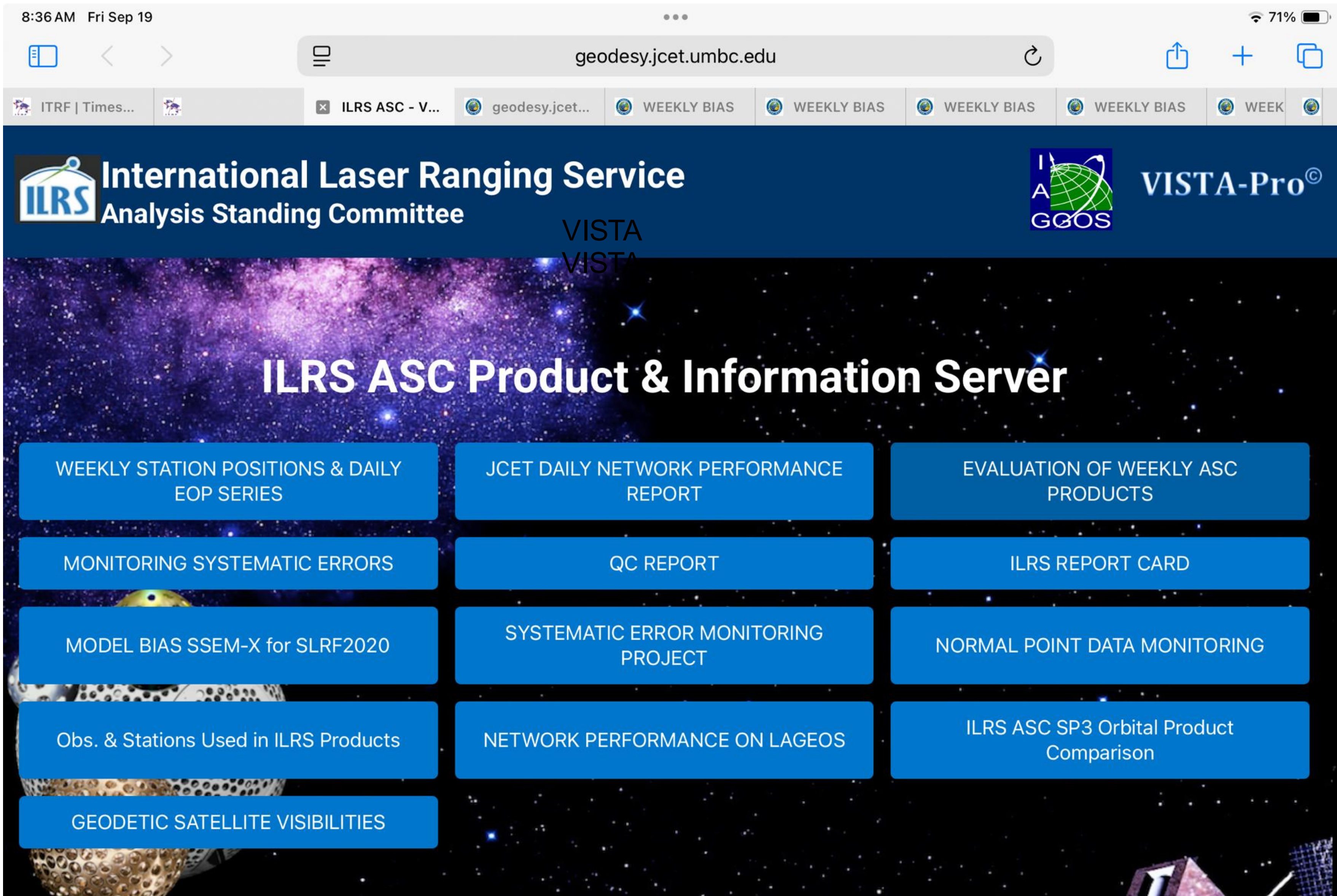
A Tale of Two Stations
YARL and HERL

Peter Dunn

Peraton

VISTA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71%
geodesy.jcet.umbc.edu
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WEEKLY BIAS
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ILRS
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Analysis Standing Committee
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JCET DAILY NETWORK PERFORMANCE REPORT
EVALUATION OF WEEKLY ASC PRODUCTS
MONITORING SYSTEMATIC ERRORS
QC REPORT
ILRS REPORT CARD
MODEL BIAS SSEM-X for SLRF2020
SYSTEMATIC ERROR MONITORING PROJECT
NORMAL POINT DATA MONITORING
Obs. & Stations Used in ILRS Products
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ITRF | Times... | ILRS ASC - V... | geodesy.jcet... | WEEKLY BIAS | WEEKLY BIAS | WEEKLY BIAS | WEEKLY BIAS | KLY BIAS | S

Station Systematic Errors Estimated from SLR DATA

2019 Reanalysis & 2025 Extension Project Results since 1993

v230 + v280

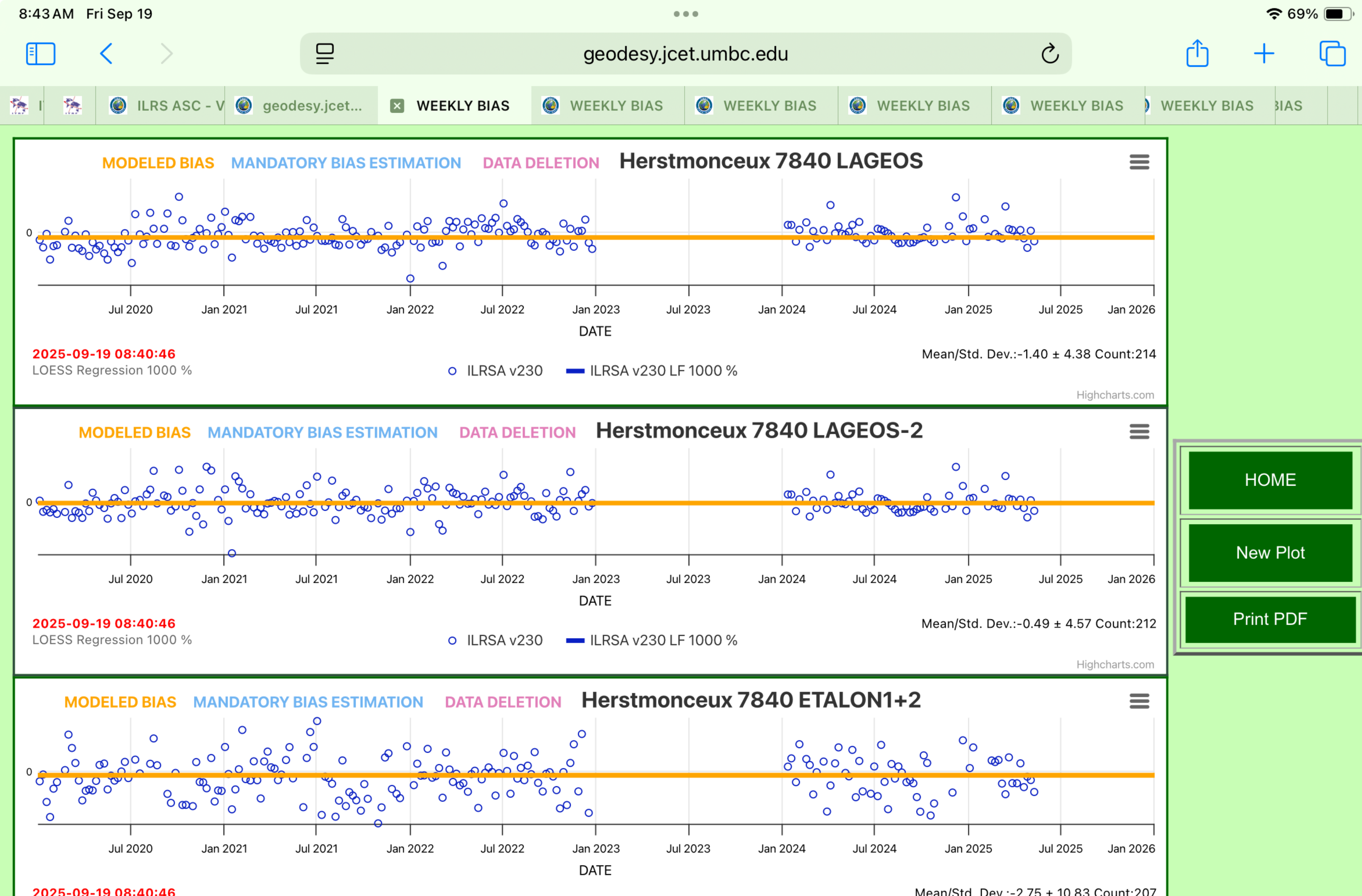
EDITED ±100 mm SUBMISSIONS

☑ **ILRSA**

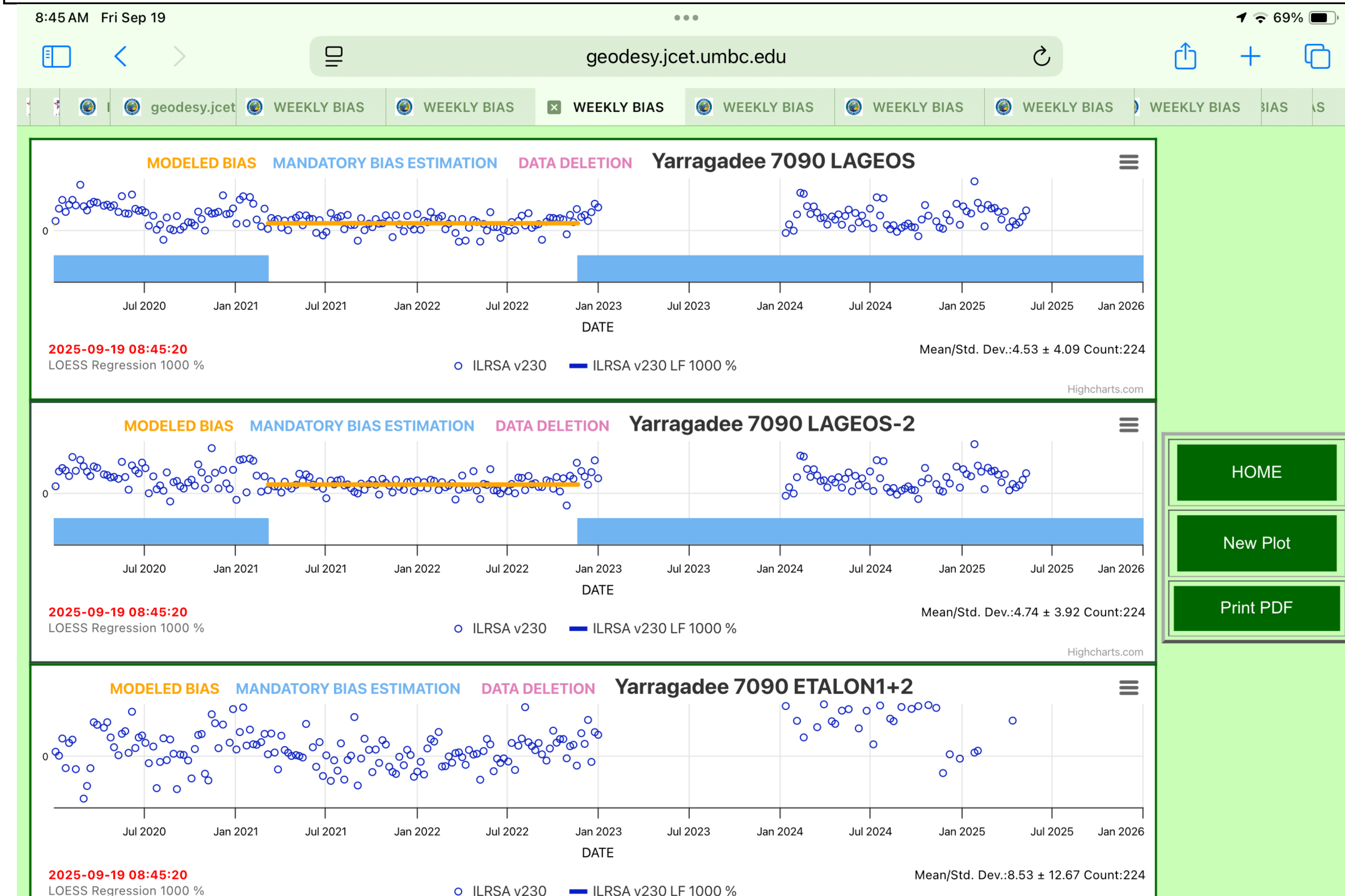
Start (MM-DD-YYYY):	8-1-1990	
End Date (MM-DD-YYYY)	01-01-2026	
Station	7090 Yarragadee	
Plot Size	Minimum	Maximum
Y axis	-20	20
LOESS regression	1000 %	

Submit | Reset form | Return to Main Page

Hx since 2000



YARL



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WEEKLY BIAS
MODELED BIAS
MANDATORY BIAS ESTIMATION
DATA DELETION
Yarragadee 7090 LAGEOS
0
Jul 2020
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
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Jan 2025
Jul 2025
Jan 2026
DATE
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LOESS Regression 1000 %
ILRSA v230
ILRSA v230 LF 1000 %
Mean/Std. Dev.:4.53 ± 4.09 Count:224
Highcharts.com
Yarragadee 7090 LAGEOS-2
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LOESS Regression 1000 %
Mean/Std. Dev.:4.74 ± 3.92 Count:224
HOME
New Plot
Print PDF
Yarragadee 7090 ETALON1+2
2025-09-19 08:45:20
LOESS Regression 1000 %
Mean/Std. Dev.:8.53 ± 12.67 Count:224

CONCLUSIONS

We can separate RB from height in a week
for strong stations
with a few mm. accuracy

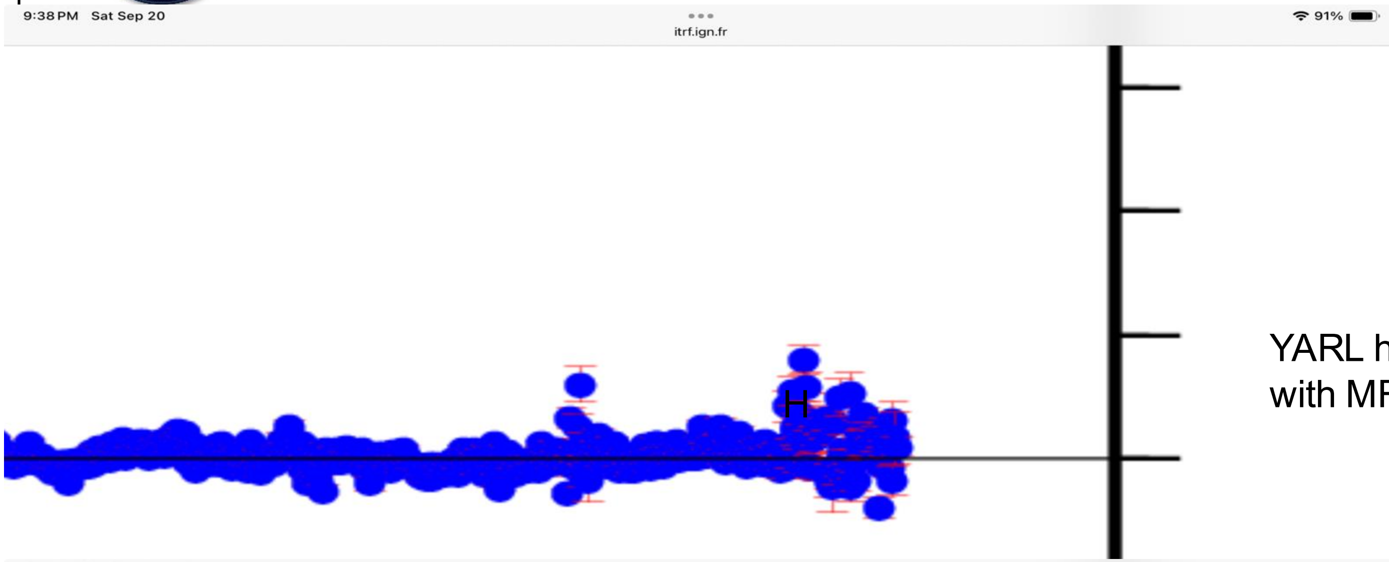
Mandatory Bias Estimation degrades the performance of a station.

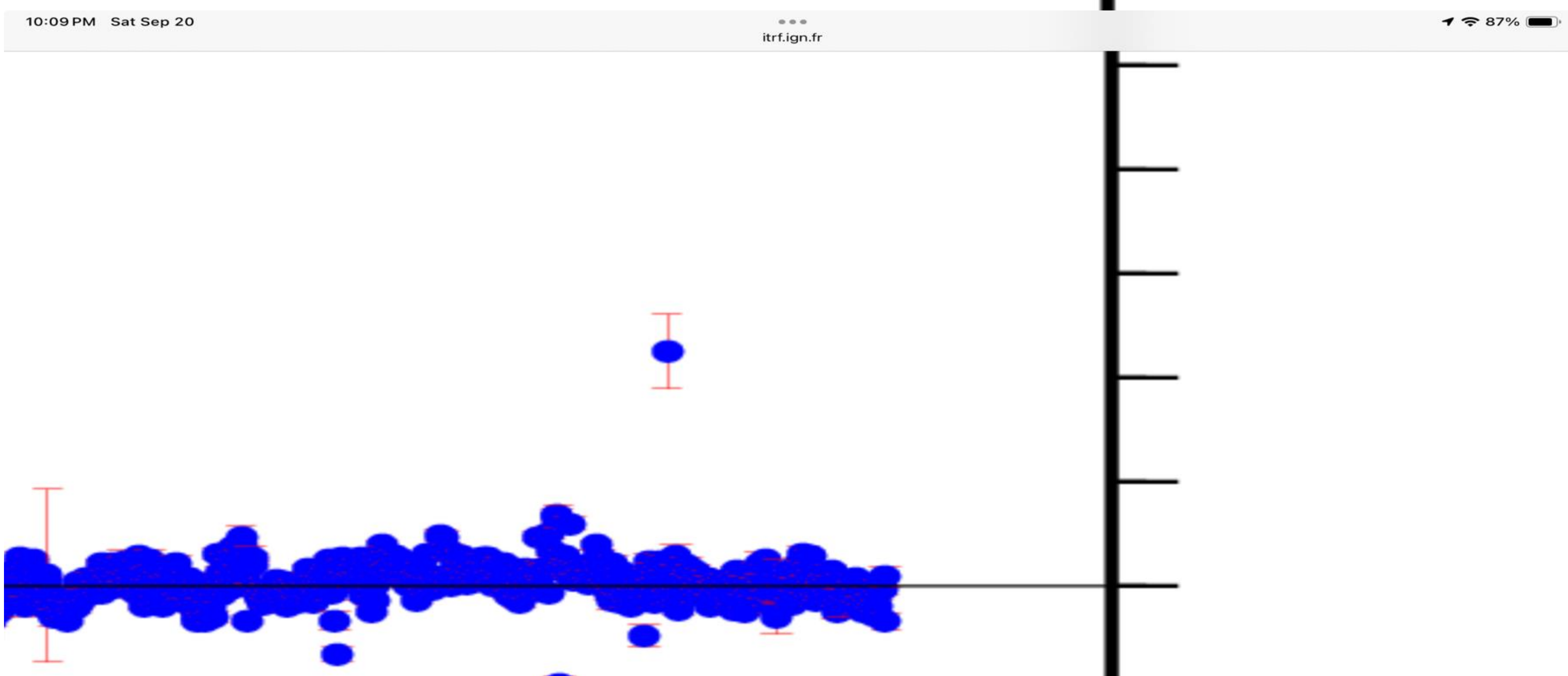
And de-weights it in the estimation scheme.

MBE has severely affected the performance of YARL in ITRF2020_u2023

IT WILL DEGRADE THE REFERENCE FRAME SOLUTION IF APPLIED TO THE STRONGEST STATIONS

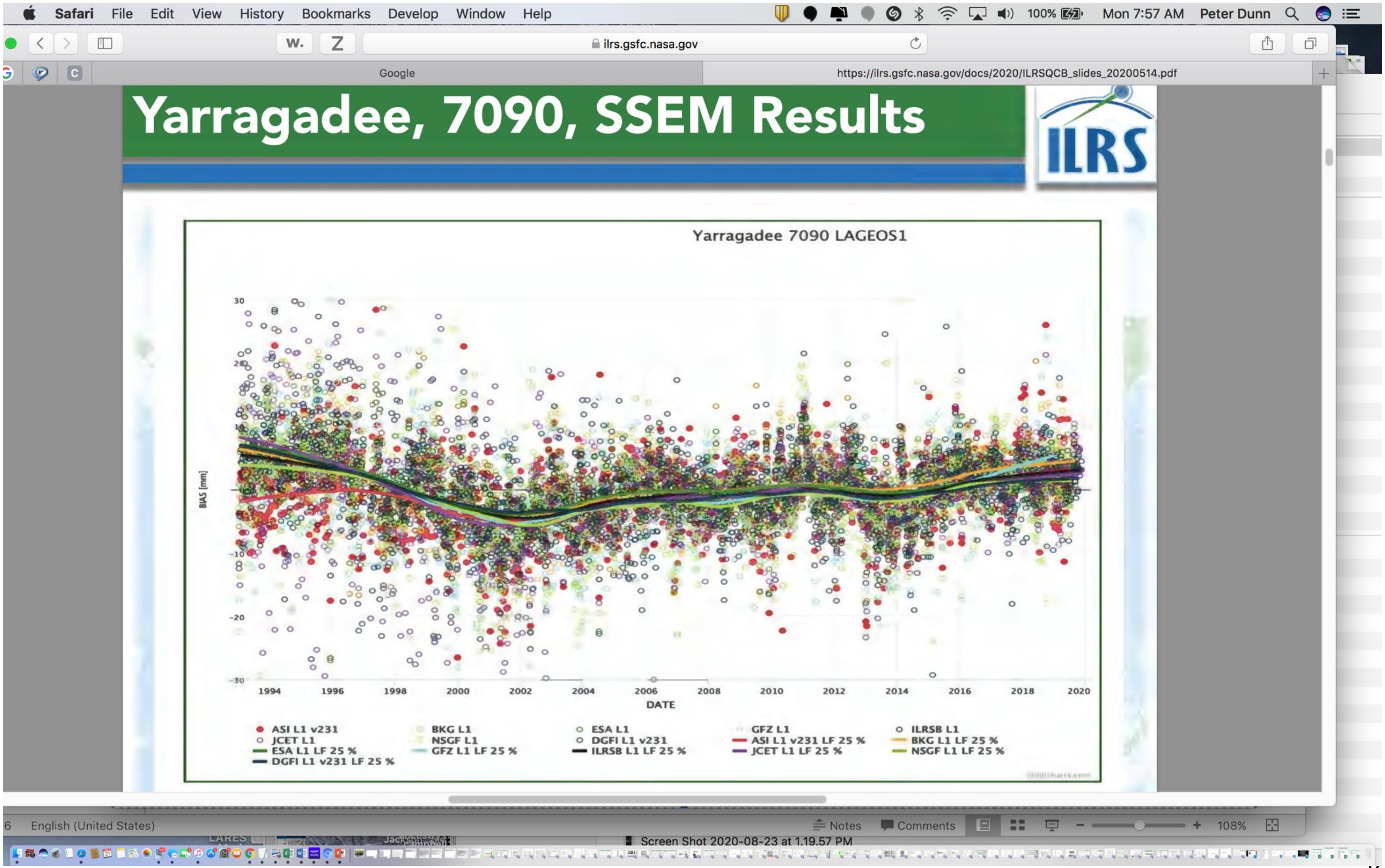
YARL and Hx heights in ITRF20_u2023





YARL has degraded performance with MRB

SIX CENTIMETER VERTICAL SCALE



Data Handling File Updates and Systematic Errors

Van S. Husson, Peter Dunn
ILRS QCB

29-September-2025

Discontinuities in NASA SLR ITRF2020 Station Heights

7210 Haleakalā LURE

7080 McDonald

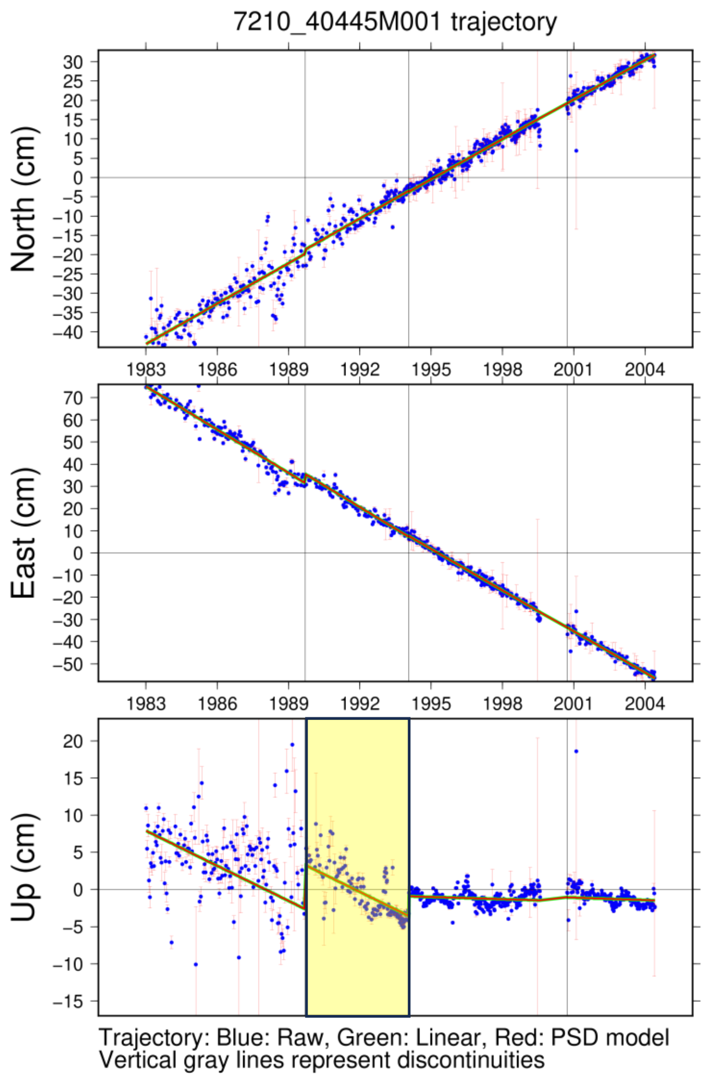
7105 Greenbelt

7501 Harteebeesthoek

The Dilemmas with Station Height Discontinuities

- If the computed ITRF site velocities are the same before and after a discontinuity in Up, which sets of heights are more accurate?
- Other Analysts (e.g. altimetric missions) using these coordinates should see a discontinuity in the range biases
- System engineers will not know if the RB was caused by an inaccurate station height or a systematic error in the station

