2 Campaign log

This Section provides a concise narrative of the campaign activities, including timeframe, geographical coverage, key objectives, participating organisations, and main personnel roles.

2.1 Team

The campaign took place on March 11, 2025, with the following personnel:

- Jean-Charles Sausserau (iTECH-Drone, UAV pilot)
- Tom Bruel (vorteX-io, Engineer)

2.2 Super-sites

The campaign covered two super-sites (Figure 1):

- Chalampé
- Ottmarsheim

The campaign also covered an additional site in Fessenheim for extended studies by SERTIT.

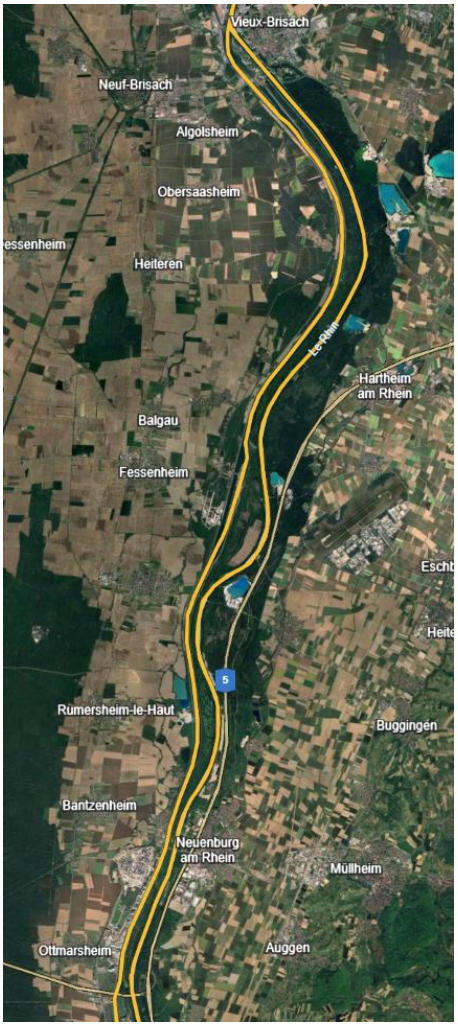

Figure 1: Flight plan of the campaign.

2.3 Instruments

The Matrice 350 RTK boasts a robust design, powerful propulsion, good protection rating, and excellent flight performance in harsh environments. The aircraft and remote controller feature a four-antenna transceiver system that intelligently selects the two optimal antennas for signal transmission, with all four antennas receiving signals simultaneously. This significantly improves anti-interference capabilities and optimizes transmission stability. The drone and its radio have an IP54 protection rating. The operating temperature range allows for flight in extremely hot or cold environments.

It is equipped with the VTX-2 sensor from vorteX-io. This lidar sensor was designed on a DJI gimbal that allows SDK connection with the drone, allowing full control of the sensor through the drone's control interface.

3 Sensor performance analysis

3.1 Base positioning

To obtain high-quality positioning for drone flights, GNSS base station measurements are required to perform PPK processing. The better the quality of the base station positioning, the more accurate the altimeter positioning will be. The base station position is excellent, with a standard deviation (STD) of 0.2 mm (Figure 2 and Figure 3).

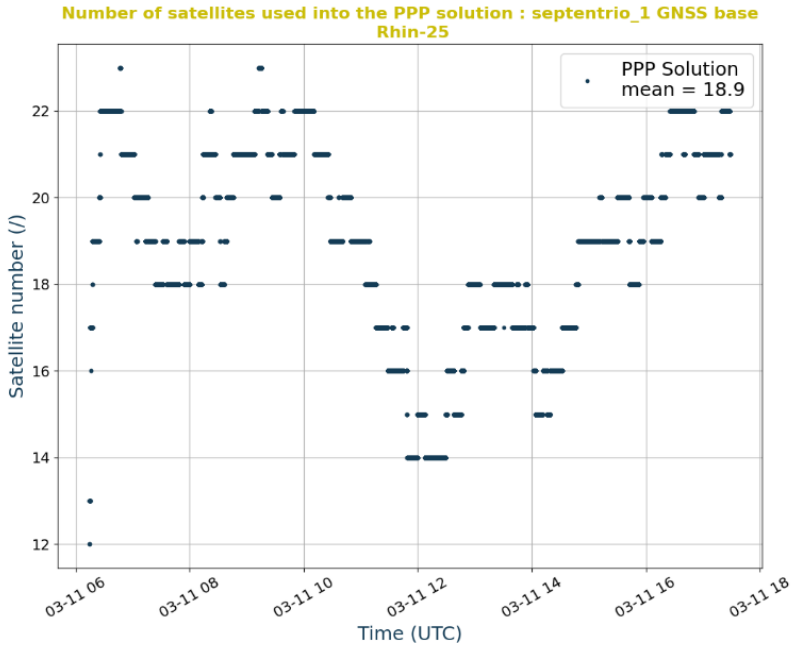

Figure 2: Number of satellites used in the PPP solution.

