Combination of the two radio space geodetic techniques with VieVS during CONT14

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FWF Der Wissenschaftsfonds.
TU WIEN
CHALMERS UNIVERSITY OF TECHNOLOGY
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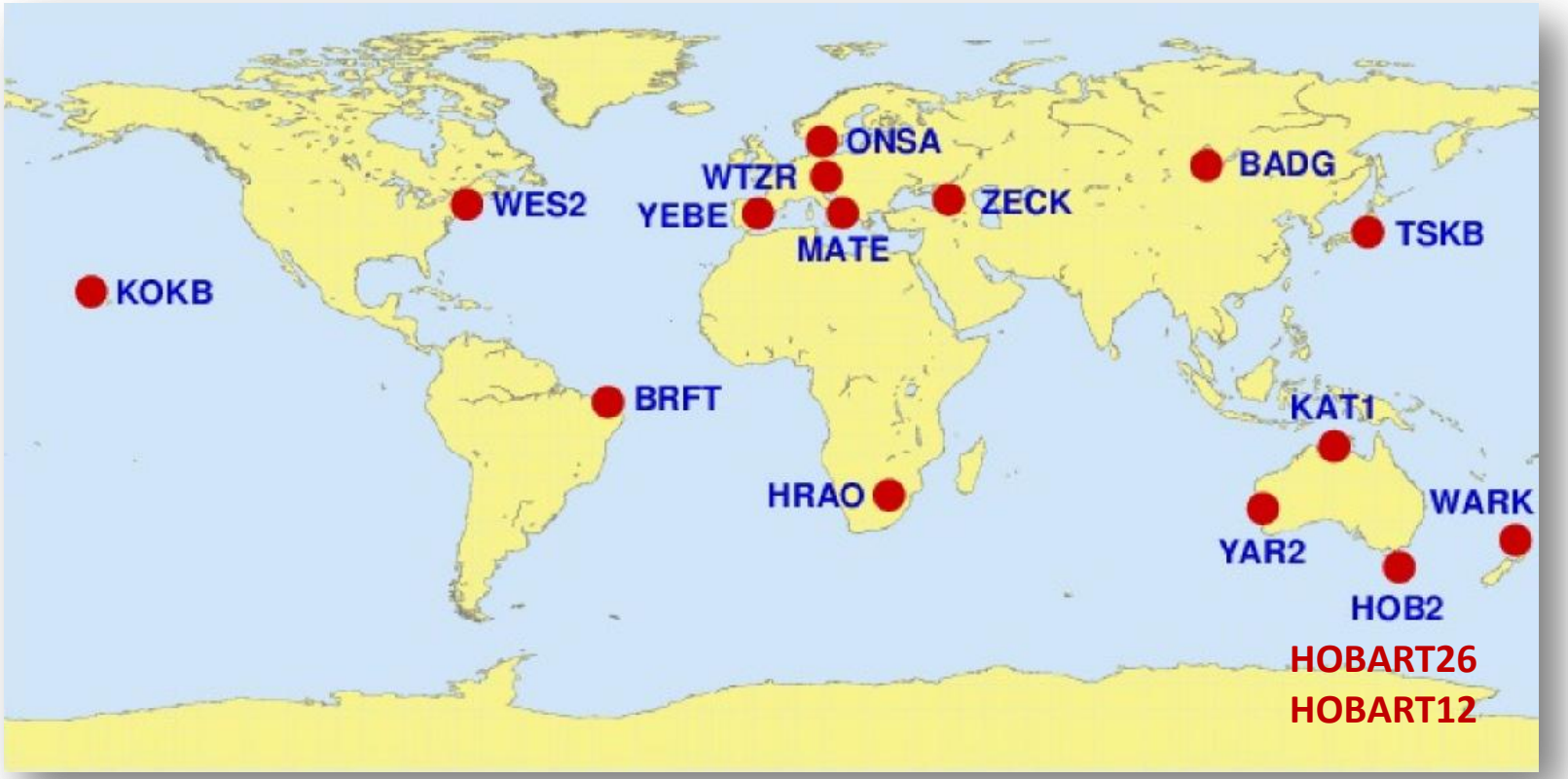
CONT14

- **15 IVS sites co-located with IGS stations**
- CONT14 VLBI data + co-located GNSS data



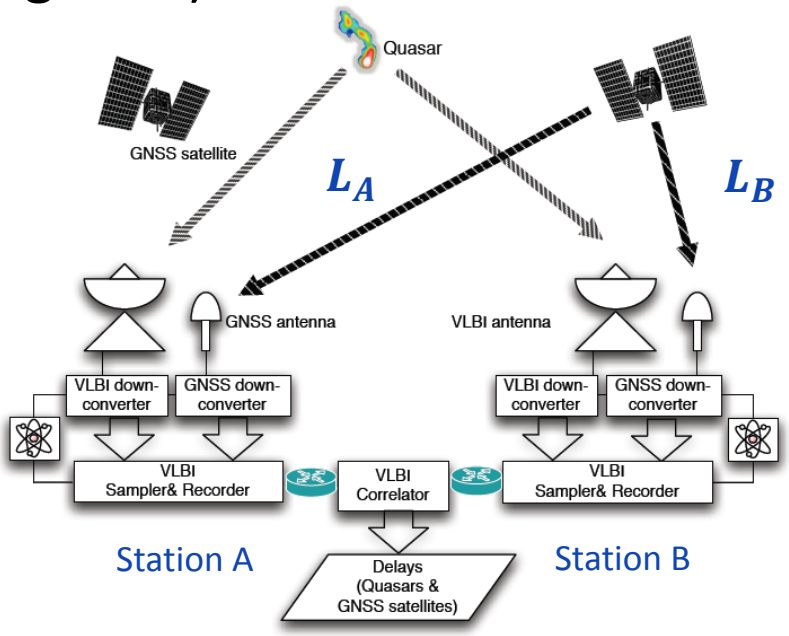
May 6, 2014 @ 00:00:00 UT - May 20, 2014 @ 23:59:59 UT at 16 sites

Generate VLBI-like GNSS delays

- ✓ following GV hybrid concept
- ✓ generate virtual correlator outputs (GNSS delays) based on real data
- ✓ GPS phase measurements during CONT14
- ✓ well corrected w.r.t ionosphere, ambiguity, PCV, phase wind-up effect
- ✓ take a difference (at the same receiving time)

$$\tau = \frac{L_A - L_B}{c}$$

L_A & L_B : corrected phase measurements betw. a satellite and ground station A & B



Combined data

```
                                                    :
2014  5  6  0  0 14.00 ZECKGNSS YEBEGNSS PG27     sc     0.00087610986364441 ...
2014  5  6  0  0 14.00 ZECKGNSS YEBEGNSS PG32     sc    -0.00743789326648105 ...
2014  5  6  0  2 44.00   BADARY NYALES20 1741-038 qq     0.00305870044155989 ...
2014  5  6  0  2 44.00   BADARY ZELENCHK 1741-038 qq    -0.00900384964409374 ...
                                                    :
```

- ✓ GNSS : differenced values from real GNSS measurements (multiple scans at the same epoch)
- ✓ VLBI : CONT14 data
- ✓ sorted by order of time regardless of data type
- ✓ same weight to every observation
- ✓ processed by modified VieVS

