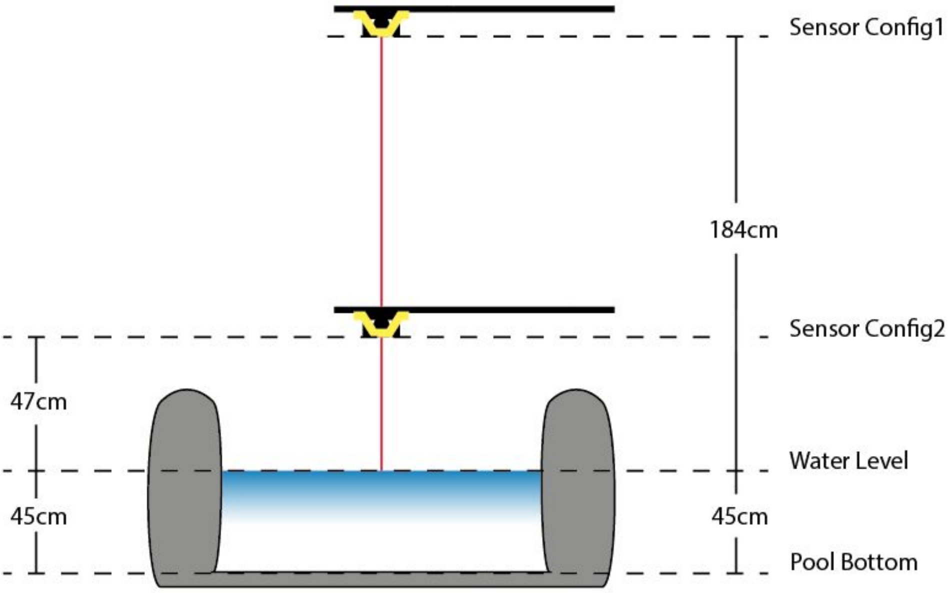

White paper:

TeraRanger One Performance Over Water

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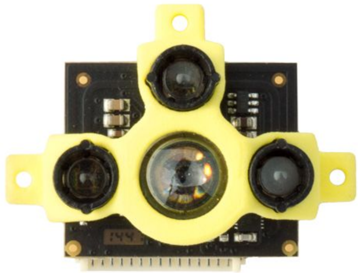
TeraRanger One testing: performance above water



Introduction

Driven by customers, we have conducted a test to showcase the results of TeraRanger One (TR1) sensor performance above water. In this test, the TeraRanger One was used above water at different heights, water surface types and under two ambient light conditions. The aim of this test was to examine how these conditions affect the performance of the TeraRanger One above water.

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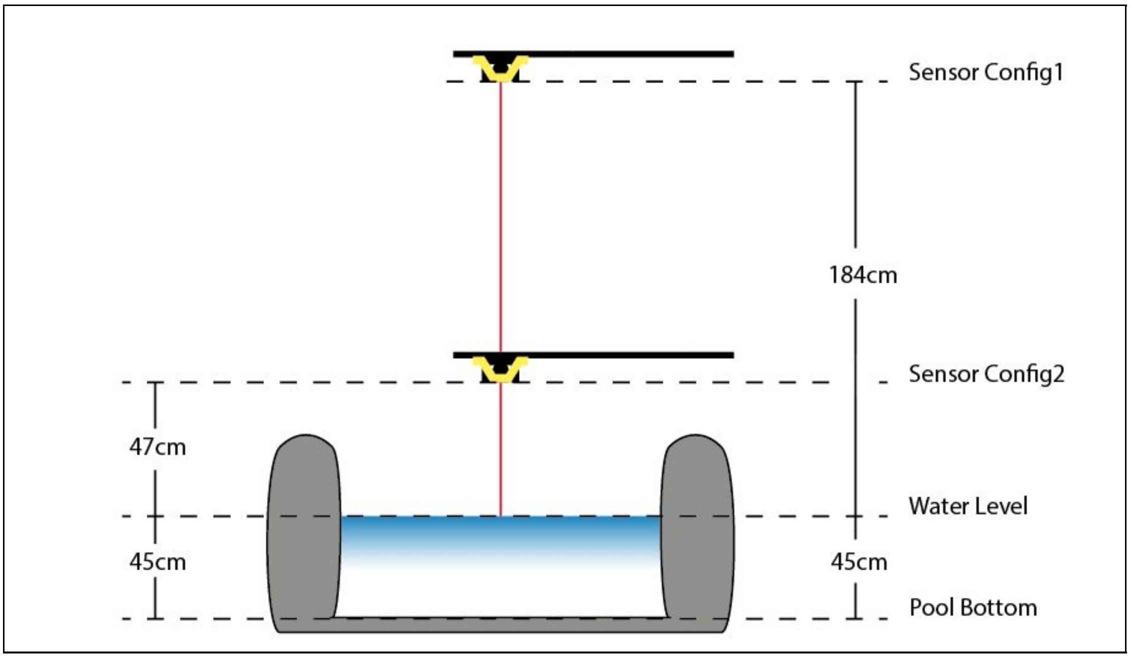
Test in the lab

