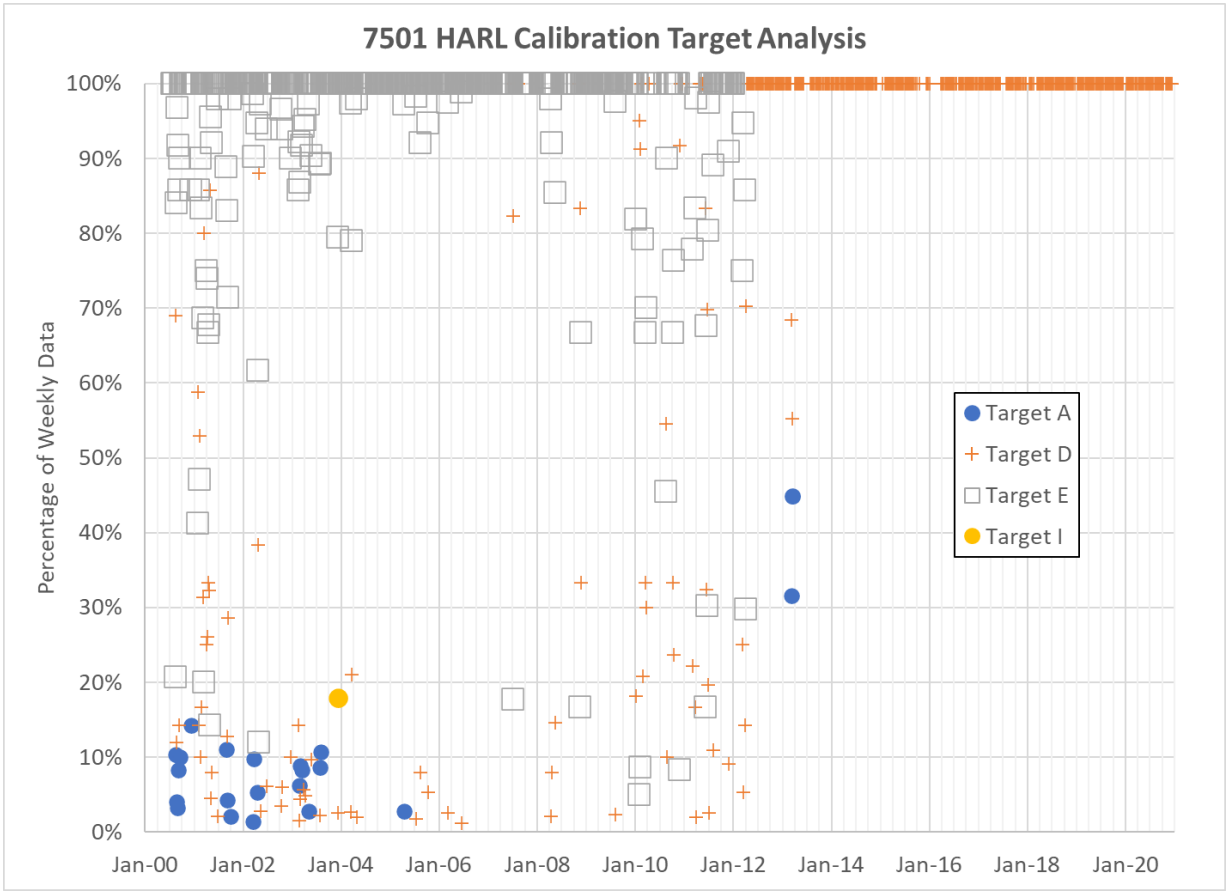
7501 HARL Analysis

ILRS Quality Control Board

Van S Husson

21-Sep-2022

7501 HARL Calibration Target Time Series

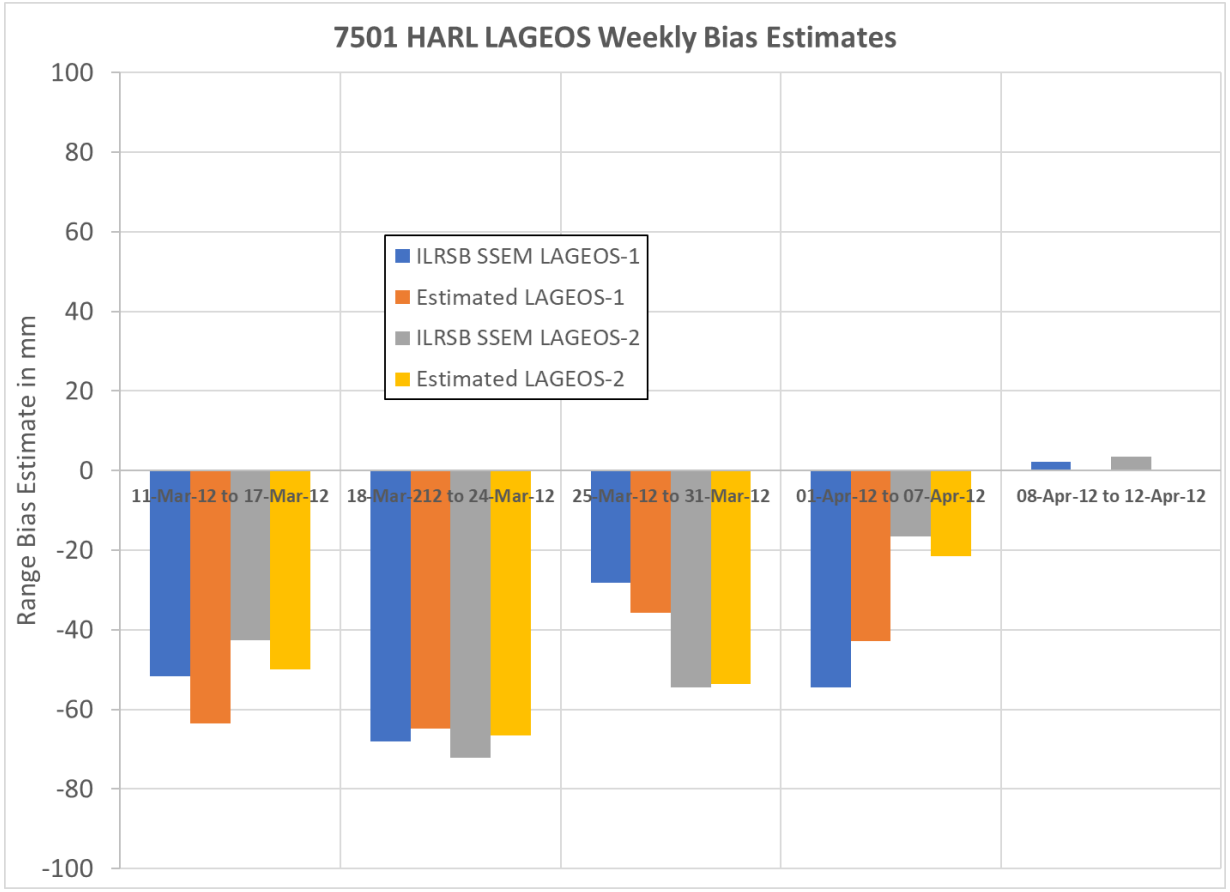


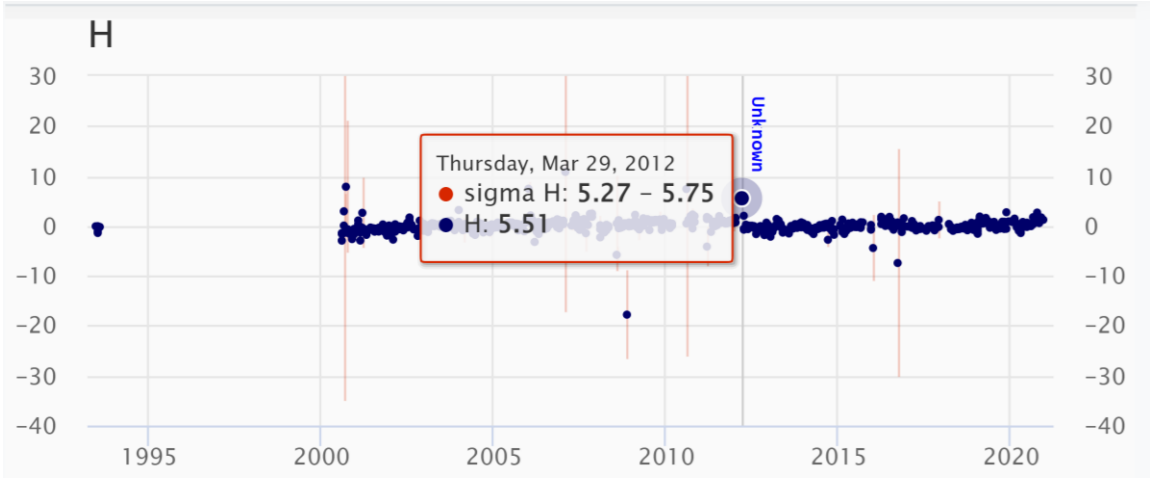
- 7501 Target E was prime before 4-Apr-2012 with Target D as the backup along with Targets A&I. Target D became prime after 4-Apr-2012.
- 7501 was down between 12-Jan-2012 and 10-Mar-2012 due to laser failure. Prior to resuming tracking on 11-Mar-2012, the calibration distance for Target E was changed by -66 mm. The bias induced by this changed was documented in the ILRS Data Handling File (See excerpt from Data Handling file below)
- Between 11-Mar-2012 to 4-Apr-2012, 7501 would alternate between targets with Target E being prime. On 4-Apr-2012, a MINICO was taken between Targets E & D with an offset of -5.4 mm after accounting for the -66 mm error. Post MINICO, 7501 discontinued the use of Target E for operations.

ILRS Data Handling File Version 27-Apr-2020

```
7501  ---  mm    A  12:071:00000  12:073:64080  R        -66.00          source VH 191219
7501  ---  mm    A  12:074:21600  12:074:79200  R        -66.00          source VH 191219
7501  ---  mm    A  12:077:57600  12:079:08400  R        -66.00          source VH 191219
7501  ---  mm    A  12:079:36000  12:080:05400  R        -66.00          source VH 191219
7501  ---  mm    A  12:080:14400  12:089:75600  R        -66.00          source VH 191219
7501  ---  mm    A  12:090:43000  12:092:07800  R        -66.00          source VH 191219
7501  ---  mm    A  12:092:64800  12:094:28800  R        -66.00          source VH 191219
```

7501 HARL LAGEOS Bias Estimates and ITRF2020 Height Residuals





LAGEOS-1 Bias Correlation	LAGEOS-2 Bias Correlation
0.78	0.98

- **Left chart contains the LAGEOS-1 and -2 range biases (ILRSB SSEM observed and estimated). The estimated biases are based on the percentage of time Target E was prime multiplied by -71.5 mm (minus 66 [calibration distance error] plus a minus 5.4 [MINICO])**
- **Right chart is a zoom of the ITRF2020 7501 height residuals. For some reason, two height residuals were not generated for the GPS weeks 11-Mar-2012 to 17-Mar-2012 and 18-Mar-2012 to 24-Mar-2012. The 7501's ITRF2020 height discontinuity coincides with the permanent calibration target switch.**

Simosato 7838 Data Analysis

Van S. Husson

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ILRS Quality Control Board

21-Sep-2022

7838 Simosato LAGEOS-1 Return Rates

```
h1 CRD 2 2022  9 13  7
h2 SISL 7838 36  3  4 ILRS
h3 lageos1 7603901 1155 8820 0 1 1
h4 1 2022  9 13  7 19 45 2022  9 13  7 30 52  0 0 0 0 1 0 2 0
h5 1 22 091200 HTS 25501
c0 0 532.000 std lzr rcv tmr swv met ctg
c1 0 lzr Nd-Yag 1064.00 1000.00 3.00 28.0 na na
c2 0 rcv mcp 532.000 na na na na na na na na na na 0
c3 0 tmr DST_FURY-10M-SP1 Agilent_5071A Eventech_A033-ET 0033027 na
c5 0 swv WSRS v116 WSRS v116
c6 0 met Ota_Keiki OW-7-420 na Ota_Keiki OW-1-1 W1121A1008 Ota_Keiki OW-4 21I00-9754
40 26752.3222524 0 std 6790 6431 0.000 144465.0 8.0 53.0 0.259 -0.021 -4.7 3 2 0 3  40.7
41 25872.1824844 0 std 3627 3423 0.000 144461.0 0.0 53.4 0.224 -0.048 -1.4 3 2 0 1  36.0
41 27547.9201229 0 std 3163 3008 0.000 144469.0 0.0 53.4 0.293 0.007 -7.9 3 2 0 2  47.9
11 26385.8945114 0.044152481699 std 2 120.0 1 41.0 0.000 0.000 0.0 0.0 0 na
11 26424.7834590 0.044092242385 std 2 120.0 8 52.0 -0.417 -1.522 41.6 0.0 0 na
11 26599.0363130 0.044144114783 std 2 120.0 4 55.0 -0.127 -1.008 6.0 0.0 0 na
11 26784.0815834 0.044773775312 std 2 120.0 3 44.0 -0.631 -1.500 18.2 0.0 0 na
11 27052.1294996 0.046682116828 std 2 120.0 7 31.0 -0.597 -0.628 30.6 0.0 0 na
50 std 41.0 -0.410 -0.953 26.0 0
```

