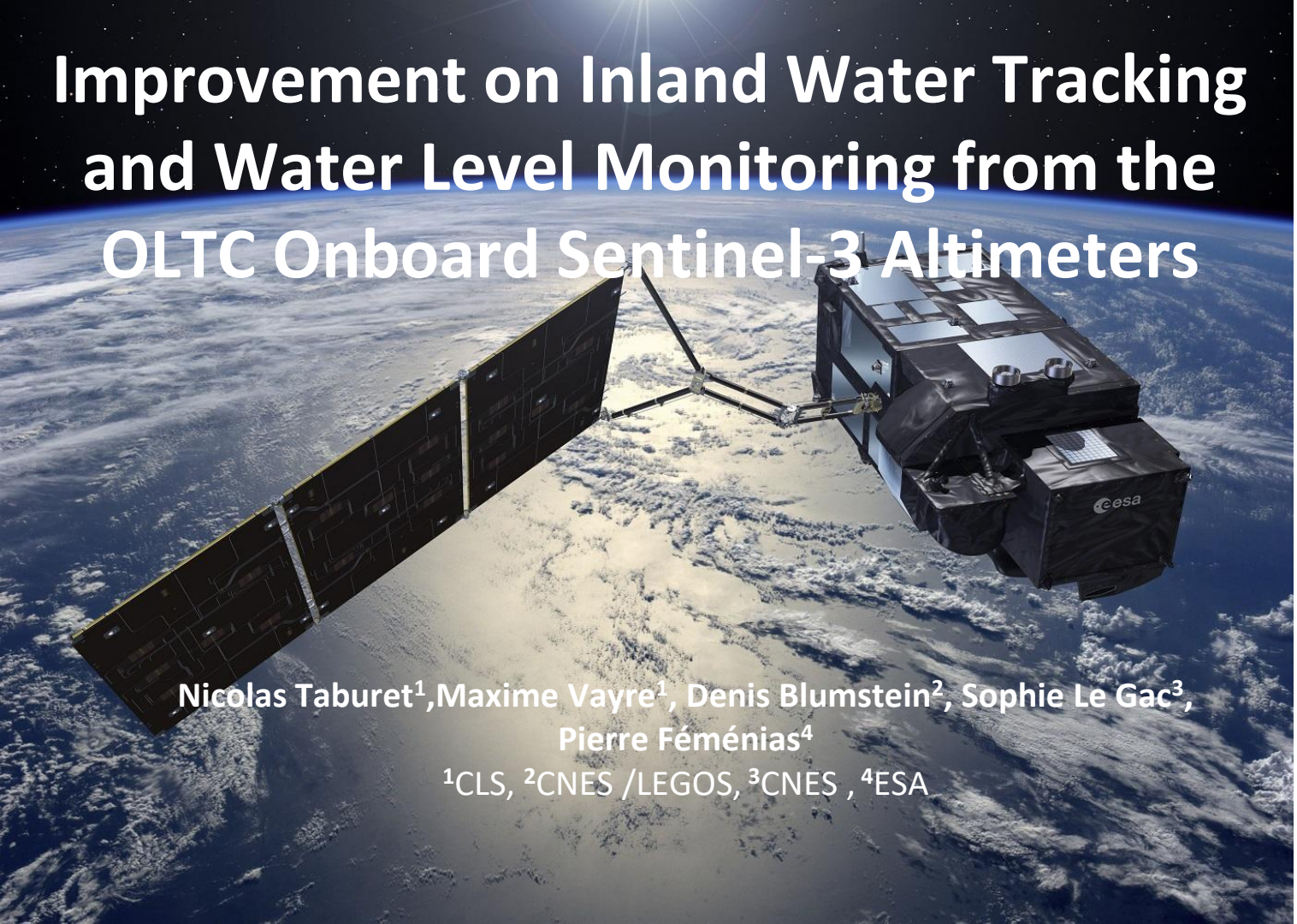
Improvement on Inland Water Tracking and Water Level Monitoring from the OLTC Onboard Sentinel-3 Altimeters



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Context

- Over inland waters, ground elevation changes can make the onboard altimeter tracker loose the returned echoes by water bodies in Closed Loop (CL) tracking mode
- Open Loop (OL) tracking mode in implemented onboard Sentinel-3A and Sentinel-3B Surface Topography Missions. It uses an elevation Open Loop Tracking Command (OLTC) to set up the altimeter receiving window.

