Multi-technique combination at observation level with NAPEOS
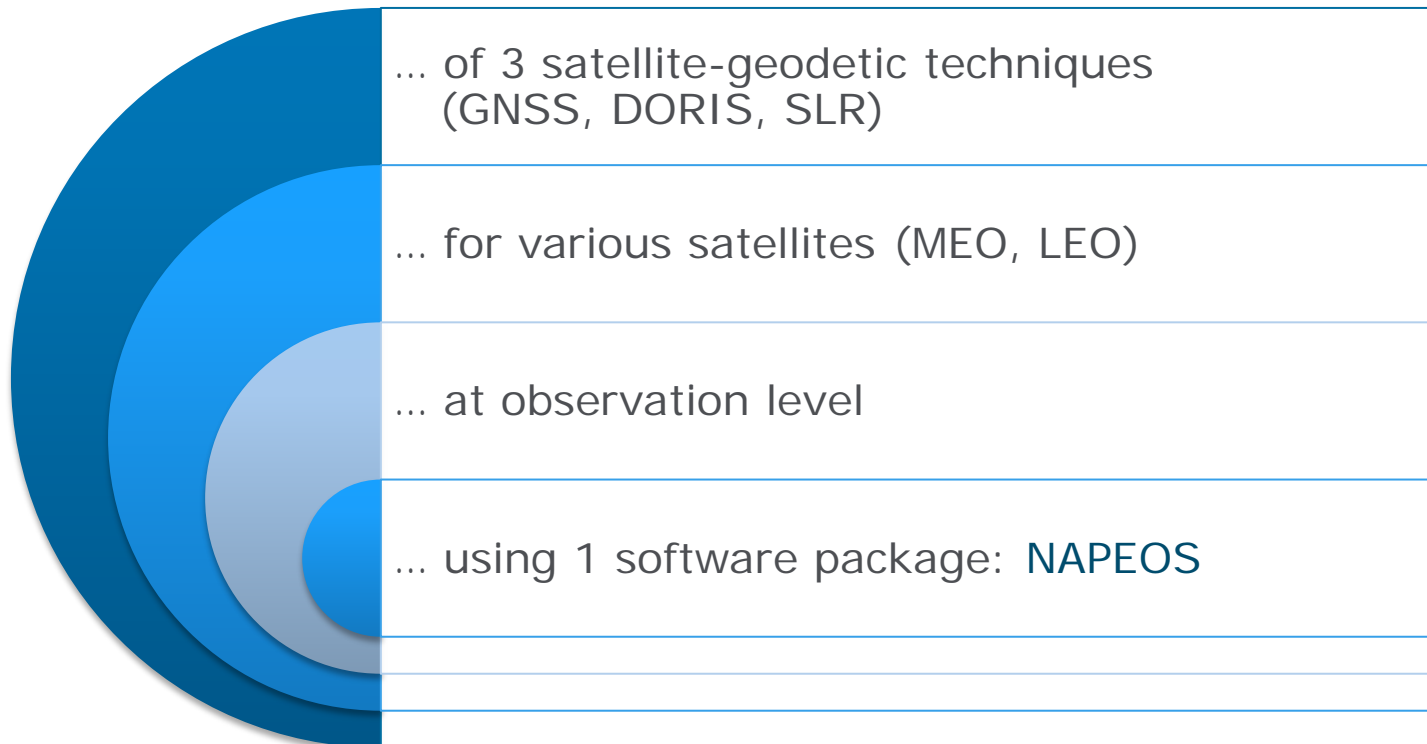
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Combination ...

	... of 3 satellite-geodetic techniques (GNSS, DORIS, SLR)
	... for various satellites (MEO, LEO)
	... at observation level
	... using 1 software package: NAPEOS

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Motivation

IERS products

- ITRF / ICRF / EOP
- produced by individual analysis centers (process only one space-geodetic technique: GNSS, SLR, DORIS, VLBI)

