MGEX data analysis at CODE - first experiences

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Contents

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- RINEX data issues
- MGEX rapid routine at CODE
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- Summary

MGEX data monitoring

- Data sources: CDDIS, BKG, IGN
- Number of stations: 25 (DOY 50) - 40 (DOY 200)
- RINEX types:
  - Versions: 2.11, 3.00, 3.01, 3.02
  - for some stations RINEX2 and RINEX3
  - established IGS stations and new stations
- Supported satellite systems (DOY 175, 40 MGEX stations):
  - **GPS**: 40 stations
  - **GLONASS**: 38 stations
  - Galileo: 34 stations
  - SBAS: 23 stations
  - COMPASS: 6 stations
  - QZSS: 2 stations

=> Our main focus is on: Galileo

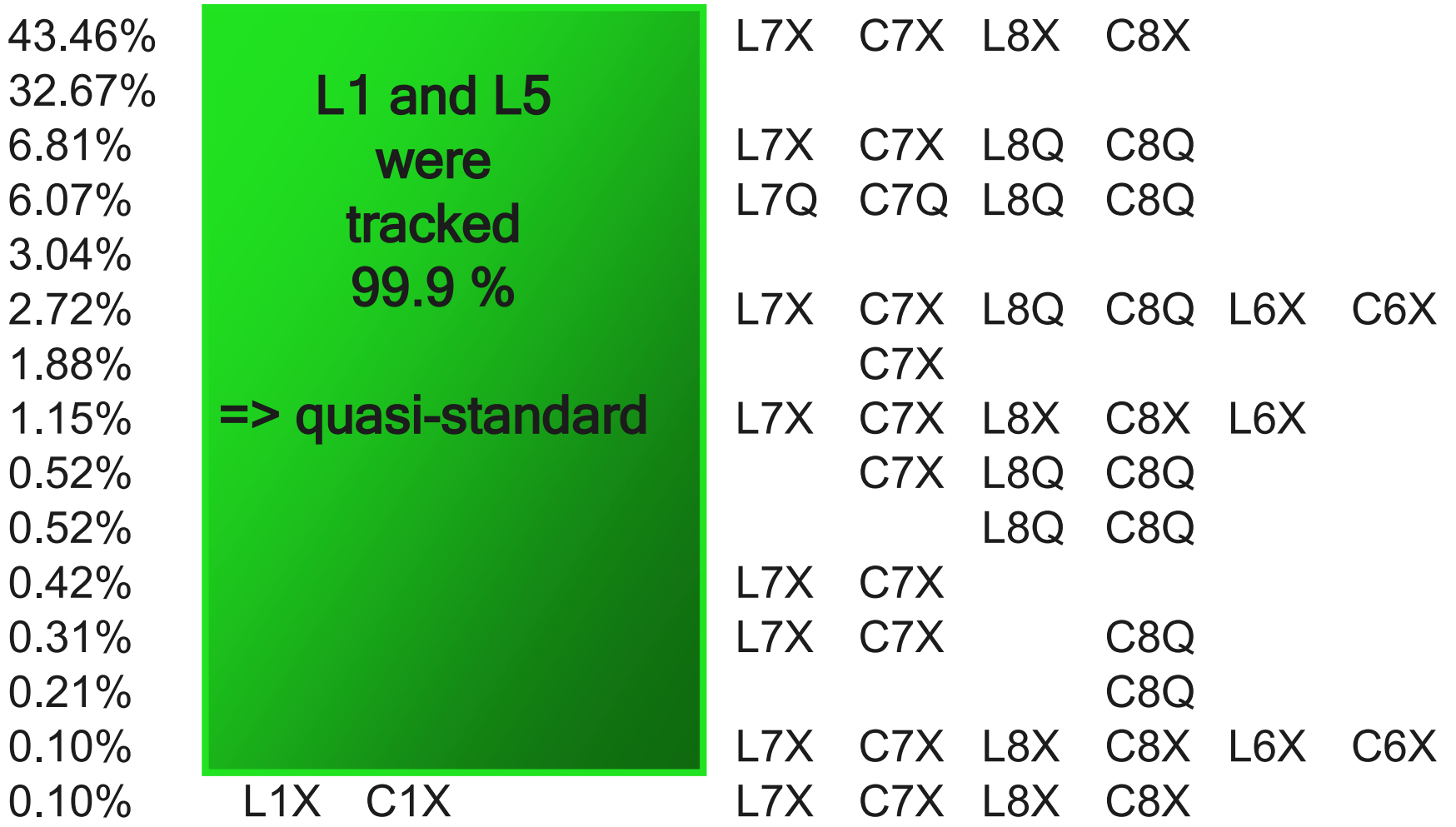
MGEX data monitoring

Tracking overview for Galileo

43.46%	L1X	C1X	L5X	C5X	L7X	C7X	L8X	C8X		
32.67%	L1X	C1X	L5X	C5X						
6.81%	L1X	C1X	L5X	C5X	L7X	C7X	L8Q	C8Q		
6.07%	L1C	C1C	L5Q	C5Q	L7Q	C7Q	L8Q	C8Q		
3.04%	L1C	C1C	L5Q	C5Q						
2.72%	L1X	C1X	L5X	C5X	L7X	C7X	L8Q	C8Q	L6X	C6X
1.88%	L1X	C1X	L5X	C5X		C7X				
1.15%	L1X	C1X	L5X	C5X	L7X	C7X	L8X	C8X	L6X	
0.52%	L1X	C1X	L5X	C5X		C7X	L8Q	C8Q		
0.52%	L1X	C1X	L5X	C5X			L8Q	C8Q		
0.42%	L1X	C1X	L5X	C5X	L7X	C7X				
0.31%	L1X	C1X	L5X	C5X	L7X	C7X		C8Q		
0.21%	L1X	C1X	L5X	C5X				C8Q		
0.10%	L1X	C1X	L5X	C5X	L7X	C7X	L8X	C8X	L6X	C6X
0.10%	L1X	C1X			L7X	C7X	L8X	C8X		

MGEX data monitoring

Tracking overview for Galileo



MGEX data monitoring

Tracking overview for Galileo

43.46%	L1X	C1X	L5X	C5X	L7X	C7X	L8X	C8X		
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6.07%	L1C	C1C	L5Q	C5Q	L7Q	C7Q	L8Q	C8Q		
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0.42%	L1X	C1X	L5X	C5X	L7X	C7X				
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0.21%	L1X	C1X	L5X	C5X				C8Q		
0.10%	L1X	C1X	L5X	C5X	L7X	C7X	L8X	C8X	L6X	C6X
0.10%	L1X	C1X			L7X	C7X	L8X	C8X		

MGEX data monitoring

Tracking overview for Galileo

Exceptions:

- CUT0 on DOYs 110-127
- GRA2 on single days

0.10% L1X C1X

MGEX data monitoring

Tracking overview for Galileo

6.07%	L1C	C1C	L5Q	C5Q	L7Q	C7Q	L8Q	C8Q
3.04%	L1C	C1C	L5Q	C5Q				

In about 90 % of the cases the code-type „X“ is used on these frequencies.

RINEX data issues: E12 code issue

- **Trimble** NETR9 (15):
  - temporarily constant C1X code values
  - Firmware Vers. 4.43 (ONS1): C1X = 33554431.992 for E12
  - Firmware Vers. 4.60: C1X = 67108862.992 for E12
- **Javad** TRE_G3TH DELTA (11):
  - temporarily large code values around +160 000 000 for E12
- **Leica** GR10 (1) /GR25 (1) /GRX1200+GNSS (3):
  - temporarily no L1-tracking or no E12 tracking at all
- **Septentrio** POLARX4TR (2):
  - no issues
- **Novatel** OEM6 (1):
  - temporarily large code values around -140 000 000 for E12
- **IFEN** SX_NSR_RT_800 (1):
  - no code observations for E12 since around DOY 150 (later also E11)

=> since DOY 179 E12 tracking normal for all receivers (E12 clock reset?)
=> similar issues observed for GIOVE-A in late June 2012

RINEX data issues: GIOVE naming issue

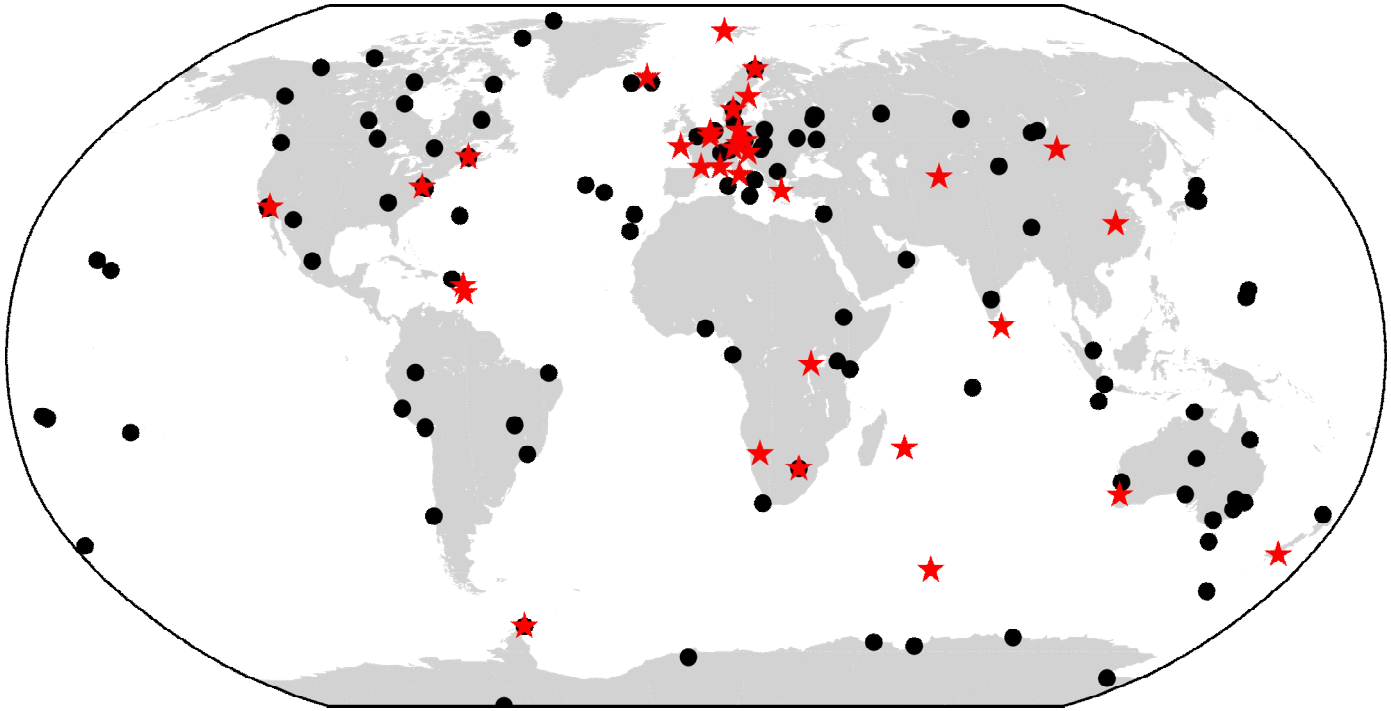
- No common PRNs for GIOVE satellites
- GIOVE-A (E01): **E01**, E31, E51
- GIOVE-B (E16): E02, **E16**, E32, E52
- Other PRNs in use: E03, E04, E05, E06, E14, E18, E27, E33, E34, E36, E49, E50

