VLBI-like GNSS delays in the analysis of CONT11

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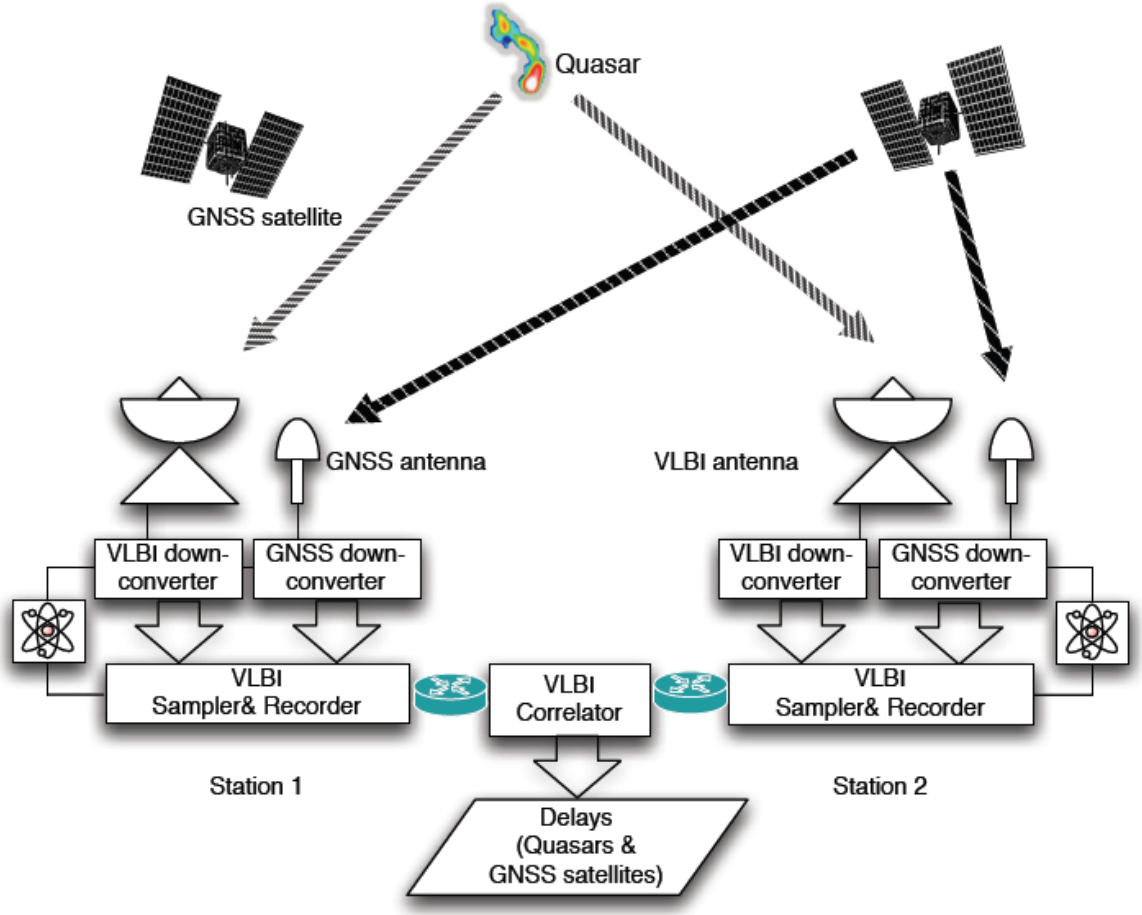
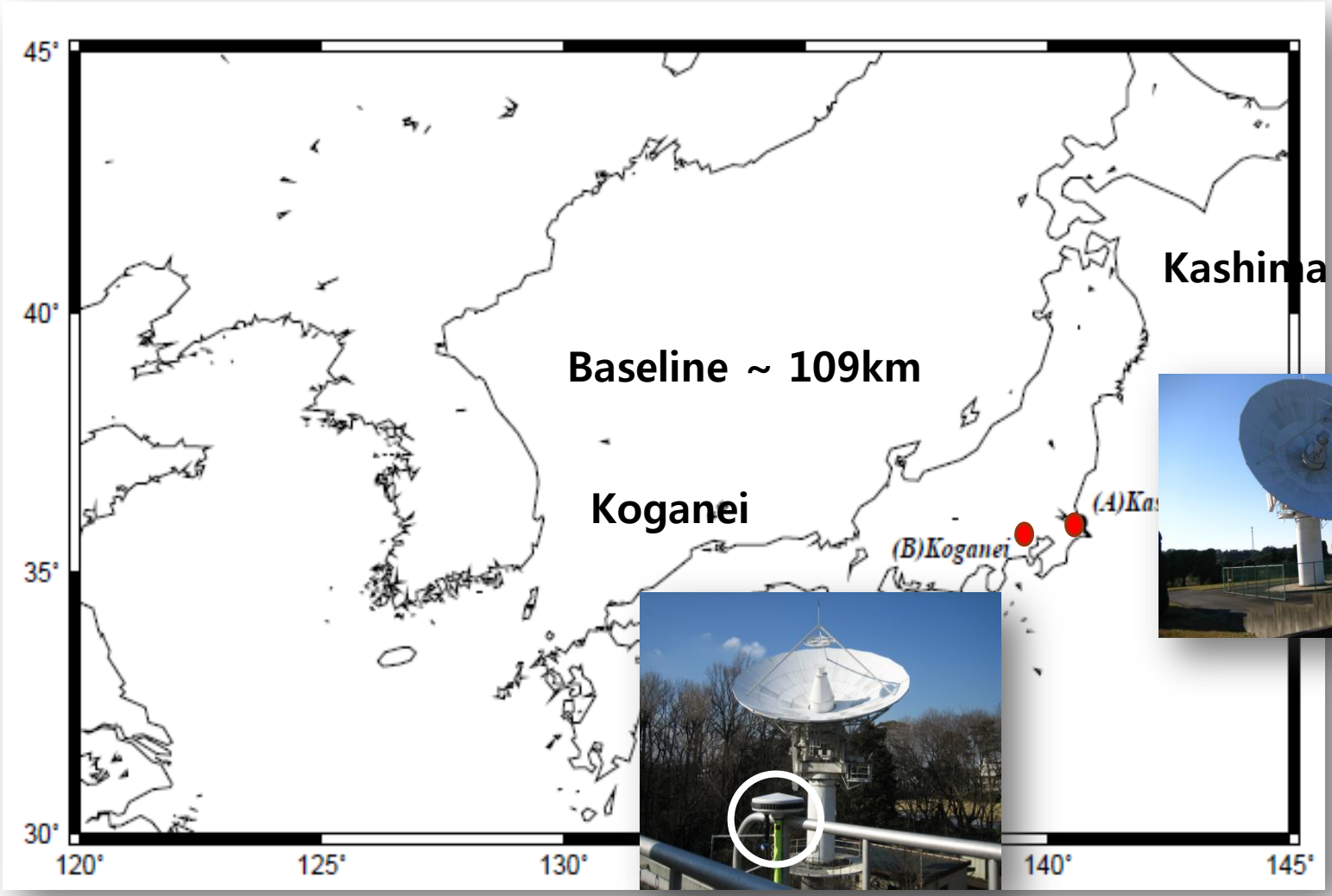
FWF Der Wissenschaftsfonds.
TU WIEN
CHALMERS UNIVERSITY OF TECHNOLOGY
UNIVERSITY of TASMANIA AUSTRALIA