- They replaced their detector on 9-Dec-2021, but this change did not appear to have much impact on their return rates
- LAGEOS-1 max return rate is 0.05 % from the CRD taken on 13-Sep-2022

7838 Simosato LARES-2 Return Rates

```
h1 CRD 2 2022  9 13  6
h2 SISL 7838 36  3  4 ILRS
h3 lares2 2208001 5988 53105 0 1 1
h4 1 2022  9 13  6 13 53 2022  9 13  6 16  1  0 0 0 0 1 0 2 0
h5 1 22 091200 DGF 25501
c0 0 532.000 std lzr rcv tmr swv met ctg
c1 0 lzr Nd-Yag 1064.00 1000.00 3.00 28.0 na na
c2 0 rcv mcp 532.000 na na na na na na na na na na 0
c3 0 tmr DST_FURY-10M-SP1 Agilent_5071A Eventech_A033-ET 0033027 na
c5 0 swv WSRS v116 WSRS v116
c6 0 met Ota_Keiki OW-7-420 na Ota_Keiki OW-1-1 W1121A1008 Ota_Keiki OW-4 21I00-9754
40 22493.6935830 0 std 7671 7318 0.000 144473.0 6.0 53.0 0.348 0.138 -0.9 3 2 0 3  51.5
41 20660.7125828 0 std 4285 4098 0.000 144470.0 0.0 53.4 0.344 0.082 2.8 3 2 0 1  51.0
41 23012.1015161 0 std 3386 3220 0.000 144476.0 0.0 53.4 0.351 0.193 -4.5 3 2 0 2  52.1
11 22433.9462123 0.039359546721 std 2 30.0 2 63.0 0.000 -2.000 44.7 0.0 0 na
11 22444.6616205 0.039368317300 std 2 30.0 1 31.0 0.000 0.000 0.0 0.0 0 na
11 22543.8194263 0.039543520852 std 2 30.0 2 15.0 0.000 -2.000 -10.7 0.0 0 na
11 22561.4135216 0.039592233629 std 2 30.0 1 31.0 0.000 0.000 0.0 0.0 0 na
50 std 31.0 0.000 -0.307 22.0 0
```

- **LARES-2 maximum return rate is 0.21 % from this CRD on 13-Sep-2022**
- **The LARES-2 Bin Size should be 120 seconds**

Graz 7839 Data Analysis

Van S. Husson

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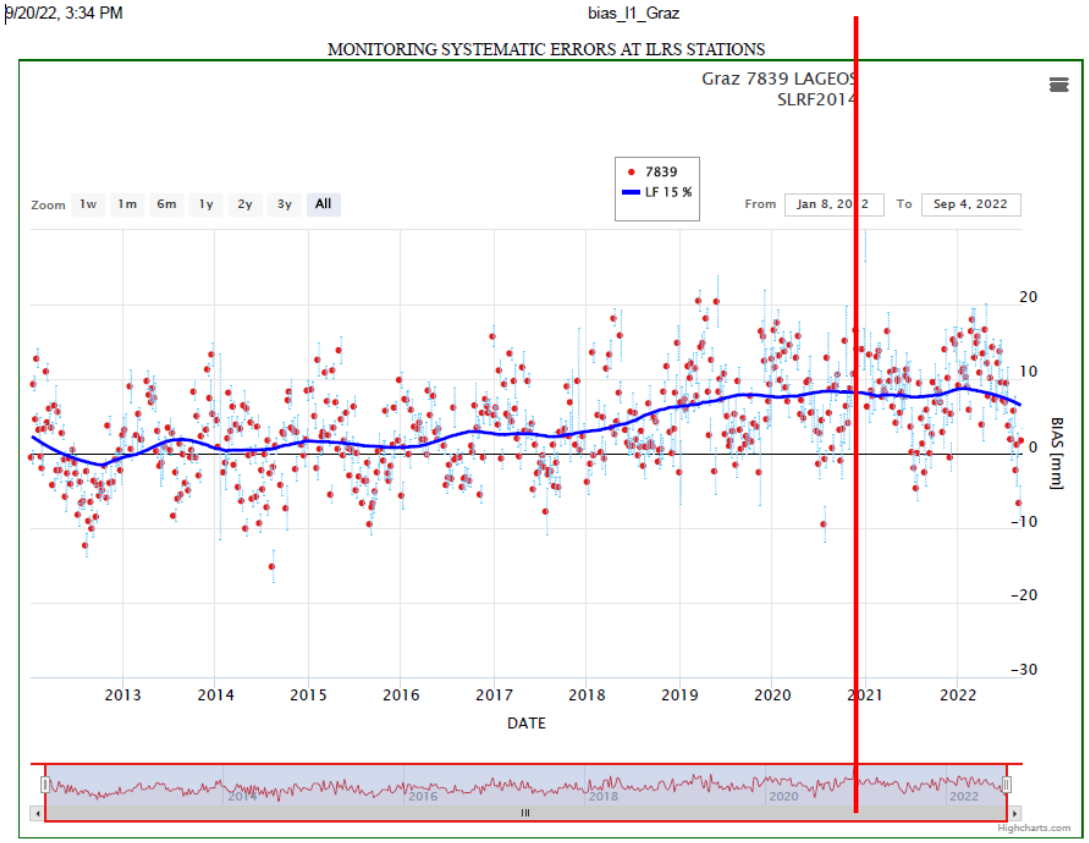
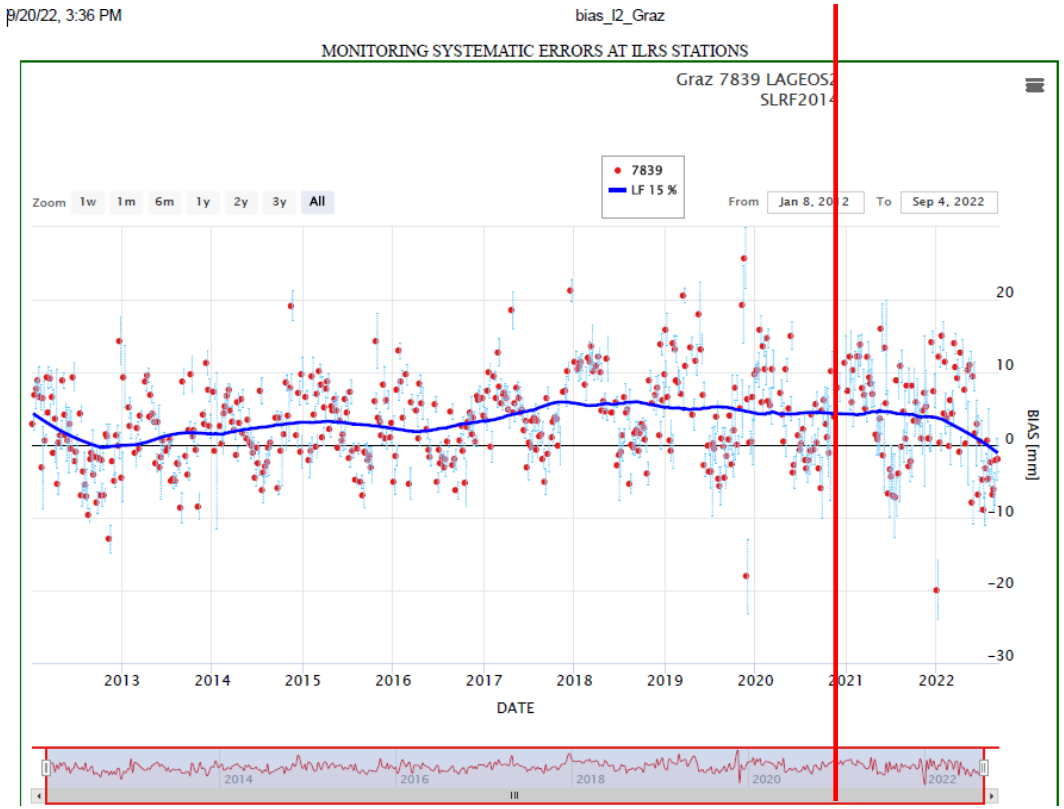
ILRS Quality Control Board

21-Sep-2022

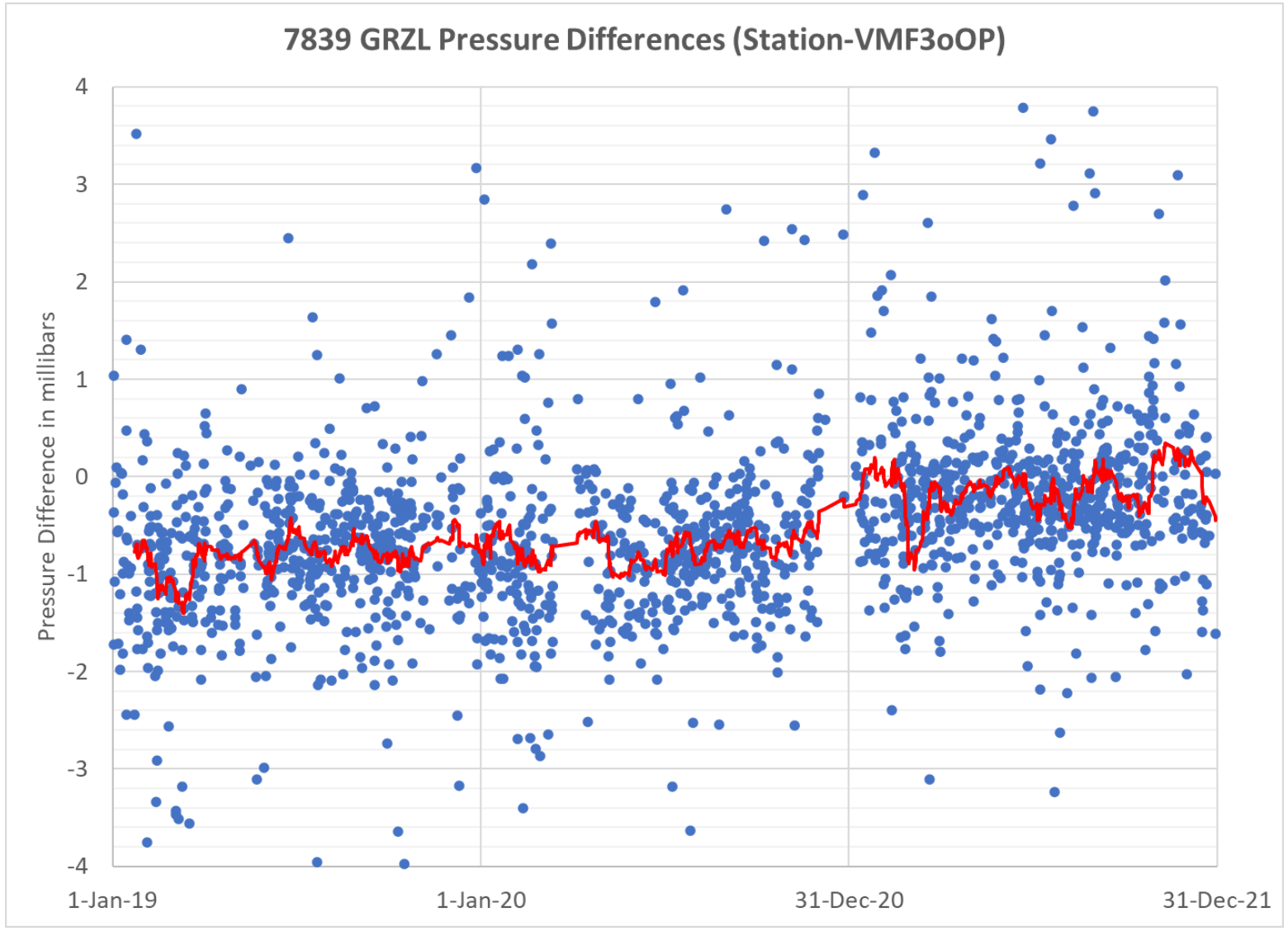
JCET Graz 7839 LAGEOS Range Biases





- The JCET LAGEOS-1 and -2 range bias estimated above (left and right chart; respectively) are based on ITRF2014 station coordinates and the original 7839 data release (i.e. release '0' with a drifting MET3 barometer). The 7839 MET3 was replaced on 10-Dec-2020 denoted by the red line.
- On 29-Jun-2022, a new laser start diode was installed.