MGEX rapid: overview

- Modified CODE IGS rapid procedure
- Modifications: Galileo data processing, Bernese development version, data import, special cluster for MGEX-stations, no ambiguity fixing and no stochastic orbit parameters for Galileo, extended orbit validation, 5-day long-arcs added
- Number of stations: 145 - 150
- Time interval: 2012, DOY 130 - 170
- RINEX types: RINEX2.xx and RINEX3.0x
- Frequencies:
  - GPS+GLONASS: L1, L2
  - Galileo: E1 (L1), E5a (L5)

MGEX-Rapid: station distribution

Number and distribution of tracking stations contributing to the CODE MGEX-Rapid solution



● GPS: 147 GLONASS: 120 ★ Galileo: 35

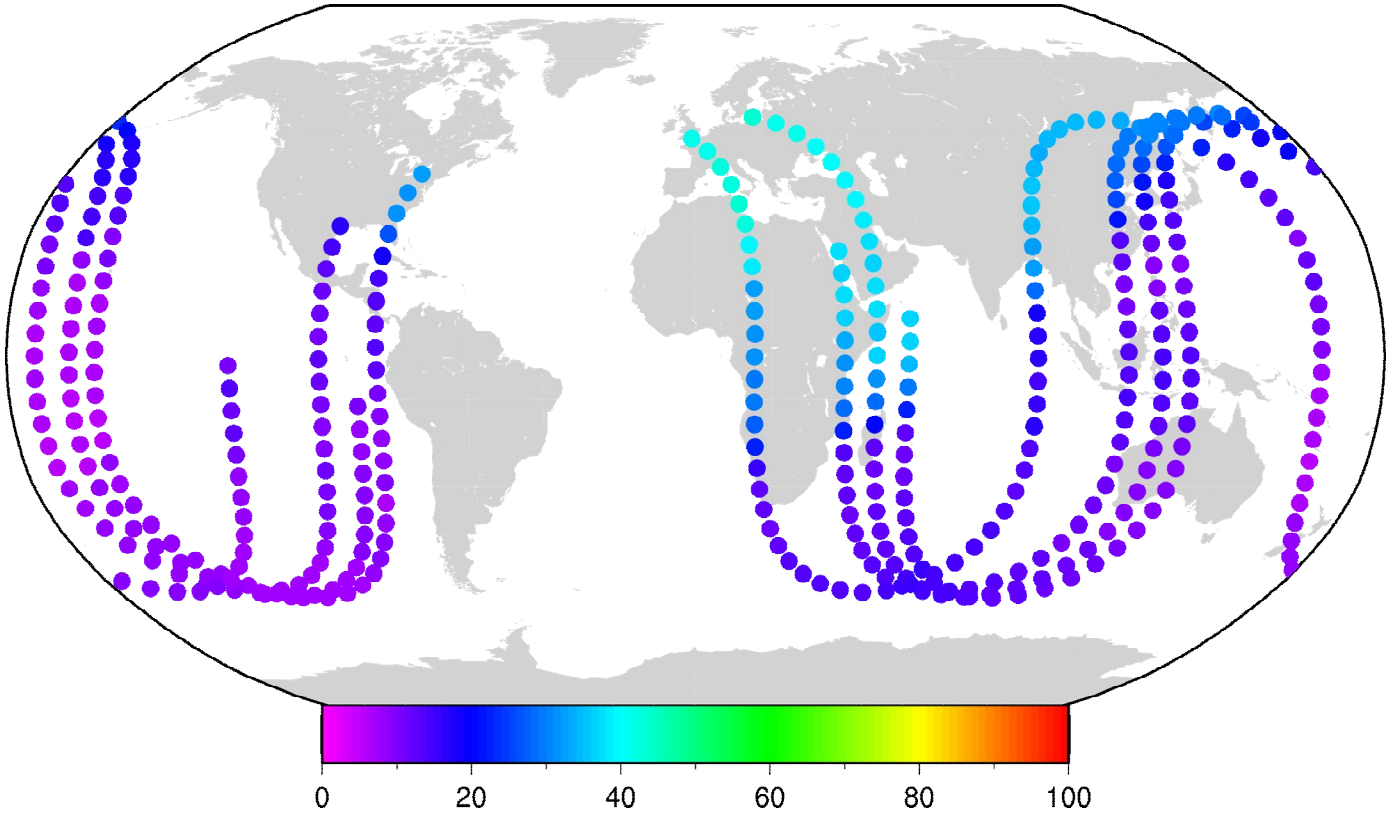
=> 20000 - 24000 SD obs. per Sat/d

=> 16000 - 19000 SD obs. per Sat/d

=> 1000 - 3500 SD obs. per Sat/d

MGEX-Rapid: „trackability“

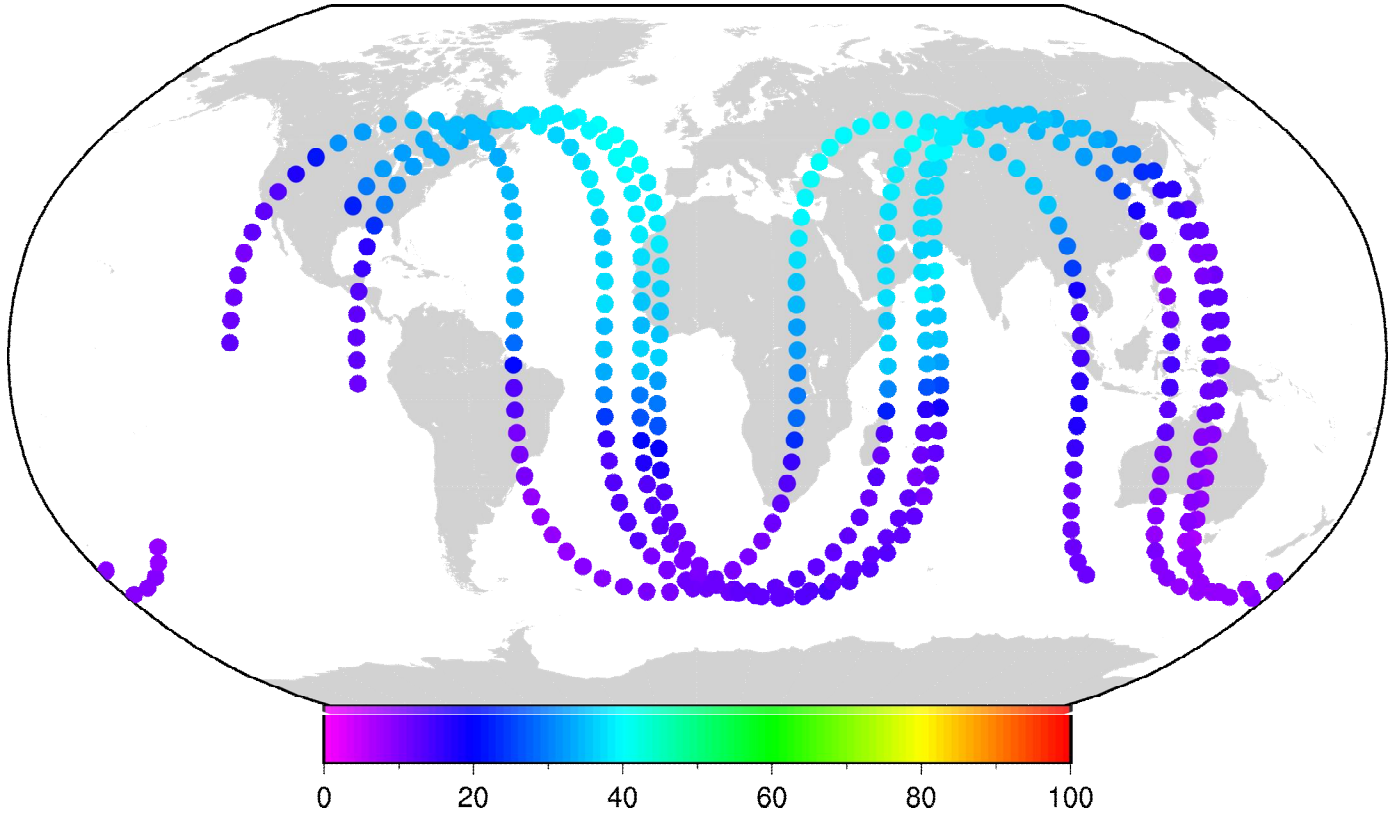
Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); sampling 15 min; **DOY 150**



=> only parts of a daily orbit arc are covered with observations

MGEX-Rapid: „trackability“

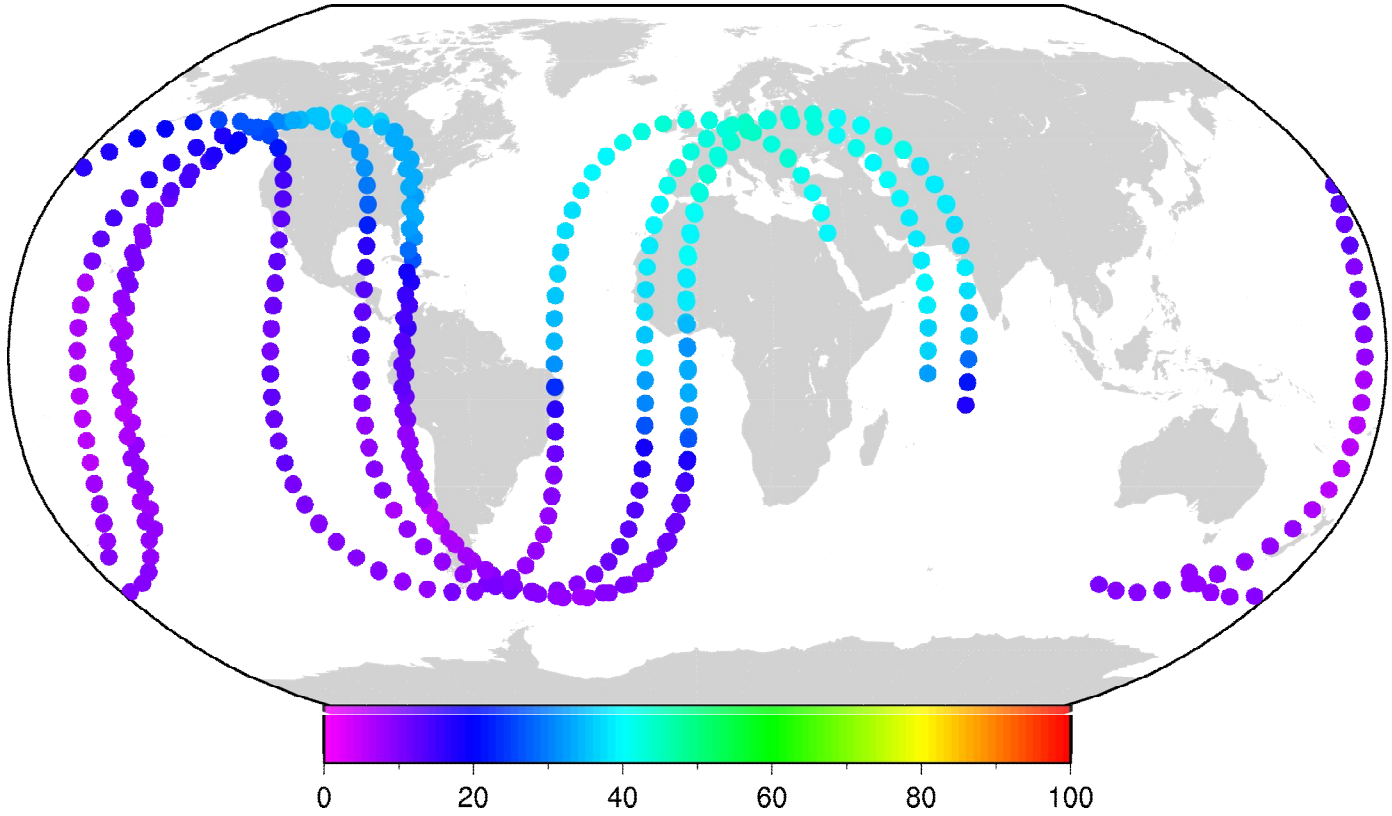
Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); sampling 15 min; **DOY 151**



