ILRS QCB Meeting
March 24th, 2025
9:00 – 11:00 AM EST (13:00 UTC)
Next QCB Meeting: May 19th, 2025, 09:00-11:00 AM EDT (13:00 UTC)

Participants: Andreja Susnik, Peter Dunn, Randy Ricklefs, Matthew Wilkinson, Mike Pearlman, Graham Appleby, Magdalena Kuzmicz-Cieslak, Van Husson, Stefan Riepl, Alexandre Belli, José Carlos Rodríguez Pérez, Tom Oldham, Mathis Blossfeld, Claudia Carabajal.

Agenda:
Peter:
- Update on discontinuities.

Van:
- Investigation into ITRF2020_U2023 NASA SLR Height Discontinuities
- NASA SLR Local Site Survey Issues
- Handling of Fullrate Data from Systems with Leading Edge (LE) Filters

Claudia:
- ILRS CB updates.

Notes from the ILRS QCB Meeting on March 24th, 2025:

Peter Dunn – see presentation.

Discontinuities at an active earthquake station: MOBLAS4

In ITRF2020-u2023, the SLR station 7110 (MONL) exhibits non-linear vertical motion between earthquake events.

Model discontinuities are introduced only at known earthquake occurrence times for MONL. The height rate is assumed linear in the time segments between discontinuities in ITRF2020-u2023.

The vertical displacements at SLR and GNSS (MONP) agree at most earthquake discontinuity times.

MONP also shows vertical displacements at non-geodetic discontinuities which affects long-term height definition.

MONL shows short-term non-linear behavior in the two year series preceding the 2010 M7.2 event.

This was confirmed by a two year span of DORIS observations from MODB.
The MONP height series determined at NGL had a different discontinuity distribution than that chosen by the IGN.

This gave a different inter-seismic deformation pattern between the first two earthquakes.
The SGF SATAN analysis of the MONL height series confirmed the long term (30 year) variation seen by both the SLR and GNSS systems.

The MONL height series produces a robust measure of the vertical variation at Monument Peak with discontinuity events limited to the occurrence times of earthquakes > magnitude 7.

Van Husson - see presentation.

Investigation into ITRF2020_U2023 NASA SLR Height Discontinuities

Two legacy (7080 at McDonald and 7210 at Haleakalā) and two active NASA SLR stations (7501 at Hartebeesthoek and 7105 at Greenbelt) in the ITRF2020 2023 Coordinate Update (ITRF2020_u2023) exhibit 'unknown' height discontinuities of several mm or more.

The two types of Station Systematic Error Modeling (SSEM) analysis (SSEM-X and SSEM) proved invaluable in determining the potential root cause of these discontinuities.

The treatment of biases based on the ILRS Data Handling File (DHF) along with the SSEM-X and SSEM results were presented for each station.

7080 McDonald Analysis

The 7080 ITRF2020_u2023 up residuals exhibit a discontinuity the week starting Sunday, January 28, 1996, coinciding with a discontinuity in the SSEM-X LAGEOS-1,-2 weekly Range Biases (RBs).

These RB discontinuities were caused by how the different analysis centers handled the DHF barometric corrections. Half the analysis centers applied the barometric corrections prior to RB estimation and the other half didn't. This bifurcation of handling barometric corrections caused a discontinuity in the ITRF2020 up residuals.

Based on comparisons of the station's barometric pressures to the Vienna Mapping Function for optical frequencies (VMF3o), updated barometric corrections can be provided for the DHF.

7501 Hartebeesthoek Analysis

The 7501 data yield can be extremely low in their summer months (January through March) due to their rainy season. The 7501 ITRF2020_u2023 up residuals exhibit two 'unknown' discontinuities (April 2012 and April 2021), both each exceeding 10 mm in the downward direction and both after tracking outages.

The 7501 ITRF2020_u2023 up residuals have a slight upward trend while the VLBI Hartebeesthoek station's (7232) up residuals are flat (i.e. no upward or downward motion).

Note:
The SLR Dutch transportable system MTLRS occupied 7501 for a few months in 1993 and post August 2000 MOBLAS-6 occupied 7501.

