March 20th, 2023.

ILRS QCB Meeting January 18th, 2022 (version 3)
Virtual Meeting (9 AM – 11:37 AM EST – 14:00 UTC)
Next Meeting:
March 20th, 2023
9:00 am – 11:00 am EDT (14:00 (14:00 UTC)

Participants:

Erricos Pavlis, Van Husson, Thomas Varghese, Stefan Riepl, Matthew Wilkinson, Mathis Blossfeld, Mike Ferguson, Randy Ricklefs, José Carlos Rodríguez Pérez, Peter Dunn, Frank Whitworth, Mike Pearlman, Justine Woo, Frank Lemoine, Graham Appleby, Julie Horvath, Claudia Carabajal.

The charts from the meeting will be available at (when posted):
https://ilrs.gsfc.nasa.gov/science/qcb/qcbActivities/index.html

Agenda:

Analysis Centers – Erricos

- Baikonur 1887 QC Evaluation
- Riga 1884 Status
- SOS Wettzell 7827 Evaluation
- BIAS [mm] HartRAONASA 7501- LAGEOS

Van Husson:

- LAGEOS-2 minus LAGEOS-1 SSEM Range Biases
- ITRF2020 SLR Scale Analysis

Peter Dunn:

- Large height jump at HART in 2012 (picked up in ITRF2014, and ITRF 2020 SSEM analysis)

Other items by other members.

Erricos – Quarantine station analysis, Bias validation (see slides):

ECP showed the QC analysis for Baikonur 1887 which presents a clearly different bias in the Sept.-Oct. 2022 period vs what is estimated during the December 2022 period, after a one-month brake in operations. Reached out to the station for any details as to what they did during the November brake and Evgeny Titov and Andrey Sokolov replied. The first stated that they did not do much and that their analysis shows the same bias throughout the Sept. to December period. Van has subsequently look into some of their signal strength and day data and has some theories as to what may have caused the change in the bias, nothing conclusive yet. Sokolov also said that he knows they were doing some work which Titov may have not been aware of, so we are waiting to hear more from the Russians. Van is checking to see if we can share slides with the Russians and ask them to supply some specific data that could illuminate the issue.

The similar chart with the Riga 1884 QC analysis shows that the station is doing well with the new equipment but it is struggling to collect enough LAGEOS-2 data in order to get out of quarantine. Interestingly, it is negatively biased in all three targets (2 LAGEOS and LARES), albeit only by -5 to -8 mm ± ~15 mm.

A third QC analysis chart for SOS Wettzell was briefly shown, mainly to inform Stefan about his system which came back into operations recently without undergoing any validation. System seems to perform nominally and there is no reason for more concern.

Other slides that had been submitted were not shown or discussed due to lack of time. One set refers to the missing height estimates of 7501 in ITRF2020. We can visit next time for discussion, to clear up what is the problem causing these missing points.

Van Husson (see slides):

LAGEOS-2 minus LAGEOS-1 SSEM Range Biases
Van using the LAGEOS -1 and -2 SSEM results published on the JCET web site at http://geodesy.jcet.umbc.edu/BIAS_v230_EDIT/index+231.php analyzed LAGEOS range bias differences (LAGEOS-2 minus LAGEOS-1) from 14 ILRS core sites for the two periods, before and after 14-Mar-2012. This is the day, that David Lucchesi observed a change in the LAGEOS-2 semi-major axes. For eleven of the fourteen stations, the LAGEOS range bias differences (LAGEOS-2 minus LAGEOS-1) increased post 14-Mar-2012. These differences appear to have some correlation with station latitude.

ITRF2020 SLR Scale Analysis
In the ITRF2020 SLR scale results, there are four distinct periods of scale estimate. During the 1st period. there was only a single satellite, LAGEOS-1, in solution and the scale estimates are almost always negative with a large scatter. During the 2nd period, Etalon-1 and Etalon-2 data were incorporated and the scale estimates were scattered around zero albeit slightly negative. During the 3rd period, LAGEOS-2 data was incorporated. The 3rd period scale estimates were skewed negative with a noticeable decrease in scatter over Periods 1 & 2. There is a clear discontinuity in the scale estimates between Periods 3 and 4, but there was no change in the SLR satellite constellation. July 1997 marks the beginning of the 4th period where the scale estimates were centered around zero with some mm level systematic trends.
Changes in the SLR satellite constellation did impact the ITRF2020 SLR scale results. Some of the systematics in period 4 appear to be correlated to changes in the spatial and temporal distribution of LAGEOS and Etalon data from the ILRS core sites.
Frank Lemoine commented that DORIS ITRF scale changes were also correlated with changes in the DORIS satellite constellation.

