Changes to the quarantine procedure on the ILRS website:

5/10/2024

https://ilrs.gsfc.nasa.gov/network/site_procedures/quarantine_procedure.html#:~:text=The%20ILRS%20Station%20Quarantine%20Procedure,ASC)%20has%20verified%20the%20data.

Procedures for SLR Data Quarantine

General Procedure for Data Quarantine

The ILRS Station Quarantine Procedure avoids transmission of questionable data (because of station upgrade or outage) from the stations into the operational data files until the Analysis Standing Committeee (ASC) has verified the quality of the data. Therefore, ILRS Operations Centers (OCs) must hold the data outside of the operational data stream but deliver them instead to the ILRS Data Centers (DCs, CDDIS and EDC); the DCs will will then store the quarantined data in separate directory structure so that the data are available for the Analysis Standing Committee (ASC) to review and analyze. This procedure also allows us to keep track of stations that are undergoing significant maintenance or upgrades and ascertain the impact on the station data and performance.

The following points explain when a station's data can be placed in quarantine and what steps must be followed by the station and ILRS OCs and ILRS Data Centers, and the ILRS ASC

- The OCs will move any station data into quarantine if the station has not provided data for a period of 90 days;
- Stations may declare that their data should be in quarantine by informing their OC and the CB;
- Stations planning to be out of operation for any major maintenance or upgrade activity that could affect the data must inform the ILRS Central Bureau (CB) well ahead of the activity; they should also provide an estimated time for completion of the maintenance or the upgrades; As a courtesy to the community and ILRS data users, the stations should notify the community via SLRMAIL of any impending upgrades or significant maintenance to their station.
    - Once the CB receives the inttial notice, with guidance from the Analysis Standing Committee (ASC) and the CB's engineering personnel, the ILRS CB will decide if quarantine of the station data is required;
- When in quarantine, stations should provide the CB and the ASC with monthly updates on their progress of their maintenance activites or upgrades;
- Once stations are ready to return to normal operations:
    - They should send a message informing the CB, including a description of any system changes that have been made;

- The stations should also update their configuration files, site log and configuration history log (as appropriate);
- Newly collected data which has been kept in quarantine will now be examined by the ASC.

- The ASC will analyze the quarantined data and declare when data have been validated using the criteria of a minimum of 20(1) acceptable passes on each satellite (LAGEOS 1, LAGEOS-2 and LARES and LARES-2) within a sliding 60-day(2) time interval;

(1) Stations should collect more than the minimum 20 passes since during the analysis some passes might l be rejected as outliers even if they looked valid at the station level. Stations should collect a minimum of five normal points per pass to facilitate the analyses of the ASC.
(2) Stations should aim to provide the required observations within a 60-day time interval; in some cases due to satellite visibility, weather, etc., the ASC may allow some flexibility.

[~~If the site is or aspires to be an ILRS core site, the station should strive for a standard deviation in the Normal Points to LAGEOS-1 and -2 and LARES-1 and -2 under 10 mm in standard deviation; in addition, they should also aim to minimize any systematic errors and their variability, such as range biases; the QC evaluation will focus on these parameters.~~] Replaced by the statement below.

The station should strive for Normal Point precisions (standard error) to the geodetic spheres (LAGEOS 1,2 and LARES 1,2 satellites) of 1 mm; it is recognized that this target may not be possible for legacy systems with long-pulses widths and/or low repetition rates; but all stations should aim to minimize their systematic errors and their variability, such as range biases. The QC evaluation will focus on these parameters.

The ASC will provide periodic updates to the ILRS CB on the progress of the analyses and then inform the ILRS CB when the station data have been validated; the ILRS CB will then notify both the station and the NASA and the EDC OCs; the OCs will then release the previously quarantined data with any caveats specified by the ASC (such as allowable time periods);

- The ASC will inform the CB when the station data have been validated; the CB will then notify the station and the NASA and the EDC OCs; the OCs will release the previously quarantined data with any caveats specified by the ASC (such as allowable time periods);
- The EDC (in consultation with the ASC and the ILRS CB) will maintain a tabulation of all quarantine periods by station.

Quarantine Procedure for Unique Situations

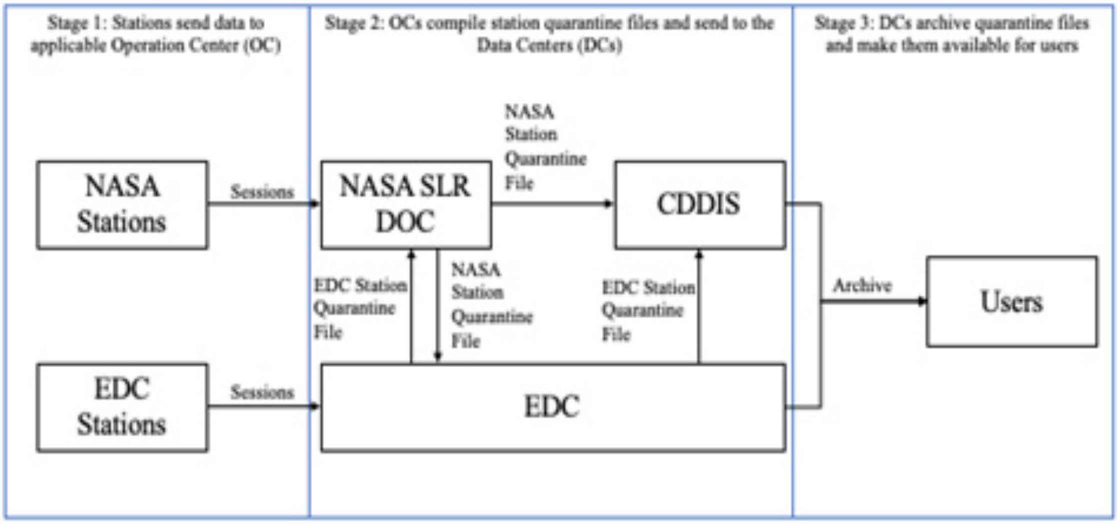
Some system changes may occur with a period of concurrent operation of the new and old configurations before data from the new configuration starts flowing through the operational channels. An example of this is the parallel operation of the Time Interval Unit (TIU) and the new Event Timer (ET) at MOBLAS-5 (Yarragadee) during the first half of 2017. The period of concurrent operation can provide a very powerful data set for comparison and evaluation while the old configuration data continue to flow through the Operations and Data Centers (OCs and DCs). Note: Although in the case of the TIU/ET transition, the passes and points are nearly identical, small differences in the data may occur; the ranges are not identical due to the improved RMS of the ET and the normal points can differ in number of included observations, rms, and range. When the Analysis Standing Committee (ASC) gives its approval, the station may begin sending the new configuration data (in this example, the new ET data set) rather than the old configuration data. The stations would notify the community of the transition (e.g via SLRMAIL), which should happen seamlessly. This procedure would apply to any transition that the Central Bureau (CB) deems would affect the ranging signal path:

- For information purposes, the station will inform the CB of the details of the system change and the planned schedule.
- The CB, in consultation with the ASC, will concur on whether the change warrants detailed examination.
- If examination is warranted, the station will continue to flow data using the old system configuration in the routine manner and file the new configuration data locally.
- The ASC will specify the span of data required for the examination.
- At the direction of the CB, the OCs will establish a file of these data (either in a quarantine or an engineering status) where the specified new configuration data are to be submitted.
- The station may submit the new configuration data into the file at its convenience and will alert the ASC and the CB when the data requirement has been fulfilled.
- The ASC will organize and conduct its evaluation and interact with the stations as necessary to expedite the process.
- The ASC will inform the CB when the station has passed the evaluation.
- The CB will then ask the station to:
    - transition to sending its new configuration data through the operational channels;
    - update its configuration files, site log, and configuration history log (as appropriate); and
    - inform the community of the date of transition.
- The CB will notify the NASA and the EDC OCs of the transition.
- The new configuration data files submitted for the evaluation process will remain available at the DCs for access by the general community for additional studies.

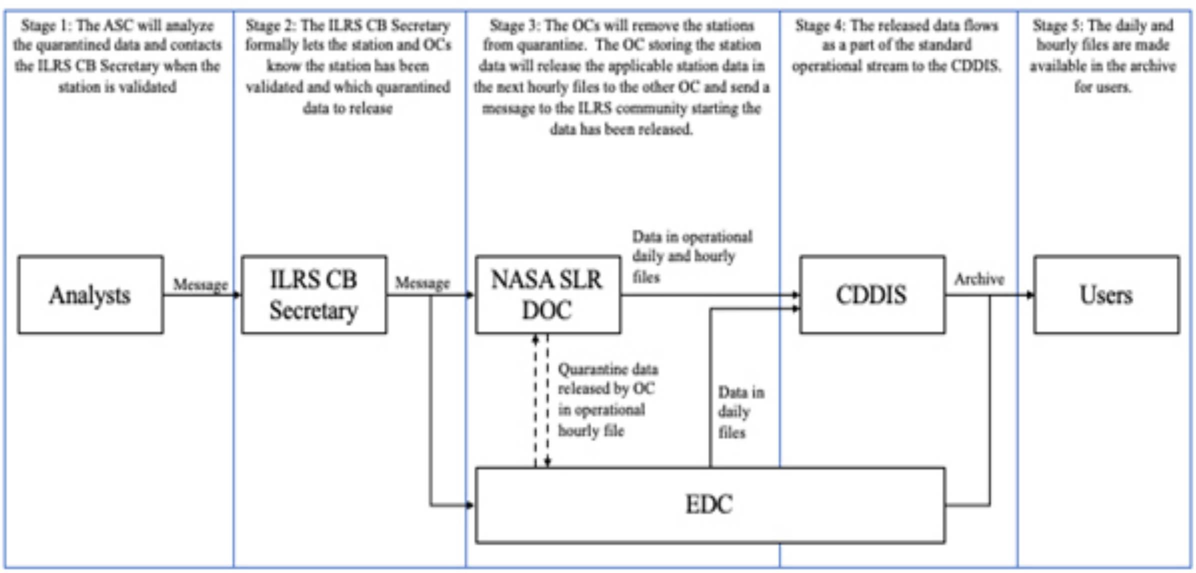
The situation presented above represents an example of an unique situation. For other circumstances, the station should coordinate with the CB and the ASC to determine, based on the particular situation, what are the appropriate steps to take, and properly document the nature and timing of the changes in stations laser ranging system.

If there are any questions, please contact your OC or the ILRS CB.

Quarantine Data



Release of Quarantine Data



ILRS QCB Meeting

5/13/2024

Mike Pearlman & Claudia Carabajal

Agenda

Tentative agenda is included below:

- Station Quarantine Procedure – Frank
- ILRS Survey and Station Plan – Matt/Claudia/Mike
- Missions updates: Mike/Claudia
  . Missions SLR Tracking Report Template
  . IRNSS, ADRAS-J, any other updates.
  . Galileo Campaign
- Update on Stanford Counters - Graham
  . What action is practical?
- Input from Van:
  . The LE Filter Continued (15 to 20 minutes)
  . Using VMF Data to Model Tropospheric Errors in Legacy SLR Data (10 to 15 minutes)
  . 7090 YARL and 7110 MONL LAGEOS Tracking Statistics (10 to 15 minutes)
  . How should we address non-uniform pre-preprocessing at the stations?
- Input from Justine
  . Do we want to maintain FR files; How do we keep track of FR - NP voids? Notification of FR or NP voids?
- Update on the COM models for the Geodetic Satellites – Frank/Jose

Agenda, Notes, and materials from the last QCB meeting on March 11, 2024 can be accessed here:
https://ilrs.gsfc.nasa.gov/science/qcb/qcbActivities/index.html

ILRS Survey and Station Plan

- Survey was sent the first group of Stations.
- We will need to respond to the Surveys when they come in.
- We will be putting together the review committee.

Stations contacted: Borowiec, Tahiti, Riga, Svetloe, Metsahovi, Simosato, Hartebeesthoek, Beijing, Mendeleevo, San Juan.

Missions SLR Tracking Report Template

- Template (version 1.6) was sent out to the active LEO satellites to start.
- Responses will be posted on the ILRS website.
- We will be putting together the review committee.

Missions contacted: Cryosat-2, Geo-IK-2, GRACE-FO-1 and GRACE-FO-2, HY-2B, HY-2C, HY-2D, ICESat-2, Jason-3, PAZ, SARAL, Sentinel-3A, Sentinel-3B, Sentinel-6A/Jason-CSA, Swarm-A, Swarm-B, Swarm-C, SWOT, TanDEM-X, TerraSAR-X.

ADRAS-J, IRNSS, ALOS-4 updates

- ADRAS-J (launched February, 2024) will not be needing support from ILRS.
- News from QZS-1 mission. Removing QZS-1, keeping the QZS-2/3/4/1R on the priority list.

Contacts: Kakeru Fukumitsu (kakeru-fukumitsu@nec.com) (not Kaishi Iwasa)

Junko Matsuyama (matsuyama.junko@nec.com)

Yoshihiro Iwamoto (ys-iwamoto@nec.com)

- QZS-5/6/7, there is a possibility of the launches sequentially from the beginning of next year.
- IRNSS tracking: Mission requested that tracking be resumed for the following satellites on the Tracking Priority list:
    - #1 IRNSS-1J
    - #2 IRNSS-1I
    - #3 IRNSS-1C
    - #4 IRNSS-1F
    - General Pool: IRNSS-1B, and 1E (since this one was not mentioned with the 4 above)
    - Removing IRNSS-1D
- Signed agreements received so far from the following stations for ALOS-4 tracking:

Potsdam, Kunming, Graz, Shanghai, Zimmerwald, Wettzell, Herstmonceux, Golosiiv.

Galileo For Science Update – May 2024

- The campaign will continue for the two Galileos in elliptical orbit (201 and 202) after the end of April.
- We are expecting them to add other satellites at a later time.
- Changes to the priority list were done ILRS added Galileo 201 to the priority list in place 34, moving Galileo 202 and other missions to places 35 and higher.
- Message was sent to the stations.
- Tracking reports from Van are now posted on the ILRS website: https://ilrs.gsfc.nasa.gov/science/SLR_science_campaigns/galileo_for_science.html

International Workshop on Laser Ranging – Kunming 2024

Celebrating 60 Years of SLR (1964-2024), Cooperation in the new era of ILRS

- The Yunnan Observatories and the International Laser Ranging Service (ILRS) are pleased to announce that the 23rd International Workshop on Laser Ranging will be held in Kunming, China during 20-26 October 2024.
- More details can be found in the workshop website online with the link below (recently updated):

