Systematic SLR errors detected in precise orbit determination

Toshimichi Otsubo

Hitotsubashi University

Email: t.otsubo@r.hit-u.ac.jp

Hitotsubashi University

Rapid (6-hourly) QC at Hitotsubashi Univ

Geoscience Hitotsubashi

Multi-Satellite Bias Analysis Report v2

for Worldwide Satellite Laser Ranging Stations

being updated every 6 hours!

Latest Analysis Report: >> from **18h UTC, 21 Oct 2018** to **18h UTC, 04 Nov 2018** (updated 20:32 UTC, 4 Nov 2018)

sat	orbit fit WRMS in mm	# pass/# NP	1st site(ID
Lageos-1	7	281 / 2429	Yarraga
Lageos-2	11	261 / 2344	Yarraga
Etalon-1	19	47 / 203	Yarraga
Etalon-2	14	41 / 197	Yarraga
Ajisai	25	362 / 4350	Yarraga
Lares	12	240 / 2502	Yarraga
Starlette	17	360 / 3411	Mt Stron
Stella	33	205 / 1613	Yarraga

and more satellites (GNSS and LEO) are included in the report

http://geo.science.hit-u.ac.jp/slr/bias/

SpringerLink

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Rapid response quality control service for the laser ranging tracking network

Authors | Authors and affiliations

Toshimichi Otsubo, Horst Müller, Erricos C. Pavlis, Mark H. Torrence, Daniela Thaller, Vladimir D. Glotov, Xiaoya Wang, Krzysztof Sośnica, Ulrich Meyer, Matthew J. Wilkinson

Original Article

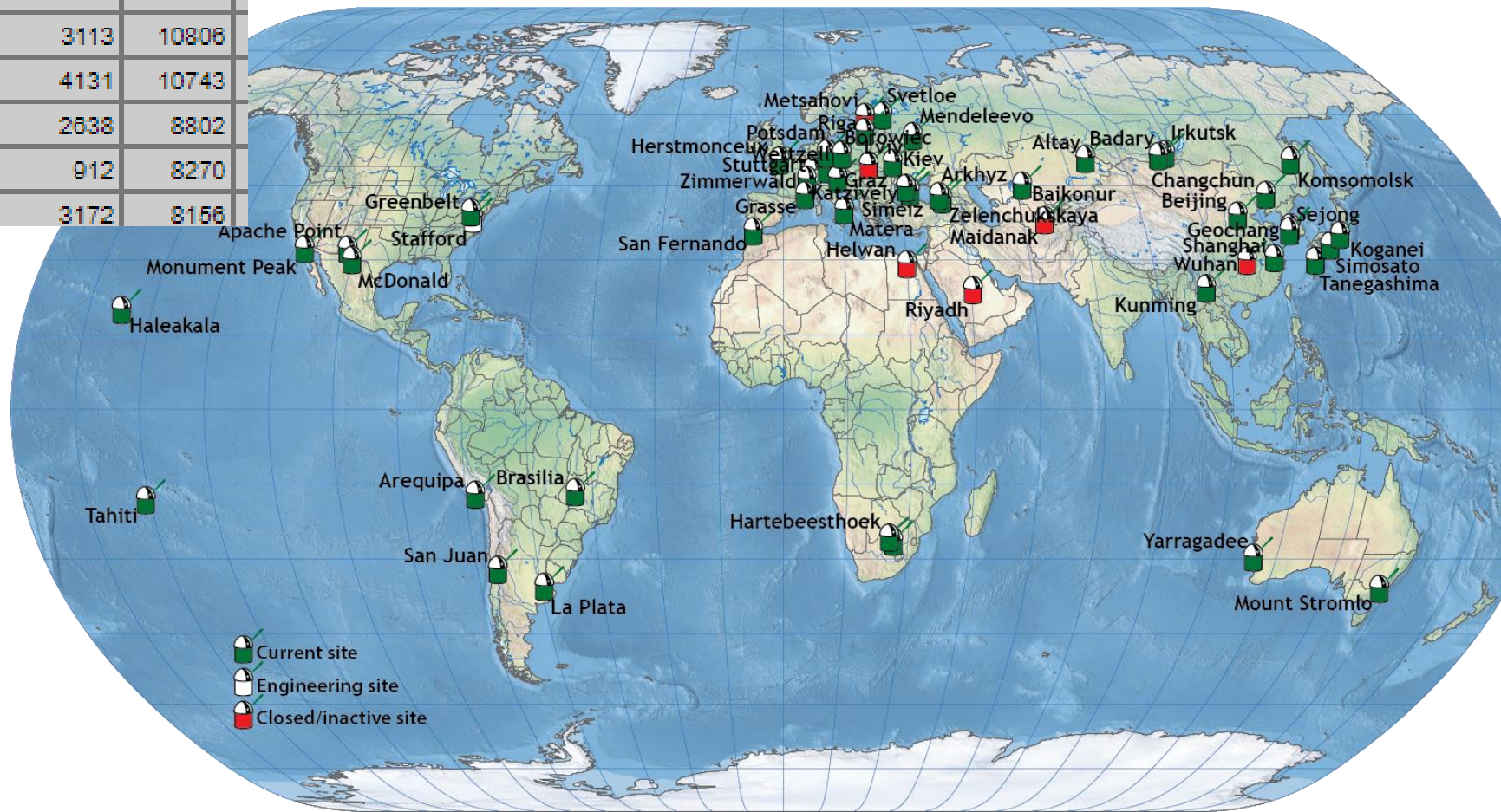
First Online: 10 September 2018

104 Downloads | 2 Citations

Thank you, Australia.

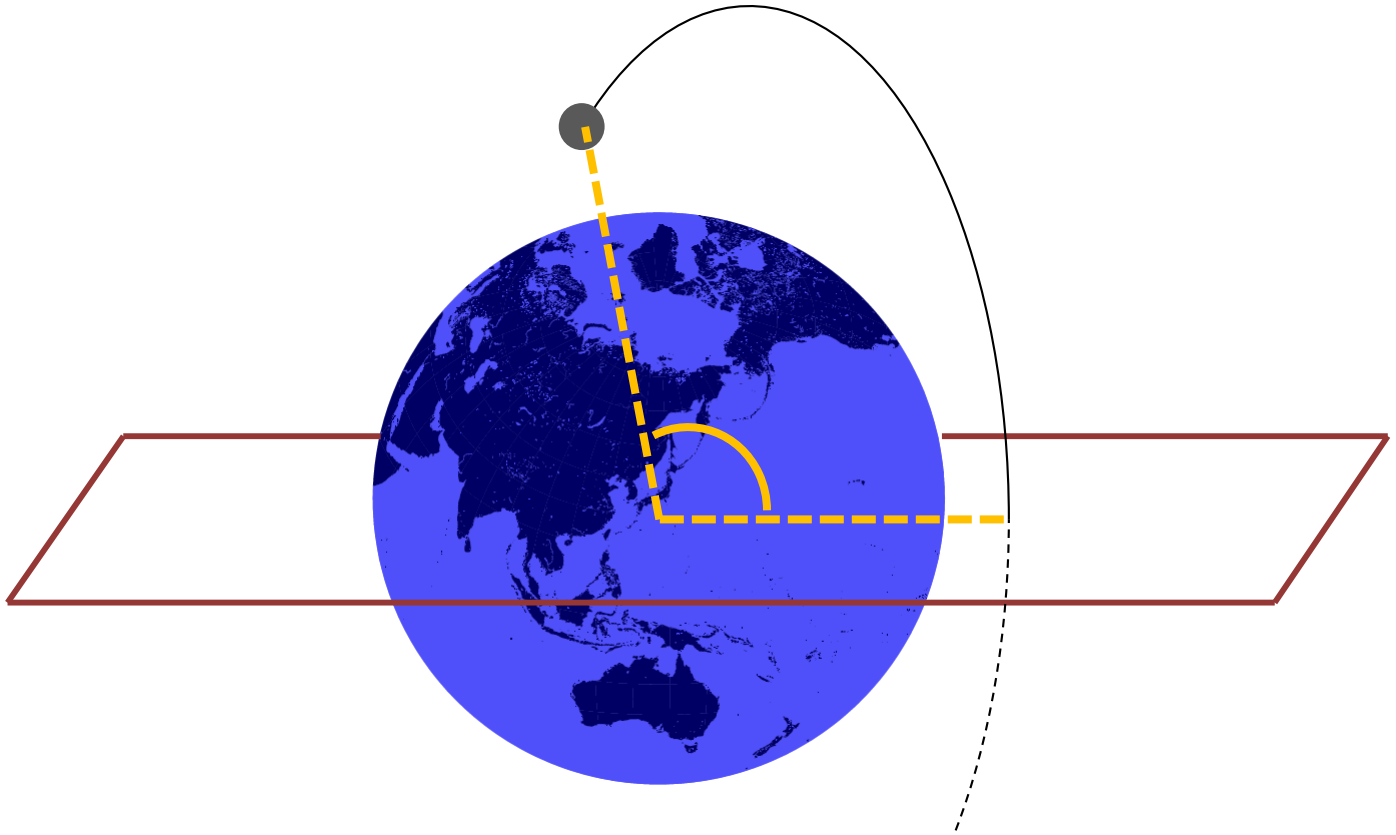
SLR Global Performance Report Card: Oct 2017-Sep 2018

