Latest GNSS orbit modelling improvement at CODE

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Outline

Latest GNSS orbit modelling improvement at CODE:

1. Motivation to review the radiation pressure modelling
2. Update of the CODE radiation pressure model
3. Verification of the updated model
4. Summary and Outlook

Motivation

- The radiation pressure modelling at CODE is based on an empirical model from Tim Springer:
  - The a priori model consist of nearly 20 parameters for several resonance periods of the satellite revolution (Springer et al., 1999).
  - On top of this model up to nine parameters may be estimated from the observations (Extended CODE model; Beutler et al., 1994).

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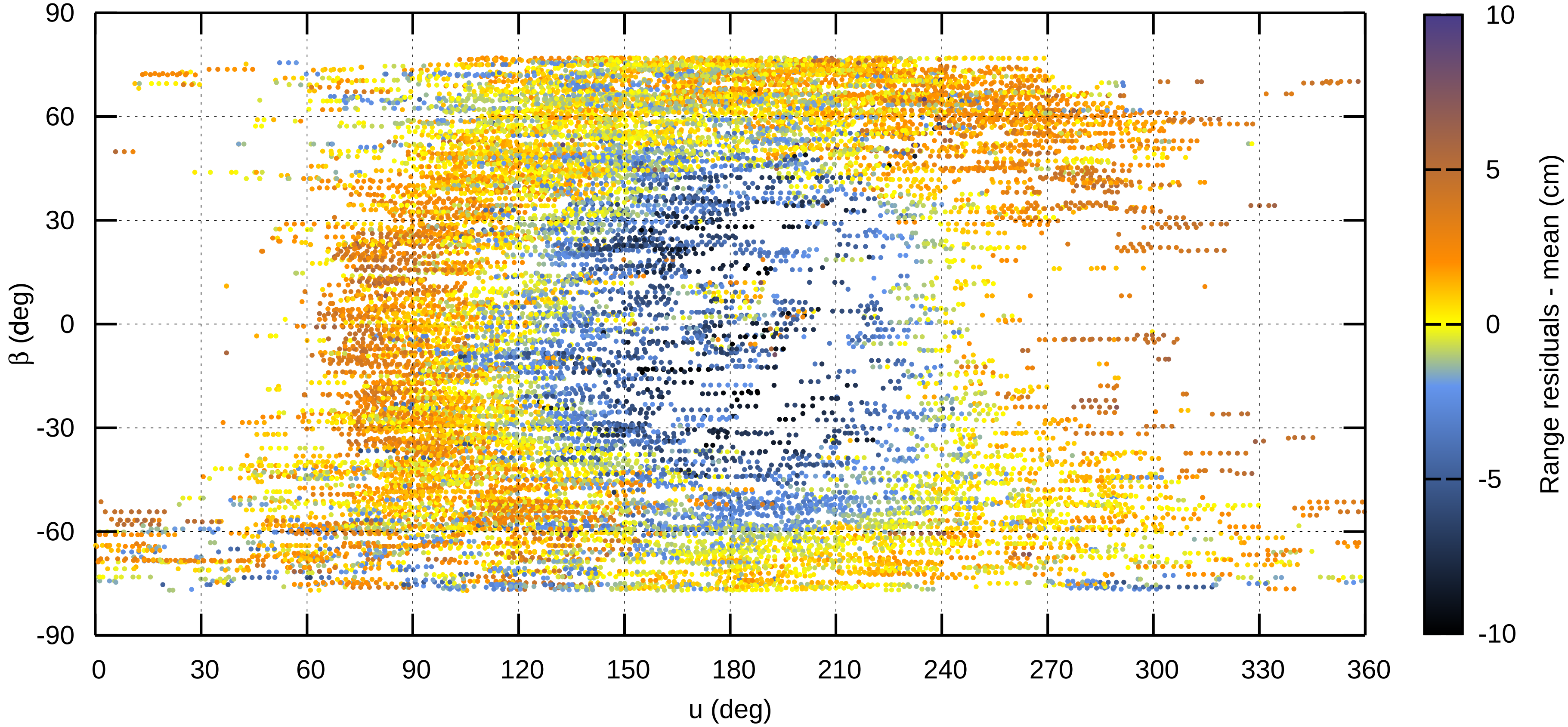
  - On top of this model up to nine parameters may be estimated from the observations (Extended CODE model; Beutler et al., 1994).

- After nearly seven year a review of the model became necessary
  - to verify the model parameters for the GPS satellites,
  - to estimate model parameters for launched GPS satellites (since that time), and
  - to obtain a first set of model parameters for GLONASS satellites.

Motivation

SLR residuals in cm to CODE final orbits (G05 and G06)



Urschl et al., 2007

Updated CODE Radiation Pressure Model

- Parameters of the updated CODE radiation pressure model are estimated by
  - moving seven-day fits of CODE final orbits
  - time interval: 2000 – 2006
  - some of the parameters are block–specific others individual for each satellite

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- A priori radiation pressure models for comparison:
  - NONE: no a priori model
  - ROCK: ROCK model (Fliegel and Gallini, 1996)
  - CODE'99: old CODE model as published by Spinger, 1999
  - CODE'07: updated CODE model

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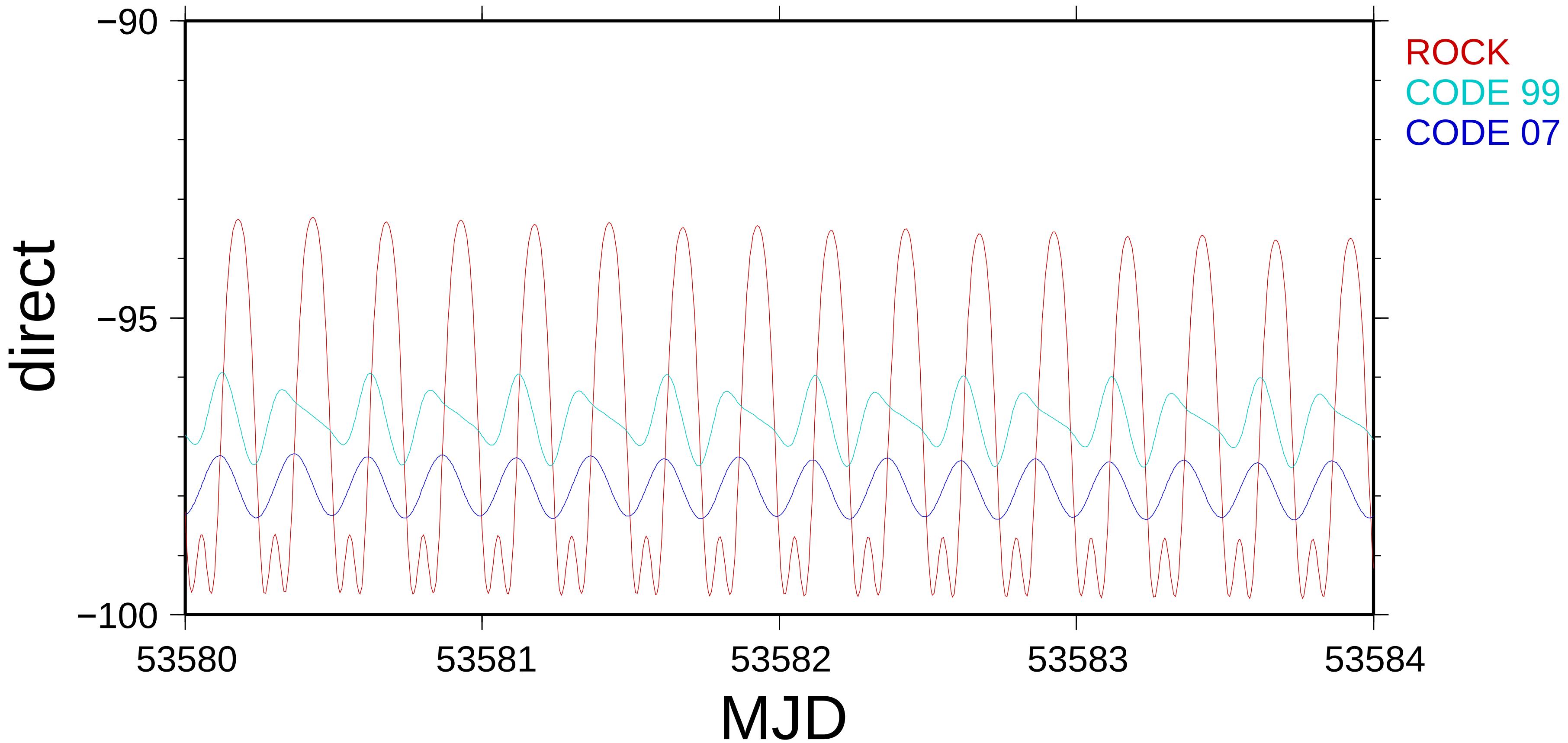
- The full orbit estimation was performed
  - based on the different a priori models
  - estimated RPR parameters: three constant and once per revolution for one component.

Updated CODE Radiation Pressure Model

Comparison between the a priori radiation pressure models

satellite→Sun component



Satellite G15 (Block II)

unit: $\mathrm{m/s}^2 \cdot 10^{-9}$

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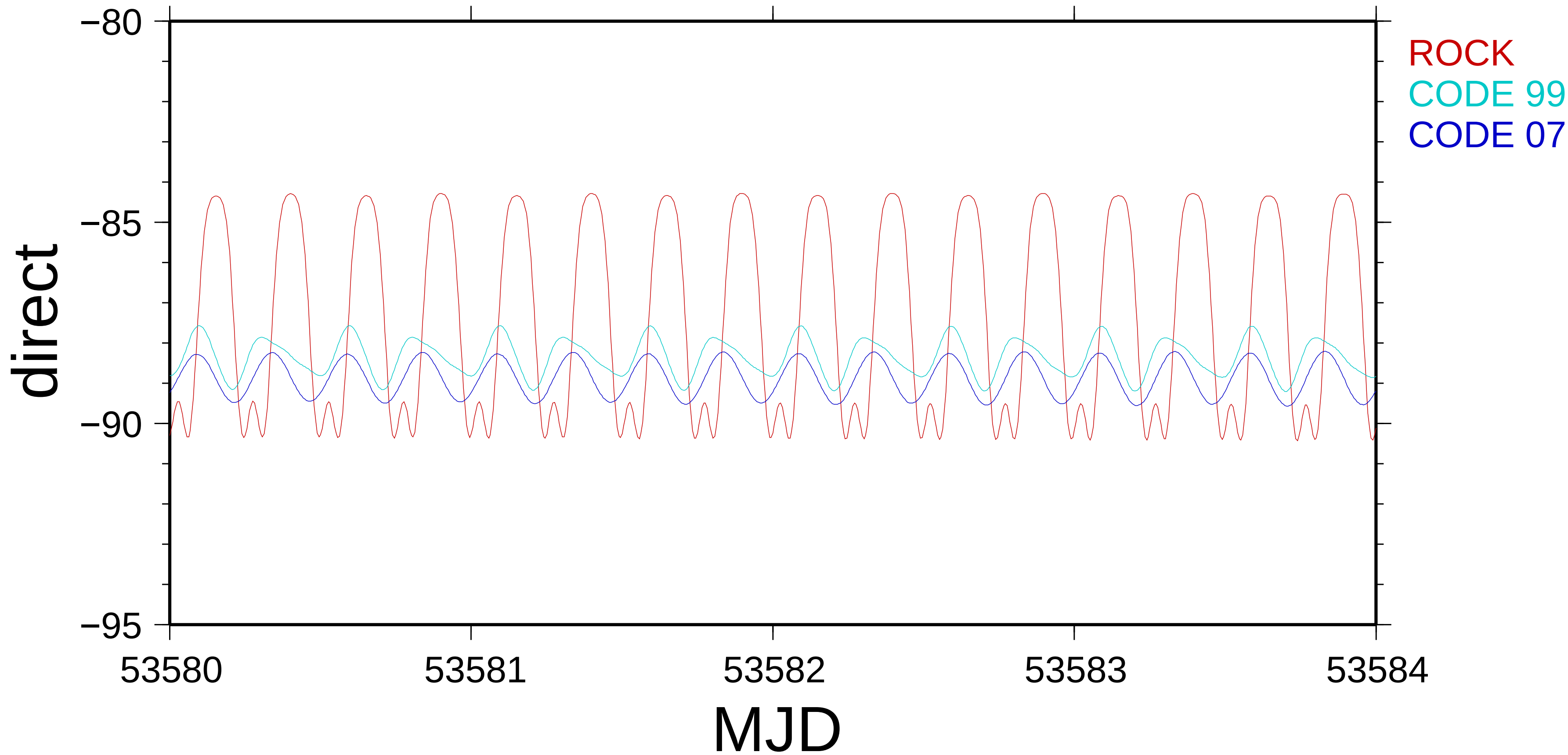


