Uncertainty of GNSS antenna phase center corrections

Ralf Schmid

Deutsches Geodätisches Forschungsinstitut (DGFI)
Munich, Germany
e-mail: *schmid@dgfi.badw.de*

Achievements of the IGS in recent years

implemented with **igs05.atx** (in November 2006):

- **absolute** receiver antenna calibrations (i.e., calibrations independent of a reference antenna)
- consideration of the **radome effect** (if calibration available)
- satellite-specific **satellite antenna *z*-offsets**
- block-specific **satellite antenna PCVs** (phase center variations)

implemented with **igs08.atx** (in April 2011):

- **GLONASS-specific** receiver antenna corrections

→ considerable reduction of technique-specific biases

Uncalibrated radomes at co-located stations (I)

Romero (2012)

→ errors of up to **several cm** by ignoring the radome

Uncalibrated radomes at co-located stations (II)

Agency	Station	Antenna	Radome	Removed	Reinstalled
JPL	**AREQ**	AOAD/M_T	JPLA	2011-08-19	2012-02-03
	CRO1	ASH701945G_M	JPLA	2011-04-01	2011-06-24
	FAIR	ASH701945G_M	JPLA	2012-04-27	2012-08-04
	GODE	AOAD/M_T	JPLA	2012-07-06	2012-12-13
	MDO1	AOAD/M_T	JPLA	2013-02-22	tbd.
	MONP	ASH701945B_M	SCIS	—	—
	SANT	AOAD/M_T	JPLA	—	—
	SHAO	AOAD/M_T	JPLA	—	—
	TIDB	AOAD/M_T	JPLA	—	—
	TID1	AOAD/M_T	JPLA	—	—
	TID2	AOAD/M_T	JPLA	—	—

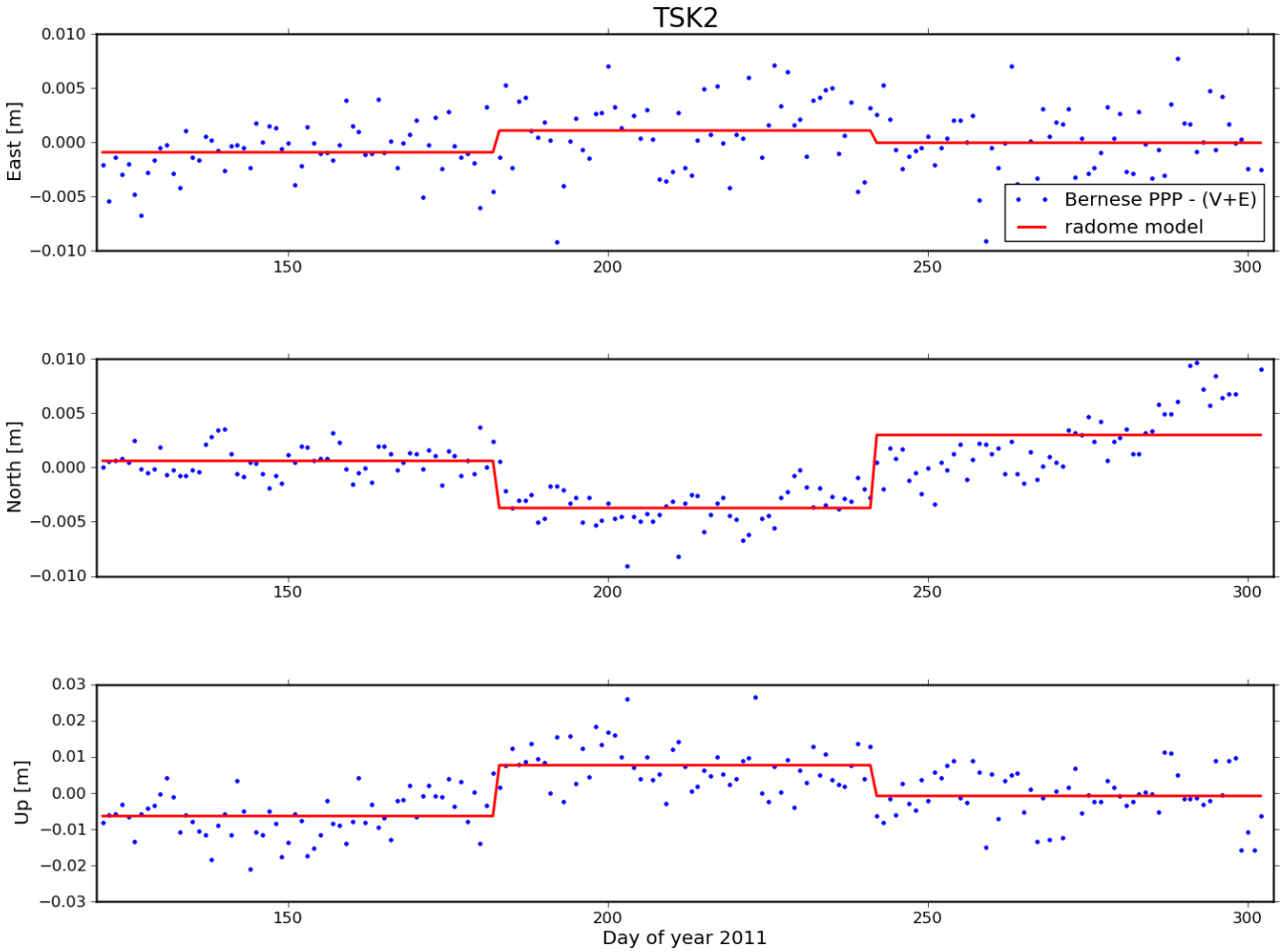
→ CRO1 results questionable due to switch from IGS05 to IGS08 in April 2011

