Nadir altimetry over land: Achievements using the Open-Loop Tracking Command (OLTC)

Benefits for inland waters users

S. Le Gac[1], F. Wery[1],
A. Homerin[2], J.-B. Barneix[2], M. Boussaroque[3,4], F. Boy[1], N. Picot[1], P. Féménias[5]
[1]CNES, [2]Noveltis, [3]HydroMatters, [4]LEGOS, [5]ESA/ESRIN

florian.wery@cnes.fr
oltc@noveltis.fr

Overview

- Background on OLTC for inland waters
- OLTC updates in 2023
- Validation results
- OLTC website
- Conclusion

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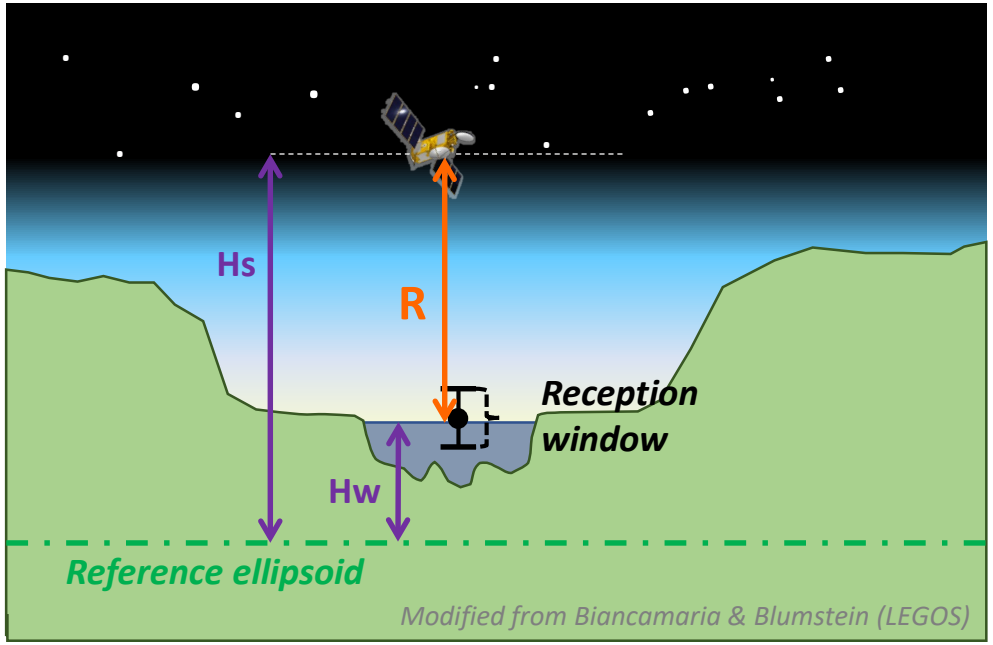
Altimetry over inland waters : principles



R = Range distance between satellite and water surface
Hs = Altitude of satellite above ref. ellipsoid
Hw = Altitude of water surface above ref. ellipsoid

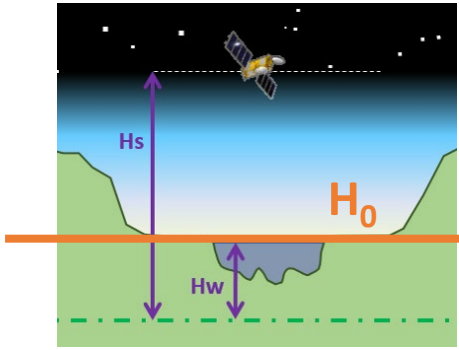
Radar altimeters provide accurate **range** measurement between the instrument and the surface.
The range estimation **R** results from **on-board operations (*tracking*)** and **on-ground post-processing (*retracking*)** of the waveforms.