Between 11-Mar-2012 and 3-Apr-2012 MOBLAS-6 (7501) RBs were bifurcated by ~66 mm when the station began the transition to a new operational calibration target while alternating taken calibration data between the legacy and the new calibration target. All data taken during this period with the legacy calibration target was biased by -66 mm relative to previous data due to a 66 mm change in the target range used in data reduction. The last pass taken with the legacy calibration target was 3-Apr-2012 and starting on 4-Apr-2012, all calibrations were taken with the new calibration target.

The switch to a new calibration target in April 2012 most likely altered the RB due to the following two systematic error sources:

1. A survey error to either or both targets
2. HP5370B Timer Interval Counter (TIU) non-linearities

Based on the DHF, a fixed RB was to be applied to all MOBLAS-6 LAGEOS data from the beginning of its occupation (i.e. August 2000) until 19-Feb-2017. Not accounting for a RB change when the calibration target switch occurred in April 2012 is the potential root cause of the up discontinuity.

The height discontinuity in April 2021 coincides with a change in the RB treatment based on the DHF. A fixed +13 mm LAGEOS RB was to be applied to data taken prior to April 2021 while post 1-Apr-2021, a RB is to be estimated post. There was a reduction in 7501 LAGEOS data yield in 2021; evidenced by an increase in the ITRF2020_U2023 residual error bars. An adequate LAGEOS data yield is needed to simultaneously solve for RB and station height.

7105 Greenbelt Analysis

There is an 'unknown' 8 mm discontinuity in the MOBLAS-7 ITRF2020_2023U up residuals starting on 20-August-2020. This date corresponds well with the date, 14-Aug-2020, when a known mm level calibration error was eliminated and documented in the 7105 station change history. The calibration error pertains to tracking satellites (LAGEOS and Etalon) at a higher PMT voltage than its corresponding calibration data inducing a positive range bias of several or more mm.

Based on the DHF, starting on 16-Feb-2020 a constant 7105 range bias of -5.1 and -4.3 on LAGEOS-1 and LAGEOS-2; respectively, is to be applied. This is approximately 6 months prior to a known change in the station's RB. Since there was a real RB change on 14-Aug-2020, but was not modelled, the station height absorbed the RB change inducing a discontinuity.

7210 Haleakalā Analysis

There are three discontinuities in the ITRF2020 7210 Up residuals. The first two are quite large at several cm.

The second height discontinuity occurred in late January 1994, when the station switched the frequency of its HP5370A Time Interval Unit (TIU) from internal to external on 21-Jan-1994. Its TIU had been on internal frequency since August 1989 (reference: cddis.nasa.gov/archive/slr/slrhst/schsci/sch_7210.log). A TIU on internal frequency will induce a time varying range dependent error and therefore estimating only a RB will not remove all the systematic trends.

The first discontinuity occurred post August 1989. Based on the downward trend in the up residuals prior to August 1989, it appears the 7210 TIU may have also been on internal frequency during most of that period.

The third up discontinuity occurred in September 2000 after being offline for a year while; system upgrades were completed and ranging operations resumed. This height discontinuity in

September 2000 also coincides with a 18 to 19 mm change in applied RB (Reference: DHF version 20250206).

Summary

The treatment of systematic errors based on the DHF has induced discontinuities in the up residuals from a few NASA SLR stations.

All known elevation, range, and/or range-rate dependent errors need to be applied 'a priori' before any resultant range bias is estimated.

NASA SLR Local Site Survey Issues

Since 2004, the frequency of NASA SLR local site surveys has decreased. In addition, the needs of the ILRS from these local site surveys were not coordinated in advance and therefore ILRS needs were not always satisfied, i.e. SLR calibration piers were sometimes not surveyed; final survey reports were not timely and sometimes never generated; and some reports exhibited inaccuracies.

The NASA SLR network currently has no dedicated survey support since Troy Carpenter retired and the passing of James Long. Geoscience Australia also has had a reduction in surveying resources since 2021.

There was a discussion of how to resolve the apparent scale issue in the 2024 Greenbelt local survey.

There was also a discussion about the Russian SLR sites that are collocated with VLBI have never been surveyed.

Handling of LE Fullrate Data

There is no standard edit criterion used within the ILRS network in the generation of Normal Points (NPs) and the systems that have implemented a Leading Edge (LE) filter. Also, the LE filter systems lack a standard in terms of which FullRate (FR) observations are included in their FR data. The FR filter flag, which indicates which FR observations were used and which were excluded in the NP formation process, is not properly used either.