Uncalibrated radomes at co-located stations (III)

Agency	Station	Antenna	Radome	Removed	Reinstalled
BKG	**LHAZ**	ASH701941.B	SNOW	tbd.?	—
GA	**YAR2**	AOAD/M_T	JPLA	2012-05-23	2012-09-28
GSI	**SYOG**	AOAD/M_T	DOME	—	—
	TSKB	AOAD/M_T	DOME	2011-07-01	2011-08-30
	TSK2	(TRM29659.00)	(DOME)	2011-07-01	2011-08-30
LMV	**ONSA**	AOAD/M_B	OSOD	—	—
NICT	**KGNI**	ASH701945C_M	SCIS	—	—
	KSMV	ASH700936E	SCIS	—	—
NMA	**NYA1**	ASH701073.1	SNOW	—	—
	NYAL	AOAD/M_B	DOME	—	—
WHU	**WUHN**	(ASH700936E)	ENCL	—	—

→ **8 out of 22** stations participated; TSK2 antenna replaced by calibrated one

Uncalibrated radomes at co-located stations (IV)



preliminary results by P. Rebischung (2011; corrected for post-seismic relaxation)

→ local tie corrections will be available for several ITRF2013 stations

Calibration status of the IGS network

Status of 440 IGS stations in January 2013:

Absolute robot calibration (azimuthal corrections down to 0° elevation)	76.8%
Converted field calibration (purely elevation-dependent PCVs above 10°)	7.7%
Uncalibrated radome (or unmodeled antenna subtype)	15.5%

Examples for unmodeled antenna subtypes (initially undetected!):