  https://23rdworkshop.casconf.cn/

- Registration fee setup done
- Logo and poster
- Working on Program Committee

The Leading Edge (LE) Filter Continued

13-May-2024 ILRS QCB

Van Husson

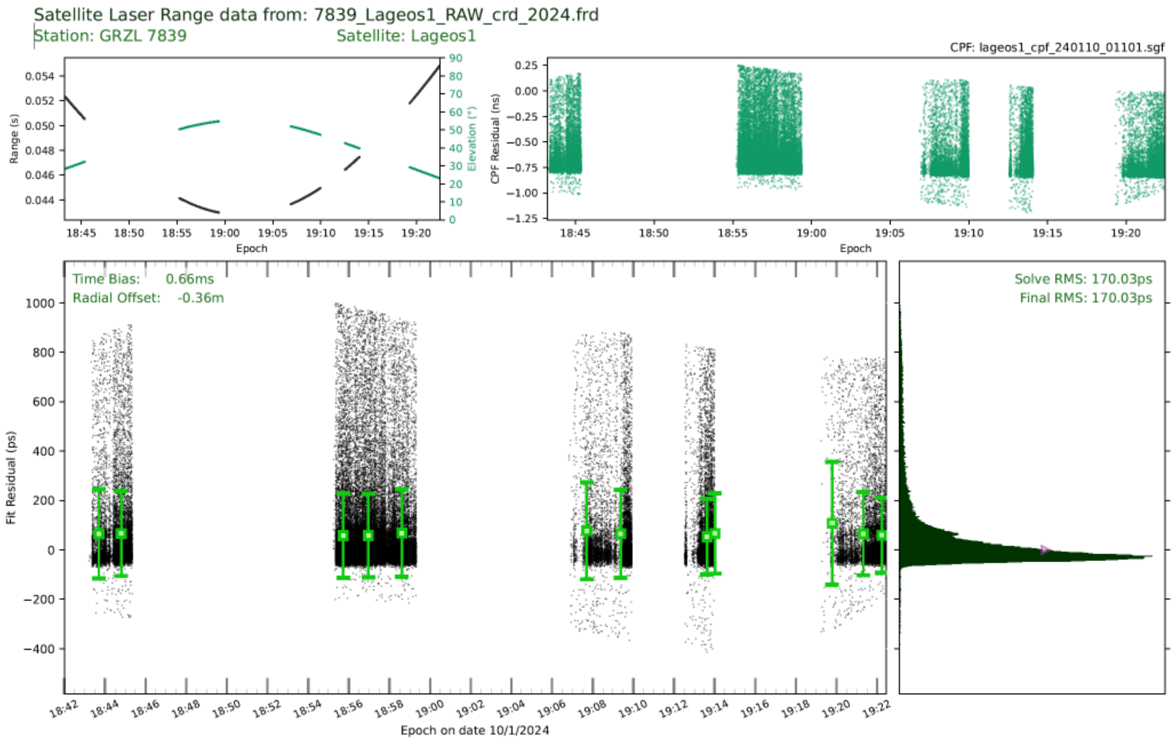
Conclusions from Last Meeting

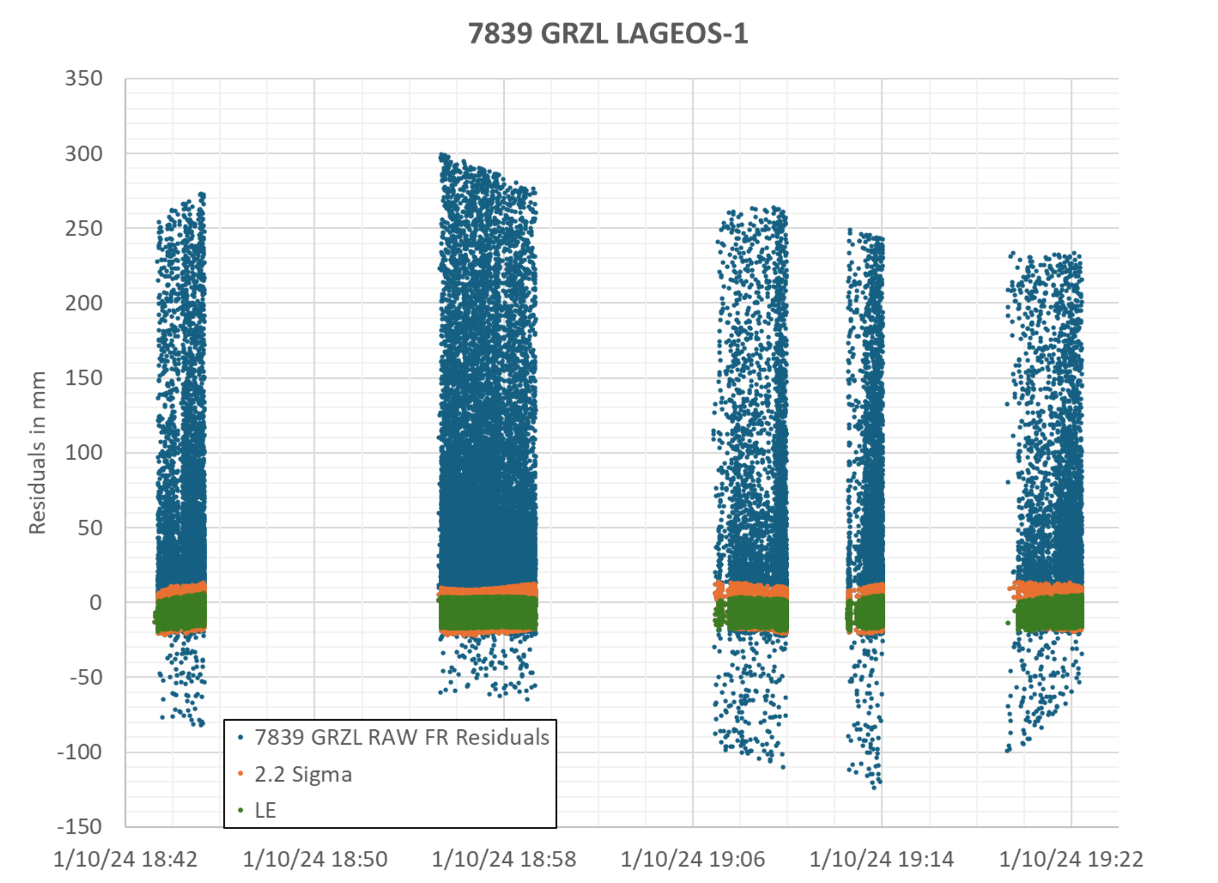
- **Five systems with different configurations have currently implemented the LE Filter (7839 Graz, 7821 Shanghai, 7237 Changchun, 7701 Izana, and 7306 Tsukuba) and possibly more systems on the way (i.e. new DiGOS system in Yebes)**
- **Three of these systems (7839, 7821 and 7237) provide only the LE returns in their FullRate (FR) data while the two DiGOS systems (7701 and 7306) provide FR data based on a 2.2 sigma filter**
- **7839 Graz had the most consistent moments (RMS, skew, and kurtosis) using the LE filter**
- **The LE filter can introduce random and/or systematic errors in the station generated normal points (NPs)**
  - Failure to flatten the LE residuals can introduce random errors in the NPs. Sparse data and/or time gaps can present challenges in flattening the residuals
  - A 20 mm LE filter constrains the satellite RMS to a very narrow range (4 to 6 mm); If the RMS of the unfiltered returns increases or decreases, systematic errors will be introduced in the LE NPs
  - Stations must properly document the LE filter implementation in their site logs to avoid introducing errors in the geodetic Center of Mass corrections
  - Applying the LE filter to a satellite that was unintended will introduce systematic errors (e.g. Graz's Etalon data)
- **The filter flag in the CRD fullrate 10 Range Records need to be properly set to indicate data and excluded returns**
- **Action: What level of filtering is the "Best" approach for providing FR data**

What's New Since Last Meeting

- 7839 GRZL provided five LAGEOS-1 and five LAGEOS-2 FR and NP datasets with different levels of filtering applied (raw; 2.2 sigma; & LE)

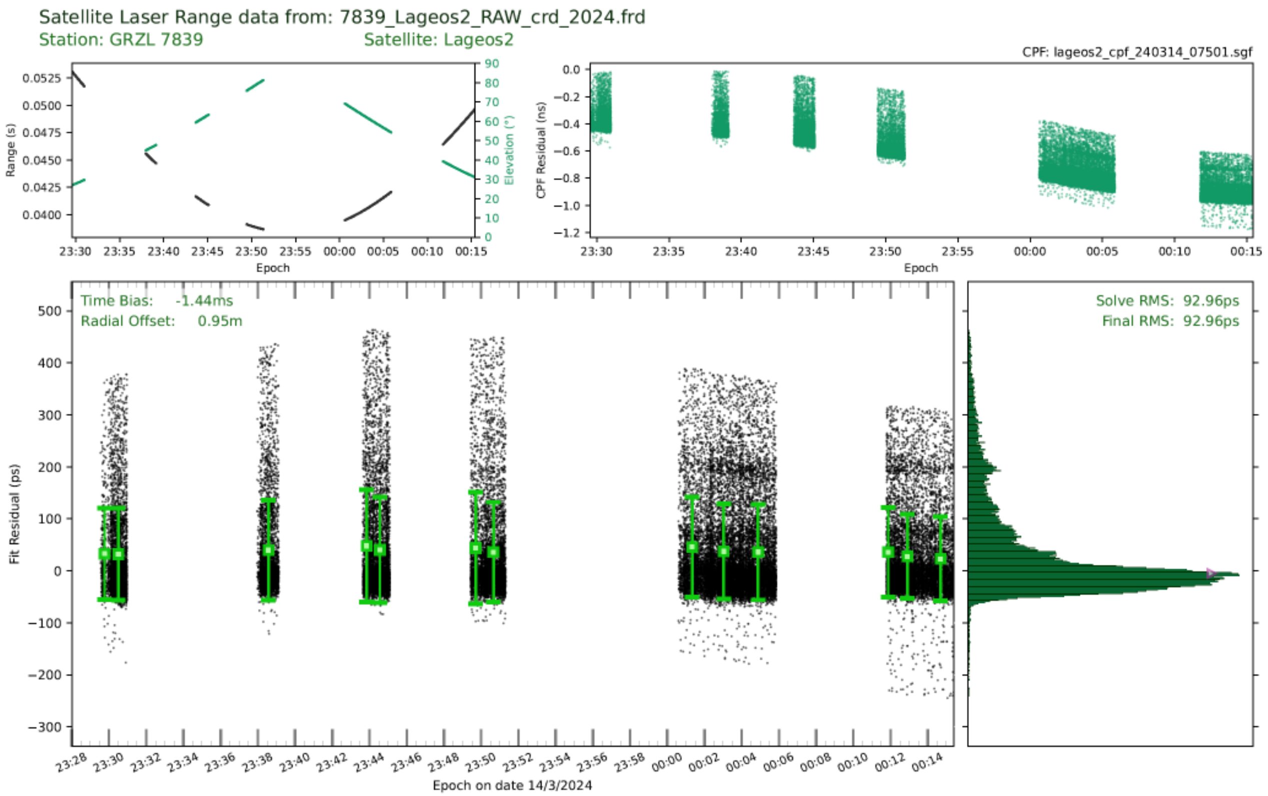
7839 GRZL Raw LAGEOS-1 Fullrate Residuals from OrbitNP

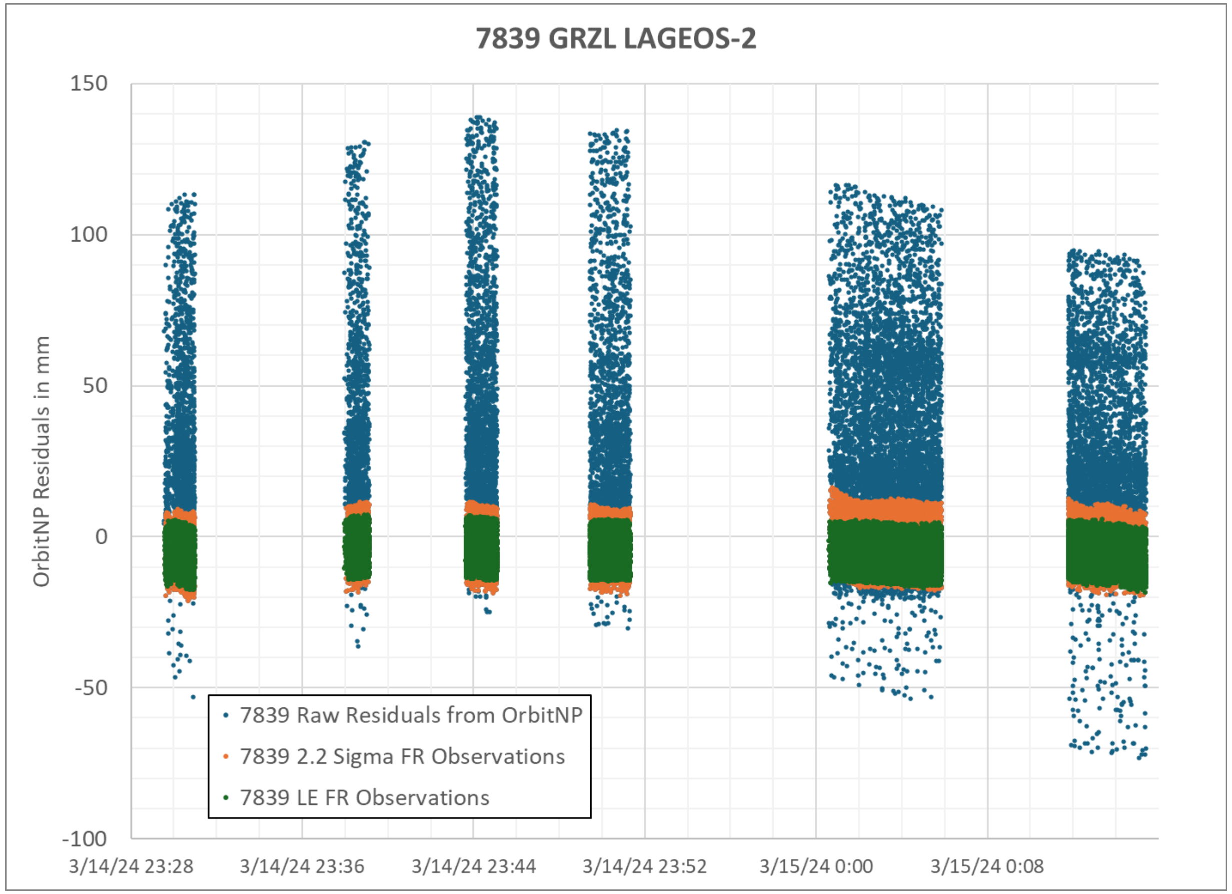




- ❑ **Left Chart: OrbitNP Analysis of 7839 GRZL Raw LAGEOS-1 Fullrate data**
- ❑ **Right Chart: OrbitNP 7839 GRZL Fullrate residuals with the observations from the 2.2 sigma and a LE filter, respectively**

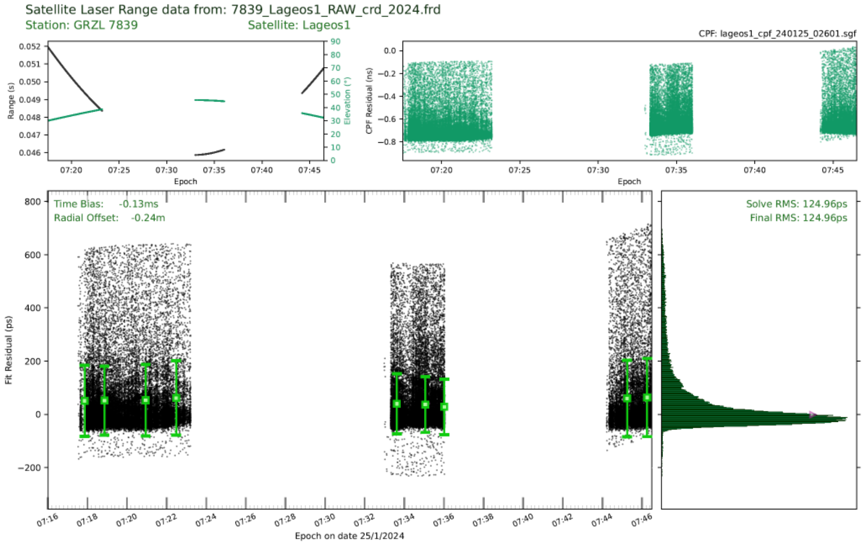
7839 GRZL Raw LAGEOS-2 Fullrate Residuals from OrbitNP

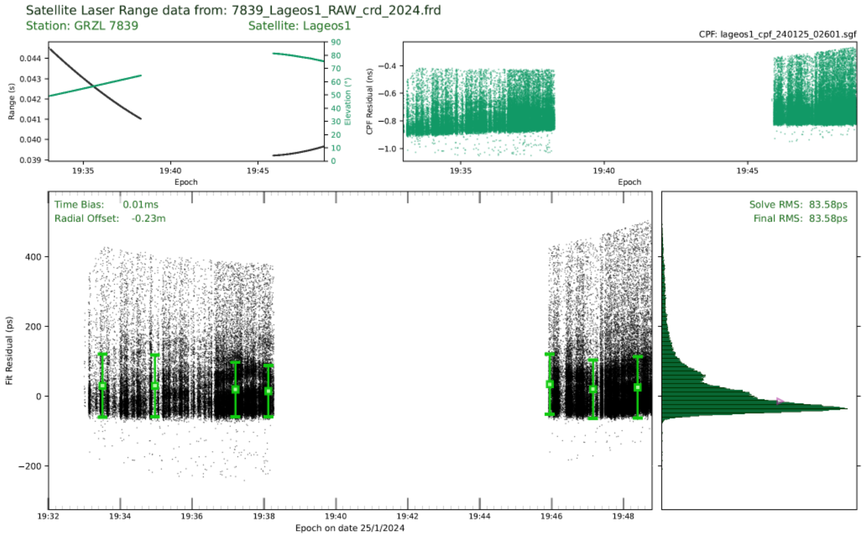


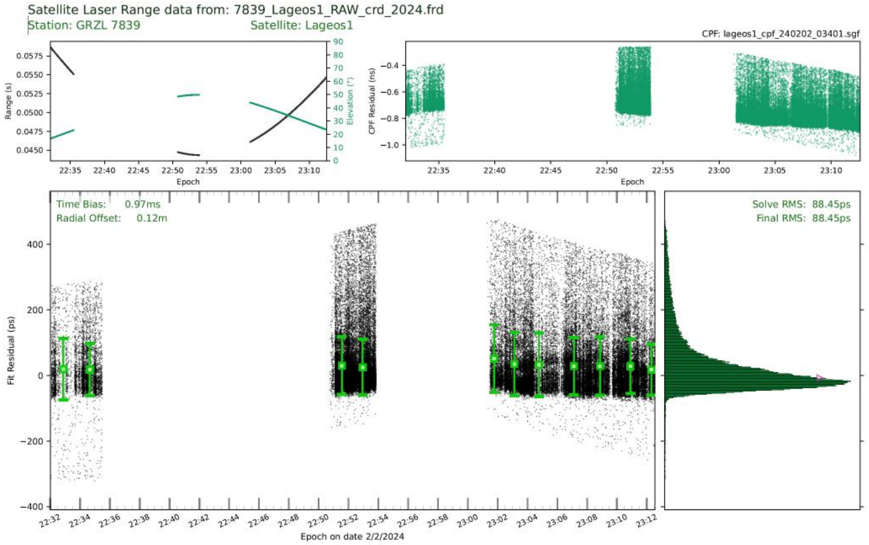


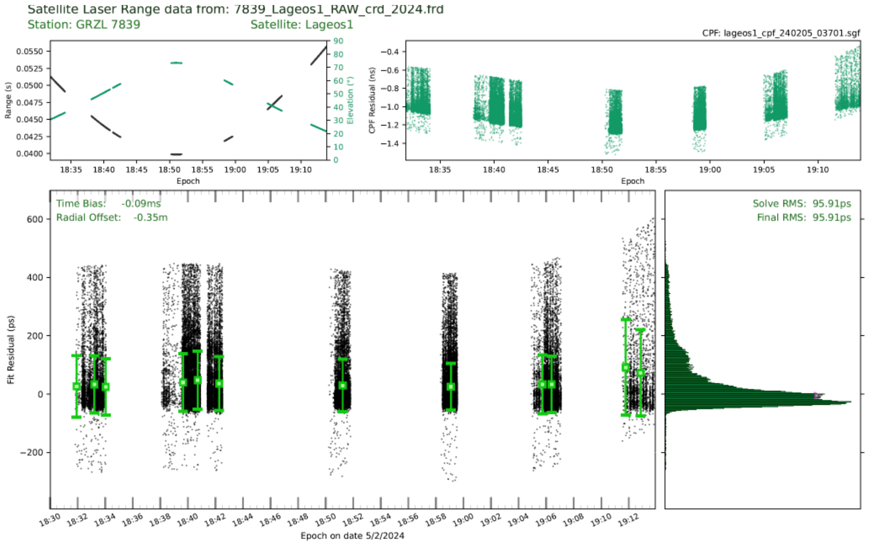
- **Left Chart: OrbitNP Analysis of 7839 GRZL Raw LAGEOS-2 Fullrate data**
- **Right Chart: OrbitNP 7839 GRZL Fullrate residuals with the observations from the 2.2 sigma and a LE filter, respectively**

