Riga – Latvia
ILRS Technical Workshop
October 2-5 2017

WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES

GOVUS – a new on-line tool for the evaluation of SLR observations to GPS, GLONASS, Galileo, BeiDou and QZSS

How do we evaluate our current performance?

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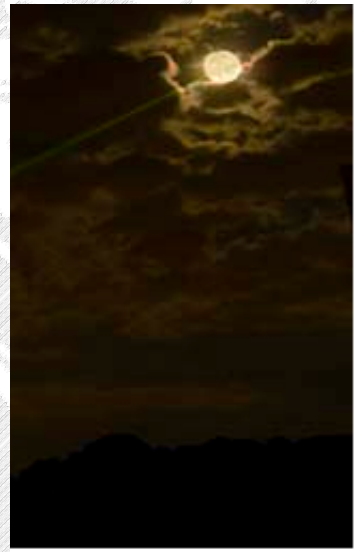
GOVUS
SLR@MULTI-GNSS SERVICE

New ILRS AAC at IGG



atmosphere - NRL/Jake Griffin

has informed the ILRS that SpinSat re-entered late on March 11, 2017. The last track of the satellite was received that day at 22:39 UTC from a Space Surveillance Network station located in the UK. NRL has expressed its gratitude to the ILRS for supporting the mission.

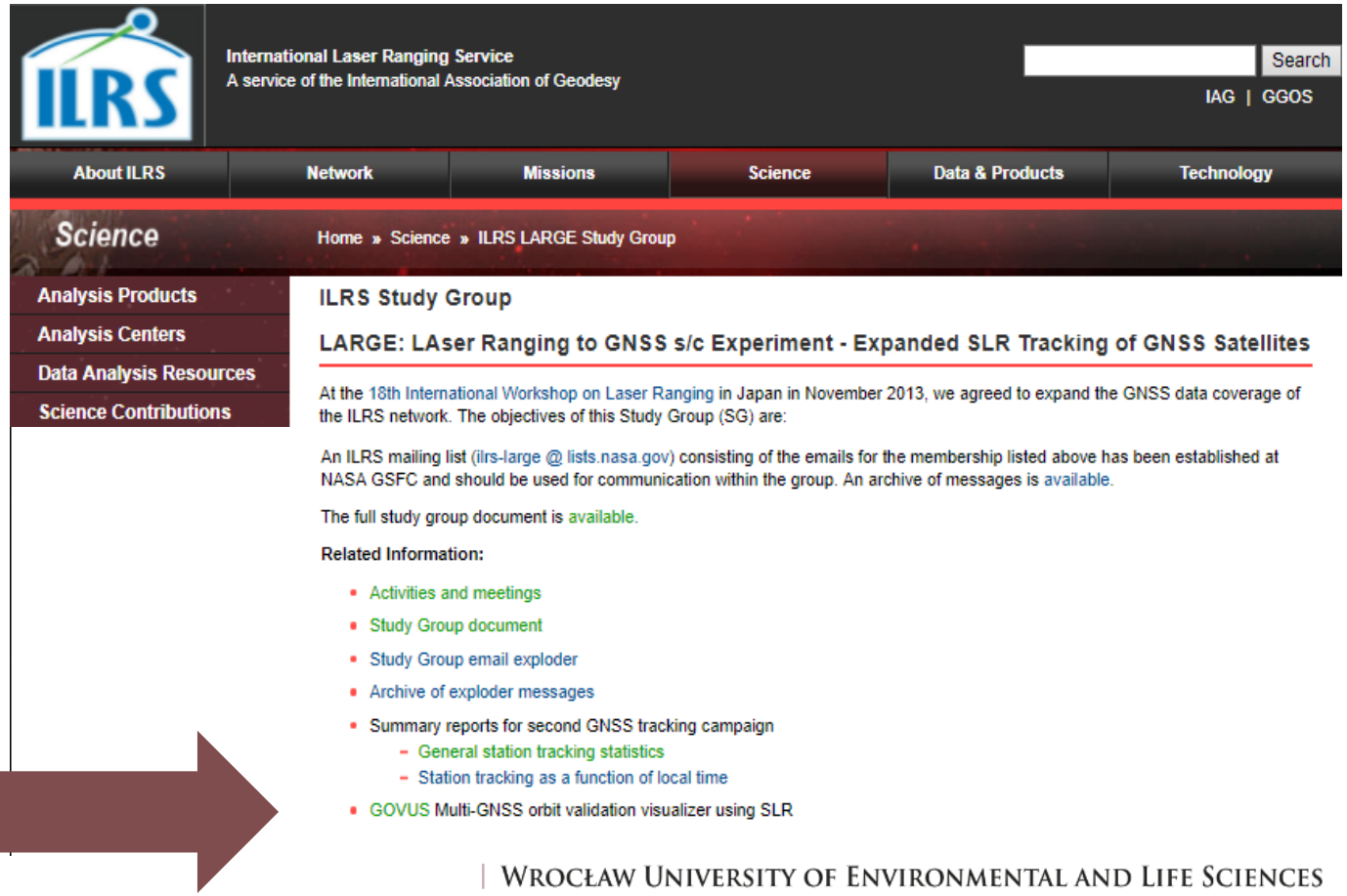
- **New ILRS AAC at IGIG** - The ILRS is pleased to welcome the Wroclaw University of Enviromental and Life Sciences (WUELS), Institute of Geodesy and Geoinformatics (IGIG) as an ILRS Associate Analysis Center (AAC). Krzysztof Sosnica's group at the Institute is generating scientific products based on the SLR observations to new GNSS systems on the operational basis. IGIG generates daily reports that include a comparison between IGS MGEX orbits of GLONASS, Galileo, BeiDou MEO, BeiDou IGSO and QZSS satellites and SLR observations collected by a global network of ILRS stations.

ds

k are nearly saturated in
is presently assessing its
its utility. We recently sent
rs and groups to ask for

New ILRS Associate Analysis Center at the Institute of Geodesy and Geoinformatics, WUELS, Wroclaw, Poland

- https://ilrs.cddis.eosdis.nasa.gov/science/ILRS_LARGE_sg/index.html
- http://multi.slrgnss.rhcloud.com