JPSREGANT_DD_E
JPSREGANT_SD_E

LEISR399_INT

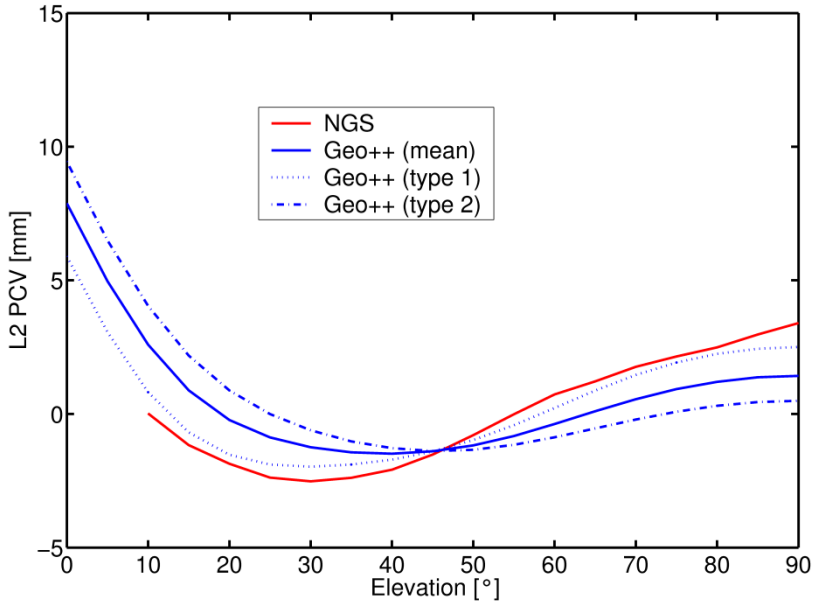
JAVTRIANT

?

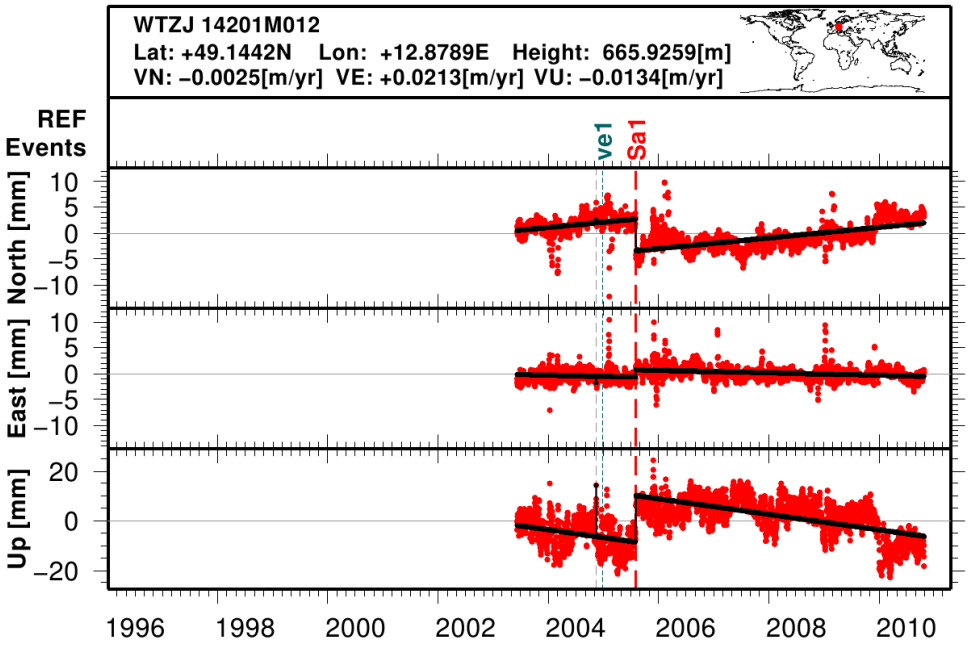
further undetected subtypes?