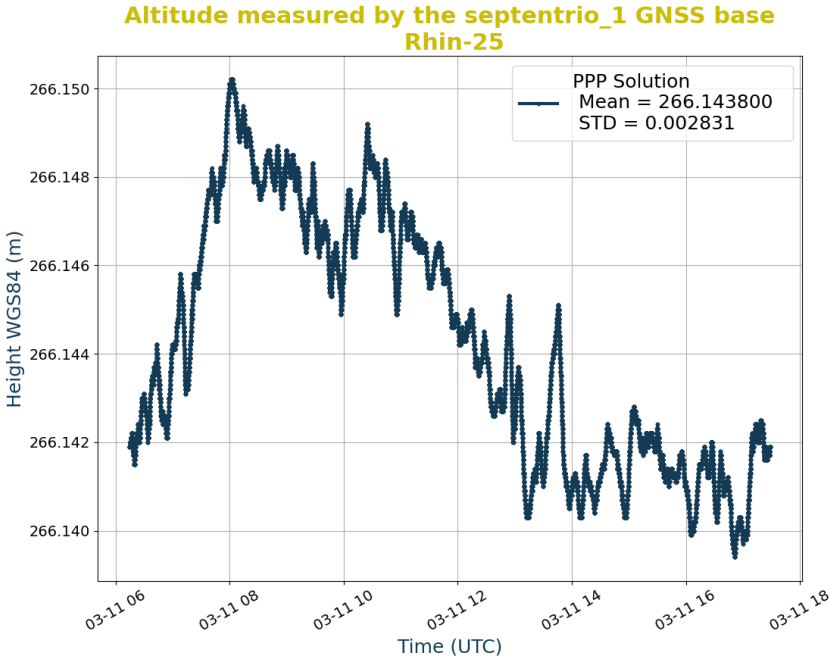

Figure 3: Altitude measured by the GNSS base.

3.2 Altimeter positioning

The positioning of the drone flights is very good, with all ambiguities resolved during positioning (Figure 4). We have great confidence in the altimeter positioning across all flights over the Rhine River.