Site Information		Data Volume			
Column 1	2	3	4	5	6
Location	Station Number	LEO pass Tot	LAGEOS pass Tot	High pass Tot	Total passes
Baseline		2300	600	3000	3500
Yarragadee	7090	16965	2671	9812	29448
Changchun	7237	8847	904	4871	14222
Zimmerwald_532	7810	7732	1098	4036	12866
Mount_Stromlo_2	7825	6578	1115	3113	10806
Herstmonceux	7840	5793	819	4131	10743
Matera_MLRO	7941	4725	1439	2638	8802
Greenbelt	7105	6476	882	912	8270
Wettzell	8834	4375	609	3172	8156



Argument of Latitude

= Argument of Perigee + True Anomaly



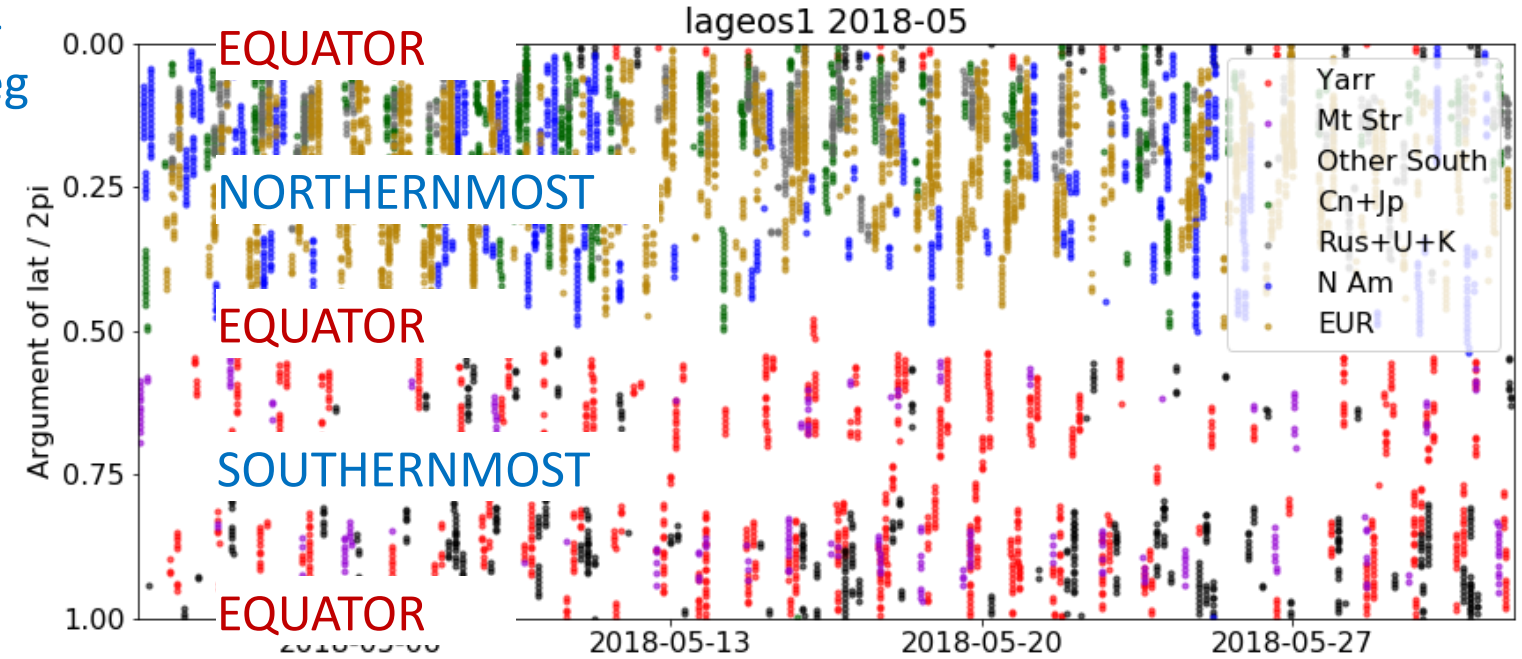
0, π, 2π: At the equator