The first OLTC versions onboard S3A and S3B allowed to obtained promising results in terms of Water Surface Height monitoring over rivers, lakes and réservoirs, e.g.:

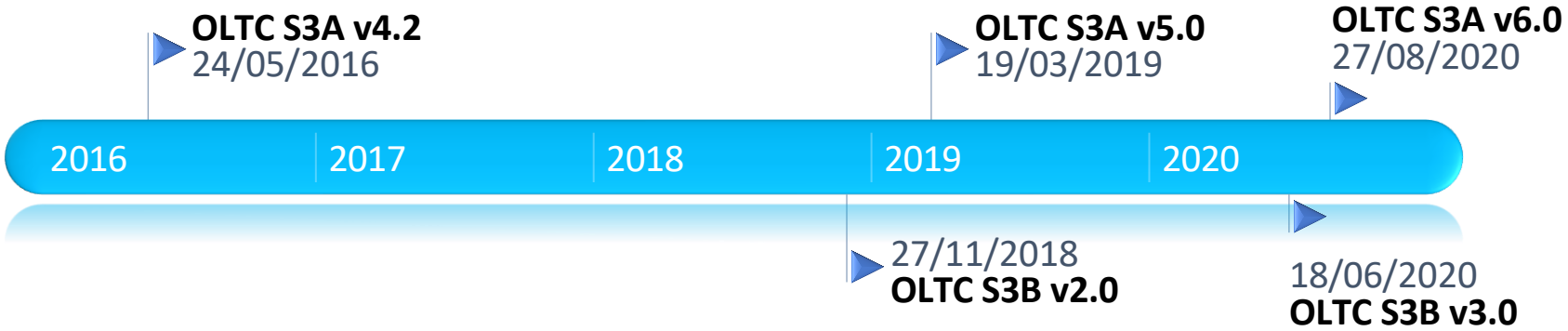
- Le Gac S. et al., Benefits of the Open-Loop Tracking Command (OLTC): Extending conventional nadir altimetry to inland waters monitoring. Adv. Space Res. 2019, doi:10.1016/j.asr.2019.10.031.
- Blumstein D., Major Upgrade of OLTC on Sentinel-3A and 3B in 2018 : Benefits for Inland Waters Users (Living Planet Symposium, May 2019)

S3 Mission Performance Center provides regular quality assessment of Sentinel-3A and B altimetric data over inland waters and emphasized the benefits of the successive OLTC upgrades

S3A & S3B STM - Acquisition modes

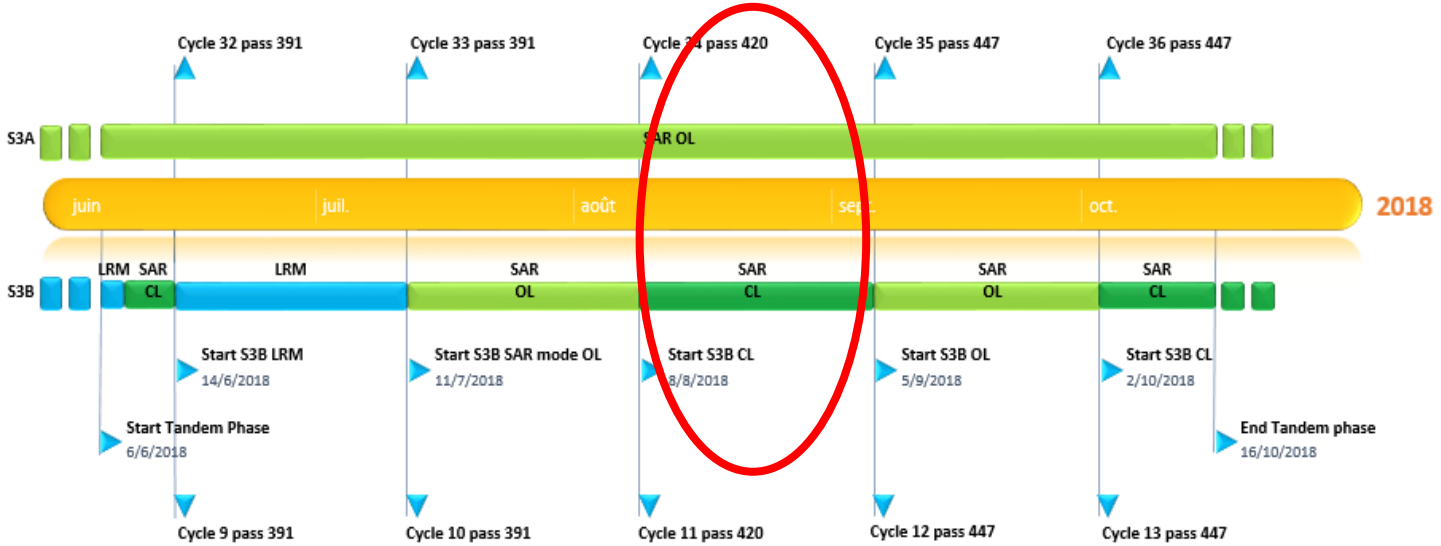
- SRAL onboard S3A & S3B can track the surface in autonomous mode (Closed Loop) or using prior elevation information (Open Loop tracking mode)
- OL tracking mode requires an Open Loop Tracking Command (OLTC) file which is uploaded onboard