7210 HALL ITRF2020 Height Residuals



- **There are three 'unknown' discontinuities in the 7210 HALL ITRF2020 height residuals. The first two discontinuities are quite large (i.e. a few cm)**
- **The 7210 HALL HP5370A Time Interval Unit (TIU) was on internal frequency from August 1989 to 21-Jan-1994 based on the legacy configuration change records (see yellow highlighted area on the chart)**
- **A frequency error will be range dependent and will drift linearly over time**
- **Based on the height residuals from 1983 to 1989, the station's HP5370A was most likely also on internal frequency because the lead engineer liked keeping the TIU on internal frequency because it yielded the best single shot RMSs**
- **The height residuals post 21-Jan-1994 to 1999 were not very stable, more on that later**

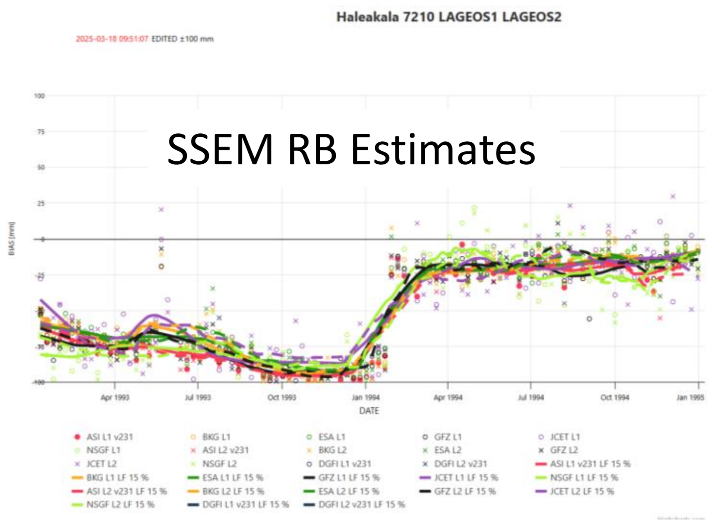
7210 HALL DHF Entries and SSEM Range Biases

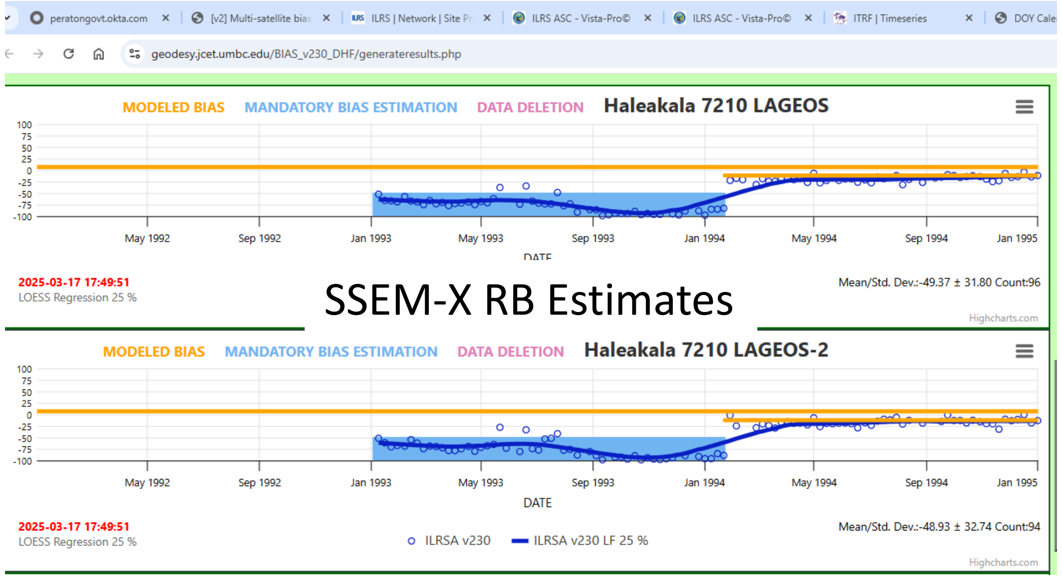
*COD	Pad_id	S		PT	Start Date	End Date	Bias Code	Bias	STD	Rate	UNIT	Comments
	7210			A	83:001:00000	87:255:00000	R	25			mm	
	7210			A	87:255:00000	93:001:00000	R	-37			mm	
	7210	51	501	A	93:003:00000	94:023:00000	E				mm	
	7210	51	501	A	94:023:00000	99:220:00000	R	-12	0.7		mm	
	7210	51	501	A	00:261:00000	04:158:00000	R	6.5	0.6		mm	
	7210	52	501	A	93:003:00000	94:023:00000	E				mm	
	7210	52	501	A	94:023:00000	99:220:00000	R	-12.7	0.7		mm	
	7210	52	501	A	00:261:00000	04:158:00000	R	6.6	0.7		mm	

Legend	
51	LAGEOS-1
52	LAGEOS-2
	all Satellites

Legend	
R	Appy
E	Estimate

- Based on the DHF, a constant Range Bias (RB) of -37 mm is to be applied to all 7210 satellite between 12-Sep-1987 and 1-Jan-1993
- Between 1-Jan-1993 to 23-Jan-1994, the LAGEOS RBs are to estimated
- Post 23-Jan-1994, a constant RB (+6.5/+6.6 mm) is to be applied





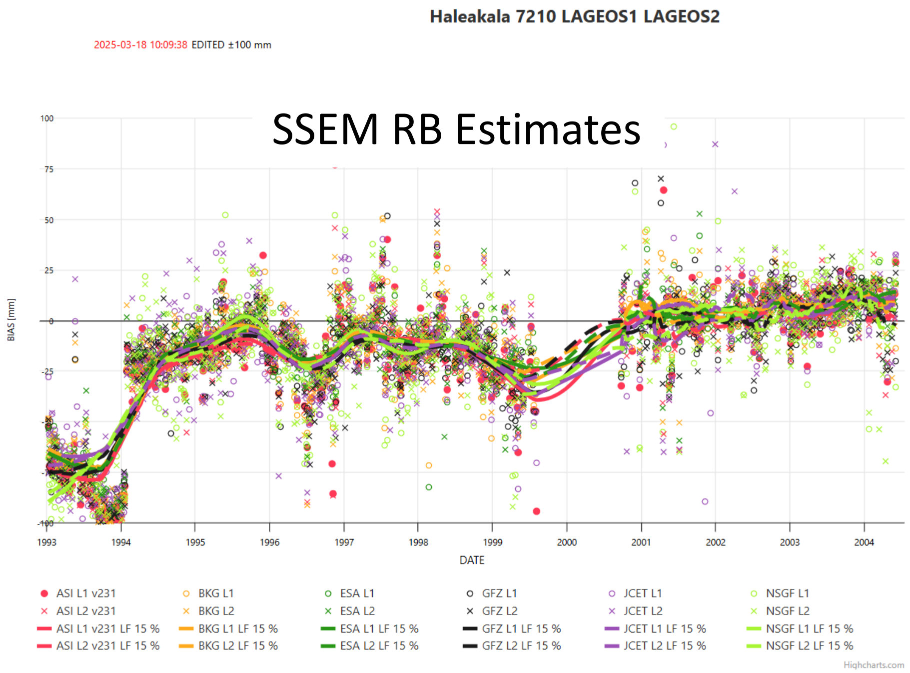
7210 HALL DHF Entries and SSEM Range Biases

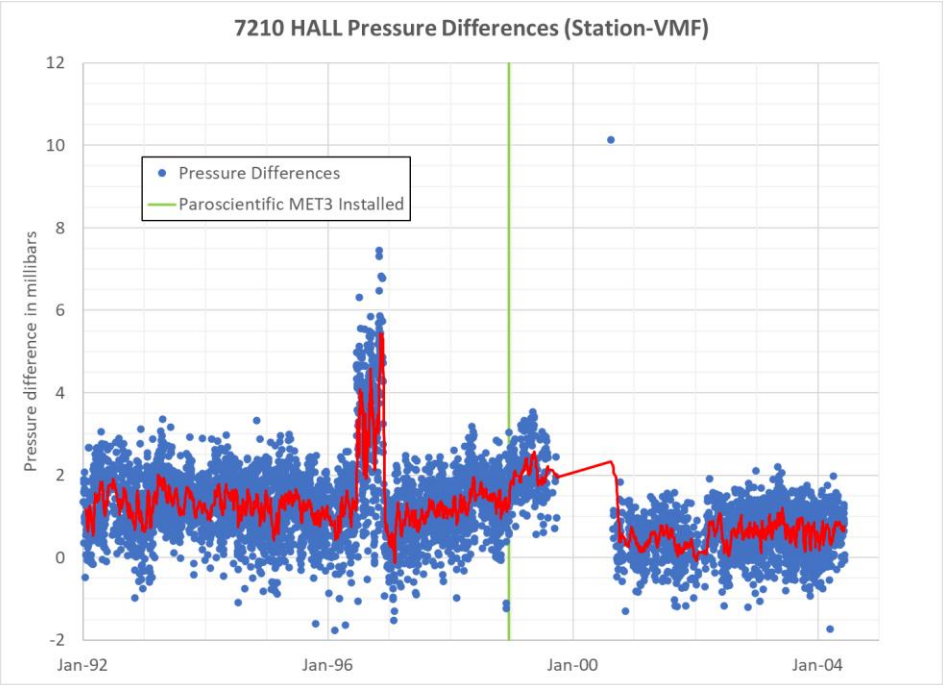
*COI	Pad_id	S		PT	Start Date	End Date	Bias Code	Bias	STD	Rate	UNIT	Comments
	7210			A	83:001:00000	87:255:00000	R	25			mm	
	7210			A	87:255:00000	93:001:00000	R	-37			mm	
	7210	51	501	A	93:003:00000	94:023:00000	E				mm	
	7210	51	501	A	94:023:00000	99:220:00000	R	-12	0.7		mm	
	7210	51	501	A	00:261:00000	04:158:00000	R	6.5	0.6		mm	
	7210	52	501	A	93:003:00000	94:023:00000	E				mm	
	7210	52	501	A	94:023:00000	99:220:00000	R	-12.7	0.7		mm	
	7210	52	501	A	00:261:00000	04:158:00000	R	6.6	0.7		mm	

Legend	
51	LAGEOS-1
52	LAGEOS-2
	all Satellites

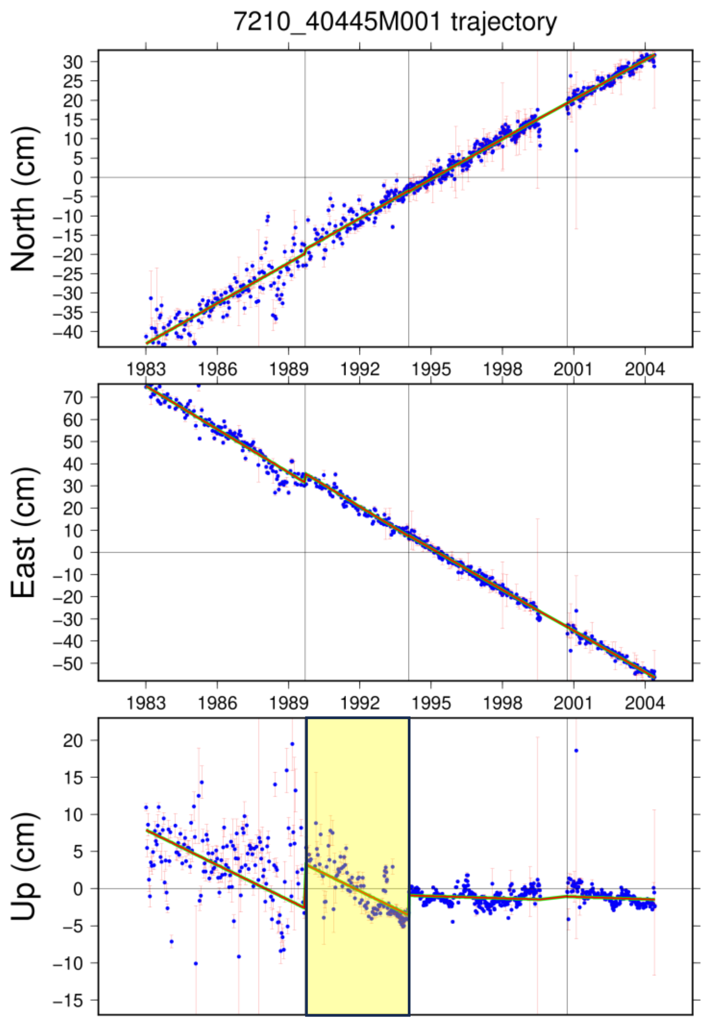
Legend	
R	Appy
E	Estimate

- Based on the DHF a constant LAGEOS-1 and LAGEOS-2 RB of -12 and -12.7 mm; respectively, is to be applied to all data between 23-Feb-1994 and 6-Aug-1999
- Based on SSEM results the range bias had some obvious variations during this period (‘94 to ‘99). The negative dip in SSEM range biases in 1996 were caused by a unmodeled change in the station’s barometric pressures





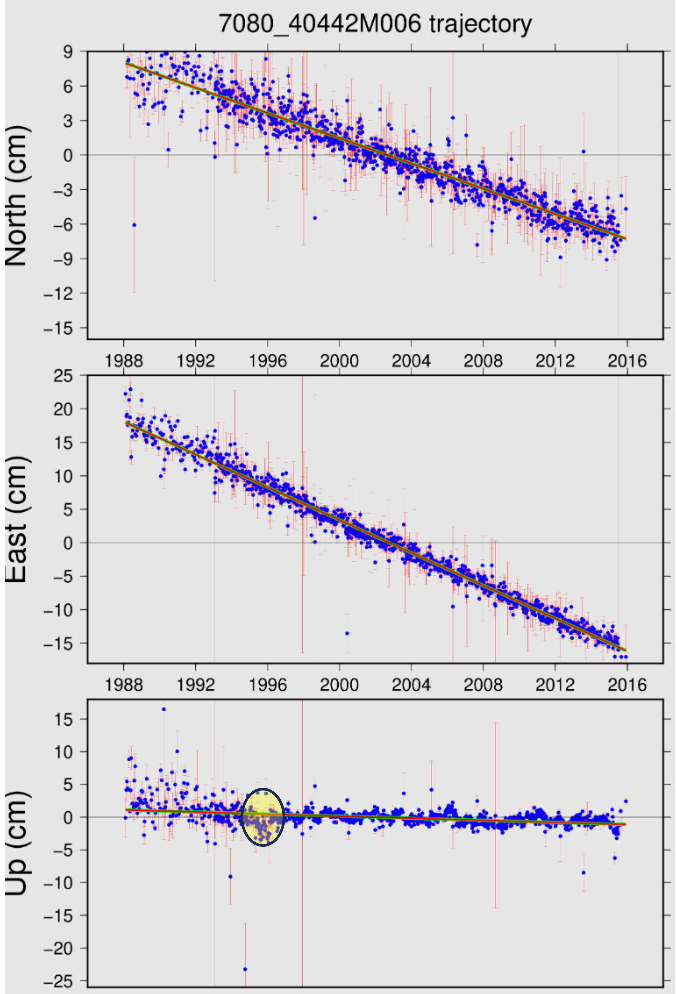
7210 HALL Data Handling Summary and Recommendation



Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

- **Solving for a range bias will not remove any range (e.g. frequency) or elevation dependent (e.g. tropospheric) errors**
- **The following actions will remove the 7210 height discontinuities**
- **Actions:**
  - ASC to update the DHF to delete all 7210 prior to 21-Jan-1994 and remove any 7210 Epoch errors prior to 21-Jan-1994
  - Van to generate 7210 tropospheric corrections for the DHF
- **Post update of the DHF, compute new 7210 RB estimates and revise the updated DHF accordingly**

7080 MDOL ITRF2020 Height Residuals



Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

- **There are no ‘marked’ discontinuities, but if you look closely there is a small Up discontinuity in 1996, see yellow highlighted area**

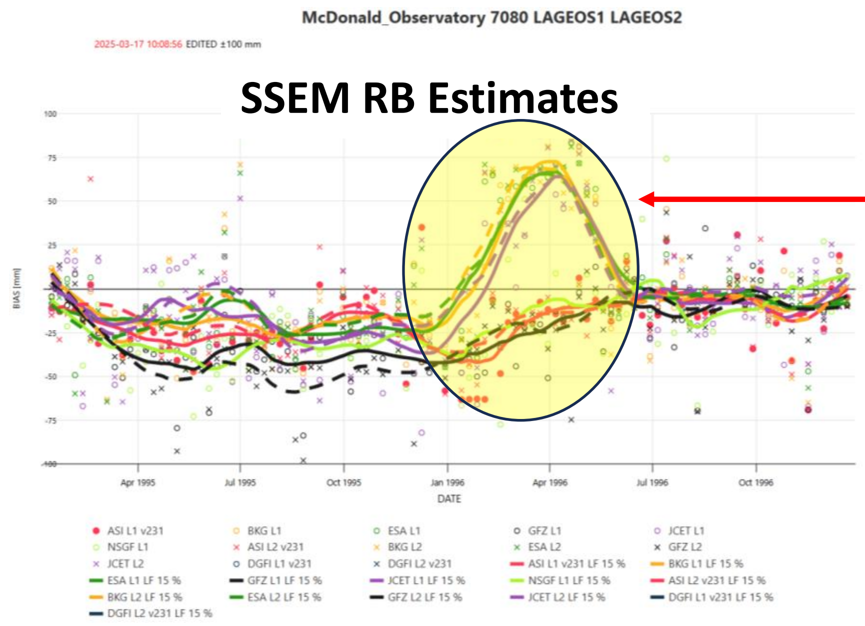
7080 Different Application of Tropospheric Biases by the ACs

- ❑ When a tropospheric bias is to be applied along with range bias estimation the application of the tropospheric bias is not consistent
- ❑ Below is an DHF example from McDonald (7080), where the tropospheric biases are in a period of RB estimation

*COI	Pad_	S			Start Da	End Da	Bias Co	Bi	S	Ra	UN	Com
	7080	51	501	A	93:001:00000	96:133:00000	E				mm	
	7080	52	501	A	93:001:00000	96:133:00000	E				mm	
	7080			A	95:065:00000	96:025:86400	P	-2.1			mB	BRE
	7080			A	96:026:00000	96:115:86400	P	-10.3			mB	BRE
	7080			A	96:116:00000	96:129:72000	P	-9.7			mB	BRE

Legend
Esitmate
Pressure Error

Legend	
51	LAGEOS-1
52	LAGEOS-2
	all Satellites

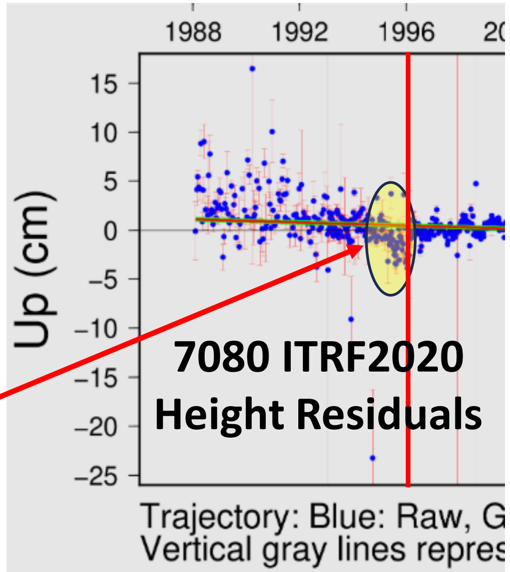


Issue:

RBs estimates vary by ACs; Some ACs didn't apply tropo bias before RB estimation

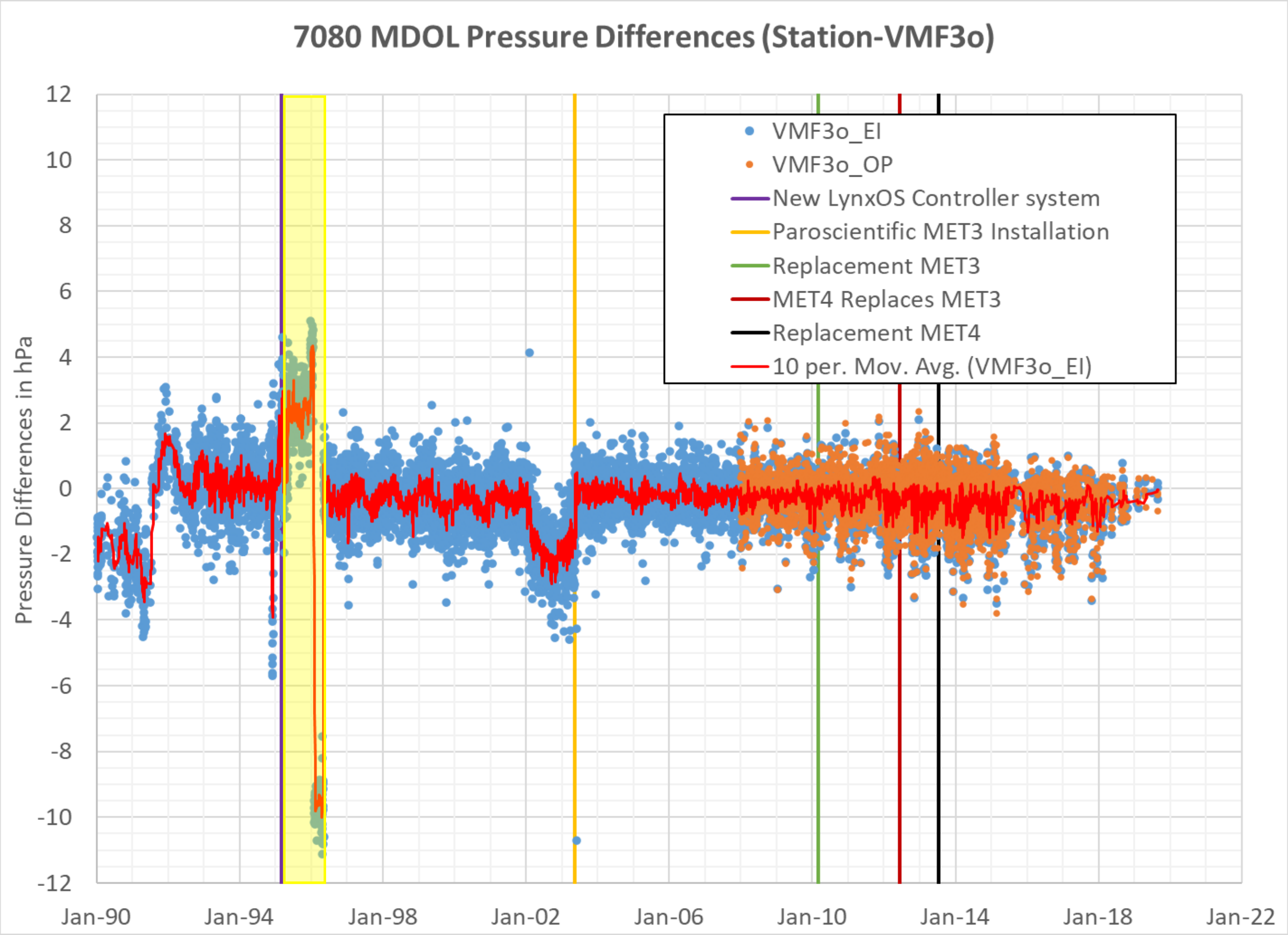
End result:

Height Discontinuity



Solution: Always apply tropo/epoch biases *a priori* when estimating RBs

7080 Tropospheric biases in the DHF are missing/inaccurate



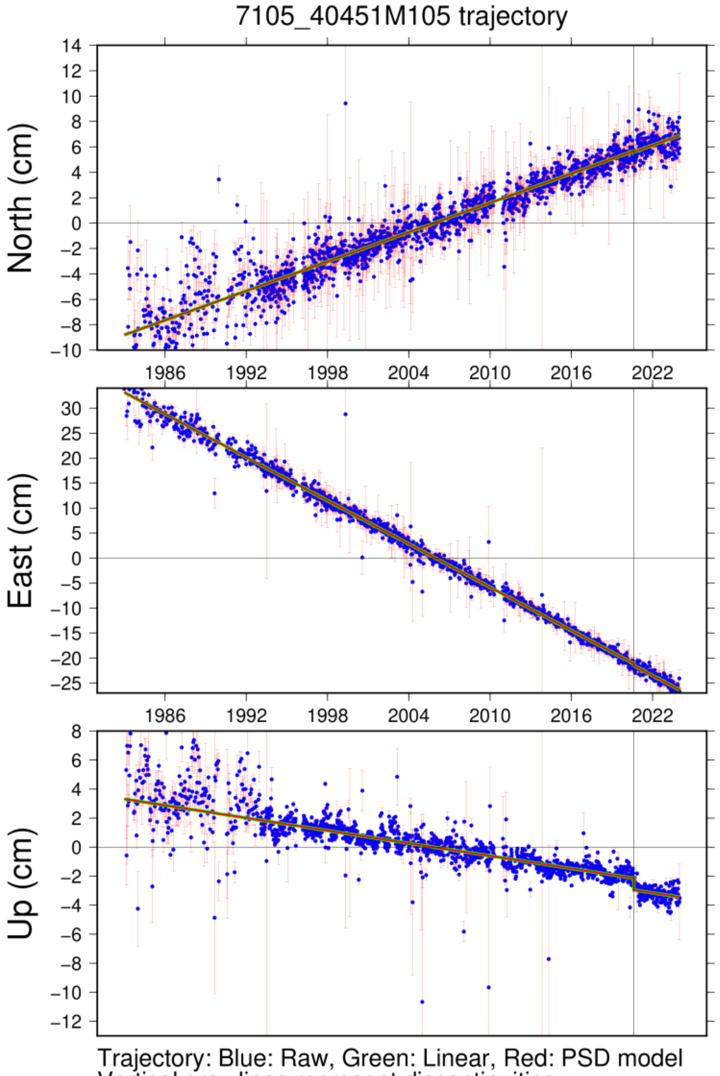
- The current ILRS Data Handling File only has barometric corrections for the period highlighted in yellow and the first -2.1 mB entry has the wrong sign (minus vs. plus) leading to some inaccurate station heights

*COI	Pad_	S			Start Da	End Da	Bias Co	Bi	S	Ra	UN	Com
	7080			A	95:065:00000	96:025:86400	P	-2.1			mB	BRE
	7080			A	96:026:00000	96:115:86400	P	-10.3			mB	BRE
	7080			A	96:116:00000	96:129:72000	P	-9.7			mB	BRE

- **Recommendation:** Implement the following DHF tropo bias updates and each AC must apply these tropo biases *a priori* then estimate a RB

	7080			A	90:001:00000	91:199:00000	P	-1.8	0.5		mB	BRE
	7080			A	94:333:54000	94:335:32400	P	-4.6	0.5		mB	BRE
	7080			A	95:065:00000	95:362:08100	P	2.4	0.5		mB	BRE
	7080			A	95:362:08100	96:025:86400	P	4.4	0.5		mB	BRE
	7080			A	96:026:00000	96:129:72000	P	-9.4	0.5		mB	BRE
	7080			A	02:038:00000	03:137:00000	P	-1.7	0.5		mB	BRE
	7080			A	03:150:26340	03:150:43200	P	-11.5	1.0		mB	BRE

7105 GODL ITRF2020 Height Residuals and DHF



Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

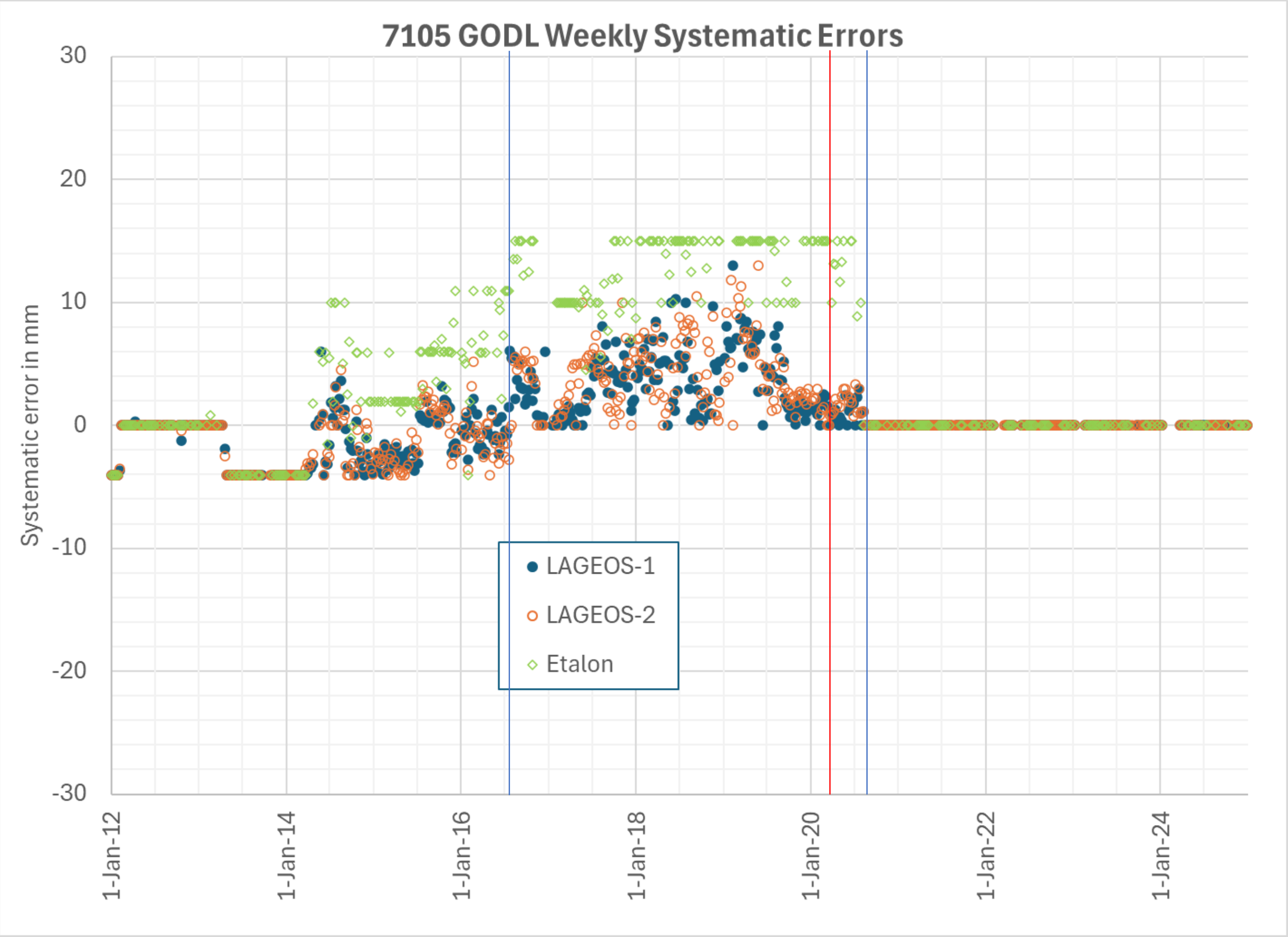
*CODE	Pad_id	Sat	T	PT	Start Date	End Date	Bias Code	Bias	STD	Rate	UNIT	Comments
	7105	51	501	A	93:017:00000	95:253:00000	R	-6.3	0.7		mm	
	7105	52	501	A	93:017:00000	95:253:00000	R	-6.2	0.6		mm	
	7105	53	501	A	93:001:00000	00:044:00000	E				mm	
	7105	54	501	A	93:001:00000	00:044:00000	E				mm	
	7105	51	501	A	96:056:00000	98:193:00000	R	3.4	0.7		mm	
	7105	52	501	A	96:056:00000	98:193:00000	R	3	0.7		mm	
	7105	51	501	A	98:193:00000	10:122:00000	R	-2.9	0.3		mm	
	7105	52	501	A	98:193:00000	10:122:00000	R	-2.9	0.3		mm	
	7105	53	501	A	00:226:00000	16:346:00000	R	2.6	0.6		mm	
	7105	54	501	A	00:226:00000	16:346:00000	R	2.6	0.6		mm	
	7105	51	501	A	10:339:00000	17:029:00000	R	-7.1	0.3		mm	
	7105	52	501	A	10:339:00000	17:029:00000	R	-6	0.3		mm	
		51			17:029:00000	20:047:00000						
		52			17:029:00000	20:047:00000						
	7105	53	501	A	17:029:00000	20:047:00000	R	17.5	0.8		mm	
	7105	54	501	A	17:029:00000	20:047:00000	R	17.5	0.8		mm	
	7105	51	501	A	20:047:00000	00:000:00000	R	-5.1	0.4		mm	
	7105	52	501	A	20:047:00000	00:000:00000	R	-4.3	0.4		mm	
	7105	53	501	A	20:047:00000	00:000:00000	R	7.4	0.8		mm	
	7105	54	501	A	20:047:00000	00:000:00000	R	7.4	0.8		mm	

Legend
no range bias estimation , not in DHF
Estimate the RB
apply fixed Range Bias

Legend	
51	LAGEOS-1
52	LAGEOS-2
53	Etalon-1
54	Etalon-2

- **There is an 8 mm ‘unknown’ discontinuity in the 7105 ITRF2020_U2023 height residuals on 20-August-2020**
- **Based on the last 4 entries in the DHF, a -5.1, -4.3, +7.4, & +7.4 mm LAGEOS-1, LAGEOS-2, Etalon-1, & Etalon-2 range biases; respectively, are to be applied starting on 16-Feb-2020 (Day 047), 6 months before the height discontinuity**

7105 GODL Systematic Errors based on Engineering Tests



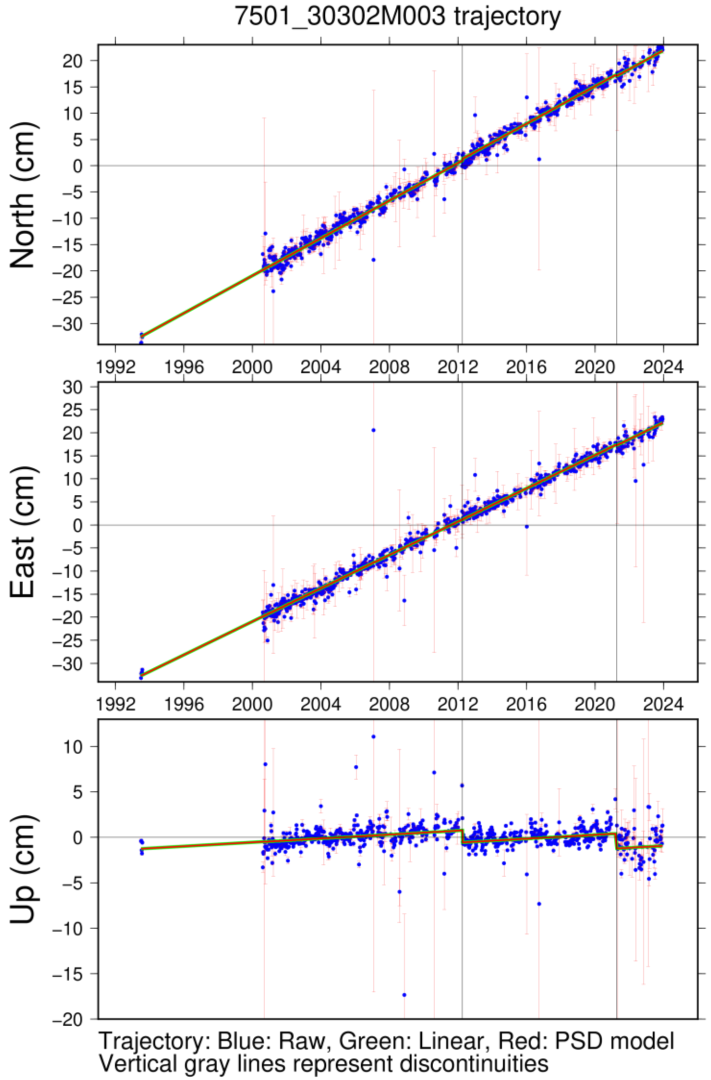
- Here is a weekly time series of 'quantifiable' 7105 GODL systematic errors based on engineering ground tests (i.e. PMT Tests) along with HP5370B vs Event Timer comparison results. The event timer was installed on 27-Jul-2016, represented by the first vertical blue line.
- On 14-Aug-2020, represented by the second vertical blue line, the 7105 GODL PMT voltage systematic error was eliminated by taking calibrations at the same PMT voltage as the corresponding satellite data. However; the DHF indicates a change in the LAGEOS Range Bias (RB) 6 months prior, represented by vertical red line. The discontinuity in the ITRF2020_U2023 station height was just 6 days later on 20-Aug-2020. This is no coincidence since the date of the 'real' RB change was 6 months later than the date in the DHF and the station height absorbed the 'real' RB change

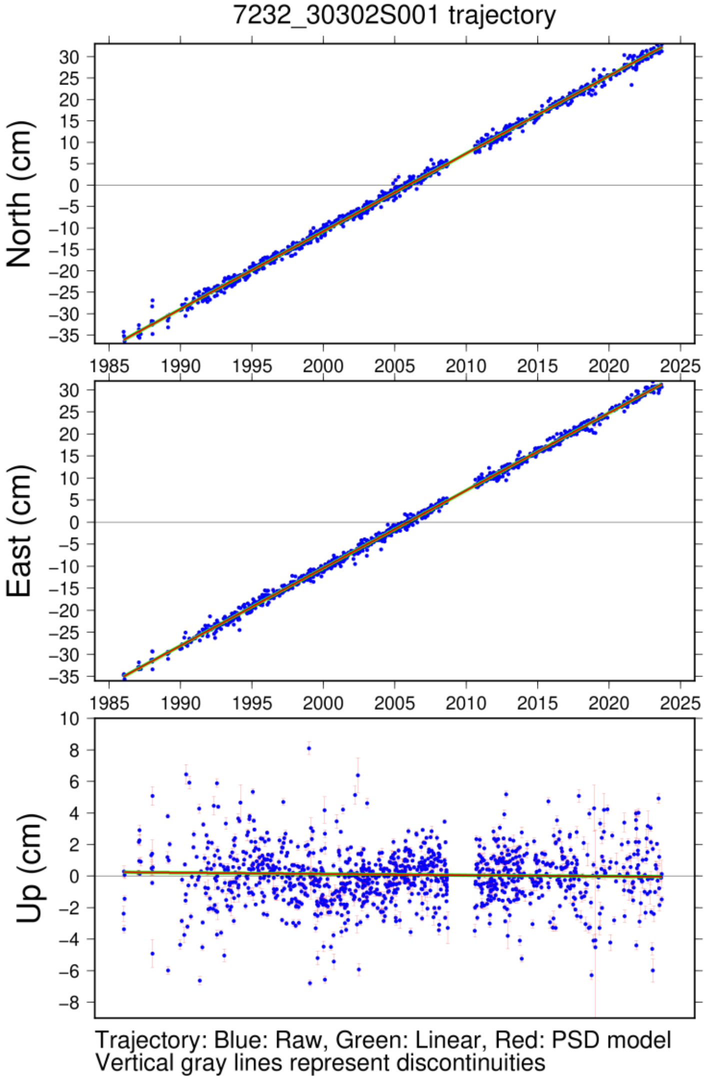
7105 GODL DHF Recommendations

*CODE	Pad_id	Sat	T	PT	Start Date	End Date	Bias Code	Bias	STD	Rate	UNIT	Comments
	7105	51	501	A	20:227:00000	00:000:00000	R	-5.1	0.4		mm	
	7105	52	501	A	20:227:00000	00:000:00000	R	-4.3	0.4		mm	
	7105	53	501	A	20:227:00000	00:000:00000	R	7.4	0.8		mm	
	7105	54	501	A	20:227:00000	00:000:00000	R	7.4	0.8		mm	

- **Changing the start date from day 047 to 227, should resolve the 7105 Height discontinuity**

Hartebeesthoek ITRF2020_U2023 SLR (7501) and VLBI (7232) Station Residuals





- 7501 is SLR (MTLRS in 1993 and MOBLAS-6 since 2000) and 7232 is VLBI
- There are two unknown discontinuities (>10mm) in the 7501 'Up' residuals. The SLR height rate is slightly positive while the VLBI height rate is flat
- The two 7501 unknown height discontinuities were in 12-April-2012 and 12-April-2021; respectively

7501 HARL Data Handling File Range Biases Instructions

*	Pad_i	S		PT	Start Date	End Date	Bias Cod	Bias	STD	Rate	UNIT	Comments
	7501	51	501	A	00:219:00000	17:050:00000	R	1.7	0.3		mm	
	7501	52	501	A	00:219:00000	17:050:00000	R	2.1	0.3		mm	
	7501	53	501	A	01:111:00000	00:000:00000	R	13.5	0.6		mm	
	7501	54	501	A	01:111:00000	00:000:00000	R	13.5	0.6		mm	
*	7501			A	12:071:00000	12:073:64080	R	-66.0			mm	
*	7501			A	12:074:21600	12:074:79200	R	-66.0			mm	
*	7501			A	12:077:57600	12:079:08400	R	-66.0			mm	
*	7501			A	12:079:36000	12:080:05400	R	-66.0			mm	
*	7501			A	12:080:14400	12:089:75600	R	-66.0			mm	
*	7501			A	12:090:43000	12:092:07800	R	-66.0			mm	
*	7501			A	12:092:64800	12:094:28800	R	-66.0			mm	
	7501	51	501	A	17:057:00000	19:041:00000	R	6.0	0.6		mm	
	7501	52	501	A	17:057:00000	19:041:00000	R	6.8	0.7		mm	
	7501	51	501	A	19:041:00000	21:001:00000	R	13.1	1.1		mm	
	7501	52	501	A	19:041:00000	21:001:00000	R	13.0	1.1		mm	
	7501	51	501	A	21:001:00000	00:000:00000	E				mm	
	7501	52	501	A	21:001:00000	00:000:00000	E				mm	

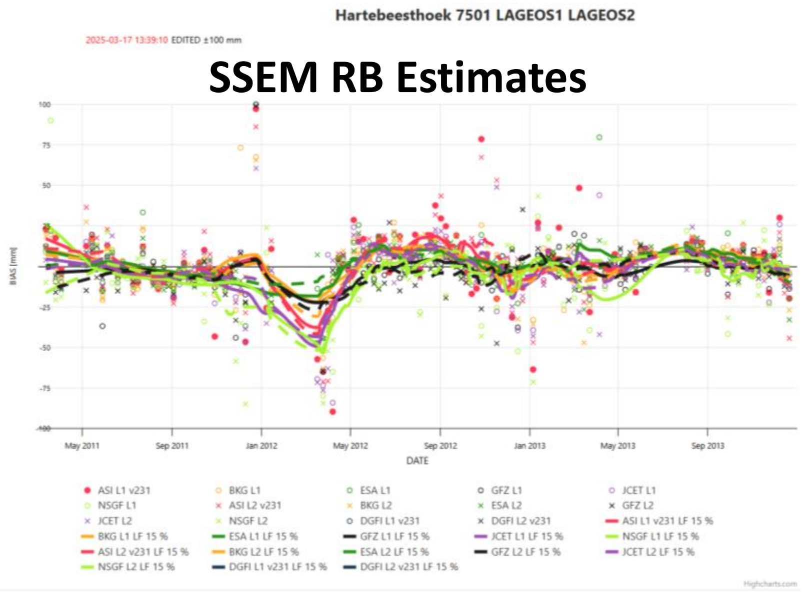
Legend	
51	LAGEOS-1
52	LAGEOS-2
53	Etalon-1
54	Etalon-2
	all Satellites

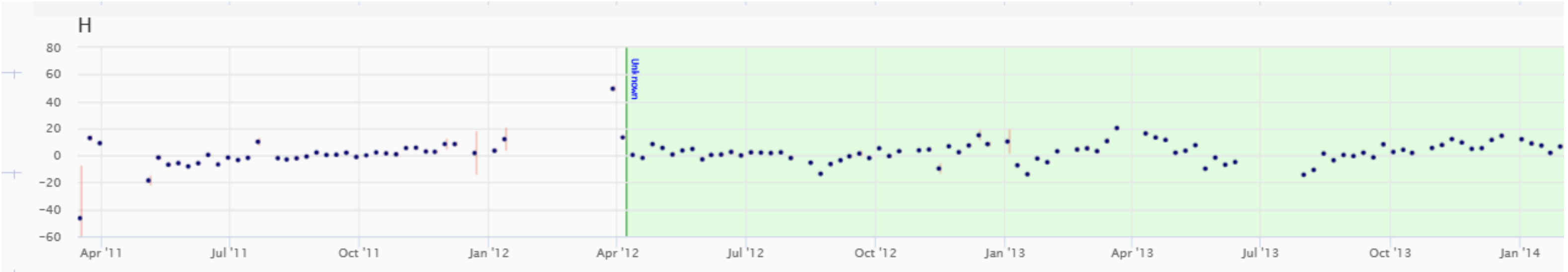
Legend	
R	Apply
E	Estimate
*	Optional

- **According to the DHF, applying the intermittent -66mm range biases were optional**
- **MOBLAS-6 had a laser failure in January 2012 and was offline until 12-Mar-2012. During their down time, the onsite target range of their 'legacy' operational target was modified by 66 mm, inducing a -66 mm RB on data taken using that target. Also, in March 2012 they began to transition to a new ground target. Before they completed the transition their alternated taking operational calibration from both their old and new targets. This is why some passes were biased by -66mm and some were not. The switched exclusively to their a new calibration target on 5-Apr-2012**
- **According to the DHF, a constant range bias (1.7 and 2.1 mm) were to be applied to all LAGEOS-1 and -2 data; respectively, from 6-Aug-2000 to 19-Feb-2017**