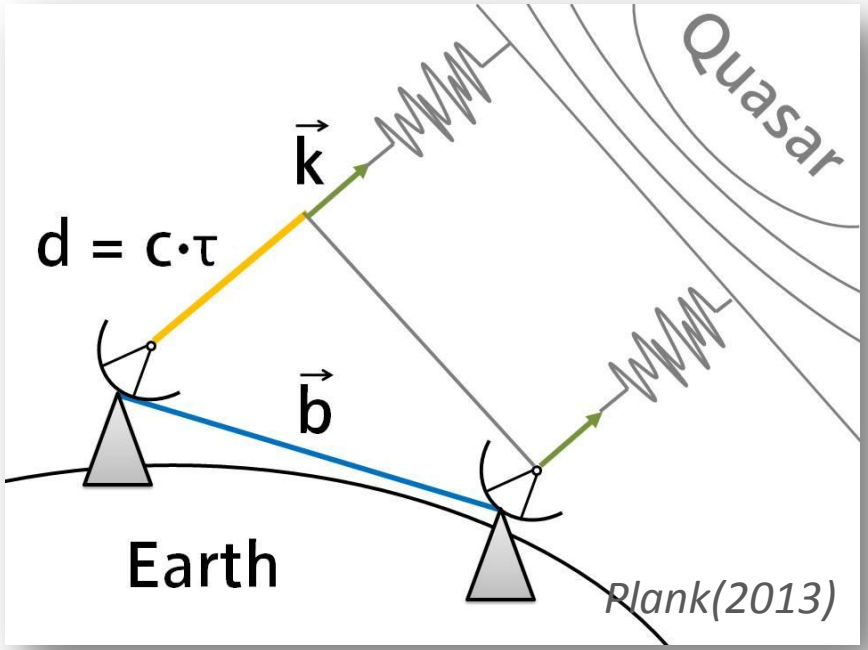
Geometric models

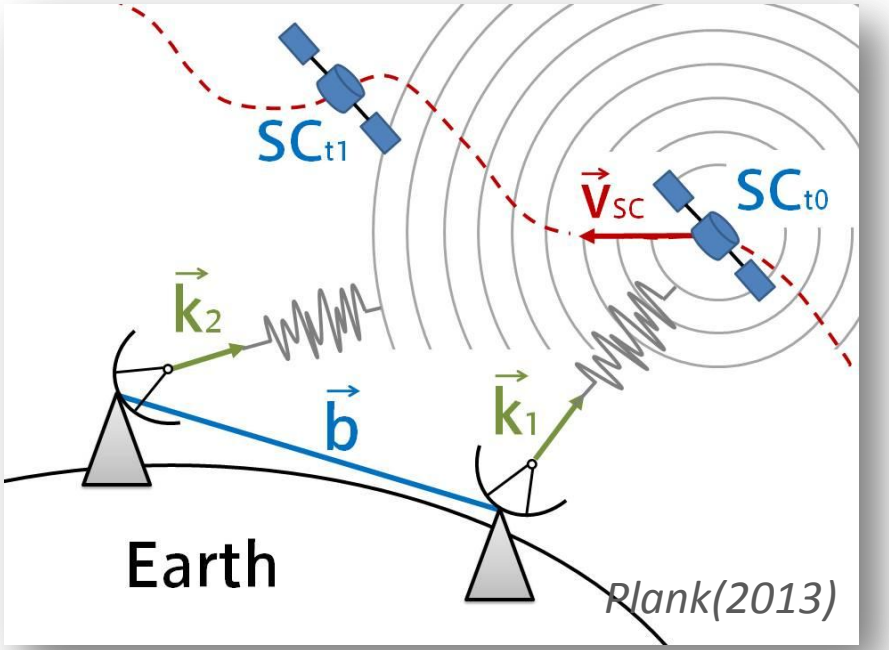
VLBI

- plane wave front
- stable sources

GNSS *Klioner (1991)*

- curved wave front
- fast moving sources





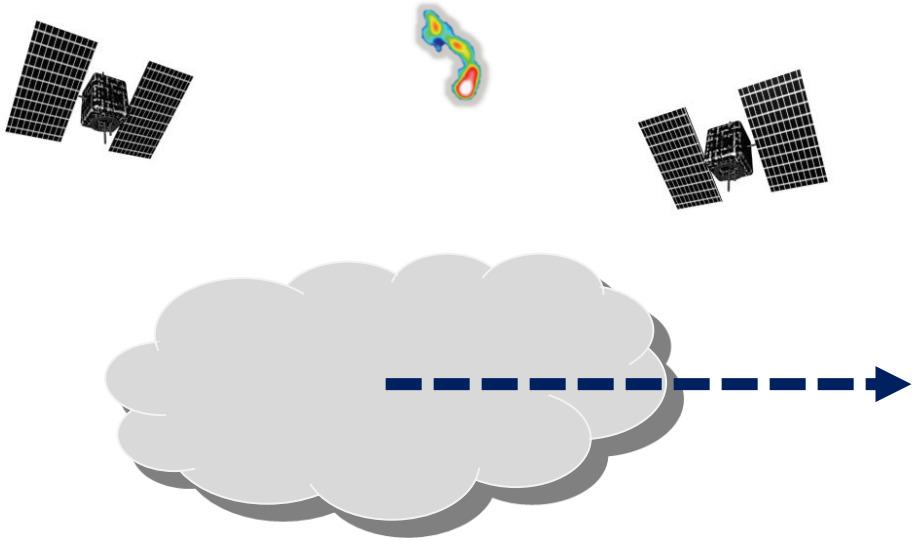
- Other geophysical models are the same
- The constraints for parameters are also the same.

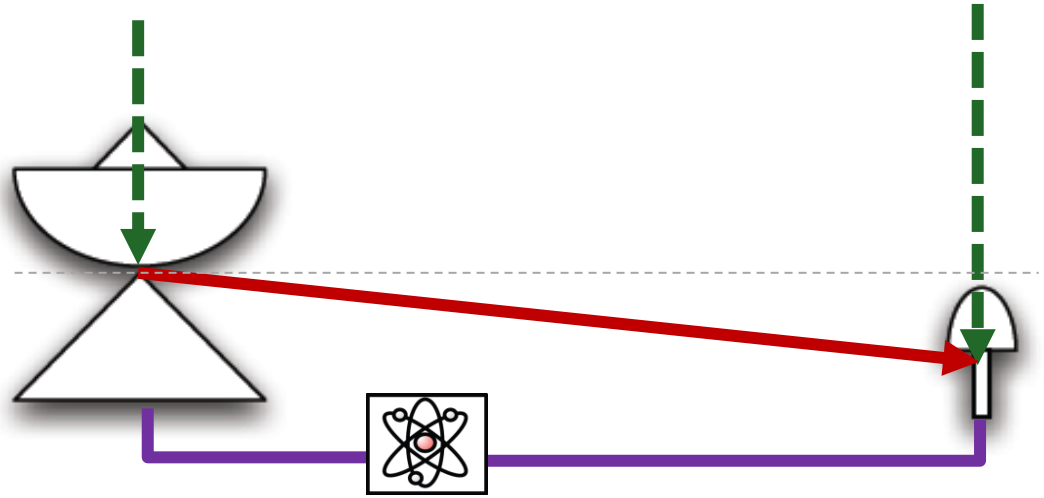
General analysis strategy

	Models & a prioris
Sources	ICRF2/IGS final orbit
Station coordinates	ITRF2014
EOP	IERS 08 C04
Solid Earth tide	IERS 2010 conventions