Overview

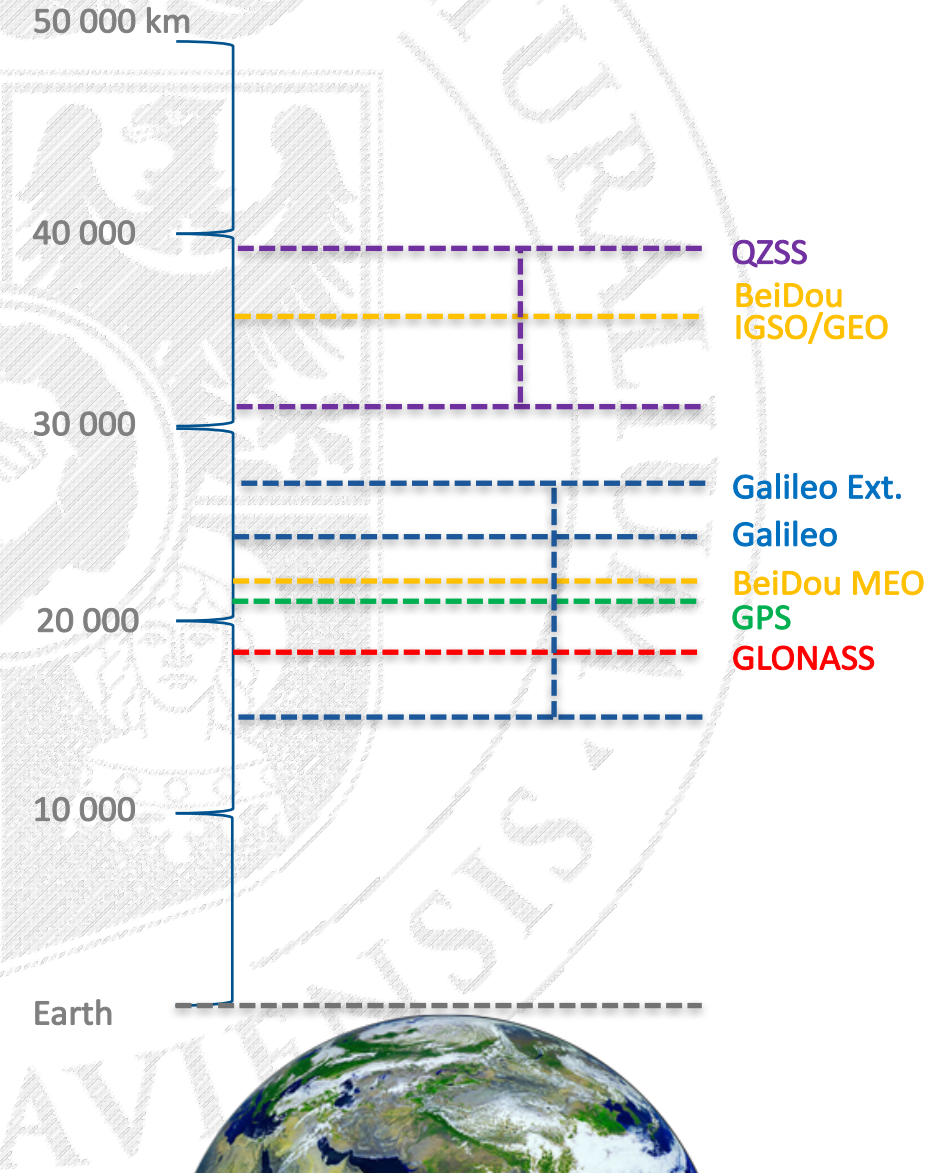
- **Main goal**: Processing of **SLR observations to new GNSS systems**: **GLONASS, Galileo, BeiDou, QZSS, GPS Block III** (in future) and supporting the MGEX/LARGE activities
  - * IGS Multi-GNSS Pilot Project
  - ** ILRS Study Group: Laser Ranging to GNSS s/c Experiment

- **Current activities**

1. **Validation of microwave-based GNSS orbits** using SLR observations (Near-real time every day validation) ← fast feedback for stations
2. **Web-application development (GOVUS)** for the analysis of SLR residuals to GNSS

A. maintain the database storing data related with SLR@GNSS

Current activities (1) **Orbit validation**



- Currently we are focused on the **CODE* orbit solution**, which is delivered in the frame of MGEX (Prange et al. 2017)
  GLONASS, Galileo, BeiDou-2 (excluding GEO), QZSS
  ~60 satellites

- Computational process of SLR validation is made using modified version of **Bernese GNSS software**** (version 5.2)

* **Center for Orbit Determination in Europe**

** Bernese GNSS Software
Version 5.2

Current activities (1a) **Daily Reports and Database System**

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multiGNSS Quick-Look Residual Analysis Report
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Remarks: - Residuals are referred to the SLRF2014.
         - Antenna thrust (GLONASS, Galileo, QZSS)
         - Albedo model (GLONASS, Galileo, QZSS)
         - GPS satellites are indicated with the character 'G',
           GLONASS satellites with the character 'R'
           Galileo satellites with the character 'E'
           BeiDou satellites with the character 'C'
           QZSS satellites with the character 'J'
         - The SLR residuals are calculated w.r.t. official microwave
           MGEX CODE 3-day GNSS orbits.

More statistics and the description of the solutions are available at:
multiGNSS Orbit Validation Visualizer Using SLR (GOVUS)
http://www.multi-slrgnss.rhcloud.com

