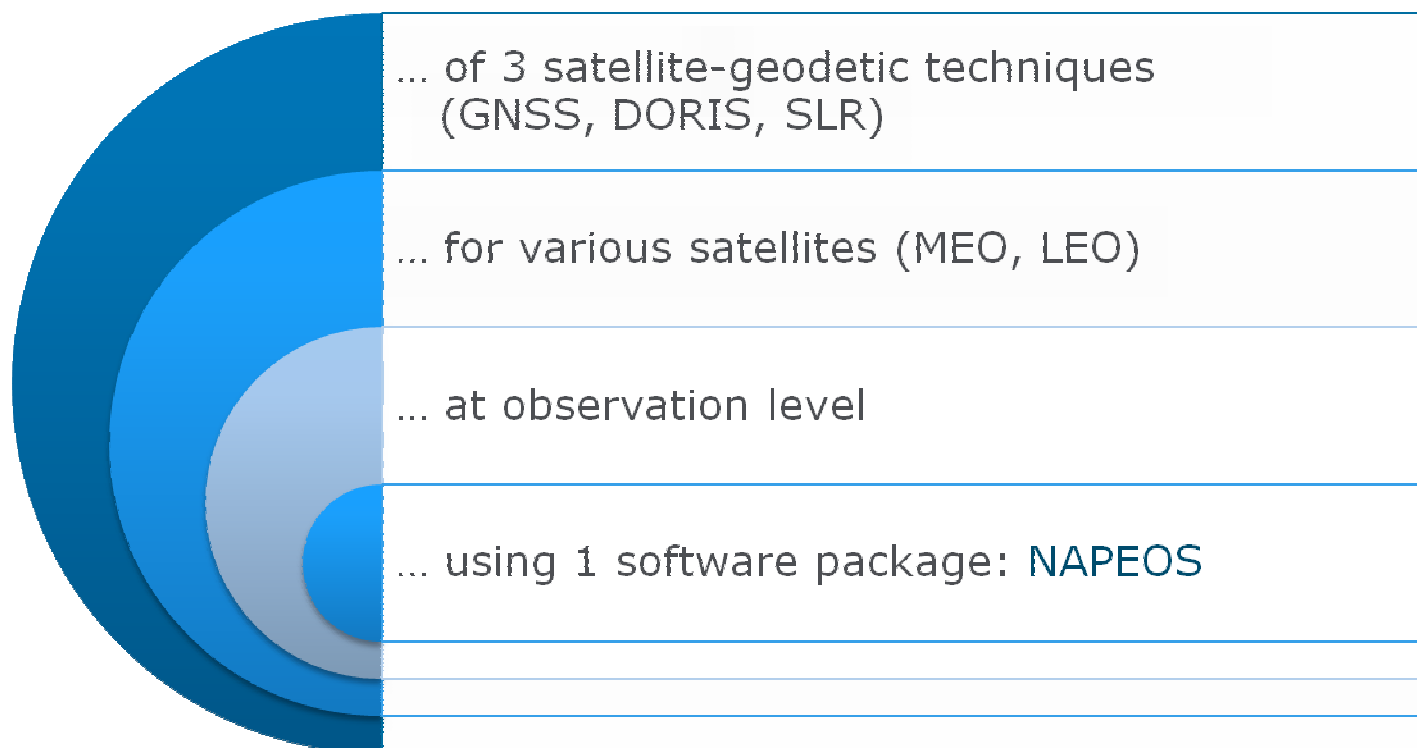


# Multi-technique combination at observation level with NAPEOS

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## Combination ...