Environment and setup



Design of experiments

- 2 Distances:
  - Config 1: 184 cm between the water level and the TR1 sensor
  - Config 2: 47cm between the water level and the TR1 sensor

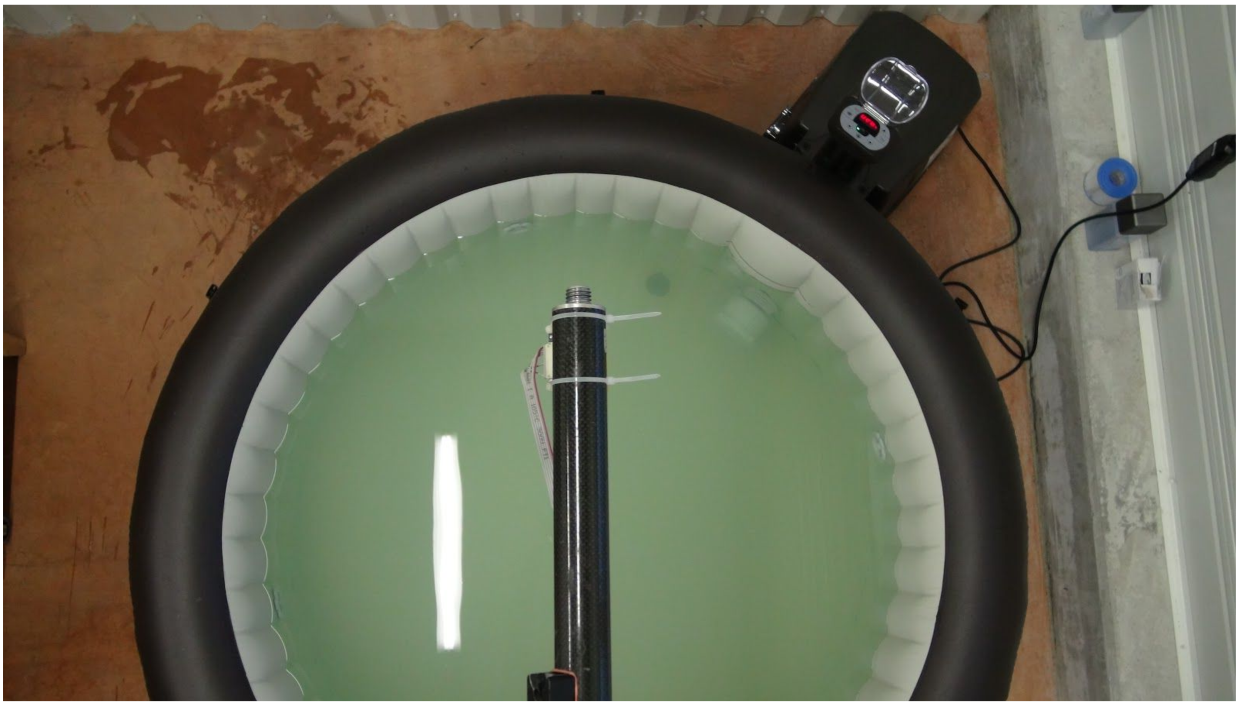
- 2 Ambient Lighting:
  - Low: Nearly dark
  - Medium: Sunny weather (no direct sunlight)

Tests have been made inside, with the pool close to windows. (see picture below in next page)

