ILRS QCB Meeting
July 21th, 2025
9:00 – 11:00 AM EST (13:00 UTC)
Next QCB Meeting: September 29th, 2025, 09:00-11:00 AM EDT (13:00 UTC)

Participants: Van Husson, Théo Gravalon, Randy Ricklefs, Matthew Wilkinson, Andreja Susnik, Eleonore Saquet, Alexandre Couhert, Franck Reinquin, Adrian Baños Garcia, J. Moyard, Franck Mercier, Graham Appleby, Magdalena Kuzmicz-Cieslak, Frank Lemoine, José Carlos Rodríguez Pérez, Alexandre Belli, Stefan Riepl, Mike Pearlman, Peter Dunn, Susan Blondel, Claudia Carabajal.

Agenda:

Van Husson:
- 7090 Yarragadee Analysis.

Eleonore Saquet and Alexandre Couhert (CNES)
- Clearing systematic range biases from SLR observations: assessment and outlook (Eléonore Saquet, Alexandre Couhert, Franck Reinquin, and Adrian Banos Garcia).

Claudia Carabajal/Mike Pearlman:
- Updates from the ILRS CB.

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Notes from the Meeting:

Van Husson - see presentation.

7090 Yarragadee Analysis:

Data Yield (passes and normal points)

Starting in January 2023, the 7090 YARL weekly height residuals in the 2023 Update to the ITRF2020 solution exhibited an increase in scatter and error bars. Van tried to investigate the potential root causes including a decrease in geodetic data volume (LAGEOS-1, LAGEOS-2 and LARES-2, Etalon- and Etalon-2); a decrease in data quality; changes in data handling by the Analysis Standing Committee; or a combination of factors.

There was a 15 and 21% decline in LAGEOS-1 and LAGEOS-2 pass counts; respectively, in 2023 versus 2022. On the surface, the 2023 LAGEOS pass counts should have been more than sufficient to compute accurate coordinates including station heights.

Diving a little deeper into the actual LAGEOS Normal Point (NP) bin statistics revealed the number of weak LAGEOS NPs (i.e. NPs with <=3 fullrate observations) have been trending upward since 2012, but 2023 was not an outlier.

The percentage of total yearly LAGEOS NPs were aggregated per range for the years 2012 and 2023. This analysis revealed the percentage of LAGEOS-1 NPs plateaued between 6200 and 8500 km in 2012, while the trend in 2012 LAGEOS-2 NP data was quite different. In 2023, the NP percentage per range for each satellite (LAGEOS-1, LAGEOS-2 and LARES-2) had a precipitous drop-off starting around 7500 km (i.e. elevation angles below ~35 degrees). In addition in 2023, the percentage of weak NPs steadily increased with range.

John Reis from the University of Texas, presented his analysis of weak NPs at a September 2020 QCB meeting. In the case of Yarragadee he concluded “the fit RMS increases from 6.5 to 7,6 mm for 7090”. He concluded weak NPs “are clearly worse than NPs with at least 6 (or even 3) returns.”

Data Quality (Single Shot RMSs)

Average 7090 monthly single shot RMSs (calibration and satellite) were erratic in 2023 and peaked in November 2023. The high RMSs were attributed to laser problems. Single shot NP Bin RMSs were evaluated as a function of satellite range for several different years. In 2023, the NP Bin RMSs as a function of range were more trended than other years.

Range Biases and Data Handling

Yarragadee SSEM and SSEM-X Range Bias (RB) results were presented for LAGEOS-1, LAGEOS-2 and Etalon along with GMV Sentinel RBs for 2023 and 2024. Based on SSEM results, there were two periods when the 7090 RBs appeared to moderate, resulting in RB estimation instructions in the latest ILRS DHF. One of these periods encompassed all of 2023 and the other period encompassed all of 2020. There was an abrupt change of ~25 mm in the Etalon RB in October 2023 that coincided when the secondary receiver chain was updated; however, this RB discontinuity is not currently documented in the DHF.

Calibration Data Analysis

Yarragadee data was analyzed since 1-Jan-2017 to determine how well LAGEOS, Sentinel and Etalon data was calibrated in terms laser transmit energy, return signal strength and PMT voltage. In general, Sentinel data was the best calibrated in terms of laser transmit energy because the same laser fire rate of 10 Hz was used for tracking and calibration data. Return signal strengths were stronger from the ground target than the satellite tracking data irregardless of satellite. Higher PMT voltages tended to be used when tracking satellites versus the corresponding calibration data.

