Analysis of VLBI and GNSS ties in CONT campaigns

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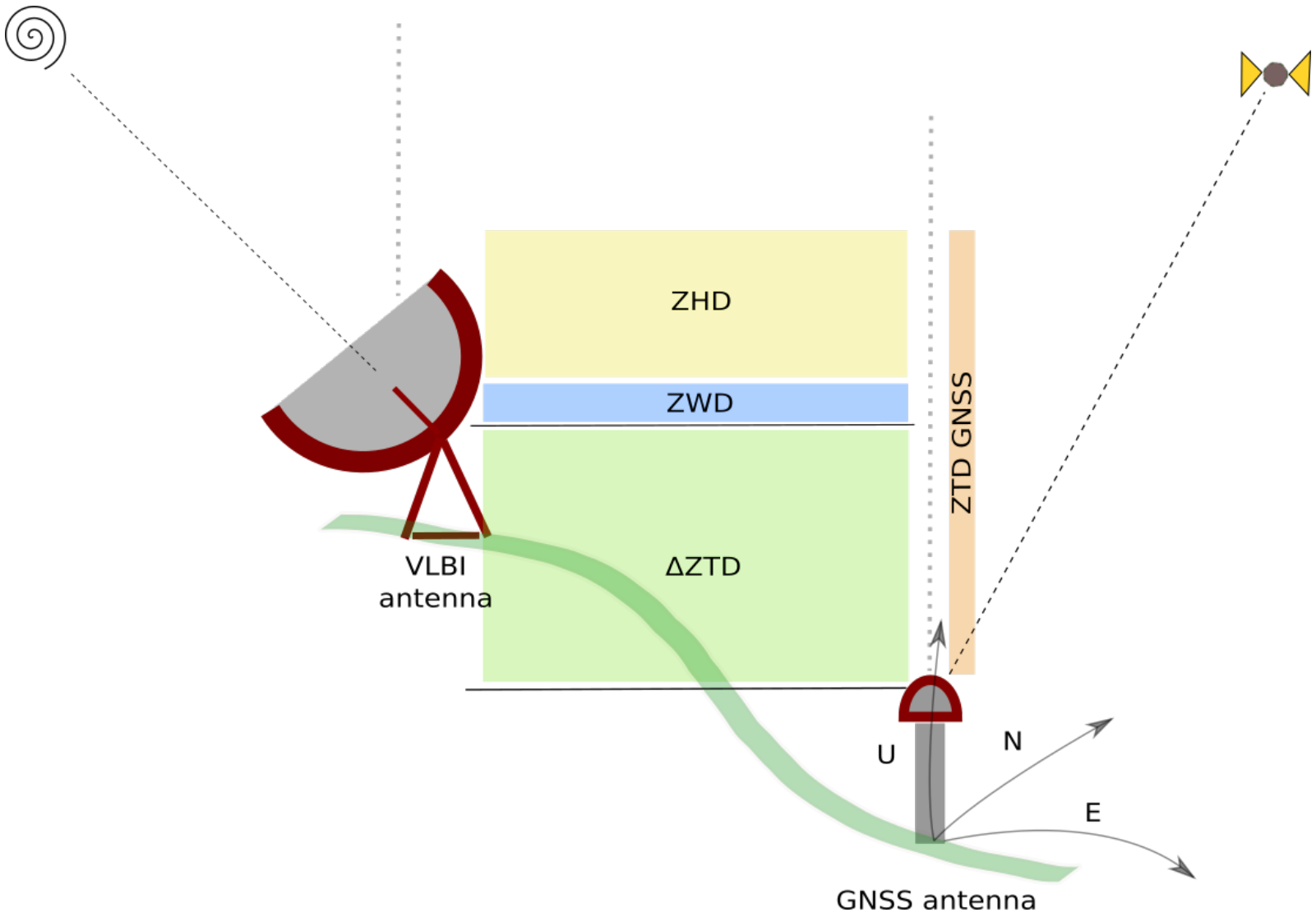
Motivation and goals

- Motivation: VLBI analysis at National Geographic Institute of Spain (IGE). GNSS background.

- Goals:

1. Assess VLBI and GNSS ties in CONT campaigns
    - Zenith Troposphere Delay
    - Antenna coordinates repeatabilities
    - Polar motion
2. Usage of GNSS-derived parameters in VLBI analysis

Motivation and goals



CONT campaigns

- IVS effort to provide continuous VLBI sessions during 15 days.

Campaign	Start date	End date	#stations
CONT02	16/10/2002	31/10/2002	8
CONT05	12/09/2005	27/09/2005	11
CONT08	12/08/2008	26/08/2008	11
CONT11	15/09/2011	28/09/2011	14
CONT14	06/05/2014	20/05/2014	16
CONT17	28/11/2017	12/12/2017	14

- One of its goals is the inter-technique comparison taking advantage of co-located sites (IGS-IVS).

