

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

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# 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).
  - ◆ If calibration not available for an antenna/radome combination, the calibration for the corresponding antenna without a radome is used.
- 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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## ■ IGS–Repro01, the CODE contribution:

- ◆ Contribution of CODE is computed at IAPG/TUM (P. Steigenberger)  
(IAPG/TUM is a member of the CODE consortium since January 2009)
- ◆ Interval 1994––2008, as a GPS–only solution
- ◆ For more details we refer to the poster *P. Steigenberger et al.: CODE contribution to IGS reprocessing: status and perspectives*

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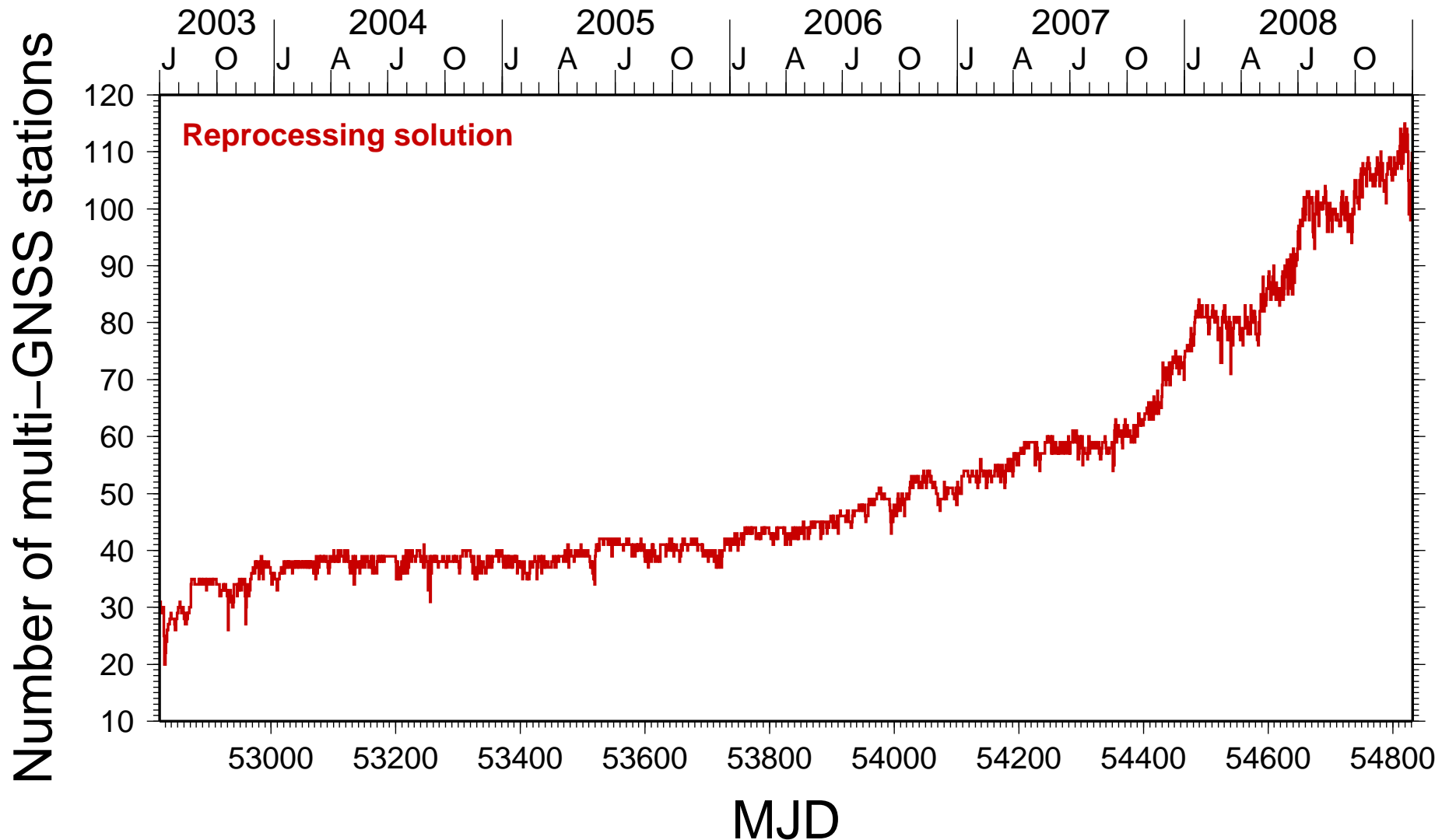
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## ■ IGS–Repro01, GLONASS–extension:

- ◆ 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)

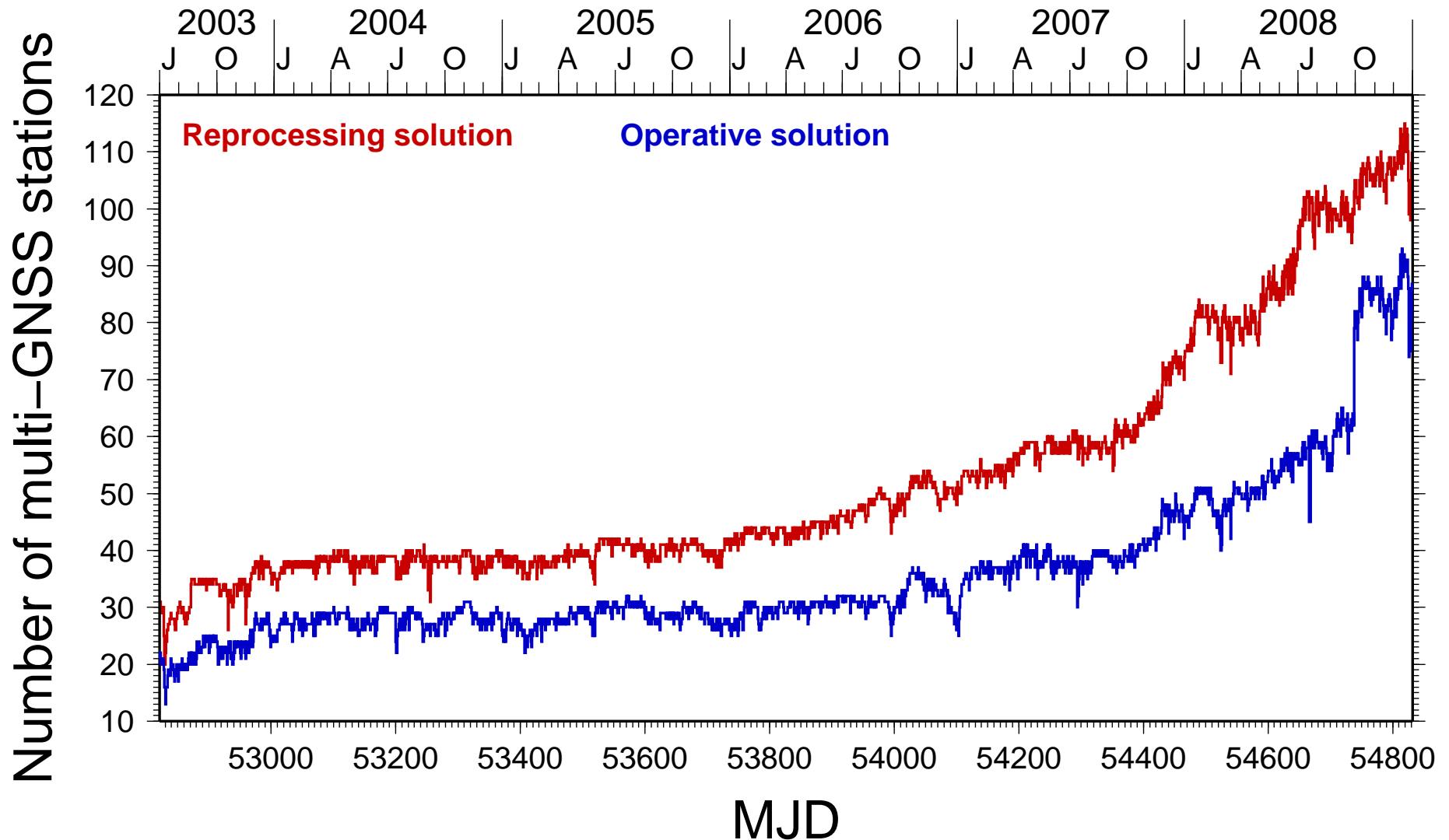
# Number of GLONASS Stations

## GLONASS tracking receivers in the CODE–Reprocessing



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# List of antennas in EGU05.ATX

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ASH701945E_M NONE	2	4	1	2	7	2	9	COPIED	JPLA
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LEIAT504GG NONE	25	49	21	41	2	8	0	ROBOT	
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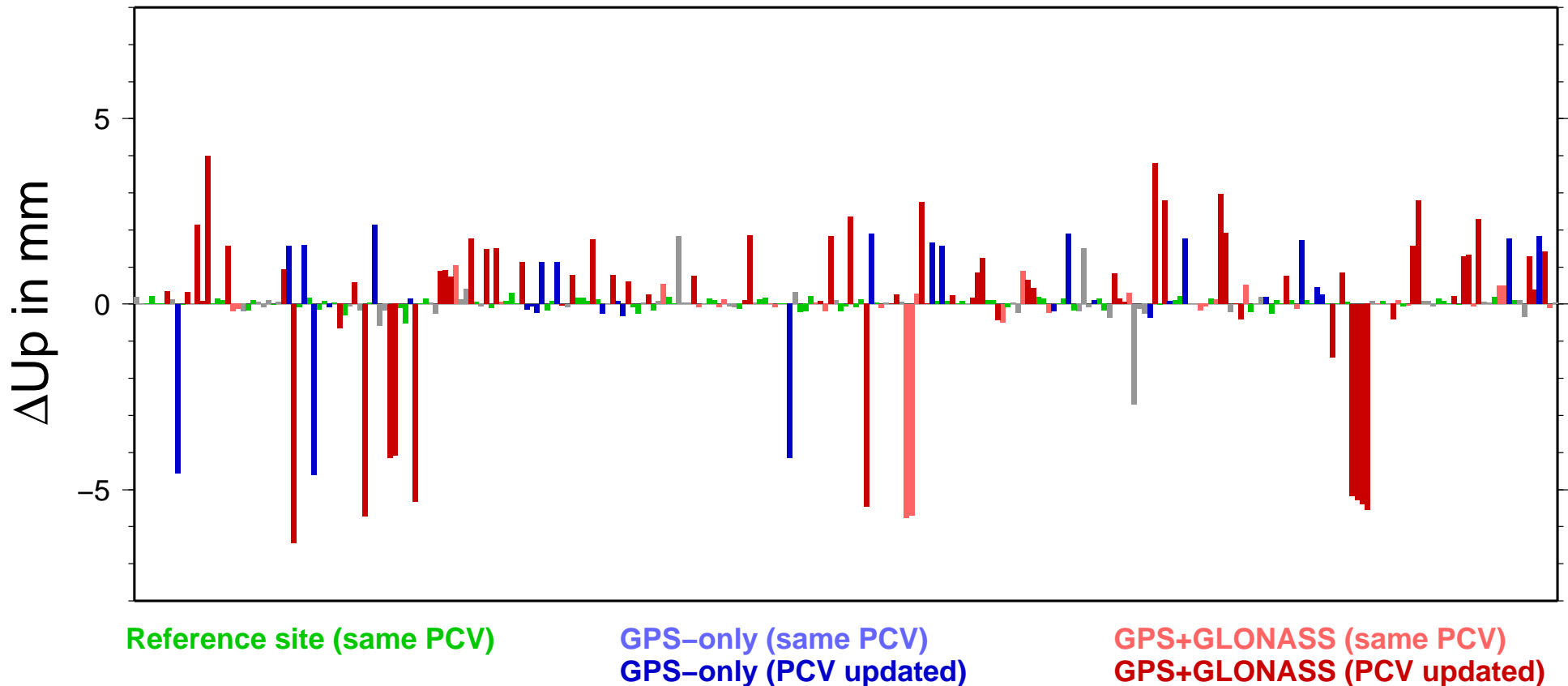
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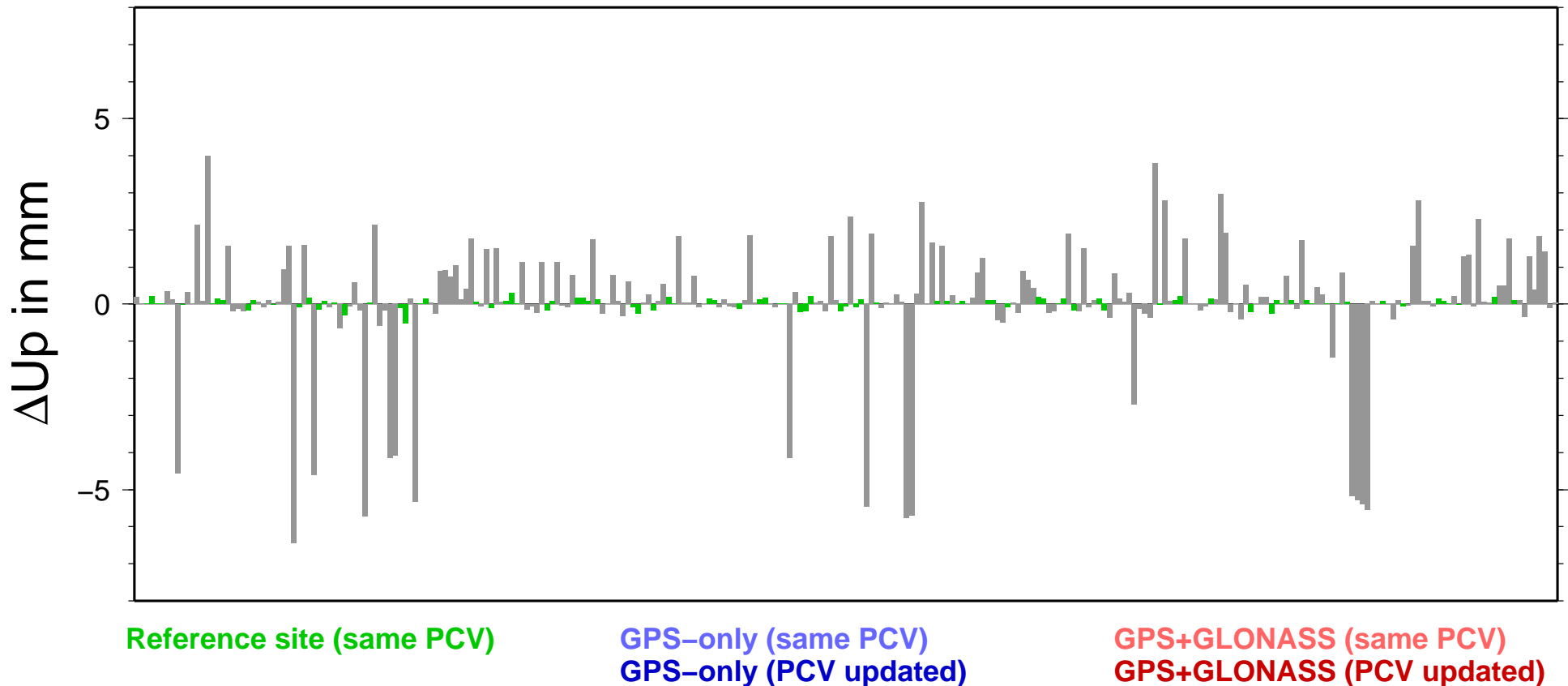


