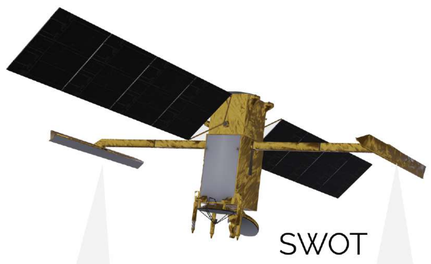
2025 SWOT Science Team Meeting

Validation of SWOT Lake water level using in situ measurements

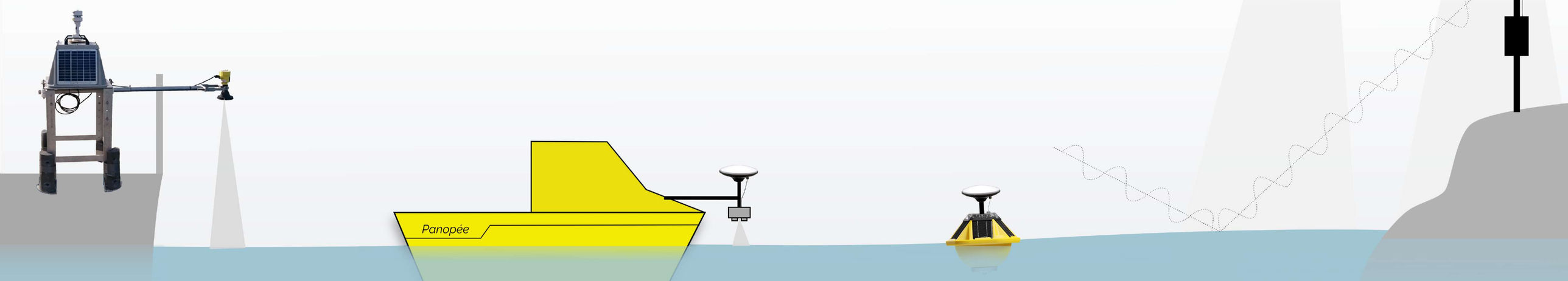
- Results from a student project at Lake Guerledan (France) -

CHUPIN Clémence[1], BOSSER Pierre[1], ENET Severine[1], BEAU Clémentine[1], BEDART Scott[1], BESNARD Zoé[1], HENNEUSE Lola[1], MONOURY-HOMET Kim[1], RIDEL Siméon[1], FAGUET Jules[1,2]

1. Lab-STICC / M3, École Nationale des Sciences et Techniques Avancées (ENSTA) / IP Paris, Campus de Brest, France
2. École Nationale des Sciences Géographiques (ENSG), France



As part of an engineering student project, we have tested KaRin's abilities on one of Brittany's largest freshwater bodies: the Guerlédan dam lake. Since 2015, this lake is the playground for hydrography and robotics students at the École Nationale Supérieure des Techniques Avancées (ENSTA) [1]. This year, six students were responsible for the lake's instrumentation to monitor water levels, with the aim of comparing the collected data with SWOT observations in the area.



EPONIM

Equipement Ponctuel pour l'Observation du NIveau de la Mer

- Autonomous radar tide gauge developped at Shom [2], with real-time visualization on a mobile application.
- Installed on the top of the dam to allow inter-comparison of all systems.
- Need of levelling to tie the mesurement to legal reference system.

GNSS & Low-cost Altimeter

- Combination of a low-cost GNSS antenna and receiver (Septentrio), low-cost acoustic altimeter and weather sensor, developped by the students.
- Can be deployed over a boat or an Unmanned Surface Vehicle (USV) for 2D measurements of the water surface.

GNSS Buoy & pressure gauge

- Low-cost GNSS buoys developped by previous student projects [3] using Septentrio Mosaic receivers.
- RBR duet^3 and solo^3 pressure gauges moored in the lake for several months, in particular under Sentinel-3a track.
- Absolute water level referencing thanks to joint measurement periods.

GNSS IR

GNSS Interferometric-Reflectometry

- Absolute sea level measurements techniques based on the analysis of GNSS signals reflected by the antenna's environment.
- Water height computation based on spectral analysis using the Python package Gnssrefl [4].
- Need to optimize antenna positioning (height, location of water surfaces, etc.).