	Parameters	Interval
Clocks	PWL offsets	1 hr
	Clock rate and quadratic term	1 day
Zenith Wet Delays	PWL offset	2 hr
Gradients	East&west components	6 hr
Station coordinates	NNR/NNT to ITRF2014	1 day

Common parameters at the co-located sites





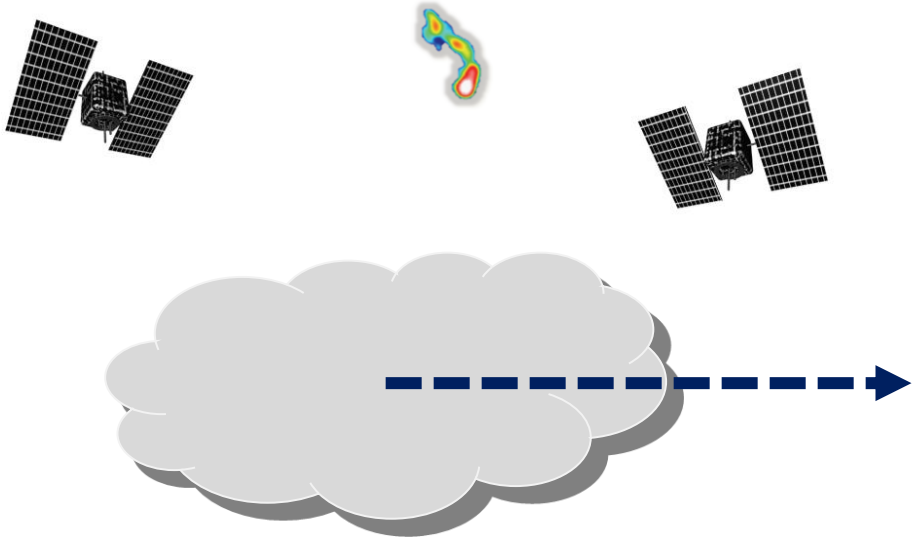
✓ Troposphere gradients

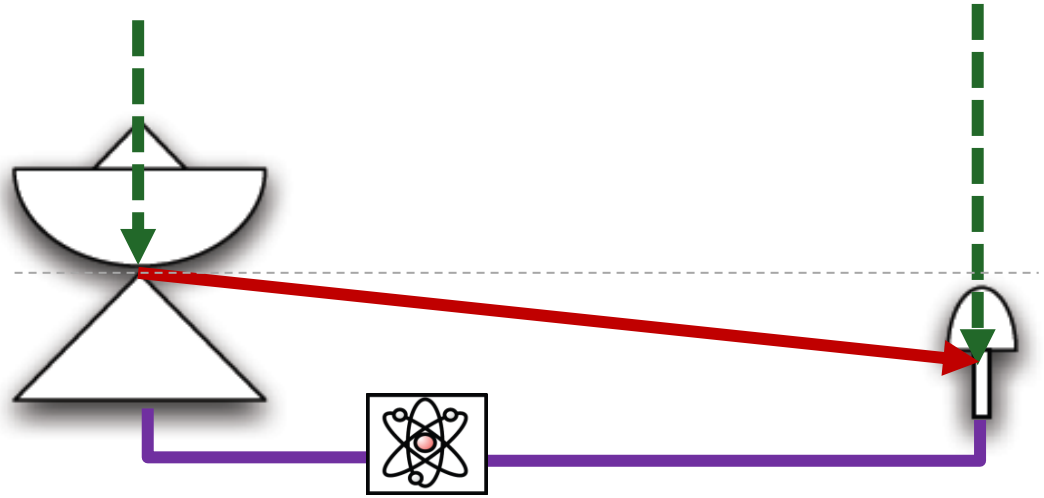
✓ Zenith Wet Delays

✓ Local tie

✓ Clock – clock rate

Common parameters at the co-located sites





✓ **Troposphere gradients**

