MGEX data analysis at CODE – current status

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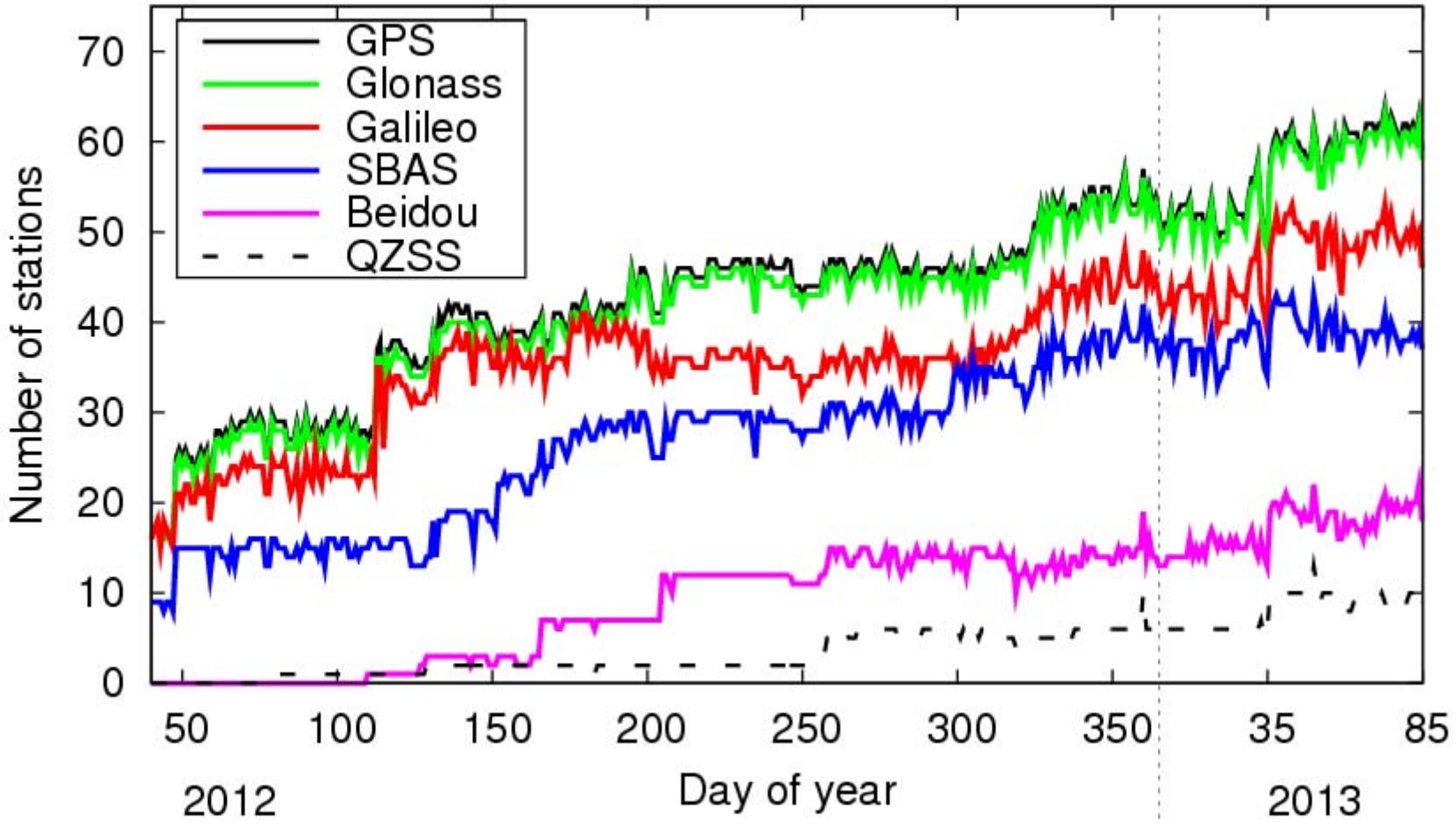
MGEX data monitoring

- Data sources: CDDIS, BKG, IGN (MGEX plus RINEX3 directories)
- Number of daily files/stations: up to 70 on DOY 75, 2013 (RINEX2 and RINEX3)
- RINEX versions: 2.11, 2.12, 3.00, 3.01, 3.02
- For some stations RINEX2 and RINEX3 are available
- Established IGS stations and new stations
- Public access to MGEX monitoring results via FTP:
  => ftp://ftp.unibe.ch/aiub/mgex/

MGEX data monitoring

Satellite systems supported by MGEX (RINEX3)



MGEX data monitoring

Observation types: GPS

Availability	L1		L2		L5	
	phase	code	phase	code	phase	code
47.20%	C	C	W, X	W, X	X	X
21.23%	C, W	C, W	W, X	W, X	X	X
6.55%	C	C	W, X	W, X		
6.55%	C, W	C, W	W	W		
4.91%	C	C, W	W, L	W, L	Q	Q
4.63%	C	C	W	W		
1.64%	C	C	W	W	X	X
1.64%	C	C	P	P		
1.64%	C	C	D	D	Q	Q
1.64%	C	C	D	D		
1.64%	C	C	W	W, X	X	X
0.62%	C	C	D, X	D, X	X	X
0.06%	C	C	W, X	W, X	X	X
0.06%	C		D			

MGEX data monitoring

Observation types: GPS

Availability	L1		L2		L5	
	phase	code	phase	code	phase	code
47.20%	C	C	W, X	W, X	X	X
21.23%	C, W	C, W	W, X	W, X	X	X
6.55%	C	C	W, X	W, X		
6.55%	C, W	C, W	W	W		
4.91%	C	C, W	W, L	W, L	Q	Q
4.63%	C	C	W	W		
1.64%	C	C	W	W	X	X
1.64%	C	C	P	P		
1.64%	C	C	D	D	Q	Q
1.64%	C	C	D	D		
1.64%	C	C	W	W, X	X	X
0.62%	C	C	D, X	D, X	X	X
0.06%	C	C	W, X	W, X	X	X
0.06%	C		D			

MGEX data monitoring

Observation types: Galileo

	L1		L5		L6		L7		L8	
Availability	phase	code	phase	code	phase	code	phase	code	phase	code
38.32%	X	X	X	X			X	X	X	X
29.58%	X	X	X	X						
16.92%	X	X	X	X			X	X	Q	Q
2.20%	X	X	X	X			X	X		
0.87%	X	X	X	X	X	X	X	X	X	X
6.85%	C	C	Q	Q			Q	Q	Q	Q
2.28%	C	C	Q	Q						
2.99%			X	X			X	X	X	X

- Best observed new GNSS: Galileo

MGEX data monitoring

Observation types: Galileo

	L1		L5		L6		L7		L8	
Availability	phase	code	phase	code	phase	code	phase	code	phase	code
38.32%	X	X	X	X			X	X	X	X
29.58%	X	X	X	X						
16.92%	X	X	X	X			X	X	Q	Q
2.20%	X	X	X	X			X	X		
0.87%	X	X	X	X	X	X	X	X	X	X
6.85%	C	C	Q	Q			Q	Q	Q	Q
2.28%	C	C	Q	Q						
2.99%			X	X			X	X	X	X

- Main observation type/tracking mode: „X“
  => Ambigous information
  => Possible problem for bias handling and ambiguity resolution

MGEX data monitoring

Observation types: Galileo

	L1		L5		L6		L7		L8	
Availability	phase	code	phase	code	phase	code	phase	code	phase	code
38.32%							X	X	X	X
29.58%										
16.92%							X	X	Q	Q
2.20%							X	X		
0.87%					X	X	X	X	X	X
6.85%							Q	Q	Q	Q
2.28%										
2.99%			X	X			X	X	X	X