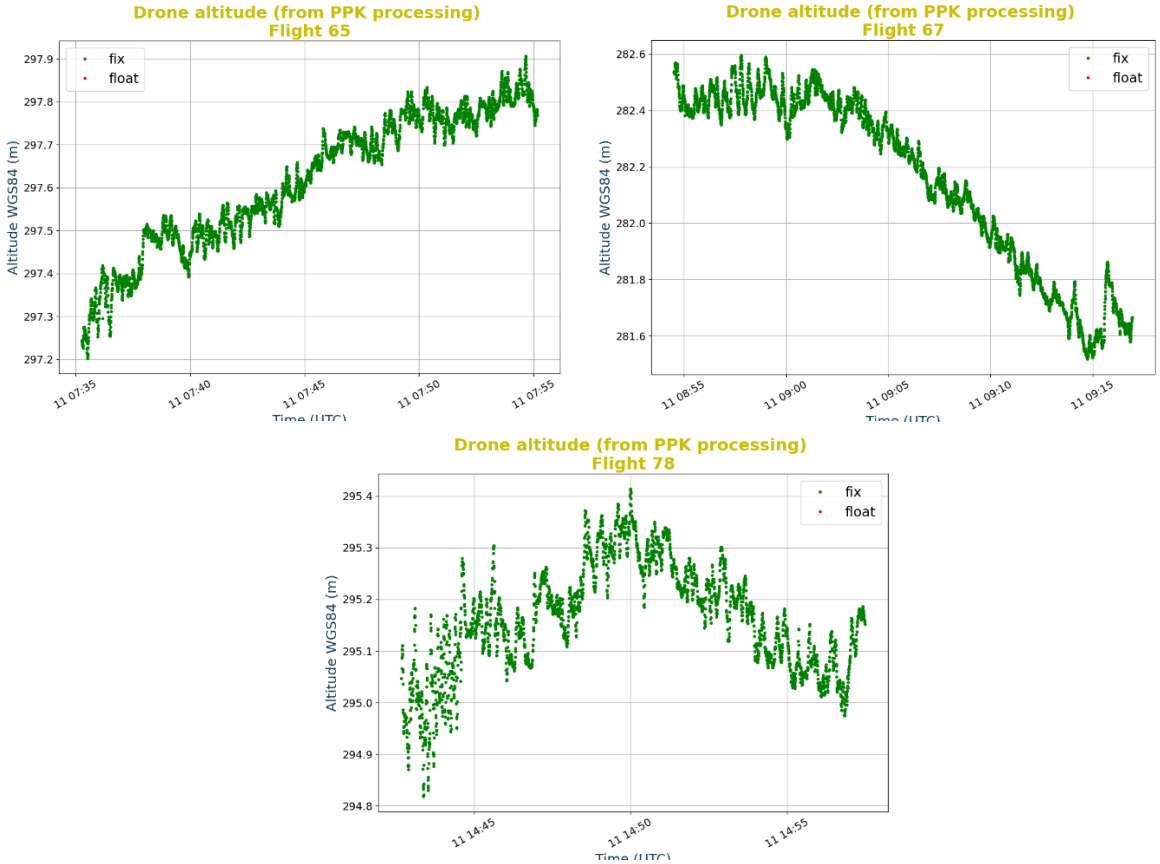

Figure 4: Drone altitude from PPK processing of flights 65, 67, and 78, respectively.

3.3 Quality of the lidar measurements

The quality of the LiDAR measurements is excellent, with no gaps in the data and no significant mispointing corrections required (Figure 5). There is almost no missing data across all flights conducted during the day. The two central beams performed exceptionally well. No notable mispointing was detected, confirming that the new gimbal is functioning as intended.

