Latest improvements in CODE's IGS MGEX solution

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Contents

- Current status of the CODE MGEX solution
- Planned model changes
- Importance of satellite meta data
- Empirical SRP model for ON
- Summary and outlook

Focus of MGEX-related activity since last IGS WS

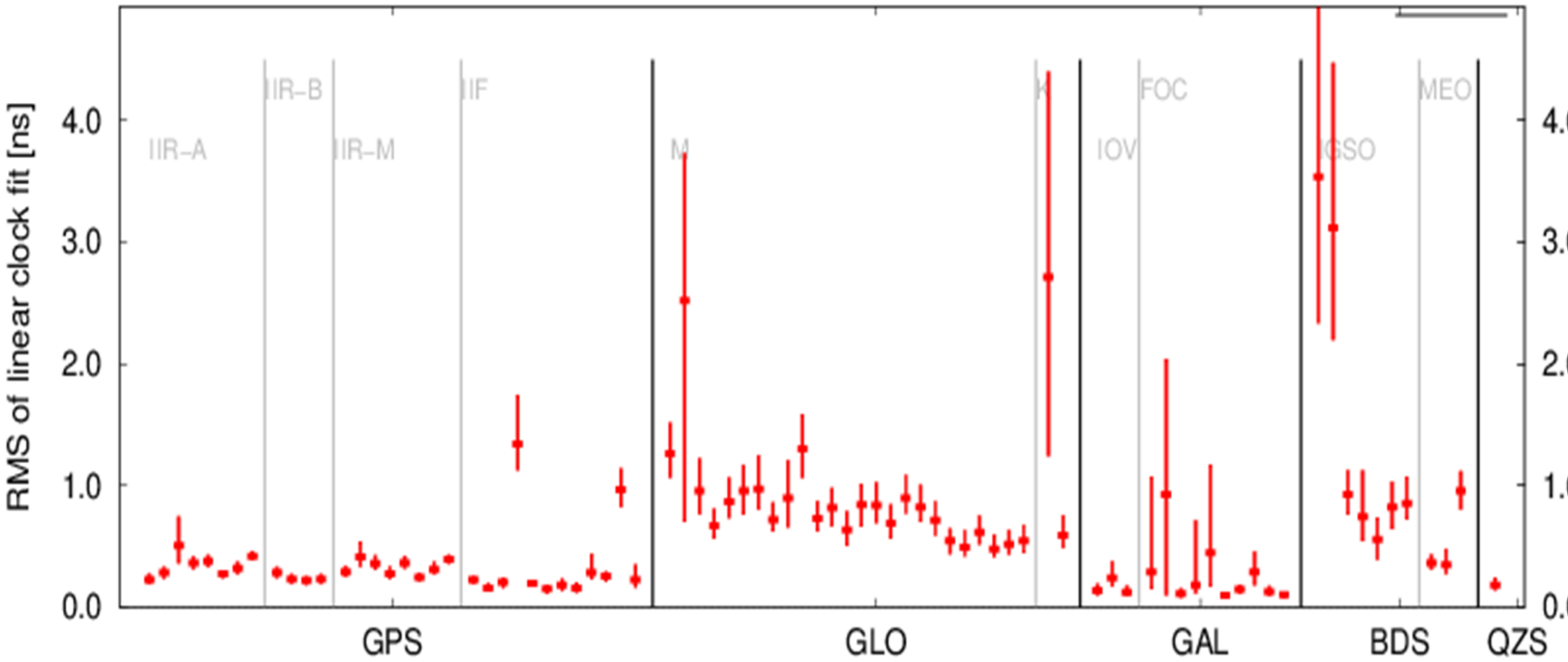
- Survey of preliminary state:
  - Publication in JoG (doi 10.1007/s00190-016-0968-8)

- Operations and related tasks:
  - Adaptation to long RINEX3 file names
  - Switch to default antenna model (Steigenberger et al., 2016)
  - Switch to IGS14