## 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

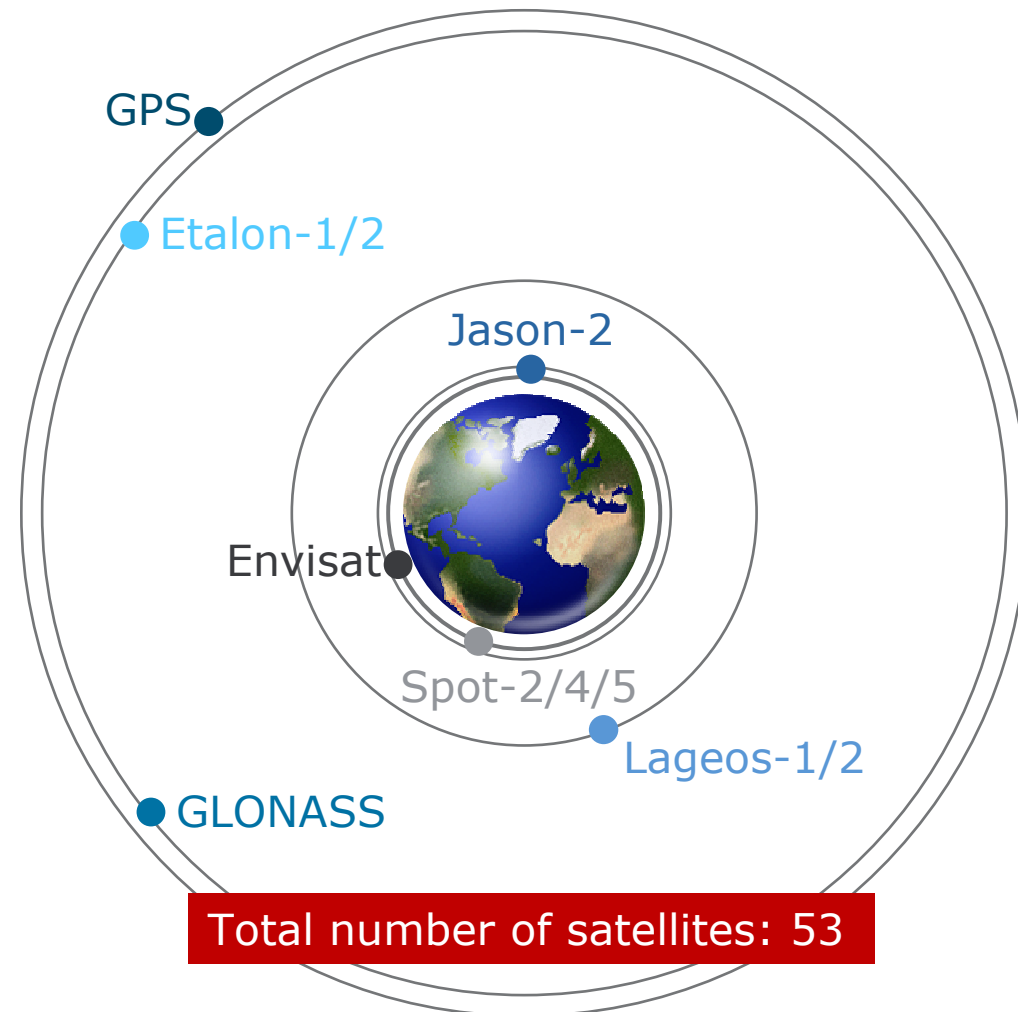
## Multi-technique combination

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

# Used satellites



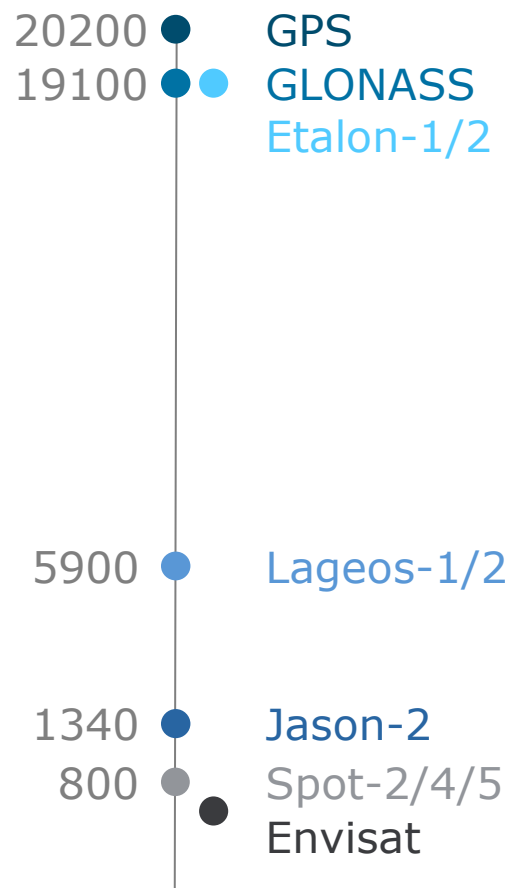
GPS		31
GLONASS		13
Etalon-1/2		2
Lageos-1/2		2
Jason-2		1
SPOT-2/4/5		3
Envisat		1