Waveforms are acquired in the altimeter **reception window**, which is set by the **on-board tracking mode :**

- **« Closed-Loop »** mode aka *autonomous mode*
- **« Open-Loop »** aka *Diode/DEM*

- The size of the reception window of the altimeter is **60 meters by design**
- Closed-Loop mode has some drawbacks e.g. **loss of tracking** or **tracking of the wrong surface**

➔ **Defining on-board *a priori* water body average elevation H_0 is key to acquire measurements in all terrain configurations**



Modified from Biancamaria & Blumstein (LEGOS)

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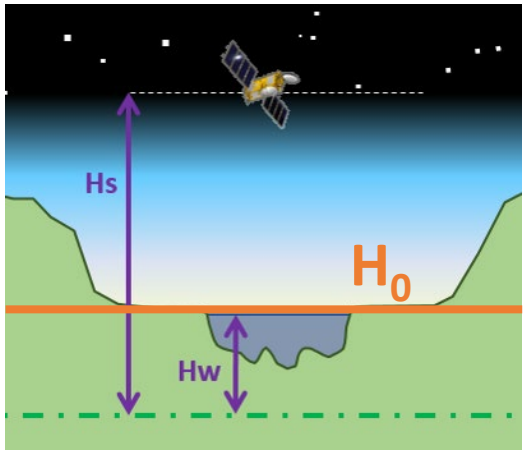
Altimeter onboard optimization : OLTC tables

A database of hydrological targets serves as input for on-board OLTC tables generation :

- Only for water bodies located under the satellite ground track **(nadir altimetry)**
- Define water body center **position** and **size** (along-track width)
- Define **average elevation** command H_0 with a possible variability of about ±10 m to fall in the tracking window and allow retracking



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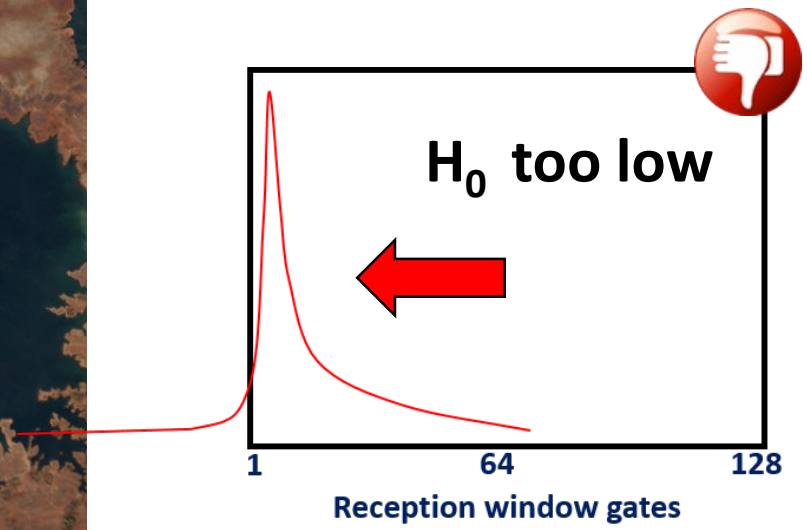

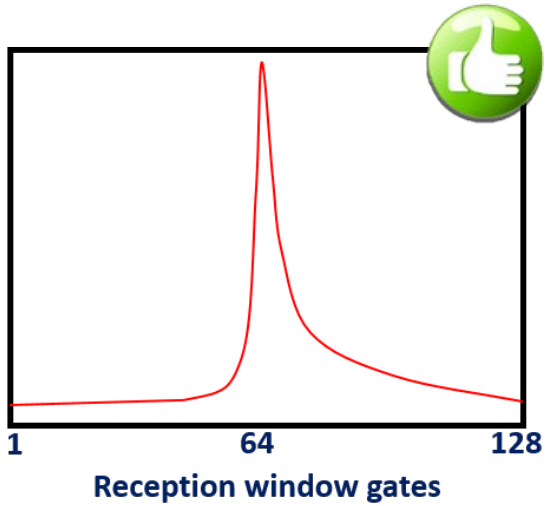

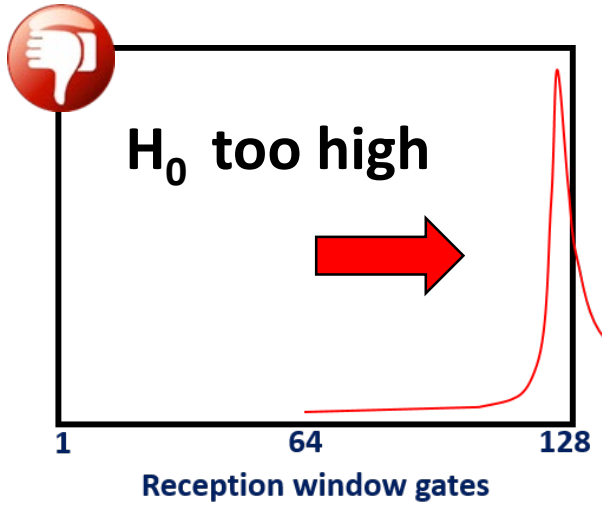

The website https://www.altimetry-hydro.eu allows you to view onboard elevations and contribute to the virtual stations database !