- Upgrade of operational status:
  - Full integration into CODE IGS routine (software, configuration, merge of data bases)
  - Reaction to MGEX status change at IGS WS 2016
  - Better coordination of parallel developments

COM clock validation 2016: daily linear fit

(Median and IQR; satellites in eclipse or normal mode are not considered)



⇒ Galileo PHM, QZS-1, most GPS IIR and IIF: excellent clocks (even suited for orbit validation)

⇒ Some GPS IIF, GLONASS, Galileo RAFS: worse (RMS: 0.5 ns or bigger)

⇒ BeiDou: mixed performance

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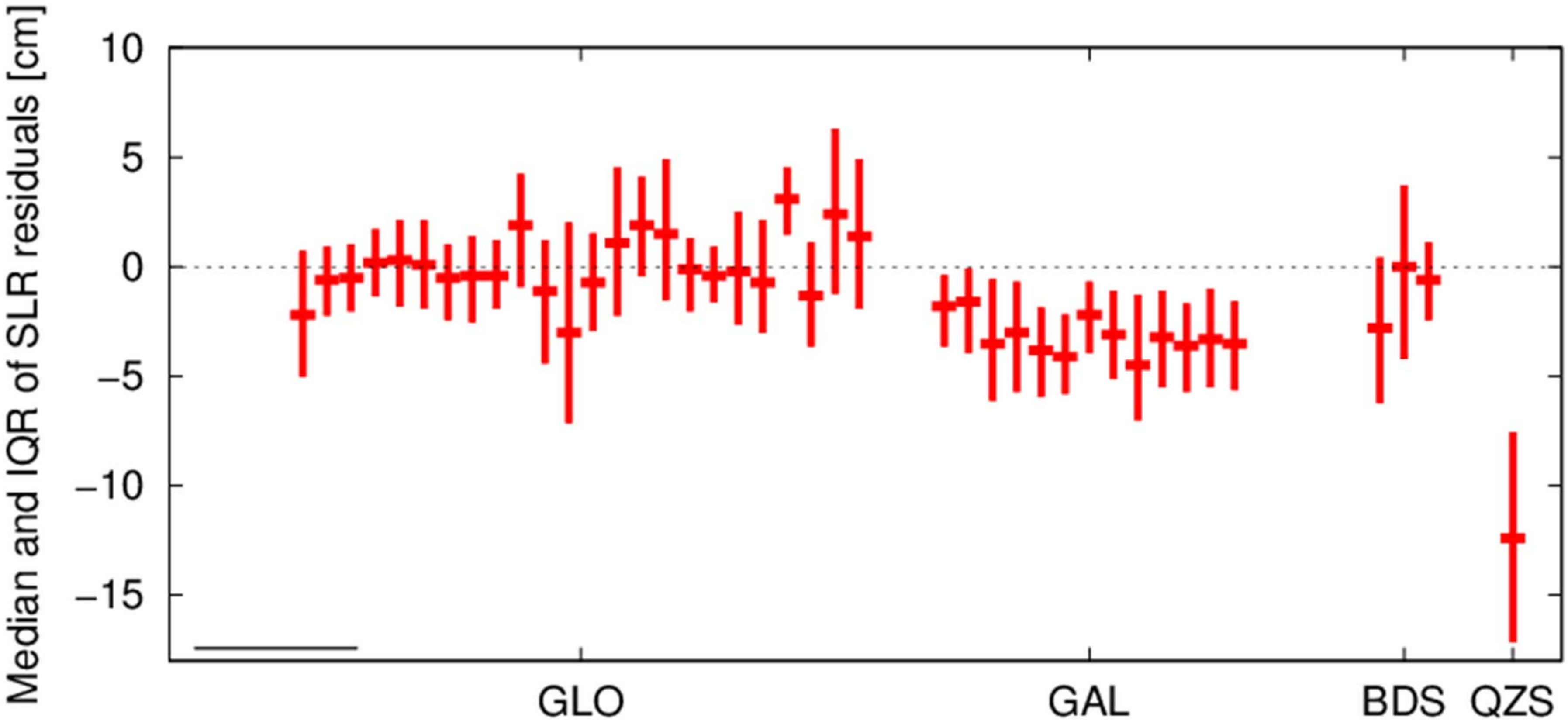
COM orbit validation 2016: SLR residuals