Open Loop Tracking Command used



Open Loop vs Close Loop S3 performance comparisons – Tandem Phase

- To compare tracking modes performances, data acquired during the tandem phase during which S3B was circulated between various configurations while S3A remained as the reference are used

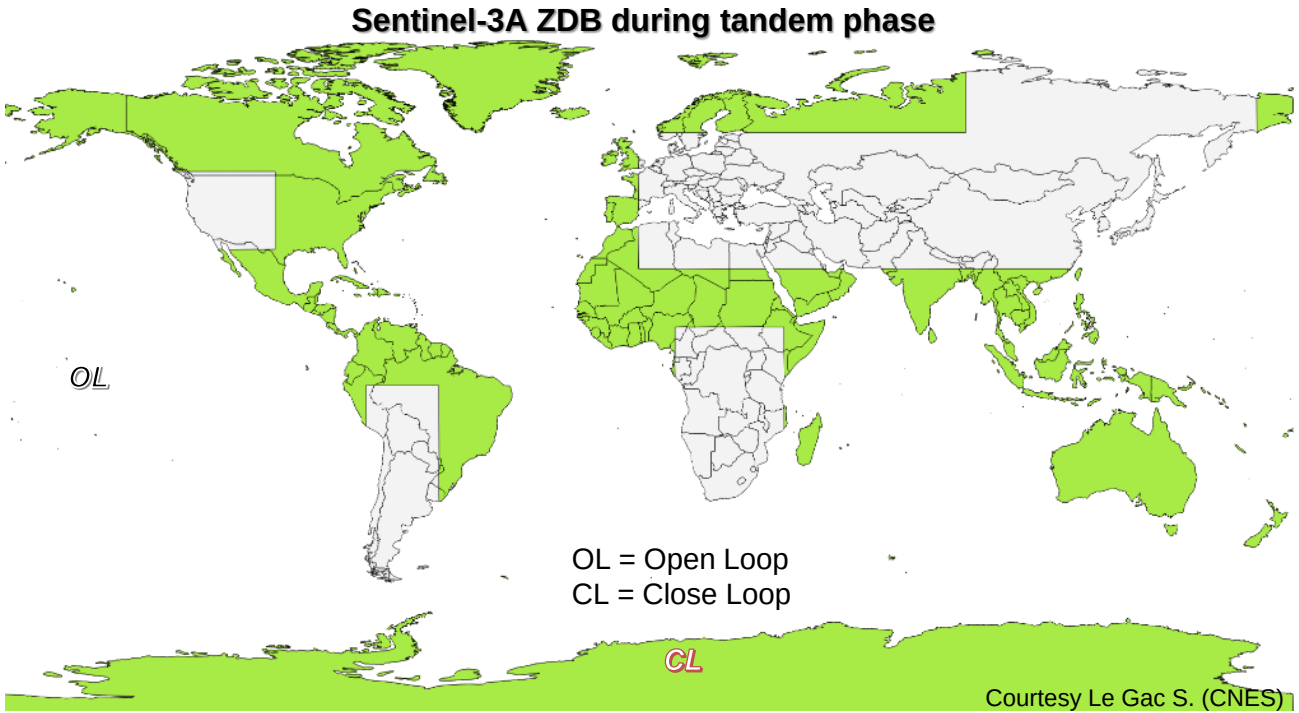


- The data acquired in CL during the period covering S3B Cycle 11 Pass 420 to Cycle 12 (CL) are compare to S3A data acquired during Cycle 34 Pass 420 to Cycle 35 Pass 446 (OL)