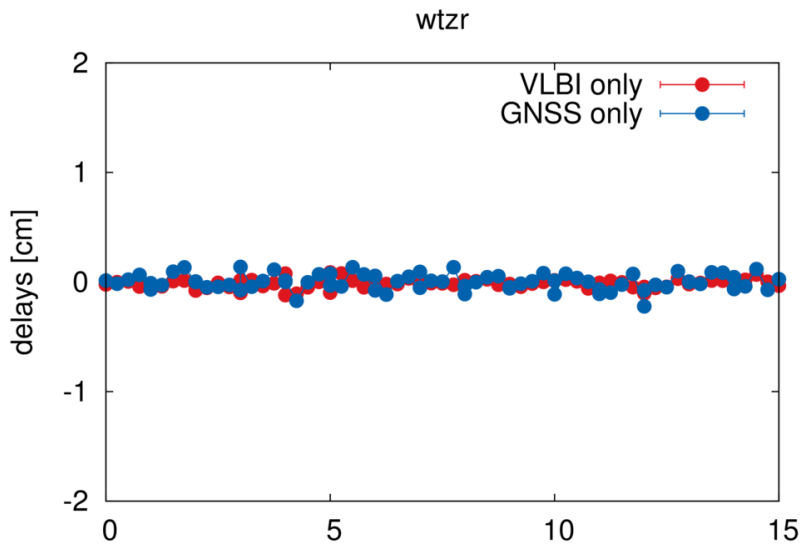
✓ Zenith Wet Ddelays

✓ Local tie

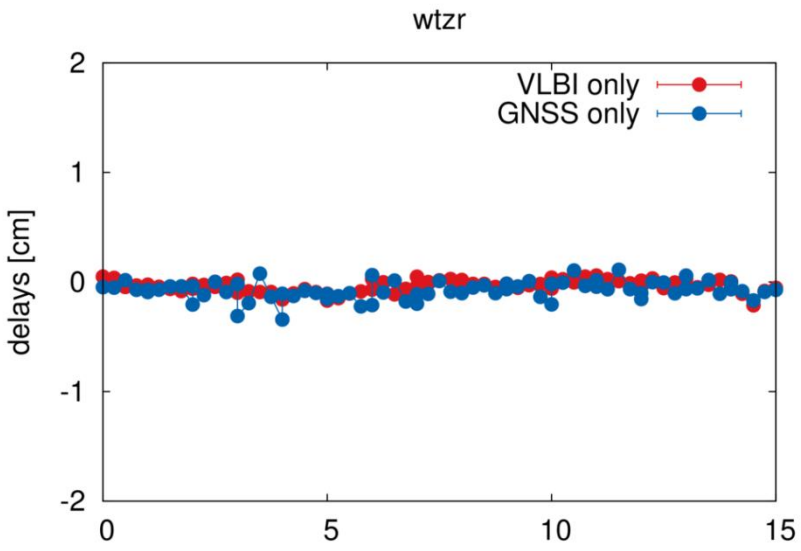
✓ Clock – clock rate

Common parameters – tropo. gradient

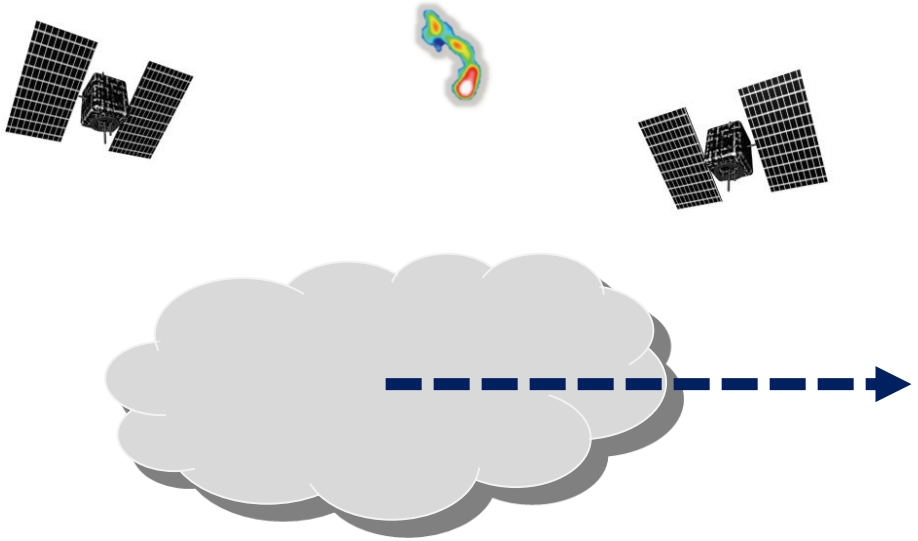
NGR

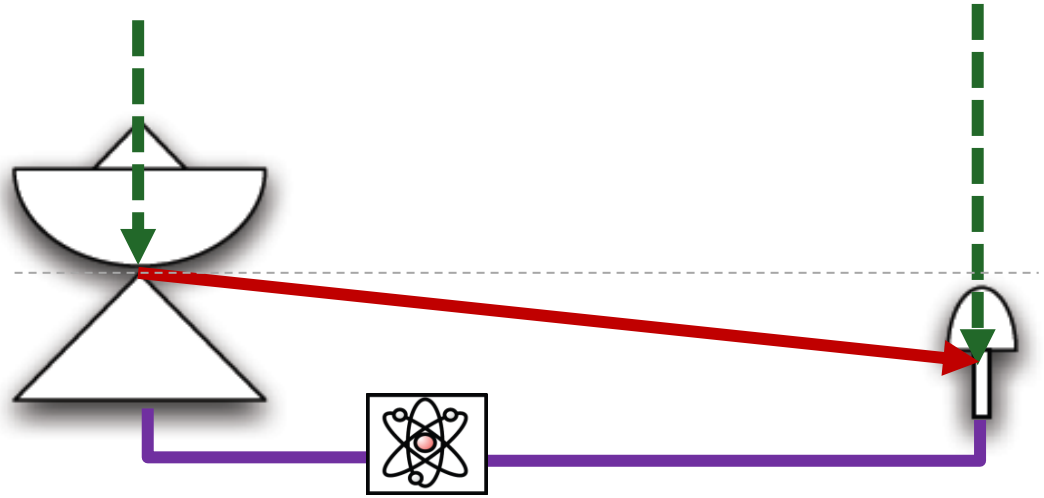


EGR



Common parameters at the co-located sites





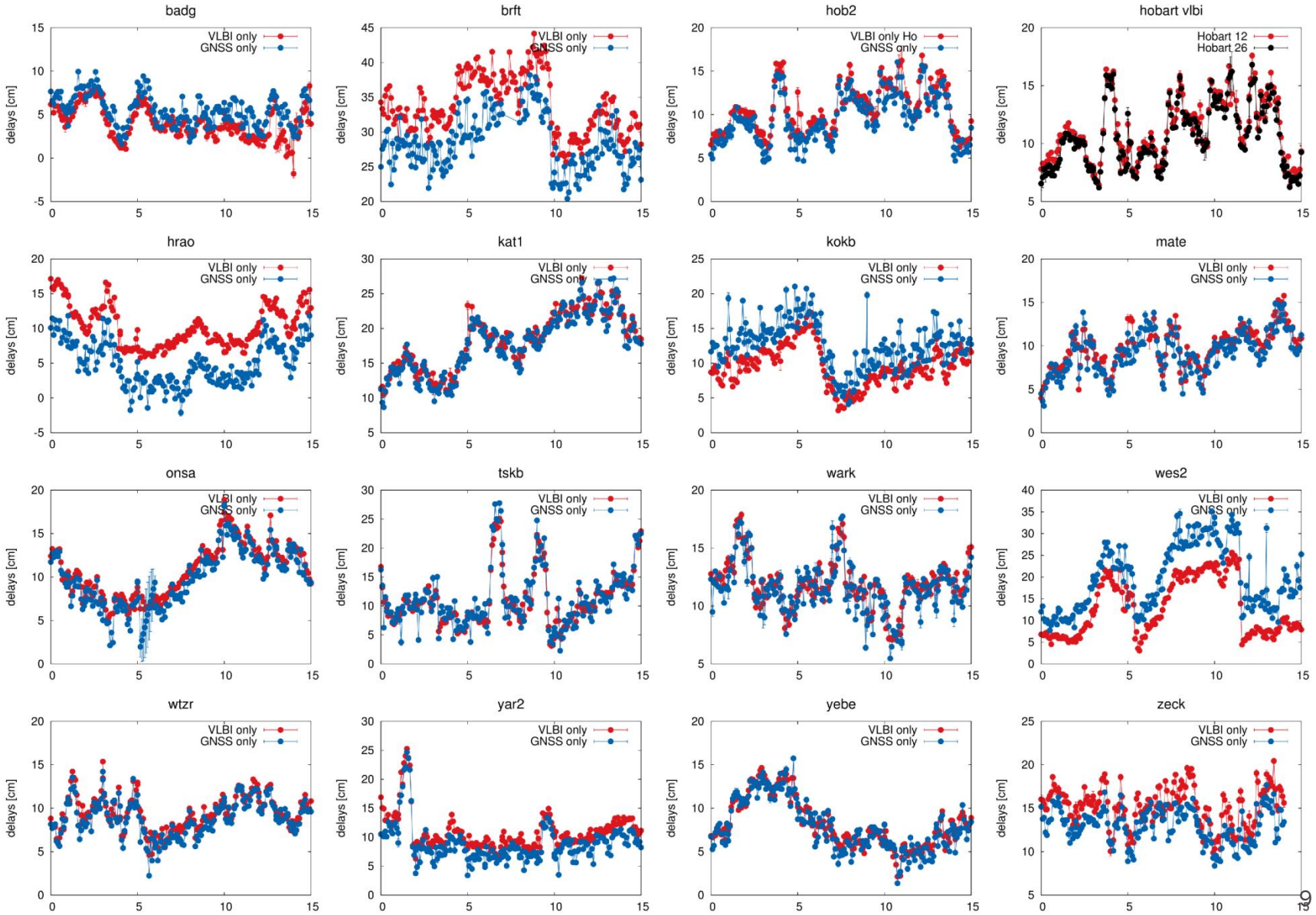
✓ Troposphere gradients

✓ **Zenith Wet Delays**

✓ Local tie

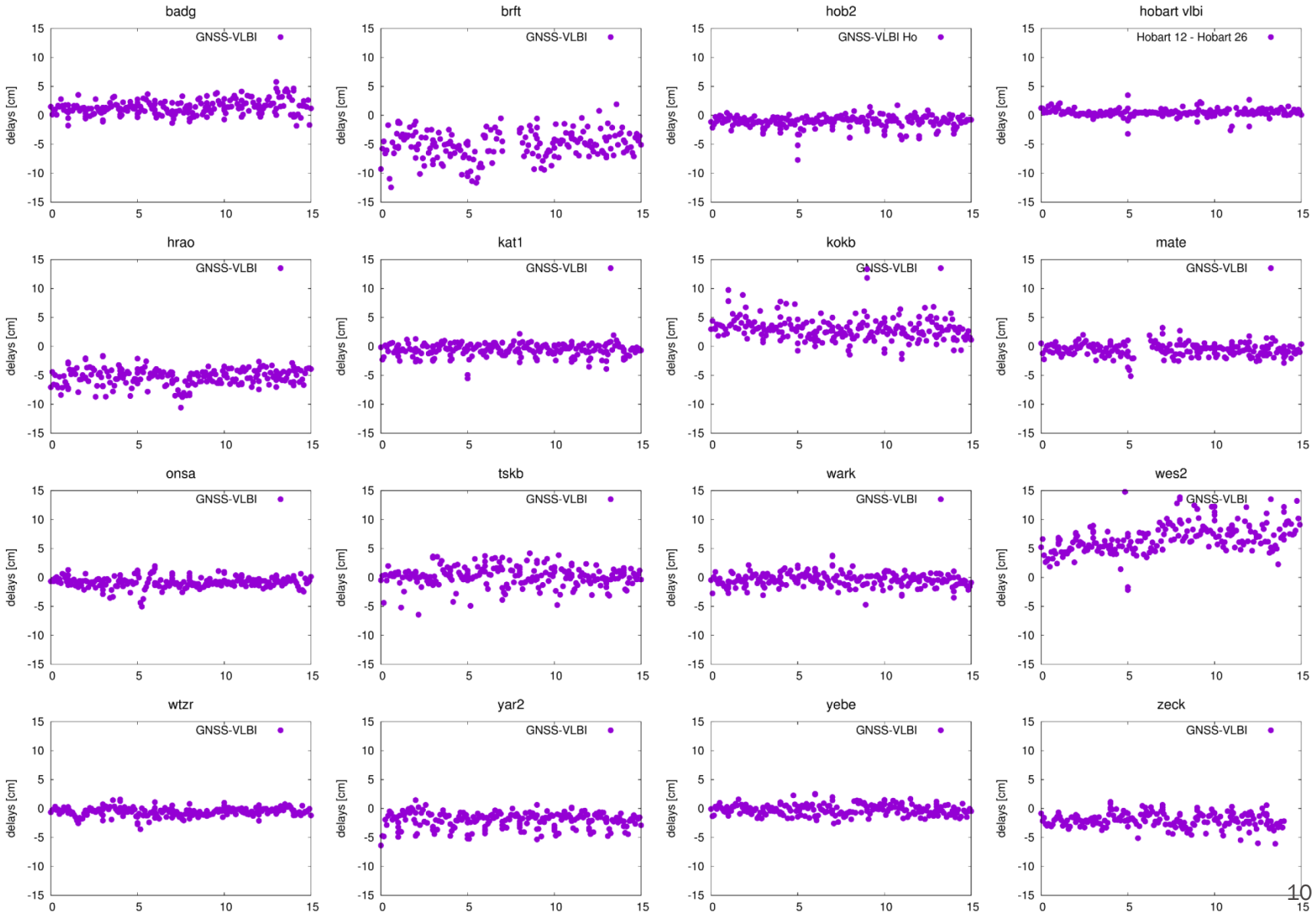
