The Use of System–Dependent Antenna Phase Center Models in a Global Multi–GNSS Analysis

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Vienna, Austria; 19–24 April 2009

What does the IGS today?

IGS05.ATX: Absolute antenna phase center model

- IGS05.ATX is compatible to IGS05 reference frame.
  - Correction values for an antenna are not updated if it is used on one of the reference stations of the IGS05.
- absolute calibrations (robot or compatible) for antenna and radome
  - All available corrections for the antenna/radome combinations are used.
  - Remaining antenna/radome combinations made compatible from other sources (e.g., relative field calibrations).
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- GPS–only calibrations
  - GPS–derived models are used for all active GNSS.
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Some questions for this presentation

Introduction of system–dependent antenna phase center models?

- What is the magnitude of the differences in the receiver antenna phase center model?
- What is the impact of system–dependent models on a multi–GNSS solution?
- What is their impact on the (non–GPS) satellite antenna phase center models?

Data basis: CODE–reprocessing

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    (IAPG/TUM is a member of the CODE consortium since January 2009)
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  - For more details we refer to the poster *P. Steigenberger et al.*:
    CODE contribution to IGS reprocessing: status and perspectives

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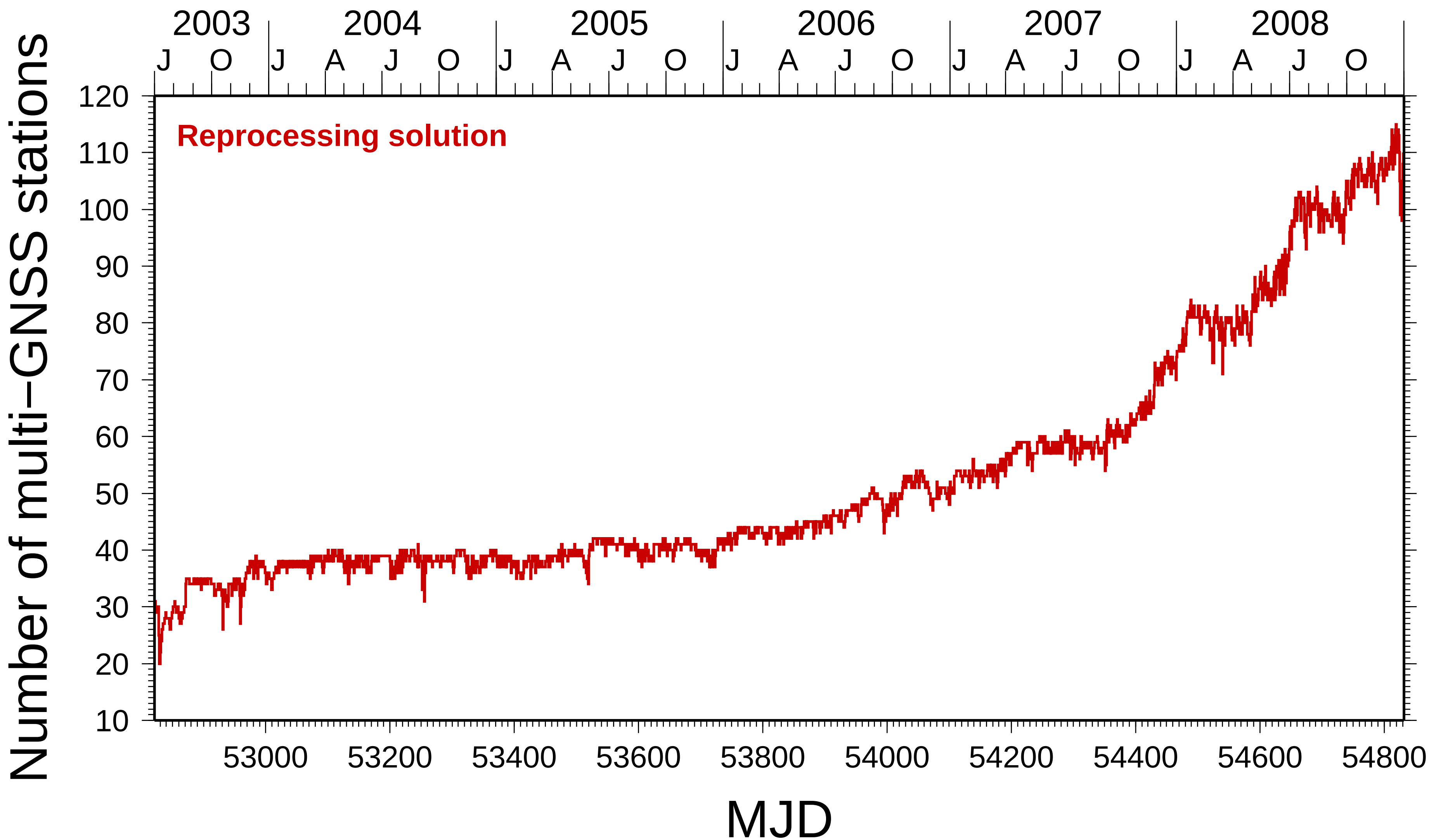
- **IGS–Repro01, GLONASS–extension:**
  - All available GLONASS–tracking stations are processed as a separate GPS+GLONASS cluster and added to the GPS–only solution on NEQ–level.
  - current status: interval from 9 June 2003 to the end of 2008
    (continuation into the past till the beginning of the IGEX project in fall 1998 is planned)

Number of GLONASS Stations

GLONASS tracking receivers in the CODE–Reprocessing



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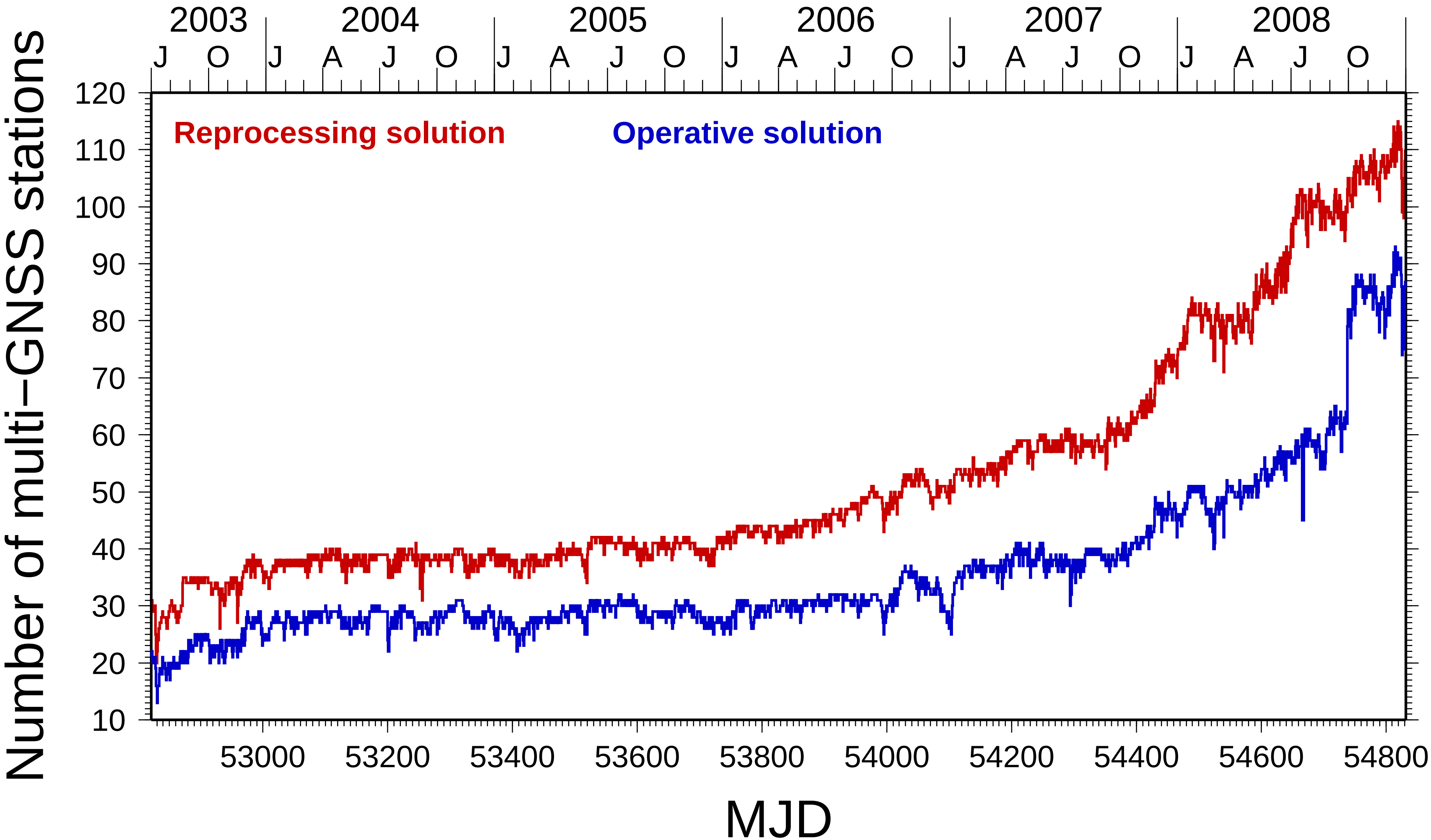

List of antennas in EGU05.ATX

Antenna/radome	GPS: Ant	GPS: Cal	GLO: Ant	GLO: Cal	Reference	GNSS	GPS–only	Calibration	in IGS05	also used fo
ASH700936D_M NONE	2	27	3	6	3	2	1	ROBOT		DOME, JPL
ASH701945E_M NONE	2	4	1	2	7	2	9	COPIED		JPLA
JPSREGANT_DD_E NONE	24	153	1	6	0	8	0	ROBOT		
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LEIAT504GG NONE	25	49	21	41	2	8	0	ROBOT		
LEIAT504GG LEIS	79	157	70	136	1	11	0	ROBOT		
LEIAX1202GG NONE	14	28	14	28	0	1	0	FIELD		
NOV702GG NONE	2	4	2	4	0	1	0	ROBOT		
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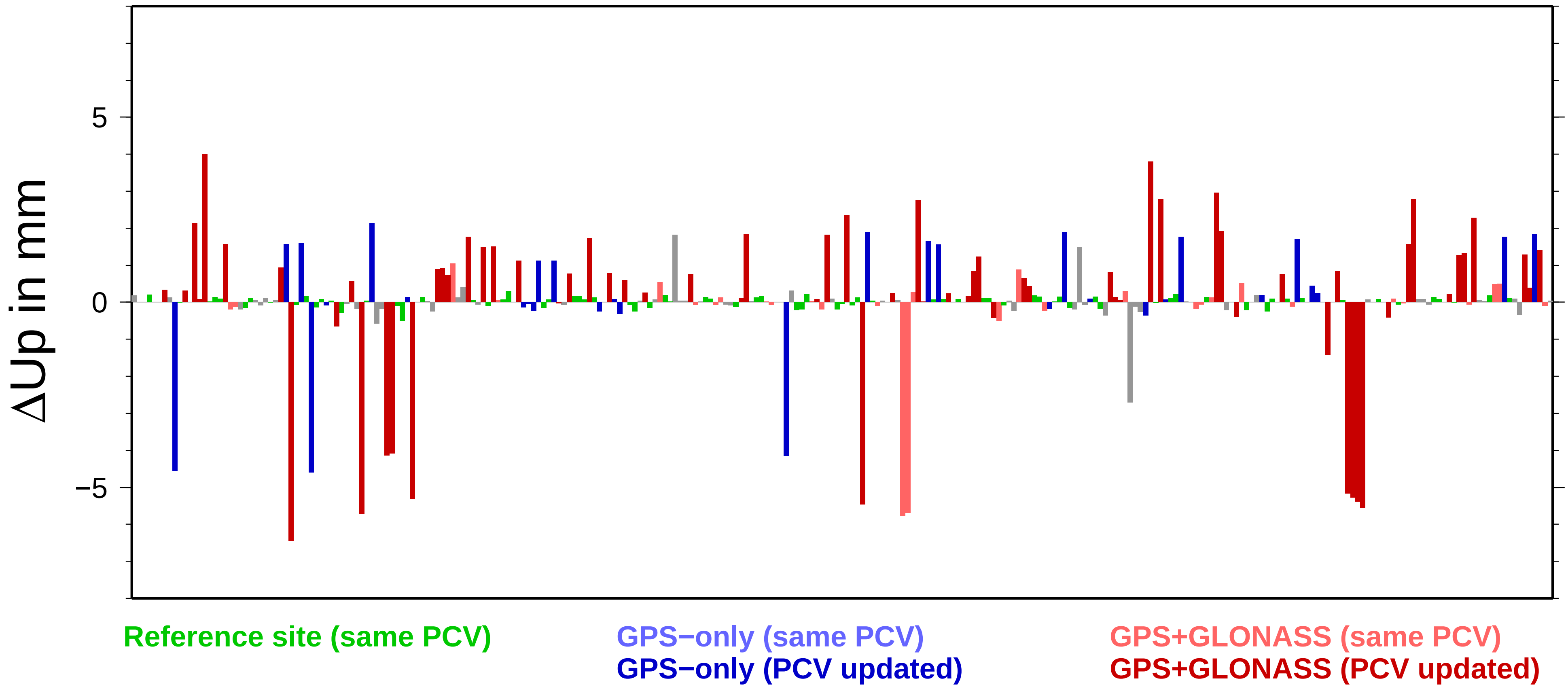
Update of the antenna phase center model

(using the GPS–derived corrections for GPS **and** GLONASS)
Differences in the long–term solution for the vertical component



At least one year of observations for each station in this plot – gives 281 stations.

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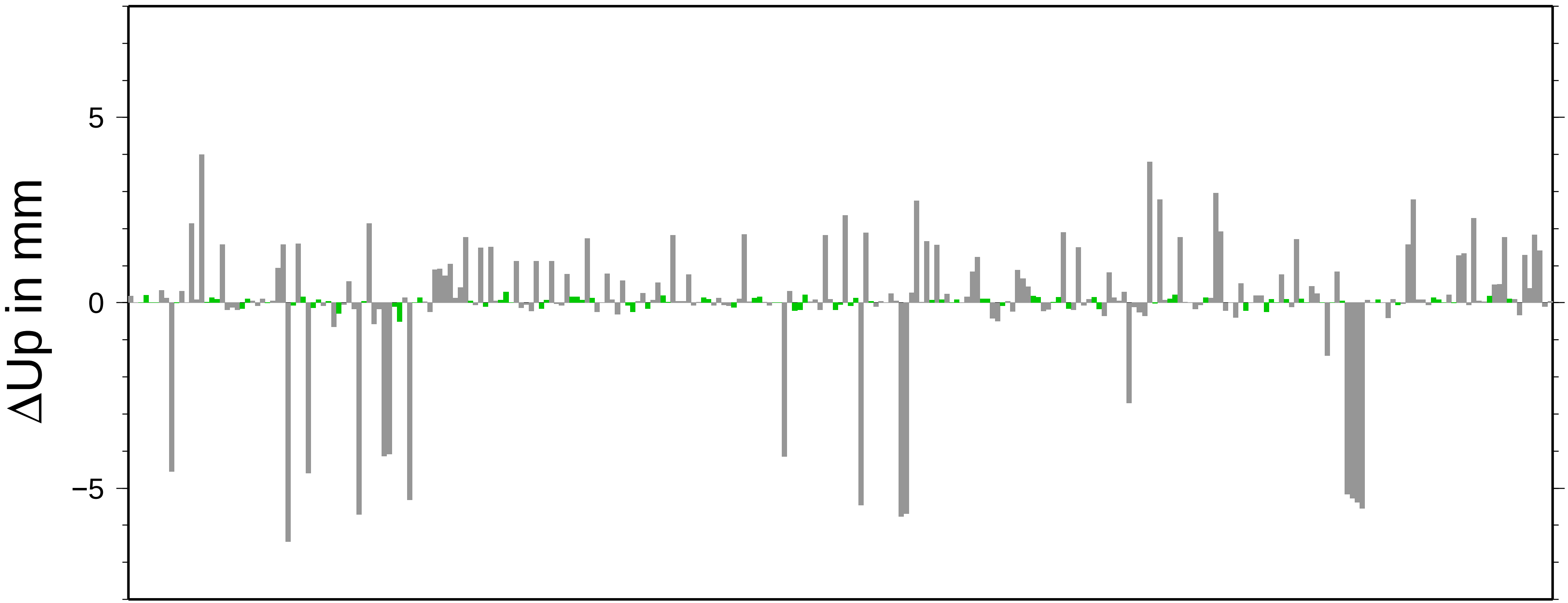

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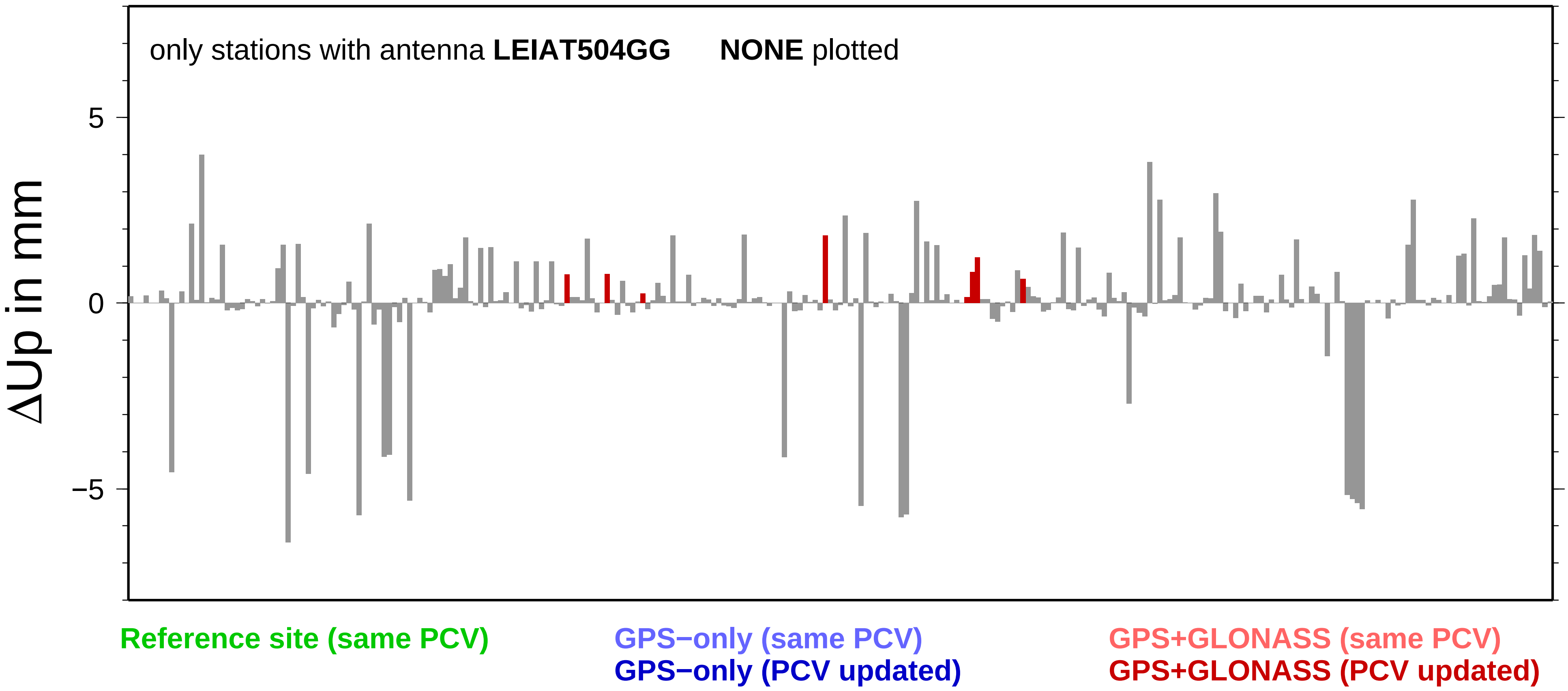