L1 + L5 availability nearly 97 %

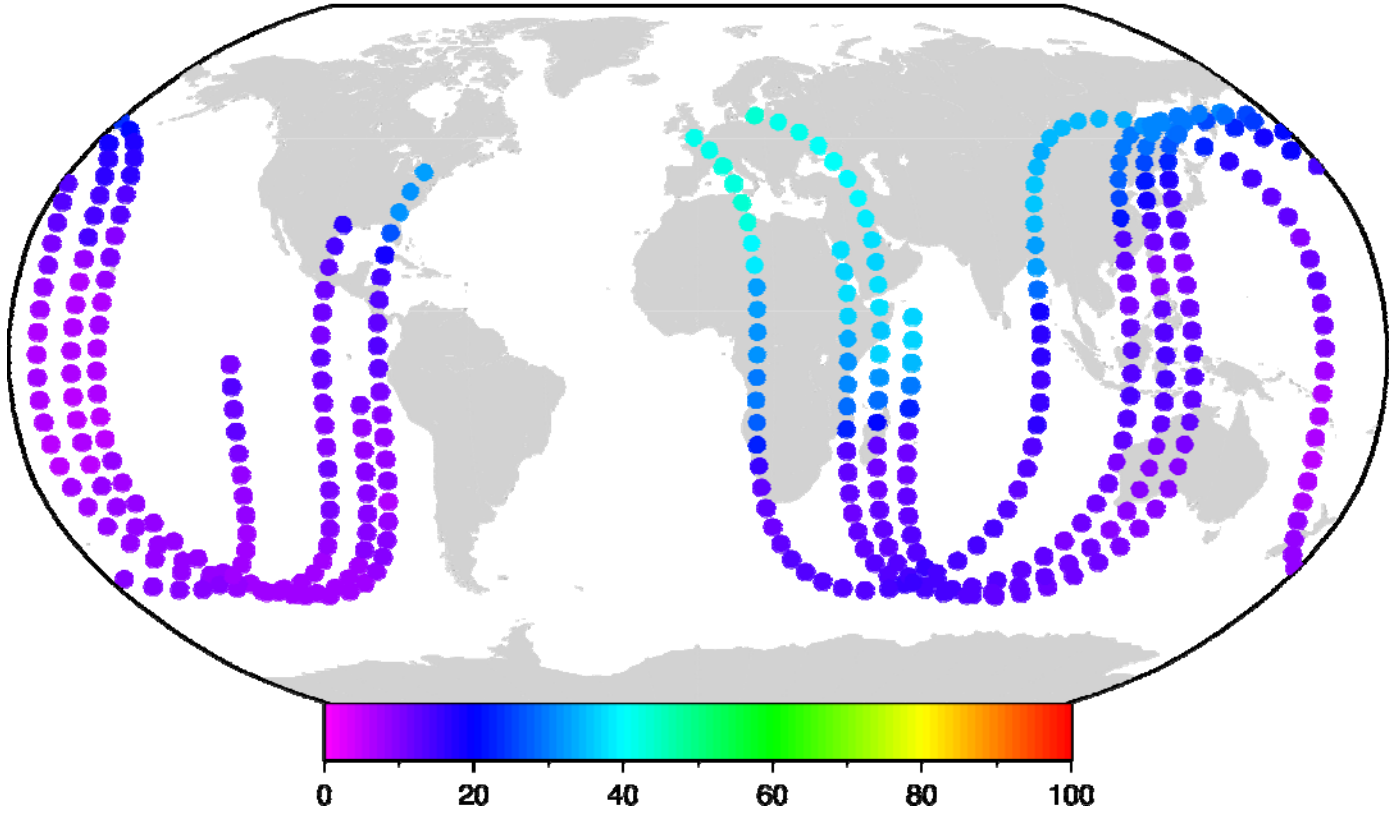
- L1 (E1) and L5 (E5a) nearly fully observed

CODE MGEX orbit solution

GNSS considered:	**GPS + GLONASS + Galileo** (up to 60 satellites)
Processing mode:	offline (delayed)
Timespan covered:	GPS-weeks 1689–1720 (DOY 12/146–12/364)
Number of stations:	150 (GPS + GLONASS), 30 -35 (Galileo)
Processing scheme:	double-difference network processing (observable: phase double differences)
Signal frequencies:	L1+ L2 (GPS + GLONASS), E1 (L1) + E5a (L5) (Galileo)
Orbit characteristic:	3-day long arcs
Reference frame:	IGS08 (until week 1708); IGb08 (since week 1709)
IERS conventions:	IERS2003 (until 1705); IERS2010 (since 1706)
Product list:	daily orbits (SP3) and ERPs
Distribution:	ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/
Designator:	“com”

CODE MGEX orbit solution: „trackability“

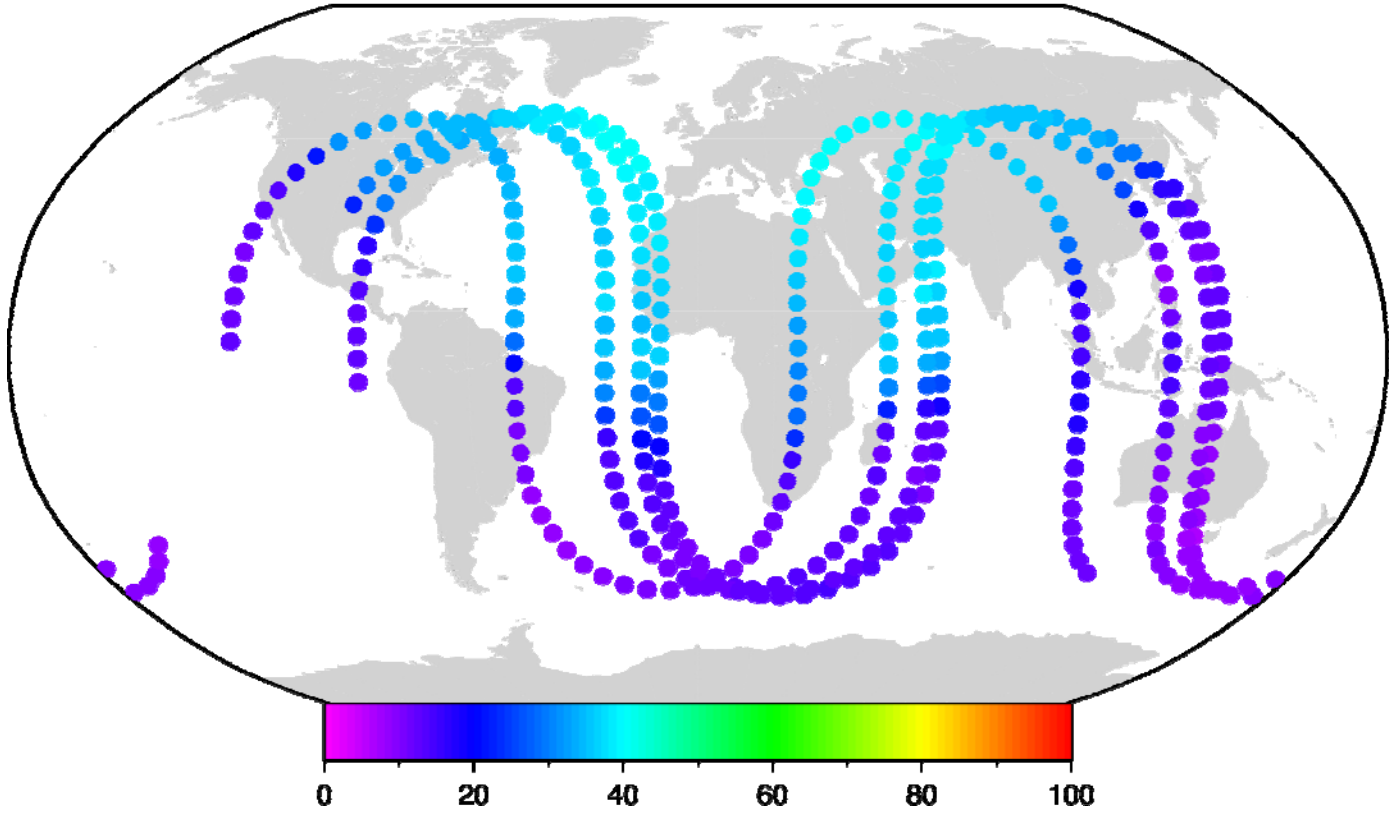
Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); sampling 15 min; **DOY 12/150**



