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Enhancing the Swiss Permanent GPS Network for GNSS

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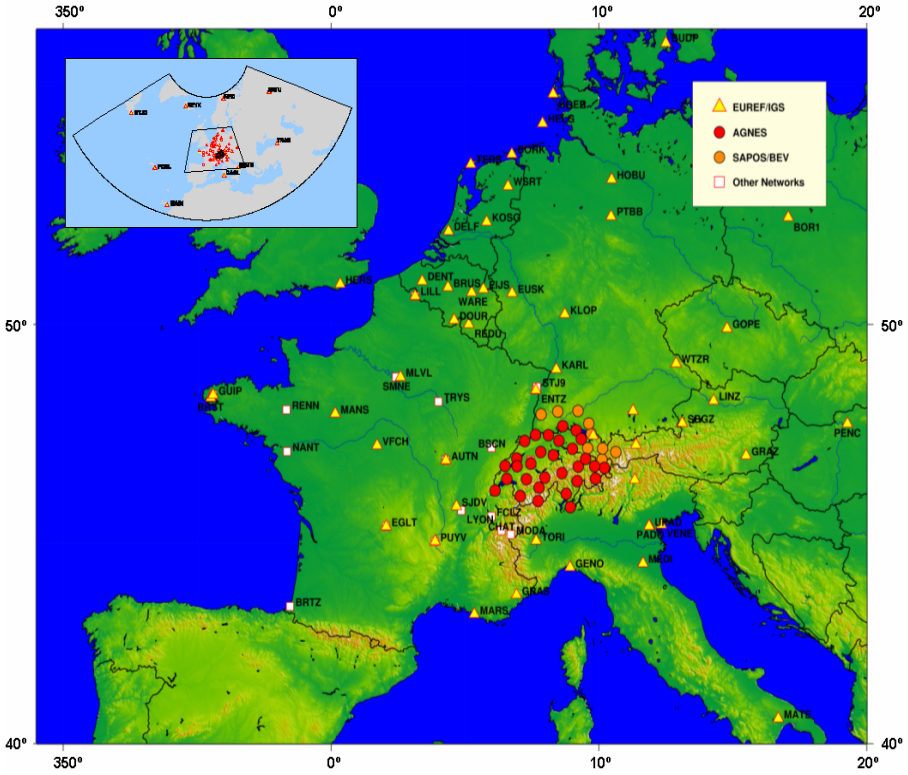
GLONASS data used for EUREF solutions

- swisstopo‘s official contribution based on GLONASS data since GPS week 1400 (Nov. 2006)
- 4 stations equipped with combined GNSS receivers in swisstopo’s subnetwork
- Orbit information used from CODE (instead of IGS)
- Ambiguities not fixed

Enhancing the Swiss Permanent GPS Network (AGNES) for GLONASS

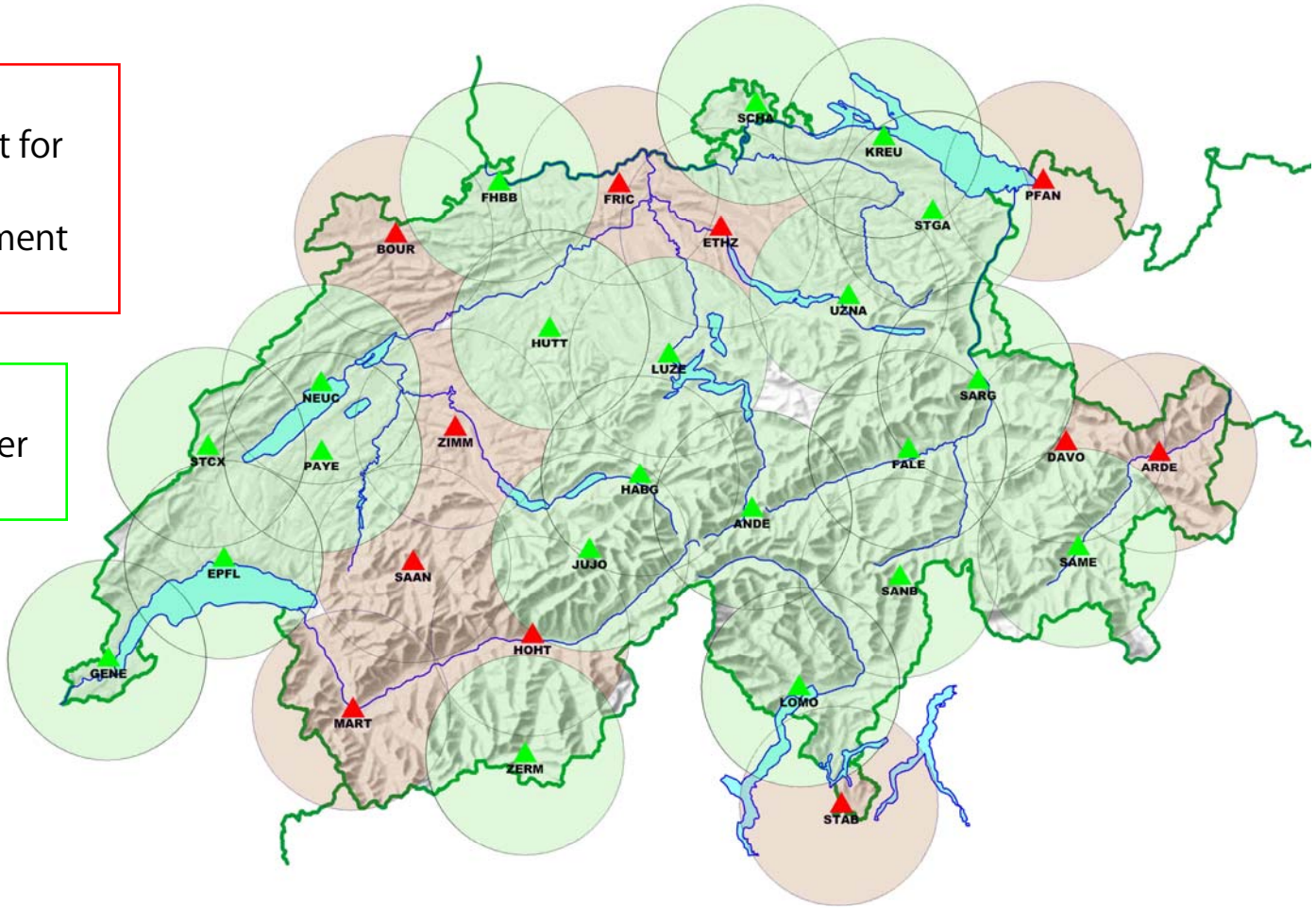


- Increasing number of operational GLONASS satellites
- Leica and Trimble with new GNSS receivers on the market
- Galileo: operational status delayed
- Decision swisstopo: Enhancement of AGNES for GLONASS (mainly due to RTK applications)
- Trimble NetR5 receivers and Zephyr GNSS antennas