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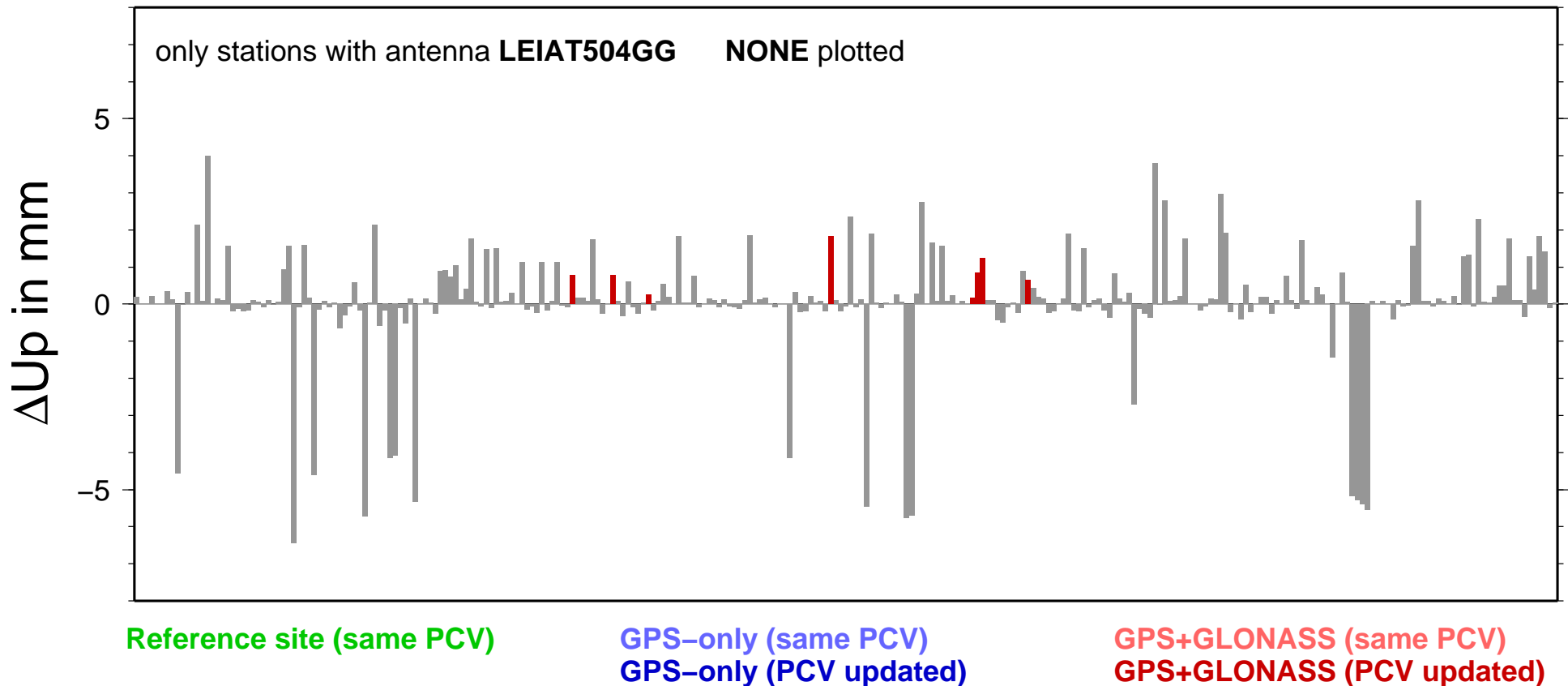
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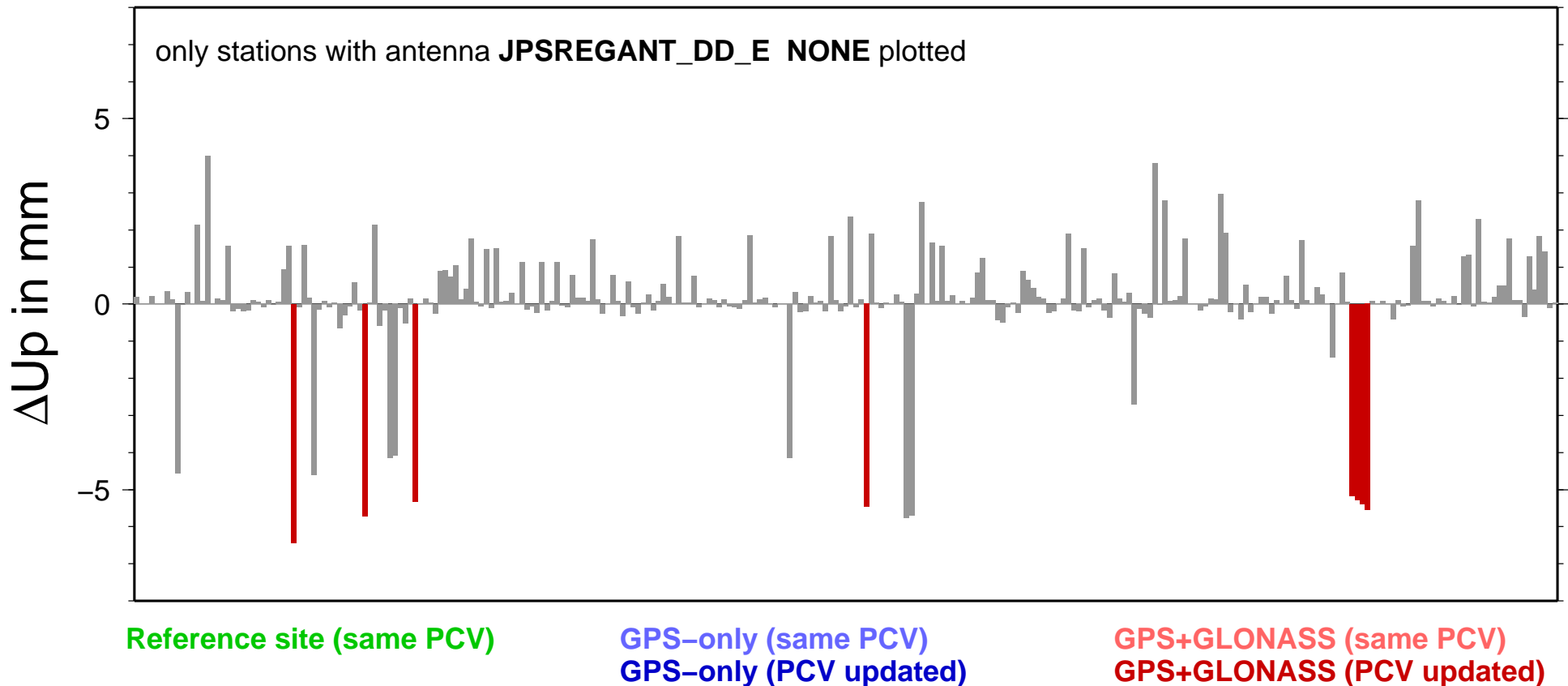


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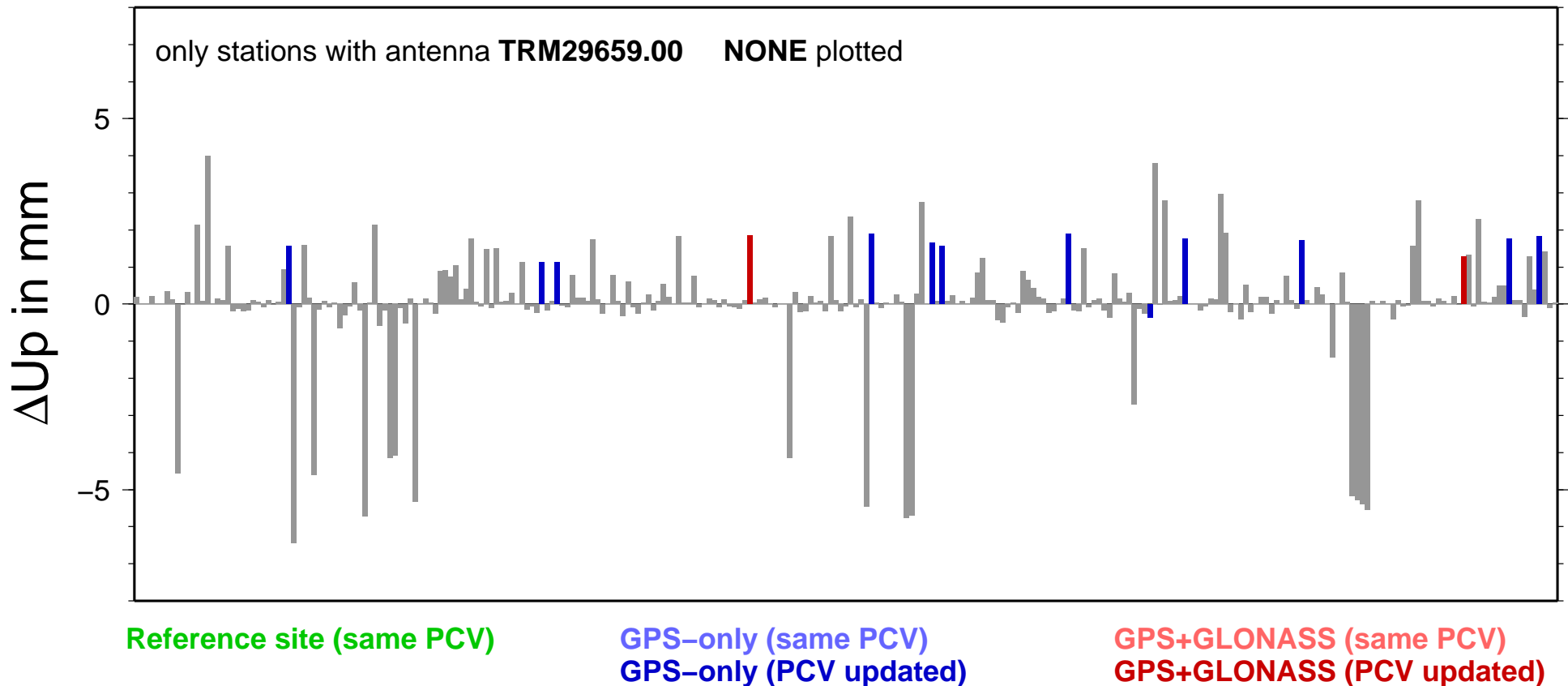


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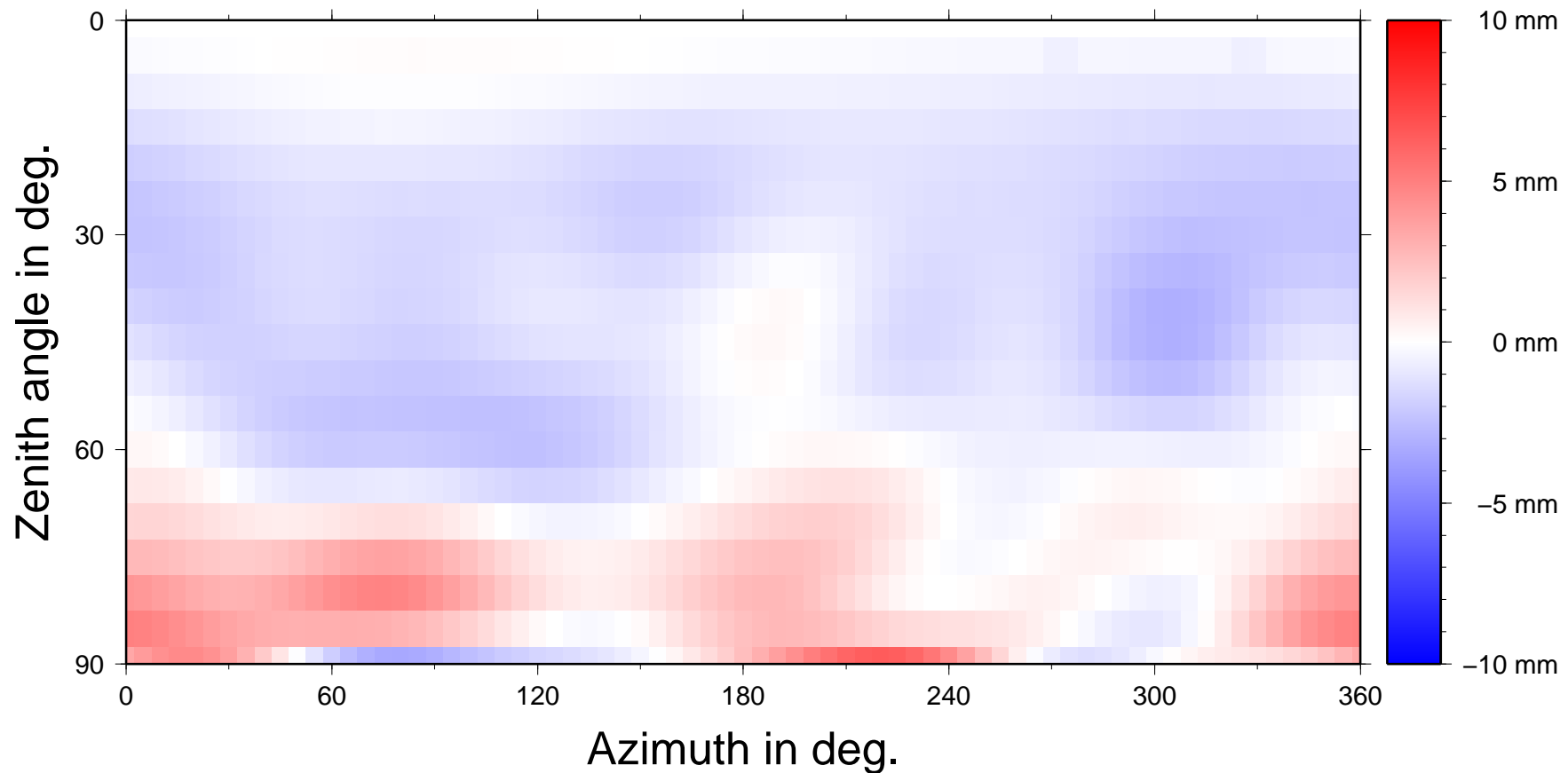


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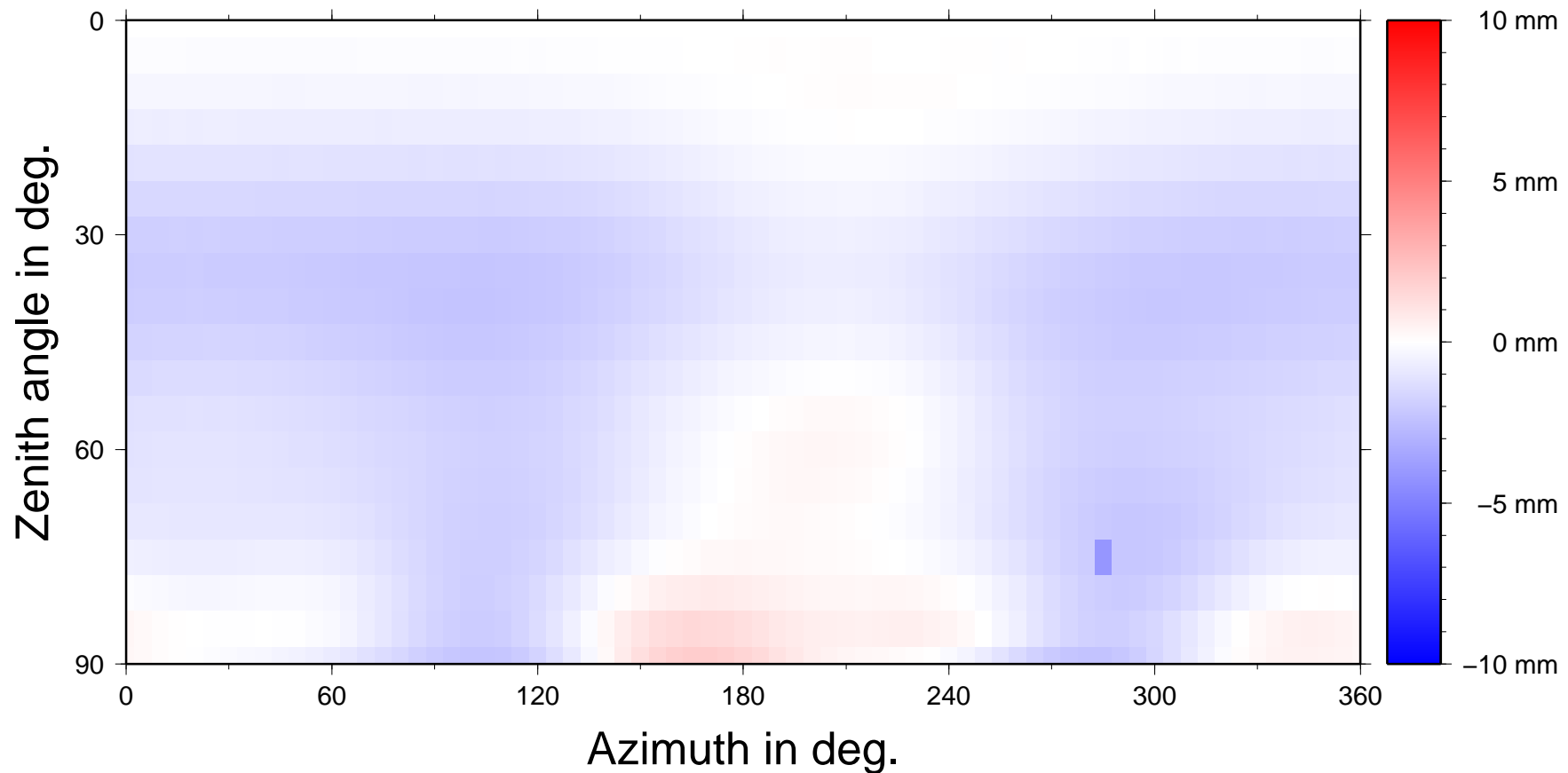
(Antenna: ASH701945E\_M NONE)



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

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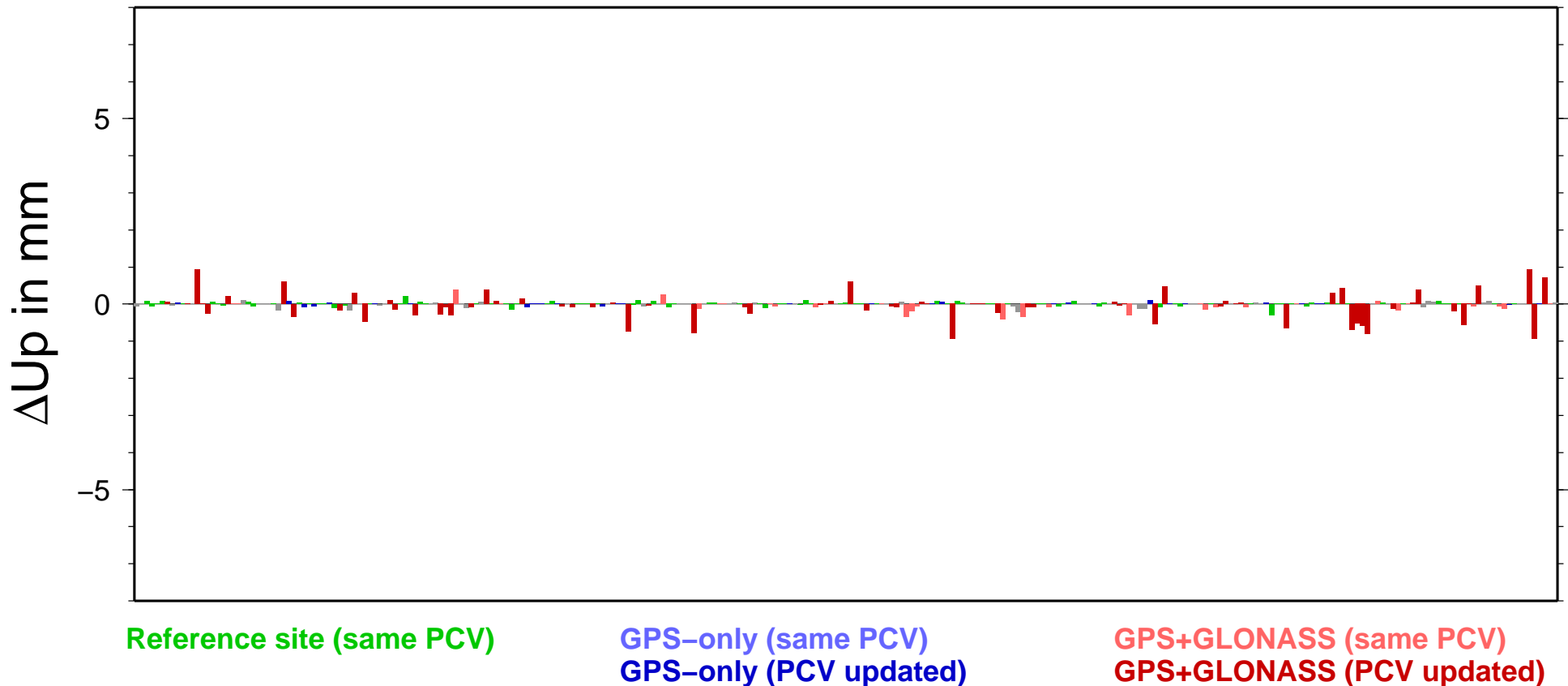
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# System-dependent calibration