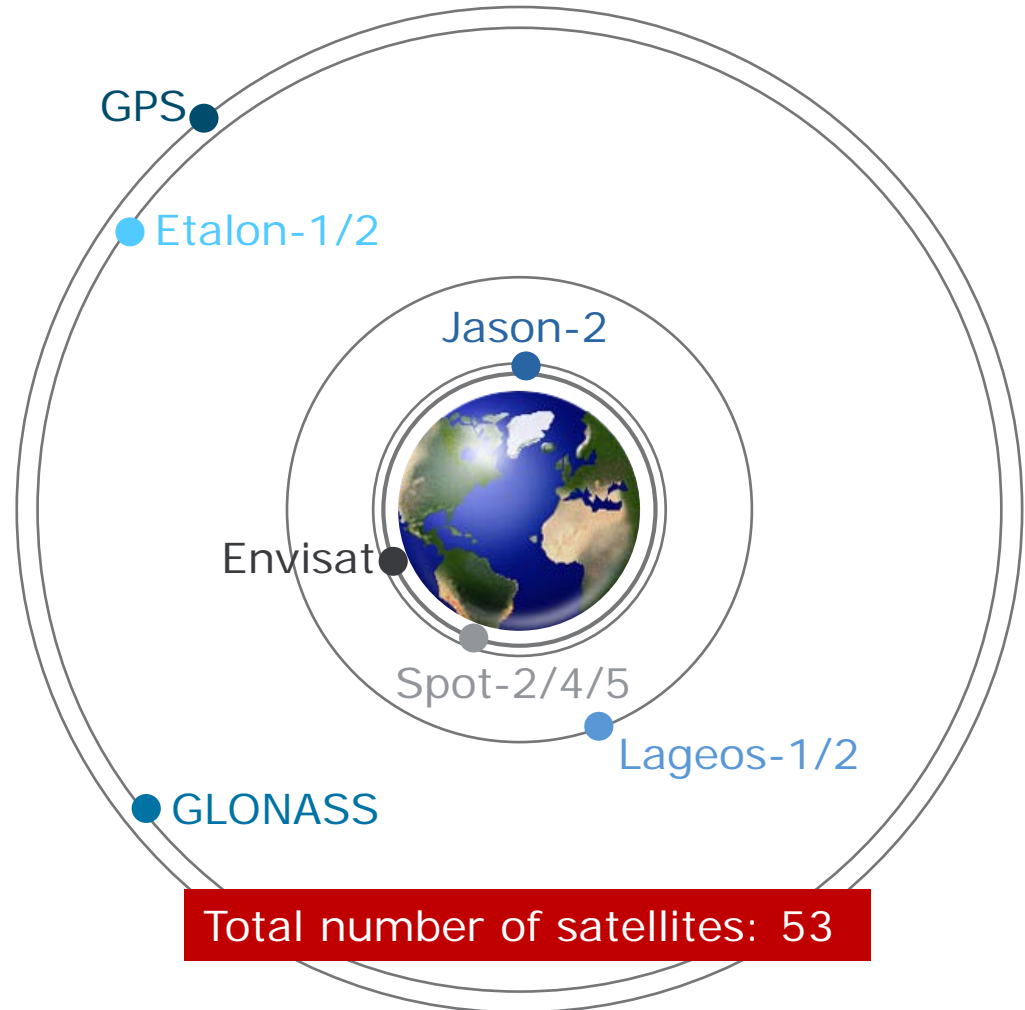## Technique-dependent combination

- IGS, ILRS, IDS, IVS
- no guaranty on homogeneity / consistency between techniques
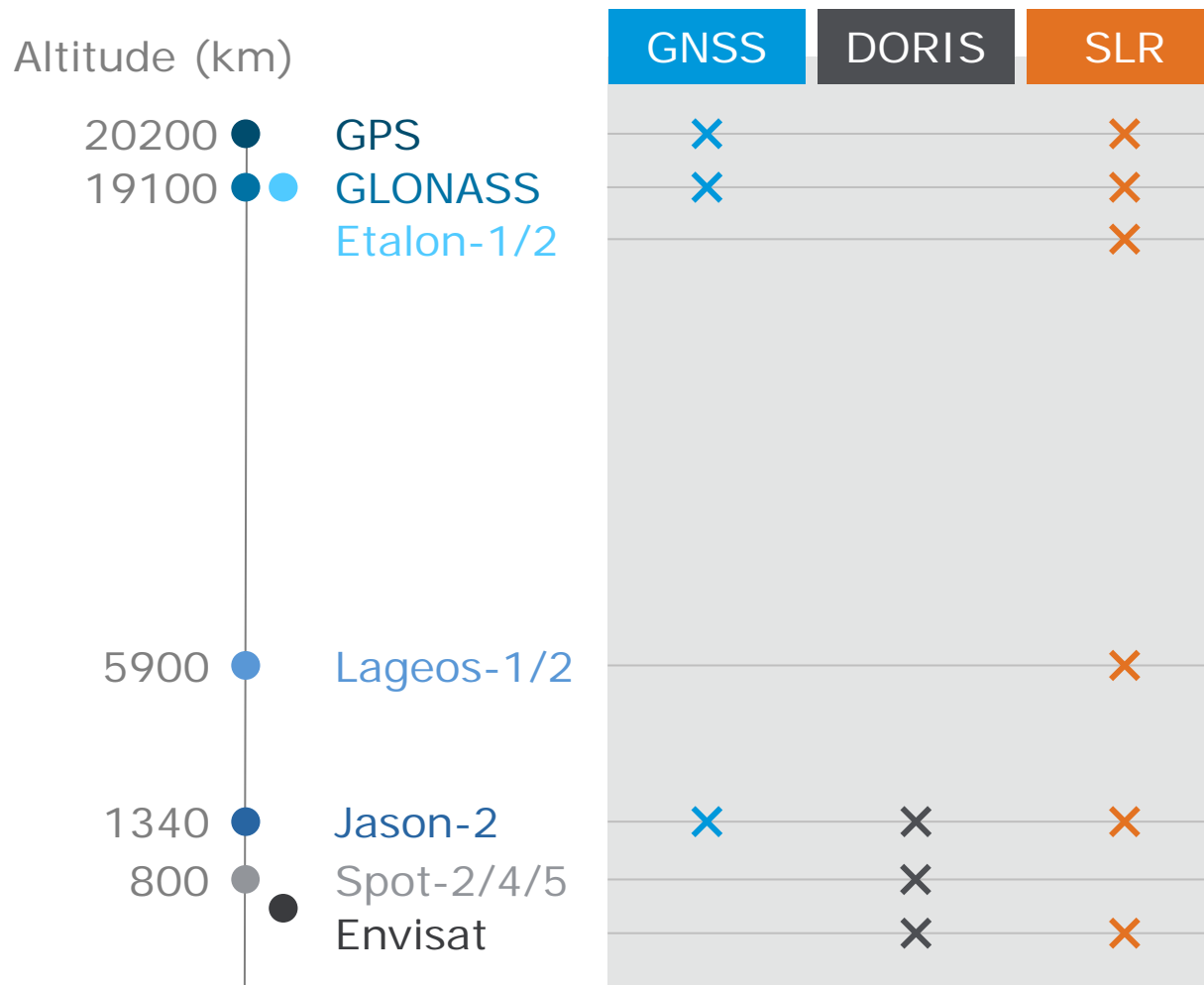
Multi-technique combination

- at observation level
- process techniques together in one run
- make use of different strengths and weaknesses
- detect and reduce technique specific systematic behaviour

