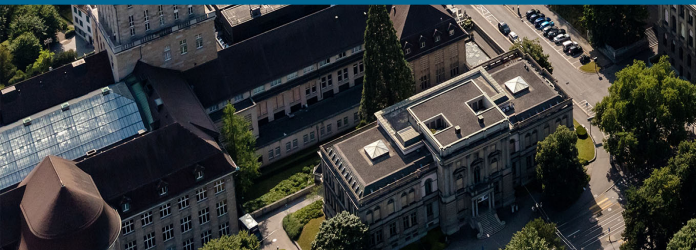# Local Tie Analysis at Fundamental Sites in the CONT17 Campaign

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Overview and Research Goals

A **consistent** estimation of the TRF is required to achieve higher precision levels (GGOS requirements).

Typically, **terrestrial ties** are used to realise this combination.

Highly accurate **tropospheric ties** and clock ties are alternative ways to link co-located stations, and motivate the analysis of their use in the TRF determination.

Goal: GNSS and VLBI joint processing (**observation level**), and investigations on the impact that **terrestrial and tropospheric ties** have on the precision of a TRF.

Zenith Tropospheric Delay at Onsala: VLBI and GNSS
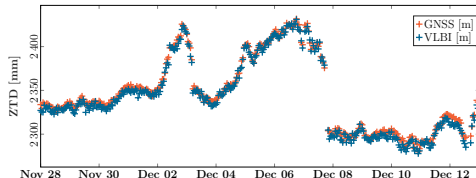
Zenith Tropospheric Delay at Wettzell: VLBI and GNSS

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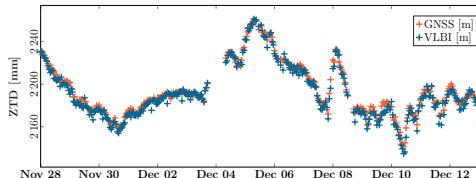
Processing Strategy and Data Analysis

CONT17 Campaign + ca. 180 GNSS stations (G+R)

Joint estimation using **Bernese Software: VLBI version**

Estimated parameters:

- Daily station coordinates (NNR–NNT)
- Daily Earth orientation parameters (EOP)
- Zenith tropospheric delays (1 h) + Gradients (24 h)
- VLBI clock offsets (3 h)
- Geocentre coordinates (GCC)
- GNSS orbits

Combined solutions (15-day rigorous combination):

- GNSS + VLBI + Terrestrial ties
- GNSS + VLBI + Terrestrial ties + Tropospheric ties
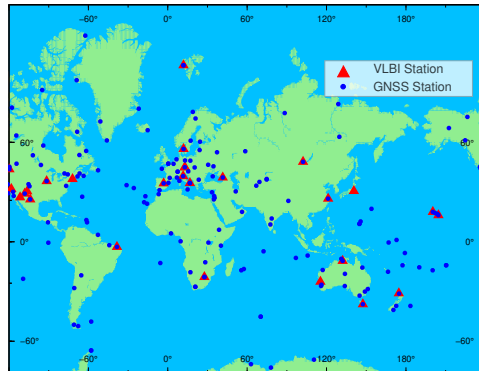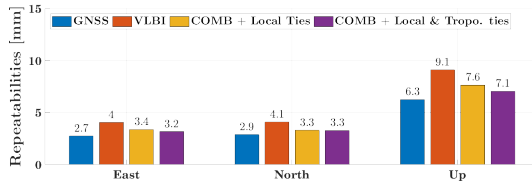
Results: Coordinate Repeatabilities

Joint estimation of daily coordinates using NNR-NNT conditions, with mm-level repeatabilities over the 15-day time span.

Benchmark for comparison: GNSS-only and VLBI-only solutions.

Combined solution with local and troposphere ties improves the overall performance: vertical component from ZTD and horizontal components from common troposphere gradients:

Repeatabilities (RMS) − 15 Days Solution

Only GNSS Stations

Only VLBI Stations

	GNSS		VLBI	
	G/CLTTT	CLT/CLTTT	V/CLTTT	CLT/CLTTT
East	7%	4%	5%	5%
North	14%	0%	5%	3%
Up	10%	8%	9%	7%

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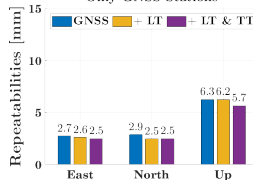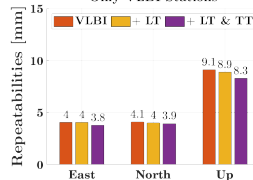
Results: Earth Orientation Parameters

Estimated EOPs: polar motion, UT1-UTC, and celestial pole offsets, with daily resolution.

External reference for comparison: CODE final solution.

All solutions agree with CODE at approximately the same level for X-Pole and UT1-UTC.