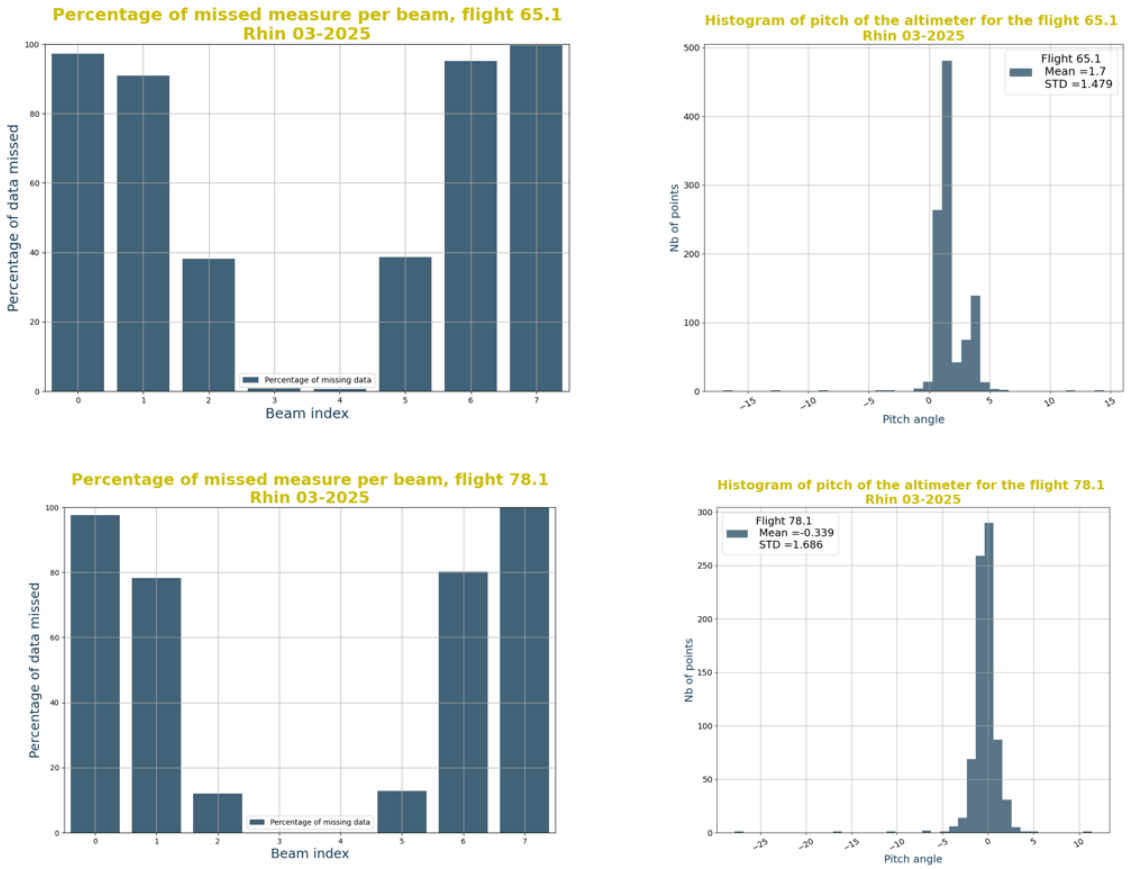

Figure 5: examples of the percentage of missed measures and the histogram of pitch for flights 65 (top panels) and 78 (bottom panel).

A problem was detected during data processing for one of the campaign flights. Missing data was identified on Flight 83. This issue is visible on the map displaying the KML of two flights (Figure 6):

- The flight on the right shows nominal operation.
- Flight 83, on the left, exhibits missing data.

The nature of the missing data is different from what has been observed so far.

Figure 6: KML of flight 83 (left) and flight 78 (right).

When we calculate the percentage of missing data for this flight (Figure 7), the results appear very good. This percentage is computed by comparing the number of NaNs in the LiDAR measurements to the total number of measurements. However, the issue we are encountering for the first time is that the LiDAR is not recording all measurements — not even the NaNs. We suspect a LiDAR malfunction, potentially related to its power supply. Further investigation is required to characterize the cause of this issue.

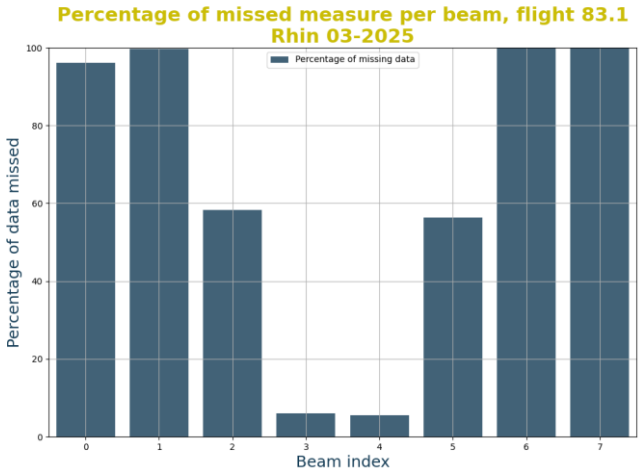

Figure 7: Percentage of missed measures per beam for flight 83.

4 Data acquisition and processing report

4.1 Processing and results

The main processing steps for the vorteX-io drone altimeter measurements are:

- Positioning of the base by PPP.
- Positioning of all the flights by PPK with the base as reference.
- Combining all the acquired data (GPS, IMU and lidar) to obtain raw water surface height (WSH) per flight.
- Processing the full reach by combining all the flights to obtain the linear.

When we calculate water height using LiDAR and positioning data (two examples are presented on Figure 8), the results are comparable to those from previous campaigns. Some noise is present in the data, with an amplitude of less than 5 cm, which is consistent with earlier observations.

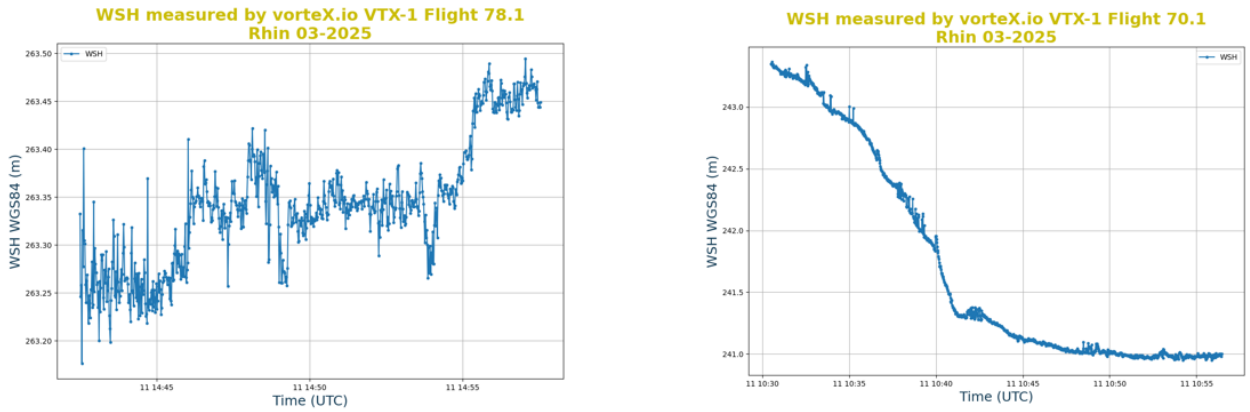

Figure 8: Water Surface Height measured by vorteX-io drone altimeter (flights 78 and 70).