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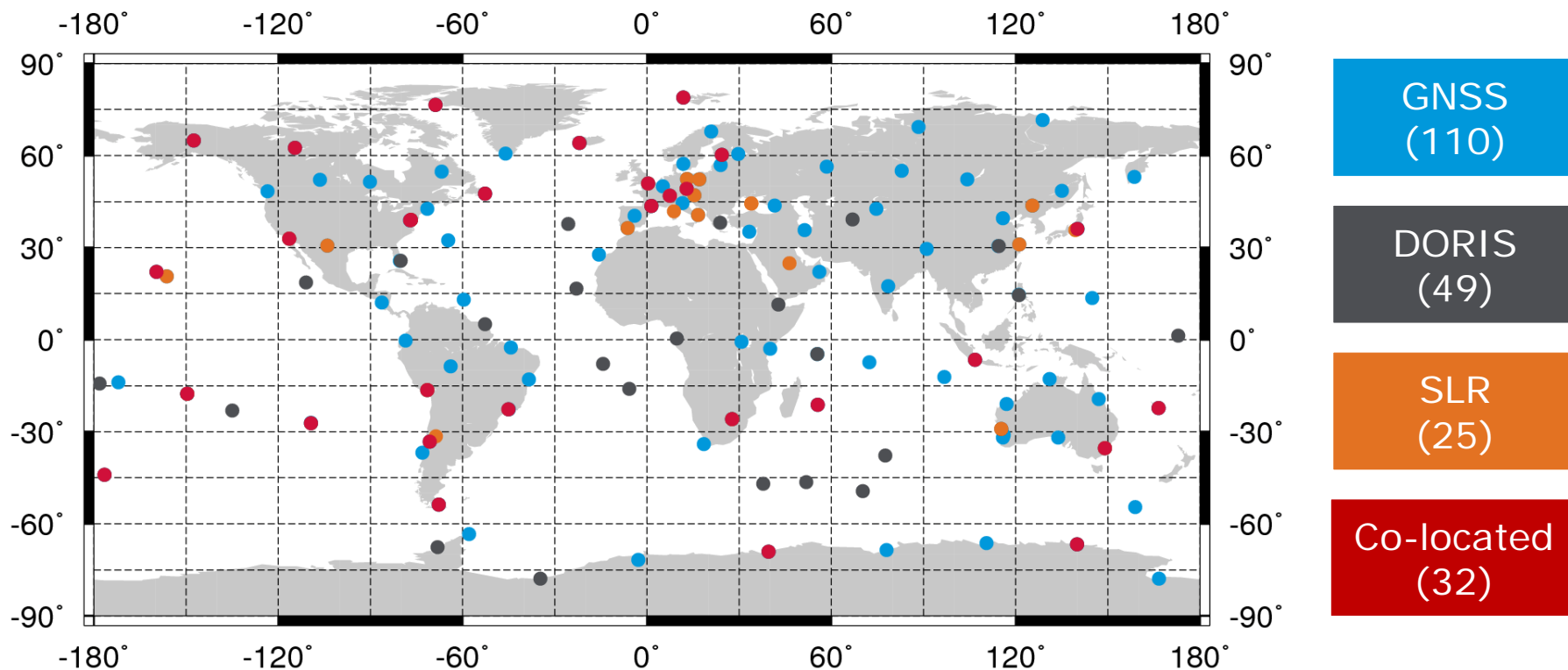
Used satellites

GPS		31
GLONASS		13
Etalon-1/2		2
Lageos-1/2		2
Jason-2		1
SPOT-2/4/5		3
Envisat		1

GPS
Etalon-1/2
Jason-2
Envisat
Spot-2/4/5
Lageos-1/2
GLONASS

Total number of satellites: 53

Combining measurement types

Altitude (km)		GNSS	DORIS	SLR
20200	GPS	✕		✕
19100	GLONASS	✕		✕
	Etalon-1/2			✕
5900	Lageos-1/2			✕
1340	Jason-2	✕	✕	✕
800	Spot-2/4/5		✕	
	Envisat		✕	✕

Station distribution (DoY 223)

GNSS (110)

DORIS (49)

SLR (25)

Co-located (32)

Typical number of stations: ~184

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Processing with NAPEOS (1/2)

Models and Reference frame

- ITRF2008 reference frame
- IERS2003 standards
- Box-Wing model for all LEO satellite surface forces
- extended Antex IGS08 for GPS antenna phase center model

Observations

- 10/08/2008 – 30/08/2008 (CONT08)
- 1-day arc solutions
- 1 min sampling rate of GNSS observations (GNSS stations, Jason-2)

# Processing with NAPEOS (2/2)

Estimated parameters

- satellite orbits, clocks, station coordinates, EOPs, troposphere
- GPS: integer ambiguities (~90%) (GPS satellites, Jason-2)
- DORIS: range rate bias per pass

Performance

- Typical number of daily parameters: 16'000 + 220'000 clock parameters
- CPU time: 120 min @2.8GHz Intel Xeon CPU
- Memory: 6 GB