STATION ID       SAT  START PASSAGE   DUR   #OBS  MEAN  STD   #OBS  MEAN   STD
                 PRN  yy/mm/dd hh:mm (min)  GOOD  (mm)  (mm)   BAD   (m)   (m)
-------------------------------------------------------------------------------
1868 12341S001   R02  17/08/11 16:53   92     7   -36   12
1868 12341S001   R11  17/08/11 17:13   28     5   -37   16
1874 12309S003   R03  17/08/11 18:04   92     9   -30   15
1874 12309S003   R04  17/08/11 18:49   63     6   -19   16
1879 12372S001   R02  17/08/11 17:15    5     3   -46    3
```

What we can find ?

- **Summary of validation** result covering **last 20 days** from submmision date in reference to the availability of new ephemeris end Earth Rotation Parameters
- **About the authors and solution (SLRF2014, Antenna Thrust and Albedo Model)**

Where ?

On the webpage

- **http://multi-slrgnss.rhcloud.com/slr/daily/**

Using the url pattern

- *multi-slrgnss.rhcloud.com/report/17%doy_REPORT.ALL*

doy is a „day of the year” of report submision

Example

http://multi-slrgnss.rhcloud.com/report/17077_REPORT.ALL

download report from 77th day of the year 2017

Current activities (1b) **Daily Reports and Database System**

We maintain the **accesible database system** which includes SLR@GNSS information about:

- **ILRS laser stations** (including detector type, repetition rate, energy, timer type, wavelength)

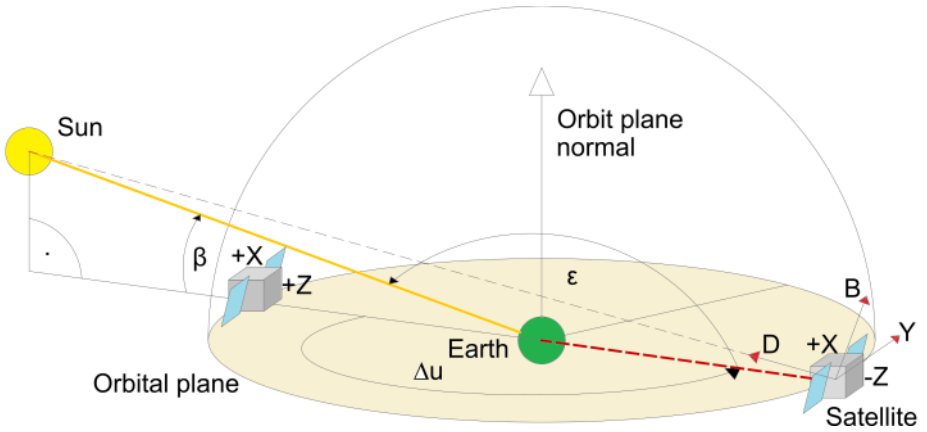
Nr	Code	Place	Count	Plate	SUBN	Long [°]	Lat [°]	Laser Type	WL [nm]	MRR [Hz]	DT	Timer	Beam	PulseW [ps]	ME [mJ]
1884	RIGL	Riga	Latvia	Eurasian	EUROLAS	56.948 N	24.059 E	ND:YAG	532	10	PMT	event	0.008	150	120

