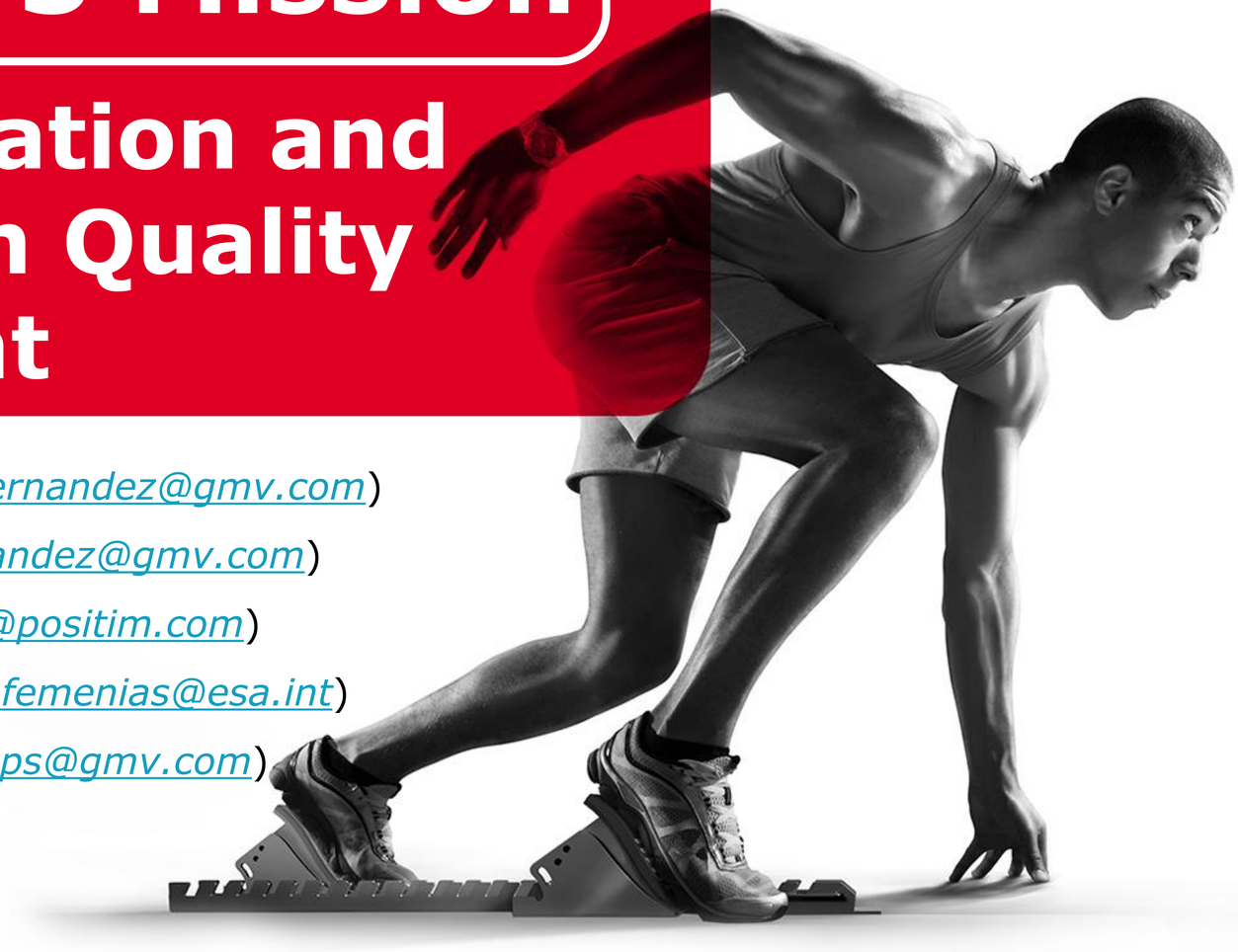
Copernicus Sentinel-3 Mission

Orbit Validation and SLR Station Quality Assessment



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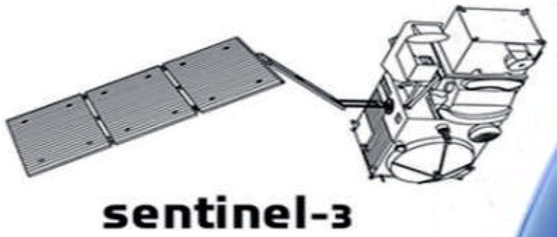
Copernicus Precise Orbit Determination (POD) Service