# Combining measurement types

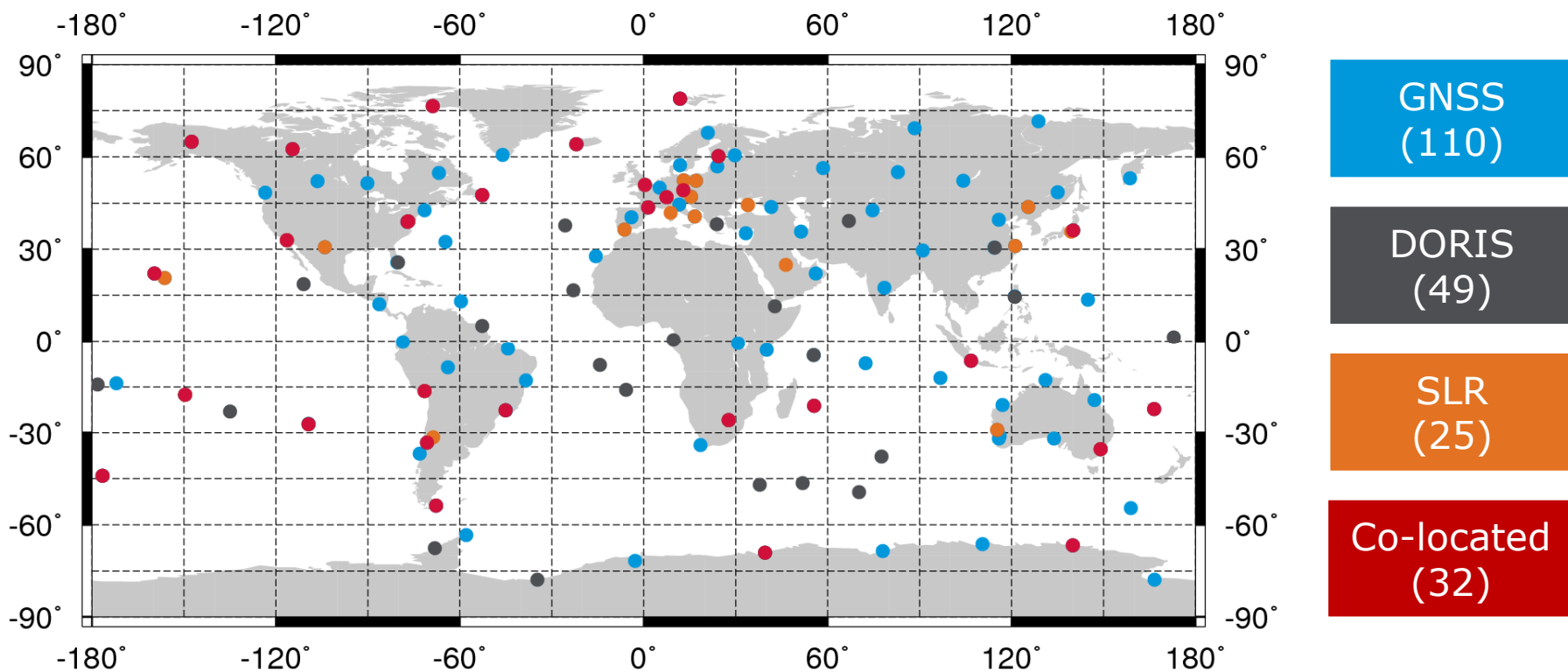


Altitude (km)



	GNSS	DORIS	SLR
GPS	X		X
GLONASS	X		X
Etalon-1/2			X
Lageos-1/2			X
Jason-2	X	X	X
Spot-2/4/5		X	
Envisat		X	X