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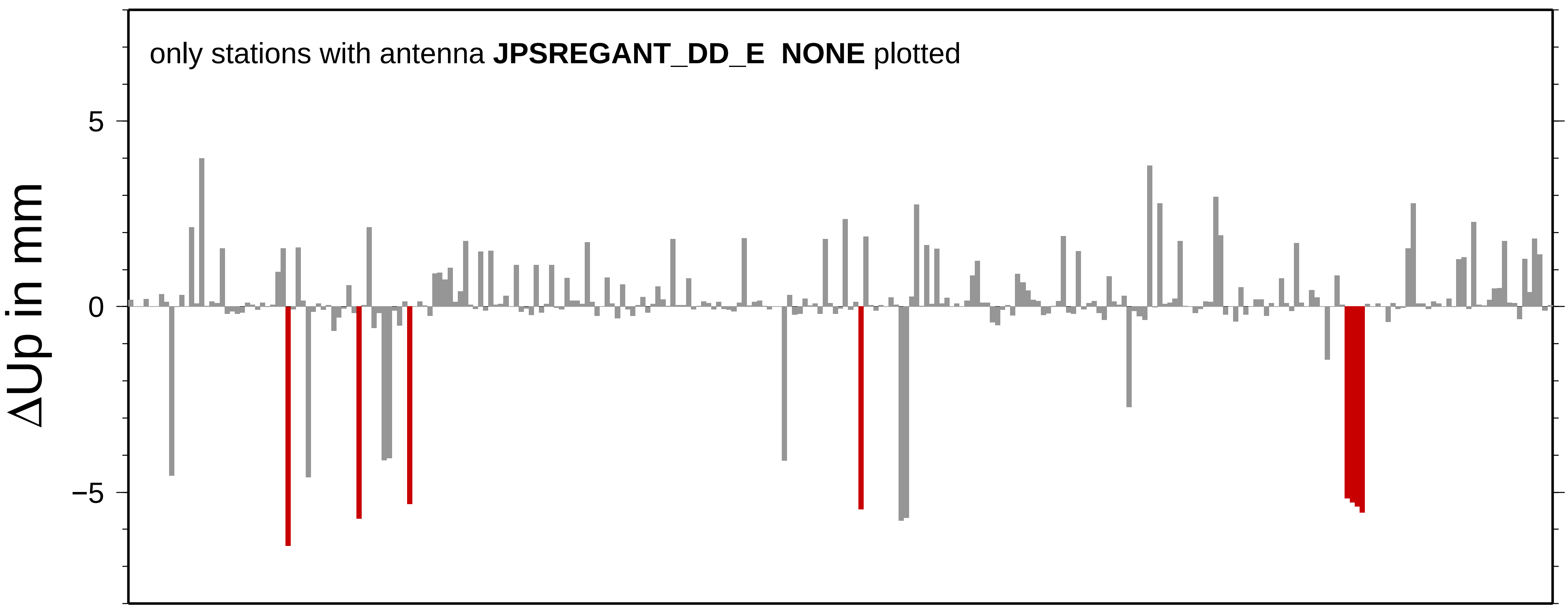

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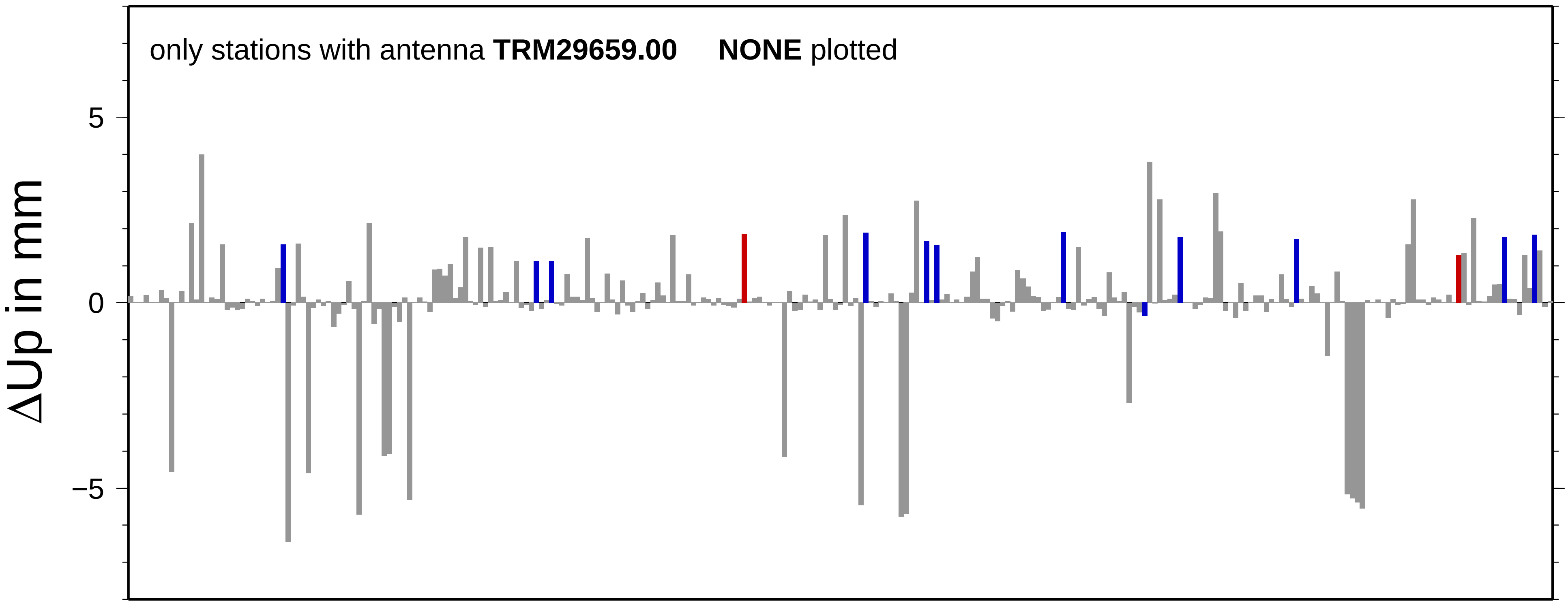

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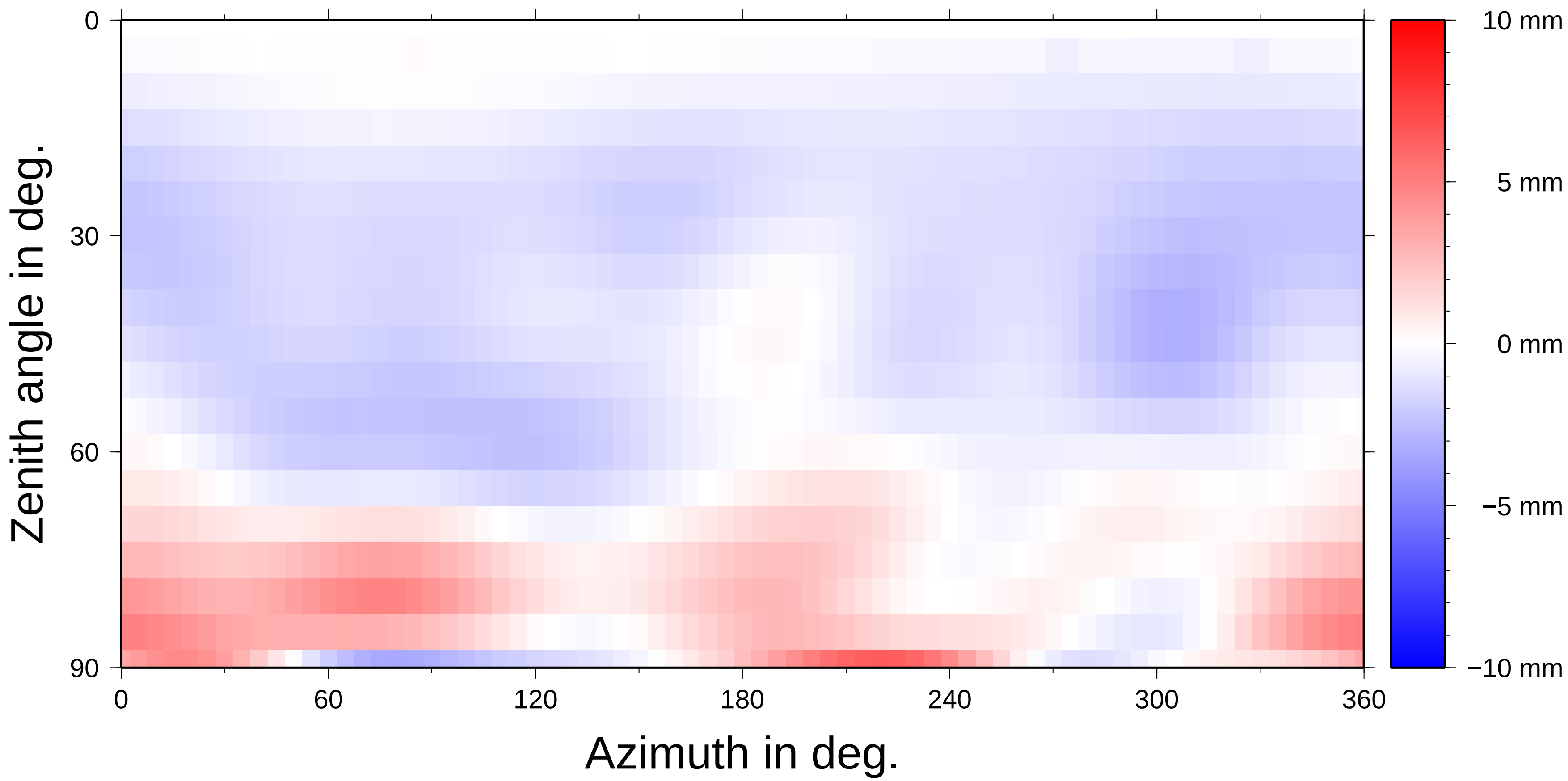
System–dependent calibration

Differences in the elevation/azimuth–dependent components of the GPS and GLONASS antenna phase center models

(Antenna: ASH701945E_M NONE)



The mean difference is absorbed by the inter–system bias.

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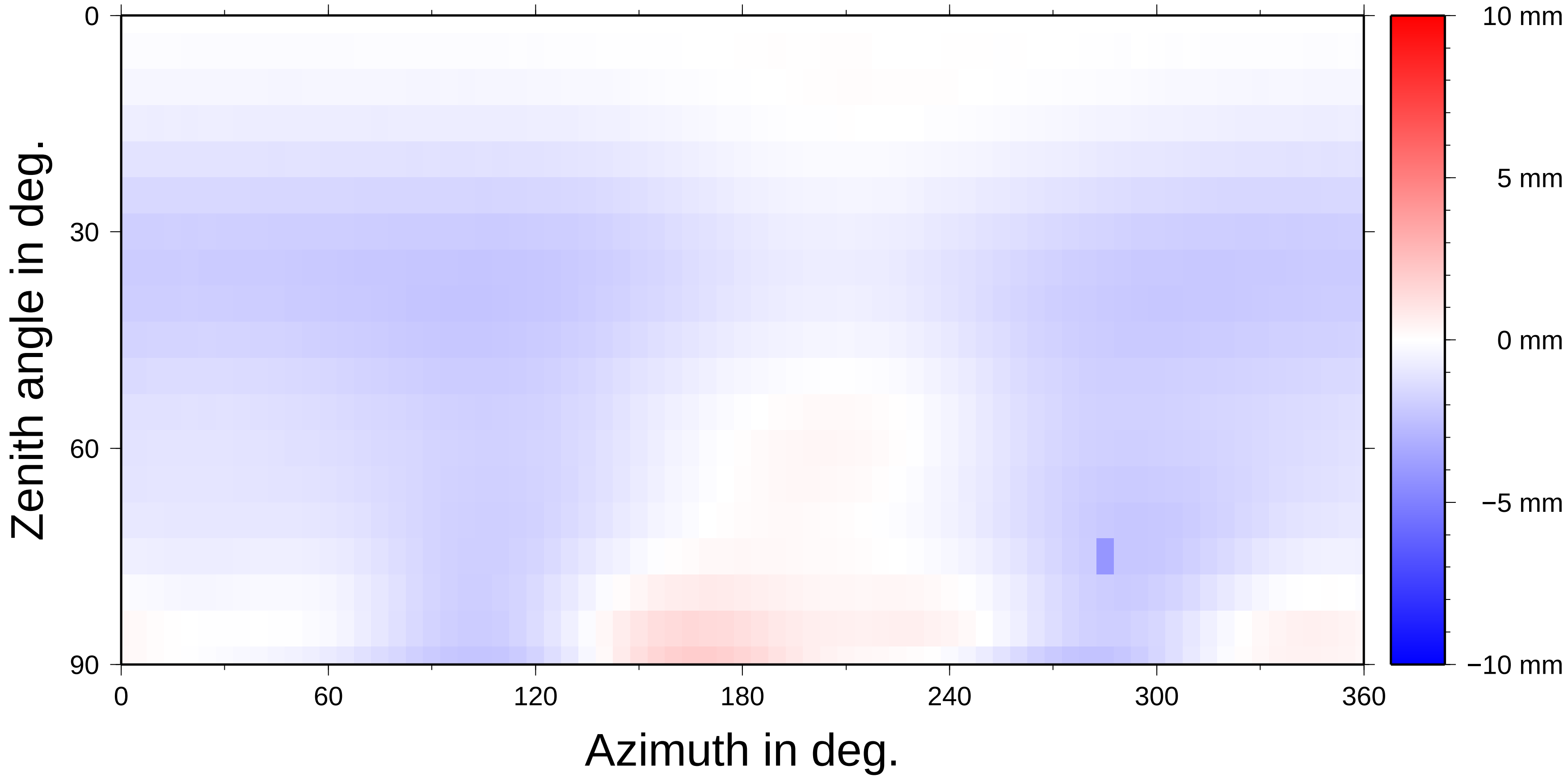

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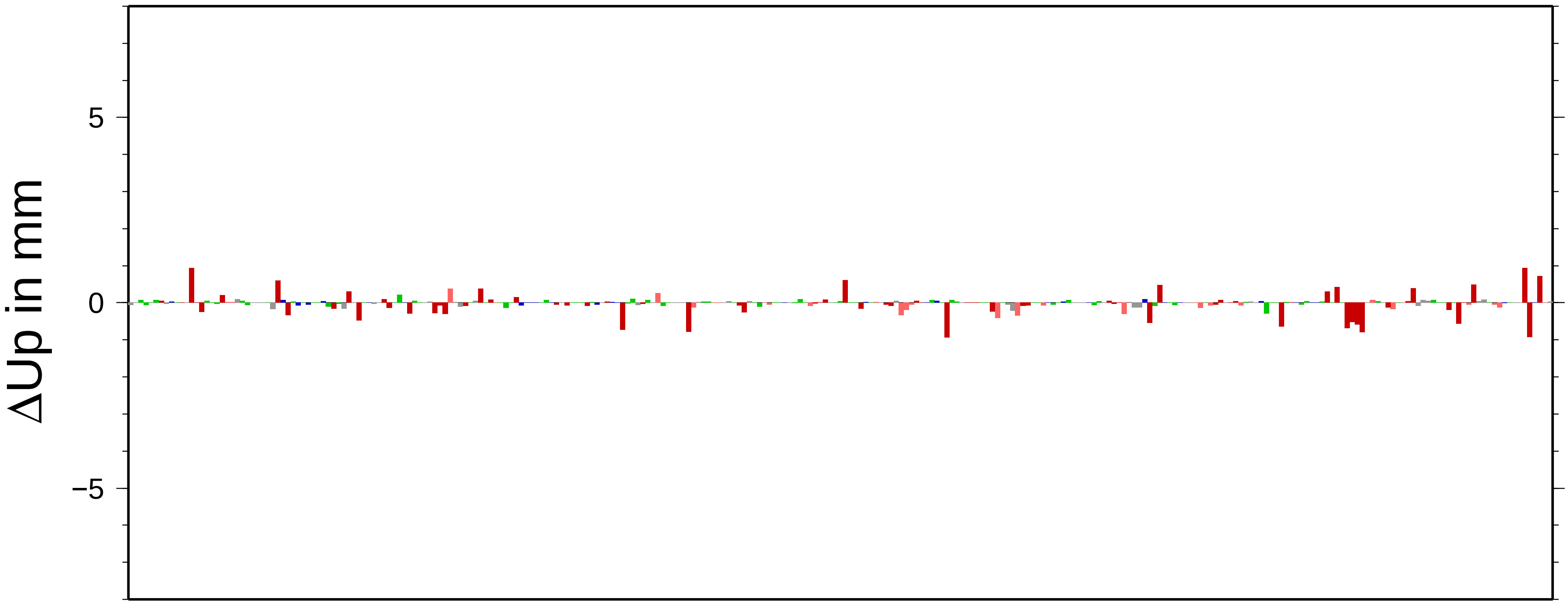
System–dependent calibration

Use of GLONASS–specific antenna phase center corrections

(instead of using the GPS–derived corrections for GPS and GLONASS)