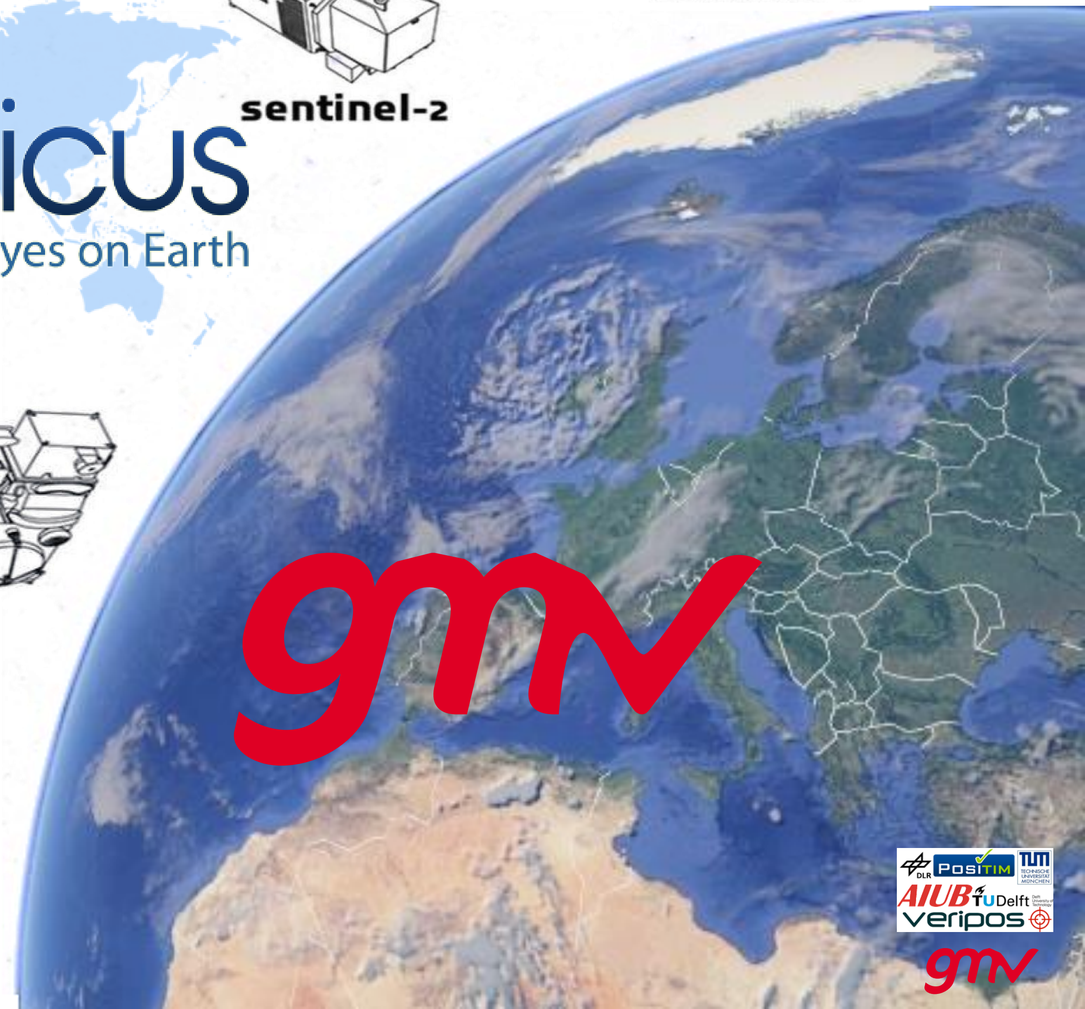
esa

EUMETSAT



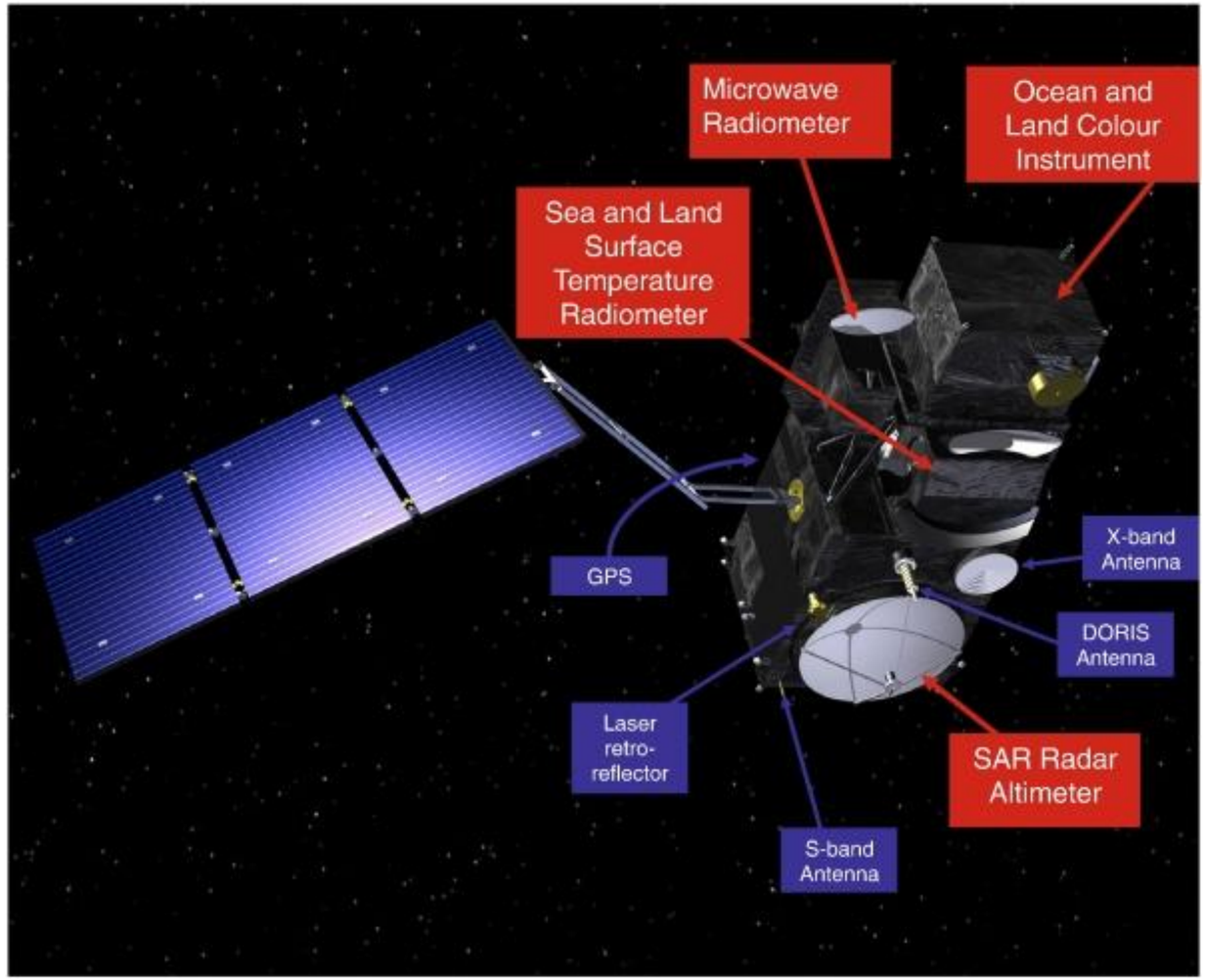
- Sentinel satellites are equipped with various Earth observation instruments.
- **Mission requirements**: high levels of orbit accuracy.

Copernicus POD Service



Who We Are

Sentinel-3A and Sentinel-3B satellites



- From the six satellites operated by the Copernicus program, two of them are equipped with a **Laser Retro Reflector** (LRR):
  - **Sentinel-3A**
  - **Sentinel-3B**

- Thus, Sentinel-3 satellites can be tracked by the **Satellite Laser Ranging** (SLR) stations providing us valuable observations in order to validate the satellite orbits of both Sentinel-3 satellites.