More details in Taburet et al.
Remote Sens. **2020**, *12*(18), 3055 https://doi.org/10.3390/rs12183055

Open Loop vs Close Loop S3 performance comparisons – Tandem Phase

- During the Tandem phase, OLTC version used onboard S3A was v4.2.
- Areas over which S3A was operated in OL are defined by the Zone Data Base (ZDB)



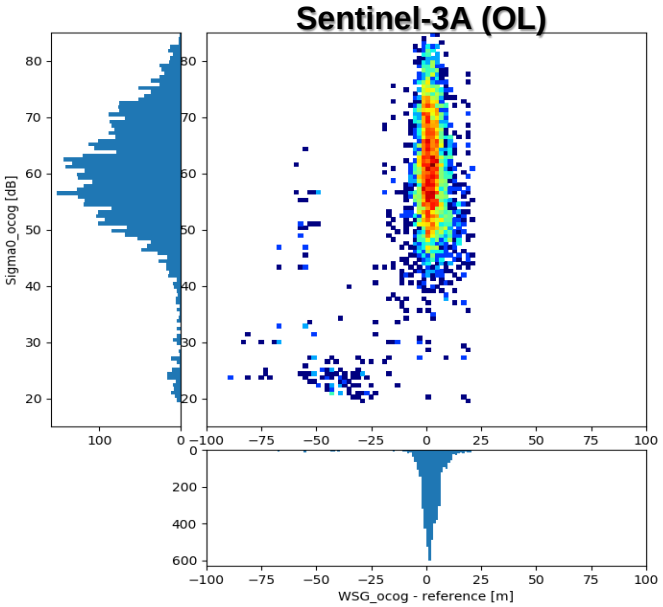
Open Loop vs Close Loop S3 performance comparisons – Tandem Phase

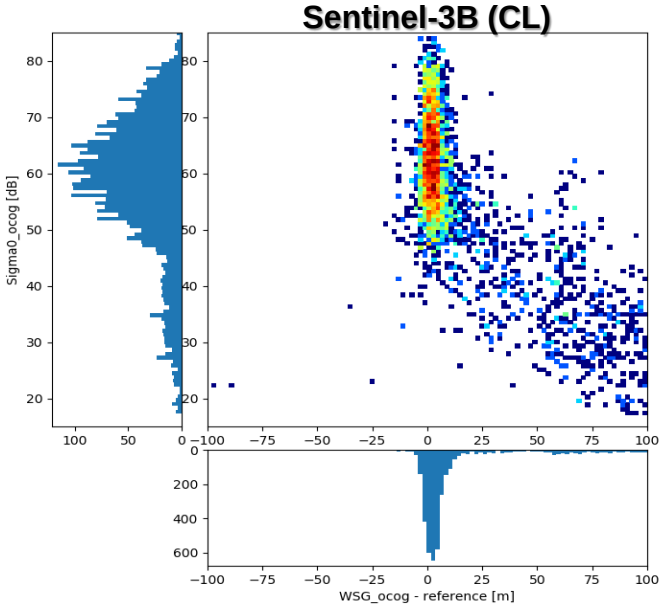
- **Data are extracted within OLTCv4.2 polygons** defined around Virtual Stations (VS, intersection between S3A ground tracks and rivers) for which the OLTC was fine-tuned (= elevation information was precisely set up. See also **D. Blumstein presentation on the construction of OLTC**)

Red : one OLTCv4.2 polygon over Vienne river (France). Yellow : S3A (&S3B during tandem phase) theoretical ground track. S3A 20Hz data (western track, OL mode) present much higher Sigma0 OCOG values than S3B data (eastern track, CL mode).