When we reconstruct the hydrological topography profile (Figure 9 and Figure 10), we obtain very good results, with a profile that matches the dynamics of the Old Rhine.

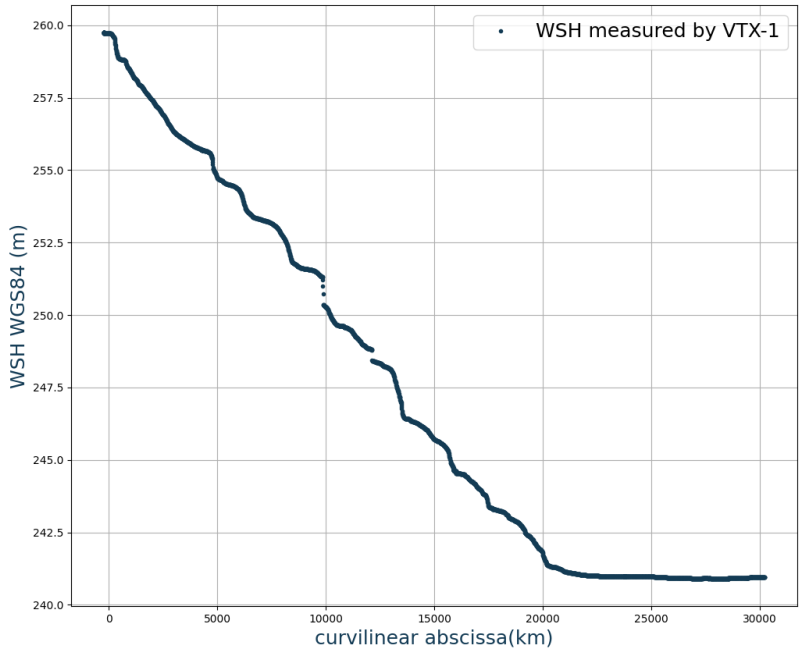

Figure 9: Old Rhine hydrological topography profile

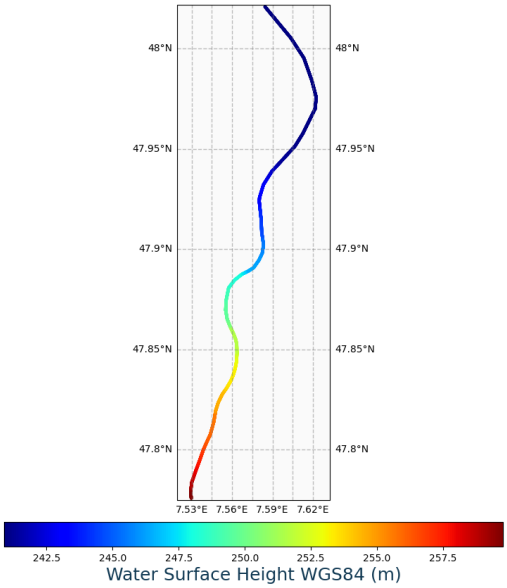

Figure 10: Old Rhine Water Surface Height along the river.

The results on Grand Canal d'Alsace are similar to those obtained on the Old Rhine (Figure 11 to Figure 14). The topography was captured during the drone campaign, with the dam located in the middle of the profile, dividing it into two sections.

Oscillations of about 2 to 4 cm have been observed on the Grand Canal of Alsace. These oscillations have currently no physical explanation.