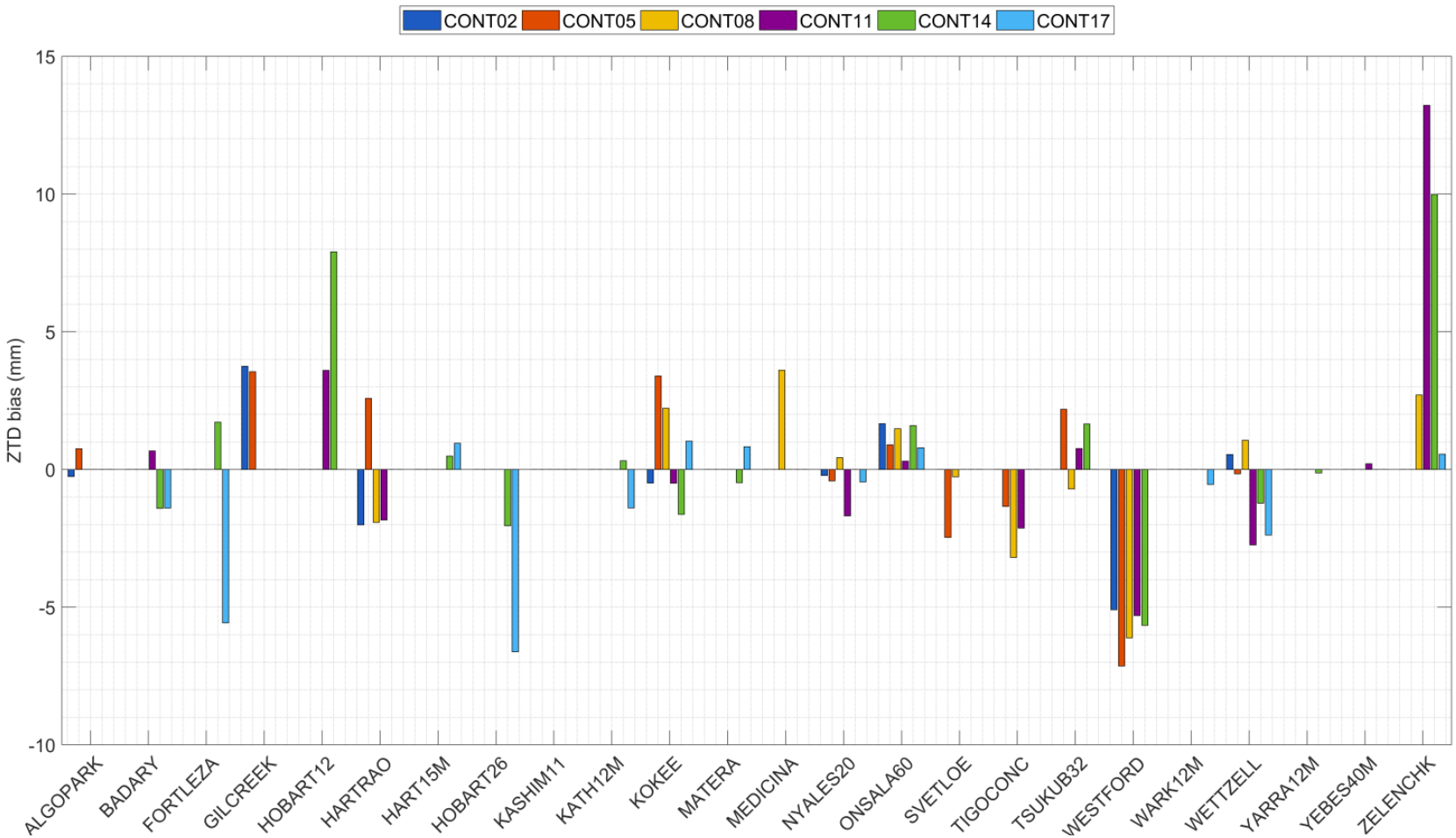
1. VLBI-GNSS troposphere differences

Comparison of Zenith Troposphere Delays (ZTD) in CONT campaigns

- ZTD compared in co-located antennas.
- Bias due to height difference is removed: hydrostatic (Saastamoinen, 1972) and wet (Brunner and Rüeger, 1992).
- GNSS solution: CODE solution (Dach et al. 2018) using Bernese GNSS Software.
- VLBI solution: IGE solution using VieVS 3.1 (Böhm et al. 2018).