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

CODE MGEX orbit solution: „trackability“

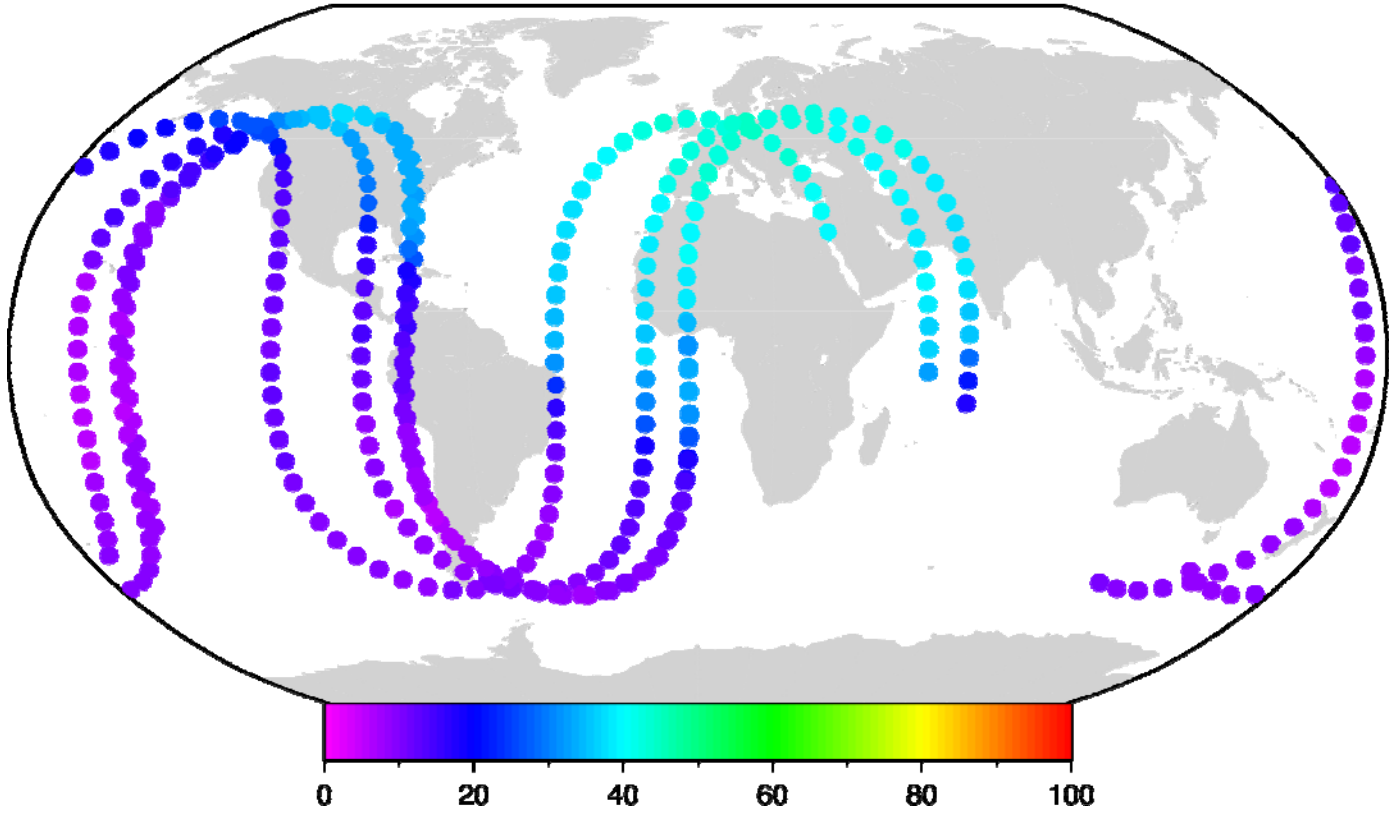
Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); sampling 15 min; **DOY 12/151**



=> ... mainly by European stations

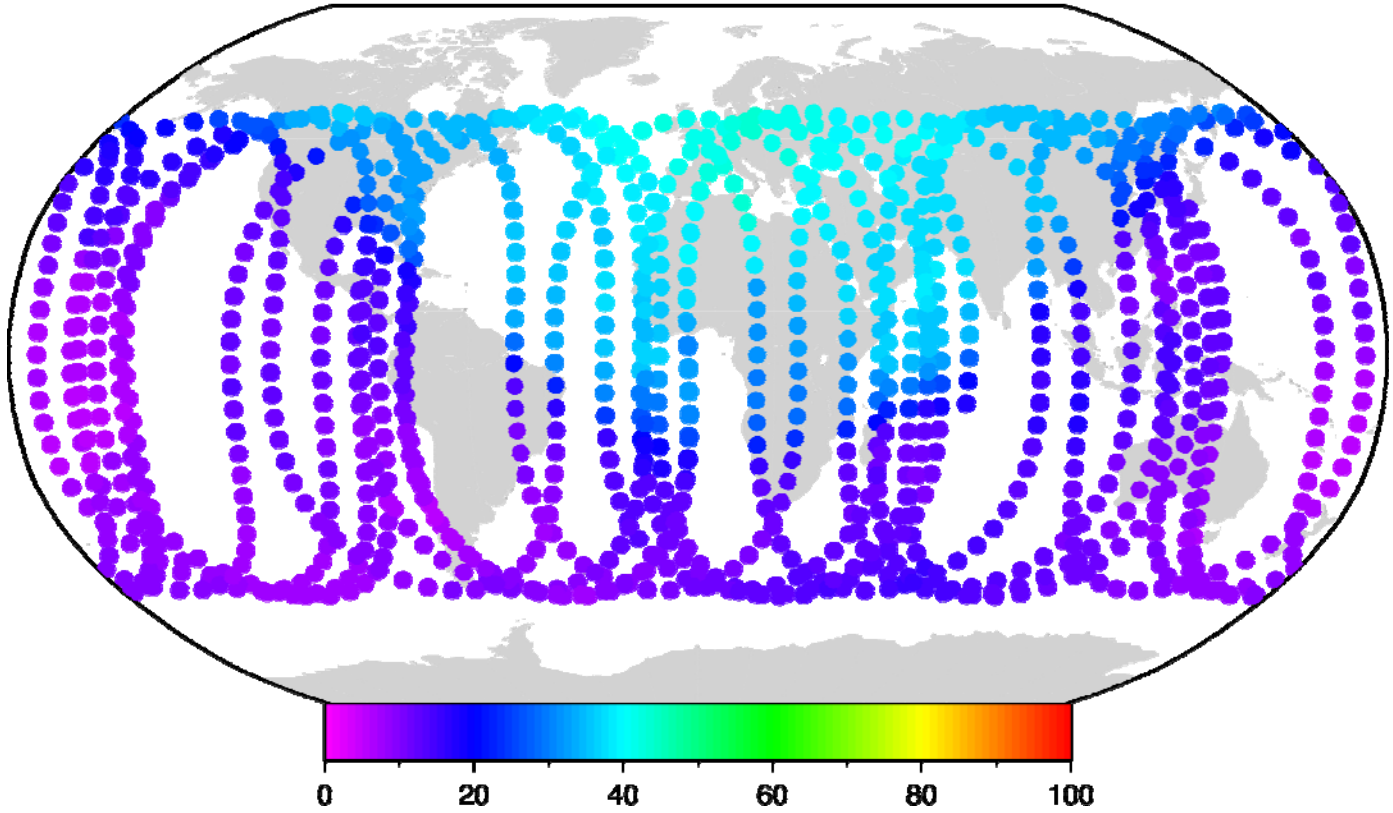
CODE MGEX orbit solution: „trackability“