GPS(or GNSS)-VLBI Hybrid System



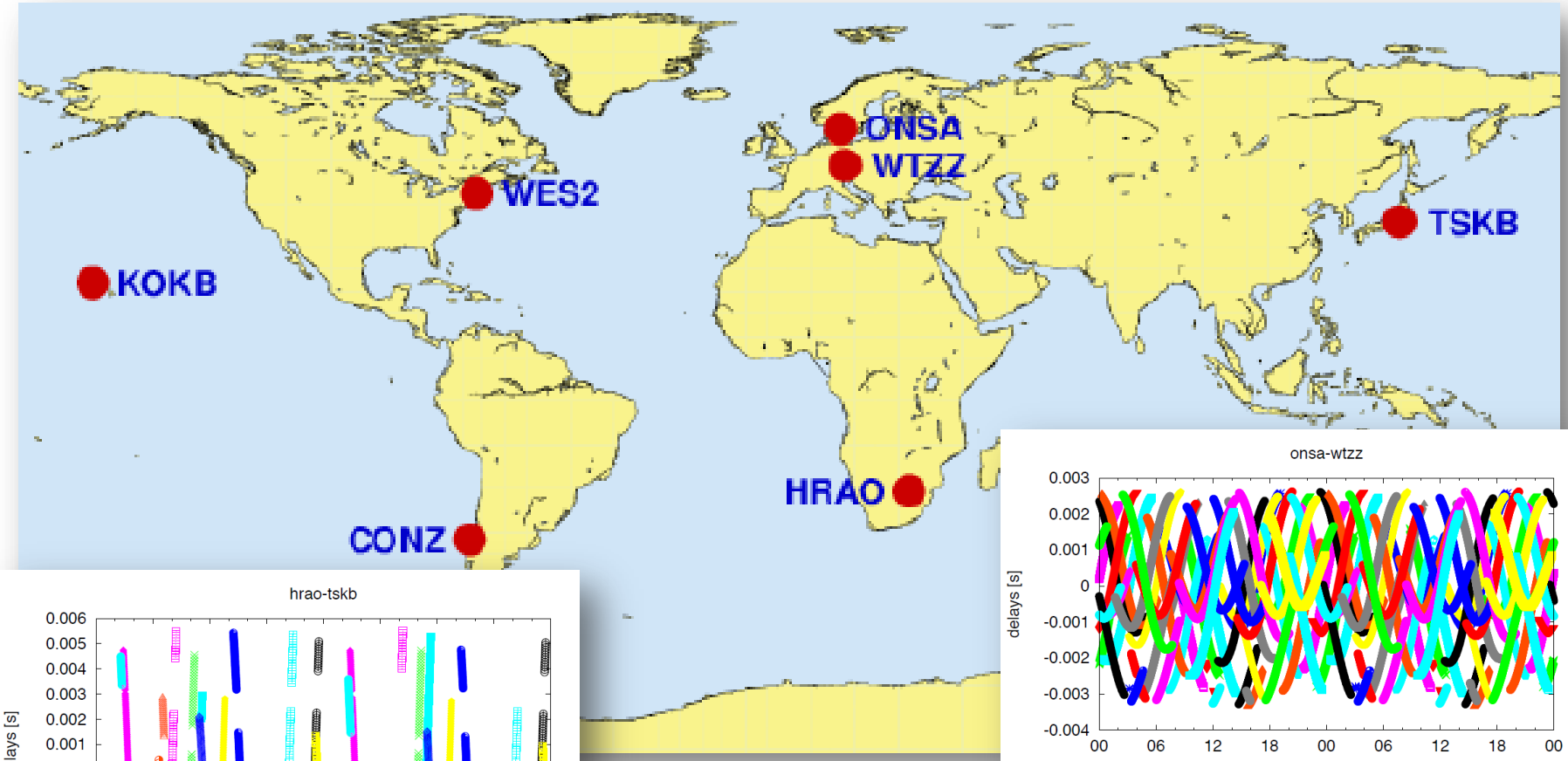
Motivation : enhancement of VLBI geodesy
+ observation level combination