The JPSREGANT problem

- antenna set-up probably changed in 2000
- subtypes detected by Geo++ GmbH in 2002/03
- subtypes considered by IGS in 2012: coordinate corrections of up to ± 20 mm in the vertical component [IGSMAIL-6662]



→ fewer/smaller jumps in ITRF2013 time series



WTZJ time series from CODE reprocessing (Steigenberger 2011)

Quality of phase center calibrations (I)

Calibration institutions approved by the IGS:

Geo++ GmbH

Univ. Hannover

SenStadt Berlin

Univ. Bonn

NGS (GPS-only)

Geo++ specifications (Wübbena et al., 2003, 2006):

- precision/standard deviation for L1/L2 PCVs: **< 0.5 mm**
- repeatability (different place/robot): **< 1 mm**

IGS requirements for new calibration institutions (since Newcastle 2010):

- **< 1 mm** agreement with robot results above 10° elevation and
- **< 2 mm** below 10° for azimuthal PCVs

DGFI EGE

Quality of phase center calibrations (II)

Amplification of PCV uncertainties in the position domain:

- amplification by a **factor of 3**, if the ionosphere-free linear combination is applied
- further amplification depending on troposphere modeling, etc.
- PCV errors superimposed by **station-specific effects** like multipath

Calibration institutions cannot meet the IGS requirements for every antenna type:

- **near-field multipath** of the calibration instrumentation is the dominant error source (Aerts et al., 2013)
- **diversity of the antenna quality** as regards the phase center stability

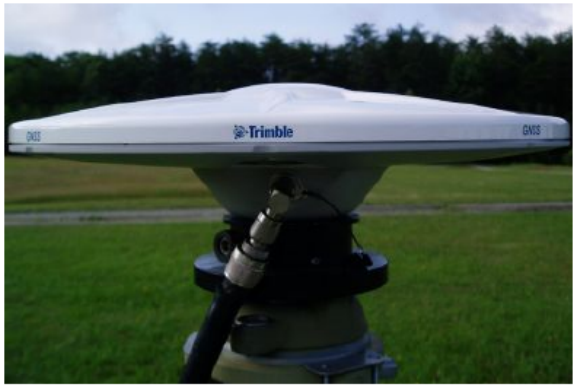
→ **Absolute** GNSS station positions cannot be determined with mm accuracy

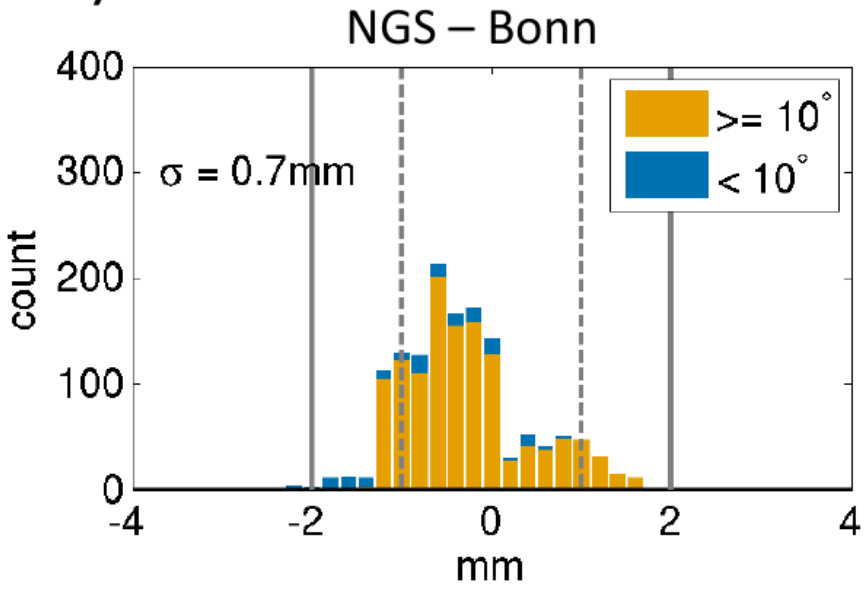
Calibration differences for identical antennas (I)