- Properties of Sentinel-3 satellites:
  - Low Earth Orbit (LEO) satellites
  - Altitude: 814.5 km
  - Polar orbit: Inclination 98.65 deg

Who We Are

Current Priority List

Priority	Mission	ILRS Name	COSPAR ID	SIC	Sponsor	Altitude (km)	Inclination (degrees)	Comments
1	LightSail-2	lightsail2	1903629	4202	The Planetary Society	720	24	
2	GRACE-FO-1/2	gracefo1 gracefo2	1804701 1804702	0123 0124	NASA JPL and the German Research Centre for Geosciences (GFZ)	500	89	1-month campaign
3	ICESat-2	icesat2	1807001	6873	NASA	496	92	Restricted tracking; authorization required
4	CryoSat-2	cryosat2	1001301	8006	ESA	450-720	92	
5	PAZ	paz	1802001	2501	HISDESAT	514	97.44	
6	TanDEM-X	tandemx	1003001	6202	Infoterra/ DLR/GFZ/CSR	514	98	Tandem with TerraSAR-X
⋮								⋮
13	STSAT-2C	stsat2c	1300301	3804	MEST, KAIST	300 - 1500	80	
14	Sentinel-3B	sentinel3b	1803901	8011	ESA/EUMETSAT	814.5	98.65	Restricted tracking; authorization required
15	Sentinel-3A	sentinel3a	1601101	8010	ESA/EUMETSAT	814.5	98.65	Restricted tracking; authorization required
16	Swarm-A/C	swarma swarmc	1306702 1306703	8007 8009	ESA	460 530	88.35 88.95	
⋮								⋮

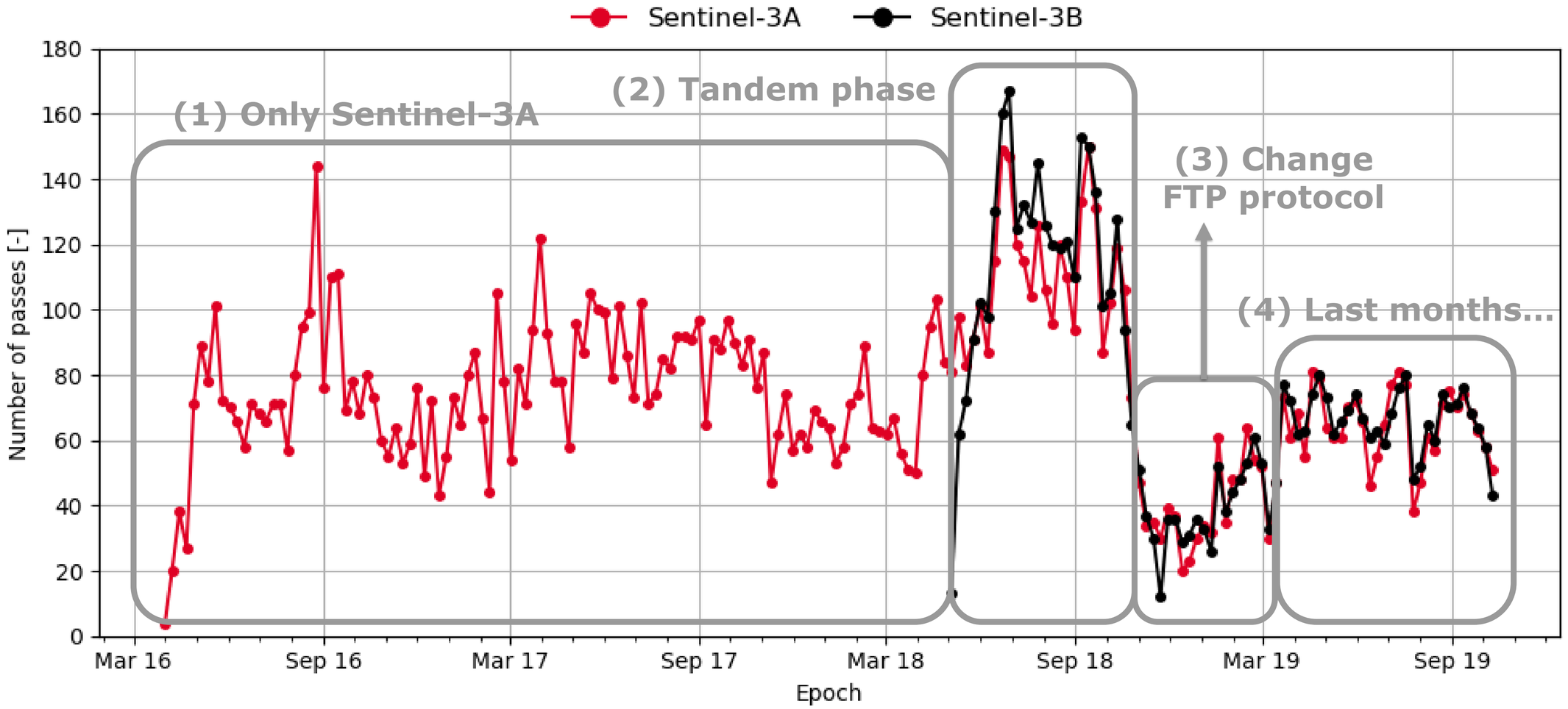
ESA is **very grateful** for the support provided by the ILRS community, which helps at the long term validation and valorization of the Sentinel-3 orbit and science products.