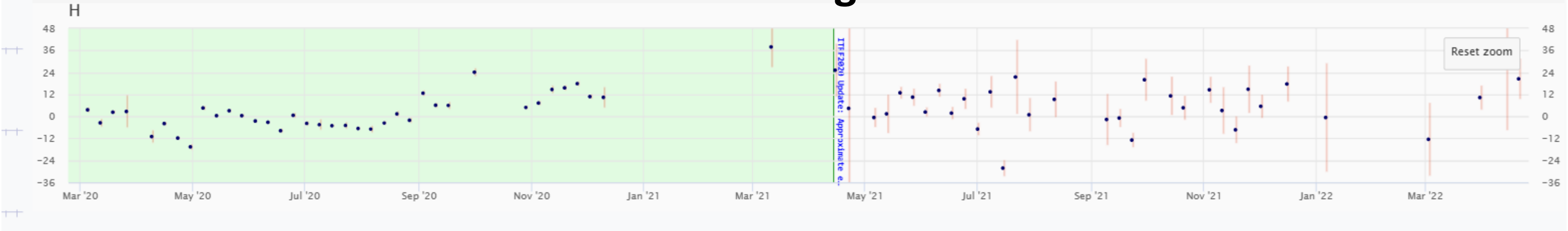
7501 HARL Range Bias Estimates and ITRF2020 Station “Up” Residuals

SSEM RB Estimates





7501 ITRF2020 Height Residuals



- ❑ **The two 7501 unknown height discontinuities were in April 2012 and 2021; respectively. The 7501 LAGEOS data was more sparse post April 2021, evidenced by the larger error bars**
- ❑ **The SSEM RBs were different pre and post April 2012, but a constant RB was modelled, so the RB change was absorbed in the station height, inducing a discontinuity. A RB was introduced switching to a new calibration target, exposing either a local survey error and/or due to HP5370B non-linearities**
- ❑ **LAGEOS range biases were held fixed at +13 mm prior to January 2021 and were to be estimated after that. Did that bias treatment induce the height discontinuity. See next slide**

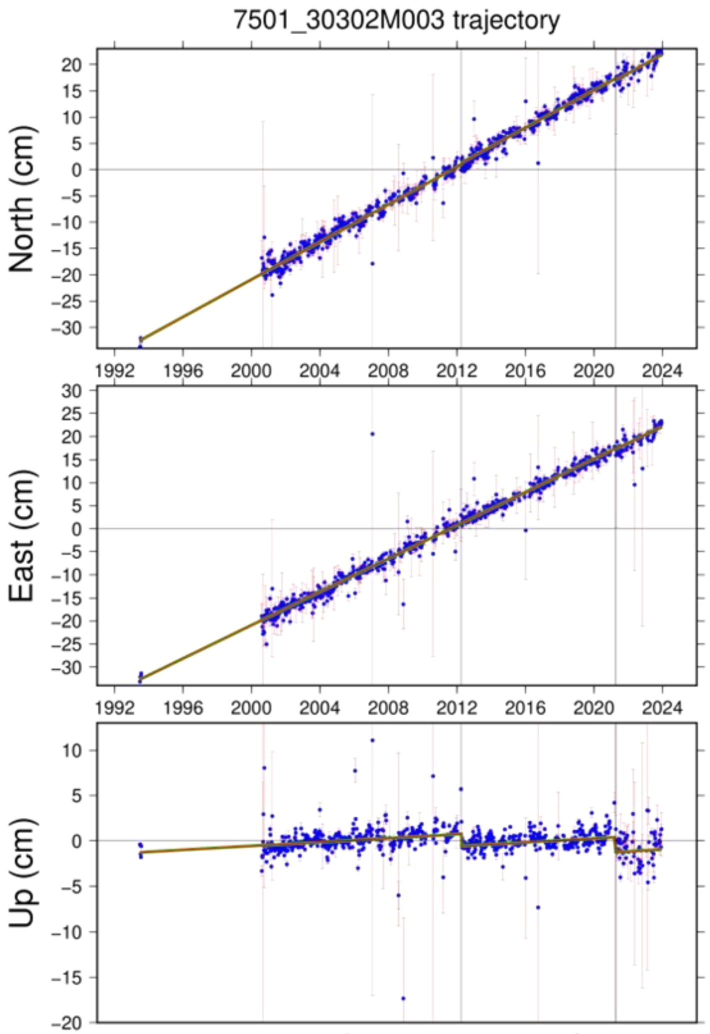
7501 HARL LAGEOS-1 Passes per Hour and Year

7501 HARL LAGEOS-1 Passes per Hour per Year

GMT	Local	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
0	2		4	2	27	5	11	19	15	5	14	11	16	27	21	29	24	8	21	25	21	31	15	2	18
1	3		2	8	20	5	4	18	17	3	15	8	10	24	17	23	19	11	16	18	14	19	14	11	10
2	4		2	4	21	12	5	22	7	1	7	7	5	20	18	13	18	13	14	23	22	18	8	6	14
3	5		3	6	19	13	10	19	10	6	18	5	4	15	17	9	20	11	13	8	14	12	7	8	5
4	6		1	7	15	12	2	18	9	2	10		2	11	10	5	14		4	4	3	2			1
5	7		2	8	18	9	1	14	2	3	7	1	5	12	4	9	8		1		1				
6	8		17	9	19	8	6	14	3	7	1	2	4	6	7	4	5		1						
7	9		14	11	17	6	2	9	4	2		1	3	5	10	5	8	1	1						
8	10		11	9	14	0	3	7	1	2	2	2	9	8	10	7	7	1	1						
9	11	1	16	6	13	1	7	3	4	9		3	9	8	14	9	4	2	1						
10	12	1	12	16	12		8		4	3	5	4	12	4	10	15	4	1	1		1				
11	13		16	15	8	3	4		5	4	2		10	6	7	16	1			2					
12	14	2	8	17	2	3	7		3	6	2	1	14	2	5	13			1						
13	15		8	16	15	6	7	2	5	4	2		18	4	7	14			3						
14	16		13	18	12	8	5	8	2	4	5		12	6	5	17		1	3		1				
15	17	1	8	39	18	14	4	16	4	5	7		17	10	9	19			9		5	5			2
16	18	6	16	38	31	9	12	27	5	14	16	2	22	16	13	24	7	5	16	5	17	17		7	8
17	19	4	20	34	30	11	20	24	6	8	13	5	29	16	20	27	12	8	24	9	24	27	2	5	6
18	20	3	22	28	24	12	23	29	2	8	14	5	32	26	20	34	17	5	35	19	22	25	13	6	13
19	21	6	16	28	29	5	17	31	2	8	24	12	31	17	16	25	26	5	27	20	17	26	8	6	13
20	22	5	22	27	34	7	19	26	3	5	20	11	30	25	14	26	30	4	25	29	14	26	8	2	12
21	23	5	17	18	35	3	9	27	2	3	14	11	25	24	16	31	30	6	20	26	25	22	8	6	18
22	0	0	4	6	30	2	12	34	12	3	17	9	24	26	25	28	27	4	18	25	15	25	17	5	16
23	1		6	12	25	2	6	22	11	3	21	11	11	23	15	21	16	9	20	18	17	20	8	8	17
Total		34	260	382	488	156	204	389	138	118	236	111	354	341	310	423	297	95	275	231	233	275	108	72	153

- **Accurate range bias determination relies upon adequate LAGEOS data yield with good spatial and temporal resolution**
- **Noticed than since 2014, there is a noticeable reduction in daylight LAGEOS ranging and a large drop off in system performance in 2021, when range biases are to be estimated**

7501 HARL DHF Recommendations



Trajectory: Blue: Raw, Green: Linear, Red: PSD model
Vertical gray lines represent discontinuities

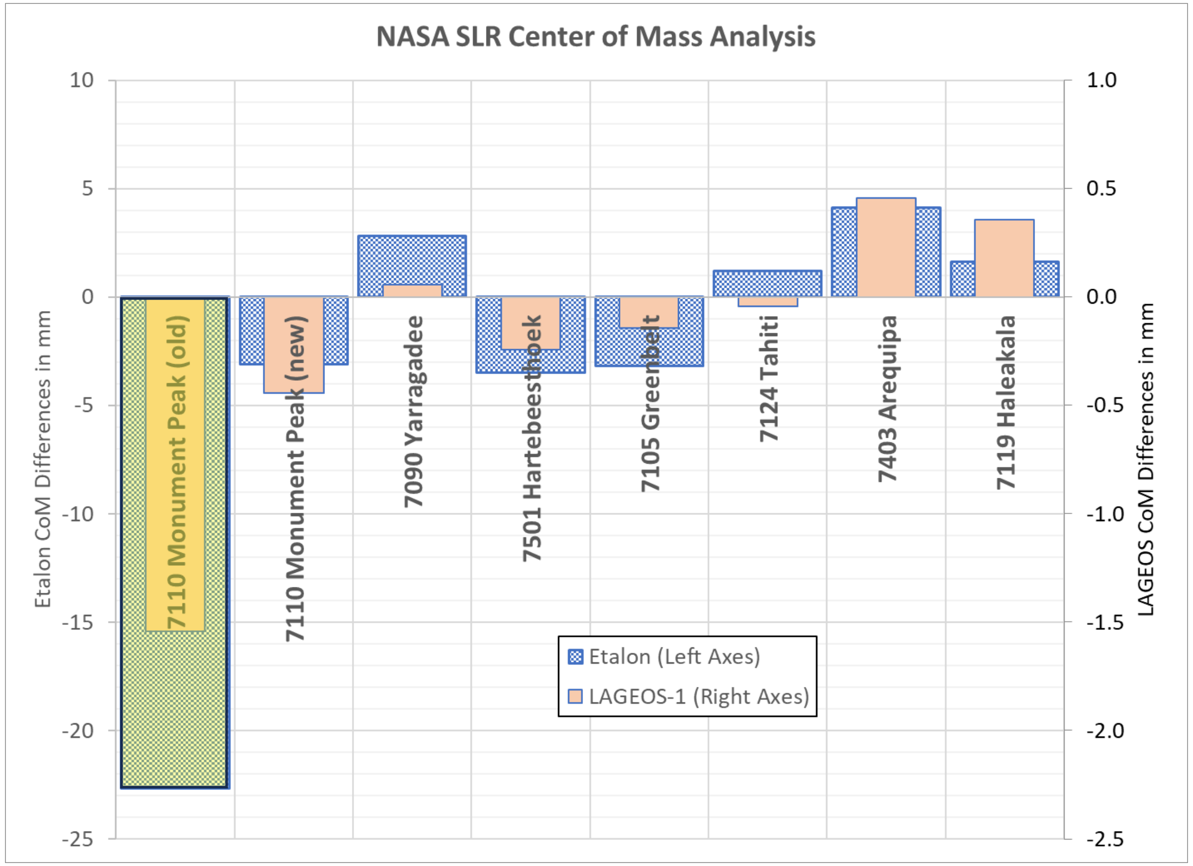
- ❑ **The optional intermittent -66mm RB correction in April 2012 should be applied *a priori* or delete all data when the station was intermittently switching between ground targets from day 71 to day 94, 2012 (March 11 to April 3, 2012)**
- ❑ **Break the period day 219, 2000 to day 50, 2017 into two periods and recompute the average RB for each period. See below:**

*CODE	Pad_id	Sat	T	PT	Start Date	End Date	Bias Code	Bias	STD	Rate	UNIT	Comments
	7501			A	12:071:00000	12:094:28800	X					
	7501	51	501	A	00:219:00000	12:071:00000	R	TBD	TBD		mm	
	7501	51	501	A	12:094:28800	17:050:00000	R	TBD	TBD		mm	
	7501	52	501	A	00:219:00000	12:071:00000	R	TBD	TBD		mm	
	7501	52	501	A	12:094:28800	17:050:00000	R	TBD	TBD		mm	

- ❑ **There are no RB estimates for the MTLRS data taken in 1993. Is there enough MTLRS data to separate a RB from a height error? Deleting this data coupled with the recommendations above may result in a new 7501 height rate**

Other Data Handling Issues

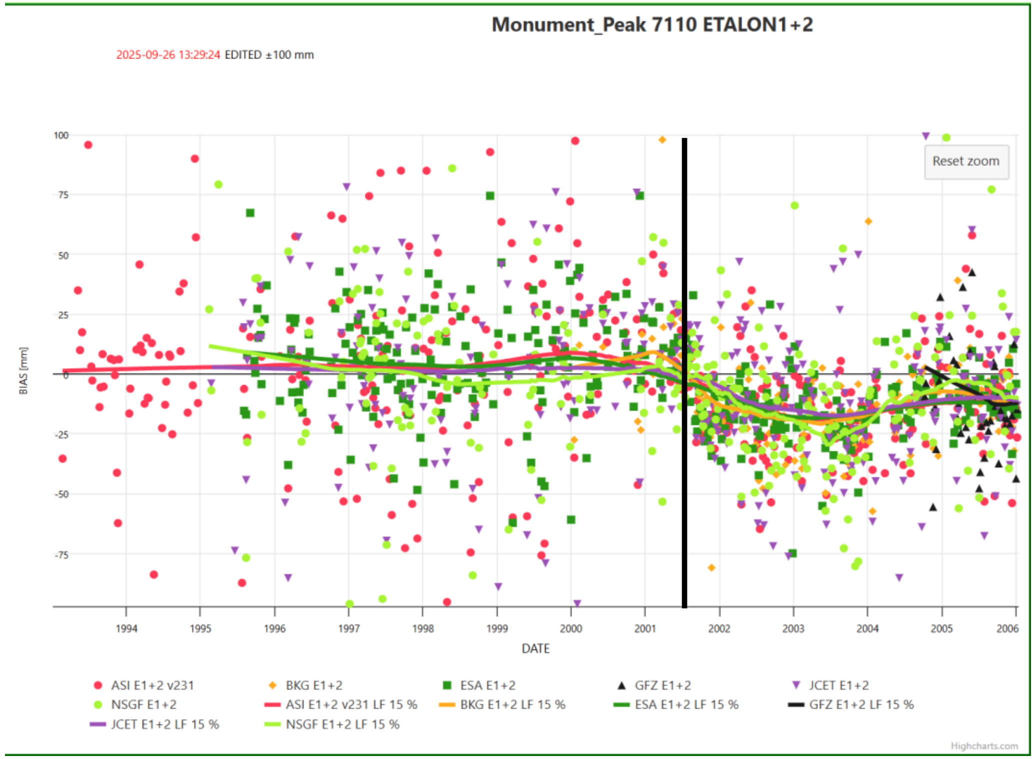
Retroactive Center of Mass (CoM) changes need to be accounted for in the DHF/RB estimates



- NASA SLR systems have nearly identical receiver systems. By comparing their CoM corrections, it was obvious the 2019 7110 MONL CoMs corrections were too small relative to the other NASA systems. An error in the CoM will induce a fixed RB, same magnitude as the error. A CoM too small induces a negative RB while a CoM too large induces a positive RB
- The CoM corrections for several stations were updated in 2022 including 7110 MONL. These 7110 updates brought them more in-line with the other NASA systems.
- In the past year, it was discovered the MCP-PMT change occurred four months later than originally reported in the site log. The site log was updated accordingly. Below are the 7110 CoM corrections before (2019) and after (2022)

Start Date	End Date	Detector	Version	LAGEOS-1	LAGEOS-2	Etalon	Comments
3/31/1986	8/19/2001	MCP-PMT ITT F4129F	191217	245.6	245.4	583.0	
8/19/2001	1/1/2050	MCP-PMT Photek PMT318	191217	244.6	243.9	563.8	
12/5/2002	1/1/2050	MCP-PMT Photek PMT318	220915	245.7	245.2	583.4	Start date should be 05-Dec-2002, site log had the wrong date but has since been updated
Old - New		MCP-PMT Photek PMT318		-1.1	-1.3	-19.6	

7110 MONL Etalon Biases



- The original 7110 Etalon CoM induced a -19 mm RB on 19-Aug-2001, See the black vertical line on the SSEM results on the left chart
- Below are the current 7110 MONL Etalon-1/-2 RB corrections in the DHF. The 7110 data post 19-Aug-2001 needs to be reprocessed with the 2022 LAGEOS and Etalon CoM corrections which will result in changes to the DHF

	COI		SO		START_DATE	END_DATE__		__E-VALUE_	STD_D	_E-RATE	UN	CMN
	7110	53	501	A	01:238:00000	00:000:00000	R	-14.5	0.5		mm	
	7110	54	501	A	01:238:00000	00:000:00000	R	-14.5	0.5		mm	

PT	Satellite
51	LAGEOS-1
52	LAGEOS-2
53	Etalon-1
54	Etalon-2

M	Bias Type
R	Range Bias

Other 7110 MONL Items of Interest

- In the Fall of 2019, Erricos asked me to investigate NASA SLR systematic errors and provide updates to the ILRS DHF for ITRF2020
- By December 2019, I provided some 'known' systematic errors for NASA SLR systems. This analysis was based on low hanging fruit e.g. I was unaware of the Vienna Mapping Function for Optical frequencies (VMF3o) and its usefulness
- Below was my most significant 7110 DHF RB redline provided (+5.7 mm RB) along with an update to the system eccentricities

7110 --- mm A 18:137:00000 00:000:00000 R **5.70** source VH 191219

- **Excerpts from my 7110 2019 DHF redline footnotes:**
  - "A set of eccentricities based on the November 2011 7110 survey were missing. The SINEX eccentricity files (in UNE and XYZ) were updated.
  - The system eccentricities and prime calibration targets have both exhibited mm level movement over the long term. Between November 2011 and May 2018, the distance to the prime calibration target changed by more than 5 mm. In an email exchange with the station, there was one event that seems noteworthy between 2011 and 2018 that may have led to mm level changes in system eccentricities. On October 9, 2014 (Day 282), the mount azimuth power amplifier failed which drove the azimuth drive at maximum speed into the dead limit of the shock absorber resulting in the heavy metal mount being bent.
- **Did the ACs use the new 2011 eccentricities in ITRF2020 which was a retroactive change 9 years later?**

Pad	Pt	Solu	T	Start	End	UNE	Up(m)	North(m)	East(m)	Delta Up (mm)	Delta North (mm)	Delta East (mm)	Comments
7110	A	1	L	83:227:00000	86:316:86399	UNE	3.2090	-0.0330	-0.0150				
7110	A	1	L	86:324:00000	88:121:86399	UNE	3.2100	-0.0330	-0.0150	1.0	0.0	0.0	
7110	A	1	L	88:121:00000	92:069:86399	UNE	3.2130	-0.0330	-0.0160	3.0	0.0	-1.0	
7110	A	1	L	92:122:00000	03:099:86399	UNE	3.1890	-0.0260	-0.0190	-24.0	7.0	-3.0	Mount swap with MOBLAS 8 at 7109
7110	A	1	L	03:143:00000	11:316:86399	UNE	3.1880	-0.0213	-0.0208	-1.0	4.7	-1.8	Post Mount Repair
7110	A	1	L	11:317:00000	18:136:86399	UNE	3.1900	-0.0260	-0.0180	2.0	-4.7	2.8	
7110	A	1	L	18:137:00000	00:000:00000	UNE	3.1895	-0.0242	-0.0148	-0.5	1.8	3.2	

Other 7110 MONL Items of Interest

- Based on the May 2018 survey, a 7110 RB of +5.7mm +/- 2mm was identified but not adopted in the DHF because it is more than 10 mm difference from the estimated LAGEOS SSEM-X RBs (see the SSEM-X RBs on the next slide).
- What other systematics have resulted in a SSEM estimated RB of -5 mm.

2019 Proposed DHF

7110 --- mm A 18:137:00000 00:000:00000 R 5.70 source VH 191219

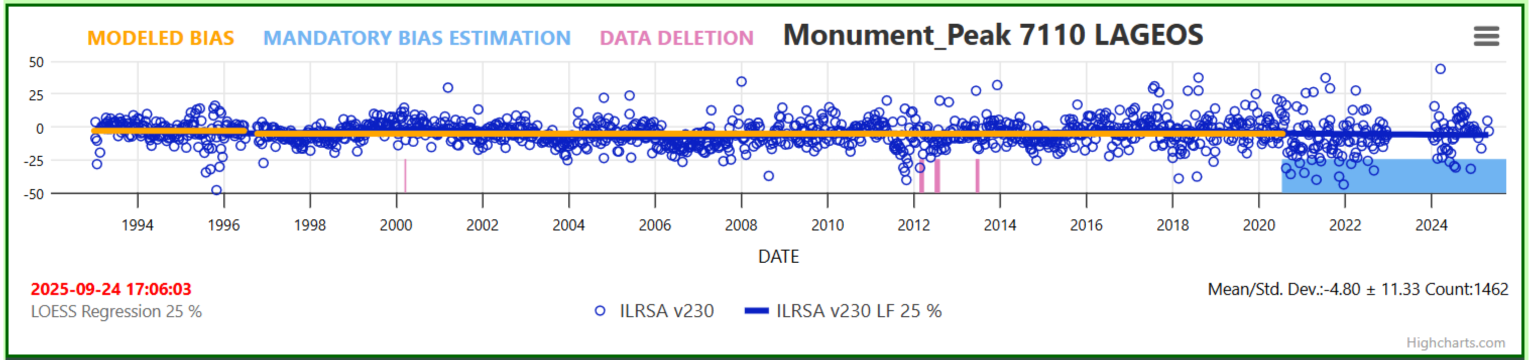
Current DHF

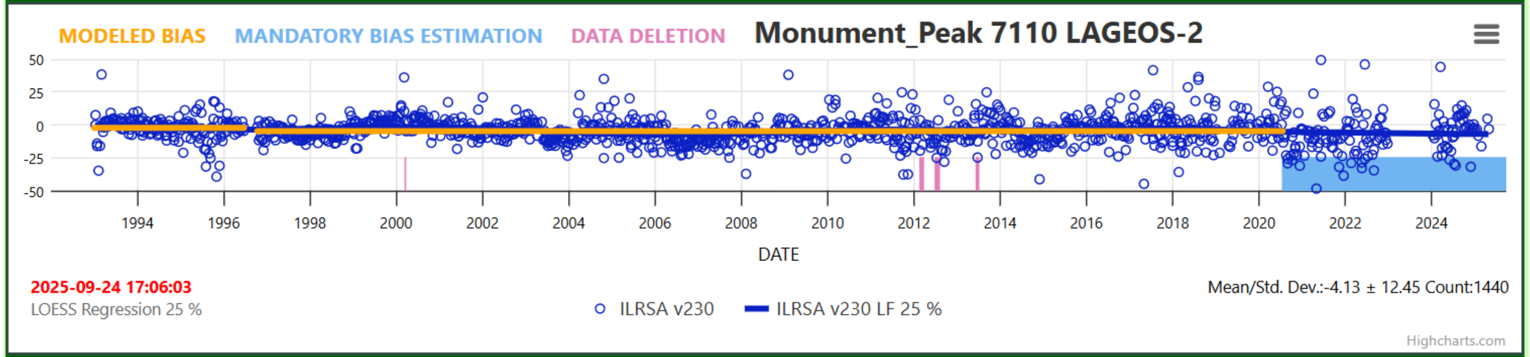
	CO		SO		START_DATE	END_DATE__		__E-VALUE_	STD_D	_E-RATE	UN	CMN
	7110	51	501	A	96:287:00000	20:201:00000	R	-5.2	0.2		mm	
	7110	52	501	A	96:287:00000	20:201:00000	R	-4.8	0.2		mm	
	7110	51	501	A	20:201:00000	30:000:00000	E				mm	
	7110	52	501	A	20:201:00000	30:000:00000	E				mm	

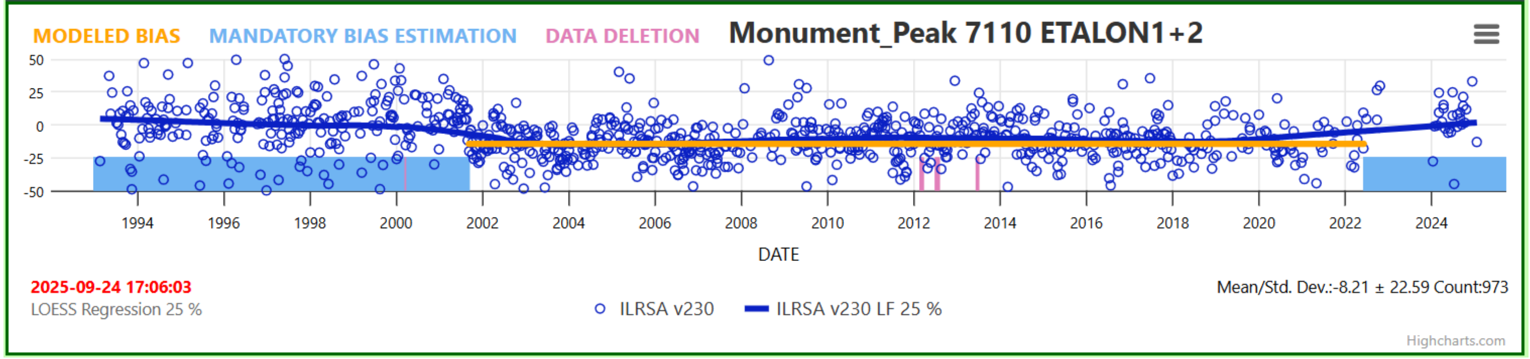
PT	Satellite
51	LAGEOS-1
52	LAGEOS-2

M	Bias Type
R	Range Bias
E	Estimate

Other 7110 MONL Items of Interest (continued)

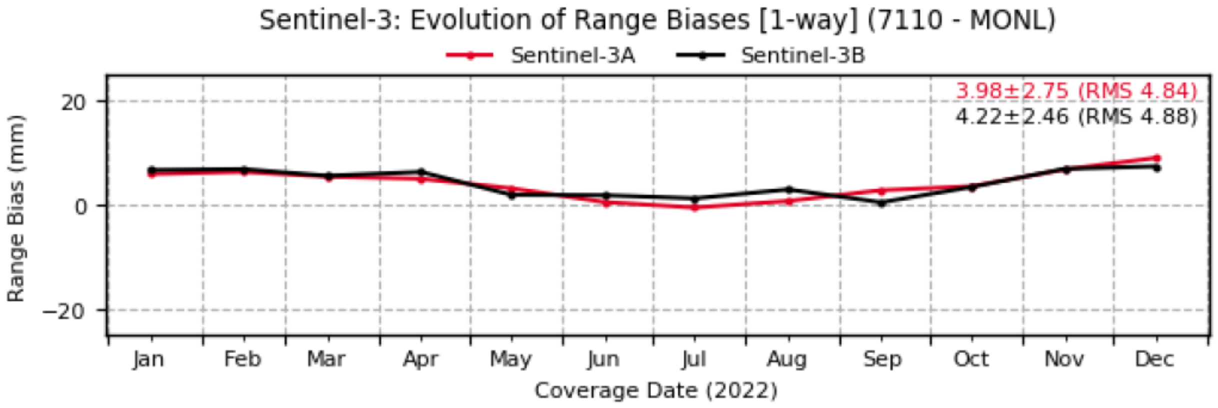






- Based on the DHF, 7110 LAGEOS-1/-2 RBs are to be estimated since 19-Jul-2020. The LAGEOS RBs on average are <-5 mm.
- There was a 7.1 and a 4.9 M earthquake in July 2019 and April 2020; respectively, in southern California. The 7110 ITRF2020_U2023 coordinates have a discontinuity coinciding with the 7.1 M earthquake?
- Prior to 2021, the 7110 ITRF2020 height is based on fixed LAGEOS-1/-2 RBs (See the orange lines in these charts) based on the original 2019 CoMs. Will updating the CoM and estimating a new 'fixed' RB alter the station height?