π/2: At the northernmost point

3π/2: At the southernmost point

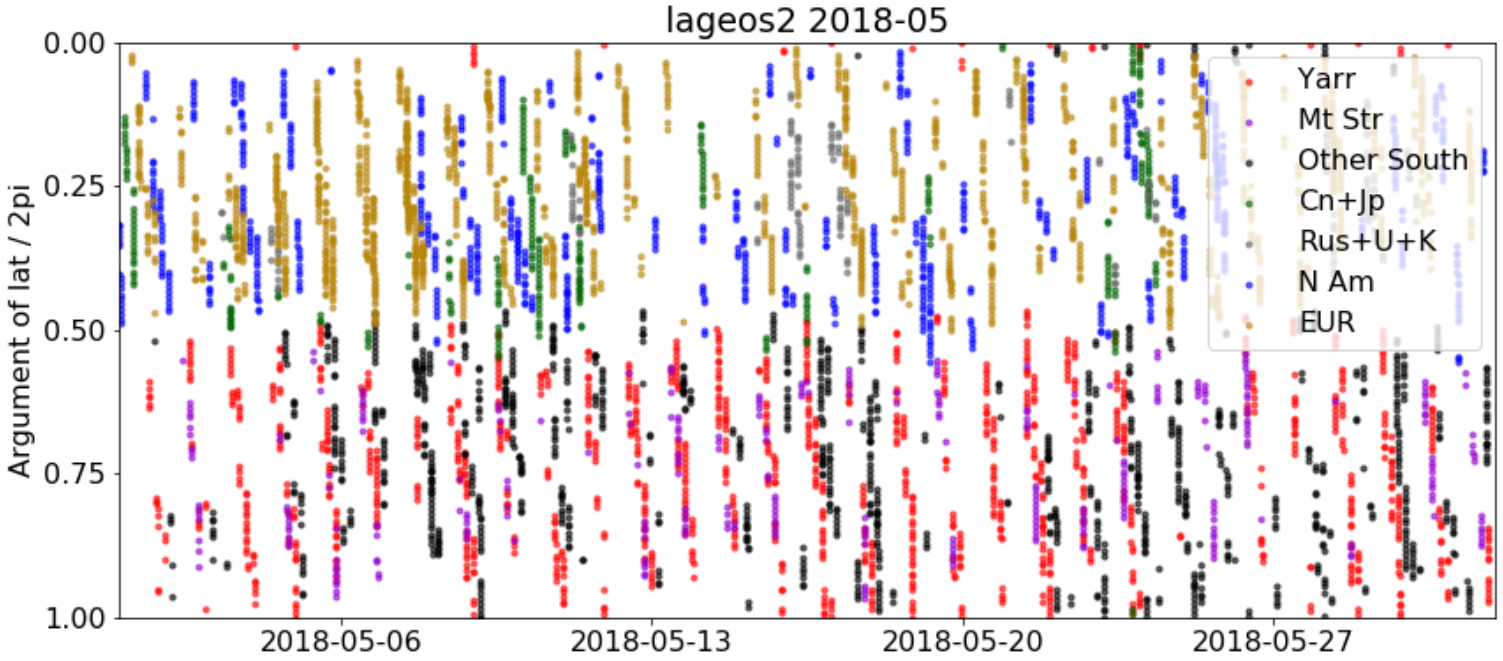
LAGEOS 1

i = 110 deg



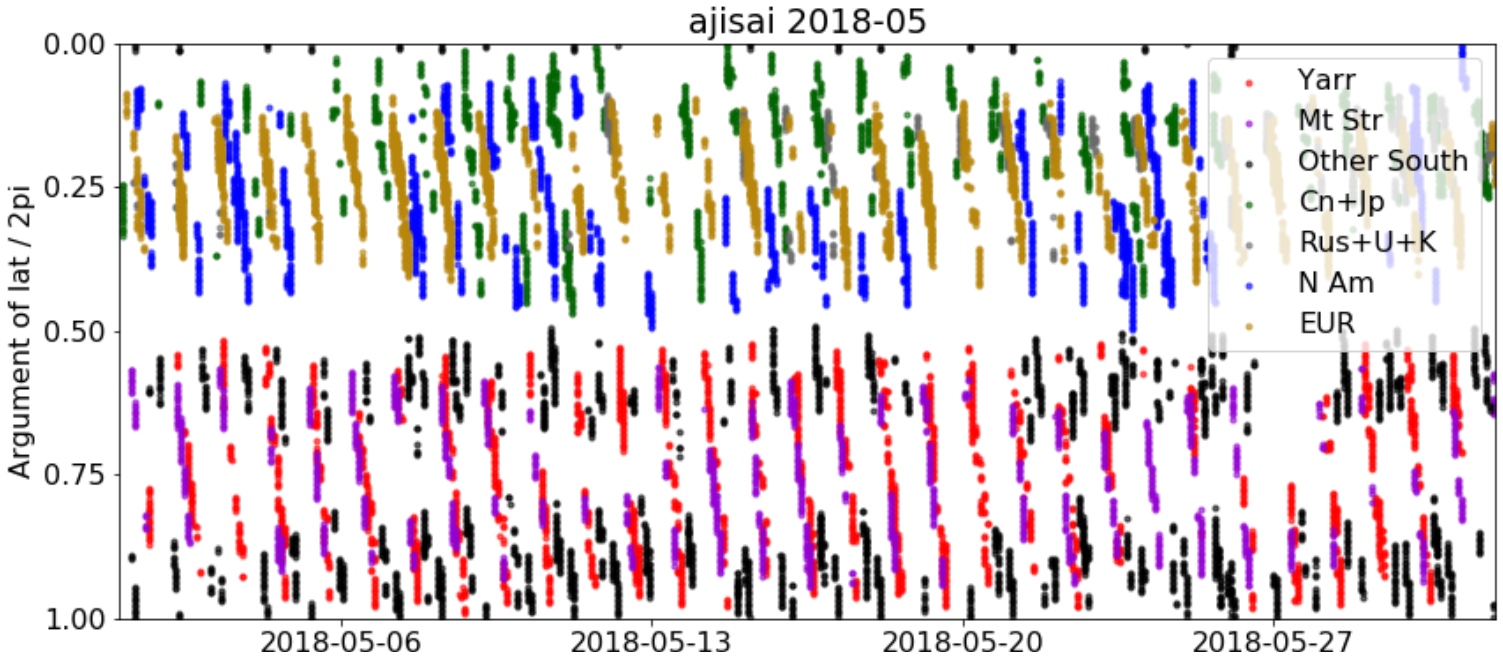
LAGEOS 2

i = 53 deg



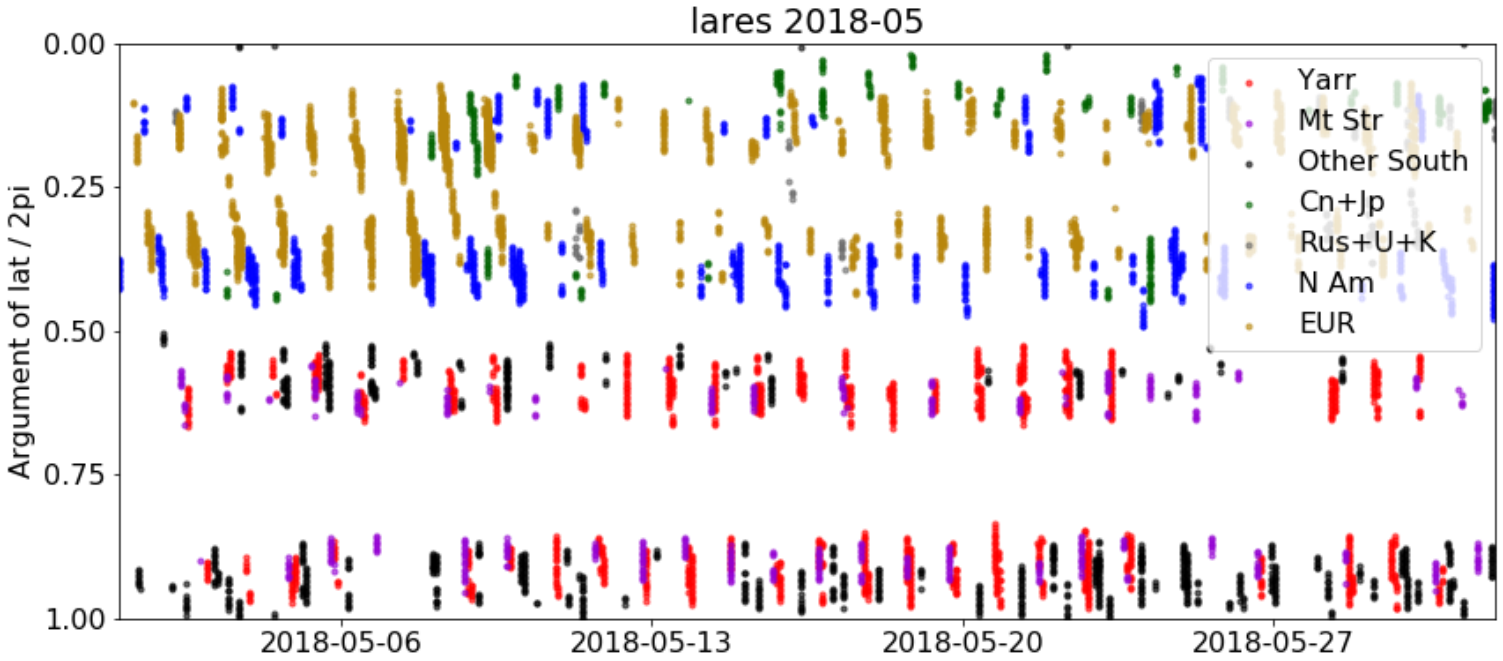
AJISAI

i = 50 deg



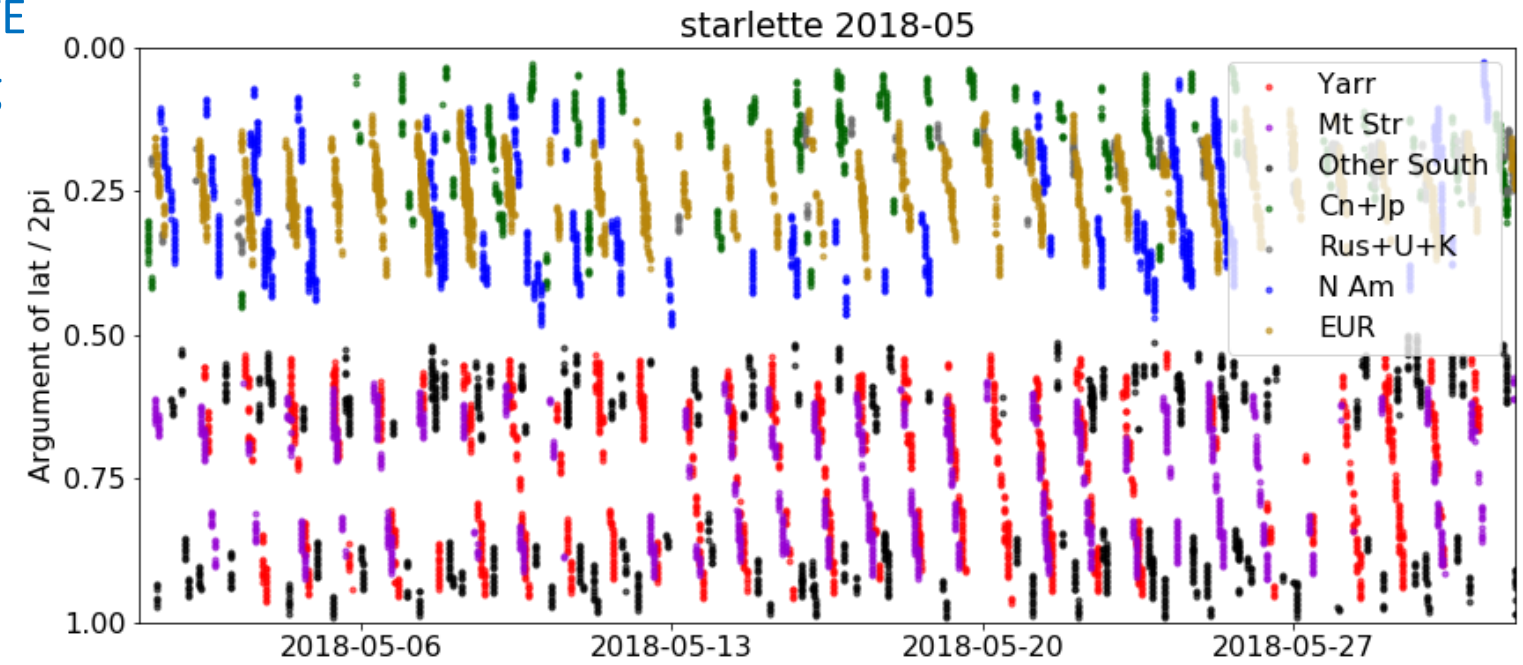
LARES

i = 70 deg



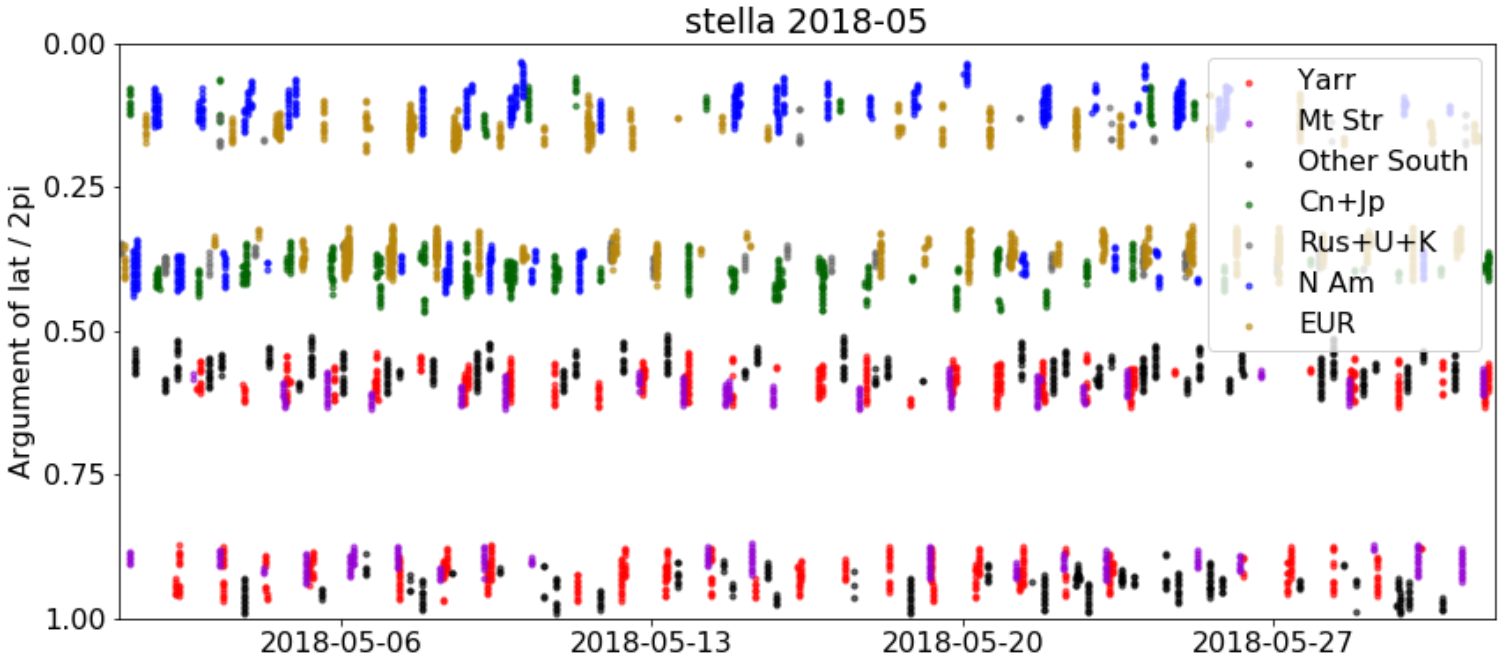
STARLETTE

i = 50 deg



STELLA

i = 99 deg



Now let us back to the main point.

Data quality.

“GGOS wants 1 mm” (1)

- Does it mean that we need to achieve:
  - 1 mm single-shot RMS?
  - 1 mm NP stability during a pass?