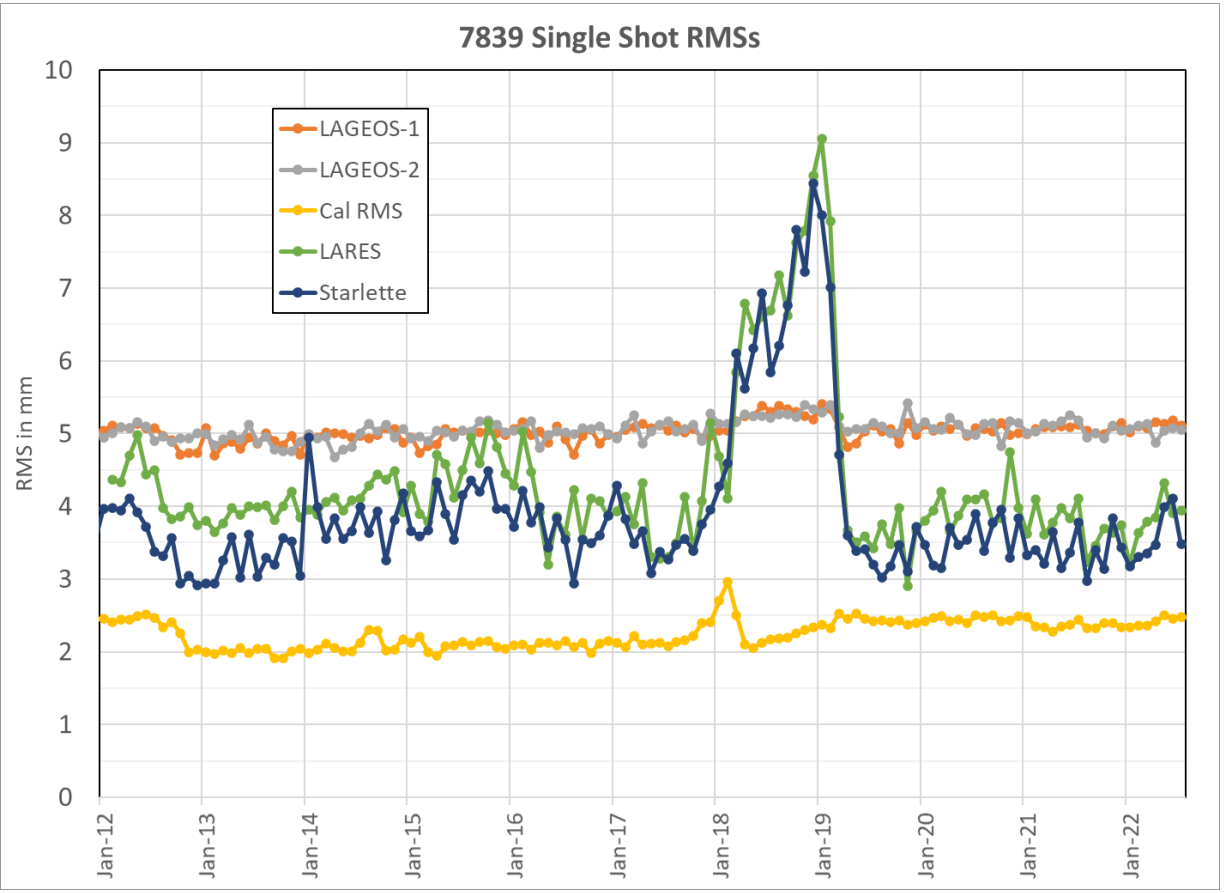
Graz 7839 Barometric Comparisons to VMF3o

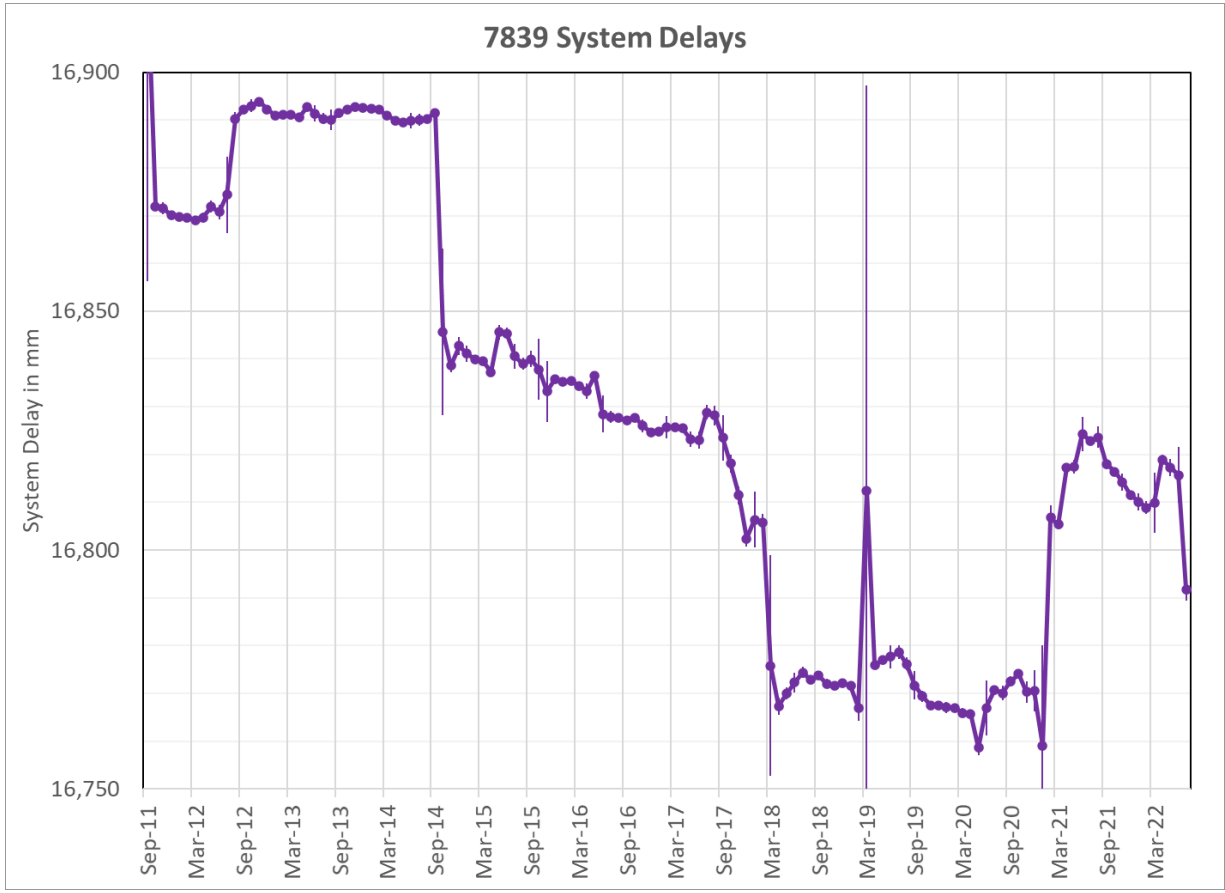


Year	Graz Pressure - VMF (mBar)	Std Dev of Pressure Differences (mBar)
2019	**-0.82**	**1.58**
2020	**-0.68**	**1.58**
2021	**-0.12**	**1.59**

- **By comparing the Graz (release '0') barometric pressures to the Vienna Mapping Function for optical wavelengths (VMF3o) confirms the Graz MET3 barometric error was corrected when it was replaced on 10-Dec-2020.**

Graz 7839 Geodetic Single Shot RMSs





- Left Chart: Single shot RMSs in 2020 to 2022 appear nominal and are relatively stable.
- On 19-Mar-2021, Lambda/4 re-installed, circular polarization.
- On 29-Jun-2022, a new laser start diode was installed, the system delay decreased by 25 mm. This appears to be around the same time the LAGEOS range bias decreased.

Instituto Geográfico Nacional
Centro Nacional de Información Geográfica

Updates to the centre of mass corrections in preparation for ITRF2020 products

José Rodríguez
IGN-Yebes ASC
Sep 21, 2022

Gobierno de España · Ministerio de Transportes, Movilidad y Agenda Urbana · Instituto Geográfico Nacional
Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"
Infraestructuras Científicas y Técnicas Singulares
YEBES

Where are we

- For the final run of the PP on systematic errors, and the first batch of REPRO2020 solutions (1993–2020), the CoM version adopted was v200608
- For the ITRF2020 reanalysis, the ASC was asked to deliver solutions for the 1983–1993 period, valuable for the computation of the different global TRF solutions (IGN, DGFI, JPL)
- Given the inferior quality of the observations, and the sparse information available, a coarse approach was followed to provide the corrections for several missing pre-ILRS stations → v210511 adopted for the reanalysis
- The ILRS ASC will soon transition to ITRF2020 standards for their daily and weekly products
- Recent station updates and missing stations motivate the last update of the corrections

Updates

- Christian Schwatke's automatic service emails me every time there is a site log change, with all the details
- If changes do not impact the CoM computation, they are ignored
- Otherwise I archive them for future inspection
- 17 stations were in the list for examination in this update:

  1824, 7080, 7105, 7110, 7124, 7249, 7396, 7701 (new), 7816 (new),

  7821, 7824, 7825, 7838, 7839, 7841, 7941, 8834

- Only the changes in 10 stations required a recomputation:

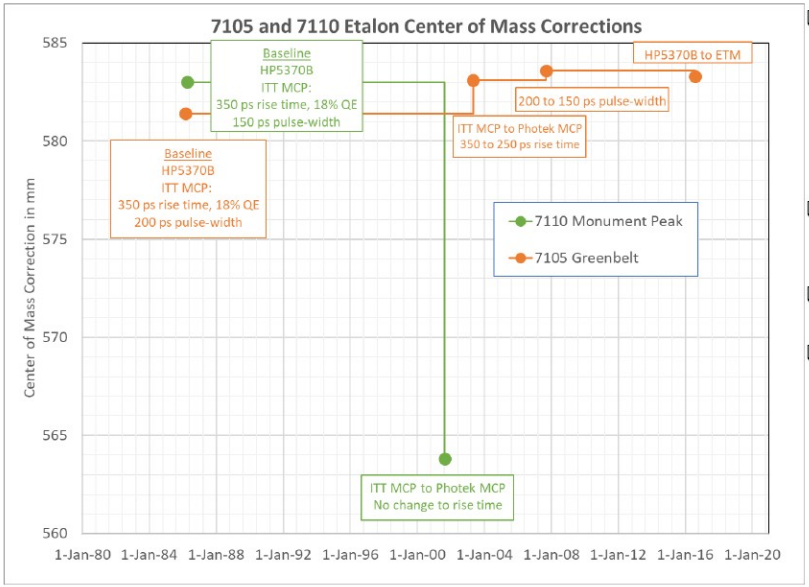
  7110, 7124, 7249, 7396, 7701 (new), 7821, 7824, 7838, 7941, 8834

Updates

- Some stations were contacted for clarifications
  - Replies from 1824 GLSL, 7249 BEIL, 7821 SHA2, 8834 WTZL
  - No reply yet from 7396 JFNL (minor issue)
- The changes detailed in the site logs were very minor, e.g. slight changes in laser pulse widths or detector jitter
- I fixed some minor inconsistencies in my logs, discovered while checking the new changes
- I updated the NP database to estimate return rates for the latest system configurations
- The results are not very exciting *[boo!]*…which means that minor changes don't derail the model *[yay!]*

The interesting case: 7110

7110 and 7105 Etalon CoMs



- This is a time series of 7110 (MOBLAS-4) and 7105 (MOBLAS-7) Etalon CoM corrections. The system configuration changes are annotated inside the boxes. Based on the 7110 MCP-PMT change there was a 20 mm drop in the MOBLAS-4 CoM correction on 19-August-2001
- 7110 and 7105 currently have the same system configuration, but the CoM corrections are quite different
- Did the 20 mm drop in the 7110 Etalon CoM impact the estimated range bias?
- If the CoM correction is in error by 'z', it will induce an apparent range bias = 'z'. For example, if the CoM is too small by 1 mm, it will induce an apparent -1 mm range bias.