Open Loop vs Close Loop S3 performance comparisons – Tandem Phase

Better altimeter hoocking on water surfaces in OL than CL



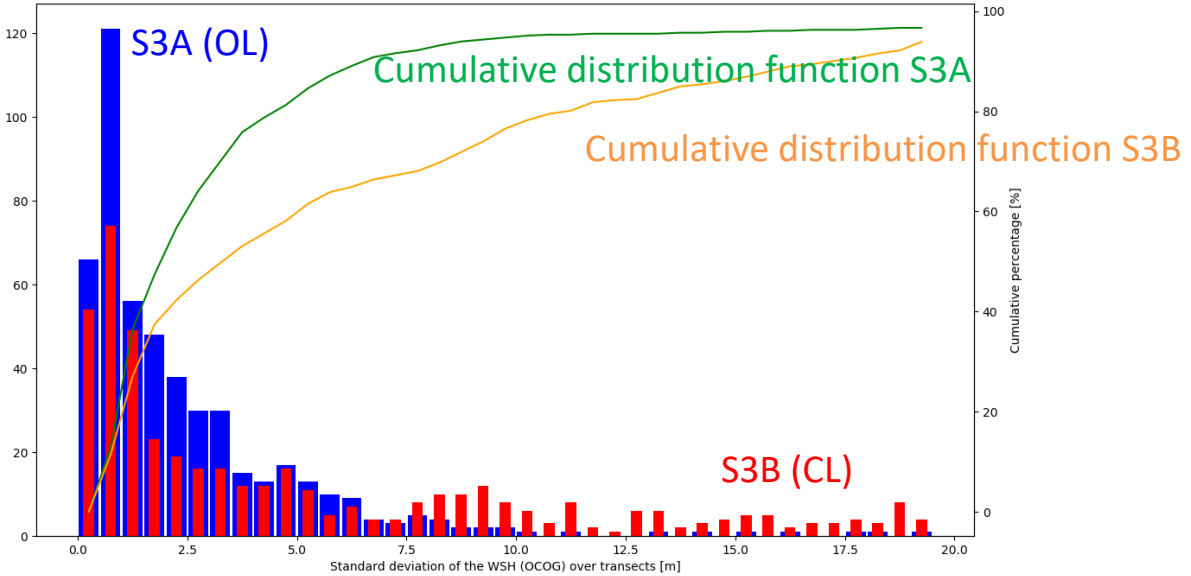


Density plots in the Sigma0 OCOG/(water surface height [WSH OCOG]—OLTC elevation information) space.

- ❑ Emphasizes that high Sigma0 values is a proxy for water detection
- ❑ Much less data over water with low (<45dB) sigma0 values in OL (S3A) than in CL.
- ❑ Low Sigma0 data points associated with non-water targets in CL correspond to surfaces at higher elevations than the reference water bodies

Open Loop vs Close Loop S3 performance comparisons – Tandem Phase

Consistent WSH estimates standard deviation per transect between OL and CL



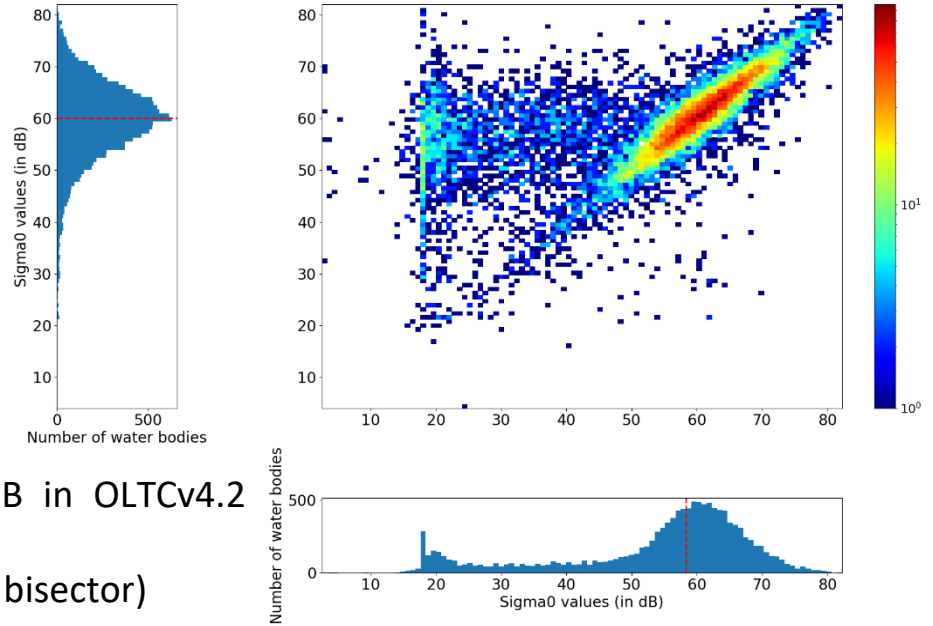
Distribution of WSH standard deviation per transects over the OLTCv4.2 polygons over which S3A was in OL.