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 12/152**



CODE MGEX orbit solution: „trackability“

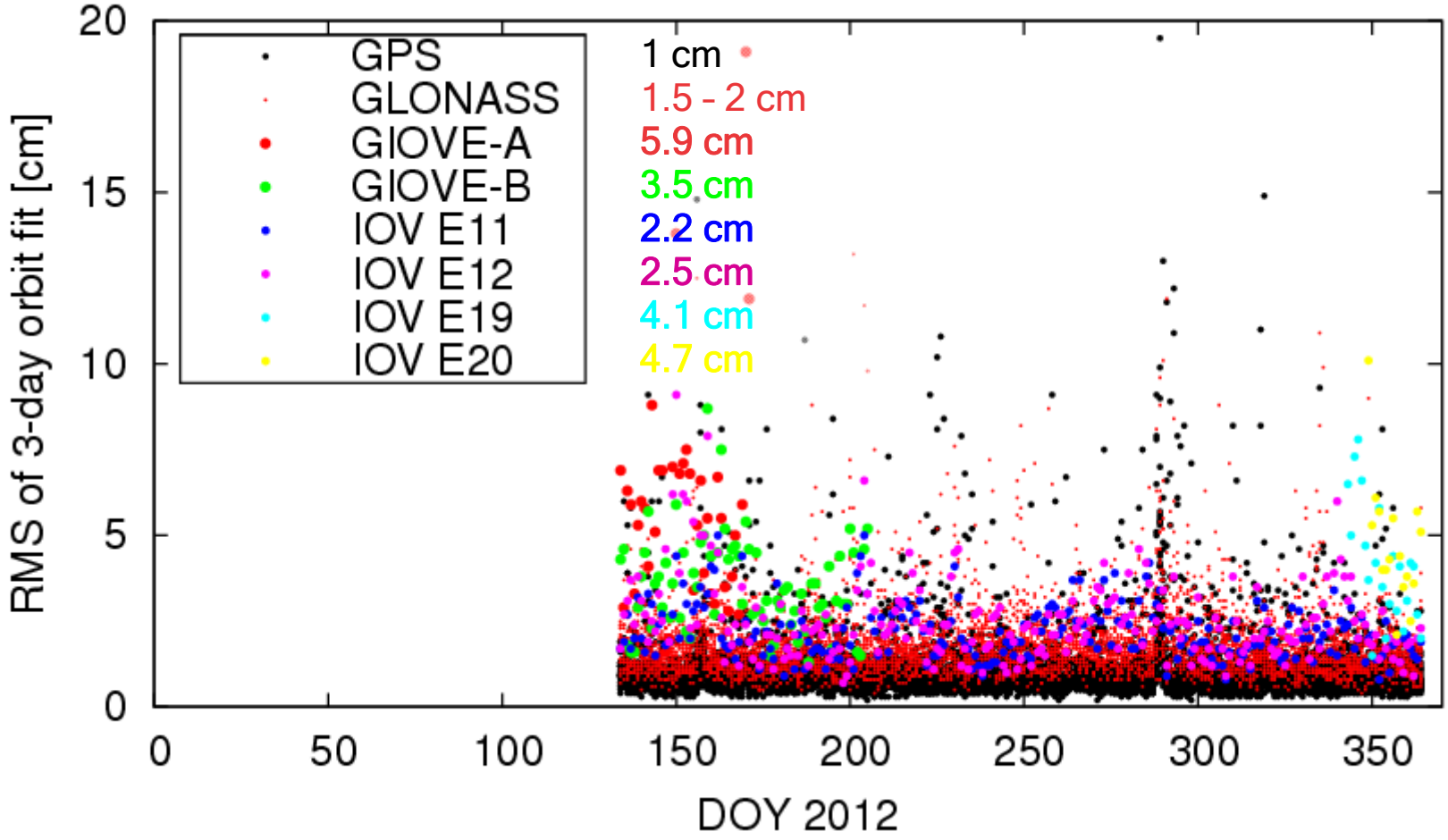
Number of stations that could theoretically track the satellites of the **Galileo** constellation (as a function of their orbit position - represented by ground tracks); **DOYs 12/150 - 152**