Differences in the long–term solution for the vertical component



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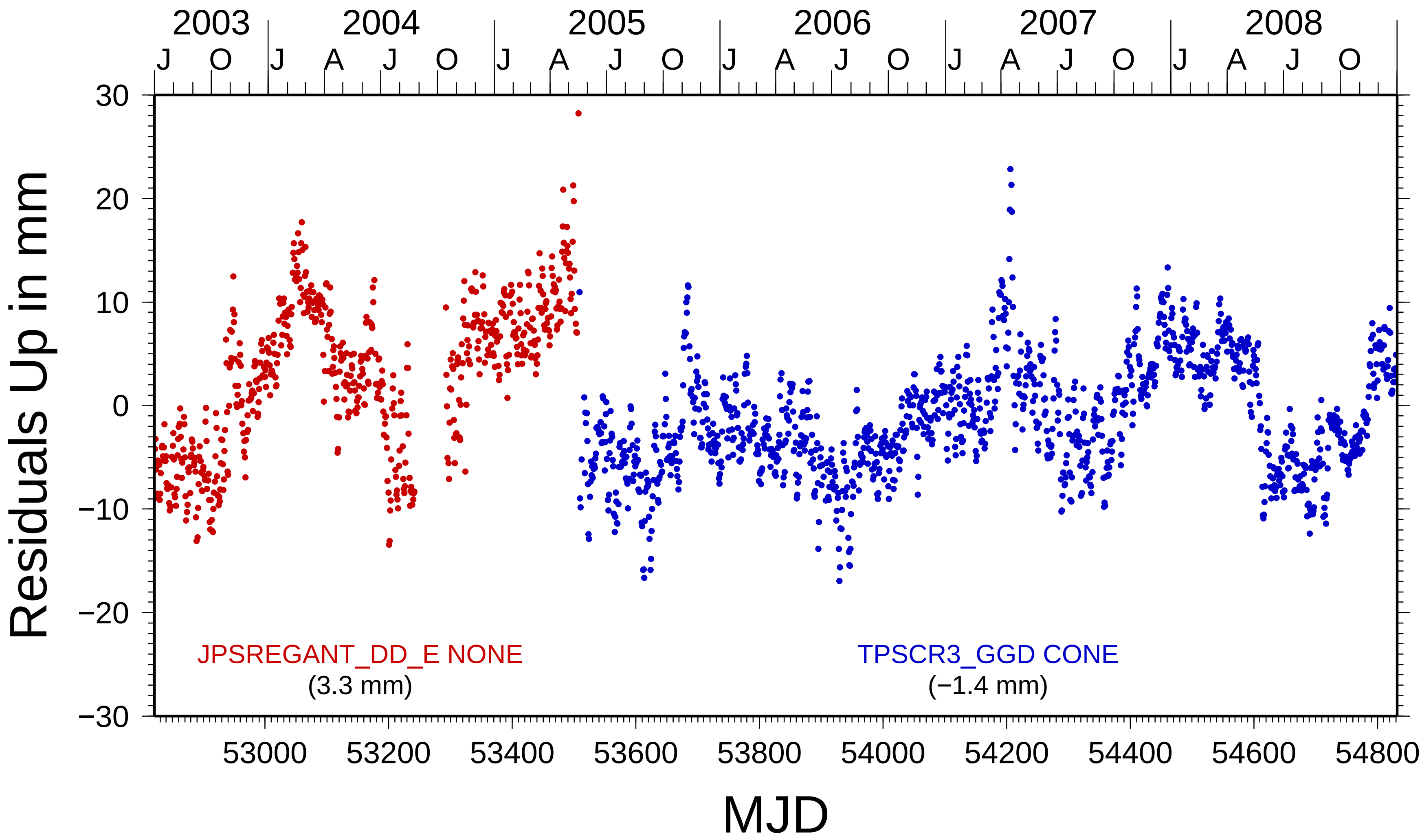
Time series for station CONZ

(IGS05.ATX, GPS model also used for GLONASS)



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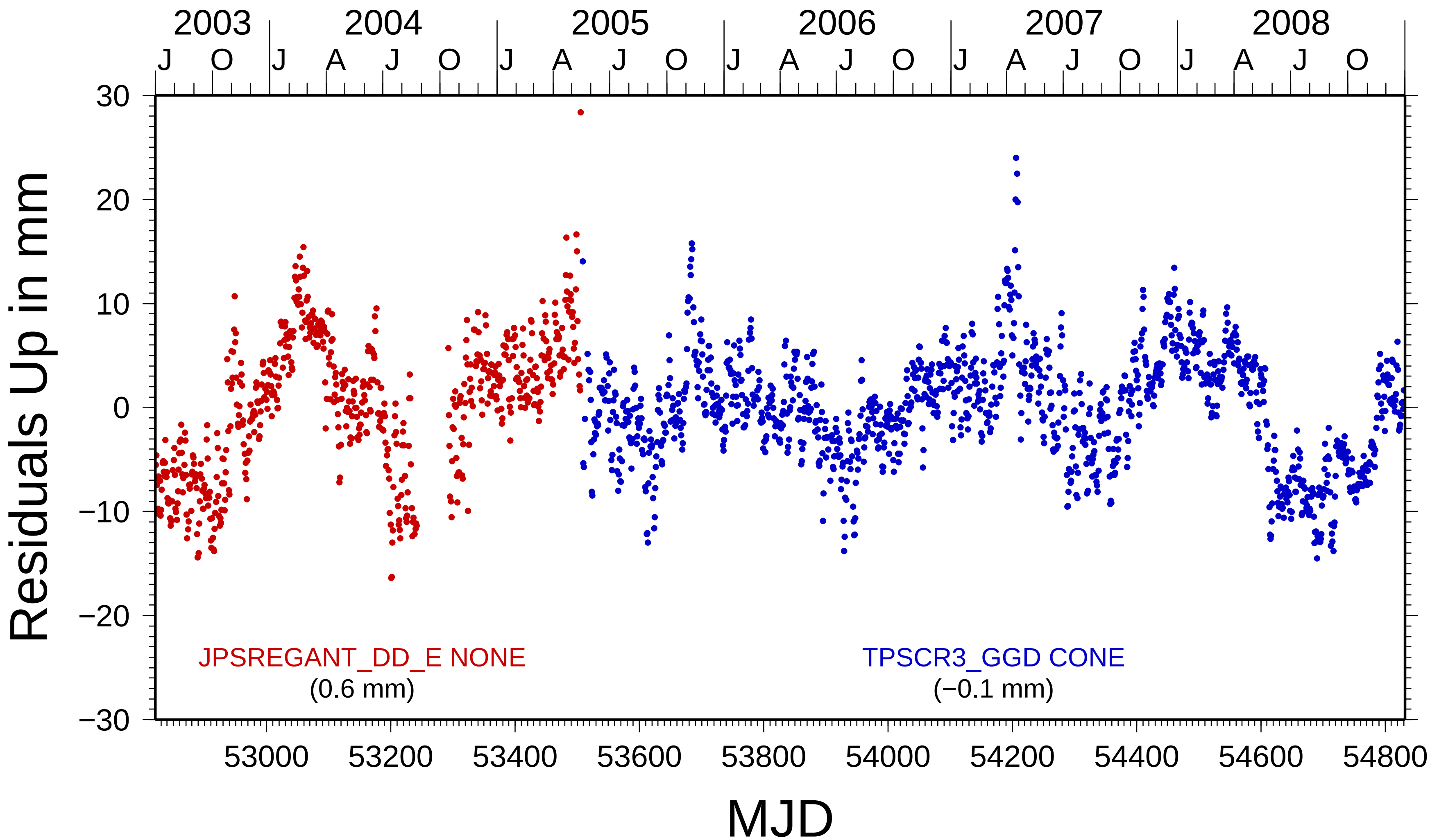
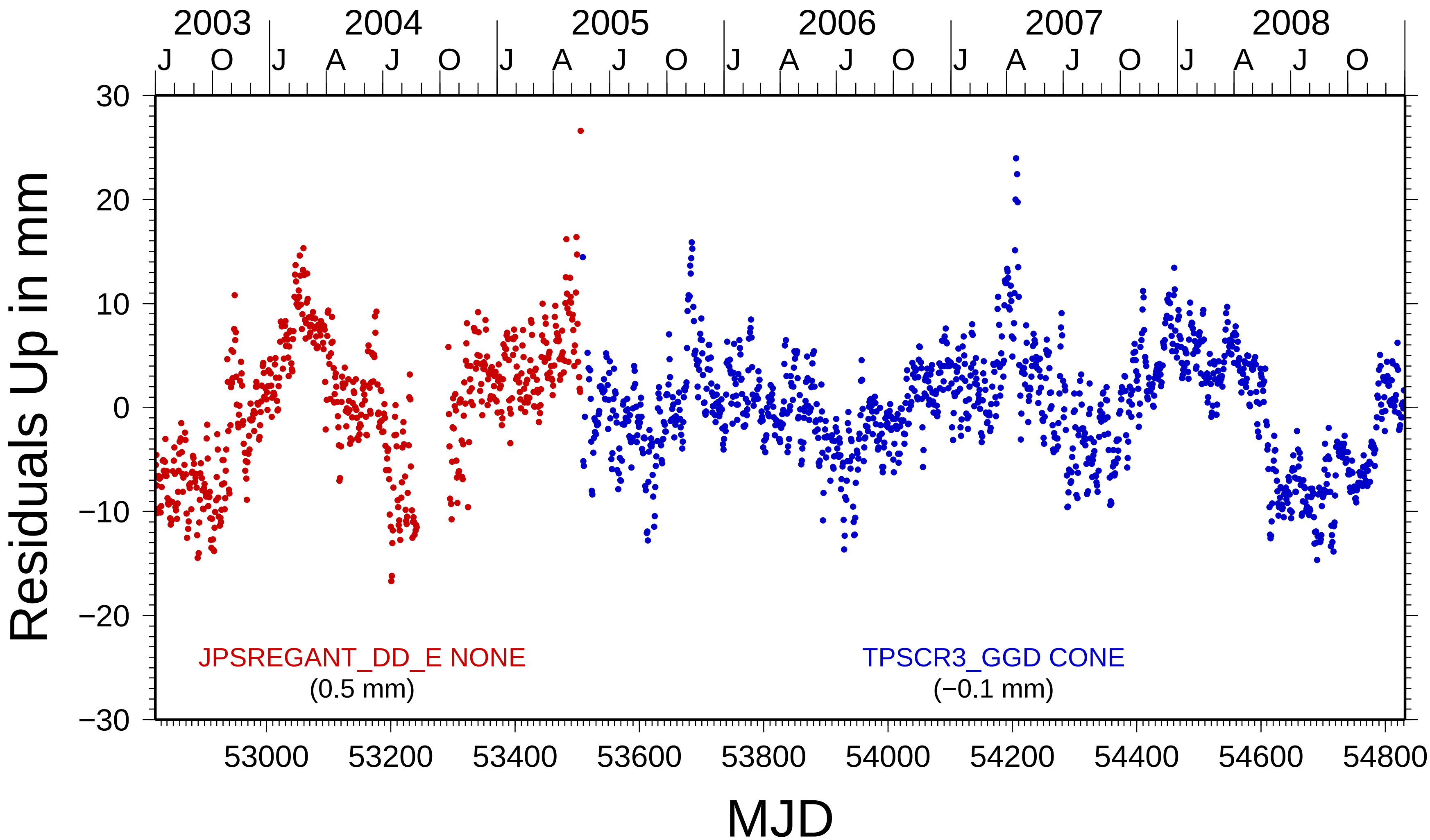


System–dependent calibration

Time series for station CONZ

(EGU05.ATX, special GLONASS corrections)



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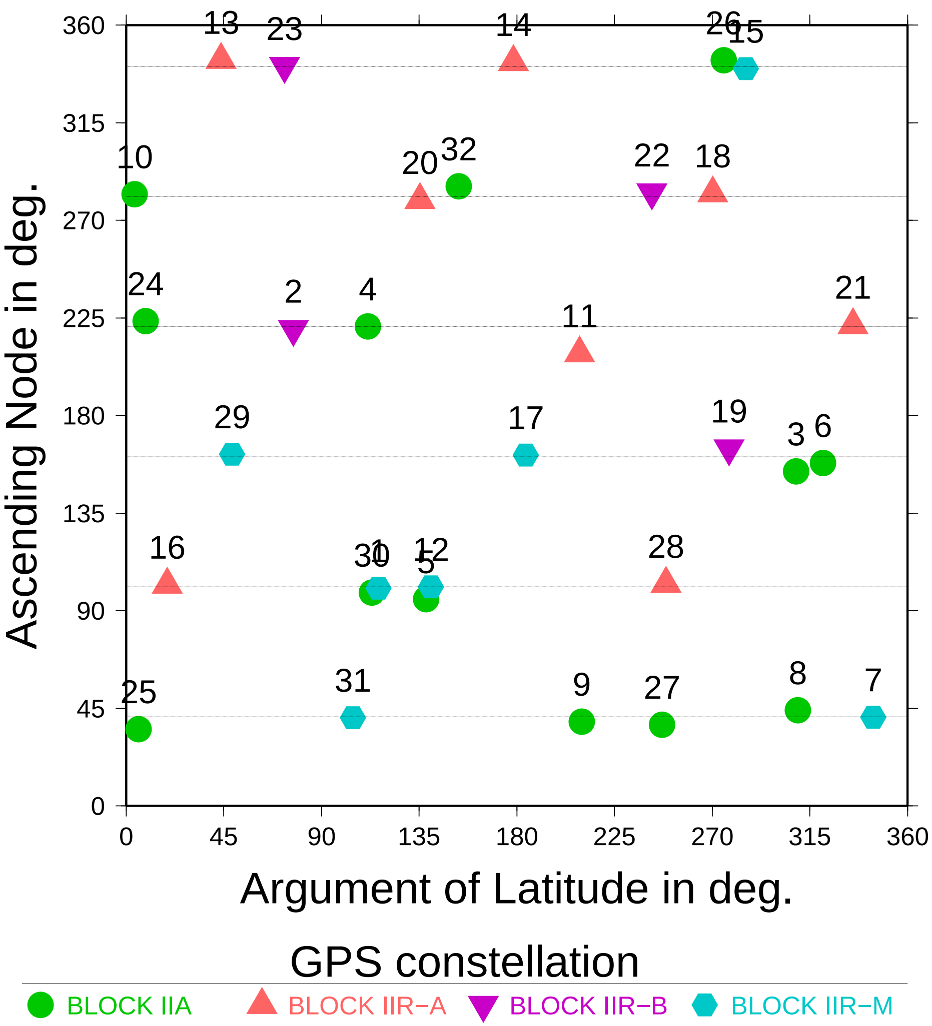
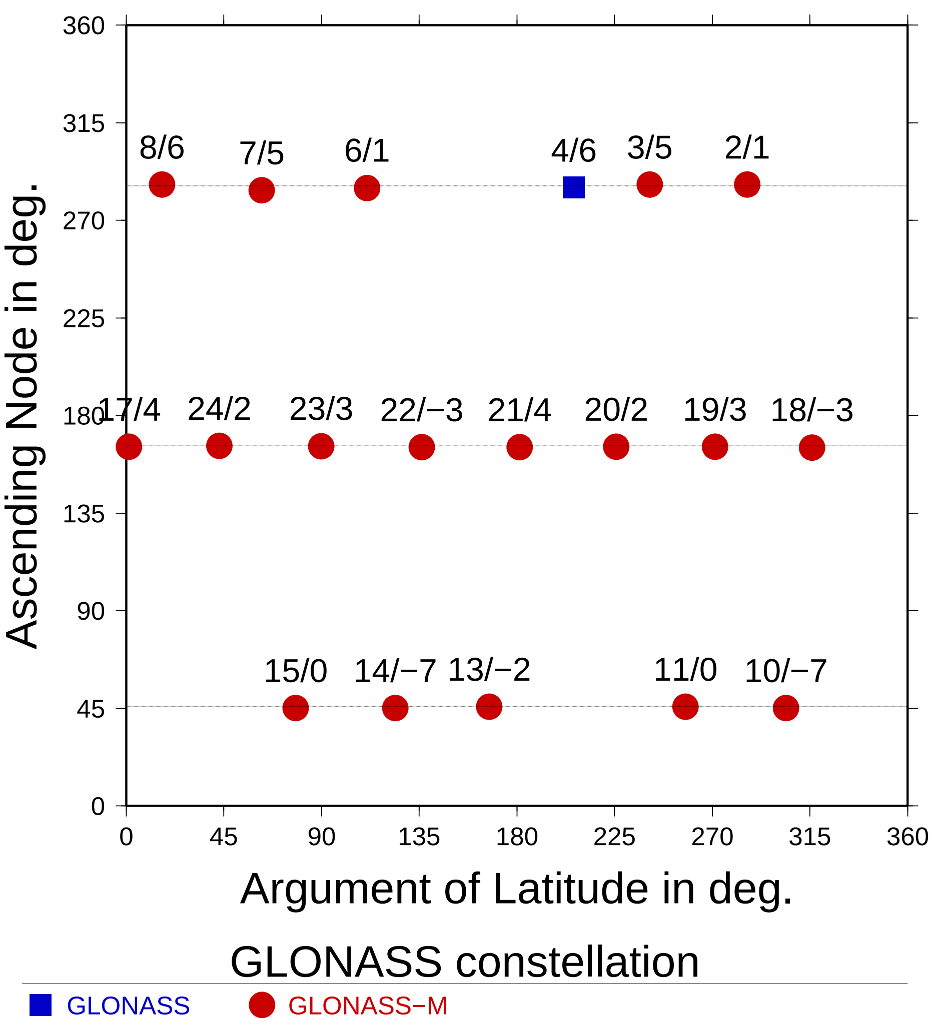
Why to update the satellite antenna model?