- ❑ Median value of the standard deviation per transect : 1.7m in OL and 3.1m in CL.
- ➢ WSH transect dispersion is smaller in OL than in CL

S3 performances in OL – Benefits from OLTC updates

- S3A data are extracted within OLTCv5.0 polygons around VS for which the OLTC is fine-tuned in v5.0 but was not in v4.2 (but were OL was nevertheless used). Extraction period : cycles 29 to 41 (OLTCv4.2) and cycles 43 to 55 (OLTCv5.0)

Distribution of the Sigma0 OCOG median values for each water target for which a fine-tuned elevation prior is defined in OLTCv5.0 (Vertical axis) but was not specifically tuned in OLTCv4.2. (Horizontal axis).



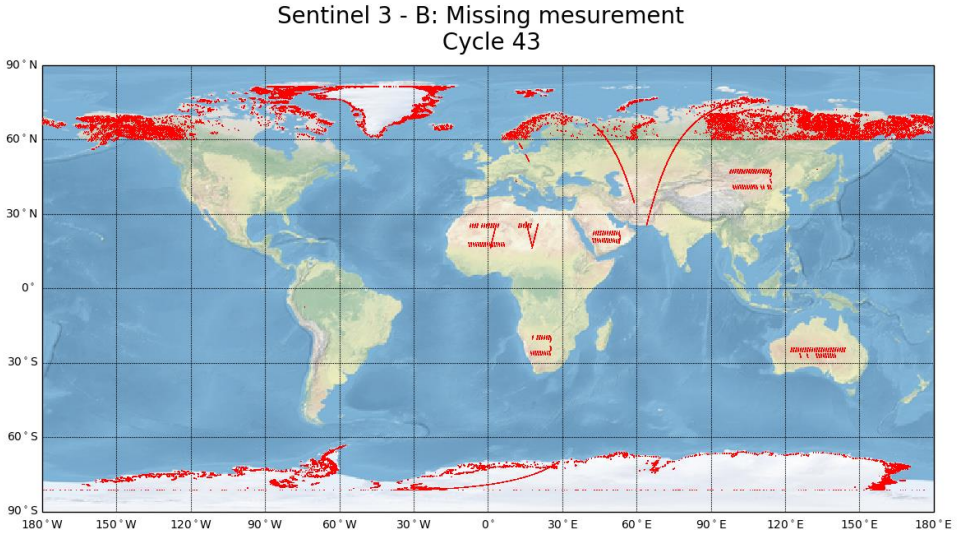
- Water Bodies where Sigma0 0C0G < 45 dB in OLTCv4.2 present values > 45 dB in OLTCv5.0.
- Very few degradations (points below the first bisector)
- Significant increase in the number of river targets over which water level can be estimated with Level-3 algorithms : 5788 in OLTCv4.2 → 7553 in OLTCv5.0: 30% increase.

See also **S. Le Gac presentation on the 2020 S3A&B OLTC updates** (content, activation and first results)

S3 routine performance monitoring over inland waters

- S3 Mission Performance Centre continuously monitors the quality of the L2 PDGS Land products over inland waters (https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-altimetry/data-quality-reports)
- OL benefits also appear in these cyclic reports

Data unavailability



Cyclic monitoring of missing 20Hz data over land.

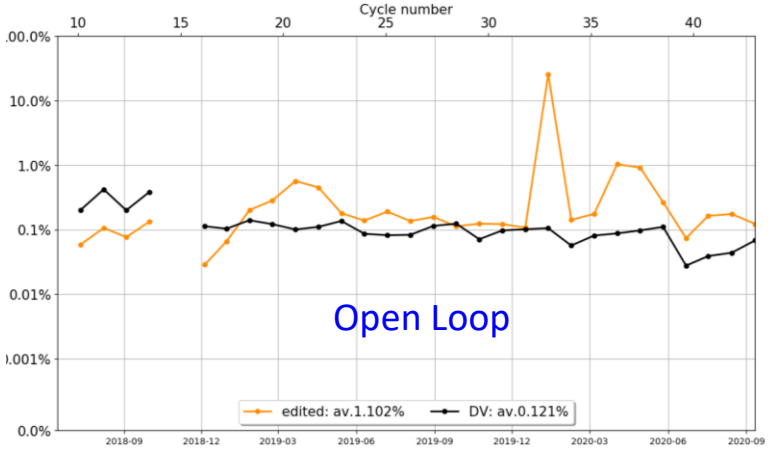
- More data in CL areas (>60° latitude) (and at the transition to calibration areas)