GPS station repeatability
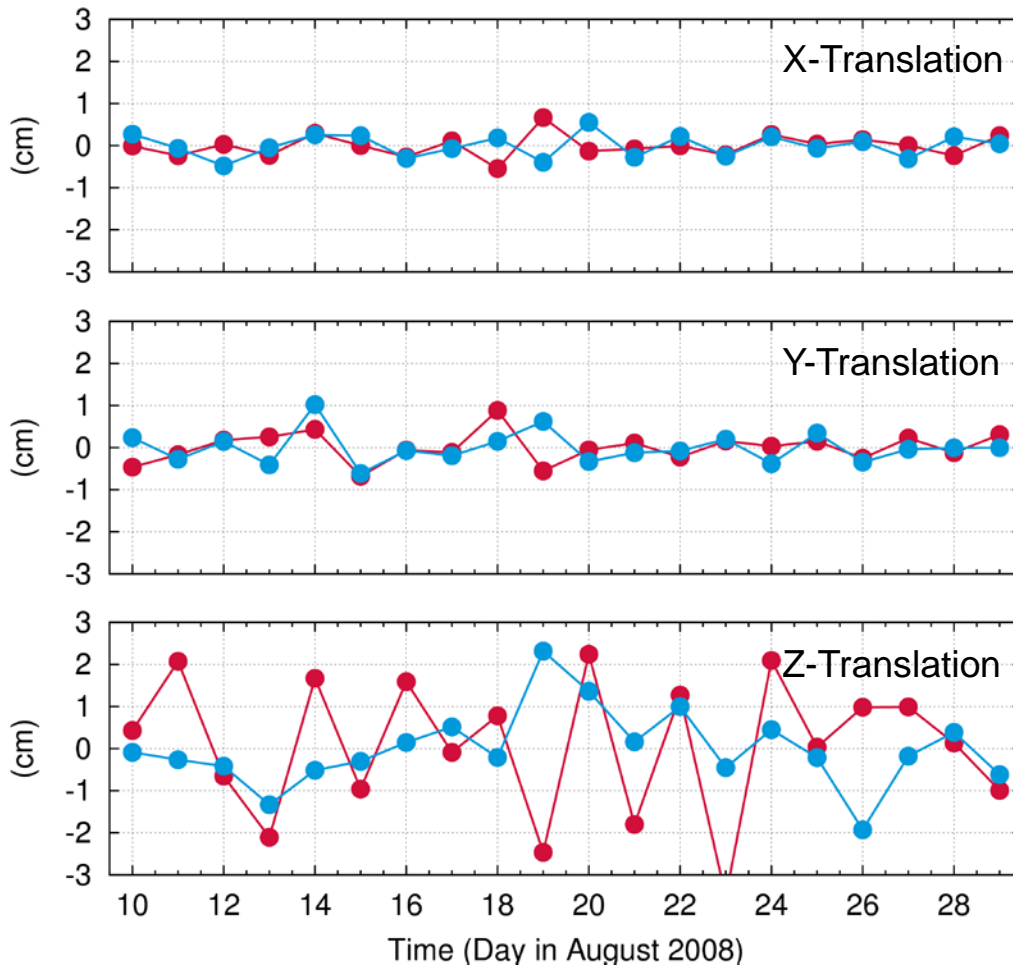## ... of daily solutions – without Helmert transformation
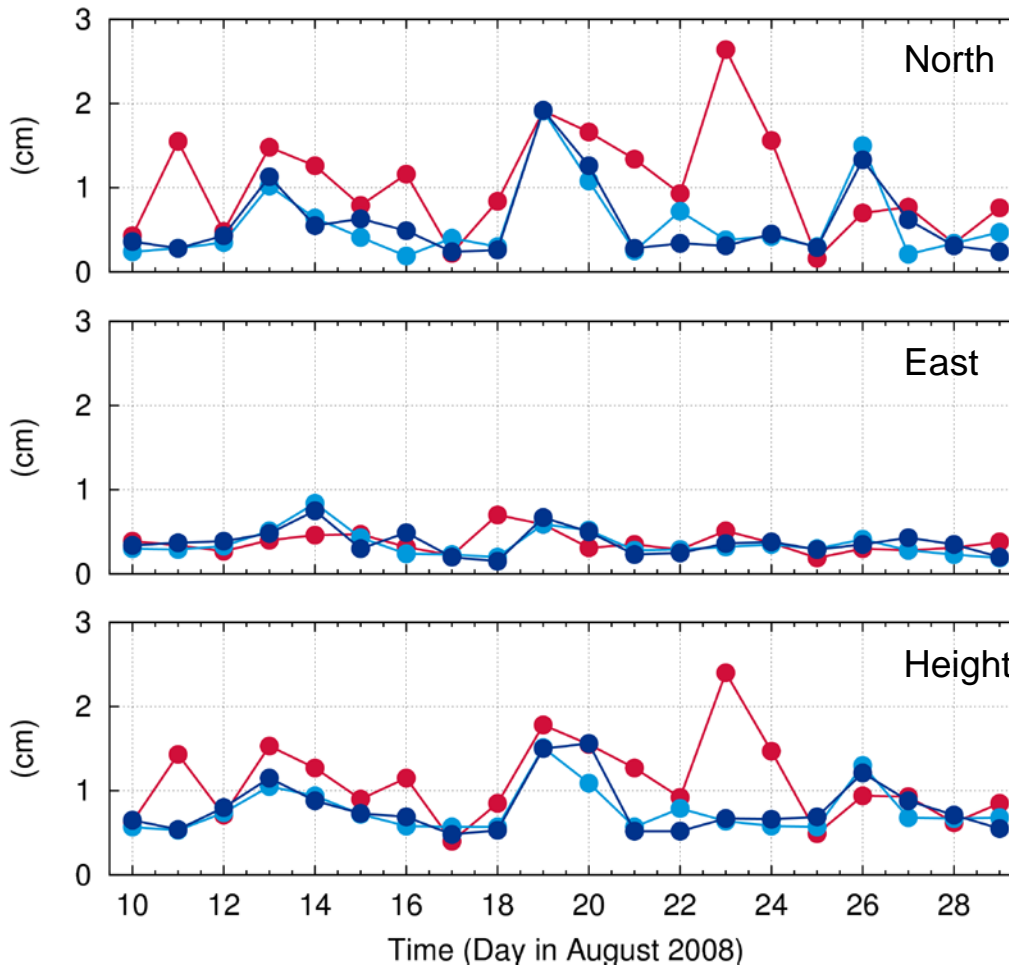
Mean RMS (STD)