Current GNSS constellation

Day of year 2009:100





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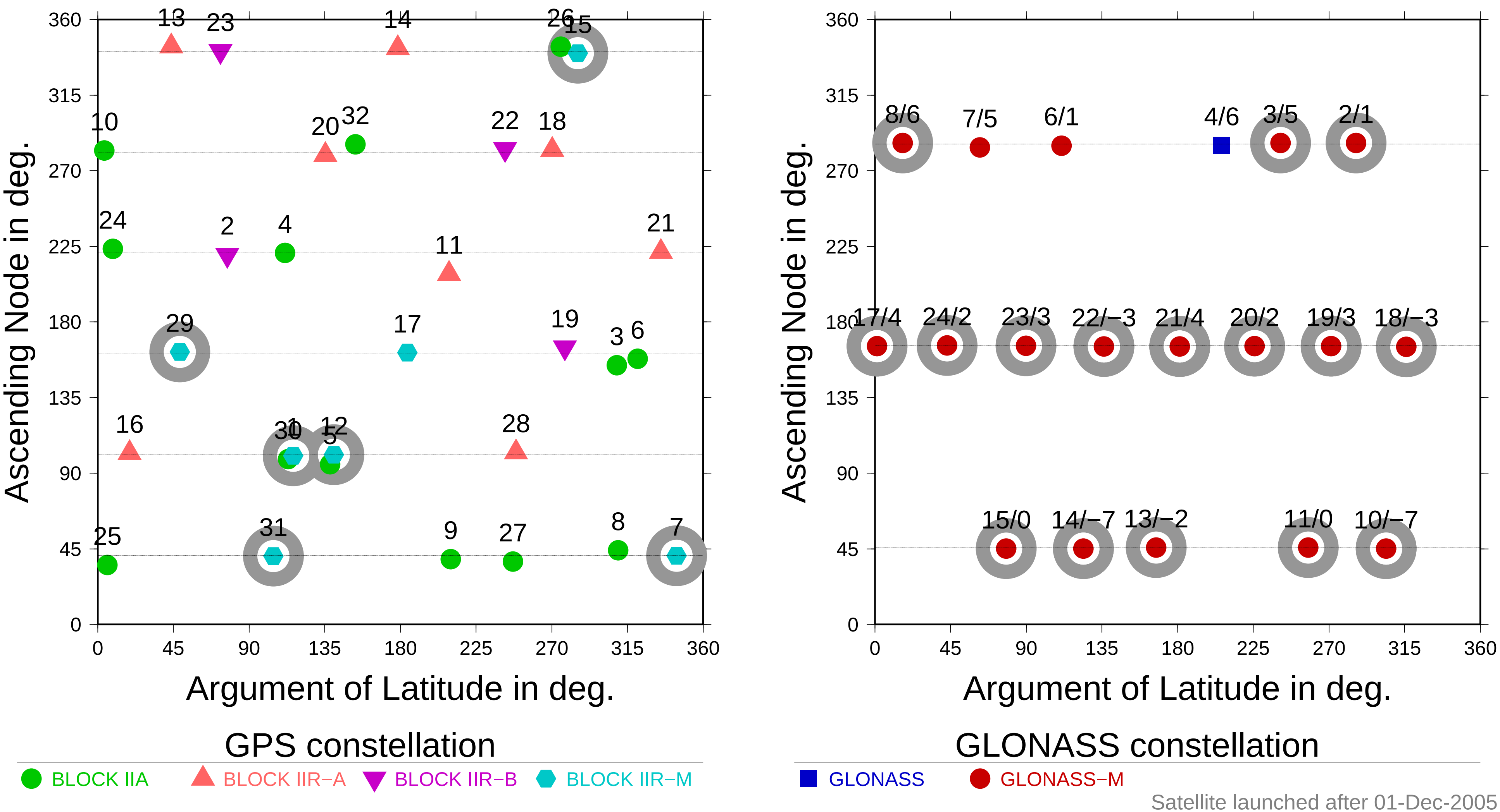
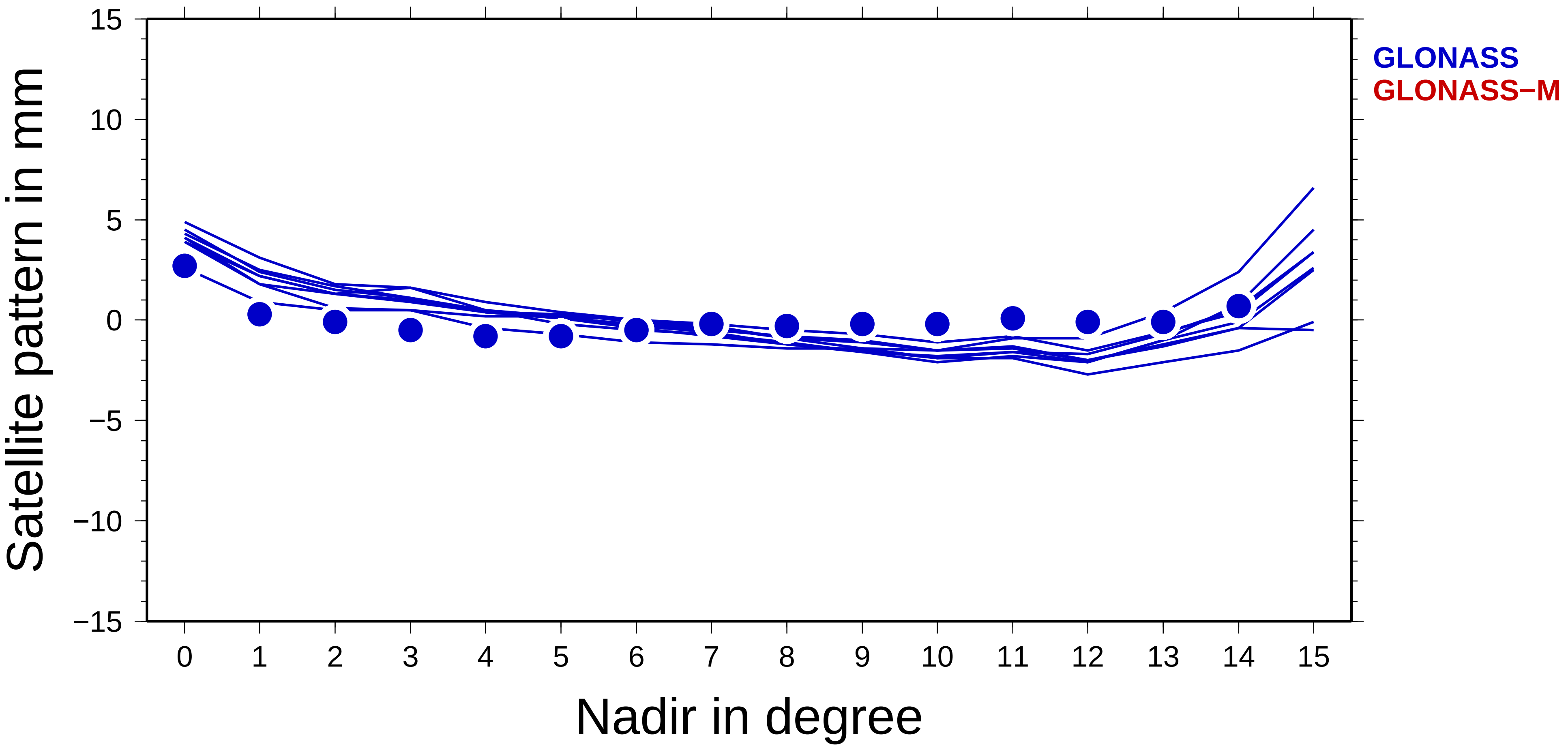


GNSS satellite antenna pattern

Nadir–dep. variations of the satellite antenna phase center

Solution from year 2003, minimum 90 days



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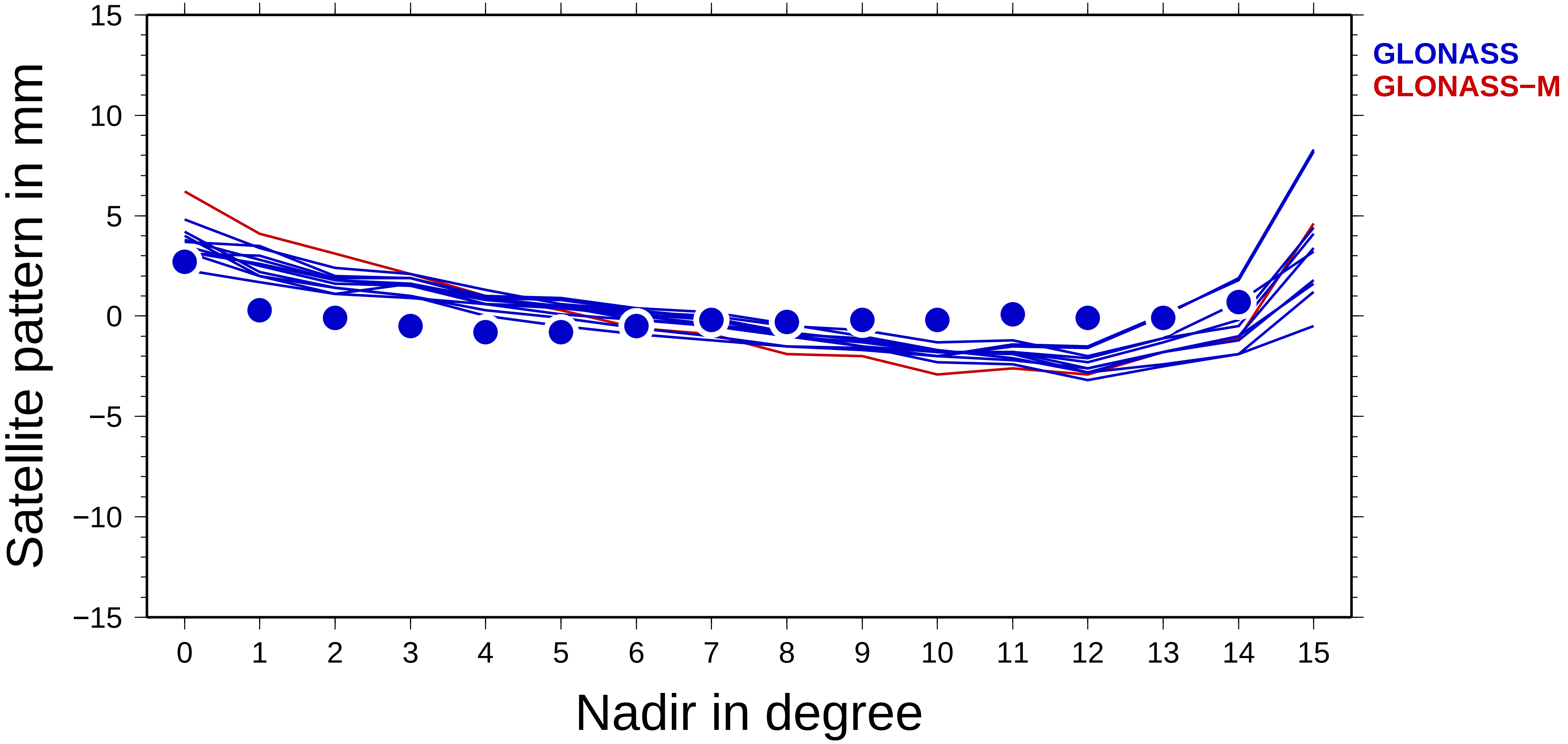

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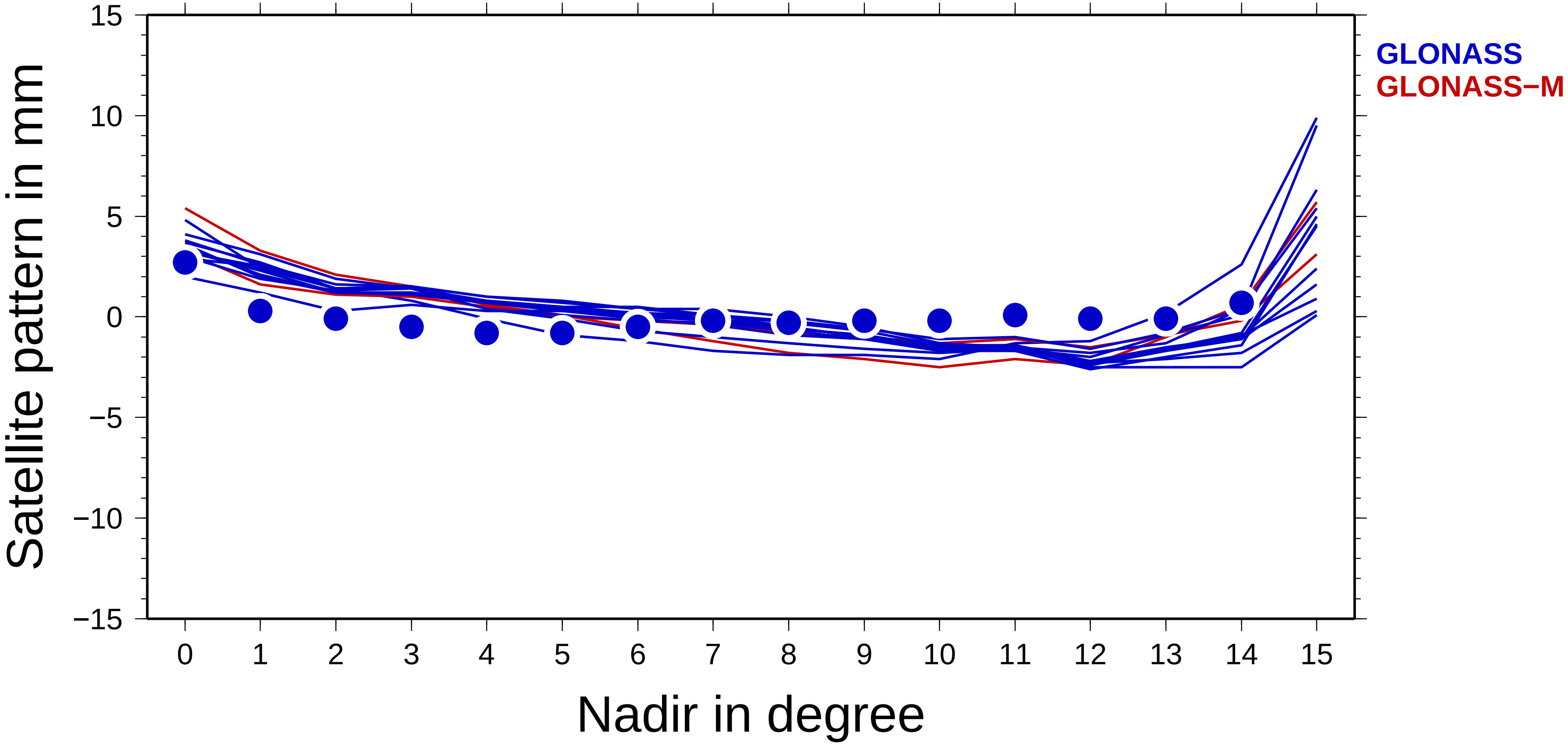

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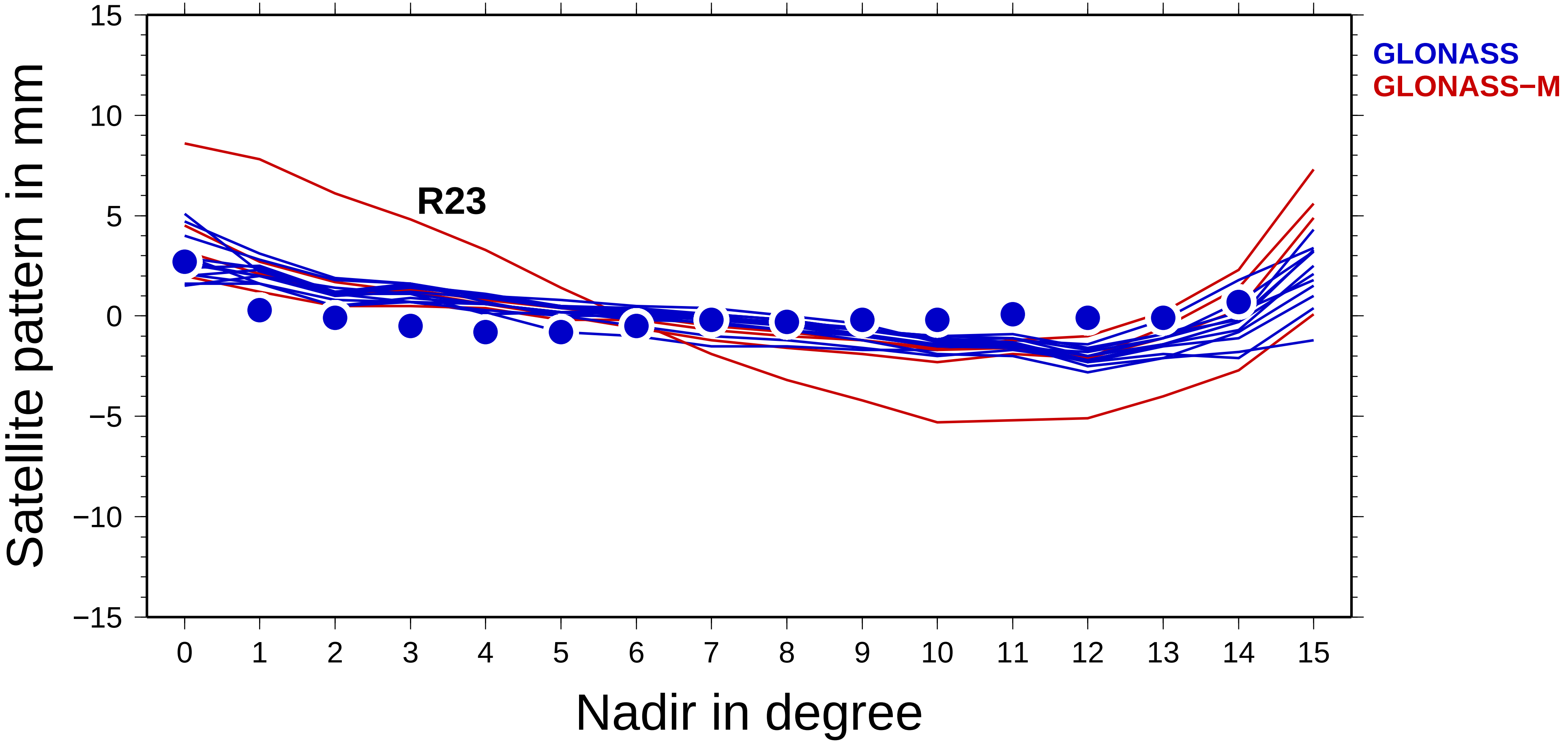