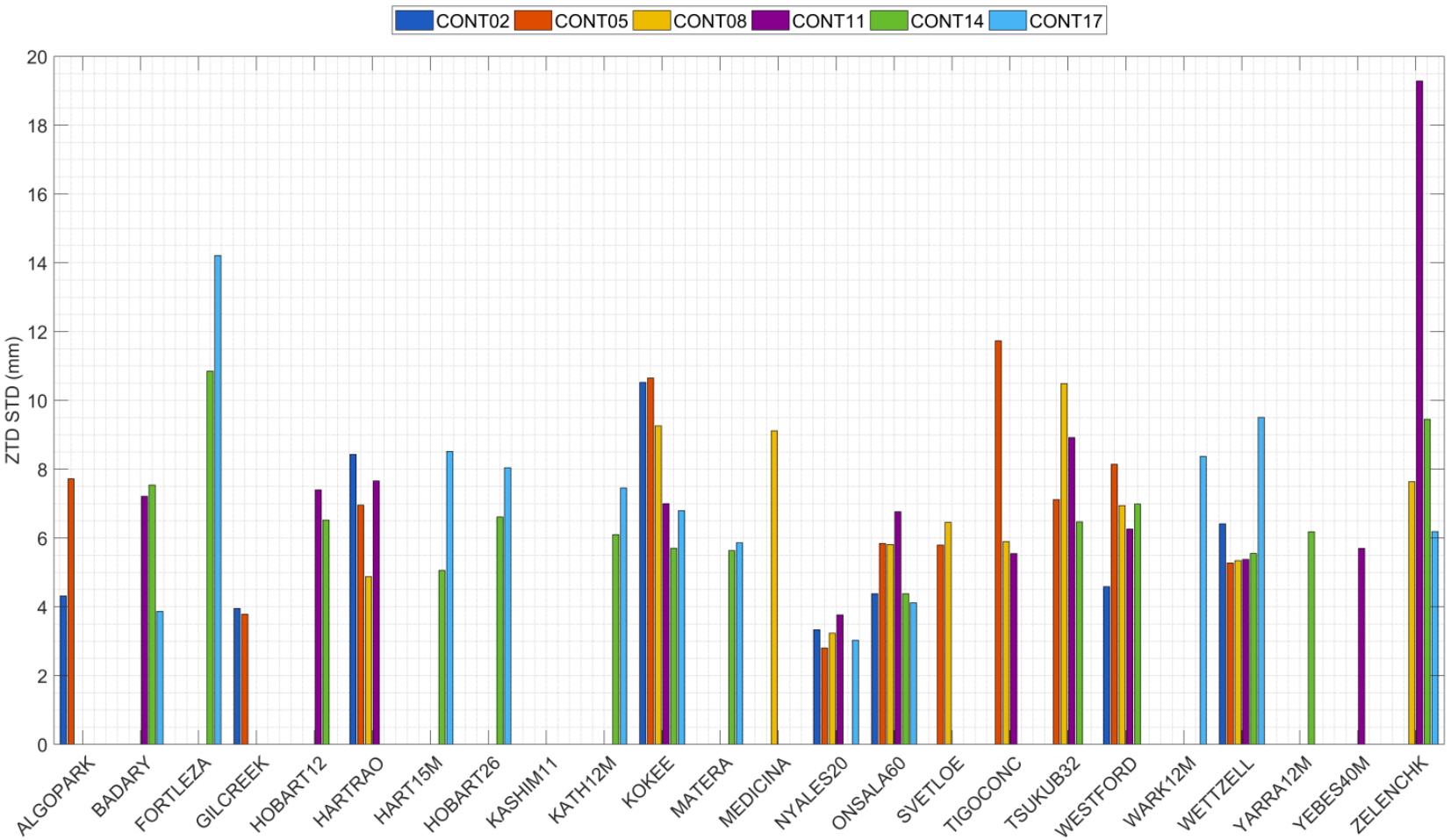
1. VLBI-GNSS troposphere differences

Mean bias over all CONT campaigns < 1 mm



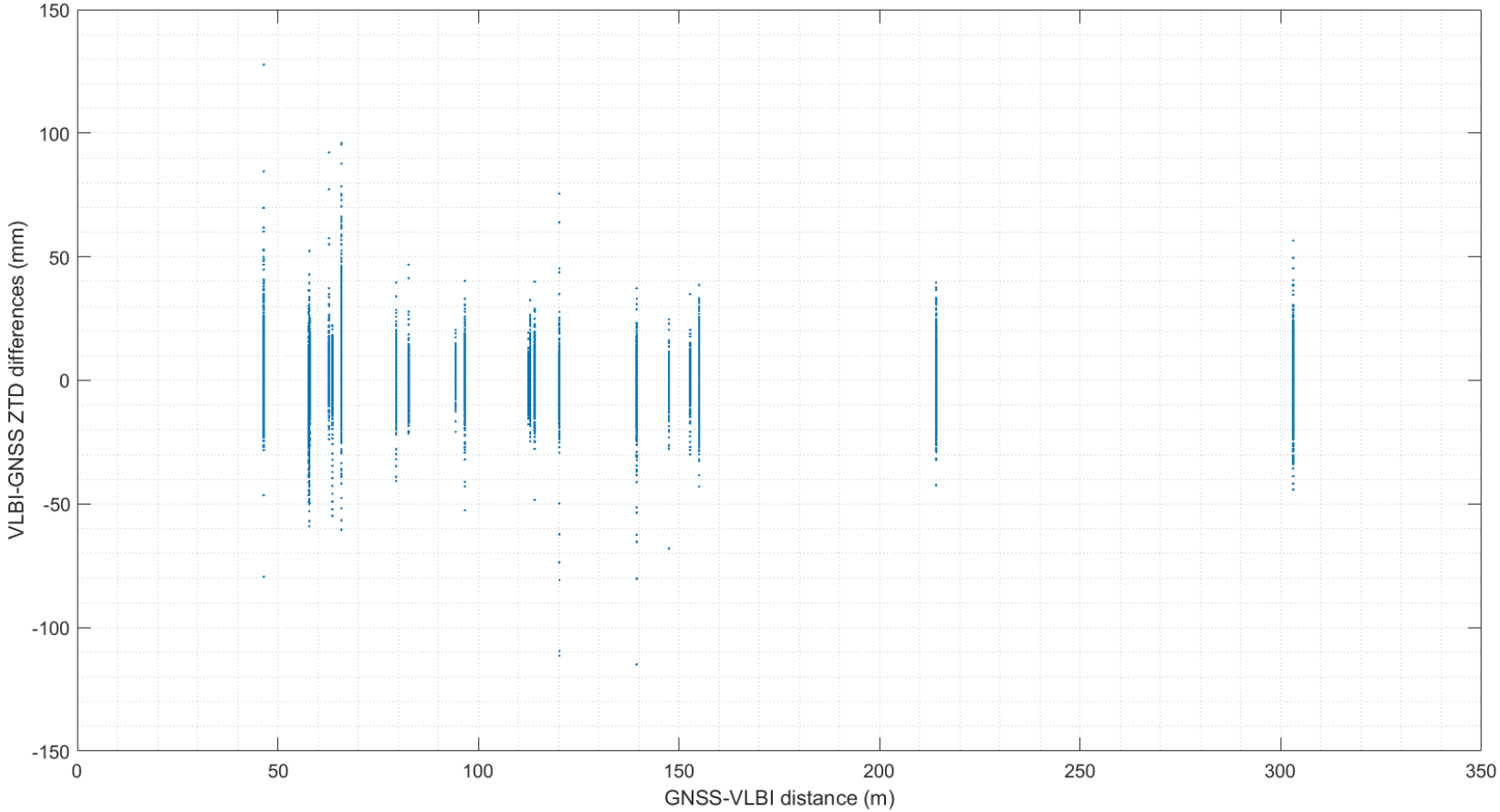
1. VLBI-GNSS troposphere differences

Mean standard deviation over all CONT campaigns $\sim$ 6 mm



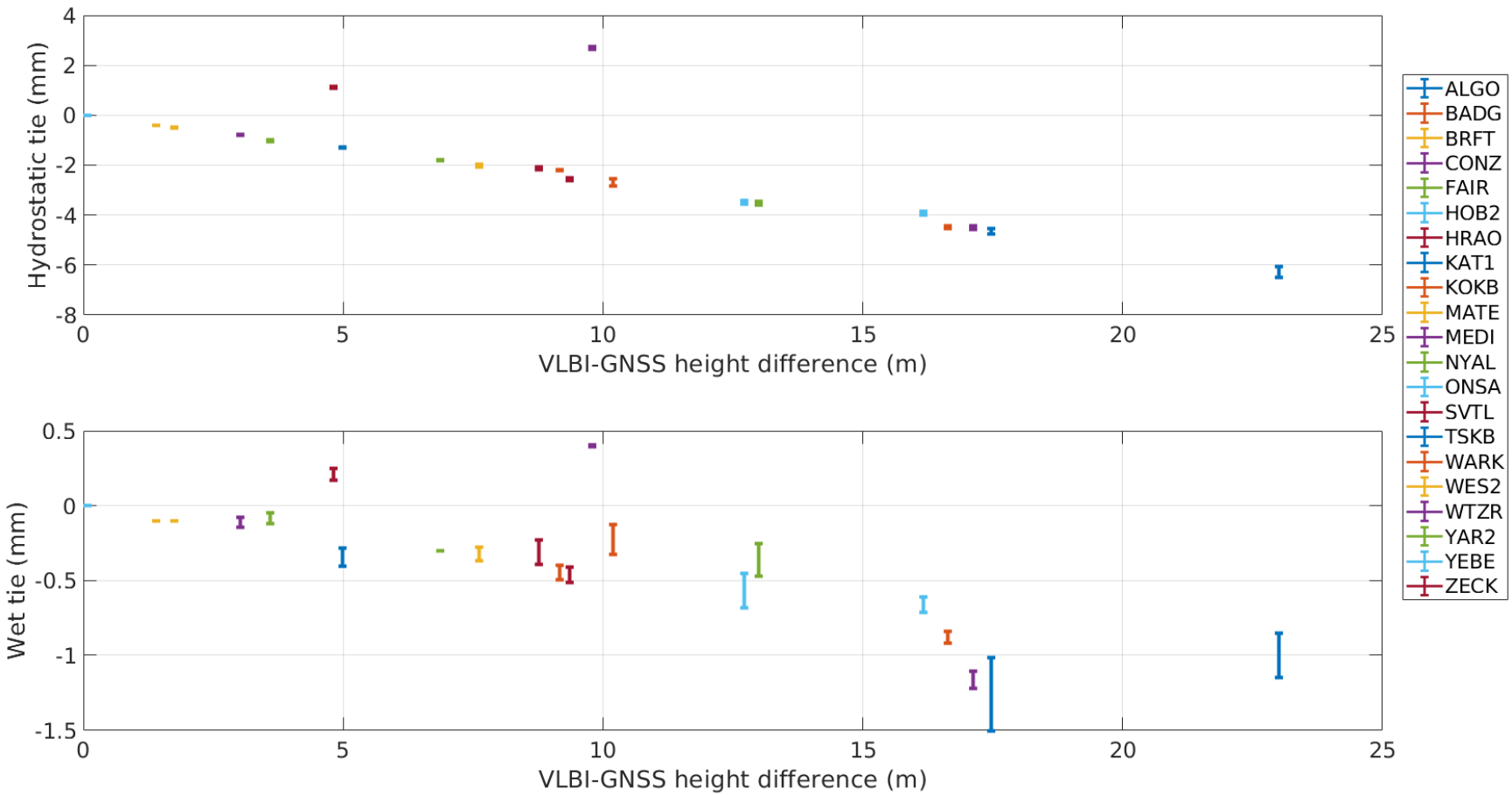
1. VLBI-GNSS troposphere differences

Differences show no correlation with the local tie length.



1. VLBI-GNSS troposphere differences

Stability of hydrostatic and wet ties < 0.5 mm