System characterization ground tests were presented to try and quantify the impact of any calibration errors. Also, the station's barometric data was aggregated every 6 hours to compare it to the Vienna Mapping Function for optical frequencies (VMF3o).

The preliminary June 2024 Yarragadee site tie report was analyzed to determine any changes in the location of the system reference point and to determine any errors in the existing onsite target distances

Randall's Comments
Randall was sent most of the slides prior to the meeting and his comments were presented verbatim.

Conclusions
The scatter increase of the Yarragadee 2023 ITRF height residuals has several contributing factors that were listed**.**

Also, potential systematics errors that would contribute to positive range bias were listed.

SLR Range Biases: Assessment and Outlook – See presentation by
E. Saquet[1,2], A. COUHERT[2,3], J. MOYARD[2], S. BLONDEL[2] , F. Mercier[2,3] A. BANOS-GARCIA[1,2], F. REINQUIN[2,3]

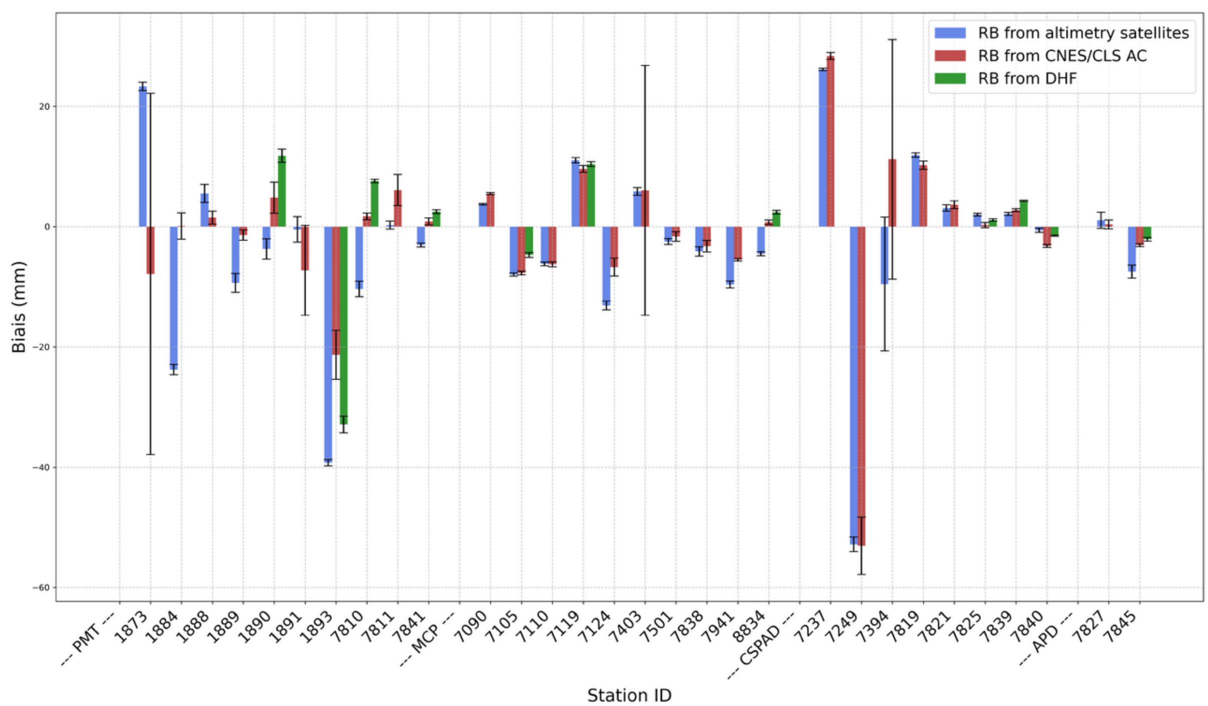
(1) Collecte Localisation Satellites, Ramonville Saint-Agne, France
(2) Centre National d'Etudes Spatiales, Toulouse, France
(3) GET-Université de Toulouse (CNES, CNRS, IRD, UT), Toulouse, France

At the ILRS QCB meeting, Eleonore presented work that started a few years ago. A presentation about the SLR range biases was given at the EGU this year. An overview of that presentation was given, introducing the subject, and discussing the range biases comparison made with the analysis center and the SLR research comparison. Suzanne presented material on main sea-level applications of the range biases.