- **satellites** (information about the orbit, plane, slot, time variables such as antenna and LRA offsets, PRN)

Identification				Date		Offset		Satellite			Orbit							SLR/LRA			
PRN	SVN	COSPAR	NORAD	From	To	Offset MV	Offset LRA	Mass [kg]	Type	System	orbit	plane	slot	ALT [km]	RP [h]	i [°]	e	Size	Coat	CC	CC dim	Shape
E18	201	2014-050A	40128	22/08/14	Active	0.1600 -0.0100 1.0500	1.0199 0.0140 0.5585	661.0	FOC	Galileo	MEO	E-Ext	1	23225	12.94	50.1	0.002	331.0/ 248.7	NO	60	28.2/19.1	rectangular

- **SLR residuals** (since 2012, time, ◁ in Sun-Satellite-Earth frame)

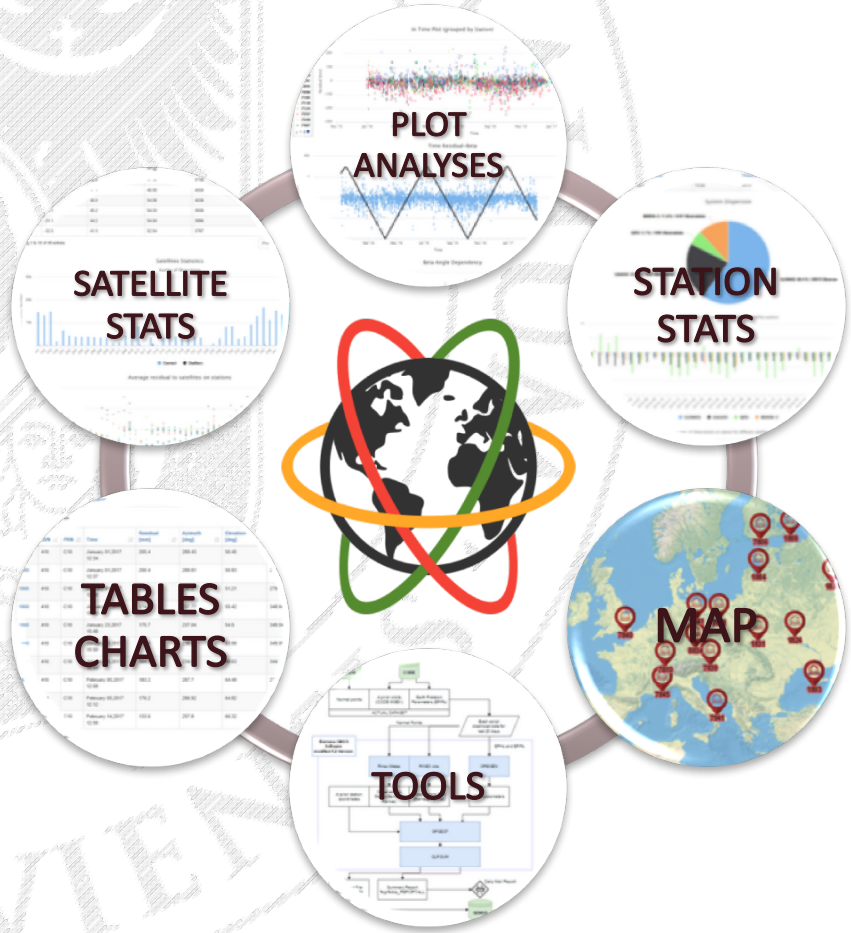
NR	PRN	SVN	Date	Time	Res [mm]	Az [°]	Elev [°]	Az. Sat. [°]	Nadir [°]	Δu [°]	B [°]
7090	E12	102	12/05/25	00:22	-18.8	248.67	56.88	77.03	6.77	-112.77	61.34



What can we do with the data ? (1) GOVUS

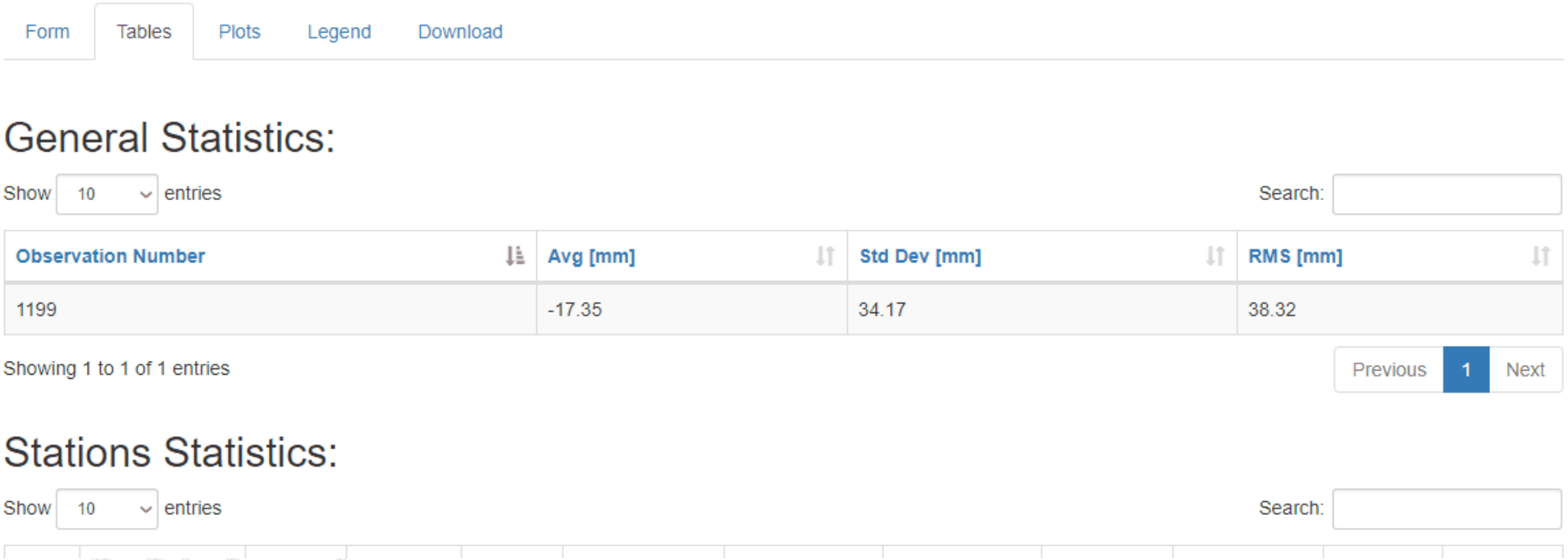
GOVUS
SLR@MULTI-GNSS SERVICE

- **Analyses using the GOVUS on-line application:**
  http://multi-slrgnss.rhcloud.com



How can we read the data ? **(1) GOVUS**

- Using GOVUS we can easily generate filtered dataset
  select particular stations or satellites, change the **timerange,** limit to **specific feature** (**detector/timer** type, **orbital plane**): check the prepared form (**multi-slrgnss.rhcloud.com/slr/plot**)
- Analyse and download the plots:
  dozen of different plots
- Generate tables with core statistics
  general, for stations and satellites



The tutorial movie available at: (**multi-slrgnss.rhcloud.com/slr/info**)

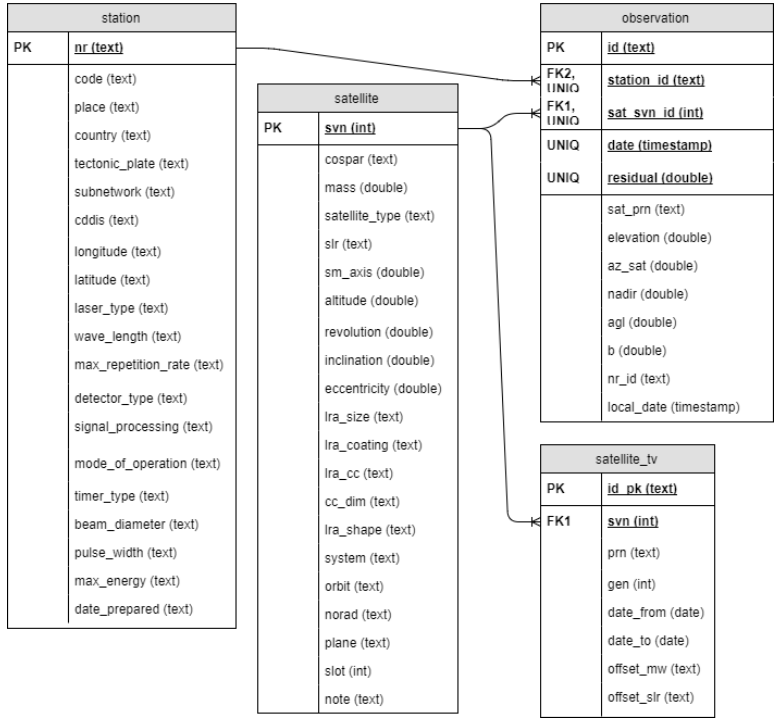
How can we read the data ? (2) GOVUS SQL Explorer

- We share the structure of the database and the tool, which allow to perform the raw sql query: multi-slrgnss.rhcloud.com/explorer