Overall Statistics

Overall Statistics

S-3A/B: Temporal evolution of satellite passes

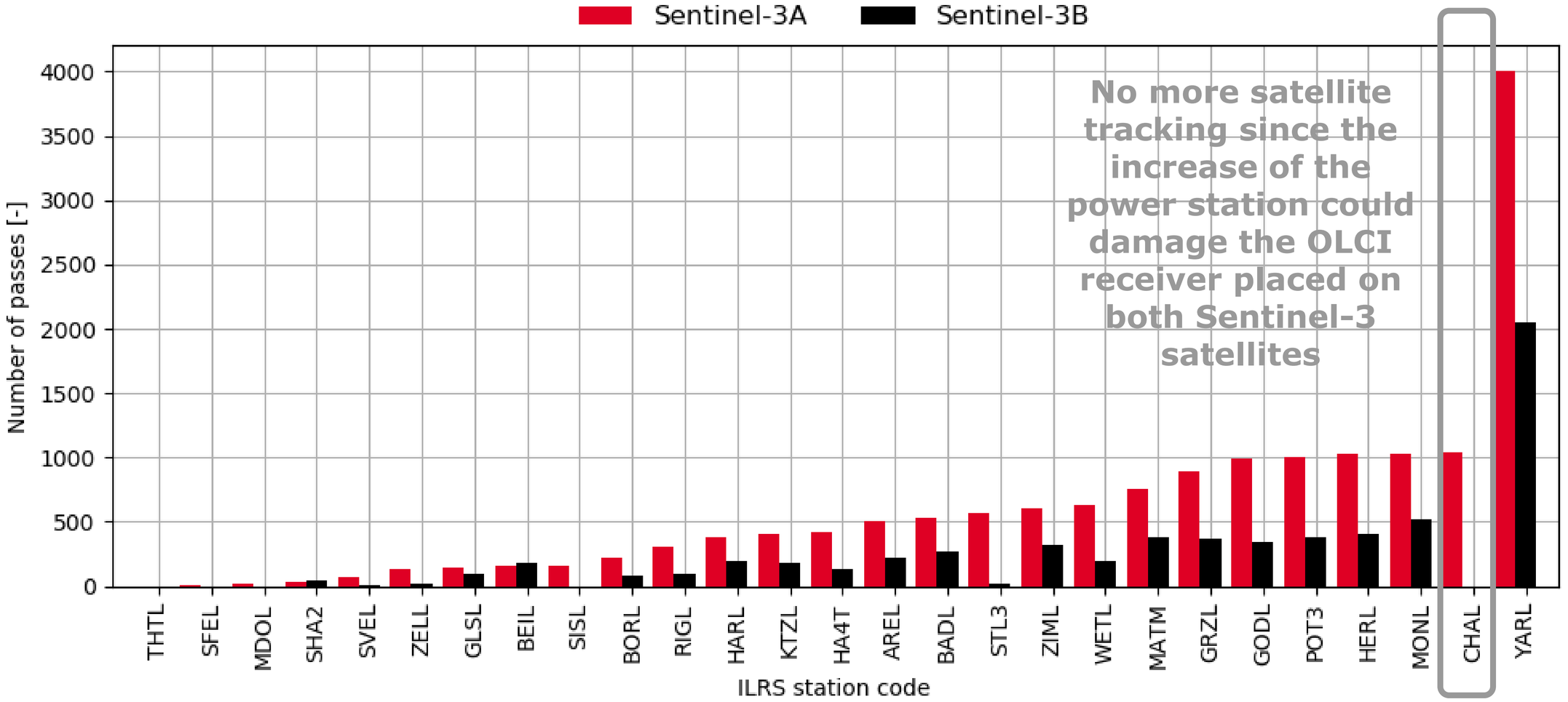
- The statistics regarding the complete satellite missions until now are shown on a weekly basis.



Overall Statistics

S-3A/B: Total number of passes

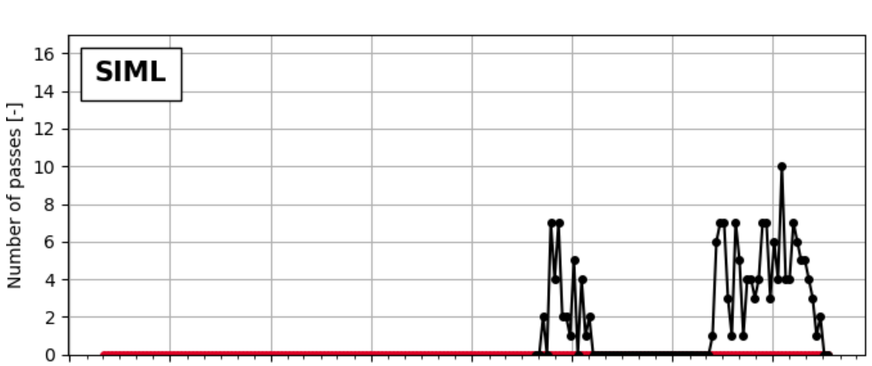
- The statistics regarding the complete satellite missions until now are shown per SLR station.



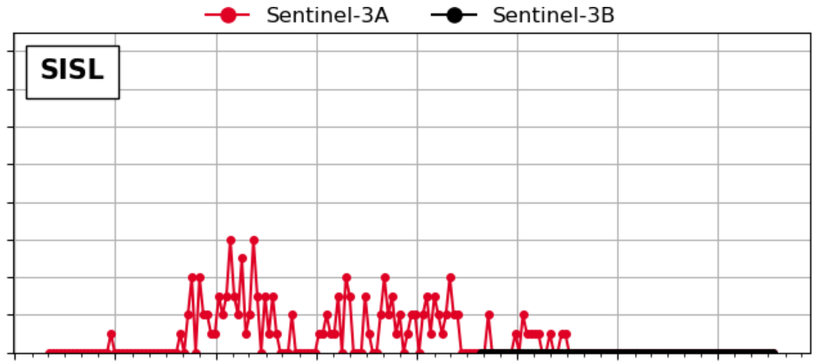
Overall Statistics

S-3A/B: Temporal evolution of satellite passes

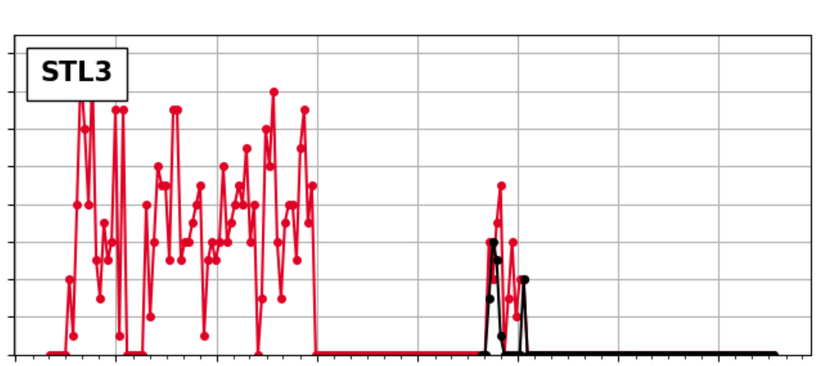
- There are a few SLR stations that present an unexpected behaviour.