The SLR data provides strong tracking information for GNSS or DORIS based orbits and essentially also provide an independent validated accuracy for altimetry dedicated satellite missions, especially in the radial direction. One can ask how to better use SLR observations and eventually reduce the systematic errors.

A set of validations of the orbit would need 1 mm RMS short term accuracy with long term stability within 0.1 mm per year, per decade, to monitor the evolution of the regional sea-level patterns. It is now essential to clear system range biases from the SLR observations for the future missions, such as Genesis, or for the next generation of altimetry satellites.
Currently, to clear those systematic range biases, there are two solutions: 1) use a reduced set of SLR observables from a non-full core network; 2) use regular service reviews provided by the by the Copernicus POD series.

A new approach is stablished to enlarge the core network of SLR stations once the range biases are taken into account. For this work, altimetry satellites are used to determine the SLR range biases. One bias per station per year. For that we use the satellite Cryosat-2 and Saral which are DORIS only, and Sentinel-3A and Sentinel-6A, which are GNSS and DORIS. Use the fixed orbits from the POE-G standards from CNES and with we also adjusted the station position in East, N, Up. On the other side, the CNES/CLS Analysis Center uses the geodetic spheres, such as LAGEOS-1 and 2 and LARES-2 to compute the range biases with the orbits. The goal is to assess the quality of the range biases with their approach.



The chart shows all the range biases computed; in blue it's the range biases from altimetry satellites. In red, it's biases from the CNES/CLS Analysis Center, and in green it's from the data on the Data Handling File (DHF). The green column has few biases because there are not a lot of range biases for each station in the DHF.

There are some stations that show really big formal error such as Station 1973, for example, with not so many observations. The adjustment is difficult to do when there are not many observations. The adjustment is quite difficult when there are not enough measurements. There is a really good agreement between the method presented and CNES/CLS Analysis Center results from many stations.

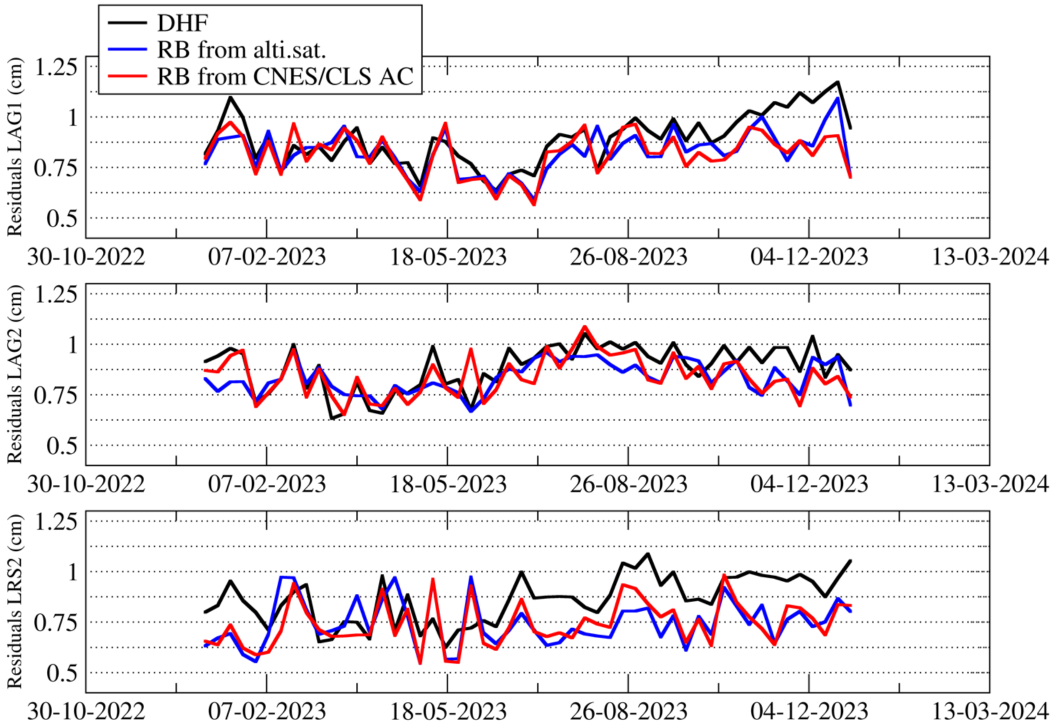
COMPARISON OF THE SLR STATION RANGE BIAS SOLUTIONS (2023)

