Zenith troposphere delays and gradients from VLBI, GNSS, DORIS, water vapor radiometer, and numerical weather models during continuous VLBI campaigns

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Hall A-C (Moscone South)
8:00 AM - 12:20 PM

1. INTRODUCTION

The main purpose of this study is to show the agreement of zenith troposphere delays (ZTD) and troposphere gradients derived from:

- Space geodetic techniques:
  - Global Navigation and Satellite Systems (GNSS),
  - Very Long Baseline Interferometry (VLBI),
  - Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS),
- Numerical weather models (NWM):
  - European Center for Medium-Range Weather Forecasts (ECMWF) (global coverage),
  - Japan Meteorological Agency (JMA)- Operational Meso-Analysis Field (MANAL) (over Japan),
  - Cloud Resolving Storm Simulator (CReSS) (over Japan),
- Water vapor radiometer (WVR).

The comparisons were made for the 15-days continuous VLBI campaigns: CONT02, CONT05, CONT08, CONT11. In this poster, we show inter-technique and inter-campaign agreements of ZTD and gradients in terms of site specific and mean (over all stations) standard deviations (SD) and biases.

2. TROPOSPHERE BIASES

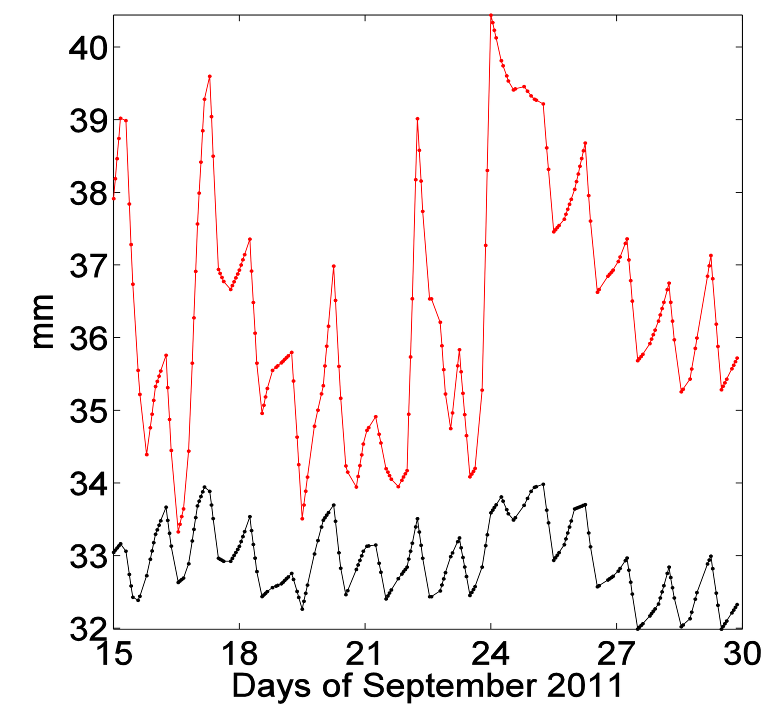

Figure 1 Troposphere biases during CONT11 campaign between the DORIS antenna (HBMB) and the reference height (VLBI antenna reference point height) at the co-located site Hartebeesthoek. Red and black lines illustrate total and hydrostatic biases, respectively.

- Troposphere hydrostatic and wet biases can be defined as the corrections on zenith hydrostatic delay (ZHD) and zenith wet delay (ZWD) estimates of a technique at an estimation epoch due to the troposphere signal delay between the technique's antenna reference point and an arbitrary reference height (e.g. VLBI ARP height for this study) at a co-located site.
- For this study, we computed troposphere hydrostatic and wet biases from the analytical equations of Brunner and Rüeger (1992) based on the height differences and 6 hourly ECMWF data of water vapor pressure, total pressure and temperature.
- Firstly, all the meteorological quantities mentioned above were interpolated to the ZTD estimation epochs.
- Then, time dependent (epoch wise) troposphere biases were calculated and reduced from each ZTD estimate before comparisons.
- In Figure 1, one can see that the hydrostatic biases during 15 days vary within 2 mm with a daily signal. However, after adding wet biases, the dispersion of total biases extend to 7 mm.