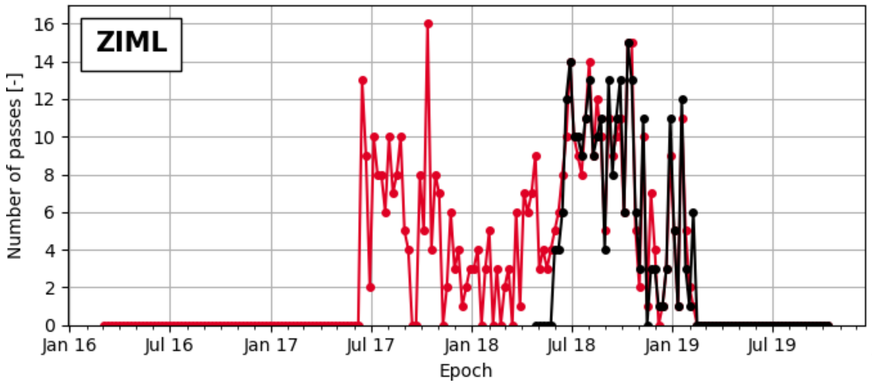
NO tracking of S-3A



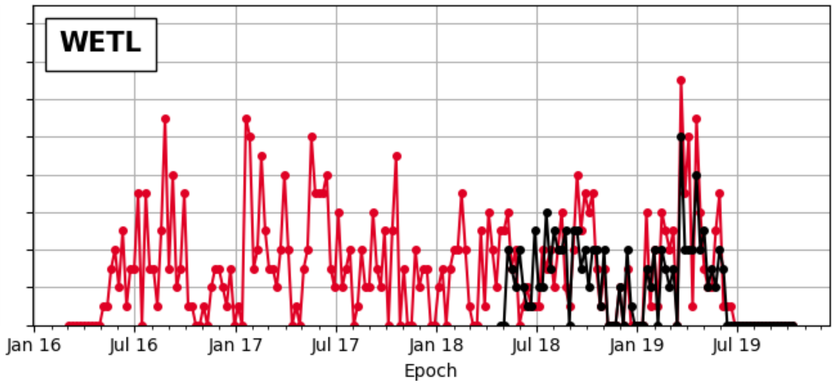
NO tracking of S-3B + loss of tracking



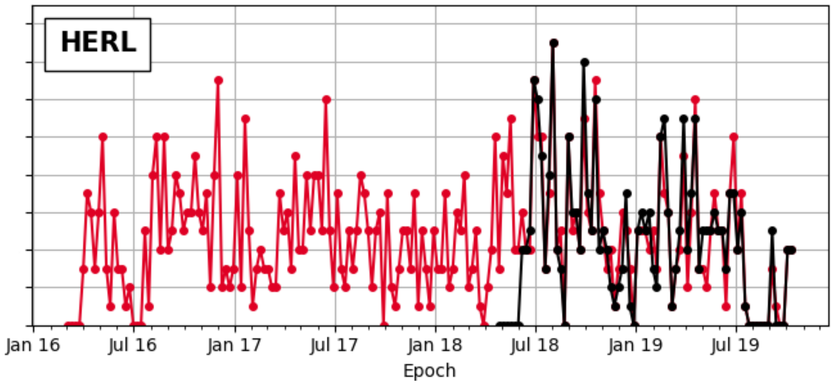
Loss of tracking



Loss of tracking



Loss of tracking



Irregular tracking in the past months

Biases Analysis

Biases Analysis

Analysis Procedure

- Two analyses have been carried out in order to evaluate the performance of the Sentinel-3A and Sentinel-3B Non Time Critical (NTC) satellite orbits:
  1. The satellite orbit has been fixed and the range bias of each SLR station has been estimated.
  2. The SLR stations coordinates have been fixed and the position of the satellite LRR has been estimated.

- Processing metrics:
  - Time periods of 4 GPS weeks (~1 month) have been considered to calculate the resulting biases.
  - The biases presented in the following slides are one-range.

Biases Analysis

S-3A/B: Mean and Standard Deviation (SLR Stations)

- The satellite orbit has been fixed and the biases of the SLR stations have been estimated.

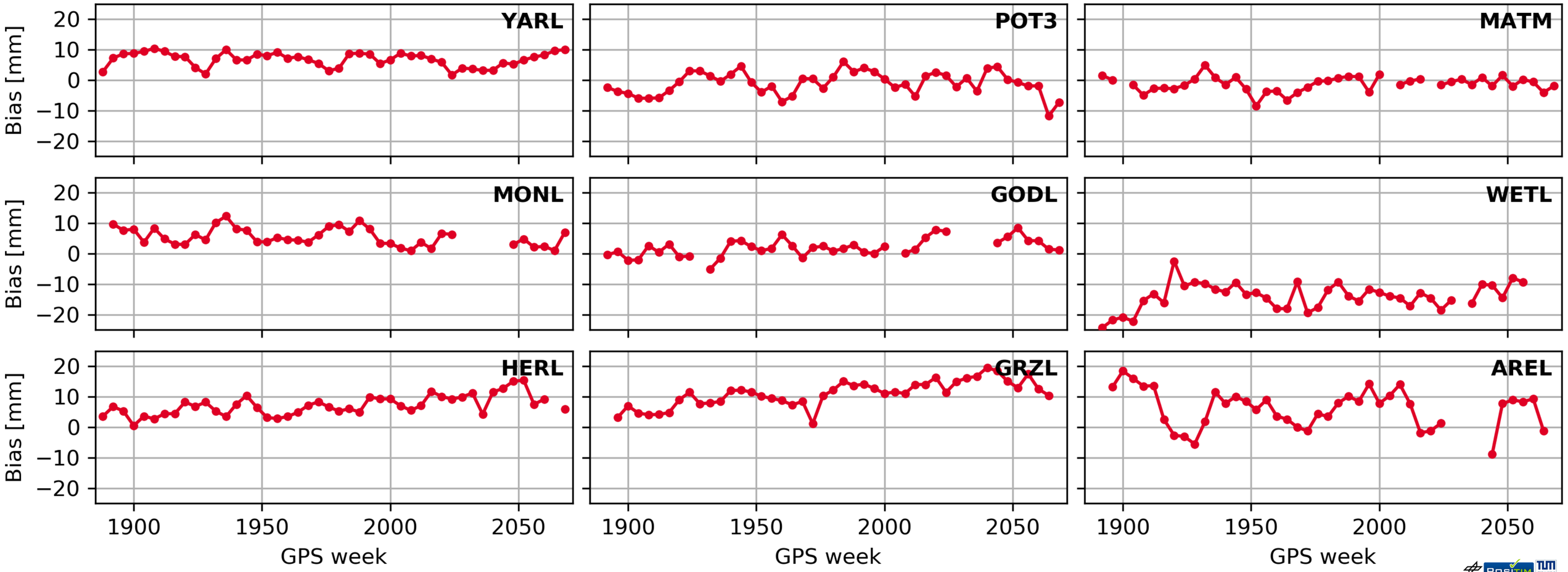
CODE	MEAN ± STD [mm]	
	S-3A	S-3B
GLSL	-25.77 ± 185.94	-46.49 ± 140.60
SIML	-	-11.65 ± 13.44
RIGL	104.46 ± 25.67	100.31 ± 28.75
SVEL	-3.16 ± 10.02	-3.33 ± 8.73
ZELL	11.49 ± 9.93	-6.19 ± 20.34
BADL	5.36 ± 8.49	9.80 ± 8.33
KTZL	-13.61 ± 13.19	-4.20 ± 10.32
MDOL	-108.18 ± 275.17	-
YARL	6.77 ± 2.30	6.11 ± 1.91
GODL	1.98 ± 2.86	4.09 ± 2.21
MONL	5.54 ± 2.85	6.77 ± 1.95
HA4T	11.32 ± 4.78	13.21 ± 3.95
THTL	-10.10 ± 0.00	-
CHAL	-10.22 ± 4.77	-