✓ Clock – clock rate

Common parameters – ZWD



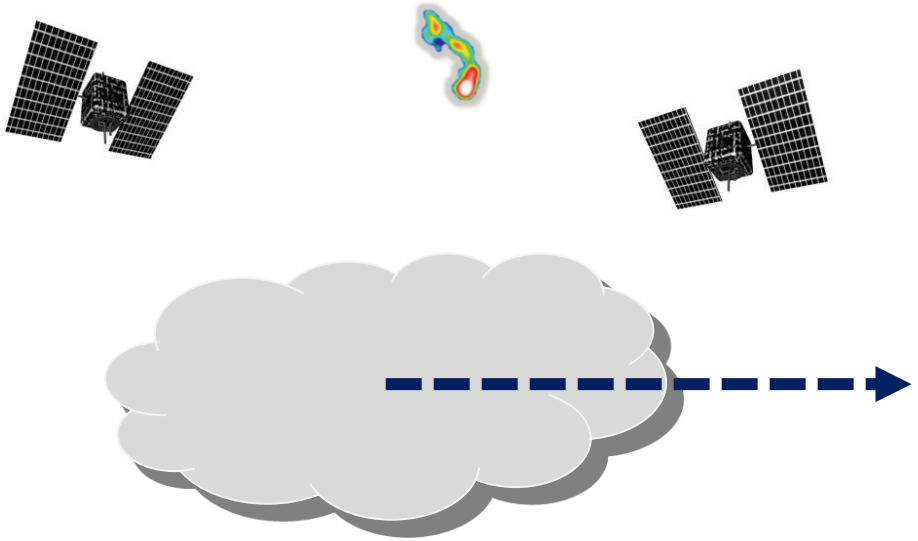
[cm]

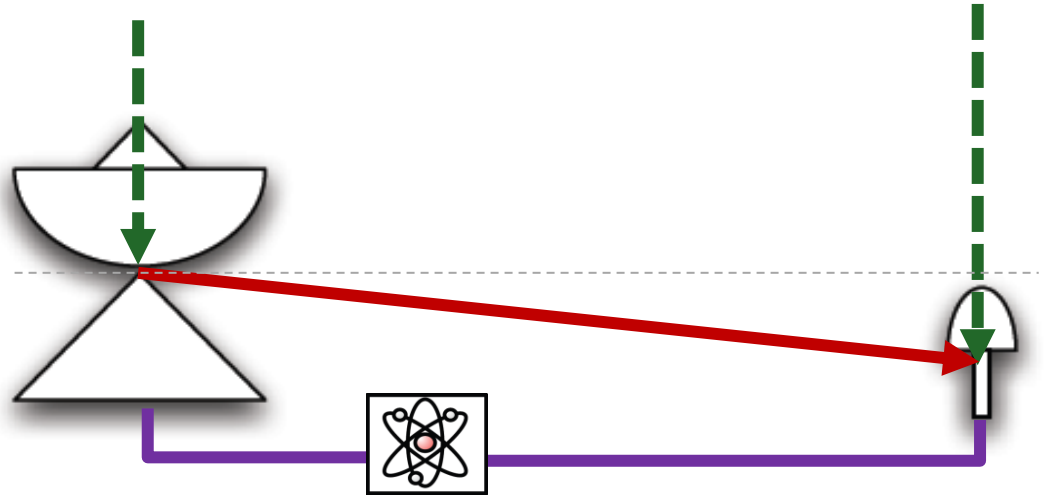
Common parameters – ZWD difference



[cm]

Common parameters at the co-located sites





✓ Troposphere gradients

✓ Zenith Wet Delays

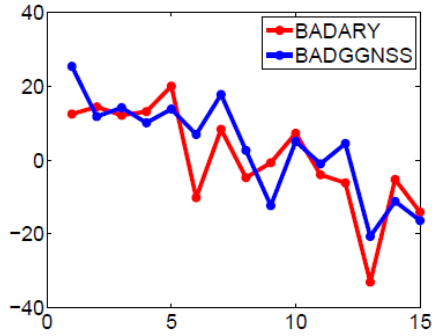
✓ Local tie

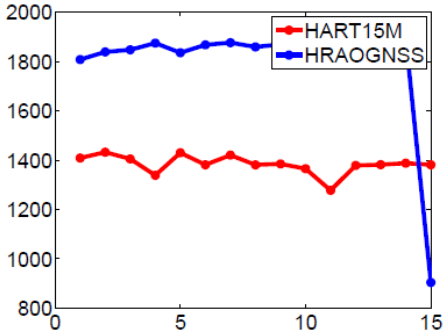
✓ **Clock – clock rate**

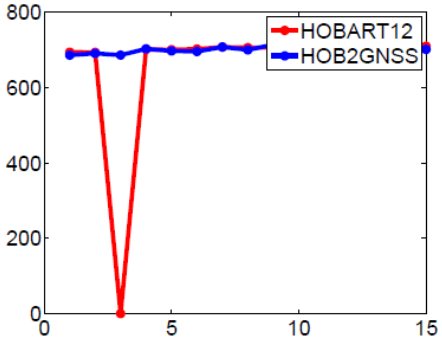
? Which sites are sharing the clock ?