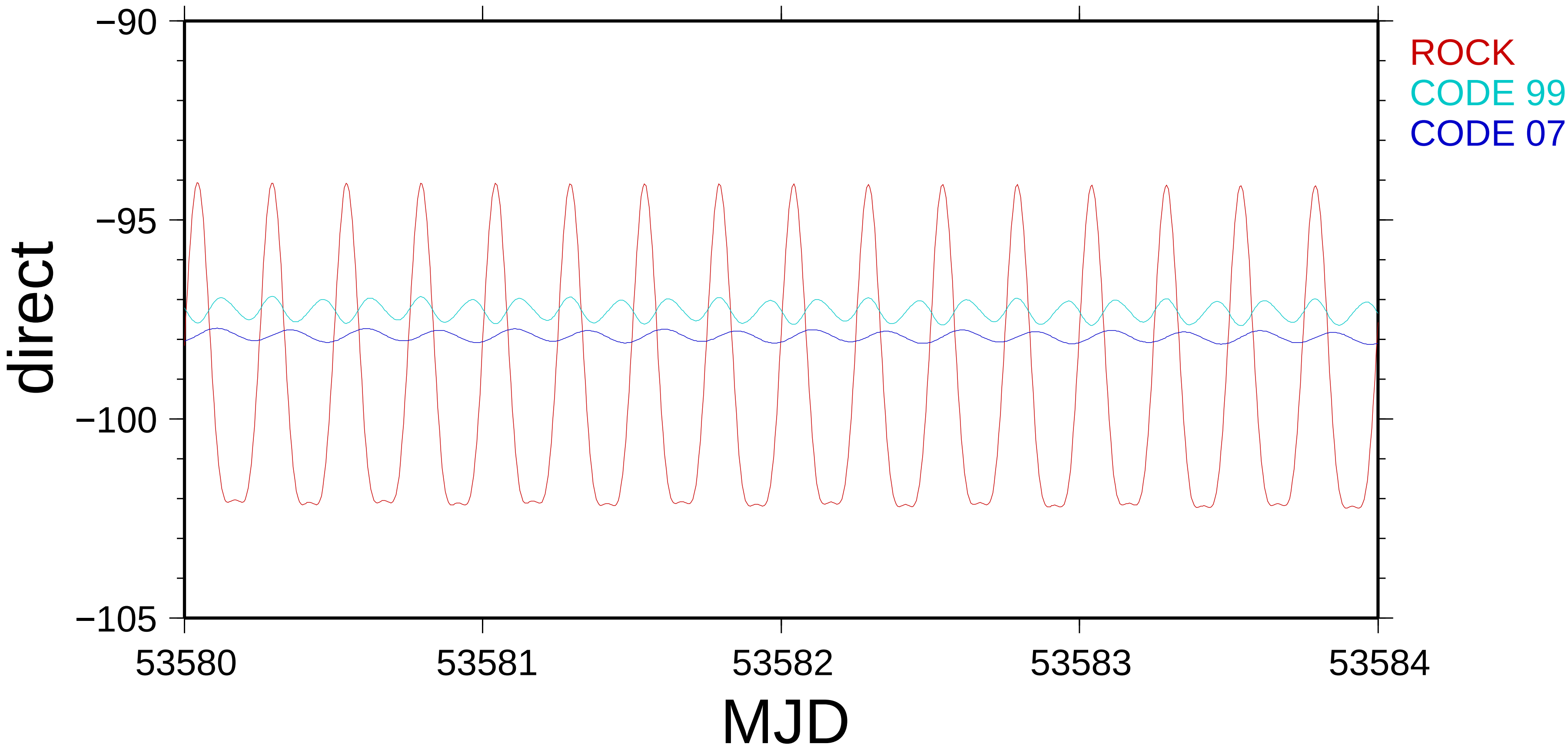
Satellite G05 (Block IIA)

unit: m/s$^2 \cdot 10^{-9}$

Updated CODE Radiation Pressure Model

Comparison between the a priori radiation pressure models

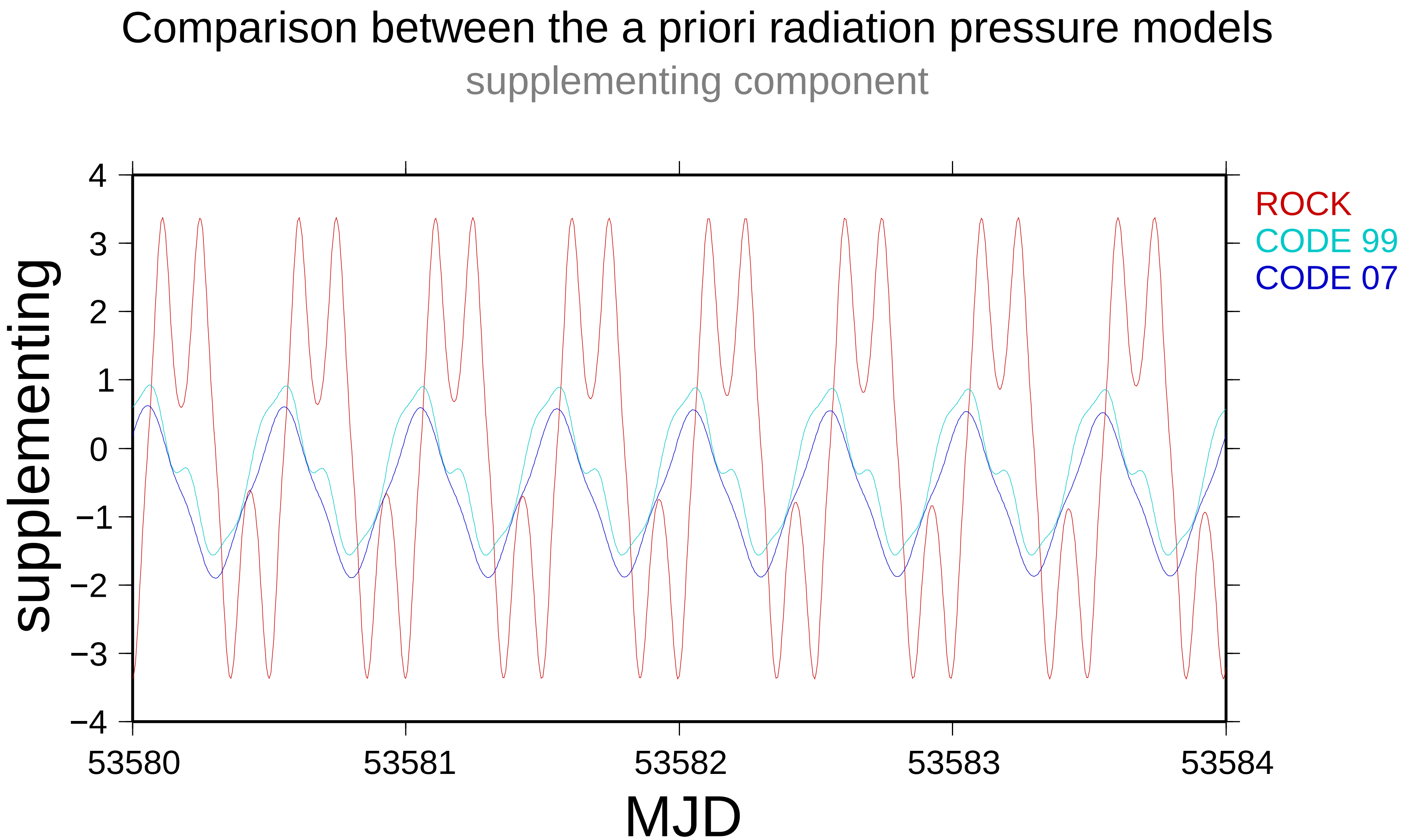
satellite→Sun component



Satellite G13 (Block IIR–A)

unit: m/s$^2 \cdot 10^{-9}$

Updated CODE Radiation Pressure Model



Satellite G15 (Block II)