Station ID	RB from alti. Sat.	RB from AC	Bias diff. (abs)	Station type
1873	23.3	-7.9	31.2	PMT
1884	-23.8	0.1	23.9	PMT
1888	5.5	1.5	4.0	PMT
1889	-9.4	-1.4	8.0	PMT
1890	-3.7	4.8	8.5	PMT
1891	-0.5	-7.3	6.8	PMT
1893	-39.3	-21.3	18.0	PMT
7090	3.7	5.5	1.8	MCP
7105	-8.0	-7.7	0.3	MCP
7110	-6.2	-6.3	0.0	MCP
7119	11.0	9.6	1.4	MCP
7124	-13.1	-6.7	6.4	MCP
7237	26.2	28.4	2.2	CSPAD
7249	-52.8	-53.1	0.2	CSPAD
7394	-9.5	11.2	20.7	CSPAD

Station ID	RB from alti. Sat.	RB from AC	Bias diff. (abs)	Station type
7403	5.9	6.0	0.2	MCP
7501	-2.5	-1.6	0.8	MCP
7810	-10.4	1.7	12.1	PMT
7811	0.3	6.1	5.8	PMT
7819	11.9	10.2	1.7	CSPAD
7821	3.1	3.6	0.5	CSPAD
7825	2.0	0.3	1.7	CSPAD
7827	1.1	0.4	0.7	APD
7838	-4.1	-3.2	0.9	MCP
7839	2.1	2.7	0.6	CSPAD
7840	-0.6	-3.2	2.6	CSPAD
7841	-3.1	0.9	3.9	PMT
7845	-7.5	-3.1	4.4	APD
7941	-9.6	-5.5	4.1	MCP
8834	-4.5	0.7	5.2	MCP

The table shows the range biases computed and the differences. In green, we have the station within 2 mm differences, in blue, between 2 mm and 5 mm differences, and in black those over 5 mm. There are several stations that have less than 2 mm differences. This result is significant because we can enlarge the core network of stations.

An SLR residuals comparison is performed, looking first at the satellites.

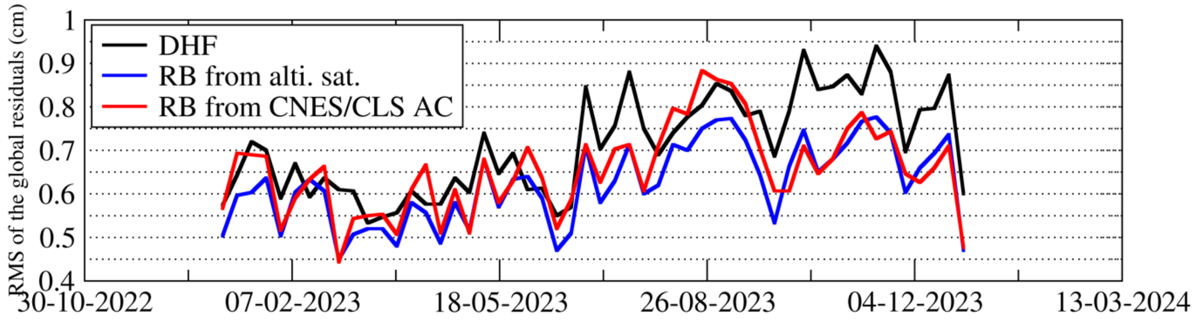


The plot shows residuals of LAGEOS-1 at the top, LAGEOS-2 in the middle, and LARES-2 at the bottom. In black, are the residuals from the DHF. In blue, residuals computed with the altimetry satellites, and in in red from the Analysis Centre.