Claudia Carabajal – see presentation.

San Fernando back in operations, soon to submit data for quarantine analysis. Submitted Site Survey for review. Van reviewed and sent to Zuher Altamimi. New occupation number, requested DOMES. Data will be corrected and submitted for quarantine analysis soon.

Xian Station submitted Site Log to EDC, working on the station page. Will submit data for quarantine analysis soon.

There have been no updates to the ILRS quarantine policy on the ILRS webpage. See the ILRS website for the full data quarantine policy as it stated on the website: https://ilrs.gsfc.nasa.gov/network/site_procedures/quarantine_procedure.html

Succession of the Director of the Swiss Optical Ground Station and Geodynamics Observatory (SwissOGS) in Zimmerwald announced.

The following events took place since 2022:
Since July 18, 2022, the SwissOGS has been jointly led by Prof. Dr. Thomas Schildknecht (Direc-tor) and Prof. Dr. Lucia Kleint (Vice-Director) in preparation for Thomas Schildknecht's retirement in September 2025.

On February 1, 2024, Lucia Kleint became Associate Professor (Extraordinaria) of the Phil.-nat.-Faculty of the University of Bern.

On February 1, 2025, following discussions with the executive board of the University and the management of the Astronomical Institute, Thomas Schildknecht will step down as Director after 15 years and Lucia Kleint will become the new Director of the SwissOGS.

Lucia Kleint received her Ph.D. degree in 2010 from ETH Zürich. She subsequently worked at the National Center for Atmospheric Research and at the Lockheed Martin Solar and Astrophysics lab (USA) until 2014, when she returned to Europe to work on ESA's Solar Orbiter mission. From 2017, she headed Europe's largest solar telescope and later the whole German Solar Observatory on Tenerife. In 2020, she was awarded a PRIMA grant, with which she became an assistant professor at the Department of Com-puter Science at the University of Geneva. Her current research group at the University of Bern, consisting of 10 members and funded by third-party sources including an ERC grant, focuses on astronomical instrumentation, machine learning, and the physics of Space Weather.

Missions:

- Received MSRF from Hideki Yamada from JAXA, for "**QPS-SAR**", which was approved for tracking support. Mission sent list of stations they want to participate with restricted tracking. Missions contacted to verify parameters for the draft agreements. **The campaign period is tentatively scheduled for August 2025.** The exact campaign period will be announced in advance via email.

- Nano FF 1-2 Mission launched in December 2023, aimed at advancing proximity operations in low Earth orbit, funded by the German Aerospace Center (DLR) and developed by Technische Universität Berlin.

  The NanoFF mission consists of two 2U-CubeSats designed to demonstrate precise relative navigation and control, leveraging GNSS-based positioning, inter-satellite communication, and autonomous formation-keeping algorithms. A key focus of NanoFF is to ensure collision-free operations while executing controlled maneuvers in close proximity, making it a critical step towards future satellite servicing and inspection applications. **Support to start in June 2025.**

- We received a MSRFs for **QZS-6** from JAXA because each satellite has slightly different features and parameters that the other QZS satellites in the constellations. This is one of 3 additional satellites that will be added to the QZSS constellation from the Government of Japan Cabinet Office. QZSS has been operating as a 4-satellite constellation since November 2018. 3 satellites are visible at all times from Asia-Oceania. They can be used in an integrated way with GPS ensuring a sufficient number of satellites for stable, high-precision positioning.

  To improve position stability, one quasi-zenith satellite, one geostationary satellite, and one quasi-geostationary satellites will be added, to create a seven-satellite constellation. This is one of those three satellites. QSS/NEC will be providing the predictions. Support for the mission was requested beginning within two months after launch, anticipated in early February of 2025, with an expected mission lifetime of 15 years; MSRF sent to MSC Co-Chairs and then the ILRS GB. **The campaign period is tentatively scheduled from April 25 to June 27, 2025.**

- **Engineering Test Satellite-9:** Contacted JAXA colleagues about ETS-9 (Engineering Test Satellite-9, https://www.satnavi.jaxa.jp/files/project/ETS-9/en/) mission, which requested access to CDDIS to test prediction files. The mission's planned launch is in 2025. ETS-9 is a demonstration satellite to achieve next generation geostationary satellite communication that will be internationally competitive, which will verify communication technology that meets market needs, and satellite bus (platform) technology to load communication instruments. The mission has a designed life of 16 years (Except payload), mass of 4.9 t, it will have an automated geostationary orbit at 36,000 km, larger power/Advanced heat control technology > 25kW, with Mitsubishi Electric Corporation as the primary contractor. It is the first Japanese geostationary satellite equipped with GPS receivers (Japan-made) for laborsaving autonomous orbital transfer and orbital maneuvering.