unit: $m/s^2 \cdot 10^{-9}$

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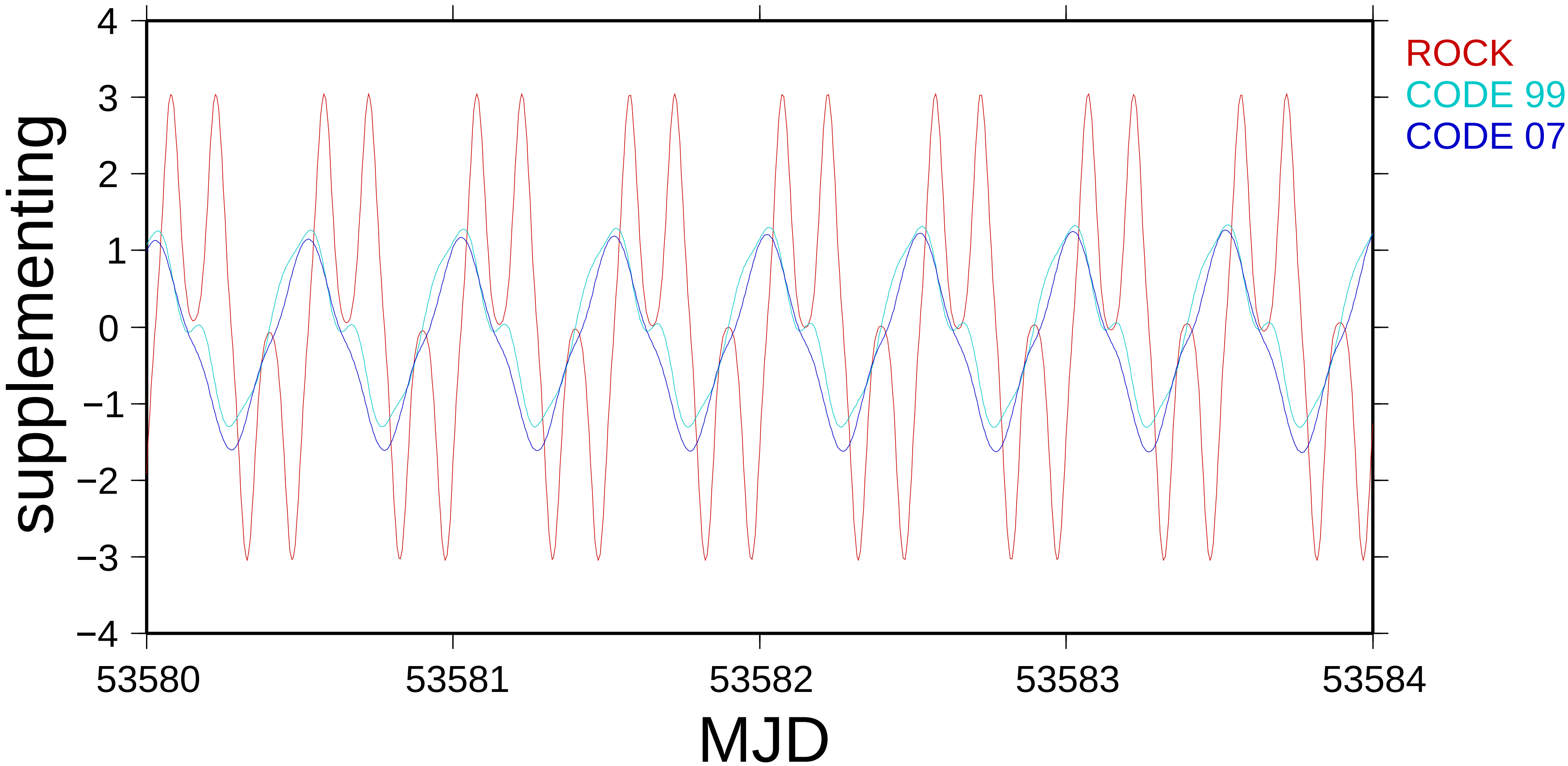
Updated CODE Radiation Pressure Model

Comparison between the a priori radiation pressure models

supplementing component



Satellite G05 (Block IIA)

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Updated CODE Radiation Pressure Model

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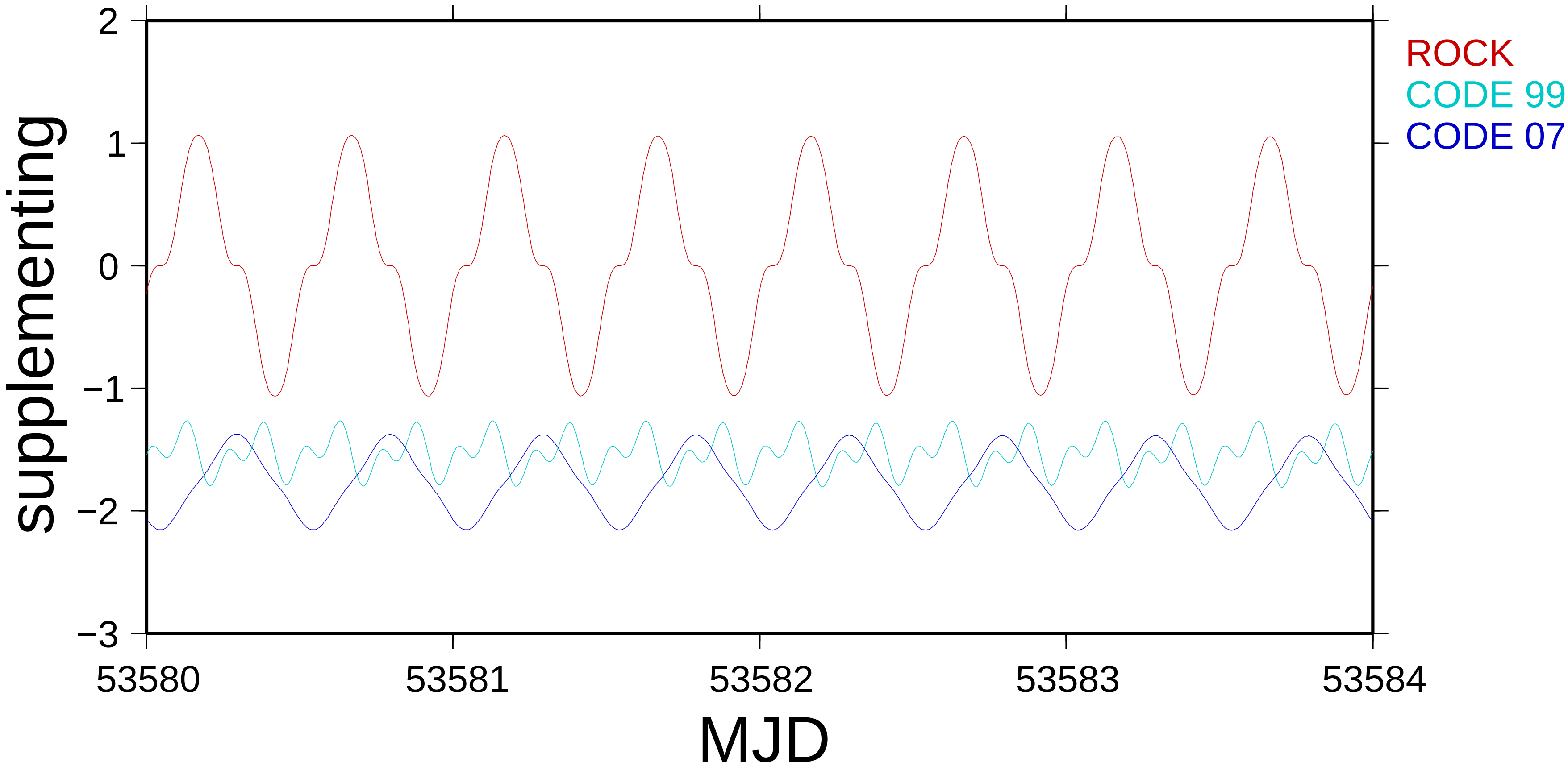

Satellite G13 (Block IIR–A)

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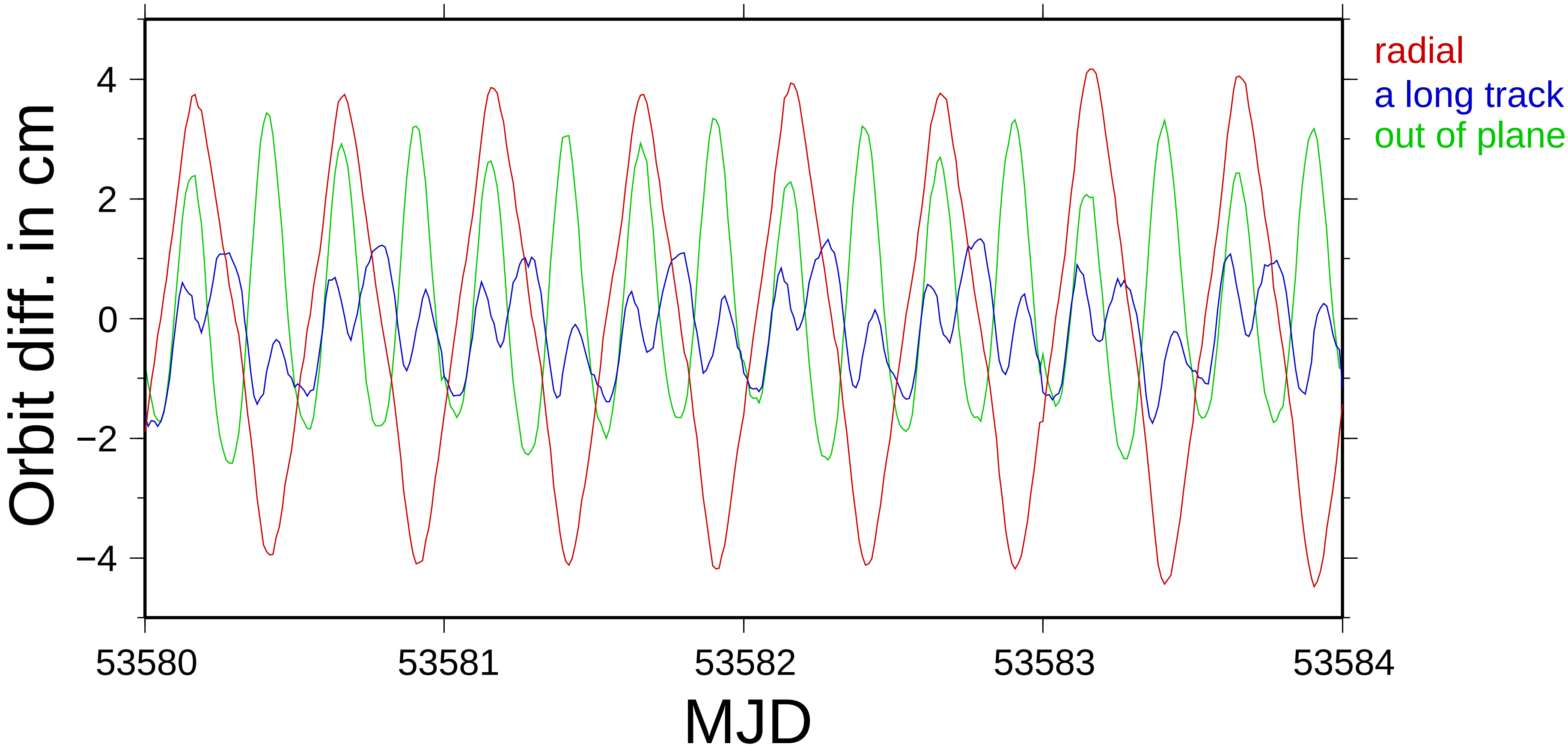
Differences in the estimated orbits using different a priori RPR models