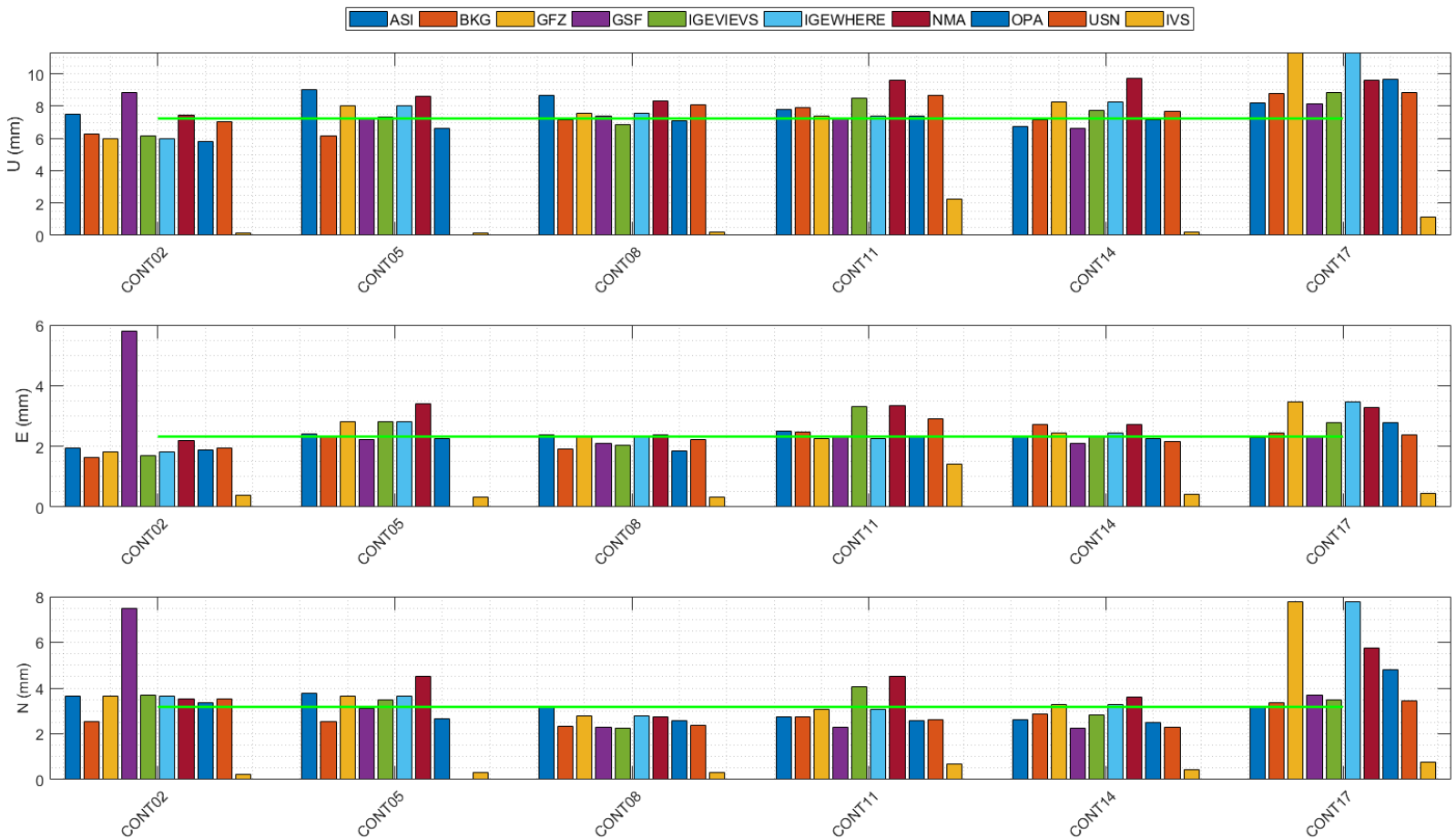
2. Coordinates repeatabilities

Comparison of repeatabilities of antenna coordinates in CONT campaigns:

- Up/East/North repetabilities are compared in co-located antennas.
- GNSS solutions from 5 IGS Analysis Centers and the IGS combined solution
- VLBI solutions from 7 IVS Analysis Centers. IVS solution and two additional solutions from IGE using two different software packages: VieVS 3.1 and Where 0.21.2 (Kirvik et al. 2017).