CODE	MEAN ± STD [mm]	
	S-3A	S-3B
BEIL	-9.75 ± 9.29	-9.20 ± 4.88
AREL	6.04 ± 6.27	4.20 ± 5.08
HARL	4.32 ± 6.48	6.90 ± 3.04
ZIML	8.16 ± 2.36	7.02 ± 2.08
BORL	-24.26 ± 9.94	-27.33 ± 7.73
SHA2	-10.03 ± 13.68	-9.01 ± 4.74
SFEL	-23.79 ± 0.00	-
STL3	7.24 ± 3.86	4.03 ± 3.10
SISL	15.58 ± 7.76	-
GRZL	11.02 ± 4.20	14.30 ± 2.82
HERL	7.14 ± 3.25	6.29 ± 4.68
POT3	-1.05 ± 3.73	-5.90 ± 5.72
MATM	-1.29 ± 2.44	-2.07 ± 2.16
WETL	-14.00 ± 4.31	-14.87 ± 4.37

Biases Analysis

S-3A: Temporal Evolution of the Range Biases (SLR Stations)

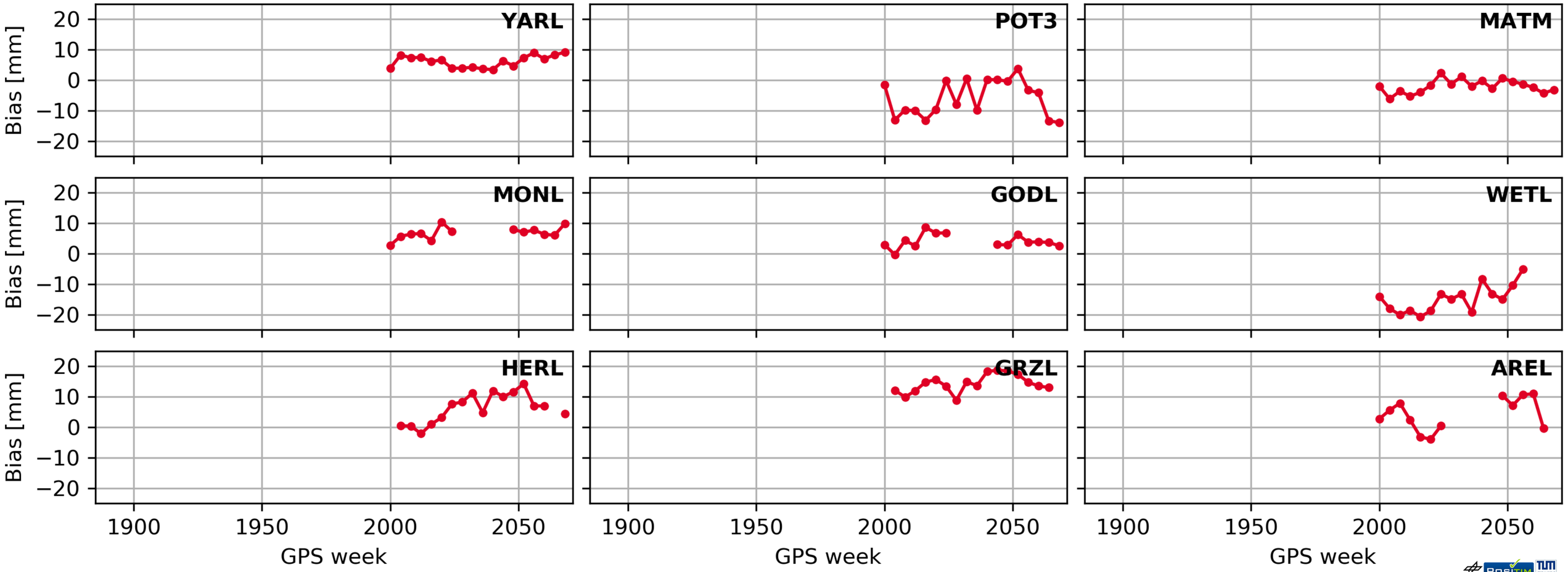
- The satellite orbit has been fixed and the range biases of the SLR stations have been estimated.



Biases Analysis

S-3B: Temporal Evolution of the Range Biases (SLR Stations)