3. SUMMARY of the DATA

Technique	Zenith total/ wet delay	Estimation interval of zenith delay	Estimation interval of gradients	Co-located with VLBI (GNSS acronyms are used for all techniques)			
				C02	C05	C08	C11
VLBI-VieVS	(ZWD), ZTD	1 hour	6 hours	All stations for all CONT campaigns			
GNSS-CODE	(ZWD), ZTD	1 hour	6 hours	All	All	All except ZECK	All except BADG
DORIS-IGN*	ZTD	per satellite pass	1 day	HRAO, KOKB, NYA1	HRAO, KOKB, NYA1	HRAO, KOKB, NYA1	HRAO, KOKB, NYA1, BADG
WVR	ZWD	1 hour	6 hours	ONSA, WTZR KOKB	ONSA, WTZR, KOKB, HRAO, TSKB, ALGO	ONSA, WTZR, TSKB	ONSA, TSKB
ECMWF	ZWD, ZTD	6 hours	6 hours	All stations for all CONT campaigns			
CReSS	(ZWD), ZTD	1 hour	1 hour	-	-	TSKB	-
JMA-MANAL	(ZWD), ZTD (ZWD), ZTD	6 hours 3 hours	6 hours 3 hours	-	TSKB	-	TSKB

* DORIS ZTD estimates were interpolated to UT integer hours except for gaps longer than one hour!

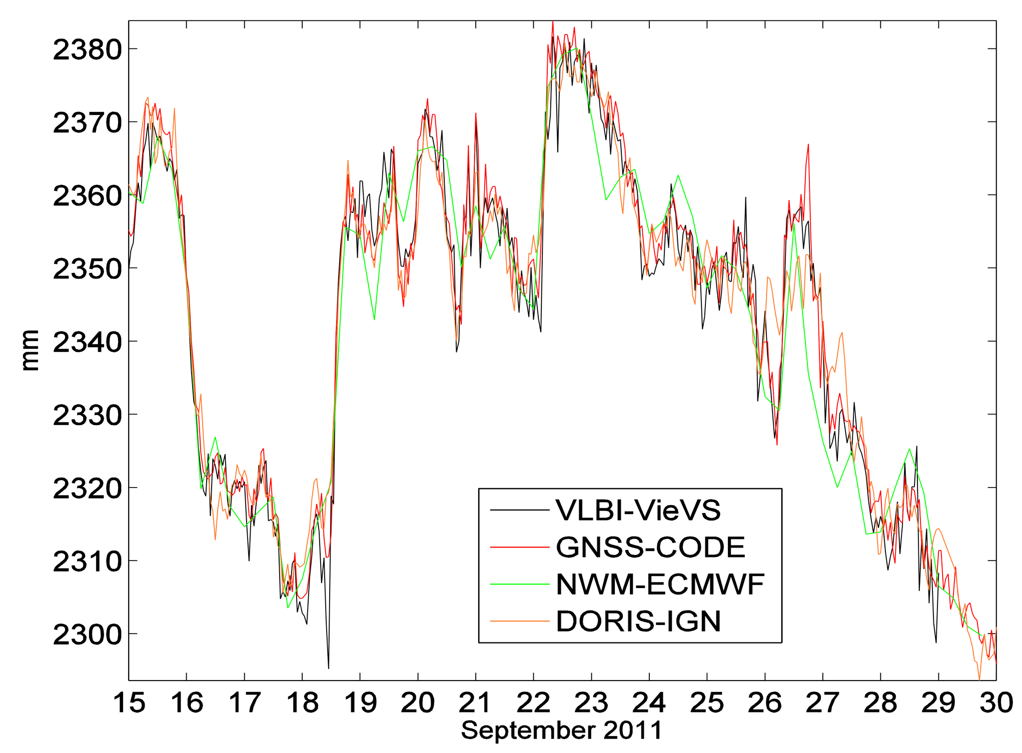

Figure 2 Troposphere ZTD of the co-located site Ny-Ålesund (Svalbard/Norway, 79° latitude) during CONT11. GNSS and DORIS antennas are NYA1 and SPJB, respectively.