4

Van Husson. *CoM and SSEM Range Bias Analysis.* QCB presentation

The interesting case: 7110

- Confirmed anomaly in the modelling chain:
  - Single variable that defines the discriminator threshold in multi-photon stations
- This is not computed automatically, but adjusted manually according to the best agreement with the NP RMS
- Set to 1, 2, or 3 photoelectrons. Probably there is no 1:1 equivalent to a tunable accesible by stations (they set voltages)
- Big impact for large targets → Etalon, Ajisai
- Reason for odd value compared to rest of MOBLAS unclear, it seems clear now that it should be the same

The interesting case: 7110

LAGEOS-1 (old/new values)

```
7110 15 08 1983 31 03 1986  com  243.6
7110 31 03 1986 19 08 2001  com  245.6
7110 19 08 2001 01 01 2050  com  244.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com  244.7
7110 31 03 1986 19 08 2001  com  245.8
7110 19 08 2001 01 01 2050  com  245.7
```

LAGEOS-2 (old/new values)

```
7110 31 03 1986 19 08 2001  com  245.4
7110 19 08 2001 01 01 2050  com  243.9
-----------------------------------------
7110 31 03 1986 19 08 2001  com  245.3
7110 19 08 2001 01 01 2050  com  245.2
```

LARES (old/new values)

```
7110 19 08 2001 01 01 2050  com  130.0
-----------------------------------------
7110 19 08 2001 01 01 2050  com  130.1
```

ETALON-1 (old/new values)

```
7110 31 03 1986 19 08 2001  com  583.0
7110 19 08 2001 01 01 2050  com  563.8
-----------------------------------------
7110 31 03 1986 19 08 2001  com  583.3
7110 19 08 2001 01 01 2050  com  583.4
```

STARLETTE (old/new values)

```
7110 15 08 1983 31 03 1986  com   75.5
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   75.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com   75.8
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   76.2
```

AJISAI (old/new values)

```
7110 15 08 1983 31 03 1986  com  981.1
7110 31 03 1986 19 08 2001  com  994.5
7110 19 08 2001 01 01 2050  com  983.1
-----------------------------------------
7110 15 08 1983 31 03 1986  com  992.9
7110 31 03 1986 19 08 2001  com  995.0
7110 19 08 2001 01 01 2050  com  996.9
```

The interesting case: 7110

LAGEOS-1 (old/new values)

```
7110 15 08 1983 31 03 1986  com  243.6
7110 31 03 1986 19 08 2001  com  245.6
7110 19 08 2001 01 01 2050  com  244.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com  244.7
7110 31 03 1986 19 08 2001  com  245.8
7110 19 08 2001 01 01 2050  com  245.7
```

LAGEOS-2 (old/new values)

```
7110 31 03 1986 19 08 2001  com  245.4
7110 19 08 2001 01 01 2050  com  243.9
-----------------------------------------
7110 31 03 1986 19 08 2001  com  245.3
7110 19 08 2001 01 01 2050  com  245.2
```

LARES (old/new values)

```
7110 19 08 2001 01 01 2050  com  130.0
-----------------------------------------
7110 19 08 2001 01 01 2050  com  130.1
```

ETALON-1 (old/new values)

```
7110 31 03 1986 19 08 2001  com  583.0
7110 19 08 2001 01 01 2050  com  563.8
-----------------------------------------
7110 31 03 1986 19 08 2001  com  583.3
7110 19 08 2001 01 01 2050  com  583.4
```

STARLETTE (old/new values)

```
7110 15 08 1983 31 03 1986  com   75.5
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   75.6
-----------------------------------------
7110 15 08 1983 31 03 1986  com   75.8
7110 31 03 1986 19 08 2001  com   76.1
7110 19 08 2001 01 01 2050  com   76.2
```

AJISAI (old/new values)

```
7110 15 08 1983 31 03 1986  com  981.1
7110 31 03 1986 19 08 2001  com  994.5
7110 19 08 2001 01 01 2050  com  983.1
-----------------------------------------
7110 15 08 1983 31 03 1986  com  992.9
7110 31 03 1986 19 08 2001  com  995.0
7110 19 08 2001 01 01 2050  com  996.9
```

The interesting case: 7110

- Double win:
  - Corrected Etalon 20 mm error (and Ajisai 14 mm)
  - Found out reason for the strange value → other instances lurking in the data?

The rest: boring

- Very small differences (mostly sub-mm), as expected from the modest system changes
- Exception for LAGEOS:
  - 7821 SHAO2 tweaked leading edge filter in 2021
  - ~3.4 mm difference in both LAGEOS and LAGEOS-2
  - Probably too early to tell if correct
- The adoption of this latest udpate should be quite painless
- I will upload it to the Yebes Observatory website soon

Riga 1884 Validation

(Preliminary Results)

E. C. Pavlis & M. Kuzmicz-Cieslak

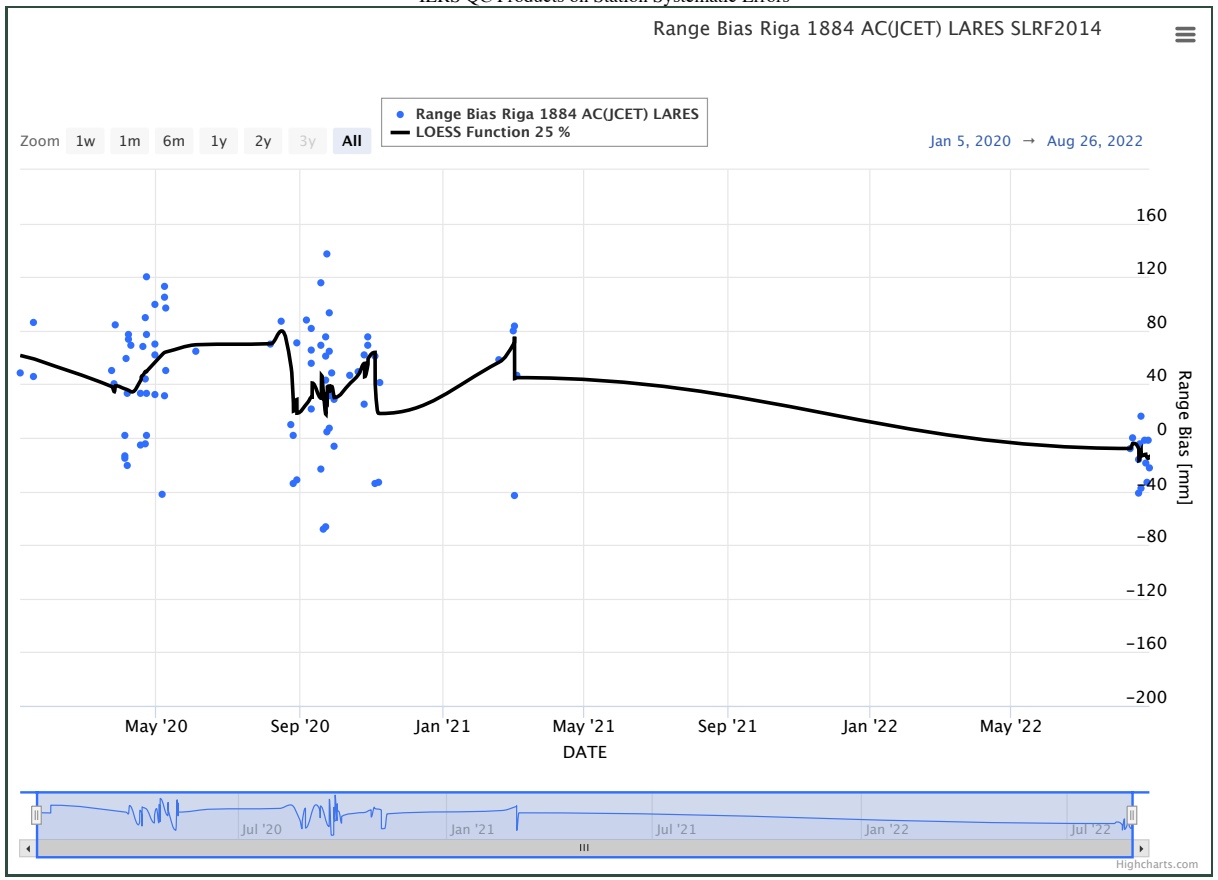
GESTAR II/UMBC

September 6, 2022

Riga (1884) QC Bias History

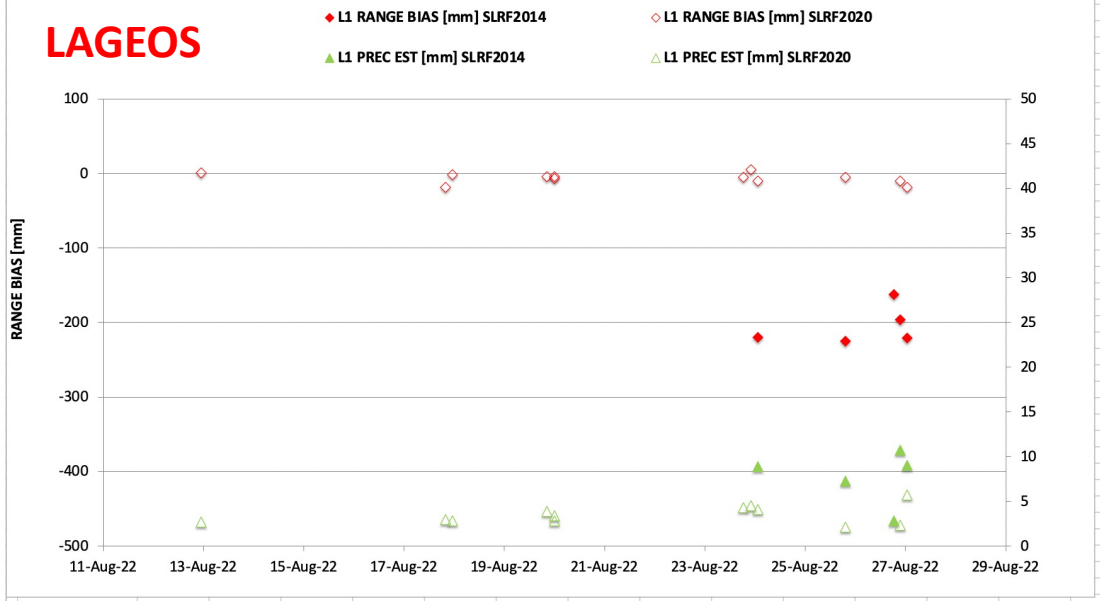
ILRS QC Products on Station Systematic Errors

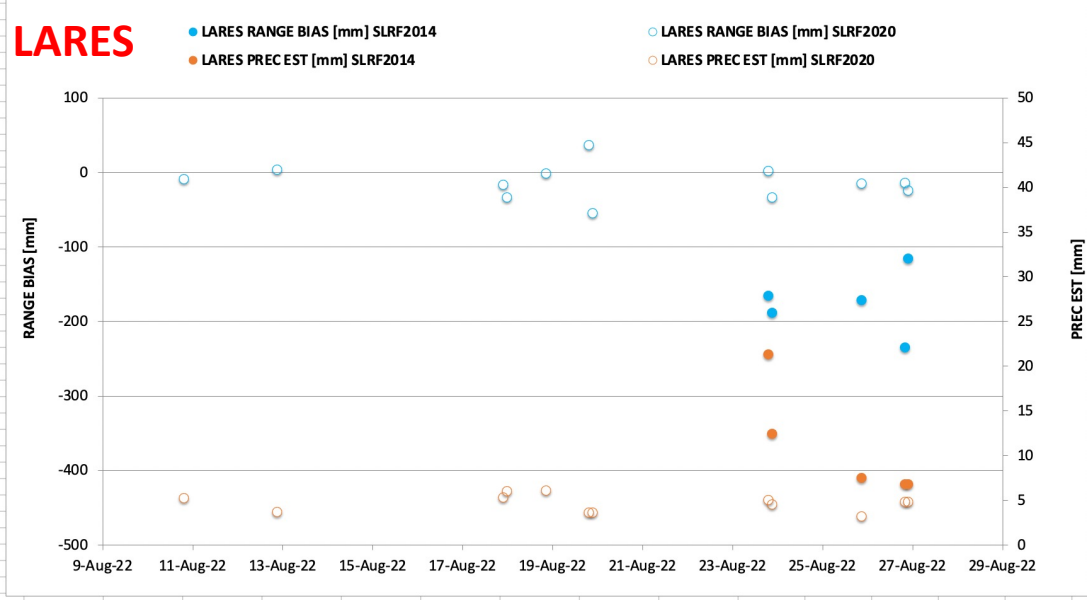
ILRS QC Products on Station Systematic Errors



Riga (1884) Validation: *SLRF2014 vs. SLRF2020*

2022.09.06
SLRF2014 vs SLRF2020





18844401SLRF2014	PREC EST [mm]	RANGE BIAS [mm]
Mean	7.7	-204.9
STD	3.0	26.3
RMS	8.2	206.2
Passes	5	5

18844401SLRF2020	PREC EST [mm]	RANGE BIAS [mm]
Mean	11.0	-175.5
STD	6.2	43.2
RMS	12.3	179.7
Passes	5	5

Values	L1	LR
Accpted	39	207
Obs.	16	12
Passes	5	5

18844401SLRF2020	PREC EST [mm]	RANGE BIAS [mm]
Mean	3.5	-6.6
STD	1.1	7.1
RMS	3.6	9.5
Passes	12	12

18844401SLRF2020	PREC EST [mm]	RANGE BIAS [mm]
Mean	4.7	-13.6
STD	1.0	23.0
RMS	4.7	25.9
Passes	12	12

Values	L1	LR
Accpted Obs.	148	207
Obs.	2	12
No. of Passes	13	12

San Fernando (7824) ETU vs TIU Comparison

M. Kuzmicz-Cieslak and E. C. Pavlis

July 27, 2022

San Fernando (7824) TIU Upgrade to ETU

- Manuel Sánchez Piedra contacted us about a possible characterization of their installation of an event timer unit (ETU) which will replace their outdated time interval counter unit (TIU);
- We described to Manuel how NASA handled this issue and the setup that we would ideally want him to replicate;
- After a review of the NASA setup the station team decided that this was not applicable at their installation, so we suggested that they try collect data at “nearly” the same time with each of the units;
- We were provided with full rate (FRD) and normal point (NPT) data collected on LAGEOS, LAGEOS-2, LARES, Starlette and Larets generally from the same pass in each case using both units sequentially (in most cases observing same pass in two parts);
- The data span the period mid-May to early December 2021, but some of the satellites are tracked only over much shorter time periods.