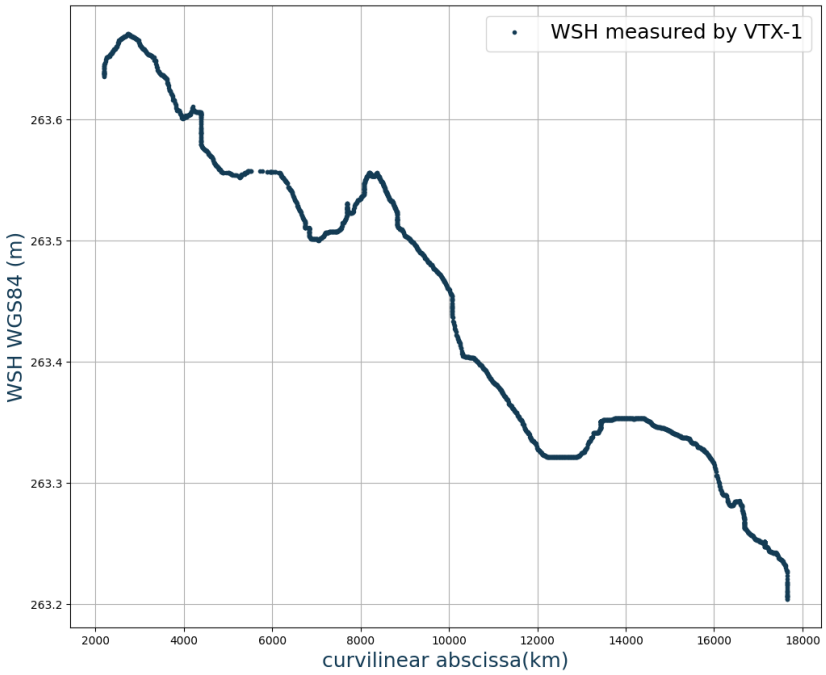

Figure 11: Grand Canal d'Alsace hydrological topography profile before the dam.

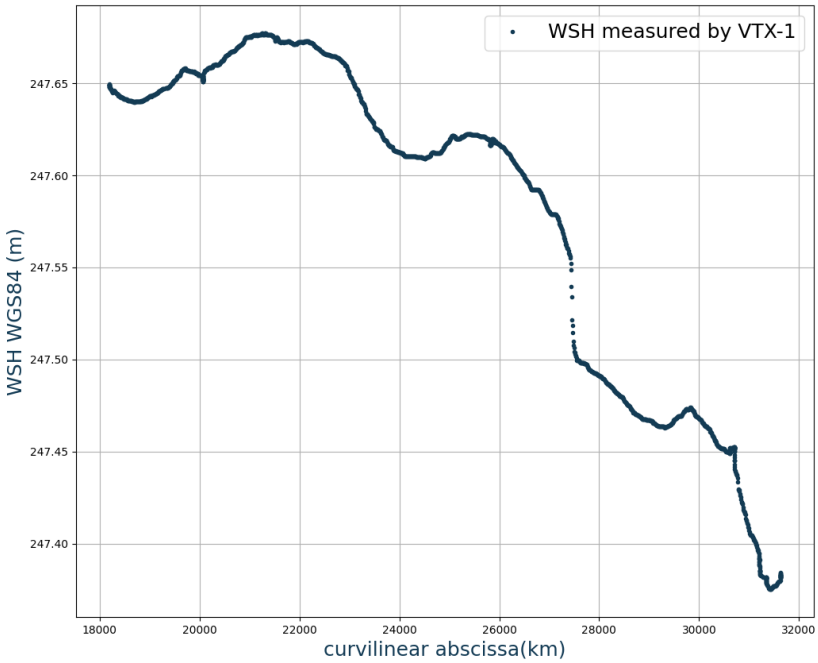

Figure 12: Grand Canal d'Alsace hydrological topography profile after the dam.

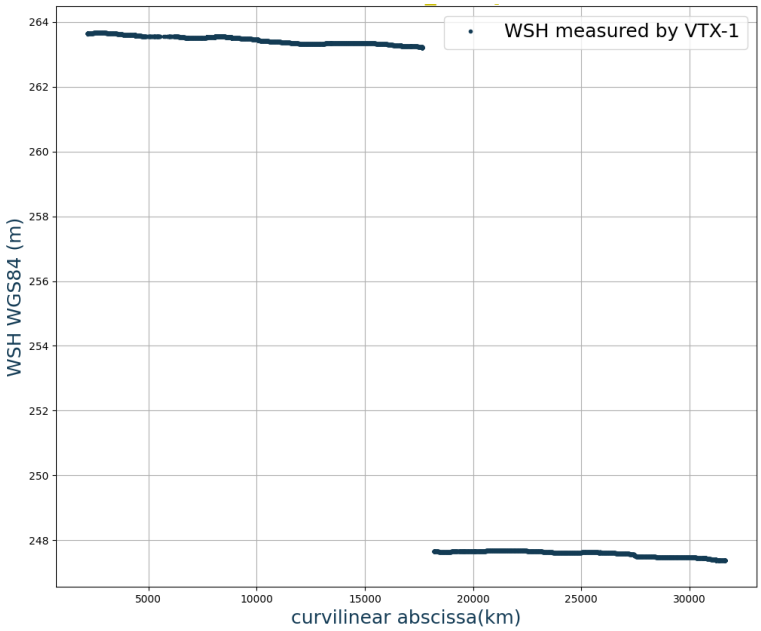

Figure 13: Grand Canal d'Alsace hydrological topography profile at the dam.