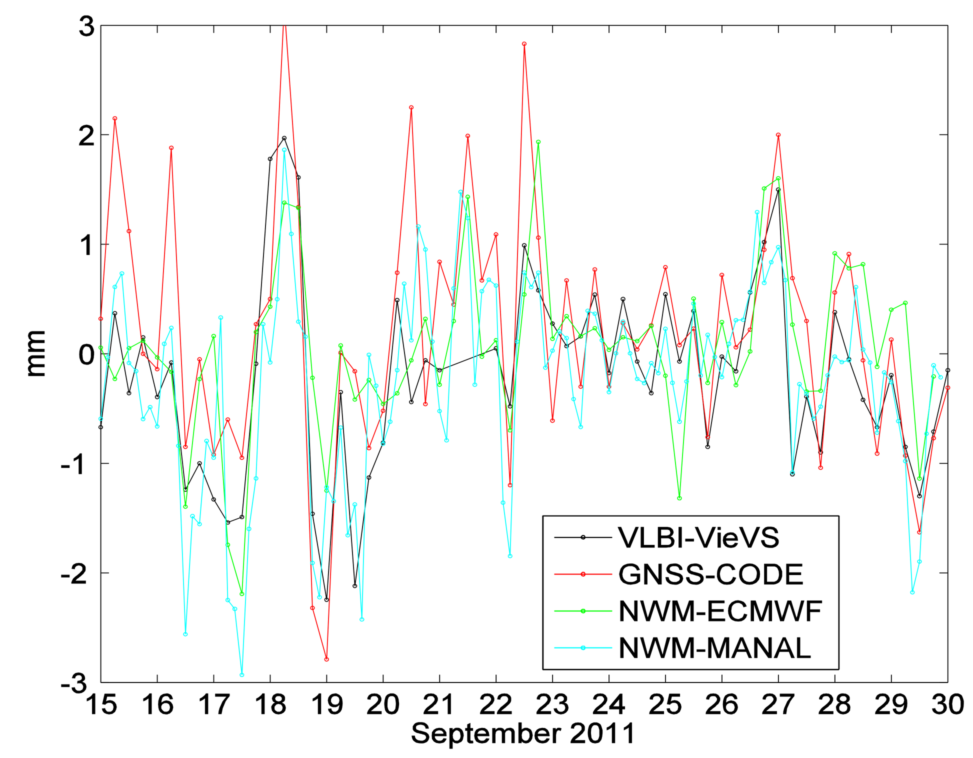

Figure 3 Troposphere east gradients of the co-located site Tsukuba (in Japan) during CONT11. GNSS antenna is TSKB.

4. RESULTS

4.1. Site-wise comparison of ZTD standard deviations (SD) and biases between GNSS/CODE and VLBI/VieVS for all CONT campaigns