Other 7110 MONL Items of Interest (continued)



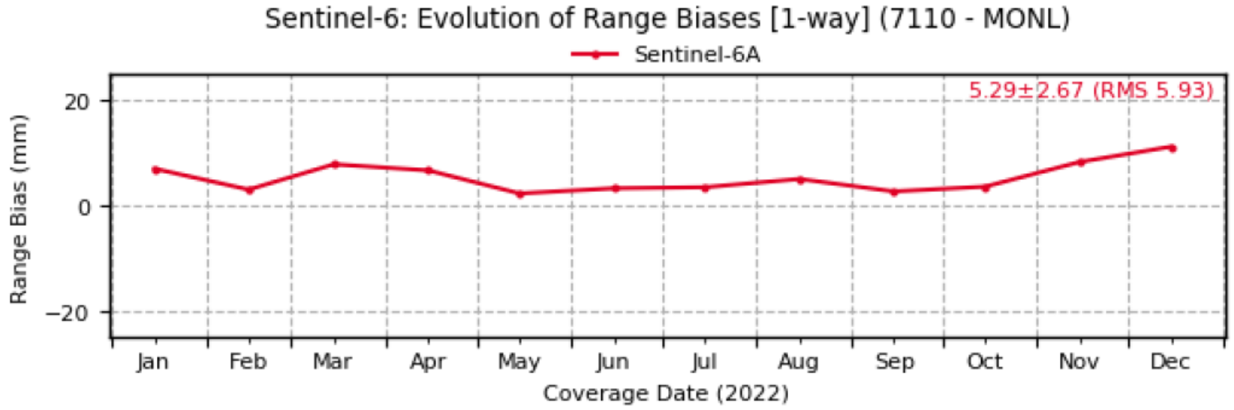


Table 4 Independent SLR residual statistics per ground station.
(*Total does not include results from Arequipa station).

Station Name	Site Code	Station #	Number of Data Points	Residual Mean (mm)	Residual RMS (mm)
Arequipa	AREL	7403	319	55.8	160.6
Graz	GRZL	7839	3,917	4.7	19.3
Greenbelt	GODL	7105	5,402	-6.2	16.7
Haleakala	HA4T	7119	1,639	7.2	23.3
Hartebeesthoek	HARL	7501	2,164	-0.6	19.5
Herstmonceux	HERL	7840	1,114	-7.5	17.6
Monument Peak	MONL	7110	4,211	5.7	20.4
Postdam	POT3	7841	1,416	-15.2	23.2
Wettzell	SOSW	7827	1,074	3.5	21.6
Yarragadee	YARL	7090	24,820	-1.2	20.2

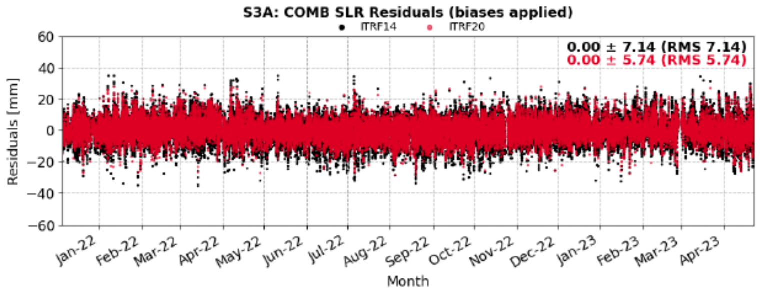
- ❑ **The left charts are the 7110 MONL 2022 Sentinel (3A, 3B, 6) RB estimates using ITRF2014 coordinates with a mean Sentinel RB of +4.5 mm**
- ❑ **The right chart contains the 7110 MONL ICESat-2 RB estimates from the ICESat-2 Precision Orbit Determination (Thomas et el) for the period 16-Sep-2018 to 19-Oct-2019 using ITRF2014 coordinates**

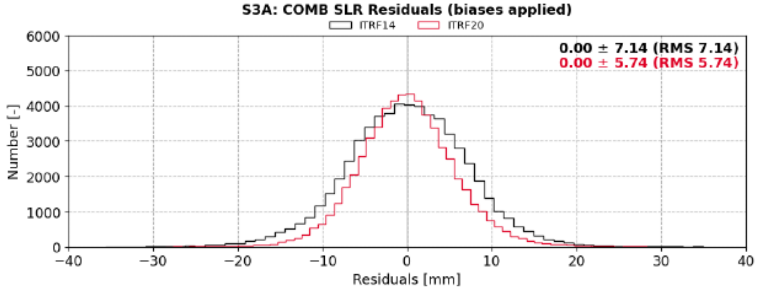
Other 7110 MONL Items of Interest (continued)

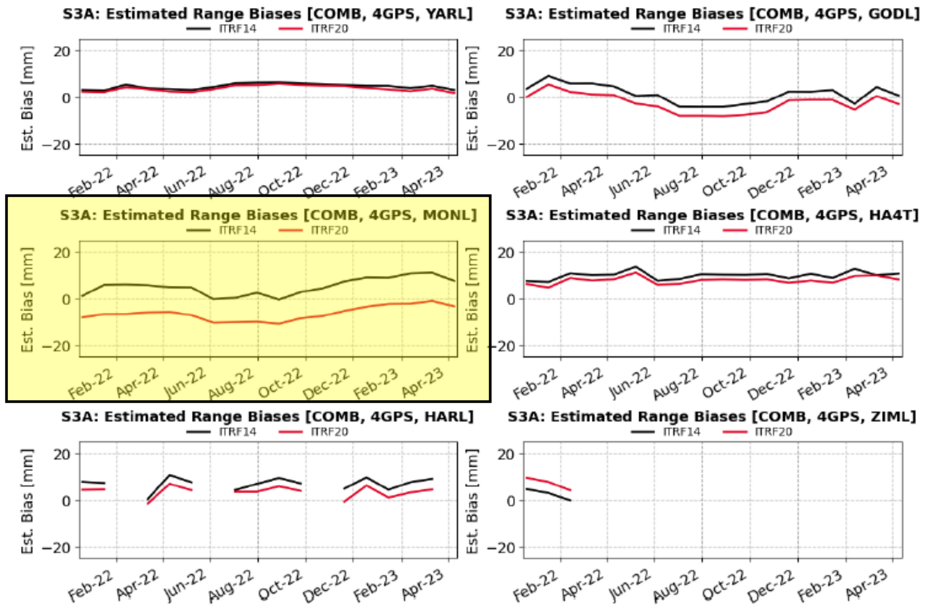
2. Mono-satellite Results

ITRF14 vs. ITRF20 [S3A, COMB]

- There is a significant **improvement** on the obtained SLR residuals when using the ITRF2020 coordinates.
- The estimated range biases between both reference systems follow a similar pattern but with a bias on the obtained values. These biases are shorter or larger depending on the SLR station.

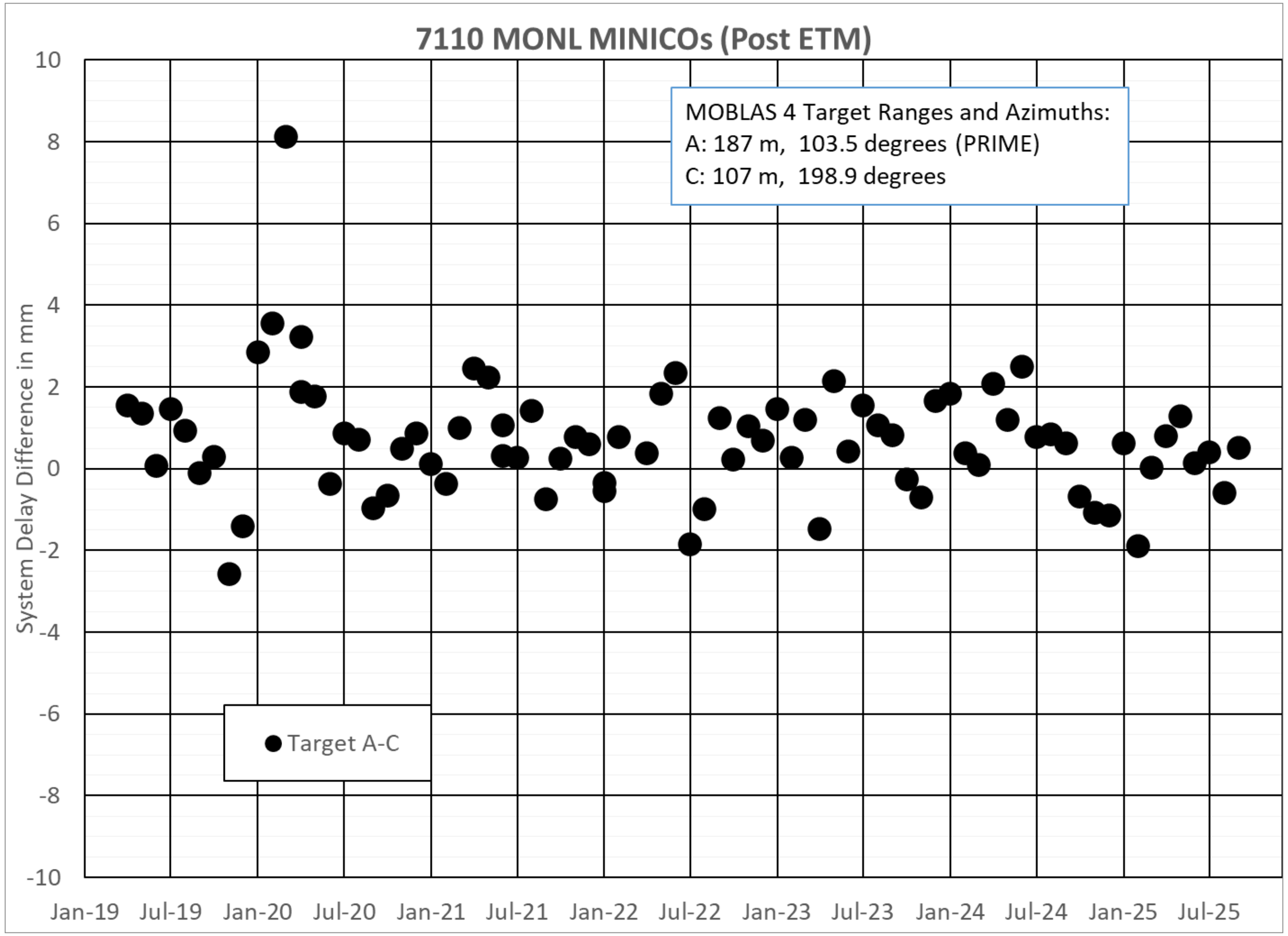






- It is interesting that the 7110 Sentinel range biases show a RB difference of ~10 mm depending upon which set of ITRF coordinates are used (2014 vs 2020). The Sentinel 2023 7110 RB using ITRF2014 coordinates are positive and more than a few mm
- Using ITRF2014 coordinates, the LEO (Sentinel and IceSat) 7110 RBs are close to the original +5.7 mm RB estimate provided to Erricos

Other 7110 MONL Items of Interest (continued)



- ❑ Left chart are the 7110 MONL Event Timer Module (ETM) MINICO results removing the +5.7 mm target range error based on the May 2018 local survey
- ❑ Should we implement the known 5.7 mm calibration target change? And if so when should we make the change (e.g. on a Sunday near the end of a month)? This change would further increase the observed negative RB on LAGEOS-1 and -2 data by 5.7 mm

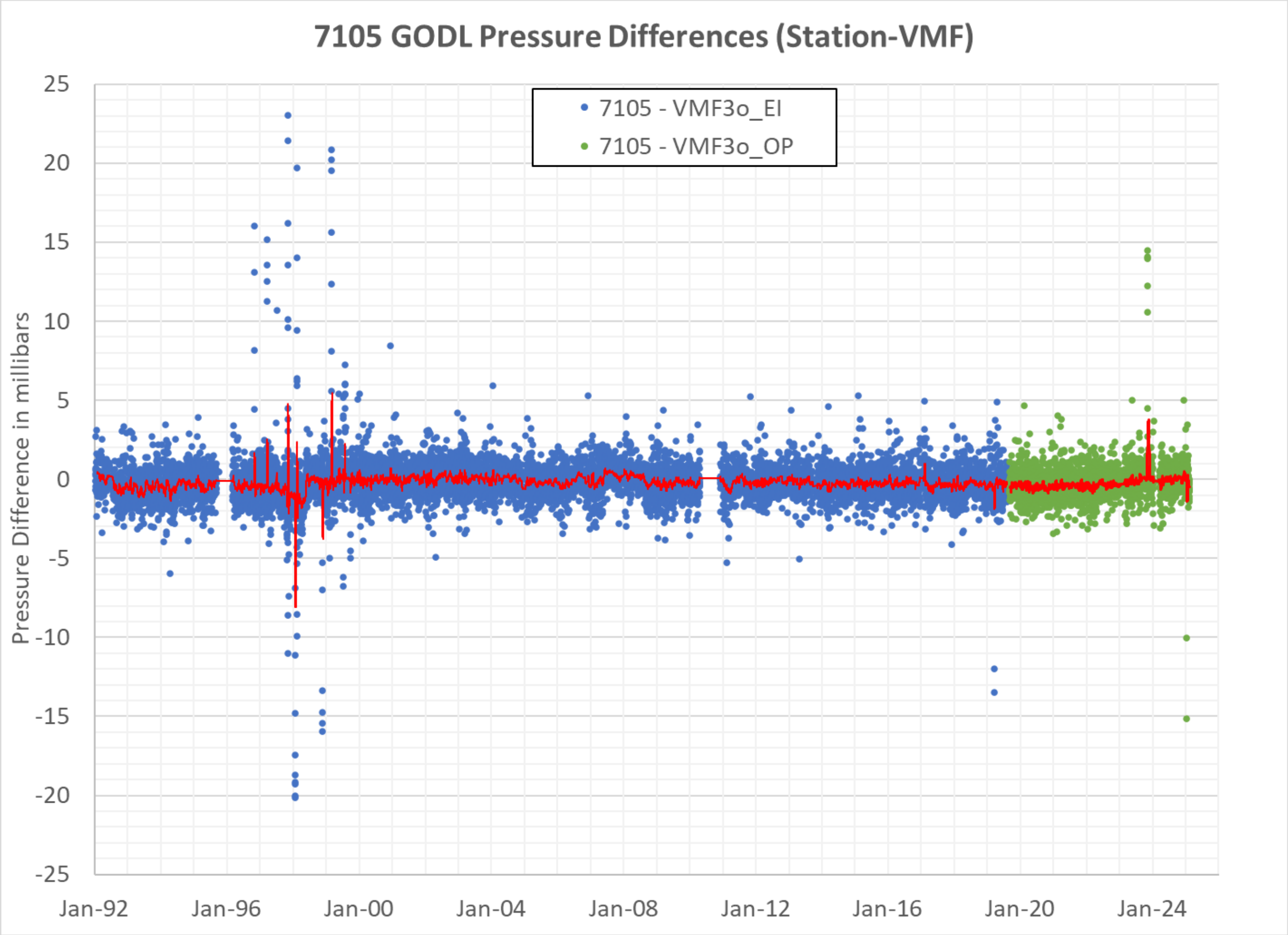
Current 7105 GODL Tropospheric Biases in the ILRS DHF

```
*
*-----------------------------------------------------------------------------
*  list of mandatory systematic errors to be applied on observation
*  with updates from ILRS/AWG reprocessing results
*-----------------------------------------------------------------------------
*-----------------------------------------------------------------------------
*CODE PT SOLN T START_DATE__ END_DATE____ M __E-VALUE___ STD_DEV _E-RATE__ UNIT   CMNTS
 7090 -- ---- A 09:344:31560 09:345:70200 T      0.90920                    ms
 7105 -- ---- A 12:296:55000 12:297:02400 T       7.0470                    ms
 7110 -- ---- A 10:173:00000 10:208:27000 T      0.00640                    ms
 7110 -- ---- A 11:115:00000 11:316:00000 T      0.00780                    ms
 7110 -- ---- A 13:164:00000 13:173:00000 T      0.89990                    ms
 7124 -- ---- A 19:295:00000 19:324:00000 T        -1.00                    ms
 7237 -- ---- A 17:038:04000 17:038:60600 U      +1.0000                    ms    ETO
 7237 -- ---- A 17:037:43200 17:037:86400 U      +1.0000                    ms    ETO
 7501 -- ---- A 00:183:00000 04:279:86399 T     -0.00605                    ms
 7501 -- ---- A 04:280:00000 06:059:86399 T     -0.00615                    ms
 7501 -- ---- A 06:060:00000 08:182:86399 T     -0.00595                    ms
 7831 -- ---- A 87:001:00000 90:182:00000 T       0.0850                    ms
 7941 -- ---- A 10:221:61200 10:223:43200 U       100.00                    ms    TDP
*-----------------------------------------------------------------------------
 7840 -- ---- A 95:358:00000 95:358:86400 H    -20.00                        %    HER
 7840 -- ---- A 95:359:00000 95:361:54000 H    -10.00                        %    HER
 7840 -- ---- A 95:361:54000 95:363:57600 H    -20.00                        %    HER
 7840 -- ---- A 95:363:57600 96:017:00000 H    -30.00                        %    HER
 7840 -- ---- A 96:017:39600 96:022:00000 H    -15.00                        %    HER
 7840 -- ---- A 96:022:00000 96:043:54000 H    -30.00                        %    HER
*-----------------------------------------------------------------------------
 7080 -- ---- A 95:065:00000 96:025:86400 P    -2.10                        mB    BRE
 7080 -- ---- A 96:026:00000 96:115:86400 P    -10.30                       mB    BRE
 7080 -- ---- A 96:116:00000 96:129:72000 P    -9.70                        mB    BRE
 7109 -- ---- A 95:284:00000 95:287:65700 P    -50.00                       mB    BRE
 7110 -- ---- A 95:105:00000 95:355:65700 P     2.00                        mB    BRE
 7105 -- ---- A 19:074:79380 19:074:79800 P        5.20                     mB    FPR
 7105 -- ---- A 19:074:79800 19:074:81000 P        4.90                     mB    FPR
 7105 -- ---- A 19:074:81000 19:074:82740 P        4.70                     mB    FPR
 7105 -- ---- A 19:074:82740 19:074:85320 P        4.60                     mB    FPR
 7105 -- ---- A 19:074:85320 19:074:86160 P        4.20                     mB    FPR
 7105 -- ---- A 19:077:09240 19:077:12300 P      -13.10                     mB    FPR
 7105 -- ---- A 19:077:12300 19:077:13020 P      -13.40                     mB    FPR
 7105 -- ---- A 19:077:13020 19:077:13380 P      -13.60                     mB    FPR
 7105 -- ---- A 19:077:13380 19:077:13980 P      -13.70                     mB    FPR
 7105 -- ---- A 19:077:19500 19:077:19920 P      -13.30                     mB    FPR
 7105 -- ---- A 19:077:19920 19:077:22800 P      -13.20                     mB    FPR
 7105 -- ---- A 19:077:22800 19:077:27240 P      -13.00                     mB    FPR
 7105 -- ---- A 19:077:27240 19:077:31620 P      -12.75                     mB    FPR
```

```
 1864 -- ---- A 90:270:00000 00:359:00000 P        -6.8       1.0                   mB
 7105 -- ---- A 99:058:21180 99:058:37180 P       -2.00       1.0                   mB    FPR
 7105 52 ---- A 99:038:09540 99:038:13140 P       -4.00       1.0                   mB    FPR
 7105 52 ---- A 99:060:34860 99:060:53100 P       021.0       1.0                   mB    FPR
 7105 51 ---- A 99:061:56340 99:061:59940 P       07.00       1.0                   mB    FPR
 7105 52 ---- A 99:138:73380 99:138:76980 P       05.60       1.0                   mB    FPR
 7105 51 ---- A 99:159:20580 99:159:24180 P       0.600       .50                   mB    FPR
 7105 51 ---- A 99:159:32580 99:159:36180 P       01.20       .50                   mB    FPR
 7105 51 ---- A 99:159:44820 99:159:48420 P       0.900       .50                   mB    FPR
 7105 51 ---- A 99:190:21300 99:190:35940 P       -1.00       .50                   mB    FPR
 7105 51 ---- A 99:191:15720 99:191:19320 P       04.00       1.0                   mB    FPR
 7105 52 ---- A 99:192:51720 99:192:70260 P       -7.50       1.0                   mB    FPR
 7105 51 ---- A 99:205:10020 99:205:13620 P       02.20       .50                   mB    FPR
 7105 52 ---- A 99:206:28620 99:206:32220 P       06.50       1.0                   mB    FPR
 7105 51 ---- A 99:206:29580 99:206:33180 P       06.20       1.0                   mB    FPR
 7105 52 ---- A 99:206:56940 99:206:60540 P       04.80       1.0                   mB    FPR
 7105 51 ---- A 99:216:07020 99:216:10620 P       -.400       .50                   mB    FPR
 7105 52 ---- A 99:216:31020 99:216:34620 P       0.700       .50                   mB    FPR
 7105 52 ---- A 99:216:47460 99:216:51060 P       0.800       .50                   mB    FPR
 7105 51 ---- A 99:266:02460 99:266:06060 P       -1.50       .50                   mB    FPR
 7105 51 ---- A 99:266:14700 99:266:18300 P       -3.20       1.0                   mB    FPR
 7105 52 ---- A 99:266:08100 99:266:11700 P       -2.00       .50                   mB    FPR
 7105 51 ---- A 99:266:27060 99:266:30660 P       -4.10       1.0                   mB    FPR
 7105 52 ---- A 99:266:23100 99:266:26700 P       -3.70       1.0                   mB    FPR
 7105 52 ---- A 99:266:39780 99:266:43380 P       -5.10       1.0                   mB    FPR
 7839 -- ---- A 02:161:00000 02:344:00000 P         -.5        .1                   mB
 7845 51 ---- A 99:237:59628 99:237:63228 P      -878.5       .30                   mB
 7849 51 ---- A 99:125:39176 99:125:42776 P       69.20       .50                   mB
 7849 51 ---- A 99:300:05234 99:300:08834 P       87.00       1.5                   mB
 7849 52 ---- A 99:300:01885 99:300:05485 P       86.00       1.5                   mB
-SOLUTION/DATA_HANDLING
```

