GASTON – ILRS support for the Galileo based project

ILRS Networks and Engineering Standing Committee

February 2021

C. Courde

Description of the ESA-GASTON project

- Recent investigation: Dark Matter (DM) could be on the form macroscopic structure (e.g. Earth-sized)
- Such structures could cross regularly the Earth !
  => New experiments in the Earth's neighborhood: Search for DM transient objects
- Our goal: Search for a coherent succession of glitches of atomic clocks onboard Galileo satellites in case of crossing

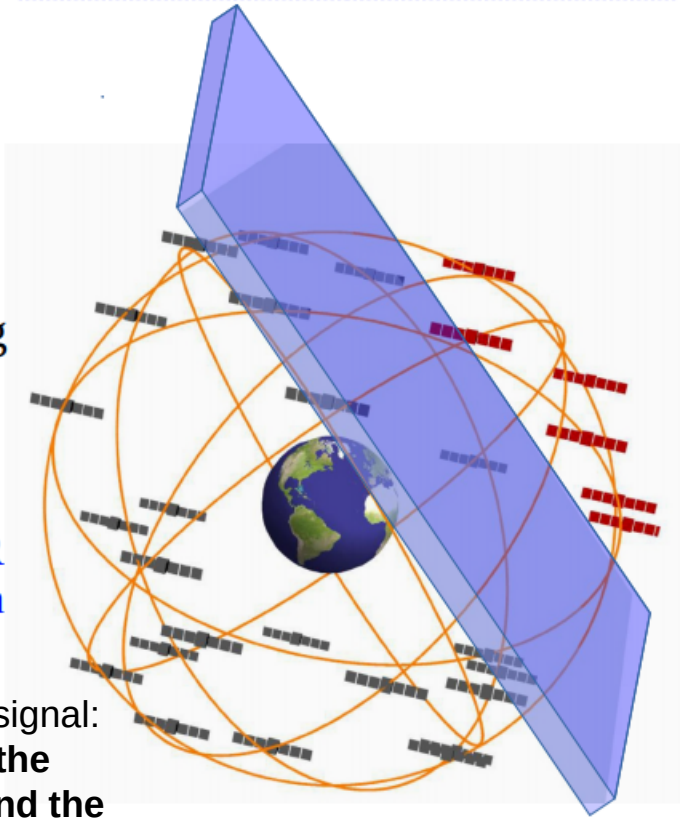
Stable H-maser onboard Galileo satellites

Deep study of systematic effects

3-month SLR campaign

Simplest case : planar structures called domain wall

A. Derevianko & M. Pospelov, Nature Phys. **10**, 2014



- The DM transient has almost no effect on the propagation of the laser signal: **SLR residuals can be used as a reference in order to disentangle the effect of the DM transient on the clocks and signal propagation, and the systematic effects due to orbital errors.**
- **Continuous SLR tracking** to a Galileo satellite **is required** by the investigation **to be happening at the exact moment a DM transient is detected**.

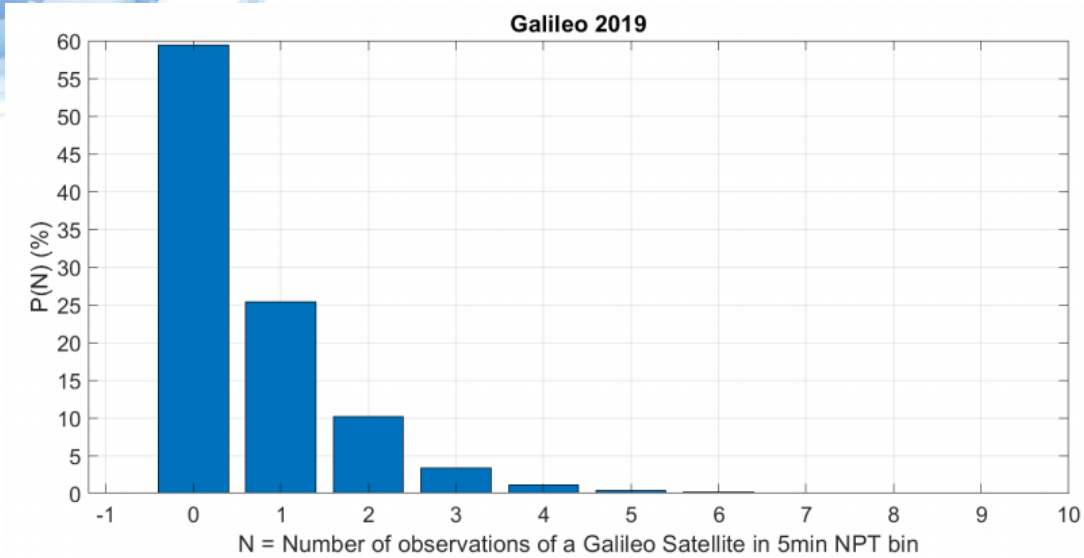
Strategy proposal for the GASTON SLR campaign

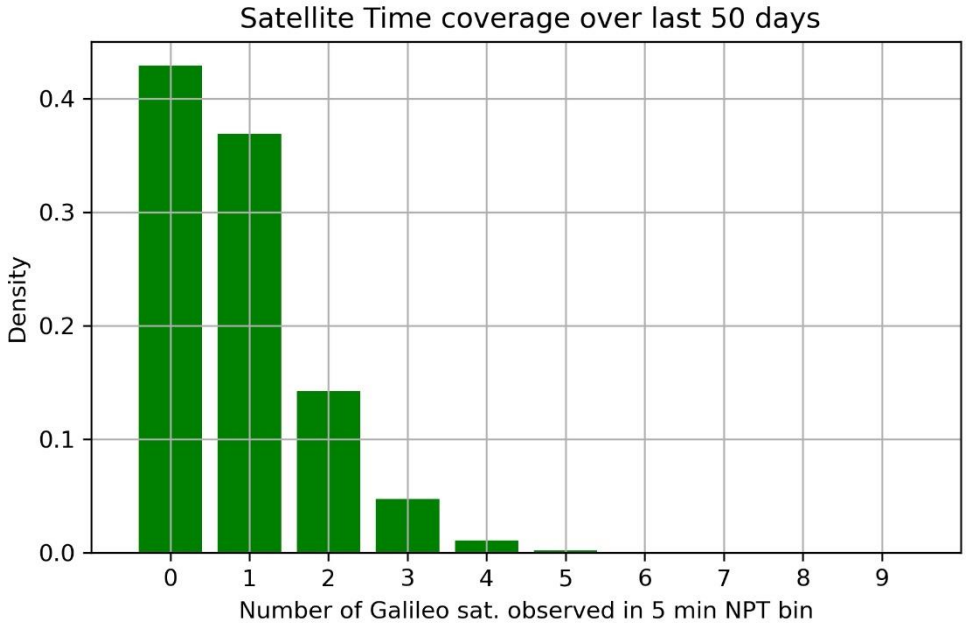
1) Ask the ILRS stations to participate to the 3 months campaign on a voluntary basis
2) Ask the station to deliver CRD and **FRD** data
3) Reduce the number of target to the satellites with the best clocks: GASTON Galileo list on the right
4) Ask the voluntary stations to install the Eurostat station status display
5) Ask the stations to check a dedicated webpage made by OCA (under construction: https://ocatools.oca.eu/galileo/) showing from the Eurostat data, the number of Galileo satellites tracked in real time. The webpage warns the stations when no Galileo is tracked and promote the station to move on one of the Galileo satellite. A color code shows the status in real time: red when no Galileo is tracked, orange when only one station tracked, yellow when two stations tracked a Galileo satellites, green when three or more stations tracked a Galileo.
6) To challenge the ILRS stations, the most contributing station over the whole campaign will win a surprise gift from Grasse SLR station.

Table 4: List of PHM with their ADEV at 30s and 15360s

Satellite name	SV ID	ADEV ($\tau = 30$s)	ADEV($\tau = 15360$s)
GSAT0102	E12	2.973e-13	1.475e-14
GSAT0103	E19	2.814e-13	6.837e-15
GSAT0203	E26	2.924e-13	4.575e-15
GSAT0205	E24	2.703e-13	3.321e-15
GSAT0206	E30	3.079e-13	1.441e-14
GSAT0207	E07	2.695e-13	2.088e-14
GSAT0208	E08	3.027e-13	6.713e-15
GSAT0209	E09	2.724e-13	7.160e-15
GSAT0210	E01	2.704e-13	5.531e-15
GSAT0211	E02	2.837e-13	1.5459e-14
GSAT0212	E03	2.858e-13	7.890e-15
GSAT0213	E04	2.813e-13	8.866e-15
GSAT0214	E05	2.862e-13	7.296e-15
GSAT0215	E21	2.793e-13	9.884e-15
GSAT0216	E25	2.915e-13	1.210e-14
GSAT0217	E27	2.900e-13	1.494e-14
GSAT0218	E31	2.960e-13	1.076e-14
GSAT0219	E36	2.765e-13	1.102e-14
GSAT0220	E13	2.803e-13	5.2544e-15
GSAT0221	E15	2.664e-13	1.057e-14
GSAT0222	E33	2.960e-13	9.225e-15