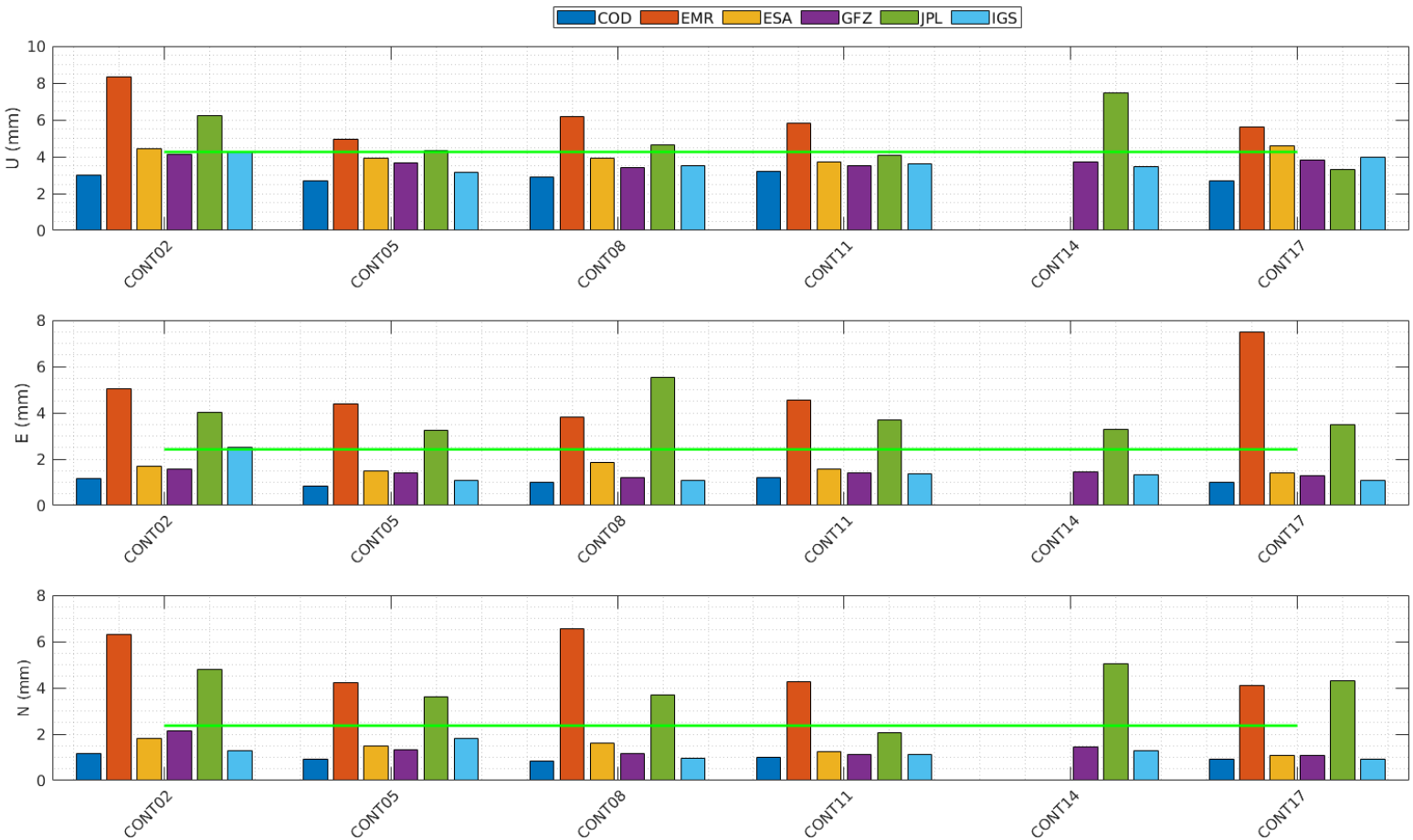
2. Coordinates repeatabilities

Mean repeatability of VLBI solutions excluding IVS solution: 7 mm in U, 2 mm in E and 3 mm in N.



2. Coordinates repeatabilities

Mean repeatability of GNSS solutions excluding IGS solution: 4 mm in U and 2 mm in E/N components.



3. Polar motion differences

Comparison of polar motion in CONT17 campaign.

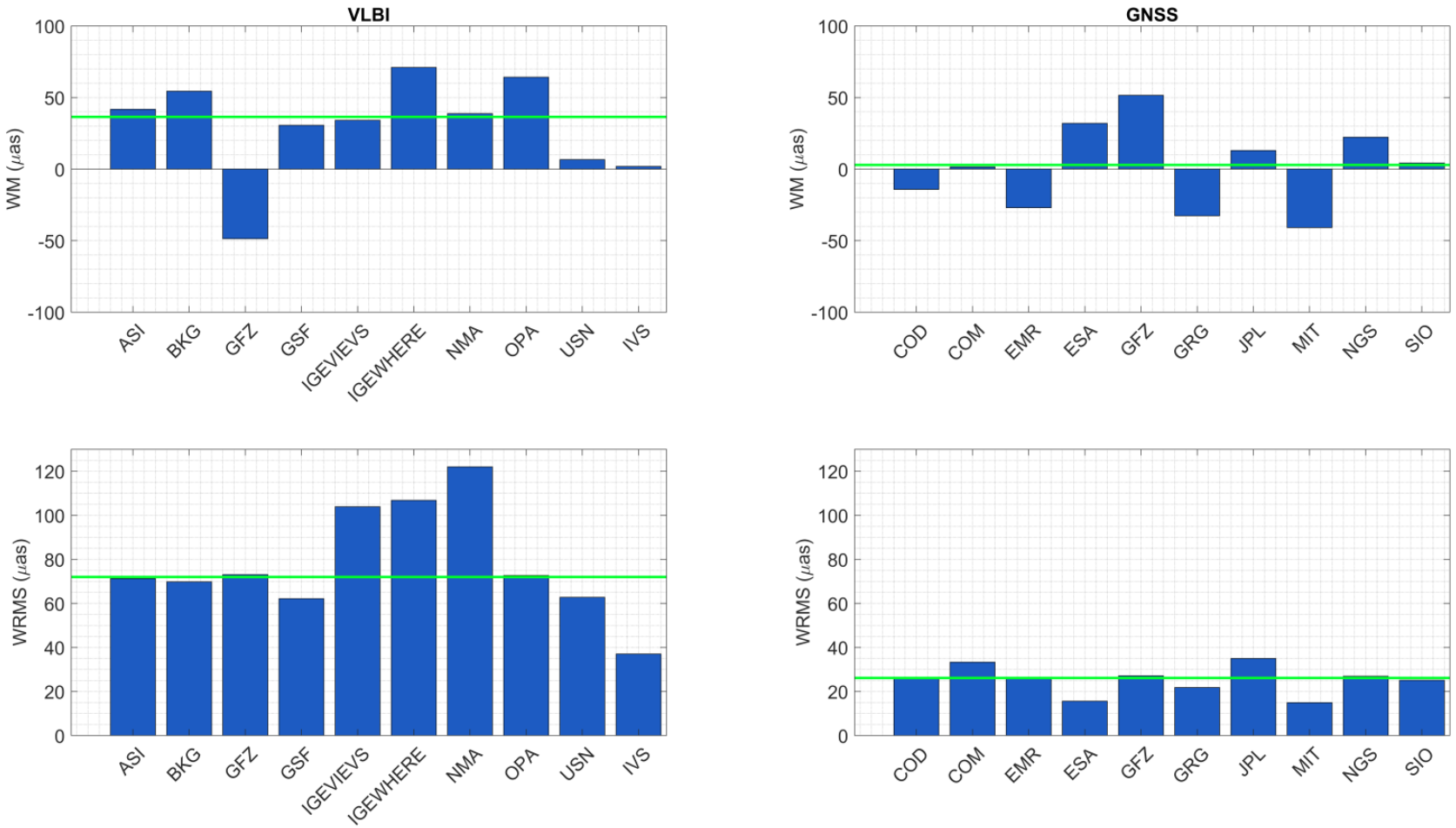
- Comparison of polar motion components with respect to IGS combined solution in terms of Weighted Mean (WM) and Weighted RMS (WRMS) of the differences (Nilsson et al. 2014).