(Median and IQR; satellites in eclipse or normal mode are not considered)



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⇒ Significant SLR offsets for Galileo and QZSS due to orbit model deficiencies with impact on radial orbit component (respectively scale)

⇒ Model improvements are needed (e.g., ANTEX, albedo, antenna thrust)

Planned model changes

Improvements of orbit model planned in the near future:

Galileo:
- Activation of albedo and antenna thrust
- Activation of IOV attitude model for all Galileo SC
- Activation of pulses (every 12h in R,S,W)
- IOV Antenna model (=> impact analysis: Villiger @plenary #6)

QZSS:
- Activation of albedo and antenna thrust ('guessed' box-wing model (own or external, e.g., Montenbruck et al. (2017))
- Later: Activation of ON attitude and suited SRP model

BDS:
- Later: Activation of ON attitude and suited SRP model

Importance of satellite meta data

- Missing satellite meta data is a limiting factor for accuracy of estimated orbits and clocks

⇒ Publication of Galileo IOV satellite meta data by the GSA in Dec. 2016 is a step towards the right direction

⇒ Missing/unsure information: we can try to make a ‘good guess’ (like previously done, e.g., for GLONASS antenna thrust; is this tolerable?)

Importance of satellite meta data

Available/assumed information:

Galileo:

- Disclosed IOV meta data (satellite mass, size, and surface properties) => sufficient for simple box-wing model
- Disclosed IOV attitude model
- Assuming same models for FOC might not be correct, but better than nothing
- Measured antenna transmit power for IOV and FOC presented by Steigenberger et al. at EGU 2017

QZSS:

- Very coarse info about satellite size provided (e.g., on MGEX website); assumption on surface properties (e.g., similar to IOV) => rough guess on simple box-wing model
- Wide range of possible SC masses is provided on the IGS-MGEX website (1800 – 4100 kg)
- Transmission power provided by Kogure et al. in: Springer Handbook of Global Navigation Satellite Systems (2017)

Importance of satellite meta data

Test	Galileo					QZSS		
Name	Al-bedo	Ant. Thr.	Atti-tude	Pulses	Median SLR [cm]	Albedo	Ant. Thr. (244 W)	Median SLR [cm]
OPER	–	–	–	–	–3.8	–	–	–7.8
ALB1	x	–	–	–	–2.0	m= 1800 kg	–	–2.6
AAT1	x	260 W	–	–	+0.6	m= 1800 kg	m= 1800 kg	+0.3
AAT2	x	130 W	–	–	–0.7	m= 3600 kg	m= 3600 kg	–3.7
EAT	x	200 W	x	–	0.0	m= 1950 kg	m= 1950 kg	–0.3
EATPA	x	200 W	x	R, S, W; 12h	+0.6	m= 1950 kg	m= 1950 kg	–0.3