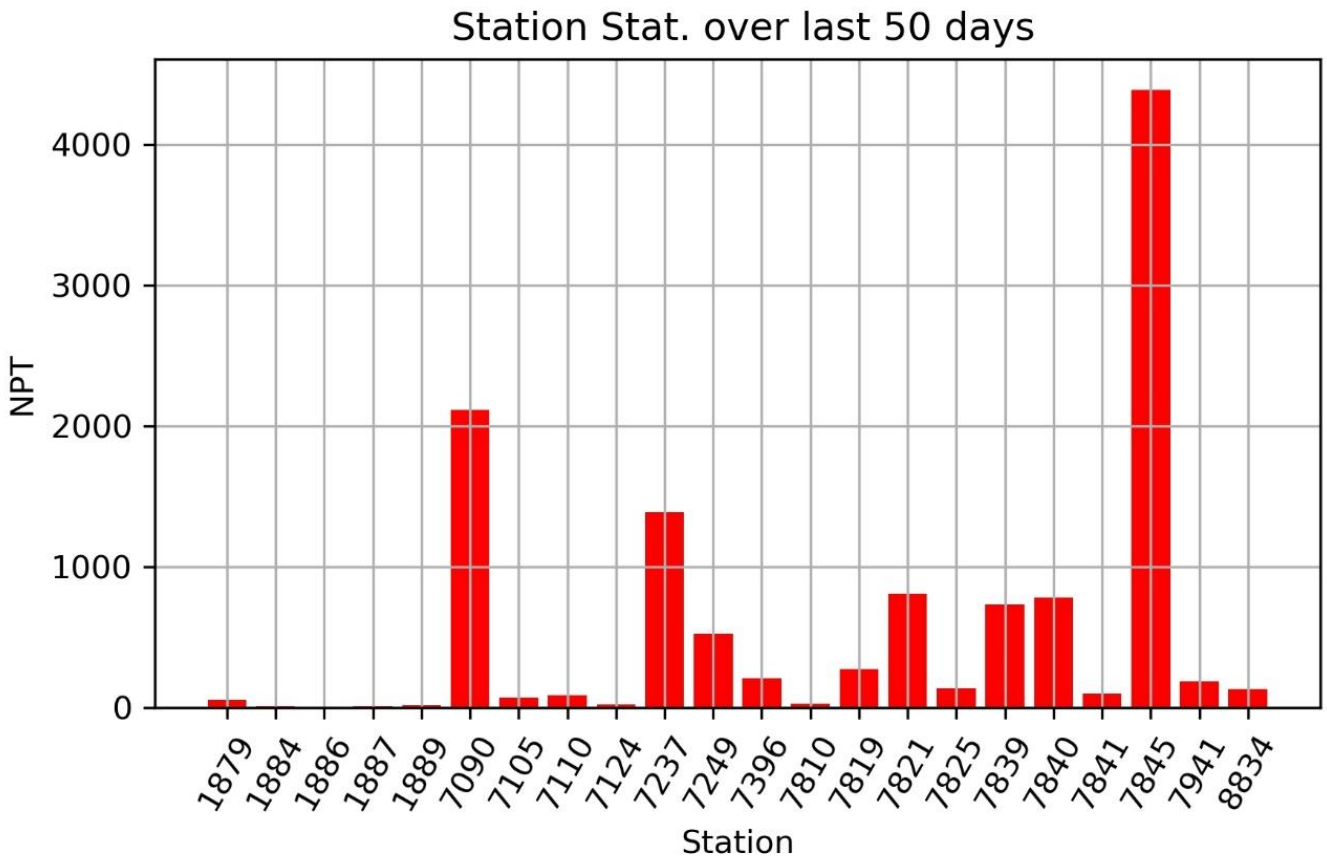
Statistics from ILRS over the last 50 days



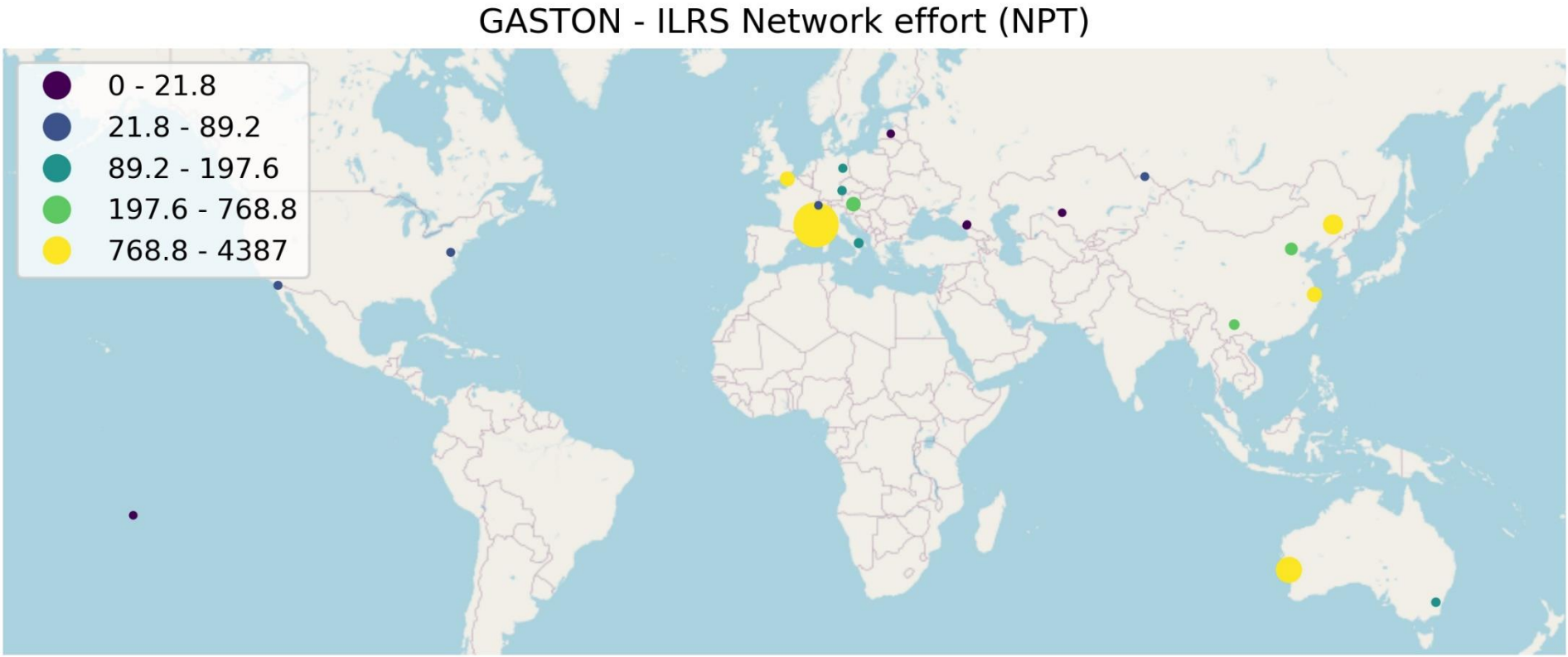


Over the last 50 days :
- From 60% to 45% of 0 Galileo sat obs in 5 min

Statistics from ILRS over the last 50 days



Statistics from ILRS over the last 50 days



Discussion and question

Thanks to all participating stations

Networks and Engineering Standing Committee (NESC)

February 25, 2021

Van S. Husson

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2020 ILRS Station Performance Rankings: (Data Quantity and Single Shot RMSs)

Site Information		Data Volume					Data Quality			
Location	Station	LEO Passes	LAGEOS Passes	HEO Passes	Total Passes	Passes Rank	Calibration RMS	Calibration RMS Rank	LAGEOS RMS	LAGEOS RMS Rank
Kiev	1824	602	36	0	638	35th	11	25th	40	40th
Komsomolsk	1868	18	168	1098	1284	31st			30	35th
Simeiz	1873	2338	366	433	3137	18th	14	27th	18	28th
Mendeleevo	1874	113	87	177	377	38th	32	30th	25	30th
Altay	1879	58	264	1613	1935	25th			28	34th
Riga	1884	535	140	124	799	32nd	6	17th	10	16th
Arkhyz	1886	472	296	1110	1878	26th			28	33rd
Baikonur	1887	0	191	519	710	34th			30	36th
Svetloe	1888	1111	403	265	1779	28th			33	38th
Badary	1890	1505	476	498	2479	22nd			34	39th
Irkutsk	1891	1072	255	312	1639	29th	40	31st	31	37th
Katzively	1893	2496	405	3	2904	20th	25	28th	28	32nd
Yarragadee	7090	17291	2677	6242	26210	1st	2.9	6th	4.8	3rd
Greenbelt	7105	5799	890	969	7658	11th	2.9	7th	9.0	12th
Monument_Peak	7110	6537	772	737	8046	8th	3.1	9th	8.3	11th
Haleakala	7119	2520	523	0	3043	19th	2.6	5th	9.4	14th
Tahiti	7124	471	109	0	580	36th	3.2	11th	7.7	8th
Changchun	7237	8886	1088	5654	15628	2nd	6.6	20th	11.7	18th
Beijing	7249	2057	349	1435	3841	17th	7.0	22nd	18.1	27th
Tanegashima	7358	136	14	0	150	39th	1.2	2nd	4.7	2nd
Sejong	7394	94	27	3	124	40th	3.8	13th	12.3	19th
Wuhan	7396	898	244	851	1993	24th	8.9	21th	7.3	6th
Arequipa	7403	4673	241	0	4914	15th	4.5	15th	9.7	15th
Brasilia	7407	90	65	243	398	37th	29.5	29th	24.0	29th
Hartebeesthoek_HARL	7501	2634	673	716	4023	16th	3.3	12th	8.2	10th
Hartebeesthoek_HRTL	7503	1257	468	807	2532	21st	28.7	21th	27.4	31st
Zimmerwald_532	7810	9468	1916	3731	15115	3rd	6.6	21th	13.6	21st
Borowiec	7811	1065	197	66	1328	30th	13.6	26th	17.6	26th
Kunming	7819	3248	620	4253	8121	7th	5.3	16th	11.4	17th
Shanghai_2	7821	2424	546	2598	5568	14th	6.7	21st	7.1	5th
San_Fernando	7824	713	59	0	772	33rd	6.2	18th	14.0	23rd
Mount_Stromlo_2	7825	5710	1239	919	7868	10th	3.1	10th	7.5	7th
Wettzell_SOSW	7827	4086	1087	4255	9428	6th	8.7	23rd	14.3	24th
Simosato	7838	1415	383	20	1818	27th	6.4	19th	13.8	22nd
Graz	7839	3249	715	3041	7005	12th	2.4	4th	5.1	4th
Herstmonceux	7840	6400	1311	3069	10780	4th	4.0	14th	12.9	20th
Potsdam_3	7841	6546	1321	2739	10606	5th	1.6	3rd	8.0	9th
Grasse_MEO	7845	510	662	1039	2211	23rd	8.8	24th	15.6	25th
Matera_MLRO	7941	4964	1704	1229	7897	9th	1.0	1st	3.1	1st
Wettzell	8834	3222	841	1609	5672	13th	2.9	8th	9.3	13th