=> ... mainly by European stations

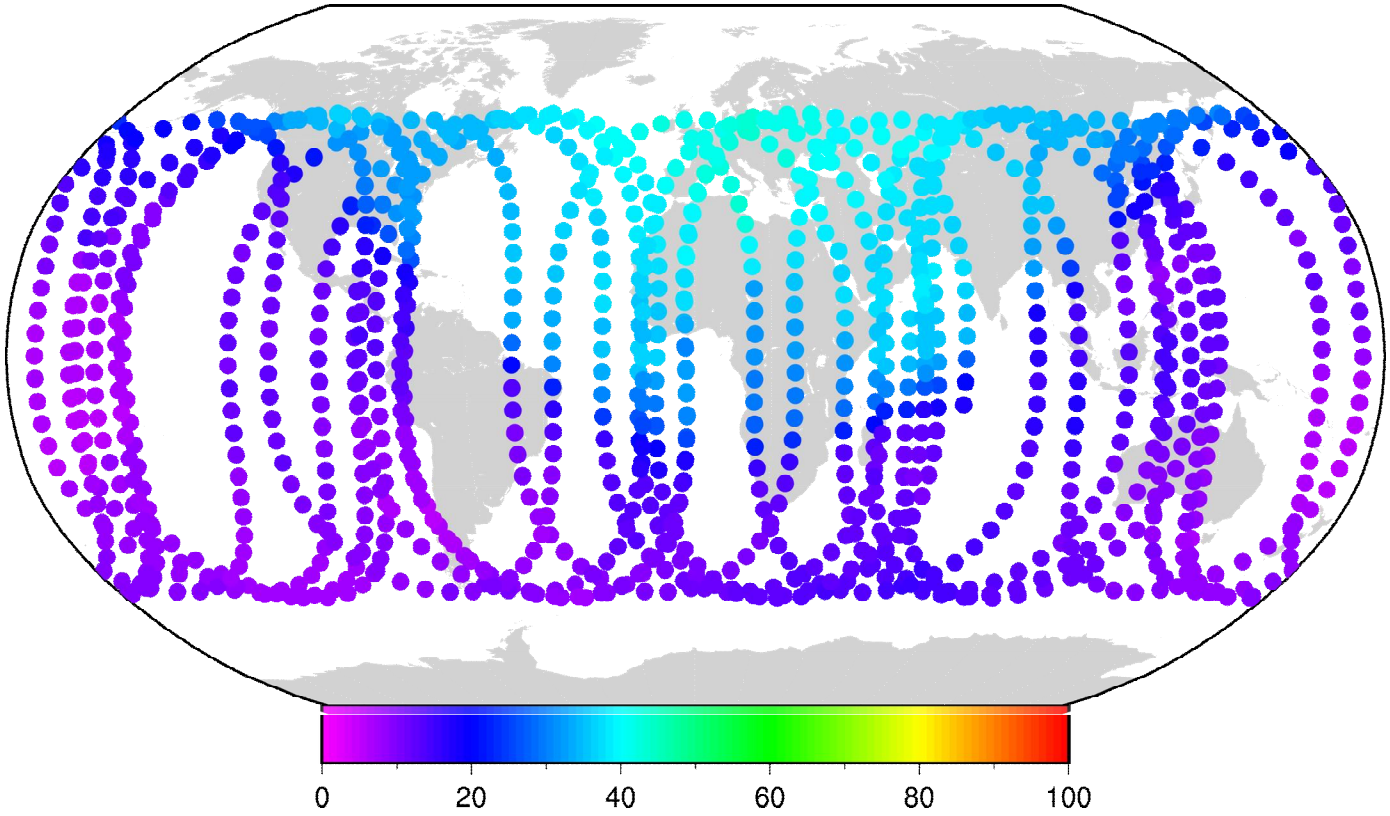
MGEX-Rapid: „trackability“

Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); sampling 15 min; **DOY 152**