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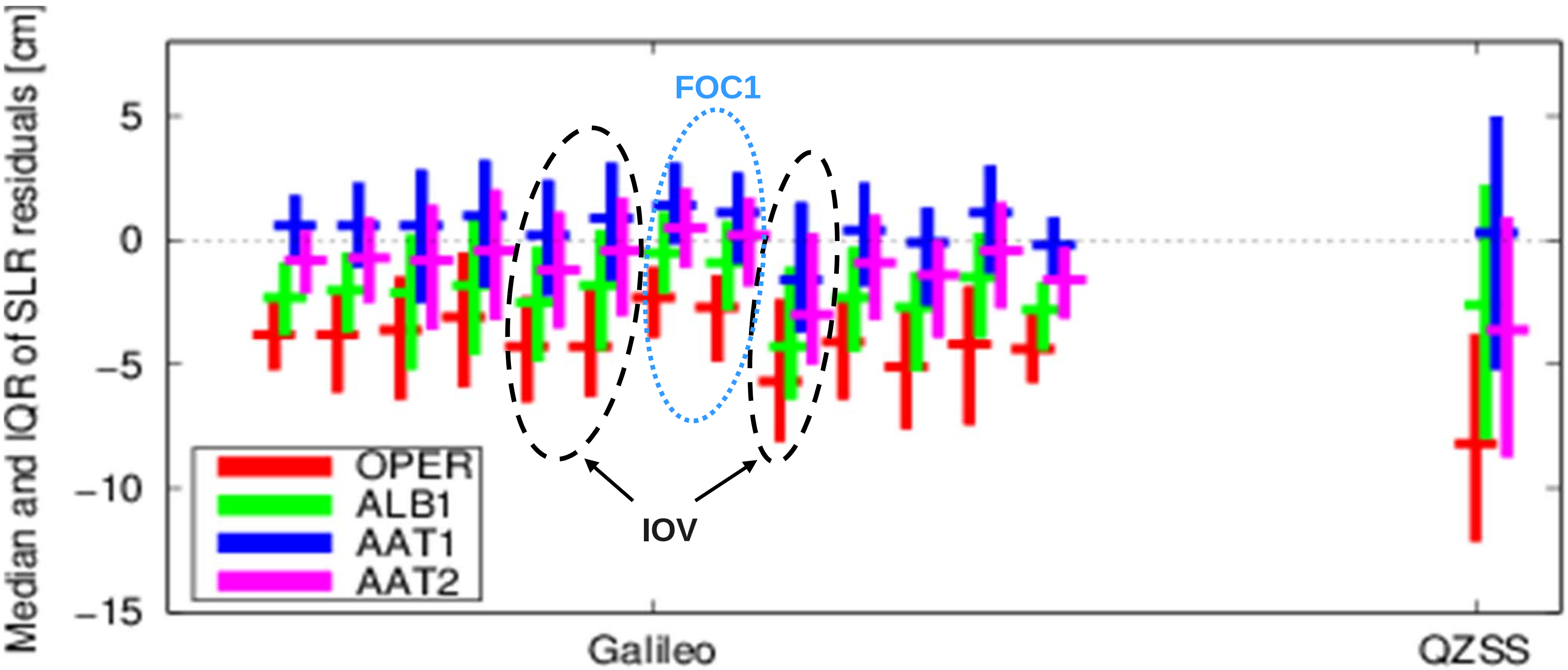
EAT	x	200 W	x	–	0.0	m= 1950 kg	m= 1950 kg	–0.3
EATPA	x	200 W	x	R, S, W; 12h	+0.6	m= 1950 kg	m= 1950 kg	–0.3

Impact albedo: +1.8 cm

Impact antenna thrust: 1 cm/100 W

Impact SC mass: 2.2 cm/1000 kg

Importance of satellite meta data



⇒ Consideration of albedo and antenna thrust reduces SLR offset

⇒ Uncertainties remain:
- Satellite macro model is rough (IOV) or guessed (FOC, QZSS)
- True satellite mass and CoM unknown (QZSS)
- Uncertainties w.r.t. transmit power
- Antenna calibration also impacts orbit scale