  - 1 mm position stability in the ILRS weekly solutions?

- In an ideal world where only random error exists

  (i.e. Error reduces at Sqrt(#OBS))

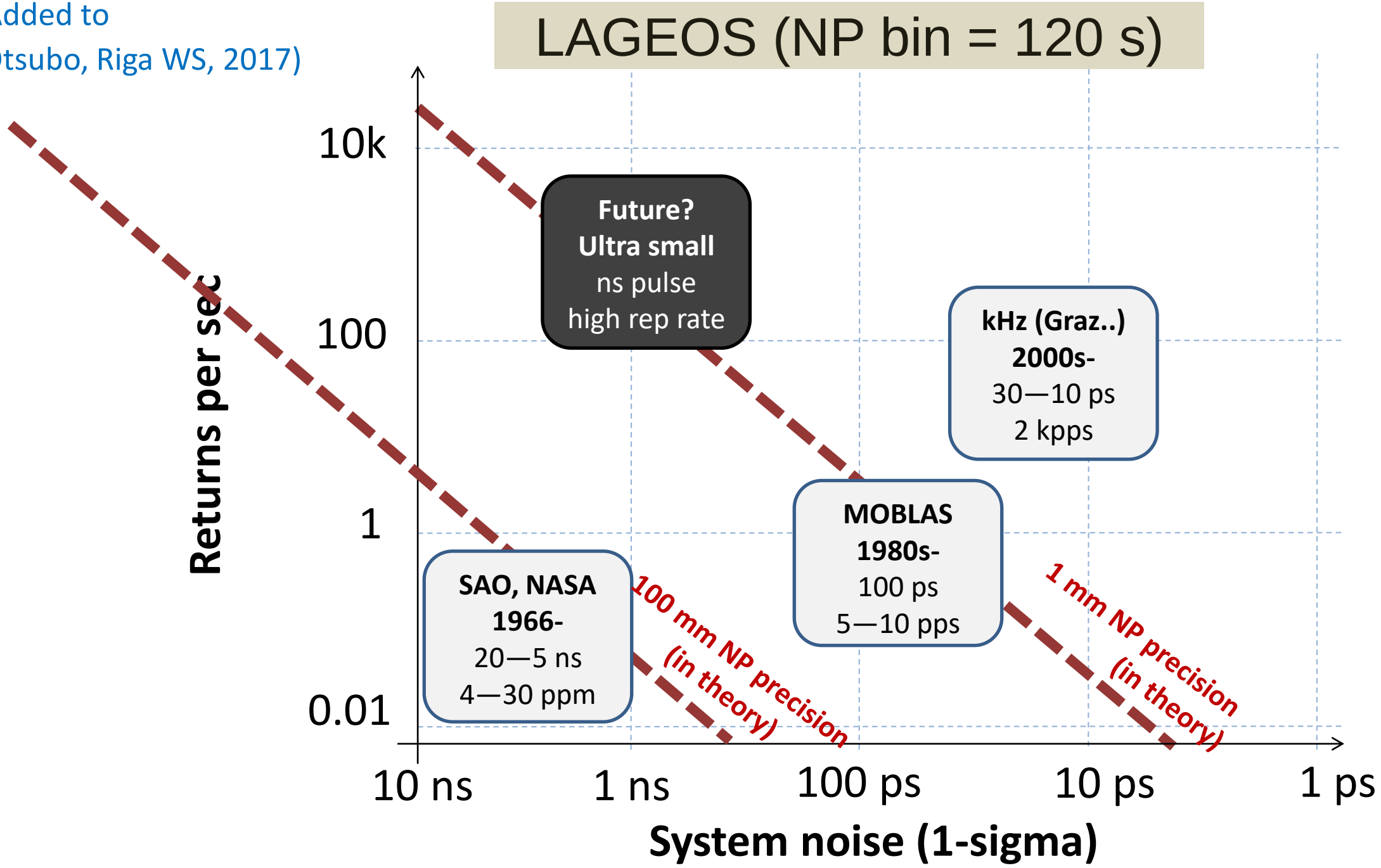
  1 mm TRF (~ 1 month) ← 1 cm RMS weekly positions x 20 stations x 5 weeks

  1 cm weekly position ← 10 cm NP RMS x 100+ NPs/week

  10 cm NP ← 1000 cm (10 m!) single shot RMS x 10000 shots/NP

Cf. Stuttgart 10 ns, 100 kHz mini-system (D Hampf on Thurs)

(Added to
Otsubo, Riga WS, 2017)



“GGOS wants 1 mm” (2)

- Does it mean that we need to achieve:

  Range bias < 1 mm?