Mathis Blossfeld noted that their DFGI Terrestrial Reference Frame 2020 (DTRF2020) solution that their SLR scale estimates did not indicate a discontinuity in July 1997.

Peter Dunn:

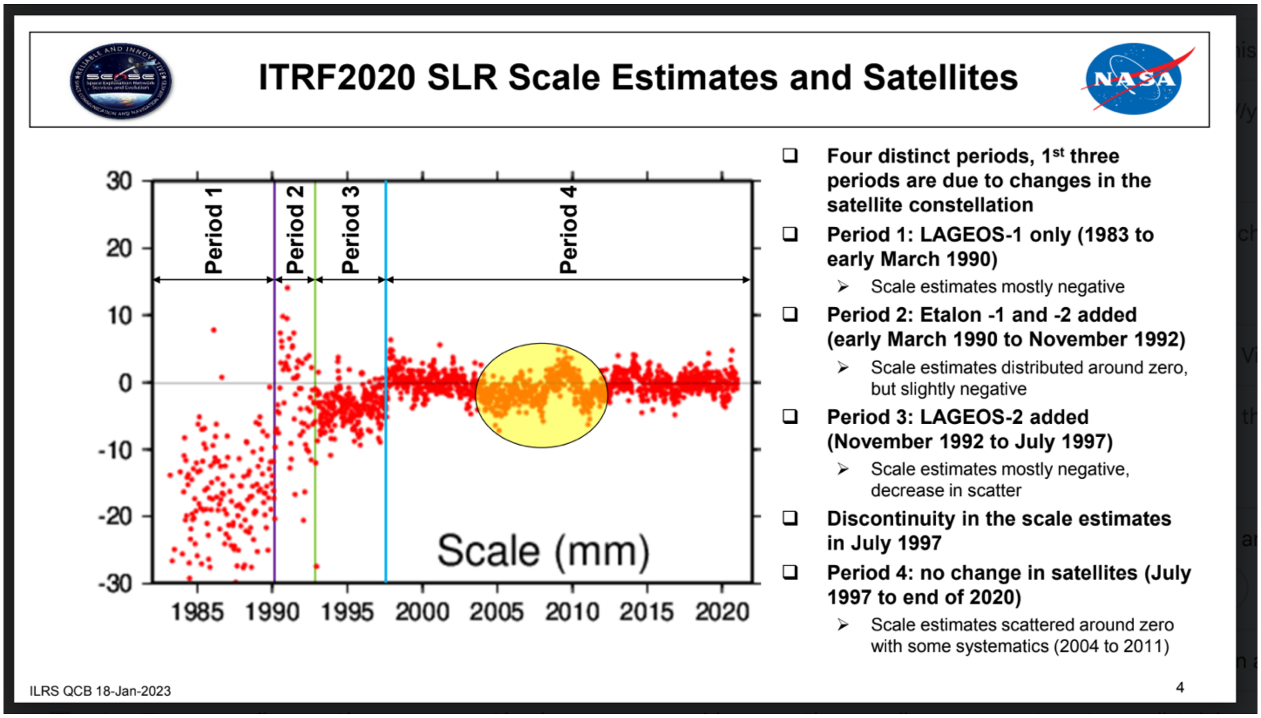
Peter Dunn noted that LAGEOS1 and LAGEOS2 range corrections which depend on satellite orientation and which were undetectable when the satellites were spinning will give systematic signatures now that they have stabilized.

He noted that Figures 18 and 19 in the LAGEOS 1 Prelaunch Report
https://ntrs.nasa.gov/api/citations/19780002257/downloads/19780002257

suggest that the difference between the range corrections to returns from the north and south poles of the satellite can reach 4 or 5 mm.

This is at the level of the discrepancies noted and the relative orientation will depend on the latitude of the tracking station.

He also referred the group to double humps seen in return profiles from the Herstmonceux station which suggests discrimination between lines of retroreflectors in a stable satellite orientation: /home/matt/Projects/FRdistrib/SLRdata/Lageos2/fr/7840_Lageos2_crd_20170618_05_00.frd



Peter commented that the next QCB meeting should start off with a small 'post mortem' on results from the last one.

Rationalizing large scale anomalies seems a fair goal if we are to Control SLR Data Quality.

He also wanted to discuss the fact that DTRF2020 does not see the recently advertised lump in VLBI scale. More discussions at the next meeting.

Mathis responded (3/20/23):
"I had a look on the ITRF2020 and the final DTRF2020 solution and the I can state the following:

1) when we do a Helmert transformation of the weekly ILRS and session-wise IVS solutions on the ITRF2020 solution, we can see the 1997 scale discontinuity in the ILRS time series and the scale drift beginning 2013.5 in the IVS time series.
2) when we do the same transformation on the final DTRF2020 solution, both systematics are visible but with much smaller values; the 1997 scale jump is there but not nearly as visible; the same holds for the VLBI scale drift..."