Legend
Top Ten in Data Volume
Top Ten in Calibration RMS
Top Ten in LAGEOS RMS

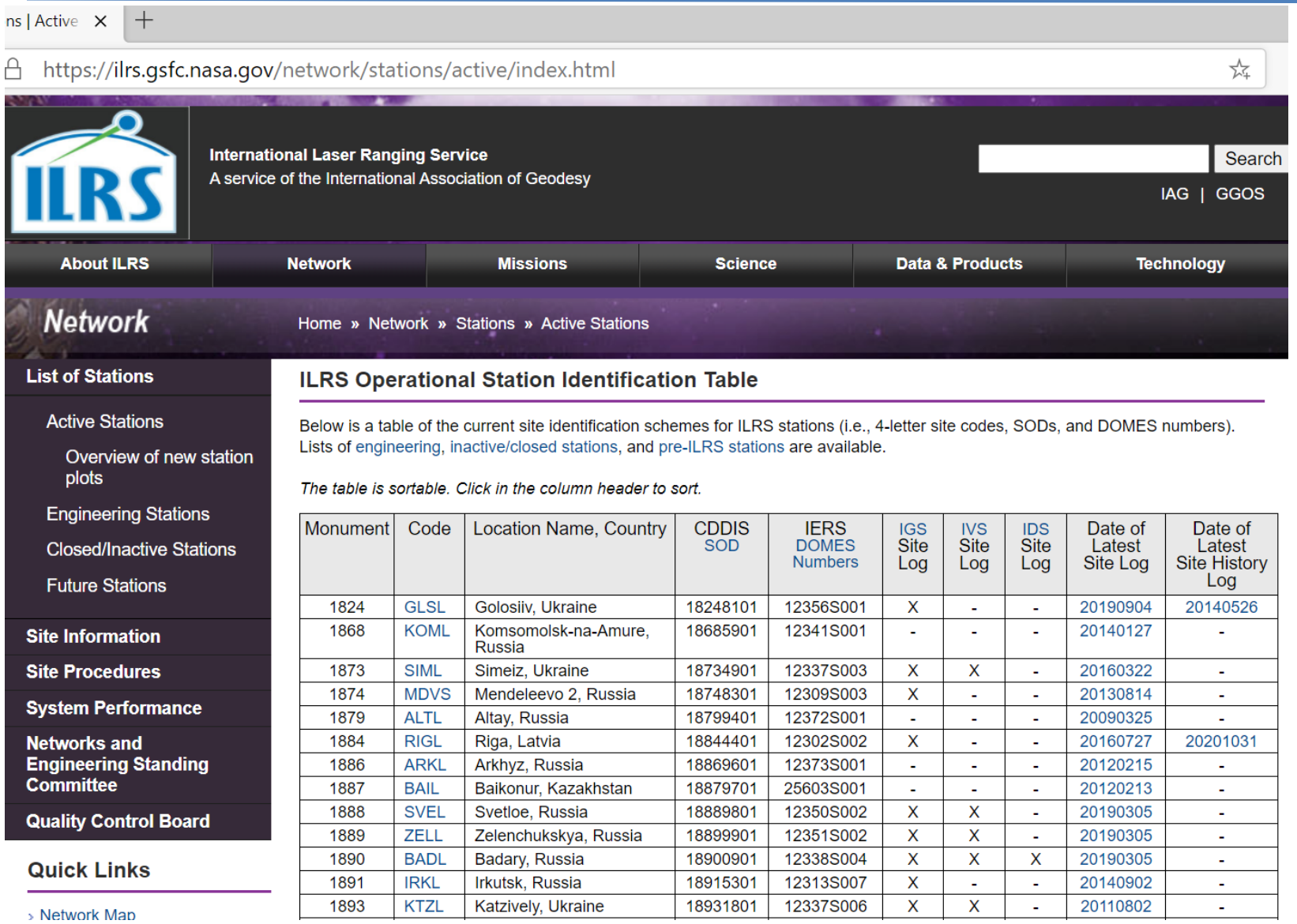
2020 ILRS Station Performance Rankings: (LAGEOS NP RMS and Range Bias Stability)

Site Information		Hitotsubashi University				JCET			
Location	Station	Col 3: NP RMS (mm)	Col 4: NP RMS Rank	Col 5: Range Bias [RB] Stab (mm)	Col 6: RB Stab Rank	Col 7: NP RMS (mm)	Col 8: NP RMS Rank	Col 9: RB Stab (mm)	Col 10: RB Stab Rank
Komsomolsk	1868	5.2	25th	14.2	31st	4.5	30th	16.3	30th
Simeiz	1873	27.5	34th	19.8	32nd	4.3	28th	9.1	Tie 18th
Mendeleevo	1874	4.4	23rd	10.0	24th	4.9	33th	17.2	32nd
Altay	1879	2.5	Tie 13th	20.7	33rd	2.5	Tie 13th	22.9	33rd
Riga	1884	1.5	Tie 5th	28.5	34th	2.2	10th	26.9	34th
Arkhyz	1886	4.0	20th	9.0	21st	3.8	24rd	11.6	27th
Baikonur	1887	4.3	Tie 21st	12.6	28th	3.4	21th	16.5	31st
Svetloe	1888	5.0	24th	7.4	19th	4.0	26th	7.0	15th
Badary	1890	5.7	Tie 27th	9.5	23rd	4.4	29th	10.4	25th
Irkutsk	1891	7.0	31th	8.8	20th	4.2	27th	9.1	Tie 18th
Katzively	1893	8.3	32st	13.5	29th	5.4	34th	10.3	24th
Yarragadee	7090	1.6	Tie 8th	1.1	5th	2.1	Tie 7th	1.7	Tie 1st
Greenbelt	7105	1.8	Tie 9th	1.4	7th	2.4	12th	3.2	8th
Monument_Peak	7110	1.6	Tie 8th	3.3	Tie 10th	2.1	Tie 7th	5.2	12th
Haleakala	7119	1.8	Tie 9th	3.5	13th	2.5	Tie 13th	2.9	7th
Tahiti	7124	5.7	Tie 27th	11.2	27th	2.5	Tie 13th	7.5	16th
Changchun	7237	3.3	18th	10.3	25th	3.1	18th	10.0	22nd
Beijing	7249	10.9	33rd	5.9	16th	4.8	32nd	11.2	26th
Wuhan	7396	3.1	Tie 15th	10.5	26th	2.3	11th	12.1	28th
Arequipa	7403	3.2	17th	3.4	12th	3.3	20th	10.1	23rd
Hartebeesthoek_HARL	7501	1.8	Tie 9th	3.3	Tie 10th	2.1	Tie 7th	6.1	14th
Hartebeesthoek_HRTL	7503	4.3	Tie 21st	4.9	15th	3.5	23nd	5.1	11th
Zimmerwald_532	7810	1.5	Tie 5th	1.0	Tie 3rd	1.7	Tie 5th	2.5	5th
Borowiec	7811	6.2	29th	9.4	22nd	4.5	31st	9.1	Tie 18th
Kunming	7819	3.8	19th	13.9	30th	3.5	22st	12.2	29th
Shanghai_2	7821	1.5	Tie 5th	4.5	14th	1.7	Tie 5th	9.2	21st
Mount_Stromlo_2	7825	2.5	Tie 13th	1.0	Tie 3rd	2.5	Tie 13th	5.3	13th
Wettzell_SOSW	7827	6.2	30th	6.0	17th	3.2	19th	4.5	10th
Simosato	7838	5.3	26th	7.3	18th	3.9	25th	7.7	17th
Graz	7839	0.9	Tie 1st	1.2	6th	1.0	1st	2.3	3rd
Herstmonceux	7840	0.9	Tie 1st	0.7	1st	1.2	Tie 2nd	1.7	Tie 1st
Potsdam_3	7841	1.1	4th	2.2	9th	1.3	4th	3.4	9th
Grasse_MEO	7845	3.1	Tie 15th	1.8	8th	3.0	17th	2.7	6th
Matera_MLRO	7941	0.9	Tie 1st	0.9	2nd	1.2	Tie 2nd	2.4	4th

Legend
Top Ten in Range Bias Stability
Top Ten in Range Bias Difference

The most important data quality metric is **range bias stability**, not calibration RMS, not satellite RMS, not normal point RMS.

Updates to Station Pages on ILRS Website



ILRS Operational Station Identification Table

Below is a table of the current site identification schemes for ILRS stations (i.e., 4-letter site codes, SODs, and DOMES numbers). Lists of engineering, inactive/closed stations, and pre-ILRS stations are available.