S3 routine performance monitoring over inland waters

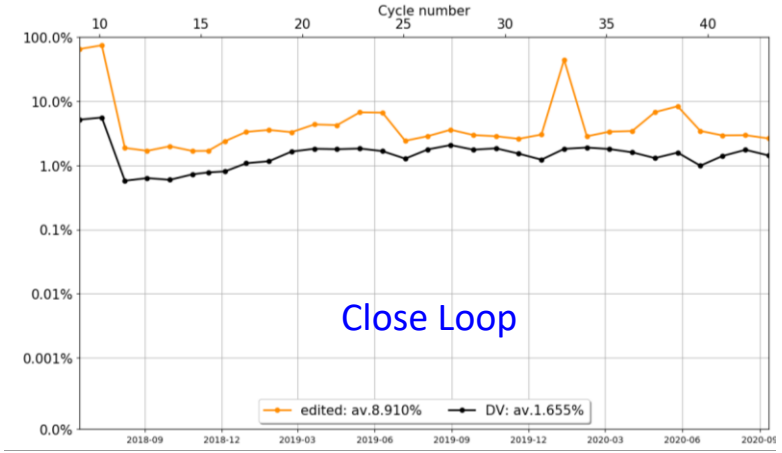
- Monitoring of the percentages of invalid / edited / valid retracker derived quantities, geophysical corrections, WSH estimates… over the 700 largest lakes worldwide.

Data invalidity

S3B. Percentage of edited /DV Sigma0 OCOG in OL



S3B. Percentage of edited /DV Sigma0 OCOG in CL

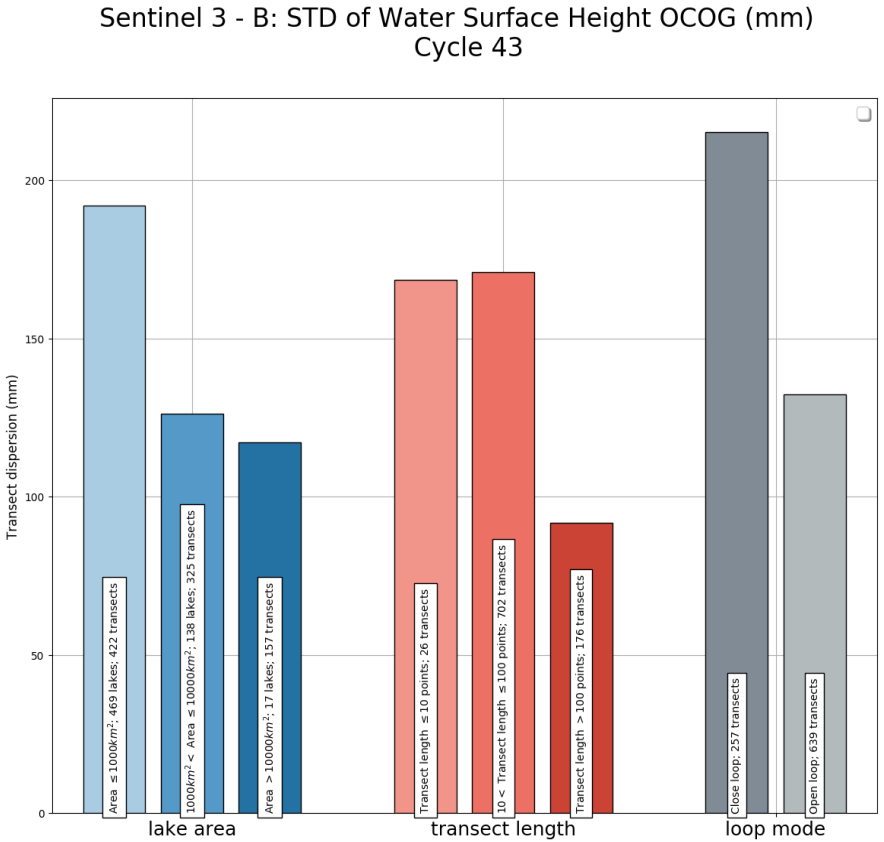


- Comparisons between OL and CL of the percentages (per cycle) of edited and default values for sigma0 OCOG in L2 PDGS Land STC products. (Lakes observed in CL are situated at latitude > 60°N)
  - ➢ Significantly less DV and edited points in OL