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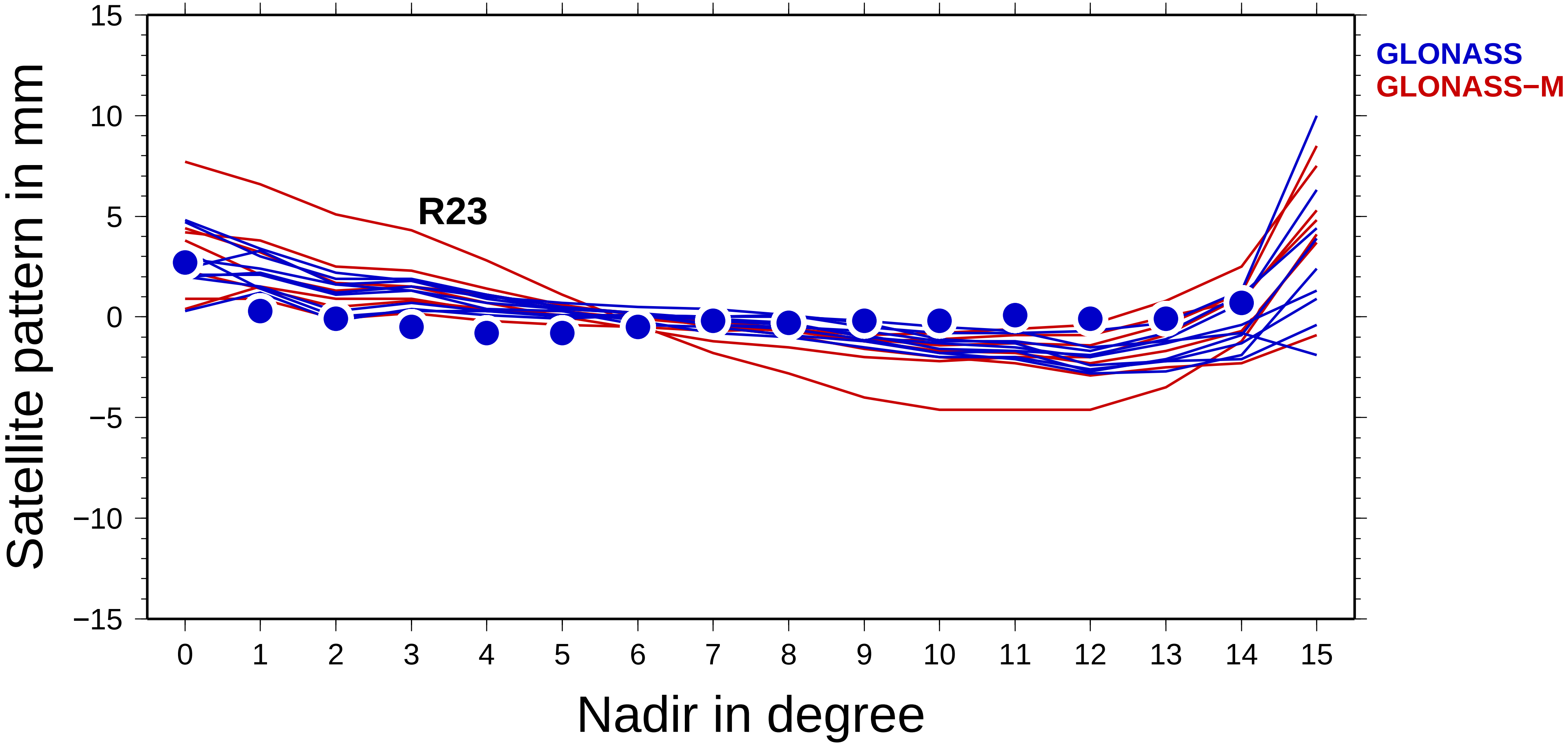
Solution from year 2007, minimum 90 days



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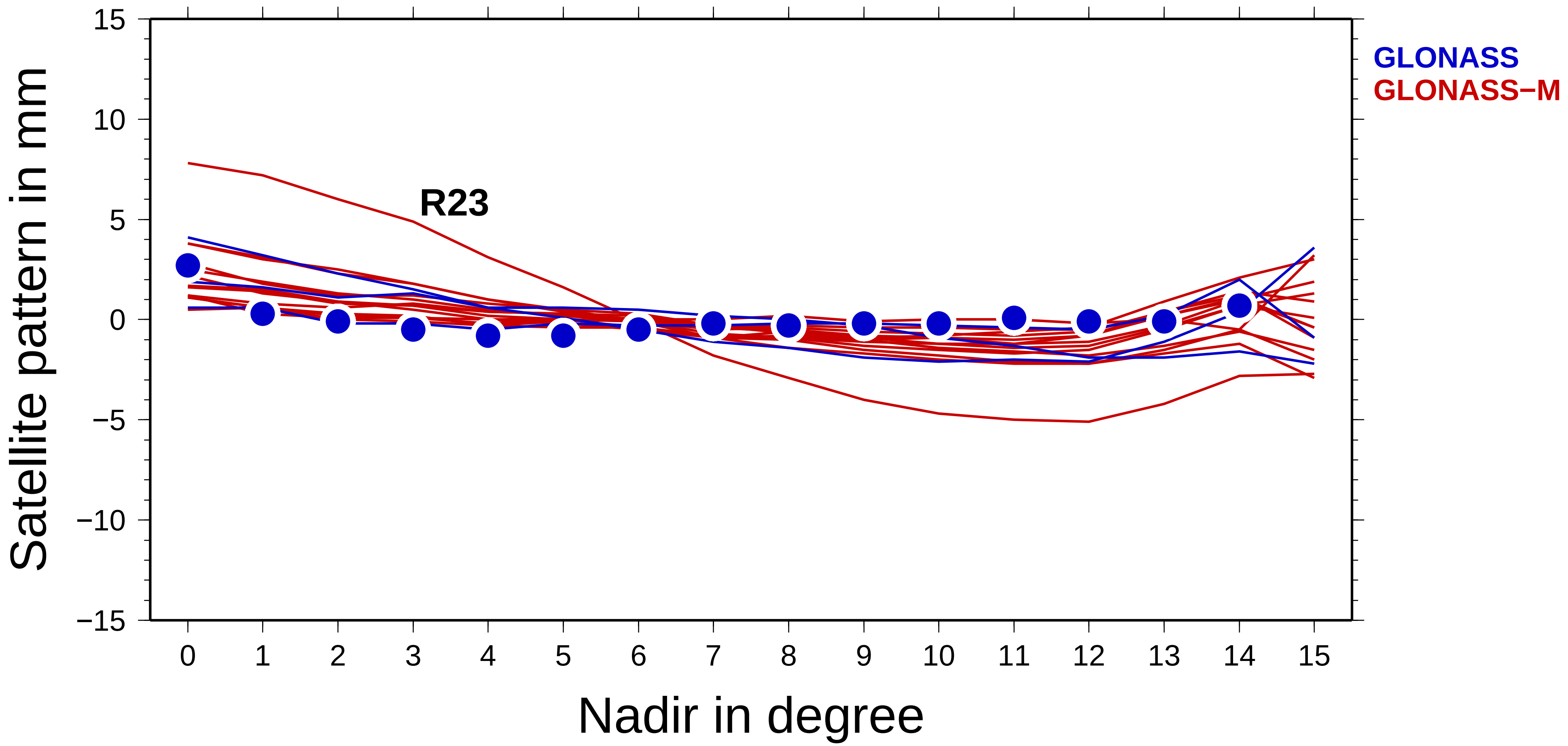
Solution from year 2008, minimum 90 days



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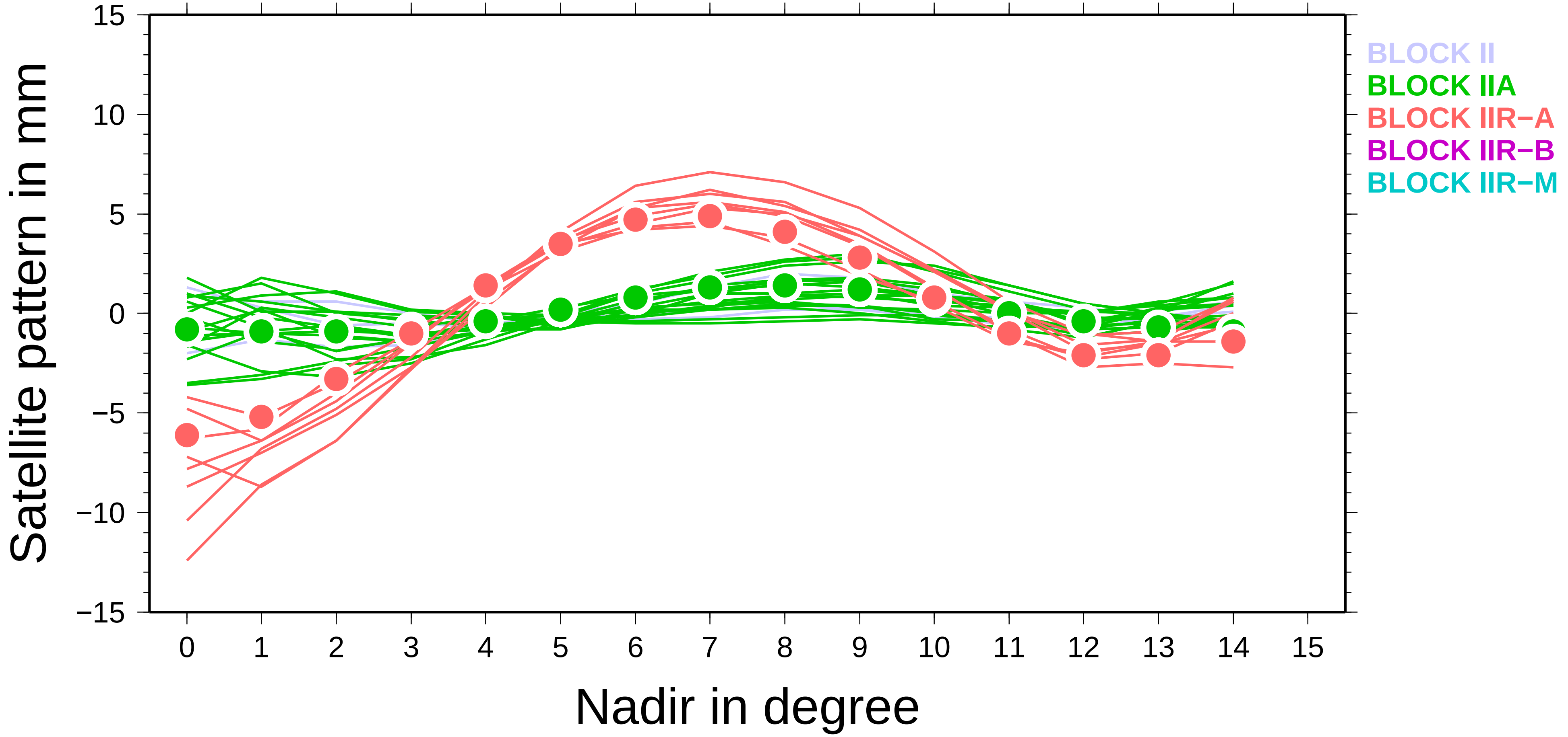

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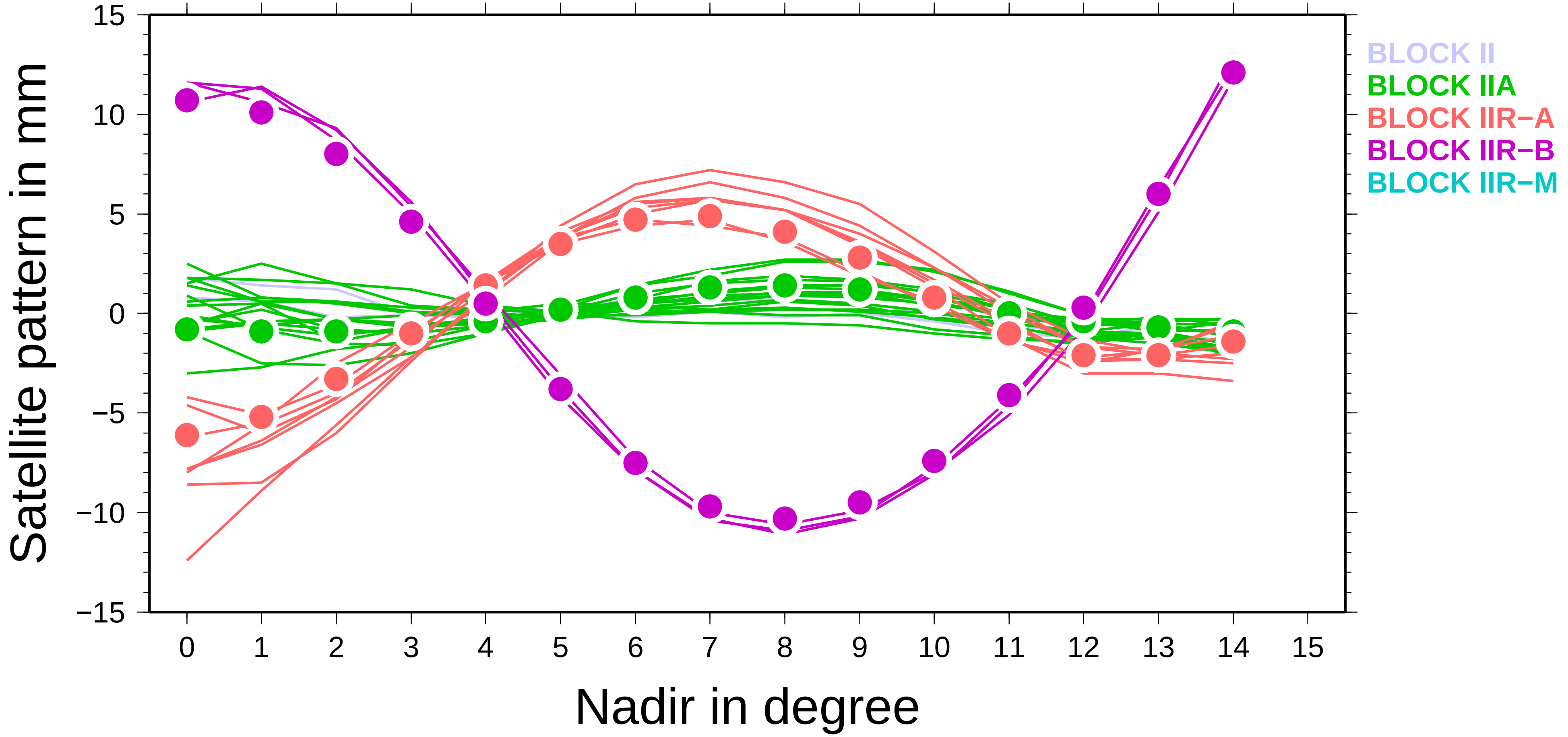

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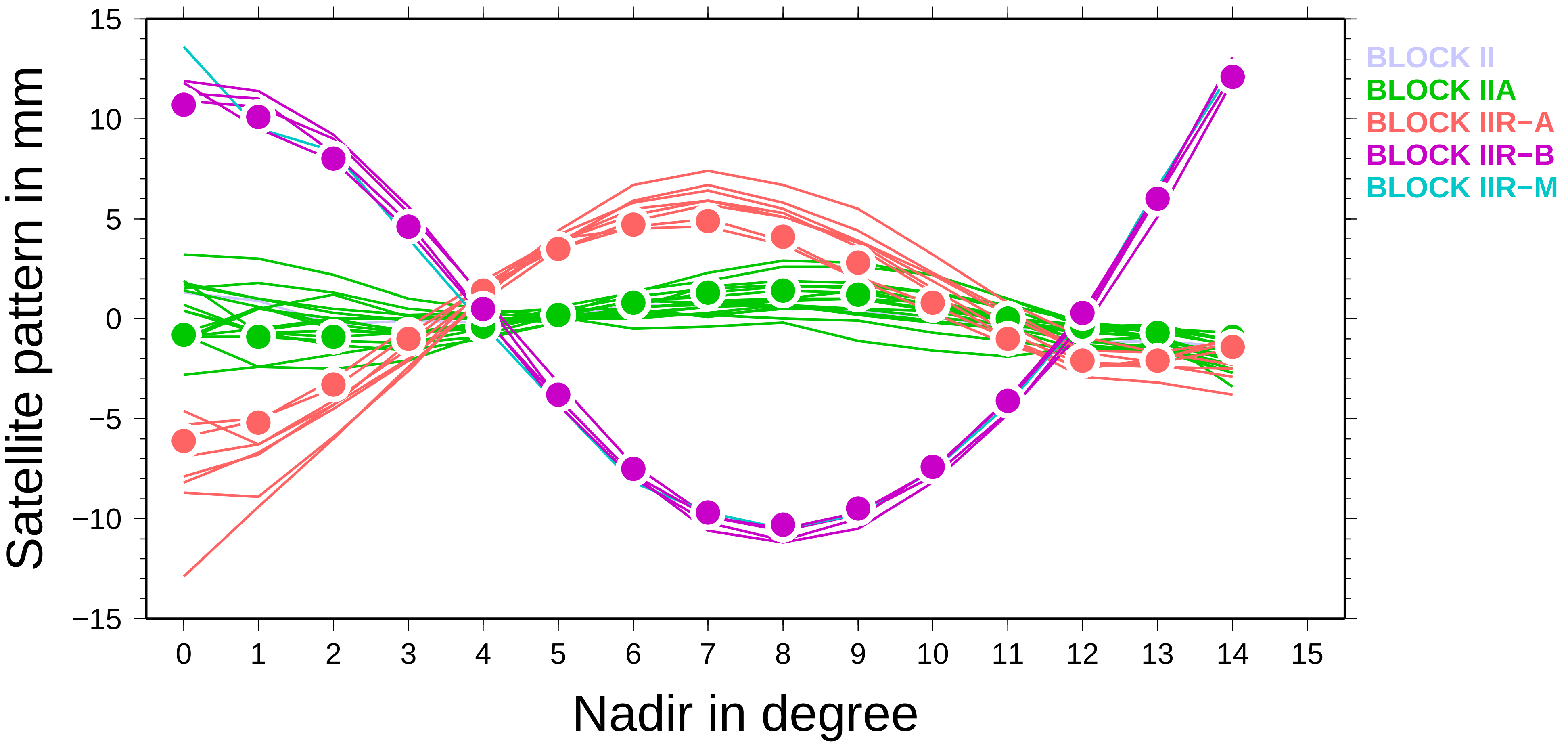