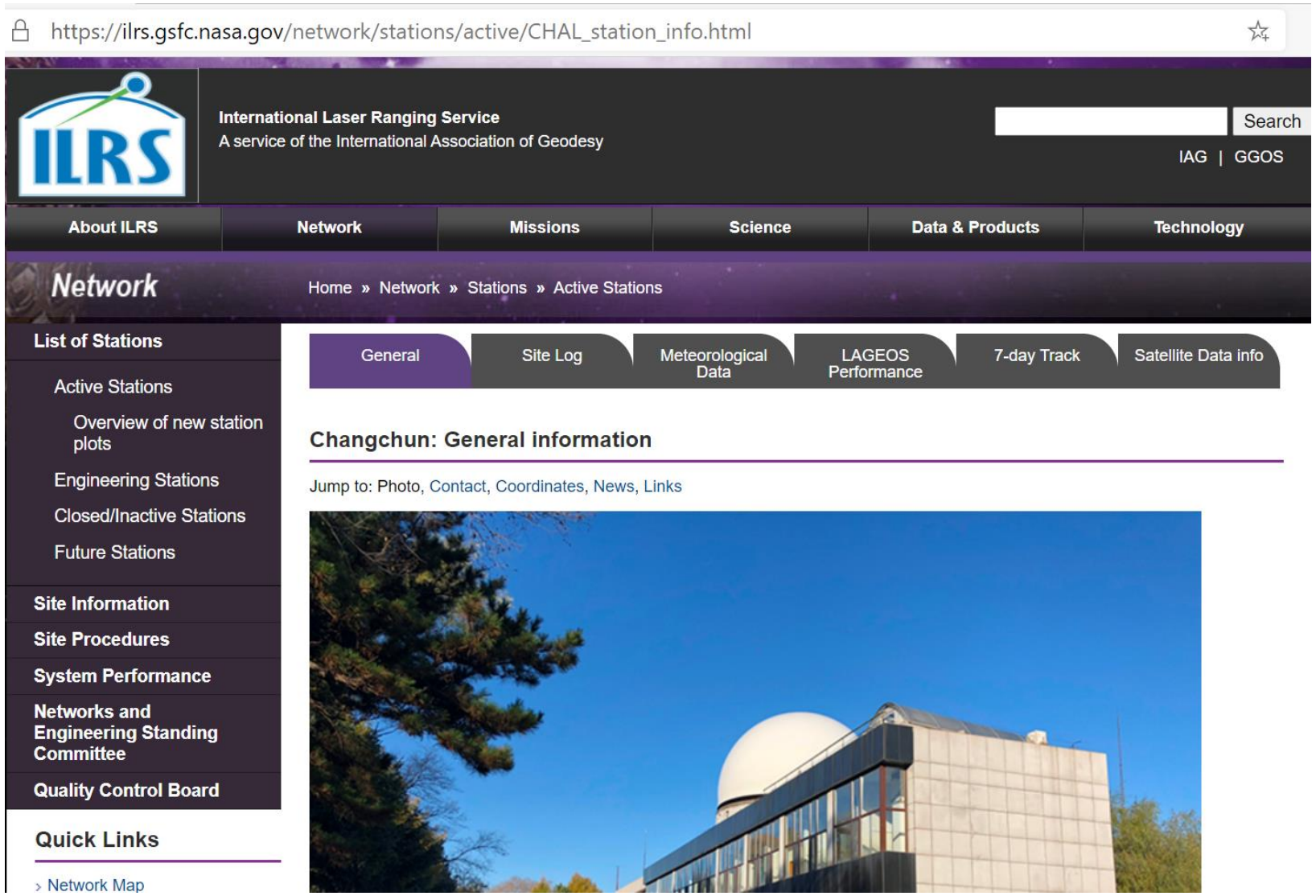
The table is sortable. Click in the column header to sort.

Monument	Code	Location Name, Country	CDDIS SOD	IERS DOMES Numbers	IGS Site Log	IVS Site Log	IDS Site Log	Date of Latest Site Log	Date of Latest Site History Log
1824	GLSL	Golosiiv, Ukraine	18248101	12356S001	X	-	-	20190904	20140526
1868	KOML	Komsomolsk-na-Amure, Russia	18685901	12341S001	-	-	-	20140127	-
1873	SIML	Simeiz, Ukraine	18734901	12337S003	X	X	-	20160322	-
1874	MDVS	Mendeleevo 2, Russia	18748301	12309S003	X	-	-	20130814	-
1879	ALTL	Altay, Russia	18799401	12372S001	-	-	-	20090325	-
1884	RIGL	Riga, Latvia	18844401	12302S002	X	-	-	20160727	20201031
1886	ARKL	Arkhyz, Russia	18869601	12373S001	-	-	-	20120215	-
1887	BAIL	Baikonur, Kazakhstan	18879701	25603S001	-	-	-	20120213	-
1888	SVEL	Svetloe, Russia	18889801	12350S002	X	X	-	20190305	-
1889	ZELL	Zelenchukskya, Russia	18899901	12351S002	X	X	-	20190305	-
1890	BADL	Badary, Russia	18900901	12338S004	X	X	X	20190305	-
1891	IRKL	Irkutsk, Russia	18915301	12313S007	X	-	-	20140902	-
1893	KTZL	Katzively, Ukraine	18931801	12337S006	X	X	-	20110802	-

The Station Plot Working Group lead by Justine Woo has redesigned the Station Performance Pages on the ILRS Website. Justine Woo also did all the programming.

To access station performance information click on the Station Code hyperlink to go to a station's main page.

Updates to Station Pages on ILRS Website



There are 6 tabs on each station's page. Four of these tabs contain interactive Plots of your data going back to when the CRD format was implemented in May 2012.

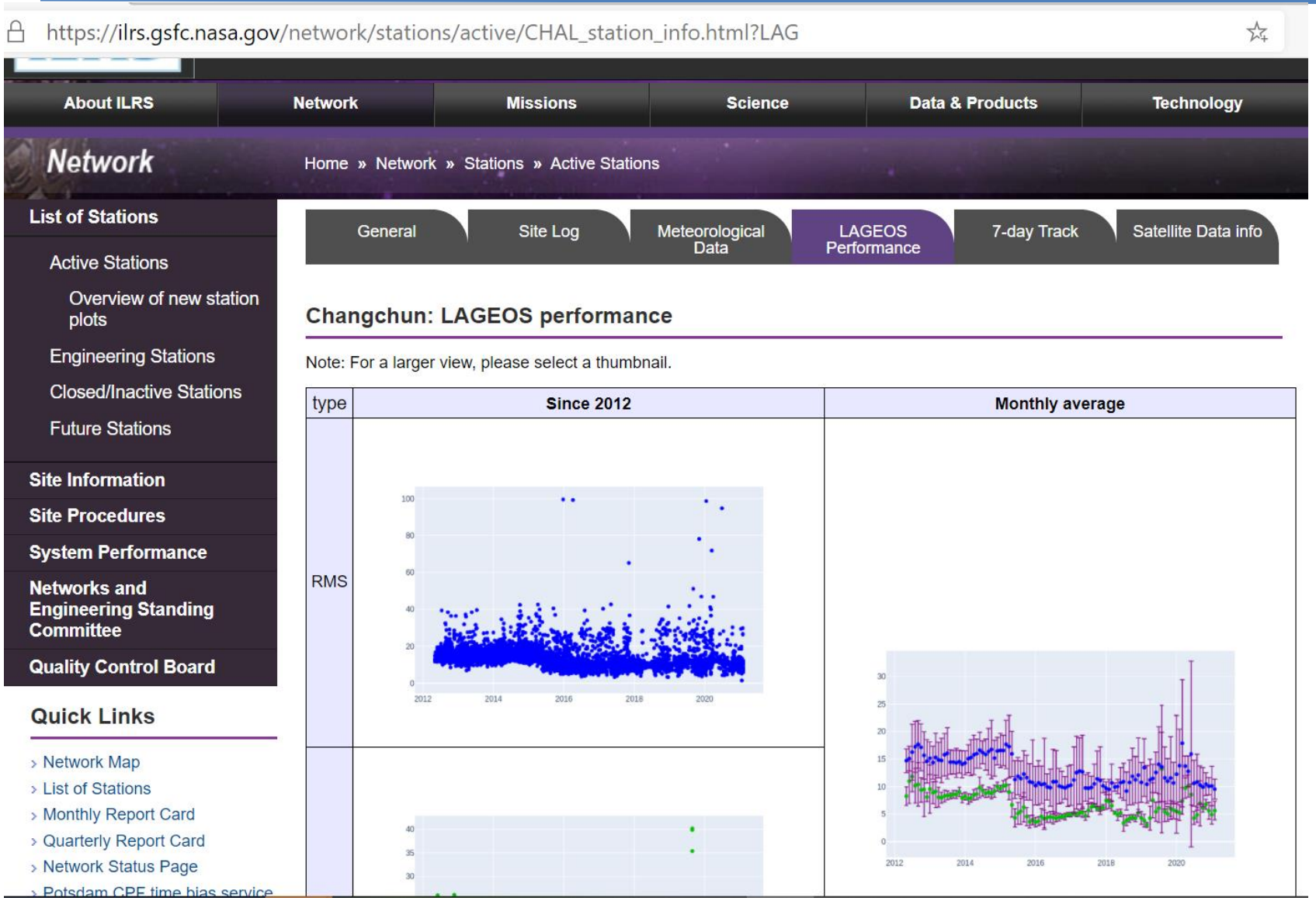
Some plots are updated daily.