- The 7105 corrections highlighted in green are fine; the 7105 corrections highlighted in yellow were LAGEOS-1 (51) and LAGEOS-2 (52) specific, but these can be expanded to be applied to other satellites

7105 GODL Barometric Pressures Differences (Station – VMF3o)



- ❑ The VMF3o data is beneficial in identifying barometric outliers. All these 7105 GODL outliers were caused by frozen barometric measurements. Some were known and documented in the current DHF, but some were not known
- ❑ The next two slides are DHF redlines to the existing 7105 GODL tropospheric corrections

7105 GODL DHF Tropospheric Bias Redlines

*	CODE	PT	SOLN	T	START_DATE	END_DATE	M	VALUE	STD DEV	UNIT	CMNTS
	7105	--	----	A	96:301:75600	96:302:10800	P	4.7	2	mB	FPR
	7105	--	----	A	96:302:10800	96:302:32400	P	8.5	2	mB	FPR
	7105	--	----	A	96:302:54000	96:302:75600	P	16.3	2	mB	FPR
	7105	--	----	A	96:302:75600	96:303:10800	P	13.4	2	mB	FPR
	7105	--	----	A	97:079:75600	97:080:10800	P	13.9	2	mB	FPR
	7105	--	----	A	97:080:10800	97:080:32400	P	12.8	2	mB	FPR
	7105	--	----	A	97:080:32400	97:080:54000	P	11.6	2	mB	FPR
	7105	--	----	A	97:080:54000	97:080:75600	P	15.5	2	mB	FPR
	7105	--	----	A	97:181:75600	97:182:10800	P	3.9	2	mB	FPR
	7105	--	----	A	97:183:75600	97:184:10800	P	11.0	2	mB	FPR
	7105	--	----	A	97:295:75600	97:297:54000	P	-3.1	2	mB	FPR
	7105	--	----	A	97:304:54000	97:304:75600	P	2.1	2	mB	FPR
	7105	--	----	A	97:304:75600	97:305:10800	P	4.8	2	mB	FPR
	7105	--	----	A	97:306:10800	97:306:75600	P	22.5	2	mB	FPR
	7105	--	----	A	97:306:75600	97:307:10800	P	16.5	2	mB	FPR
	7105	--	----	A	97:307:10800	97:307:32400	P	13.9	2	mB	FPR
	7105	--	----	A	97:307:32400	97:307:75600	P	10.2	2	mB	FPR
	7105	--	----	A	97:307:75600	97:308:10800	P	4.1	2	mB	FPR
	7105	--	----	A	97:308:32400	97:308:54000	P	-2.0	2	mB	FPR
	7105	--	----	A	97:308:75600	97:309:10800	P	-10.7	2	mB	FPR
	7105	--	----	A	97:309:10800	97:309:32400	P	-8.3	2	mB	FPR
	7105	--	----	A	97:309:32400	97:309:54000	P	-3.7	2	mB	FPR
	7105	--	----	A	97:310:10800	97:310:32400	P	2.1	2	mB	FPR
	7105	--	----	A	97:310:32400	97:310:54000	P	3.4	2	mB	FPR
	7105	--	----	A	97:313:75600	97:314:10800	P	-2.3	2	mB	FPR
	7105	--	----	A	97:314:10800	97:314:32400	P	-4.4	2	mB	FPR
	7105	--	----	A	97:314:32400	97:314:54000	P	-7.1	2	mB	FPR
	7105	--	----	A	98:025:32400	98:025:54000	P	-6.6	2	mB	FPR

CODE	PT	SOLN	T	START_DATE	END_DATE	M	VALUE	STD DEV	UNIT	CMNTS
7105	--	----	A	98:025:54000	98:025:75600	P	-10.9	2	mB	FPR
7105	--	----	A	98:025:75600	98:026:10800	P	-14.5	2	mB	FPR
7105	--	----	A	98:026:10800	98:026:32400	P	-17.2	2	mB	FPR
7105	--	----	A	98:026:32400	98:027:54000	P	-19.2	2	mB	FPR
7105	--	----	A	98:043:54000	98:043:75600	P	20.0	2	mB	FPR
7105	--	----	A	98:043:75600	98:044:10800	P	14.3	2	mB	FPR
7105	--	----	A	98:044:10800	98:044:32400	P	9.8	2	mB	FPR
7105	--	----	A	98:044:32400	98:045:10800	P	6.5	2	mB	FPR
7105	--	----	A	98:046:10800	98:046:32400	P	-5.1	2	mB	FPR
7105	--	----	A	98:046:32400	98:046:75600	P	-8.9	2	mB	FPR
7105	--	----	A	98:046:75600	98:047:10800	P	-4.0	2	mB	FPR
7105	--	----	A	98:321:75600	98:322:10800	P	-5.0	2	mB	FPR
7105	--	----	A	98:322:54000	98:323:32400	P	-15.1	2	mB	FPR
7105	--	----	A	98:323:32400	98:323:54000	P	-13.1	2	mB	FPR
7105	--	----	A	98:323:75600	98:324:10800	P	-6.7	2	mB	FPR
7105	--	----	A	99:037:79008	99:038:13140	P	-4.0	1	mB	FPR
7105	--	----	A	99:058:21180	99:058:65000	P	-2.0	1	mB	FPR
7105	--	----	A	99:060:27728	99:060:57500	P	21.0	1	mB	FPR
7105	--	----	A	99:061:01743	99:061:13938	P	14.5	2	mB	FPR
7105	--	----	A	99:061:13938	99:061:41379	P	12.4	2	mB	FPR
7105	--	----	A	99:061:41379	99:061:51692	P	8.6	2	mB	FPR
7105	--	----	A	99:061:51692	99:061:64616	P	7.0	1	mB	FPR
7105	--	----	A	99:138:68412	99:138:76980	P	5.6	1	mB	FPR
7105	--	----	A	99:159:20580	99:159:32580	P	0.6	0.5	mB	FPR
7105	--	----	A	99:159:32580	99:159:44820	P	1.2	0.5	mB	FPR
7105	--	----	A	99:159:44820	99:159:48420	P	0.9	0.5	mB	FPR
7105	--	----	A	99:190:07320	99:190:51000	P	-1.0	0.5	mB	FPR
7105	--	----	A	99:191:05400	99:191:52000	P	4.0	1	mB	FPR

- These corrections are to fix tropospheric biases when the 7105 barometric measurements were not updating, sorted by time

Legend	
current DHF Entries	
DHF Redlines	
-20.00	-24.99
-15.00	-19.99
-10.00	-14.99
-5.00	-9.99
-4.99	4.99
5.00	9.99
10.00	14.99
15.00	19.99
20.00	24.99

7105 GODL DHF Tropospheric Bias Redlines (continued)

CODE	PT	SOLN	T	START_DATE	END_DATE	M	VALUE	STD DEV	UNIT	CMNTS
7105	--	----	A	99:192:51720	99:192:78000	P	-7.5	1	mB	FPR
7105	--	----	A	99:204:68500	99:205:35200	P	2.2	0.5	mB	FPR
7105	--	----	A	99:205:72714	99:206:29580	P	6.5	1	mB	FPR
7105	--	----	A	99:206:29580	99:206:37742	P	6.2	1	mB	FPR
7105	--	----	A	99:206:37742	99:206:69461	P	4.8	1	mB	FPR
7105	--	----	A	99:206:69461	99:206:85500	P	7.0	1	mB	FPR
7105	--	----	A	99:216:07020	99:216:26607	P	-0.4	0.5	mB	FPR
7105	--	----	A	99:216:26607	99:216:47460	P	0.7	0.5	mB	FPR
7105	--	----	A	99:216:47460	99:216:51060	P	0.8	0.5	mB	FPR
7105	--	----	A	99:216:73834	99:216:83000	P	6.2	1	mB	FPR
7105	--	----	A	99:266:02460	99:266:08062	P	-1.5	0.5	mB	FPR
7105	--	----	A	99:266:08062	99:266:14700	P	-2.0	0.5	mB	FPR
7105	--	----	A	99:266:14700	99:266:23100	P	-3.2	1	mB	FPR
7105	--	----	A	99:266:23100	99:266:27060	P	-3.7	1	mB	FPR
7105	--	----	A	99:266:27060	99:266:39780	P	-4.1	1	mB	FPR
7105	--	----	A	99:266:39780	99:266:49214	P	-5.1	1	mB	FPR
7105	--	----	A	99:266:49214	99:266:70775	P	-5.8	1	mB	FPR
7105	--	----	A	99:266:70775	99:266:83959	P	-3.5	1	mB	FPR
7105	--	----	A	09:352:32400	09:352:54000	P	1.8	2	mB	FPR
7105	--	----	A	10:003:75600	10:004:32400	P	2.9	2	mB	FPR
7105	--	----	A	19:074:79380	19:074:79800	P	5.2		mB	FPR
7105	--	----	A	19:074:79800	19:074:81000	P	4.9		mB	FPR
7105	--	----	A	19:074:81000	19:074:82740	P	4.7		mB	FPR
7105	--	----	A	19:074:82740	19:074:85320	P	4.6		mB	FPR
7105	--	----	A	19:074:85320	19:074:86160	P	4.2		mB	FPR
7105	--	----	A	19:077:09240	19:077:12300	P	-13.1		mB	FPR
7105	--	----	A	19:077:12300	19:077:13020	P	-13.4		mB	FPR
7105	--	----	A	19:077:13020	19:077:13380	P	-13.6		mB	FPR

CODE	PT	SOLN	T	START_DATE	END_DATE	M	VALUE	STD DEV	UNIT	CMNTS
7105	--	----	A	19:077:13380	19:077:13980	P	-13.7		mB	FPR
7105	--	----	A	19:077:19500	19:077:19920	P	-13.3		mB	FPR
7105	--	----	A	19:077:19920	19:077:22800	P	-13.2		mB	FPR
7105	--	----	A	19:077:22800	19:077:27240	P	-13.0		mB	FPR
7105	--	----	A	19:077:27240	19:077:31620	P	-12.8		mB	FPR
7105	--	----	A	23:307:63120	23:307:65760	P	1.1	1	mB	FPR
7105	--	----	A	23:307:65760	23:307:71400	P	2.1	1	mB	FPR
7105	--	----	A	23:307:71400	23:307:78120	P	3.3	1	mB	FPR
7105	--	----	A	23:307:78120	23:308:04000	P	4.1	1	mB	FPR
7105	--	----	A	23:310:10620	23:310:15300	P	13.2	1	mB	FPR
7105	--	----	A	23:310:15300	23:310:21420	P	12.5	1	mB	FPR
7105	--	----	A	23:310:21420	23:310:43440	P	11.2	1	mB	FPR
7105	--	----	A	23:310:43440	23:310:60840	P	10.1	1	mB	FPR
7105	--	----	A	23:310:60840	23:310:72240	P	12.7	1	mB	FPR
7105	--	----	A	23:310:72240	23:311:02040	P	16.1	1	mB	FPR
7105	--	----	A	24:085:11028	24:085:41429	P	-1.4	1	mB	FPR
7105	--	----	A	24:085:41429	24:085:58558	P	-3.1	1	mB	FPR
7105	--	----	A	25:013:11970	25:013:26681	P	-16.5	1	mB	FPR
7105	--	----	A	25:013:26681	25:013:40816	P	-14.8	1	mB	FPR

Legend	
current DHF Entries	
DHF Redlines	
-20.00	-24.99
-15.00	-19.99
-10.00	-14.99
-5.00	-9.99
-4.99	4.99
5.00	9.99
10.00	14.99
15.00	19.99
20.00	24.99

- **These 7105 GODL tropospheric corrections can be made available via a text file**

7119 HA4T DHF RBs

Current 7119 DHF RBs

*	CODE	PT	SOLN	T	START_DATE__	END_DATE____	M	__E-VALUI	STD_DEV	_E-RATE__	UNIT	CMNTS
	7119	51	501	A	06:316:00000	13:223:00000	R	1.4	0.4		mm	
	7119	52	501	A	06:316:00000	13:223:00000	R	1.5	0.4		mm	
	7119	51	501	A	13:223:00000	15:018:00000	R	5.1	1		mm	
	7119	52	501	A	13:223:00000	15:018:00000	R	4.8	1		mm	
	7119	51	501	A	15:067:00000	00:000:00000	R	9.9	0.4		mm	
	7119	52	501	A	15:067:00000	00:000:00000	R	10.9	0.4		mm	

My Dec 2019 Proposed 2019 DHF RBs

7119 --- mm A 06:250:00000 13:224:43000 R 2.00 source VH 191219
7119 --- mm A 13:224:43000 15:060:00000 R 6.70 source VH 191219
7119 --- mm A 15:060:00000 30:000:00000 R 10.70 source VH 191219

7119 HA4T System Eccentricities

Pad	PT	SOLN	T	Data Start	Data End	UNE	Up (m)	North (m)	East (m)	Delta Up (mm)	Delta North (mm)	Delta East (mm)	SOD
7119	A	1	L	06:250:00000	11:088:86399	UNE	2.6320	0.0010	0.0020				71191401
7119	A	1	L	11:089:00000	13:134:86399	UNE	2.6320	0.0010	0.0020	0.0	0.0	0.0	71191402
7119	A	1	L	13:135:00000	00:000:00000	UNE	2.6304	0.0029	0.0032	-1.6	1.9	1.2	71191402

- **My Dec 2019 7119 DHF footnotes:**
  - There are several mm level range bias corrections added to account for uncompensated changes in calibration target ranges and outdated optical path calibration corrections.
  - The 7119 eccentricities in 2013 were also updated. These new eccentricities were taken in May 2013 post mount maintenance and releveling of the mount.
- **In 2025, the crew remeasured the thickness of their ND filters, which was less than 0.5 mm off from my initial estimate in Dec 2019**

7119 HA4T Range Bias Change

- On 30-Mar-2025 (day 089) at 07:00 the station removed two systematic errors (Neutral Density [ND] filter correction and a target range correction) resulting in a 11.1 mm change in system delay. Data taken after this change is shorter by 11.1 mm.
- This change will require updates to the DHF. The two entries below will require updates at a minimum:

*	CODE	PT	SOLN	T	START_DATE__	END_DATE____	M	__E-VALUE	STD_DEV	_E-RATE_	UNIT	CMNTS
	7119	51	501	A	15:067:00000	00:000:00000	R	9.9	0.4		mm	
	7119	52	501	A	15:067:00000	00:000:00000	R	10.9	0.4		mm	

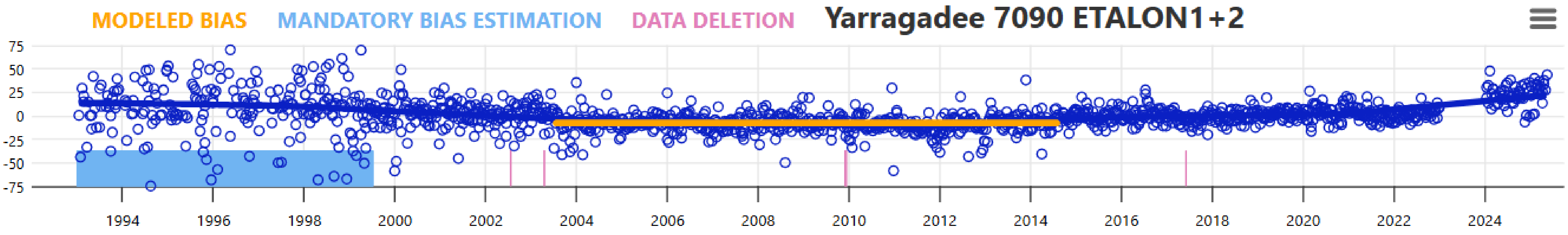
- Below are the proposed redline changes

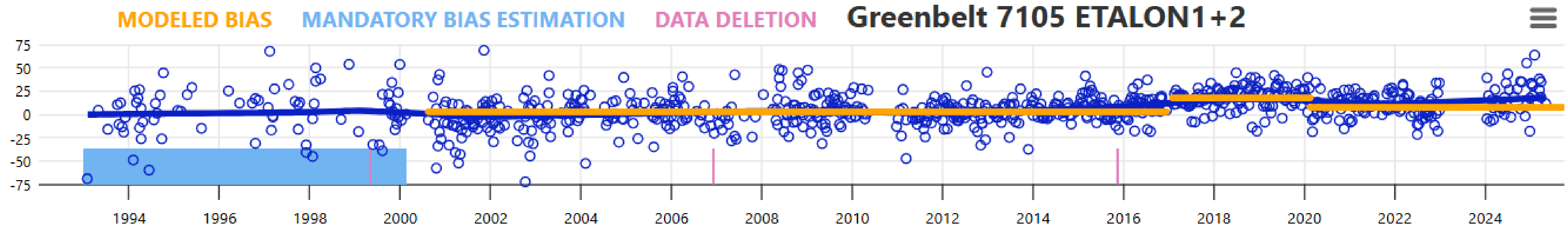
	7119	51	501	A	15:067:00000	25:089:25200	R	9.9	0.4		mm	
	7119	52	501	A	15:067:00000	25:089:25200	R	10.9	0.4		mm	

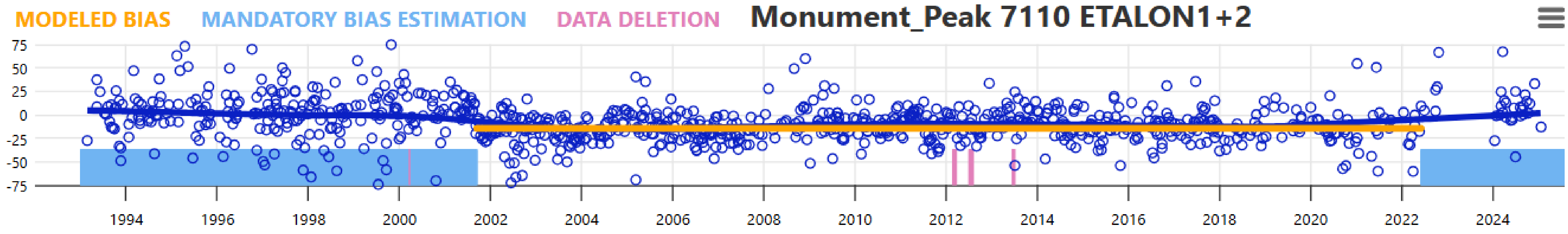
New ARSU in the MOBLAS Systems

- ❑ **The original secondary receiver system, the Amplified Receiver Signal Unit (ARSU), in the NASA MOBLAS systems used to track HEO satellites have failed the past few years and have been replaced**
  - ➢ 7090: ARSU was replaced on day 294, 2023 (21-Oct-2023)
  - ➢ 7105: ARSU was replaced on day 183, 2022 (2-Jul-2022)
  - ➢ 7110: ARSU was replaced on day 87, 2023 (28-Mar-2023)
- ❑ **Did this change alter the Etalon Range Bias?**

New Secondary Receivers in the MOBLAS Systems







Summary

- **The handling of biases in ITRF2020 has resulted in some discontinuities in NASA SLR heights**
  - Any SLR coordinate height error will induce an 'apparent' range bias in SLR short arc analysis (e.g. HITU or JCET results) and in altimeter mission analysis results
- **Estimating a fixed range bias will not remove all the systematic trends caused by a barometric or frequency error**
  - Known elevation and range-rate (epoch) dependent errors should be applied *a priori*, then estimate a range bias
  - Delete any data with a known range (frequency) dependent error
- **Good temporal and spatial LAGEOS (1,2) and LARES-2 coverage is needed to accurately separate range bias from station height**
  - Is 200 passes/year on each ITRF satellite enough data?
- **Will an error in the CoM lead to a station height error when a fixed RB is applied?**
- **Storing onsite processing statistics and processing parameters/constants to a relational DB was beneficial is researching legacy systematic errors in the NASA SLR Systems. Some legacy systematic errors are easy to determine and some are not so easy**

2024 ILRS Network Tracking Performance

Van Husson

29-Sep-2025

Peraton

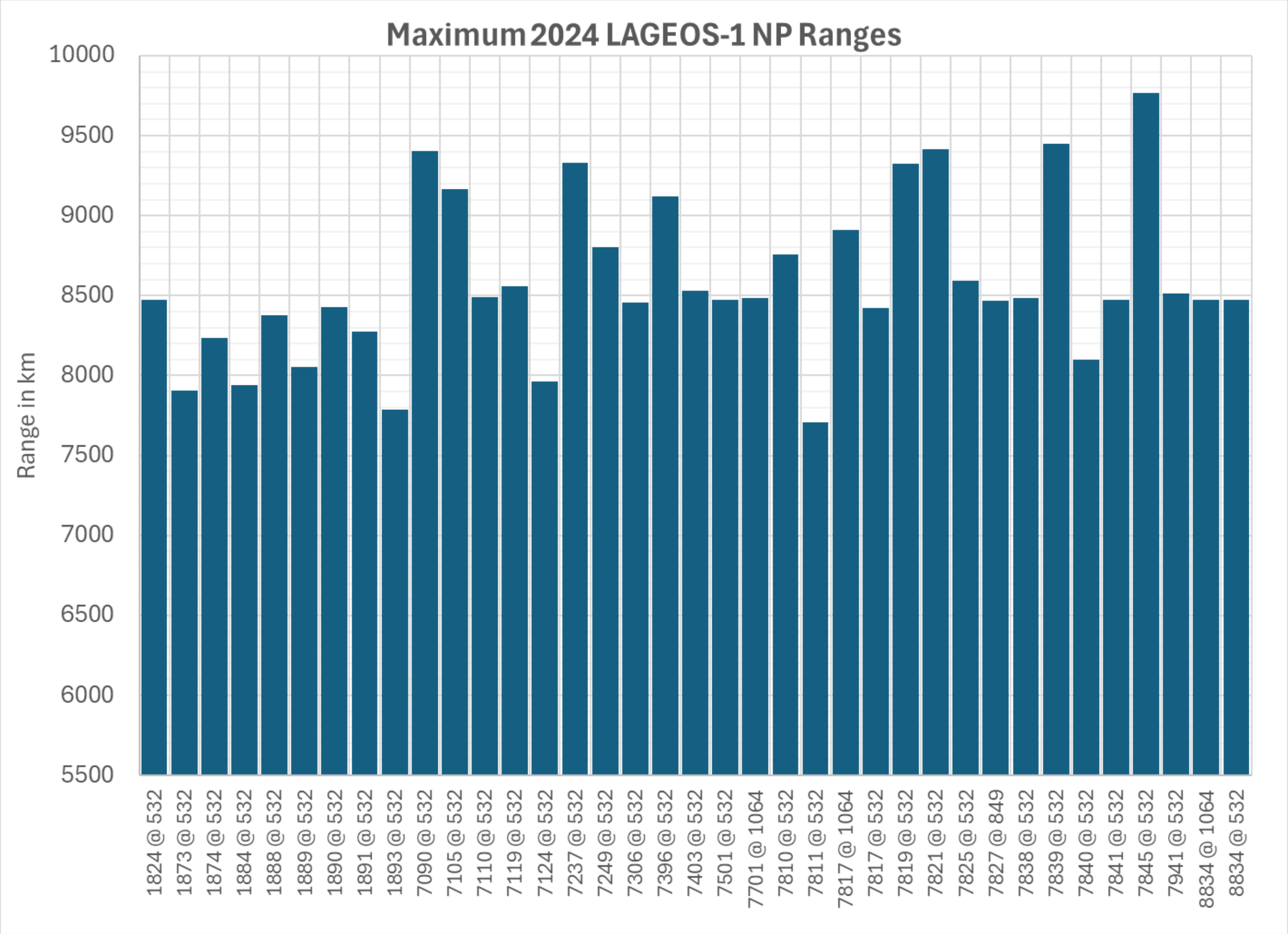
2024 ILRS Network Performance (LAGEOS Class Satellites)