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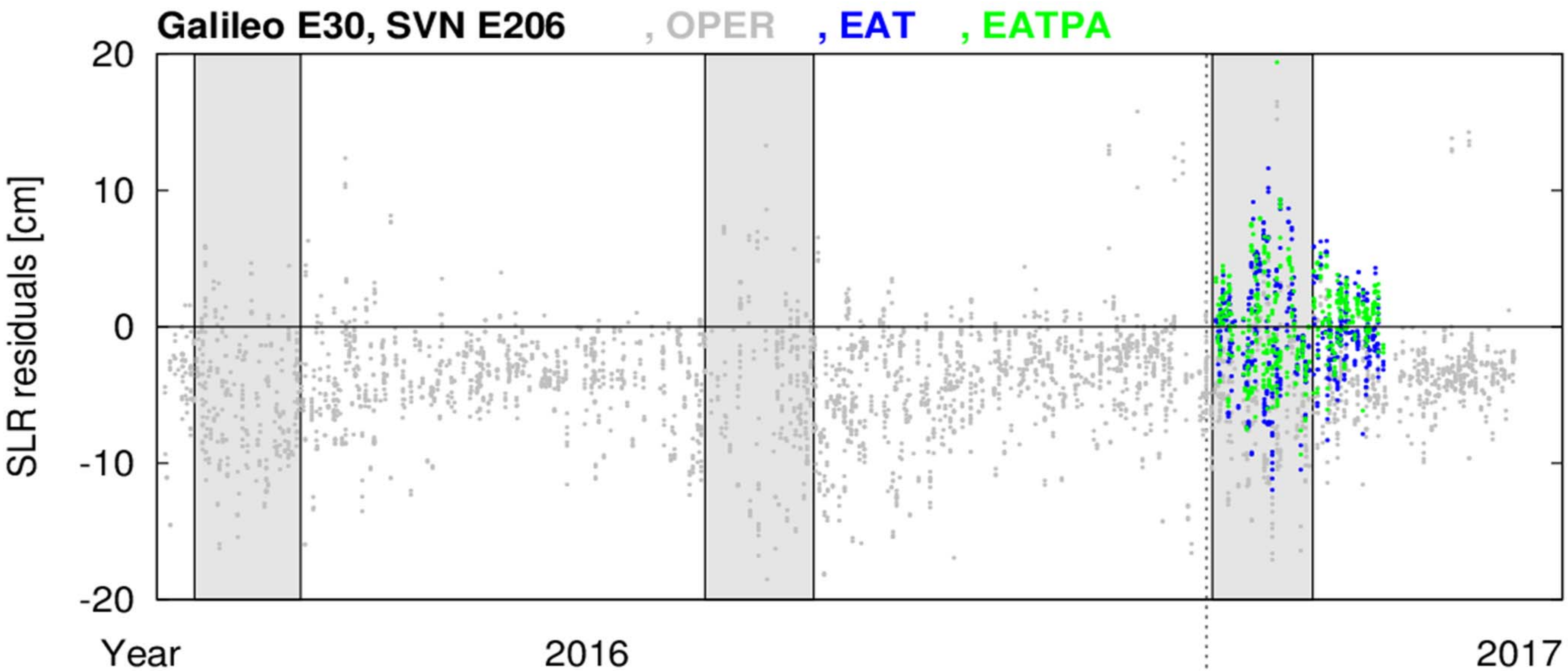
Expected impact of model changes



⇒ IOV attitude model (OPER vs. EAT): minimal impact

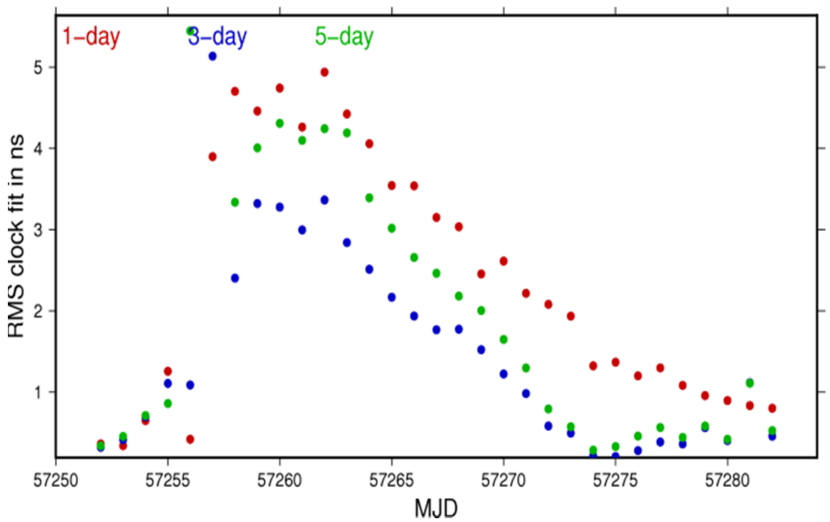
⇒ Pulses in R, S, W (EATPA): IQR drops 4.8 → 3.8 cm
(expected future configuration)