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OLTC updates in 2023 : context

Sentinel-3A, Sentinel-3B and SWOT-Nadir have been updated with new onboard OLTC tables in 2023

- **No changes over ocean** to ensure continuity
- **Correction of elevation command for a new number of hydrological targets** (see next slides) to maximize the capability of nadir altimeters to acquire measurements over inland waters
- **Upload of the first DEM for SWOT-Nadir on the Science orbit**

Organization

- LEGOS team and hydrology users provide targets to be included in OLTC tables
- NOVELTIS generates and validates the new OLTC onboard tables
- CNES coordinates the delivery of upgraded OLTC tables to the operational agency and reporting to the missions project teams
  - CNES for SWOT-Nadir
  - S3MPC/Eumetsat and ESA for Sentinel-3
- NOVELTIS provides CNES with first validation results (successful acquisition score – see next section)
- LEGOS scientists provide scientific validation in the frame of Volodia project (ESA/CNES project)
- All hydrology users are invited to dive into the new data !

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OLTC updates in 2023 : context

JASON-3

(interleaved orbit)
OLTC v5.0 since
Sept. 29, 2022
~31,500 targets

SWOT-Nadir

OLTC v3.0 since
Oct. 9, 2023
~59,000 targets

SENTINEL-3A

OLTC v6.3 since
Sept. 25, 2023
~74,000 targets

SENTINEL-6-MF

OLTC v1.3 since
May 10, 2023
~31,600 targets

SENTINEL-3B

OLTC v4.0 since
August 24, 2023
~74,000 targets
Including new high-resolution targets over continental ice

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SWOT-Nadir OLTC Status in October 2023

(CNES/LEGOS/NOVELTIS)

Science Orbit since September 2023 !

Jason-3-int. ≈ 31,000

Sentinel-3A Sentinel-3B ≈ 148,000 hydro targets

Sentinel-6-MF ≈ 32,000

SWOT-Nadir ≈ 58,000

Rivers Lakes Reservoirs

Sentinel-3 OLTC Tables Status in October 2023

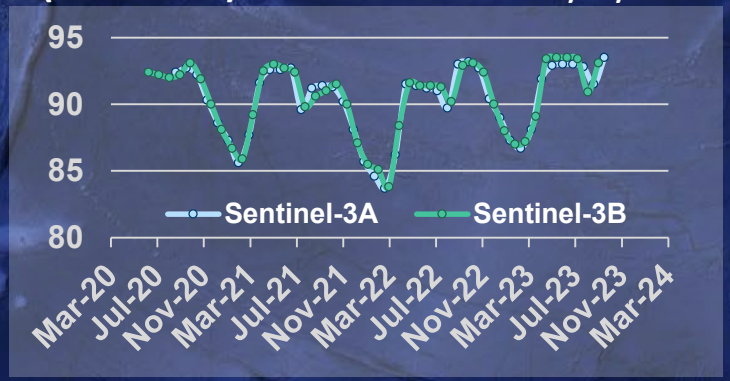
(CNES/LEGOS/NOVELTIS)

New updates in 2023 !

S3A v6.3 (Sept. 25) and **S3B** v4.0 (Aug. 24)

Signal quality performance

(% success) is monitored every cycle



Jason-3-int.
≈ 31,000

Sentinel-3A **Sentinel-3B**
≈ 148,000 hydro targets

Sentinel-6-MF
≈ 32,000

SWOT-Nadir
≈ 58,000

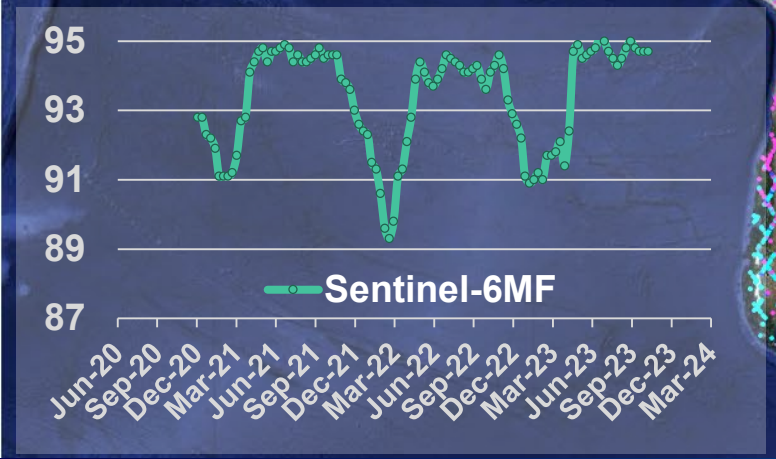
Rivers Lakes Reservoirs

Sentinel-6-MF OLTC Tables Status in October 2023

(CNES/LEGOS/NOVELTIS)