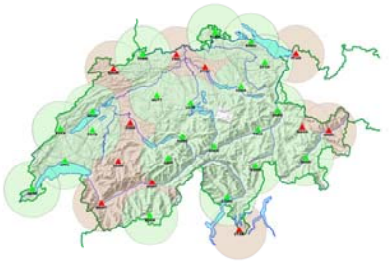
Double station concept

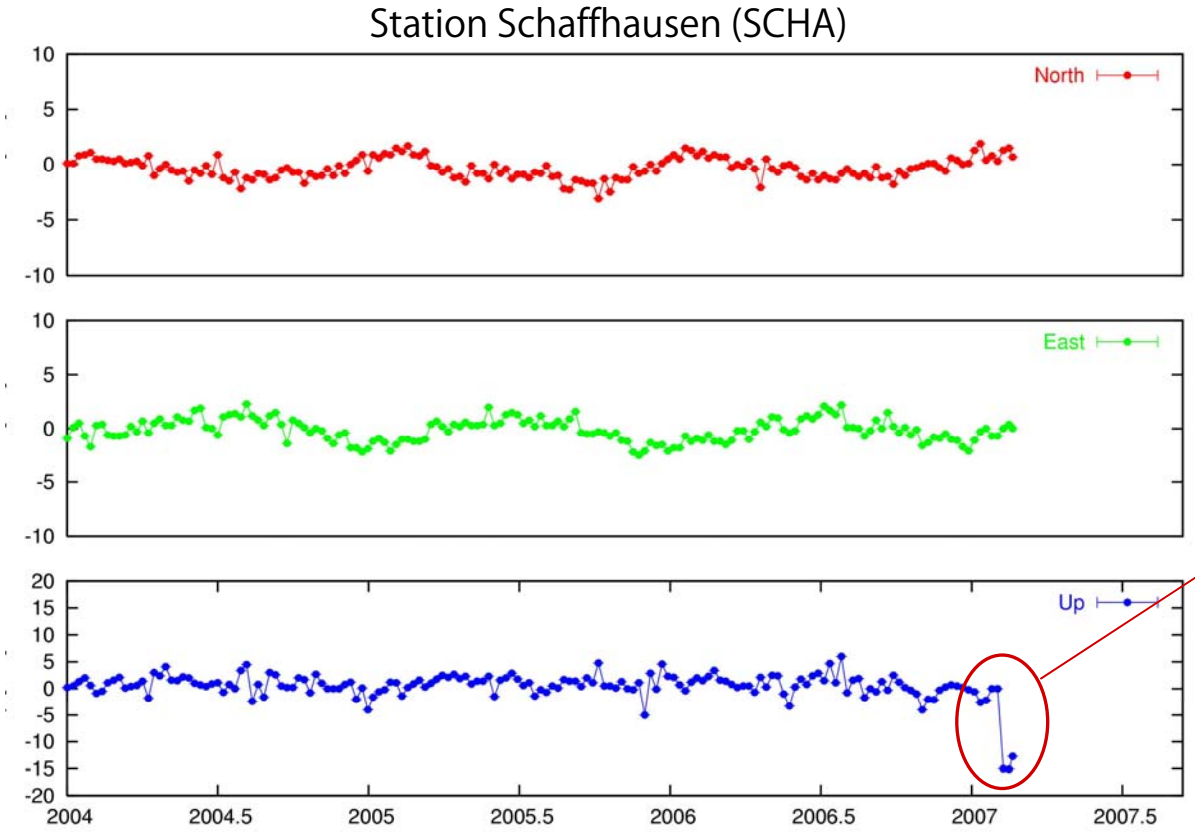
▲ „Double station“:
New antenna mount for GNSS antenna
New and old equipment run simultaneously

▲ „Normal station“:
Antenna and receiver replacement



Double stations:
Reference frame stability

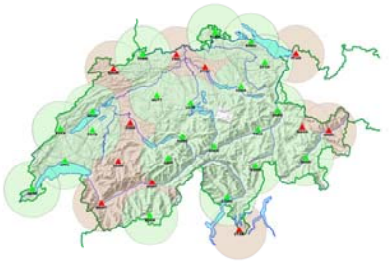


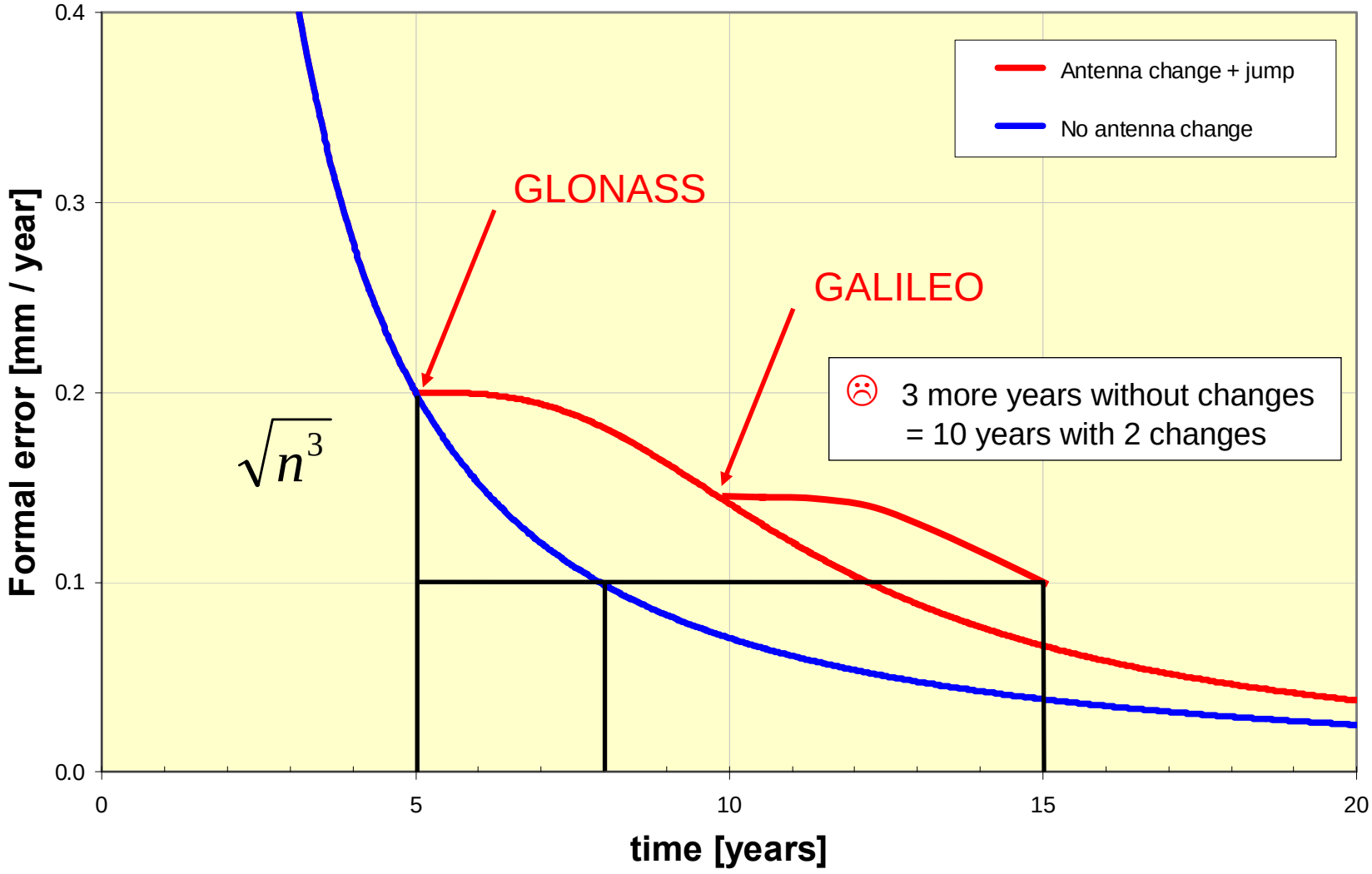


Antenna or model change

→ Double stations help to maintain the consistency of the national reference frame