- RBIAS estimation is inevitable for mm accuracy.

  Local survey: ~ a few mm?

  Center-of-mass correction model: ~ a few mm for LAGEOS.

  ILRS ASC decided to adjust & apply RBIAS for its products.

  Important: RBIAS should be constant.

SLR systematic errors

[ERROR SOURCES]

- Orbit determination
  - Acceleration models
  - EOP
  - TRF & station positions
  - Displacement models
  - Atmospheric refraction delay
  - (and more)
- Observations
  - Stability of time tag
  - Stability of range measurement
    - Calibration
    - Intensity dependence
    - Noise clipping
  - (and more)

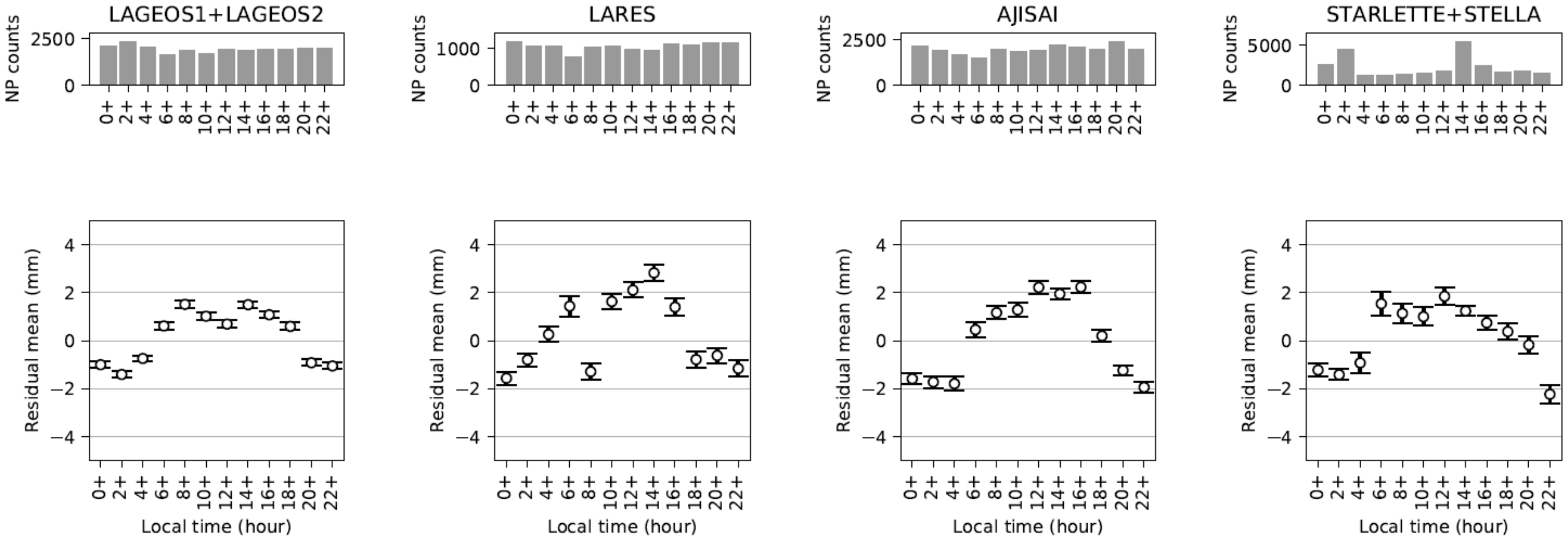
[BEHAVIOUR]

- Az/El dependence
- Time series pattern
  - Daily (Day/Night)
  - Yearly
  - Secular
  - Jump
- Satellite dependence

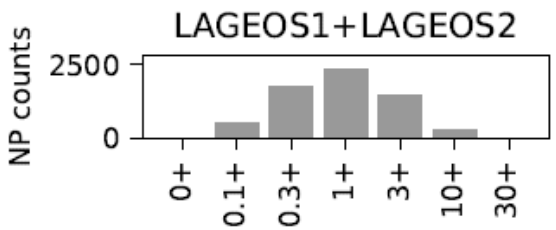
Degrades not only your station position but also the global geodetic products

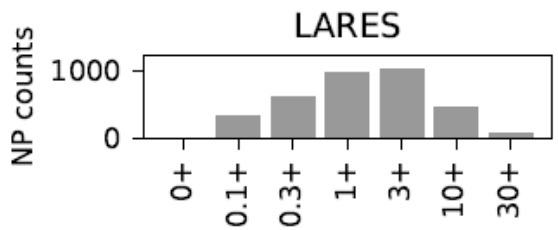
Systematic trends detected from 1-year POD