Nominal Open-Loop operating mode in 2023

Signal quality performance **(% success)** is monitored every cycle



Jason-3-int. ≈ 31,000

Sentinel-3A Sentinel-3B ≈ 148,000 hydro targets

Sentinel-6-MF ≈ 32,000

SWOT-Nadir ≈ 58,000

Rivers Lakes Reservoirs

Jason-3 Interleaved OLTC Status in October 2023

(CNES/LEGOS/NOVELTIS)

Back to **Open-Loop Mode** since **February 2023** !

Jason-3-int.
≈ 31,000

Sentinel-3A **Sentinel-3B**
≈ 148,000 hydro targets

Sentinel-6-MF
≈ 32,000

SWOT-Nadir
≈ 58,000

Rivers **Lakes** **Reservoirs**

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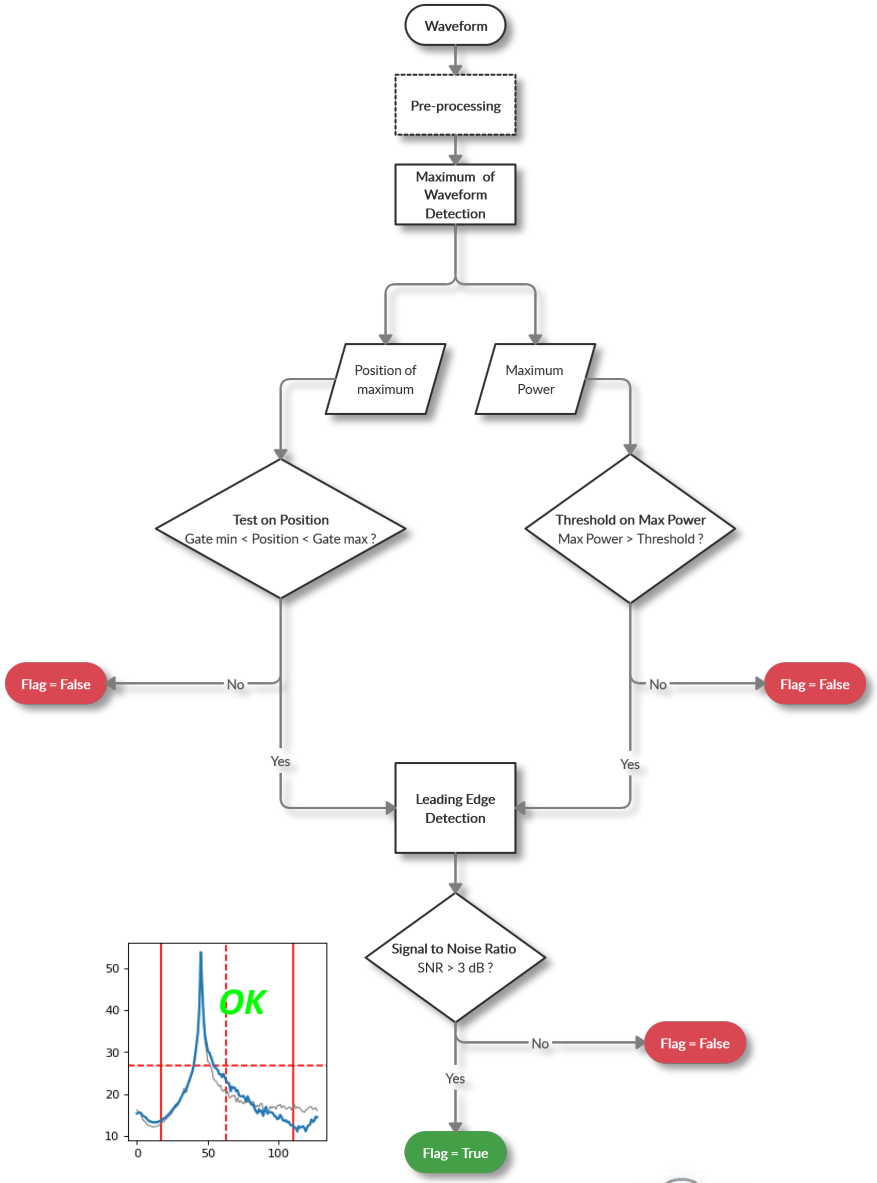
Global validation method