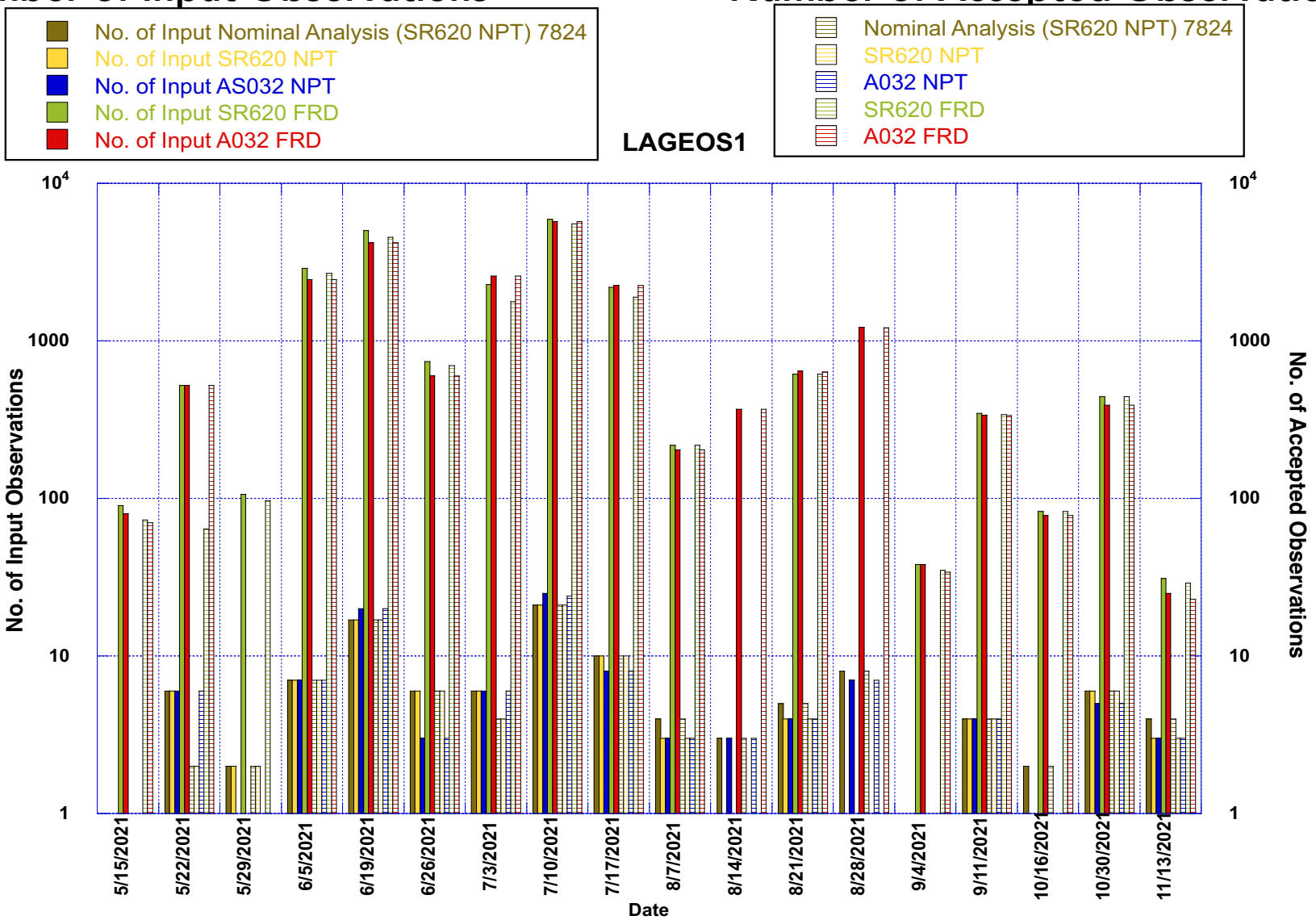
Data Analysis Approach

- Since we do not have the same observations measured by both timing units but the data come largely from the same passes, it was decided to use the operational precise orbits for these arcs and pass all the data from each group, adjusting only for a bias per arc for each group of data independently;
- We generated four groups of data from each of the LAGEOS, LAGEOS-2, LARES and Starlette passes (we do not process Larets), one for FRD and one for NPT in each case;
- To discriminate between each set we assigned different (similar) station ID Nos. to each one:
  - 2824 A032 FRD
  - 3824 A032 NPT
  - 4824 SR620 FRD
  - 5824 SR620 NPT
  - 7824 used for the nominal ILRS Daily series product
- The same color coding is used throughout this report in charts and tables