$$\mathrm{WM} = \frac{\sum_{i=i}^{N} \frac{x_i - x_{IGS,i}}{\sigma_i^2 + \sigma_{IGS,i}^2}}{\sum_{i=i}^{N} \frac{1}{\sigma_i^2 + \sigma_{IGS,i}^2}} \qquad \mathrm{WRMS} = \sqrt{\frac{\sum_{i=i}^{N} \frac{\left(x_i - x_{IGS,i} - WM\right)^2}{\sigma_i^2 + \sigma_{IGS,i}^2}}{\sum_{i=i}^{N} \frac{1}{\sigma_i^2 + \sigma_{IGS,i}^2}}}$$

- GNSS solutions from 10 IGS Analysis Centers
- VLBI solutions from 7 IVS Analysis Centers, the IVS combined solution and two additional solutions from IGE using VieVS 3.1 and Where 0.21.2.

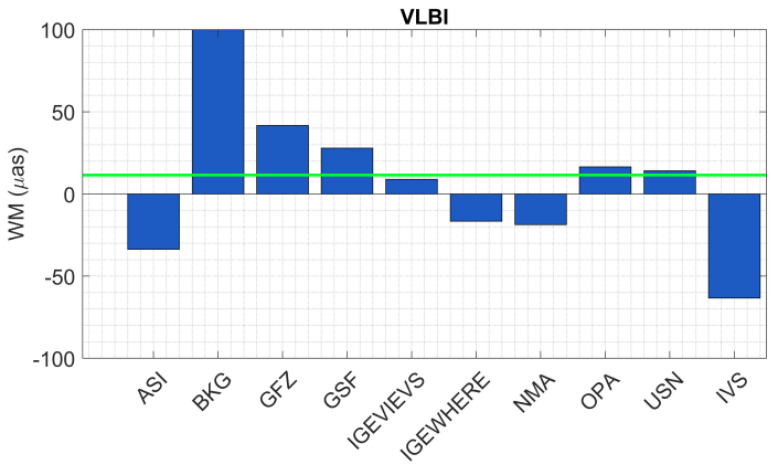
3. Polar motion differences

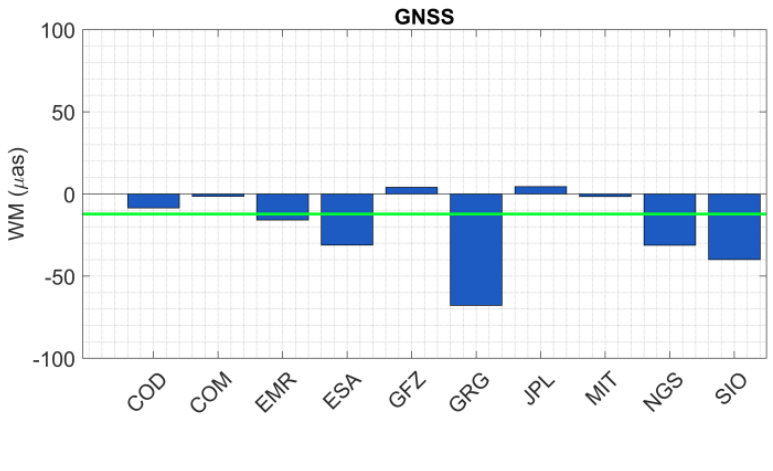
VLBI single solutions (left) and GNSS solutions (right) in the CONT17 period: WM and WMRS of x_P differences.

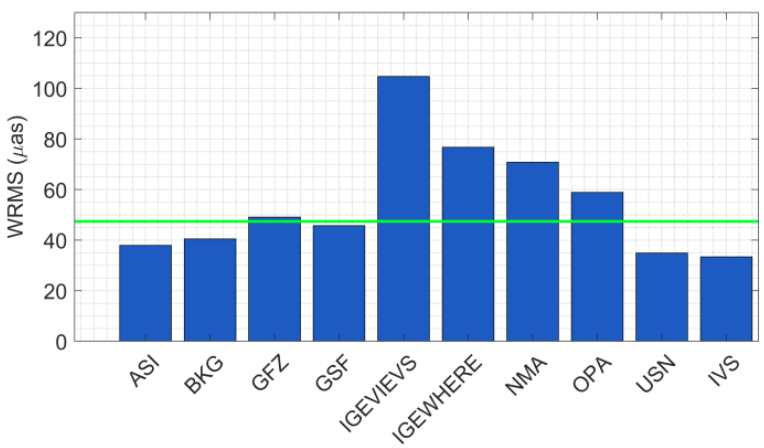


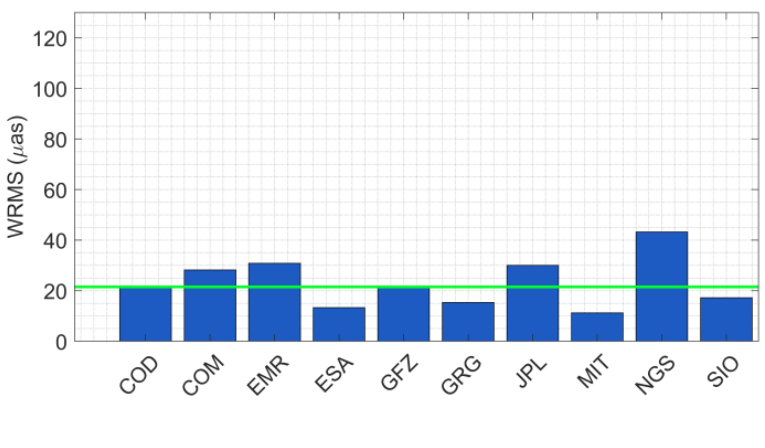
3. Polar motion differences

VLBI single solutions (left) and GNSS solutions (right) in the CONT17 period: WM and WMRS of y_P differences.