Dunn also muttered something about germanium cubes.

The next QCB meeting will be held on March 20th, 2023 at 9 am EDT (13:00 UTC).

Discussion after the meeting:

Email from Van (1/20/2023):
Presentation shared "1887 BAIL Analysis_rev1.pdf"

"FYI… Erricos's presentation got me curious to what may be the root cause of the 2 to 3 cm change in the 1887 range bias during December 2021.

I first tried to see if a barometric error might be the cause by comparing the 1887 barometric data to the 1887 VMF3o barometric data. See slide 2 in the attached presentation. This analysis eliminates a tropospheric error as the cause.

Then I noticed their data from 2021 also had some cm jumps in range bias. See Slide 3, HITU 1887 LAGEOS range biases (left axis) and the system delays (right axes) since Jan 1, 2021. Also see SSEM results are on Slide 7, where there have been several cm change in their legacy range biases.

The root cause appears to be signal strength related, see slide 4. Also notice the change in average LAGEOS-1 range on the left chart on slide 5 in December 2022. The December 2022 average LAGEOS-1 range decreased compared to data taken in July through October 2022. A decrease in average range would imply an increase in signal strength.

The data in quarantine tends to have less normal points than when they were operating in 2021 (see left chart on slide 6). Because there are not many normal points during the quarantine period, HITU did not estimate an along track error (see right chart on slide 6).

There are charts of the moments (rms, skew, kurtosis) and peak minus mean taken from their 50 session records on slide 8.

Regards, Van"

Response from Erricos (1/20/2023):
"Van thanks a lot for this check! It sounds a pretty good explanation, especially since they have had similar behavior in the past. On the other hand, it sounds scary to me that such relatively small variation in the signal strength can cause such "huge" biases!

Are the other stations (which I am sure undergo similar range variations over the year) doing a better job at keeping the signal strength more stable than Baikonur does or do most have some feedback loop that adjusts their operation on the fly? If this is a general problem, we may have to start monitoring and comparing signal-strength variations over the year for all sites…

Should I pass on the suggested cause to Andrey and Titov (after I wait for a few days to see if they come up with their own explanation as they hinted earlier)?

@VAN: can I share your slides with them? Any ITAR issues?

ecp"

Response from Van:

"Hi Erricos,

All the data I used is in the public domain (i.e. is available via the internet) but let me ask my management about ITAR issues.

They should be able to take a special ground test where they vary the return rate off the calibration target and see how much variation there is in system delay and/or raw time-of-flight.

I think signal strength issues are common to many sites. The magnitude would depend upon the detector, receive electronics, and the proficiency of the operator.

Also, they (Russian station operators/engineers) and/or the data analysts may or may not know this, but the PMT can be a major source of systematic error (Tom Varghese knows more than I based on his testing of PMTs [non MCP-PMT] in the early 1980's.). The system delay can change by centimeters depending upon where the return falls within the PMT. MCP-PMTs do not exhibit this systematic and why MCPs are superior for SLR over a regular PMT. And why NASA transitioned to MCPs in the early 1980's.

Also, if you gate a PMT (you can ask them), centimeter level biases can occur depending upon where the return falls within the PMT range gate. I think all the RCOSMOS sites have the same laser and detector packages and probably one reason their data is not as stable as SPAD or MCP stations.

Station 7503 (Hartebeesthoek) is the only RCOSMOS station that provides a calibration RMS in their CRD, which is usually higher than the corresponding satellite RMS. Calibration RMSs from a single cube should be lower than the satellite RMS assuming they are computing calibration RMS correctly. In CRD V2, stations have the option to provide raw calibration data.

Thanks and regards, Van"

Erricos will investigate.