7839 GRZL OrbitNP LAGEOS-1 Raw Residuals

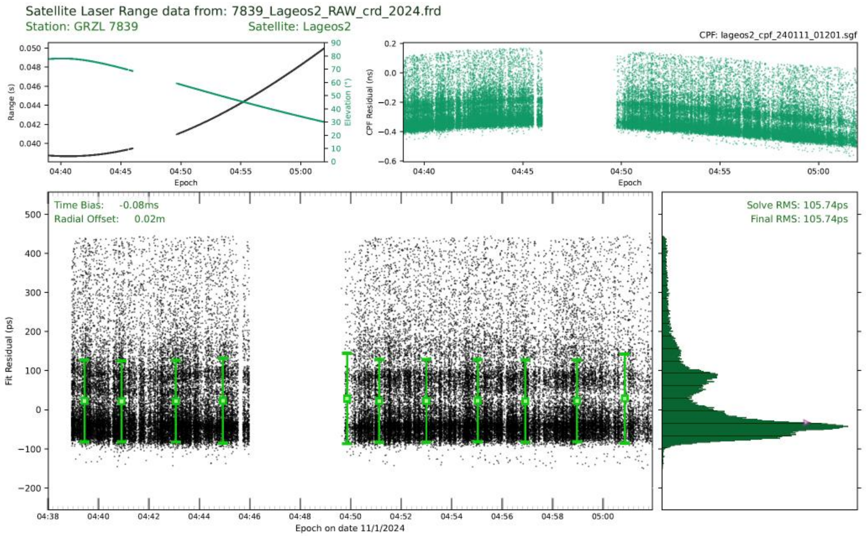


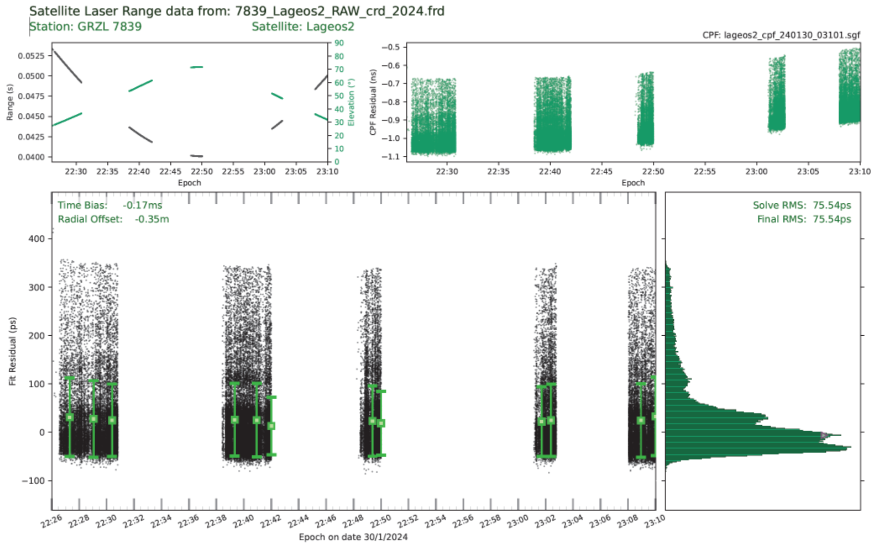


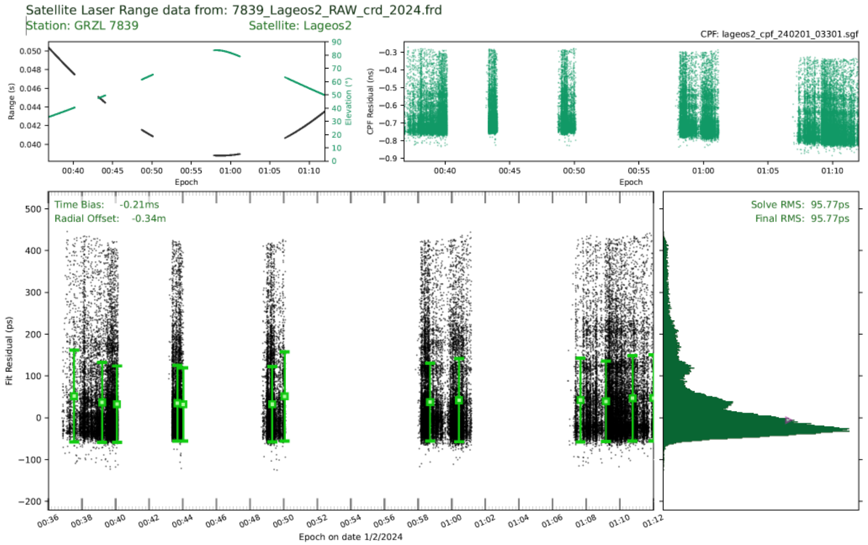


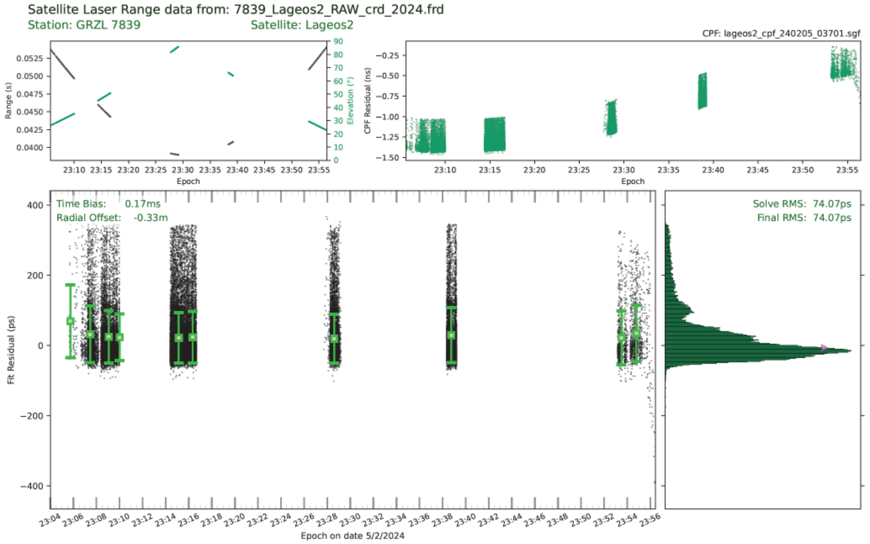


7839 GRZL OrbitNP LAGEOS-2 Raw Residuals



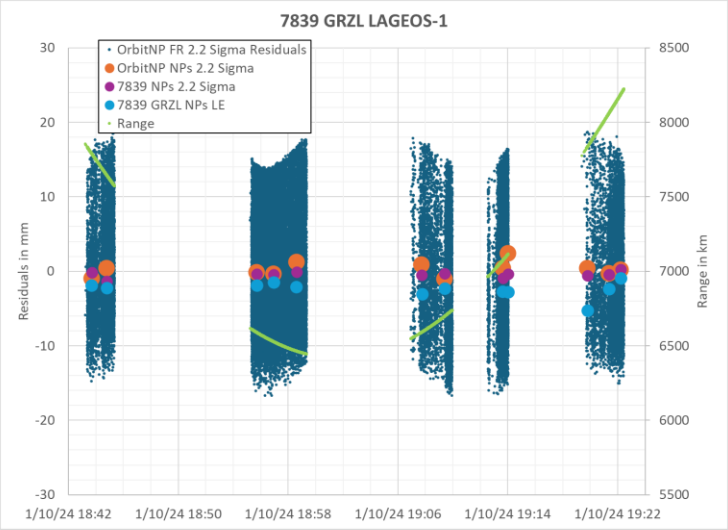


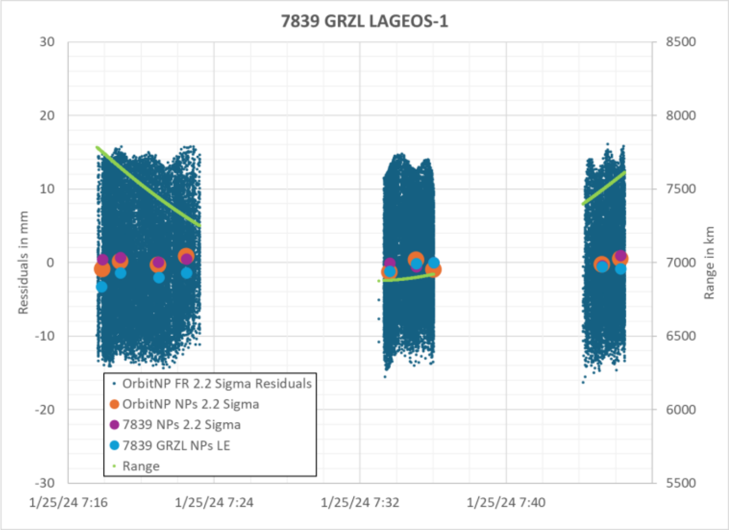


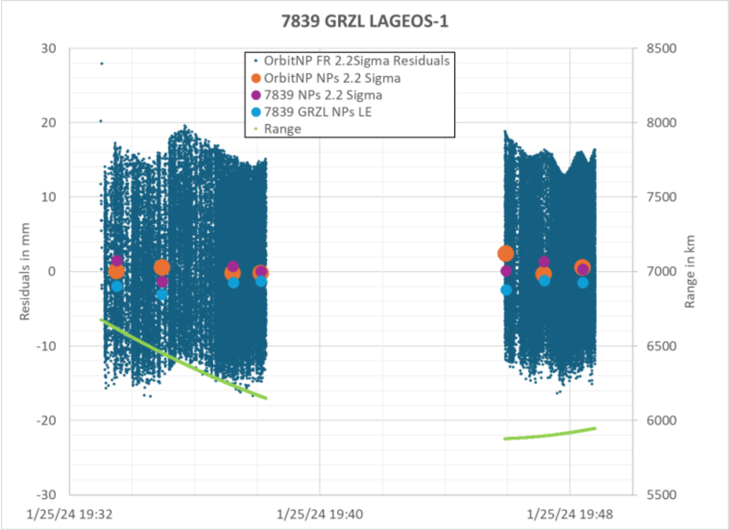


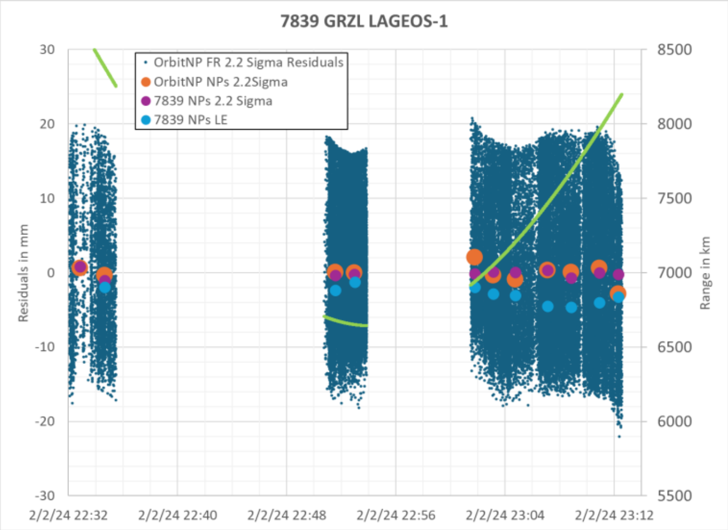
- **There are multiple peaks in the LAGEOS-2 passes**
- **Could these multi peaks explain why the range biases between LAGEOS-1 and -2 are different by a few mm?**

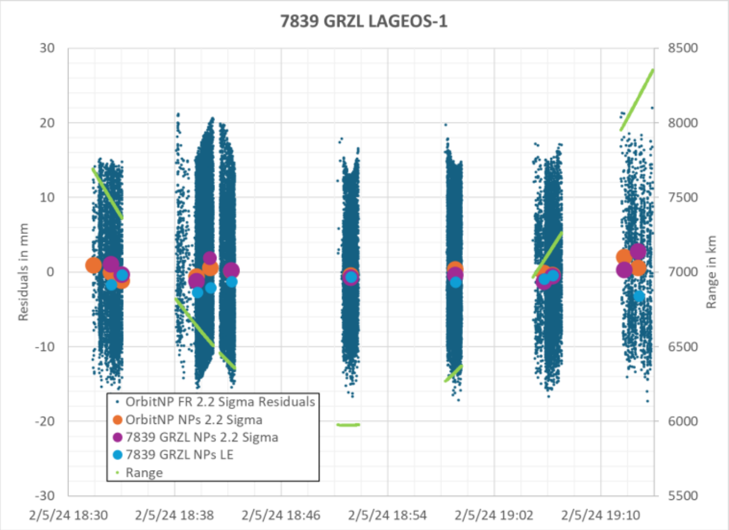
7839 GRZL LAGEOS-1 NP Analysis Using the 2.2 Sigma Filtered Data



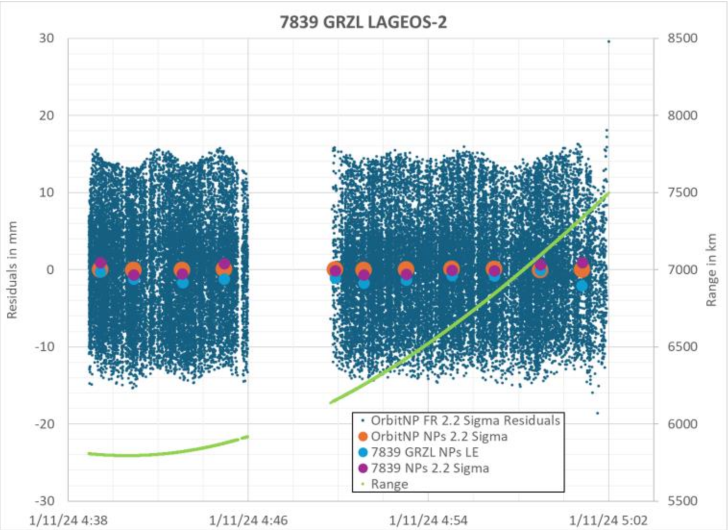


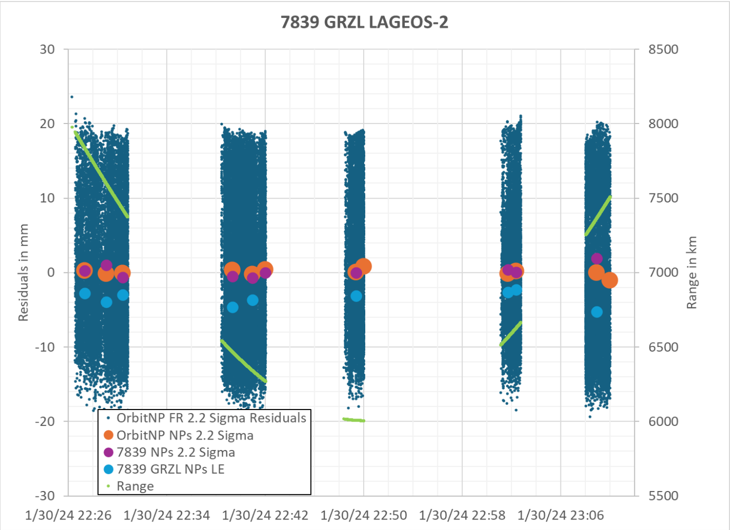


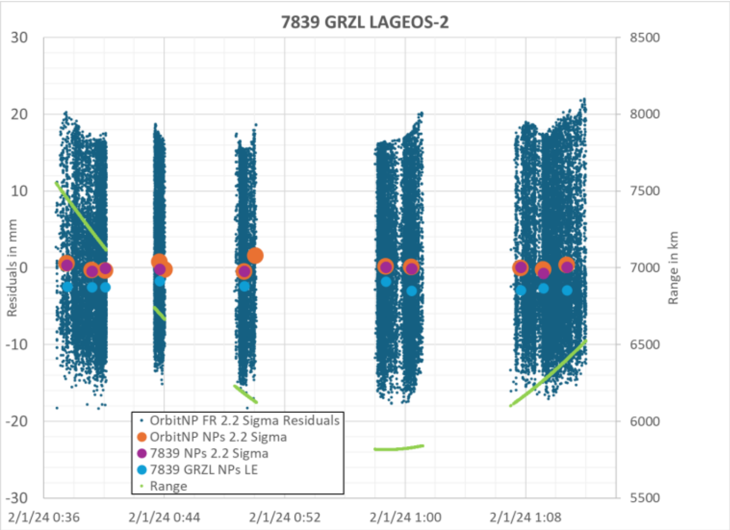


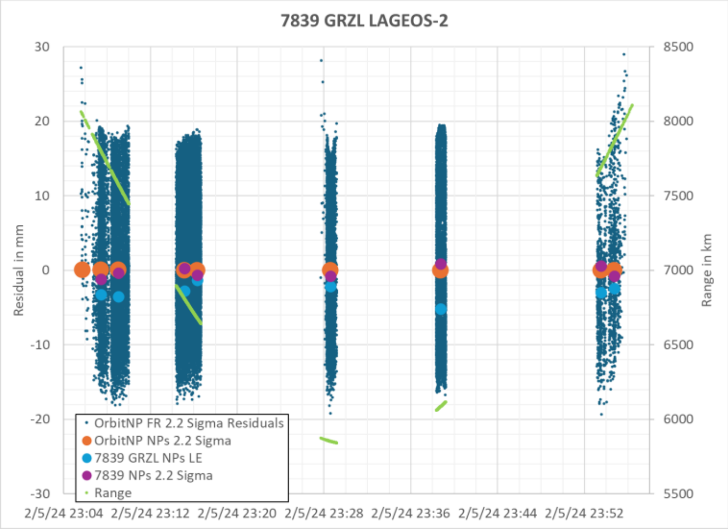


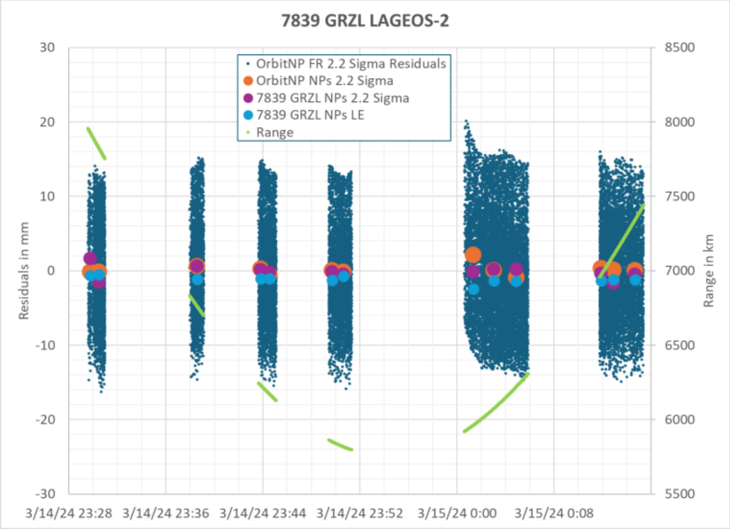
7839 GRZL LAGEOS-2 NP Analysis Using the 2.2 Sigma Filtered Data