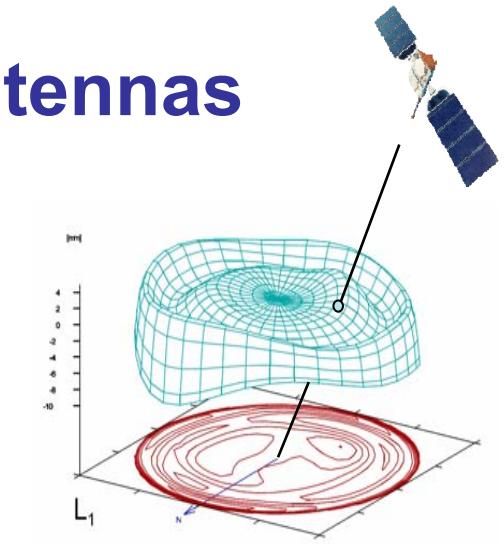
Double stations: Velocity estimation



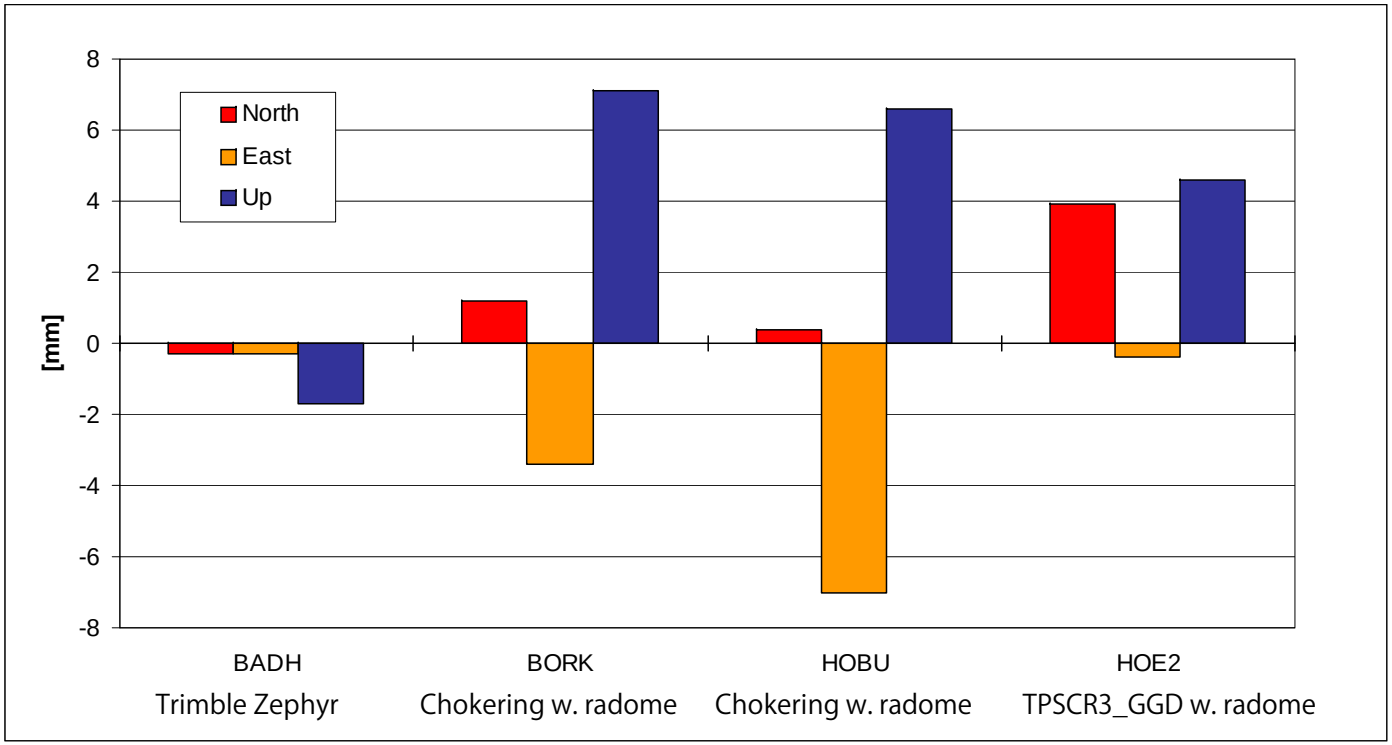


Individual calibration of the antennas

- Estimation of absolute antenna calibration models by means of calibration robots (Geo++)
- Elevation and azimuth-dependent calibration values
- Currently, only determination of type values for GLONASS
- Individual calibration values for post-processing applications, not for RTK positioning service