# Station distribution (DoY 223)



Typical number of stations: ~184

## 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)

## Estimated parameters

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

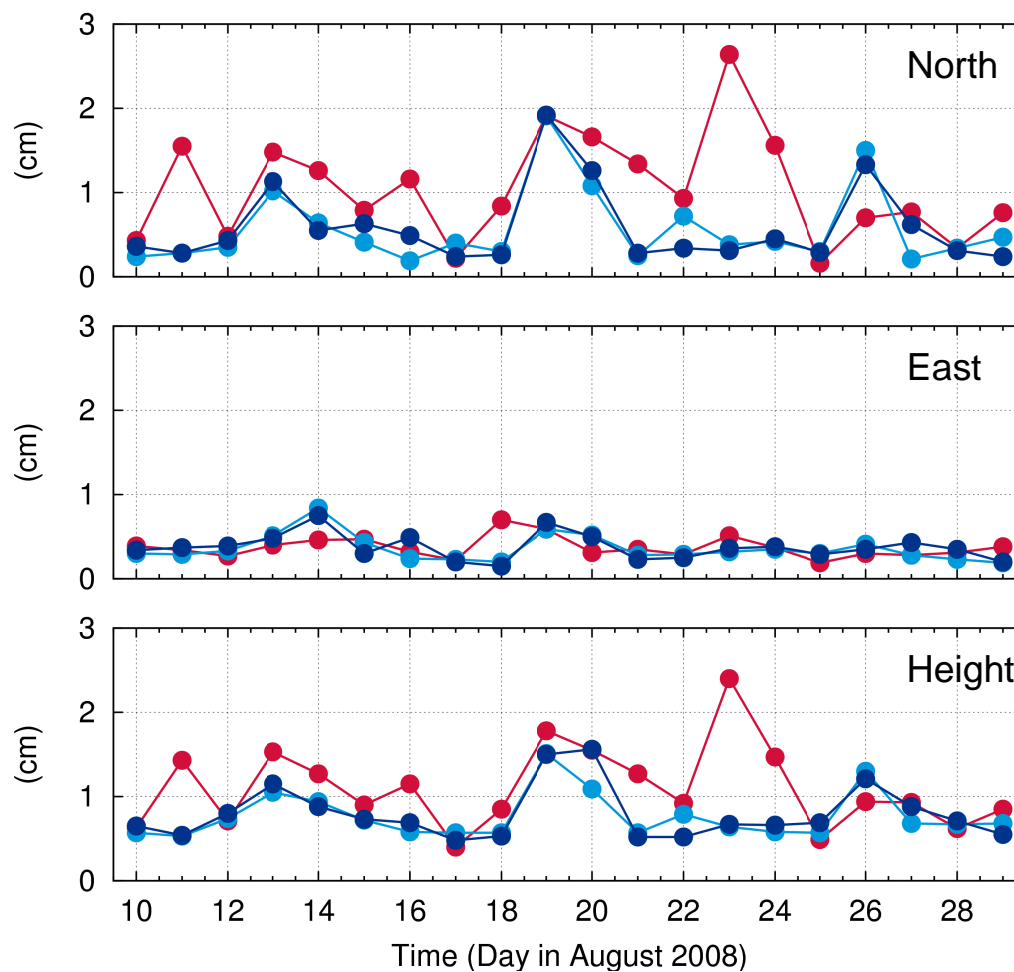
## Performance

- 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



IGS  
+JA  
ALL

Mean RMS (STD)

1.0 (±0.6)

0.6 (±0.5)

0.6 (±0.5)

0.4 (±0.1)

0.4 (±0.2)

0.4 (±0.2)

1.1 (±0.5)

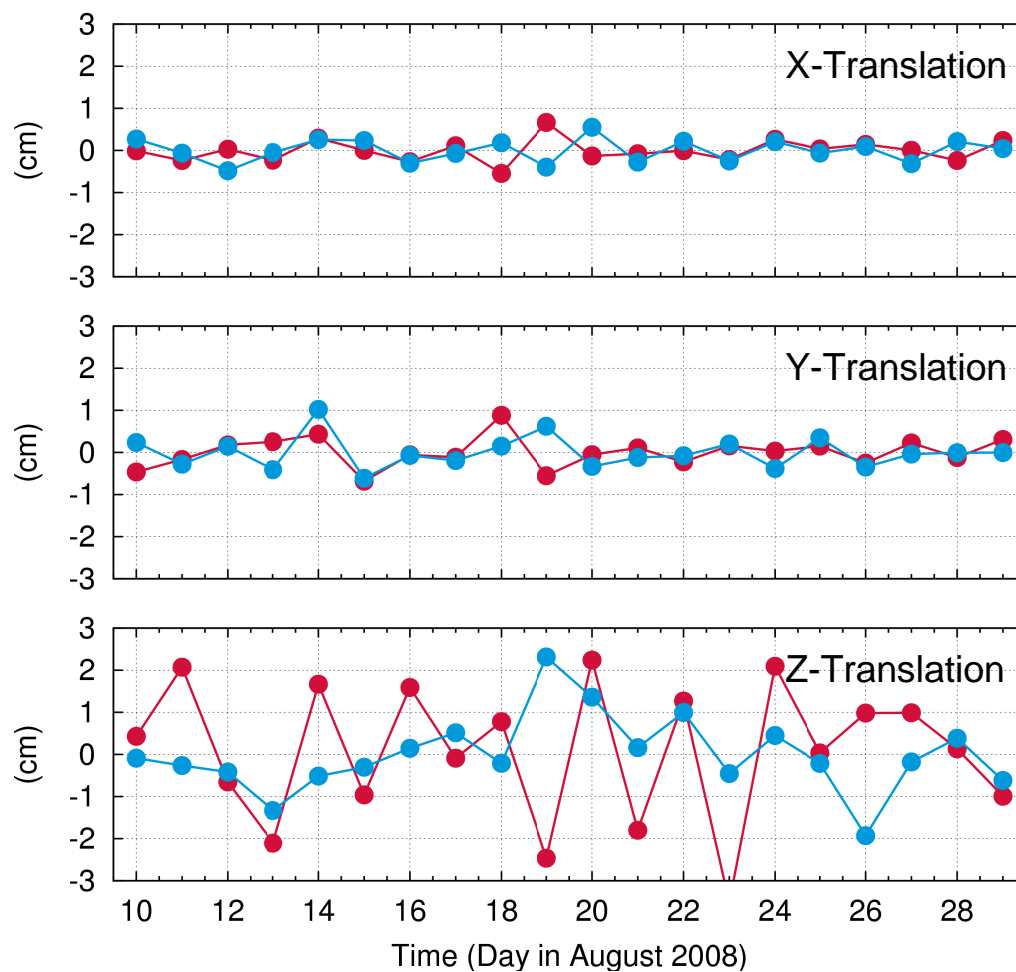
0.8 (±0.3)