MGEX-Rapid: „trackability“

Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); **DOYs 150 - 152**

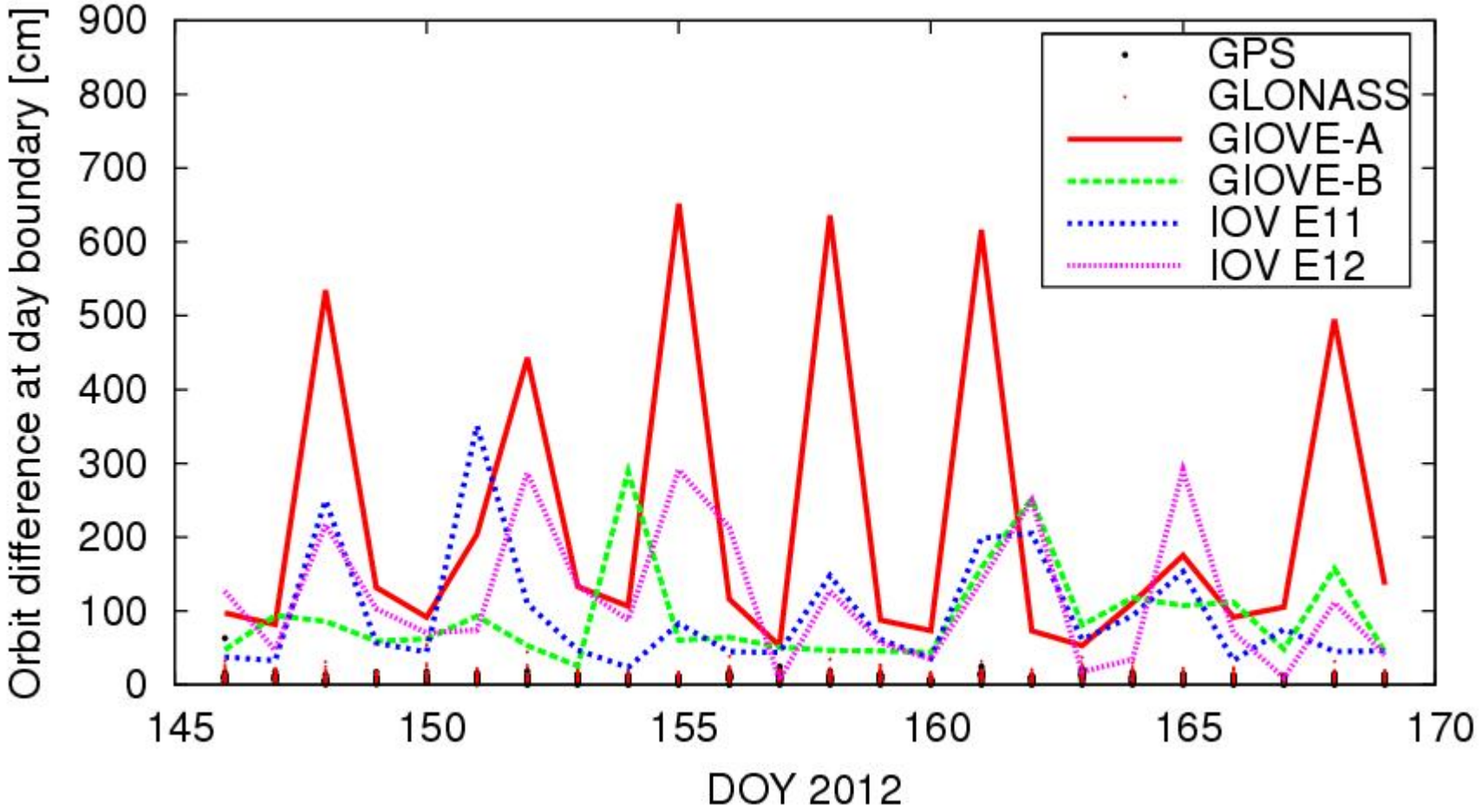


=> longarc: several passes over reasonable no. of stations

MGEX-Rapid: orbit validation: overlaps

GPS, GLONASS, Galileo: 1 day arcs

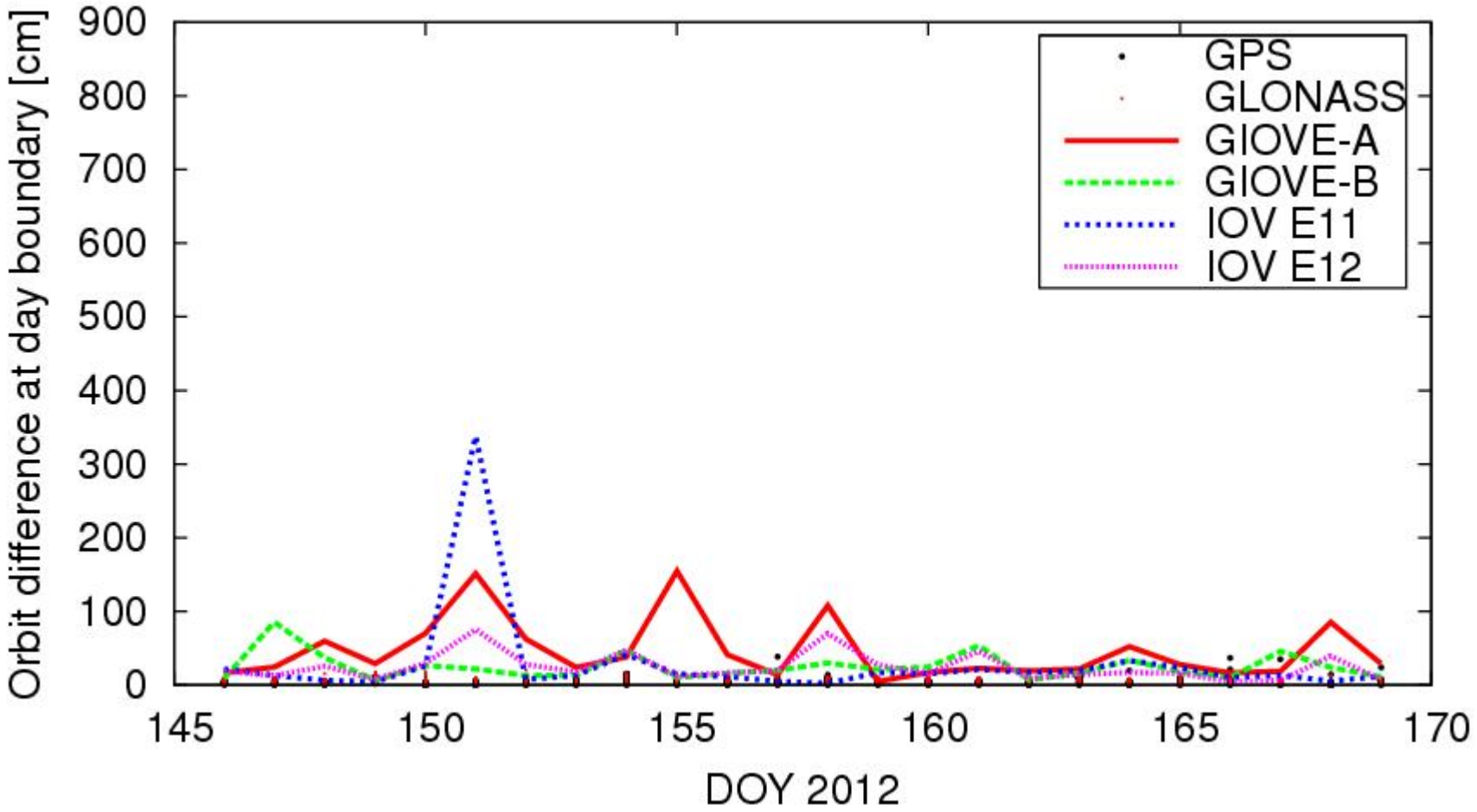
(mean: G01: 7.6 cm; R24: 10.1 cm; Galileo: 90 – 220 cm)



MGEX-Rapid: orbit validation: overlaps

GPS, GLONASS, Galileo: 3 day arcs (last; RAPID-mode)

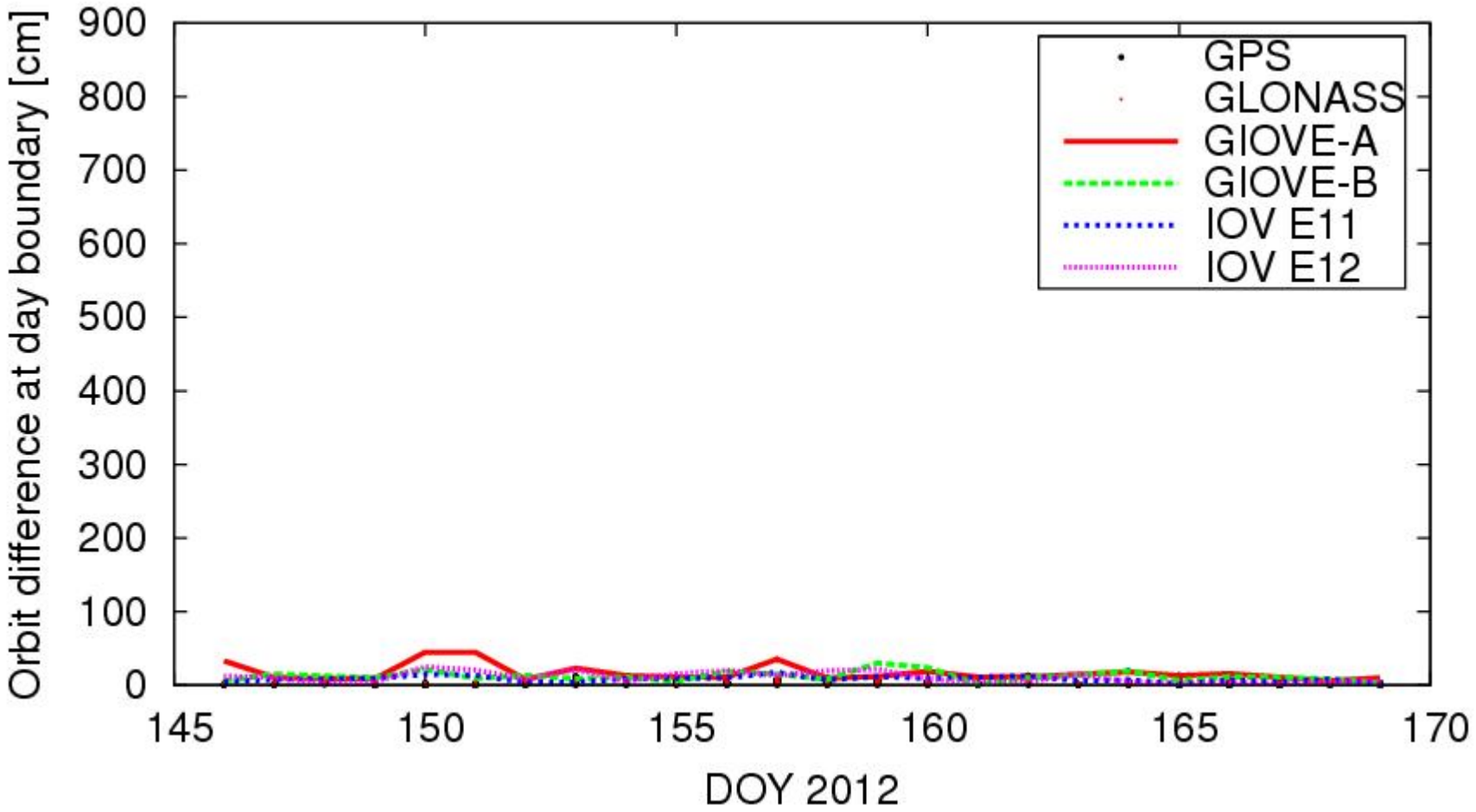
(mean: G01: 5.2 cm; R24: 5.3 cm; Galileo: 25 – 46 cm)



MGEX-Rapid: orbit validation: overlaps

GPS, GLONASS, Galileo: 3 day arcs (mid; FINAL-mode)

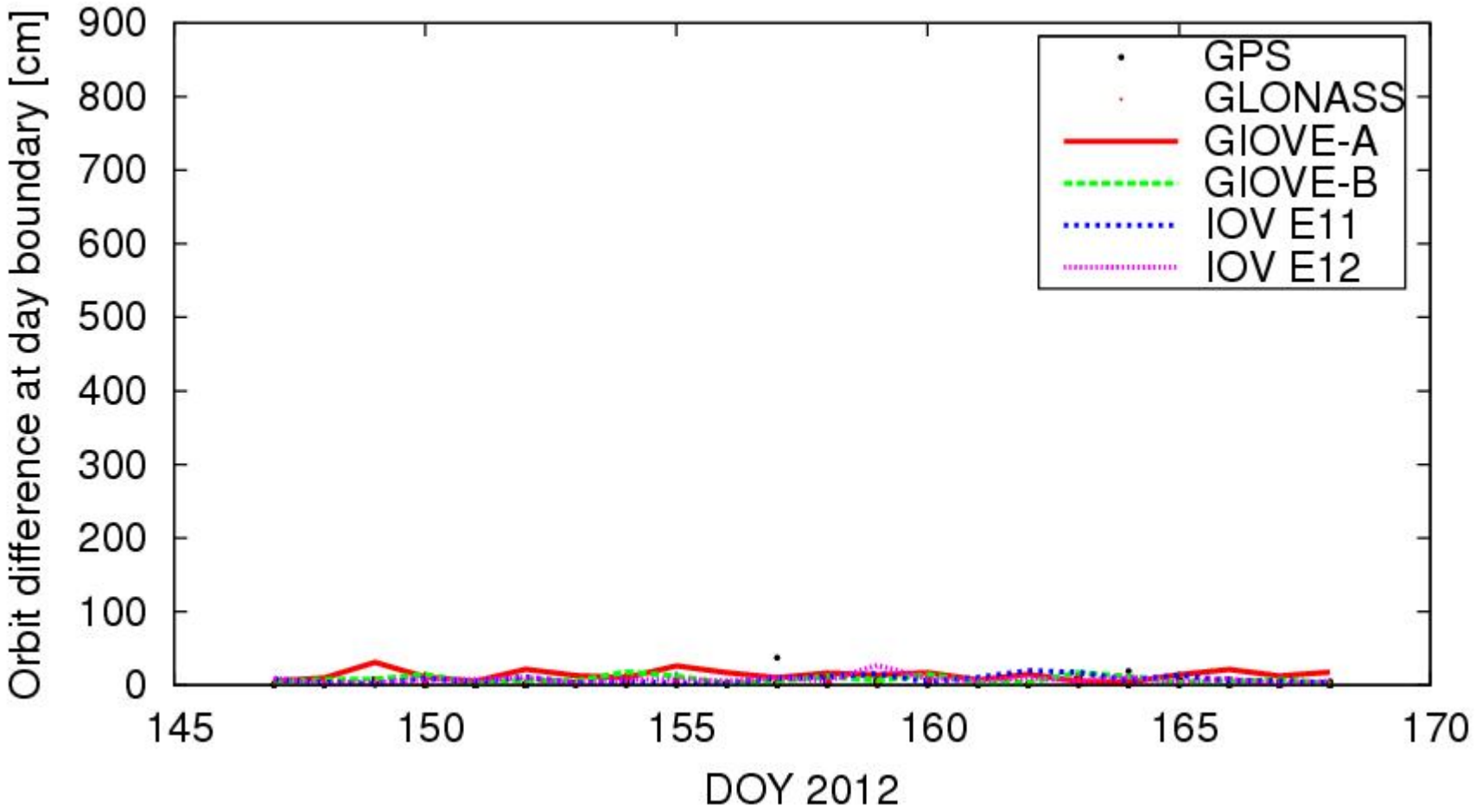
(mean: G01: 3.5 cm; R24: 3.5 cm; Galileo: 8.5 - 17 cm)



MGEX-Rapid: orbit validation: overlaps

GPS, GLONASS, Galileo: 5 day arcs (mid)

(mean: G01: 3.5 cm; R24: 3.5 cm; Galileo: 8 - 14 cm)