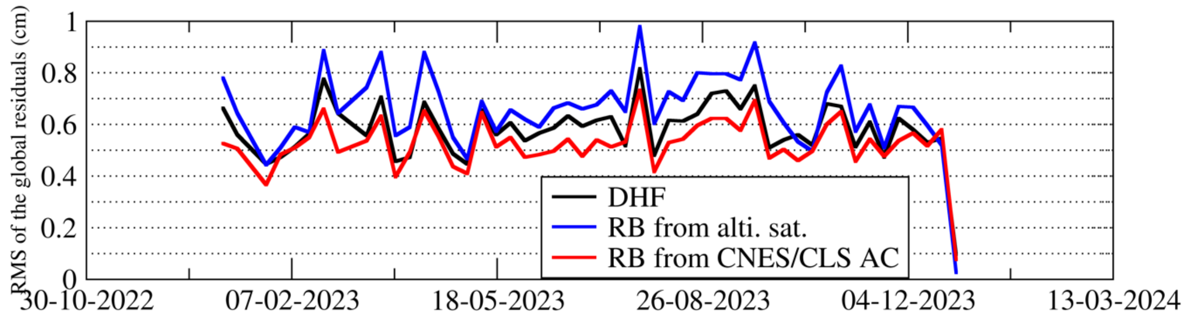
There's an improvement of the SLR residuals when we use the altimetry satellites range biases or the one computed by the Analysis Center compared to the DHF from the ILRS. The same number of biases has not been applied in all three solutions because in the black solution (DHF), there are a few stations with an associated bias.

Examples of stations' residuals for two stations, Yarragadee and Herstmonceux, for the same color system. In black, from the DHF, in blue from the altimetry satellites, and in red from the Analysis Center.

Station 7090:



Station 7840:

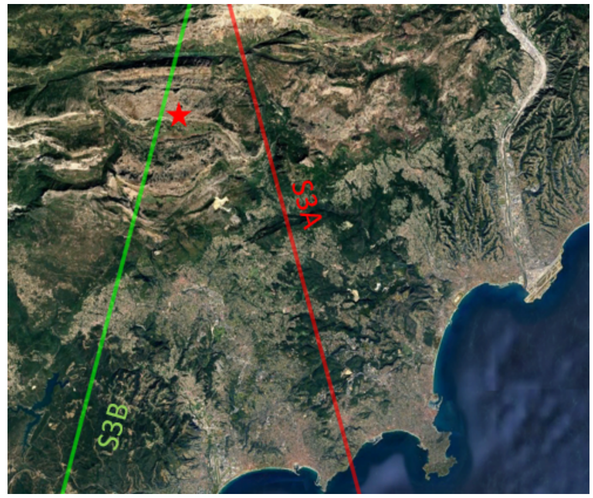


For Yarragadee, the bias estimated by the two solutions is very close (< 2 mm). The blue solution has smaller RMS than the other two solutions. For Herstmonceux, the bias estimated by the two solutions is larger (between 2 and 5 mm) and we notice that the RMS with the CNES/CLS AC solution are smaller.

The first conclusion is that LEO altimetry satellites can be used for the precise determination of SLR station biases. And, the biases determined with altimetry satellites are very consistent with the ones determined by the Analysis Center, when well tracked, with notable differences primarily emerging when formal variances are high.

Mean sea-level application:

Suzanne talked about Corner Refactors, such as the one pictured bellow, that can be used to derive an error budget of satellite altimeters.



The objective is to determine the altimeter bias with 1 mm of range accuracy over one year. The idea is that knowing the position of the corner reflector, the altimeter residuals reflect the combination of both the altimeter bias and the radial orbit error.

The laser residuals from the SLR measurements will reflect the combination of the station bias and the radial orbit error. If both are co-located, knowing the station bias, we can remove the radial orbit error from the altimeter laser residuals, and get the altimeter bias.

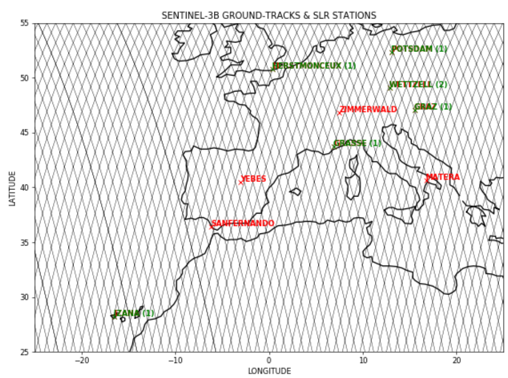
As an example, at the Calern site (Grasse), Sentinel-3A & -B altimeter errors could be evaluated from the Grasse Observatory because they have cross-track distances of 1 km and 5 km for Sentinel-3B and Sentinel-3A, respectively. The corner reflector is currently being manufactured. Regarding the SLR station, care should be paid to a singular tracking point at Zenith. Long term acquisitions of altimeter/geodetic satellites are needed for a ~2 mm accuracy yearly recovery of laser range biases.