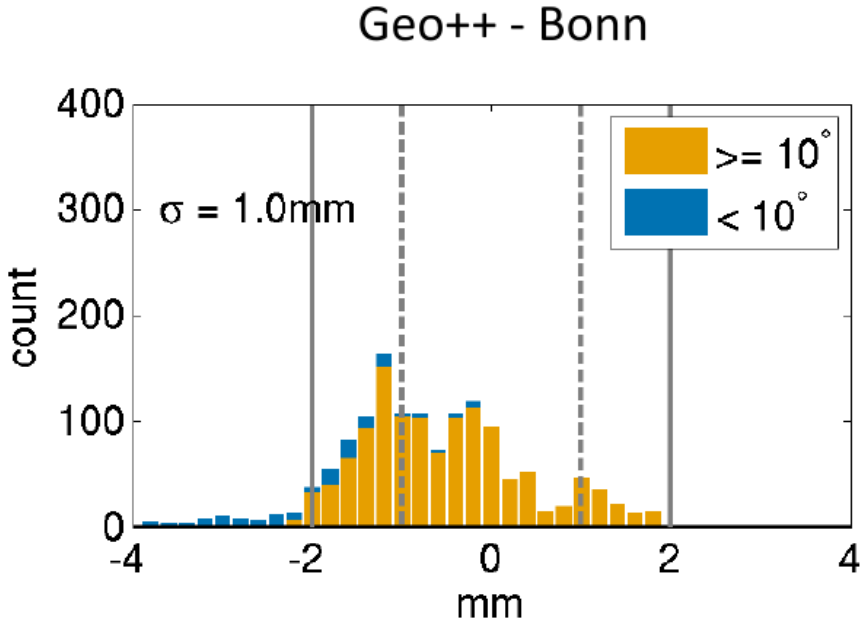
Trimble Zephyr 2 (TRM55971.00)

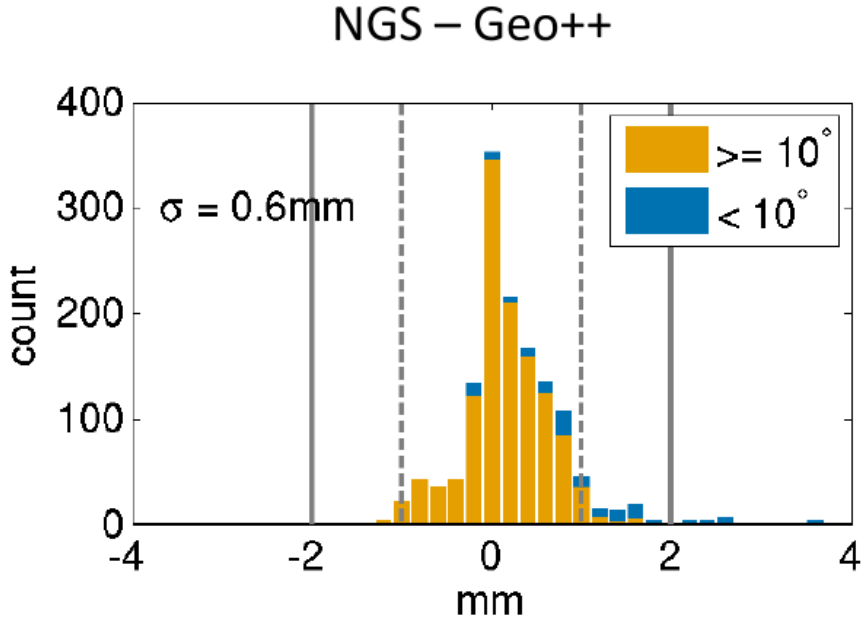
GPS L2 differences

Bilich et al. (2012)









Calibration differences for identical antennas (II)