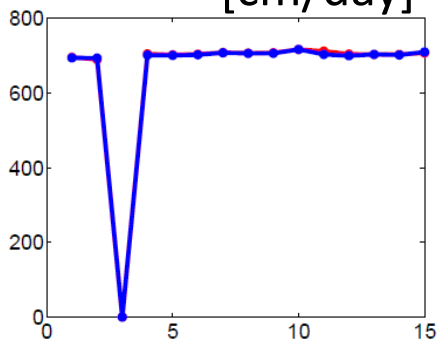
Common parameters – clock rate

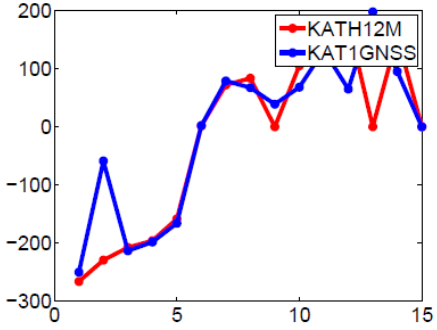
[cm/day]

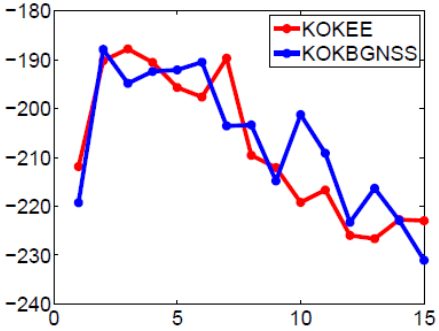


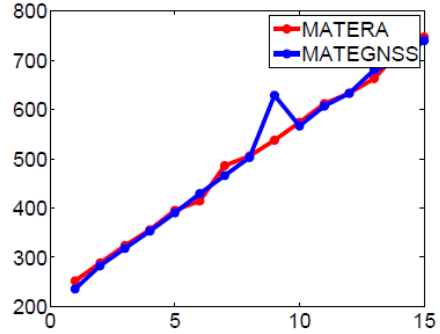


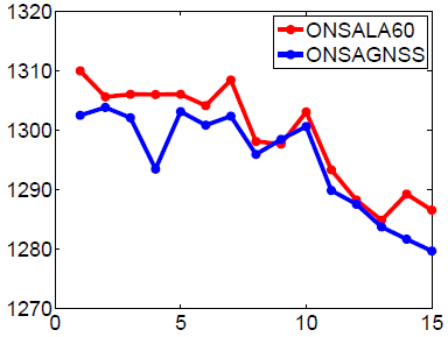


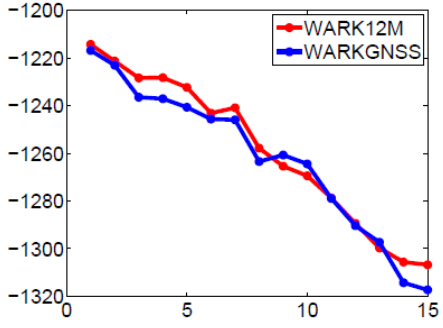