Pad / Wave	Location	Passes			Average NPs/Pass			Average Pass Length		
		LAGEOS-1	LAGEOS-2	LARES-2	LAGEOS-1	LAGEOS-2	LARES-2	LAGEOS-1	LAGEOS-2	LARES-2
1824 @ 532	Golosiiv	160	98	98	6.6	6.8	7.0	17.0	18.9	18.9
1873 @ 532	Simeiz	96	65	18	6.7	6.9	4.8	14.4	15.3	11.2
1874 @ 532	Mendeleevo	58	30	41	12.8	14.9	10.6	28.6	33.9	25.8
1884 @ 532	Riga	159	113	136	7.7	8.3	7.7	16.7	17.1	17.5
1888 @ 532	Svetloe	169	63	2	5.3	7.8	4.0	11.3	15.1	10.0
1889 @ 532	Zelenchukskya	138	93	0	6.9	9.7	N/A	17.2	23.1	N/A
1890 @ 532	Badary	270	194	0	4.6	4.9	N/A	9.0	10.0	N/A
1891 @ 532	Irkutsk	134	57	108	4.7	3.7	4.1	11.6	8.8	11.2
1893 @ 532	Katzively	106	64	22	7.0	6.0	5.8	15.1	13.9	13.3
7090 @ 532	Yarragadee	965	885	726	9.5	10.8	8.7	21.7	25.3	21.1
7105 @ 532	Greenbelt	248	188	189	8.5	12.0	9.7	18.1	27.1	21.3
7110 @ 532	Monument Peak	259	181	168	8.9	7.7	8.7	15.9	13.9	15.8
7119 @ 532	Haleakala	225	214	165	9.8	10.2	10.6	20.7	22.2	23.4
7124 @ 532	Tahiti	63	53	39	6.6	5.8	6.0	14.7	12.1	12.4
7237 @ 532	Changchun	489	411	329	4.0	4.2	3.7	12.3	15.0	10.6
7249 @ 532	Beijing	133	120	60	4.4	4.4	3.8	8.7	8.8	7.0
7306 @ 1064	Tsukuba	2	8	3	4.0	5.6	8.3	N/A	N/A	N/A
7306 @ 532	Tsukuba	162	119	76	5.2	5.3	5.0	11.0	12.2	10.5
7396 @ 532	Wuhan	164	131	125	7.8	8.5	7.2	24.8	32.0	26.2
7403 @ 532	Arequipa	144	125	69	5.1	5.3	4.5	11.3	11.9	9.5
7501 @ 532	Hartebeesthoek	67	69	47	8.6	8.5	6.1	19.9	20.4	14.3
7701 @ 1064	Izaña	150	105	103	5.8	6.6	5.4	11.6	14.8	11.9
7701 @ 532	Izaña	5	3	4	7.4	6.7	9.3	N/A	N/A	N/A
7810 @ 532	Zimmerwald	20	7	11	4.9	3.3	5.7	12.4	N/A	12.4
7811 @ 532	Borowiec	147	86	39	10.9	10.1	9.0	21.5	19.4	17.8
7817 @ 1064	Yebes	85	83	80	9.1	10.5	10.0	18.9	24.3	23.3
7817 @ 532	Yebes	14	12	7	8.7	9.3	13.3	15.5	19.3	N/A
7819 @ 532	Kunming	297	268	172	4.4	4.4	4.3	7.8	7.8	7.4
7821 @ 532	Shanghai	231	199	213	9.9	10.4	10.2	26.3	31.1	27.7
7825 @ 532	Mt Stromlo	422	361	385	8.7	10.5	11.7	17.5	22.5	24.5
7827 @ 849	Wettzell	63	42	35	3.5	4.0	3.5	20.6	25.4	16.2
7838 @ 532	Simosato	153	118	93	7.3	8.6	6.7	15.0	18.0	13.8
7839 @ 532	Graz	377	290	319	6.2	6.9	7.1	25.7	27.8	26.8
7840 @ 532	Herstmonceux	398	252	336	11.0	11.5	11.1	28.4	31.6	29.5
7841 @ 532	Potsdam	310	214	275	6.9	7.3	7.5	16.2	17.0	18.0
7845 @ 532	Grasse	290	220	226	11.2	12.8	12.1	24.3	27.8	26.5
7941 @ 532	Matera	558	455	693	7.5	8.3	12.6	17.7	20.5	26.5
8834 @ 1064	Wettzell	378	298	266	5.4	6.0	5.3	15.8	18.8	14.7
8834 @ 532	Wettzell	295	229	218	4.5	5.5	4.9	13.1	17.7	14.0

Passes Legend	NP/Pass Legend	Path Length Legend
0-50	<5	<10
50-100	5 to 10	10 to 20
100-150	>10	> 20
150-200		
200-300		
>300		

- ❑ **Some stations are averaging less than 5 NPs/pass, which is a minimum pass requirement for stations in quarantine**
- ❑ **Some stations are averaging less than 10 minutes/pass**
- ❑ **Some Russian stations are not tracking LARES-2**

2024 ILRS Network Performance (Maximum LAGEOS-1 Ranges)



- ❑ **Each station has minimum elevation tracking restrictions based on terrain; safety, and/or hardware constraints that may differ between night and day**

ILRS Normal Point (NP) Formation Requirements

- **NPs are to adhere to the Herstmonceux binning requirements**
  - Currently, Beijing (7249) is not adhering to this requirement
- **“In addition, a significant number of stations are still operating with legacy systems at 10 Hz or below. To strengthen data quality and reliability, the ILRS urges these stations, to operate with a minimum of:**
  - Daytime normal points: a minimum of 6 full-rate data points
  - Night-time normal points: a minimum of 3 full-rate data points”

Minutes from the 2003 Koetzting Workshop regards to weak NPs

- **At the EUROLAS workshop in Herstmonceux in spring 2002, a recommendation was made to require a minimum number of SLR data points per NP to improve NP data quality by avoiding poorly defined NPs. The criteria suggested was a minimum of six data points per NP in daylight and three data points per NP at night. These criteria were relaxed for stations with low data rates.**
- **The ILRS Governing Board subsequently agreed with this policy. However, in a lengthy discussion in Koetzting, there were some counter arguments were made:**
  - From analysts: in spite of the available amount of SLR data, they would like to have EVERY measured point.
  - In the case of multi-photon receivers, even single point NPs are well defined.
  - In the case of very small (FTLRS) or low-repetition-rate (Metsahovi) SLR stations, it was always agreed that this process could be relaxed.
  - Each NP data point includes the number of full-rate data points that were included in its formation, thereby providing the analysts with a mechanism for screening. At the Workshop in Koetzting, we agreed that the criteria could be relaxed and that stations could exercise their own discretion in setting minimum criteria (even a single data point) if they felt that it improved their data quality.

John Reis's Conclusions on using NPs based on Few Returns

Conclusions

- There seems to be little consistency in the assigned RMS for low-return NPTs.
  - How exactly *is* the RMS assigned for a single or two-return NPT?
  - Since the uncertainty of a low-return NPT is large, surely the assigned RMS should be correspondingly large.
- The FIT RMS increases from 6.5 to 7.6 mm for 7090, and from 7.6 to 8.5 mm for all stations (an increase in variance of 6.9 mm^2) when low-return NPTs are used.
  - The orbit difference RMS reaches 8 mm (mostly along-track).
  - The low-return NPTs are clearly worse than NPTs with at least 6 (or even 3) returns.
- While the geodetic impact of the low-return NPTs is small, there seems to be good reason to not deliver or use them due to their effect on the orbits.
  - The assigned RMS is unreliable and the analysts do not use it to inform their data weighting in any case. *This is a little worrisome.*
  - If stations continue to deliver low-return NPTs, analysts should consider editing NPTs with only 1 or 2 returns (only a few passes would be lost and these are clearly among the worst ones). *I would strongly recommend adhering to ILRS guidelines for LAGEOS-1/2.*
  - This should become less of a problem with time as high-rep-rate stations come on line (7840, for example, had only a single NPT with less than 6 returns even when the test NPT software was run to allow for NPTs from as few as a single return).

CSR Center for Space Research

The University of Texas at Austin Cockrell School of Engineering

- John Reis' conclusion slide from his 24-Sep-2020 QCB presentation on "Analysis of SLR normal points from Herstmonceux open-source normal pointing software"
- Note: John's analysis was based on January 2020 LAGEOS-1 NPs

2024 ILRS Network Performance (Analysis of NPs with 3 or less observations)

			Normal Points (NPs)						Passes					
Pad / Wave	Location	Maximum Firerate	LAGEOS-1	% of Weak LAGEOS-1	LAGEOS-2	% of Weak LAGEOS-2	LARES-2	% of Weak LARES-2	LAGEOS-1	% of Weak LAGEOS-1	LAGEOS-2	% of Weak LAGEOS-2	LARES-2	% of Weak LARES-2
1824 @ 532	Golosiiv	15 Hz	1053	30.2%	670	39.4%	688	45.1%	160	4.4%	98	11.2%	98	14.3%
1873 @ 532	Simeiz	10 Hz	645	32.1%	450	44.7%	87	29.9%	96	1.0%	65	4.6%	18	5.6%
1874 @ 532	Mendeleevo	300 Hz	740	None	448	None	436	None	58	None	30	None	41	None
1884 @ 532	Riga	10 Hz	1225	None	936	None	1049	None	159	None	113	None	136	None
1888 @ 532	Svetloe	300 Hz	896	None	493	None	8	None	169	None	63	None	2	None
1889 @ 532	Zelenchukskya	300 Hz	953	None	902	None	0	N/A	138	None	93	None	0	N/A
1890 @ 532	Badary	300 Hz	1246	None	958	None	0	N/A	270	None	194	None	0	N/A
1891 @ 532	Irkutsk	300 Hz	629	None	211	None	448	None	134	None	57	None	108	None
1893 @ 532	Katzively	10 Hz	737	40.7%	387	58.7%	128	57.8%	106	7.5%	64	14.1%	22	9.1%
7090 @ 532	Yarragadee	10 Hz	9120	12.9%	9570	15.3%	6308	14.4%	965	1.5%	885	1.4%	726	1.0%
7105 @ 532	Greenbelt	10 Hz	2117	7.2%	2261	7.3%	1832	9.1%	248	None	188	1.1%	189	1.1%
7110 @ 532	Monument Peak	10 Hz	2293	6.3%	1398	11.4%	1460	11.4%	259	None	181	1.7%	168	0.6%
7119 @ 532	Haleakala	5 Hz	2200	9.4%	2173	15.3%	1750	15.0%	225	0.9%	214	1.9%	165	3.6%
7124 @ 532	Tahiti	10 Hz	418	9.3%	308	23.4%	235	16.6%	63	None	53	None	39	None
7237 @ 532	Changchun	4000 Hz	1935	None	1725	None	1230	0.1%	489	None	411	None	329	None
7249 @ 532	Beijing	2000 Hz	589	1.2%	523	1.7%	225	1.8%	133	None	120	None	60	None
7306 @ 1064	Tsukuba	1000 Hz	8	None	45	None	25	None	2	None	8	None	3	None
7306 @ 532	Tsukuba	1000 Hz	850	None	635	None	383	None	162	None	119	None	76	None
7396 @ 532	Wuhan	4000 Hz	1276	None	1119	None	905	None	164	None	131	None	125	None
7403 @ 532	Arequipa	5 Hz	732	24.2%	659	27.3%	308	39.9%	144	4.2%	125	2.4%	69	13.0%
7501 @ 532	Hartebeesthoek	10 Hz	574	13.6%	586	18.1%	288	29.2%	67	3.0%	69	None	47	8.5%
7701 @ 1064	Izaña	400 Hz	872	None	693	None	555	None	150	None	105	None	103	None
7701 @ 532	Izaña	400 Hz	37	None	20	None	37	None	5	None	3	None	4	None
7810 @ 532	Zimmerwald	1000 Hz	97	1.0%	23	0.0%	63	0.0%	20	None	7	None	11	None
7811 @ 532	Borowiec	10 Hz	1600	0.9%	870	2.5%	352	1.4%	147	None	86	None	39	None
7817 @ 1064	Yebes	1000 Hz	776	None	872	None	802	None	85	None	83	None	80	None
7817 @ 532	Yebes	1000 Hz	122	None	112	None	93	None	14	None	12	None	7	None
7819 @ 532	Kunming	1000 Hz	1310	None	1183	None	732	None	297	None	268	None	172	None
7821 @ 532	Shanghai	5000 Hz	2283	None	2070	None	2167	None	231	None	199	None	213	None
7825 @ 532	Mt Stromlo	60 Hz	3677	None	3795	None	4519	None	422	None	361	None	385	None
7827 @ 849	Wettzell	1000 Hz	221	None	168	None	124	None	63	None	42	None	35	None
7838 @ 532	Simosato	1000 Hz	1116	7.1%	1019	9.3%	620	15.5%	153	None	118	None	93	1.1%
7839 @ 532	Graz	2000 Hz	2349	None	2008	None	2276	None	377	None	290	None	319	None
7840 @ 532	Herstmonceux	1000 Hz	4391	None	2895	None	3728	None	398	None	252	None	336	None
7841 @ 532	Potsdam	2000 Hz	2146	0.5%	1554	0.5%	2069	1.3%	310	None	214	None	275	None
7845 @ 532	Grasse	10 Hz	3253	None	2818	None	2725	None	290	None	220	None	226	None
7941 @ 532	Matera	10 Hz	4167	2.7%	3761	3.2%	8718	3.6%	558	None	455	None	693	None
8834 @ 1064	Wettzell	667 Hz	2034	None	1792	None	1409	None	378	None	298	None	266	None
8834 @ 532	Wettzell	667 Hz	1331	None	1269	None	1079	None	295	None	229	None	218	None

Firerate Legend
<15 Hz

Legend
None
<5.0%
between 5% and 10%
>10%

- ❑ **2024 NP and Pass LAGEOS Class statistics indicating how many NPs and passes would be lost if NPs with 3 or less fullrate observation; respectively, would be eliminated**
- ❑ **The weak NPs all come from systems that have firerates <15 Hz, except for Changchun (7237), Beijing(7249), and Simosato (7838), who have kHz lasers**
- ❑ **Relative to LAGEOS-1, LAGEOS-2 and LARES-2 seems to have a larger percentage of weak NPs**

Discussion

- ❑ Should the ILRS performance requirements be updated to include another TBD metric that indicates adequate sampling of the pass to help ensure a range bias can be separated from station height?
- ❑ Based on John Reis's analysis; does the QCB endorse stations to eliminate NPs based on 3 or less observations?

ILRS QCB Meeting

09/29/2025

Mike Pearlman & Claudia Carabajal

Agenda

Peter:

- The Blue Band; a cautionary tale

Van:

- 2024 ILRS Network Tracking Performance
- Data Handling File Updates and Systematic Errors

Mike/Claudia:

- ILRS CB updates

Others?

Station News

- No new station applications.
- No stations have passed quarantine.
- Engineering Stations List updates: Contacted OCTL, GEOL, SMIL, STRK, to request updates on status on current or future station activities, and any publications or papers that may describe them that they may want to share. No responses to date.

SP3c Codes:

- Continue to consolidate the information on the Spacecraft ID Correspondence Table for Orbit Exchange Files (SP3c), currently on the CDDIS site, and the ILRS site, and the IGS site.
- Some discrepancies found with SP3c codes used by CNES.
- Read information from SINEX metadata to compare or obtain the SP3c codes, especially for all the GNSS constellations.

GGOS definition of Core Sites

- Consolidated inputs, were reviewed by M. Pearlman and G. Appleby to draft the definition from the ILRS Service.

GGOS definition of Core Sites (cont.)

- We asked the community to submit their thoughts on how we should update the definition of CORE Sites. When we last defined CORE Sites about 20 years ago, we focused on SLR, VLBI. and GNSS. This time we gave folks guidelines from keeping it simple to focusing on current geodetic techniques SLR, VLBI, GNSS, and DORIS. At some time in the future when we have a better grip on some of the other techniques such as gravity field, ocean surface topography, etc. and we could revise it again.
- We received back 10 responses spanning from "make" no changes to ones with complex changes. All of them had good ideas.
- Graham and I modified our own submissions to make one single version that we think would satisfy current requirements. See below:

Geodetic Stations are considered GGOS sites if they are actively supporting data acquisition for Global Geodesy Programs with SLR, VLBI, GNSS, and DORIS in any combination or individually. Core Sites are Geodetic Stations that are accurately surveyed and properly operating with SLR, VLBI, and GNSS. Stations that also have operational DORIS tracking are termed Enhanced Core Sites. The reason we have not made DORIS a requirement for the CORE Site definition is that the decision on DORIS station location is made by the DORIS program to satisfy its needs, not by the stations themselves.

Mike and Graham suggest going with this definition.
If there is serious objection, we can schedule a telecon for those interested.

Station Surveys and Plan

- Station Surveys were sent to the following contacts/stations back in April 2025:
  - Herve Mariey (Grasse-7845)
  - Michihiro Suzuki (Simosato-7838)
  - Shinchi Nakamura (Tsukuba-7306)
  - Stefan Riepl (Wettzell-7827)
  - Johann Eckland and Ulrich Schreiber (Wettzell-8834)
  - Beatriz Vaquero Jimenez and Adolfo Garcia Marin (Yebes-7817)

  Did not respond:
  - Andrea Di Mira (Izaña-7701)
  - Dr. Michael Lachut. (Mt. Stromlo-7825)
  - Zhang Zhongping (Shanghai-7821)
  - Jie Zhang (Wuhan-7396)

- Review Team still working on the review of the Station Surveys and Plan that we received, and will be providing feedback to the stations after all inputs received from the reviewers.

Mission Updates/New Missions

- Tracking for the **NanoFF A/B** satellites was postponed to September 29th, 2025. Continued coordinating support for the NanoFF mission.
- Answered questions from the mission, consulted with the ILRS CB and the MSC Chair and Co-Chair.
- Tracking of NanoFF-B on September 29th, 2025.
- From 13th October onward, they want to record GNSS data at higher frequency for those passes, enabling a more accurate comparison with the SLR data for a later analysis, also recording raw GNSS measurements during such times.
- The ILRS CB recommended that the mission communicates in advance (via SLRMail) when the satellite will be visible by the ILRS stations, so they can attempt to include those times in their tracking schedules to support tracking, provided no conflicts or weather issues.
- Later-on, the mission would like to start tracking NanoFF-A as well (interleaving).
- Currently the two satellites are about 70 km away from each other and heading towards each other at about 8 km/day. Between 27th September and 10th October, they plan to keep the distance between NanoFF-A and NanoFF-B between 2 to 15 km. After that they plan to keep the distance between 50 km - 100 km. Need to prepare the message to the stations to announce the start of support for this mission.
- Predictions are being delivered to the CDDIS/EDC, and they have passed the QC.
- Mission page: https://ilrs.cddis.eosdis.nasa.gov/missions/satellite_missions/current_missions/nanoFF_general.html

NanoFF – Campaign details

29 September – 12 October 2025 (5 hours)

1.Stations are requested to attempt tracking NanoFF-B at their convenient times/dates.

2. Purpose: verification of GNSS-based orbit determination (low-frequency GNSS) against SLR measurements.

3. Thruster maneuvers: Δv up to 2 cm/s (~37 m mean semi-major axis change) every 3–4 days. Thruster maneuvers will be announced through the standard notification protocol and reflected in updated CPF prediction files.

13 October – 31 December 2025 (45 hours)

1. Stations are requested, if possible, to inform the mission team 18–24 hours in advance of planned tracking intervals.
    - o Satellite will be commanded to record GNSS data at higher frequency during these intervals, for later analysis.
    - o Raw GNSS data will also be recorded.
    - o The mission team understands that this subject to weather and operational constraints.
2. In line with ILRS CB's guidance, the mission will also issue SLRMail notifications (copied to ILRS CB), whenever possible, specifying recommended tracking opportunities for stations based on predictions.
3. No thruster maneuvers are planned. Differential drag will be used to control the relative along-track separation of the formation.

Mission Updates/New Missions

- Informed the ILRS GB of MSRFs submissions for QZS-5 and QZS-7 (JAXA, Kakeru Fukumitsu). Need to discuss priorities for tracking for the QZS satellites on the Priority List (mission should select 4).
- The launch date for HTV-X will be on Tuesday, October 21, 2025. Shinichi Nakamura (JAXA) will report as soon as the observation period for SLR using HTV-X is decided. Working on the ILRS Mission page for HTV-X.
- Zimmerwald was approved by the mission for Restricted Tracking for Sentinel-3A/3B.
- GRITSS orbits providers working with CDDIS. MSRF will be submitted by Stephen Merkowitz, as are materials for the ILRS GRITSS Mission page.

UAW Munich (first week of March, 2026)

The next GGOS/IERS Unified Analysis Workshop (UAW2026) is taking place at the same venue of the REFAG2026 Symposium (Munich, Germany) in the following two days (5 and 6 March 2026). For details, please see
https://geodesy.science/events/munich2026/. Need to identify within the ILRS any key issues related to data analysis that your Service would like to discuss. It is of the utmost importance to select topics that are common to other techniques, without including issues that can be treated internally by our Service.

Possible topics:

- Geophysical models and its impact on future global reference frame realizations (e.g., non-tidal loading treatment).
- ITRF updates (e.g. update chains, consistency between updates, local ties, etc.).
- Challenges in analyzing Genesis data (e.g. how will Genesis observations impact the way the IAG Services currently contribute to the ITRF?).
- Geodetic product requirements to support the Essential Geodetic Variables.

Frank Lemoine is coordinating with ASC to define topics and possible participants.