  Conceptual Design of Japan's Engineering Test Satellite-9, October 2017, DOI: 10.2514/6.2017-5427.

- **ICESat-2:** Updated the agreement from the ICESat-2 mission for Herstmonceux to track with the new laser. Tony Martino signed. Sent the signed agreement to the Station/Mission.

- **Sentinel-6B satellite:** Received MSRF from Marc Gaset, Copernicus Ground Segment System Engineer, Satellite System Ground Segments Division – EUMETSAT (incremental submission to the one approved by ILRS on May 28, 2020 for the Sentinel-6A).
  The Sentinel-6B/Jason-CSB is the follow-on to the TOPEX/POSEIDON, Jason-1, Jason-2, Jason-3 and Sentinel-6A/Jason-CSA satellites (clone of Sentinel-6A, high-precision ocean altimetry measurements). The Jason-CS Programme – established by Declaration EUM/C/83/15/Dcl.I – constitutes EUMETSAT's direct contribution to the funding, development and implementation of the Sentinel-6/Jason-CS mission, which also involves ESA, the EU, NOAA, NASA, and CNES. A secondary objective of Sentinel-6/Jason-CS is to collect high resolution vertical temperature profiles, using the GNSS Radio-Occultation sounding technique, to assess temperature changes in the troposphere and stratosphere and

support Numerical Weather Prediction. Planned to have 5.5 years lifetime each (plus 2 years consumables).

The Sentinel-6B/Jason-CS-B satellite will be launched in November 2025 to guarantee adequate overlap with Sentinel-6A/Jason-CS-A and provide full continuity of service until 2030 and beyond. Sentinel-6B is a clone of Sentinel-6A. It is the same satellite. There may be minor changes to the tracking point offsets, or CofM. The satellite will first fly tandem with S6A for calibration/validation purposes. Then S6A will be moved to another orbit, probably an interleaved orbit. Then S6B will become the official satellite providing altimeter sea surface height measurements on the TOPEX ground track.

Satellite Laser Ranging for the Sentinel-6/Jason-CS mission: accurate orbit determination is a fundamental requirement for achieving the Jason-CS mission objectives. The SLR data play such an important role in two ways:
(1) by providing robust tracking information to complement GNSS and DORIS
(2) by providing a unique and unambiguous verification of the absolute radial orbit accuracy.

- NGLR-1 mission that was approved by the ILRS GB. Mission was informed. Firefly Aerospace's Blue Ghost Mission 1 successfully Launched at1:11 a.m. EST on January 15, 2025 and began its 45-Day transit to the Moon. The NGLS-1 mission will be contacted. Preparing to support the mission.\ https://fireflyspace.com/missions/blue-ghost-mission-1/

  March 2, 2025, 3:08 am CST: First Image on the Moon and successful landing
  Blue Ghost captured its first Moon image after successfully landing! The image shows the Moon's surface and a top-down view of the lander's RCS thrusters (center) with a sun glare on the right side. The X-band antenna was successfully deployed, allowing to rapidly downlink high-definition imagery and videos and transmit payload science data back to Earth.

  LLR stations have successfully ranged: Grasse, Wettzell, Apache Point.
  Working on improving communication between analysis and stations.

Table 1. History Log Voids by Station (2025.04.17)

Station Location	CDP #	Time Gap(s)*	Last entry
Kiev	1824	000120-080302 080402-110515	141410
Komsomolsk	1868	NO DATA	
Simeiz	1873	NO DATA	
Mendeleevo	1874	NO DATA	
Altay	1879	NO DATA	
Riga	1884		240315
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		250407
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	230425
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	250205
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	231121
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	240305
Grasse_MEO	7845	010601-200818	240517
Matera_MLRO	7941	140902-171204 171206-210629	241024
Wettzell	8834	980720-001012 001012-090324 090324-131021 170407-190604	240605

* Assuming at least 2 year data gap

Status 2025.04.17

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