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

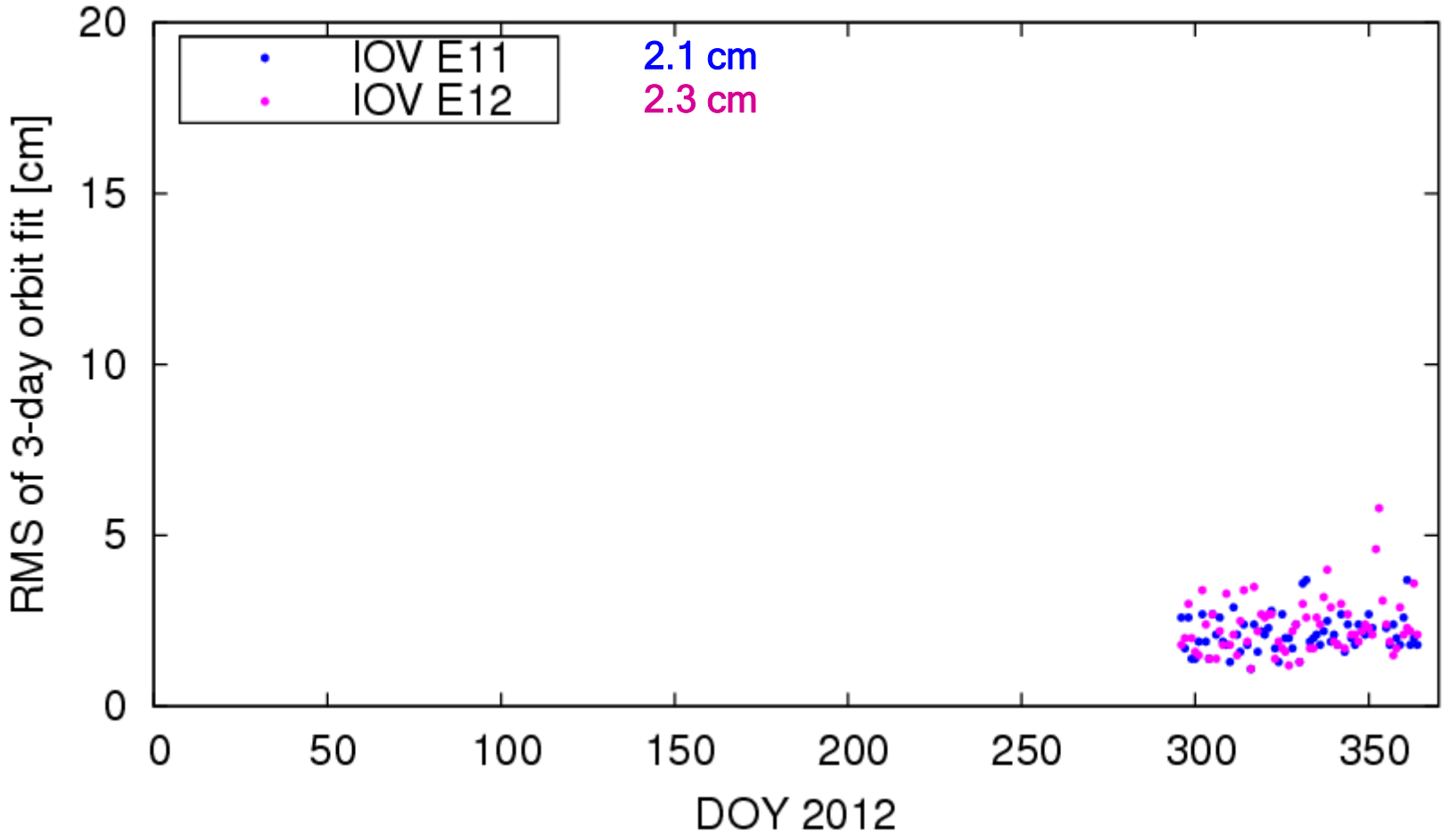
MGEX orbit validation

CODE MGEX: 3-day orbit fit



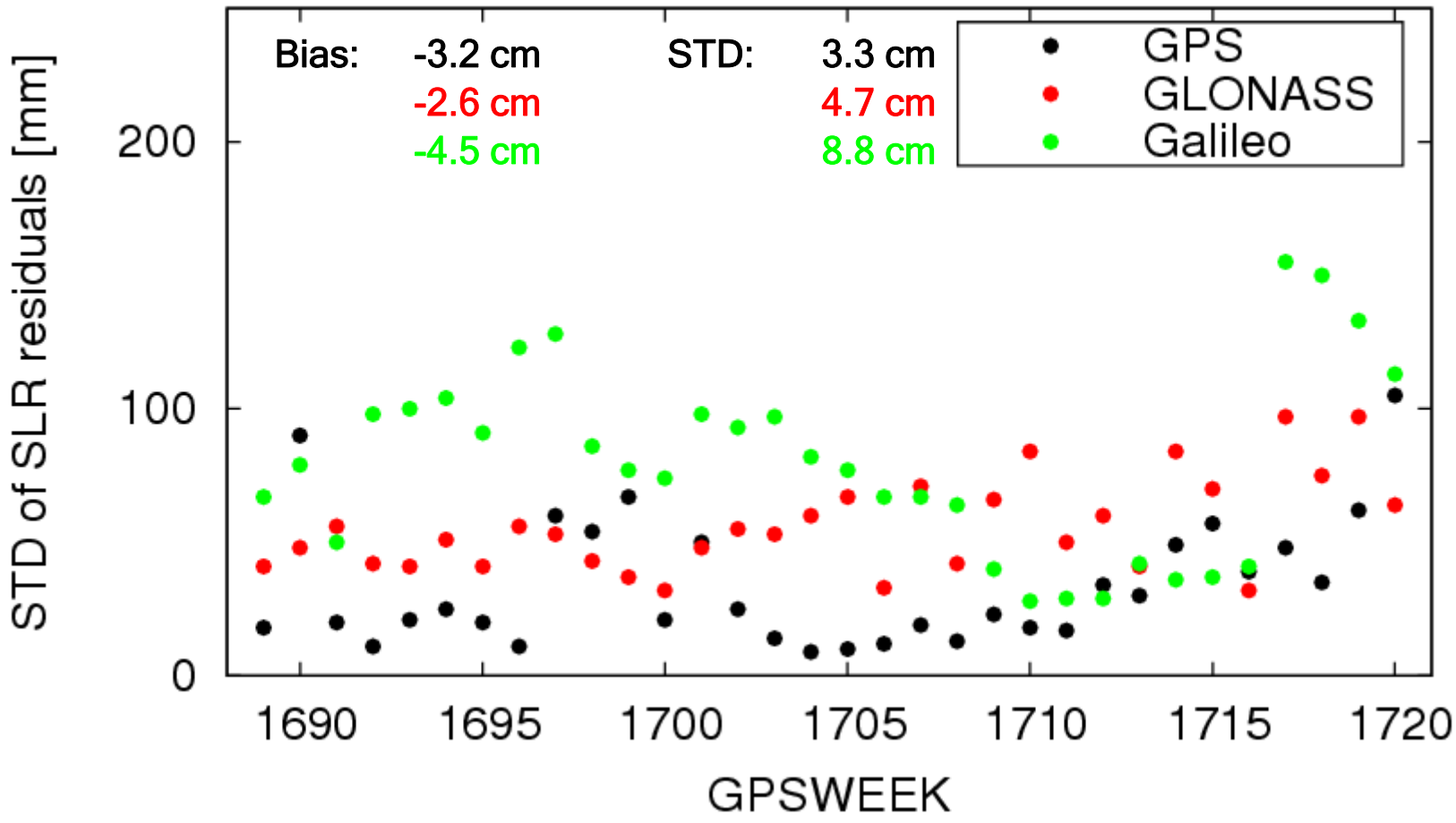
MGEX orbit validation

TUM MGEX: 3-day orbit fit



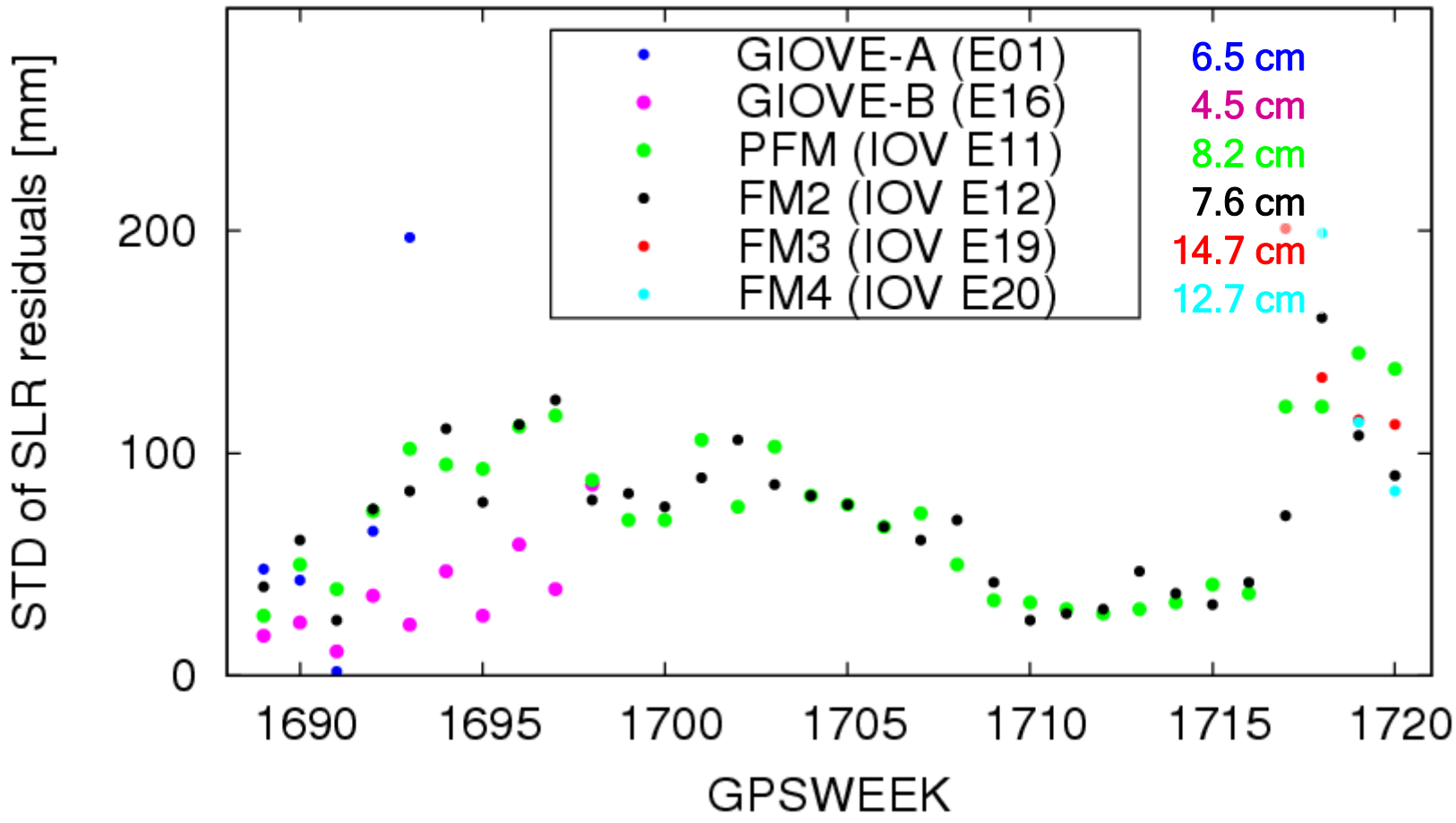
MGEX orbit validation

CODE MGEX: STD of SLR residuals per week



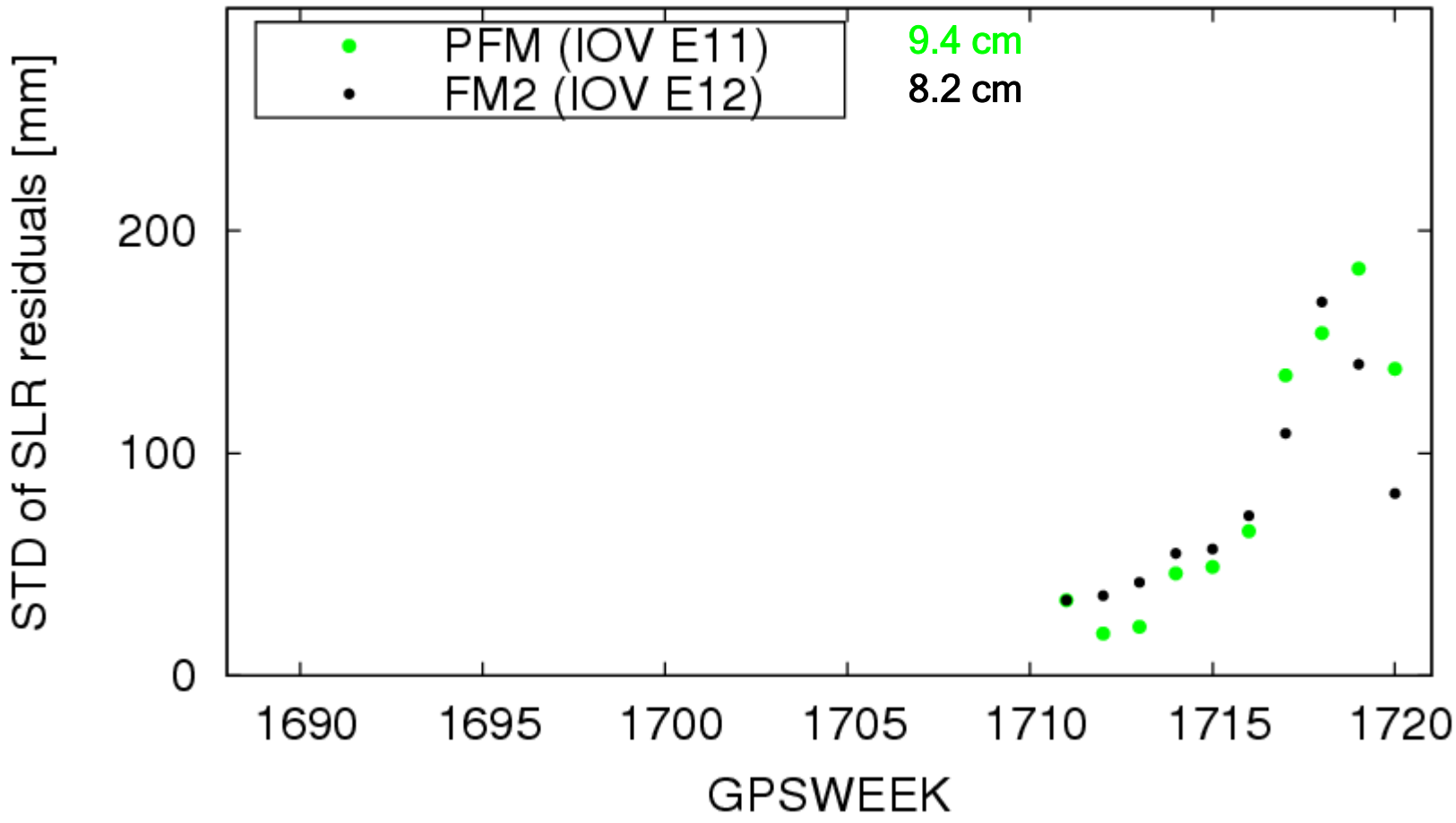
MGEX orbit validation

CODE MGEX: STD of SLR residuals per week



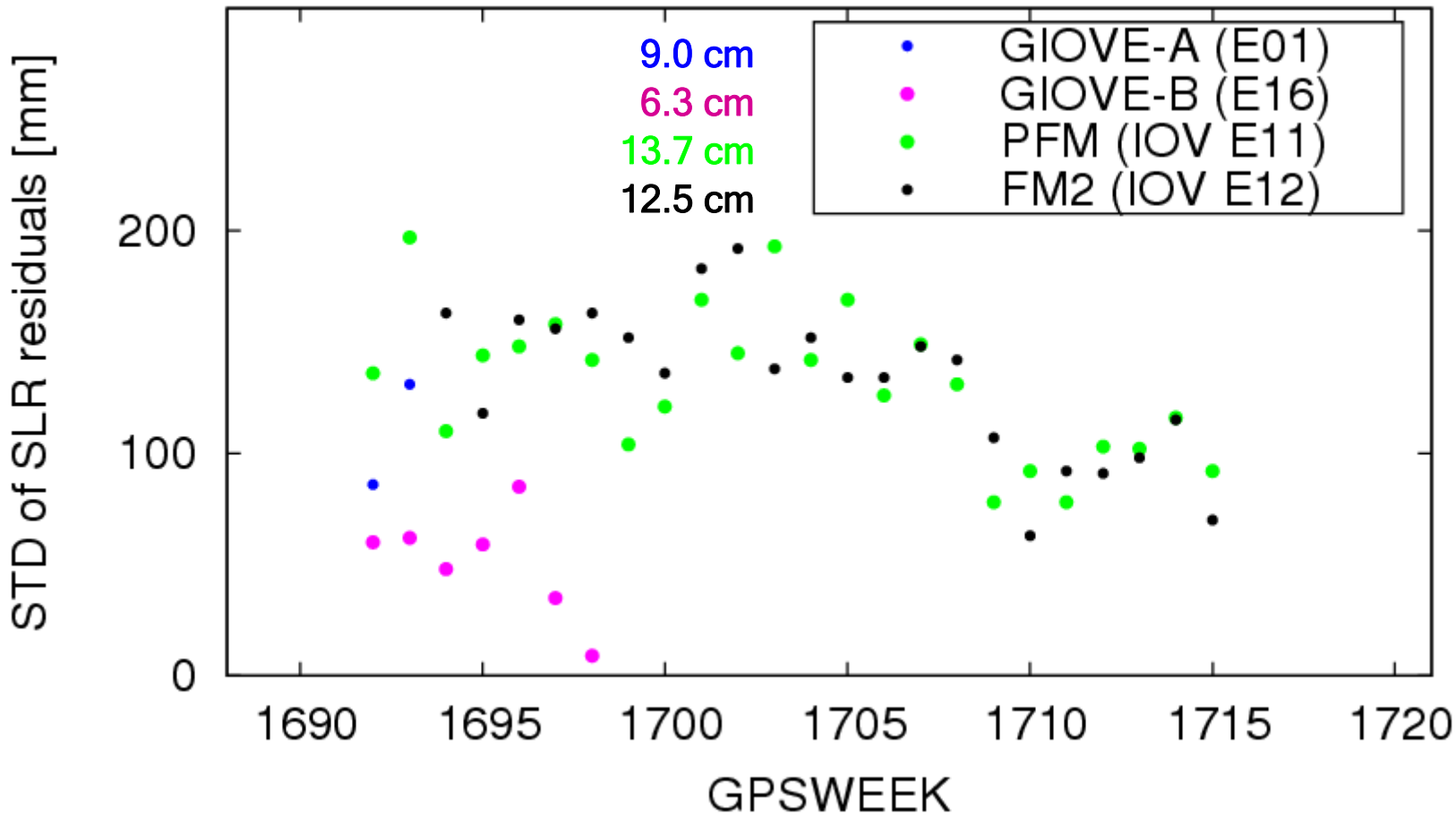
MGEX orbit validation

TUM MGEX: STD of SLR residuals per week



MGEX orbit validation

GRGS MGEX: STD of SLR residuals per week



CODE MGEX clock solution

GNSS considered:	GPS + Galileo (up to 36 satellites)
Processing mode:	offline (delayed)
Timespan covered:	GPS-weeks 1710-1720 (DOY 12/288-12/364)
Number of stations:	150 (GPS), 30 -35 (Galileo)
Processing scheme:	zero-difference network processing (observable: code+phase undifferenced)
Signal frequencies:	L1+L2 (GPS); E1(L1)+E5a (L5) (Galileo)
A priori information:	orbits, ERPs, coordinates, and troposphere from CODE MGEX orbit solution introduced as known
Reference frame:	IGb08
IERS conventions:	IERS2010
Product list:	epoch-wise (300s) satellite and station clock corrections in daily clock RINEX files; daily GPS-Galileo inter-system biases for mixed stations in Bernese DCB and BIAS-SINEX (BIA) format
Distribution:	ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/
Designator:	„com“