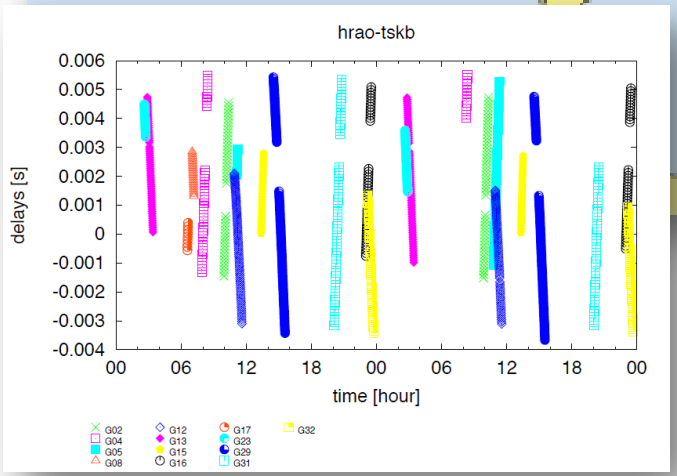
A Pilot 24-h Experiment: Single & Short Baseline



Estimating EOP, satellite coordinates and CRF was impossible

Global Network: CONT11 sites using the same clock for both VLBI and GNSS

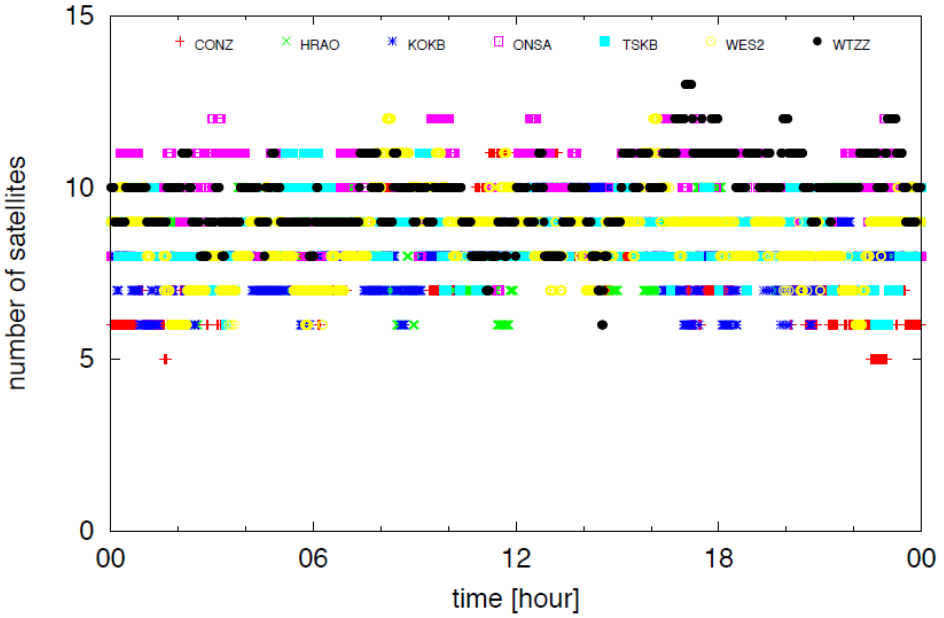




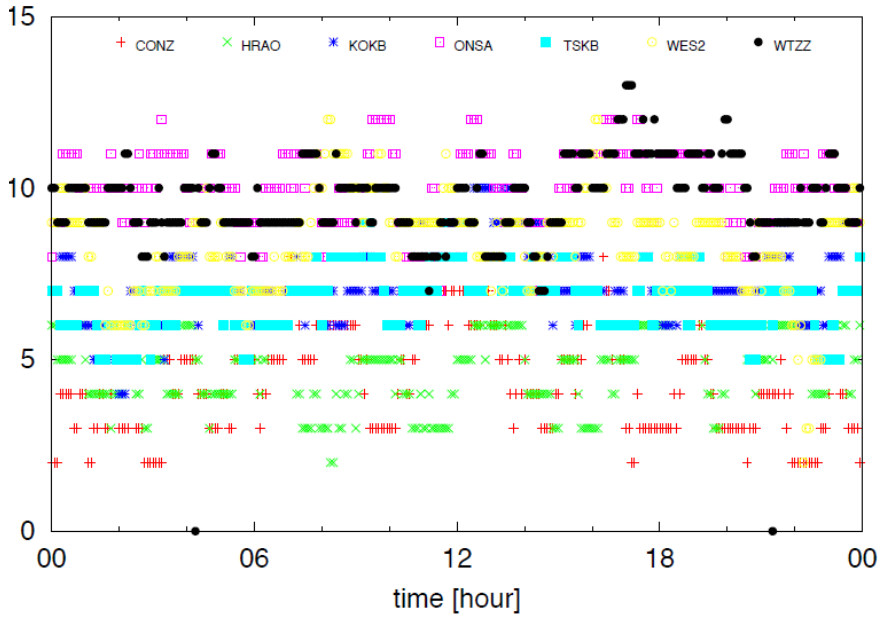
- ✓ No data between CONZ – TSKB
- ✓ No data between HRAO – KOKB
- ✓ Data on 19 baselines

Global Network: How many satellites can be seen?

GNSS PPP
Station based



VLBI-like GNSS delay
Baseline based



data points: 176,438 (every 30s during 24h)