a priori RPR model: ROCK – CODE'07



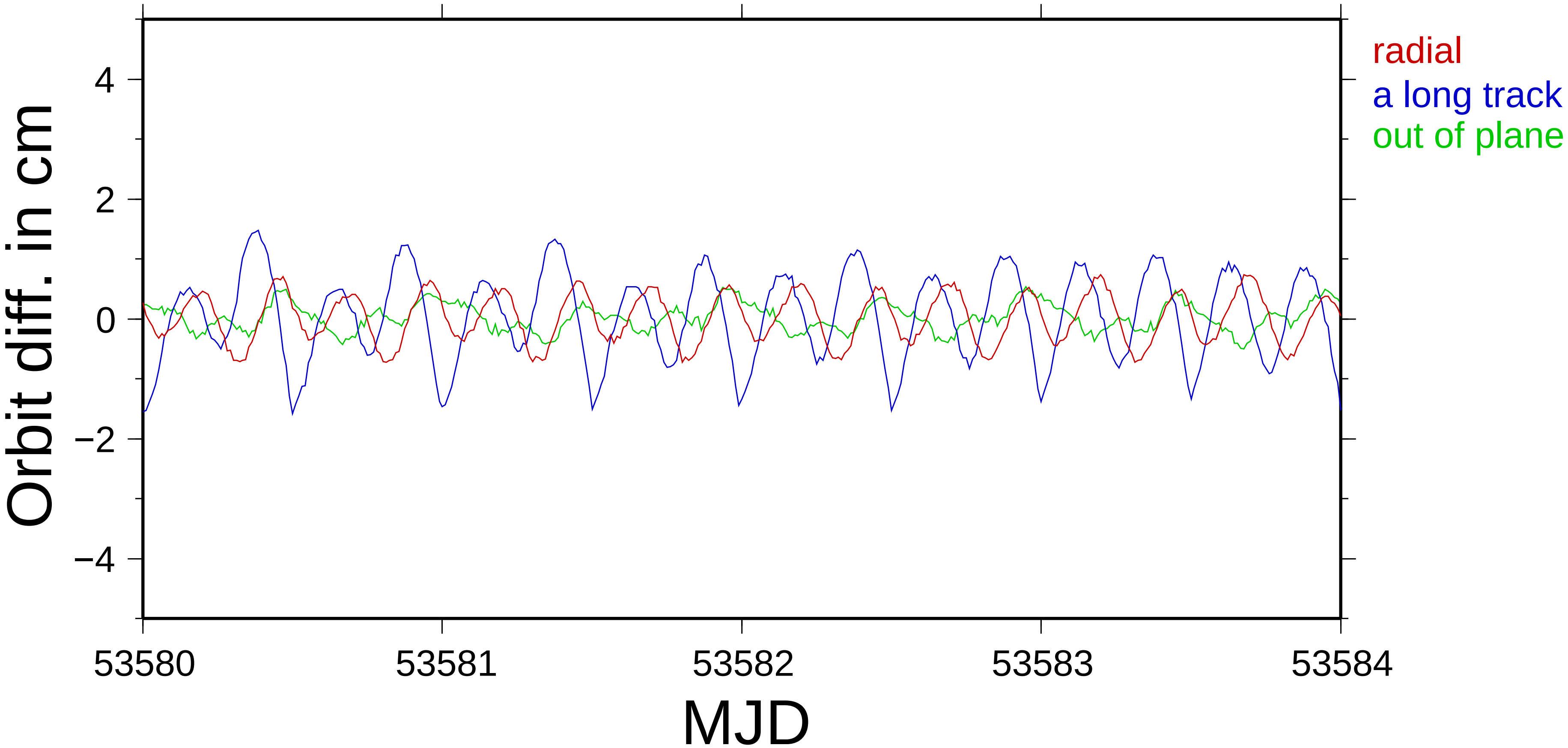
Satellite G05 (Block IIA)

RMS: 1.9 cm

Updated CODE Radiation Pressure Model

Differences in the estimated orbits using different a priori RPR models

a priori RPR model: CODE'99 – CODE'07



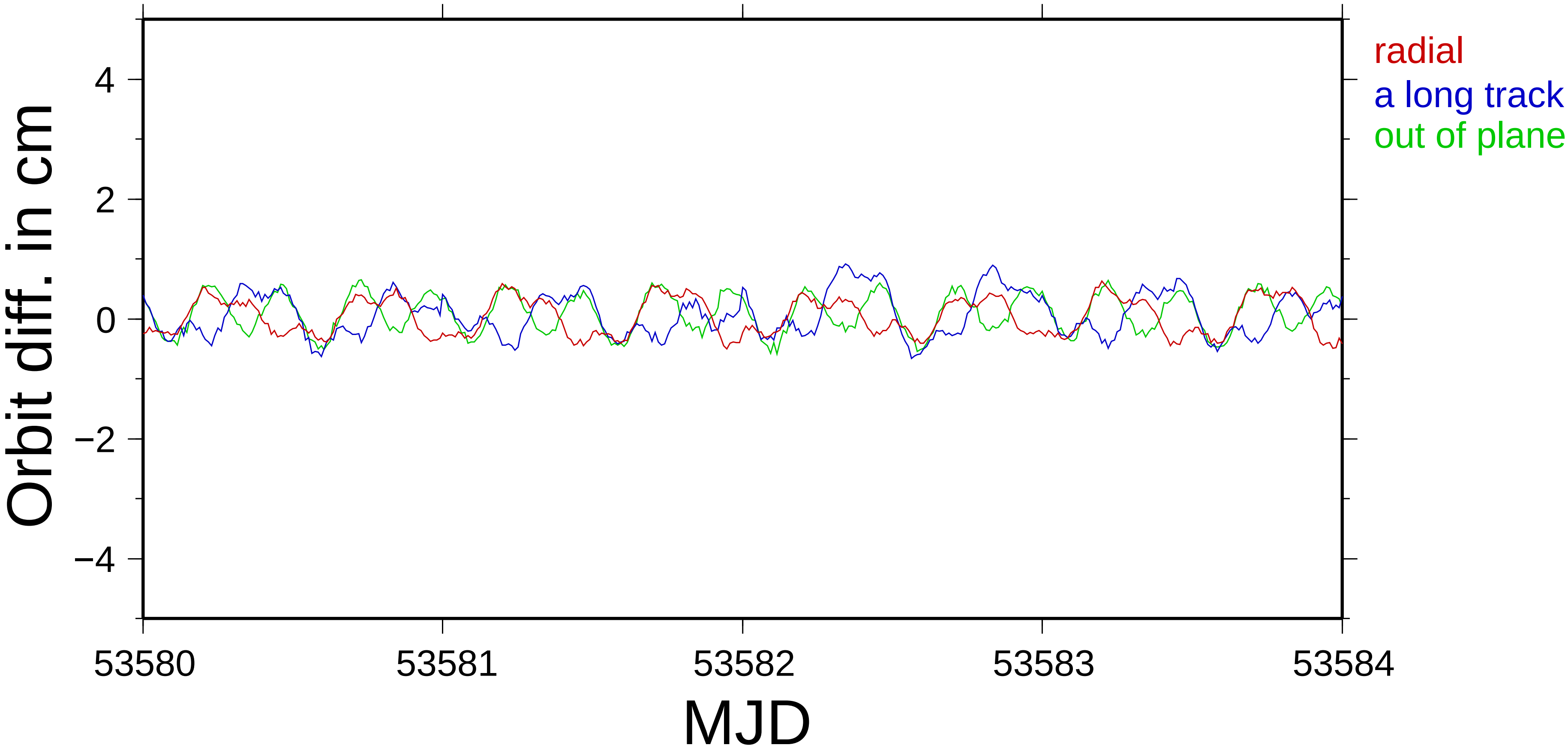
Satellite G05 (Block IIA)

RMS: 0.5 cm

Updated CODE Radiation Pressure Model

Differences in the estimated orbits using different a priori RPR models

a priori RPR model: NONE – CODE'07



Satellite G05 (Block IIA)

RMS: 0.3 cm

Updated CODE Radiation Pressure Model

Differences in the estimated orbits using different a priori RPR models

RMS of the differences w.r.t. the CODE’07 a priori model over 10 days.

PRN	ROCK	CODE’99	NONE	PRN	ROCK	CODE’99	NONE
G15	1.9	0.5	0.4				
G01	1.8	0.2	0.2	G10	1.7	0.2	0.4
G03	0.8	0.3	0.2	G13	1.9	0.4	0.3
G04	1.4	0.3	0.3	G24	1.6	0.4	0.3
G05	1.9	0.5	0.4	G25	2.2	0.2	0.4
G06	0.4	0.3	0.2	G26	1.6	0.3	0.3
G07	0.6	0.3	0.2	G27	2.3	0.3	0.5
G08	2.3	0.3	0.5	G29	1.6	0.3	0.3
G09	1.9	0.3	0.6	G30	1.9	0.4	0.3
G13	2.4	0.4	0.3				

unit: cm

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Verification of Radiation Pressure Models

- A long–term prediction over 15 days is used to verify the radiation pressure models.

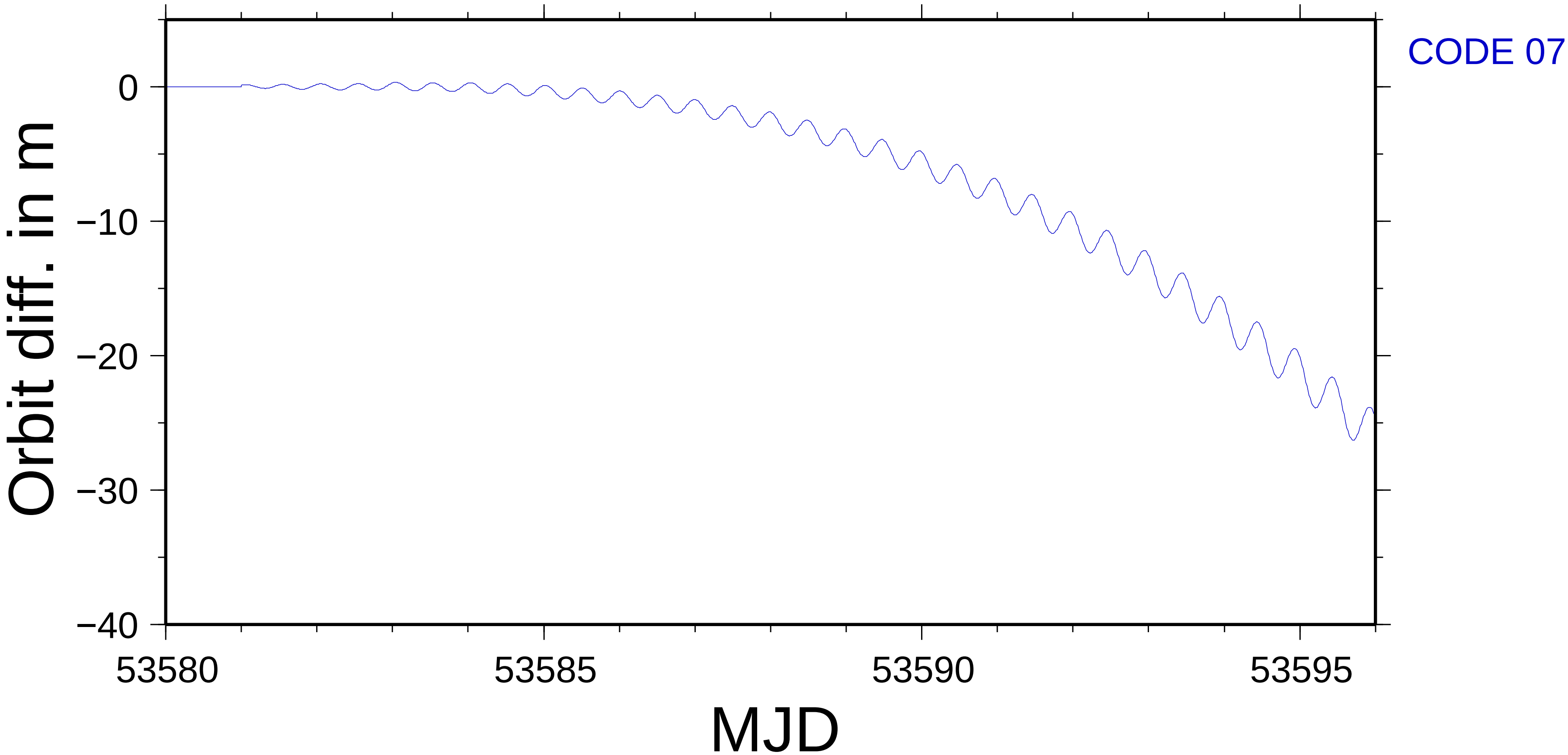
- Rules for the orbit prediction:
  - Integration over three days of the estimated orbits
  - Apart from the six initial osculating elements only the direct radiation pressure component is estimated. All other components are only taken from the models.