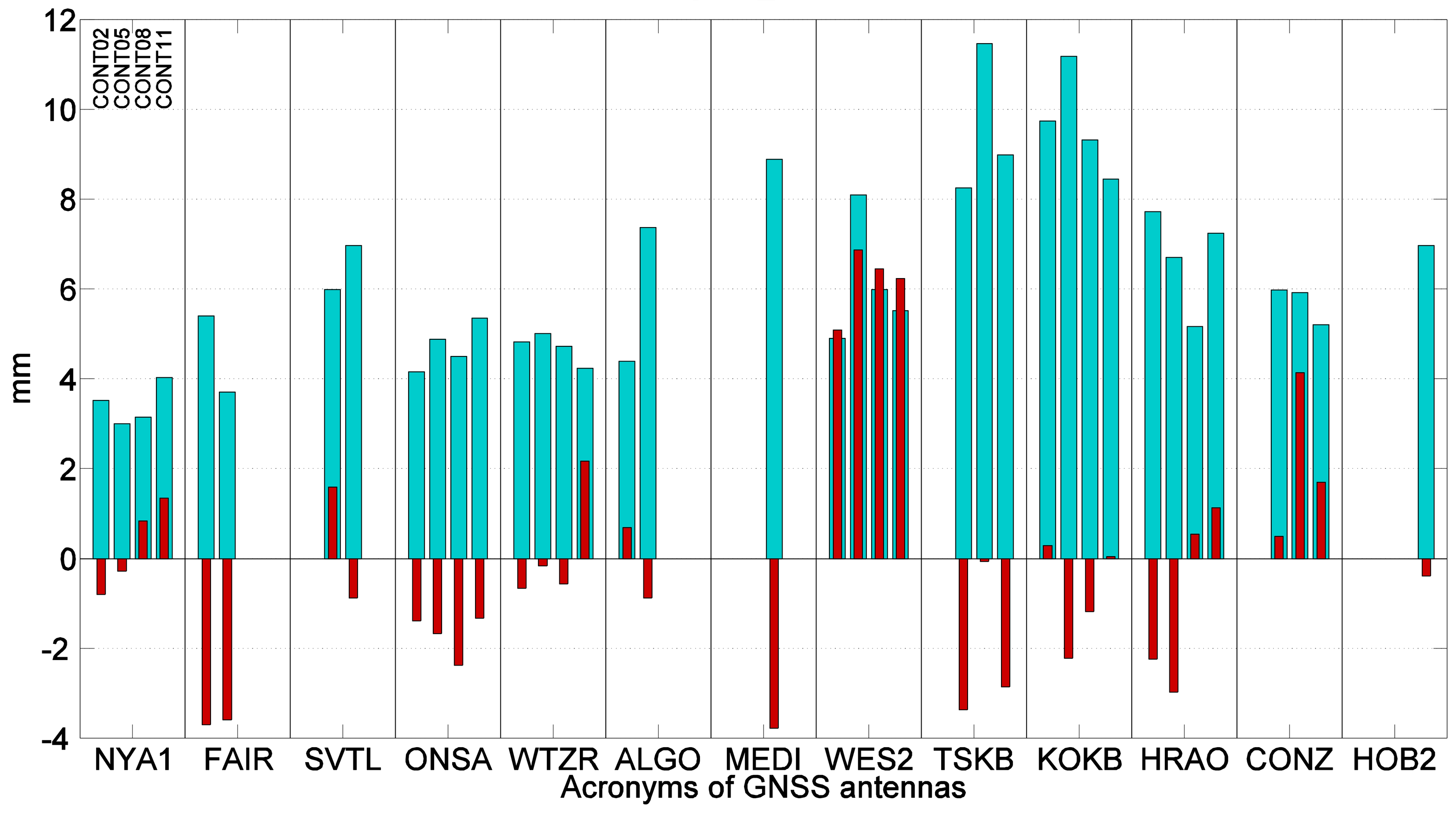

Figure 4 Standard deviations (SD) and biases of the ZTD differences between GNSS/CODE and VLBI/VieVS solutions. Cyan and red bars show SD and biases, respectively.

- SD are smaller than 4 mm at Ny-Ålesund (NYA1).
- SD are larger than 8 mm at Tsukuba (TSKB) and Kokee (KOKB).
- SD at Onsala (ONSA) and Wettzell (WTZR) are on the order of 4-5 mm.
- Large positive biases of about 6 mm at Westford (WES2).
- Negative biases of about 2 mm at Onsala.
- ZTD agreement does not improve with time.

4.2. Site-wise comparison of east gradient standard deviations (SD) and biases between GNSS/CODE and NWM/ECMWF for all CONT campaigns

- SD are larger at Tsukuba, Kokee, and Westford compared to other sites.
- Positive biases increase steadily from 0.4 to 0.7 mm at Westford (WES2), and 0.2 to 0.4 mm at Tigo Concepcion (CONZ).
- Kokee has negative biases of about 0.3 mm.
- Except for Kokee, SD are not decreasing over time.
- No clear improvement of the agreement of gradients over time.