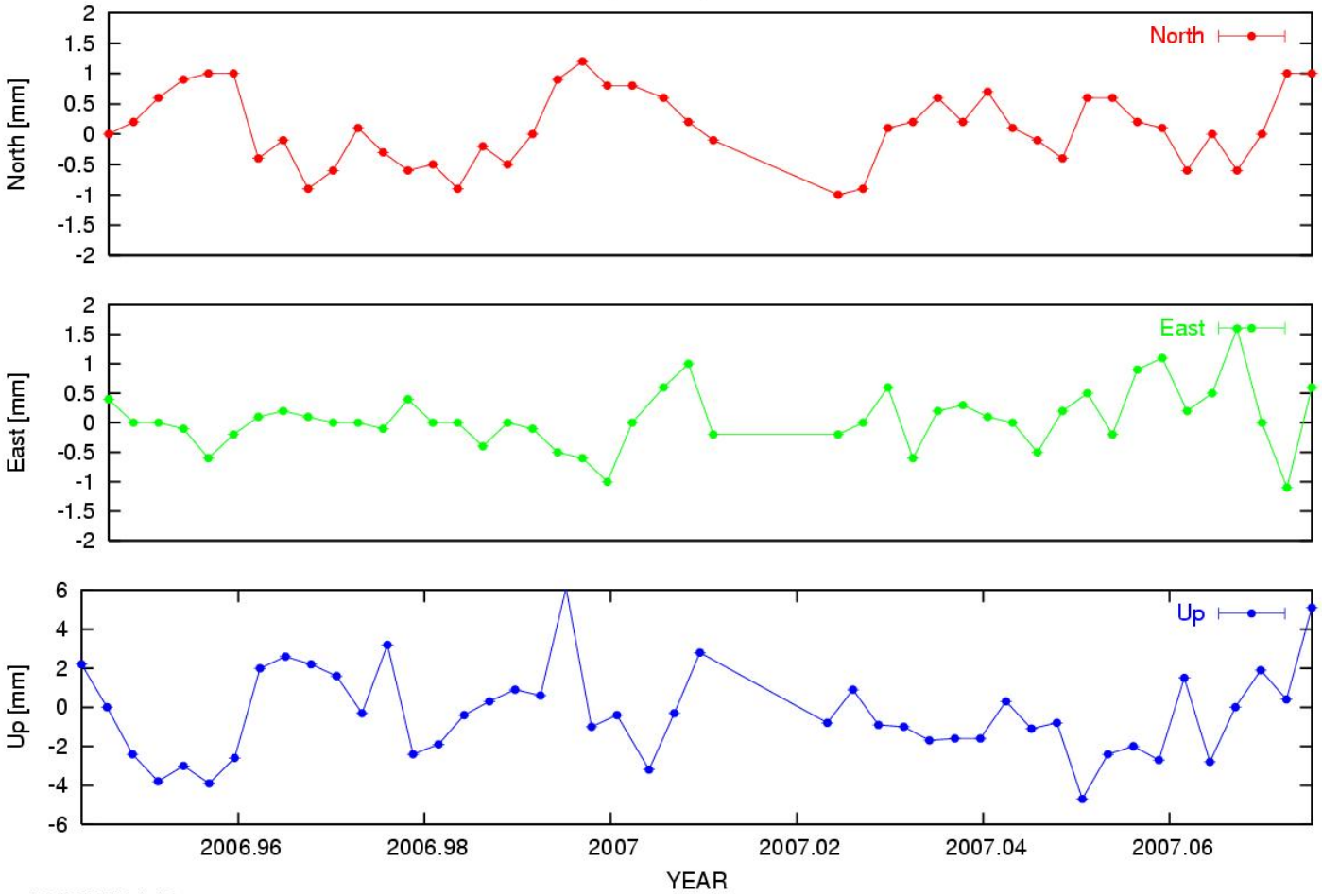
Individual antenna calibration values ↔ antenna type calibration (EUREF solution)



4 of 30 stations with individual calibration values in swisstopo's subnetwork

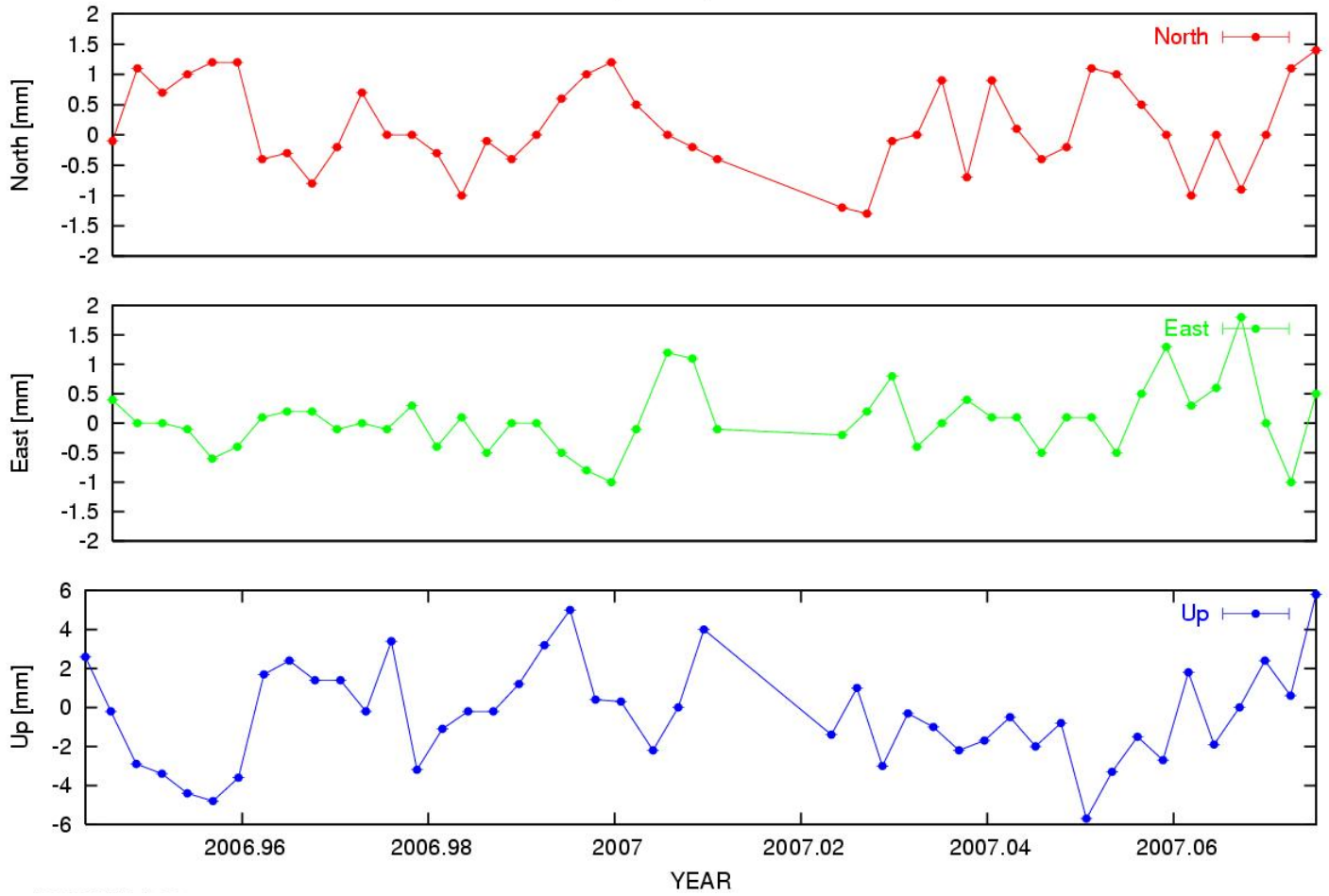
Post-processing long baselines: Influence on the repeatability (EUREF solution)

GPS solution: Station WTZR, 7 weeks



Post-processing long baselines: Influence on the repeatability (EUREF solution)

GPS/GLONASS solution: Station WTZR, 7 weeks



Post-processing long baselines: Influence on the coordinates (EUREF solution)

Difference between GPS solution and GPS/GLONASS solution:

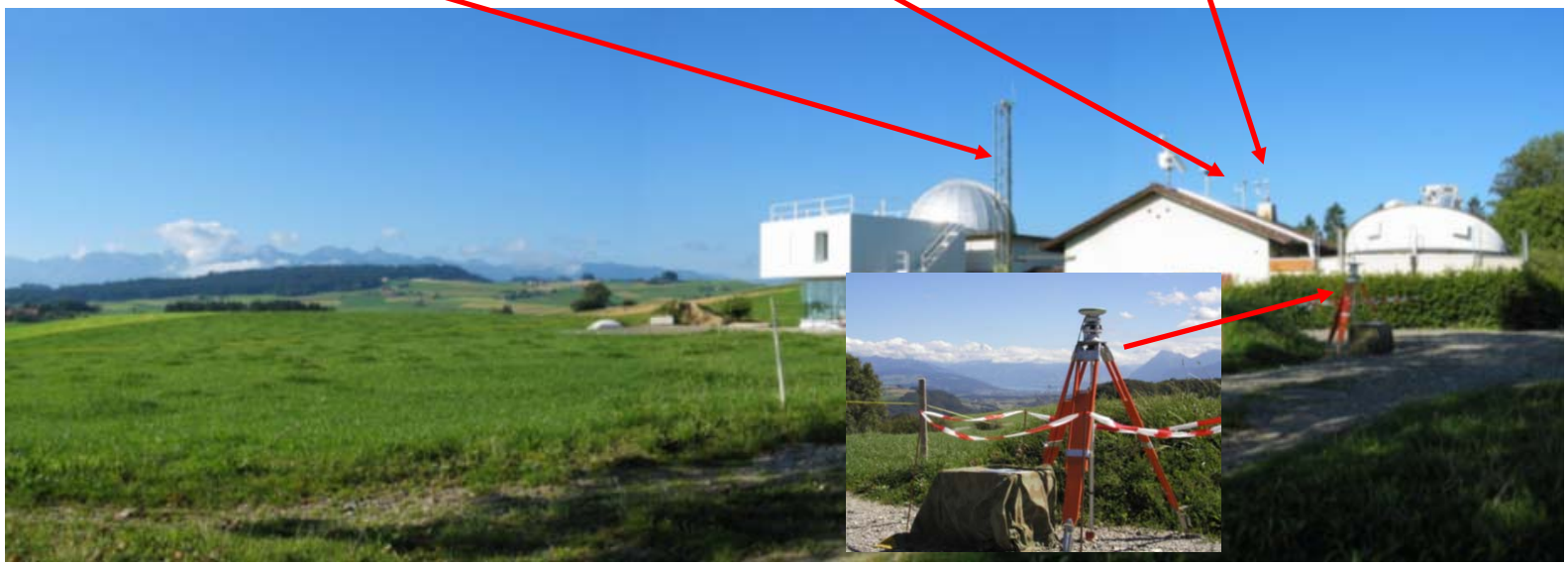
	North [mm]	East [mm]	Up [mm]
BORJ (Borkum, Ge)	- 0.3	0.1	- 0.7
HELG (Helgoland, Ge)	0.1	- 0.1	0.3
WTZR (Wettzell, Ge)	0.1	0.0	0.3
HOE2 (Hoernum, Ge)	0.0	0.1	- 0.1

GNSS tests Zimmerwald: Short baselines

ZIMM Trimble NetRS (GPS)

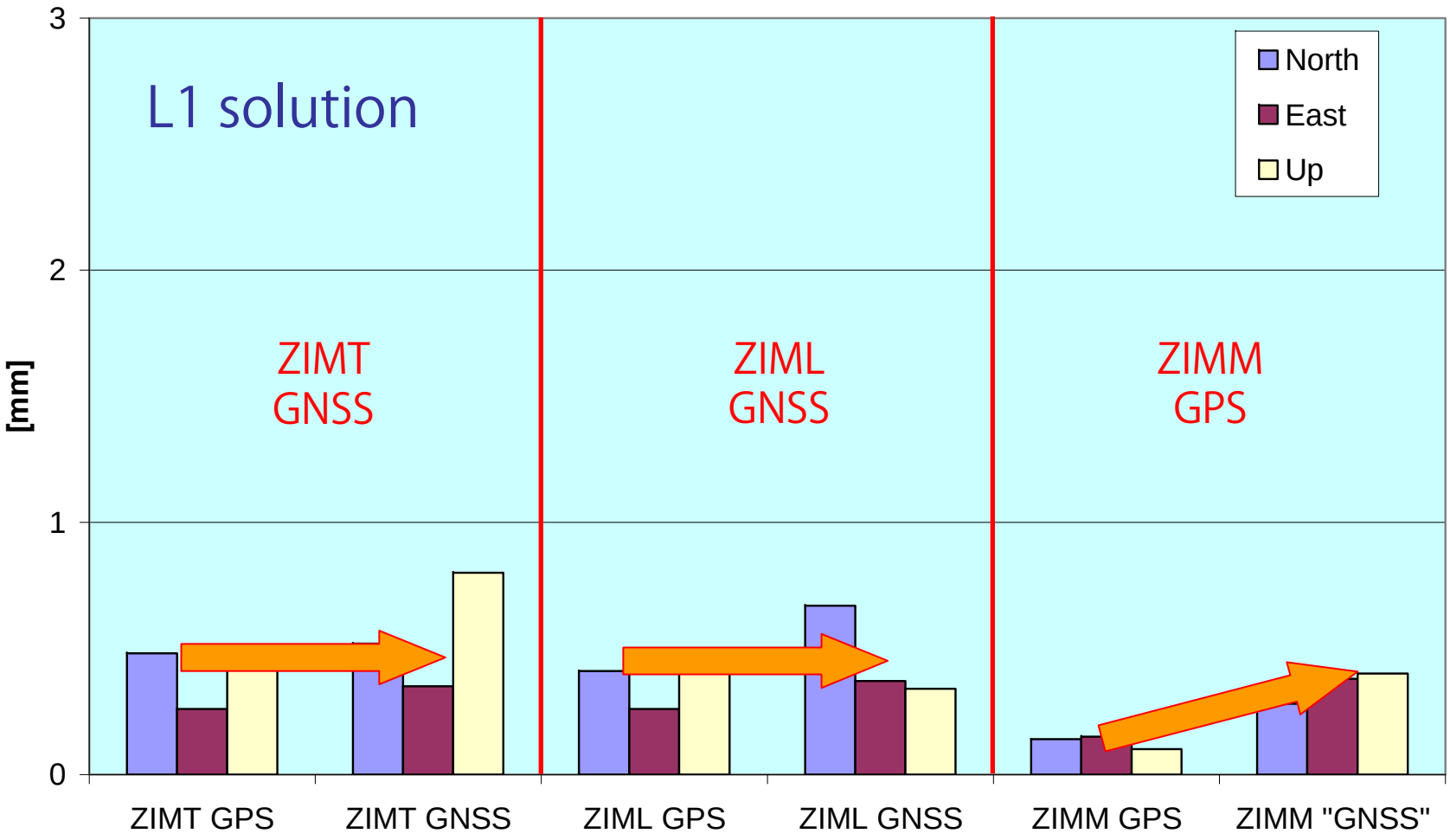
ZIMT Trimble NetR5 (GNSS)