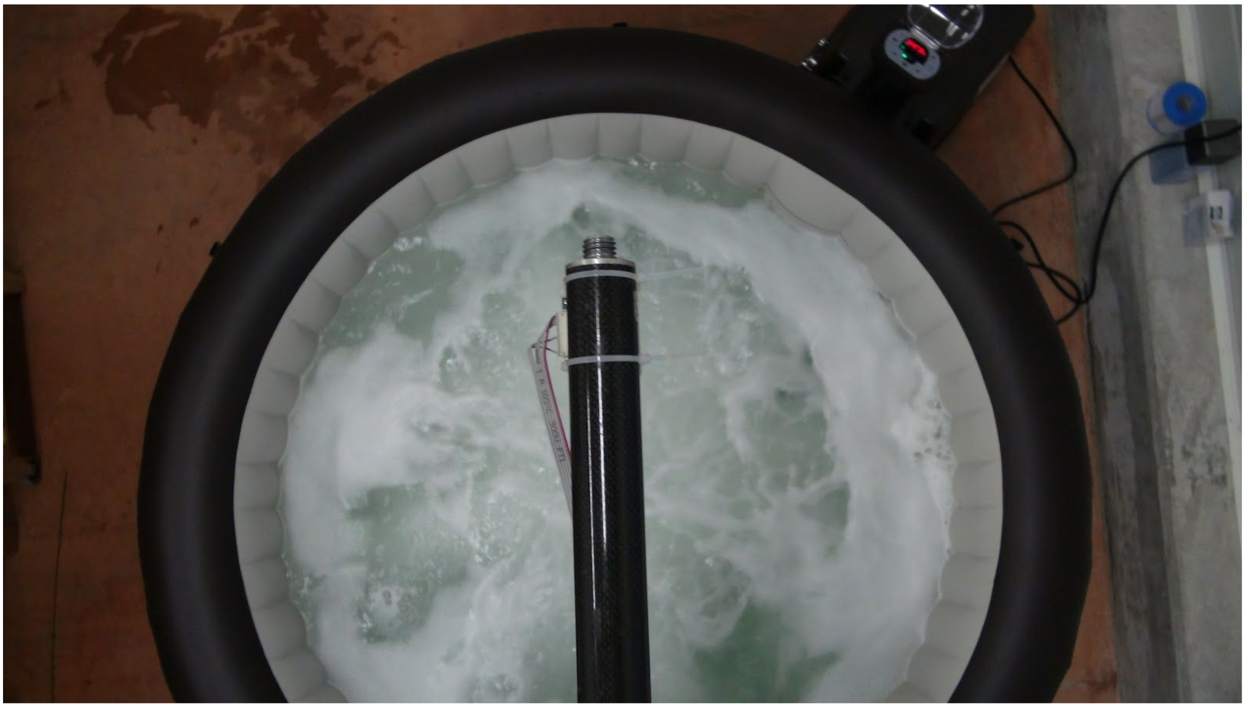
- Sensor used
  - TR1 Type A
  - Mode used: Precise (600 Hz)
  - Taken from stock and is representative of the sensor sold

- Graphs used:
  - Same scale
  - Made with 1250 distance measurements

- 2 Water conditions:
  - Static: Flat surface



  - Bubbles : Jacuzzi ON with bubbles in order to create white foam typical of moving water