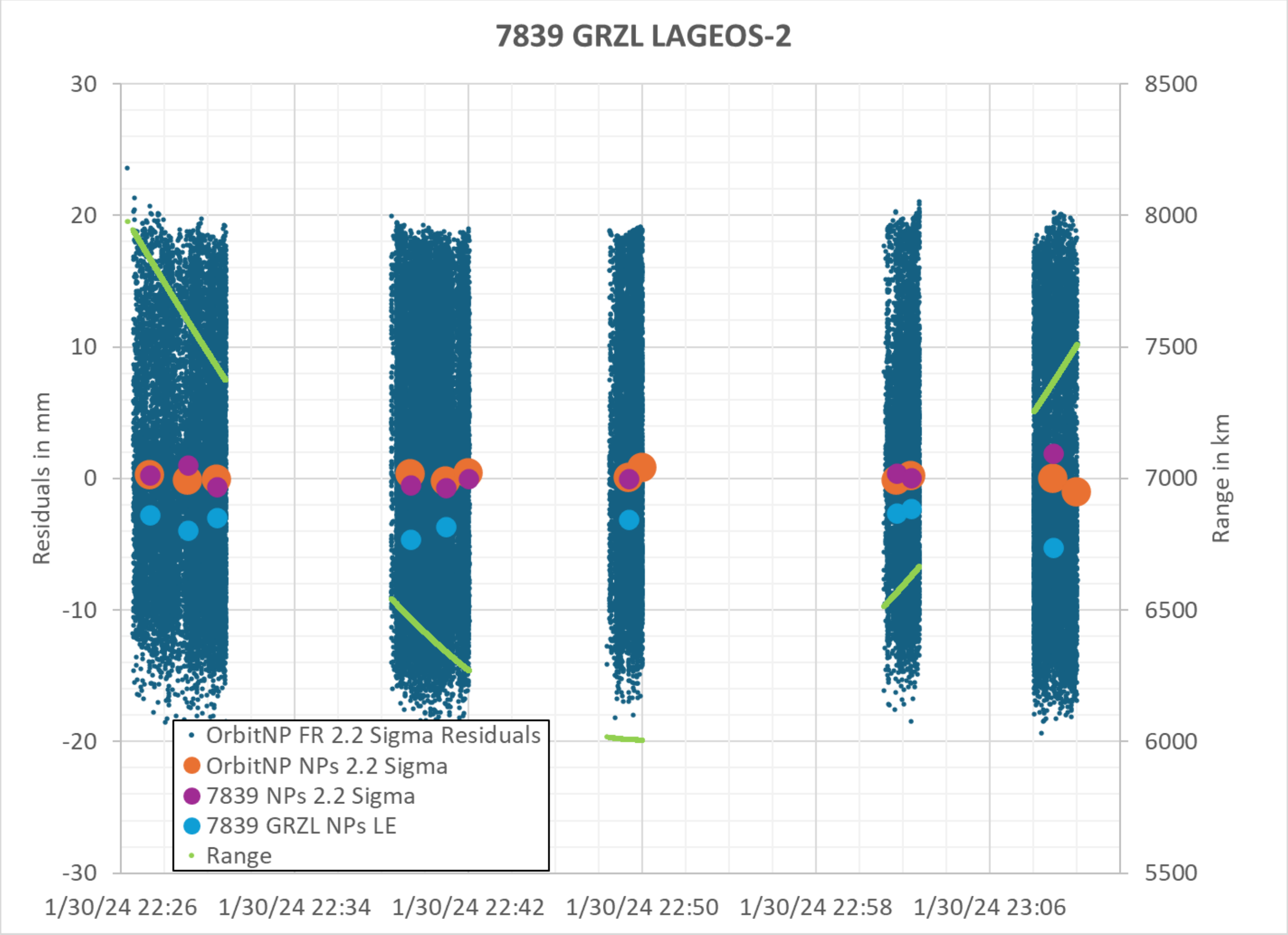








2.2 Sigma NP Comparisons (OrbitNP versus the Graz Station)

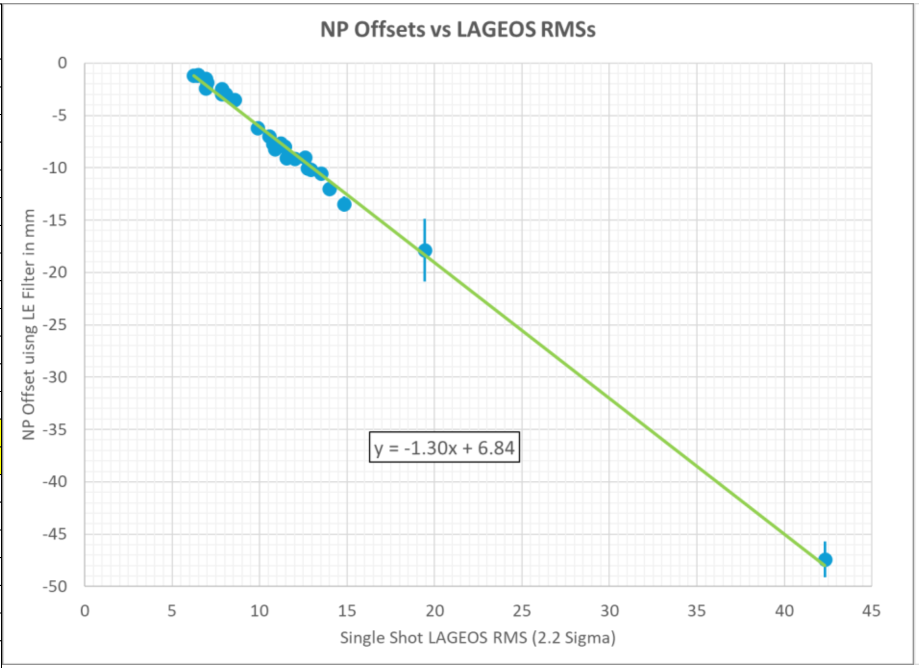


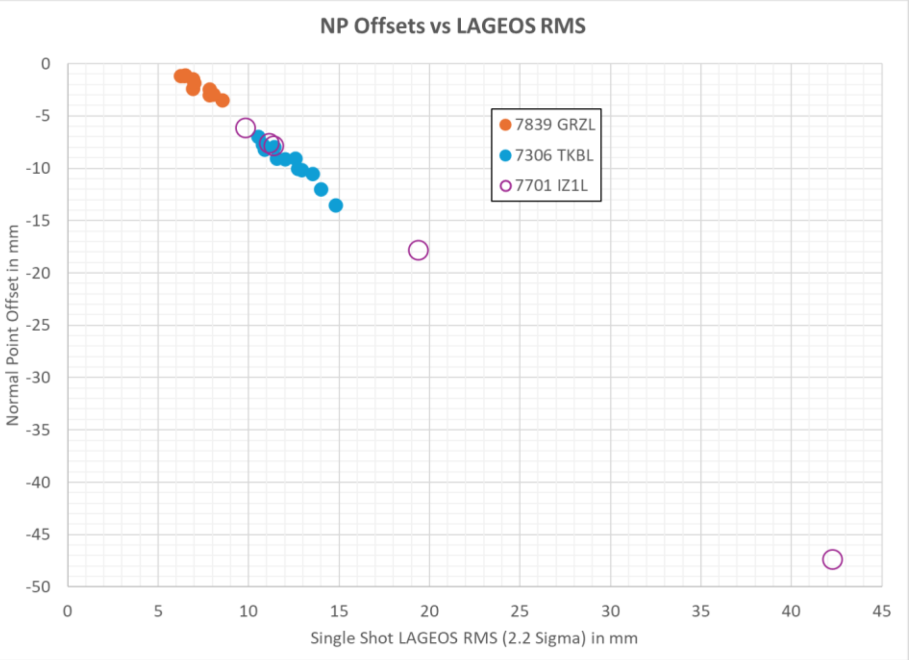
NP Comparison based on 2.2 Sigma Edit								
source	epoch	Tof	pts	rms	skew	kurtosis	p-m	ToF Diff in mm
OrbitNP	80839.287963891	0.052271263528	3773	54.0	0.48	-0.48	-24.80	0.30
Station	80839.287963891	0.052271263530	3773	53.7	0.44	-0.61	-22.60	
OrbitNP	80943.042263891	0.050711842020	6615	55.1	0.40	-0.74	-25.00	1.05
Station	80943.042263891	0.050711842027	6615	55.0	0.43	-0.71	-26.10	
OrbitNP	81024.357763890	0.049535280992	4707	55.4	0.34	-0.85	-25.40	-0.60
Station	81024.357763890	0.049535280988	4707	55.3	0.33	-0.88	-27.60	
OrbitNP	81559.906863897	0.043144606705	10429	60.0	0.20	-1.08	-31.10	-0.45
Station	81559.906863897	0.043144606702	10429	60.0	0.20	-1.06	-47.30	
OrbitNP	81656.369963898	0.042314203510	13895	58.8	0.23	-1.02	-28.40	-0.75
Station	81656.369963898	0.042314203505	13895	58.8	0.25	-1.00	-46.80	
OrbitNP	81720.621963897	0.041827020303	125	58.8	0.21	-1.04	-35.10	0.00
Station	81720.621963897	0.041827020303	125	59.1	0.22	-1.03	-38.60	
OrbitNP	82162.800663901	0.040079168315	11543	54.7	0.47	-0.72	-29.10	0.00
Station	82162.800663901	0.040079168315	11543	54.7	0.48	-0.69	-34.10	
OrbitNP	82200.333963898	0.040068765780	62	58.7	0.38	-1.10	-39.80	N/A
Station								
OrbitNP	82902.389163890	0.043794208159	3680	50.2	0.41	-0.40	-17.90	0.45
Station	82902.389163890	0.043794208162	3680	50.1	0.41	-0.40	-28.90	
OrbitNP	82943.679063892	0.044220664342	5833	52.1	0.43	-0.51	-21.40	0.00
Station	82943.679063892	0.044220664342	5833	52.0	0.44	-0.57	-36.80	
OrbitNP	83336.548163889	0.049141867896	10348	62.1	0.24	-1.06	-34.70	1.95
Station	83336.548163889	0.049141867909	10348	62.0	0.19	-1.03	-23.10	
OrbitNP	83401.017263900	0.050075082081	47	66.7	0.31	-1.11	-42.60	N/A
Station								
							Average	0.19
							Std Dev	0.81

- There can be small differences in the NPs generated by OrbitNP and the Station using the 2.2 Sigma edited fullrate data as input. Also, there can be differences in the minimum number of NPs used to create a NP

LE NP Offset from 2.2 Sigma Fit versus 2.2 Sigma Single Shot RMS

Pad	Satellite	Date and Time	Wave (nm)	2.2 Sigma RMS (mm)	NP offset in mm	Std Error in mm
7306	LAGEOS-1	1/21/2023 13:51	532	10.86	-8.20	0.73
7306	LAGEOS-1	2/14/2023 11:34	532	11.42	-7.98	0.88
7306	LAGEOS-2	2/21/2023 10:42	532	10.76	-7.70	1.07
7306	LAGEOS-2	1/29/2024 21:47	1064	14.81	-13.49	1.81
7306	LAGEOS-2	2/4/2024 13:34	532	10.53	-6.98	0.59
7306	LAGEOS-1	2/9/2024 12:50	532	13.52	-10.53	1.58
7306	LAGEOS-2	2/9/2024 16:03	532	12.92	-10.17	0.21
7306	LAGEOS-2	2/12/2024 14:34	532	12.01	-9.11	1.24
7306	LAGEOS-2	2/15/2024 9:00	1064	14.00	-12.00	0.99
7306	LAGEOS-1	2/15/2024 11:52	532	12.58	-9.03	1.58
7306	LAGEOS-1	2/16/2024 10:06	532	11.54	-9.04	1.41
7306	LAGEOS-2	2/16/2024 10:50	532	12.73	-10.02	0.96
7701	LAGEOS-1	1/8/2023 13:46	1064	11.44	-7.94	1.58
7701	LAGEOS-1	2/13/2023 10:44	532	42.32	-47.41	3.40
7701	LAGEOS-1	2/13/2023 20:54	1064	19.43	-17.88	8.50
7701	LAGEOS-2	2/14/2023 21:50	1064	11.20	-7.68	1.01
7701	LAGEOS-2	2/13/2024 23:57	1064	9.87	-6.20	1.19
7839	LAGEOS-1	1/10/2024 18:42	532	6.91	-2.41	0.40
7839	LAGEOS-1	1/25/2024 7:16	532	6.23	-1.19	0.38
7839	LAGEOS-1	1/25/2024 19:32	532	7.00	-1.82	0.26
7839	LAGEOS-1	2/2/2024 22:32	532	7.84	-2.97	0.43
7839	LAGEOS-1	2/5/2024 18:30	532	6.93	-1.45	0.36
7839	LAGEOS-2	1/11/2024 4:38	532	6.48	-1.10	0.23
7839	LAGEOS-2	1/30/2024 22:26	532	8.56	-3.48	0.37
7839	LAGEOS-2	2/1/2024 0:36	532	7.84	-2.47	0.17
7839	LAGEOS-2	2/5/2024 23:04	532	8.05	-2.94	0.43
7839	LAGEOS-2	3/14/2024 23:28	532	6.45	-1.18	0.18





- There is a linear relationship between the 2.2 sigma RMS and the LE NP Offsets. As the 2.2 Single Shot RMS increases the LE NPs will be biased more negative. The CoM corrections may account for some of this bias change

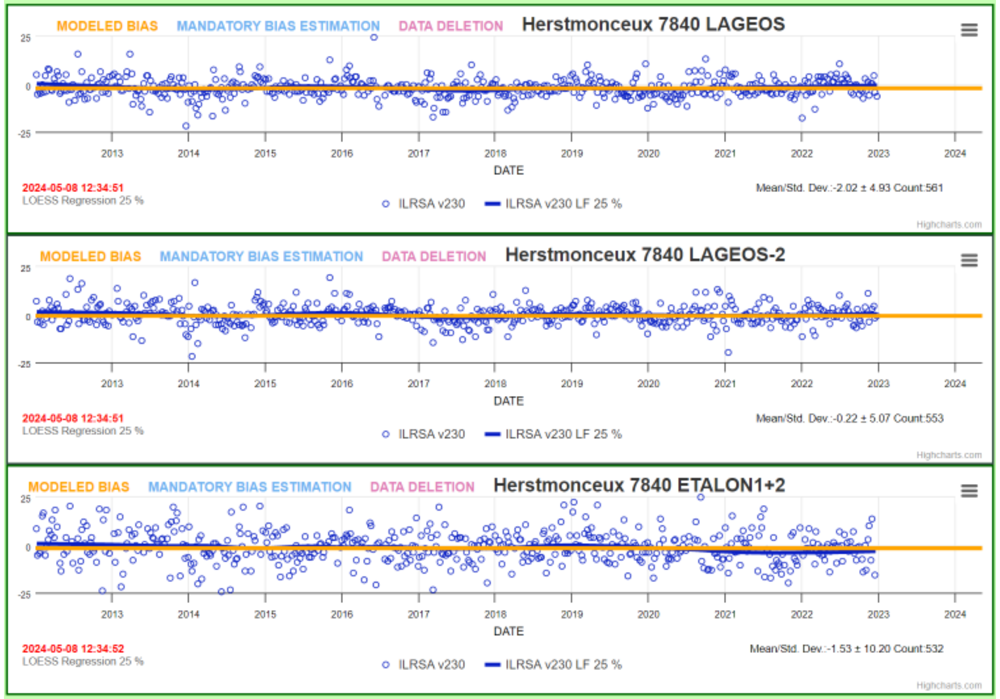
LAGEOS-1, -2 Center of Mass (CoM) Corrections

Station and Filtering	LAGEOS-1 CoM in mm	LAGEOS-2 CoM in mm	Comments
7839 Graz 2.2 Sigma	247.3	246.9	
7839 Graz LE Filter	250.4	250.3	
LE Filter - 2.2 Sigma	3.1	3.4	
7701 Izana 2.2 Sigma (532 nm)	246.7	246.3	
7701 Izana LE Filter (532 nm)	TBD	TBD	
7701 Izana 2.2 Sigma (1064 nm)	247.5	247.0	
7701 Izana LE Filter (1064 nm)	TBD	TBD	
7821 Shanghai 2.2 Sigma	247.8	247.6	Site log indicates LE Filter was implemented on 21-Jul-2021, but the data indicates 25-Apr-2021
7821 Shanghai LE Filter	251.2	251.0	
LE Filter - 2.2 Sigma	3.4	3.4	
7237 Changchun 2.2 Sigma	244.7	244.0	
7237 Changchun LE Filter	TBD	TBD	

- **The CoM Corrections increase if you apply a LE filter because the NPs are closer to the LE of the spacecraft's retroreflector array**

Discussion

- ❑ **What level of filtering is the “Best” approach for providing FR data for the LE systems?**
- ❑ **What can be done, if anything, to monitor the inherent single shot RMS of stations that have implemented a LE filter?**
- ❑ **Do the multiple peaks in the 7839 Graz LAGEOS-2 raw residuals explain why stations tend to have a more positive range bias on LAGEOS-2 versus LAGEOS-1 and does applying a 20 mm LE filter mitigate a LAGEOS range bias difference?**