IGS	1.0	(±0.6)
+JA2	0.6	(±0.5)
ALL	0.6	(±0.5)

	0.4	(±0.1)
	0.4	(±0.2)
	0.4	(±0.2)

	1.1	(±0.5)
	0.8	(±0.3)
	0.8	(±0.3)

Unit: cm

Adding Jason-2 to the IGS solution
Helmert transformation parameters

Mean RMS (STD)

X-Translation

IGS

+JA2

0.0	(±0.3)
0.0	(±0.3)

Y-Translation

0.0	(±0.4)
0.0	(±0.4)

Z-Translation

0.1	(±1.6)
0.0	(±0.9)

Unit: cm

Time (Day in August 2008)

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DORIS station repeatability
... of weekly solutions – without Helmert transformation
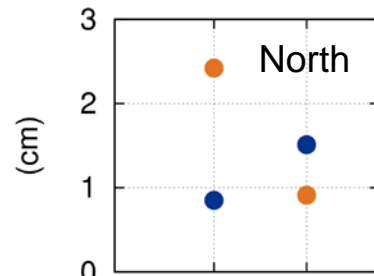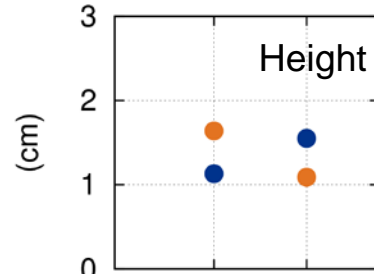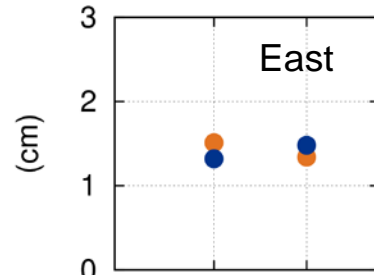
Mean RMS (STD)

1.7	(±1.1)
1.2	(±0.5)

1.4	(±0.1)
1.4	(±0.1)

1.4	(±0.4)
1.3	(±0.3)