data points: 137,564 (every 30s during 24h)

can see all of satellites

make pairs with other stations

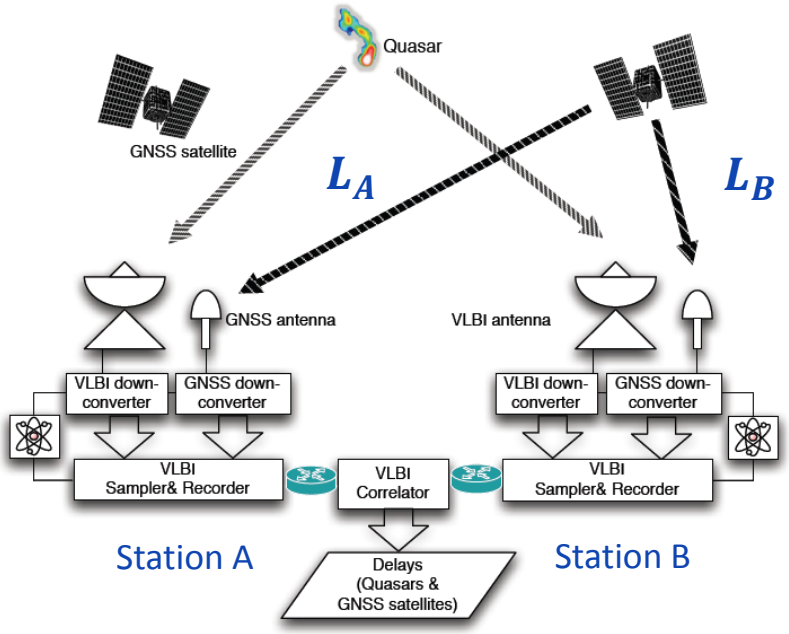
Generate VLBI-like GNSS delays

- ✓ No simulated data with only clock, zwd and white noise
- ✓ Test VieVS to process GNSS delay based on real observation
- ✓ GPS phase measurements
- ✓ well corrected w.r.t ionosphere, ambiguity, PCV, phase wind-up effect

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

L_A & L_B : corrected phase measurements b.t.w a satellite and ground station A & B