MGEX-Rapid: orbit validation: overlaps

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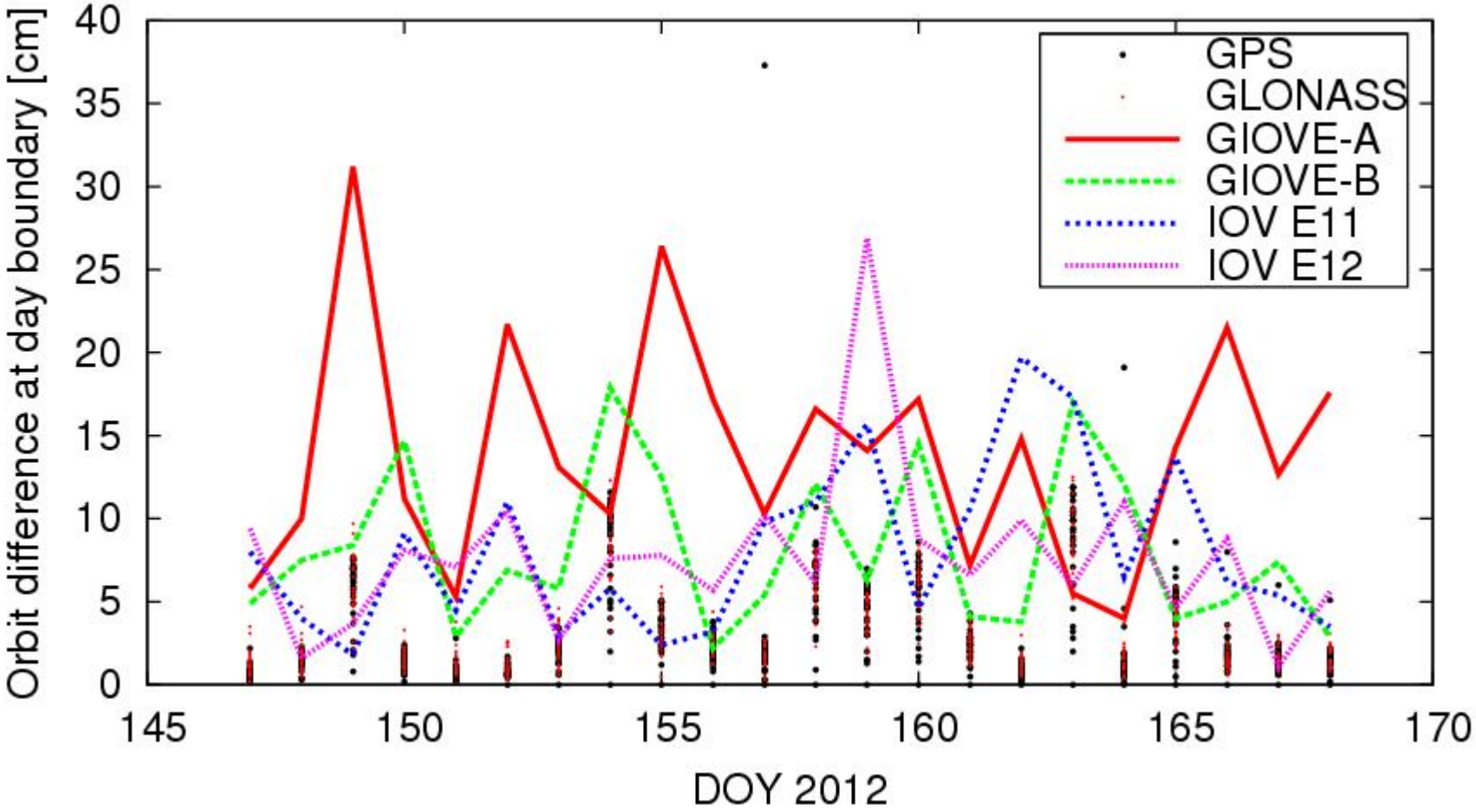
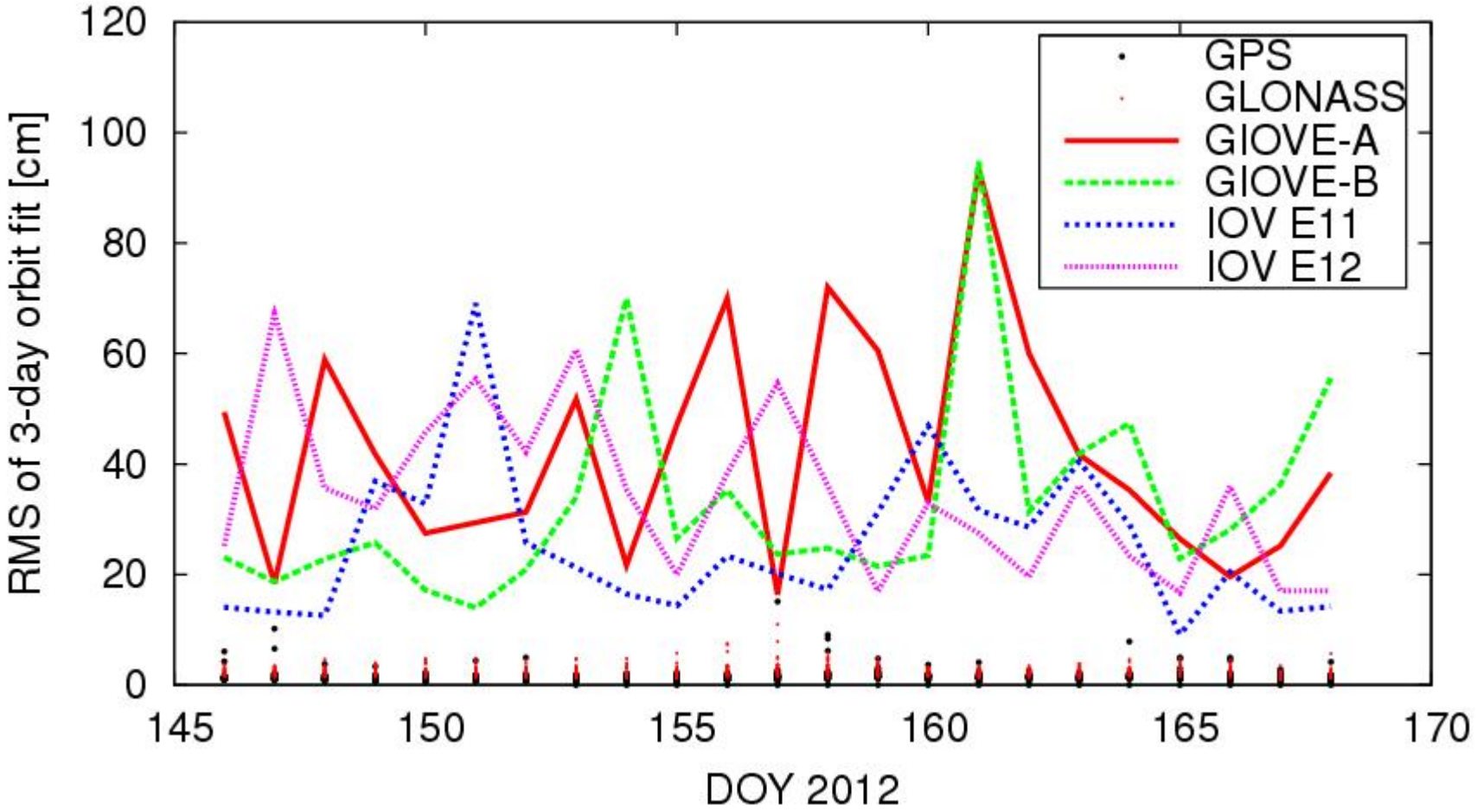
(mean: G01: 3.5 cm; R24: 3.5 cm; Galileo: 8 – 14 cm)



MGEX-Rapid: orbit validation: 3-day orbit fit

GPS, GLONASS, Galileo: 1 day arcs

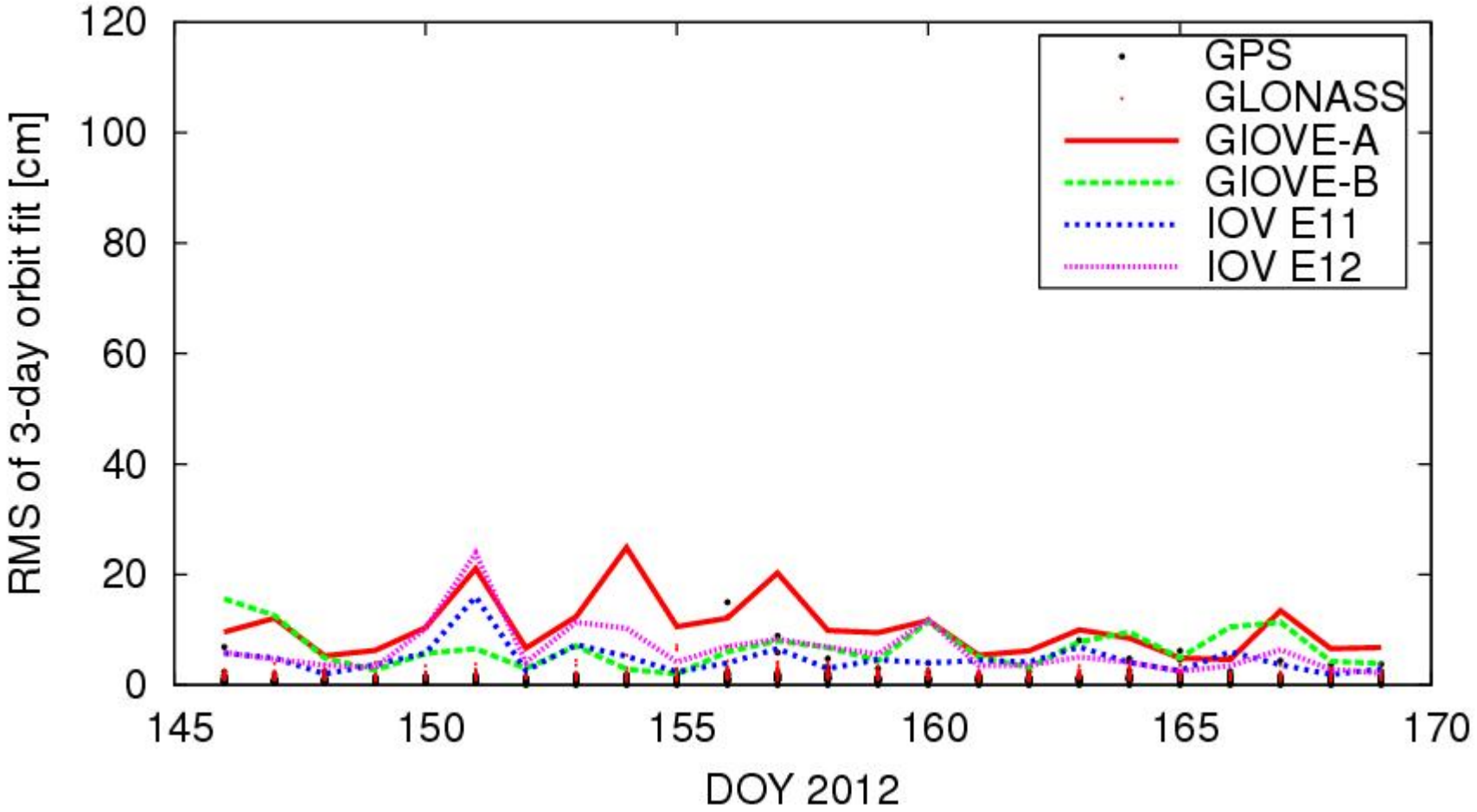
(mean: G01: 1.5 cm; R24: 2.4 cm; Galileo: 25 – 42 cm)