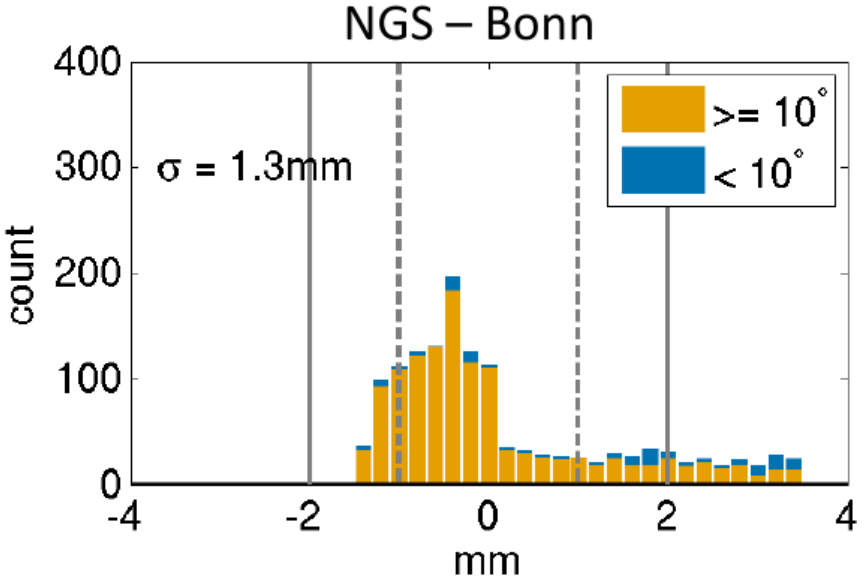
Bilich et al. (2012)