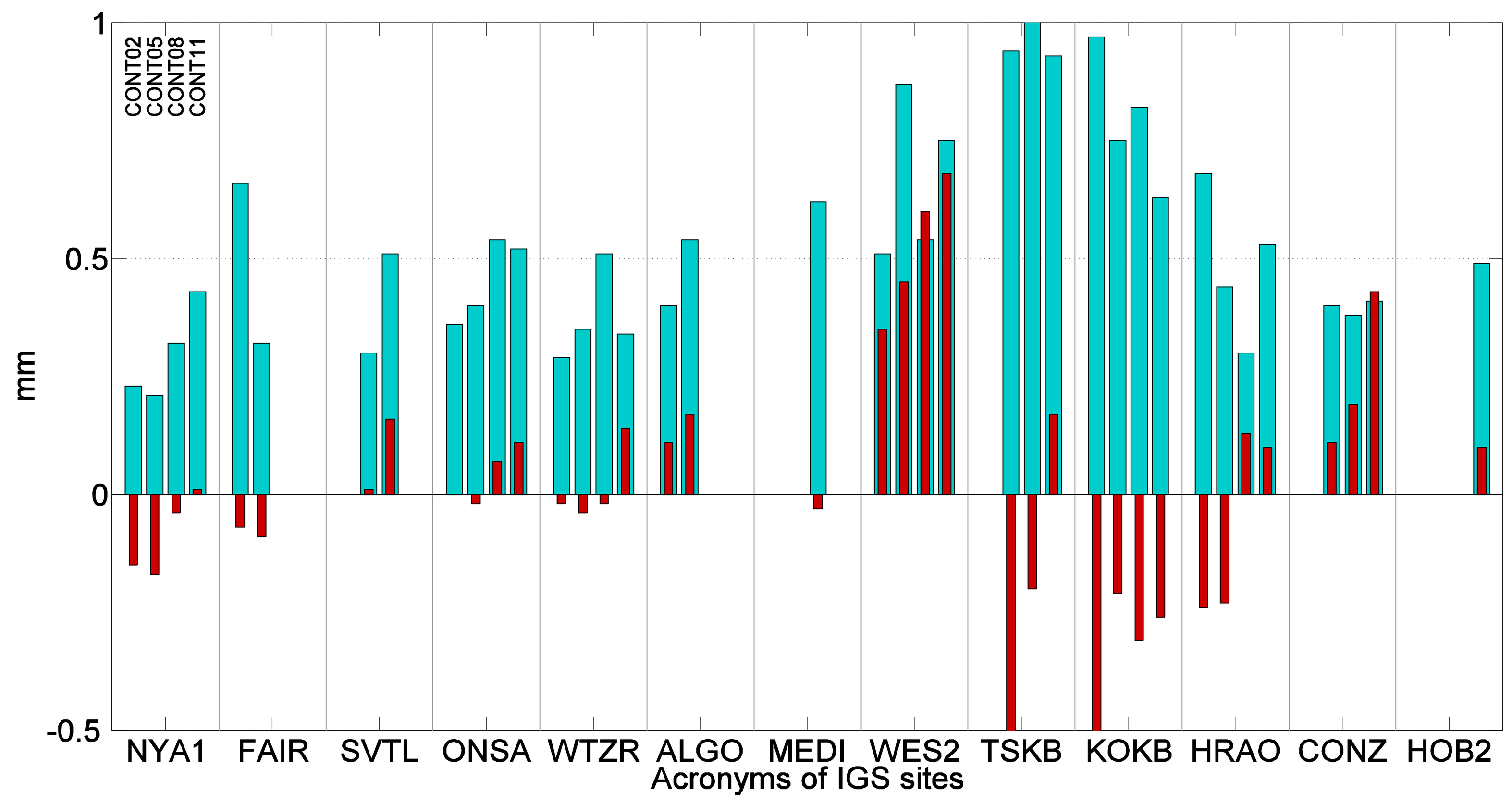

Figure 5 SD and biases of the troposphere east gradients differences between GNSS/CODE and NWM/ECMWF solutions. Cyan and red bars show SD and biases, respectively.