ZIMJ Javad (GNSS)

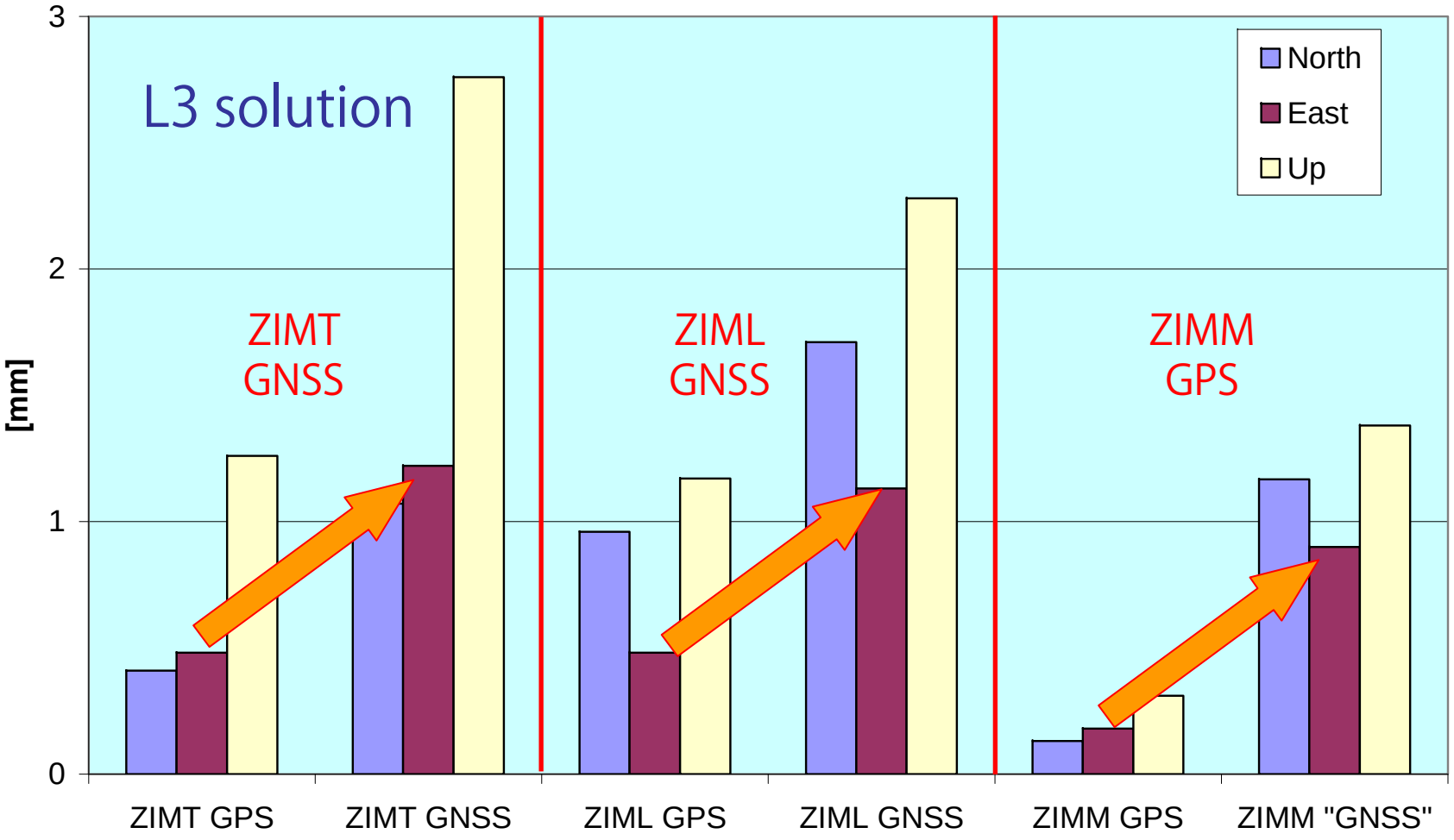


ZIML Leica 1230 (GNSS)

Short baselines: Repeatability BSW5.0+; 7 days



Short baselines: Repeatability BSW5.0+; 7 days

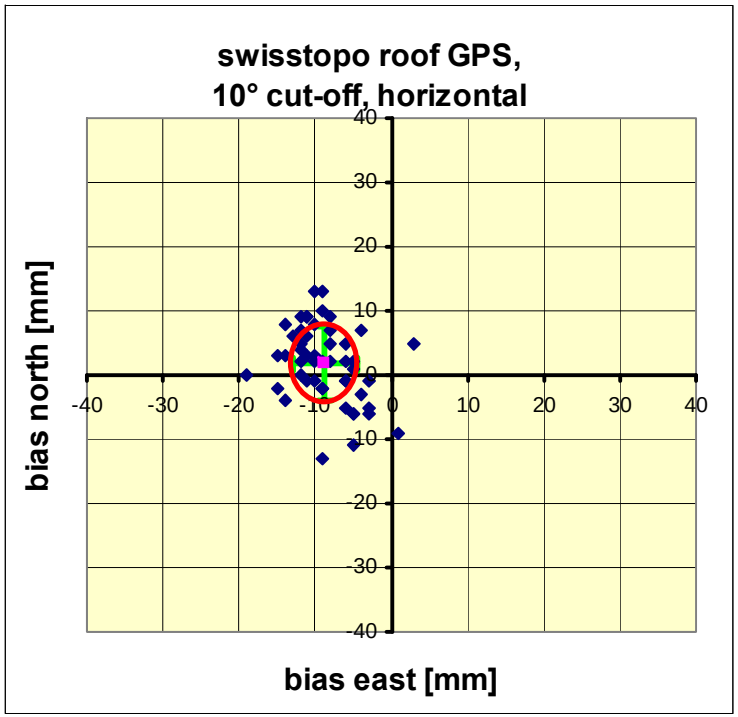


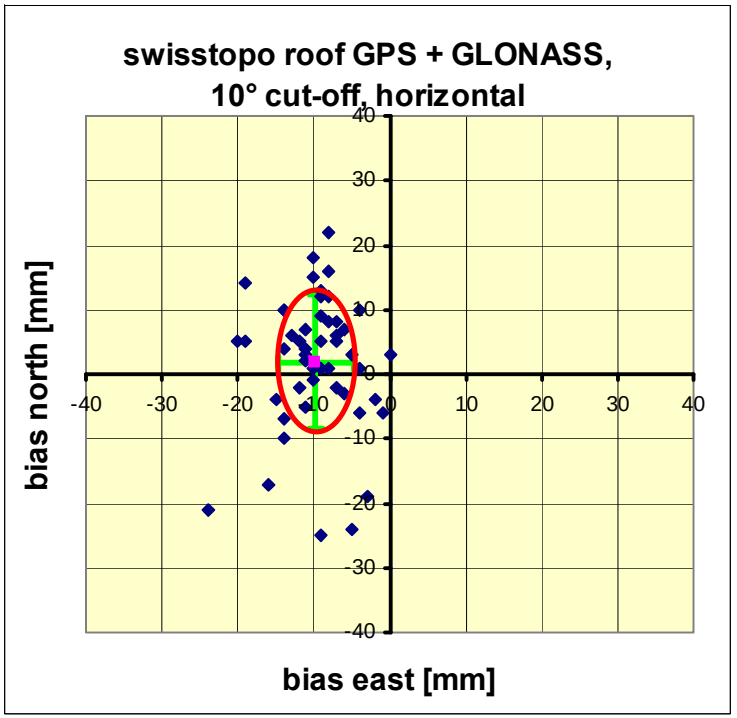
→ Further tests by CODE (inter-system phase biases, initialisation for ambiguity fixing, ...)