ILRSA LAGEOS v230 Mean/Std. Dev.:-2.02±4.93 Count:561
ILRSA LAGEOS-2 v230 Mean/Std. Dev.:-0.22±5.07 Count:553
ILRSA ETALON1+2 v230 Mean/Std. Dev.:-1.53±10.2 Count:532

Using VMF Data to Model Tropospheric Errors in Legacy SLR Data

13-May-2024 ILRS QCB

Van Husson

Peraton

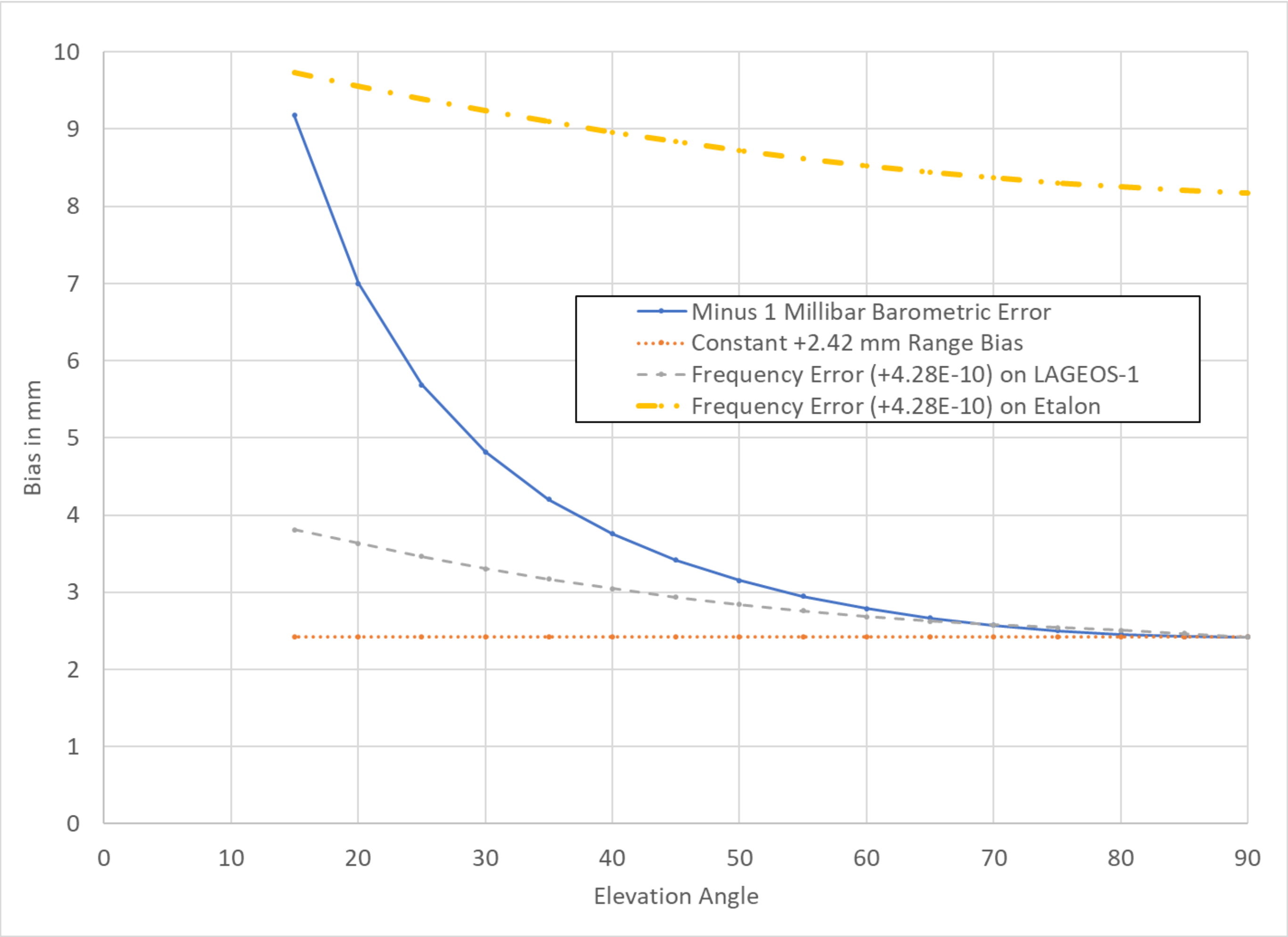
Vienna Mapping Functions 3 for Optical Frequencies (VMF3o)

- **There are 3 flavors of VMF3o with the first being the most precise**
  1. VMF3o_EI: European Centre for Medium-Range Weather Forecast (ECMWF) ERA-Interim Numerical Weather Models (NWM) data based on a climate reanalysis. Time Span: January 1, 1990, to August 31, 2019
  2. VMF3o_FC: ECMWF forecasted NWM
  3. VMF3o_OP: ECMWF operational NWM. Data is available next day. Time Span: January 1, 2008 to present
- **VMF3o Reference: https://link.springer.com/article/10.1007/s00190-020-01385-5**

Common Issues with SLR Barometric Measurements

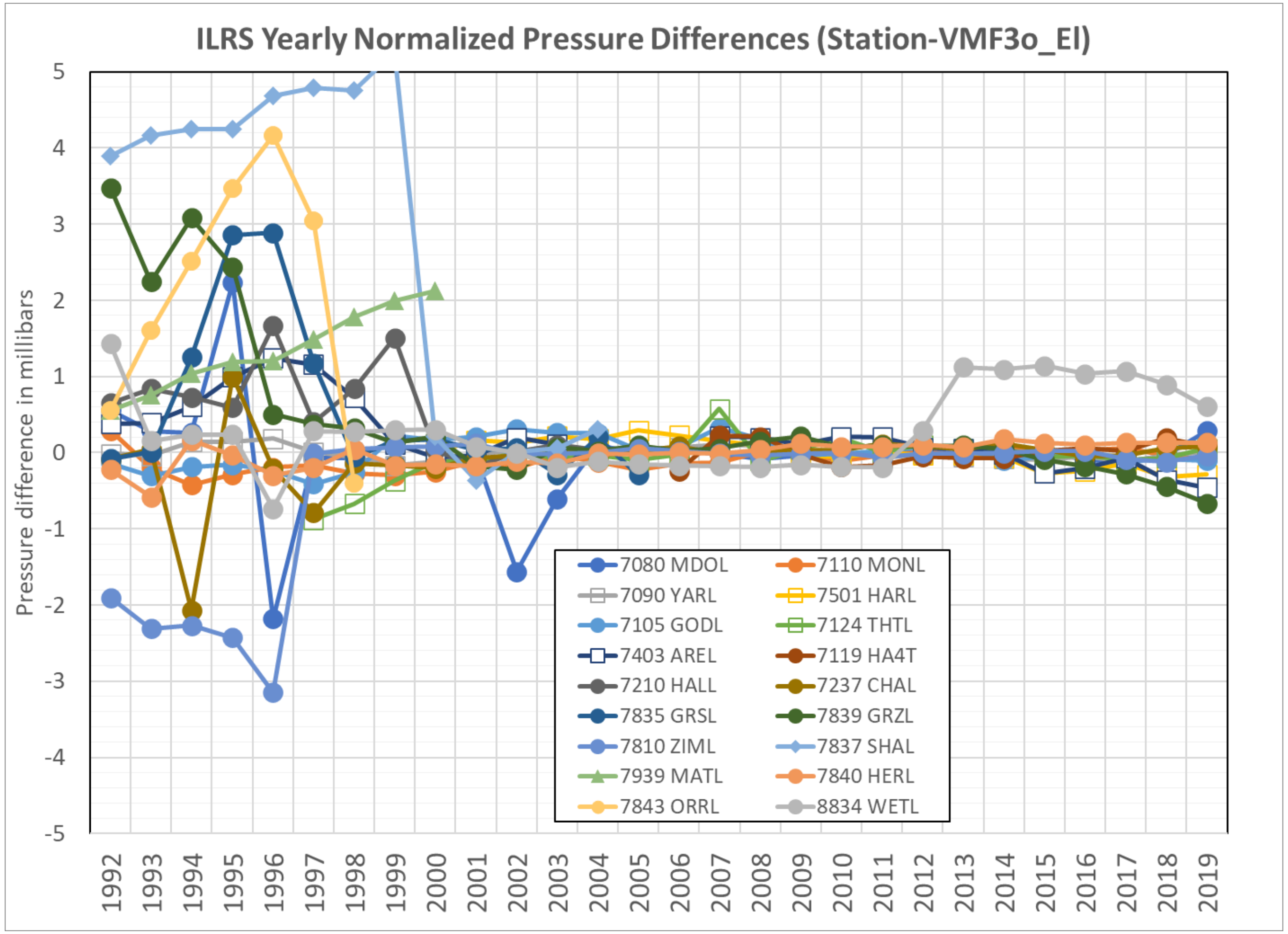
- Meteorological measurements do not always update
- Barometric sensors can and will drift over time
- Infrequent calibration cycles
- Changing a barometric sensor and/or a recalibration may induce a discontinuity
- Height differences between the barometric sensor and the System Reference Point (SRP) are not modelled in the onsite data reduction (e.g. a 10-meter height difference in 8834 WETL)

SLR Systematic Error Signatures as a Function of Elevation



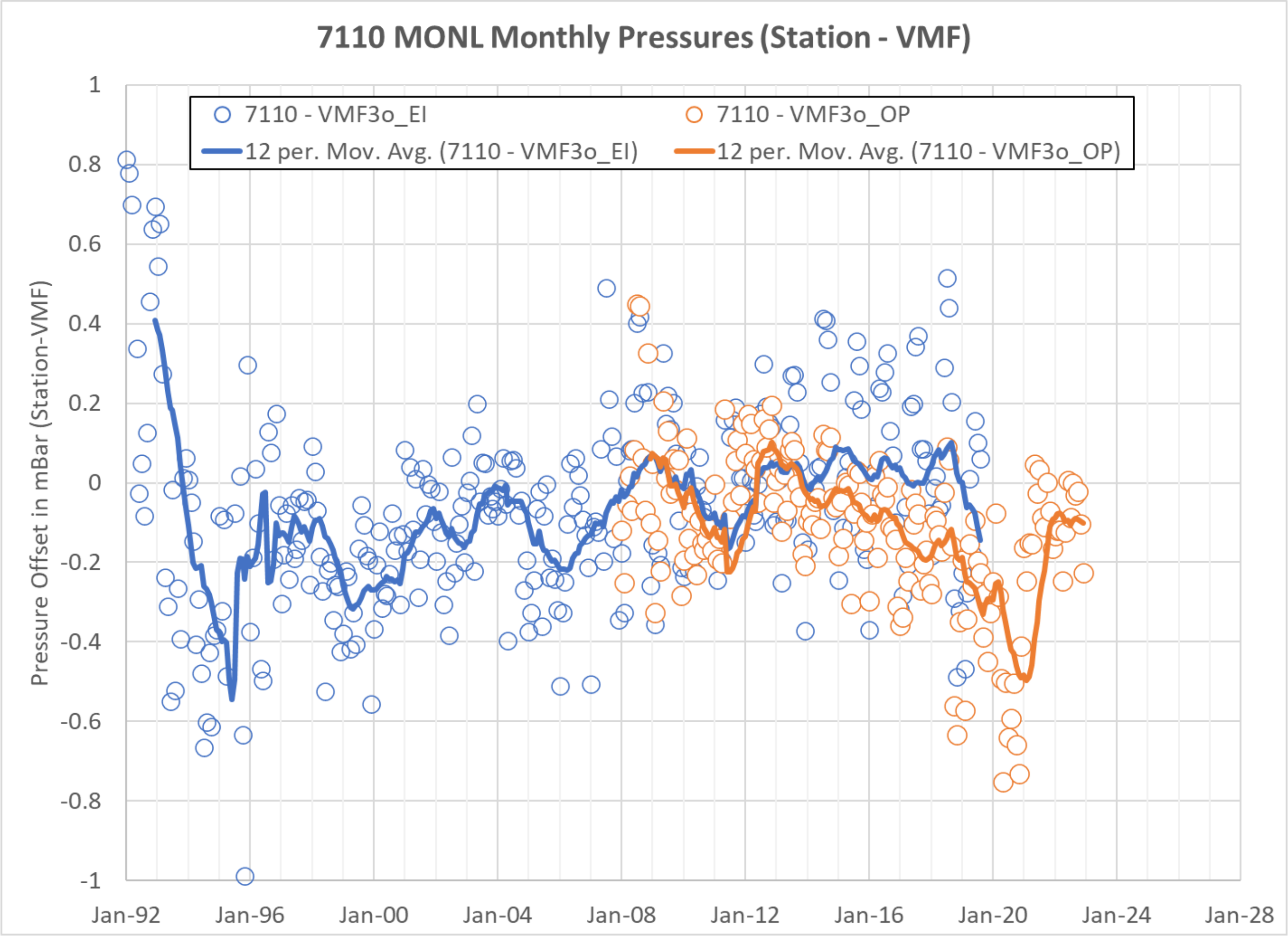
- **At zenith, the following errors on LAGEOS would have the same magnitude but would have different magnitudes at 15 degrees**
  - -1.0 millibar barometric error
  - +4.28E-10 frequency error
  - +2.42 mm fixed range bias
- **A frequency error would impact Etalon more than LAGEOS**
- **Frequency and barometric errors are silent SLR data quality killers since these errors do not impact data precisions (i.e. single shot RMS, normal point RMS, calibration RMS)**
- **Solving for a range bias will not remove the bias signatures caused by a barometric or frequency error. If not modelled, these errors will impact station height**
- **Epoch error signatures are range-rate dependent and not shown**

ILRS Core Sites Barometric Analysis



- ❑ **Using the VMF3o_El data, here is a time series of yearly barometric offsets from ILRS core sites, 1992 to 2019**
- ❑ **Most of these tropospheric errors are undocumented in the current Data Handling File (DHF) and some current DHF barometric corrections can be 'recalibrated'**

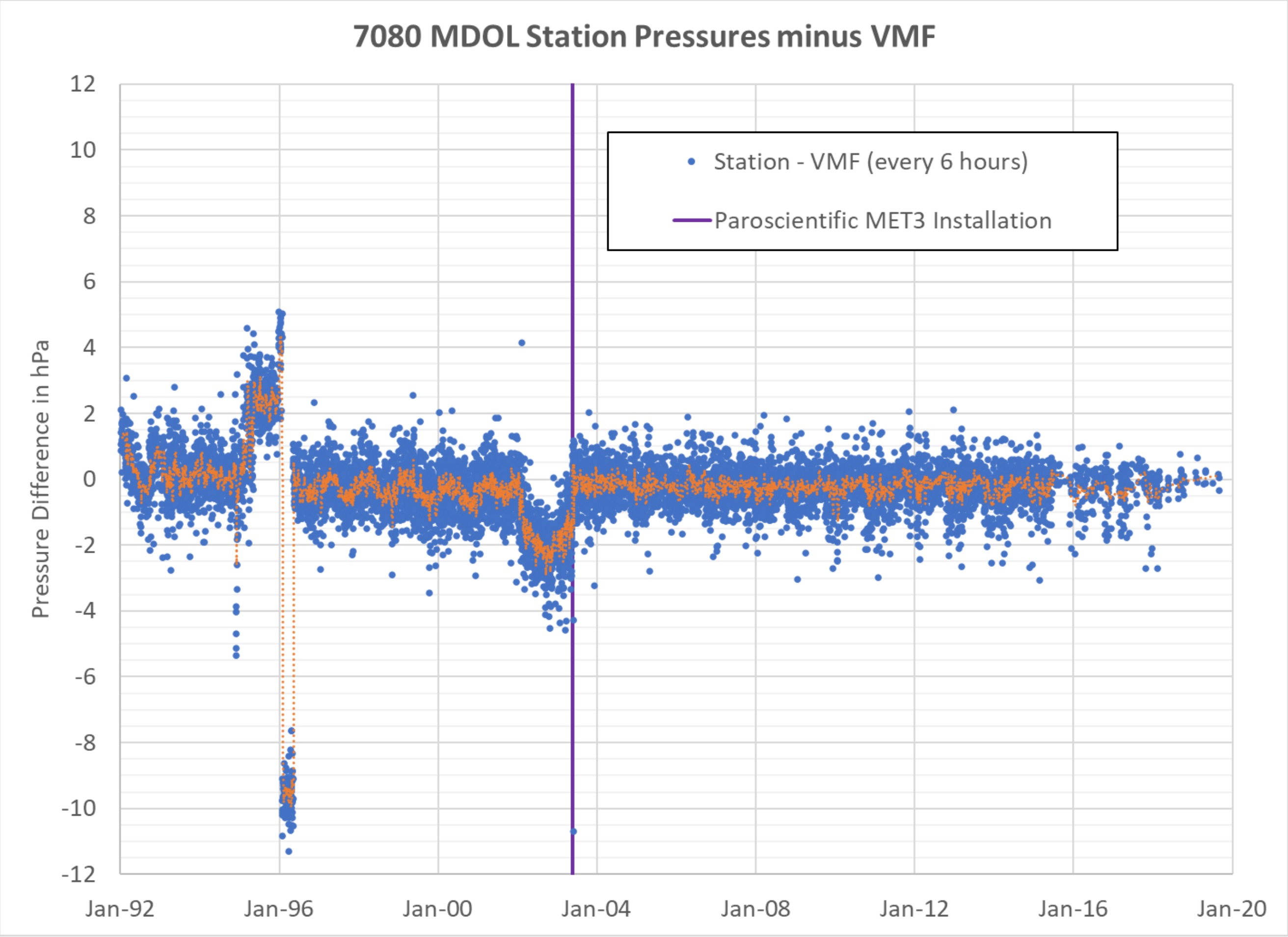
7110 MONL Monthly Pressure Differences



- ❑ VMF3o_EI and VMF3o_OP have different start and end dates
- ❑ The VMF3o_EI and VMF3o_OP can drift apart