The 4 tabs are

1. Meteorological Data
2. LAGEOS Performance
3. 7-day Track
4. Satellite Data Info

For more information about this plots Click on the "Overview of new station plots" On the left menu bar.

Updates to Station Pages on ILRS Website



On the LAGEOS Performance Page you can track the RMS performance of your system on a pass segment or monthly basis.

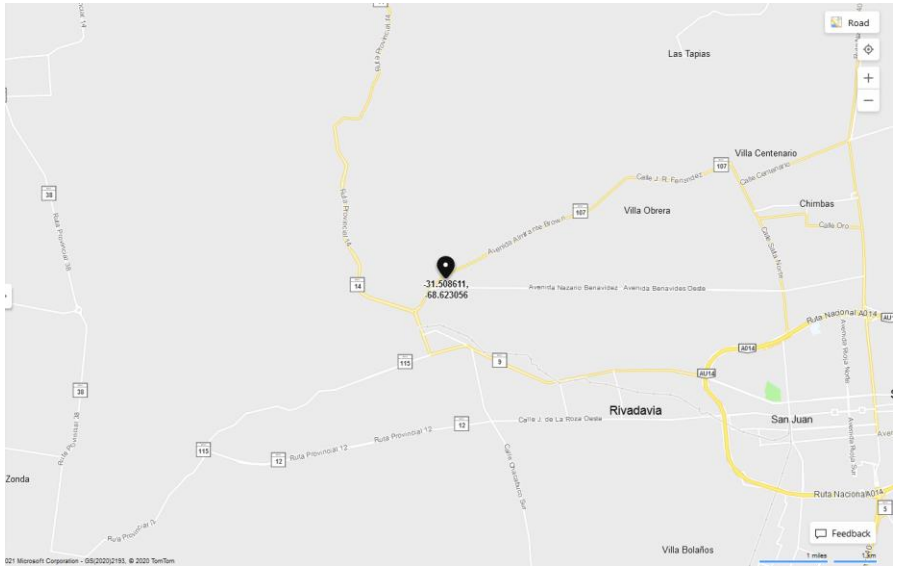
Now, both your monthly calibration and satellite RMSs are graphed on the same plot.

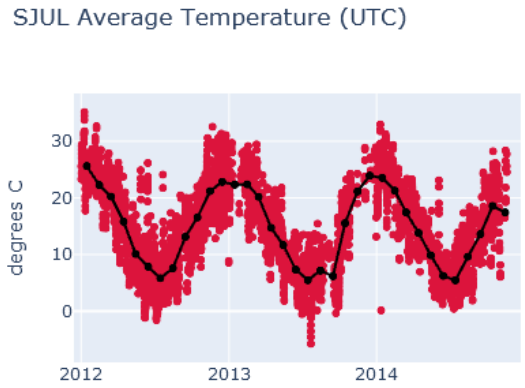
You can also track changes in your system delay another critical system performance parameter.

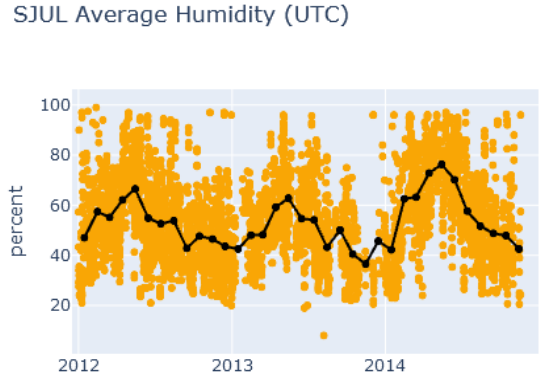
Progress on San Juan laser station (7406)

Background Info

- The San Juan laser station (SJUL) is located at (S 31°30'31", W 68°37'23", 727.3m) in San Juan of the Republic of Argentina.
- The station sits in the campus of Observatorio Astronomico "Felix Aguilar" (OAFA), affiliated to Universidad Nacional de San Juan (UNSJ).

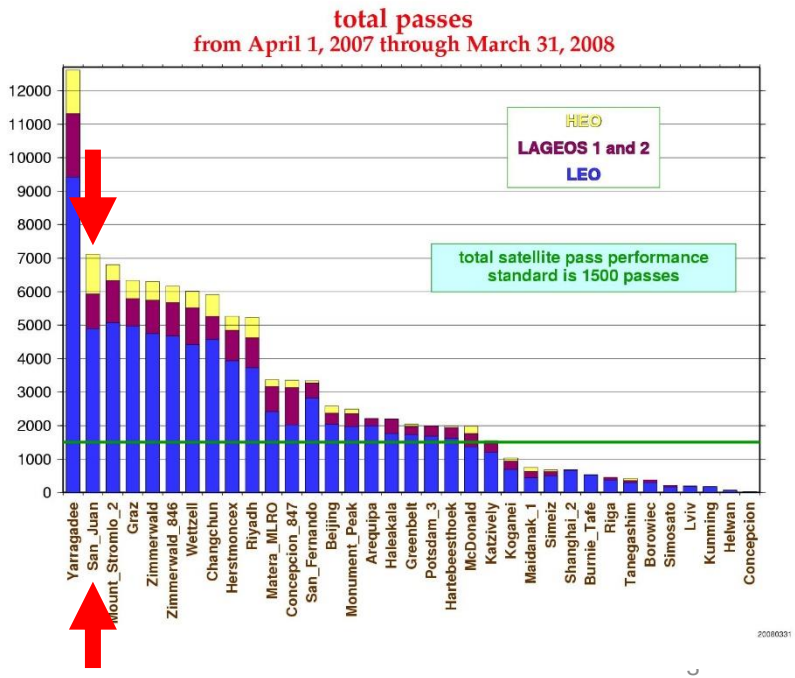






Establishment of SJUL station

- An SLR system with a 60cm-diameter telescope was made in China and was moved to the OAFA of UNSJ at the end of 2005 and it started observation and provide data to International Laser Ranging Service (ILRS) at the end of February, 2006.



SJUL station status and plan

Modules	Current Status	Plan
Telescope	60-cm Cassegrain with Az-El mount	Upgrade encoder, repair servo
Laser	Nd:YAG @532nm 50mJ x 20 Hz, FWHM 50ps	Nd:YAG @532nm 1.2mJ x 1 kHz, FWHM 35ps
Detector	C-SPAD	Keep
Timer	SR620	Event Timer A032
Controls	Computer	Upgrade software

- The SJUL station stopped data upload since 2014.

Progress Timeline

- July 2019
  - Check equipment before packing.
- September 2019
  - Equipment on board for Argentina.
- November 2019
  - Equipment arrived in San Juan.
- February 2020
  - Planned to start work in San Juan.
- ……
- Now
  - Waiting for end of epidemic.
  - Waiting for consular service.

Future Applications?

- The SJUL station is important in ILRS network
- And what other things can be done at the site?
- I heard about:
  - Laser communication
  - Quantum experiment (With QUESS/Mozi satellite)
  - Lunar laser ranging
  - What do you think?

Many thanks to Agentina colleagues And ILRS community

Instituto Geográfico Nacional
Centro Nacional de Información Geográfica

Information needed for CoM computation and data quality assessment

IGN/Yebes ASC

José Rodríguez

2021-02-25

Gobierno de España · Ministerio de Transportes, Movilidad y Agenda Urbana · Instituto Geográfico Nacional

Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

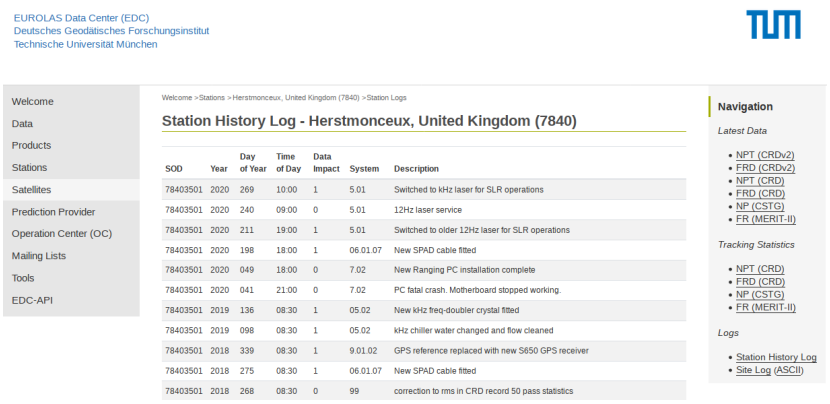
Infraestructuras Científicas y Técnicas Singulares

YEBES

The Site logs and Station Change History logs are vital to ensure the quality of ILRS products:

- They are needed for the computation of suitable centre of mass corrections for the satellites tracked
- They contain information that can reveal the cause(s) of potential problems in the data
- They are a useful resource for the SLR community (*who's using or doing what?*)

I will highlight next some of the most important items needed, and provide examples of their use


EUROLAS Data Center (EDC)
Deutsches Geodätisches Forschungsinstitut
Technische Universität München

Welcome
Data
Products
Stations
Satellites
Prediction Provider
Operation Center (OC)
Mailing Lists
Tools
EDC-API

Welcome >Stations >Herstmonceux, United Kingdom (7840) >Station Logs

Station History Log - Herstmonceux, United Kingdom (7840)