MGEX-Rapid: orbit validation: 3-day orbit fit

GPS, GLONASS, Galileo: 3 day arcs (last; RAPID-mode)

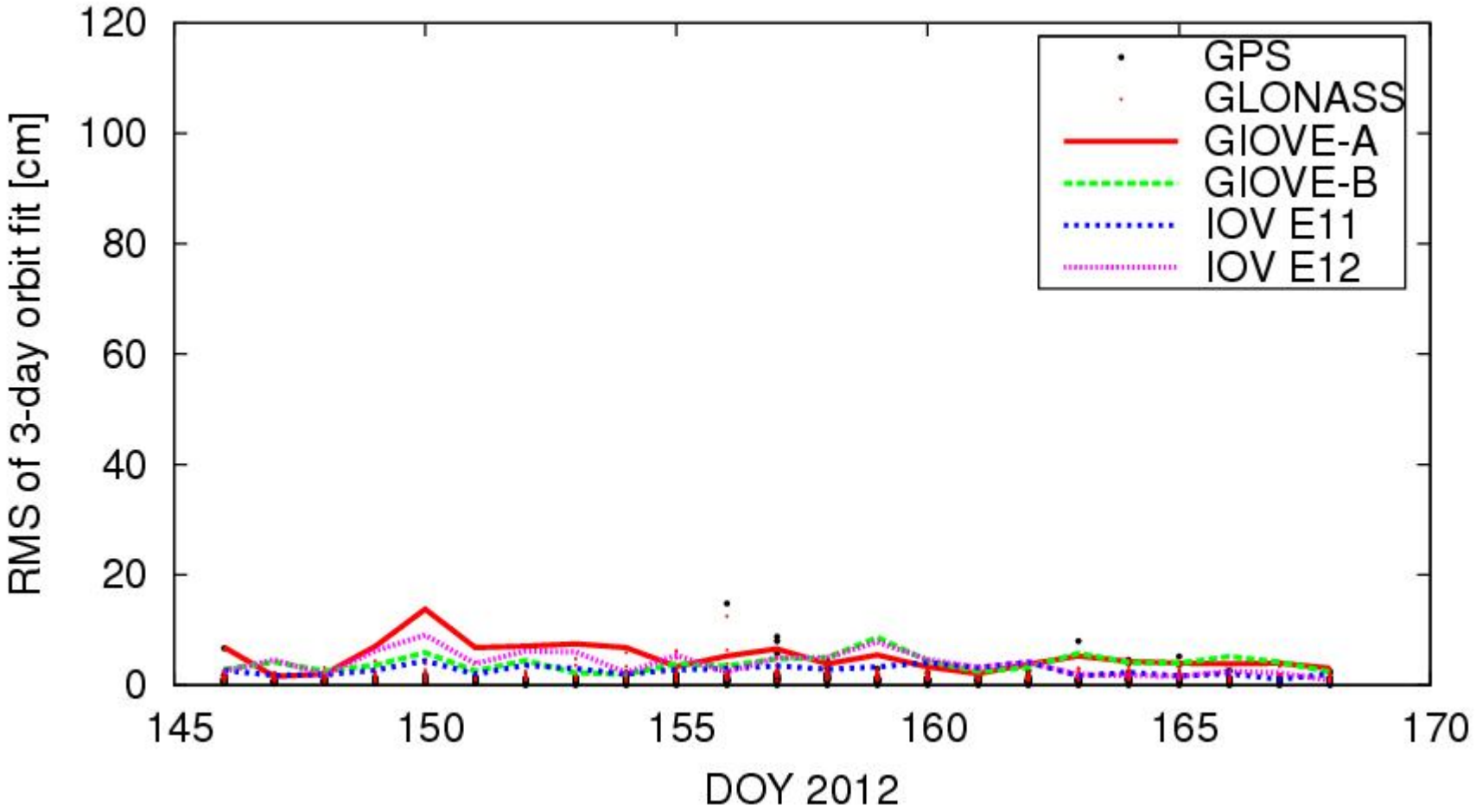
(mean: G01: 1.2 cm; R24: 1.8 cm; Galileo: 4.8 - 10.4 cm)



MGEX-Rapid: orbit validation: 3-day orbit fit

GPS, GLONASS, Galileo: 3 day arcs (mid; FINAL-mode)

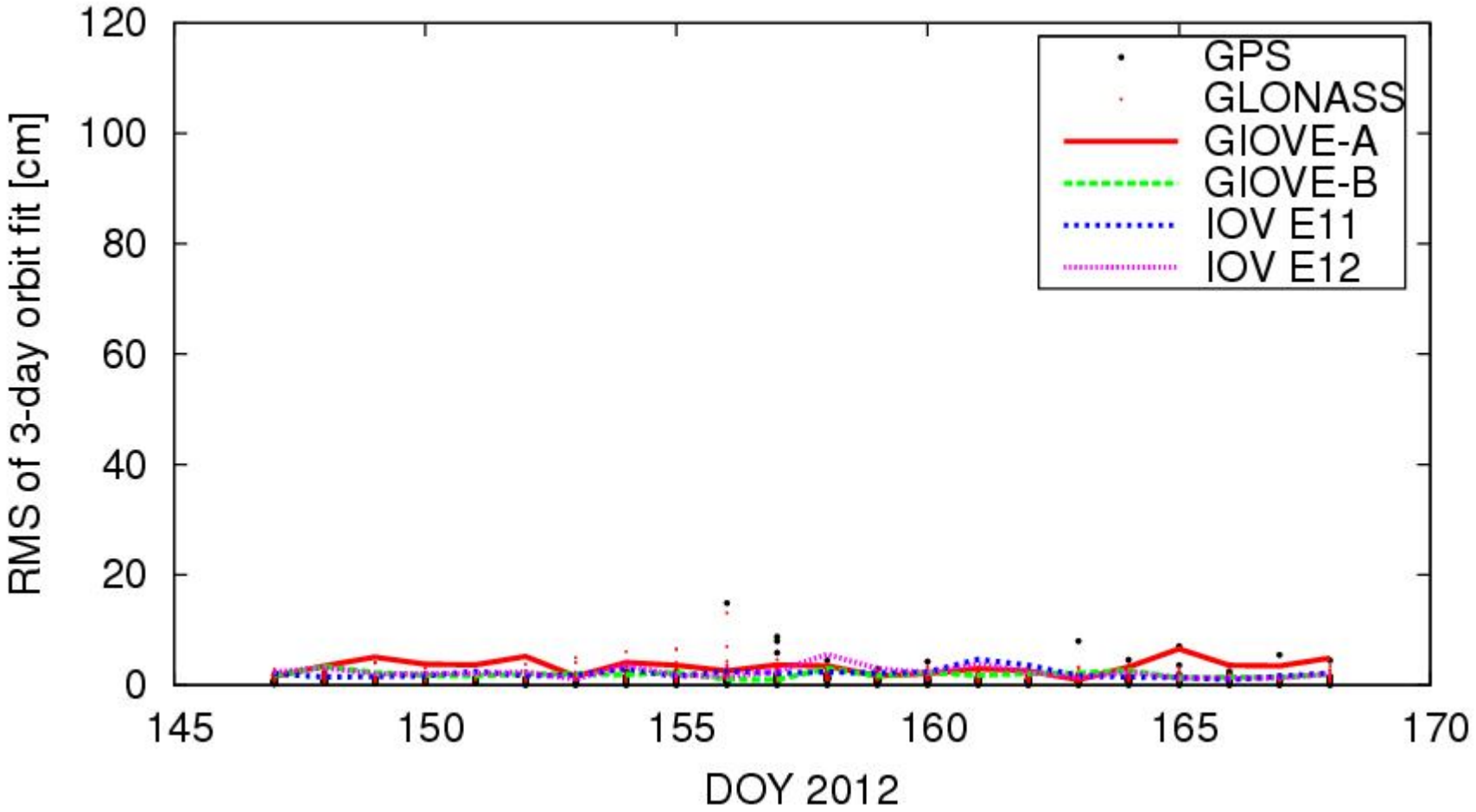
(mean: G01: 1.0 cm; R24: 1.6 cm; Galileo: 2.7 - 5.1 cm)



MGEX-Rapid: orbit validation: 3-day orbit fit

GPS, GLONASS, Galileo: 5 day arcs (mid)

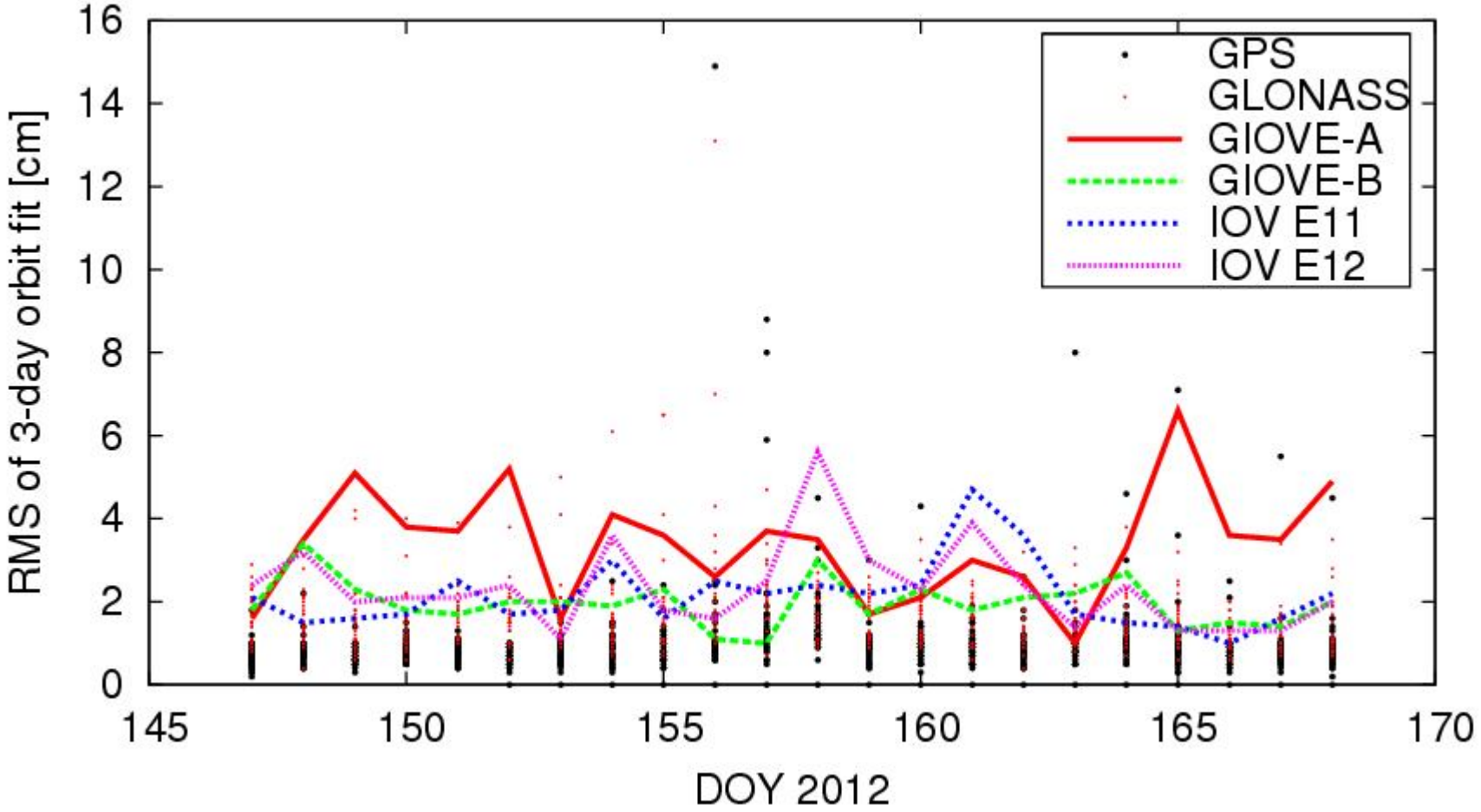
(mean: G01: 0.9 cm; R24: 1.5 cm; Galileo: 2.0 - 3.4 cm)