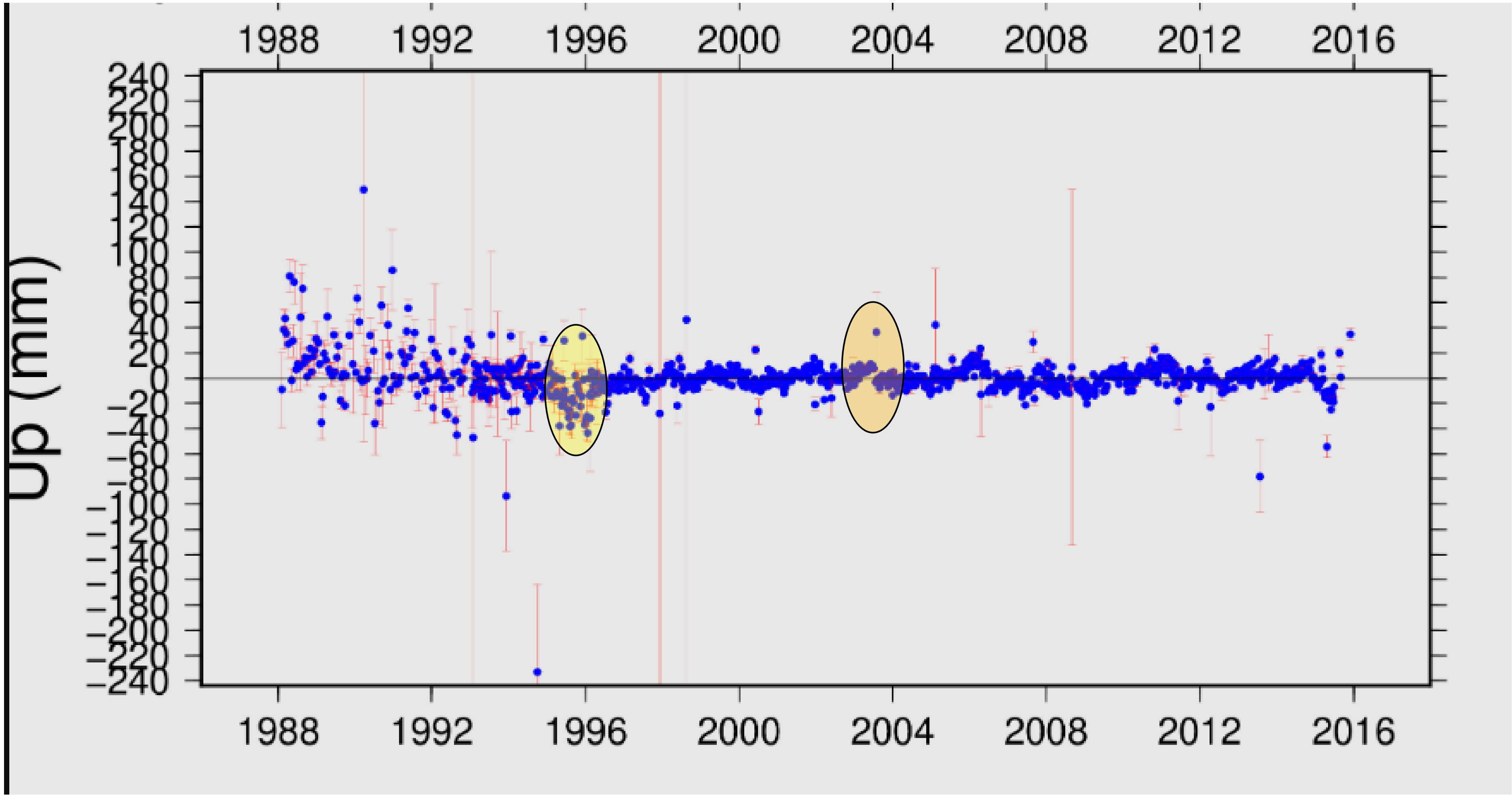
7080 MDOL Barometric Pressure Data Analysis

CODE	PT	SOLN	T	START_DATE__	END_DATE____	M	__E-VA	STD_DE	_E-RAT	UNIT	CMNTS
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



- **The table contains the current 7080 barometric corrections in the DHF**
- **Each data point in the chart is a six-hour difference in the average 7080 six-hour pressure (from NP tracking data) and the VMF**
- **Based on the pressure differences in the chart, the sign of the first barometric DHF correction highlighted in yellow should be a plus not a negative**
- **The pressure errors in 2002 and 2003 are not in the DHF**
- **Also, the sensor prior to the Paroscientific unit being installed had some small seasonal variations**
- **The next slide shows the impact of 7080 barometric modeling errors on its ITRF2020 station height**

7080 MDOL ITRF2020 Height Residuals



- Errors in the 7080 pressures highlighted here caused some mm level discontinuities in their station heights

Summary/Discussion

- For the next ITRF, barometric pressure error models can be developed and/or updated for the ILRS DHF. After applying any new tropospheric corrections new range biases will need to be determined
- Are the small (tenths of mbars) seasonal pressure differences in the station’s barometric sensors; the VMF; or a combination?

7090 YARL and 7110 MONL LAGEOS Tracking Statistics

13-May-2024 ILRS QCB

Van S Husson

Introduction

- **Two NASA Systems (7090 YARL and 7110 MONL) have reported that LAGEOS-2 signals have gotten weaker relative to LAGEOS-1. Is there any data to support this?**
- **7090 YARL is a 24/7/365 operation while 7110 MONL is 16 hours a day/5 days a week operation (plus days off for personal time and holidays)**
- **We will slice and dice their LAGEOS tracking statistics since 1993**
  - Passes per Month per Year
  - Passes per Day per Year
  - Passes per Hour per Year
  - Fullrate Observations per NP per Year

7090 YARL and 7110 MONL LAGEOS Passes per Month per Year

7090 YARL LAGEOS-1 Passes per Month per Year

Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	38	86	56	68		34	62	43	43	89	51	89	120	80	96	157	108	158	126	81	75	130	116	111	162	216	173	192	216	305	195
Feb	49	39	38	40		40	56	57	39	94	62	67	95	108	71	121	104	133	125	114	110	160	101	183	186	217	197	110	169	295	209
Mar	59	38	44	37	11	40	55	38	47	123	109	92	67	114	126	127	146	160	167	142	126	156	117	133	282	225	136	112	313	213	226
Apr	42	49	39	50	22	40	53	54	42	77	103	78	114	139	98	145	127	147	134	101	85	145	127	140	292	190	139	123	134	182	230
May	40	30	21	36	23	31	36	62	45	83	104	75	86	141	120	143	148	110	145	157	106	99	180	152	326	228	183	179	194	205	170
Jun	40	49	31	46	44	27	50	52	49	76	129	62	77	167	115	146	57	139	117	79	132	152	153	131	265	210	133	185	212	229	84
Jul	38	39	16	14	33	39	48	45	35	68	127	32	95	123	98	109	113	117	106	148	116	137	147	125	173	160	210	196	108	223	122
Aug	61	53	49	35	37	36	52	53	41	72	106	77	62	145	118	110	111	143	126	150	71	120	142	126	186	161	212	134	176	206	169
Sep	36	28	29	33	67	50	39	60	56	45	67	77	85	133	96	86	137	152	138	135	109	117	213	148	177	154	189	169	209	122	171
Oct	34	60	33	36	54	52	37	54	47	60	125	90	73	120	131	112	146	179	108	149	88	149	159	169	170	157	166	178	198	206	162
Nov	43	60	42	39	44	53	46	52	76	45	61	84	90	100	149	125	157	160	127	134	111	121	170	160	175	169	163	97	241	250	181
Dec	70	68	33	49	53	53	37	43	76	37	70	101	105	109	102	96	159	108	93	92	151	140	160	151	185	165	152	149	179	203	175
Total	550	599	431	483	388	495	571	613	596	869	1114	924	1069	1479	1320	1477	1513	1706	1512	1482	1280	1626	1785	1729	2579	2252	2053	1824	2349	2639	2094

7110 MONL LAGEOS-1 Passes per Month per Year

Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	10	47	14	47	35	53	45	24	9	29	49	71	5	40	36	12	11	17	42	31	21	51	26	7	22	18	8	41	14	23	23
Feb	5	16	27	29	32	38	51	25	33	38	43	16	21	16	19	10	2	14	24	13	32	28	36	21	22	20	4	25	19	15	26
Mar	72	31	41	31	54	81	62	30	68	37	64	12	19	14	53	22	5	21	26	25	27	41	40	20	15	15	3	13	14	18	21
Apr	58	22	29	35	63	63	39	26	17	38	14	20	34	53	39	18	11	20	39	32	40	25	42	9	30	24	12	31	11	11	41
May	47	26	40	48	70	60	80	46	55	59	11	56	44	66	43	38	9	10	28	44	28	31	31	24	33	37	14	35	14	13	32
Jun	50	48	41	59	60	94	95	34	60	47	66	37	34	62	50	27	15	12	1	34	31	29	18	16	43	40	24	30	8	29	11
Jul	71	28	30		58	63	83	25	44	46	30	57	52	24		4	18	33	36	31	25	36	51	34	23	8	15	30	13	16	21
Aug	67	28	33		57	45	96	41	38	79	34	31	45	39	13	2	34	44	50	26	23	31	59	28	34	24	22	9	13	13	15
Sep	64	20	49	17	53	46	77	48	47	66	84	34	41	37	9	27	35	45	36	25	19	26	44	23	22	50	21	16	30	9	26
Oct	37	51	53	23	72	70	90	26	42	54	74	15	56	42	5	27	13	25	40	21	38	33	41	31	28	29	18	28	26	34	34
Nov	27	31	42	30	63	31	69	49	33	54	55	24	44	54	4	10	8	35	15	27	39	31	33	33	20	17	3	19	22	23	16
Dec	51	42	32	30	53	36	59	52	21	40	48	26	28	35	3	8	18	29	21	8	34	21	27	27	20	13	14	13	11	35	18
Total	559	390	431	349	670	680	846	426	467	587	572	399	423	482	274	205	179	305	358	317	357	383	448	273	312	295	158	290	195	239	284

7090 YARL LAGEOS-2 Passes per Month per Year

Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	34	66	55	49		37	54	50	40	69	73	65	110	82	107	131	123	162	100	75	86	120	85	110	141	187	191	162	172	296	195
Feb	31	48	51	39		53	36	59	31	71	83	61	70	110	72	113	121	148	99	109	103	154	76	154	206	207	195	98	172	288	189
Mar	31	47	43	40	18	49	40	42	51	85	104	93	41	123	122	111	154	159	160	154	134	138	106	133	277	225	129	106	328	188	237
Apr	37	48	32	41	19	49	29	50	46	46	87	102	66	119	113	112	121	125	123	118	79	111	146	99	281	197	151	107	152	191	217
May	58	26	23	29	22	54	18	54	50	37	74	122	69	128	143	131	133	114	145	162	103	75	209	126	294	236	190	154	215	193	127
Jun	46	38	45	38	32	46	38	39	60	70	105	89	78	139	119	139	46	135	120	84	135	131	160	102	257	212	135	134	223	230	65
Jul	43	52	24	19	38	46	44	37	47	71	90	40	110	119	85	122	94	127	79	141	121	123	133	105	180	149	222	168	103	207	57
Aug	38	30	41	34	35	27	57	29	50	70	86	85	109	111	126	118	109	128	119	122	82	111	121	144	176	124	202	115	199	186	125
Sep	31	22	31	43	59	40	46	30	46	75	84	40	115	131	104	116	113	132	137	139	102	138	163	128	164	137	195	171	183	156	123
Oct	34	49	31	41	53	35	56	36	42	68	137	51	95	121	122	126	145	158	119	140	118	161	93	133	169	126	193	143	147	232	175
Nov	41	60	40	32	43	46	46	52	58	39	69	69	92	111	133	103	151	143	120	117	83	136	150	134	200	114	175	102	212	256	192
Dec	47	59	36	52	48	50	26	47	64	37	85	87	91	103	101	97	151	90	90	97	126	146	128	152	168	139	124	139	192	176	200
Total	471	545	452	457	367	532	490	525	585	738	1077	904	1046	1397	1347	1419	1461	1621	1411	1458	1272	1544	1570	1520	2513	2053	2102	1599	2298	2599	1902

7110 MONL LAGEOS-2 Passes per Month per Year

Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	11	36	10	27	41	41	49	24	11	33	46	57	8	34	31	15	9	17	39	22	19	48	23	5	14	11	5	24	7	26	17
Feb	4	25	21	33	58	22	60	13	24	44	41	14	21	14	10	13	5	9	25	17	16	27	33	18	17	14		22	7	13	20
Mar	28	45	19	45	70	60	70	40	33	53	56	6	30	11	34	19	14	6	22	28	19	23	39	12	8	11	1	15	10	9	16
Apr	41	36	17	50	71	42	35	32	6	51	16	14	25	34	19	11	15	2	32	36	24	16	46	7	11	21	3	8	12	9	33
May	54	26	22	41	80	39	47	54	24	54	15	41	23	51	28	7	23	5	17	38	25	20	24	19	14	36	13	9	17	5	14
Jun	67	29	53	28	71	75	62	55	38	23	83	31	23	52	33	9	22	11	1	17	31	24	8	14	18	22	14	11	14	10	5
Jul	66	31	50		49	80	38	31	50	9	50	38	26	38	1	5	18	32	30	20	13	26	20	34	15	6	15	15	9	5	9
Aug	46	21	32	2	47	71	63	26	57	32	35	35	27	43	22	1	9	59	42	11	25	24	19	27	36	15	22	5	5	10	12
Sep	42	27	36	19	40	53	69	30	64	36	72	40	25	33	15	20	3	36	33	18	17	34	17	15	30	20	12	18	14	23	26
Oct	32	42	43	23	58	59	73	16	49	59	70	21	27	42	11	33	4	17	32	17	21	38	24	21	41	17	4	47	9	28	48
Nov	22	27	32	27	52	37	65	39	27	51	40	24	32	41	3	14	8	25	17	36	17	23	40	13	8	11		12	5	13	21
Dec	34	45	26	28	42	37	47	47	24	34	39	30	25	26	7	10	15	19	16	9	22	13	38	17	11	15	8	8	11	14	13
Total	447	390	361	323	679	616	678	407	407	479	563	351	292	419	214	157	145	238	306	269	249	316	331	202	223	199	97	194	120	165	234

- **7110 MONL outperformed 7090 YARL in 1997, 1998 and 1999 when they had more operational staff**

7090 YARL and 7110 MONL LAGEOS Passes per Day per Year

7090 YARL LAGEOS-1 Passes Per Day Per Year

Day	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sunday	49	45	47	48	33	43	58	67	81	93	153	135	137	211	194	201	240	238	189	209	173	238	276	235	349	338	314	249	322	409	305
Monday	57	43	47	58	64	69	84	93	90	124	165	142	168	199	195	242	230	248	204	206	171	223	245	240	360	324	297	283	293	332	284
Tuesday	114	130	81	99	58	80	84	96	97	130	169	137	141	199	197	213	219	264	221	184	181	219	257	237	384	330	320	264	324	347	289
Wednesday	105	121	75	79	62	82	94	91	88	141	163	142	153	245	187	196	209	249	247	220	180	230	274	271	378	305	267	262	362	380	306
Thursday	97	102	63	94	56	73	84	95	89	126	156	148	161	227	189	199	195	231	213	225	178	212	239	253	390	331	291	249	340	377	260
Friday	66	74	50	62	62	67	78	91	81	130	143	110	142	211	176	208	199	263	226	225	211	275	238	270	386	307	278	271	345	377	330
Saturday	62	84	68	43	53	81	89	80	70	125	165	110	167	187	182	218	221	213	212	213	186	229	256	223	332	317	286	246	363	417	320
Total	550	599	431	483	388	495	571	613	596	869	1114	924	1069	1479	1320	1477	1513	1706	1512	1482	1280	1626	1785	1729	2579	2252	2053	1824	2349	2639	2094

7090 YARL LAGEOS-2 Passes Per Day Per Year

Day	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sunday	45	36	40	60	31	48	44	62	84	88	156	129	152	201	186	205	230	235	170	230	178	211	221	209	360	296	322	226	339	388	254
Monday	53	40	40	72	62	67	75	77	82	118	156	143	162	195	203	220	214	226	193	219	180	198	221	202	325	288	333	259	277	329	259
Tuesday	101	120	88	81	58	85	70	77	90	119	176	143	130	179	186	210	206	237	209	188	177	220	219	242	370	292	295	225	328	352	264
Wednesday	85	106	86	83	57	102	82	83	80	128	152	141	136	231	180	177	194	234	221	203	176	214	249	232	346	286	296	230	348	373	291
Thursday	70	90	70	84	57	80	71	78	94	91	146	137	144	213	204	191	201	227	215	198	174	216	219	216	404	278	263	191	327	380	241
Friday	55	65	54	49	53	78	79	75	81	101	148	100	161	199	185	193	196	242	200	202	200	240	224	201	384	313	266	262	338	391	293
Saturday	62	88	74	28	49	72	69	73	74	93	143	111	161	179	203	223	220	220	203	218	187	245	217	218	324	300	327	206	341	386	300
Total	471	545	452	457	367	532	490	525	585	738	1077	904	1046	1397	1347	1419	1461	1621	1411	1458	1272	1544	1570	1520	2513	2053	2102	1599	2298	2599	1902