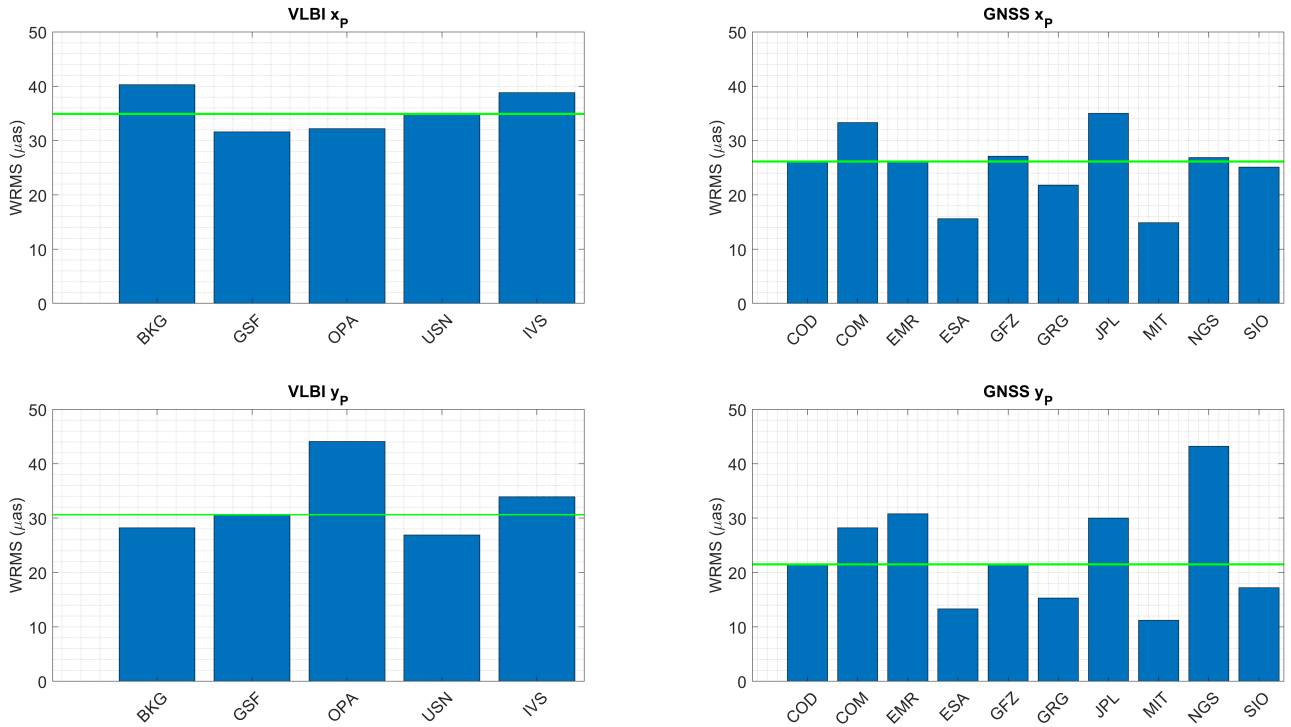






3. Polar motion differences

VLBI global solutions (left) vs GNSS solutions (right) in the CONT17 period: WRMS of x_P, y_P differences.



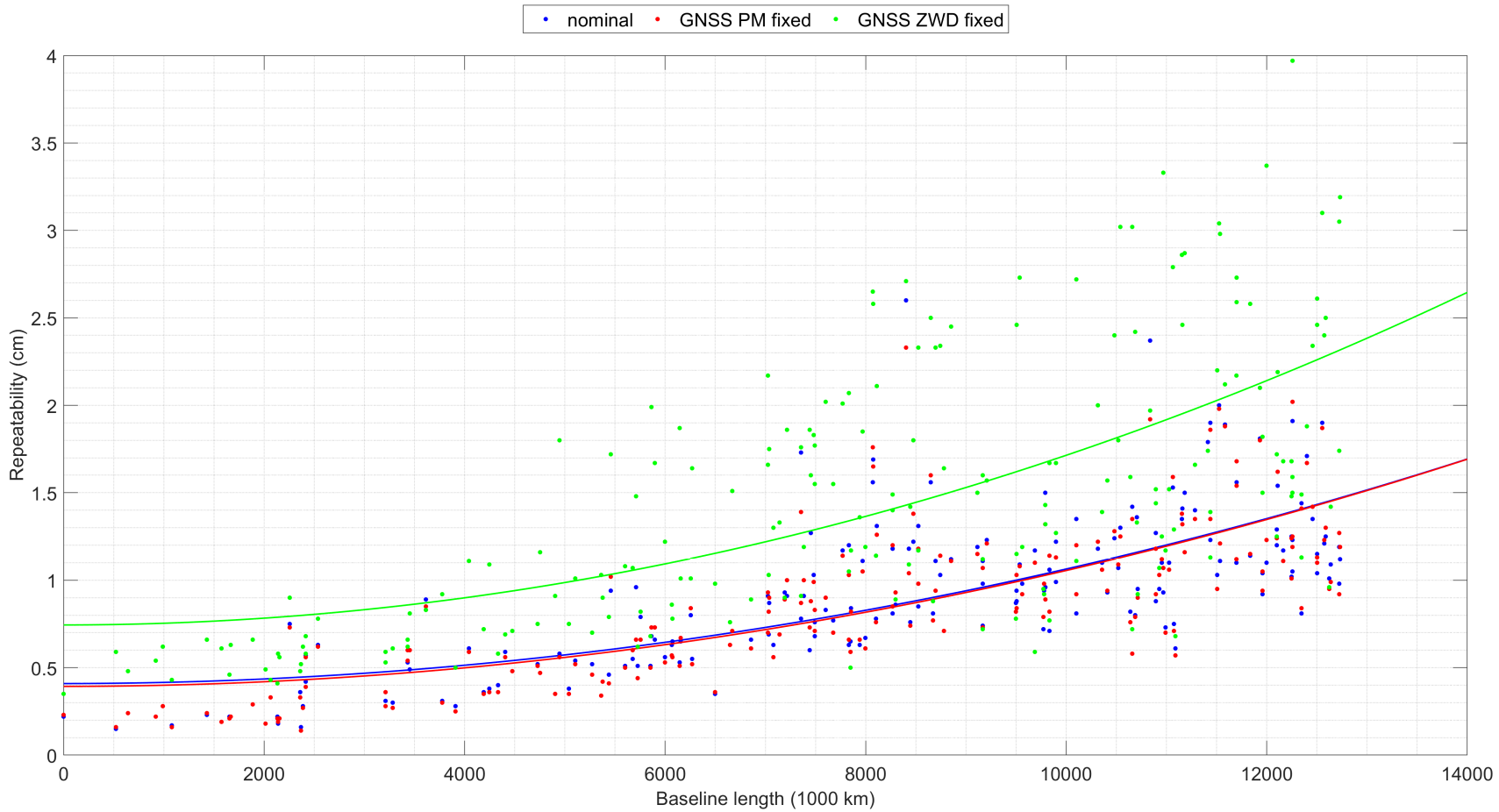
Similar values to previous CONT campaigns $\sim$ 30 μas (Nilsson et al. 2014).