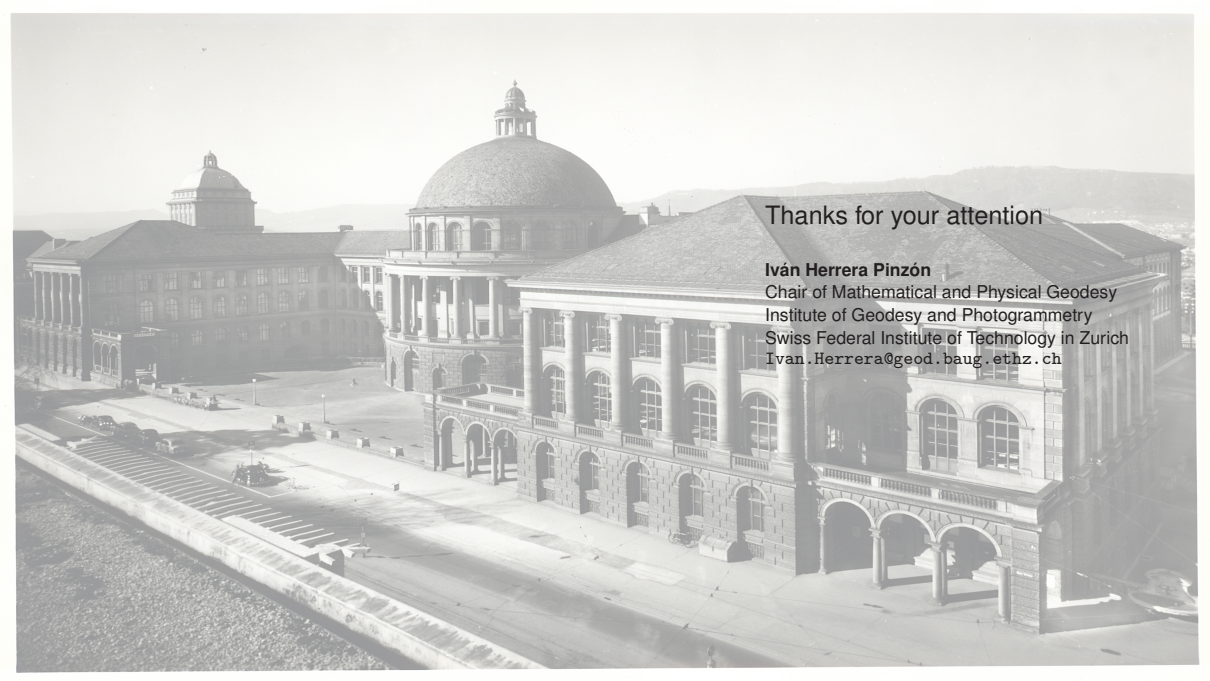For Y-Pole the agreement is better for the combined solutions.

Combined solution with local and troposphere ties improves polar motion estimation, compared to the individual solutions:

	G/CLTTT	V/CLTTT	LT/CLTTT
X-Pole	8%	21%	12%
Y-Pole	14%	57%	-1%
UT1-UTC	–	-7%	-2%

EOPs (RMS) – 15 Days Solution
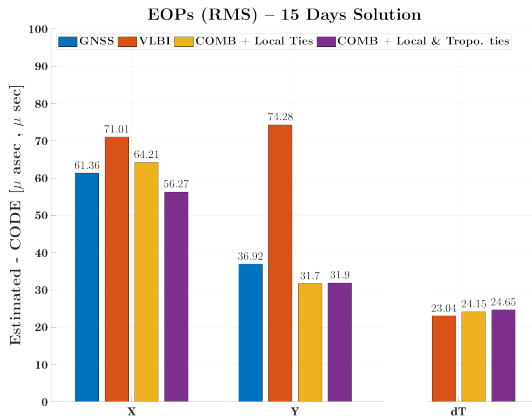
Summary and Conclusions

- A **rigorously** combined solution VLBI-GNSS for the estimation of a TRF has been achieved.
- This solution profits from the use of **local and tropospheric ties** at (selected) co-location sites.
- The combined solution with local and troposphere ties generally **improves the precision** of all the estimated geodetic parameters.
- In particular: **coordinate repeatabilities**, **polar motion** components are improved.
- The remaining parameters (not shown) show similar levels of improvement, compared to the individual solutions.
- Future: variance component estimation for the weighting, studies certain parameters in the combination (e.g GCC), combine intensives with GNSS via tropospheric ties. . .

Thanks for your attention

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Backups Results: Geocentre Coordinates

Geocentre coordinates available in the combined solutions.

Daily estimates and a 15-day solution with sub-mm formal errors.

Combined solution with local and troposphere ties improves only the estimation of the Z component, compared to the individual solutions:

	G/CLTTT	CLT/CLTTT
X	-50%	4%
Y	-3%	4%
Z	47%	10%

Geocentre Crds. [mm] − 15 Days Solution