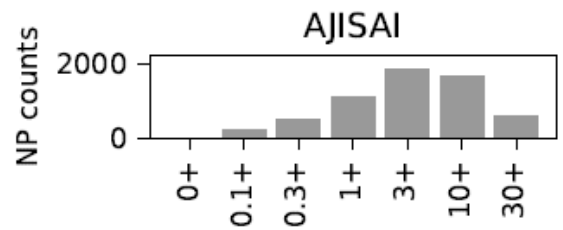
7090: wrt Local Time

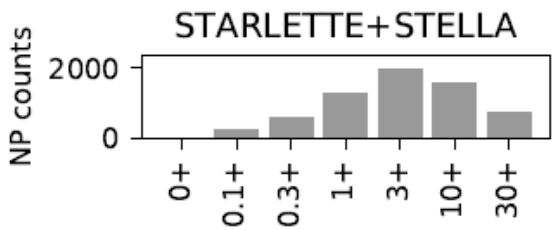


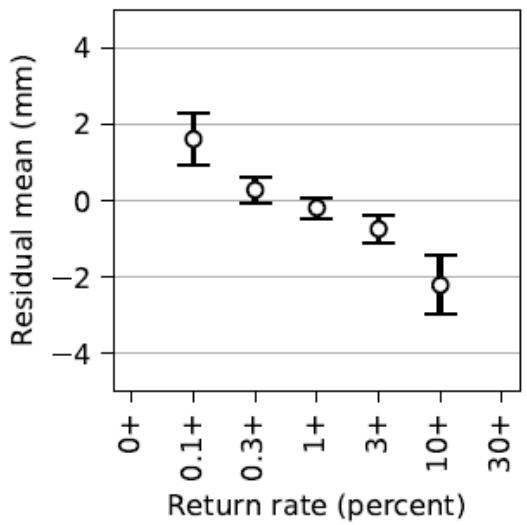
7237: wrt Return Rate

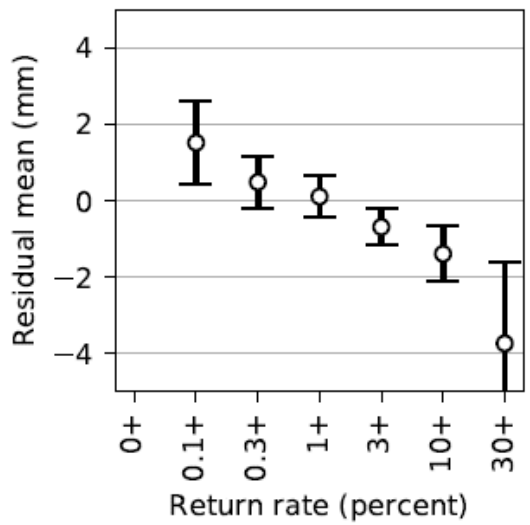


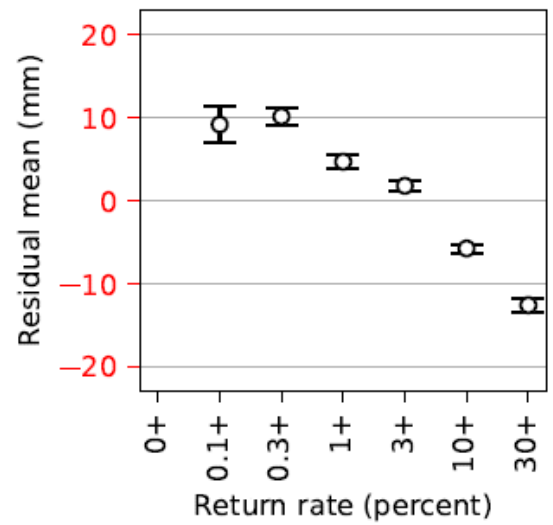


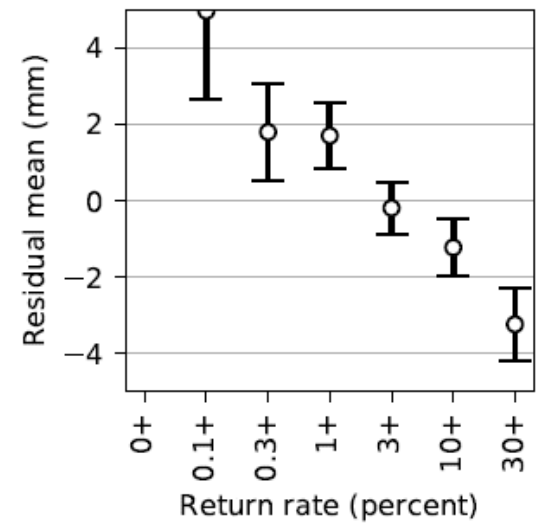




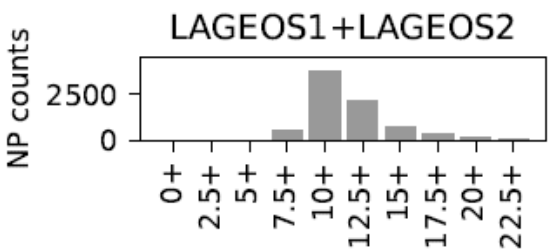


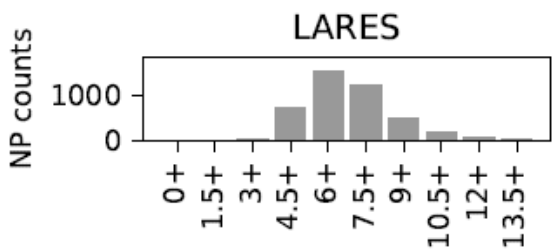


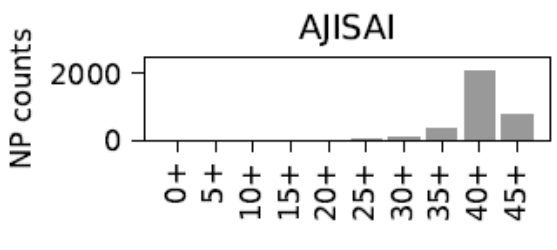


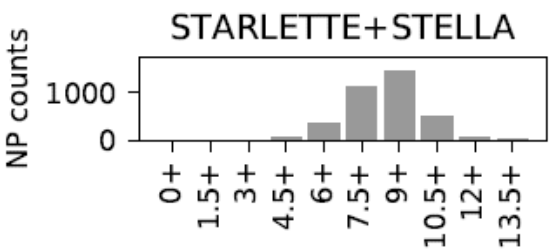


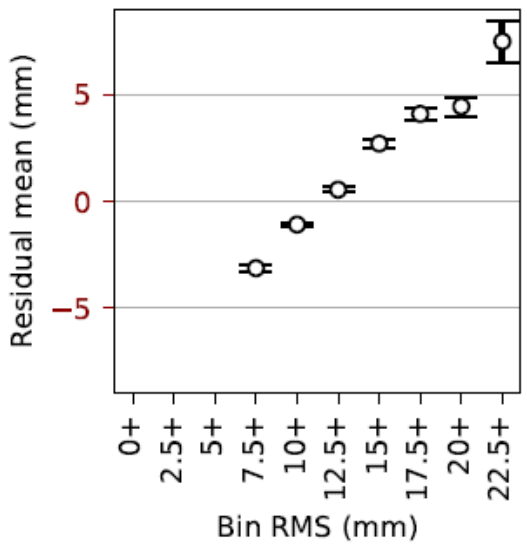