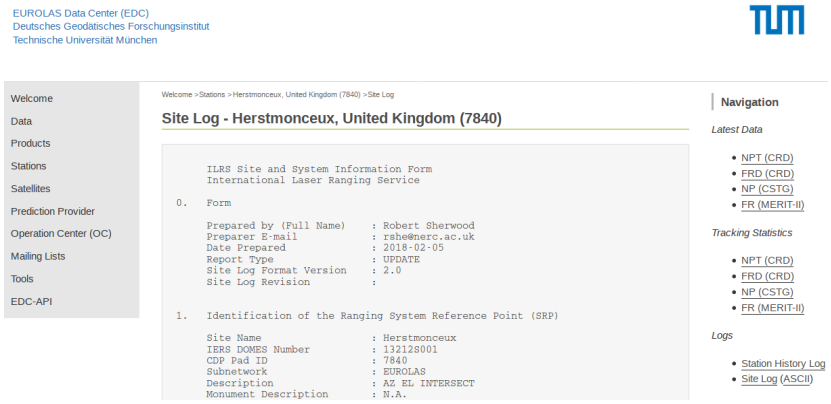
SOD	Year	Day of Year	Time of Day	Data Impact	System	Description
78403501	2020	269	10:00	1	5.01	Switched to kHz laser for SLR operations
78403501	2020	240	09:00	0	5.01	12Hz laser service
78403501	2020	211	19:00	1	5.01	Switched to older 12Hz laser for SLR operations
78403501	2020	198	18:00	1	06.01.07	New SPAD cable fitted
78403501	2020	049	18:00	0	7.02	New Ranging PC installation complete
78403501	2020	041	21:00	0	7.02	PC fatal crash. Motherboard stopped working.
78403501	2019	136	08:30	1	05.02	New kHz freq-doubler crystal fitted
78403501	2019	098	08:30	1	05.02	kHz chiller water changed and flow cleaned
78403501	2018	339	08:30	1	9.01.02	GPS reference replaced with new S650 GPS receiver
78403501	2018	275	08:30	1	06.01.07	New SPAD cable fitted
78403501	2018	268	08:30	0	99	correction to rms in CRD record 50 pass statistics

Navigation

Latest Data
- NPT (CRDv2)
- FRD (CRDv2)
- NPT (CRD)
- FRD (CRD)
- NP (CSTG)
- FR (MERIT-II)

Tracking Statistics
- NPT (CRD)
- FRD (CRD)
- NP (CSTG)
- FR (MERIT-II)

Logs
- Station History Log
- Site Log (ASCII)


EUROLAS Data Center (EDC)
Deutsches Geodätisches Forschungsinstitut
Technische Universität München

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Site Log - Herstmonceux, United Kingdom (7840)

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     ILRS Site and System Information Form
     International Laser Ranging Service

0.   Form

     Prepared by (Full Name)    : Robert Sherwood
     Preparer E-mail            : rshe@nerc.ac.uk
     Date Prepared              : 2018-02-05
     Report Type                : UPDATE
     Site Log Format Version    : 2.0
     Site Log Revision          :