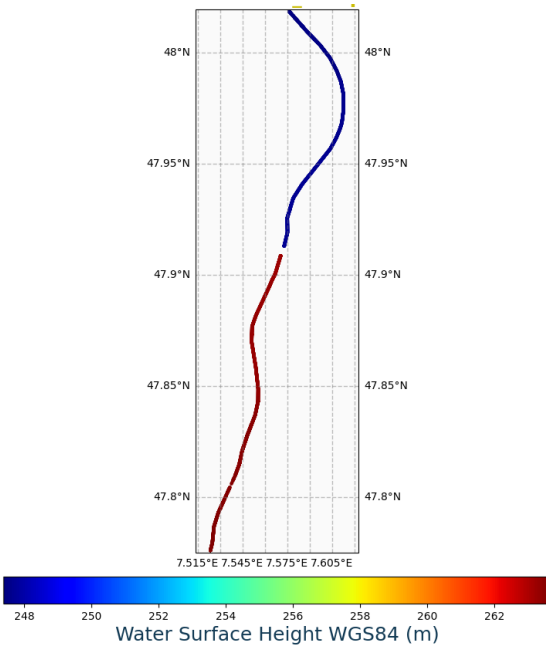

Figure 14: Grand Canal d'Alsace Water Surface Height along the river.

4.2 Data quality – overview

This section provides an overview of the data quality obtained during the drone campaigns at each site. For each flight, we indicate whether the data are fully usable. When a flight is not exploitable, the issue that caused this is described. Other minor issues that affected the flight are also reported.

Super site	Flight ID	Exploitable flights	Main issue identified	Minor issue identified
Old Rhine - Ottmarsheim	65	Yes	No major issue	-
	66	Yes	No major issue	-
	67	Yes	No major issue	-
	68	Yes	No major issue	-
	70	Yes	No major issue	-
	72	Yes	No major issue	-
Grand Canal d'Alsace - Chalampé	73	Yes	No major issue	-
	74	Yes	No major issue	-
	75	Yes	No major issue	-
	76	Yes	No major issue	-
	77	Yes	No major issue	-
	78	Yes	No major issue	-
	79	Yes	No major issue	-
	81	Yes	No major issue	-
	82	Yes	No major issue	-

	83	Yes	No major issue	Some LiDAR measurements are not stored (~35% of missing RAW data)
	84	Yes	No major issue	-

5 Data quality assessment and evaluation through maturity matrix

To compare with the micro-stations and validate the drone flights, we calculated many altimetric references for these stations. Despite a few outliers, the positioning results are consistent with each other, which allows us to have confidence in the positioning of the micro-stations.

Over the Old Rhine, we observe good agreement with the micro-stations ottmarsheim_2 and fessenhaim_1 with differences of 2 cm and 3 cm, respectively (Figure 15). A difference of 10 cm is obtained with the micro-station ottmarsheim_1. We will reanalyze the elevation reference to understand this bias.