- Global validation is performed through a **performance indicator**
- **This indicator is based on the 20 Hz waveforms analysis** (position of the maximum, leading edge detection, signal to noise ratio)
- **Performance indicator** → global **rate of successful acquisitions**
- **OK** indicates that the OLTC elevation a priori information is correctly defined and a relevant WSH can be retrieved
- **NOK** indicates that the OLTC elevation command needs to be adjusted, or that the observed surface is complex with several water bodies, or that the altimeter was not able to acquire signal (calibration, platform manoeuver,…)

More details in
Le Gac et al.
ASR 2019



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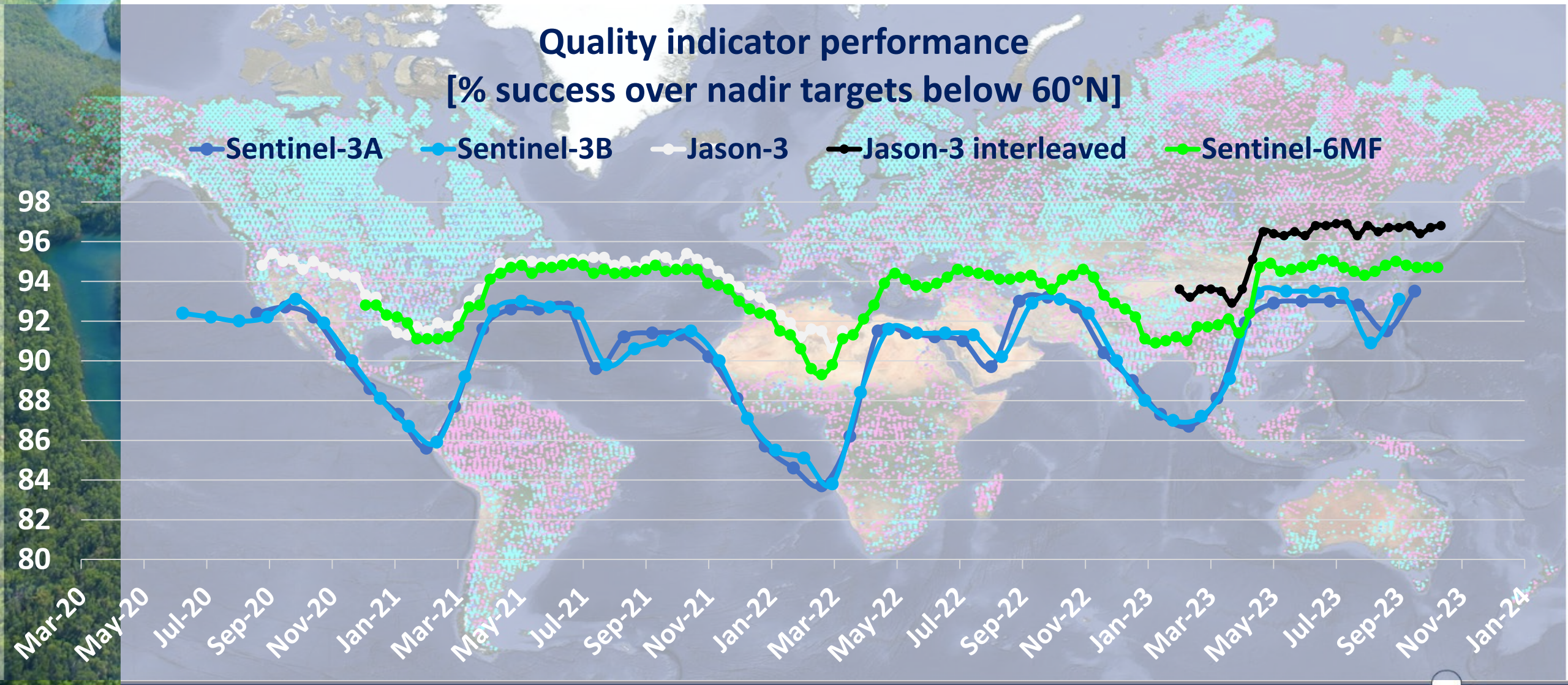
OLTC status in 2023 : detailed numbers



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https://www.altimetry-hydro.eu

A new version of the OLTC website has come live in 2023!