Lake in situ instrumentation

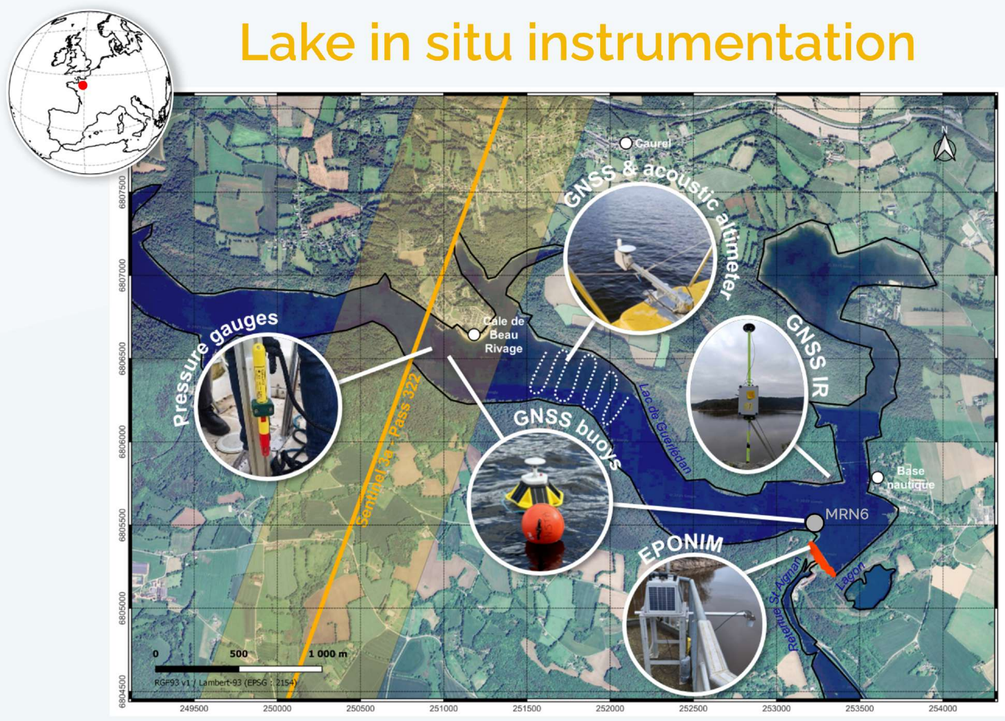
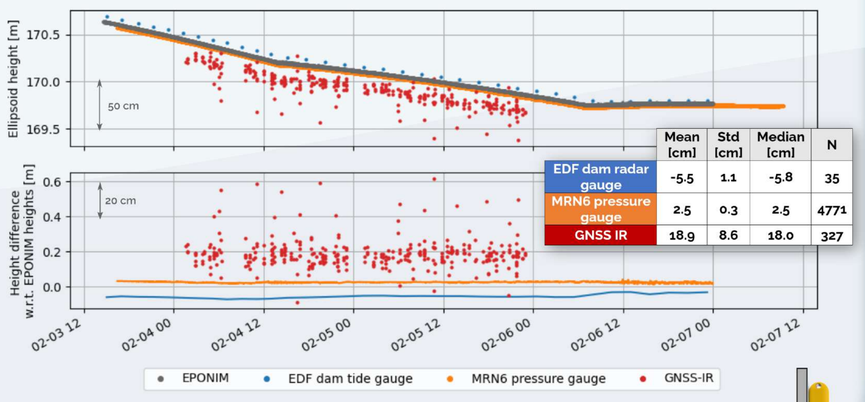


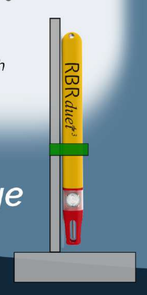
Figure 1 - Location of instruments deployed in February 2025 on lake Guerlédan.

- Sensors inter-comparison during common periods using EPONIM radar gauge as reference.
- Consistent water levels evolutions, despite inter-sensor biases in the range 2-20 cm.



	Mean [cm]	Std [cm]	Median [cm]	N
EDF dam radar gauge	-5.5	1.1	-5.8	35
MRN6 pressure gauge	2.5	0.3	2.5	4771
GNSS IR	18.9	8.6	18.0	327

Figure 2 - Lake surface elevation measured in February 2025 (upper pannel) and height differences with respect to EPONIM radar gauge (lower pannel). Statistics on the diffrences are listed on the table.



Pressure gauge

SWOT data analysis

- SWOT measurements over the lake (SWOT HR Raster 100m [5]).