4. GNSS-derived parameters in VLBI processing

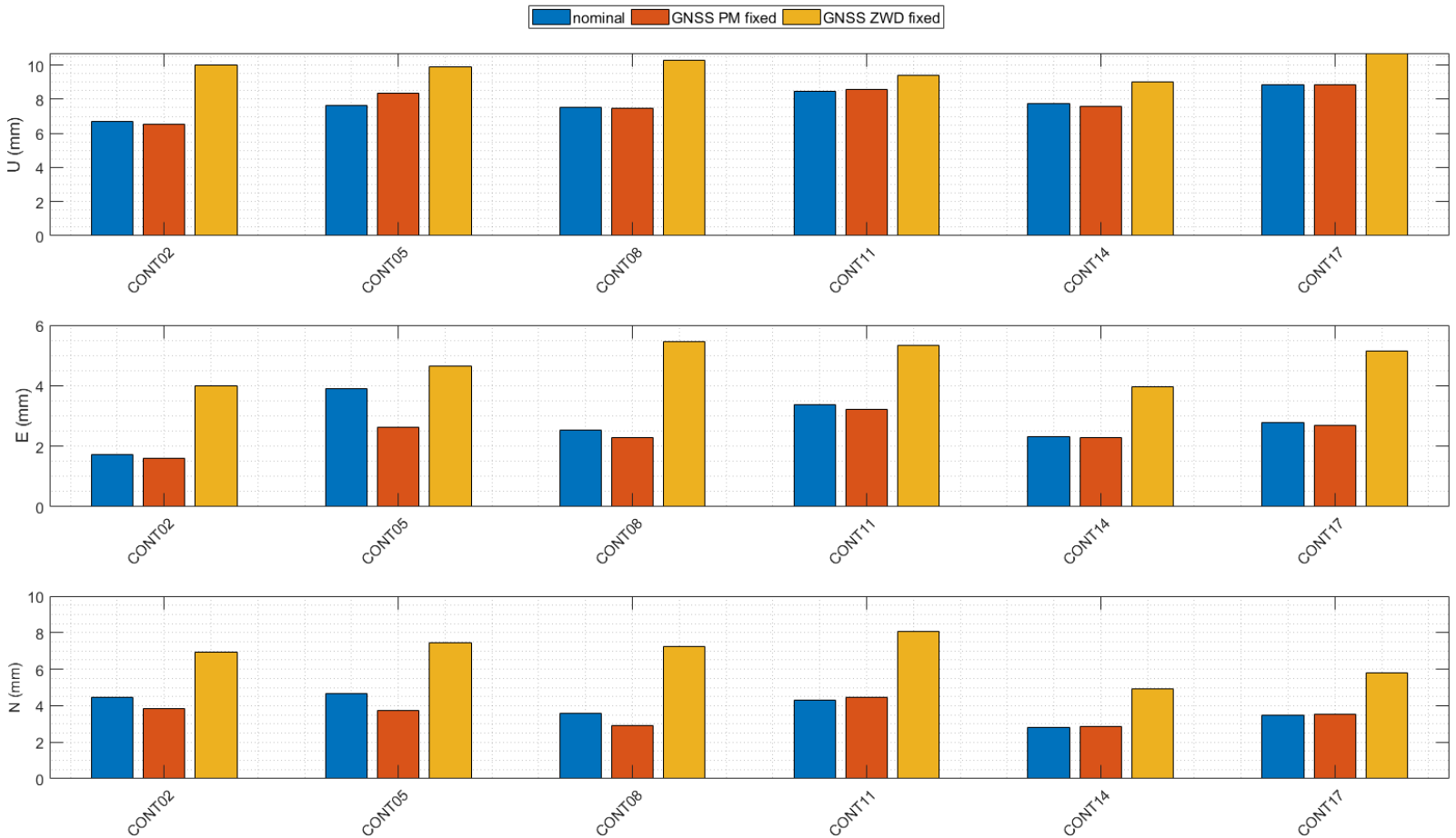
What is the effect of using GNSS-derived parameters in VLBI processing?

- Test#1: Polar motion fixed to IGS combined solution.
- Test#2: Zenith Wet Delay (ZWD) and gradients fixed to GNSS (CODE) solution.
- Processing software: VieVS 3.1 + new functionality to read and interpolate GNSS ZWD in the VLBI observation epoch.
- Dataset: all CONT campaigns.

4. GNSS-derived parameters in VLBI processing



4. GNSS-derived parameters in VLBI processing



Conclusions

The analysis of the 6 CONT sessions focused on VLBI-GNSS ties leads to the following conclusions:

- VLBI-GNSS ZTD differences show a mean bias < 1 mm and standard deviation of 6 mm. No correlation with the local tie length.
- VLBI and GNSS solutions show similar repeatabilities in N/E components but Up repeatability is better in GNSS solutions.
- Similar precision of VLBI global solutions and GNSS solutions in polar motion estimation for CONT17, in line with previous CONT campaigns.
- Polar motion fixed to IGS combined solution provides similar repeatability in VLBI solution whereas ZWD and gradients fixed to GNSS values degrades the VLBI solution.

Questions? Thanks for your attention

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