1.   Identification of the Ranging System Reference Point (SRP)

     Site Name                  : Herstmonceux
     IERS DOMES Number          : 13212S001
     CDP Pad ID                 : 7840
     Subnetwork                 : EUROLAS
     Description                : AZ EL INTERSECT
     Monument Description       : N.A.
```

Navigation

Latest Data
- NPT (CRD)
- FRD (CRD)
- NP (CSTG)
- FR (MERIT-II)

Tracking Statistics
- NPT (CRD)
- FRD (CRD)
- NP (CSTG)
- FR (MERIT-II)

Logs
- Station History Log
- Site Log (ASCII)

CoM: things *included* in the modelling

- Cube corner retroreflector physical characteristics (material, size, recess depth)
- Retroreflector array geometry (individual CCR positions and orientations)
- Average return rates
- Laser pulse length and frequency
- Photodetector type and characteristics (jitter and rise time if multi-photon)
- Timing device precision
- Operation policy (single-photon/everything else)
- Data reduction procedure (CAL & SAT)

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GROUND SEGMENT INFORMATION

CoM: things *not included* in the modelling

- Laser polarisation
- Level of theory: geometrical optics
- Presence of other devices in the detection chain, like amplifiers
- Contribution to electrical signals spread caused by e.g. cabling
- Calibration with different setups to those used for satellite ranging
- Gross deviations from stated operational policy
- Any divergence from nominal operation (as detailed in system logs)
- Any deviation from stated data reduction policy
- Any other undocumented issues

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GROUND SEGMENT ISSUES

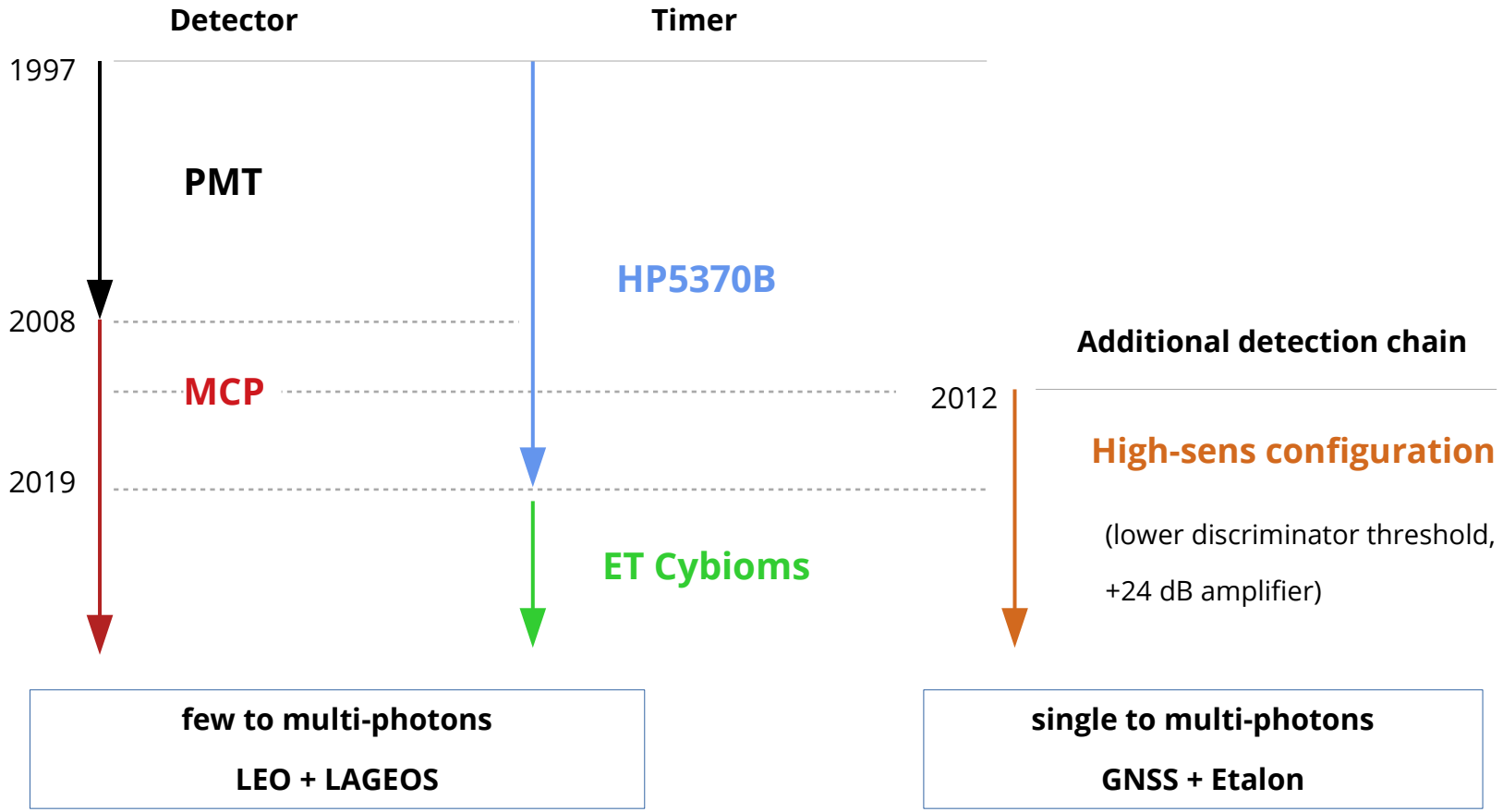
With the information provided, CoM values can be computed, and potential anomalies monitored and rationalised

- The **Analysis Standing Committee** monitors range biases for the whole network, current and historical
- Several Analysis Centres make available **QC solutions** for the most recent data
- The **Quality Control Board** discusses issues that may need consideration

Table 2: Performance parameters based on various Analysis Centers' rapid orbital analysis results.

Site Information		DGFI Orbital Analysis				Hitotsubashi Univ. Orbital Analysis				JCET Orbital Analysis				MCC Orbital Analysis				SHAO Orbital Analysis			
Station Location	Station Number	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP
Baseline		10.0	20.0	10.0	95	10.0	20.0	10.0	95	10.0	20.0	10.0	95	10.0	20.0	10.0	95	10.0	20.0	10.0	95
Kiev	1824									8.7				33.5				0.0			
Komsomolsk	1868					5.2	15.4	16.6	100	4.5	21.0	20.9	96	5.2	21.0	11.1	97	3.8	22.2	10.9	92
Simeiz	1873					26.2	32.2	19.8	98	4.7	43.9	8.8	55	20.6	46.9	15.8	85	9.5	59.8	36.5	56
Mendeleevo	1874					4.7	22.2	10.4	100	5.3	24.1	17.0	91	38.8	9.5	5.9	96	5.2		13.8	95
Altay	1879					2.2	20.2	21.5	100	2.3	24.9	24.4	99	3.6	20.1	16.7	99	0.9	22.8	15.6	96
Riga	1884					1.5		28.1	100	2.7		27.9	79	3.0				1.0		28.7	92
Arkhyz	1886					3.5	28.3	9.0	100	3.6	30.3	12.7	93	3.7	25.8	9.1	98	2.7	31.1	10.9	97
Baikonur	1887					4.1	13.5	13.0	100	3.5	27.2	20.6	93	11.7	14.2	11.3	97	2.8	27.0	23.6	95
Svetloe	1888					5.2	9.1	7.8	100	4.1	20.3	6.9	94	5.9	15.0	5.0	98	3.4	27.3	5.2	94
Zelenchukskaya	1889					3.0				3.0											
Badary	1890					6.7	15.9	10.1	100	4.9	26.7	10.2	95	7.1	16.0	8.0	96	3.5	33.3	8.7	93