## 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

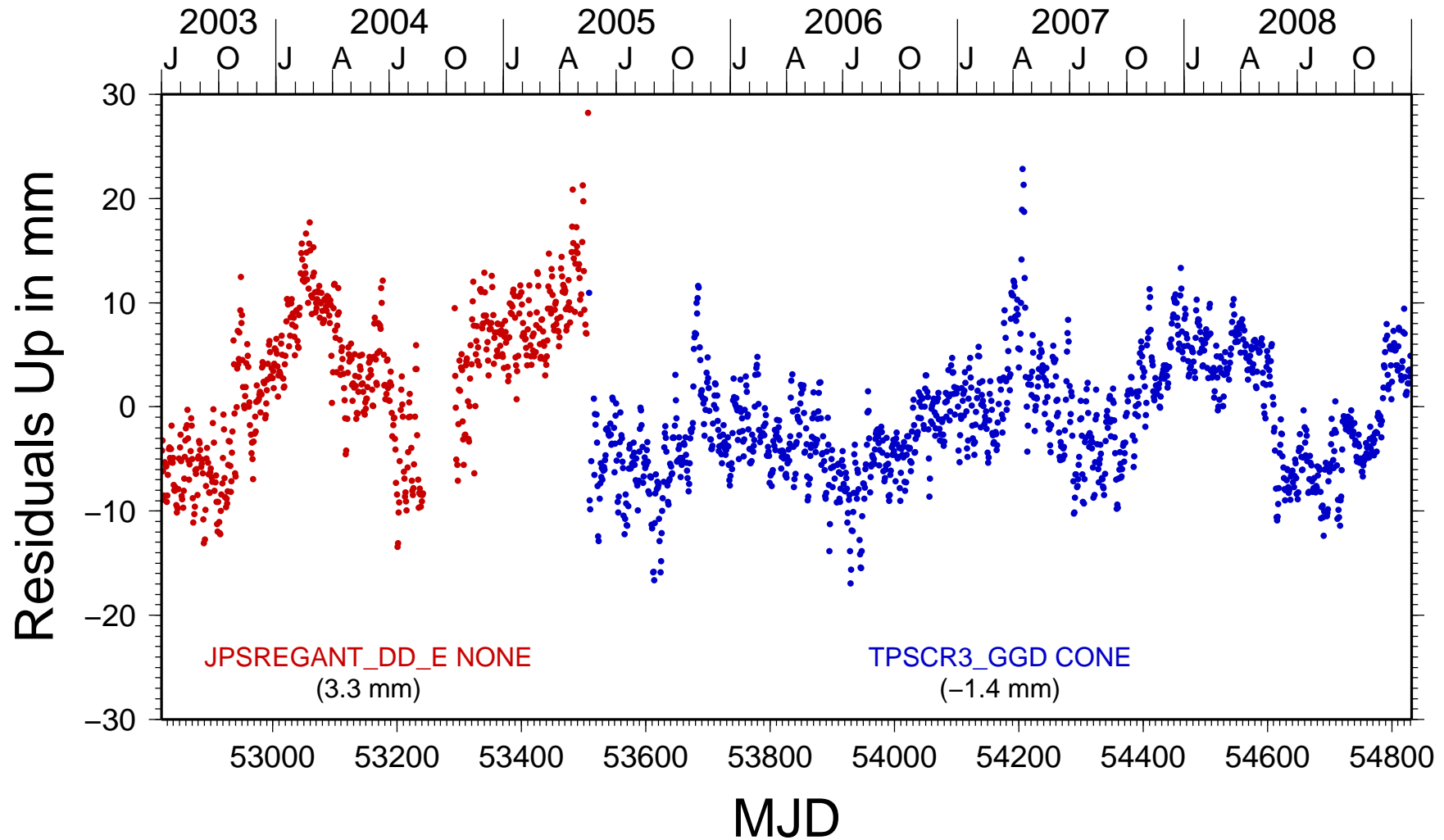


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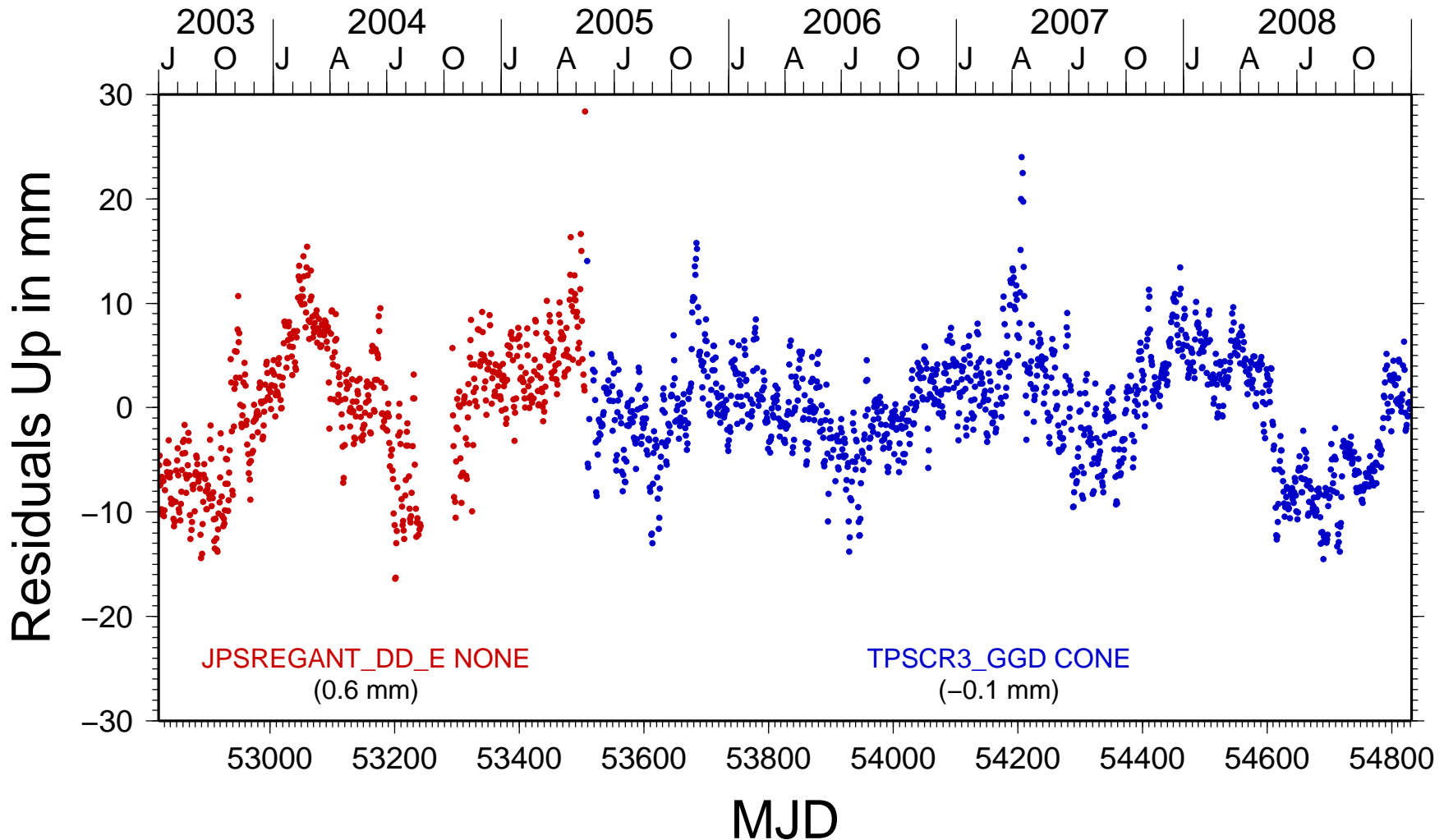
(IGS05.ATX, GPS model also used for GLONASS)



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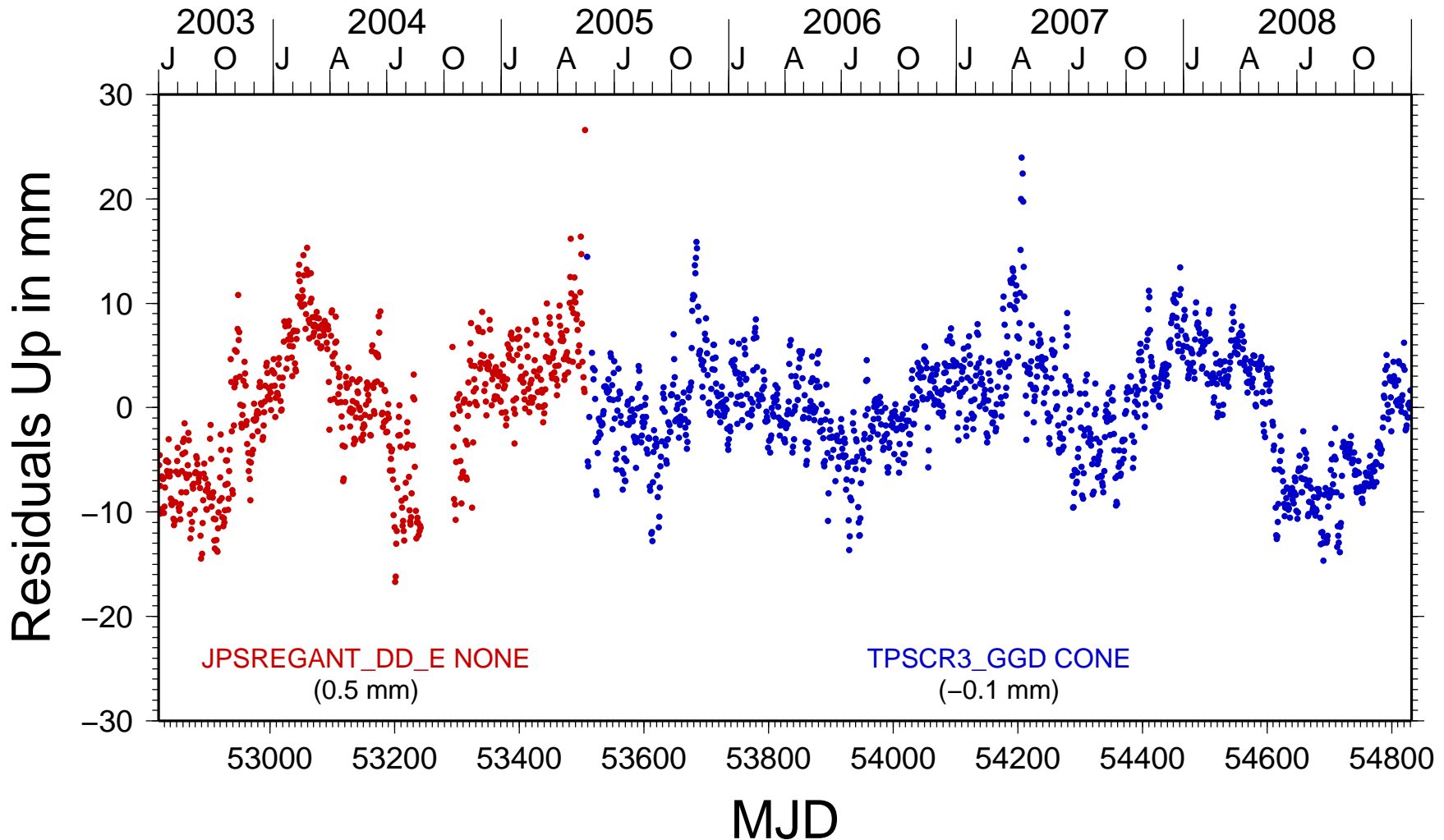
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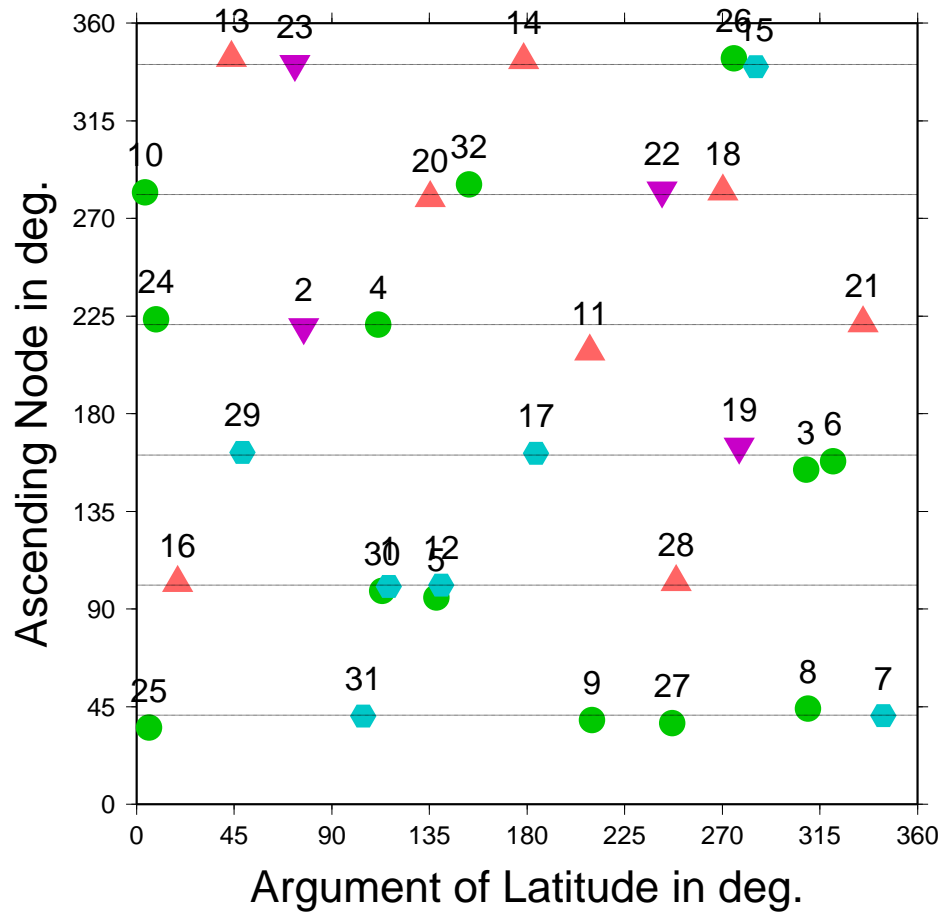
## Time series for station CONZ (EGU05.ATX, special GLONASS corrections)



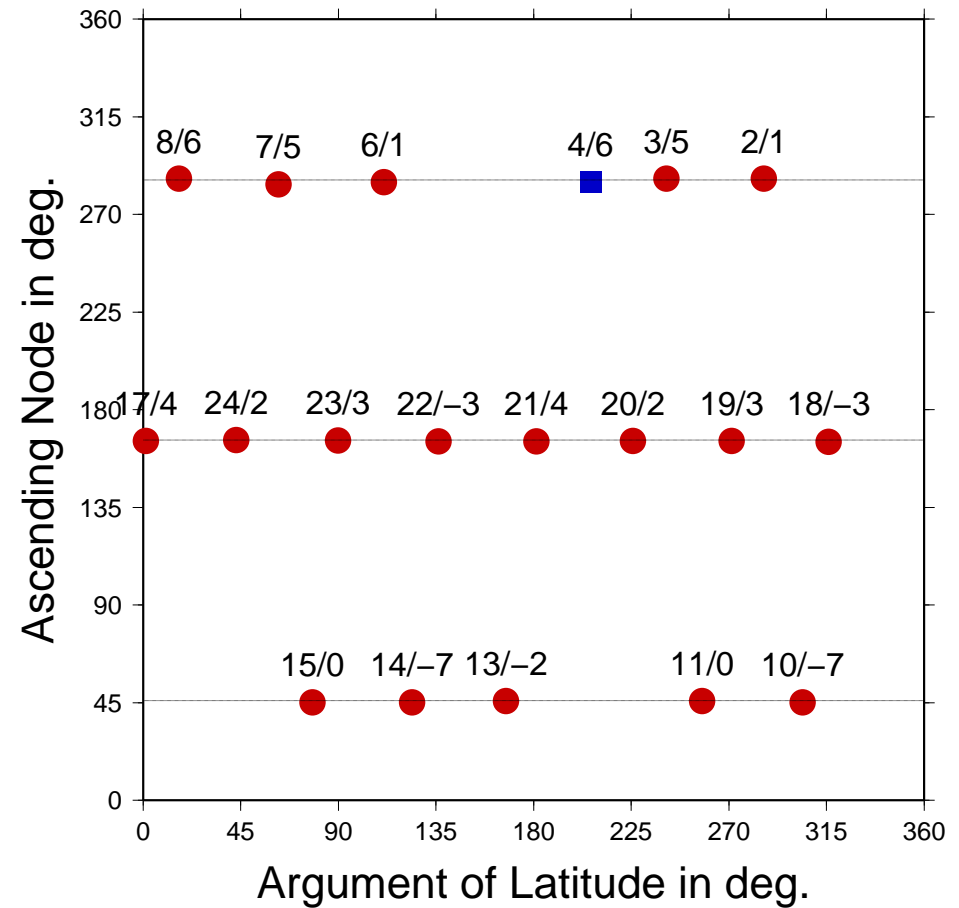
# Why to update the satellite antenna model?