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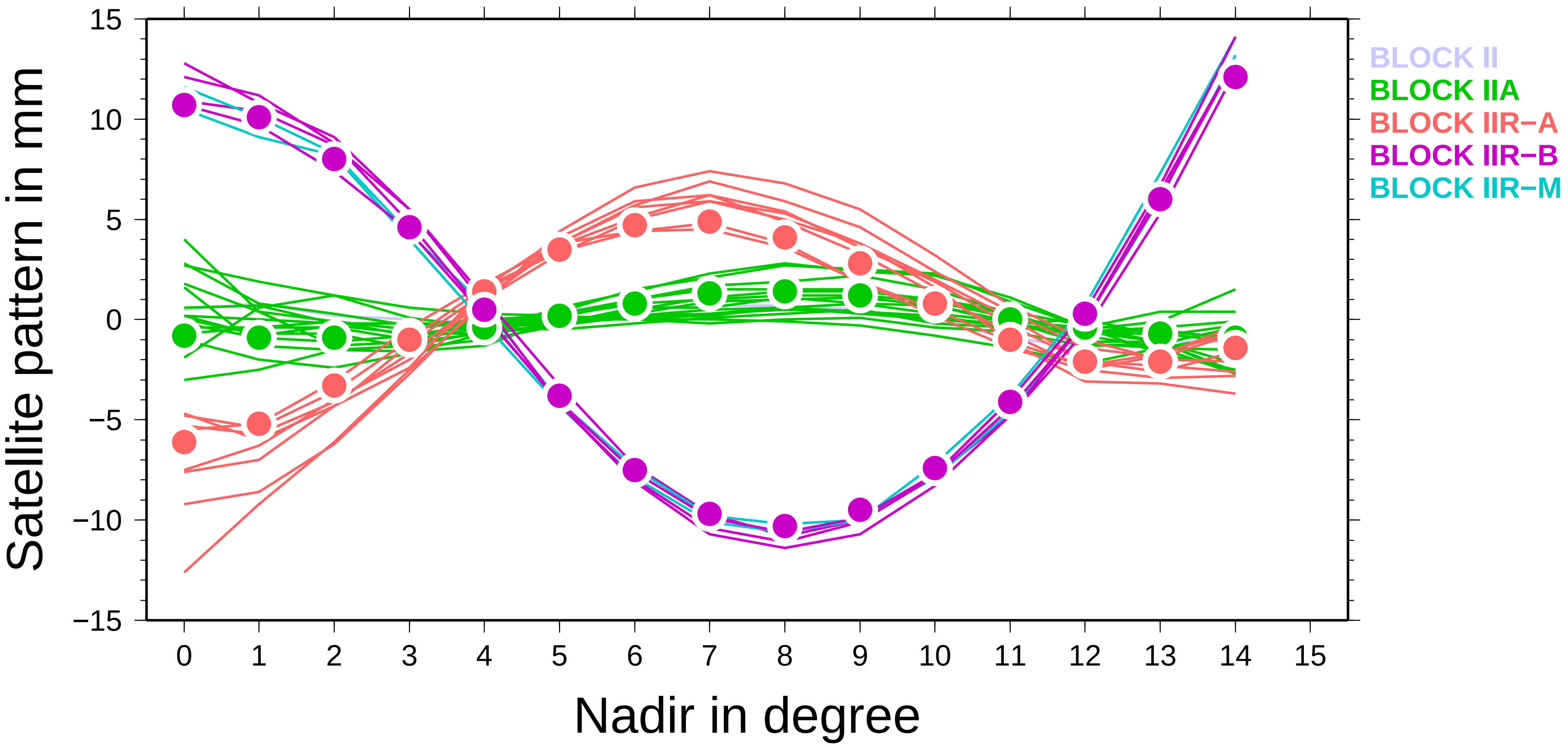

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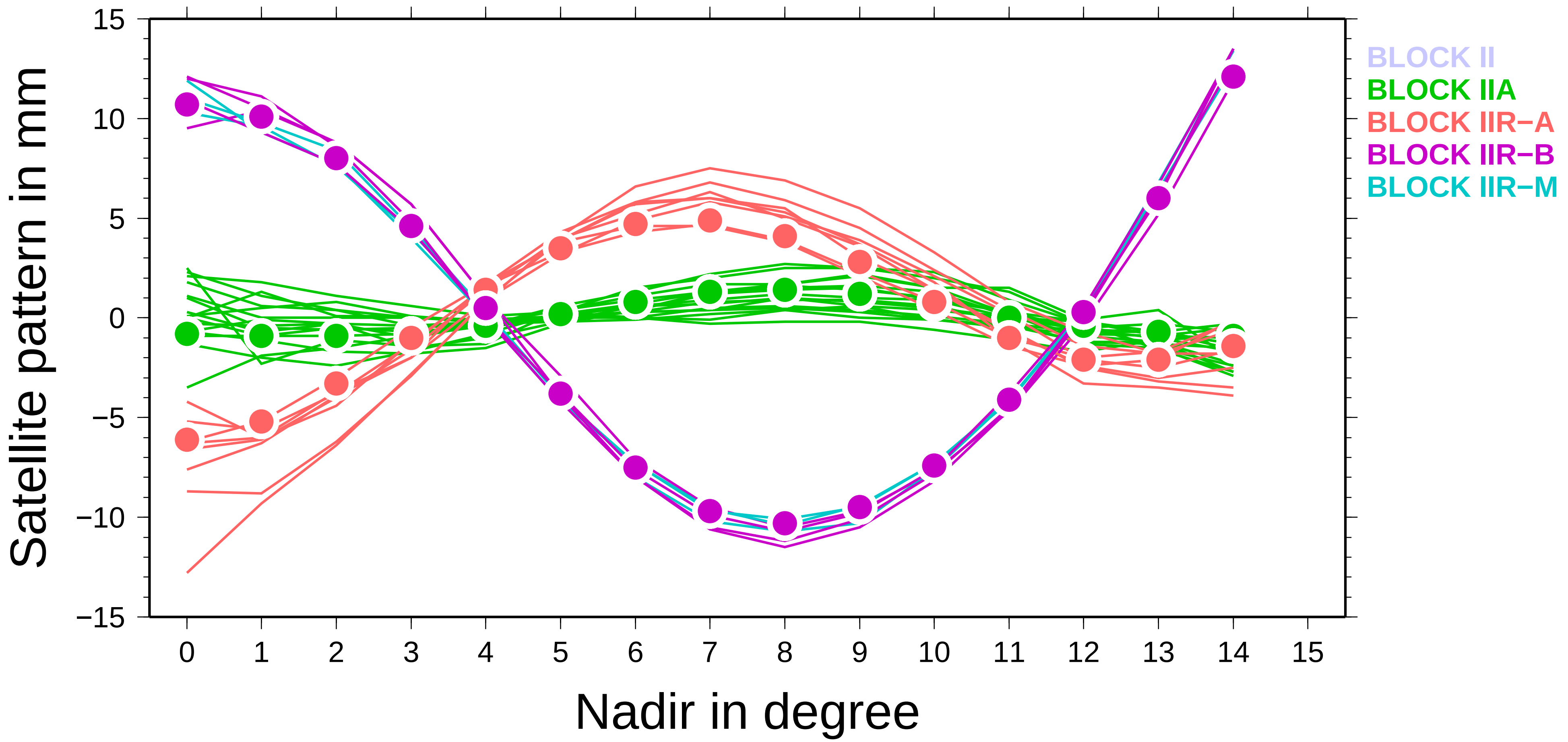

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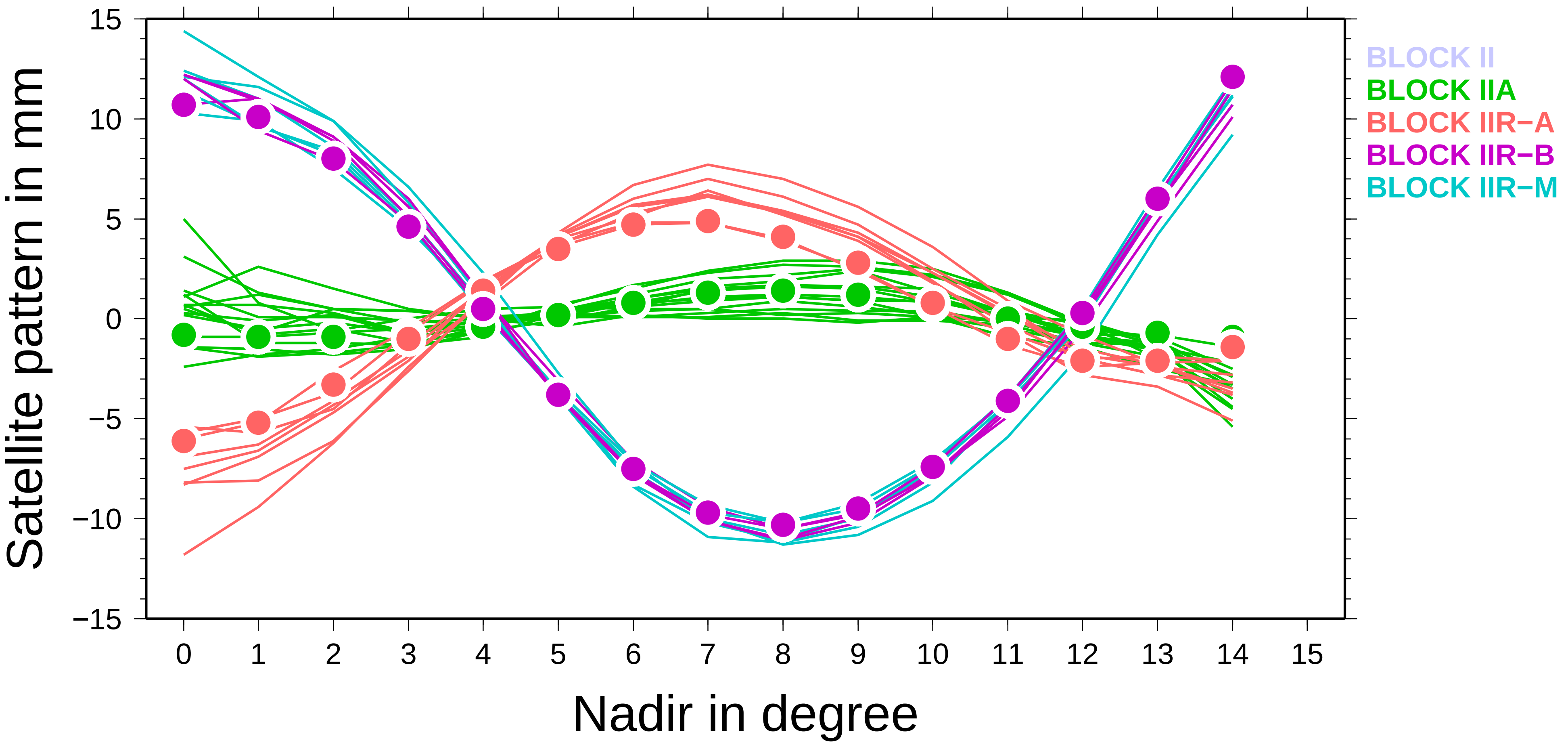

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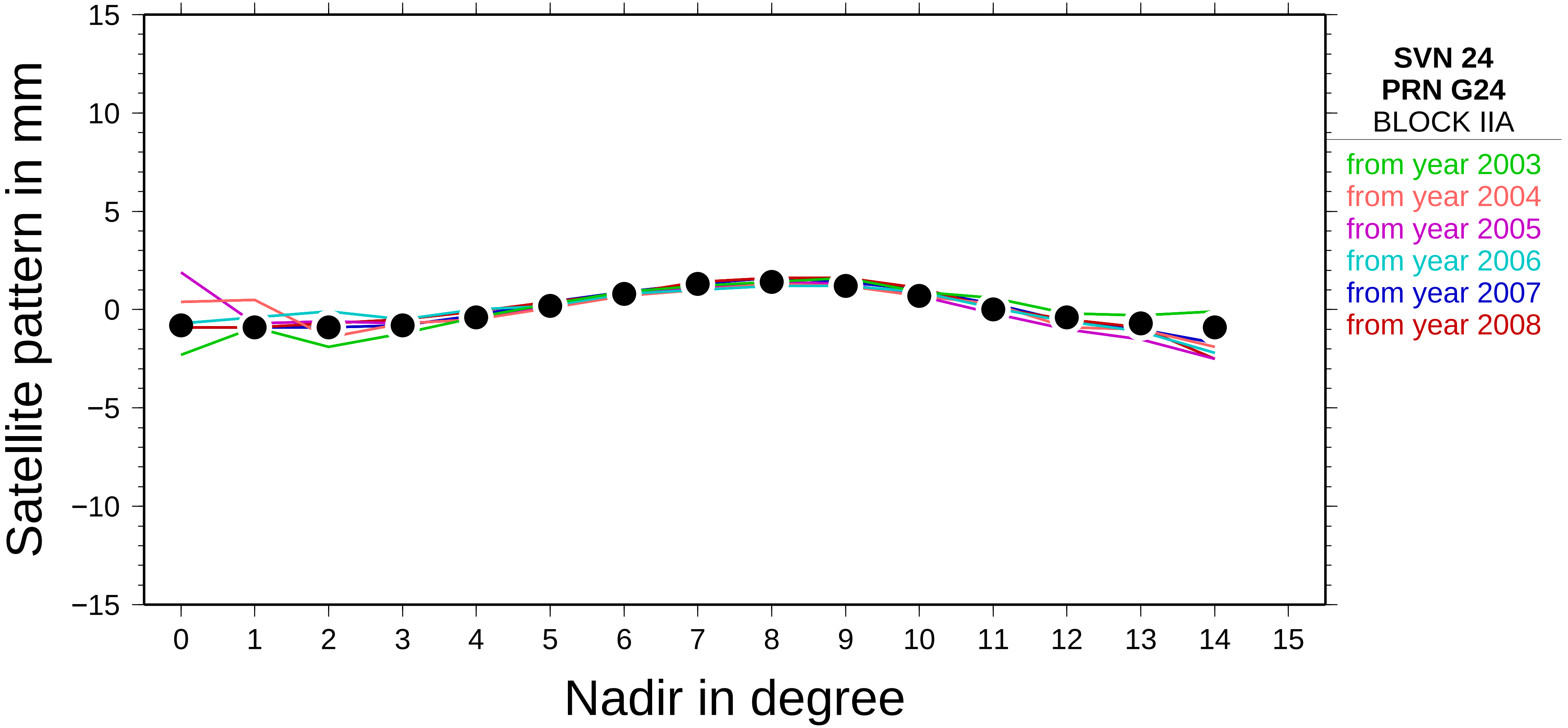
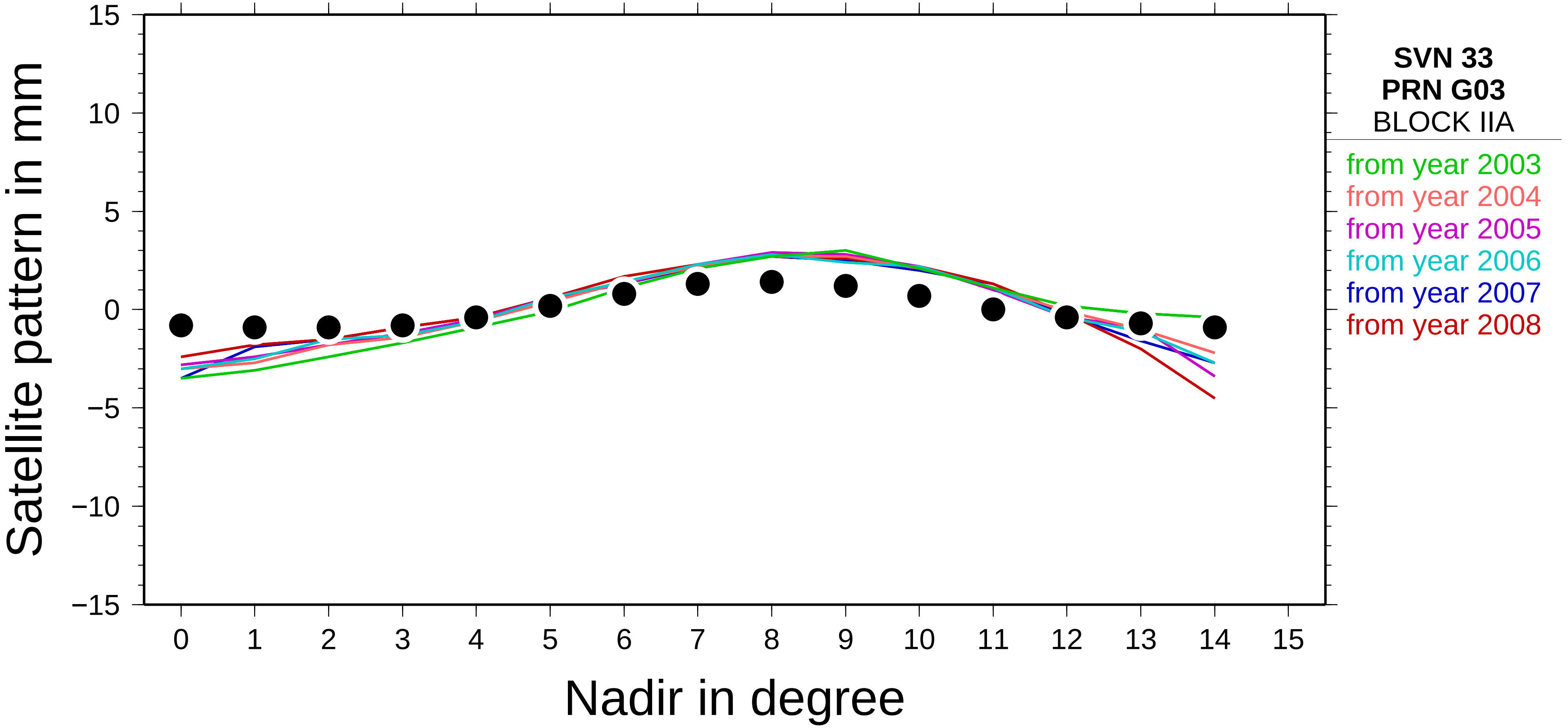
Nadir–dep. variations of the satellite antenna phase center

Satellite SVN 24/PRN G24, minimum 90 days



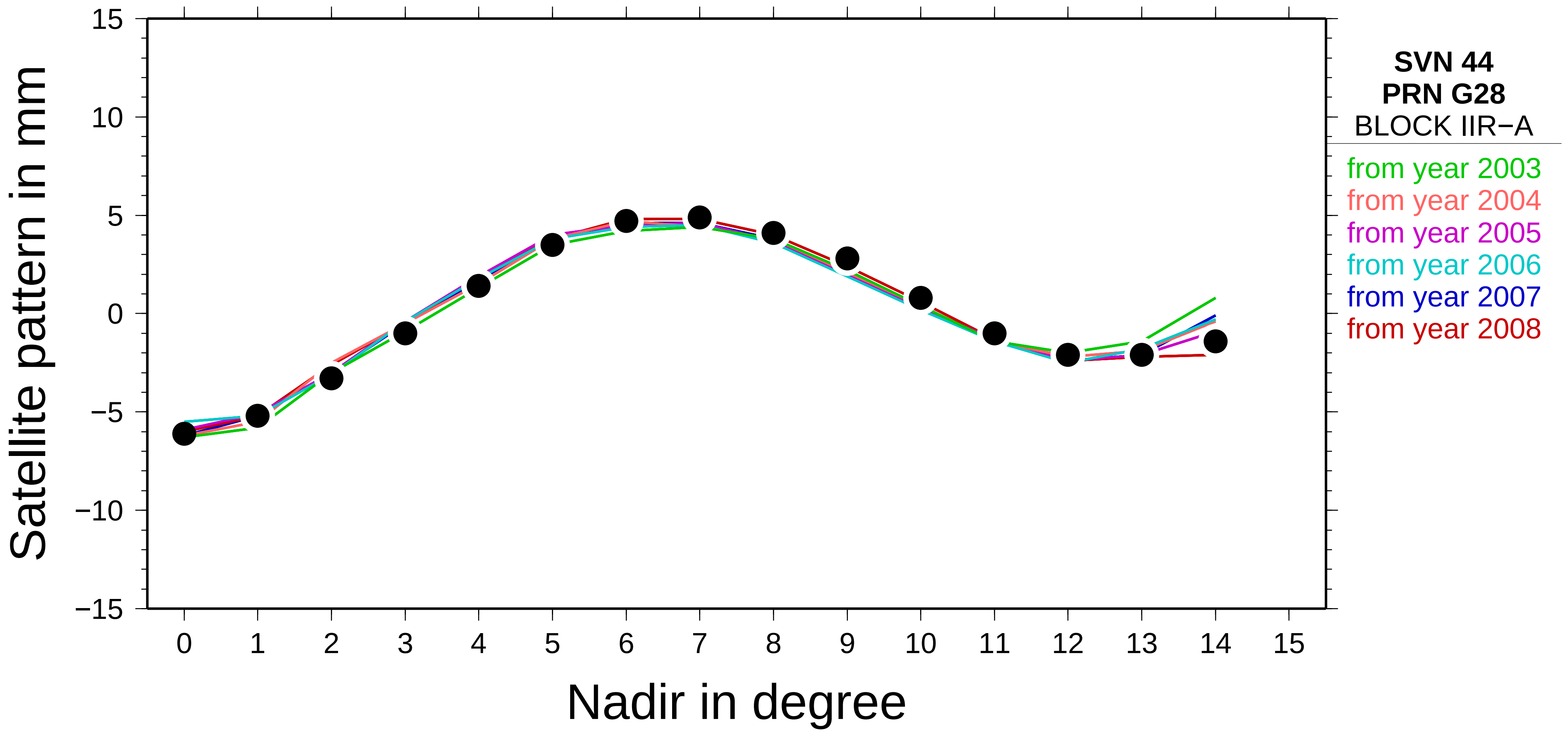
Nadir–dep. variations of the satellite antenna phase center