Irkutsk	1891					6.5	20.2	9.1	100	5.6	20.0	9.3	89	6.8	9.7	3.8	94				
Katzively	1893					7.8	22.3	13.5	98	5.2	25.0	11.9	77	8.8	18.0	8.8	90	7.8	21.8	10.4	94

Example: tracking system changes in Tahiti 7124



Example: tracking time series jumps in 7838 Shimosato

Although **SLR** has far **fewer discontinuities** than **GNSS**, they are known to happen

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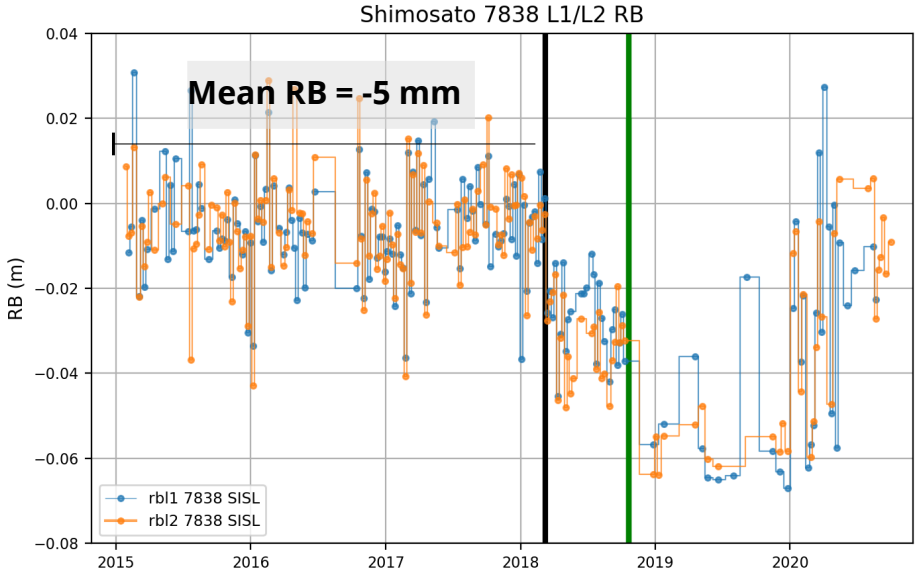

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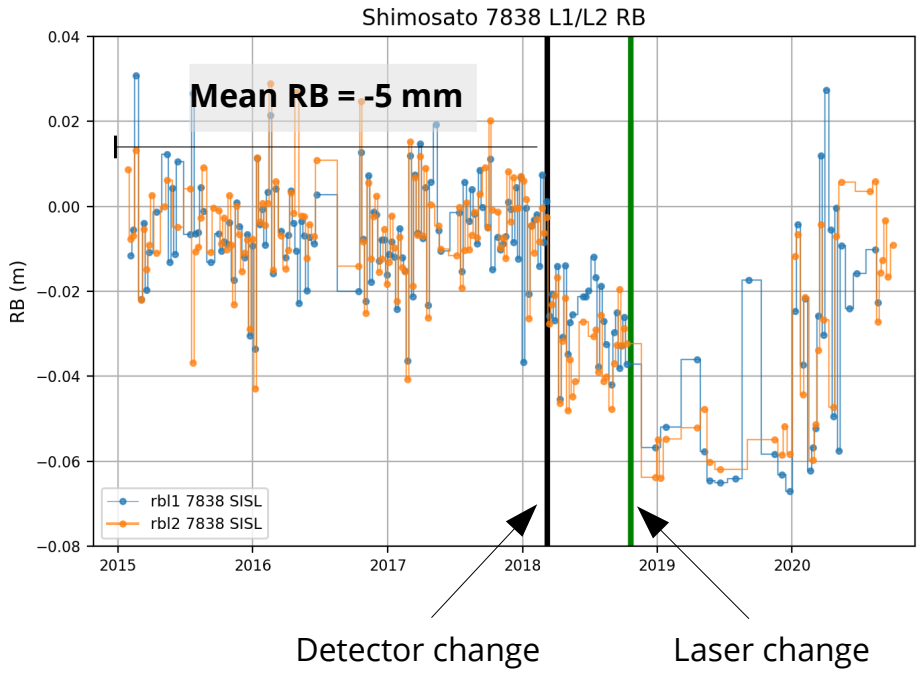

With the information provided, we an correlate significant events with features in the data:

- New **detector** in early 2018, similar characteristics to previous one
- New **laser** in late 2018: 10 ps increase in pulse width: small change

Example: tracking time series jumps in 7838 Shimosato

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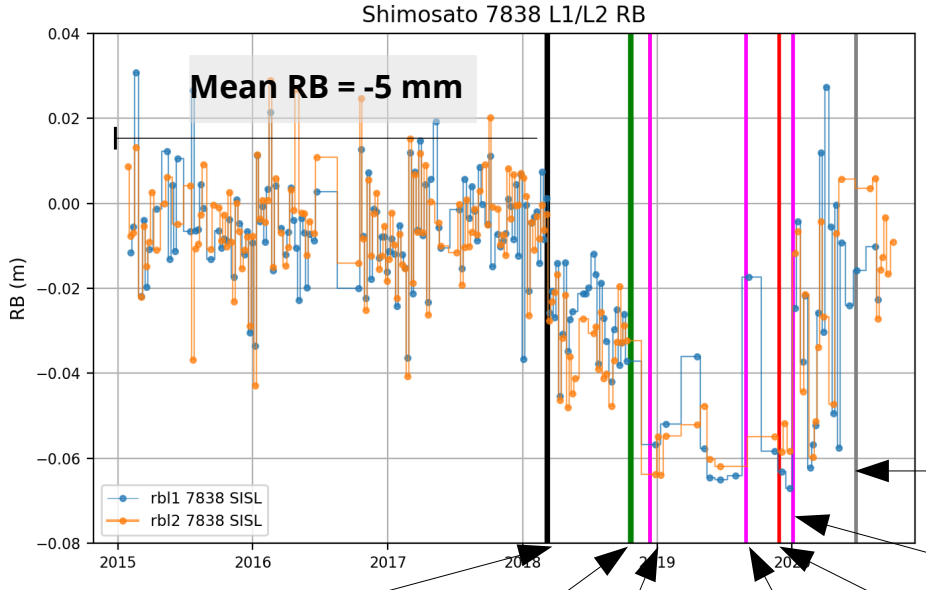

Detective work required to assess which events are significant → only possible thanks to accurate log keeping

New discrimination system

Amplifier disabled

Amplifier switch

Amplifier off

Amplifier on

Laser upgrade

Detector replaced

Example: tracking time series jumps in 7838 Shimosato

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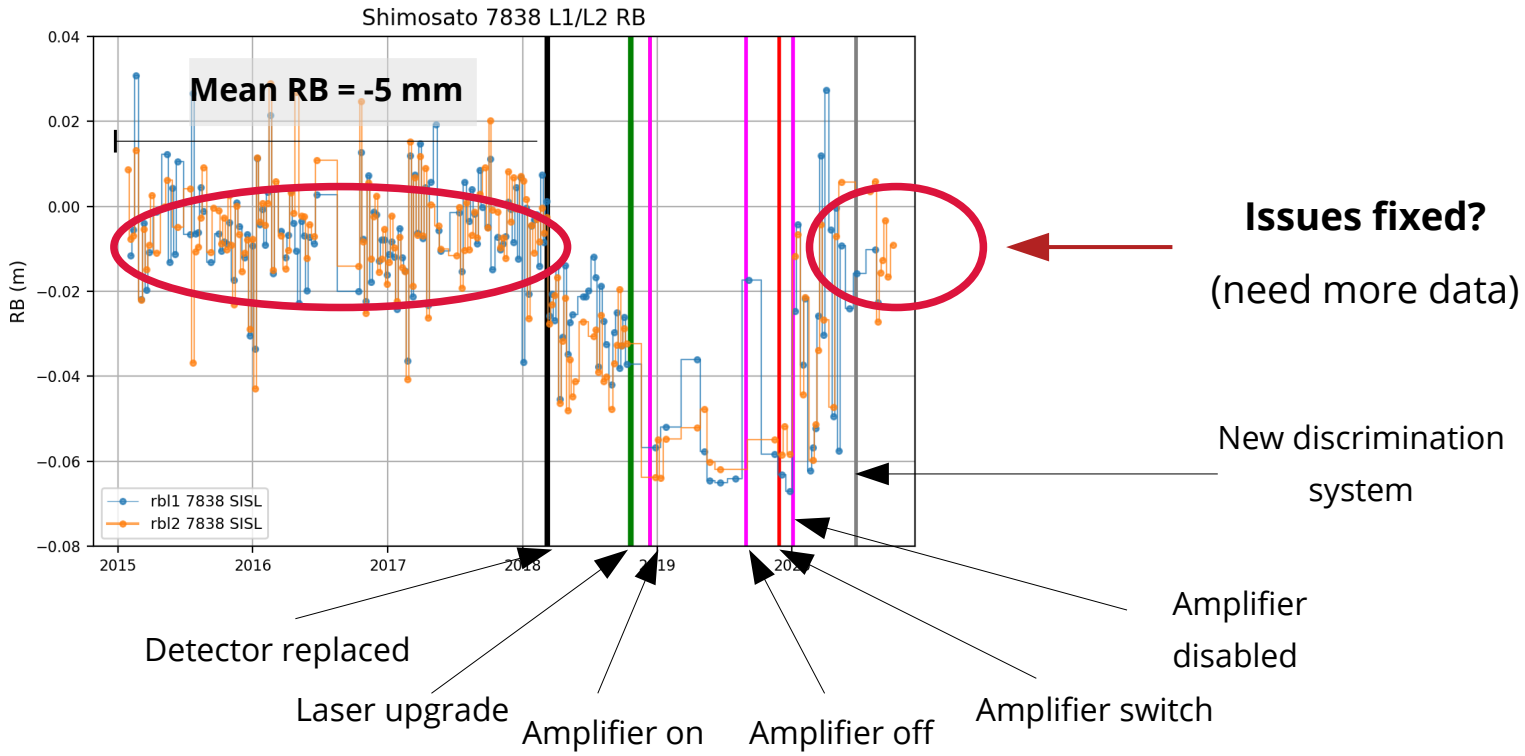


Concluding notes

- For CoM modelling nominal operation always assumed
- Computations performed on the basis of the information available:
  - If something changes, it has to be reflected in the logs
- Long-term, stable biases are modelled well by the Analysis Standing Committee
- Discontinuities need all possible information to rationalise
- Online resources available to track station performance
- The ILRS community itself is a resource that can offer help

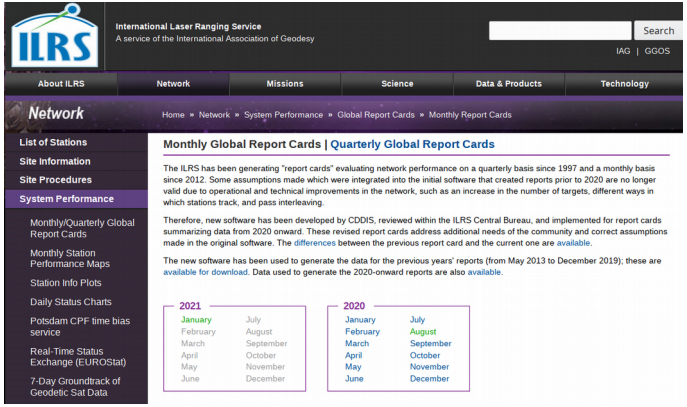
- I commend the stations mentioned (Tahiti, Shimosato) for making the required information available

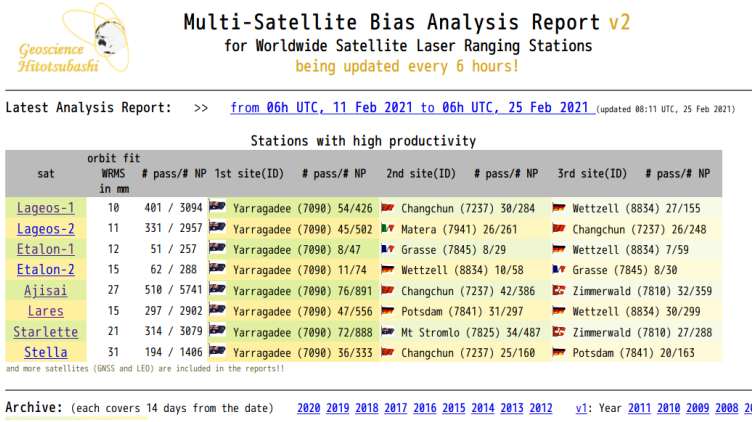
Some online resources

https://ilrs.gsfc.nasa.gov/network/system_performance/global_report_cards/monthly/

http://geodesy.jcet.umbc.edu/ILRS_AWG_MONITORING/

http://geo.science.hit-u.ac.jp/slr/bias/





Thank you

2. CoM: things *adjusted* in the modelling

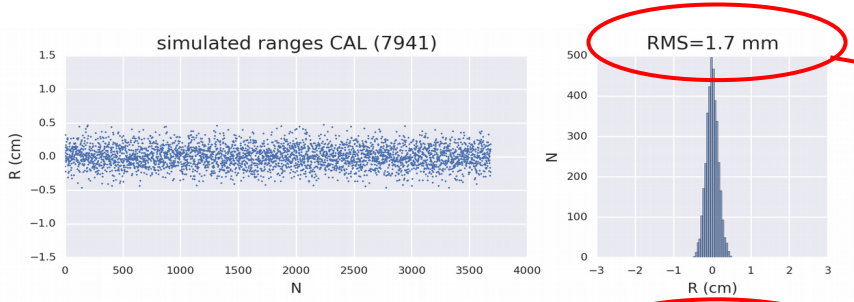
- Average **optical properties** of retroreflector array
  - Includes aberration, thermal effects and imperfect geometry (or CCR spoiling)
  - How? → from millions of strictly single-photon data points from Herstmonceux
  - Does it work? → YES (Rodríguez et al, Upgraded modelling for the determination of centre of mass [...], JoG 2019)

- **Discriminator settings** for multi-photon operation and PMT/MCP detectors
  - Nobody knows these values, and they change if station engineers tweak settings
  - How? → Manually, on the basis of agreement between simulated and empirical detection distributions
  - Does it work? → Confident for LAGEOS, more uncertain for bigger targets

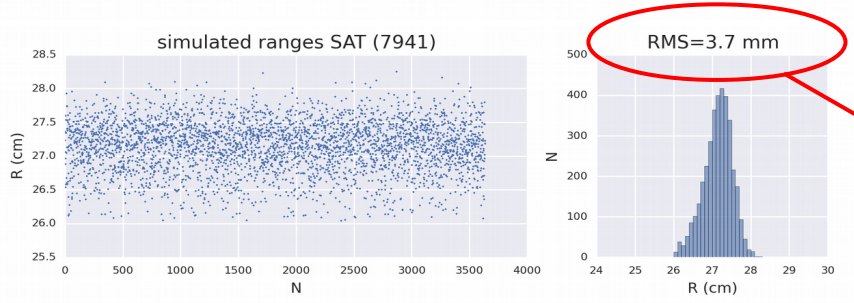
From Rodríguez et al. Updated CoM tables […], Canberra, 2018

3. CoM computation

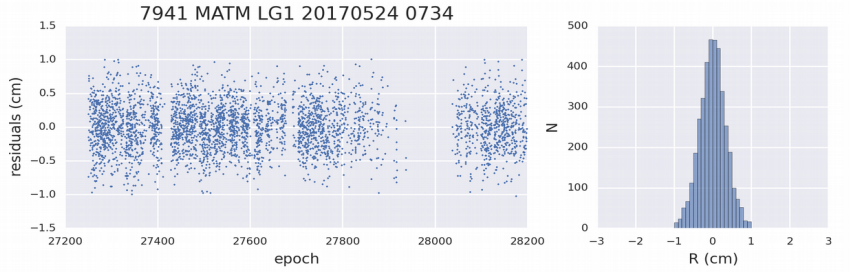
CAL simulation

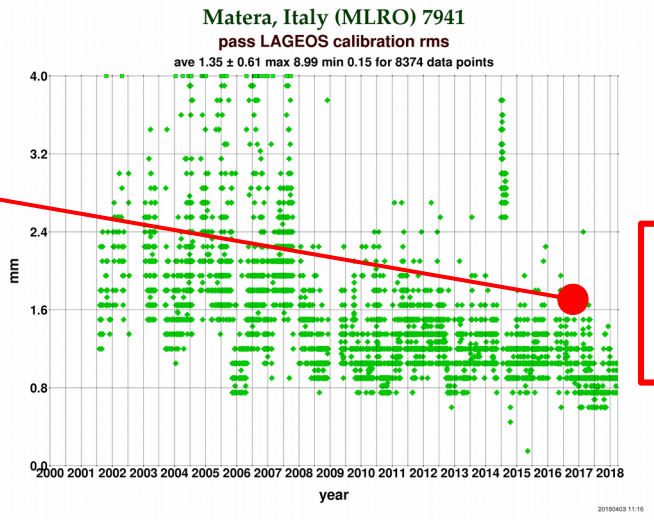


SAT simulation

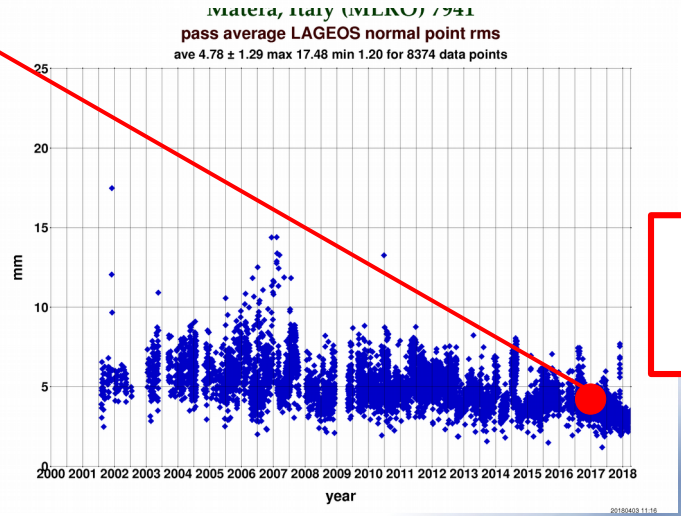


SAT empirical





CAL RMS consistency ?



SAT RMS consistency ?