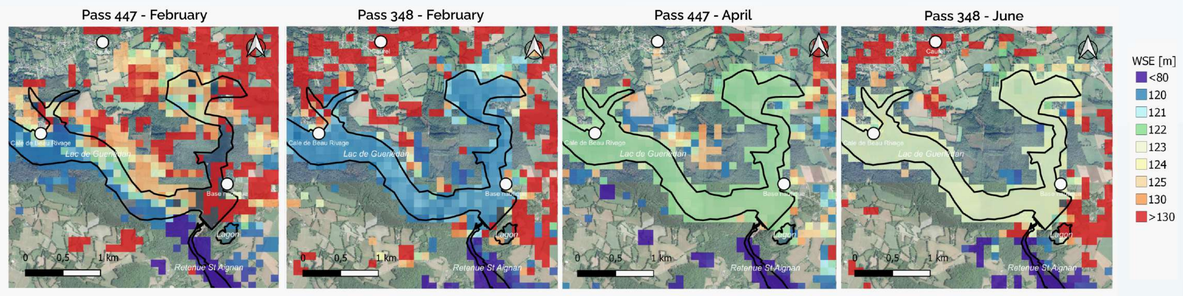


Figure 3 - SWOT Water Surface Elevation above geoid in 2024 over the lake.

- The coupled GNSS & acoustic altimeter system enabled space-based acquisitions on the lake during SWOT overflight (February 2025) for direct water level comparison.

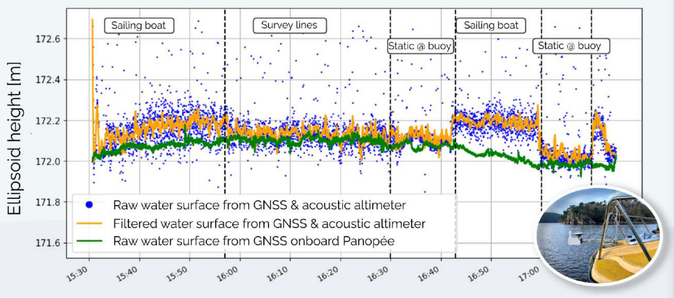


Figure 4 - GNSS & acoustic altimeter system measurements the 5th October, 2024.

- Water surface height varies greatly depending on the SWOT pixel considered, with biases >1m compared to in situ measurements.

	Pixel 1	Pixel 2	Pixel 3	Pixel 4
SWOT WSE [m]	161,0	184,3	171,1	174,8
SWOT WSE uncertainty [m]	2,3	1,1	2,7	1,4
GNSS & altimeter mean WSE [m]	169,76	169,76	169,74	169,75
Difference [m]	**-8,76**	**14,54**	**1,36**	**5,05**

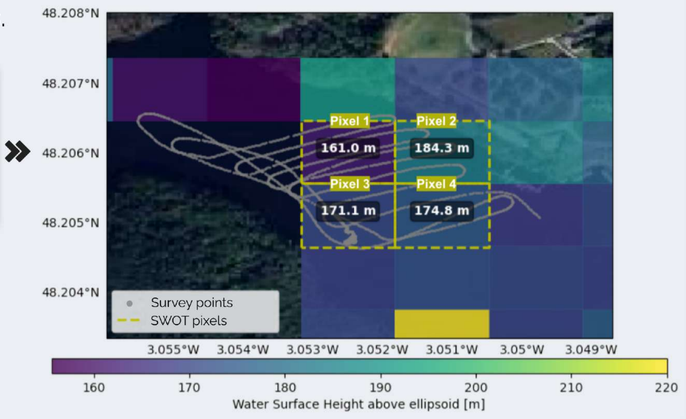


Figure 5 - SWOT measurement the 6th February 2025 on the lake, superimposed on the GNSS & acoustic altimeter system track the same day (grey points). Values inside the pixel show SWOT WSE values.

- Need to check the land/water classification, geolocation parameter and atmospheric corrections used in the SWOT WSE computation.

Conclusion & Perspectives

- Despite remaining inter-sensor biases, all instrument deployments were successful: the EPONIM radar and pressure sensors ensure reliable in situ measurements for comparisons.
- GNSS IR observations can be improved by using, for example, a system of antennas tilted at 90°, or dedicated processing algorithms [6].
- SWOT observations were retrieved from the lake, but a thorough analysis of corrections and flags is required to explain absolute biases observed with in situ measurements.
- Satellite data analysis will be completed by adding Sentinel-3a observations over the lake and permanent in situ sensors from vorteX-io [7], with the aim of making Lake Guerlédan a Fidutial Reference Measurement (FRM) site [8].

References

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