Updated features include:

- Display of hydro targets used in OLTC tables on Sentinel-3A, Sentinel-3B and Sentinel-6-MF (New!)
- Improved map interface
- Improved responsiveness
- Documentation and informations available

Everybody can contribute to the OLTC tables contents by proposing new hydro targets!

New feature foreseen in 2024 : direct download of the OLTC targets from the website

Stay tuned !

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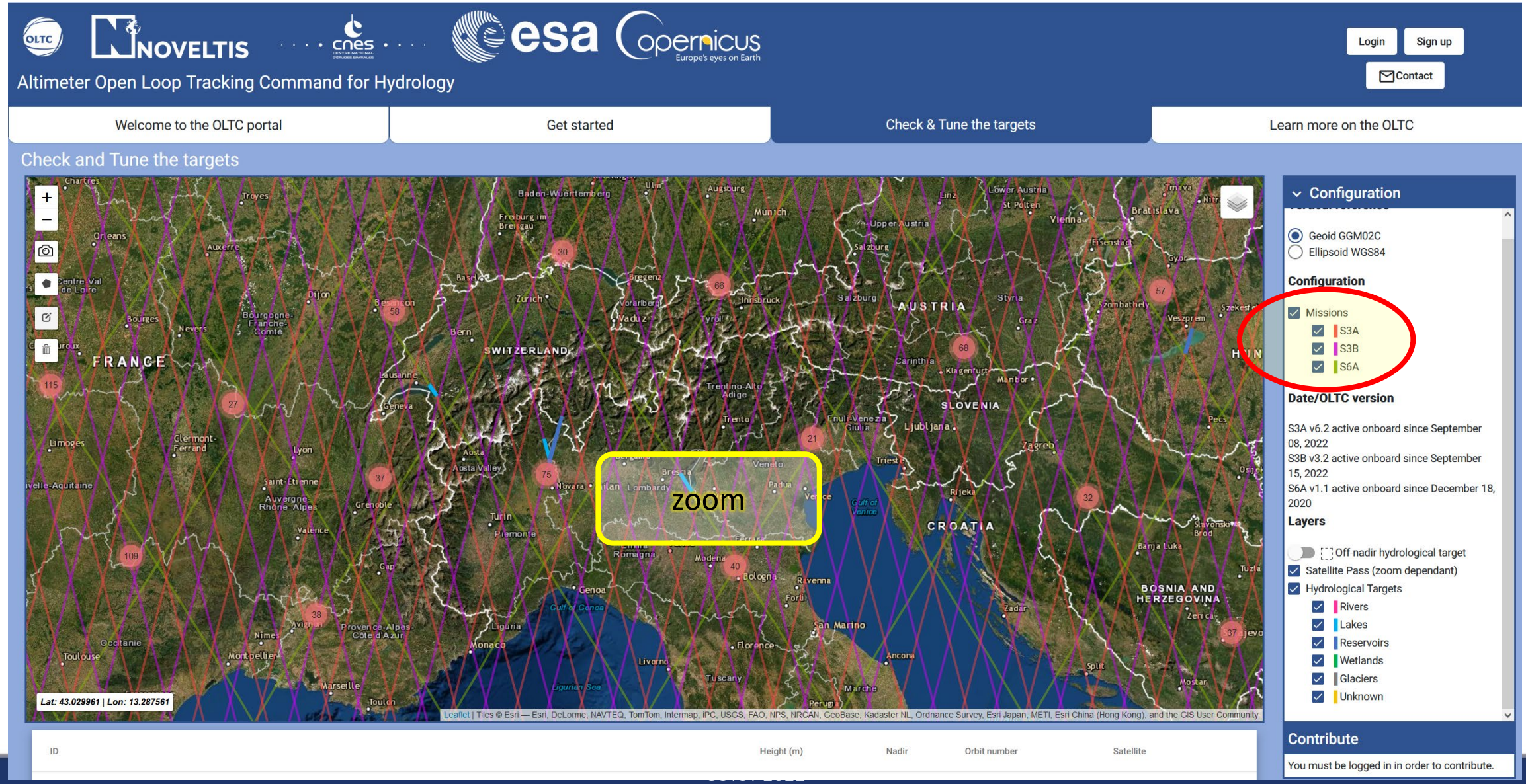
https://www.altimetry-hydro.eu