⇒ Orbit errors remain increased during eclipses (why?)

Orbit normal mode (ON)

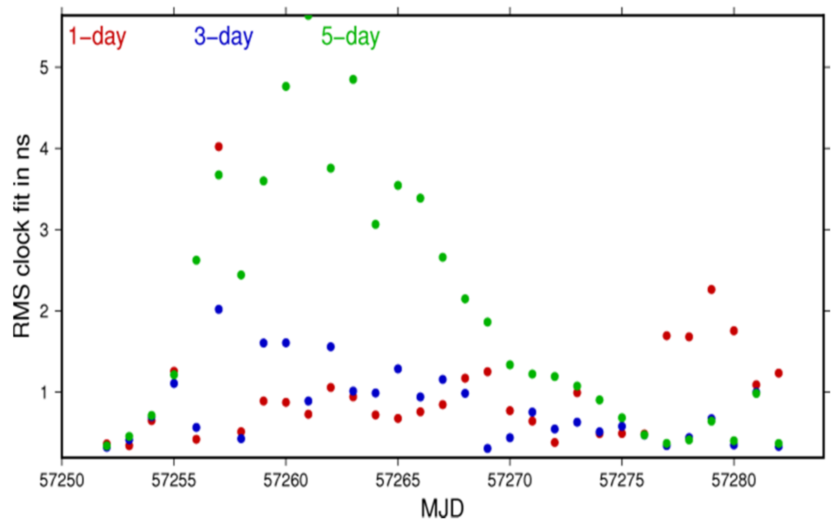
- Tests with QZS-1 and BDS POD
- Simulating and testing empirical SRP models using different decompositions and parameterizations (ECOM-N v…)

QZS-1 with ECOM2



Classical ECOM SRP models are not suited for ON

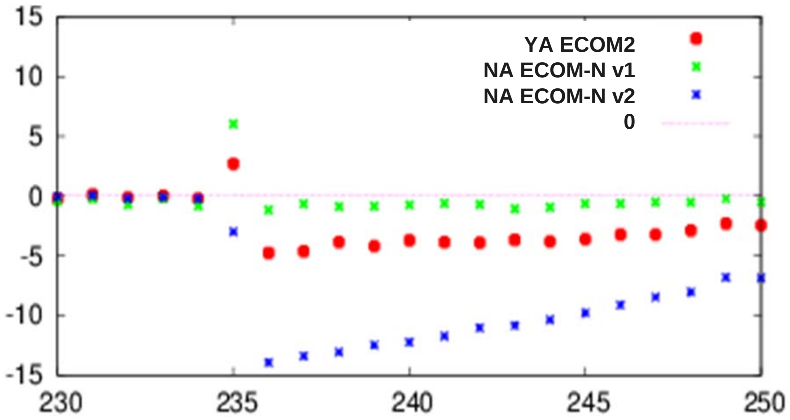
QZS-1 with ECOM-N v2



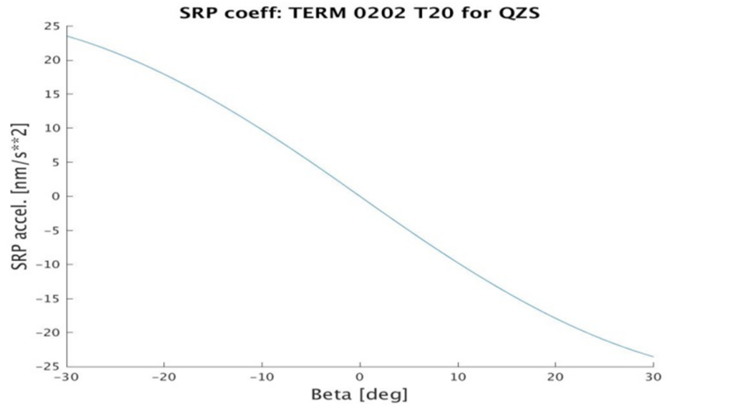
New SRP models: improvement for shorter arcs