- The predicted orbits are compared with the estimated orbit for the corresponding day.

- The experiment was carried out for three months at the end of year 2005.

Verification of Radiation Pressure Models

Differences in the estimated and predicted orbits
using different a priori RPR models



Satellite G27 (Block IIA)

Verification of Radiation Pressure Models

Differences in the estimated and predicted orbits
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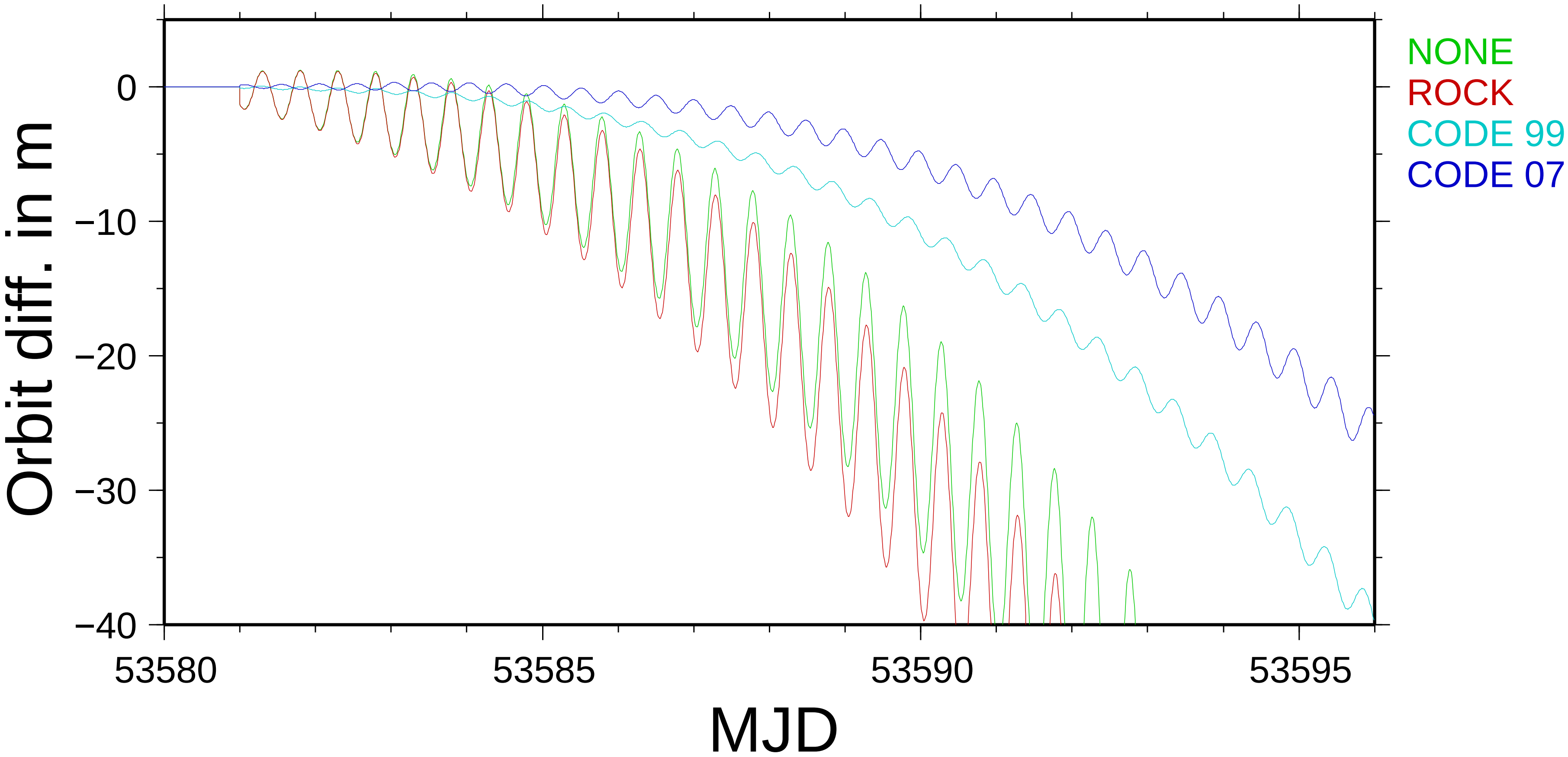

Satellite G27 (Block IIA)

Verification of Radiation Pressure Models

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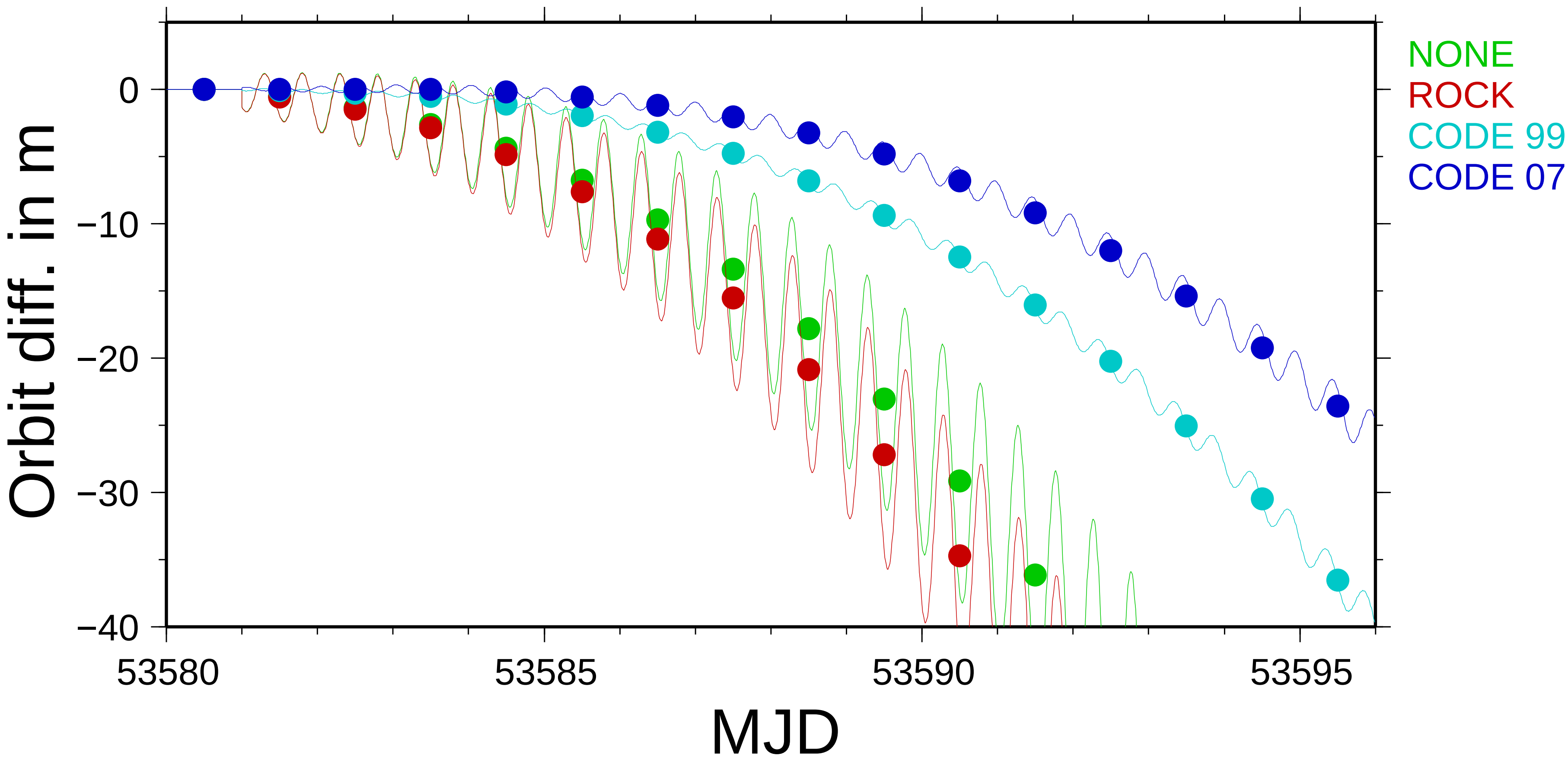

Satellite G27 (Block IIA)

