EPN Repro2: A Reference Tropospheric Dataset over Europe

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and the EPN Repro2 team
Outline

- EPN Repro2 Campaign (1996-2013 with extension to 2014)
  - Features of the delivered solutions
- Homogeneously reprocessed long-term tropo products
  - Preliminary & Final Combined ZTD Solution
  - Horizontal Gradient Evaluation
- EPN Repro2 end-user
- Summary
GNSS Solutions: SW & Network coverage

- **5 ACs**: ASI GOP IGE LPT MUT
- **5 (+3) input solutions available**
- **Tropospheric Parameters**: ZTDs & Gradients

**5 (+3) Solutions**
- ASI (GIPSY, Full EPN)
- GOP (Bernese, Full EPN)
- LPT (Bernese, EPN sub-net)
- IGE (Bernese, EPN sub-net)
- MUT (GAMIT, Full EPN)

**3 Bernese Solutions**
- GOP (Full EPN network)
- LPT (EPN Sub-network)
- IGE (EPN Sub-network)

**3 Solutions (Full EPN)**
- ASI (GIPSY)
- GOP (Bernese)
- MUT (GAMIT)

- **Different software**
- **Different networks**
- **Same software**
- **Different networks**
- **Different software**
- **Same network**

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Features of the solutions

- **GLONASS**
  - available since 2003, very few stations at the beginning
  - only used LPT and IGE solutions

- Different PCV corrections used: *‘type mean’ & ‘type mean + individual’*

- Non Tidal Atmospheric Loading: *Yes/No*

- **Orbits**
  - CODE reprocessed: IGE, GOP, LPT, MUT
  - JPL reprocessed: ASI

- Different MF used: **GMF & VMF1**
Impact of GLONASS

LPT processing, Courtesy E. Brockmann

ZTD trend computed over 111 sites

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KLOP00DEU (KLOP): differences between ‘individual’ & ‘type mean’ calibration

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>Diff. Up</th>
<th>Diff. ZTD</th>
<th>Antenna + Radome</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-06-27 : 2013-06-28</td>
<td>8.7 mm</td>
<td>-1.3 mm</td>
<td>TRM55971.00 TZGD</td>
</tr>
</tbody>
</table>

MUT processing, Courtesy A. Araszkiewicz

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Individual vs Mean Type calibration

KLOP00DEU (KLOP): AC Bias & STD w.r.t. the combination for 2007

1433 KLOP antenna change

Results from the combination

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Impact of NT-ATL on ZTD and Height

MUT processing, Courtesy A. Araszkiewicz

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EPN-Repro2: Available Sites

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EPN-Repro2: Sites Redundancy

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Preliminary Repro2 ZTD Combination

- 8 input solutions: AS0, GO0, GO1, GO4, LP0, LP1, MU4

**Purpose:**
- test all the available solutions
- flag the outliers
- send feedback to the ACs

**IWV Accuracy for Regional Climate**
*(E-GVAP II Product Requirements Document)*

- Threshold: 3 kg/m²
- Breakthrough: 1.5 kg/m²
- Goal: 1 kg/m²

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Final Repro2 ZTD Combination

- 5 input solutions: AS0, GO4, IG0, LP1, MU2

![Graph showing weekly mean and standard deviation of ZTD combinations over a period from 1980 to 2018. The graph includes a line for each input solution (AS0, GO4, IG0, LP1, MU2) with markers for weekly mean and standard deviation. The graph highlights a range of +2 mm to -2 mm and 2.5 mm.]

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ASI: Repro2 vs Repro1+Operational

Repro1 & Operational

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

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## Evaluation of Horizontal Gradients

<table>
<thead>
<tr>
<th>TROPOSPHERE Estimated Param</th>
<th>AS0</th>
<th>GO4</th>
<th>IG0</th>
<th>LP1</th>
<th>MU2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZTD (5min)</td>
<td>ZTD (1h)</td>
<td>ZTD (1h)</td>
<td>ZTD (1h)</td>
<td>ZTD (1h)</td>
<td></td>
</tr>
<tr>
<td>GRAD (5min)</td>
<td>GRAD (6h)</td>
<td>GRAD (6h)</td>
<td>GRAD (24h)</td>
<td>GRAD (24h)</td>
<td></td>
</tr>
<tr>
<td>Cut-off angle</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>MAPPING FUNCTION</td>
<td>VMF1</td>
<td>VMF1</td>
<td>GMF</td>
<td>VMF1</td>
<td>VMF1</td>
</tr>
<tr>
<td>ZTD/GRAD time stamp</td>
<td>hh:30 24 estimates/day</td>
<td>hh:30 (and hh:00) 24(+24) estimates/day</td>
<td>hh:30 24 estimates/day</td>
<td>hh:30 (and hh:00) 24(+24) estimates/day</td>
<td>hh:30 24 estimates/day</td>
</tr>
</tbody>
</table>

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**GNSS Twin Sites**

**VLBI and GNSS co-located sites**

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2013 May 20 UTC 00

1 mm

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MEDI East, North Gradients

ERA-Interim as reference

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Water vapour is under-sampled in the current meteorological and climate observing systems. **Climate community** only now starting to use GNSS tropospheric products.

COST ACTION GNSS4SWEC  
WG3: GNSS for climate monitoring

J. Jones at al. ‘**COST ACTION ES1206: Advanced GNSS Tropospheric Products for Monitoring Severe Weather Events and Climate (GNSS4SEC)**’
gnss iwv trends and variability

- Assessment of Med-CORDEX, Euro-CORDEX climate model simulation using GNSS IWV long time series.

- IGS Repro1 (1996-2010) used as reference reprocessed GPS solution.

→ Data after 2010 are required!

- The climate groups expressed the need for more spatially dense GPS ZTD/IWV data over Europe.

→ EPN Repro2 compliant to both requirements!

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Summary

- **EPN Repro2 Campaign**: 1996-2013/2014 homogeneously reprocessing tropospheric products from **5 EPN ACs**.

- Impact of the features of the contributing solutions evaluated prior to the combination.

- **Preliminary** EPN Repro2 ZTD **combination** based on 8 input solutions (**AS0, GO0, GO1, GO4, IG0, LP0,LP1, MU4**) done to test them, to flag the outliers, to send feedback to the Acs.

- **Final** EPN Repro2 ZTD **combination** based on 5 input solutions (**AS0, GO4, IG0,LP1, MU2**) done. Same solutions used by the EPN ACC in the final combination of the EPN positions.

- **Horizontal Gradients** evaluation, both intra-technique and inter-technique, on a EPN sub-network.

- Comparison with respect to radiosonde data is on-going.

- Products will be available to the user community.
Acknowledgment

EPN Repro2 Working Group

Araszkiewicz Andrzej         MUT
Brockmann Elmar              LPT
Di Tomaso Simona            ASI/CGS
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