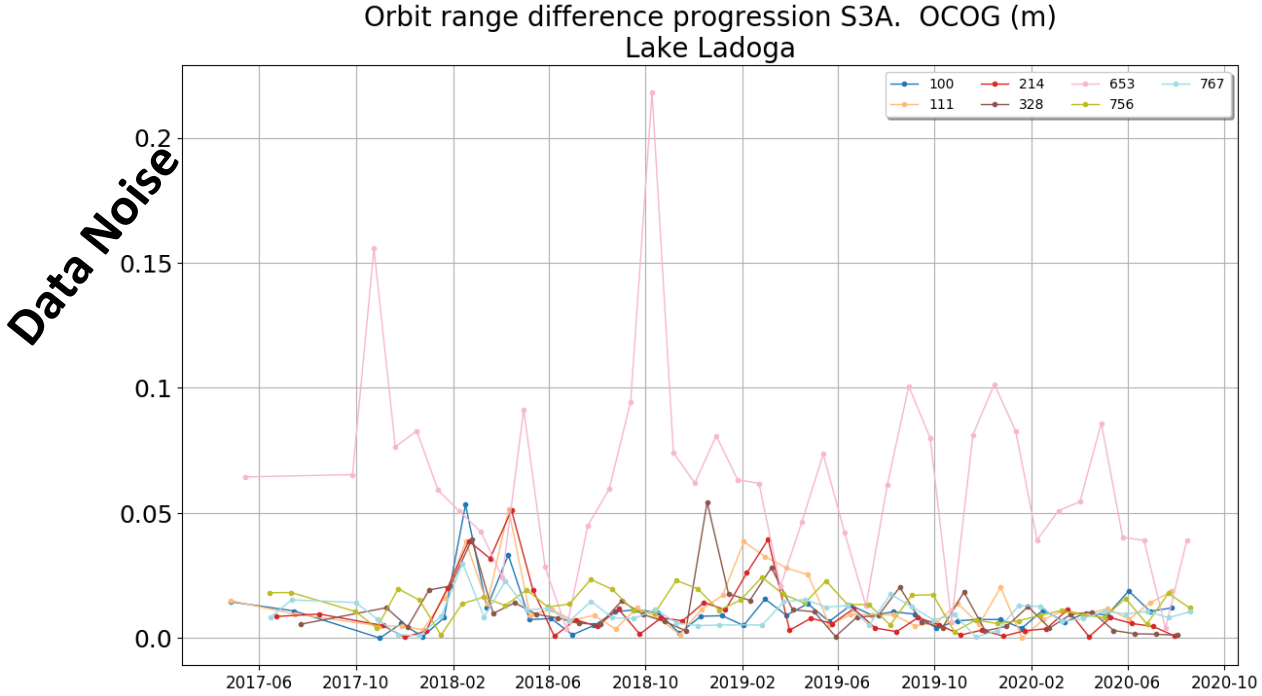
- Median of the Water Surface Height standard deviation deviation across transects (lake crossings)

Data precision

- ~13cm in OL
- >20cm in CL



- Median of the difference of the (orbit – range) quantity in between two consecutive 20Hz points



- Provide an estimate of the noise at 20Hz associated with the retracking algorithm (OCOG here)
- Pass 653 (pink) very small and near lake coast : ground increases the noise
- See if further improvement when OL will be used at latitude > 60°

Conclusions and perspectives

OL presents benefits over CL in terms of available and valid data. Accuracy and precision in WSH estimates is also improved.

- Comparisons of OL and CL performances over the tandem phase : almost no missing or invalid 20 Hz data in OL, it reaches about 12% in CL.
- Accuracy improved in OL : 5.3% of points with |WSH-water elevation reference|>15m. While of the order of 24.9% in CL.
- Updates increasing the number of fine-tuned OLTC targets allows significant increase in the number of targets over which the altimeter detects water
- MPC advises that a flag indicating whether the OLTC was fine-tuned or not for each of the 20 Hz data points will be added in the L2 PDGS Land products. Users will be strongly encouraged to use it to select WSH estimates over water targets for which a fine-tuned OLTC is defined.
- Routine MPC cycle monitoring also confirms the stability of these results

More details in Taburet et al. *Remote Sens.* **2020**, *12*(18), 3055 https://doi.org/10.3390/rs12183055

OLTC last updates and ZDB extensions

- OLTCv6.0 (S3A) since 27/08/2020. OLTCv3.0 (S3B) since 18/06/2020
- See also S. Le Gac presentation on the 2020 S3A&B OLTC updates (content, activation and first results)
- ZDB updates (use of OL at latitudes > 60°N) : S3B 21/10/2020. S3A 07/11/2020.

Thank you for your attention