4.3. Campaign-wise comparison of ZTD mean standard deviations (SD) and biases between pairs of techniques

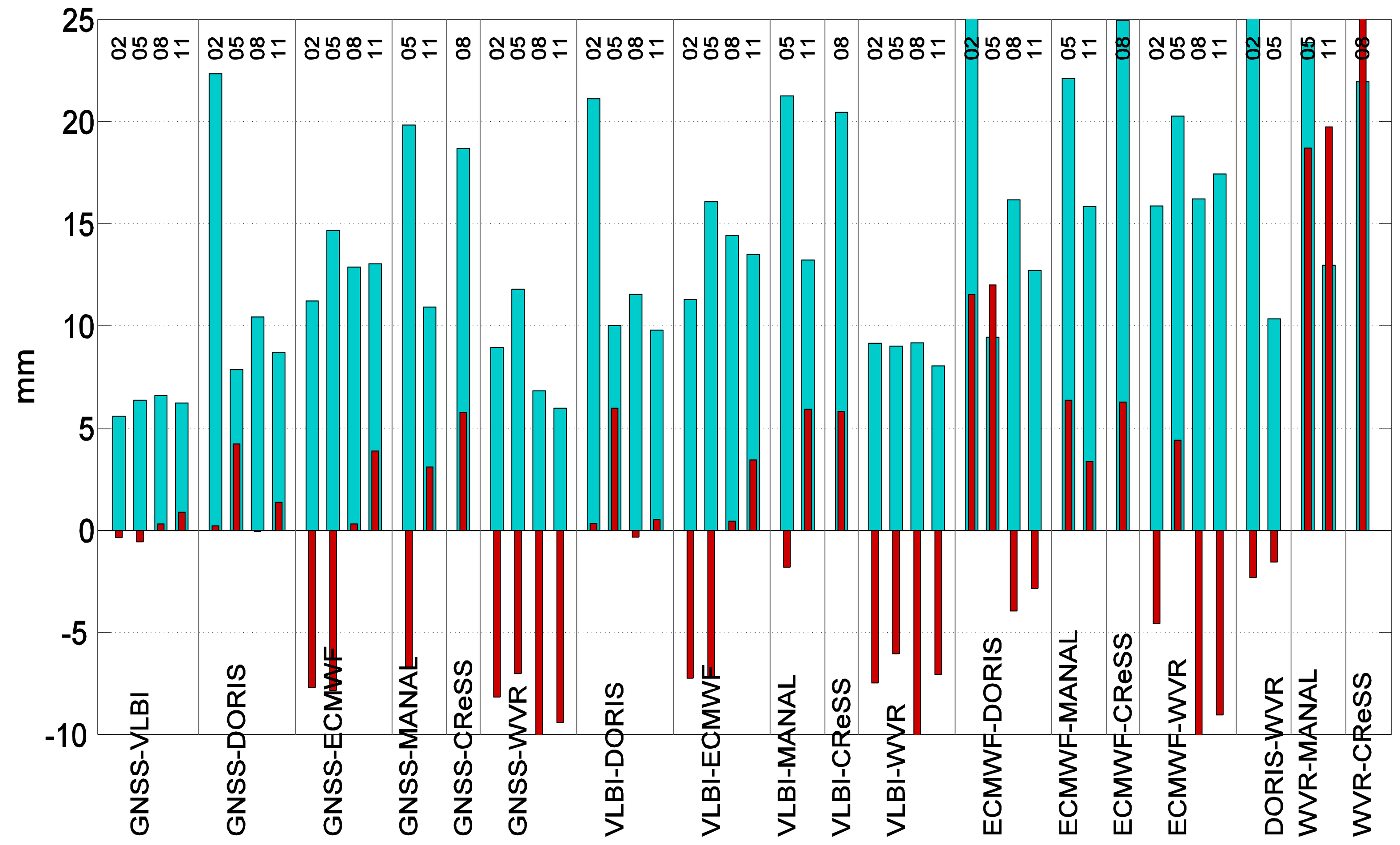

Figure 6 Mean (over all stations) SD and biases of the ZTD differences between two techniques during CONT campaigns. Cyan and red bars show SD and biases, respectively.

- Mean SD between GNSS and VLBI are on the order of 5 to 5.5 mm for all CONT.
- Mean SD of DORIS wrt GNSS, VLBI, and WVR reduce by more than 10 mm after CONT02.
- Mean SD of JMA-MANAL between GNSS, VLBI, and WVR reduce more than 10 mm for CONT11 wrt CONT05.
- ECMWF mean SD wrt space geodetic techniques during last three CONT varies between ~10 to ~15 mm.

Reference: Brunner FK, Rüeger JM (1992) Theory of the local scale parameter method for EDM. Bulletin Géodésique 66:355-364.

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