Operational Water Level monitoring with satellite altimetry in Copernicus Global Land Service

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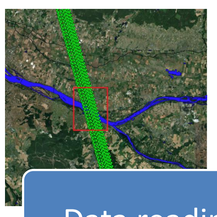
Context

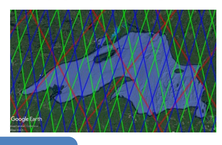
Inland water is a more and more pressured resource for the population needs as well as a societal risk for local populations. It is also a fundamental element for industry and agriculture, therefore becoming an economic and political stake. The monitoring of inland water level, proxy to freshwater stocks, conditions of navigability on inland waterways, discharge, flood prevention, is thus an important challenge. With the decreasing number of publicly available in situ water level records, the altimetry constellation brings a powerful and complementary alternative.

The Lake and River Water Level products of Copernicus Global Land service provide **water level time series and their associated uncertainties** using the Copernicus **satellite altimeters** (Sentinel-3A, Sentinel-3B and Sentinel-6MF) over the water targets located beneath these satellites passes. The production and delivery of the water level timeseries take place in a timely manner: **3 days after observation**.

Processing

- Processing based on Hysope software, prototyped by Legos. Evolutions and maintenance **co-funded** by **CNES Theia Project** and **Copernicus** program.
- Input data: **Level 2 STC** (short time critical) satellite altimetry data (Sentinel-3A, Sentinel-3B and Sentinel-6MF – in continuation of Jason altimeters -). The service transitioned to the S3 Thematic Hydro products end of September 2023.
- Separate processing chains over rivers and lakes:
  - **Virtual Stations** (VS) are **monomission** products defined at the intersection of a satellite ground track and a river
  - **Lake** products are **multimission**, all satellite passes over a lake are combined and **bias corrected**

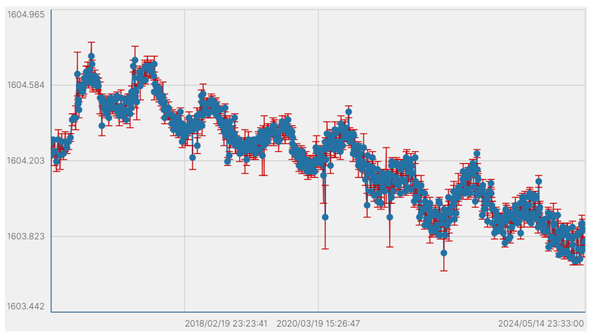




Data reading
- By altimetry ground track
- For each mission

Data selection
- Geographical extraction per VS or lake

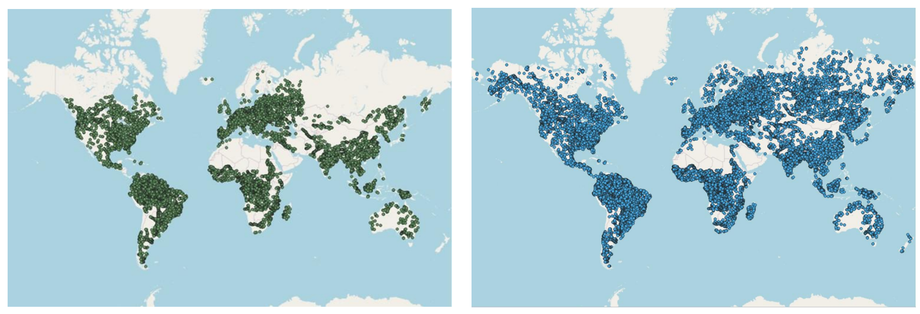
WSH computation
- Outlier rejection
- Intermission and interpasses bias correction (for lakes)
- Median of valid points
- Uncertainty computation



Example of water Level timeseries and associated uncertainties. Zoom in the timeseries over lake IssykKul

Coverage

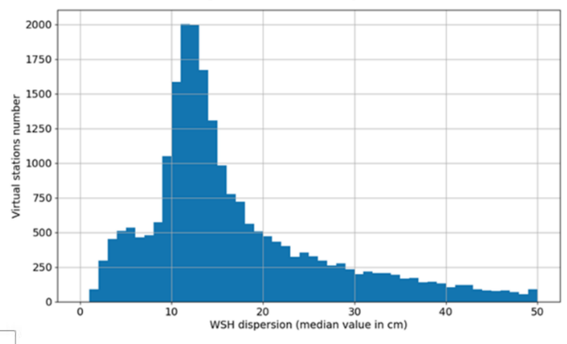
- Provide users with **worldwide near-real-time water level time series and uncertainties** on inland water targets located beneath satellites tracks.
- The lake and river water level products are **updated daily.**
- The temporal repeatability for each product depends on the satellites revisit:
  - Every **10 days for Jason/Sentinel-6MF** and **27 days for Sentinel-3A&B river** products
  - Revisit time over **lakes**: **depends on their latitude and surface. T**he larger their surface, the more overflown by several satellite passes, the smaller is the time in between two revisits