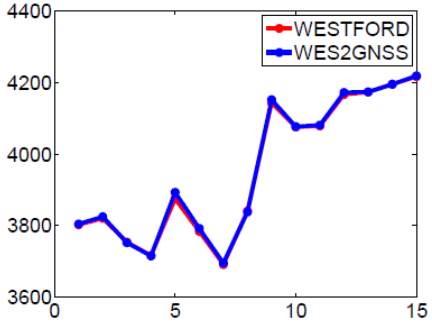


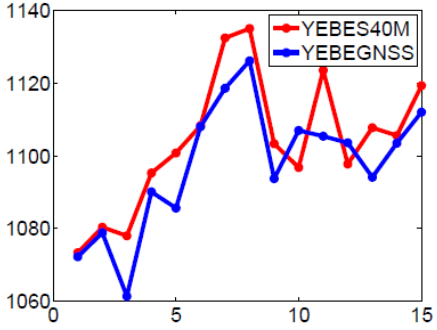


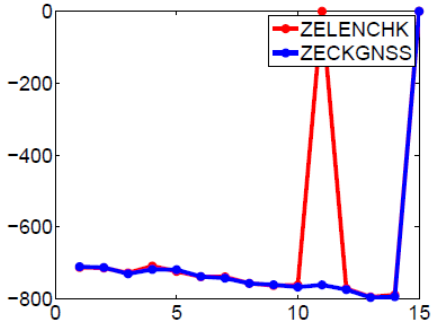






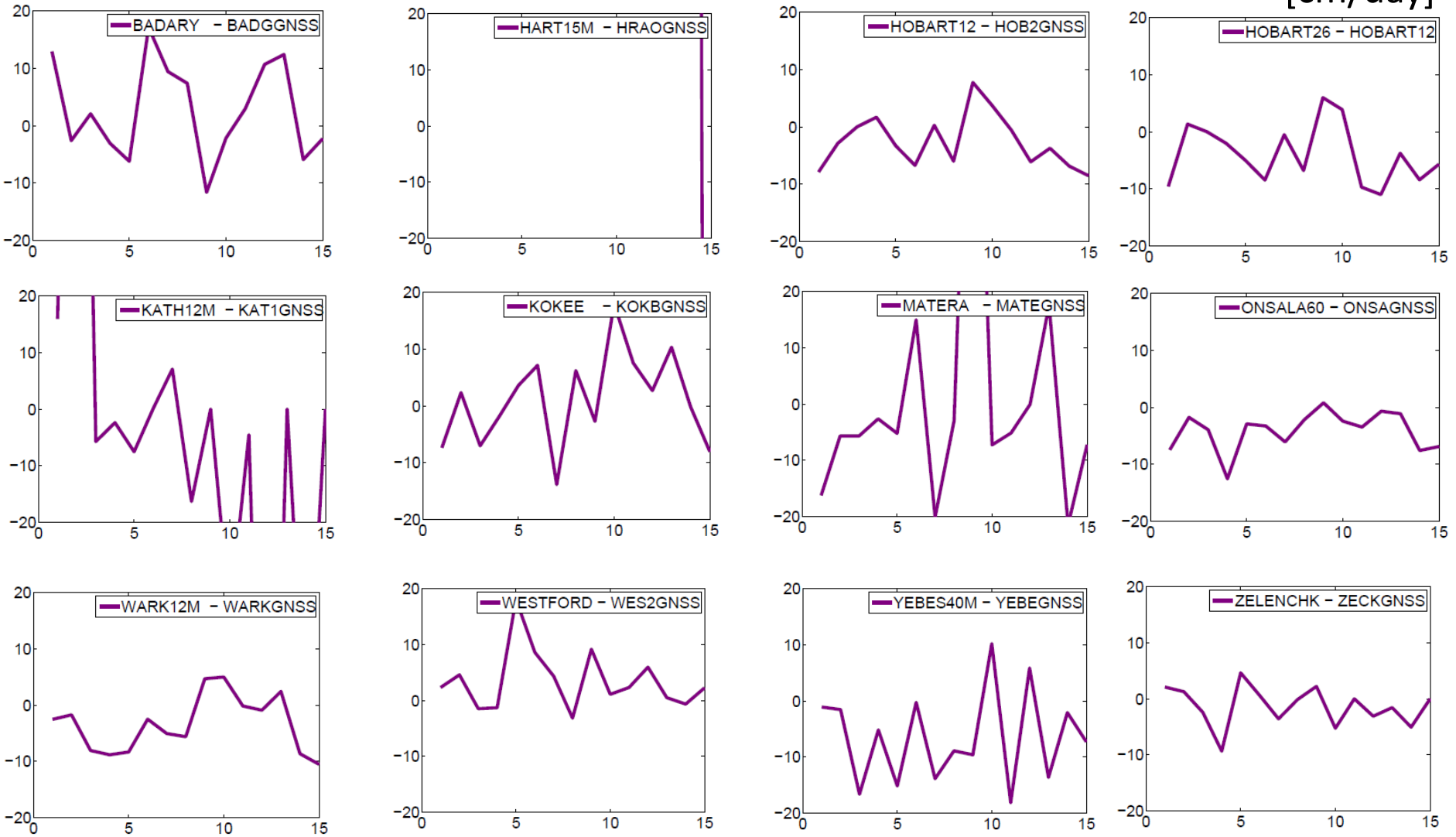






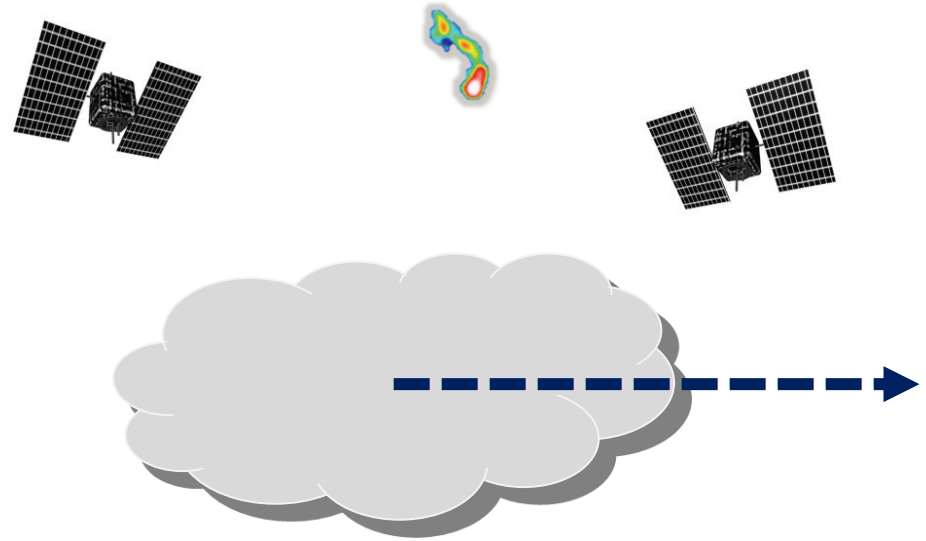
Common parameters – clock rate differences

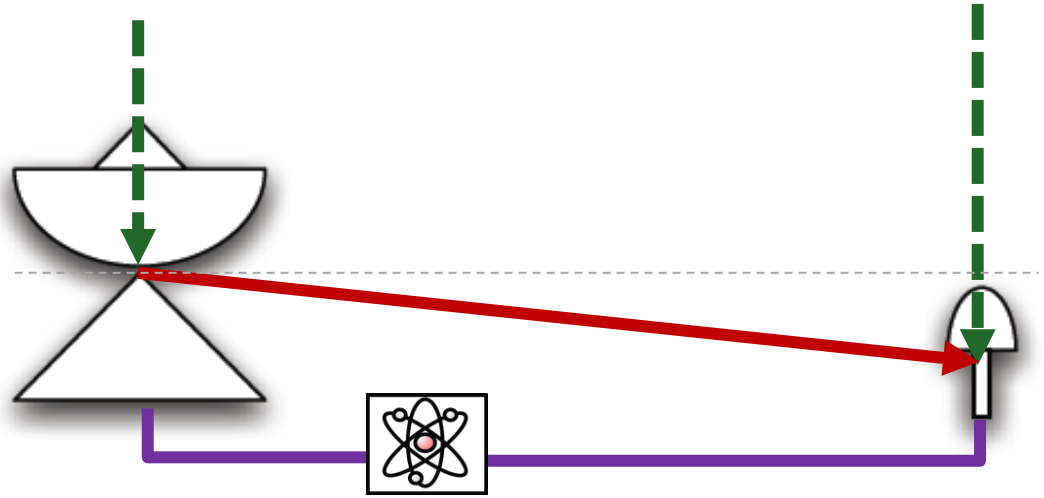
[cm/day]