0.8 (±0.3)

Unit: cm

# Adding Jason-2 to the IGS solution

## Helmert transformation parameters



IGS  
+JA  
2

Mean RMS (STD)

0.0 (±0.3)

0.0 (±0.3)

0.0 (±0.4)

0.0 (±0.4)

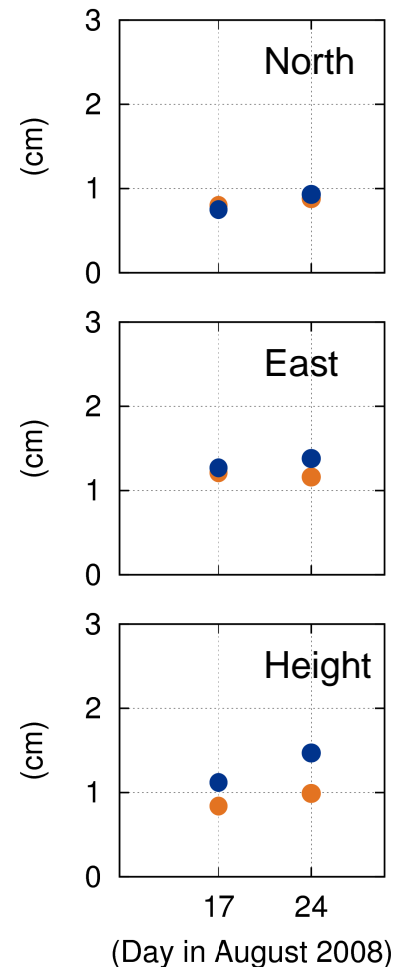
0.1 (±1.6)

0.0 (±0.9)

Unit: cm

# DORIS station repeatability

... of weekly solutions



Mean RMS (STD)

0.8 ( $\pm 0.1$ )

0.8 ( $\pm 0.1$ )

1.2 ( $\pm 0.0$ )

1.3 ( $\pm 0.1$ )

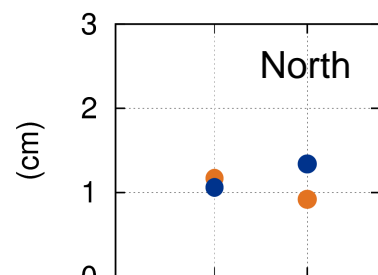
0.9 ( $\pm 0.1$ )

1.3 ( $\pm 0.2$ )

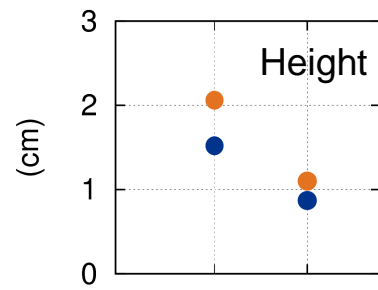
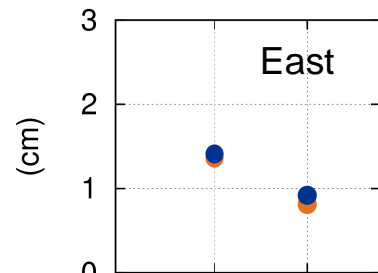
Unit: cm

