Common clock check and combination of co-located space geodetic techniques during CONT14

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ABSTRACT In order to analyze different technique data in one single analysis software, i.e. the Vienna VLBI Software (VieVS), we compute GNSS single differences between the ranges from two stations to a satellite, using phase measurements with most of the errors corrected by the c5++ software. With VieVS, we estimate site common parameters, i.e. zenith wet delays, troposphere gradients and clock parameters, applying inter-technique constraints as well as station coordinates. Applying common clock constraints depends on sharing and/or performance of the same clock during the sessions; which we assess by comparing the clock rates. For the station coordinates at the co-located sites, local tie vectors are introduced as fictitious observations. In this poster, we present the comparison results between the combination solutions and the single technique solutions in terms of station position repeatability to check combination performance during 15-day CONT14. In addition, we show a comparison of clock-rates at co-location sites.

1. Co-located GNSS & VLBI Network during CONT14

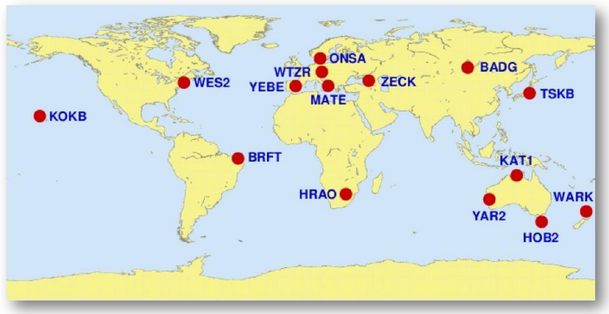


Fig 1 Co-located IGS & IVS Network during CONT14. Site names follow to IGS code.

During CONT14, 15 IVS sites are co-located with IGS stations. Especially Hobart has two IVS stations and one IGS station co-located.

In this work, we construct virtual GV hybrid observations during IVS CONT14 campaign. While we take quasar group delay measurements for VLBI, differenced values of post-processed range values (=single differences with most of the errors corrected) are used for GNSS. We regard those data set as GV hybrid observations in this analysis.

3. Combination Strategy

✓ Troposphere gradients

$$NGR_{GNSS} - NGR_{VLBI} = 0 \pm 2cm$$
$$EGR_{GNSS} - EGR_{VLBI} = 0 \pm 2cm$$

✓ Zenith Wet Delay (ZWD)

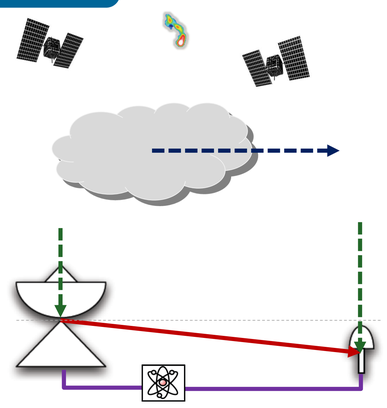
$$ZWD_{GNSS} - ZWD_{VLBI} = \Delta ZWD \pm 1cm$$

✓ Local tie

$$dx_{GNSS} - dx_{VLBI} = \Delta x - (x_{GNSS} - x_{VLBI}) \pm 3cm$$

✓ Clock rate

$$clk_rate_{GNSS} - clk_rate_{VLBI} = 0 \pm 10cm/day$$



	Models & a prioris
Sources	ICRF2/IGS final orbit
Station coordinates	ITRF2014
EOP	IERS 08 C04
Geometric model	VLBI: Consensus model
	GNSS: Klioner (1991)[1]
Solid Earth tide	IERS 2010 conventions

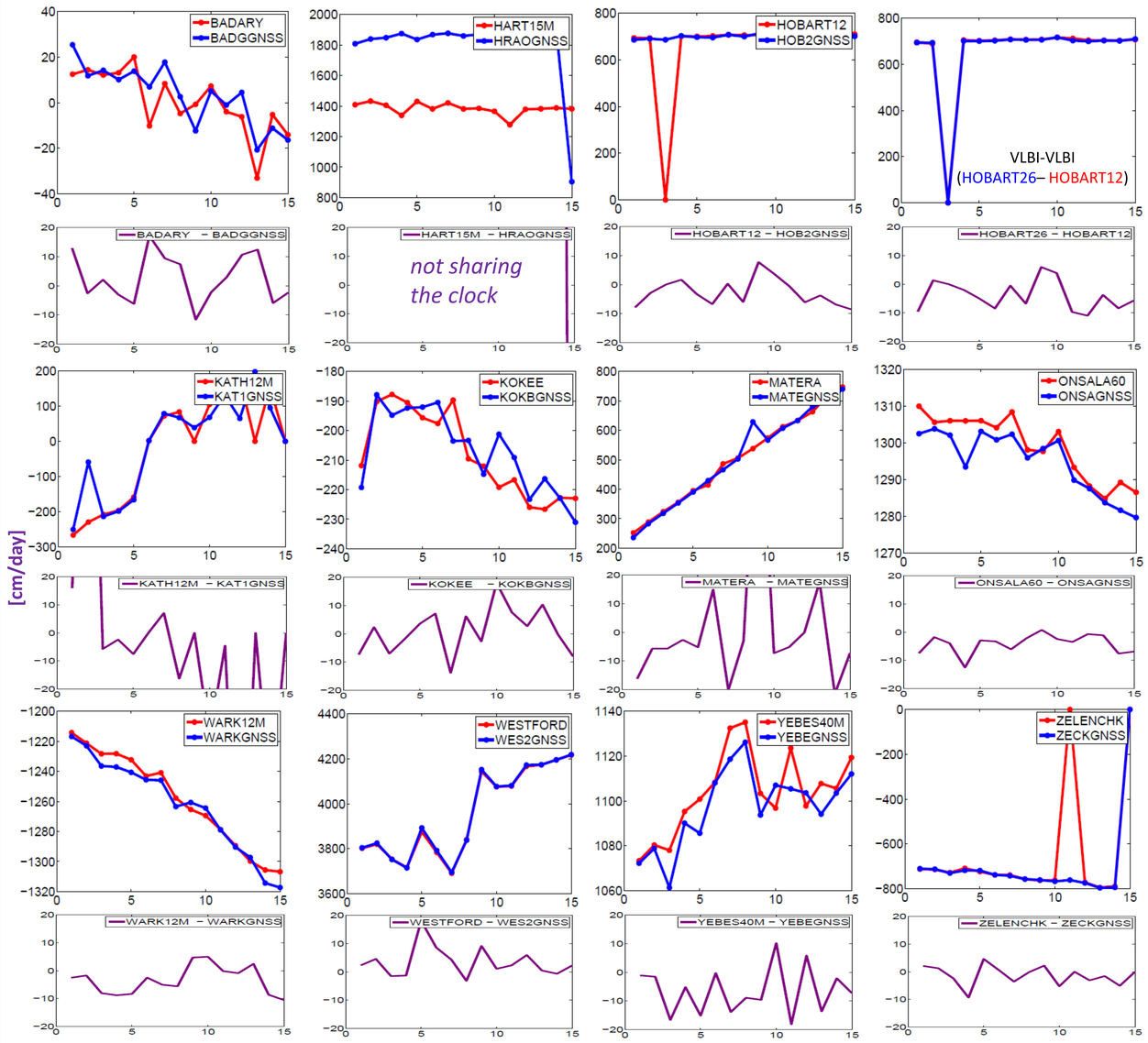
	Parameters	Int.
Clocks	PWL offsets	1hr
	Clock rate	1day
ZWD	PWL offsets	2 hr
Gradients	East&north components	6 hr
Station coordinates	NNR/NNT to ITRF2014	1 day