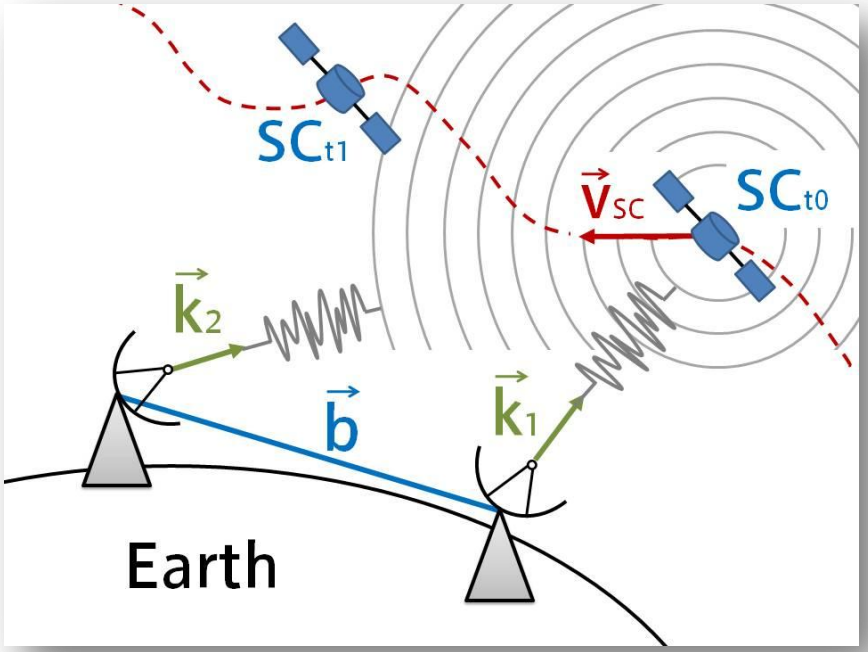
Let's regard them as correlated data "GNSS delay"



VieVS for GNSS delays

VieVS$_2$tie handles

Plank(2013)



- Selene same beam data
- Chang'E-1 VLBI tracking data
- Glonass GNSS observations

(simulation, scheduling)

+ GNSS delays

for multiple satellites

Analysis for GNSS delays only

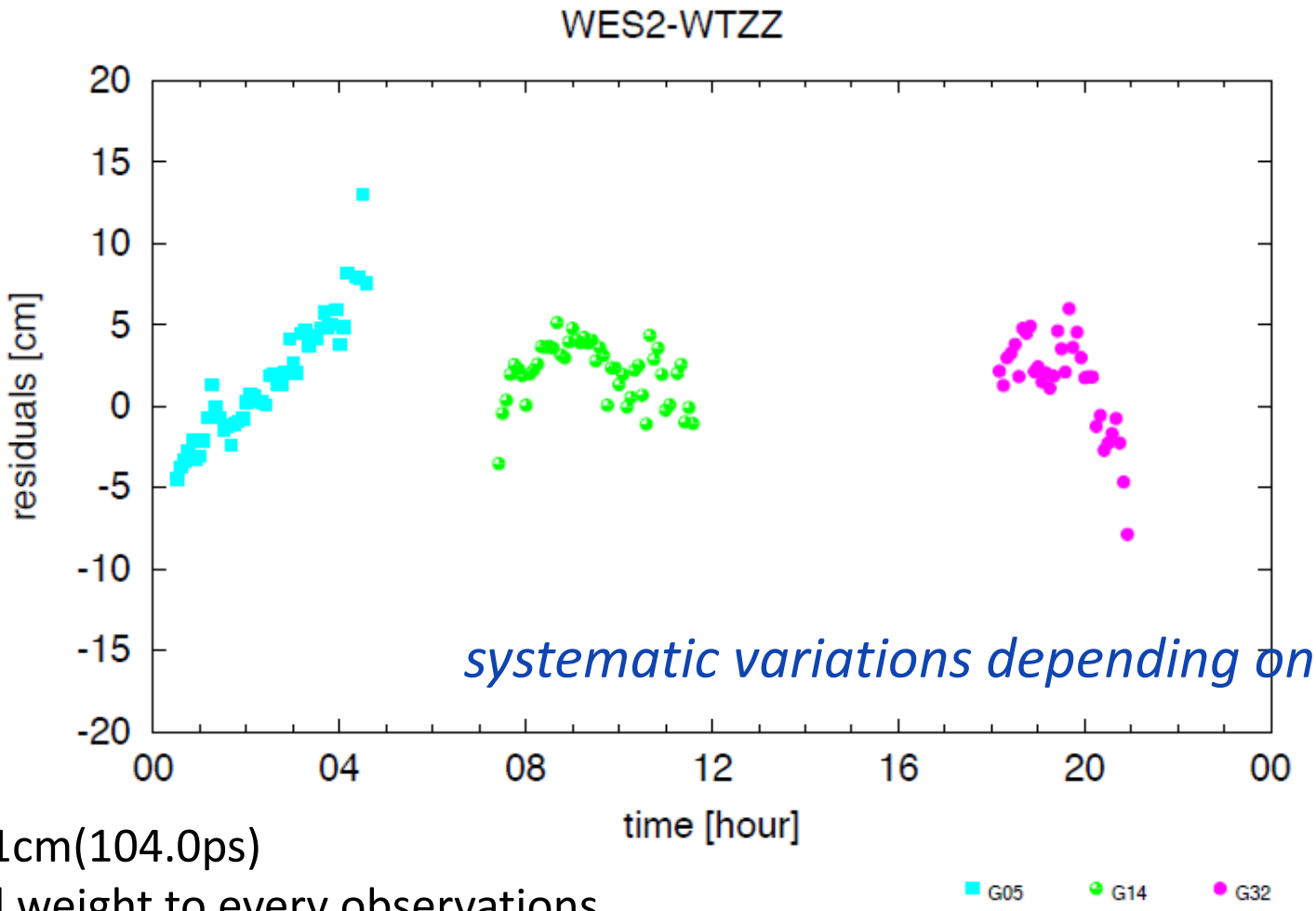
	Models / a prioris
Satellite orbit	IGS final orbit
Station coordinates	From PPP solution
Solid Earth tide	IERS 2010 conventions
Ocean Loading	FES2004
EOP	IERS C04 08
Troposphere delay	ZHD from GPT VMF No gradients
Ionosphere	Already corrected in the data
clock	Corrected from PPP solution