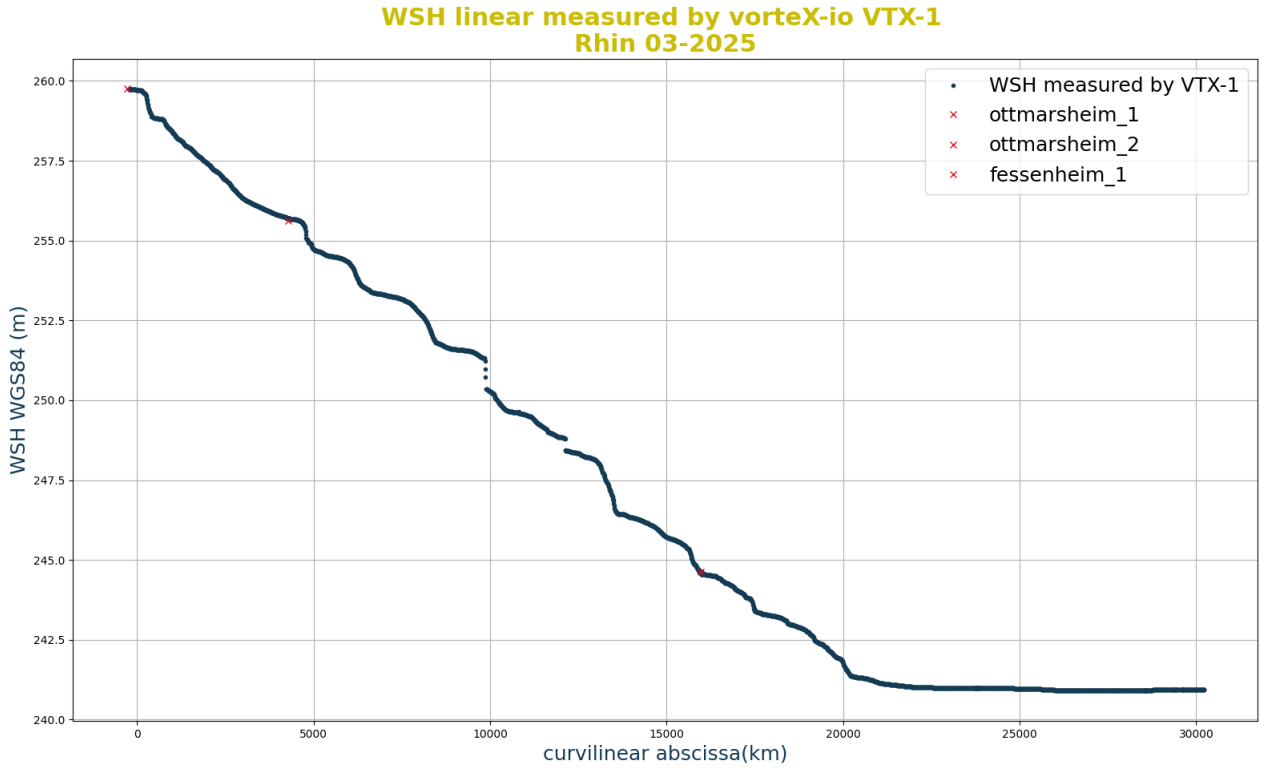

Figure 15: Comparison between WSH linear and micro-stations over Old Rhine.

Over the Grand Canal d'Alsace, we observe a good agreement with the micro-stations chalampé_1 with a difference of 8 cm (Figure 16). Even though the comparison with the micro-station gives correct results, we need to understand the origin of this slight bias. This could be due to:

- Micro-station positioning,
- Drone positioning,
- Different geophysical corrections.

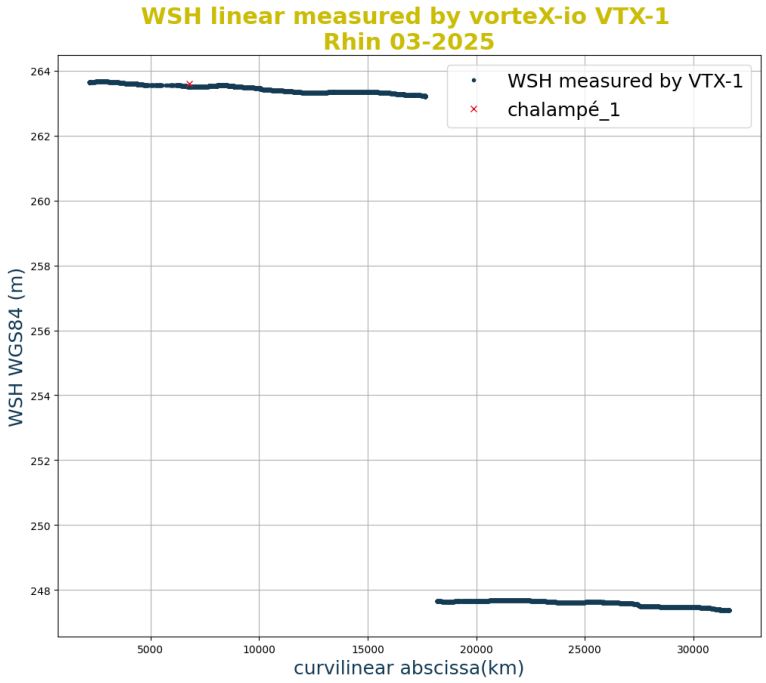

Figure 16: Comparison between WSH linear and micro-stations over Grand Canal d'Alsace.

This section will be completed in the final version of the report.