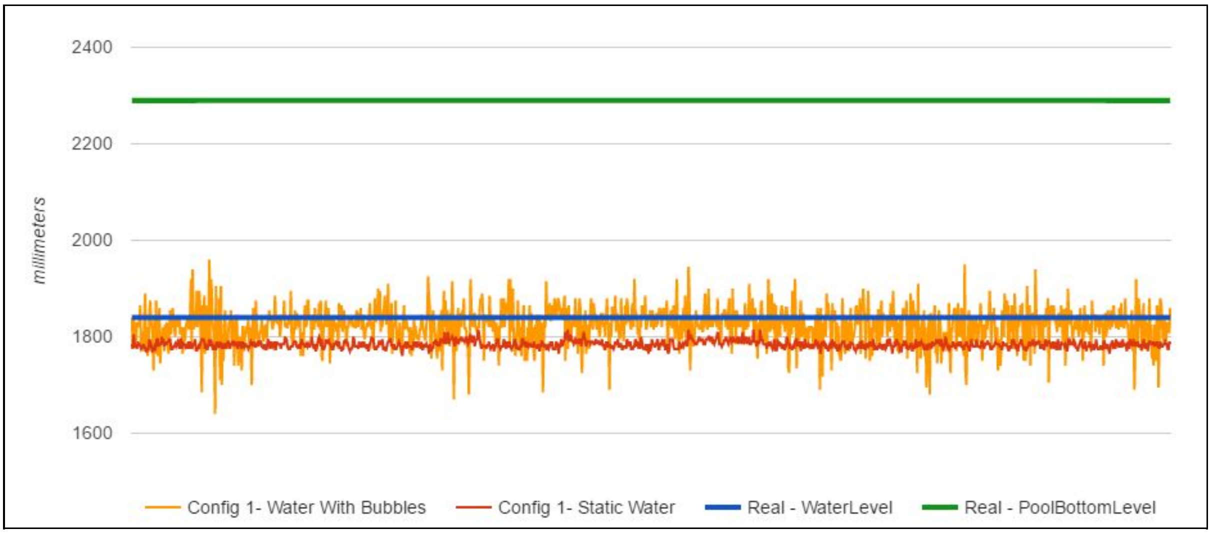


Test Results

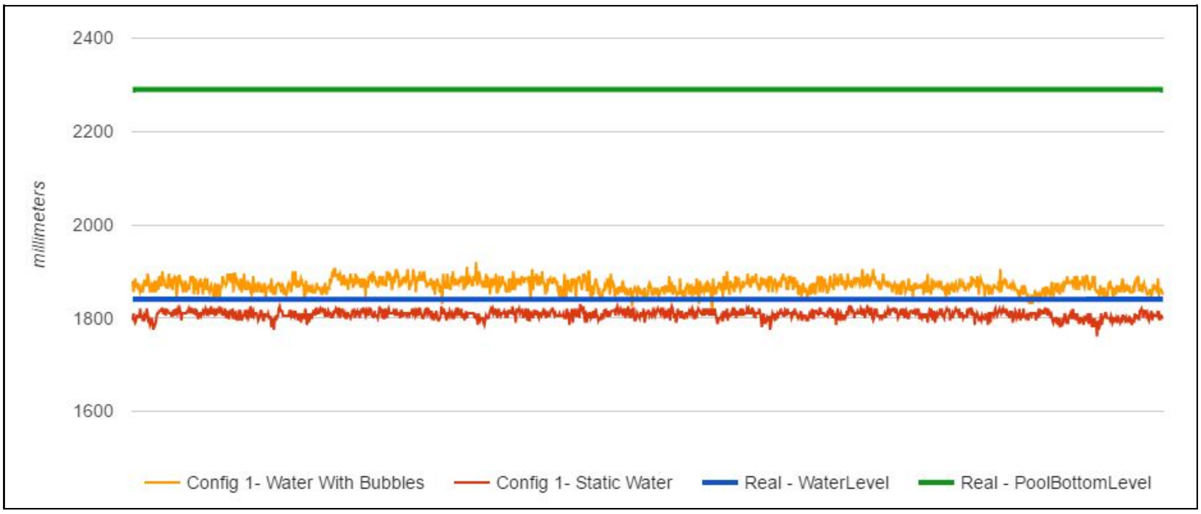
Config 1: longer distance

- **Real Water level: 184.00 cm from TR1**
- **Real Pool Bottom Level: 229.00 cm from TR1**
- **2 Ambient Lights : Low : Nearly dark**
- **Medium : Sunny weather (no direct sunlight)**