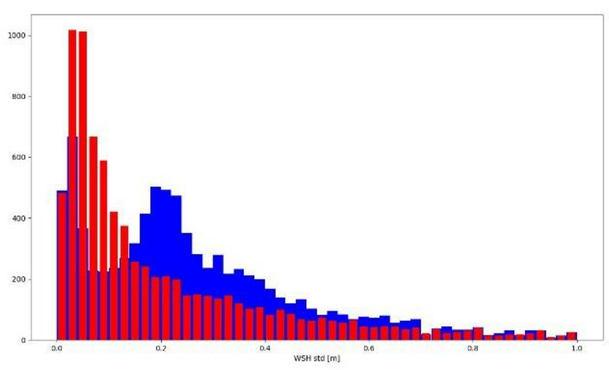


Left (green dots) VS locations in the V2.1 of the product (11 335 VS in total). Right (blue dots) locations in V3 since 2023 (22 829 VS in total)

Statistical assessment

- Quality assessment is regularly performed, and results are publicly available within the Quality Assurance Report
- Overall the river dataset, WSH timeseries have a **completeness of 96 %**
- Available in average within **2.25 days after data acquisition** by the satellites
- **Median uncertainty** is about **13 cm** over the sample of 22829 VS. However, it remains larger than 30 cm for several VS (about 12 % of the full dataset) due to river steps or slopes





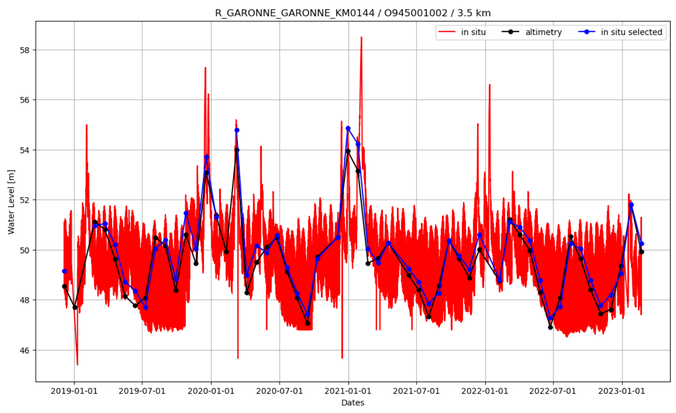
- Mission comparisons: improvements brought by the introduction of Sentinel-6MF in place of Jason-3. The uncertainties on rivers water level are improved.

Distribution of uncertaintes associated with the Jason-3 (blue) and the S6-MF (red), over a same period during the tandem phase (2021-10-03 to 2022-02-01) in the river products over 749 VS.

Performances with respect to InSitu data

Over **rivers**, comparisons with in situ data over **136 VS** in France. In situ data were gathered from French SCHAPI network (https://hydro.eaufrance.fr) within 5km of the altimetric VS. A maximum threshold of 30 minutes was used to select in situ data corresponding to each point of the altimetric timeseries.

- **Median unbiased RMSE** is of **31.3 cm for S3A** (40 VS), **35.3 cm for S3B** (39 VS) and **30.2 cm for J3/S6** (15 VS whose time period length is dominated by J3). **Median correlation** are of respectively **0.76, 0.79 and 0.82.**



Over **lakes** comparisons were performed with in situ data from the ANA (Brasil), FOEN (Switzerland), Canadian Water Office, USGS (USA) and Hidricos (Argentina) over **69 sites**

- **Median unbiased RMSE** is of 13 cm and median correlation of 0.95.

Recent evolutions

- Increase the number of monitored rivers and lakes (from ~500 in 2016 to more than 22000 now)
- Ensuring continuity of Jason timeseries with Sentinel6-MF (April 2022) and quality assessment
- Integrate S3 Thematic Hydro products in the processing (2023)
- Correct for river slopes (2024)

Future evolutions (mid and long term)

- Continue increasing the number of monitored rivers and lakes
- Process off-nadir water bodies
- Integrate SWOT nadir and SWOT swath altimetry data.

Usefull links (data access and docs)

https://land.copernicus.eu/en/products/water-bodies/water-level-rivers-near-real-time-v2.0
https://land.copernicus.eu/en/products/water-bodies/water-level-lakes-near-real-time-v2.0
Products also available on https://hydroweb.next.theia-land.fr/