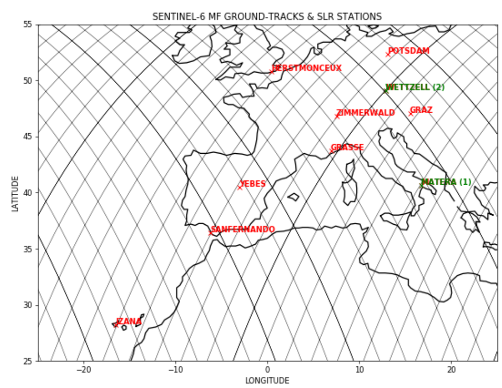
This is of interest for precise orbit determination as well as well as the IRLS working group. With a passive network of stations, we could refine orbit related sea-level errors. First, only to evaluate regional orbit errors with corner reflector and then with a well distributed ground network of such corner reflectors we could also add them as measurements in the orbit determination process.

One of the challenges is the stability and knowledge of the SLR station bias. Today, a long-term regional satellite altimeter orbit error can be quantified using SLR residuals and applying the yearly determined range bias that Eleonore presented.

A new objective will be to reduce this time scale to the length of a few weeks.
For this, regular laser tracking will be needed for a few well identified altimeter and geodetic satellites in order to calibrate more frequently this range bias.
Current CR developments include:

- 1 CR (Corner Reflector) in the French Pyrenees (1 Sentinel-3A and 2 Sentinel-6 MF tracks), 1 CR in Spain, 2 CRs in Crete
- Definition of additional calibration sites collocated with SLR stations in preparation for Sentinel-6 NG of the corner reflector.





Sentinel 3B ground tracks with SLR stations, with cross-tracks along track distance smaller than 10 kilometers in green. They will be suitable for the colocation of the corner reflector and the SLR station. There is four or five in Europe for Sentinel-3B and two for Sentinel-6.

Q&A discussion:
The limitation of the distance between the SLR station and the Corner Reflector, the criteria is that selected stations that were located less than 10 kilometers from the ground track are selected. The corner reflector needs to be less than 10 kilometers from the ground tracks if you want to be able to get the echoes from the radar altimeter reflecting and going back to the satellite.

Given the good homogenous tracking for Sentinel-3B, for instance, many SLR stations could be useful. It could be a criterion used to define the orbits of Sentinel-6 NG, if this calibration proved to be useful for validating the altimeter bias.

Is there is a need to have the Corner Reflector surveyed relative to the SLR station or they are independent, and you do just relative monitoring? There's a maximum range you can have between the two instruments, which needs to be studied. They do not need to be exactly at the same place. It's easier if they are closer, because then you can have a good measurement of the relative distance between the two instruments.

There is a corner cube reflector cluster at Hertsmonceaux, but the overhead pass may be closer than 10 km, several kilometers away.

The strategy proposed to increase the number of core network stations is to characterize the station biases. There are many good SLR stations in term of SLR residuals. If their range biases are not corrected, they are not good enough to perform the validation. If range biases of these specific stations can be corrected, the station can be used for validating the radial orbit accuracy. The point here is to keep the SLR station having bias, but good SLR residuals once you have corrected this range bias. Currently, final reprocessed orbits have a radial orbit accuracy between 5 to 7 mm. The expectation is to have this type of SLR residuals for the used SLR stations, at least at high elevation.

Current tracking of the geodetic satellites is sufficient. Dedicated tracking campaigns may be discussed, recommending some specific targets. Using altimeter satellites which already have good orbits one can use SLR data to separate the station coordinates errors from the range bias. Including three to four altimeter satellites is already very good to separate obit errors from station position and range bias errors.

This exercise shows very clearly that there's a very good agreement between the biases the CNES/CLS people estimated with the spherical satellites and the altimeter satellites. Biases coming from the spherical satellites will be independent from the altimeter. The approach is to have two independent set of range biases, and use the one which is consistent between the two approaches. One should be careful regarding what biases to use for sea-level applications. What is expected is that with an increased number of satellites, one can separate the orbit errors from the station bias and get the correct altimeter biases. Biases that come from the spherical satellites, come from an independent source. For some stations, there is a lack of observations for the geodetic satellites. It would be a complimentary data source, but there are many stations that have trouble tracking these geodetic satellites.