SQL Explorer | New Query | Playground | Logs

10 Most Recently Used

Query	Last Run	CSV
KAMIL PYTA	08/29/2017 11:32 a.m.	
Elongation (Satellite SVN)	08/25/2017 2:03 p.m.	
system statistics (ECOM)	08/25/2017 1:58 p.m.	
Beta ranges	08/19/2017 1:14 a.m.	
Elongation (Satellite type)	08/16/2017 11:12 a.m.	
SATELLITE SHAPE/NADIR	08/14/2017 12:18 p.m.	
GROUP BY SATELLITE TYPE	08/14/2017 11:50 a.m.	
TOP stations for system	08/07/2017 6:50 p.m.	
Percentage System Dispersion	08/07/2017 10:14 a.m.	
station statistics	08/02/2017 5:23 p.m.	



ask for account:
radoslaw.zajdel@igig.up.wroc.pl

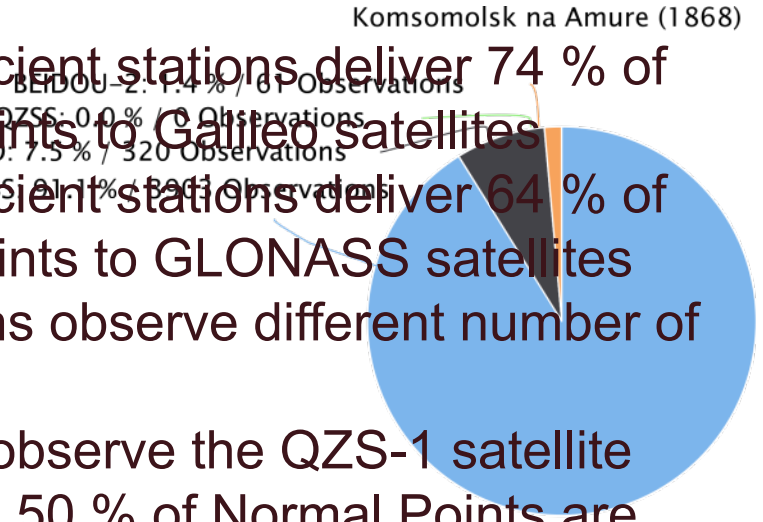
The tutorial movie available at: (multi-slrgnss.rhcloud.com/slr/info)

What can we do with the data ? **GNSS tracking performance of laser stations**

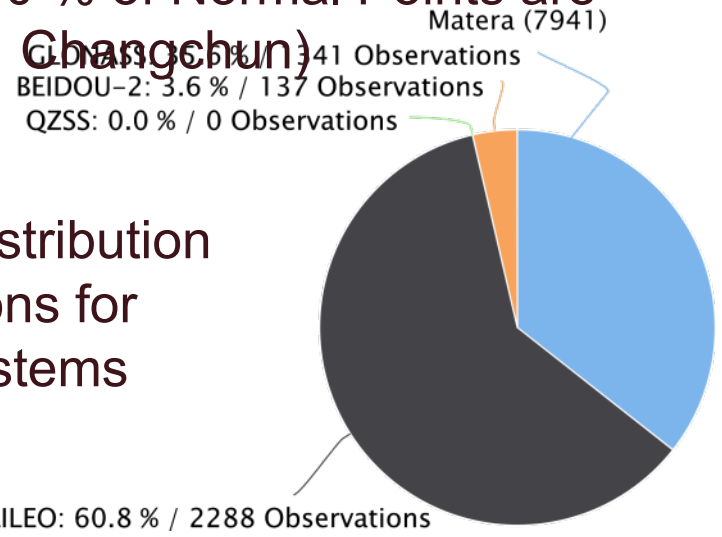
- GOVUS is a **great source of information about the stations' performance**

	Galileo				GLONASS				QZSS			
RANK	STATION	NO. OBS.	SATELLITES	% OF OBS.	STATION	NO. OBS.	SATELLITES	% OF OBS.	STATION	NO. OBS.	SATELLITES	% OF OBS.
1	7090	7082	13	19,3	7090	8112	13	11,8	7237	556	1	53,1
2	7839	3627	13	9,9	7839	8081	26	11,8	7821	213	1	20,3
3	7237	3623	13	9,9	7237	6466	16	9,4	7090	210	1	20,1
4	7825	3240	13	8,8	7840	5489	26	8,0	7825	34	1	3,3
5	8834	2812	13	7,6	1879	3993	16	5,8	7249	33	1	3,2
6	7840	2804	13	7,6	8834	3978	16	5,8				
7	7941	2288	13	6,2	1868	3903	16	5,7				
8	7821	1500	12	4,1	7821	3875	23	5,6				
Total				73,4				63,9				100

- 8 most efficient stations deliver 74 % of Normal Points to Galileo satellites
- 8 most efficient stations deliver 64 % of Normal Points to GLONASS satellites