Orbit normal mode (ON)

- Size of some new SRP parameters is a function of the Beta angle

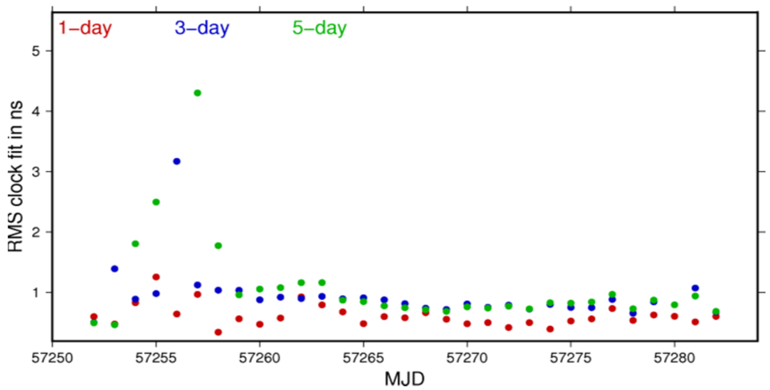


Estimated SRP coefficient of QZS-1

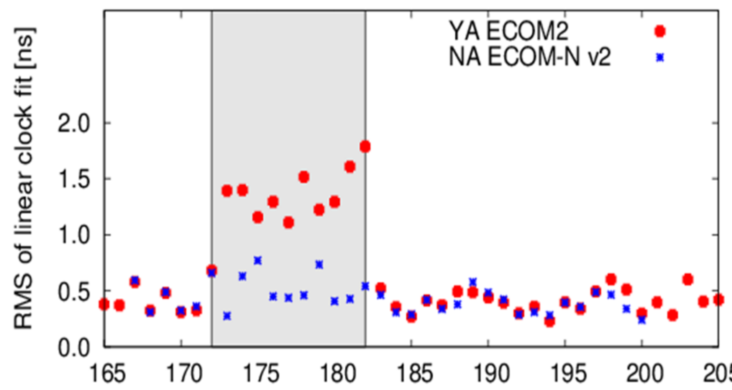


Simulated SRP coefficient of QZS-1

QZS-1 with ECOM-N v4



C11 with ECOM-N v2



- QZS-1: consideration of Beta: improvement also for long arcs

BDS: simple (no Beta-dependency) SRP model sufficient

COM to-do list

- ☑ Implementation of Galileo, QZSS, BeiDou (except GEOs)
- ☑ Use of RINEX3 files from IGS and EPN - now also with long file names; selection of observation types
- ☑ Improved SRP model for yaw-steering attitude (ECOM2, Arnold et al., 2015)
- ☑ Proper handling of observation biases; BIAS-SINEX
- … Attitude laws for GPS, GLONASS, Galileo eclipses
- ☑ Tuning of ambiguity resolution for Galileo, BeiDou, QZSS
- … Albedo radiation modelling for Galileo, QZSS, BeiDou
- … Antenna thrust for (GLONASS), Galileo, QZSS, BeiDou
- … Normal attitude and related SRP models for QZSS and BeiDou
- … ANTEX (PCO+PCV) for Galileo, QZSS, BeiDou

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  See clock- and bias-related presentations by Schaer (plenary #3) and Villiger (plenary #6)
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  See ANTEX-related presentation by Villiger (plenary #3)

Thank you

for

your attention!