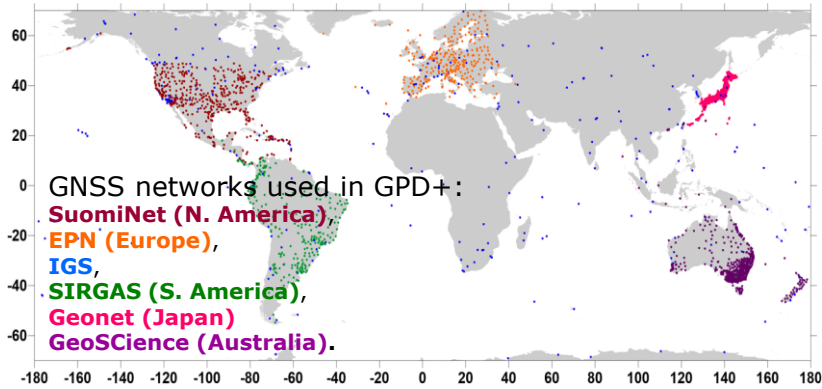
- 12 hour forecasts for a 3 week period.
- The model is generally too dry.
- GNSS-ZTD moistens the model on all levels.

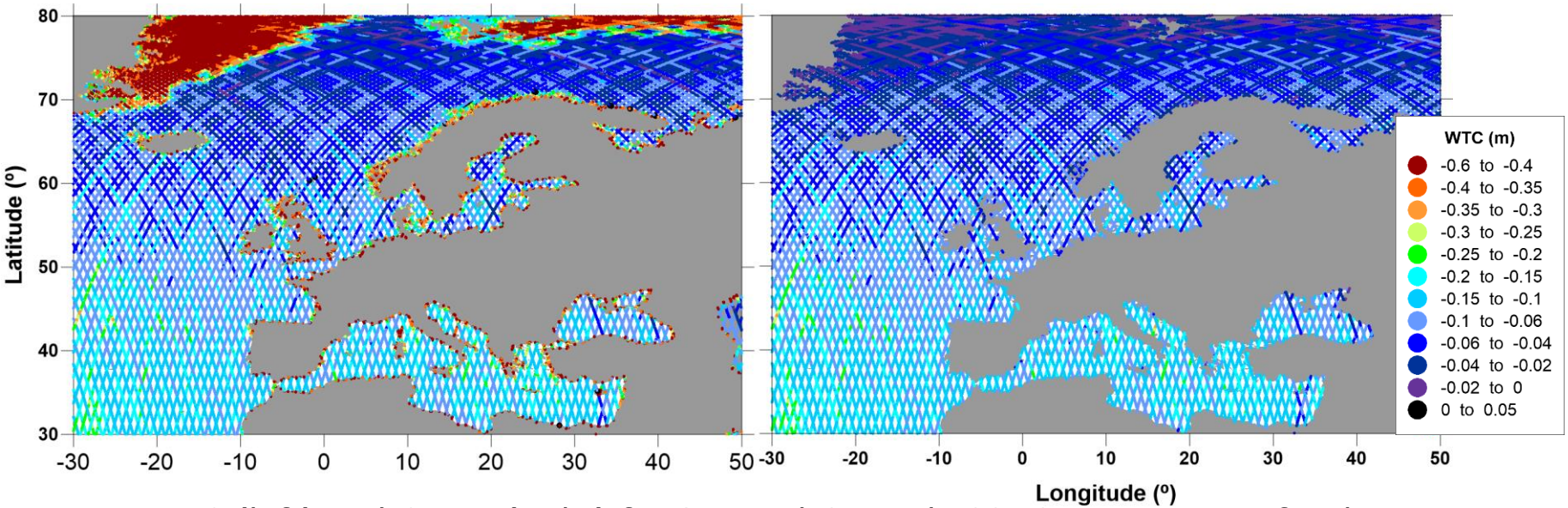


Courtesy of M. Ridal SMHI, the Swedish Meteorological and Hydrological Institute

EPN ZTD in the estimation of improved WTC for satellite altimetry

- GPD+ (GNSS-derived Path Delay Plus) algorithm developed at UPorto to estimate improved Wet Tropo Correction (WTC) for satellite altimetry.
- Improvement particularly relevant over coastal regions and inland waters, where the measurements from the on-board microwave radiometers (MWR) become invalid.
- GPD+ WTC are currently provided operationally to the Sentinel-3A/3B and CryoSat-2 missions, then incorporate into the NTC (Non-Time Critical) and GOP (Geophysical Ocean Products) L2 products.





MWR WTC (left) and GPD+ (right) for Sentinel-3B cycle 32. GPD+ corrects for the noisy extreme negative values present in the MWR WTC in coastal regions

Courtesy of B. Vasconcellos and J M. Fernandes , University of Porto

Summary and Next Steps

- Overview of the status of the EPN operational tropo products
- EPN ZTD are operationally used in Copernicus Regional Re-Analysis and Wet Tropo Correction for Satellite Altimetry
- Final tropo combination: 10/17 ACs (ASI, BEK, BEV, COD, LPT, MUT, NKG, ROB, UPA and WUT) are providing final tropo product
- Rapid daily tropo combination: 7/11 ACs (ASI, BEK, IGE, MUT, ROB, UPA, WUT) are providing rapid daily tropo product that will be use for testing a daily rapid combination
- EPN-Repro3 is in the pipeline

Acknowledgment: *the EPN ACs for providing the solutions used for the combination, the EPNCB for making available some of the plots used in this presentation, the TU Vienna for the auxiliary data used in the ZTD2IVW conversion and the GNSS site owners for the collection and distribution of GNSS rinex data.*
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