	Parameters	Interval
Clocks	PWL offsets	5 min.
	Clock rate and quadratic term	1day
ZWD	PWL offset	2 hr
Gradients	East&west components	6 hr
Station coordinates	NNR/NNT, PWL offset	6 hr
EOP	-	-

Results of GNSS delays only

- post-fit residuals

during 1st day of CONT11



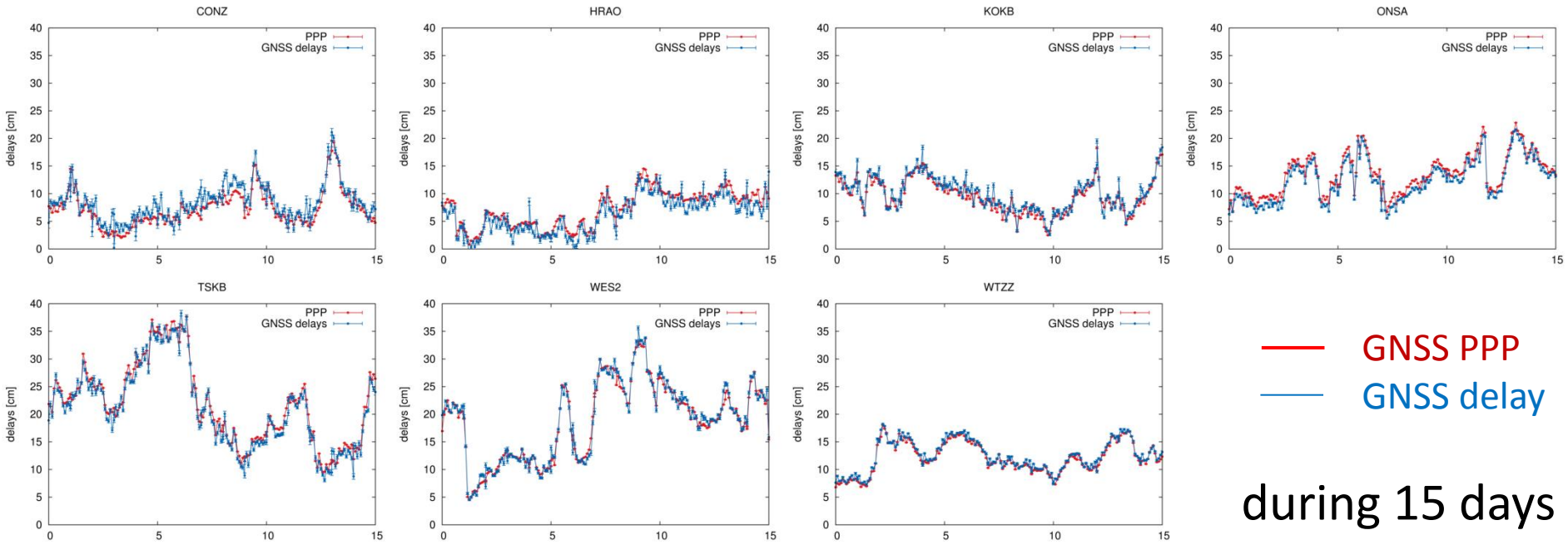
systematic variations depending on satellites