José's email from 1/23/23:
"Hi, Van

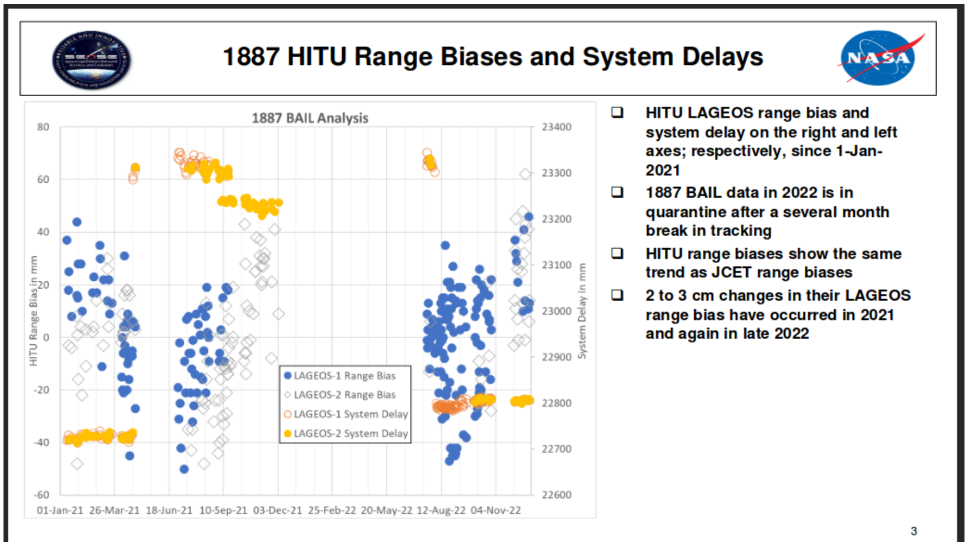
Thank you for looking at this. cm-level problems is what we should focus on.

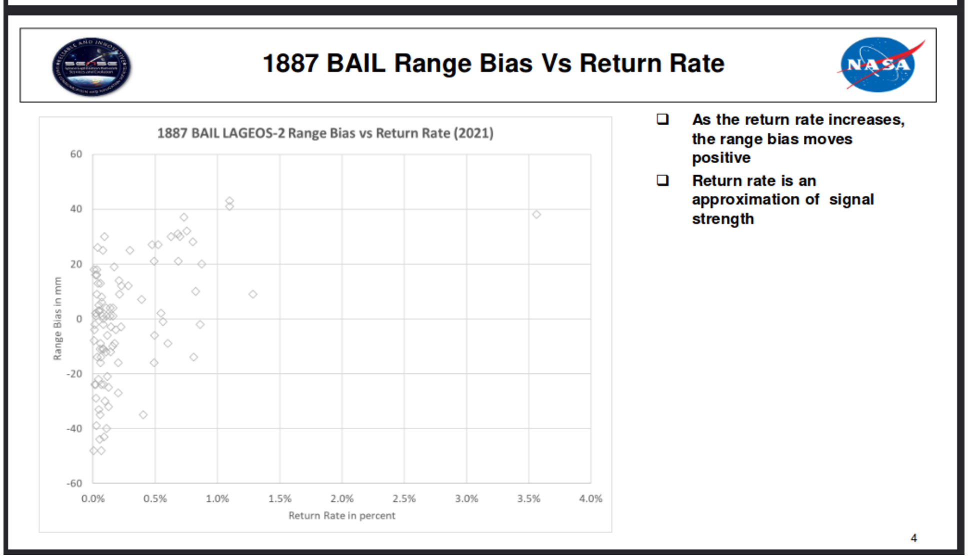
But I'm not seeing the return rate correlation as clearly as you do. Your RB vs return rate plot does not show a particularly strong trend between the two, with most points bunched at <0.2% return rate and just a few between 0.5-1%. I wouldn't want to fit a trend line there.

On the other hand, the RB vs system delays plot seems more telling to me. This shows clearly visible periods identifiable by different system delays, seemingly correlated with changes in RB. We know that changes in system delays imply changes/tweaks in the station setup, which can easily be responsible for changes in its behaviour and ultimately the observations.

We do know indeed that changes in signal strength can cause a lot of problems, but I'm not convinced (yet?) that that's what we are seeing here.

Kind regards,
José”





Response from Van (1/23/23):
“Hi Jose, Erricos,

Based on Jose’s comments, I generated two more charts and a table where I focused just on the period July to December 2021 using LAGEOS-2 only (see last slide). There are two populations of system delays during these 6 months. Between the 5th and 17th of September 2021, the system delays were bimodal implying 2 different modes of operation.

The average system delay change between the two populations was 70 mm with a corresponding range bias change of 33 mm (almost half the system delay change). There is a linear correlation between range bias and system delay with either system delay population, which is indicative of a calibration issue (see the left chart last slide).

When the system delay was above 23260 mm in 2021, the satellite return rates had little variation. When the system delay was below 23260 (starting on the 5th of September 2021), there is more variation in the return rate and more variation in the bias (see the right chart and the table at the bottom of the last slide).

If the station can tell us what caused the 2 lines of system delays between the 5^{th} and 17^{th} of September 2021, this may shed some light to their biases changes in 2021 and 2022.

It would be great if they could characterize their PMT, their constant fraction discriminator and their event timer so we had a better understanding of their systematic error sources.

Regards and happy Chinese new year, Van”