# SLR station repeatability

... of weekly solutions



ILRS  
ALL



17 24  
(Day in August 2008)

Mean RMS (STD)

1.0 ( $\pm 0.2$ )

1.2 ( $\pm 0.2$ )

1.1 ( $\pm 0.4$ )

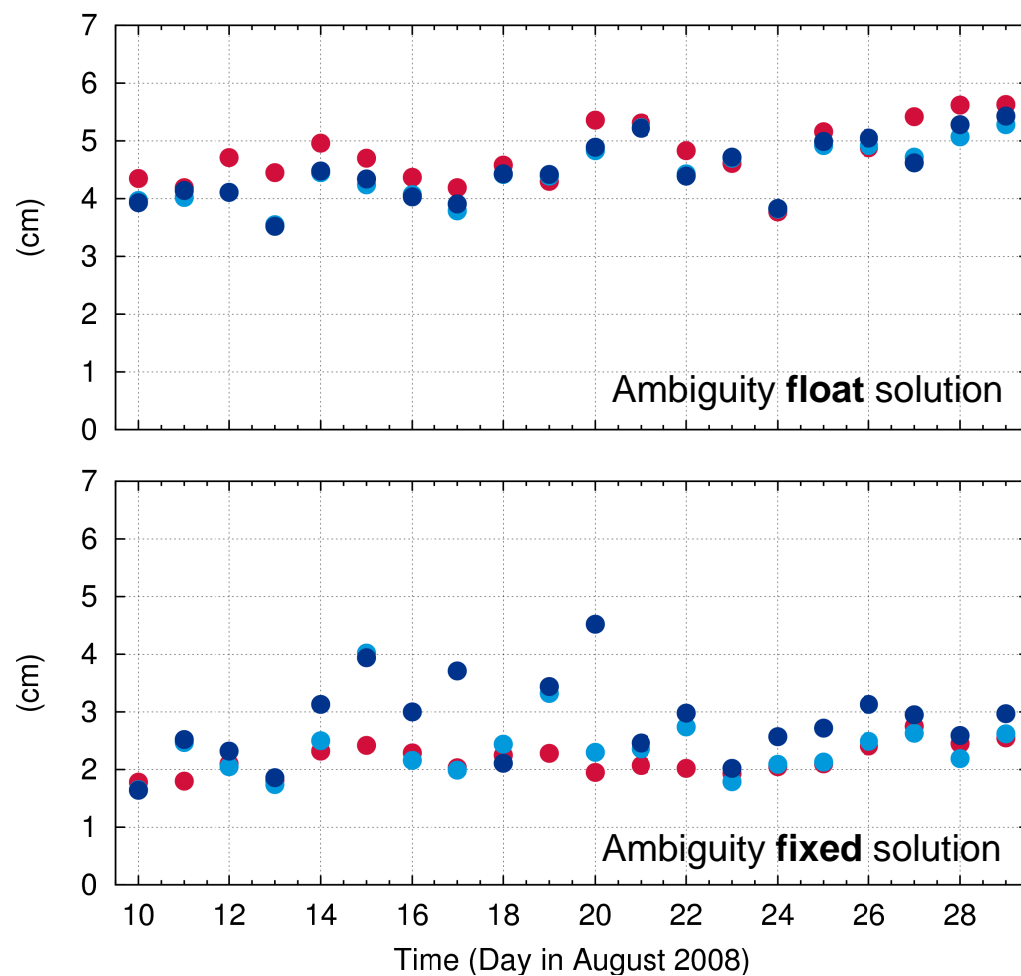
1.2 ( $\pm 0.3$ )

1.6 ( $\pm 0.7$ )

1.2 ( $\pm 0.5$ )

Unit: cm

# Orbit overlap errors for GPS satellites



Mean RMS (STD)

4.8 ( $\pm 0.5$ )

4.4 ( $\pm 0.5$ )

4.5 ( $\pm 0.5$ )

2.2 ( $\pm 0.3$ )

2.4 ( $\pm 0.5$ )

2.8 ( $\pm 0.7$ )

Unit: cm

## 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?

## Multi-technique combination at observation level

### Next steps

- Tuning of orbit parameter set-up
- Estimation of GPS antenna phase center offsets (Z-component)
- Processing of CONT11 period