## Current GNSS constellation

Day of year 2009:100



● BLOCK IIA ▲ BLOCK IIR-A ▼ BLOCK IIR-B ◆ BLOCK IIR-M

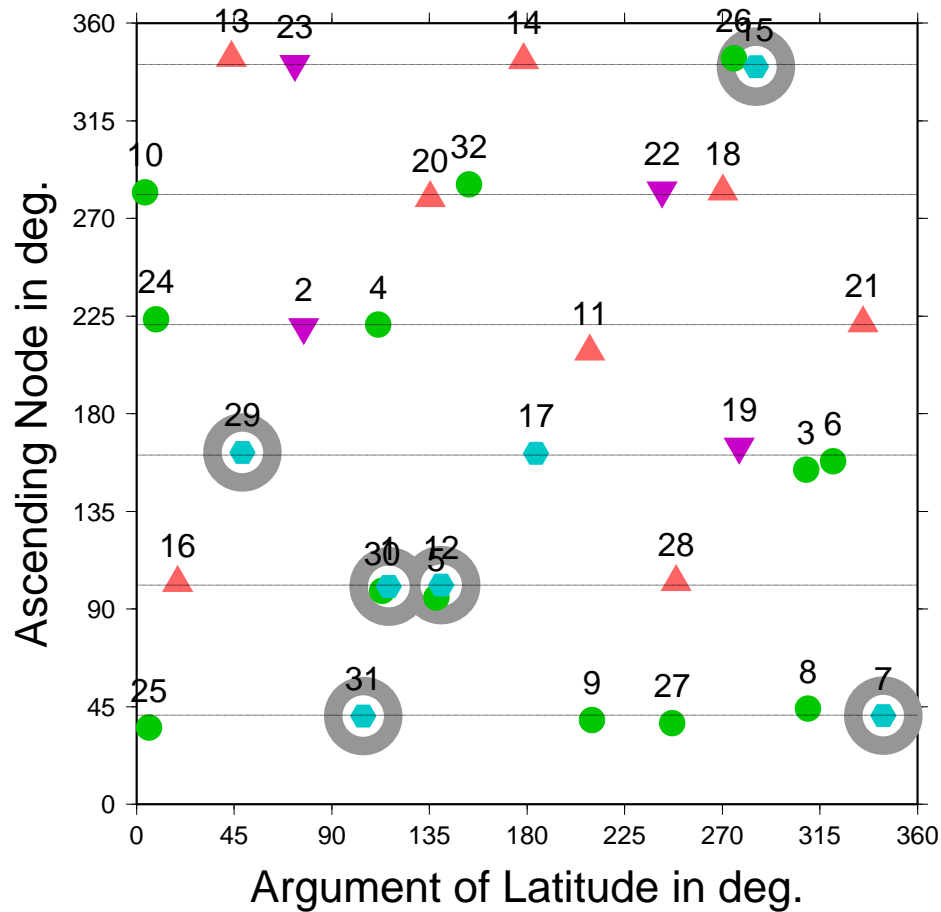


■ GLONASS ● GLONASS-M

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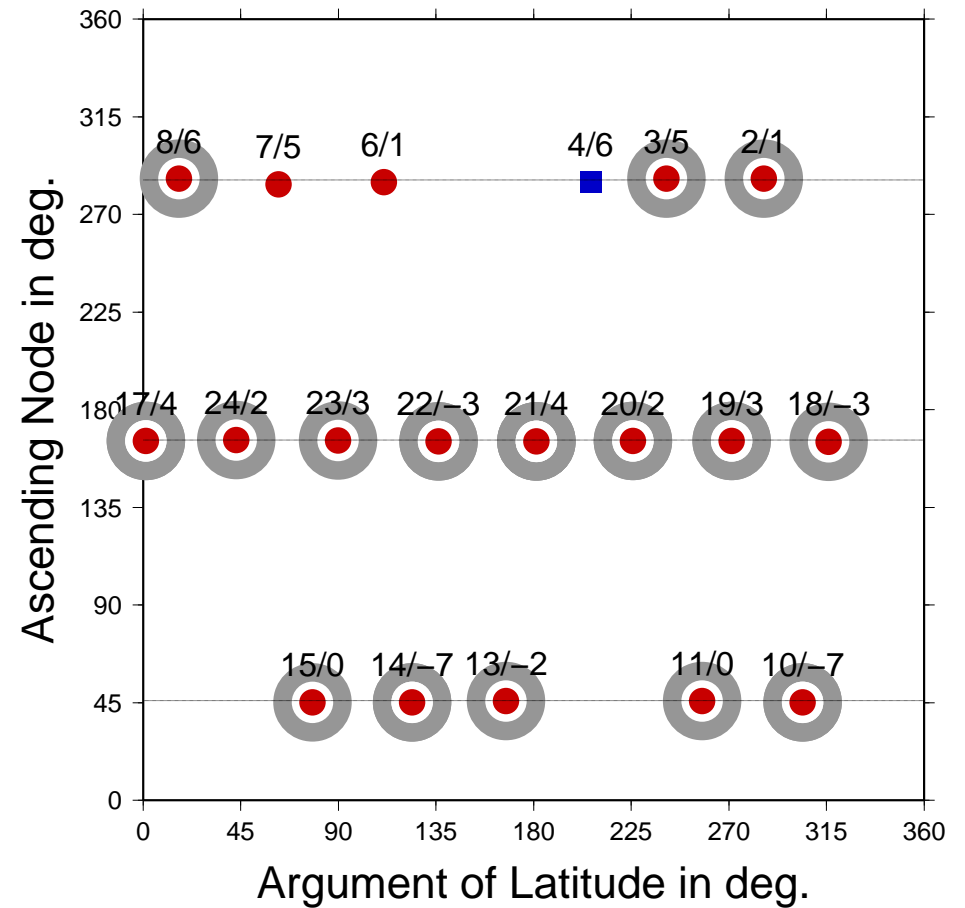
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GPS constellation

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GLONASS constellation

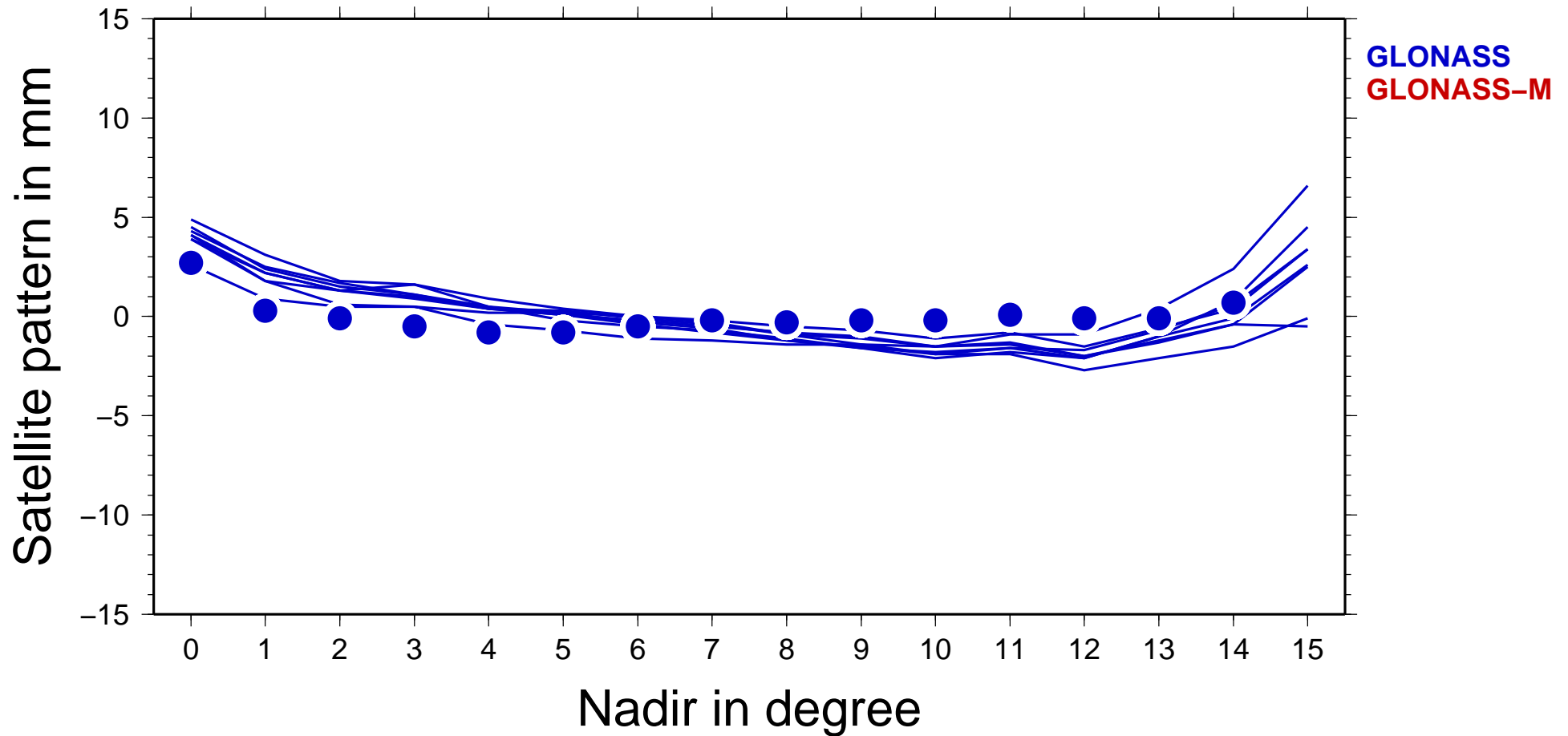
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Satellite launched after 01-Dec-2005

# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

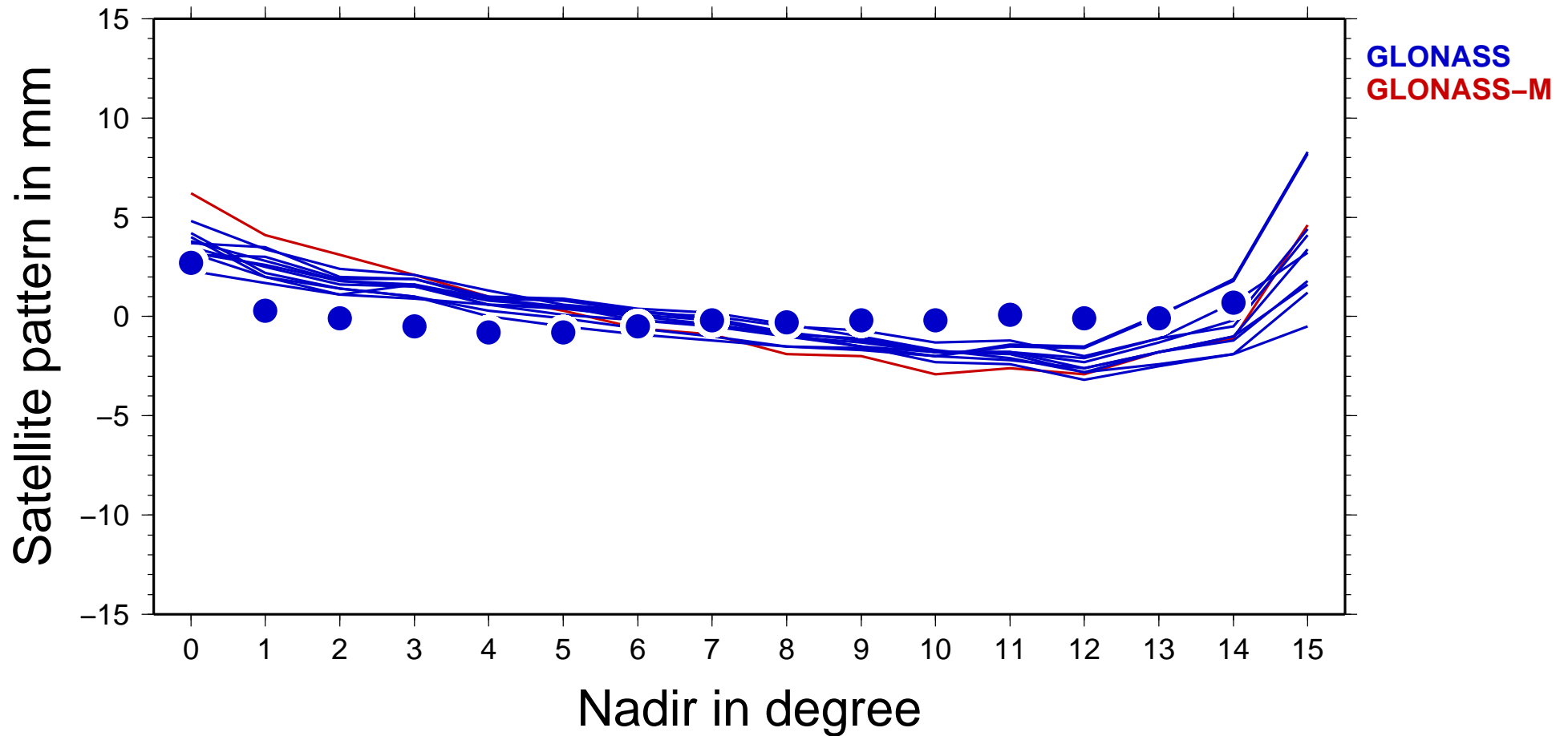
Solution from year 2003, minimum 90 days



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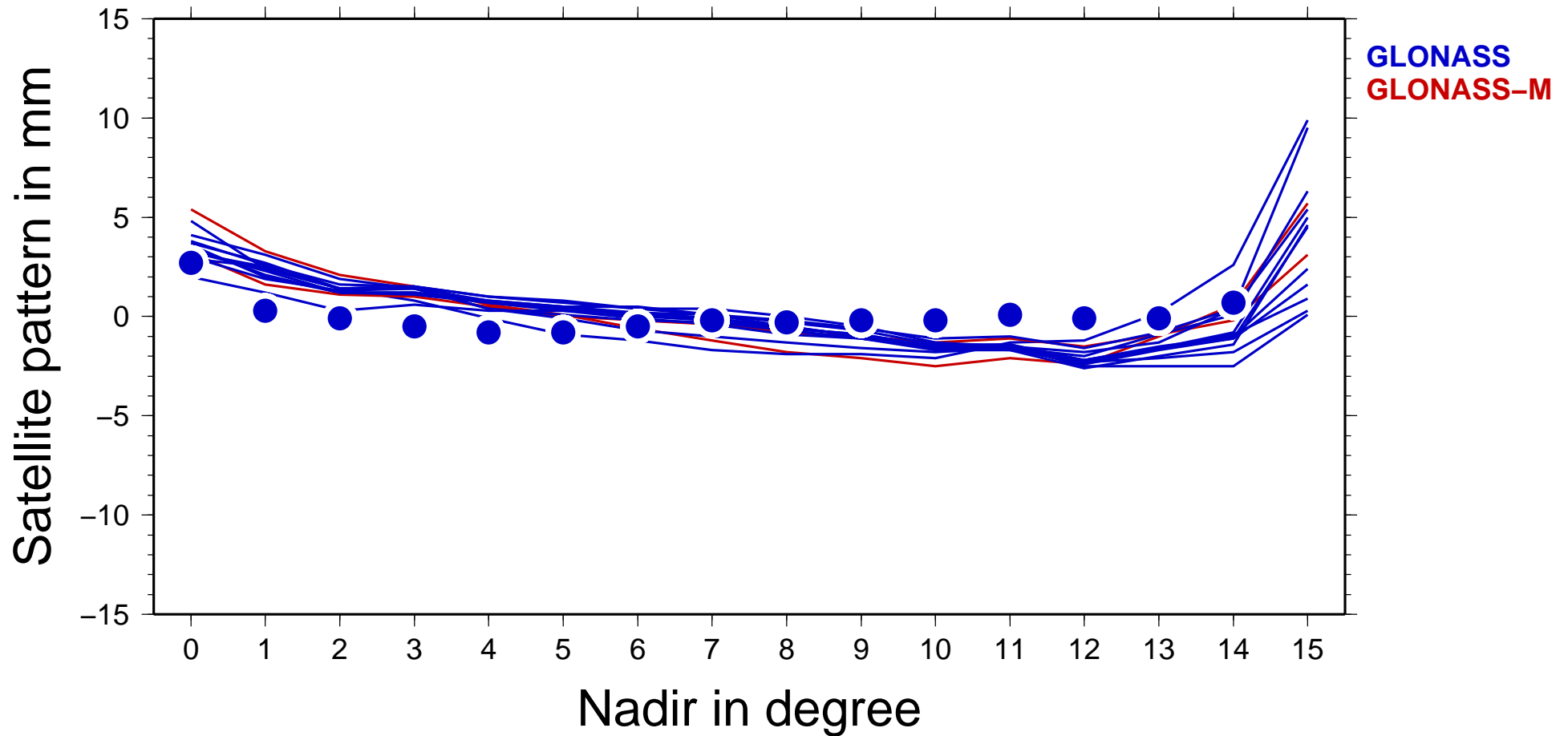
Solution from year 2004, minimum 90 days