- The stations observe different number of satellites
- 5 stations observe the QZS-1 satellite (more than 50 % of Normal Points are delivered by Changchun)

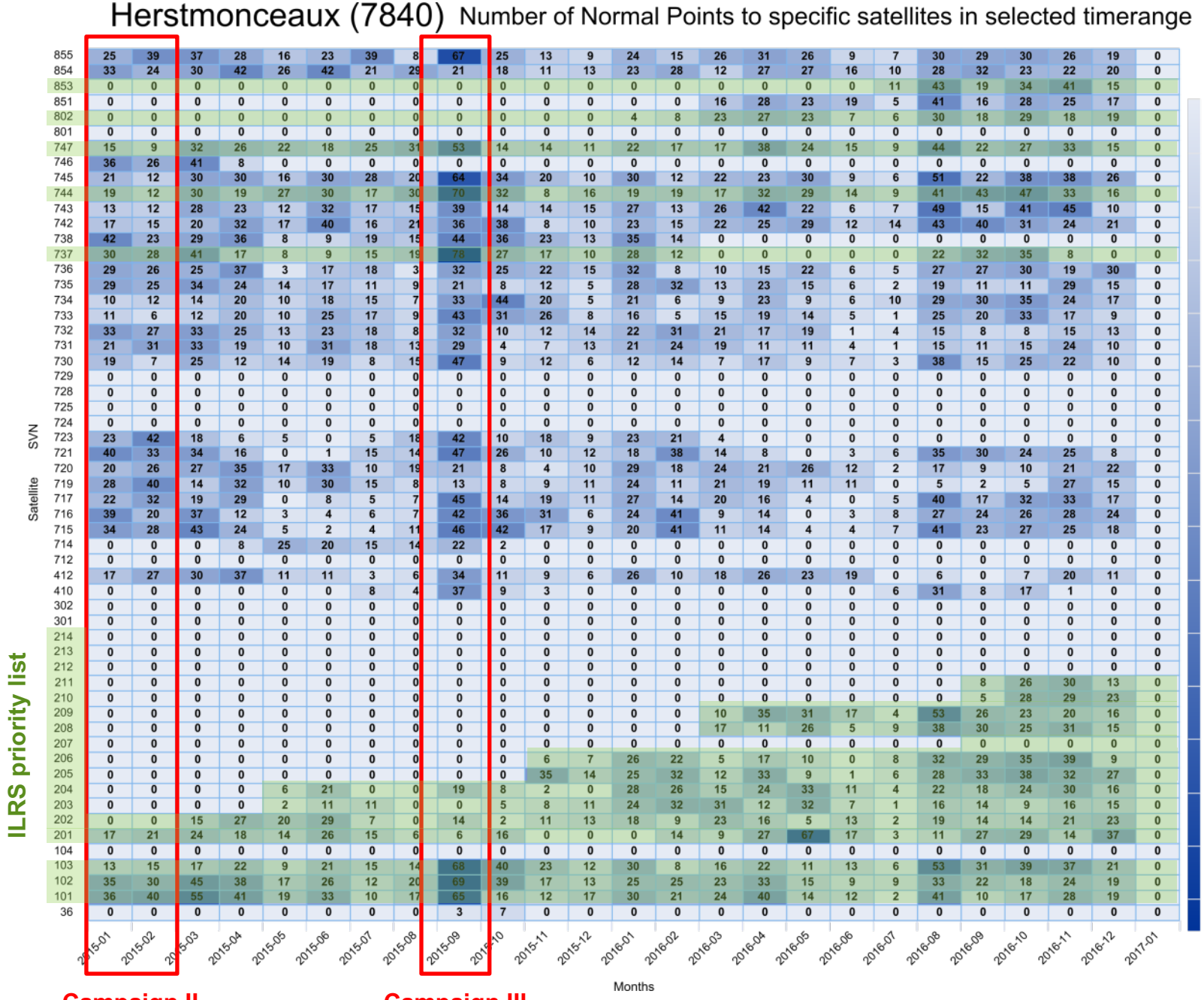


Check the distribution of observations for particular systems



What can we do with the data ?
How do we track multi-GNSS constellation ?

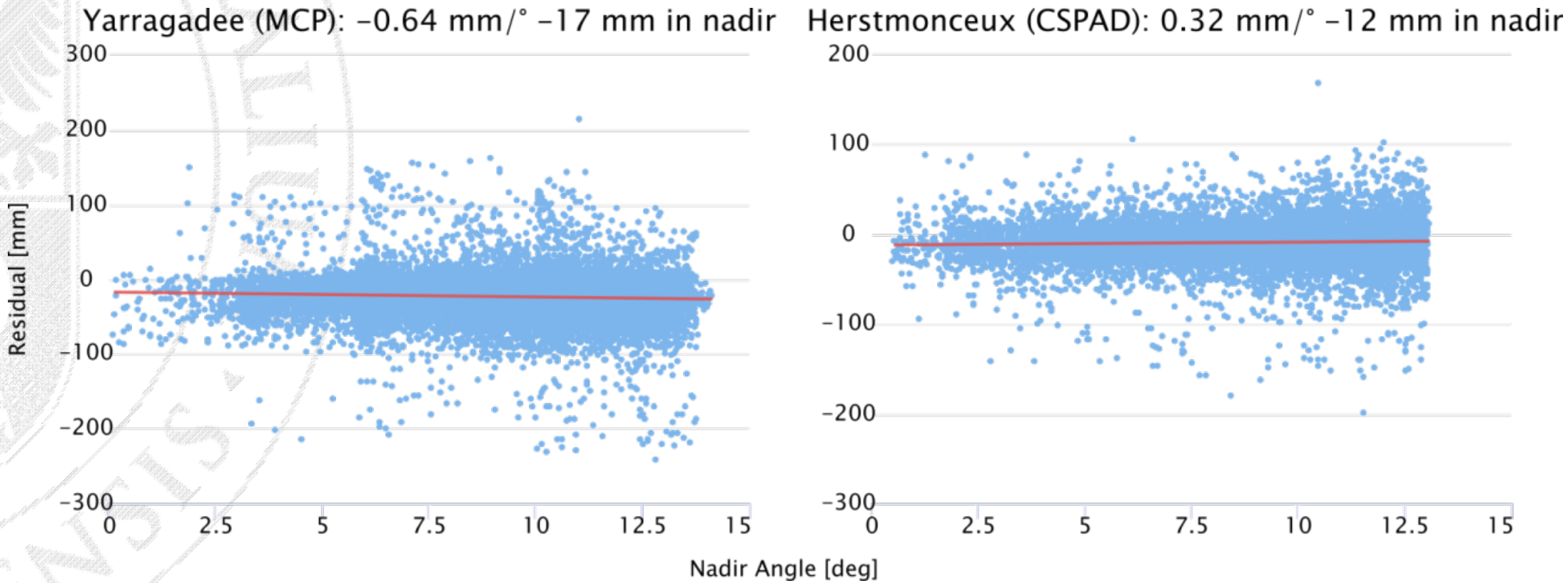
- Monitor the **number of Normal Points to particular satellites** collected by **specific laser stations** in **selected timerange**
- The status of Expanded SLR **Tracking Campaigns of GNSS Satellites**
- How do we meet the requirements of the **ILRS tracking priority list**



What can we do with the data ? **Vulnerability to Satellite Signature Effect**

- We can monitor the systematics related to the stations for example the Satellite Signature Effect

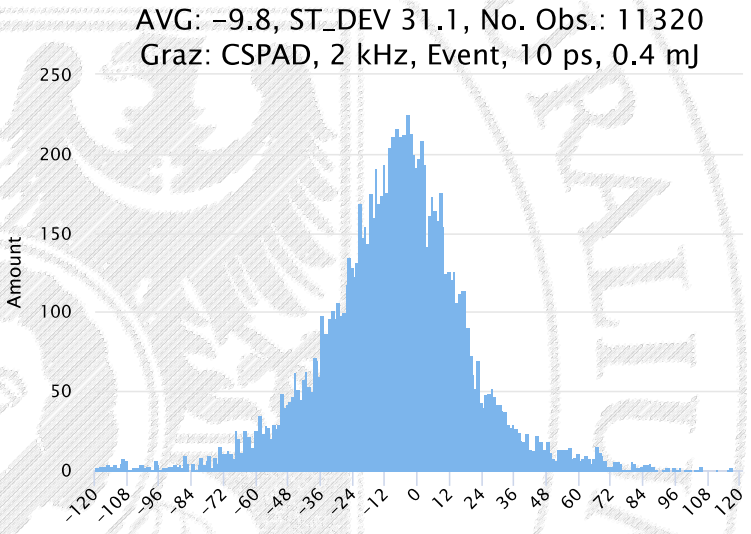
Multi-photon detectors are more affected to the Satellite Signature Effect

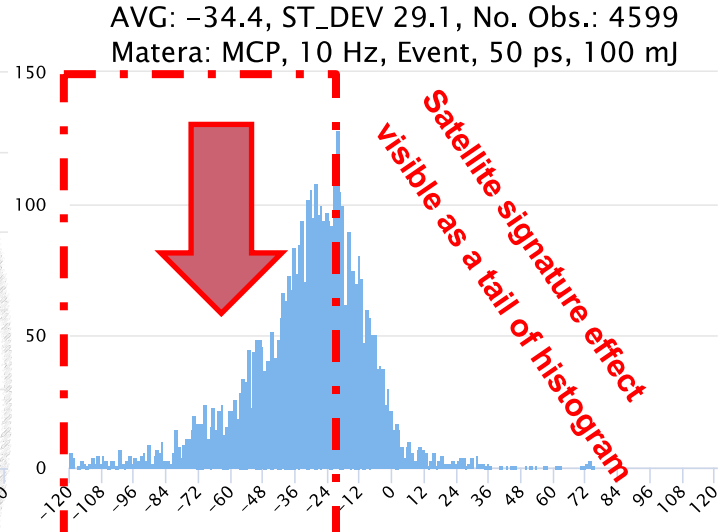


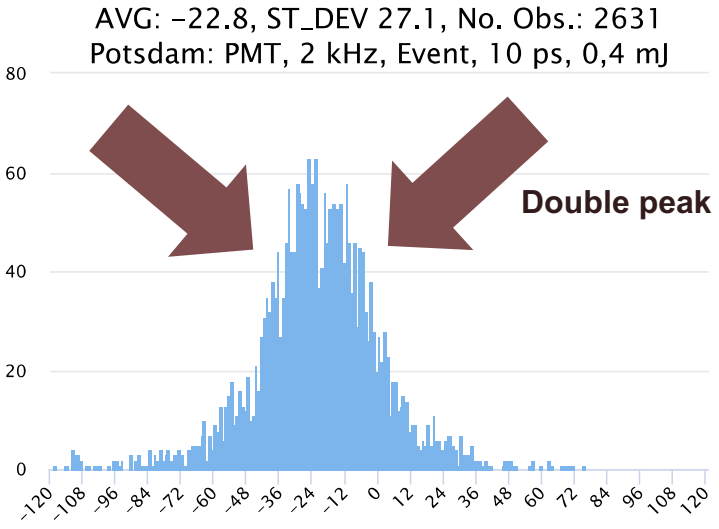
Dataset: uncoated GLONASS-M; year: 2016

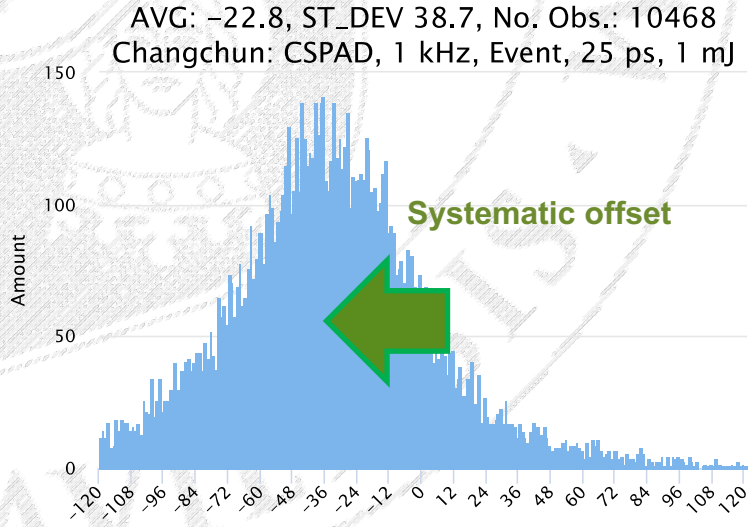
What can we do with the data ? **Analyses of stations' histograms**

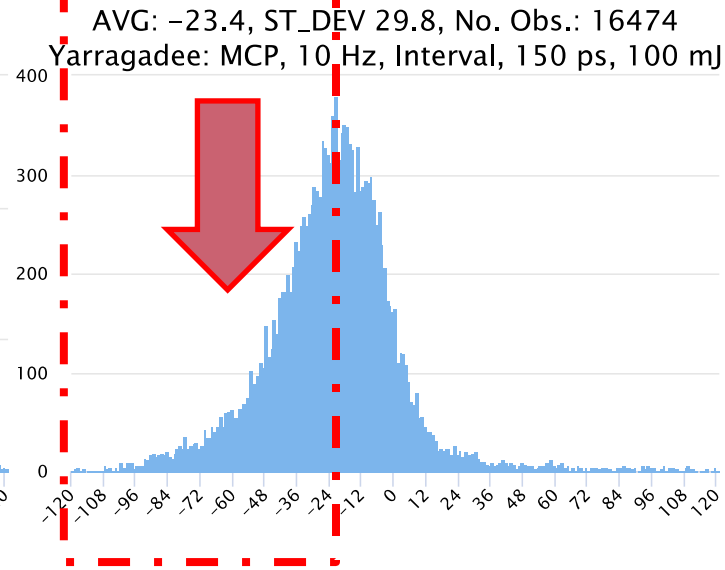
- Histograms of SLR residuals to investigate the different types of systemtics

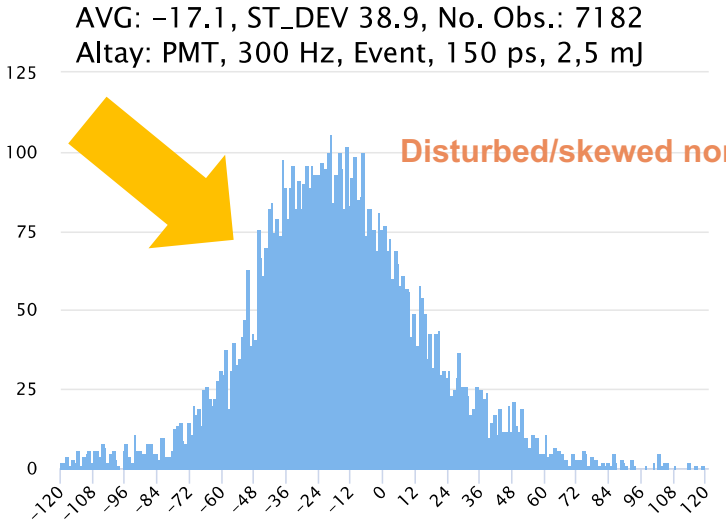






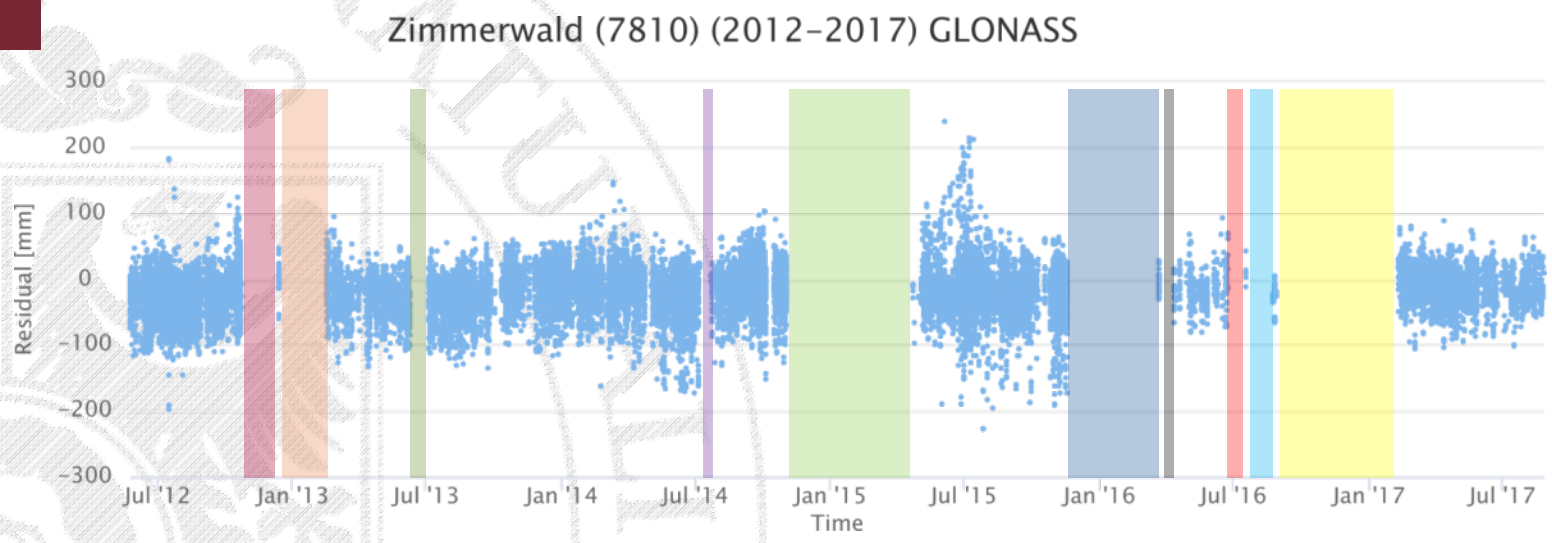






Dataset: uncoated GLONASS-M; year: 2016

What can we do with the data ?



Discontinuities in tracking *resulted from the stations' upgrades or any unexpected problems*

FROM		TO		DURATION
DATE	DOY	DATE	DOY	[days]
27.08.2016	240	10.02.2017	41	166