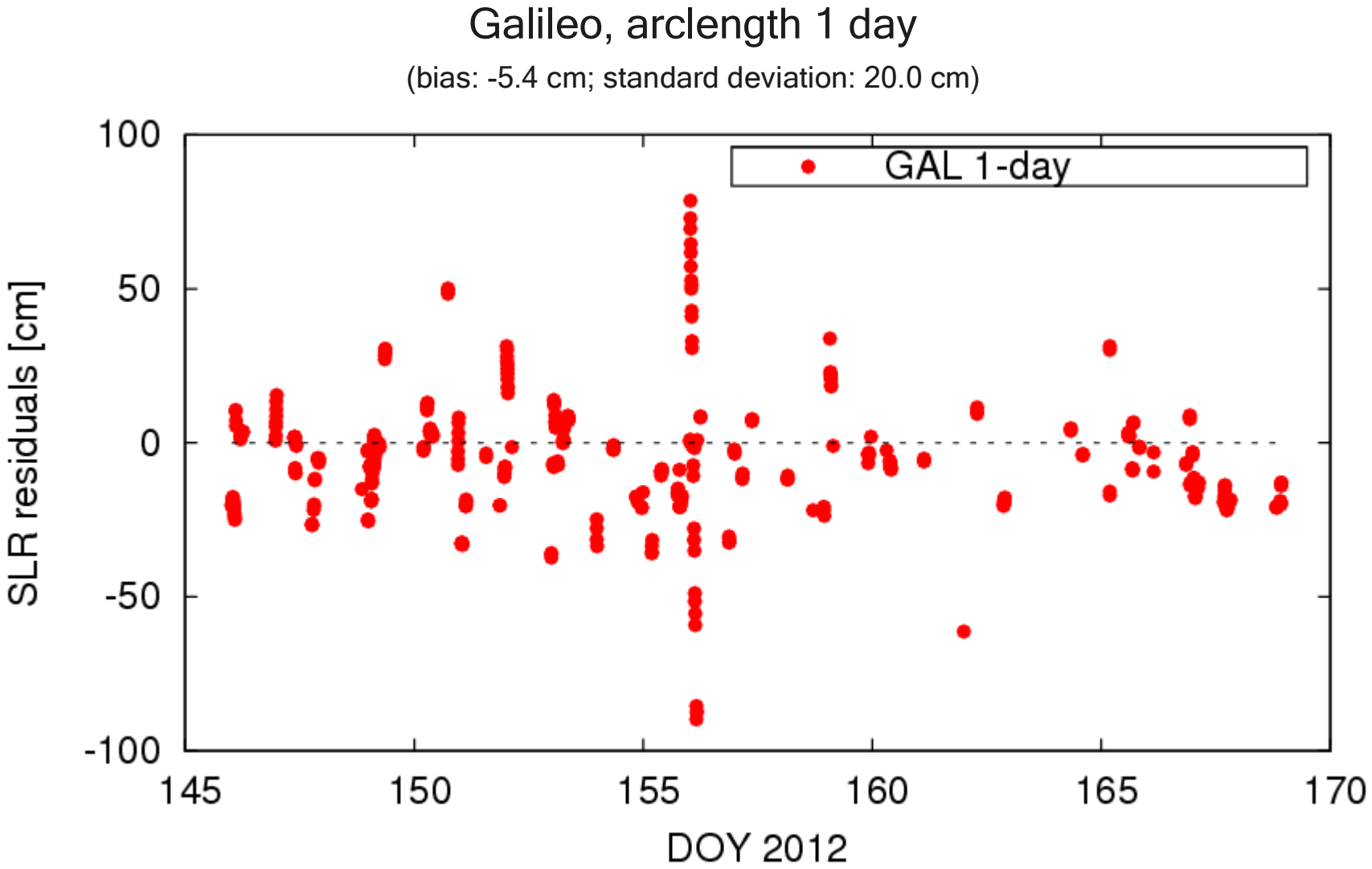
MGEX-Rapid: orbit validation: 3-day orbit fit

GPS, GLONASS, Galileo: 5 day arcs (mid)

(mean: G01: 0.9 cm; R24: 1.5 cm; Galileo: 2.0 – 3.4 cm)



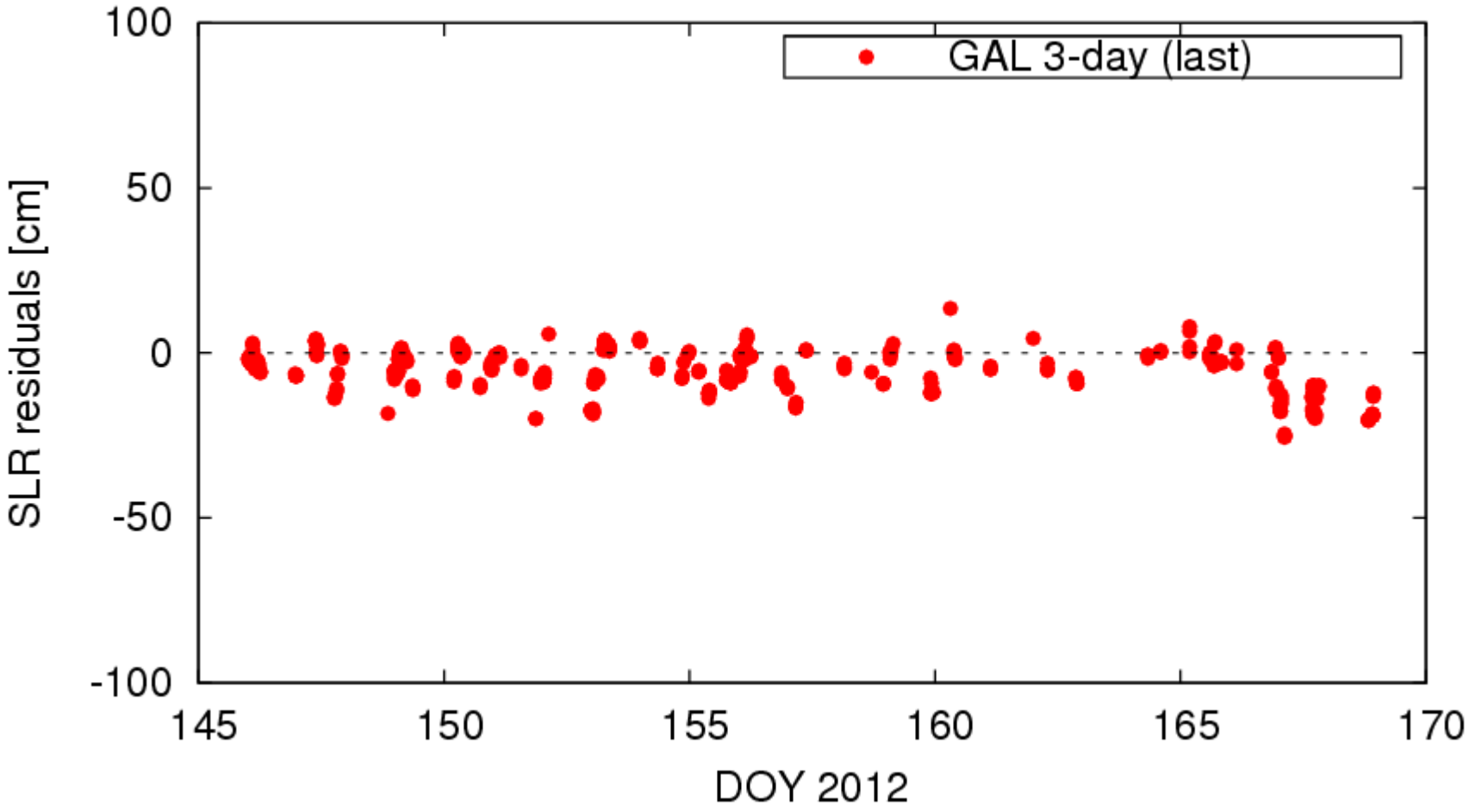
MGEX-Rapid: orbit validation: SLR residuals



MGEX-Rapid: orbit validation: SLR residuals

Galileo, last day of 3-day longarc (RAPID-mode)

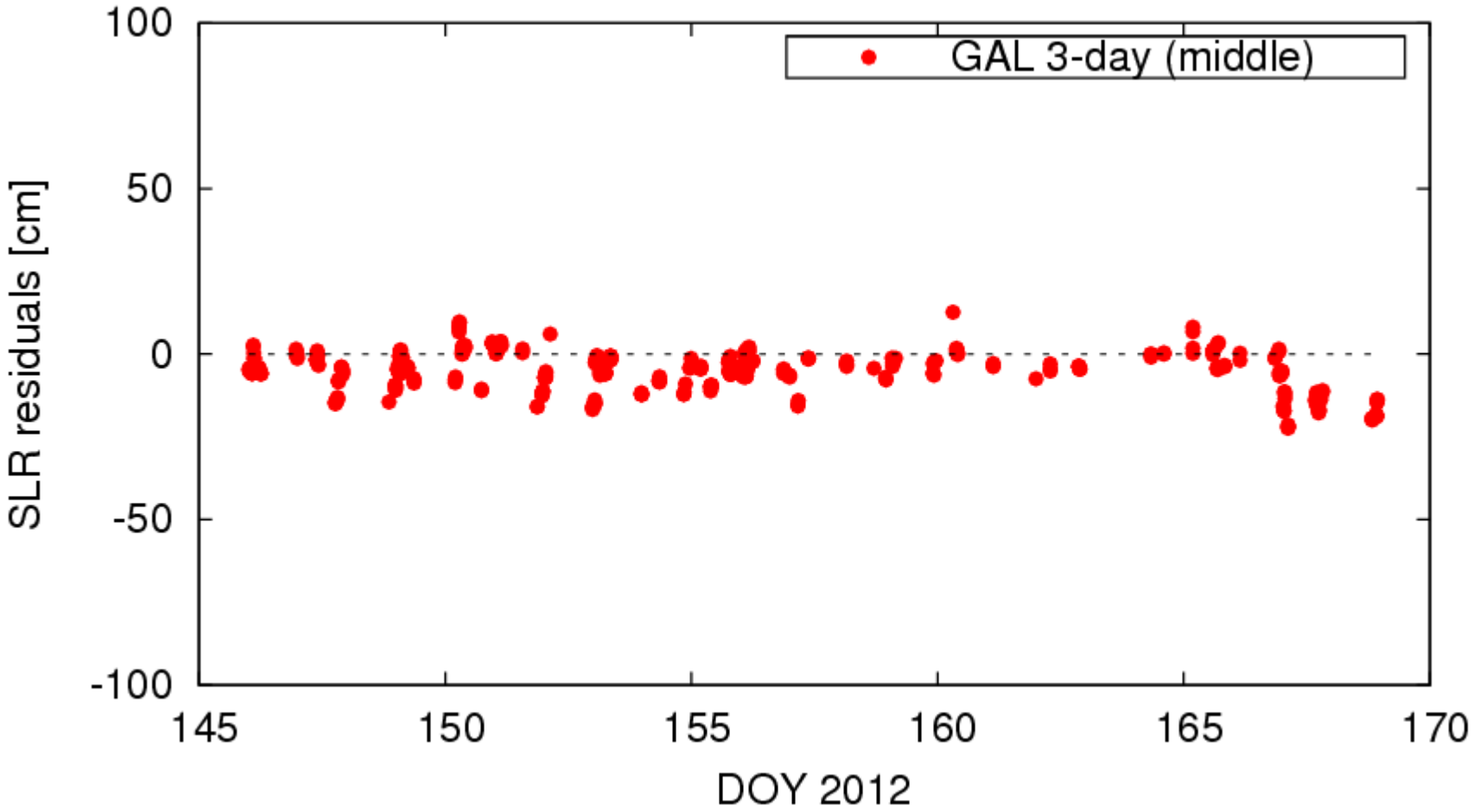
(bias: -5.0 cm; standard deviation: 6.4 cm)