7110 MONL LAGEOS-1 Passes Per Day Per Year

Day	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sunday	55	37	42	25	93	81	122	60	59	74	91	18	8	20																	
Monday	52	29	39	43	92	104	109	60	53	80	77	25	24	43	8	13	29	25	40	37	38	44	48	23	40	33	13	37	16	24	37
Tuesday	77	64	48	50	84	92	119	47	60	87	79	71	68	71	48	40	47	58	64	64	77	80	84	51	71	58	36	59	34	43	55
Wednesday	118	82	85	63	112	96	135	62	77	92	82	65	75	106	56	46	38	68	76	64	73	83	94	55	65	63	30	63	43	50	52
Thursday	120	93	105	62	96	105	117	80	73	96	79	78	86	93	64	39	40	75	89	64	70	76	94	59	65	58	32	59	41	59	60
Friday	84	50	68	63	94	94	114	63	76	88	84	83	83	97	52	41	25	60	66	63	68	80	98	56	62	64	30	54	43	50	65
Saturday	53	35	44	43	99	108	130	54	69	70	80	59	79	52	46	26		19	23	25	31	20	30	29	9	19	17	18	18	13	15
Total	559	390	431	349	670	680	846	426	467	587	572	399	423	482	274	205	179	305	358	317	357	383	448	273	312	295	158	290	195	239	284

7110 MONL LAGEOS-2 Passes Per Day Per Year

Day	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Sunday	39	32	41	33	101	79	100	61	51	57	91	21	8	11										1							
Monday	33	35	35	35	91	87	84	49	51	65	72	28	18	34	10	18	23	17	28	30	19	44	40	17	24	17	12	23	12	20	31
Tuesday	59	52	44	40	85	87	94	49	54	87	75	62	45	72	43	32	34	50	51	50	56	57	64	39	45	37	19	34	21	27	44
Wednesday	94	85	72	52	97	98	104	62	68	72	78	64	61	97	43	35	35	55	69	57	44	64	69	40	48	42	14	48	19	40	37
Thursday	105	86	82	57	100	98	96	66	67	68	85	68	51	78	48	38	30	60	73	52	59	60	73	50	49	41	19	39	29	34	55
Friday	69	65	55	58	107	79	98	60	62	71	79	65	55	76	41	25	23	46	65	55	52	67	60	40	44	44	23	38	26	37	50
Saturday	48	35	32	48	98	88	102	60	54	59	83	43	54	51	29	9		10	20	25	19	24	25	15	13	18	10	12	13	7	17
Total	447	390	361	323	679	616	678	407	407	479	563	351	292	419	214	157	145	238	306	269	249	316	331	202	223	199	97	194	120	165	234

7090 YARL and 7110 MONL LAGEOS Passes per Hour per Year

7090 YARL LAGEOS Pass Per Hour Per Year

GMT	Local	1993	1994	1995	1996	1997	1998	1999	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	8	22	18	22	19	5	16	8	12	20	9	27	29	20	34	58	40	40	78	49	55	48	58	63	53	75	87	71	39	97	74	50
1	9	31	18	26	26	5	24	10	4	17	8	28	14	11	40	72	30	39	103	47	32	54	43	45	80	63	78	82	59	94	77	78
2	10	26	28	19	26	11	11	8	10	15	7	16	12	2	37	57	33	38	113	40	49	69	31	37	74	53	61	84	60	76	84	77
3	11	33	21	17	27	12	16	11	14	16	10	13	14	22	41	44	37	52	108	33	35	59	34	30	92	65	55	103	58	71	107	75
4	12	38	21	12	21	10	10	20	14	19	15	11	9	16	28	53	39	53	86	32	35	57	35	31	97	49	57	116	58	51	118	67
5	13	33	18	6	28	11	13	32	21	18	26	8	12	21	35	33	42	43	80	37	42	58	39	52	84	46	61	132	50	57	132	63
6	14	19	25	11	26	17	9	25	20	17	37	11	10	23	39	42	48	57	69	47	42	49	47	52	73	53	76	95	52	62	141	39
7	15	32	17	11	12	16	20	42	30	24	58	22	24	26	31	37	66	54	61	56	46	43	51	48	79	93	92	110	56	55	142	43
8	16	22	27	12	11	22	21	44	27	30	65	25	22	57	41	46	65	46	46	80	44	46	83	59	66	106	82	91	54	73	114	44
9	17	16	36	8	23	26	24	43	33	34	73	40	42	69	47	51	81	45	56	88	59	43	89	65	67	137	80	78	69	72	121	50
10	18	17	34	16	16	30	23	46	34	38	62	54	51	81	58	55	101	44	48	107	54	61	98	74	69	156	89	61	85	88	120	60
11	19	22	39	23	19	29	29	39	55	34	61	74	70	87	63	63	101	58	71	116	70	56	119	73	82	200	94	85	106	93	121	115
12	20	20	46	23	23	31	26	35	45	29	68	78	63	75	75	65	88	66	55	90	51	62	126	68	68	205	70	63	125	100	120	166
13	21	24	41	13	26	27	21	27	44	30	69	97	53	76	90	67	88	74	71	78	56	60	93	71	68	169	73	66	135	77	84	176
14	22	22	34	29	26	27	20	31	49	23	61	105	71	68	96	69	79	71	71	77	68	48	97	88	67	146	94	60	140	68	79	177
15	23	27	26	20	29	22	32	32	47	29	47	107	62	52	104	52	70	88	62	70	84	55	82	80	78	130	84	59	110	79	98	154
16	24	24	33	22	27	19	25	32	41	31	47	69	38	49	96	47	55	88	73	52	73	58	74	97	71	120	84	91	113	87	102	141
17	1	24	18	16	18	17	26	24	30	22	34	63	35	53	89	54	70	92	40	53	93	54	65	97	78	98	113	86	88	93	128	101
18	2	22	16	14	18	11	26	22	20	25	23	49	29	56	80	42	59	104	62	52	97	54	66	117	70	111	149	88	78	81	110	70
19	3	17	9	23	12	11	26	12	21	21	24	47	42	60	90	60	64	93	65	57	90	44	49	124	79	106	155	104	77	148	152	95
20	4	15	15	19	18	7	22	8	14	34	22	41	62	43	80	63	62	84	68	58	94	39	65	135	62	103	155	83	66	205	153	76
21	5	15	24	28	8	7	17	7	10	29	20	57	57	41	77	65	53	76	69	62	75	52	71	114	62	98	144	72	57	226	112	92
22	6	12	17	19	8	7	20	7	12	21	14	40	58	34	55	60	61	58	78	77	77	61	62	93	53	101	112	82	37	173	74	53
23	7	17	18	22	16	8	18	6	6	20	9	32	45	27	53	65	45	50	73	54	61	50	49	72	57	96	107	91	52	123	76	32
Total		550	599	431	483	388	495	571	613	596	869	1114	924	1069	1479	1320	1477	1513	1706	1512	1482	1280	1626	1785	1729	2579	2252	2053	1824	2349	2639	2094

7110 MONL LAGEOS-1 Passes per Hour per Year

GMT	Local	1993	1994	1995	1996	1997	1998	1999	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	16	15	13	22	8	15	28	18	6	9	13	16	15	13	32	4			8	13	26	19	19	36	22	16	26	11	11	12	16	14
1	17	19	9	26	9	25	42	19	12	22	17	18	12	15	24	5	1	3	9	14	24	23	12	37	21	12	22	13	12	15	14	16
2	18	25	10	30	10	29	51	36	15	36	23	26	20	19	21	9	1	3	8	12	24	33	21	40	30	11	35	20	18	28	9	9
3	19	33	18	24	19	27	50	36	22	53	31	18	30	16	21	11	3	1	6	14	19	30	24	30	31	15	25	21	20	28	23	21
4	20	32	16	28	20	19	59	52	32	49	35	25	32	24	18	11	1	2	19	14	12	29	18	29	23	13	20	16	17	14	12	10
5	21	37	15	17	18	26	48	47	15	49	44	24	31	22	15	17	1	2	22	17	6	16	8	7	5	8	8		6		2	4
6	22	41	16	25	25	21	42	55	27	46	48	23	34	22	17	13	4	4	18	12	7	14	5		1				1			
7	23	43	23	17	20	32	48	61	25	31	42	31	22	17	21	20		1	10	7	3	6	4			1						
8	24	38	18	12	21	29	35	68	25	32	50	27	23	31	18	19	1		18	8	3	5	1									
9	1	33	16	16	19	38	29	60	32	25	49	30	22	31	14	22	4		10	7	2	10				1						
10	2	28	20	9	21	42	25	66	28	19	43	28	14	31	23	19	1		9	11	1	2										
11	3	31	19	16	15	49	24	67	30	16	51	31	16	28	15	20	13	14	17	10	2	4				1						
12	4	30	26	16	14	52	21	60	38	15	41	32	9	35	7	17	28	22	14	9	2	8										
13	5	21	21	19	19	45	27	36	27	16	27	28	20	30	5	17	30	20	16	19	6	11	24	6	10	11	1	3	20	4	18	19
14	6	20	17	12	11	31	19	31	24	8	10	25	21	14	13	9	26	19	16	23	10	19	39	15	13	26	6	12	21	11	11	16
15	7	18	21	13	17	30	14	20	15	6	8	22	6	15	16	12	23	18	13	31	15	16	41	19	10	32	10	12	28	11	11	19
16	8	12	18	15	13	33	13	23	16	9	3	24	19	13	23	13	21	20	20	34	16	18	37	22	12	29	9	10	18	12	13	24
17	9	10	23	16	10	19	12	13	13	8	4	22	9	8	24	9	13	19	10	24	15	16	29	18	18	29	14	7	25	8	12	25
18	10	9	17	13	12	27	7	12	10	5	4	22	8	10	23	11	16	22	13	22	23	23	25	22	17	24	18	3	20	7	13	30
19	11	10	11	17	13	13	14	16	5	4	4	32	6	9	30	9	10	7	14	16	21	17	22	28	13	24	21	4	22	9	18	22
20	12	12	15	16	15	17	13	7	4	1	8	19	7	5	23	1	6		15	15	22	9	23	34	13	19	13	4	12	5	21	25
21	13	15	15	17	7	16	14	13	3	2	10	23	9	7	29	1	2		6	6	14	11	10	30	11	14	11	6	10	6	18	13
22	14	13	8	18	8	19	19	18	1	1	11	13	7	2	24	3			8	12	28	12	7	33	13	11	24	8	13	10	15	10
23	15	14	5	17	5	16	26	12	1	5	11	13	7	6	26	2		2	6	8	16	6	14	42	10	15	32	8	16	15	13	7
Total		559	390	431	349	670	680	846	426	467	587	572	399	423	482	274	205	179	305	358	317	357	383	448	273	312	295	158	290	195	239	284

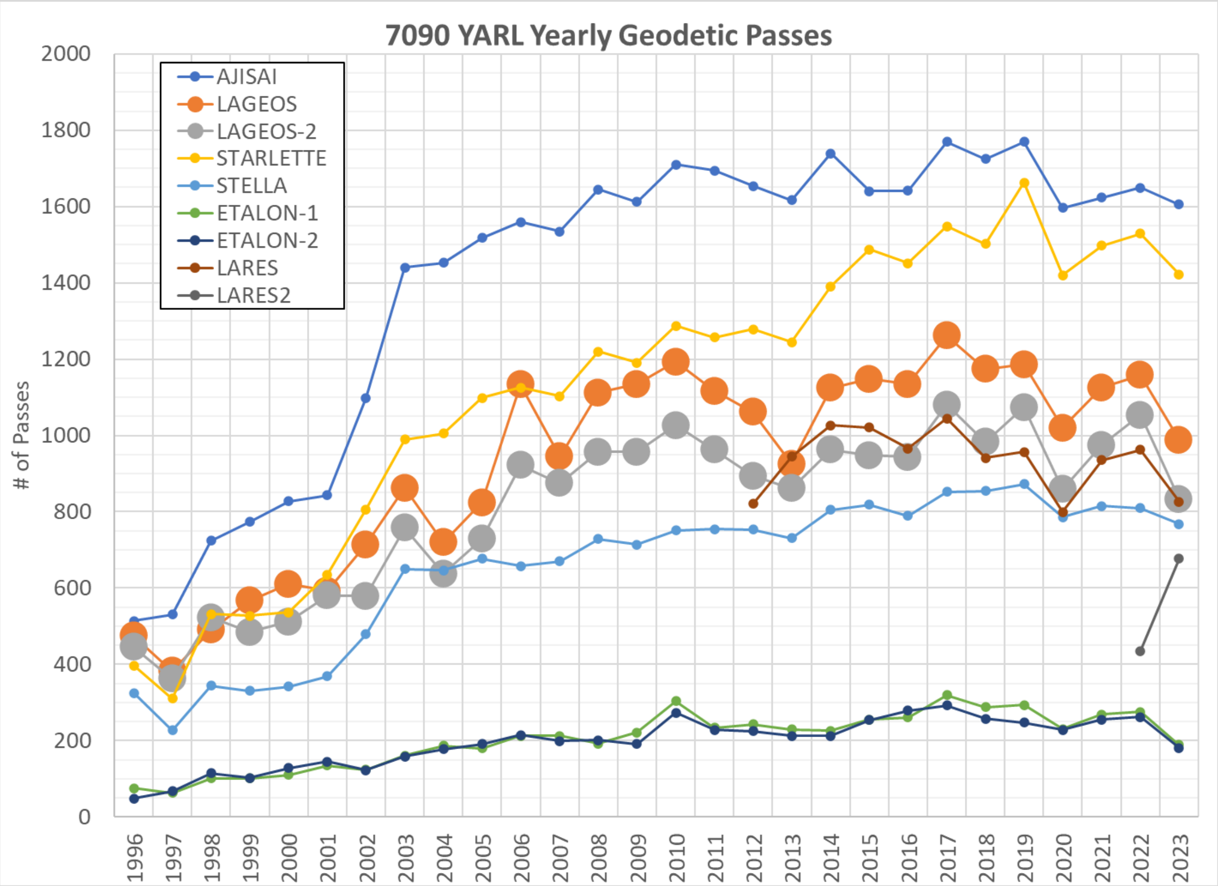
7090 YARL LAGEOS-2 Pass Per Hour Per Year

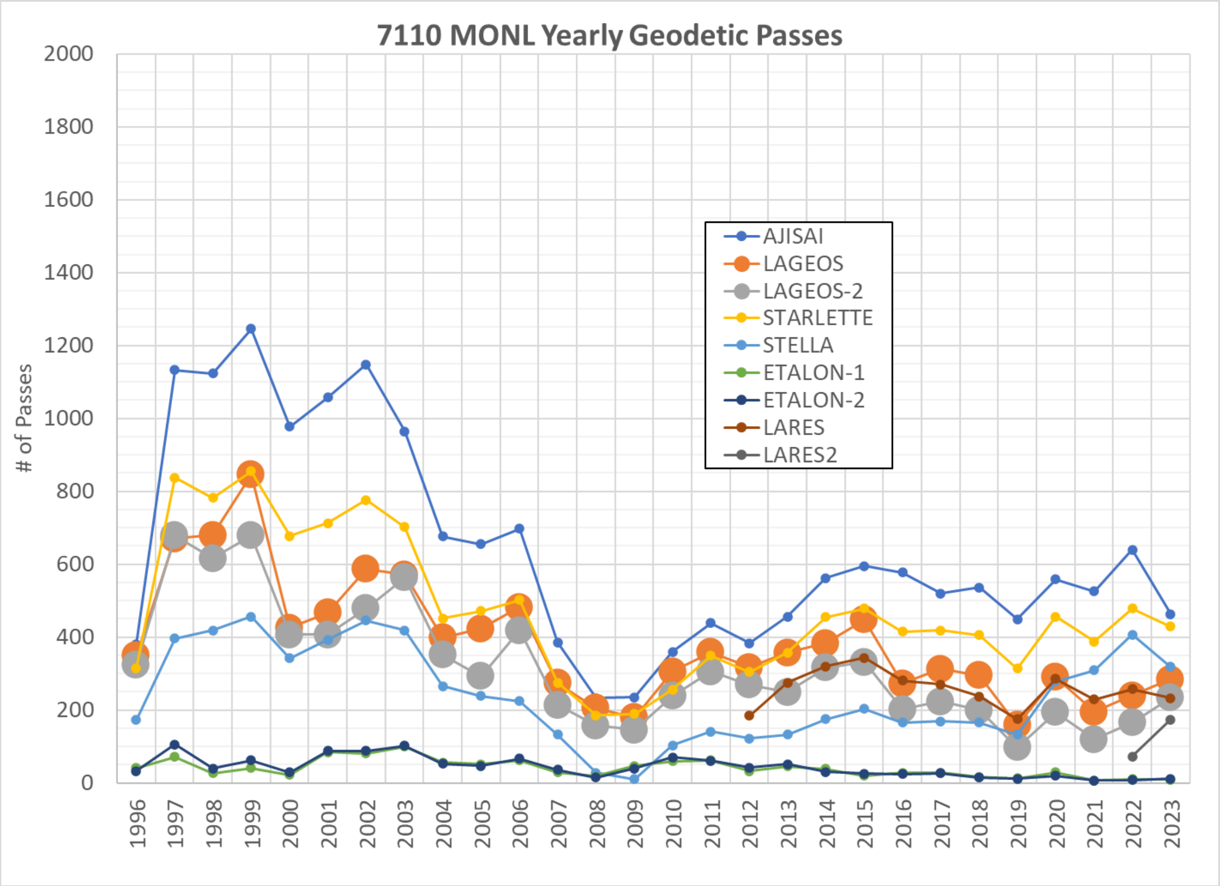
GMT	Local	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
0	8	19	21	23	26	13	14	13	10	13	17	27	18	20	47	52	39	60	74	39	58	52	41	52	62	64	83	59	46	99	70	53
1	9	31	23	20	23	10	19	7	7	13	9	21	12	15	46	51	46	42	97	43	56	52	29	54	53	63	69	61	54	106	70	46
2	10	28	21	22	32	16	17	16	13	10	18	26	9	14	52	45	27	40	84	41	45	47	38	37	53	68	52	74	59	98	96	45
3	11	29	23	16	19	10	15	12	8	13	16	24	10	24	40	50	49	37	77	41	37	36	34	35	59	60	61	73	37	73	77	33
4	12	20	21	12	22	15	17	20	12	18	17	22	10	14	41	32	39	31	72	35	34	53	37	39	65	41	52	83	50	75	91	36
5	13	22	19	12	12	15	14	24	16	17	21	21	13	18	33	49	43	30	72	51	51	42	47	46	66	67	69	76	57	76	97	21
6	14	19	24	6	15	18	18	27	23	24	31	15	12	31	29	42	51	47	64	49	38	43	42	40	59	78	61	85	46	84	100	31
7	15	20	20	10	11	22	21	32	31	30	31	36	28	25	35	48	55	42	68	67	43	44	55	58	80	97	70	108	47	79	117	38
8	16	18	27	10	14	19	20	31	36	26	54	29	30	43	54	56	59	45	58	58	46	55	69	56	65	115	79	88	42	61	104	44
9	17	16	21	12	21	24	21	39	40	26	42	50	42	49	42	56	61	38	58	75	54	57	74	62	73	133	80	106	50	75	112	43
10	18	12	42	13	19	24	28	30	33	36	57	51	46	69	58	65	88	58	74	89	56	53	75	78	89	143	81	103	38	77	138	70
11	19	9	30	18	16	24	32	36	40	34	56	86	44	68	71	57	82	78	64	86	67	61	88	73	85	155	93	118	61	91	133	102
12	20	13	25	26	23	18	26	28	40	26	59	76	57	74	72	60	70	68	68	85	61	62	96	72	65	163	77	105	90	97	151	124
13	21	21	35	29	27	15	29	35	37	37	60	73	61	85	77	62	74	74	50	66	77	55	92	72	63	149	103	90	99	83	131	107
14	22	20	24	25	21	18	26	24	34	34	52	80	60	75	103	69	89	79	71	68	76	50	92	76	62	157	93	95	93	88	119	149
15	23	18	27	31	26	14	35	27	27	32	44	85	73	67	82	74	80	84	66	62	62	61	90	69	52	135	92	91	92	75	118	139
16	24	18	23	26	24	18	36	19	25	39	31	62	52	47	84	53	60	81	56	64	65	57	80	75	50	122	91	85	84	103	104	116
17	1	16	19	27	17	13	29	18	24	29	26	38	39	45	65	60	59	77	46	64	77	55	81	66	58	125	95	79	96	83	92	103
18	2	27	17	22	16	12	22	9	16	24	17	40	39	40	59	57	62	96	67	60	85	55	78	96	60	113	110	88	89	90	83	99
19	3	18	18	18	13	9	21	9	16	24	15	38	54	61	88	71	66	76	61	51	79	63	81	89	76	114	128	97	89	145	151	134
20	4	20	17	20	10	11	17	9	12	24	10	43	62	47	64	64	61	76	65	53	85	58	66	93	49	115	118	101	87	139	118	132
21	5	21	16	15	13	7	18	4	11	22	18	50	64	52	57	55	53	79	75	60	74	53	62	89	74	85	106	73	68	149	135	87
22	6	17	16	26	19	9	19	9	7	19	21	47	31	32	50	62	54	69	72	63	72	60	54	77	57	79	107	95	63	125	100	96
23	7	19	16	13	18	13	18	12	7	15	16	37	38	31	48	57	52	54	62	41	60	48	43	66	45	72	83	69	62	127	92	54
Total		471	545	452	457	367	532	490	525	585	738	1077	904	1046	1397	1347	1419	1461	1621	1411	1458	1272	1544	1570	1520	2513	2053	2102	1599	2298	2599	1902