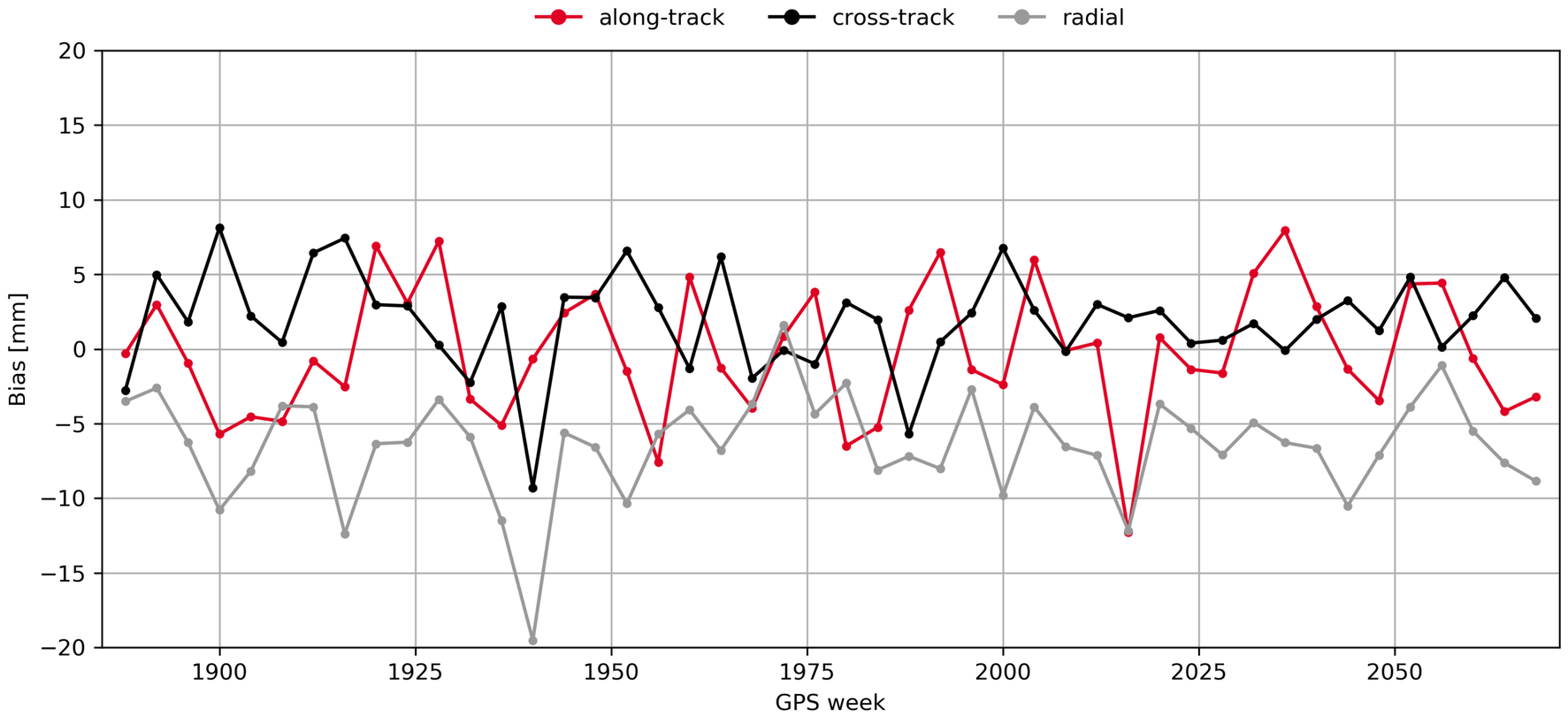
- The satellite orbit has been fixed and the range biases of the SLR stations have been estimated.



Biases Analysis

S-3A: Temporal Evolution, Mean and Standard Deviation of the Biases (Satellite)

- The coordinates of the SLR stations have been fixed and the biases of the position of the satellite LRR have been estimated (along-track [A], cross-track [C] and radial [R]).

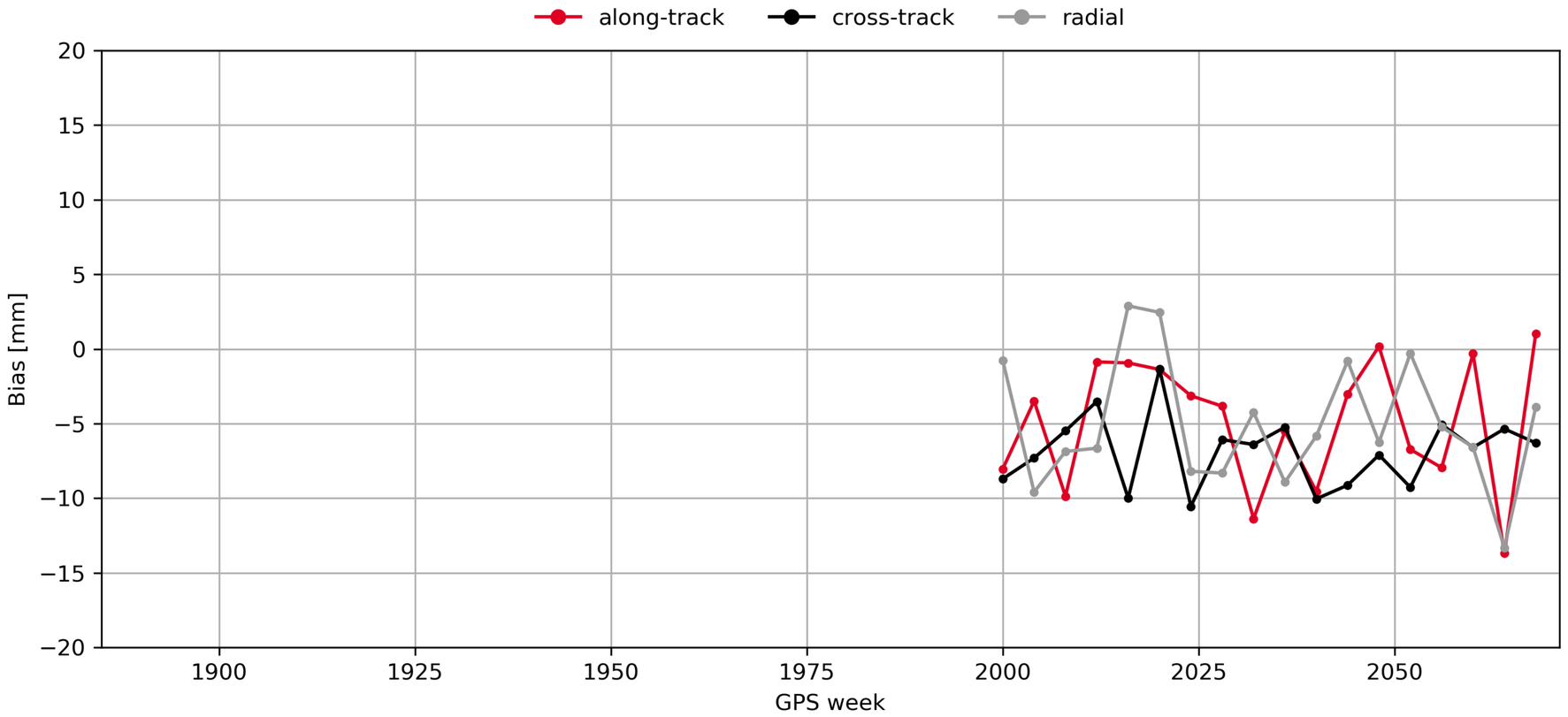


		MEAN ± STD [mm]
S-3A	A	-0.21 ± 4.39
	C	2.13 ± 2.79
	R	-6.15 ± 2.92

Biases Analysis

S-3B: Temporal Evolution, Mean and Standard Deviation of the Biases (Satellite)

- The coordinates of the SLR stations have been fixed and the biases of the position of the satellite LRR have been estimated (along-track [A], cross-track [C] and radial [R]).