7840: wrt Single-Shot RMS

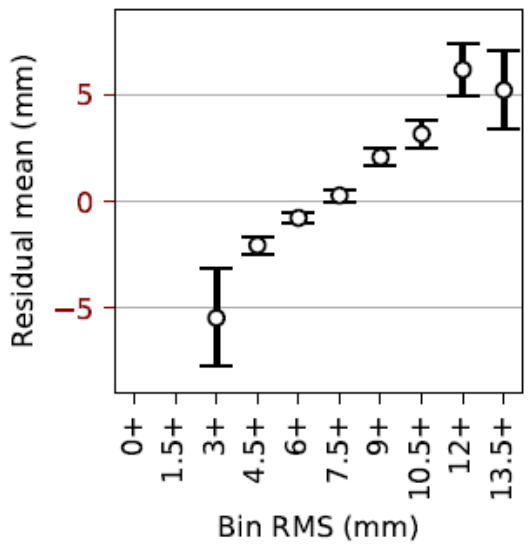


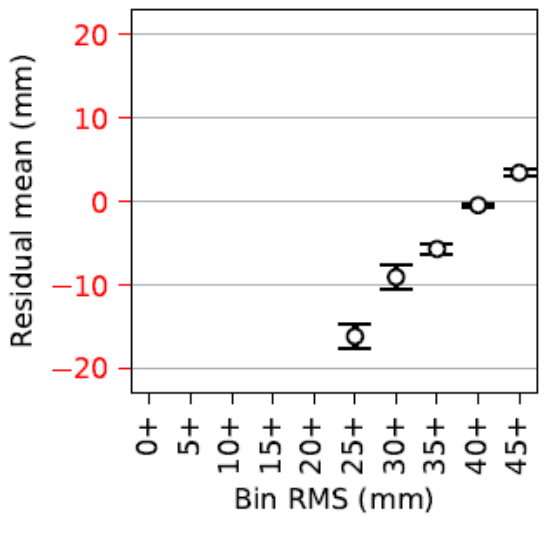


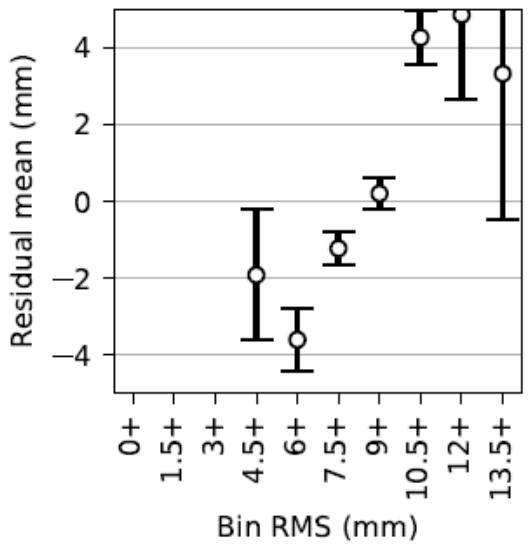






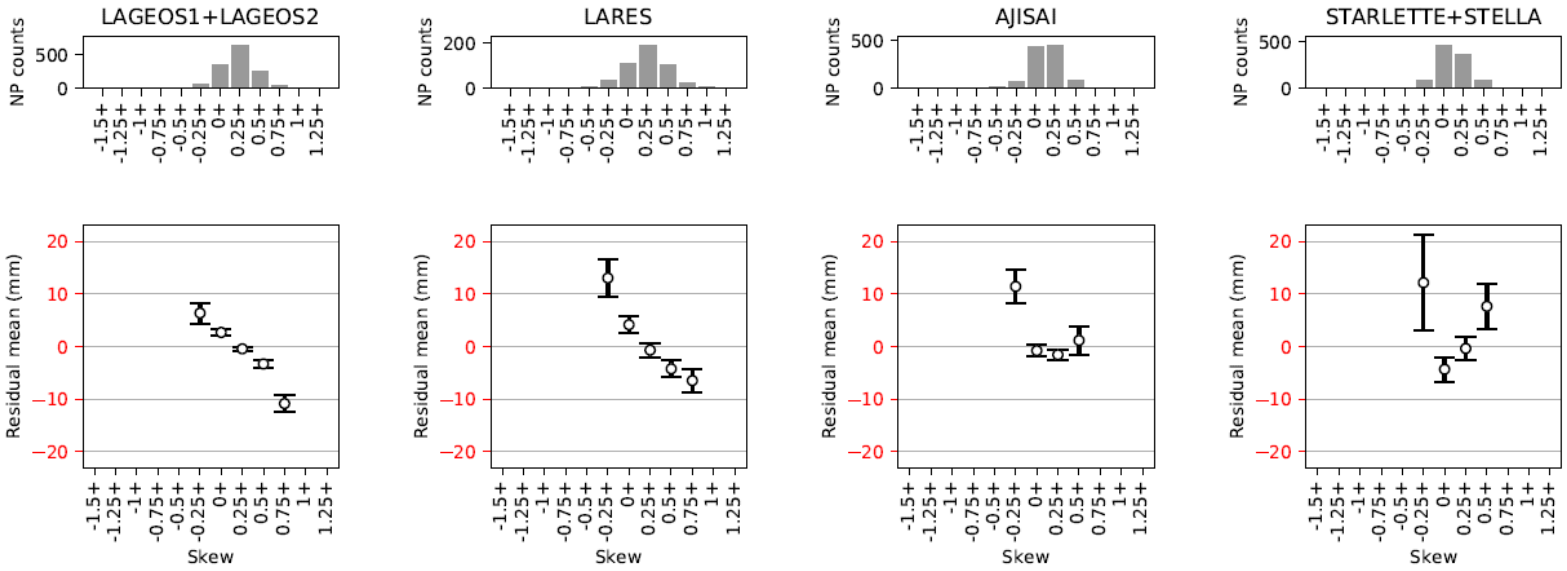




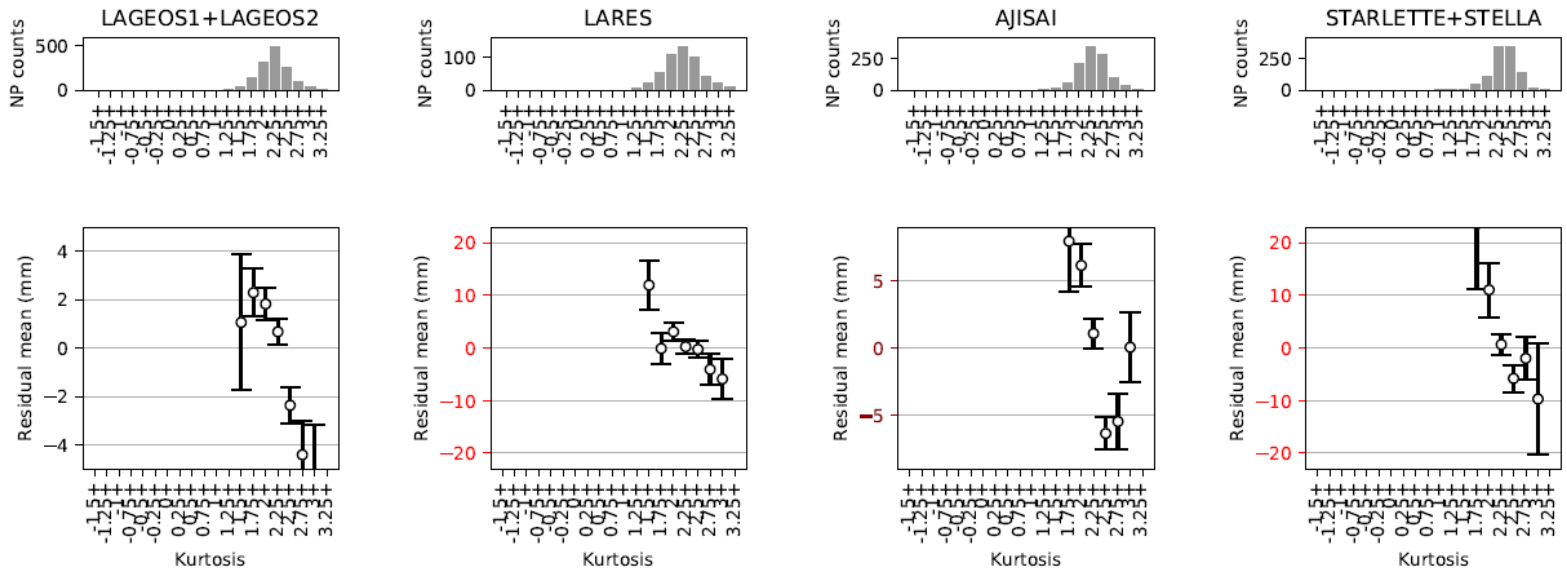


1889: wrt Skew

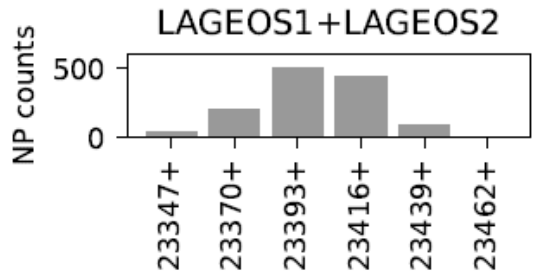
Zelenchukskya

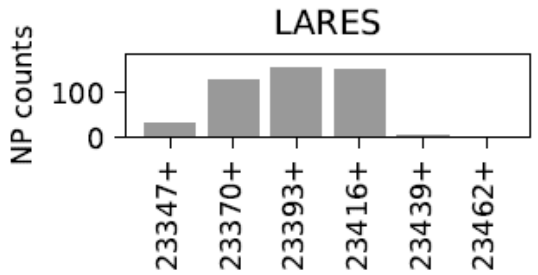


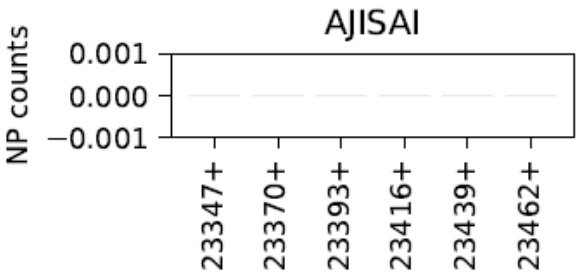
1889: wrt Kurtosis

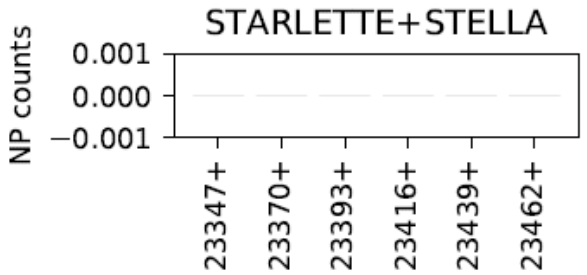


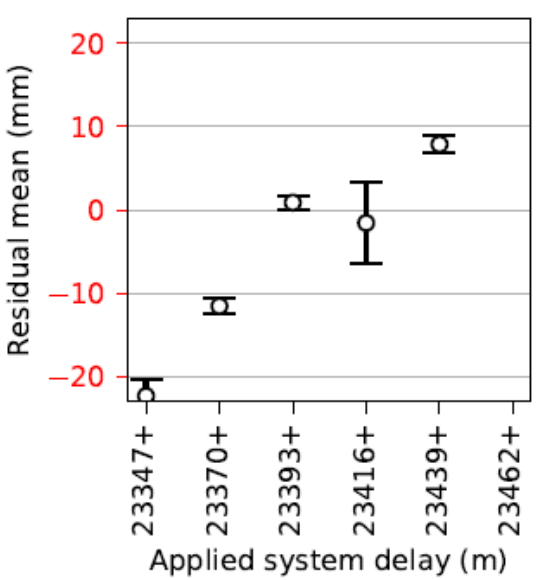
1879: wrt System delay (1)