10 cm/day ~ 0.004 ps/s

Common parameters at the co-located sites





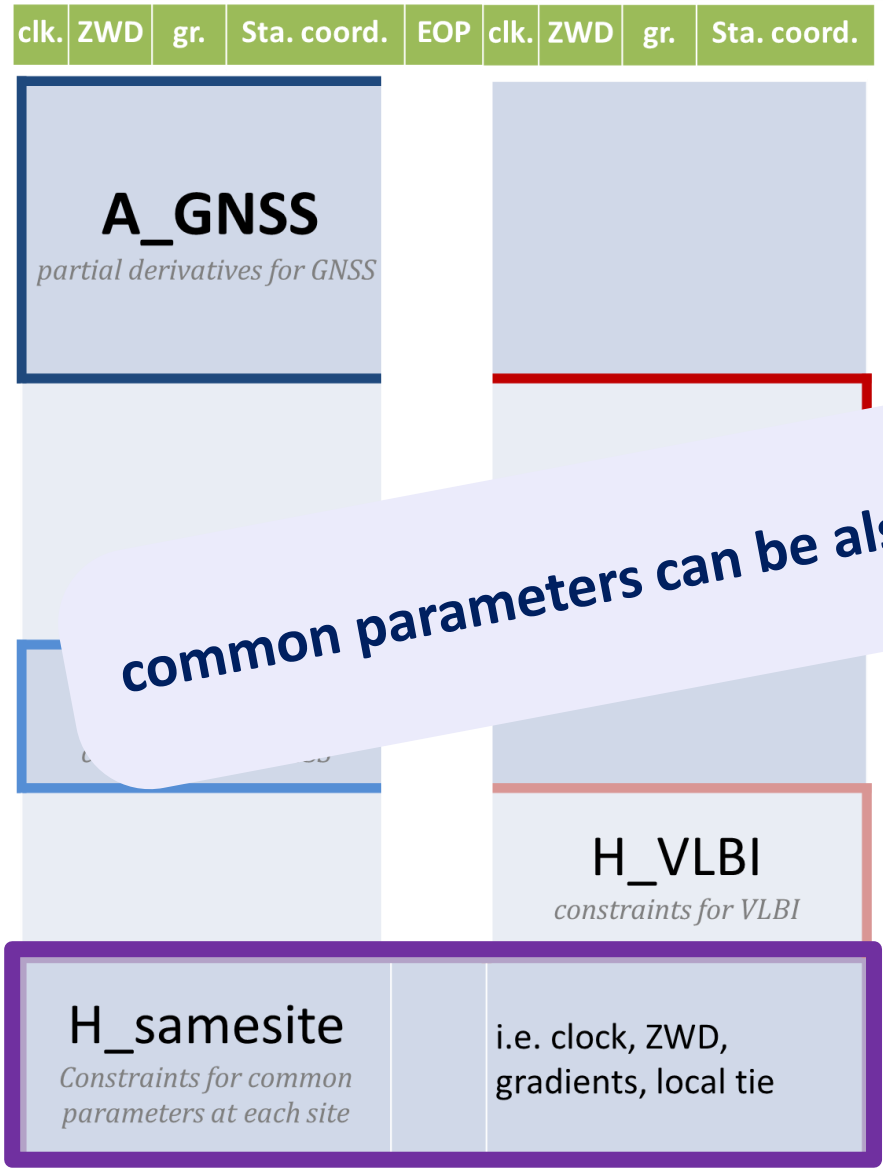
✓ Troposphere gradients

✓ Zenith Wet Delays

✓ **Local tie (7 sites)**

✓ Clock – clock rate

Combination analysis strategy



Separately estimate parameters
+ give constraints for common parameters

common parameters can be also applied in twin/sibling telescopes

- ✓ Gradients (2cm)

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

$$_{VLBI} = \Delta ZWD \pm 1cm$$

- ✓ Clock rates (10cm/day)

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

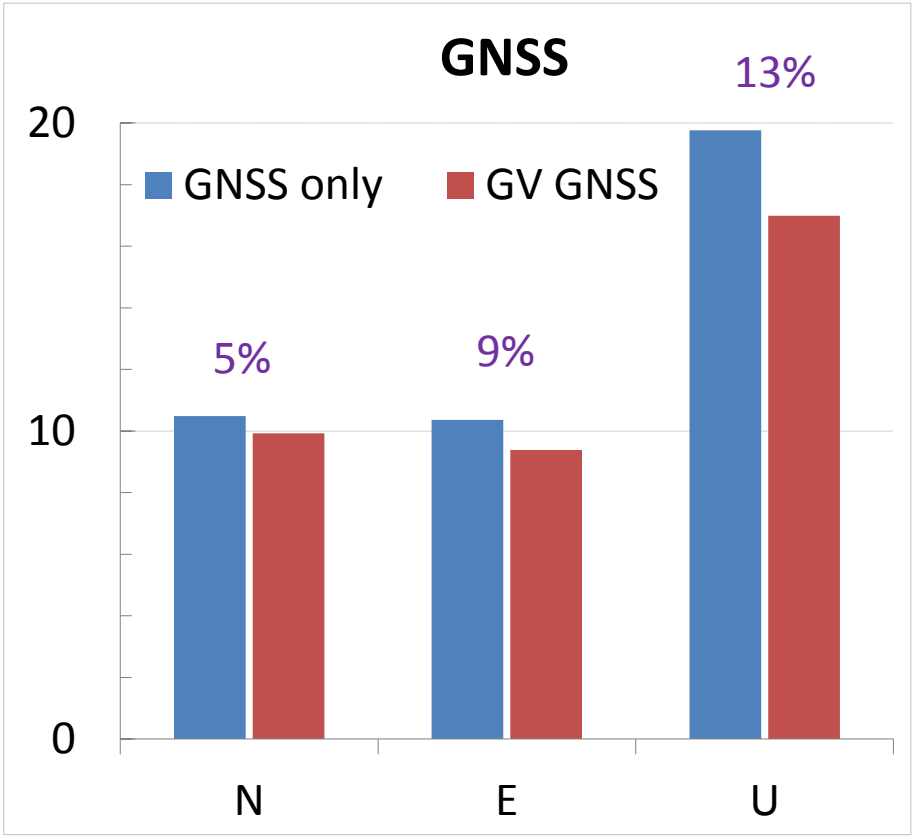
- ✓ Local tie (3cm)

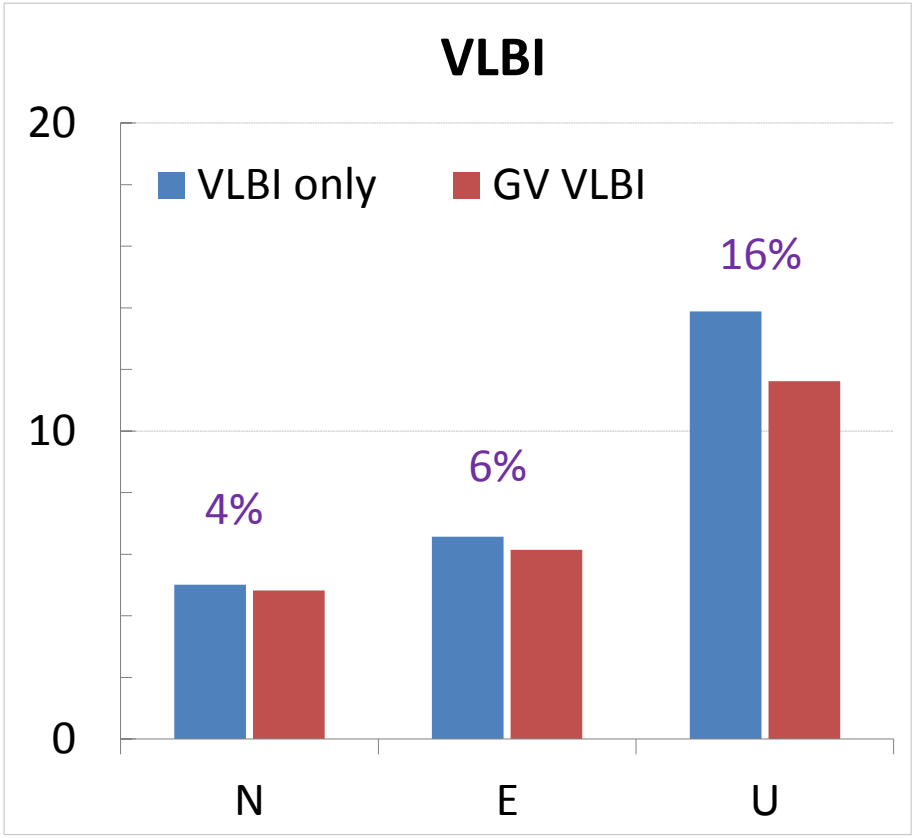
$$dx_{GNSS} - dx_{VLBI} = \Delta x - (x_{GNSS} - x_{VLBI}) \pm 3cm$$

Combination Results – all stations

Mean station position repeatability during 15days

[unit: mm]





cm-level accuracy of the model

Conclusions

- For combination, common parameters (ZWD, troposphere gradients, clock rates) were constrained between two techniques + local ties were introduced
- The combination solutions mostly improve station position repeatability in comparison with single solutions.
- Common parameters can be also applied in twin/sibling telescopes
- The GNSS geometric model (near-field model) in VieVS needs to be improved.
- The partial derivatives w.r.t. EOP for GNSS need to implemented in VieVS and then EOP will be also estimated.

Thank you for your attention!

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