Satellite SVN 33/PRN G03, minimum 90 days



Nadir–dep. variations of the satellite antenna phase center

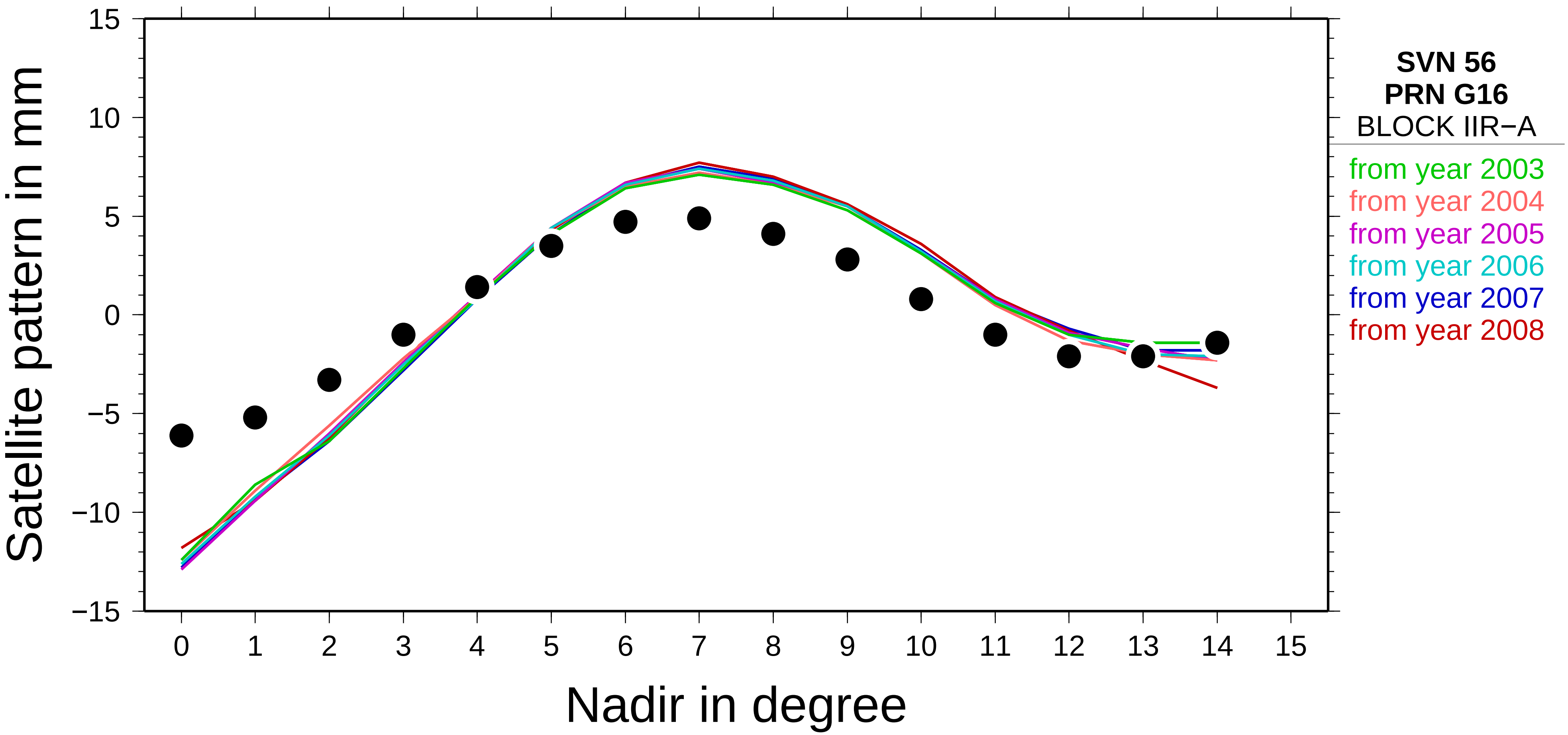
Satellite SVN 44/PRN G28, minimum 90 days



GNSS satellite antenna pattern

Nadir–dep. variations of the satellite antenna phase center

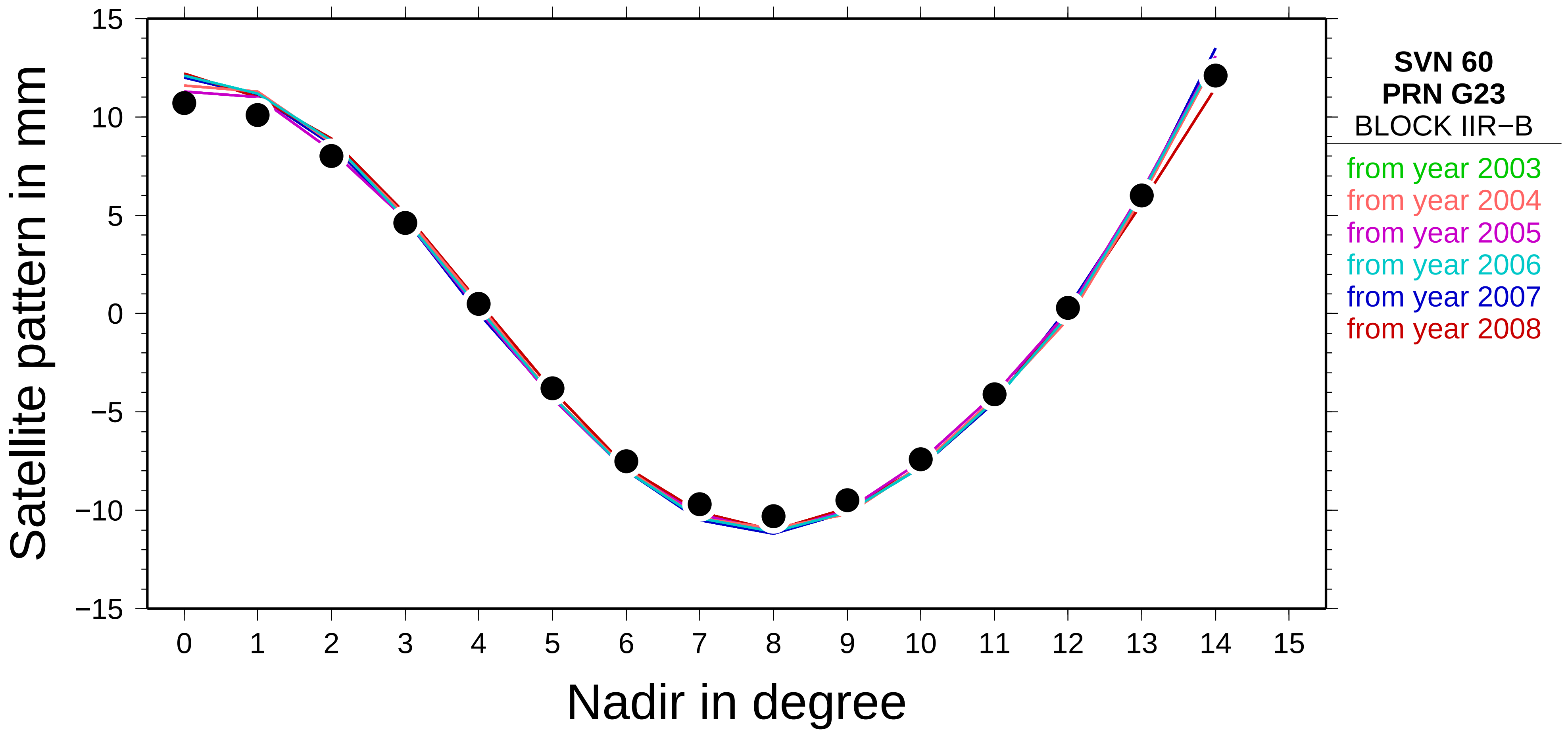
Satellite SVN 56/PRN G16, minimum 90 days



AIUB

Nadir–dep. variations of the satellite antenna phase center

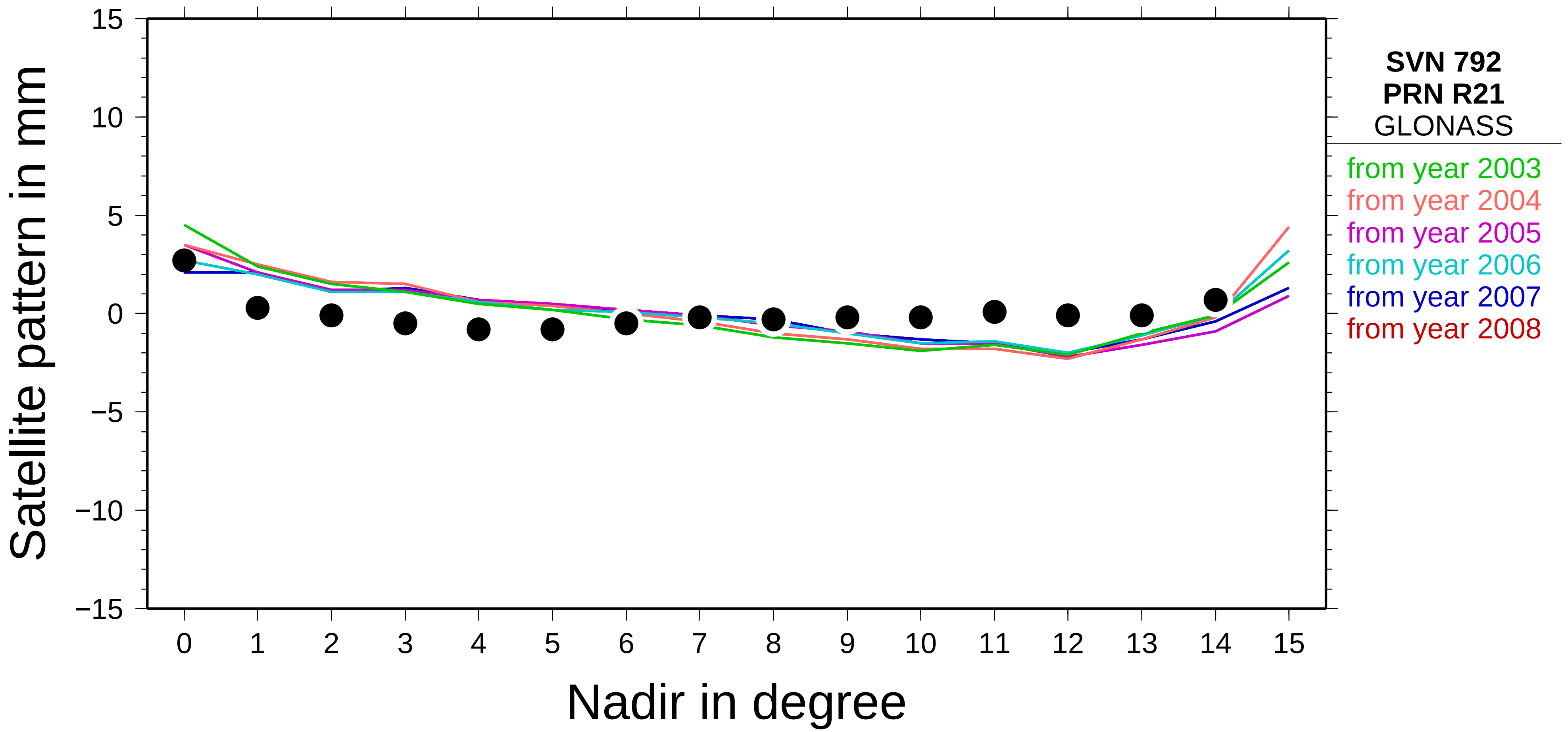
Satellite SVN 60/PRN G23, minimum 90 days



GNSS satellite antenna pattern

Nadir–dep. variations of the satellite antenna phase center

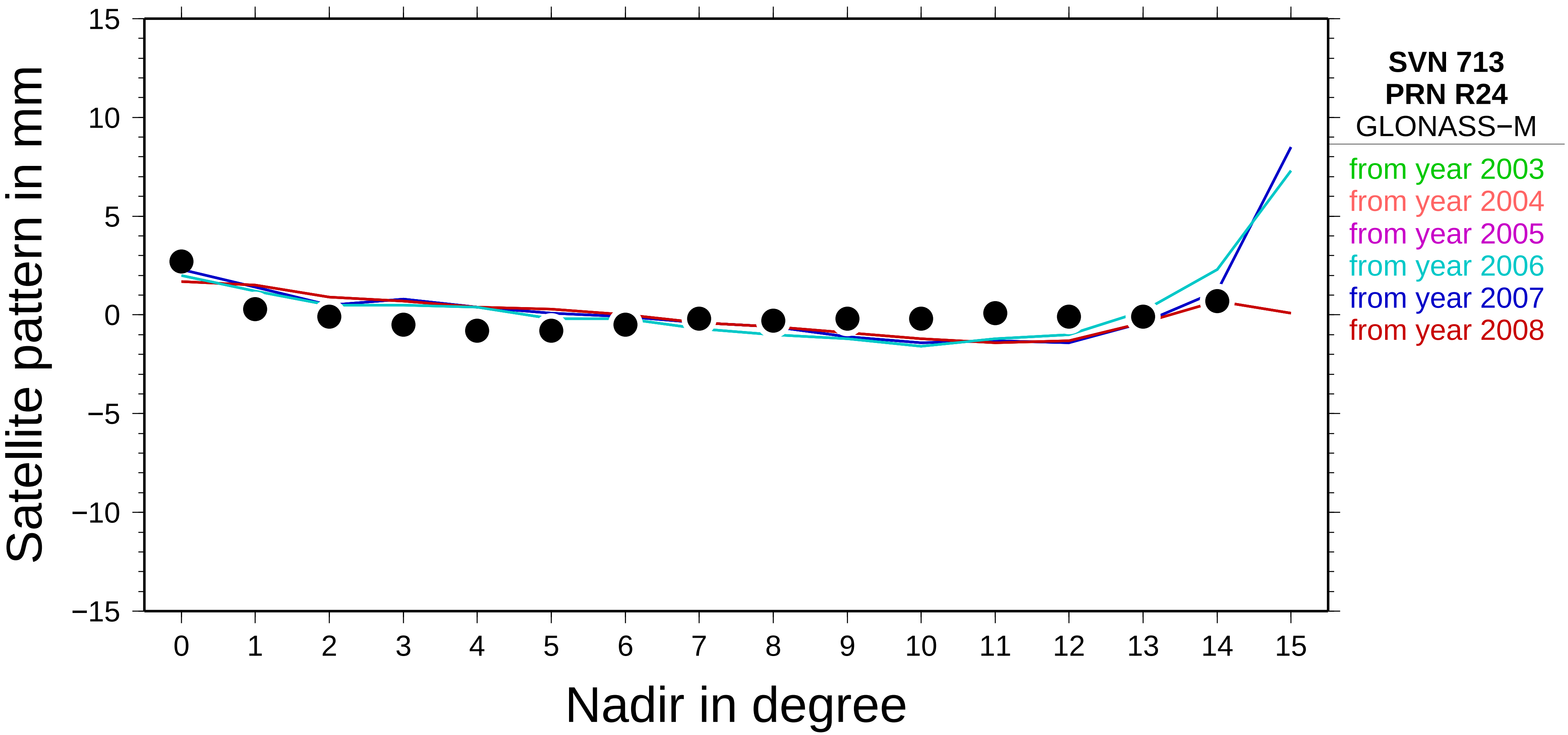
Satellite SVN 792/PRN R21, minimum 90 days