LAGEOS 1

Number of Input Observations

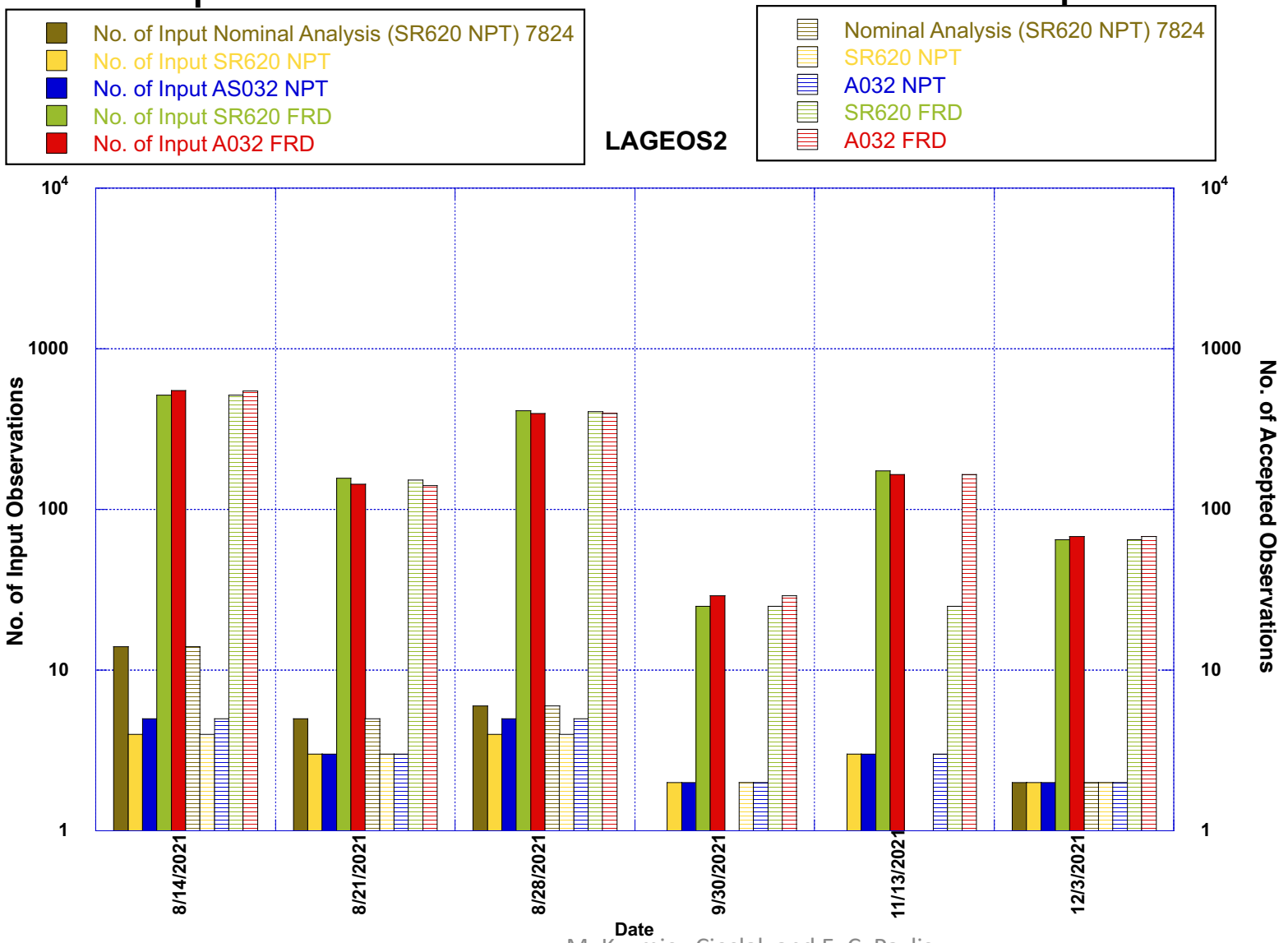
Number of Accepted Observations



LAGEOS 2

Number of Input Observations

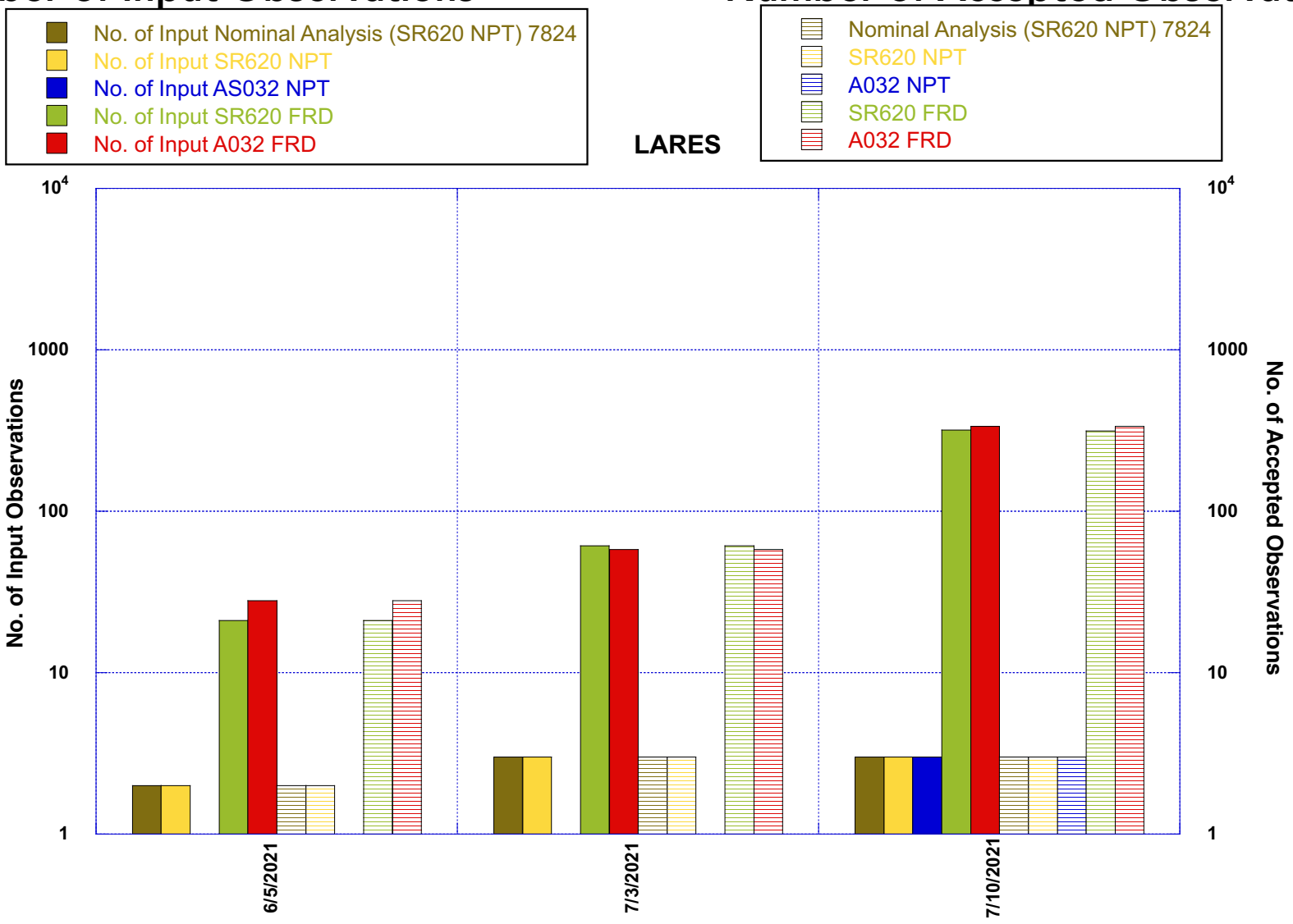
Number of Accepted Observations



LARES

Number of Input Observations

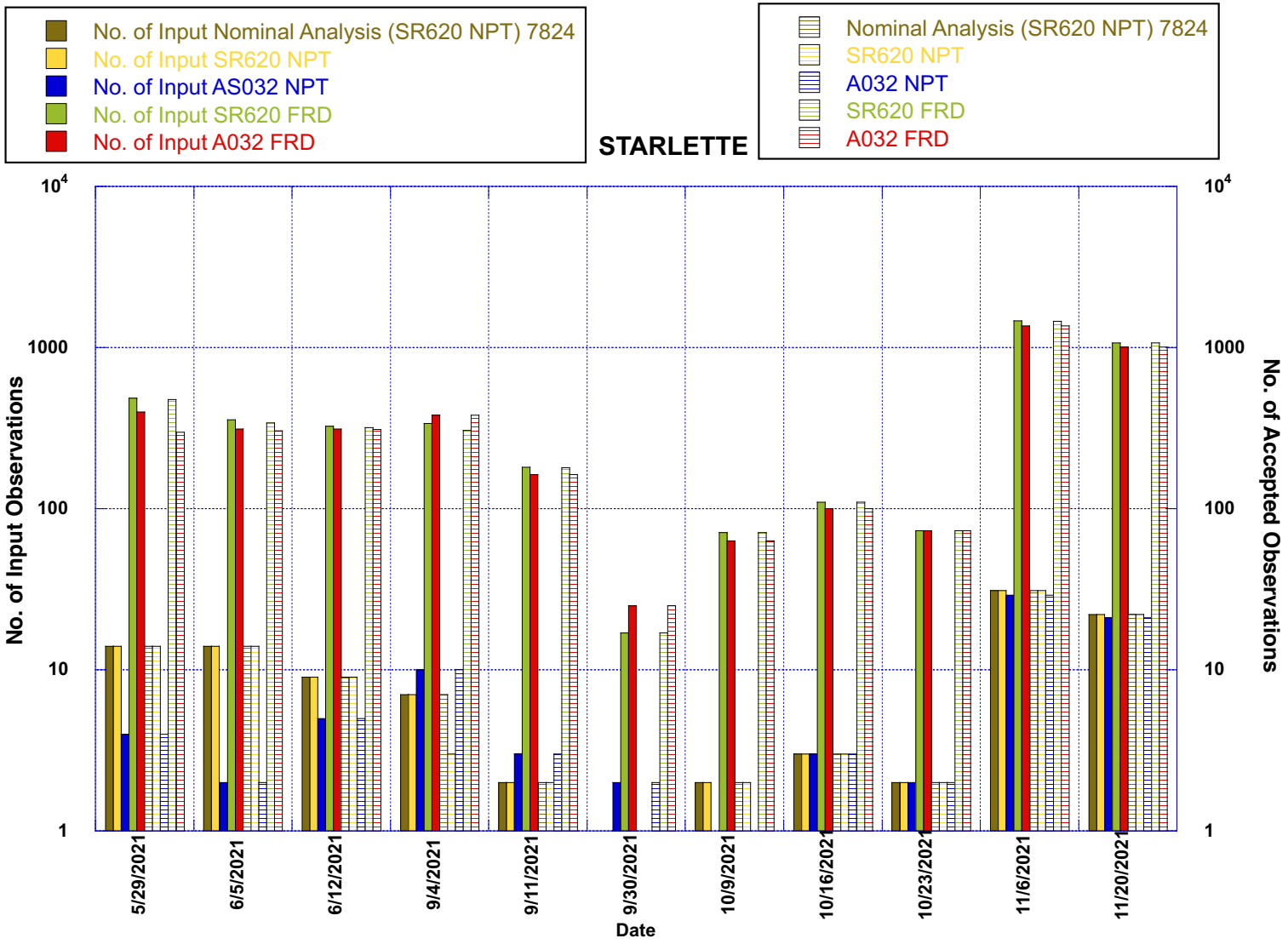
Number of Accepted Observations



Starlette

Number of Input Observations

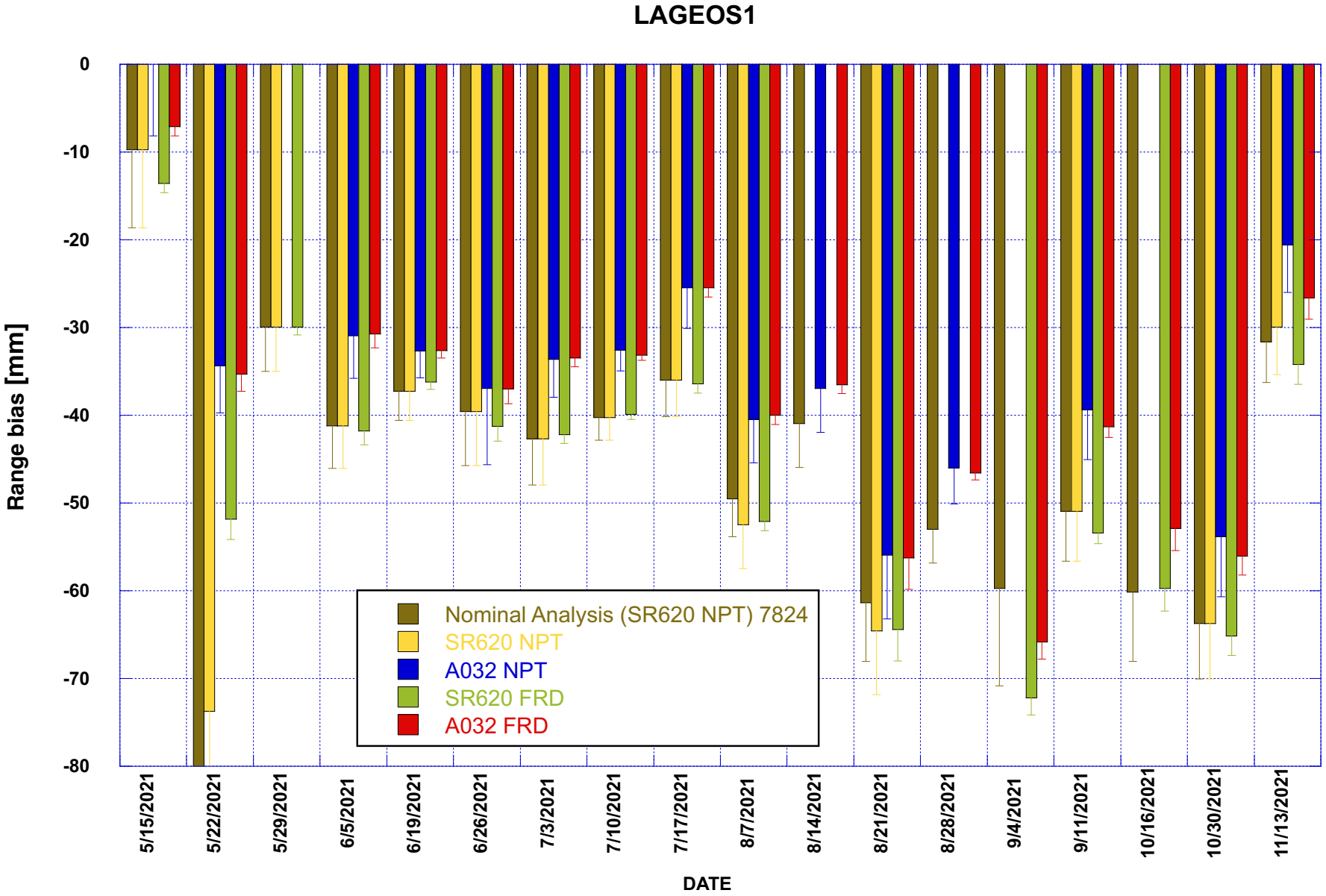
Number of Accepted Observations



Data Examination Summary

- In general, we do not have a significant number of arcs to draw firm, robust conclusions;
- The LAGEOS 1 data are the best of the four satellites, with Starlette next in line;
- LARES has only three arcs, of which, only one has a reasonable data content and it is the only one with all four groups of data present;
- All data are rather clean, editing does not remove but very few ranges in all cases.

Independent Range Biases Estimated from Each Data Group from the Same Orbit



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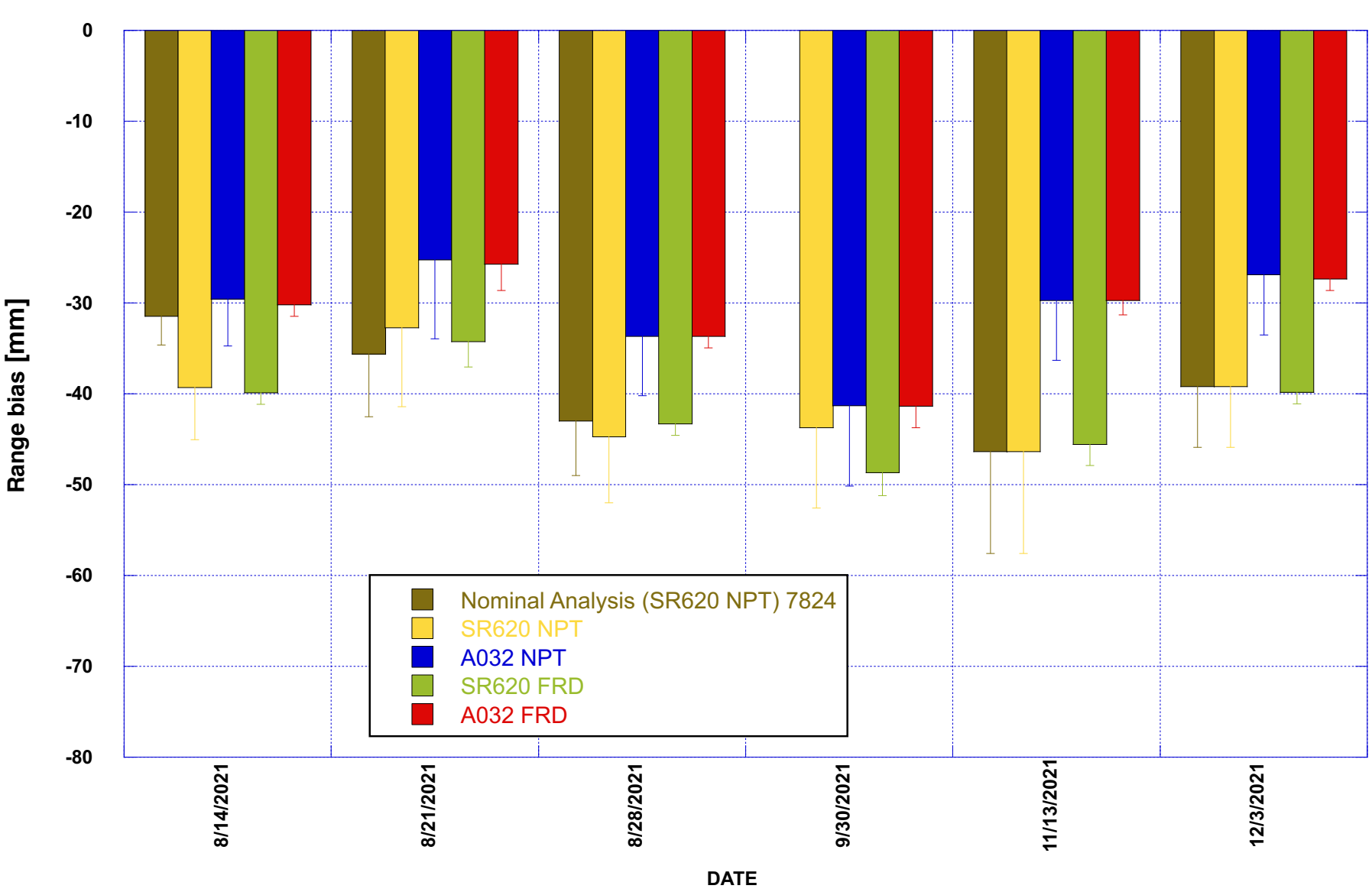