19.07.2016	201	25.08.2016	238	37
24.06.2016	176	18.07.2016	200	24
23.03.2016	83	11.04.2016	102	19
19.11.2015	323	22.03.2016	82	124
03.11.2014	307	23.04.2015	113	171
07.07.2014	188	23.07.2014	204	16
08.06.2013	159	05.07.2013	186	26
12.12.2012	347	16.02.2013	47	65
23.10.2012	297	12.12.2012	347	50

Welcome › Stations › Zimmerwald, Switzerland (7810) › Station Logs

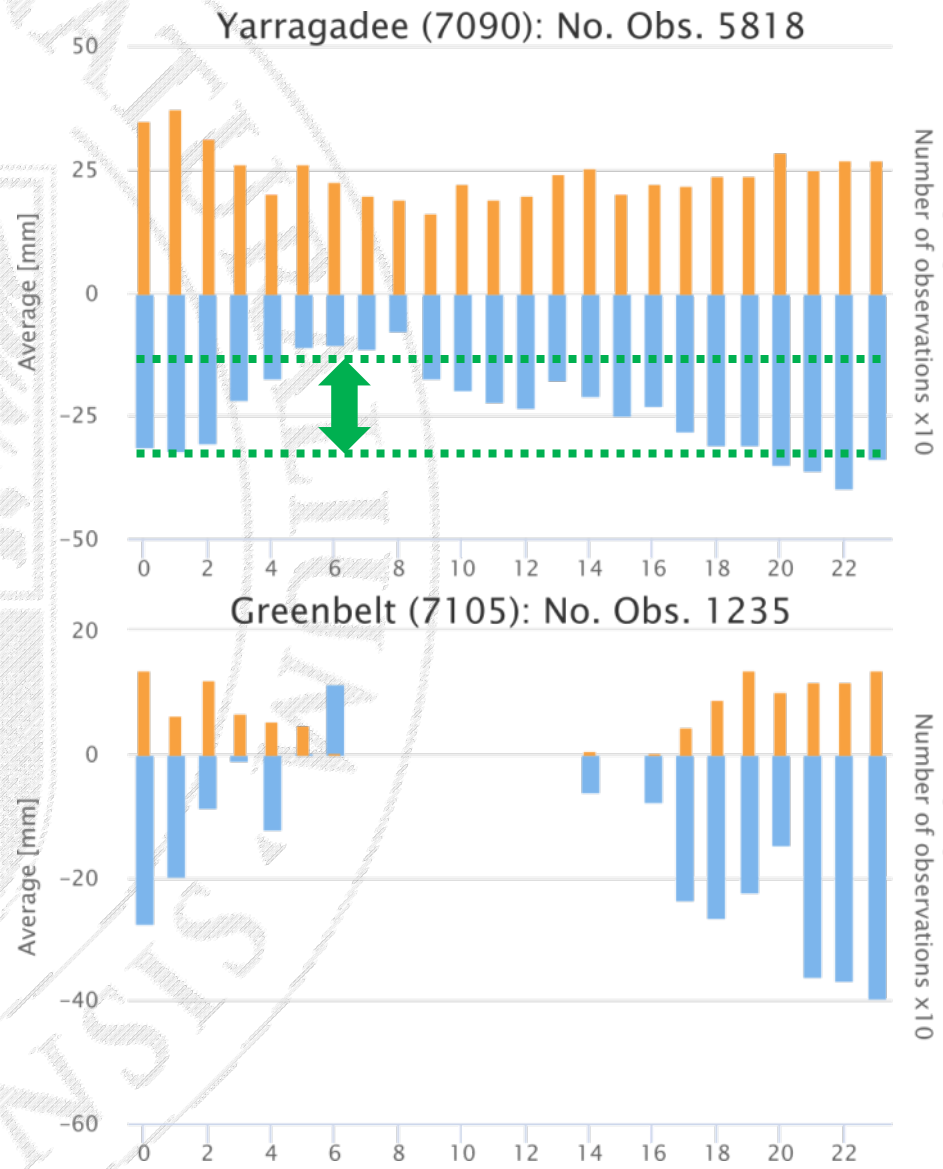
Station Logs - Zimmerwald, Switzerland (7810)

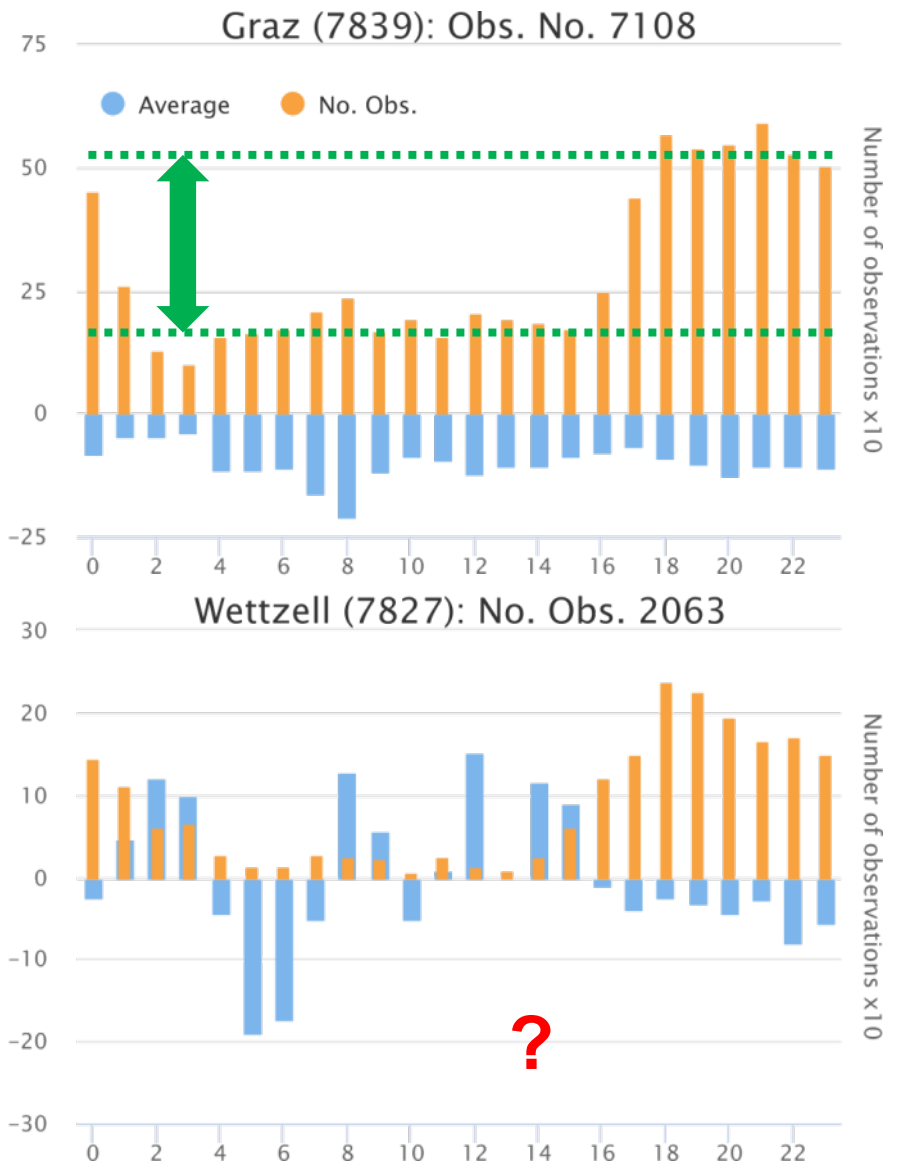
78106801	2017	019	18:00	05	LASER Chiller: DI-cartridge and particle filter exchanged (after to high conductivity).
78106801	2016	316	18:00	05.07	LASER Double pass amplifier: DPCH 256 removed (to be replaced be a new DPCH 234 in the near future).
78106801	2016	295	18:00	05.07	LASER Medox Driver: High voltage power supply defect
78106801	2016	196	18:00	05.07	LASER Double pass amplifier: Second compensation of lower gain: Startdiode: Discriminator: Threshold reduced from 0.600 V to 0.300 V.
78106801	2016	180	18:00	05.07	LASER Double pass amplifier: Second lower gain.
78106801	2016	077	18:00	05.07	LASER Double pass amplifier: DPCH 256 re-installed after repair
78106801	2015	338	18:00	05.07	LASER Double pass amplifier: DPCH 256 removed for repair.
78106801	2014	306	18:00	05.08	LASER Regeneration amplifier: Water leakage, shut down SLR-operation

What can we do with the data ? **Station tracking as a function of local time**

Differences in average SLR residuals

Lack of NP





Number of observations

complex dependencies

Dataset: uncoated GLONASS-M; year: 2016

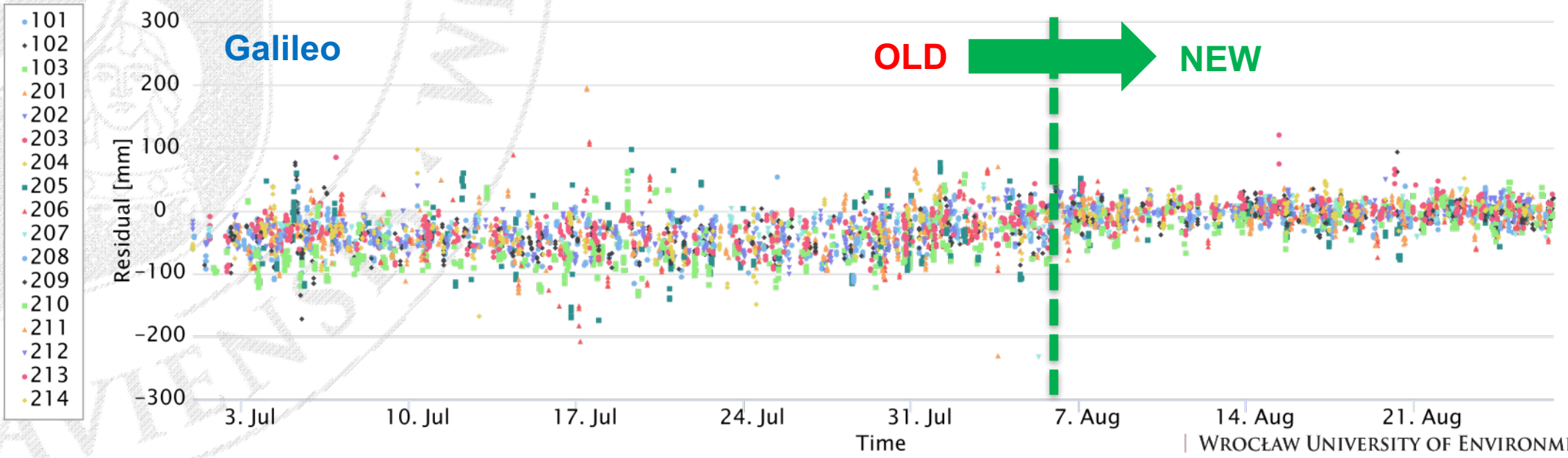
Assessment of multi-GNSS orbit quality **(model change)**