RMS: 3.1cm(104.0ps)

Identical weight to every observations

Results of GNSS delays only

- zenith wet delay



GNSS PPP

GNSS delay

during 15 days

✓ ZWDs are agreed with each other within 2cm

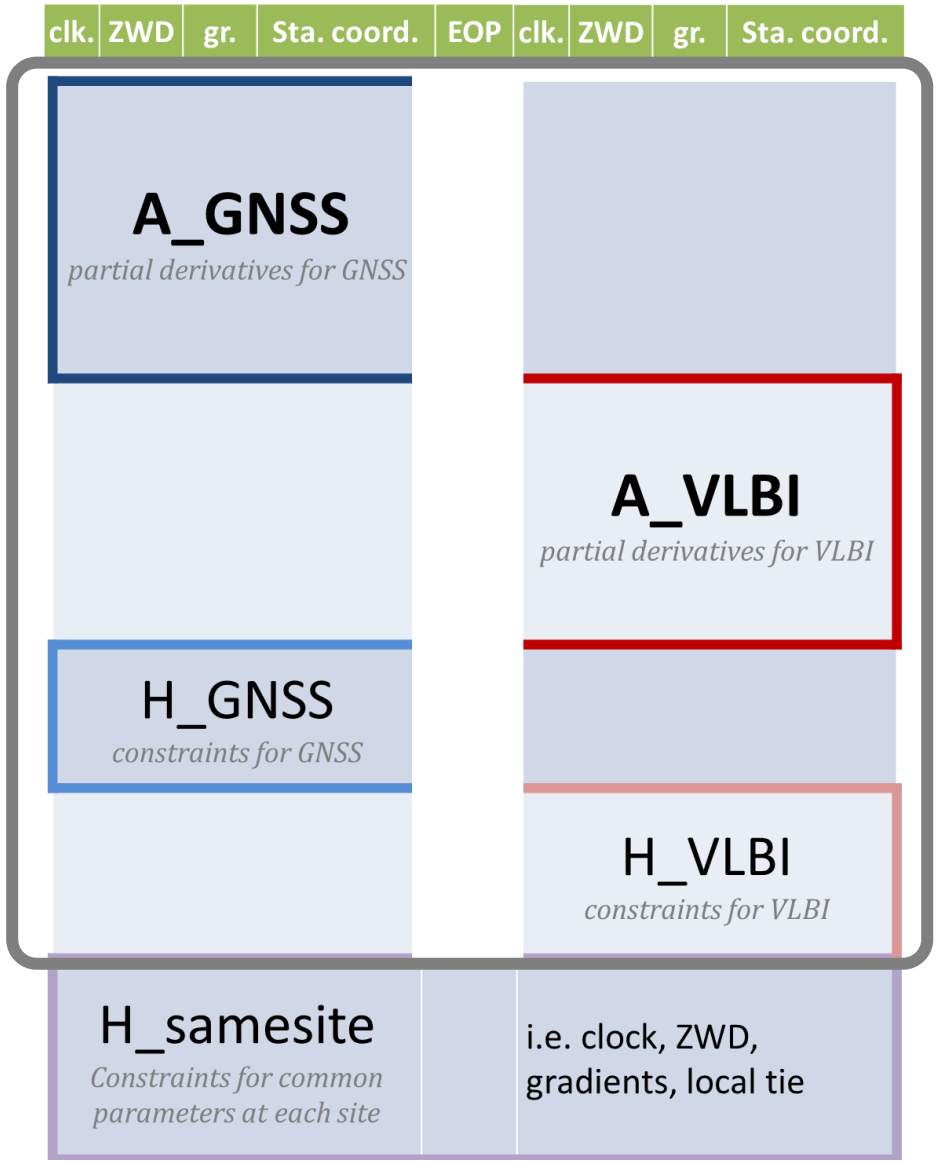
How to combine

- Data

```
                                                  ⋮
                                                  ⋮
2011  9 15  0  5 15.00 WTZZGNSS WES2GNSS PG10     sc    -0.00193562711807780  ...
2011  9 15  0  5 15.00 WTZZGNSS WES2GNSS PG13     sc     0.01079601557621570  ...
2011  9 15  0  6 50.00    KOKEE TSUKUB32 1144-379 qq     0.00732405933076071  ...
2011  9 15  0  6 50.00    KOKEE TIGOCONC 1144-379 qq     0.00542015727254934  ...
                                                  ⋮
```

- ✓ GNSS : differenced value from real GNSS measurements (multiple scans at the same epoch)
- ✓ VLBI : CONT11 data
- ✓ sorted by order of time regardless of data type

How to combine



Except geometric models, other geophysical models are same for both of them

The constraint conditions for parameters are also same for both of them.