Verification of Radiation Pressure Models

Differences in the estimated and predicted orbits
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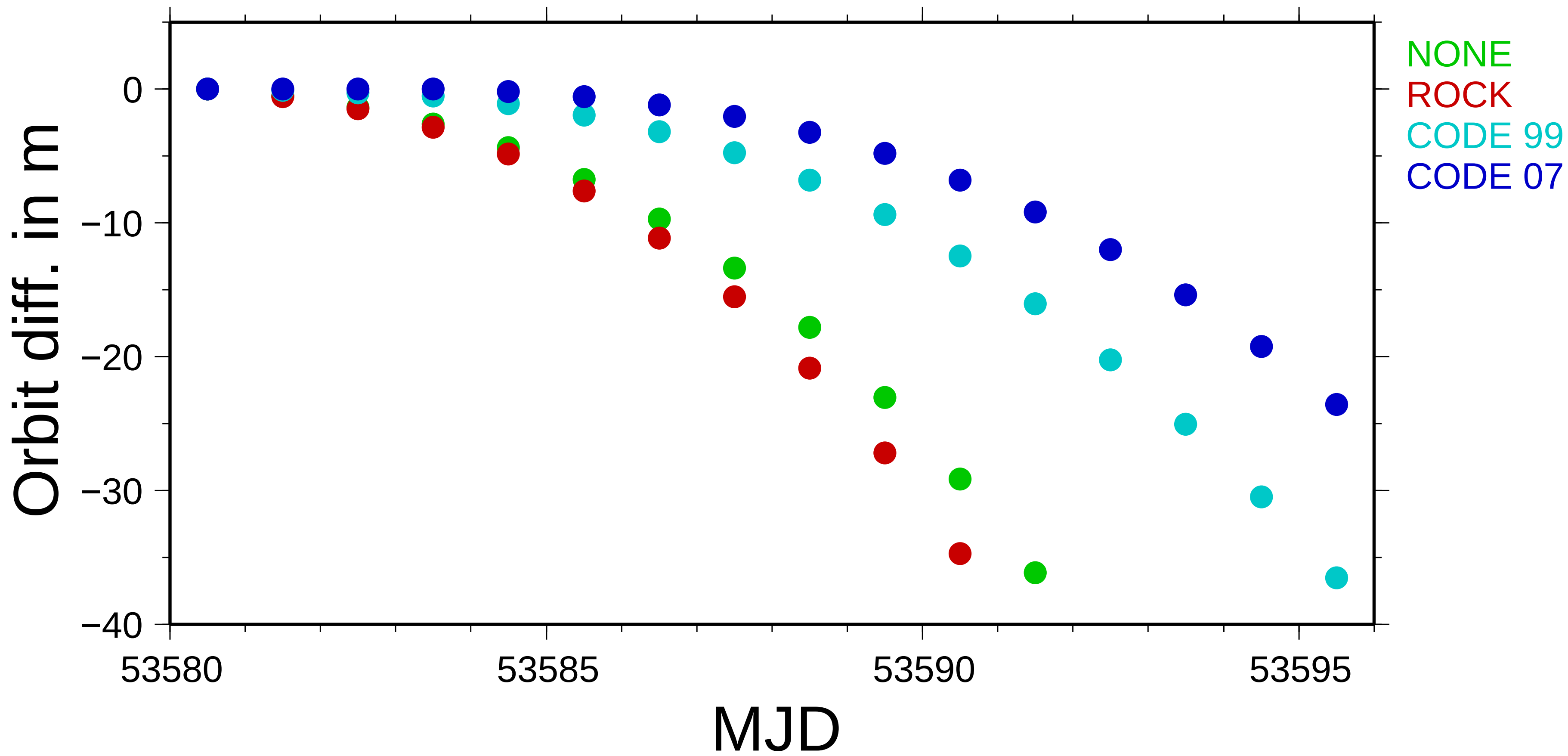
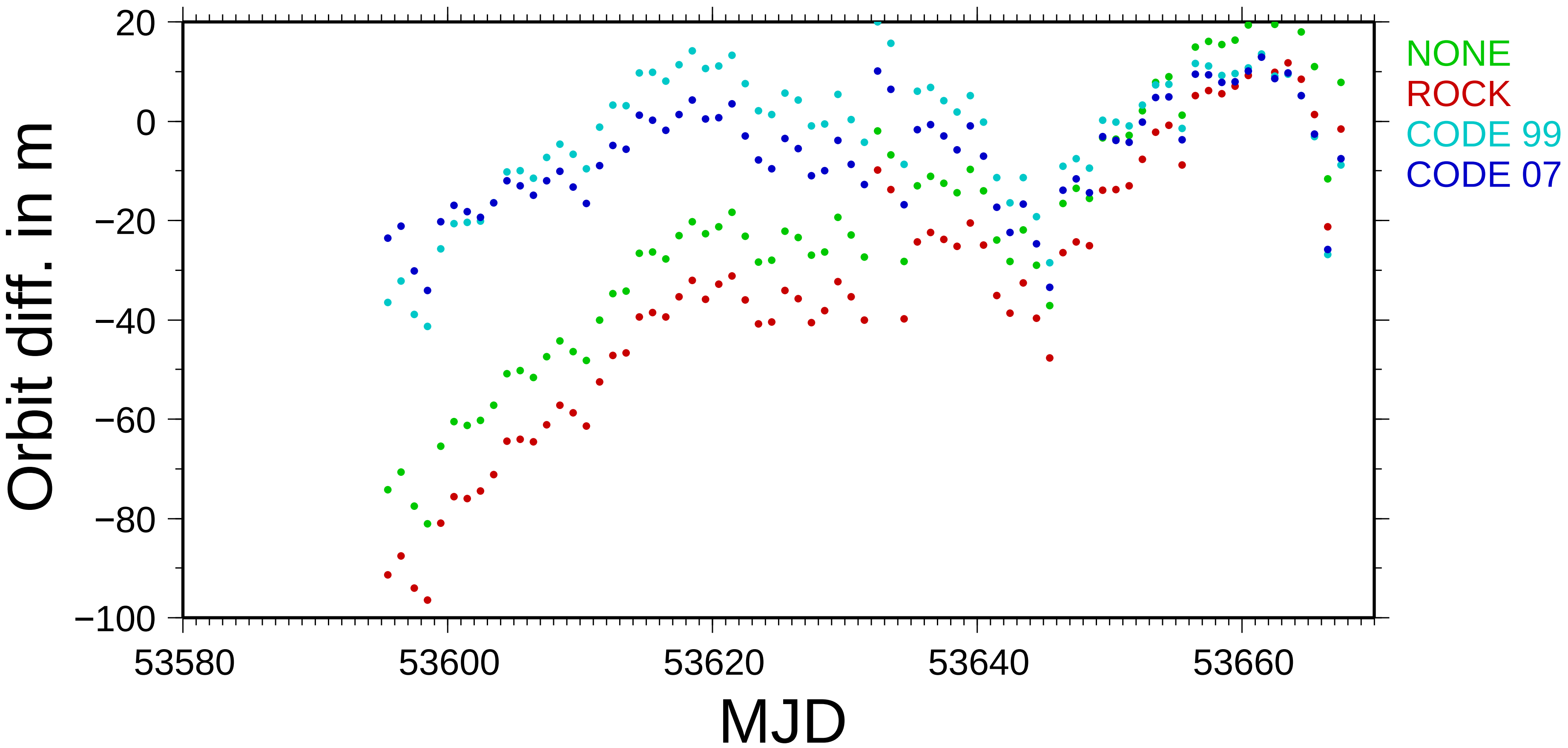


Satellite G27 (Block IIA)

Verification of Radiation Pressure Models

Differences in the estimated and predicted (15 days) orbits
using different a priori RPR models



Satellite G27 (Block IIA)

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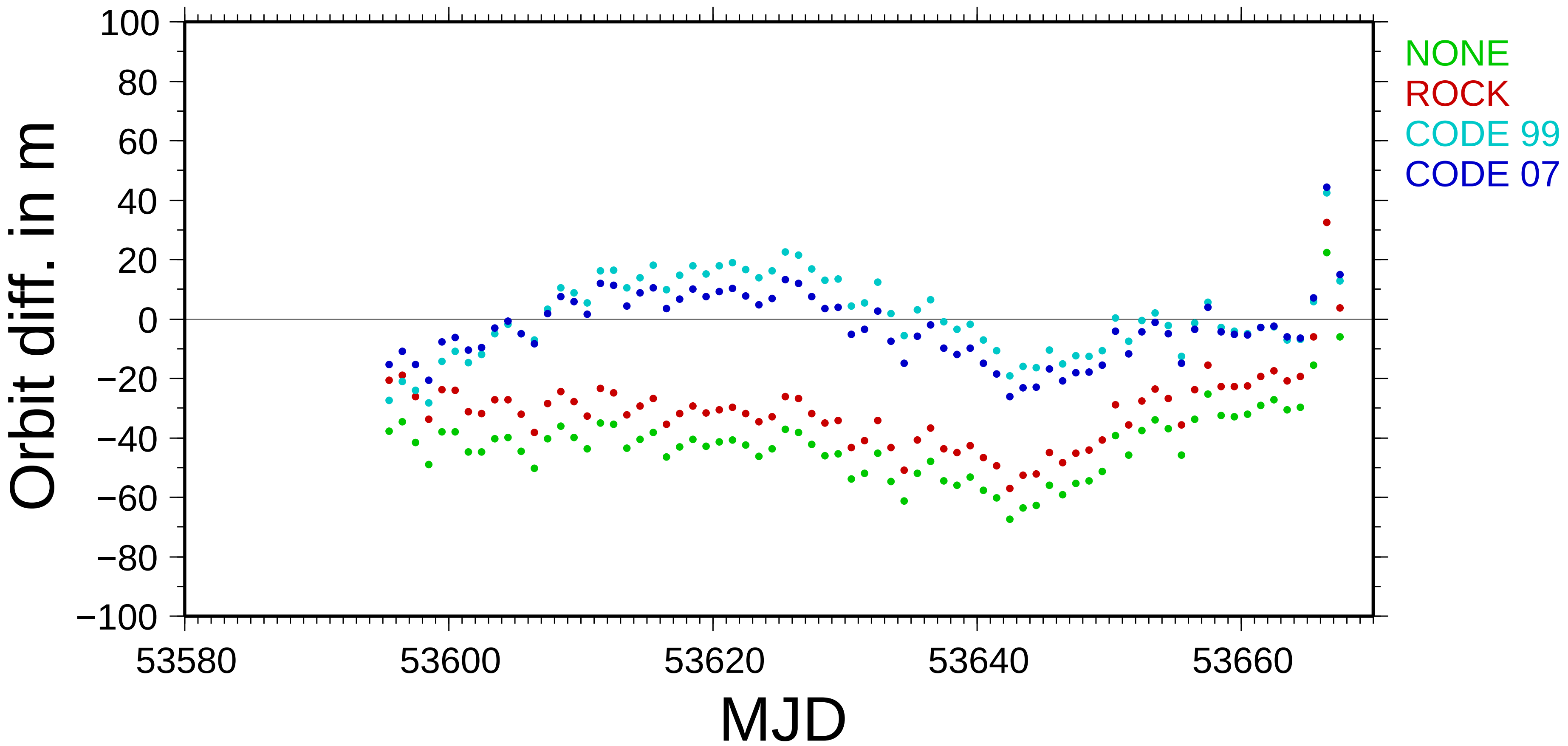

Satellite G09 (Block IIA)