7110 MONL LAGEOS-2 Passes per Hour per Year

GMT	Local	1993	1994	1995	1996	1997	1998	1999	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	16	24	17	13	15	13	22	13	6	7	7	26	11	11	16	1	2	2	1	10	13	13	27	28	9	15	14	6	13	4	2	19
1	17	19	16	20	25	26	27	19	13	16	14	25	18	2	19	4		2	4	11	15	16	17	21	12	17	18	5	15	6	2	17
2	18	24	25	17	31	28	33	47	27	32	28	37	19	11	18	4	2	3	5	14	20	30	24	34	18	18	22	13	18	16	9	18
3	19	21	26	16	22	39	36	35	24	31	33	28	15	14	18	8		1	5	8	21	20	22	24	18	22	27	8	25	16	12	17
4	20	28	18	15	16	27	39	42	29	32	30	31	16	22	19	5	1	2	12	11	18	20	15	22	14	9	11	9	11	10	13	12
5	21	25	20	18	18	38	29	35	23	27	40	30	20	10	19	12		0	11	14	9	6	9	11	5	4	7	0	5	3	1	1
6	22	24	26	16	19	36	43	49	34	33	39	24	20	21	22	8	1	2	12	5	3	8	3								1	
7	23	22	23	11	9	40	32	41	22	27	38	24	14	19	16	5			11	9	5	4	3			1						
8	24	20	19	9	6	37	40	49	33	29	39	23	15	17	19	8	1		9	2	1	2	1			0						
9	1	24	18	12	8	49	24	42	26	26	36	21	16	20	22	14	0		11	5	1	3										
10	2	21	12	12	15	39	37	42	34	29	34	21	16	20	21	17	1		12	4	3	1										
11	3	16	15	10	11	38	33	41	30	27	32	25	18	20	20	19	15	31	11	7	2	5										
12	4	16	19	16	14	42	27	38	29	30	34	24	15	26	15	10	20	15	20	7	1	2			1						1	1
13	5	12	18	15	8	35	25	32	26	14	27	24	20	11	14	14	23	16	13	17	5	13	11	5	8	6	7	2	5	5	12	6
14	6	11	14	15	12	31	24	26	17	6	7	23	21	15	13	10	17	18	19	18	17	12	19	20	11	15	10	2	9	8	13	11
15	7	12	15	17	11	30	18	25	5	4	10	17	14	10	19	14	18	12	12	26	13	15	18	15	22	13	16	4	11	7	15	11
16	8	14	15	18	11	20	17	18	10	6	7	20	9	8	19	16	14	13	11	23	20	11	18	18	19	17	9	5	13	10	22	17
17	9	14	12	18	10	29	12	20	6	5	3	24	12	7	16	10	12	8	17	29	11	10	26	13	14	10	10	5	10	5	9	10
18	10	18	12	14	8	18	18	11	3	2	2	19	13	6	15	9	13	13	14	18	23	9	17	21	9	17	6	6	16	2	11	12
19	11	12	11	17	10	16	14	13	2	2	1	18	18	3	20	13	10	6	9	25	18	10	22	13	14	15	9	4	12	6	11	19
20	12	21	7	12	8	14	15	10	2	3	5	22	9	9	17	6	3	1	6	17	10	10	14	22	10	11	5	8	6	9	8	19
21	13	13	7	19	11	15	14	7	1	6	4	23	10	2	14	3	3		4	7	18	10	18	20	5	9	8	4	5	6	9	12
22	14	15	14	14	13	11	18	10	2	5	2	23	6	5	11	1	1		4	12	8	10	16	25	5	9	6	9	10	1	3	14
23	15	21	11	17	12	8	19	13	3	8	7	11	6	3	17	3			5	7	14	9	16	19	8	15	14	7	10	6	11	18
Total		447	390	361	323	679	616	678	407	407	479	563	351	292	419	214	157	145	238	306	269	249	316	331	202	223	199	97	194	120	165	234

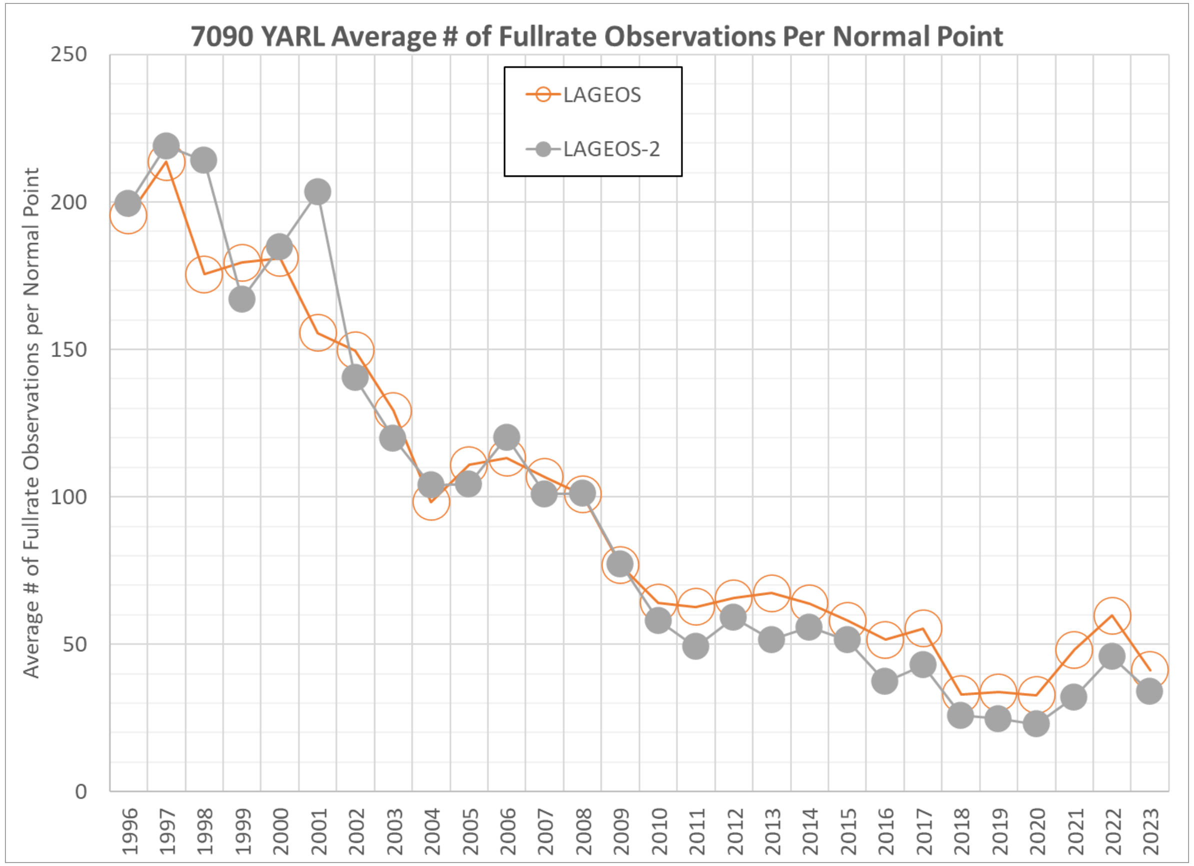
7090 YARL and 7110 MONL Geodetic Passes per Year

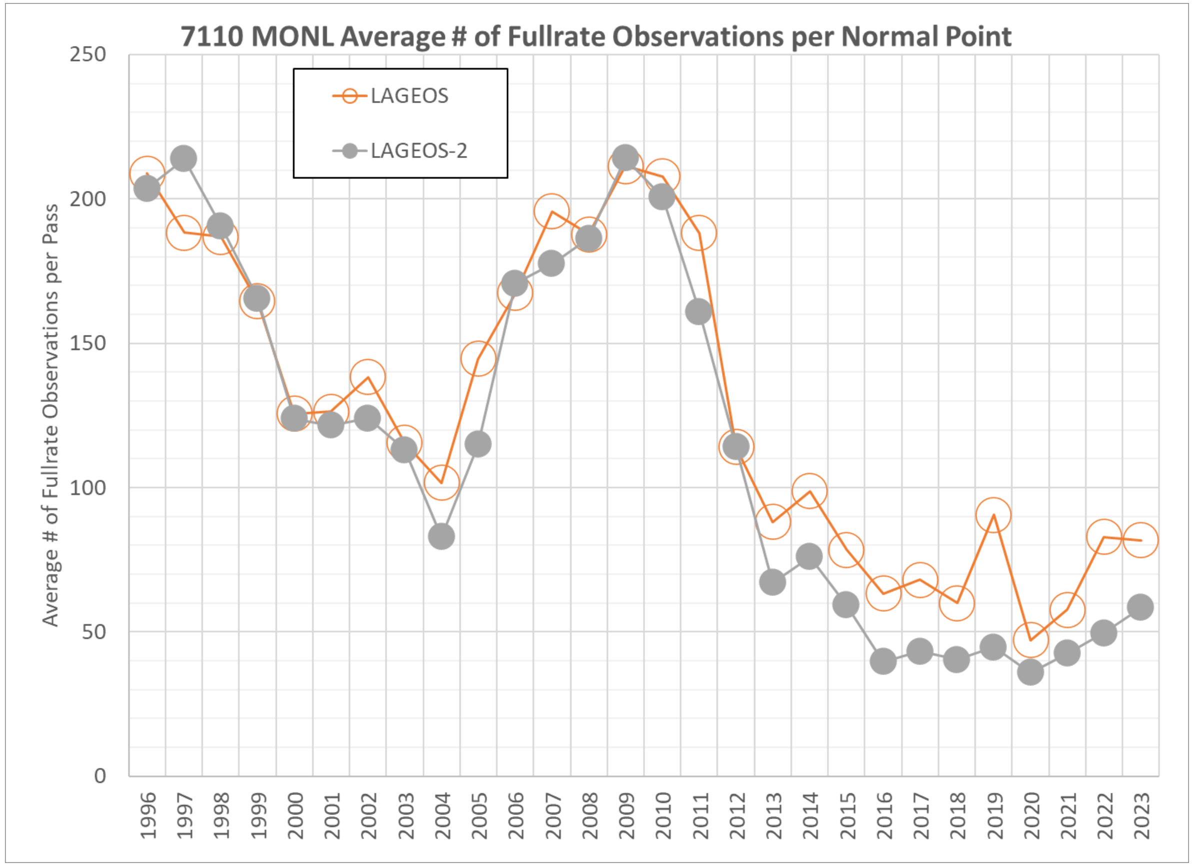




- ❑ **In 1996, 1997, and 1998;**
  - ➢ 7090 YARL tracked 1366 LAGEOS-1 and 1356 LAGEOS-2 passes (equal distribution between LAGEOSs) while
  - ➢ 7110 MONL tracked 1699 LAGEOS-1 and 1618 LAGEOS-2 passes (near equal distribution between LAGEOSs)

7090 YARL and 7110 MONL LAGEOS FR Observations per NP





	7090 L1 FR Obs/NP	7090 L2 FR Obs/NP	Diff
Before 2012	132.0	135.2	-3.1
After 2012	49.5	38.5	11.0
Delta			-14.1

- **Satellite interleaving has reduced the number of LAGEOS-1 and -2 observations per NP**
- **Did the March 2012 change in the LAGEOS-2 semi-major axes influence these trends?**

	7110 L1 FR Obs/NP	7110 L2 FR Obs/NP	Diff
Before 2012	166.1	160.2	5.9
After 2012	74.2	50.6	23.6
Delta			-17.7

Summary/Conclusions

- Slicing and dicing the data yield over the long-term from other ILRS stations can reveal trends in operational staffing levels and/or degradation in system performance
- Both 7090 YARL and 7110 MONL have seen a reduction in LAGEOS-2 signal strength relative to LAGEOS-1 signal strength

Station	4-char	Location	Wave	Detector	Callib	LAGEOS	LARES-2	LARES	Etalon	Starlette & Stella	Ajisai	Herstmonceux NP Algorithm	LAGEOS Fullrate CRD
1824	GLSL	Golosiiv	532	PMT	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	Yes	
1873	SIML	Simeiz	532	PMT	2.0σ	2.4σ	2.4σ	2.4σ	2.4σ	2.4σ	2.4σ	Yes	
1874	MDVS	Mendeleevo 2	532	PMT	3.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	Yes	
1886	ARKL	Arkhyz	532	PMT	3.0σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	Yes	
1888	SVEL	Svetloe	532	PMT	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
1889	ZELL	Zelenchukskya	532	PMT	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
1890	BADL	Badary	532	PMT	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
1891	IRKL	Irkutsk	532	PMT	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Sometimes	
1893	KTZL	Katzively	532	PMT	2.5σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7090	YARL	Yarragadee	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7105	GODL	Greenbelt	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7110	MONL	Monument Peak	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7119	HA4T	Haleakala	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7124	THTL	Tahiti	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7237	CHAL	Changchun	532	CSPAD	2.5σ	20 mm LE	20 mm LE	20 mm LE	2.5σ	20 mm LE	20 mm LE	Yes	20 mm LE
7249	BEIL	Beijing	532	CSPAD	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7306	TKBL	Tsukuba	532	CSPAD	2.2σ	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	300 mm LE	Yes	2.2 Sigma
7306	TKBL	Tsukuba	1064	SPAD	2.2σ	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	300 mm LE	Yes	2.2 Sigma
7394	SEJL	Sejong City	532	CSPAD	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	Yes	
7396	JFNL	Wuhan	532	CSPAD	2.2σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7403	AREL	Arequipa	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7501	HARL	Hartebeesthoek	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7503	HRTL	Hartebeesthoek	532	PMT	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7701	IZ1L	Izaña	532	CSPAD	2.2σ	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	300 mm LE	Yes	2.2 Sigma
7701	IZ1L	Izaña	1064	SPAD	2.2σ	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	300 mm LE	Yes	2.2 Sigma
7810	ZIML	Zimmerwald	532	CSPAD	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7811	BORL	Borowiec	532	PMT	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7819	KUN2	Kunming	532	CSPAD	3.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7821	SHA2	Shanghai	532	APD	2.2σ	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	Yes	20 mm LE
7824	SFEL	San Fernando	532	CSPAD	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7825	STL3	Mt Stromlo	532	CSPAD	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7827	SOSW	Wettzell	849.8	APD	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	2.0σ	No	
7838	SISL	Simosato	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7839	GRZL	Graz	532	CSPAD	2.2σ	20 mm LE	20 mm LE	2.2σ	2.2σ	2.2σ	2.2σ	Yes	20 mm LE
7840	HERL	Herstmonceux	532	SPAD	2.5σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
7841	POT3	Potsdam	532	SPAD	2.0σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	2.5σ	Yes	
7845	GRSM	Grasse	532	APD	2.5σ	2.4σ	2.4σ	2.4σ	2.4σ	2.4σ	2.4σ	Yes	
7941	MATM	Matera	532	MCP	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	3.0σ	Yes	
8834	WETL	Wettzell	532	SPAD	2.0σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	Yes	
8834	WETL	Wettzell	1064	SPAD	2.0σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	2.2σ	Yes	