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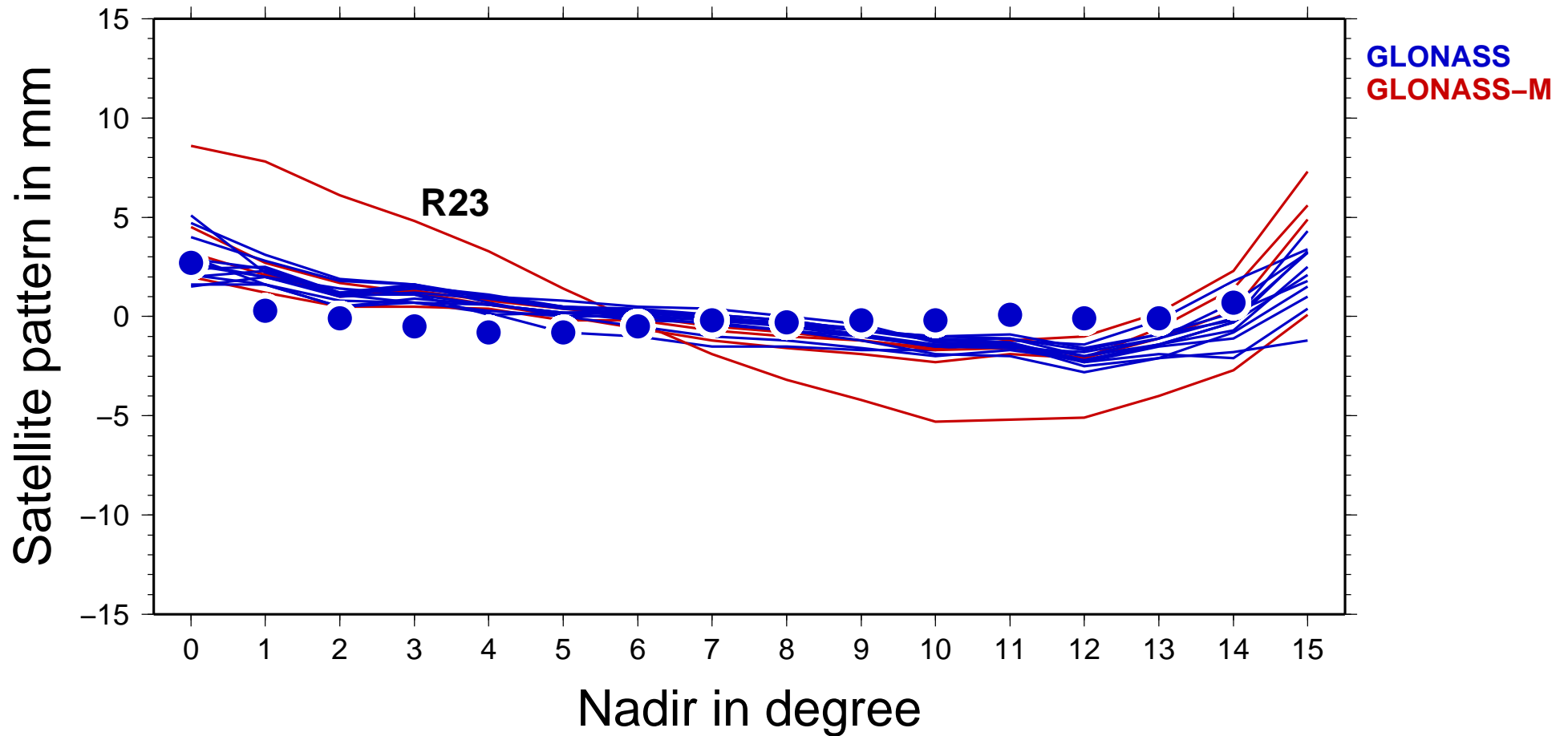
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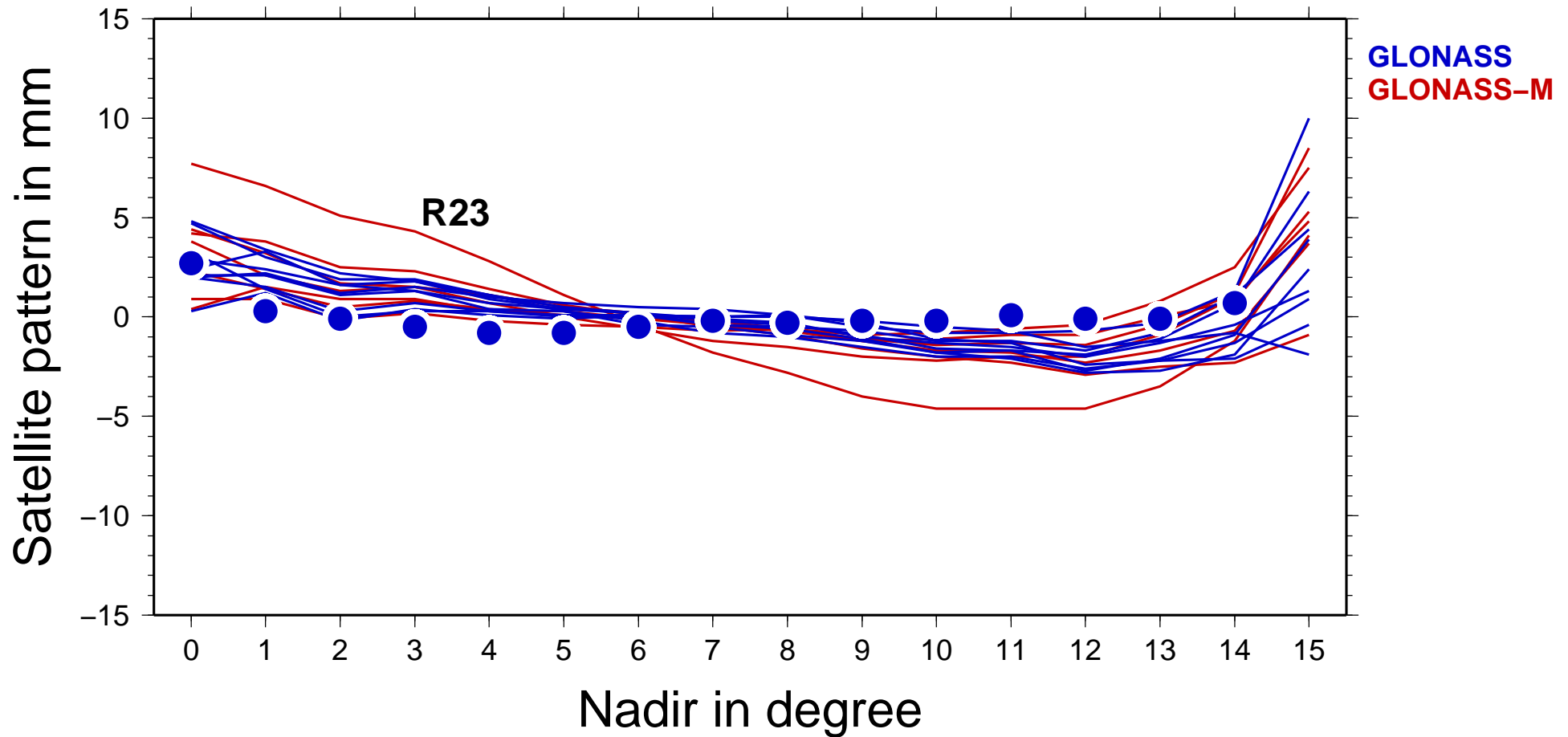
Solution from year 2006, minimum 90 days



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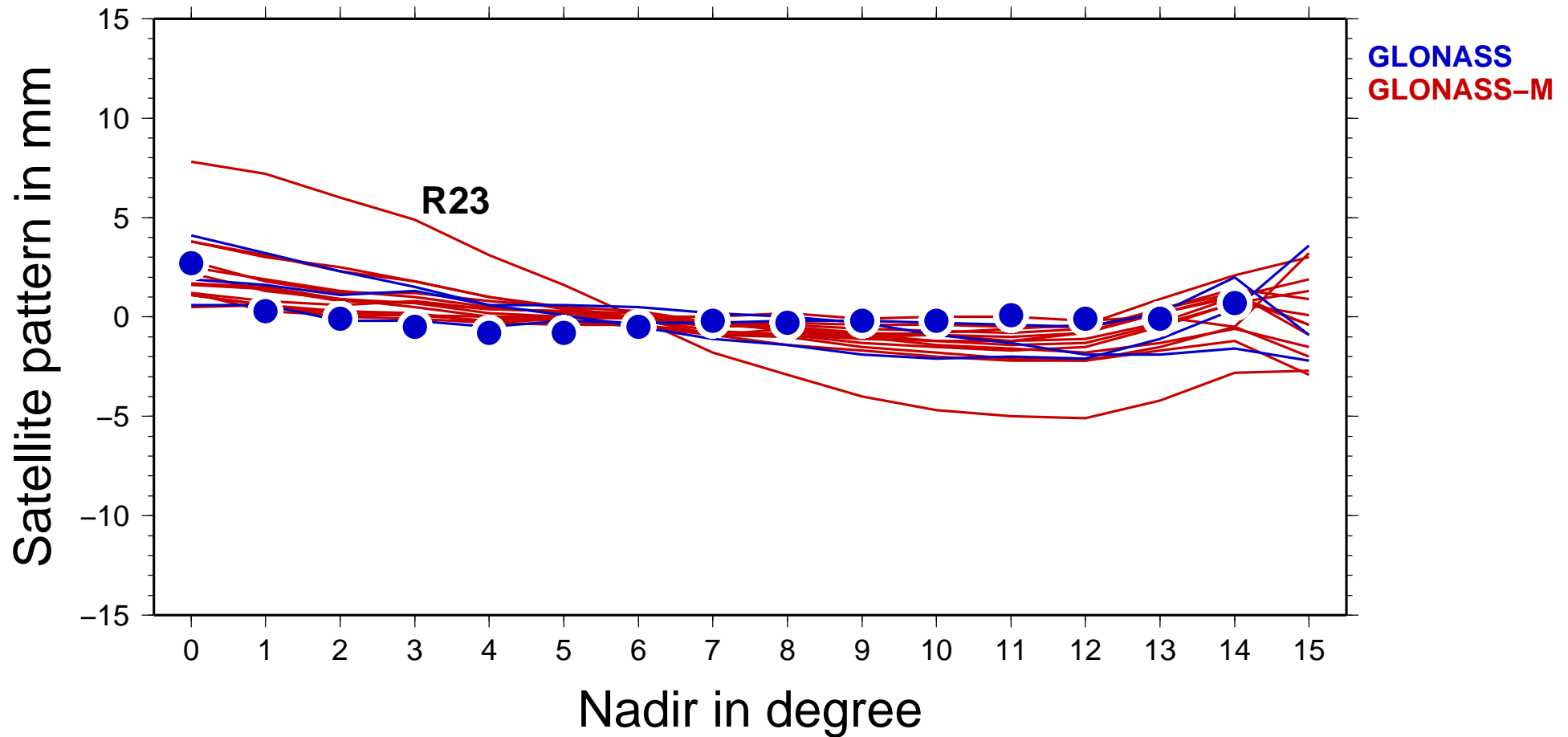
Solution from year 2007, minimum 90 days



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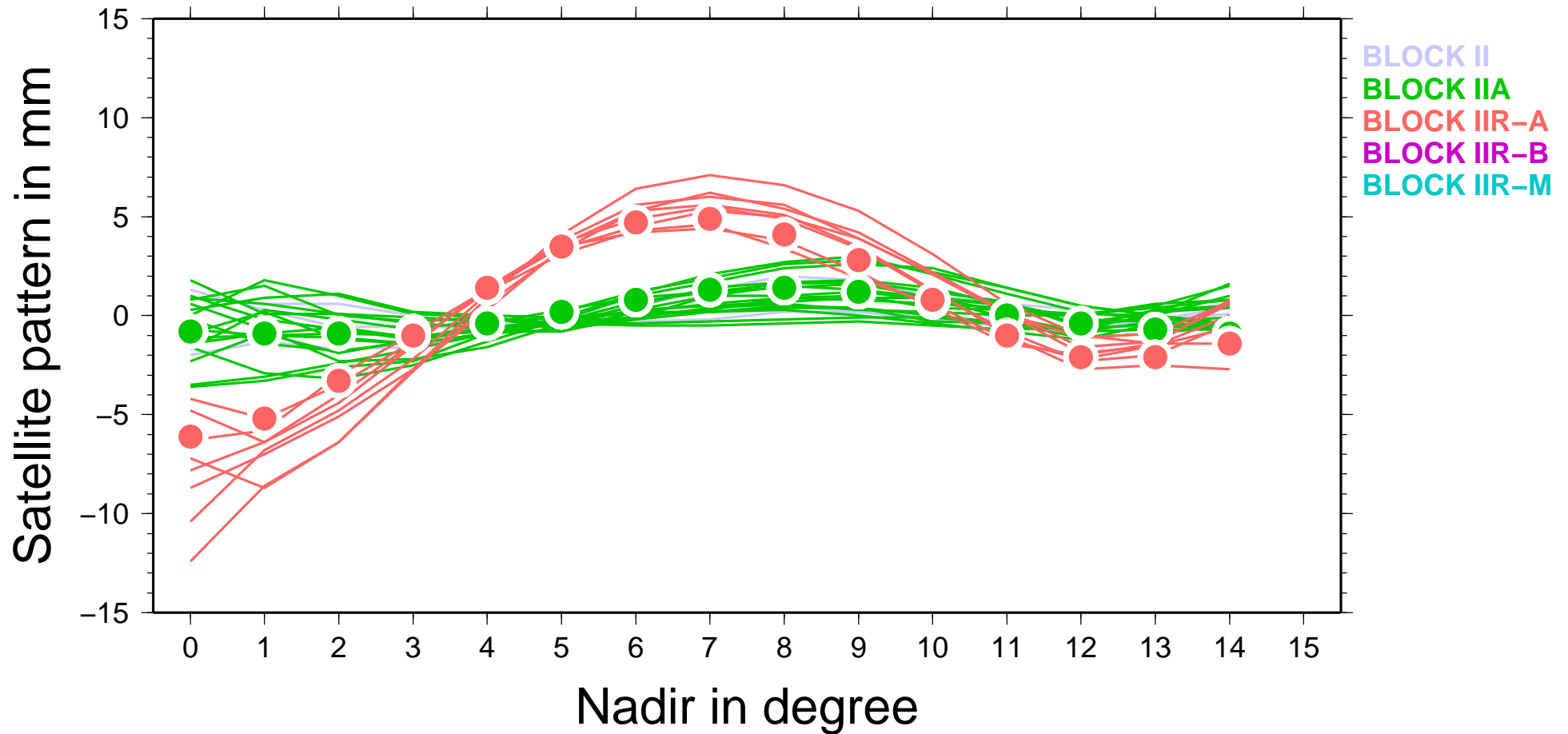
Solution from year 2008, minimum 90 days



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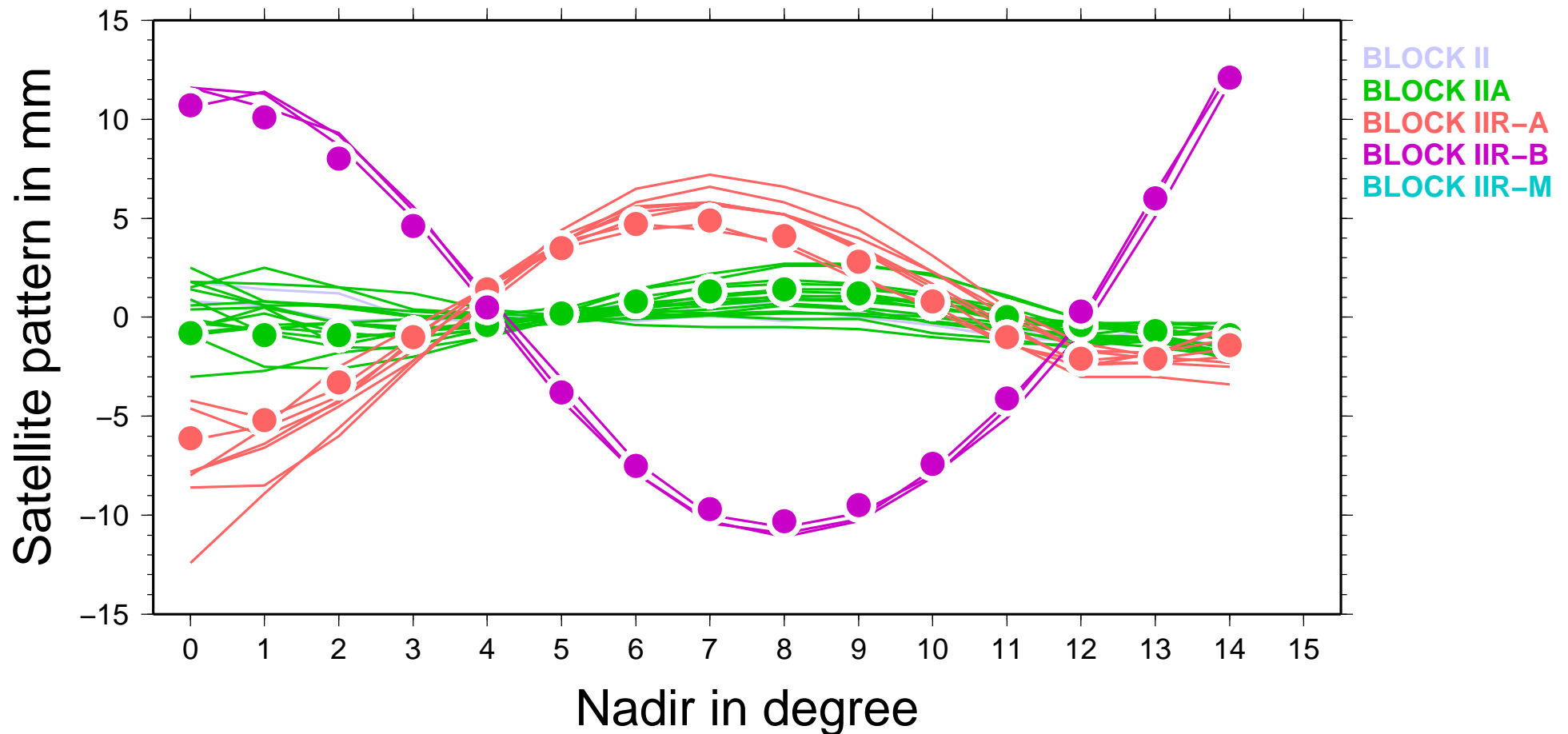
Solution from year 2003, minimum 90 days