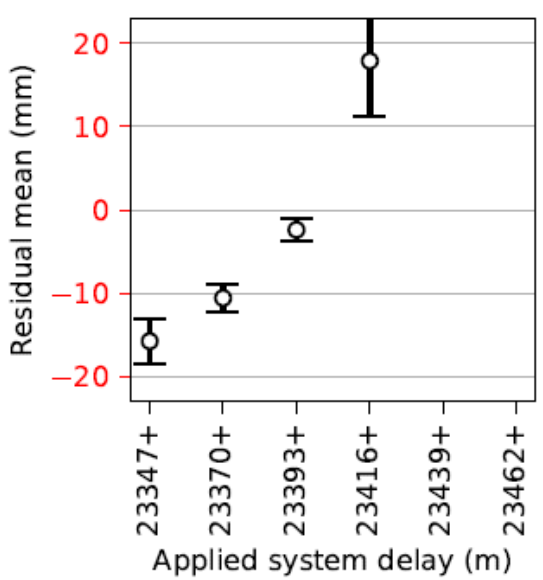


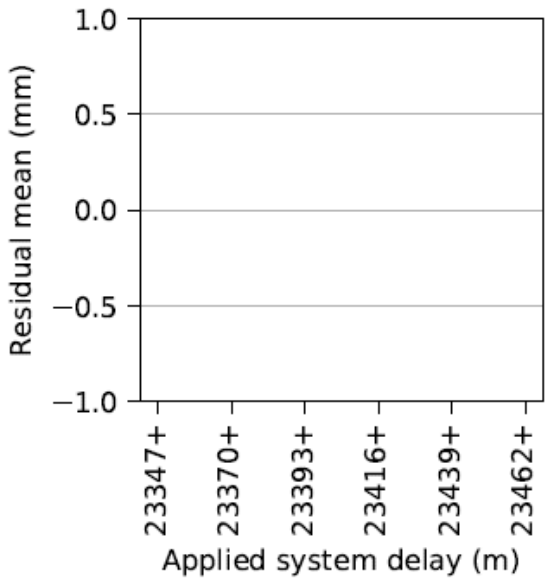


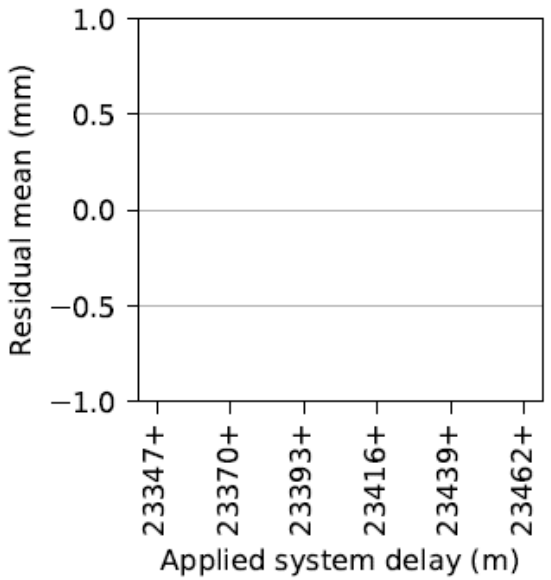




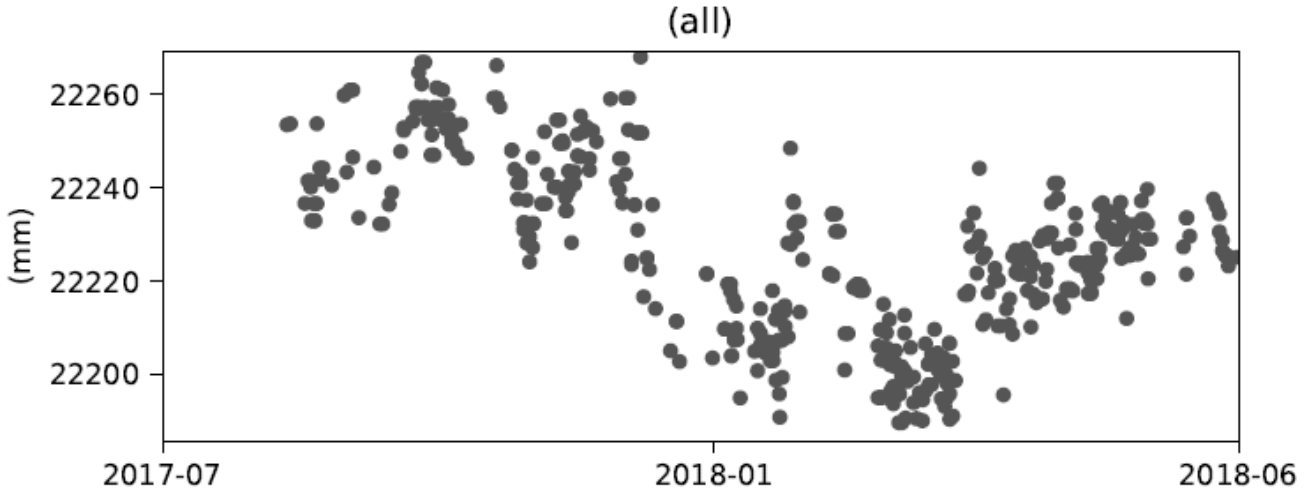




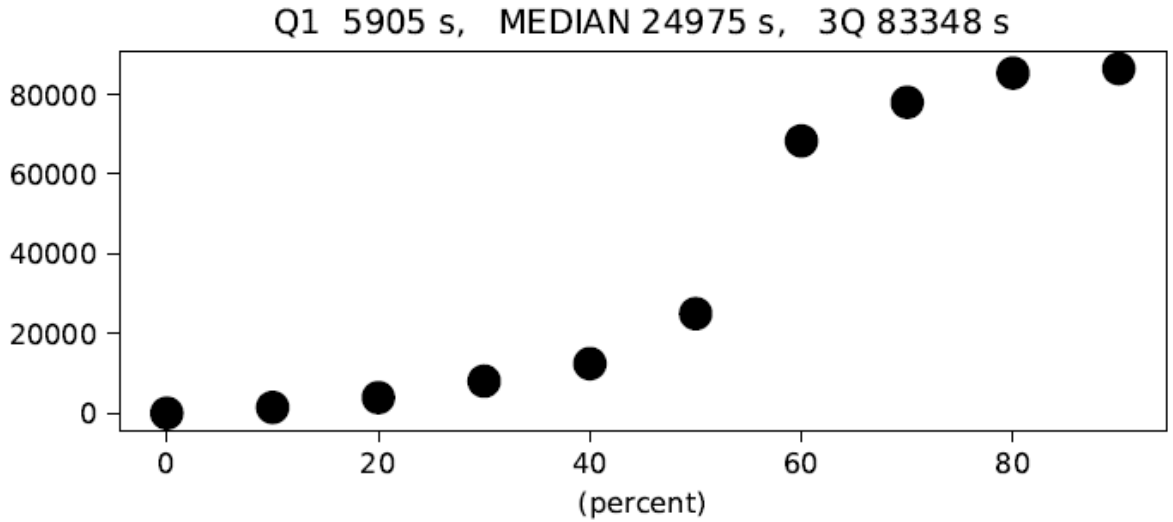




7819: System delay (all sat)



7819: Calibraton interval (cumulative)



Station-by-station statistics for 7090,7941,7825,7237,7105, 7810,7840,7110,7501,7841, 7821,8834,7839,7119,7819, 1887,7838,7249,7827,7407, 1873,1879,7845,1893,1891, 1868,1889,1886,7811 are presented in Clinic Session #3.

Summary

- Quantity

  So relying on the 2 Aussie stations: Yarragadee and Mt Stromlo.

  Largest gap in Antarctica and Equator. cf. Hattori's poster.

- Quality

  No longer pursue single shot RMS. In theory, a 10-m single-shot RMS system will suffice for the GGOS goal.

  Try to eliminate every error source in POD and Observations.

  Various systematic trends found in POD residuals.

  Long-term stability should be given importance.

- Future ILRS network

  Low cost → More stations!

Look, my station has achieved
x mm single-shot RMS
for ground-target ranging!

(Unimpressed) Sounds good.
How stable is your ground target
ranging through a day/year?

. . .

See you in the clinic session tomorrow.