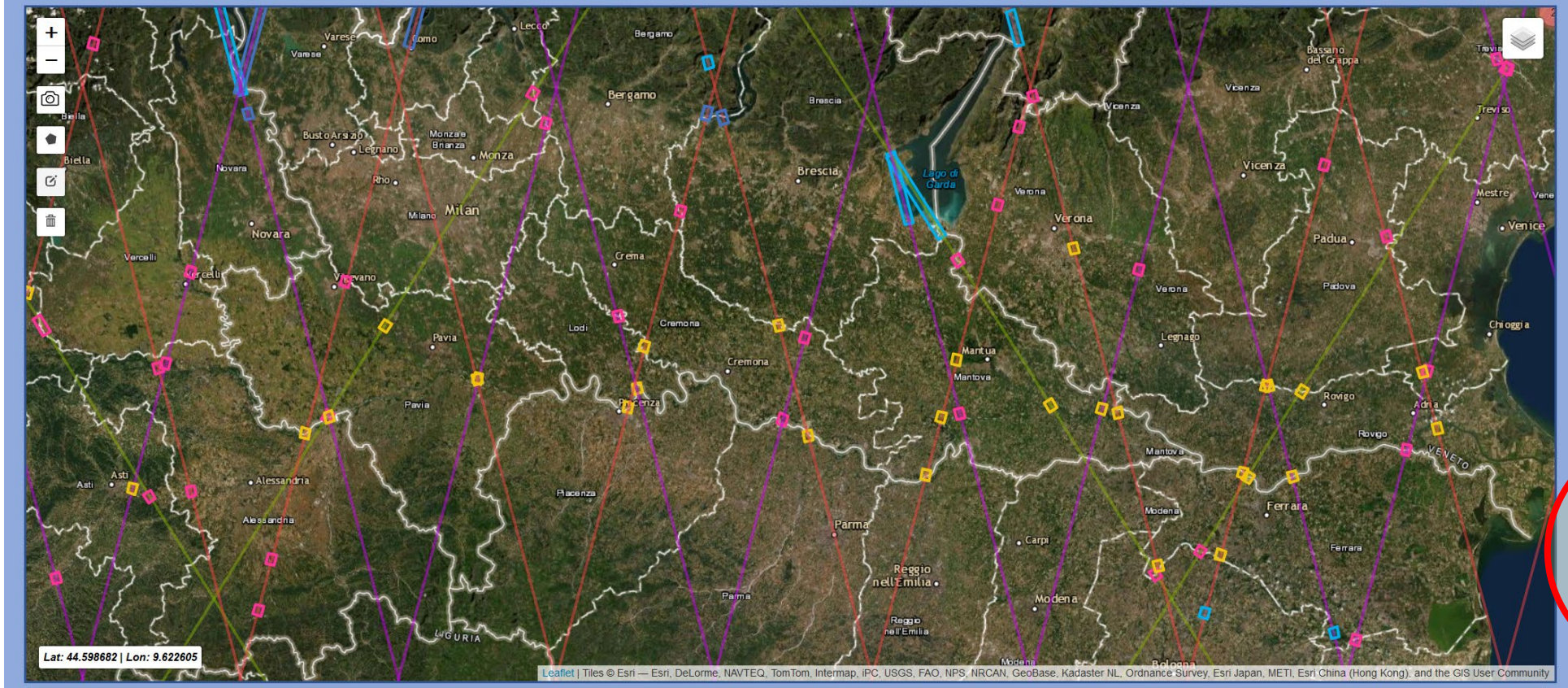
https://www.altimetry-hydro.eu

Altimeter Open Loop Tracking Command for Hydrology

Login | Sign up | Contact

Welcome to the OLTC portal | Get started | Check & Tune the targets | Learn more on the OLTC

Check and Tune the targets



Configuration

- Geoid GGM02C
- Ellipsoid WGS84

Configuration

- Missions
  - S3A
  - S3B
  - S6A

Date/OLTC version

S3A v6.2 active onboard since September 08, 2022
S3B v3.2 active onboard since September 15, 2022
S6A v1.1 active onboard since December 18, 2020

Layers

- Off-nadir hydrological target
- Satellite Pass (zoom dependant)
- Hydrological Targets
  - Rivers
  - Lakes
  - Reservoirs
  - Wetlands
  - Glaciers
  - Unknown

Contribute

You must be logged in in order to contribute.