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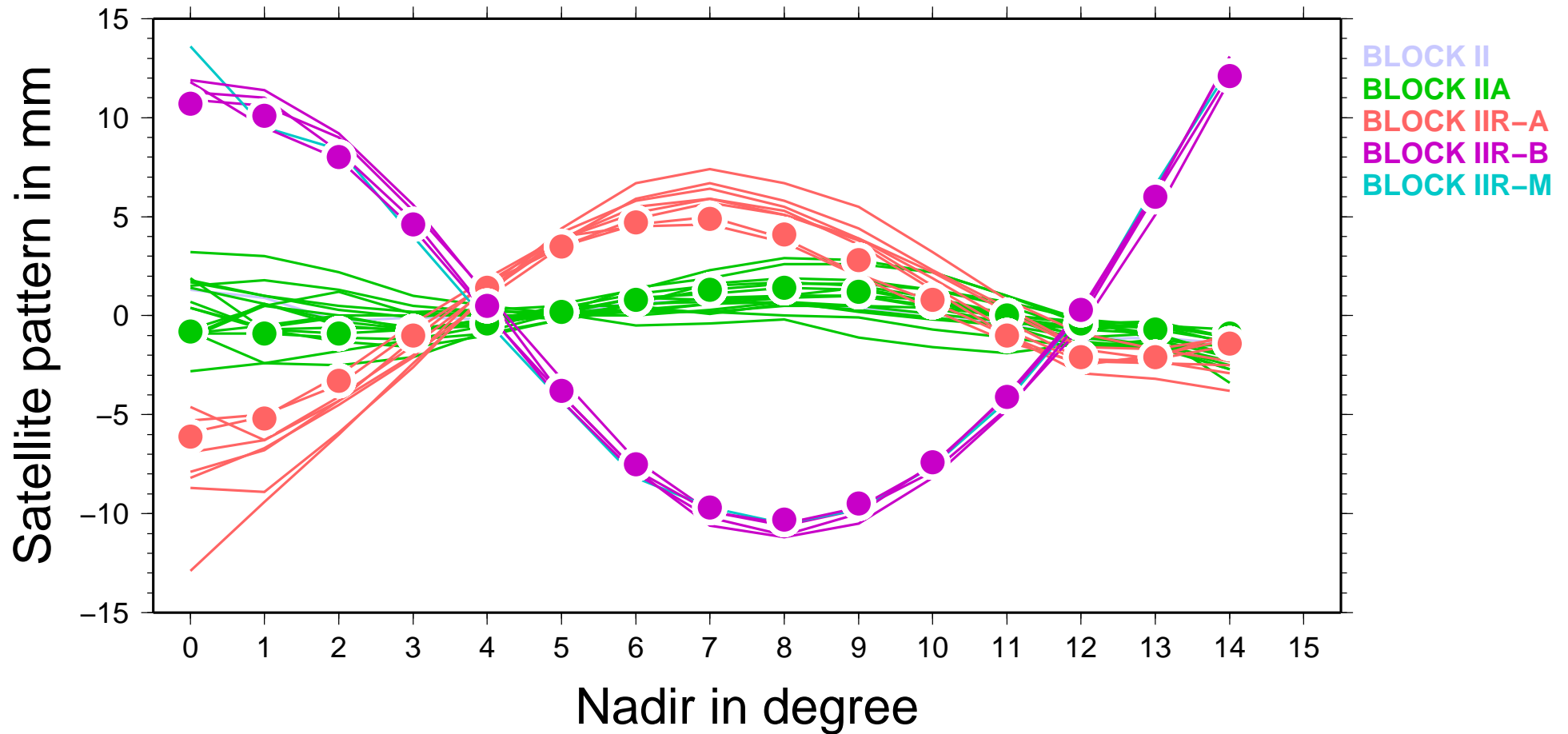
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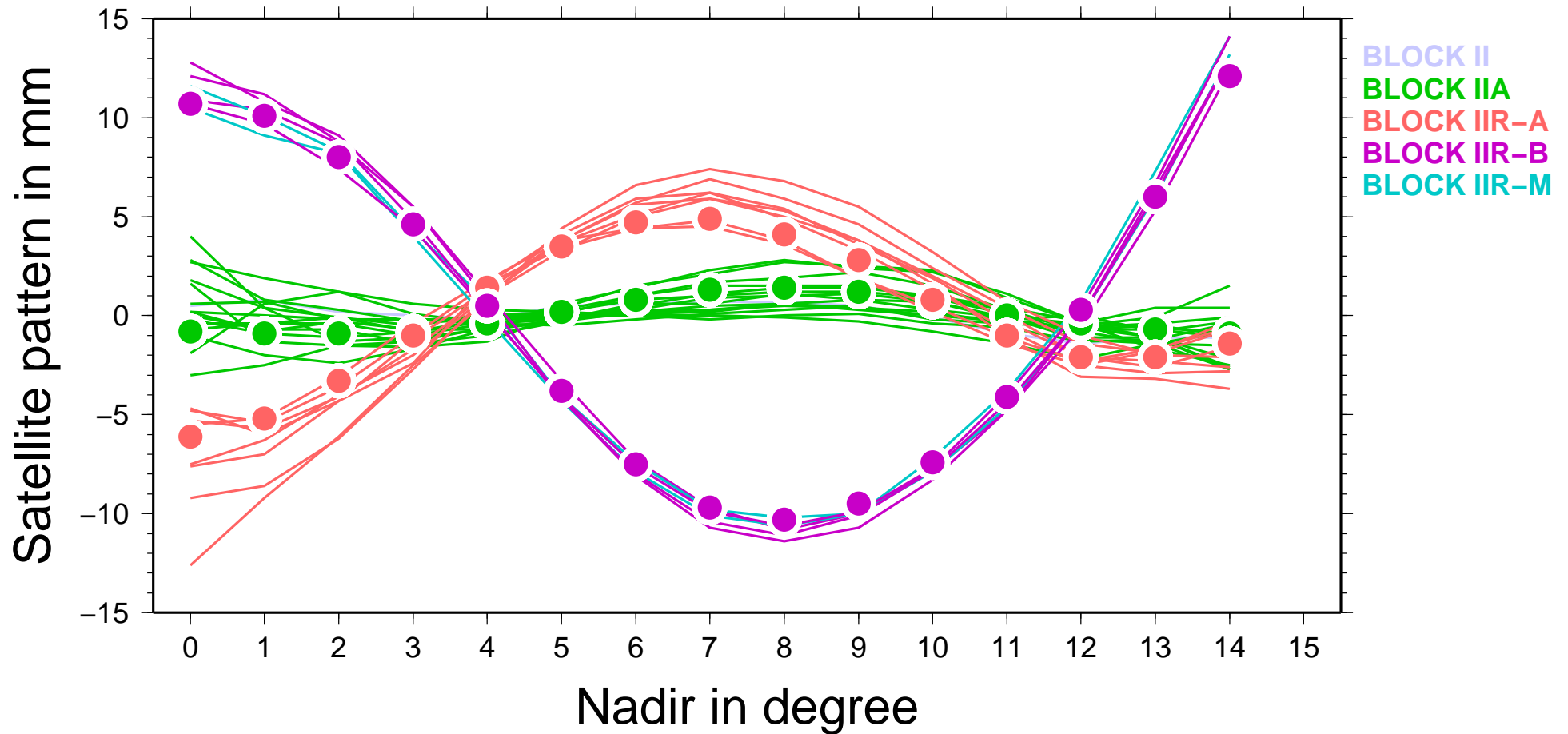
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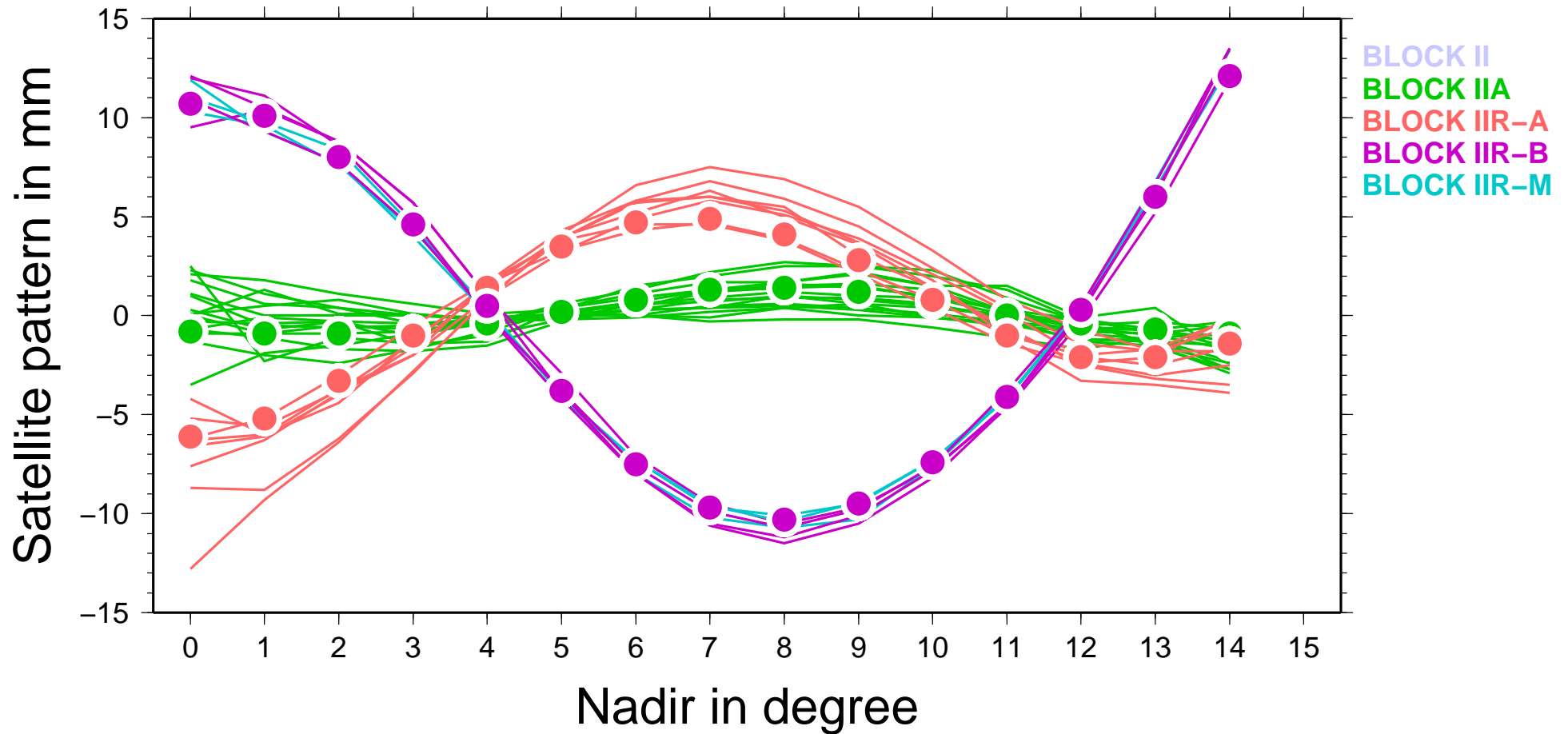
Solution from year 2006, minimum 90 days



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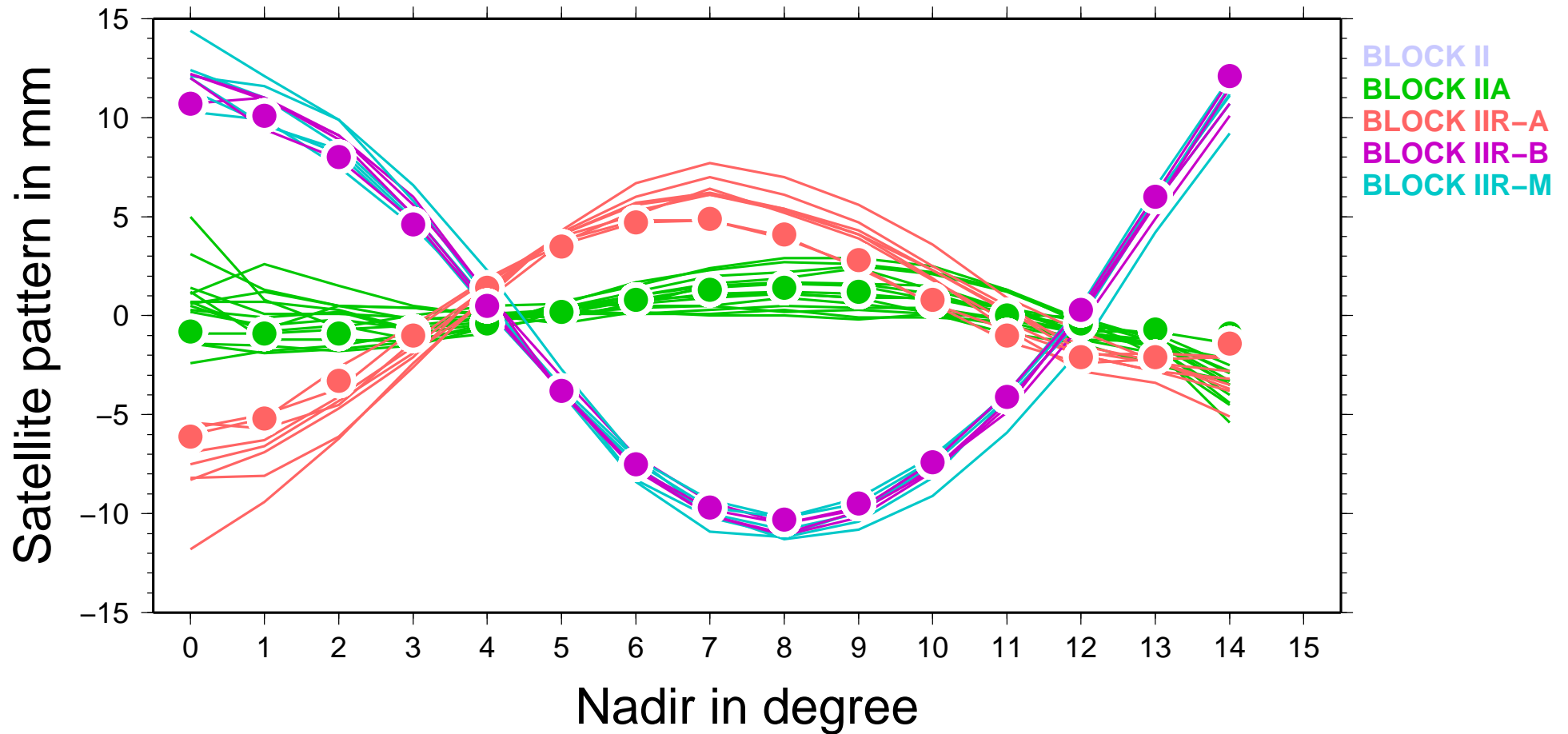
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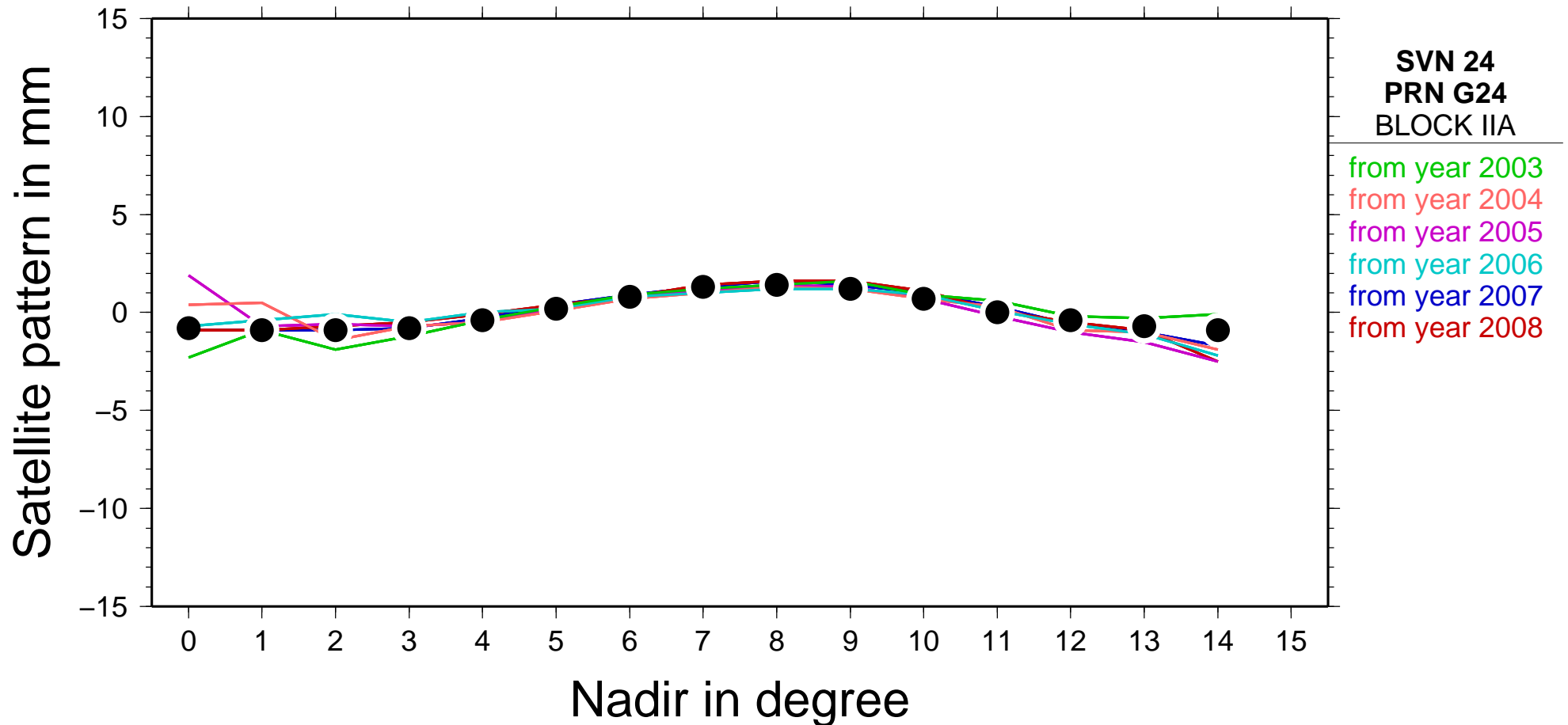
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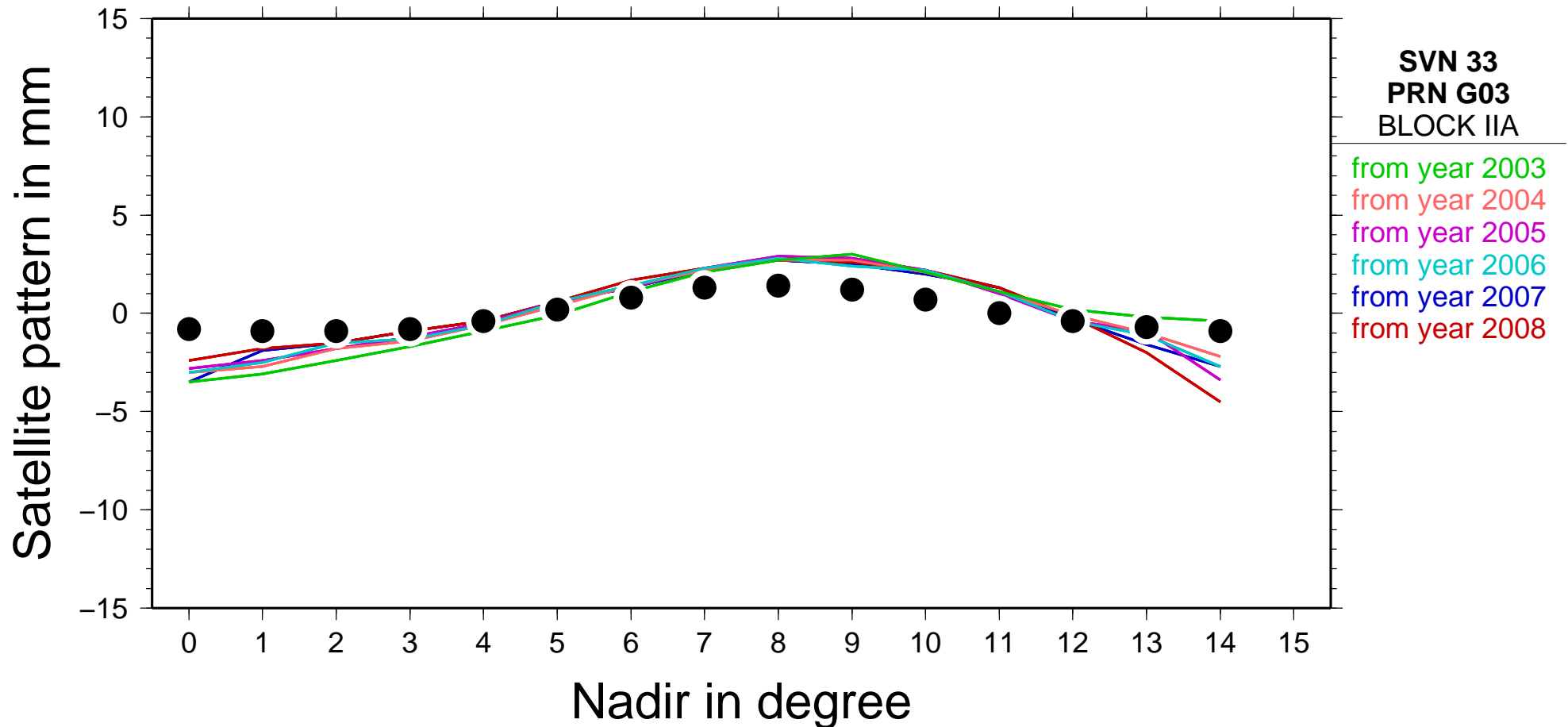
Satellite SVN 24/PRN G24, minimum 90 days