OLD (07/2017) – WITHOUT ALBEDO AND ANTENNA THRUST FOR GLONASS, GALILEO AND QZSS

NEW (08/2017) – WITH ALBEDO AND ANTENNA THRUST FOR GLONASS, GALILEO AND QZSS

	TYPE	COATING	Mean [mm]		St. Dev [mm]		No. Obs.	
			NEW	OLD	NEW	OLD	NEW	OLD
GALILEO	FOC	NO	-3,2	-35,7	19,6	34,4	1892	2951
	FOC (ext.)	NO	-1,9	-40,6	13,7	20,7	290	510
	IOV	NO	-6,2	-53,8	14,4	31,2	685	1016
GLONASS	K1	NO	-6,6	-14,3	36,7	21,4	500	795
	M	YES	-3,5	-12,9	29,3	29,6	312	442
	M	NO	-14,7	-18,7	23,8	26,7	3292	5422
	M+	NO	28,4	15,1	16,0	22,4	304	417

- The mean SLR residuals for the Galileo and GLONASS satellites decreased to the single milimeters.
- Decrease of the mean SLR residuals and the standard deviation indicate a better consistency between SLR and GNSS solutions.



Conclusions

- **The web application is working with the functionality of:**
  - **storing and updating database in a daily routine**
  - **visualizing data and allowing for plot analyses**
  - **creating dataset filtered by a user, ready for download**

- The service is **a great tool for laser stations to monitor their performance refered to GNSS tracking**
- The service is also a great source of information about the multi-GNSS orbit **quality (GPS, GLONASS, Galileo, BeiDou, QZSS) From 2012 to ∞**

- Despite of being fully operational, service is still in development stage, therefore we **encourage for testing and send your feedback**

What do you think about the project ?
How can we adjust the functionality to the stations' needs?

Contact

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Thank you for your attention

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