ID	Height (m)	Nadir	Orbit number	Satellite

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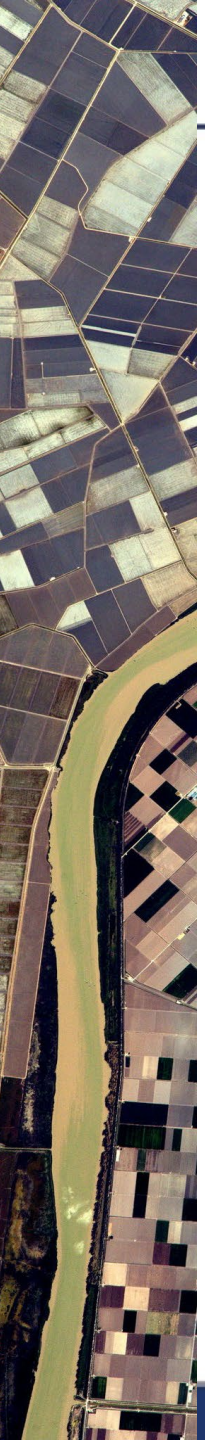

Conclusion and perspectives

- **Open-Loop tracking mode is key to inland waters observation**
  - Onboard OLTC tables are used to **set the echo reception window**
  - A **database of inland water targets** is used to generate OLTC tables over land
  - Targets are defined with **elevation H_0** and **width** of the water body (lake, reservoir, river, glacier…)

- **OLTC tables have been recently updated**
  - No changes over ocean and coastal zones
  - Sentinel-3B updated on August 24, 2023, **including high resolution commands over continental ice**
  - Sentinel-3A updated on September 25, 2023
  - **After moving to the interleaved orbit**, and operating in Closed-Loop mode during serveral months, **Jason-3 holds new OLTC tables (≈30,000 hydro targets)** and is back operating in Open-Loop Mode since September 29, 2022
  - **Sentinel-6-MF** holds the same targets database than Jason-3 during Tandem Phase

- **Global validation results show very good continuous performance !**
  - Performance is evaluated thanks to waveform shape and centering analysis (acquisition score)
  - Global performance is **>90% on Jason-3 and Sentinel-6-MF** for all inland water targets
  - Global performance is **~85% on Sentinel-3** for all inland water targets

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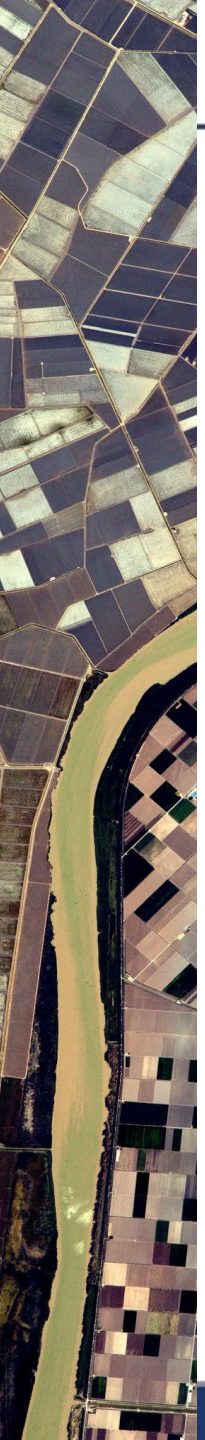

Conclusion and perspectives

- **OLTC Web portal available to the users : https://www.altimetry-hydro.eu**
  - View onboard elevations and contribute to new virtual stations !
  - **New version of the portal available soon !**

- **A massive amount of altimetry data is now available over inland waters worldwide**
  - The altimeters capability has been greatly enhanced over land thanks to OLTC tables optimization
  - Scientific data analyses and studies are required (see for example, other presentations in this session)
  - **Nadir altimetry over hydrology is an essential companion to SWOT**

- **OLTC is also used for other altimetry applications**
  - Ground calibration means, UAV-based measurements campaigns
  - Potential for continental glaciers and ice margins measurement
    → on-going studies on Sentinel-3 in preparation for CRISTAL

- **OLTC and targets database as inputs for innovative ground processing and services**
  - Fully-Focused SAR processing (cf. *Boy et al., Moreau et al., Daguze et al.*, OSTST 2023)
  - Monitoring of inland waters through dedicated services e.g. Hydroweb/Hysope

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