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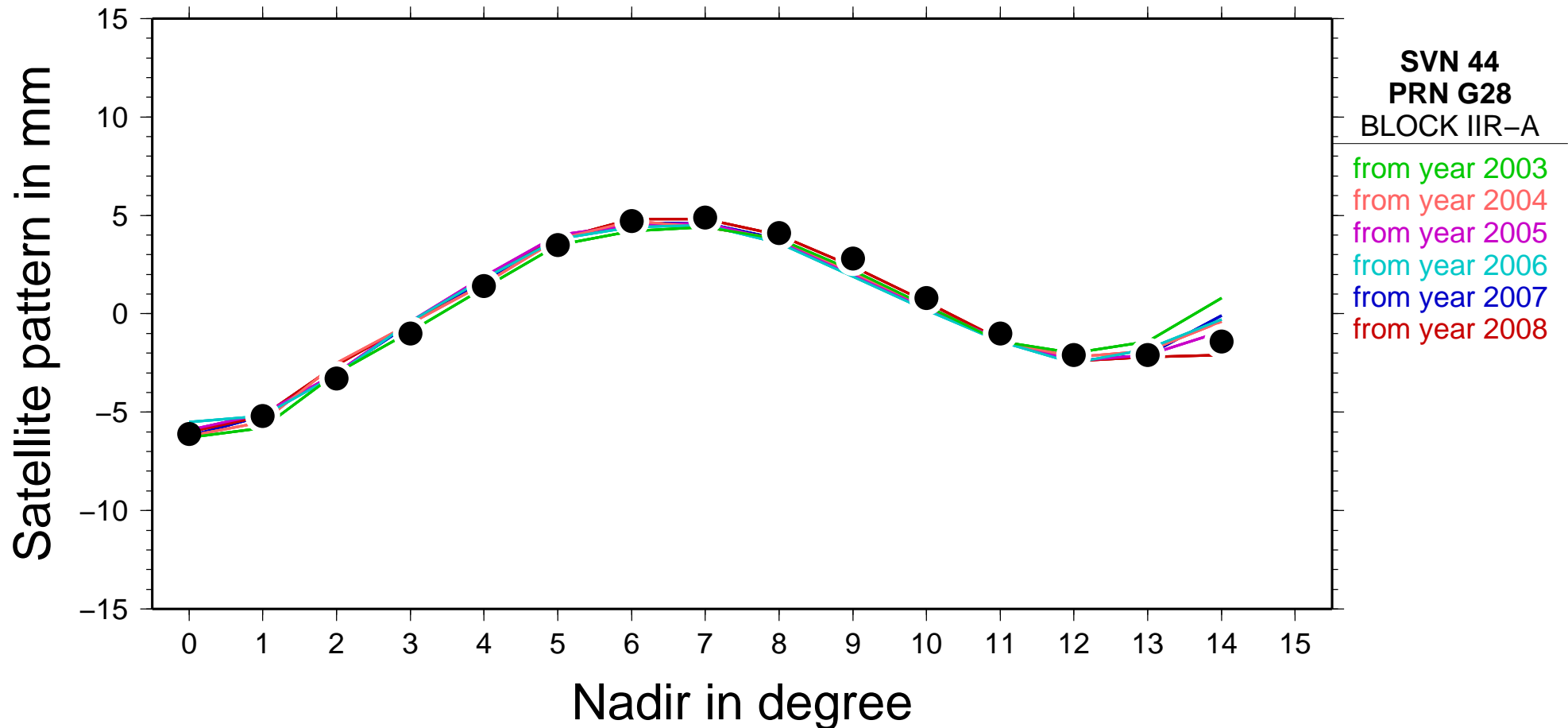
Satellite SVN 33/PRN G03, minimum 90 days



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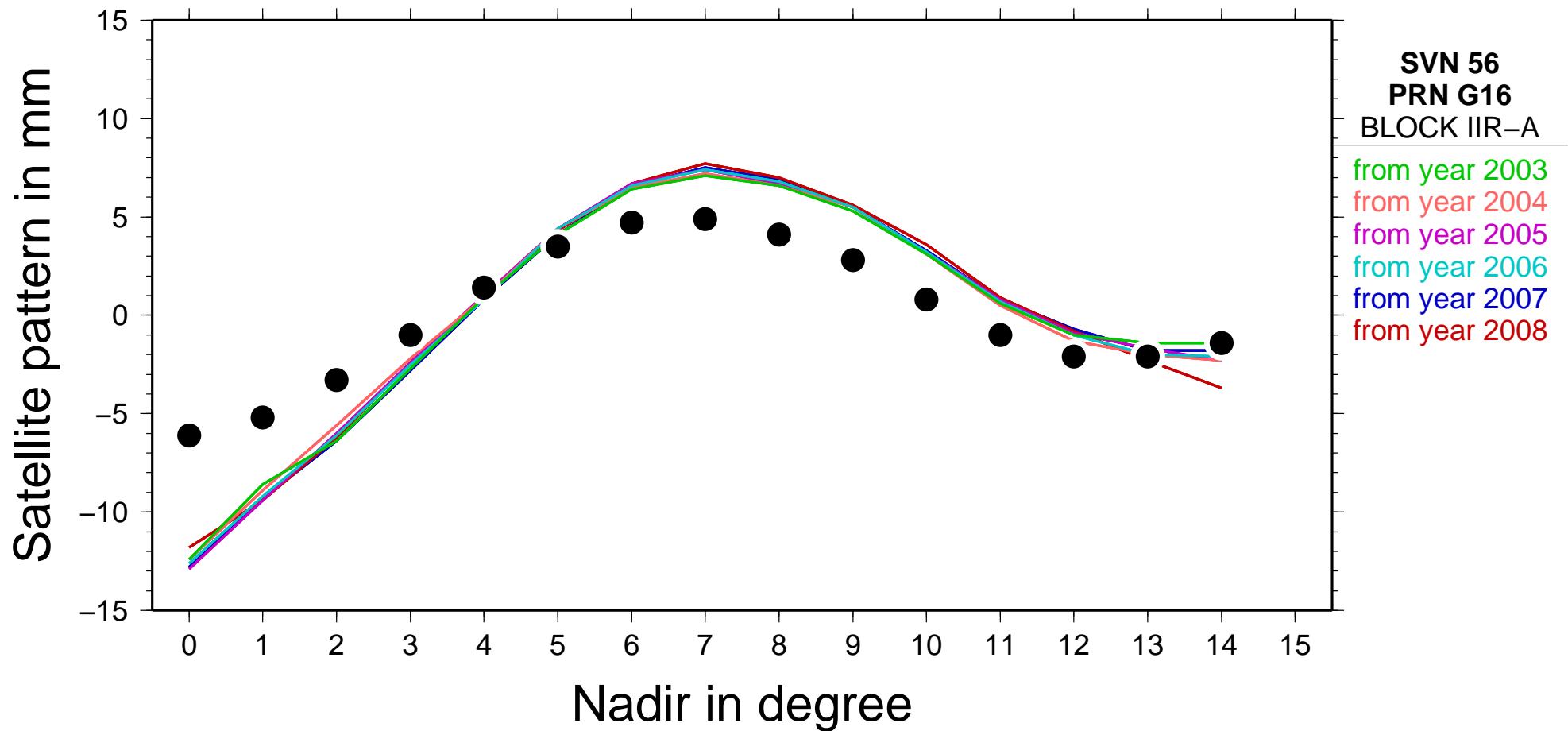
Satellite SVN 44/PRN G28, minimum 90 days



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

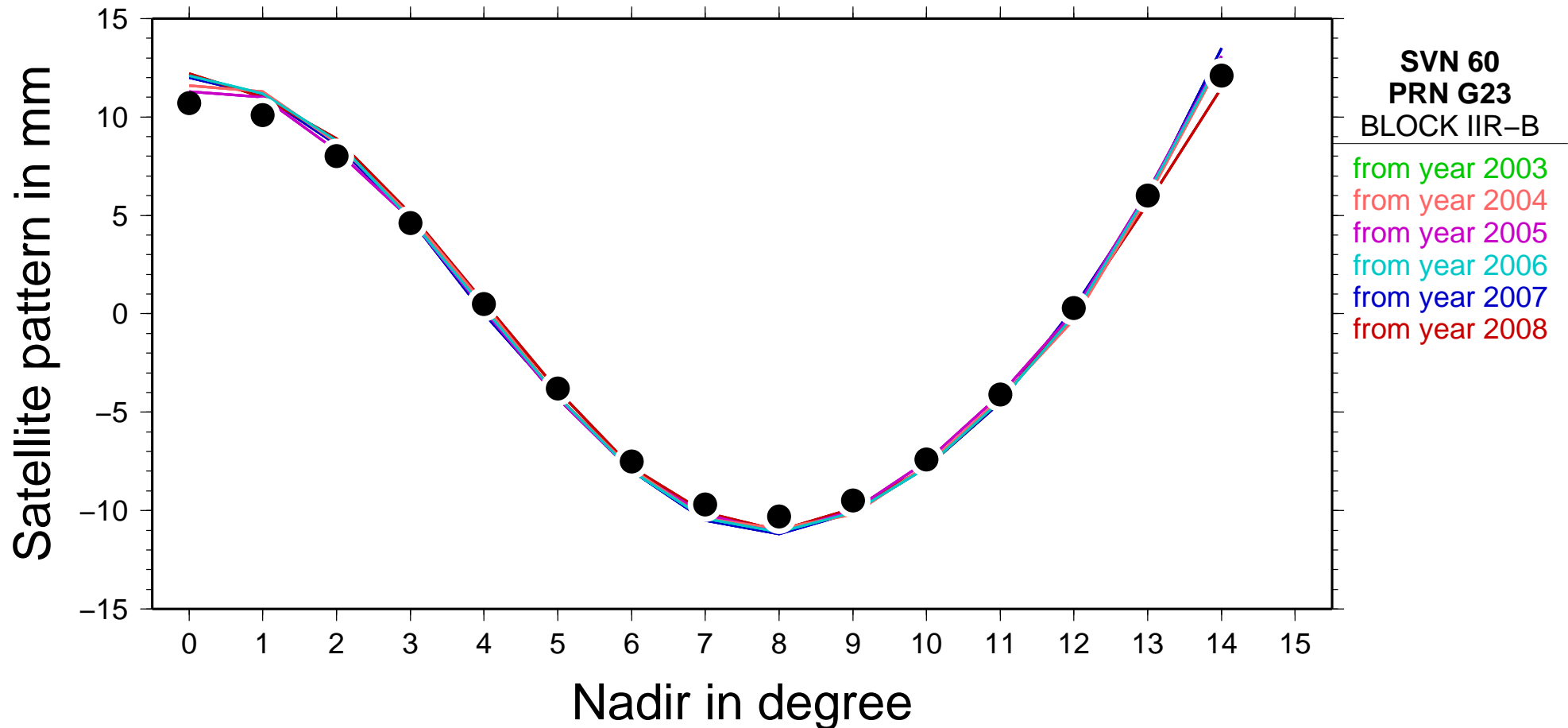
Satellite SVN 56/PRN G16, minimum 90 days



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

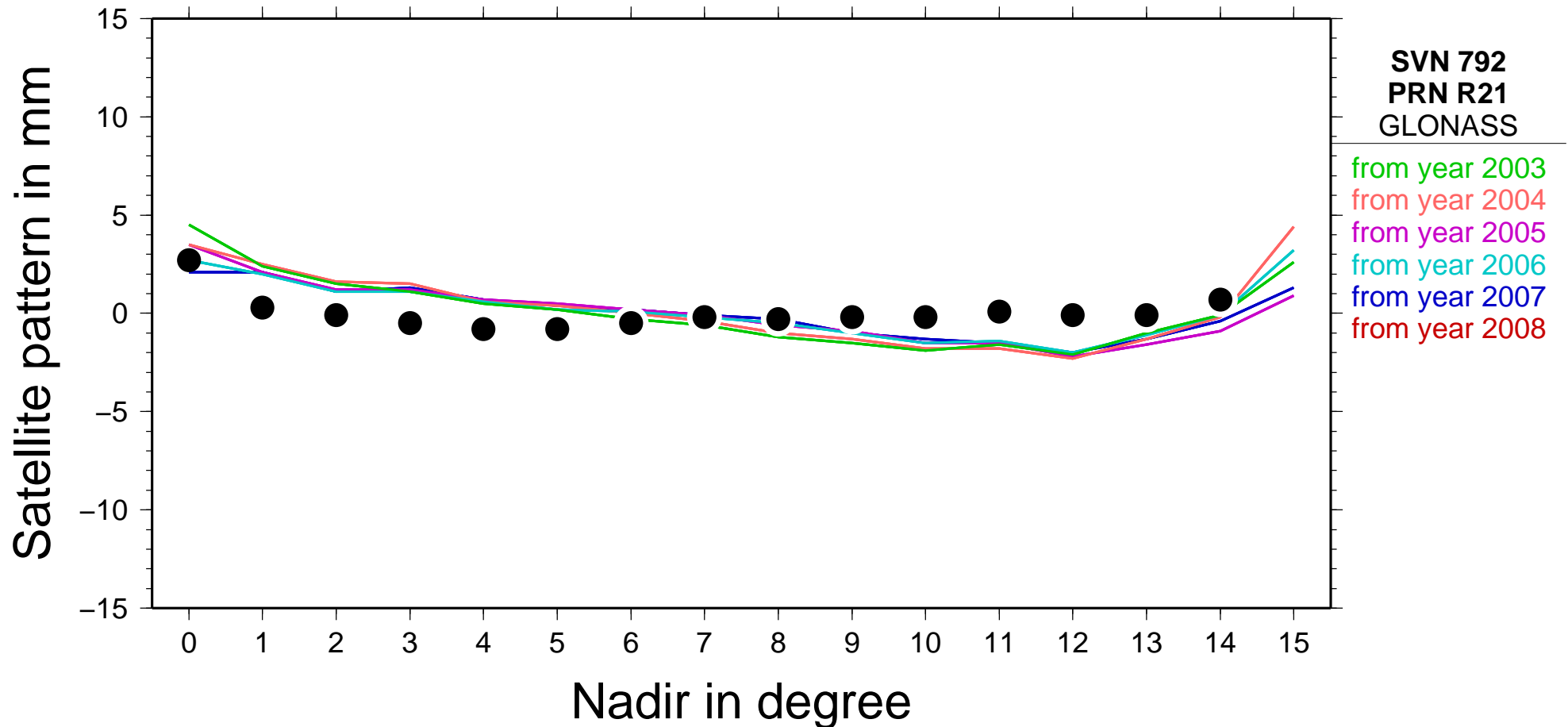
Satellite SVN 60/PRN G23, minimum 90 days



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

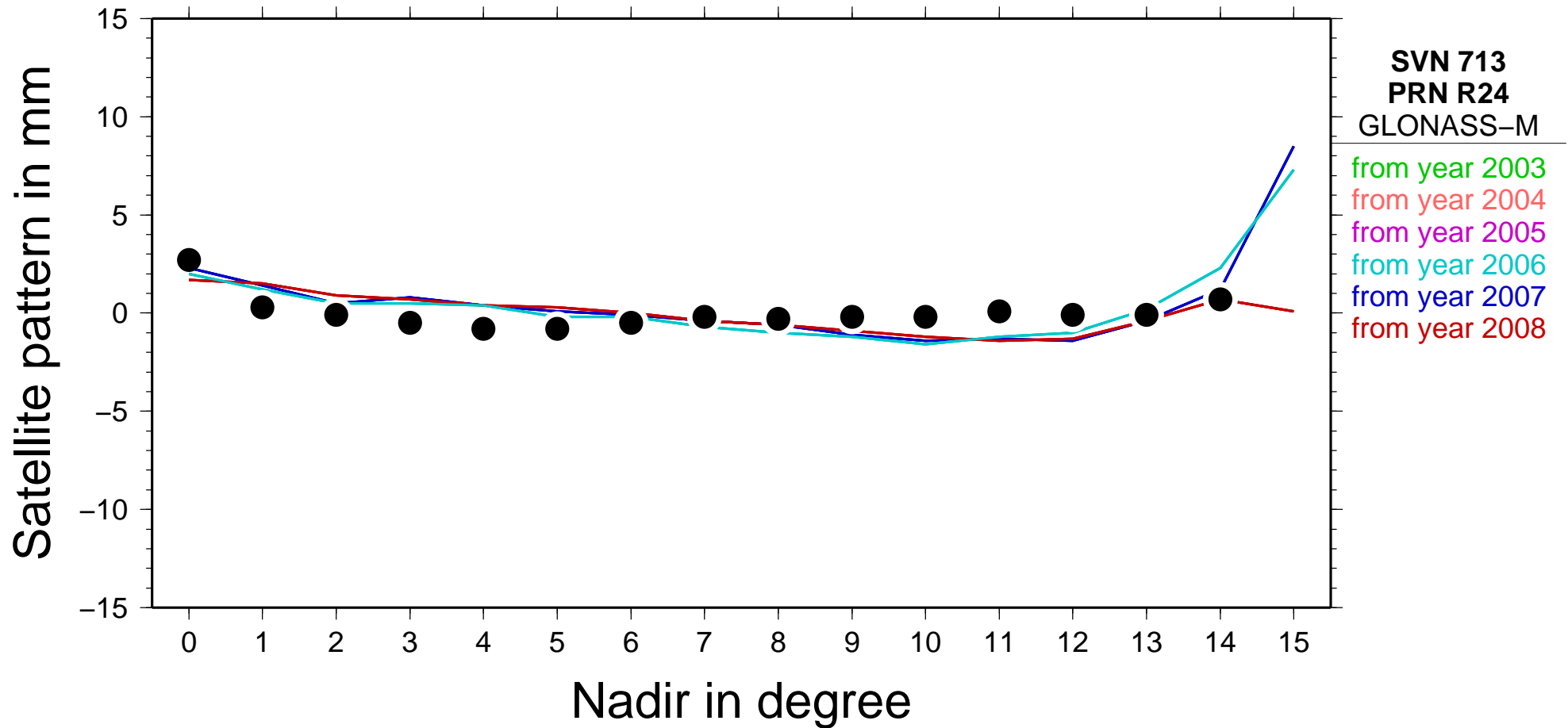
Satellite SVN 792/PRN R21, minimum 90 days