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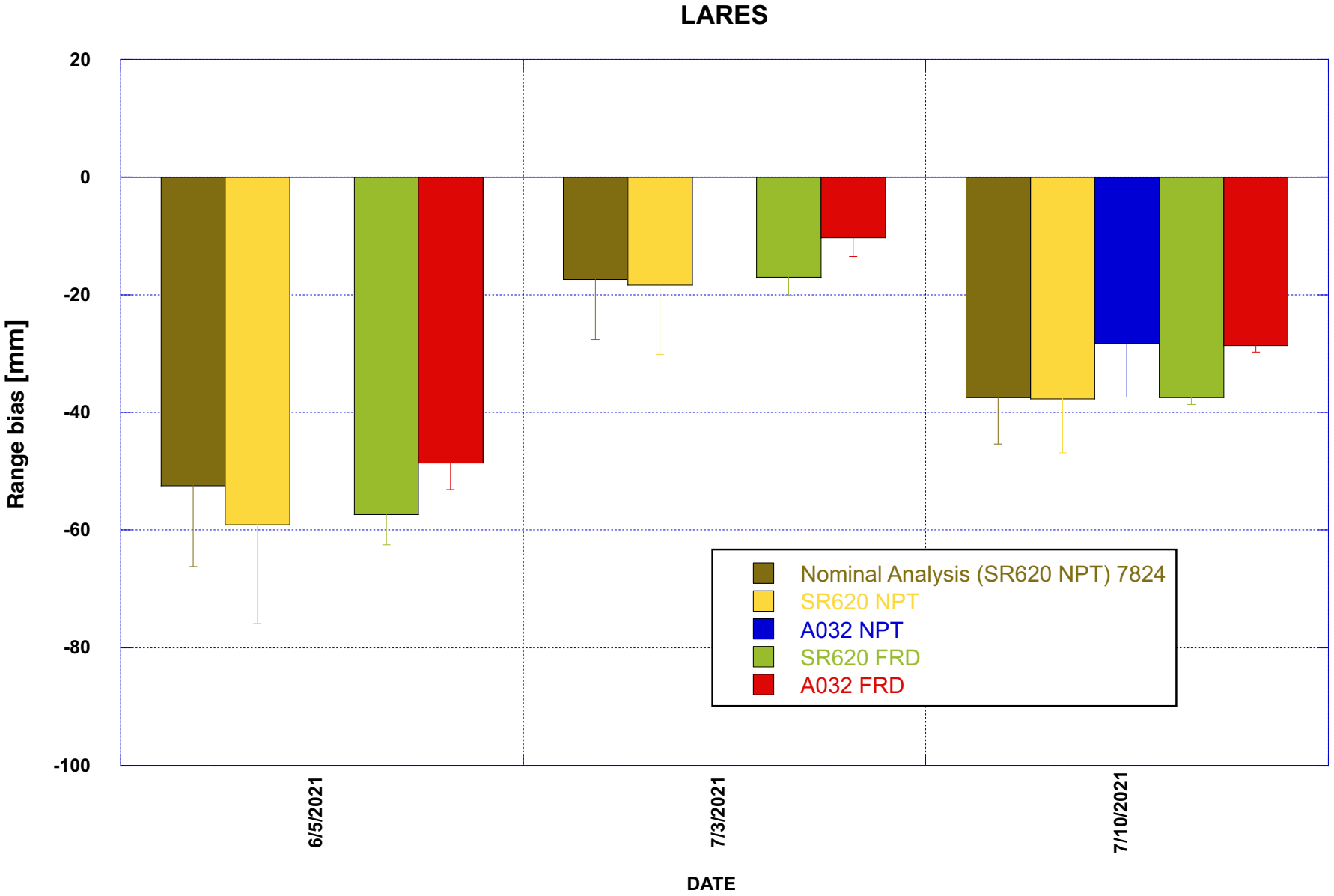

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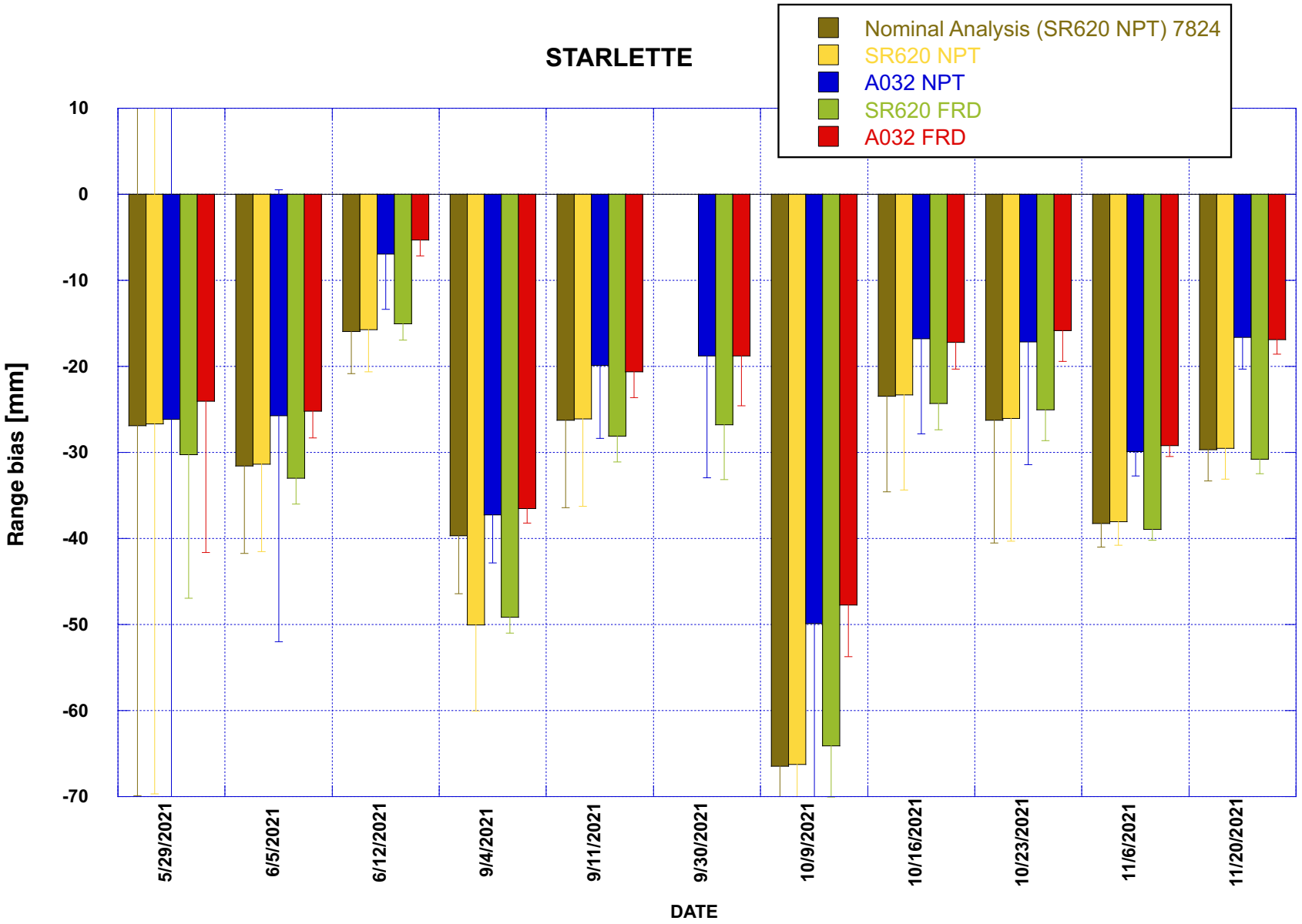


ΔBias Examination Summary

- With the additional data release, we now have sufficient number of arcs to draw some meaningful, if not entirely robust conclusions;
- As expected, the LAGEOS 1 data are the best of the four satellites, with 16 out of 18 arcs having robust estimates, Starlette is second;
- Arcs with a good data distribution in sufficient numbers result in very similar bias estimates for data of the same timing unit used, i.e. A032 or SR620, irrespective of their pedigree, i.e. whether FRD or NPT;
- The SR620 results agree in all cases with the nominal analysis bias estimates since they are essentially the same data.
- We have formed the differences of the estimated biases of like-type data from each of the two TUs and calculated their statistics whenever possible, for each of the four satellites (following tables).

Range Bias Differences Between ETU (A032) and TIU (SR620) SLR data from San Fernando (7824)

LAGEOS & LAGEOS-2

ARC Date	Full Rate Data (FRD) A032 – SR620 [mm]	Normal Point Data (NPT) A032 – SR620 [mm]
5/15/21	6.49	10.45
5/22/21	16.56	39.34
5/29/21	29.94	29.94
6/5/21	11.05	10.25
6/19/21	3.59	4.58
6/26/21	4.27	2.59
7/3/21	8.76	9.04
7/10/21	6.72	7.7
7/17/21	10.95	10.55
8/7/21	12.13	12.04
8/14/21	---	---
8/21/21	8.16	8.64
8/28/21	---	---
9/4/21	6.38	---
9/11/21	12.12	11.59
10/16/21	6.89	---
10/30/21	9.13	9.9
11/13/21	7.55	9.38
Mean and Std. Dev. (count)	10.04 ± 6.04 (16)	12.57 ± 9.51 (14)

ARC Date	Full Rate Data (FRD) A032 – SR620 [mm]	Normal Point Data (NPT) A032 – SR620 [mm]
8/14/21	9.69	9.71
8/21/21	8.5	7.48
8/28/21	9.62	11.04
9/30/21	7.29	2.39
11/13/21	15.85	16.65
12/3/21	12.44	12.36
Mean and Std. Dev. (count)	10.57 ± 2.83 (6)	9.94 ± 4.38 (6)

Range Bias Differences Between ETU (A032) and TIU (SR620) SLR data from San Fernando (7824)

Starlette & LARES

ARC Date	Full Rate Data (FRD) A032 – SR620 [mm]	Normal Point Data (NPT) A032 – SR620 [mm]
5/29/21	6.17	0.55
6/5/21	7.78	5.65
6/12/21	9.77	8.79
9/4/21	12.65	12.81
9/11/21	7.49	6.18
9/30/21	8	---
10/9/21	16.41	16.38
10/16/21	7.1	6.52
10/23/21	9.2	8.9
11/6/21	9.74	8.13
11/20/21	13.9	12.88
Mean and Std. Dev. (count)	9.84 ± 3.20 (11)	8.68 ± 4.48 (10)

ARC Date	Full Rate Data (FRD) A032 – SR620 [mm]	Normal Point Data (NPT) A032 – SR620 [mm]
6/5/21	8.77	---
7/3/21	6.69	---
7/10/21	8.88	9.53
Mean and Std. Dev. (count)	8.11 ± 1.01 (3)	--

Absolute Bias Estimates by Group of Data

- Absolute bias estimates seem to be consistent with respect to the timing unit used:
  - A032 bias estimates, whether for FRD or NPT data are fairly close to each other, in the range -24 to -39 mm with varying std. deviations by satellite, mainly due to vastly different data amounts
  - SR620 bias estimates fo r LAGEOS 1 & 2 are in the range -41 to -46 mm again whether for FRD or NPT data, but the Starlette & LARES results seem to favor a lower bias of -23 to -38 mm across all groups of data, almost a full 10 mm smaller that the LAGEOSs.
- **Negative** GEODYN bias means the station **measures short**
- **Positive** GEODYN bias means the station **measures long**

Satellite	Nominal Analysis 7824	A032 NPT 3824	SR620 NPT 5824	A032 FRD 2824	SR620 FRD 4824
LAGEOS 1	-53.03 ± 39.55	-34.59 ± 13.10	-43.71 ± 15.90	-38.63 ± 13.53	-45.89 ± 14.66
LAGEOS 2	-39.13 ± 5.27	-31.07 ± 5.28	-41.00 ± 4.55	-31.34 ± 5.12	-41.90 ± 4.62
STARLETTE	-32.44 ± 13.08	-24.09 ± 11.18	-33.30 ± 14.01	-23.39 ± 10.85	-33.23 ± 12.79
LARES	-35.78 ± 14.35	-28.19 ± 0.00	-38.37 ± 16.65	-29.14 ± 15.63	-37.25 ± 16.47