CODE MGEX clock solution

Static PPP: GPS-only, GPS+Galileo

Difference to CODE MGEX network solution:

Station	North [mm]		East [mm]		Up [mm]	
	mean	STD	mean	STD	mean	STD
BRUX	1.9	1.2	-4.3	3.2	-1.3	5.3
	1.5	1.4	-5.1	3.1	-1.5	4.8
CUT0	-0.5	1.2	0.3	2.8	-3.6	5.0
	0.0	1.3	0.8	3.1	-4.5	5.1
USN4	-0.4	1.5	0.3	2.5	-1.9	4.2
	-0.4	1.6	2.2	10.5	-3.6	11.2
USN5	-0.4	1.4	0.0	1.8	-2.3	3.8
	-0.2	1.5	-0.8	8.2	-2.9	4.9
WTZZ	0.6	2.1	-0.5	3.1	0.8	6.1
	0.6	2.1	-1.1	3.3	0.6	6.0

CODE MGEX clock solution

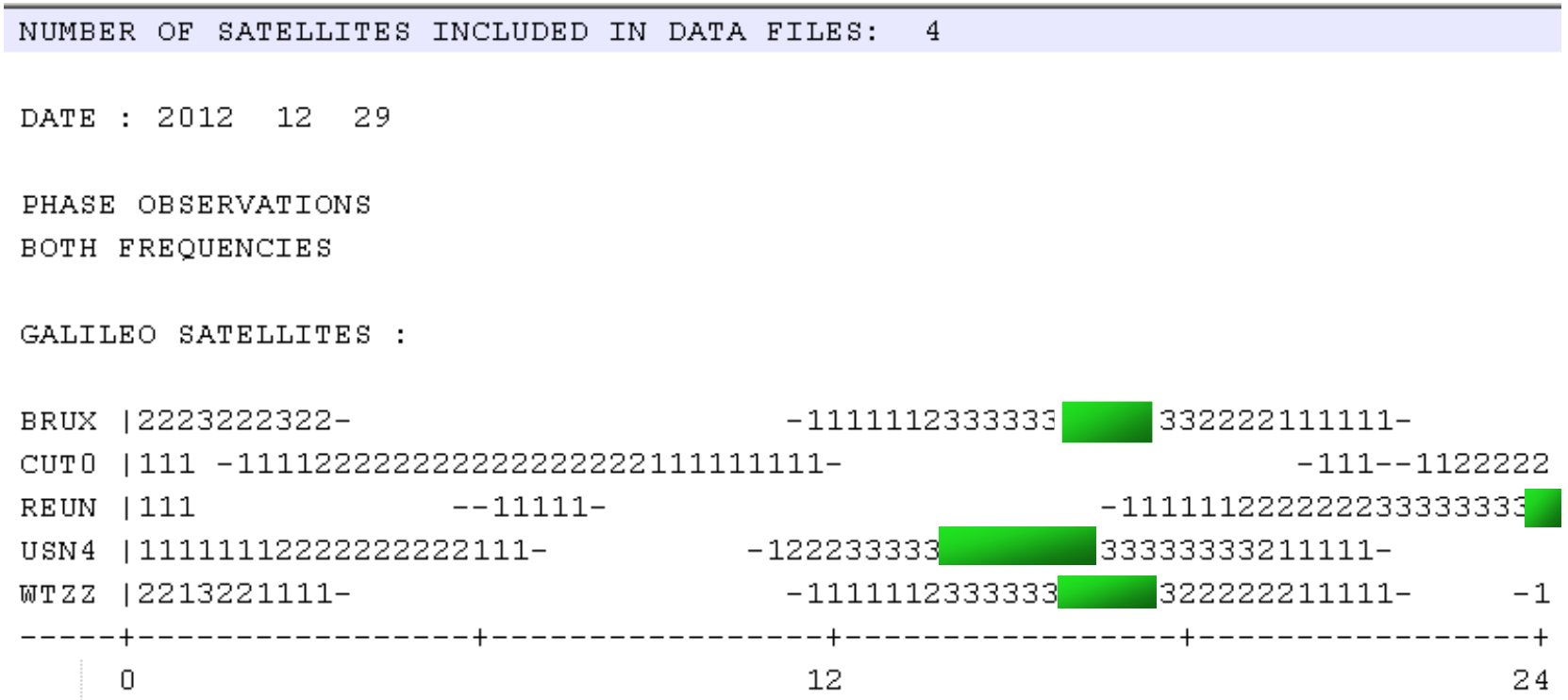
Kinematic PPP: GPS-only, GPS+Galileo

Difference to CODE MGEX network solution:

Station	North [mm]		East [mm]		Up [mm]	
	mean	STD	mean	STD	mean	STD
BRUX	1.5	7.7	-4.4	7.8	-0.8	18.5
	1.1	8.2	-4.5	9.0	-0.5	29.5
CUT0	0.8	12.8	-1.6	23.9	-3.7	29.6
	0.9	16.9	-1.6	26.3	-4.6	30.7
USN4	-1.2	6.7	-1.3	8.2	2.1	19.1
	-1.0	6.7	-0.7	8.3	1.5	19.7
USN5	-1.0	7.3	-0.6	8.4	2.3	20.2
	-1.1	10.6	-0.4	10.4	2.2	22.2
WTZZ	0.2	9.9	-0.5	9.1	0.0	22.8
	0.1	9.6	-0.7	8.8	0.3	22.1

CODE MGEX clock solution

Static PPP: Galileo-only



- 4 Galileo IOV satellites active since December 2012
- Some stations tracked all of them at the same time
- Galileo-only PPP experiment DOYs 355 – 364

CODE MGEX clock solution

Static PPP: Galileo-only

Difference to CODE MGEX network solution:

BASELINE	#OBS.	DH (MM)	DN (MM)	DE (MM)	DS (MM)
BRUX3550	440	-1.8	-8.3	14.0	16.4
BRUX3560	585	-2.9	-12.0	-42.0	43.8
BRUX3570	516	-76.6	14.2	-19.8	80.4
BRUX3580	446	55.8	-6.8	336.0	340.7
BRUX3590	546	2.0	-31.4	-54.1	62.6
BRUX3600	610	-4.4	-3.1	8.7	10.2
BRUX3610	448	6.4	-6.0	-84.3	84.8
BRUX3620	471	20.1	-23.4	-16.6	35.0
BRUX3630	674	-27.8	0.6	-11.7	30.2
BRUX3640	438	91.5	-54.7	6.2	106.8
USN43550	460	85.7	-80.8	72.9	138.5
USN43560	232	3266.7	-870.4	7438.2	8170.4
USN43570	730	7.0	-60.3	-92.9	111.0
USN43580	556	-24.3	-12.0	37.5	46.3
USN43590	280	-198.1	595.0	-372.5	729.4
USN43600	610	24.9	-89.6	-64.1	112.9
USN43610	682	67.1	11.1	-5.1	68.2
USN43620	412	-199.6	89.1	-37.0	221.7
USN43630	396	43.5	-27.4	129.6	139.4
USN43640	772	-10.8	-21.6	-37.4	44.5