AIUB

Nadir–dep. variations of the satellite antenna phase center

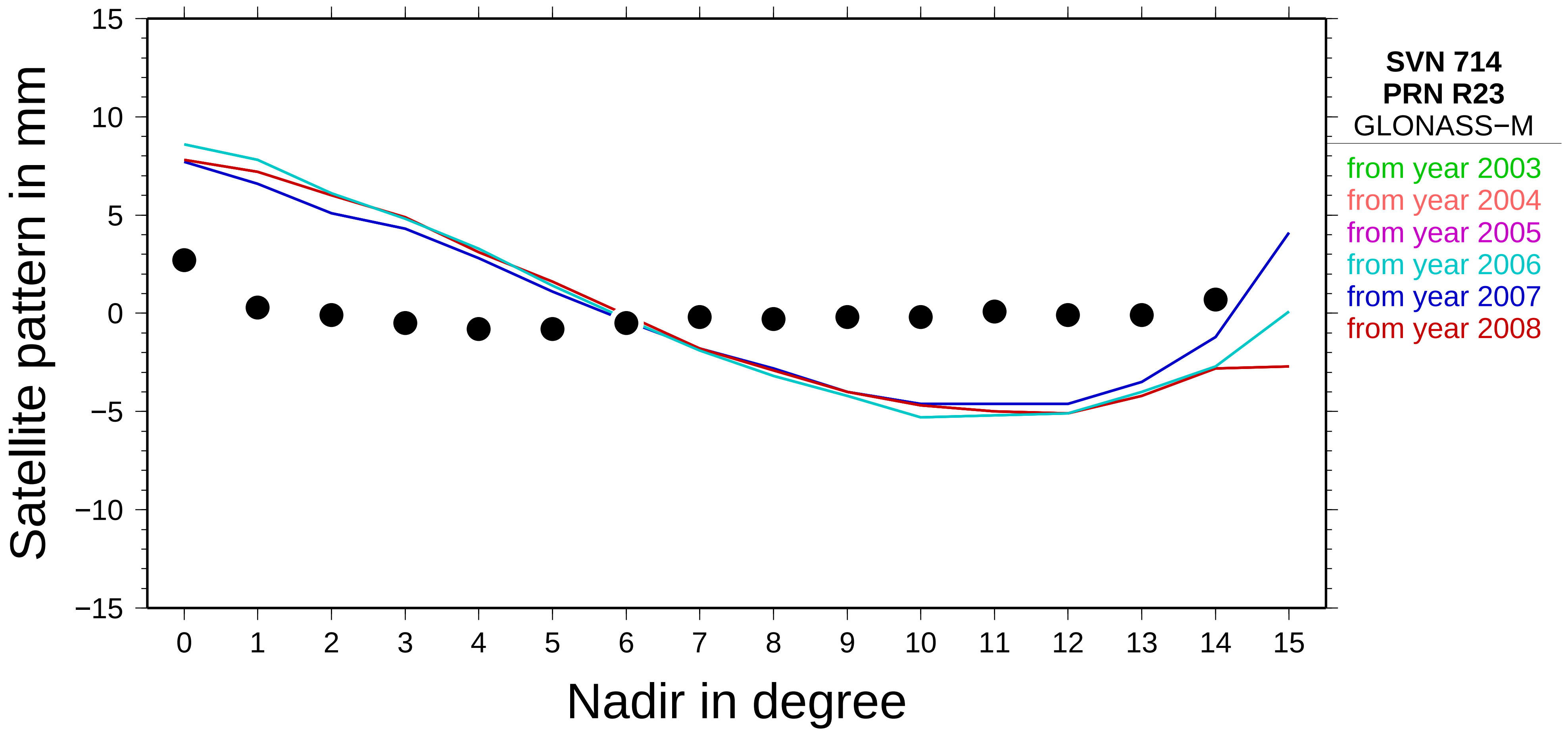
Satellite SVN 713/PRN R24, minimum 90 days



GNSS satellite antenna pattern

Nadir–dep. variations of the satellite antenna phase center

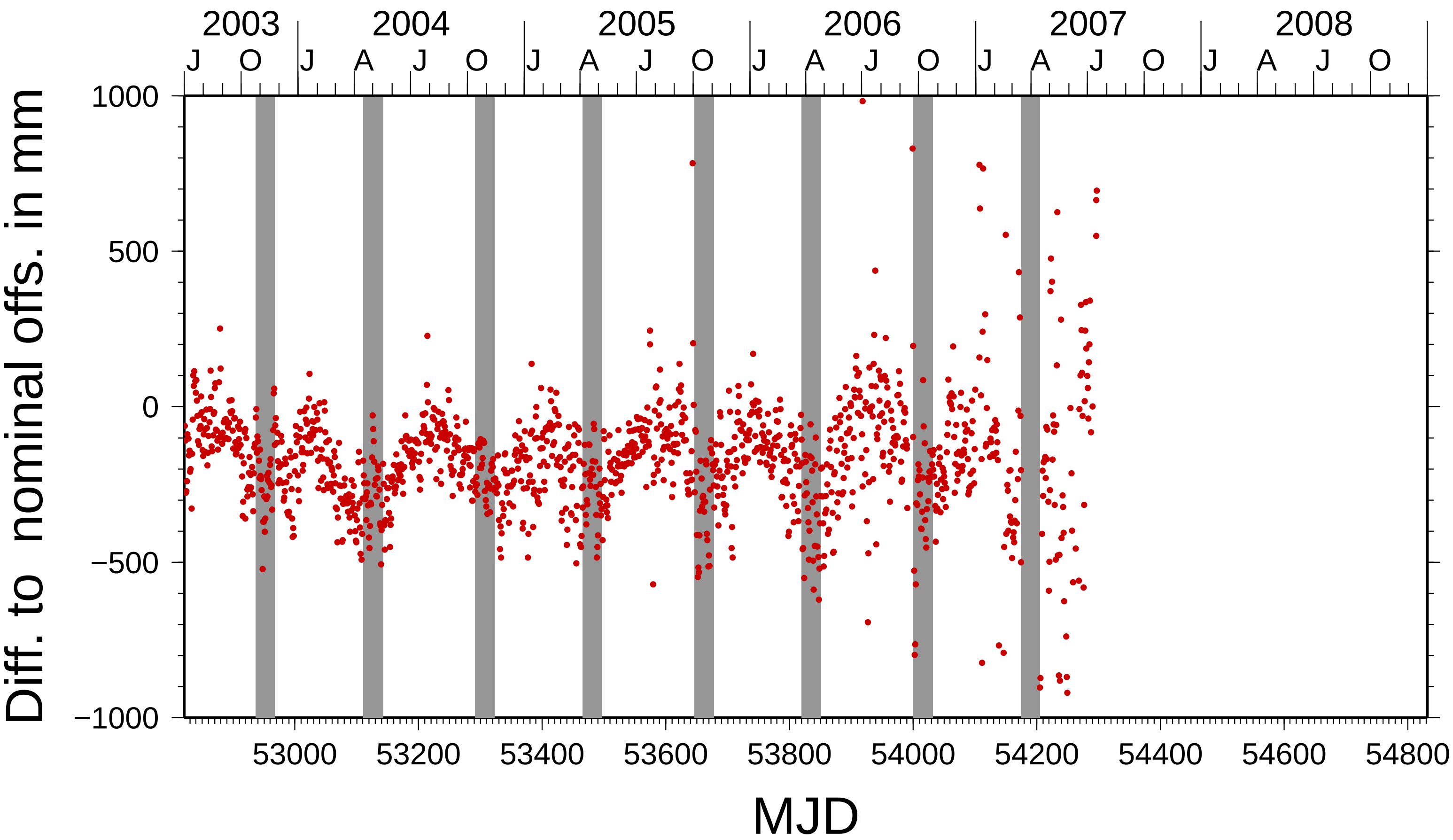
Satellite SVN 714/PRN R23, minimum 90 days



GNSS satellite antenna offsets

Daily GLONASS satellite antenna phase center offsets

Values of all GPS satellites are fixed to IGS05.ATX



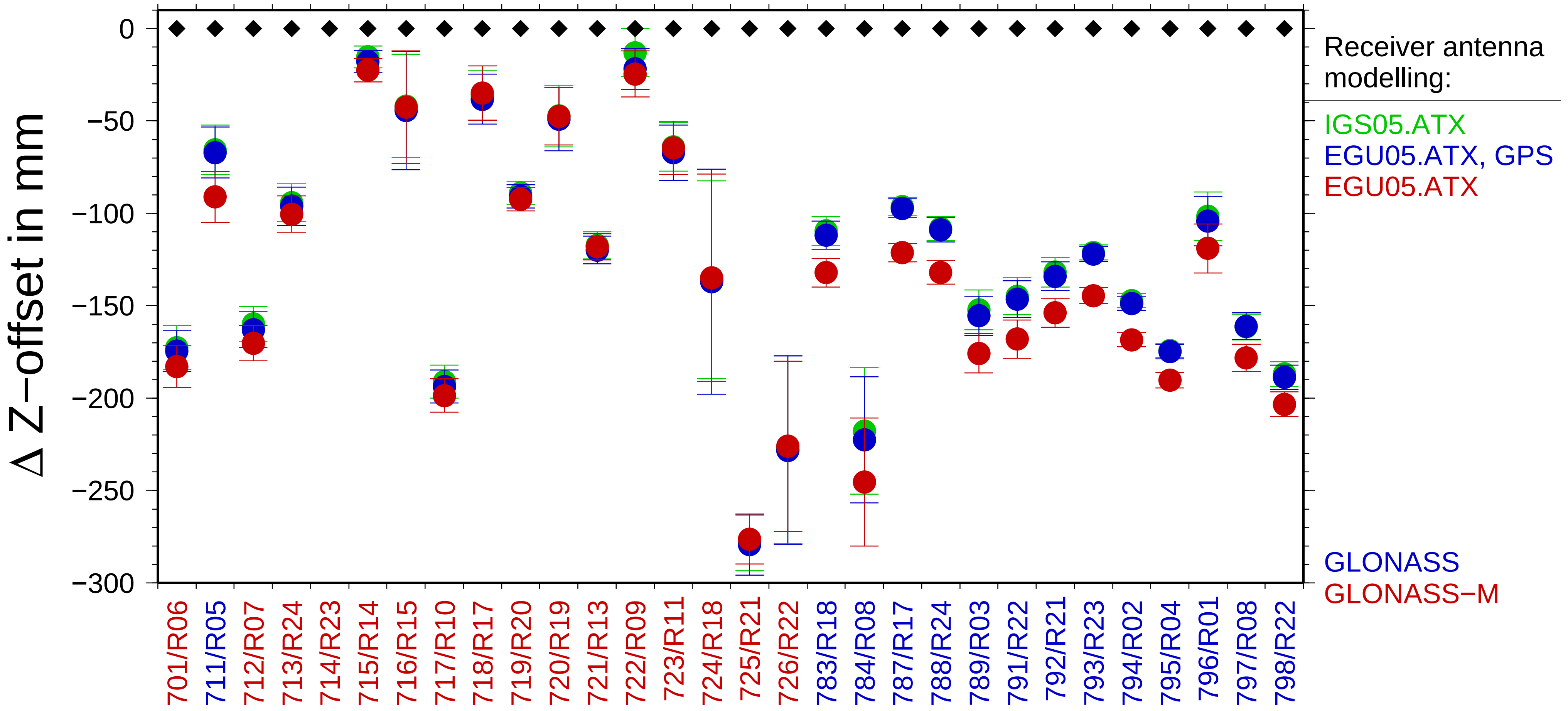
SVN 791/PRN R22 (GLONASS)

Nominal value	**IGS05.ATX**	**EGU05.ATX, GPS**	**EGU05.ATX**
2000.9 mm	1856.1 +− 10.1 mm	1854.4 +− 10.1 mm	1832.8 +− 10.3 mm

AIUB

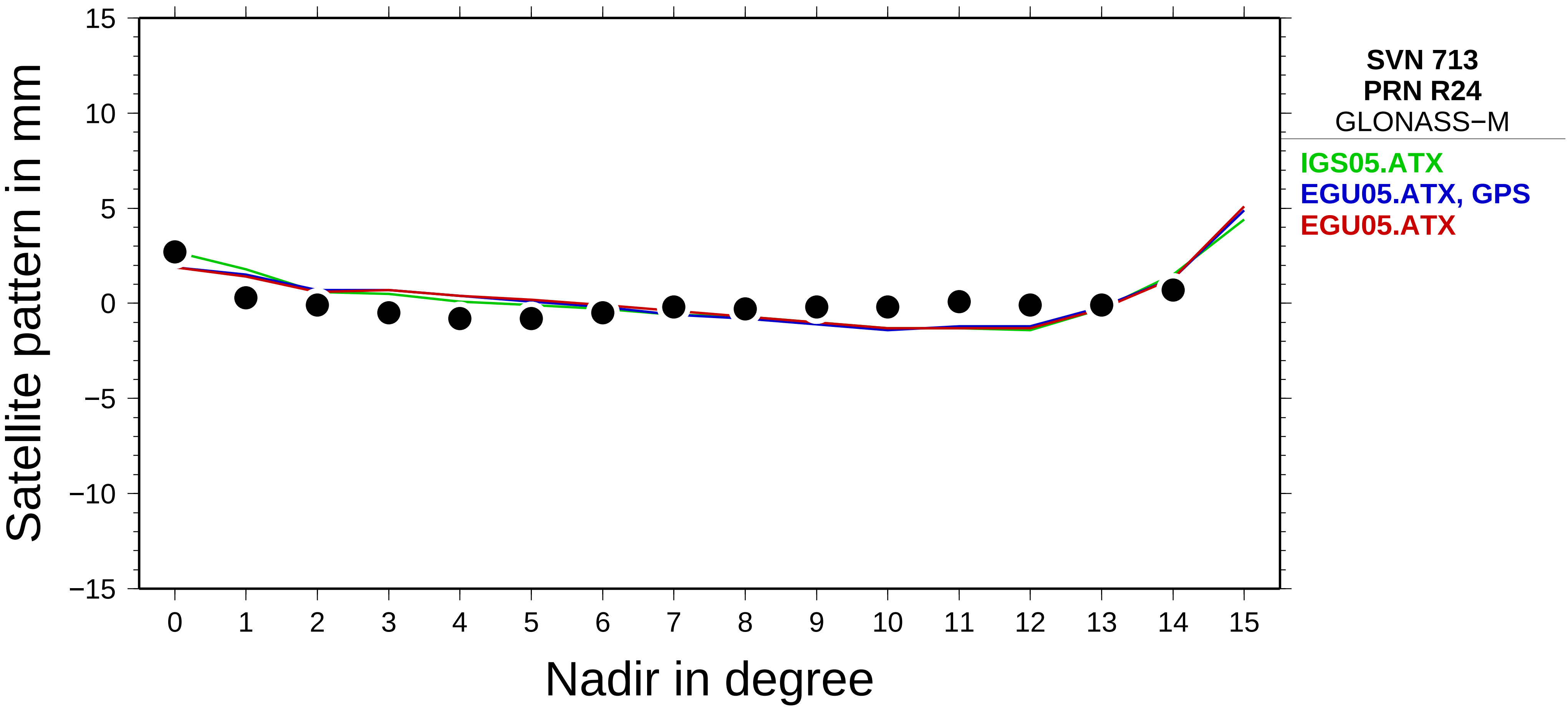
Mean GLONASS Satellite Antenna Phase Center

Values of all GPS satellites are fixed to IGS05.ATX



Nadir–dep. variations of the satellite antenna phase center

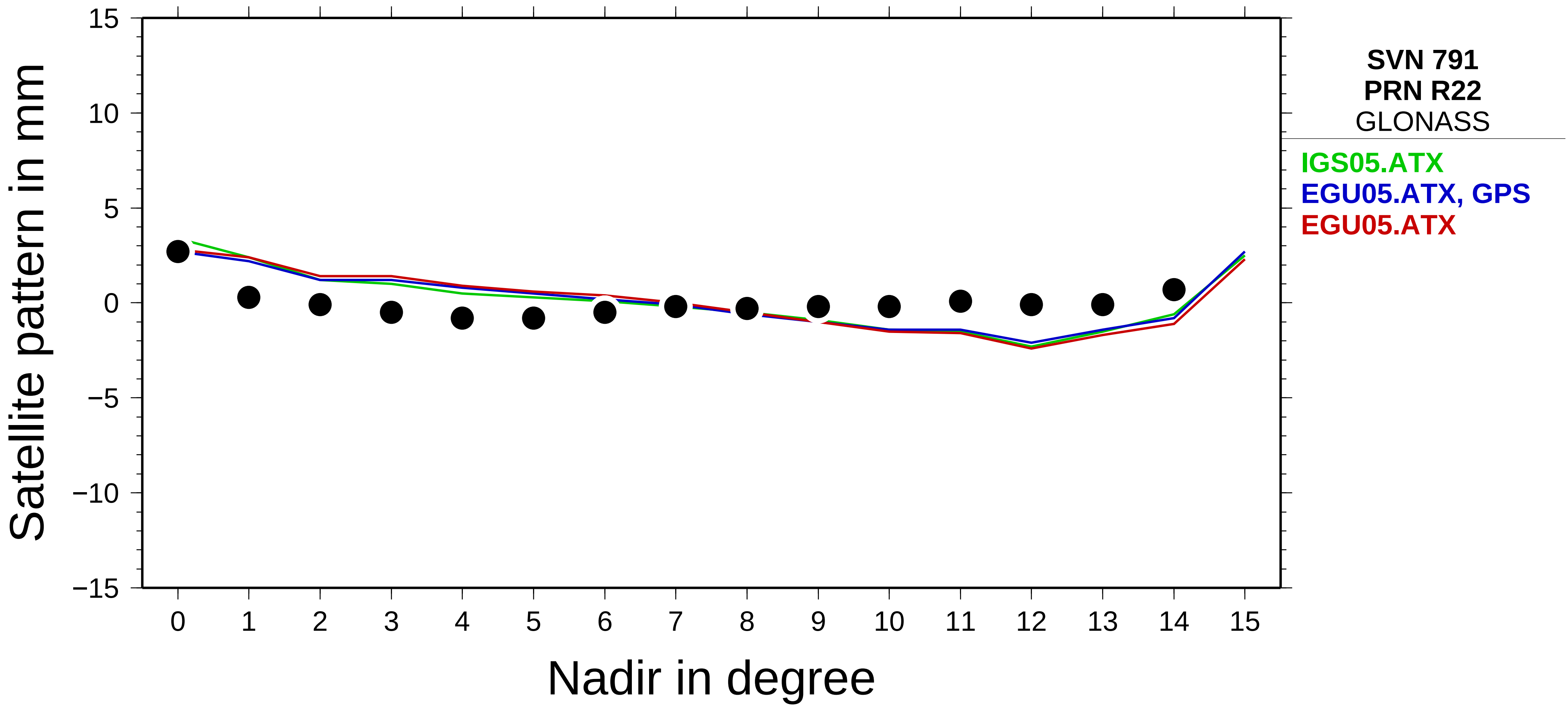
Satellite SVN 713/PRN R24



GNSS satellite antenna pattern

Nadir–dep. variations of the satellite antenna phase center

Satellite SVN 791/PRN R22



Conclusions

- For this study an updated antenna phase center correction file (*best possible*) was generated.
  - Some converted field calibrations could be replaced by robot calibrations.
  - Antenna type corrections based on more antennas/calibrations
  - These updated values affect the station coordinates by up to 5 mm.
  - A compromise between *using the best available* and *full consistency to the reference frame* needs to be found for the IGS within the antenna working group – it is somehow a chicken–and–egg–problem.

Conclusions

- GNSS–specific receiver antenna corrections are available for a few antenna types.
  - The differences between the GPS and GLONASS corrections reach values of up to 10 mm for the ionosphere free linear combination.
  - The introduction of these GLONASS–specific corrections has a systematic effect of up to 1 mm on the obtained station coordinates.
  - The GLONASS–specific type–mean values have a very different uncertainty.
  - As soon as the uncertainty is small enough these GLONASS–specific corrections should be applied.

Conclusions

- An update of the GNSS satellite antenna phase center model is necessary.
  - Nearly the complete GLONASS constellation has changed since the computation of the IGS05.ATX.
  - The GLONASS tracking situation has dramatically improved since that time.
  - The uncertainty of the estimated GLONASS satellite antenna patterns/offsets is comparable to those of the GPS satellites.

- Not all satellite antennas show the same nadir–dependent behavior as the majority of the antennas from the satellite type.
  - Examples for GPS and GLONASS satellites have been presented.
  - Satellite–specific patterns are preferable versus type–specific.