Claudia Carabajal – Updates from the ILRS CB - see presentation.

Station News:

- Tsukuba and Zimmerwald returned Restricted Tracking agreements for Sentinel 3A/3B.
- Data from Xian (new station) started to flow.
- No update/application from new SLR/LLR temporary prototype station developed at the facility in Stafford, VA, ~150 meters from the Stafford ILRS Station in Virginia (Jake G.).

- Pawel Lejba informed us that due to a failure of the old detector at Borowiec (BORL) SLR station. They are temporarily suspending tracking activities for the next 2–3 months. A new detector is planned to be installed during this period. They will keep the ILRS updated on the progress.

Mission News:

- Tracking for the Nano-FF A/B satellites has been postponed to the beginning of September. The mission is still upgrading a few things on their end and remain in touch with the colleagues from CDDIS regarding the upload of the CPF files.
- **QZS-6** (JAXA) Tracking Campaign ended.
- No news from IRNSS mission colleagues.
- Agreements to track QPS-SAR received from Beijing, Shanghai, Hetsmonceux, Tsukuba. Graz pending, trying to work on divergence.
- Launch date of the Sentinel-6B/Jason-CSB will take place on 17th November 2025. They are beginning to coordinate tests this summer with the CDDIS.
- Ex-Alta 3 mission, the University of Alberta's (Edmonton, Canada) contribution to the Canadian Space Agency CUBICS initiative, submitted a MSRF. Expected to launch in June 2026 (at the earliest). CUBICS is a Canadian Space Agency (CSA) initiative that provides professors in post-secondary institutions with an opportunity to engage their students in an end-to-end space mission adapted to their needs and their level of comfort, expertise and readiness. Selected teams will have the unique opportunity to design, build, test, launch and operate their own miniature satellite called a CubeSat. Project managers: Joanne Cai, Priya Manavalan, Tom Cundict. The Ex-Alta 3 Principal Investigator is Dr. Carlos Lange. They have worked with the MSC to fill out the MSRF for the Ex-Alta 3, and sent it for evaluation. They aim for the Ex-Alta 3 operations team to act as the primary prediction center. Given that the Ex-Alta 3 project is volunteer-run, we have also sought out a secondary (back-up) prediction center (Lumi Space). The ILRS will seek the recommendation from the MSC, and forward to the ILRS GB for their approval.

Reports to IAG:

- Submitted Travaux 2023-2025.

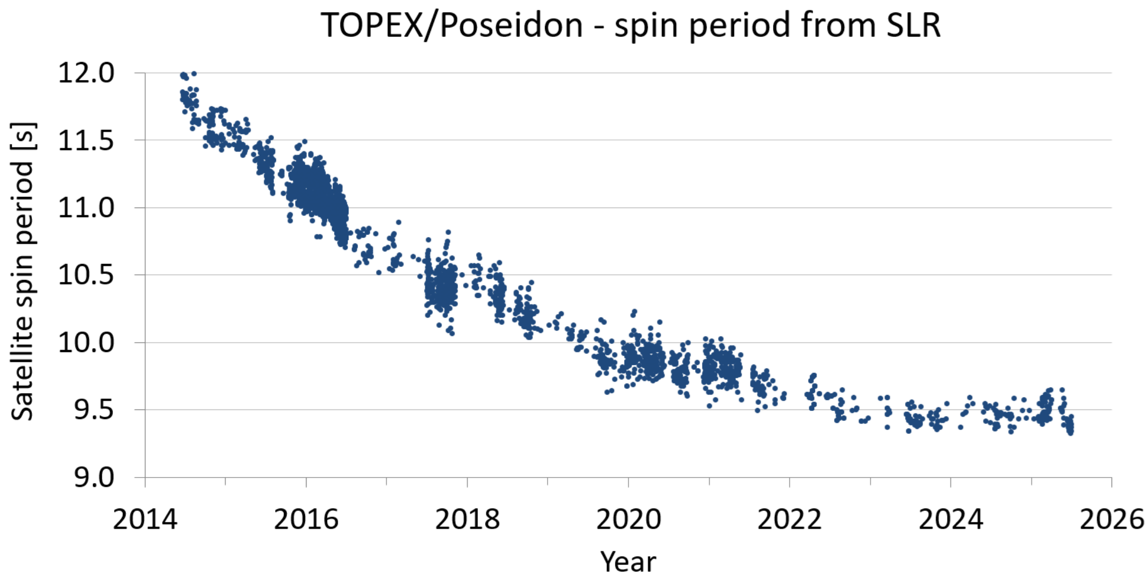
GGOS C-DIS Activities:

- DF&P standing committee and others met to go over the GNSS and SLR site log comparison to determine what keywords we may want to have added to GeodesyML, and if changes may be needed. Will meet again in late August. So far, Justine, Randy, José, Van, Kalvis, Evan, Claudia involved.

SDWG updates:

The Space Debris Study Group has been tracking Topex at the request of Daniel Kucharski. The plot shows nearly 4,000 spin period data points collected over the past 11 years. This plot shows the spin periods as observed by the stations – which includes the effect of an “apparent rotation” caused by the changing telescope view angle during a pass. The data is currently going through a cleaning process that will remove the apparent rotation and leave only the true, inertial spin period minimizing the spread of the trend.

Subsequent analysis will involve fitting a physics-based model to estimate parameters related to long-term spin evolution, with the dominant torques expected from solar radiation pressure and the Earth's gravitational field. Ultimately, this process will enable the determination of absolute attitude parameters: spin axis orientation, spin period, and rotational phase angle about the spin axis. They hope this can be determined (and predicted) at sub-degree accuracy level. The satellite attitude state forecast will be formatted and delivered in CPF files.



Interestingly, the Topex spin period has stabilized at ~9.5 s, which may indicate an equilibrium state where the major forces and torques acting on the satellite are balanced.

They will continue tracking Topex at the rate of 1-2 passes/week, uploading to the Graz space debris FTP server.

Next QCB Meeting: September 29th, 2025, 09:00-11:00 AM EDT (13:00 UTC)

Table 1. History Log Voids by Station (2025.08.20)

Station Location	CDP #	Time Gap(s)*				Last entry
Kiev	1824	000120-080302	080402-110515			141010
Komsomolsk	1868	NO DATA				
Simeiz	1873	NO DATA				
Mendeleevo	1874	NO DATA				
Altay	1879	NO DATA				
Riga	1884					250315
Arkhyz	1886	NO DATA				
Baikonur	1887	NO DATA				
Svetloe	1888	NO DATA				
Zelenchukskaya	1889	NO DATA				
Badary	1890	NO DATA				
Irkutsk	1891	NO DATA				
Katzively	1893	NO DATA				
Yarragadee	7090					250819
Greenbelt	7105					240418
Monument_Peak	7110					250414
Haleakala	7119					250330
Tahiti	7124	020825-080414	130321-191022			230520
Changchun	7237	950101-970802	020714-051002	180410-210106		240417
Beijing	7249	881101-940301	940301-981116	981116-211013		240923
Tsukuba	7306					240919
Sejong	7394	NO DATA				
Wuhan	7396	NO DATA				
Arequipa	7403	920718-951023	951023-981130	981130-010523		200629
San Juan, Argentina	7406	NO DATA				
Brasilia	7407	NO DATA				
Hartebeesthoek_HARL	7501	020409-081105				250205
Hartebeesthoek_HRTL	7503	NO DATA				
Izana	7701					230406
Zimmerwald_532	7810	030905-060203	080715-100901			250805
Borowiec	7811	030329-071227	080205-131218			211005
Kunming	7819					241208
Shanghai_2	7821	140222-170315	170720-190811			231113
San_Fernando	7824	900703-930222	971216-010124	090302-110601	180801-210518	250122
Mount_Stromlo_2	7825					210901
Wettzell_SOSW	7827	140501-160511	160511-190528	200424-230607		250319
Simosato	7838	900701-950810	950810-991007	991019-040701	080401-181212	211209
Graz	7839	150504-190311				241009
Herstmonceux	7840					240109
Potsdam_3	7841	040906-081026	081026-110501	170303-200303		250422
Grasse_MEO	7845	010601-200818				240517
Matera_MLRO	7941	140902-171204	171206-210629			250521
Wettzell	8834	980720-001012	001012-090324	090324-131021	170407-190604	240605

* Assuming at least 2 year data gap

Status 2025.08.21