Real-Time Kinematic (RTK) tests using GNSS data

- 5 km baseline (Zimmerwald to swisstopo building)
- Base station: Trimble NetR5 receiver
- Rover: Leica 1230GG receiver
- Initializations every 30 minutes during 3 days (VRS monitor box)
- Elevation cut-off: 10º and 30º

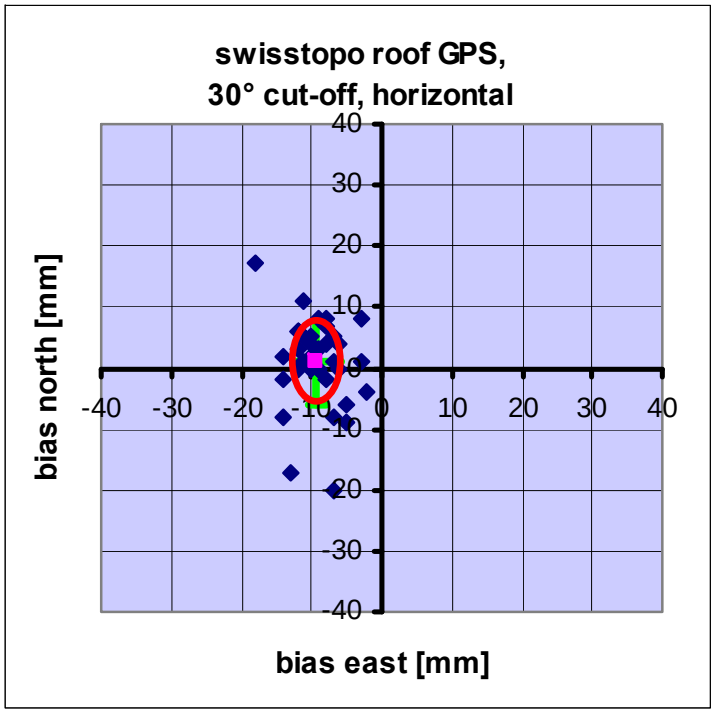
RTK tests: 10 degree cut-off angle

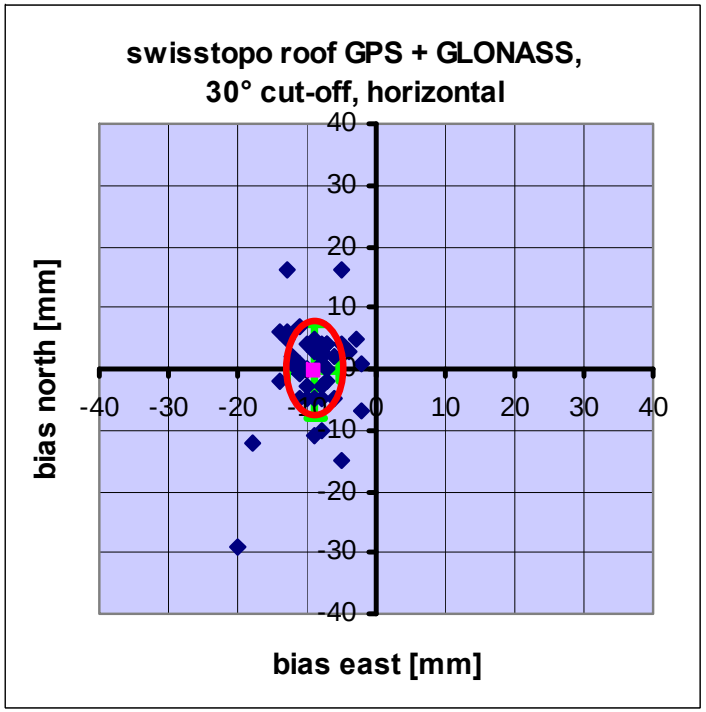




Elevation cut-off	Satellite system	Initialisation time [s]	Availability [%]
10º	GPS	3 s	100 %
	GPS+GLONASS	3 s	98 %

RTK tests: 30 degree cut-off angle





Elevation cut-off	Satellite system	Initialisation time [s]	Availability [%]
30º	GPS	67 s	62 %
	GPS+GLONASS	46 s	79 %

Conclusions

- GLONASS integration: First step towards GALILEO
- Learning process (post-processing). Further improvements possible by more satellites, more stations, and software enhancements
- We expect benefits mainly for real-time applications in
  - increased availability under difficult conditions
  - reduced initialisation times

  whereas accuracy does not (yet) improve
- The first equipment replacements will be done next week!

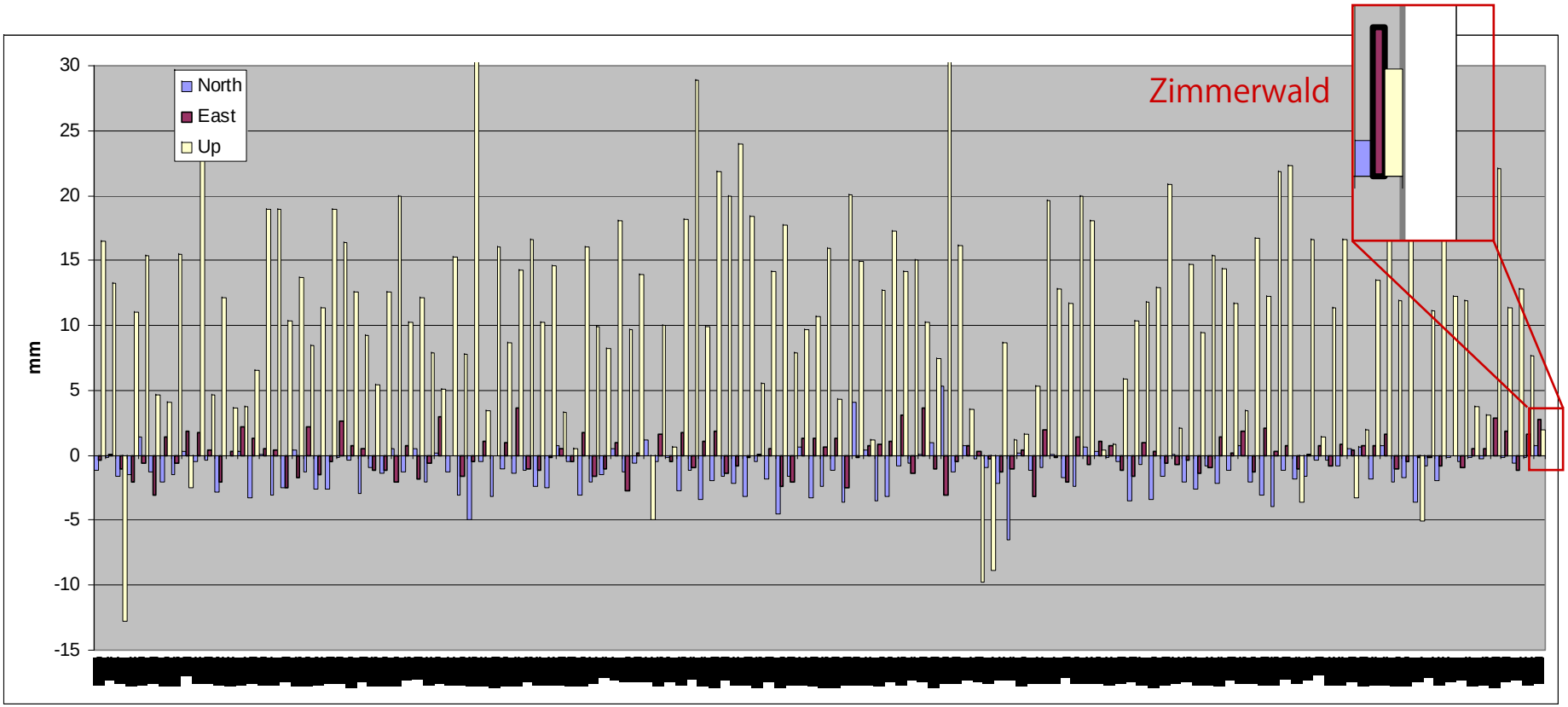
RTK tests: Availability, time for initialisation