Trimble GNSS chokering

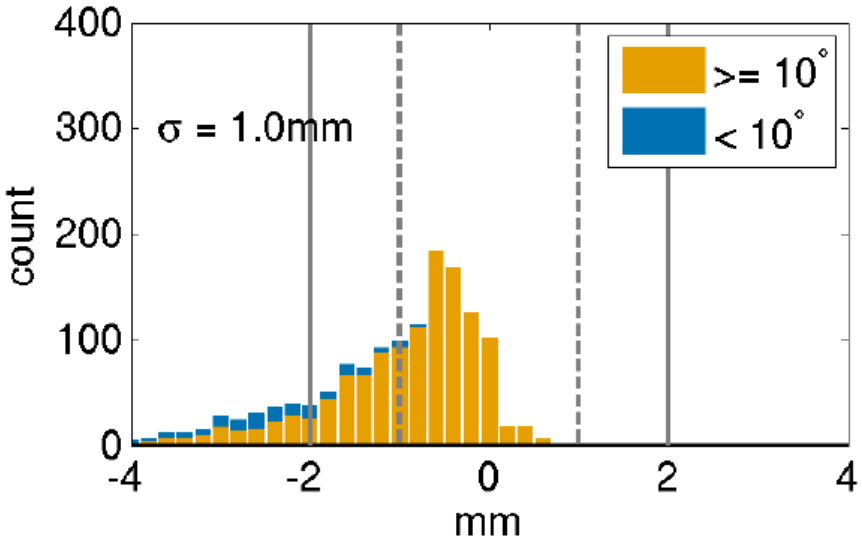
GPS L2 differences

L2 pattern size = 100 mm

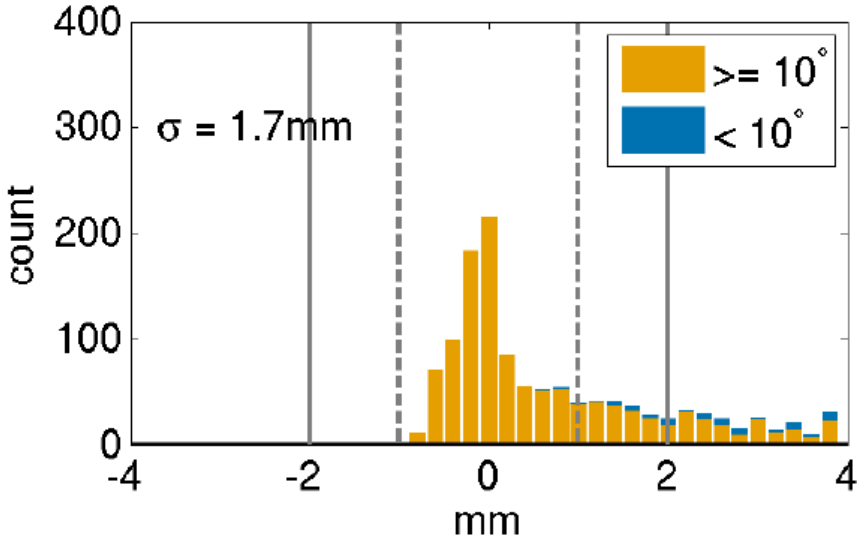
NGS – Bonn



Geo++ - Bonn

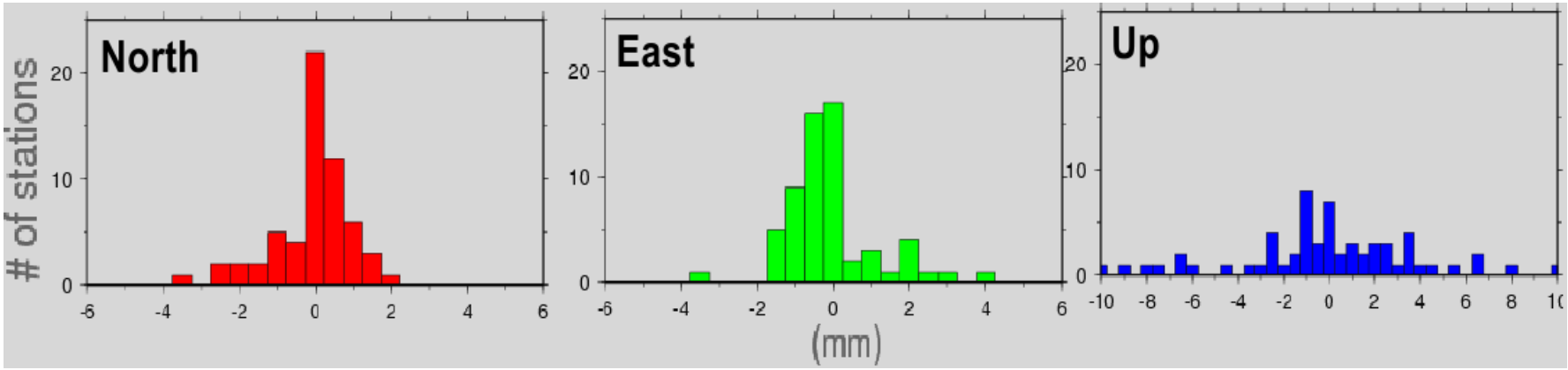


NGS – Geo++



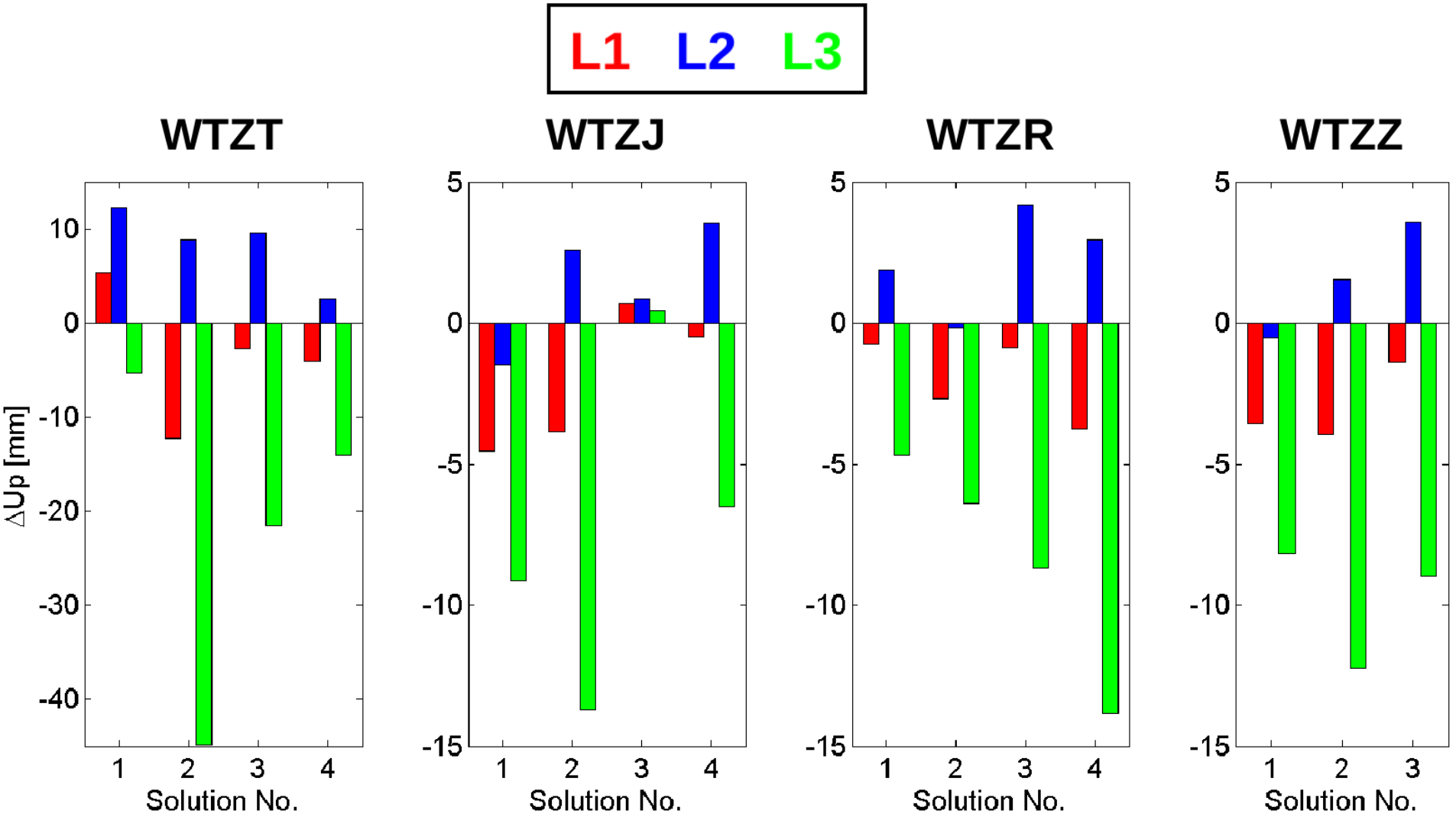
Individual vs. type mean calibrations

- EPN uses individual antenna calibrations, if available; IGS model igs08.atx restricted to type mean calibrations
- usually, differences between individual antennas of the same type are smaller than differences between calibration institutions
- however, individual calibrations would help to detect malfunctioning antennas and unreported changes of the set-up (cf. JPSREGANT problem)
- impossible to get individual calibrations for current and legacy IGS network



Position offsets induced by individual calibrations for 53 EPN stations (Baire et al., 2012)

Near- and far-field multipath dominates!?



Height differences between the baseline w.r.t. WTZA and the corresponding local tie (troposphere parameters estimated; Steigenberger et al., 2011)

Conclusions

- Considerable **reduction of GNSS-specific biases** with adoption of absolute IGS antenna phase center models (igs05.atx, igs08.atx)
- 8 out of 22 **uncalibrated radomes temporarily removed** at co-located sites to get tie corrections for ITRF2013
- **Fewer/smaller jumps** in coordinate time series due to consideration of JPSREGANT subtypes
- IGS calibration institutions **do not agree on the 1 mm level** at the moment
- Accuracy of 1 mm for L1/L2 PCVs not sufficient to realize absolute station positions on the same level due to **amplification of the error by forming the ionosphere-free linear combination**
- **Individual calibration** ideal to check the proper functioning of an antenna, but difficult to implement on the IGS level
- **Near- and far-field multipath** are most likely the limiting error source

Thanks for your attention!

SKE0