Unit: cm

Orbit overlap errors for GPS satellites
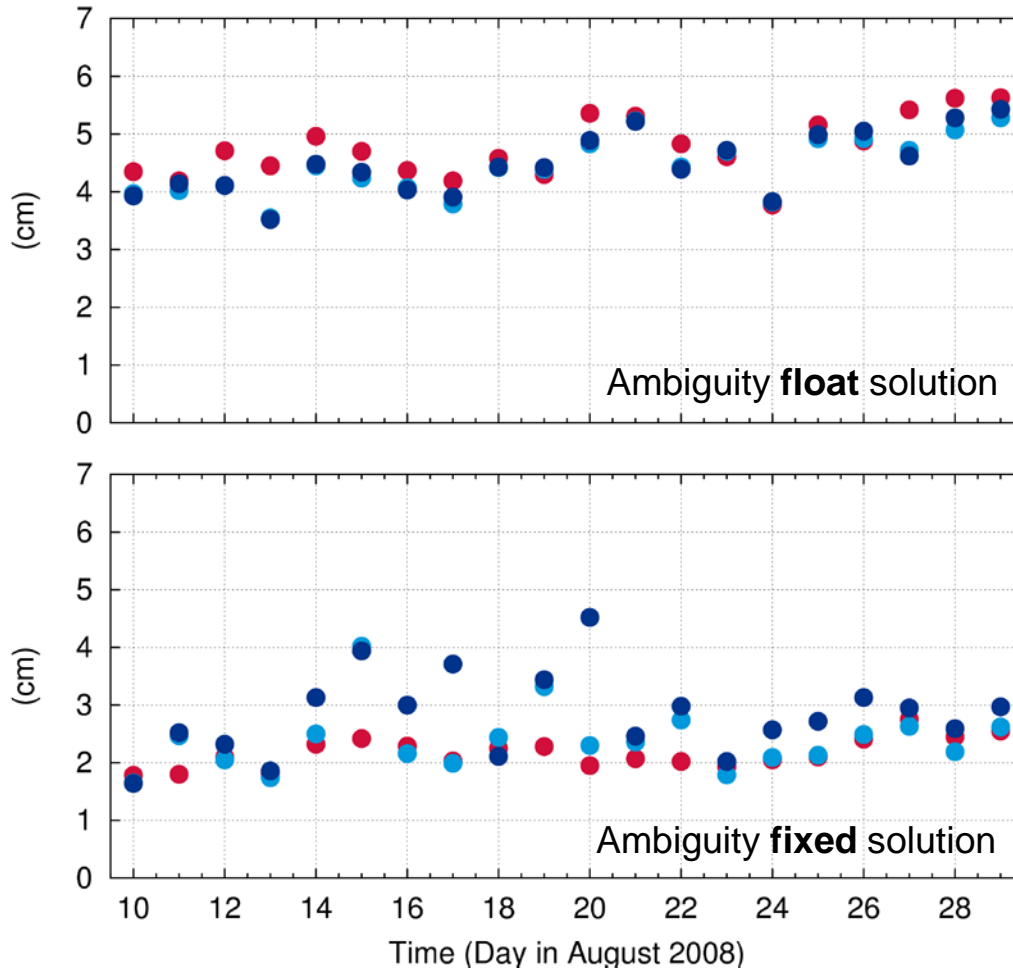
Mean RMS (STD)

IGS +JA2 ALL

4.8	(±0.5)
4.4	(±0.5)
4.5	(±0.5)

2.2	(±0.3)
2.4	(±0.5)
2.8	(±0.7)

Unit: cm

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Conclusions (1/2)

Multi-technique combination at observation level

In one global run

- Using one software package: NAPEOS

Improve accuracy and consistency of geodetic products

- Combination improves geocenter Z-component
- Combination improves GPS orbits of the ambiguity float solution

Detect inconsistencies between techniques

- Orbit overlap errors increase for the combined solution when fixing ambiguities → orbit model deficiencies?

Conclusion (2/2)

Multi-technique combination at observation level

Next steps

- Tuning of orbit parameter set-up
- Estimation of GPS antenna phase center offsets (Z-component)
- Integration of ILRS SINEX files into our combined solution (Lageos-1/2, Etalon-1/2)

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