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

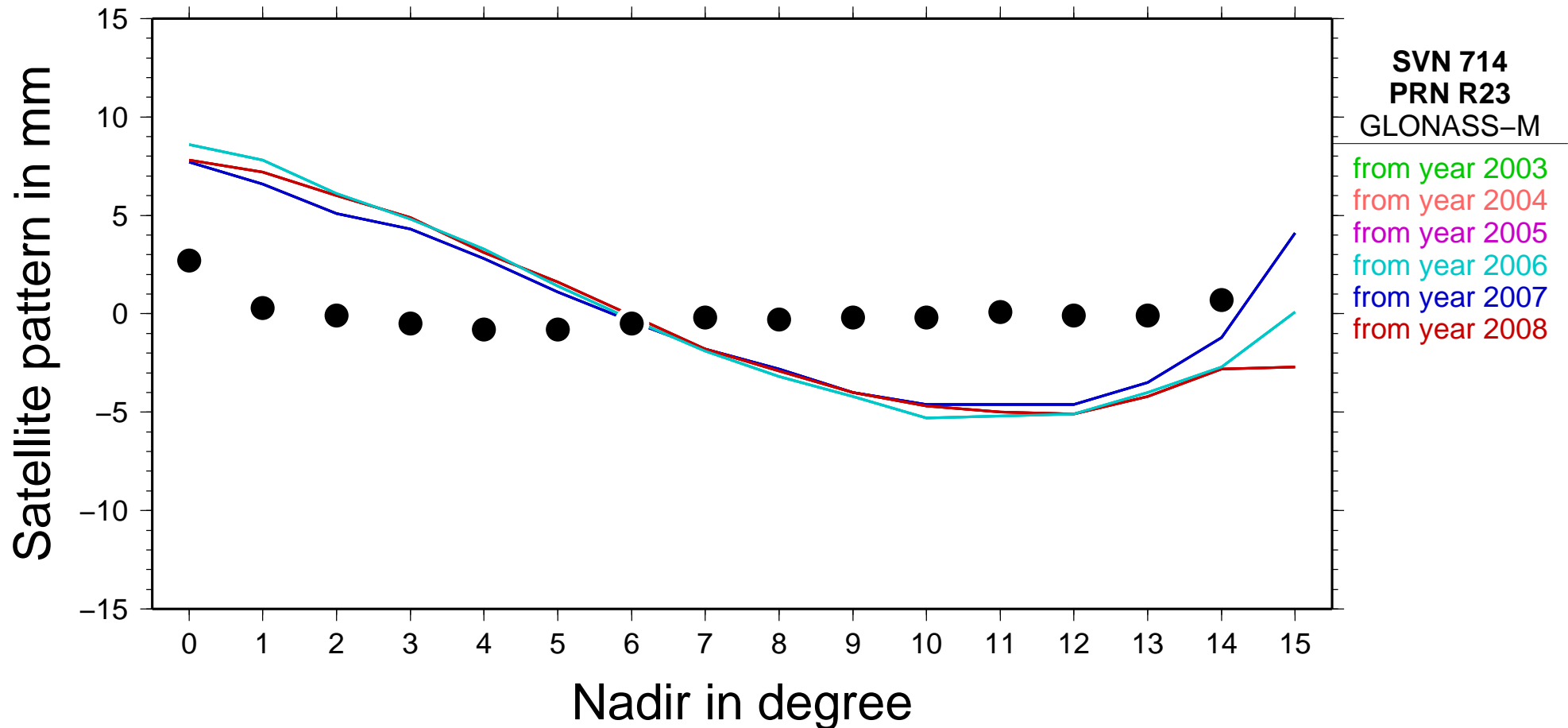
Satellite SVN 713/PRN R24, minimum 90 days



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

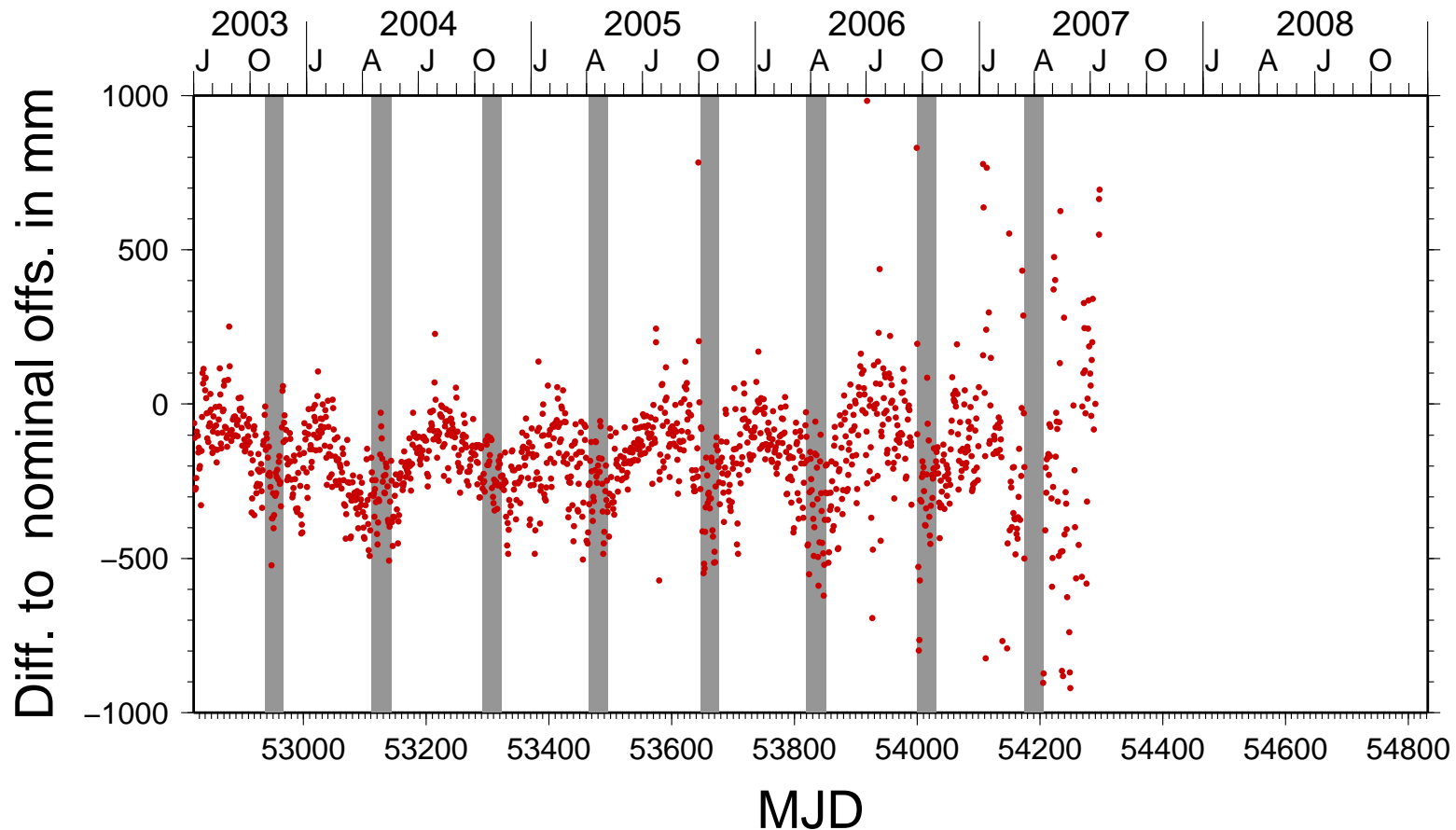
Satellite SVN 714/PRN R23, minimum 90 days



# 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  
2000.9 mm

IGS05.ATX  
1856.1  $\pm$  10.1 mm

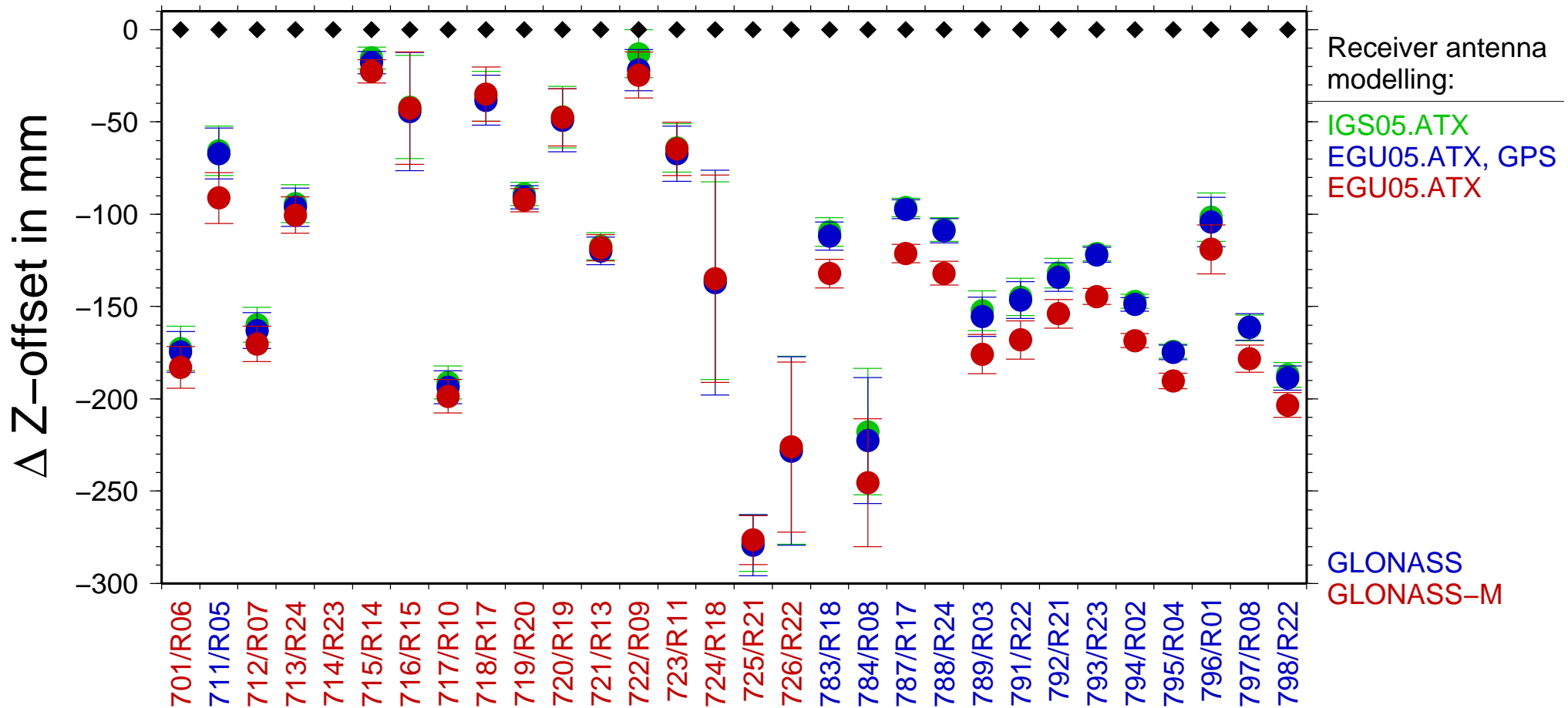
EGU05.ATX, GPS  
1854.4  $\pm$  10.1 mm

EGU05.ATX  
1832.8  $\pm$  10.3 mm

# GNSS satellite antenna offsets

## Mean GLONASS Satellite Antenna Phase Center

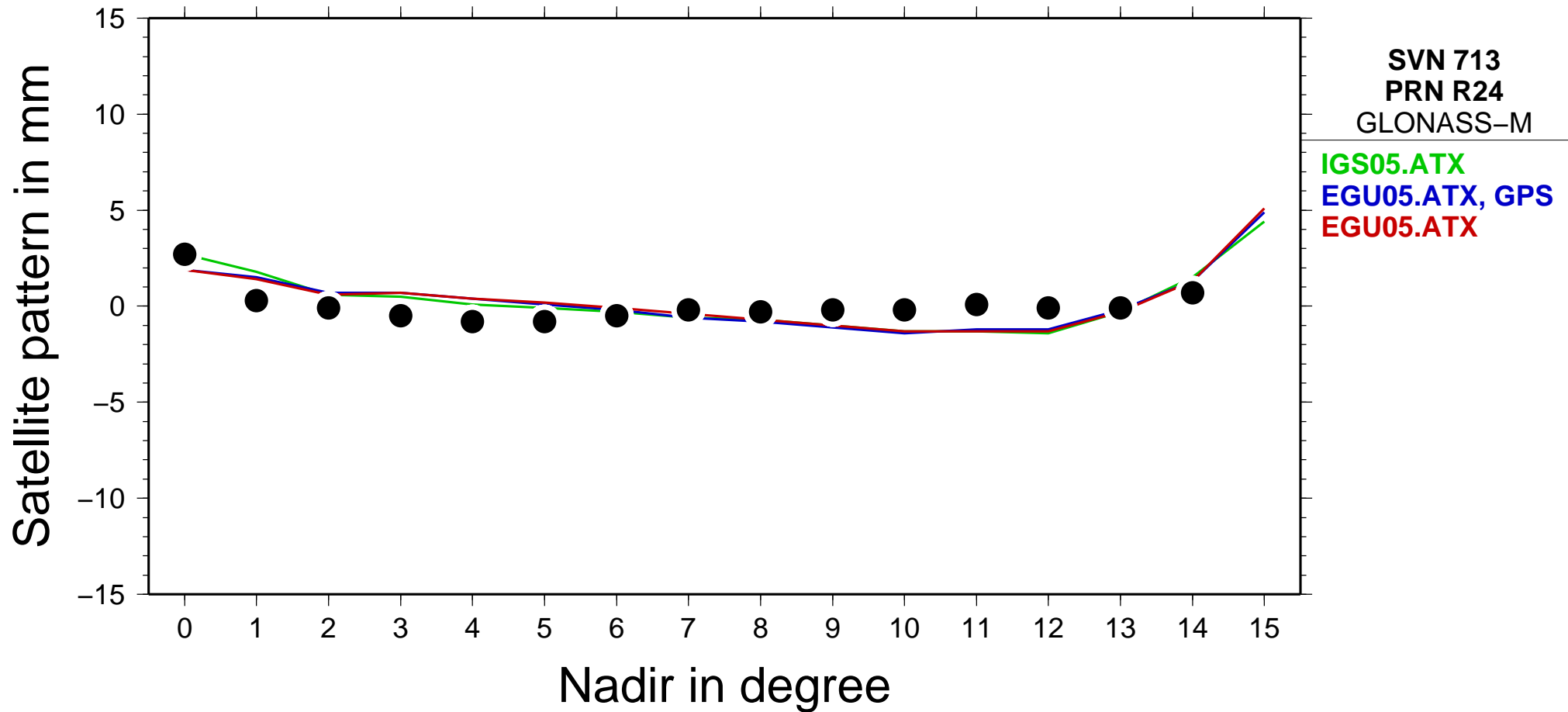
Values of all GPS satellites are fixed to IGS05.ATX



# GNSS satellite antenna pattern

## Nadir-dep. variations of the satellite antenna phase center

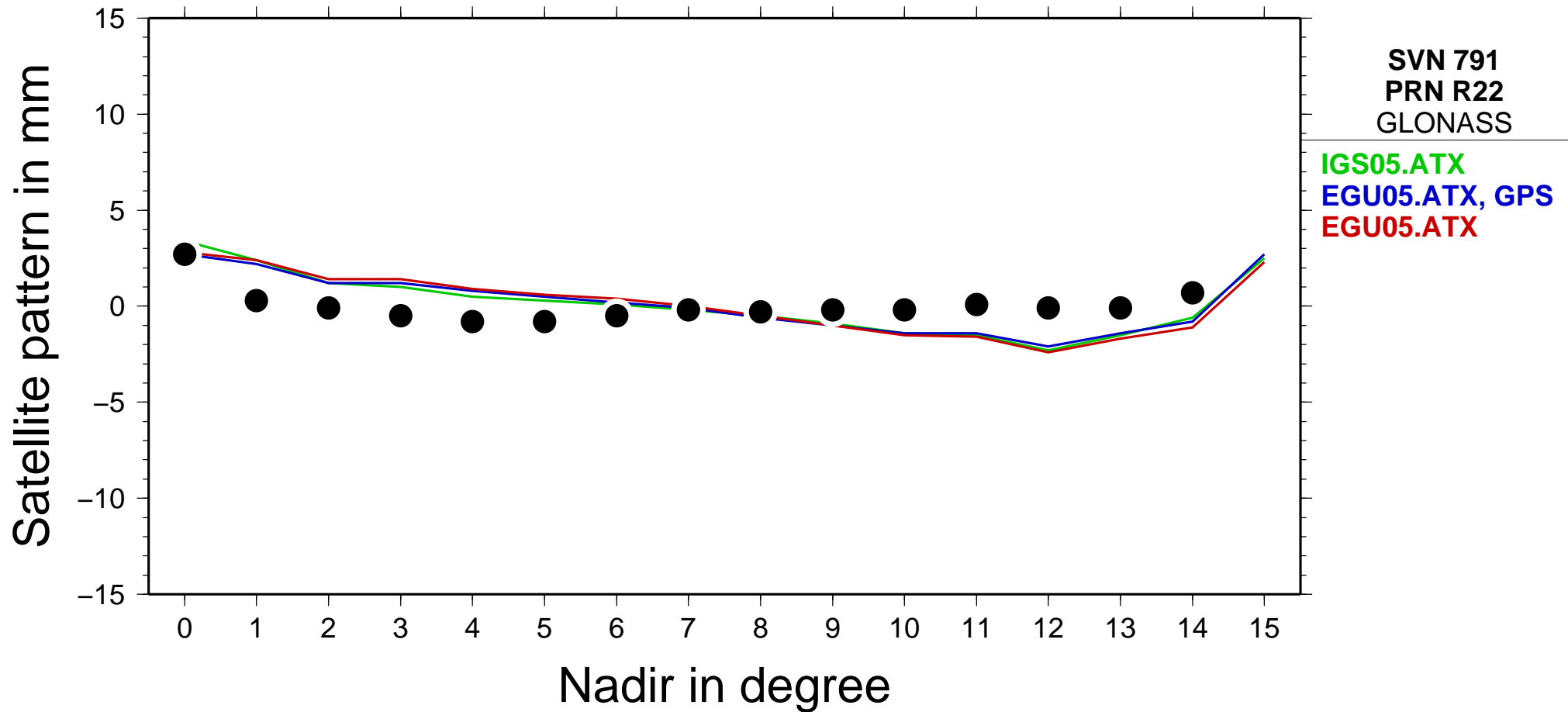
Satellite SVN 713/PRN R24



# 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.