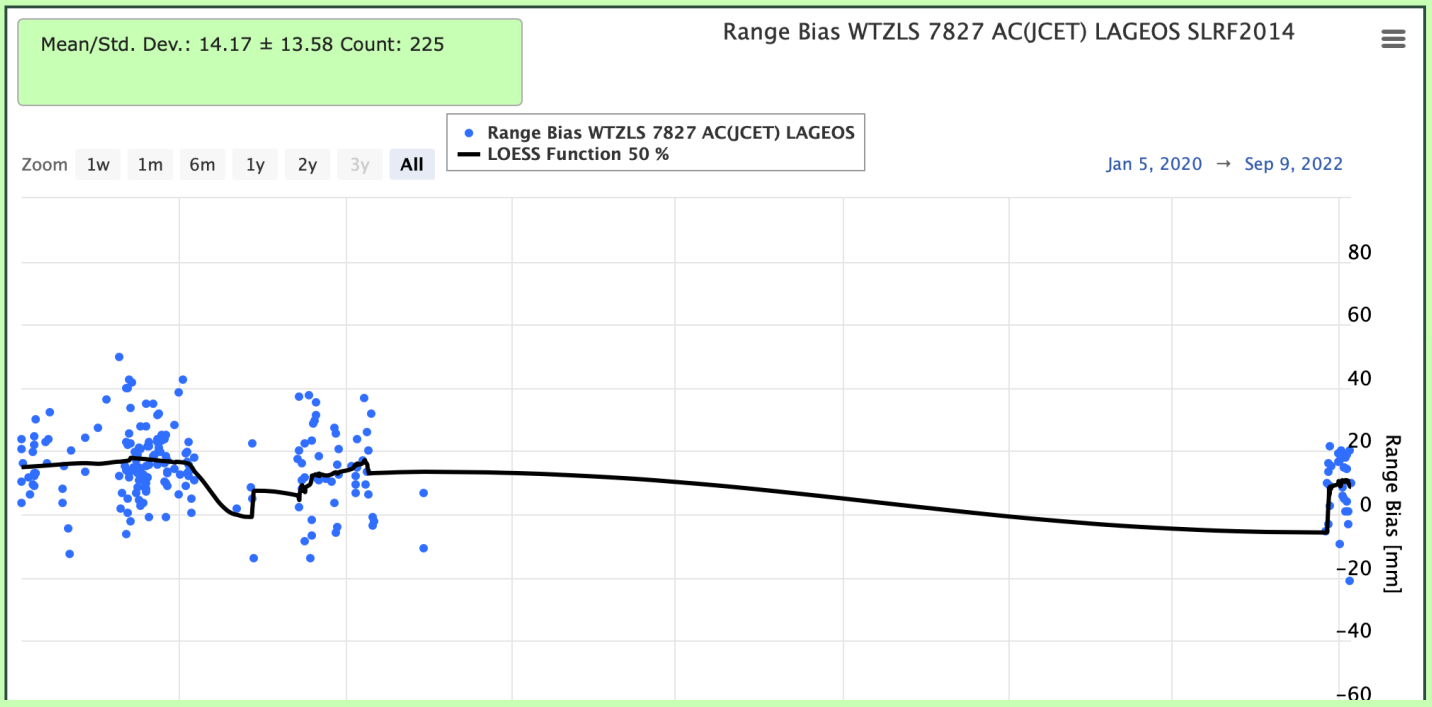
Weighted Mean of Bias Differences Between **A032** & **SR620** Ranges*

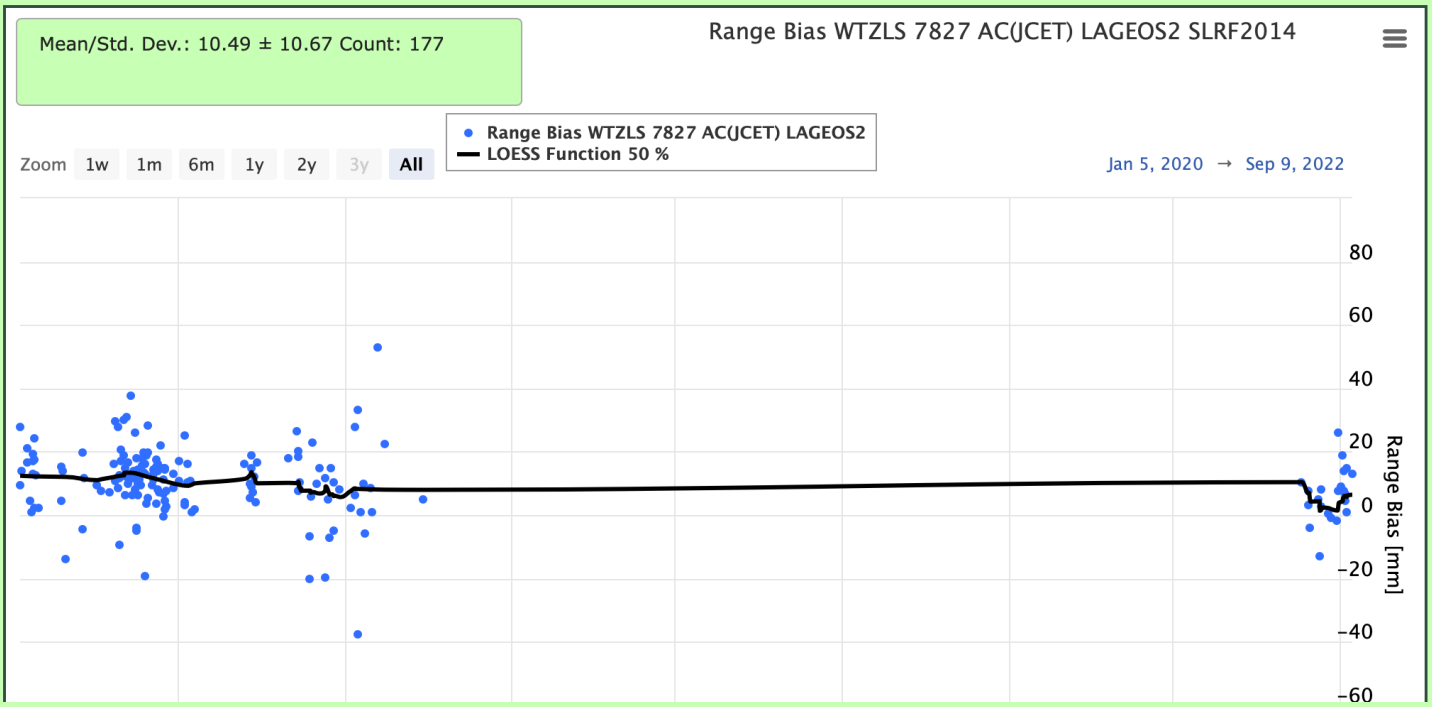
- LAGEOS + LAGEOS-2:
  - FULL RATE DATA: A032 - SR620 = 10.48 ± 2.56 mm
  - NORMAL POINT DATA: A032 - SR620 = 10.40 ± 3.98 mm
- Starlette:
  - FULL RATE DATA: A032 - SR620 = 9.84 ± 3.20 mm
  - NORMAL POINT DATA: A032 - SR620 = 8.68 ± 4.48 mm
- LARES:
  - FULL RATE DATA: A032 - SR620 = 8.11 ± 1.01 mm
  - NORMAL POINT DATA: A032 - SR620 = 9.53 ± 6.47 mm (one pass)

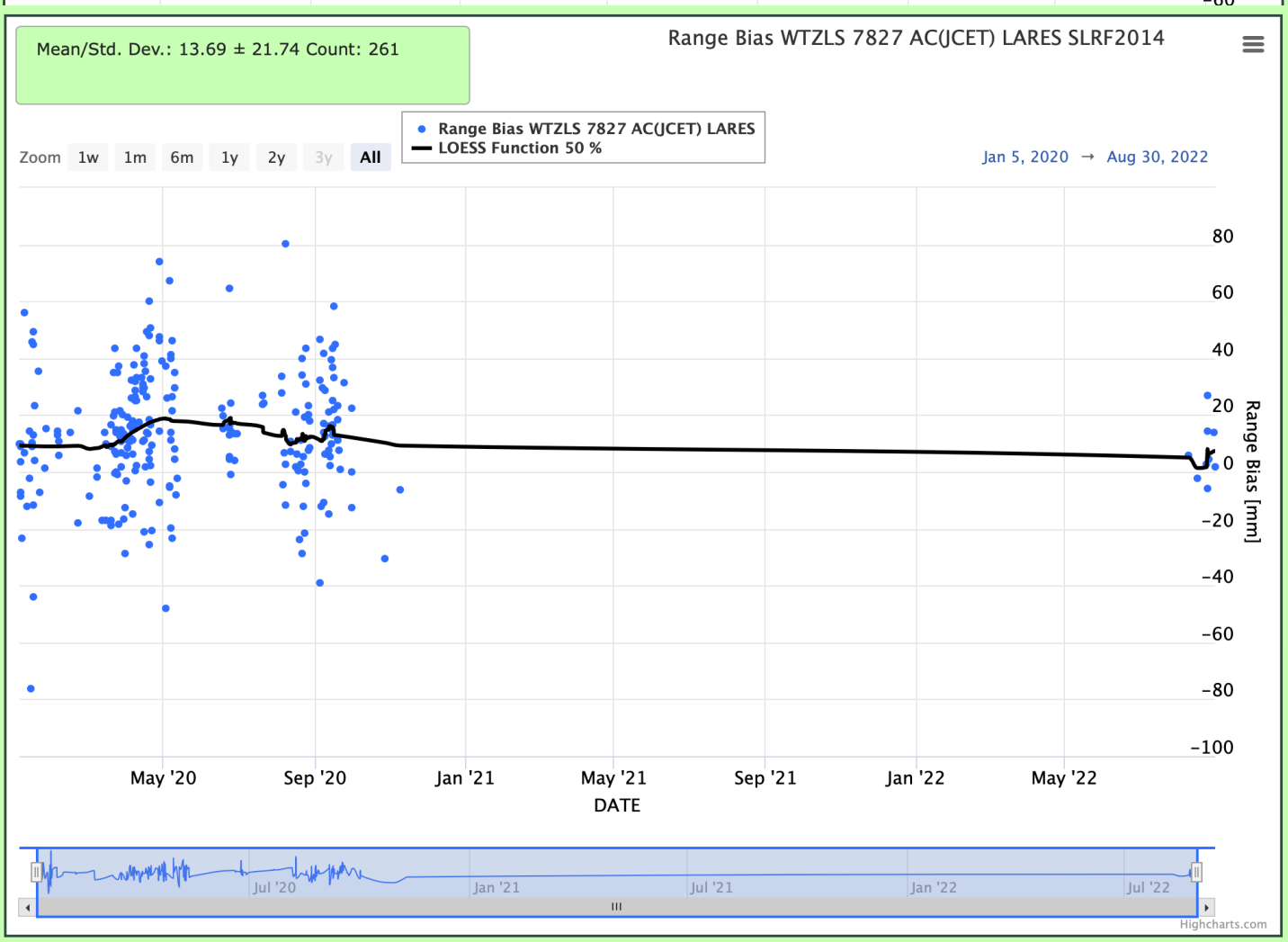
* Proxy for the bias between the two timing units (TU)

Summary of Bias Differences

- The combined result from the two LAGEOS is the most reliable of the four satellites;
  - They indicate an ~10.4 ± 3.0 mm larger bias for the ETU (A032) compared to the TIU and it seems to hold for both, the FRD and NPT data groups
- Starlette in the revised data release shows very consistent results, close to those of the LAGEOS group and can be considered reliable and consistent with the other three satellites: 9.5 ± 4.0 mm
- The average of the two estimates comes to: 9.95 ± 3.5 mm ≈ **10 mm**
- The LARES results are consistent as far as the FRD, but for the NPT group we have a single arc, so even though it is within the statistical margin, we cannot consider it a reliable estimate, nevertheless it is still consistent;
- In terms of ABSOLUTE bias magnitude, both timing units result in the San Fernando system measuring SHORT:
  - **The TIU (SR620) measures SHORTER than the ETU (A032) by ~10 mm.**


Mean/Std. Dev.: 14.17 ± 13.58 Count: 225
Range Bias WTZLS 7827 AC(JCET) LAGEOS SLRF2014
Range Bias WTZLS 7827 AC(JCET) LAGEOS
LOESS Function 50 %
Zoom 1w 1m 6m 1y 2y 3y All
Jan 5, 2020 → Sep 9, 2022
80
60
40
20
0
-20
-40
-60
Range Bias [mm]


Mean/Std. Dev.: 10.49 ± 10.67 Count: 177
Range Bias WTZLS 7827 AC(JCET) LAGEOS2 SLRF2014
Range Bias WTZLS 7827 AC(JCET) LAGEOS2
LOESS Function 50 %
Zoom 1w 1m 6m 1y 2y 3y All
Jan 5, 2020 → Sep 9, 2022
80
60
40
20
0
-20
-40
-60
Range Bias [mm]


Mean/Std. Dev.: 13.69 ± 21.74 Count: 261
Range Bias WTZLS 7827 AC(JCET) LARES SLRF2014
Range Bias WTZLS 7827 AC(JCET) LARES
LOESS Function 50 %
Zoom 1w 1m 6m 1y 2y 3y All
Jan 5, 2020 → Aug 30, 2022
80
60
40
20
0
-20
-40
-60
-80
-100
Range Bias [mm]
May '20
Sep '20
Jan '21
May '21
Sep '21
Jan '22
May '22
DATE
Jul '20
Jan '21
Jul '21
Jan '22
Jul '22
Highcharts.com