Subject: Re: [EXTERNAL] ASC meetings
Date: Tuesday, September 23, 2025 at 8:51:43 AM Eastern Daylight Time
From: Dunn, Peter (PERATON)
To: Lemoine, Frank G. (GSFC-61A0), Husson, Van (PERATON), Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC]
CC: Pearlman, Michael (GSFC-61A.0)[Smithsonian Astrophysical Observatory], Szwec, Christopher (PERATON)
Attachments: image.png, image.png

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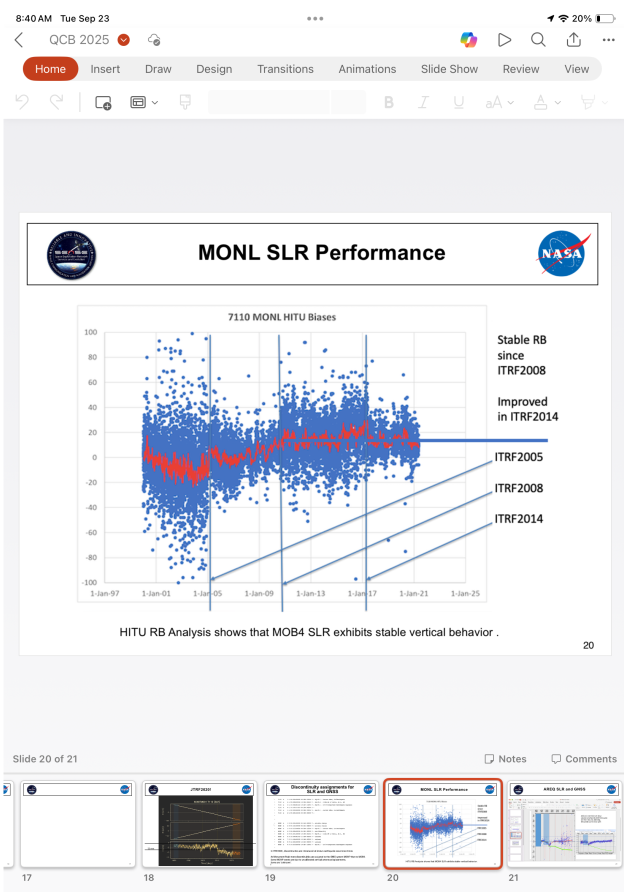
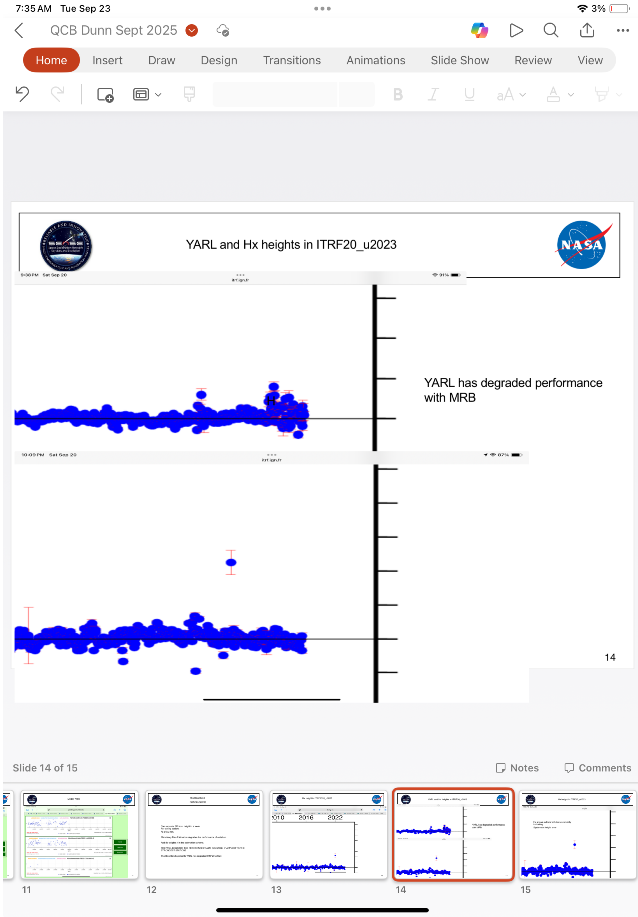
Dear QCB
There is an alternative performance assessment mechanism available to monitor SLR system accuracy.
Toshi’s routine analysis covers all stations, and all satellites.
Find below a plot showing MOB4’s evolution, up to the ITRF2020 time frame.
It shows improvement at the station which differs from the ASC interpretation.
Best,
P



From: Dunn, Peter (PERATON) <pdunn@peraton.com>

Sent: Tuesday, September 23, 2025 7:38 AM
To: Lemoine, Frank G. (GSFC-61A0) <frank.g.lemoine@nasa.gov>; Husson, Van (PERATON) <vhusson@peraton.com>; Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>
Cc: Pearlman, Michael (GSFC-61A.0)[Smithsonian Astrophysical Observatory] <mpearlman@cfa.harvard.edu>; Szwec, Christopher (PERATON) <CSZWEC@peraton.com>
Subject: Re: [EXTERNAL] ASC meetings

Frank,
Van's discontent stems from our inability to interpret the ASC products to maintain and improve system accuracy at NASA.
Most of the features in his list can be settled with clarification of the data sets input to the combination process.
That is a matter for the QCB and ASC, where the meetings cover comparisons of input from each Analysis Center in detail.
The feature which I question is the process adopted to correct the results with mandatory range bias estimates.
This might be more of a matter for the GB.
Find below a slide which illustrates the effect on MOB5's geodetic performance.
It is compared to the Hx system, arguably the second best performing station in the network.
Best,
P



From: Lemoine, Frank G. (GSFC-61A0) <frank.g.lemoine@nasa.gov>
Sent: Monday, September 22, 2025 1:44 PM
To: Husson, Van (PERATON) <vhusson@peraton.com>; Carabajal, Claudia C. (GSFC-61A.0) [SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>
Cc: Dunn, Peter (PERATON) <pdunn@peraton.com>
Subject: Re: [EXTERNAL] ASC meetings

Guten Tag,

Please make a list of items to present at the next QCB meeting, and specifically invite Antonio Basoni, David Sarrocco, Mathis blossfeld and Cinzia.

FGL-

From: Husson, Van (PERATON) <vhusson@peraton.com>
Sent: Monday, September 22, 2025 10:47
To: Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC]
Cc: Lemoine, Frank G. (GSFC-61A0); Dunn, Peter (PERATON)
Subject: RE: [EXTERNAL] ASC meetings

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Hola Claudia,

Peter and I will try and generate a list of issues to be presented.

Regards, Van

From: Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>
Sent: Monday, September 22, 2025 10:45 AM
To: Husson, Van (PERATON) <vhusson@peraton.com>; Lemoine, Frank G. (GSFC-61A0) <frank.g.lemoine@nasa.gov>; Dunn, Peter (PERATON) <pdunn@peraton.com>
Subject: Re: [EXTERNAL] ASC meetings

Van,
Mathis is trying to re-schedule that meeting.
We can make them aware.
Claudia.

[signature_1536273339][ssaihq.com]
<https://urldefense.us/v3/__https:/www.ssaihq.com/__
;!!FfR1YDxDJIYh6Xb_gA!_vUMiBu5wnFQIYfJxGUmy1wmtw2-93HVYHP-nGnAuLCVS18-qNg5Hxgx975ZJlXmndZBaQAK5aO0zvMS3NSN2knovW_x$>

Claudia C. Carabajal
Research Scientist SME
HBG Geodesy & Geophysics Group Lead
Secretary, ILRS Central Bureau
Geodesy and Geophysics Laboratory, 61A
NASA Goddard Space Flight Center
8800 Greenbelt Rd., Greenbelt, MD 20770
Claudia.C.Carabajal@nasa.gov<mailto:Claudia.C.Carabajal@nasa.gov>

From: Husson, Van (PERATON) <vhusson@peraton.com<mailto:vhusson@peraton.com>>
Date: Friday, September 19, 2025 at 3:23 PM
To: Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov<mailto:claudia.c.carabajal@nasa.gov>>, Lemoine, Frank G. (GSFC-61A0) <frank.g.lemoine@nasa.gov<mailto:frank.g.lemoine@nasa.gov>>, Dunn, Peter (PERATON) <pdunn@peraton.com<mailto:pdunn@peraton.com>>
Subject: [EXTERNAL] ASC meetings
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Fyi… I will not be able to attend the upcoming ASC meeting.

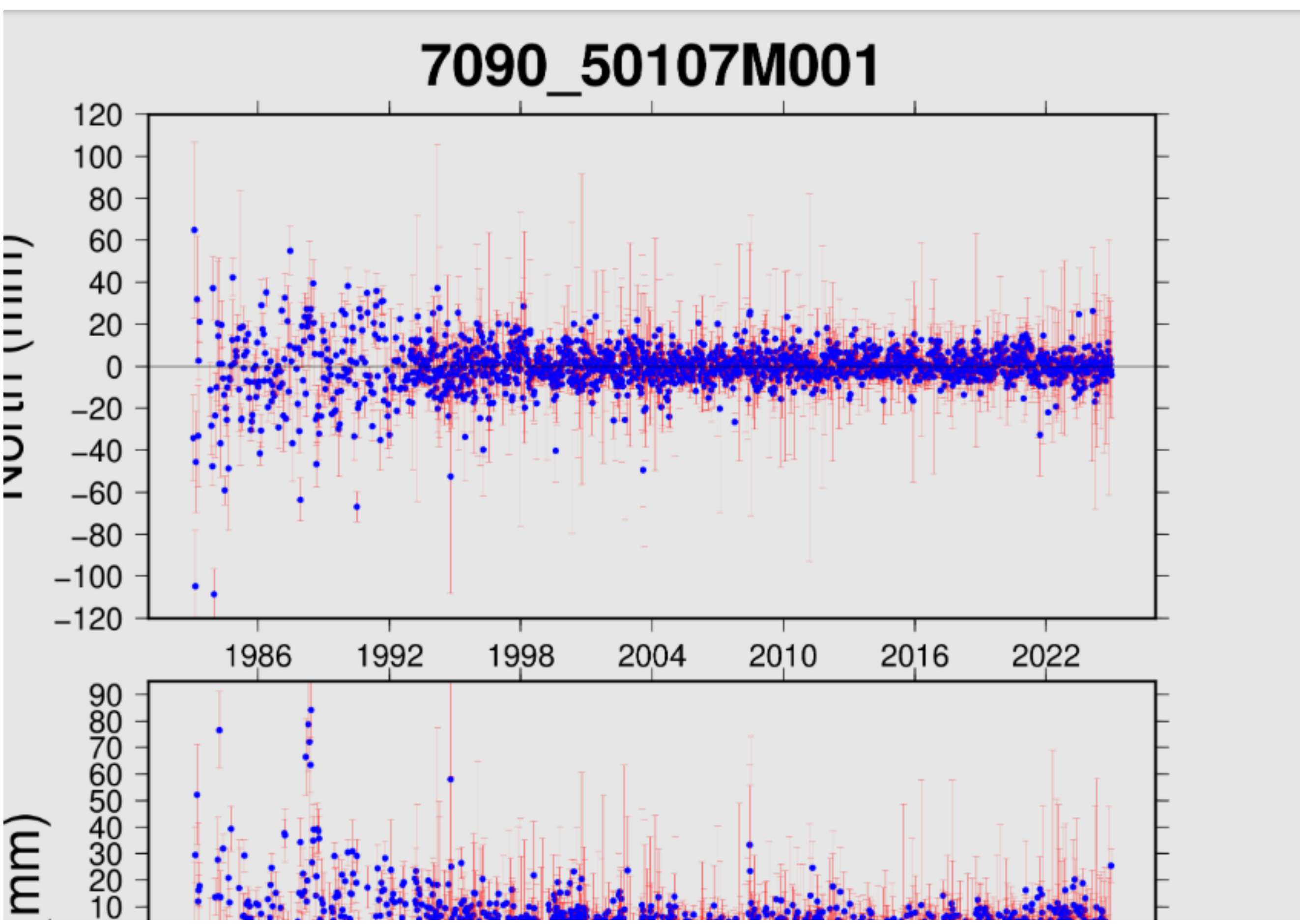
In my opinion, a two-hour meeting is not enough time to discuss all ASC related issues. Since Cinzia and Mathis rarely attend our QCB meetings, so they may not be aware that the handling of biases is causing mm level errors in the ITRF SLR coordinates (e.g. updates to SLR performance tracking goals; discontinuities in NASA station heights; local tie survey reports are not timely leading to rework by the ACs; different ACs appear to handle tropospheric biases differently [McDonald 7080 barometric errors is the prime example]; how does each ACs handle resupplied data [Graz 7839 resupplied a large chunk of Etalon data removing a large range bias, but the SSEM-X Range Bias results still indicate the initial release of this data]; how do the ACs handle updates to CoM corrections [Jose made significant changes to the CoM corrections for Monument Peak, the old CoM values are still be used based on the Data Handling File]; end users [i.e. Peter, I, and stations] do not know how to interpret some of the new analytical features added to the JCET website)

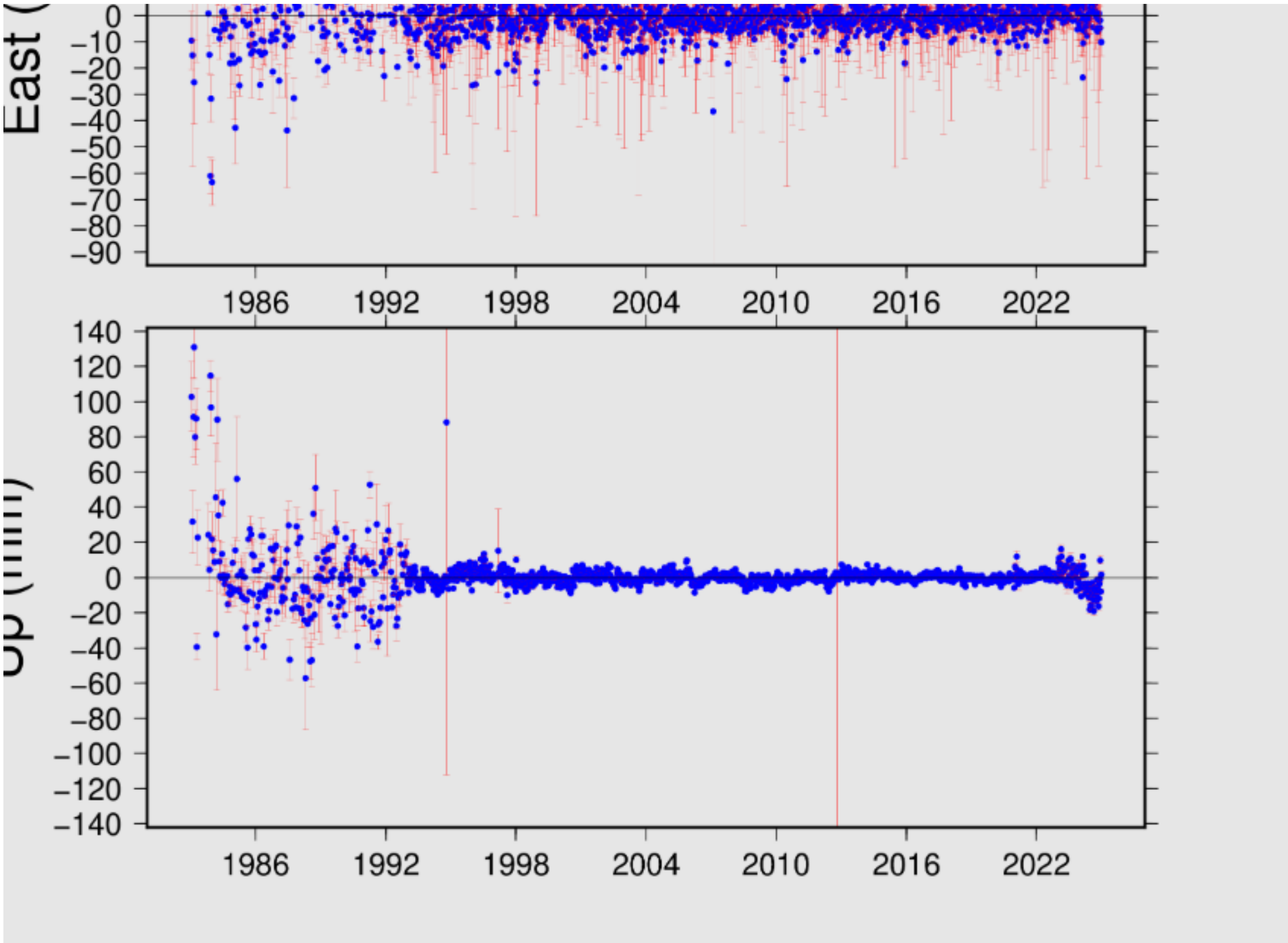
All the best and have a great weekend, Van

Subject: [ilrs-qcb] Re: ILRS QCB Meeting - Monday September 29th, 2025 - 9:00-11:00 AM EST (13:00 UTC)
Date: Tuesday, September 30, 2025 at 10:31:13 AM Eastern Daylight Time
From: Peter Dunn via ilrs-qcb
To: Husson, Van (PERATON)
CC: Rodríguez Pérez José Carlos, ilrs-qcb@lists.nasa.gov, Dunn, Peter (PERATON)
Attachments: image001.png, image002.jpg, image003.jpg, image004.png, image005.png

Thanks, Van
Clearly this known correction should be promptly conveyed to the community in an updated data handling file.
It would be included with the other corrections in the list shown at the QCB yesterday, in time for the next full re-analysis of the data.
YARL height misbehaves when mandatory range biases are estimated (MRBE) for that station.
It is an extra step in the processing of the data after the ASC has established an accurate correction from the SSEM analysis.
Thanks, Antonio!
MRBE was not included in the SSEM procedure proposed by Appleby, Rodriguez and Altamimi ten years ago.
It is a questionable attempt to accommodate 'nuisance parameters'.
The large (3 cm) drop in the apparent height of YARL seen in ITRF2020_u2023 and _u2024 occurred in 2022, when MRBE was applied at that station.
The influence of MRBE can easily be tested by repeating the analysis without applying it.
I suggest that the station's behavior would then return it to the top of the pile, where it has been for thirty years.
P

On Tue, Sep 30, 2025 at 9:03 AM Husson, Van (PERATON) <vhusson@peraton.com> wrote:

> Fyi… Hot off the press from Zuheir. The 7090 Etalon range bias changed in October 2023 by ~25mm that was not in the DHF. Not sure how much influence this had on the 7090 station height.
>
> 
>



From: Peter Dunn via ilrs-qcb <ilrs-qcb@lists.nasa.gov>
Sent: Monday, September 29, 2025 3:28 PM
To: Rodríguez Pérez José Carlos <jcrodriguez@transportes.gob.es>
Cc: ilrs-qcb@lists.nasa.gov; Dunn, Peter (PERATON) <pdunn@peraton.com>
Subject: [EXTERNAL] [ilrs-qcb] Re: ILRS QCB Meeting - Monday September 29th, 2025 - 9:00-11:00 AM EST (13:00 UTC)

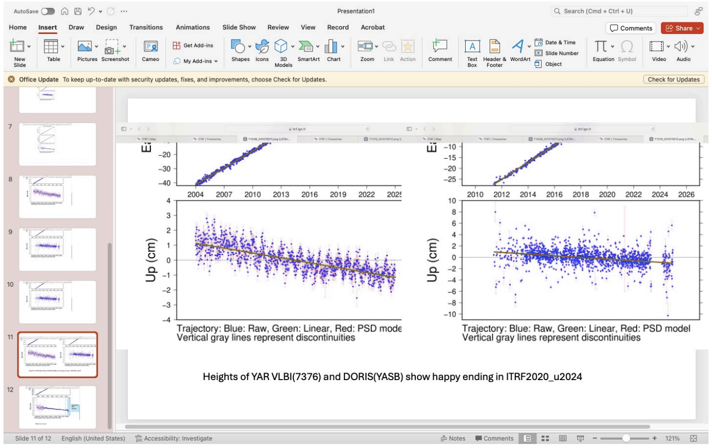
Jose

I suggest that any wonky estimates at YARL are caused by applying mandatory range biases (MRB).

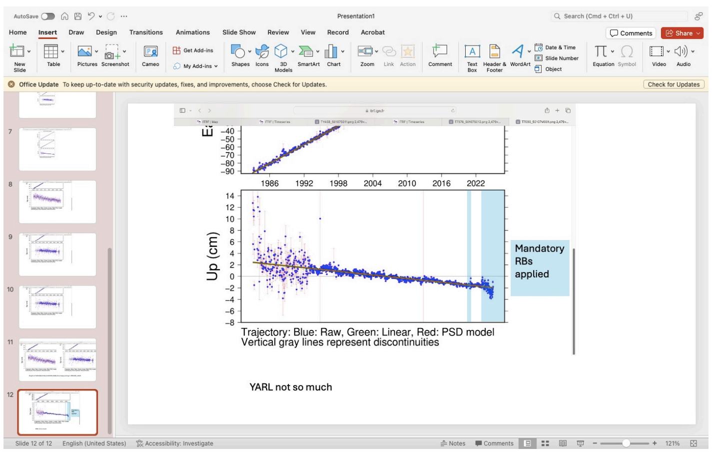
The heights at YARL from SLR solutions sans MRB show no aberrant behaviour.

They match and improve on the results from the other techniques... for thirty years.

Find below a comparison with VLBI and DORIS at the station (Thanks, Alexandre!).



the u2024 extension shows the full catastrophe at YARL



P

On Mon, Sep 29, 2025 at 2:15 PM Rodríguez Pérez José Carlos <jcrodriguez@transportes.gob.es> wrote:

> Thank you, Claudia and Peter.
>
> For the record, I think you are onto something, Peter — just not that the whole edifice of the way systematic errors are handled by the CC is inadequate. Surely not the *logic* of what appears to have been behind the decision taken about Yarragadee. If in the end Yarragadee deserves an out of jail free card already, or even some time ago, that's another story that another look at the data would help to decide without much controversy.
>
> But it's plain that the instabilities that (rightly) prompted ASI CC to request bias estimation for the station are the same that we can now see in the published time series. I'm sceptical about whether simply not estimating biases in that period would not damage the coordinates, but if we understood what caused those wonky estimates in the first place we could identify similar situations elsewhere and perhaps work out how to best handle them.
>
> Cheers
>
> José
>
> ---
>
> **From:** Peter Dunn <peterdunn2000@gmail.com>
> **Sent:** 29 September 2025 18:14
> **To:** Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>

Cc: Rodríguez Pérez José Carlos <jcrodriguez@transportes.gob.es>; ilrs-qcb@lists.nasa.gov <ilrs-qcb@lists.nasa.gov>; Peter Dunn <pdunn@peraton.com>
Subject: Re: ILRS QCB Meeting - Monday September 29th, 2025 - 9:00-11:00 AM EST (13:00 UTC)

I agree!

We need more contention to arrive at a solution with which we can all be content.

Perhaps we should ask spouses along to the next meeting.

Nice chat, Jose.

P

On Mon, Sep 29, 2025 at 12:04 PM Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov> wrote:

> I thought it was a healthy discussion…
>
> SCIENCE SYSTEMS AND APPLICATIONS, INC.
> [gcc02.safelinks.protection.outlook.com]
>
> **Claudia C. Carabajal**
>
> **Research Scientist SME**
>
> **HBG Geodesy & Geophysics Group Lead**
>
> **Secretary, ILRS Central Bureau**
>
> Geodesy and Geophysics Laboratory, 61A
>
> NASA Goddard Space Flight Center
>
> 8800 Greenbelt Rd., Greenbelt, MD 20770
>
> Claudia.C.Carabajal@nasa.gov
>
> ---
>
> **From:** Rodríguez Pérez José Carlos <jcrodriguez@transportes.gob.es>
> **Date:** Monday, September 29, 2025 at 11:51 AM
> **To:** ilrs-qcb@lists.nasa.gov <ilrs-qcb@lists.nasa.gov>, Peter Dunn <pdunn@peraton.com>, Peter Dunn <peterdunn2000@gmail.com>
> **Cc:** Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>
> **Subject:** [EXTERNAL] Re: ILRS QCB Meeting - Monday September 29th, 2025 - 9:00-11:00 AM EST (13:00 UTC)
>
>
>
> Peter,
>
> I hope I wasn't excessively forceful in our exchange. If I did, I apologise to all. My wife just turned up from the room next door asking what on earth we were arguing about, which made me wonder :)
>
> Cheers

José

From: Carabajal, Claudia C. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <claudia.c.carabajal@nasa.gov>
Sent: 26 September 2025 20:36
To: ilrs-qcb@lists.nasa.gov <ilrs-qcb@lists.nasa.gov>
Cc: Claudia Carabajal <claudia.carabajal@ssaihq.com>; David Sarrocco <david.sarrocco@e-geos.it>; Husson, Van (PERATON) <vhusson@peraton.com>; Oldham, Tom (PERATON) <toldham@peraton.com>; Alexandre Belli <alexandre.belli@ssaihq.com>; Graham Appleby - BGS <gapp@bgs.ac.uk>; Rodríguez Pérez José Carlos <jcrodriguez@transportes.gob.es>; Andreja Susnik - BGS <andsni@bgs.ac.uk>; Woo, Justine Y. (GSFC-61A.0)[SCIENCE SYSTEMS AND APPLICATIONS INC] <justine.y.woo@nasa.gov>; Gerrety, Austin (PERATON) <agerre01@peraton.com>; Lamb, Rivers (GSFC-5850) <rivers.lamb@nasa.gov>; Lemoine, Frank G. (GSFC-61A0) <frank.g.lemoine@nasa.gov>; Husson, Van S. (GSFC-450.0)[PERATON, INC] <van.s.husson@nasa.gov>; Peter Dunn <pdunn@peraton.com>; Mike Pearlman <mpearlman@cfa.harvard.edu>; Peter Dunn <peterdunn2000@gmail.com>; Antonio Basoni <antonio.basoni@e-geos.it>; Mathis Bloßfeld <mathis.blossfeld@tum.de>; Cinzia Luceri <cinzia.luceri@e-geos.it>
Subject: ILRS QCB Meeting - Monday September 29th, 2025 - 9:00-11:00 AM EST (13:00 UTC)
When: 29 September 2025 15:00-17:00.
Where: Microsoft Teams Meeting

Dear ILRS QCB colleagues,

Attached are the Notes and materials presented at the meeting on 07/21/2025.

The next ILRS QCB meeting will be held on Monday, September 29th, 2025 – 9:00-11:00 EST (13:00 UTC).

These are the agenda items I have been asked to include.

Agenda

- **Peter: The Blue Band; a cautionary tale**
- **Van:**
  - **Data Handling File Updates and Systematic Errors**
  - **2024 ILRS Network Tracking Performance**
- **Mike/Claudia: ILRS CB updates**
- **Others?**

Regards,

Claudia.

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