Verification of Radiation Pressure Models

Differences in the estimated and predicted (15 days) orbits
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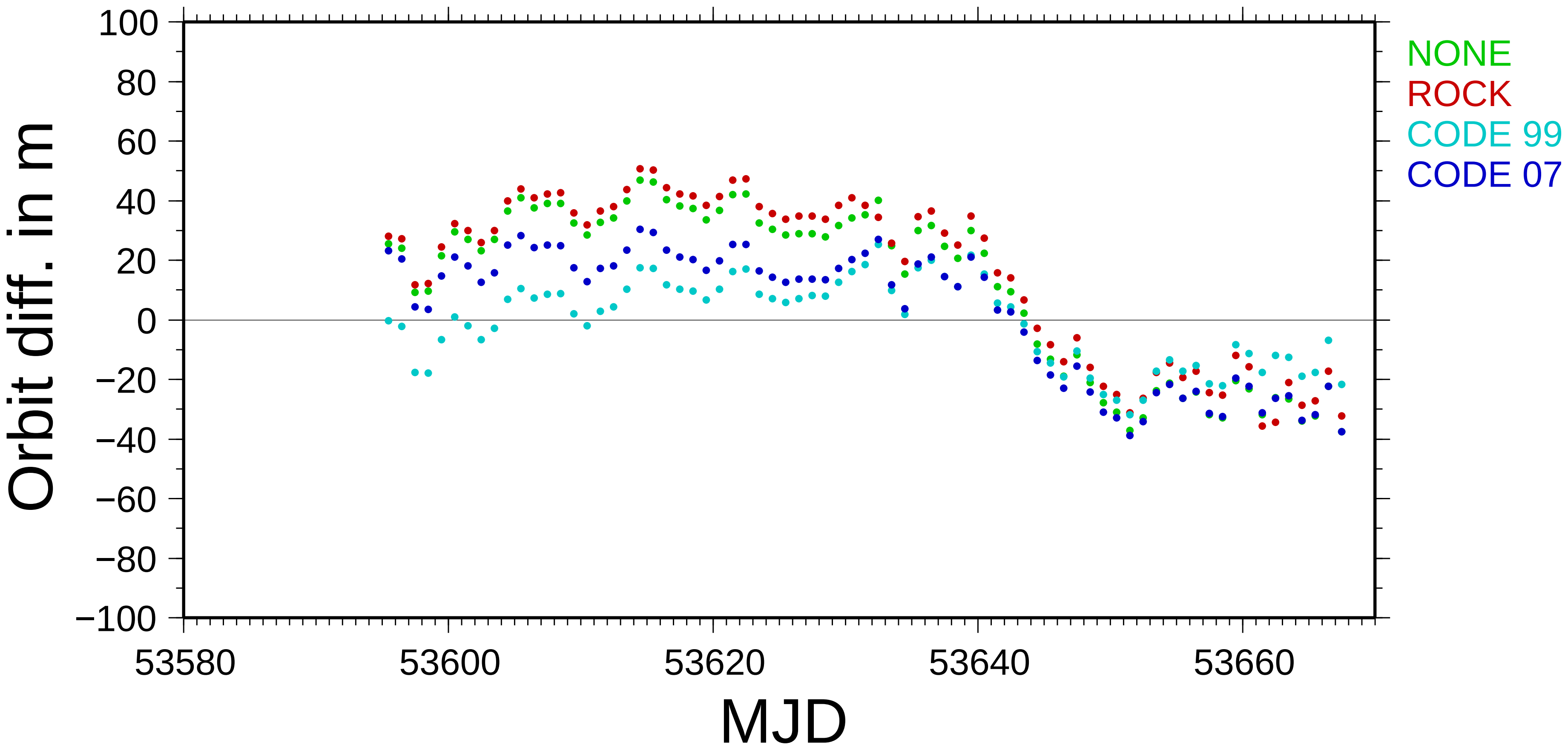

Satellite G24 (Block IIA)

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Verification of Radiation Pressure Models

Differences in the estimated and predicted (15 days) orbits
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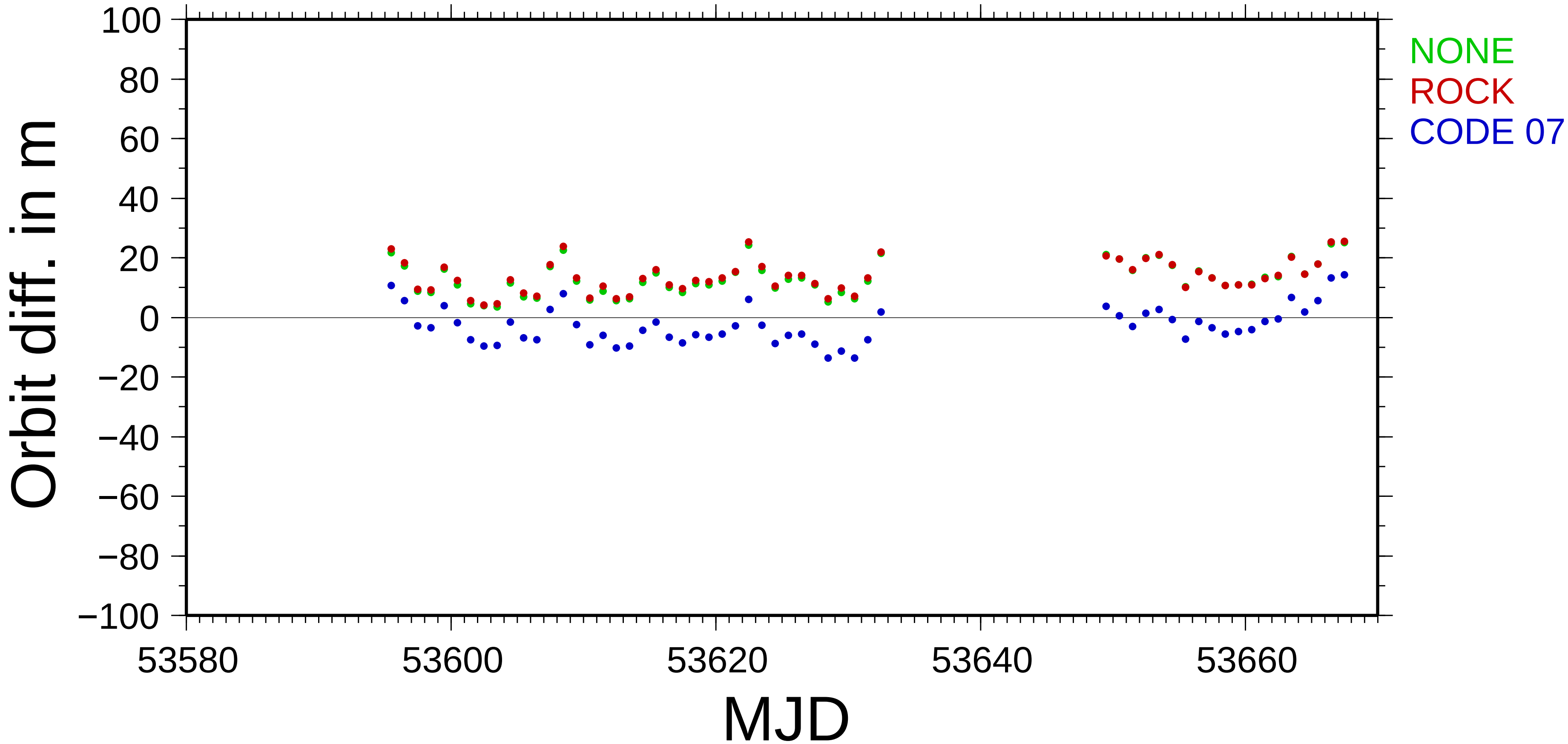
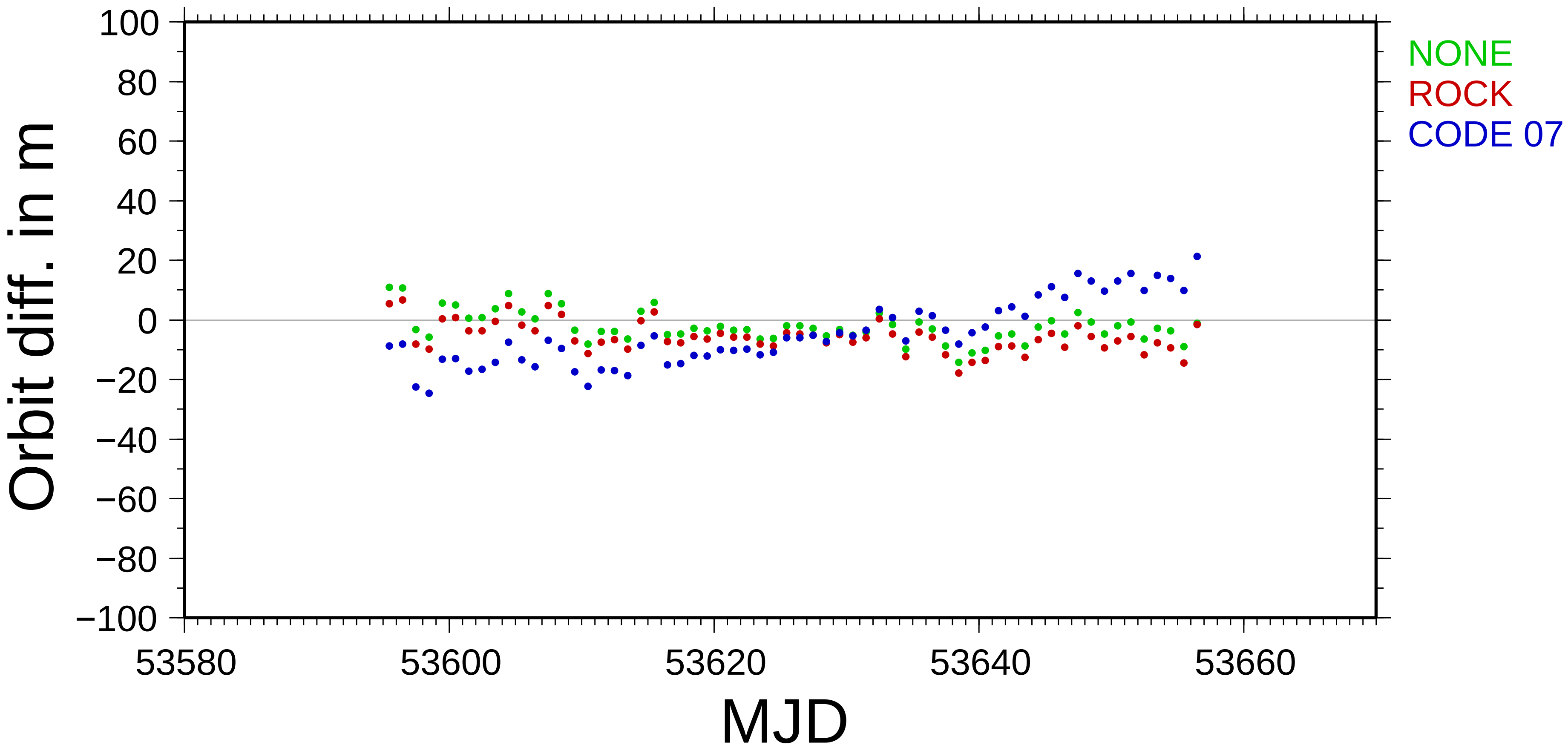


Satellite G14 (Block IIR–A)