For common parameters (troposphere gradients, ZWD, clock rates), we estimate parameters separately and apply common parameter constraints additionally (troposphere gradients and ZWD for all sites and clock rates for selected sites according to section 2). Moreover, we introduced local ties as fictitious observations. In this work, we only exploit known local survey measurements for a few stations (HRAO, HOB2, KOKB, ONSA, WES2, WTZR). This strategy can be also applied to twin/sibling telescope VLBI observations like we did for HOB2 .

[1] Klioner S (1991) General Relativistic Model of VLBI Observables. In: Proceedings of the AGU Chapman Conference on Geodetic VLBI: Monitoring Global Change, pp 188–202

2. Common Clock Check

Fig 2 Clock rates of each site which are derived from single technique solutions (red: VLBI, blue: GNSS, purple: difference) during 15 days of CONT14 campaign. The clock of WTZZ is set as a reference clock.



CONT14 does not have official information on common frequency standards for co-location sites. Nevertheless, according to Kwak et al. (2015) [2] , we have a possibility to find the co-located sites, which shared the same clocks, through comparing clock rates from single technique solutions. During CONT14 (15days), the clock rates of each site except HRAO look comparable between two techniques mostly in the range of +/- 20cm/day which corresponds to ~0.008ps/s (Fig 2).

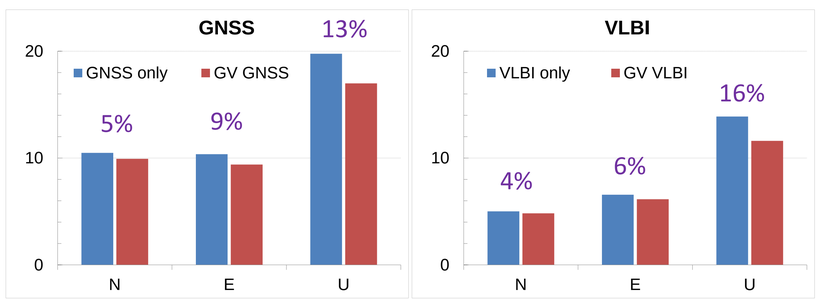
Meanwhile, clock offsets cannot be used for comparison because the cable delay variations and other instrumental delays are also absorbed into the parameters. We also do not consider quadratic terms in this study.

In Fig 2, some instant peaks indicate clock breaks at HOB2, KAT1, MATE and ZECK. We exclude those sites and HRAO for clock rate combination.

[2] Y. Kwak.et al.. (2015) Observation Level Combination of GNSS and VLBI with VieVS: a simulation based on CONT11, AGU2015

4. Combination Results

Mean station position repeatability of all sites [mm]



As a result of combination, mean station position repeatabilities are improved and both techniques gain the similar level of benefits (4-9% and 13-16% for horizontal and vertical components, respectively).

Since we are still in the test phase to process GNSS data using VieVS, the accuracy of the model involved for GNSS data is at the cm-level and thus the station position repeatability of GNSS stations is larger than the repeatability of usual GNSS solutions.

5. Conclusions

- ✓ Comparing clock rates, we could assess if co-located instruments shared the clock.
- ✓ For combination, common parameters (ZWD, troposphere gradients, clock rates) were constrained between two techniques and local ties were introduced.
- ✓ The combination solutions mostly improve station position repeatability in comparison with single solutions.
- ✓ Common parameter constraints can be also applied in twin/sibling telescopes.
- ✓ The GNSS geometric model (near-field model) in VieVS needs to be improved.
- ✓ The partial derivatives with respect to EOP for GNSS need to be implemented in VieVS and then EOP can be also estimated.