		MEAN ± STD [mm]
S-3B	A	-4.92 ± 4.25
	C	-6.86 ± 2.37
	R	-5.02 ± 4.18

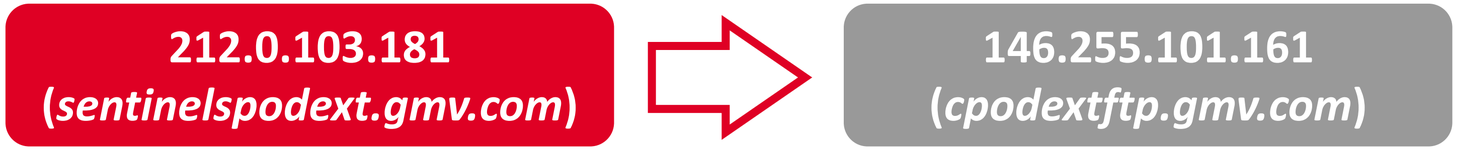
Final Comments

Final Comments

Cloud Migration

- The Copernicus POD Service is migrating the operational system, currently provided at GMV premises, to a **public cloud**.

- This migration directly impacts the ILRS community, which retrieves the **CPF predictions** from the CPOD FTP server located at GMV premises.

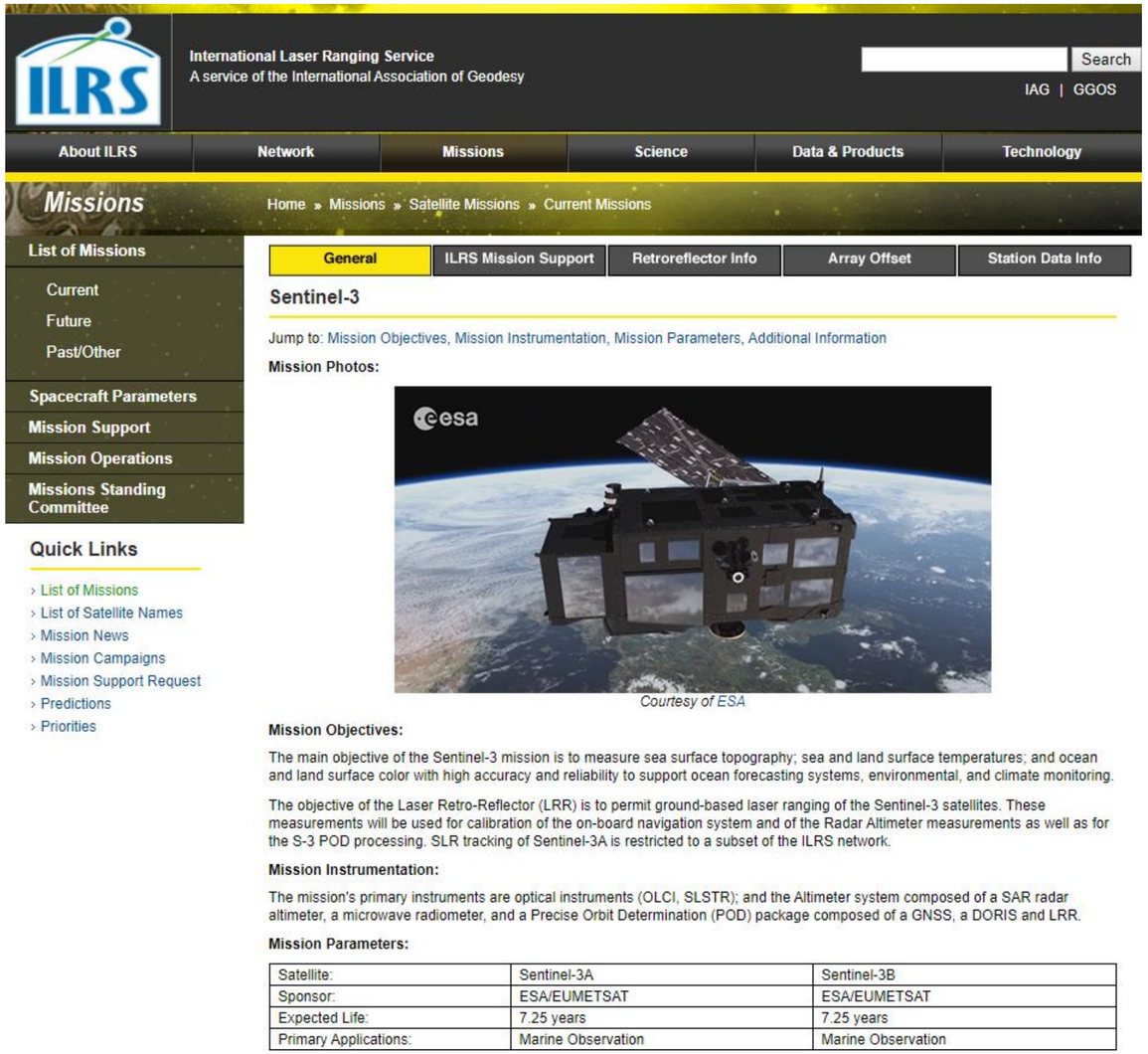


The credentials and FTP protocols (FTPS and HTTPS) will remain the same as now

- We kindly invite you to **test the connectivity** to the new FTP server in order to solve any issue as soon as possible.

Final Comments

S-3A/B: Yearly Reports



https://ilrs.cddis.eosdis.nasa.gov/missions/satellite_missions/current_missions/sn3a_general.html

Other

- ESA's Sentinel-3A yearly report on ILRS support (2016)
- ESA's Sentinel-3A yearly report on ILRS support (2017)
- ESA's Sentinel-3A yearly report on ILRS support (2018)
- Sentinel-3A macromodels
- Mass & center of mass history
- Manoeuver history
- Attitude history

Thank you

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