Introduce local ties and site common parameters

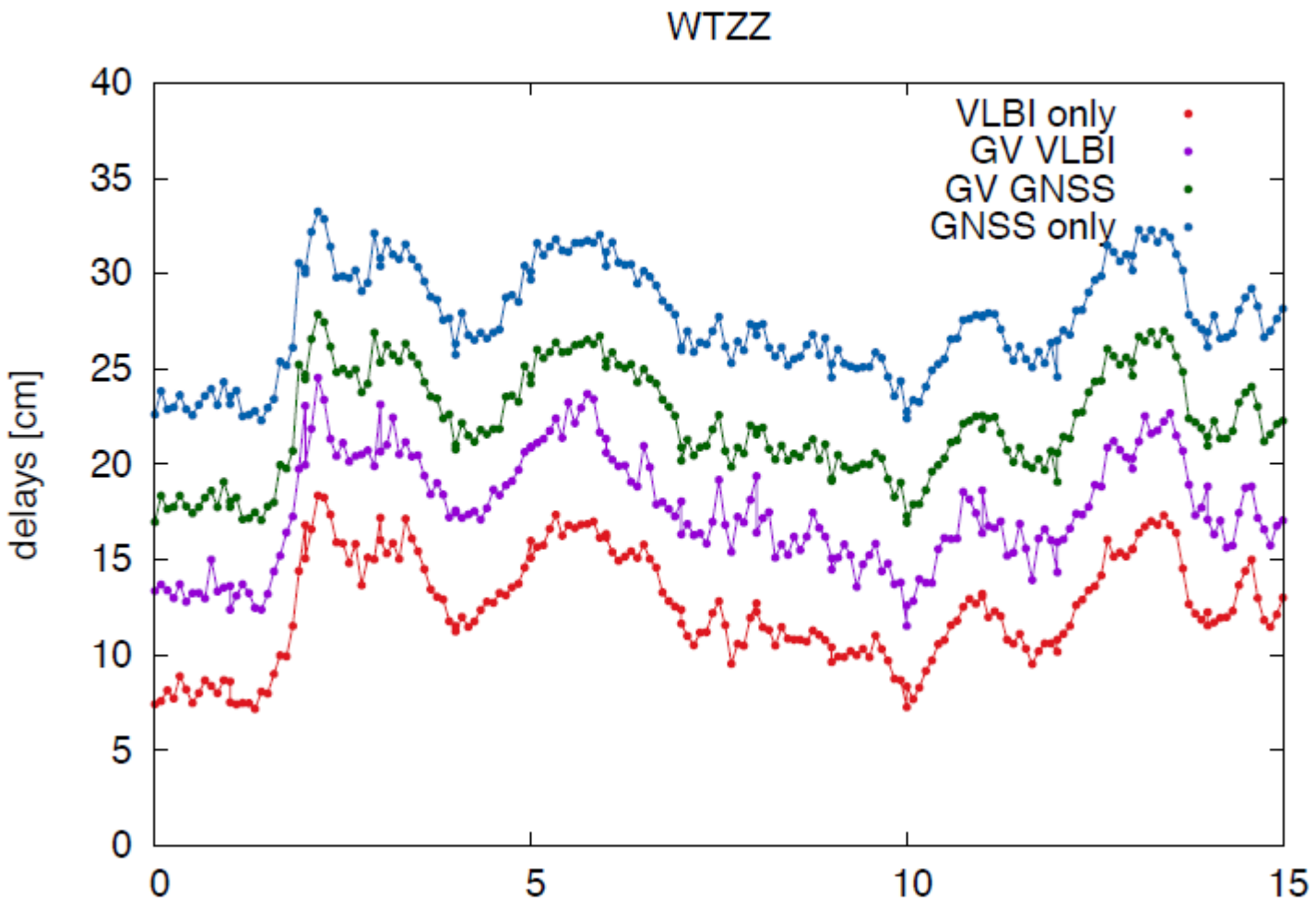
Analysis for combined delays

	Models / a prioris
Sources	ICRF2/IGS final orbit
Station coordinates	vievsTrf/PPP solution
Solid Earth tide	IERS 2010 conventions

	Parameters	Interval
Clocks	PWL offsets	5 min.
	Clock rate and quadratic term	1day
ZWD	PWL offset	2 hr
Gradients	East&west components	6 hr
Station coordinates	NNR/NNT to vievsTrf/PPP solution	1 day
EOP	-	-

Preliminary Results

- ZWDs



Conclusion and Future Works

- The individual & combined VLBI and GNSS delay data were processed in modified VieVS.
- We found cm-level accuracy of the model involved for GNSS delays so far.
- ZWDs of GNSS delays agree with PPP within 2cm.
- More investigations for systematic behavior
- Further development of VieVS for site common parameters(clock, zwd, gradients) and local tie

Thank you for your attention!

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