CODE MGEX clock solution

Kinematic PPP: Galileo-only

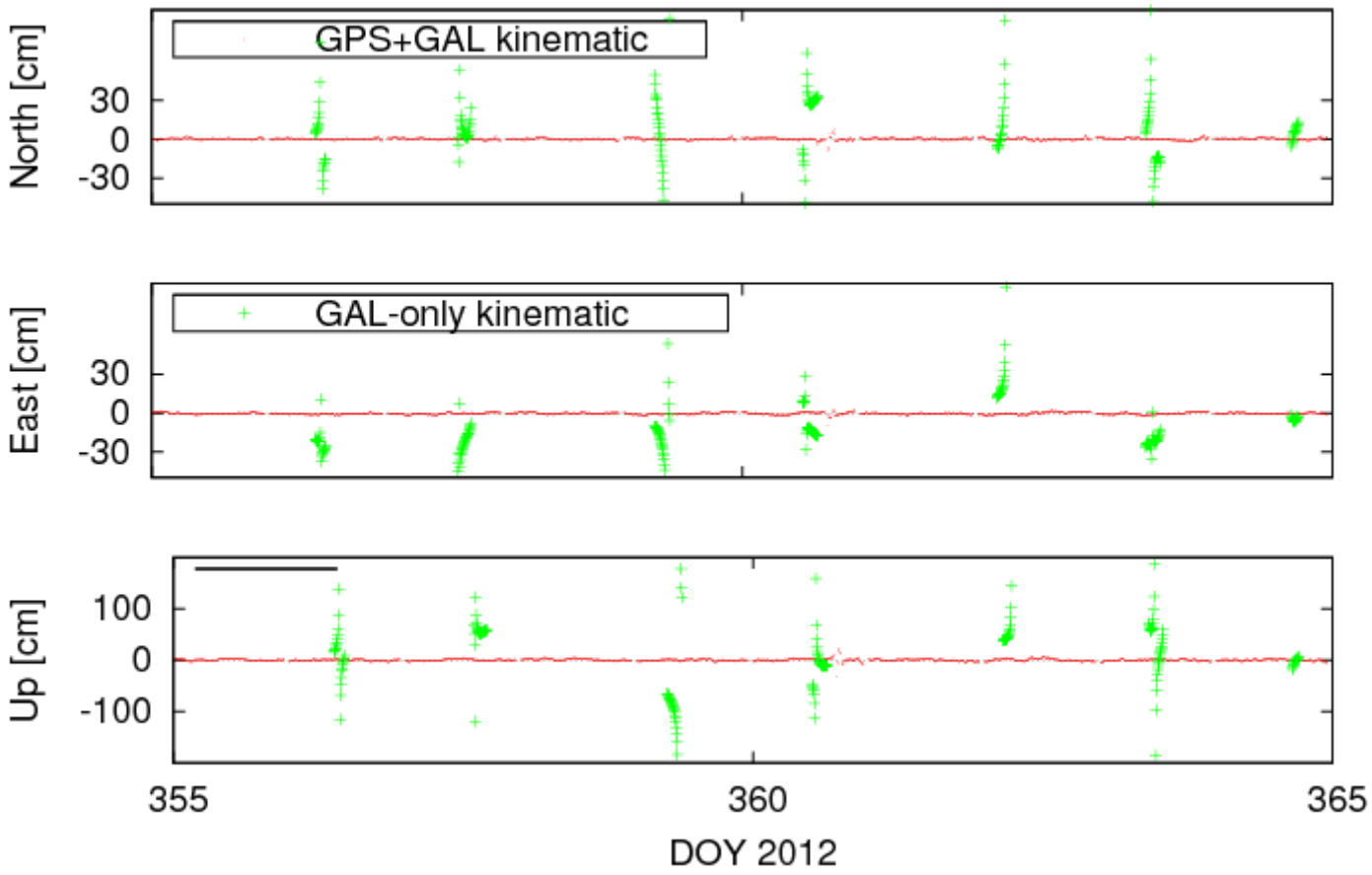
Difference to CODE MGEX network solution:

Station	Epochs	North		East		Up	
		mean	STD	mean	STD	mean	STD
BRUX	208	85.3	571.3	-133.8	258.0	75.2	762.8
REUN	39	-166.0	476.1	-81.2	129.7	521.6	456.0
USN4	166	-126.5	876.7	-128.6	321.4	-238.3	1027.3
WTZZ	47	497.6	1001.9	485.0	525.9	725.1	911.0

(threshold of 3000 mm applied for statistics computation)

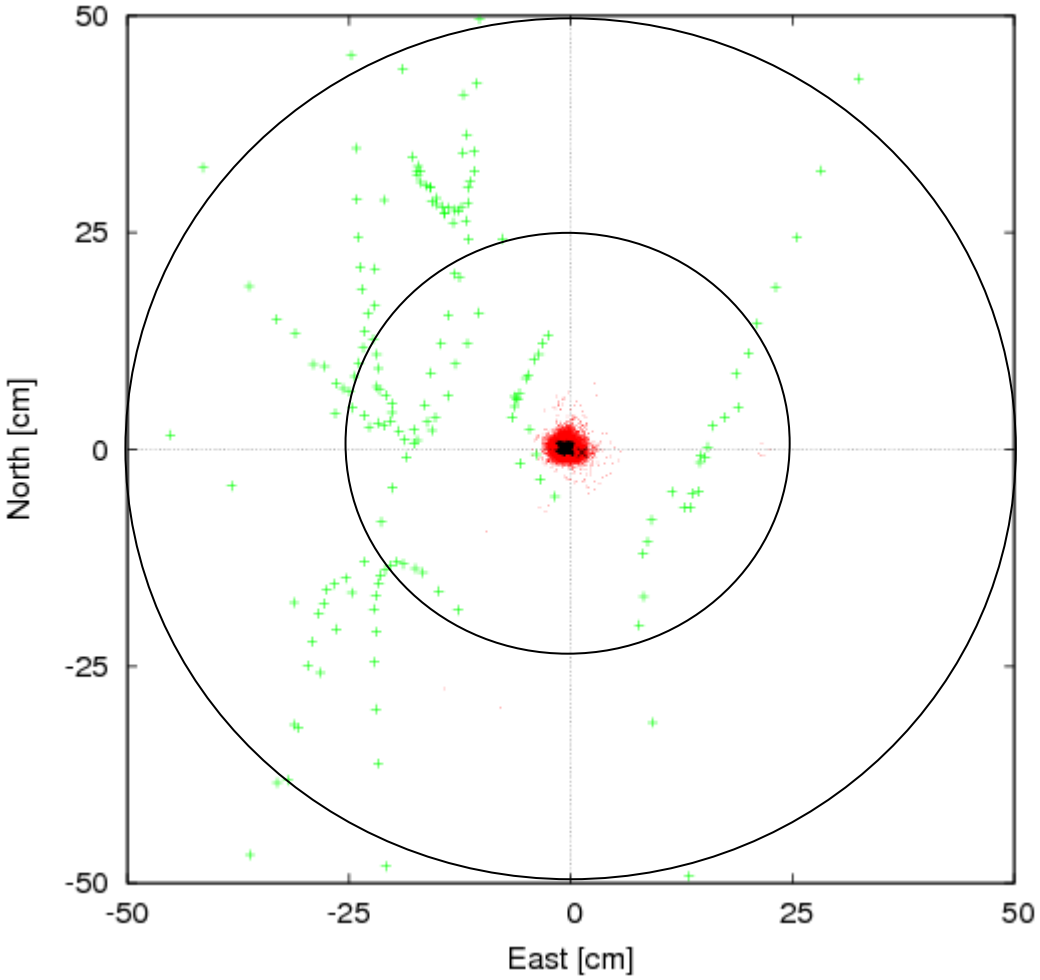
CODE MGEX clock solution

Kinematic PPP: Galileo-only



Differences between static and kinematic coordinates of IGS station BRUX

CODE MGEX clock solution



- Static GPS-only
- Kinematic GPS-only
- Kinematic Galileo-only

Differences between static and kinematic coordinates of IGS station BRUX

Summary

- CODE MGEX monitoring results for RINEX3 available via AIUB anonymous FTP => ftp://ftp.unibe.ch/aiub/mgex/
- CODE provides a MGEX-based, fully integrated, triple-system solution: GPS+GLONASS+Galileo
- Galileo orbits dramatically benefit from long arcs due to
  - the inhomogeneous station distribution and
  - its long orbit revolution time (>>12h)

Summary

- CODE GPS+Galileo clock solutions for 2012 are available
- Galileo-only PPP is in principle already possible
- A new batch of MGEX orbit and clock solutions (e.g., Jan.- March 2013) is planned
- The CODE MGEX processing is done using Bernese GNSS Software 5.2
- The analysis of MGEX data is very useful for understanding, integration, and exploitation of the new GNSS and signals.

Thank you

for

your interest!