elevation cut-off	satellite system		init [s]	east [mm]	north [mm]	horizontal [mm]	height [mm]	availability [%]
10º	GPS	bias	3.0	-8.7	1.8	11.1	15.0	100
		std	1.6	4.2	5.9	7.2	11.3	-
	GPS+GLONASS	bias	2.8	-9.6	1.8	9.8	16.3	97.9
		std	0.4	4.9	10.4	11.5	10.3	-
30º	GPS	bias	67.5	-9.2	1.1	11.7	17.7	62.5
		std	117.3	3.4	7.1	7.9	12.0	-
	GPS+GLONASS	bias	46.3	-9.0	-0.3	11.7	15.5	79.2
		std	103.9	3.7	7.7	8.5	14.2	-

std: standard deviation

Absolute antenna models: IGS

Vergleich von 132 IGS-Stationen:
Absolute und relative Antennenmodelle:
Erheblicher Einfluss (hauptsächlich Höhe)!



Influence des modèles d'antennes absolus: Groupes d'antennes (solution AGNES)

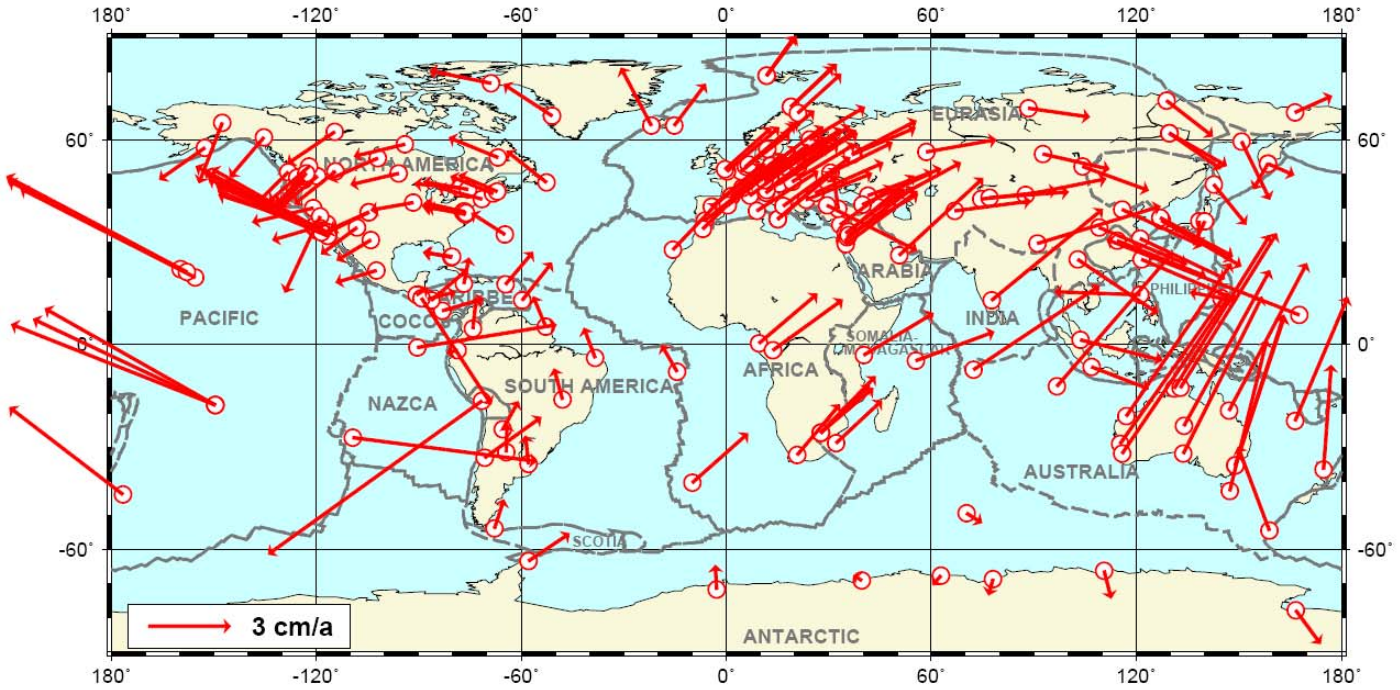
Differenz: Relativ zu absolut: Différence: relatif à absolu:

GPS-Woche 1369		Differenz [mm]			Standardabweichung [mm]		
	# Antennen	Nord	Ost	Höhe	Nord	Ost	Höhe
Trimble Chokering	14	0.5	1.7	1.1	0.2	0.2	1.0
Trimble Microcentered	21	1.9	0.4	-17.9	0.2	0.4	0.4
LEIAT504 LEIS	5	-1.2	-0.7	3.3	0.3	0.3	1.1
ASHTECH (Divers)	16	-0.5	-1.1	3.3	0.5	0.6	5.9

- Differenz = f (Antennentyp)
- Extremwerte Nord/Ost für einzelne Antennen bis 6 mm

- Différence = f (type d'antenne)
- Valeurs extrêmes nord/est pour certaines antennes jusqu'à 6 mm

Change of the reference frame ITRF2000 → ITRF2005



AGNES network:

- North: -12 mm
- East: 1 mm
- Height: -19 mm

Change GPS week 1400, November 2006