MGEX-Rapid: orbit validation: SLR residuals

Galileo, mid day of 3-day longarc (FINAL-mode)

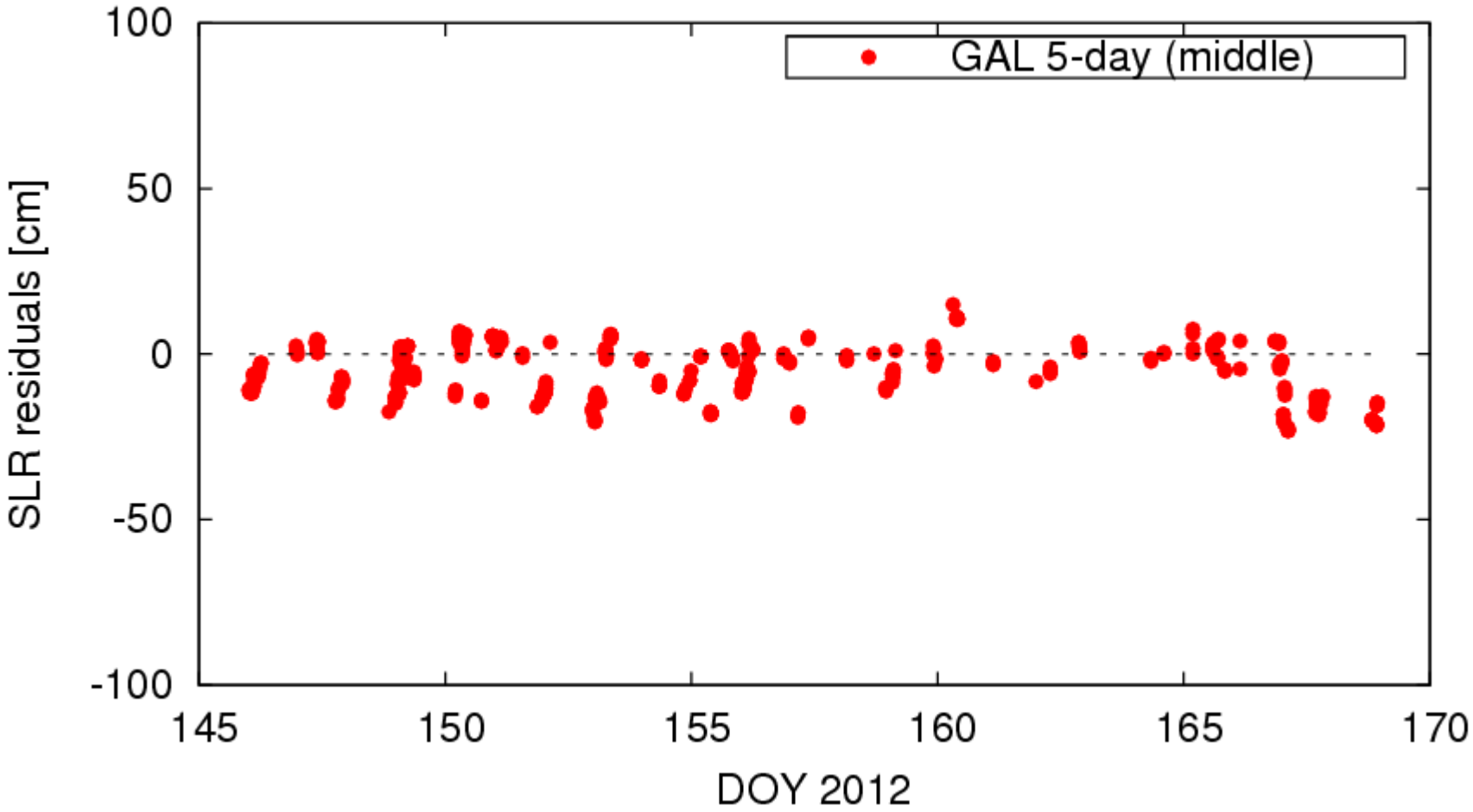
(bias: -5.0 cm; standard deviation: 5.8 cm)



MGEX-Rapid: orbit validation: SLR residuals

Galileo, mid day of 5-day longarc

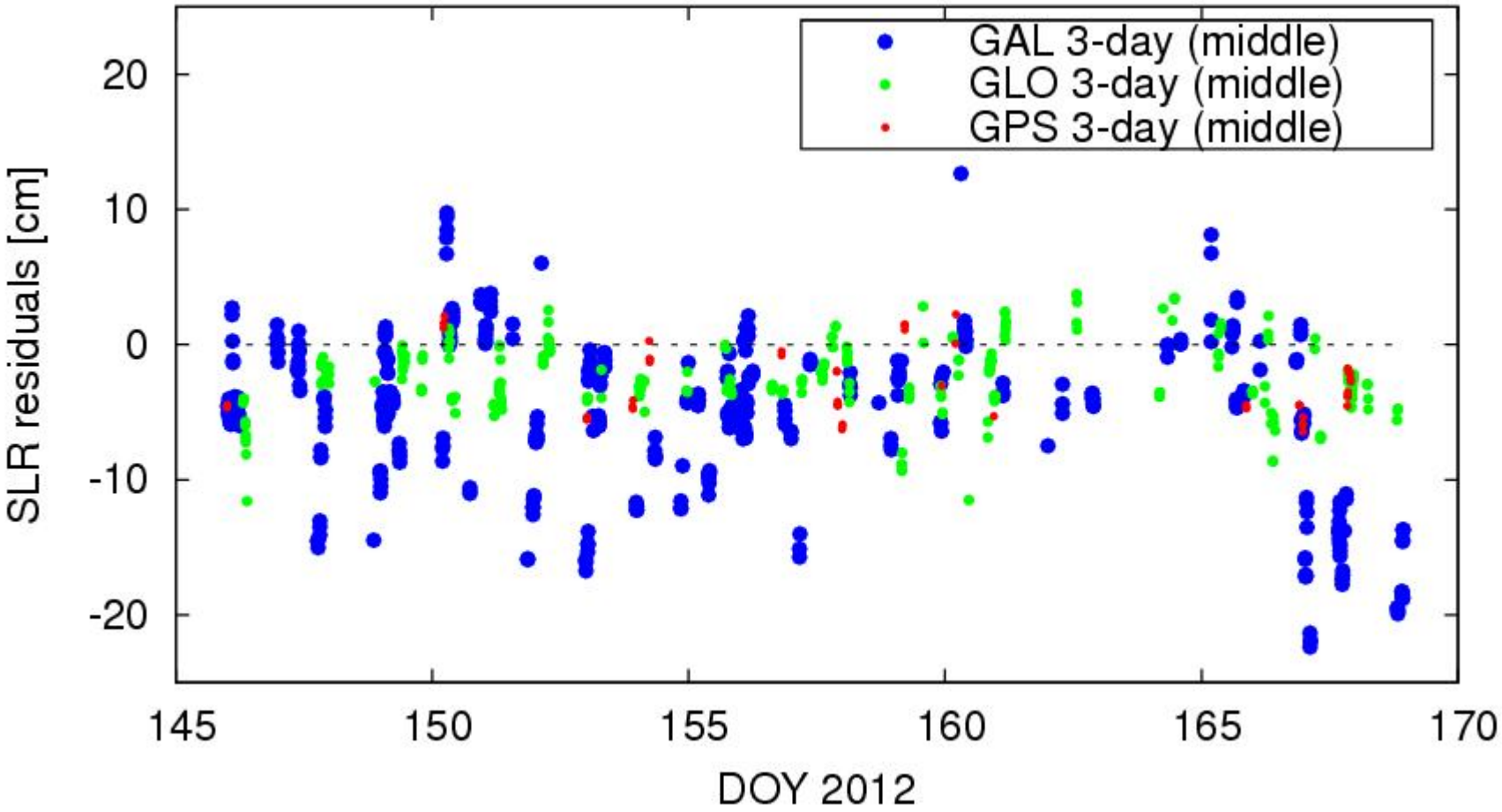
(bias: -5.4 cm; standard deviation: 7.9 cm)



MGEX-Rapid: orbit validation: SLR residuals

Comparison of satellite systems (FINAL-mode)

(GPS / GLO / GAL: bias: -3.1 / -2.5 / -5.0 cm; STD: 2.5 / 2.5 / 5.8 cm)



Summary

- The currently available MGEX data allows operational Galileo orbit determination with a promising accuracy
- Galileo orbits benefit from long arcs due to uneven station distribution
- Validation results for Galileo orbits (rapid-/final-mode):
  - Mean overlap at day boundaries: 25 - 46 / 8.5 - 17 cm
  - Mean RMS of 3-day orbit fit: 5 - 10.5 / 3 - 5 cm
  - Standard deviation of SLR residuals: 6.4 / 5.8 cm
- Inclusion of Galileo (as third GNSS) into the CODE Rapid processing is intended, if MGEX data delivery continues after close-out (1st September 2012)

Open Issues

- Need for standardization (e.g., GIOVE naming, observation types to be tracked => meanwhile solved)
- RINEX inconsistencies: ensurance of completeness and consistency (=> mostly solved)
- Tracking issues (e.g., for E12 before clock reset)
- Station distribution: most MGEX stations located in Europe

Thank you

for

your interest!