Verification of Radiation Pressure Models

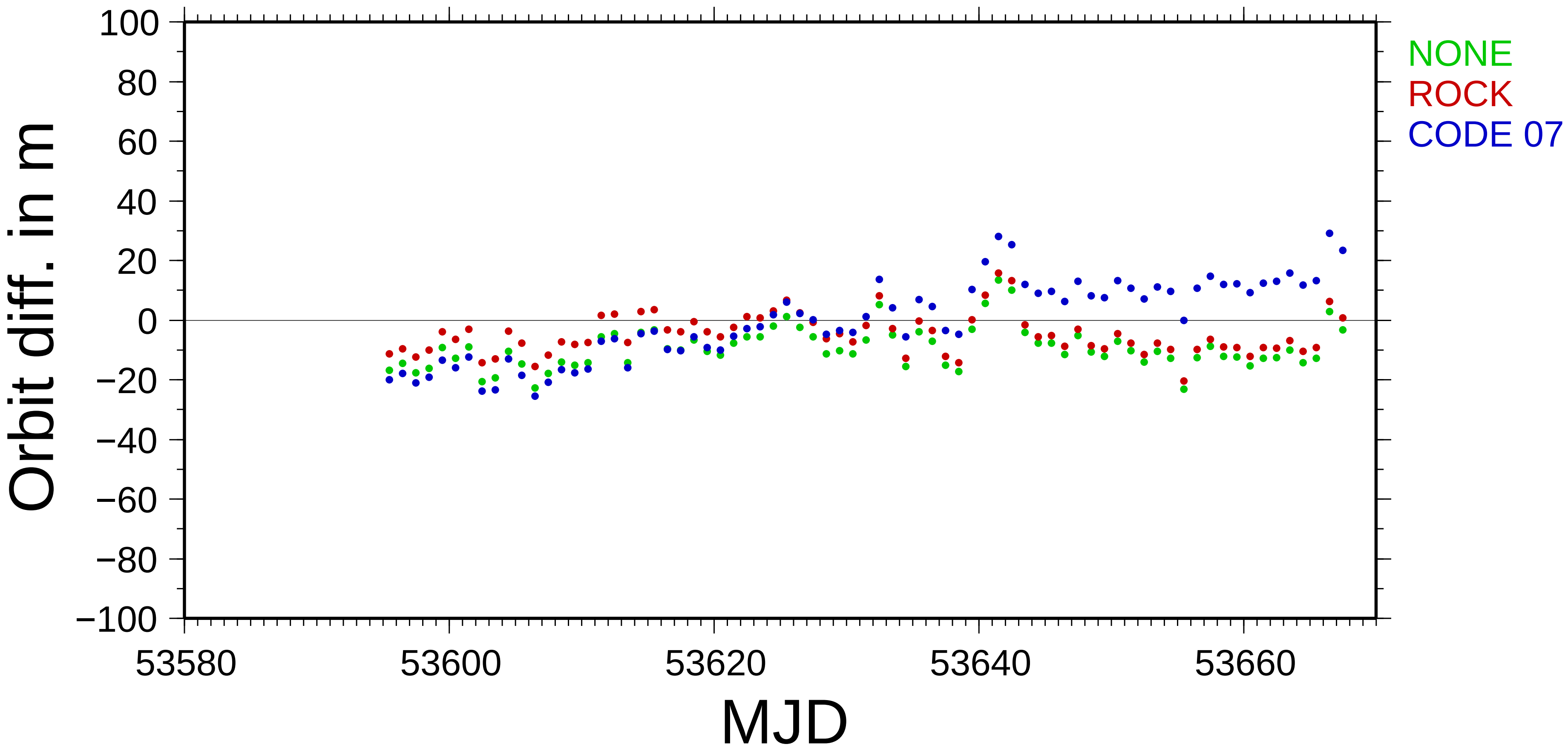
Differences in the estimated and predicted (15 days) orbits
using different a priori RPR models



Satellite G21 (Block IIR–A)

Verification of Radiation Pressure Models

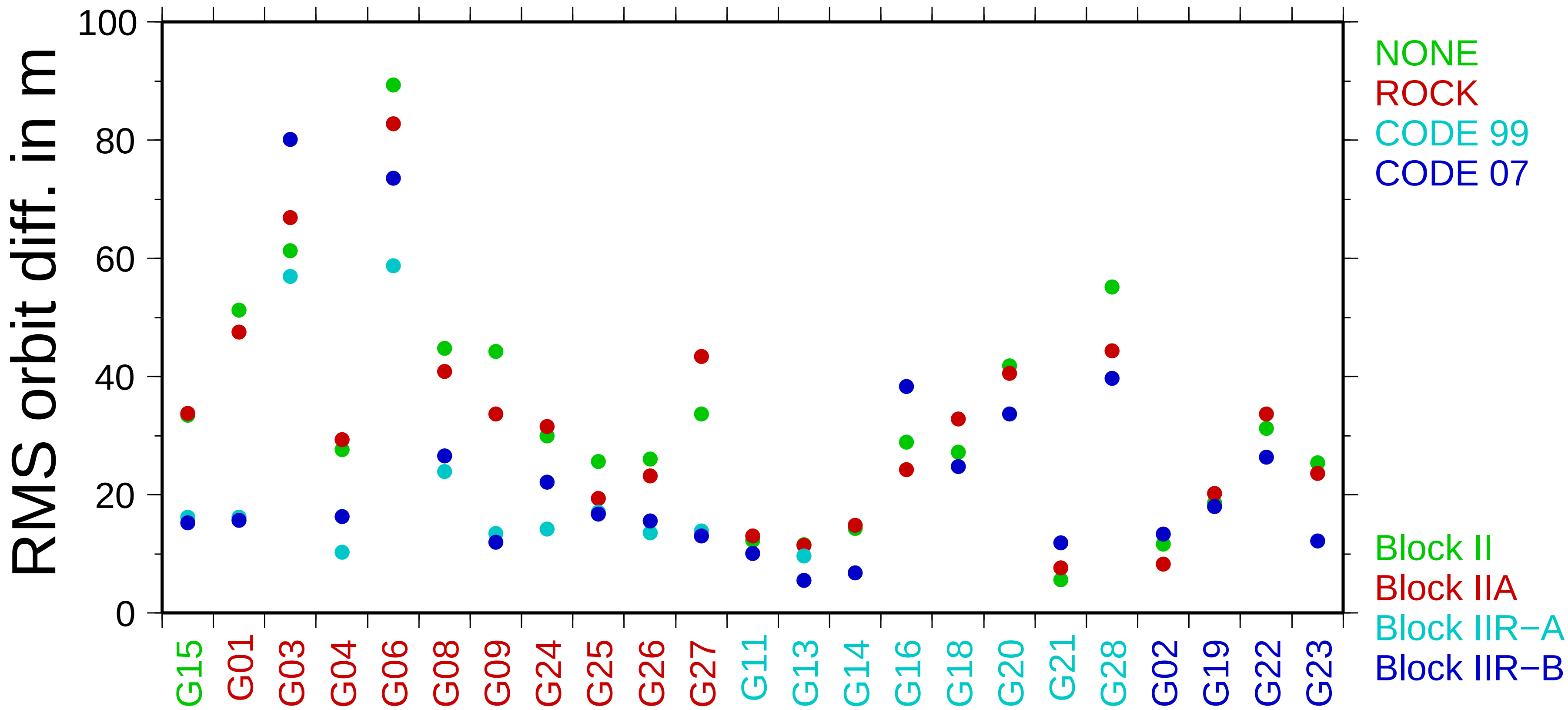
Differences in the estimated and predicted (15 days) orbits
using different a priori RPR models



Satellite G02 (Block IIR–B)

Verification of Radiation Pressure Models

Mean differences in the estimated and predicted (15 days) orbits
using different a priori RPR models



Verification of Radiation Pressure Models

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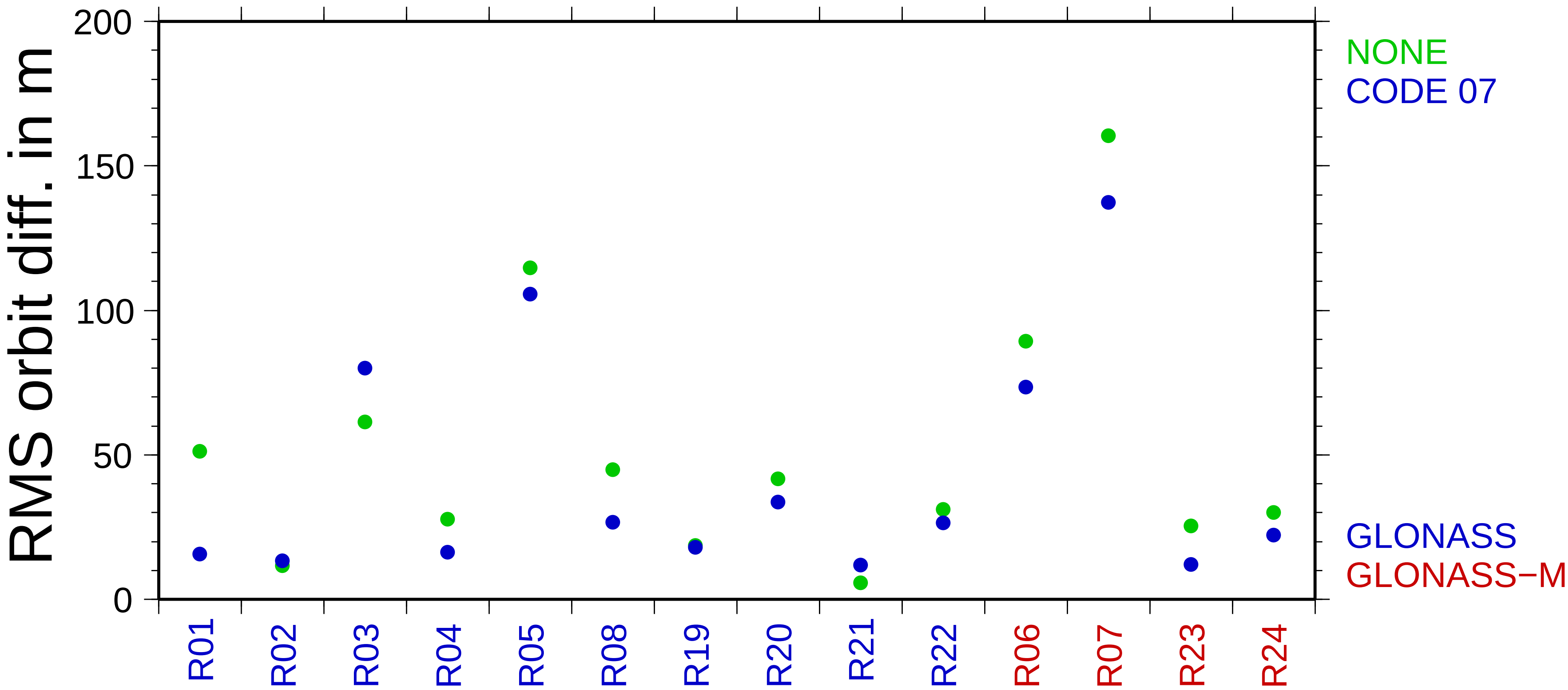

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Conclusions

- The CODE radiation pressure model that is used as a priori for the orbit determination at CODE has been updated:
  - to verify the existing CODE model for old GPS satellites
  - to extend the model to the new GPS and GLONASS satellites

- The quality of the new model is comparable with the quality of the old one.

- A long–term prediction based on the radiation pressure models has shown:
  - an advantage of the CODE model w.r.t. the ROCK model, especially for Block IIA GPS satellites.
  - an improvement for the radiation pressure modelling for most of the GLONASS satellites.

- The update of the CODE radiation pressure model shall be automatized in the frame of the CODE's IGS activities.

Outlook

More on the updated CODE radiation pressure modelling during this week:

Claudia Urschl: Assessing the quality of GNSS orbit models using SLR
Luca Ostini: Near-seasonal periods in GNSS station time series

Both papers will be presented tomorrow in the Session G1:
The impact of technique errors on reference frame accuracy and stability.