Static Water: With Bubbles / Low Ambient light

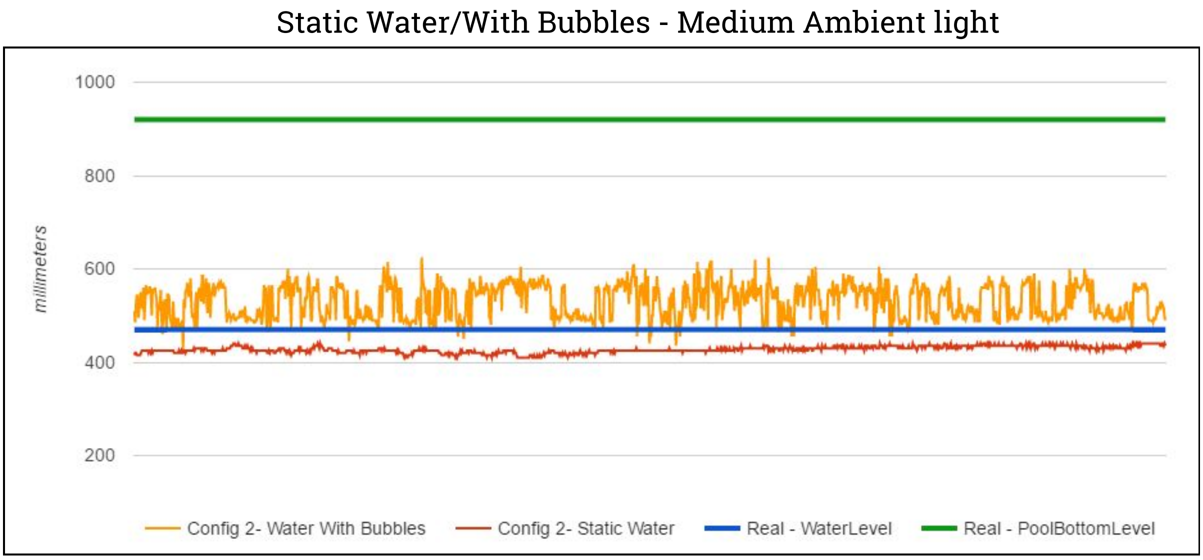


Static Water/With Bubbles - Medium Ambient light



Config 2: shorter distance

- **Real Water level: 47.00 cm from TR1**
- **Real Pool Bottom Level: 92.00 cm from TR1**
- **Ambient Light: Medium = Sunny weather (no direct sunlight)**



Conclusion

Please note that the graphs presented are reversed, meaning that the top green line represents the bottom level of the pool, while the measurements with the TeraRanger One were taken from the lower part of the graph.

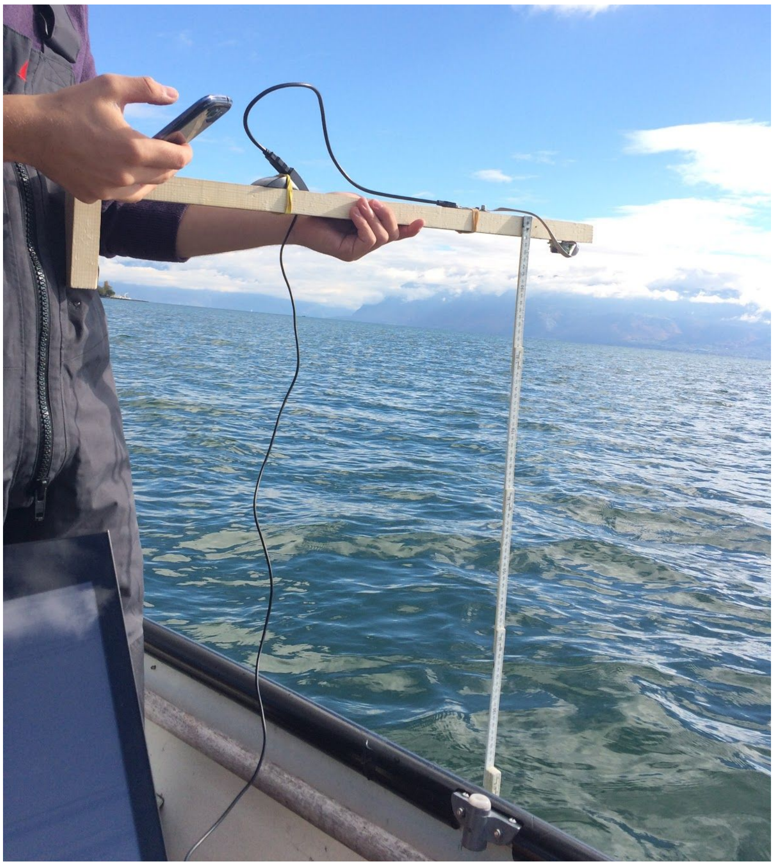
In Config 1 (longer distance), when measuring distance over static water, the results show very accurate performance without errors under both low and medium ambient light conditions. In Graph 1, measurements made over water with bubbles show a slight noise under decreased ambient light, however more accurate performance in medium ambient light conditions.
Graph 1 and 2 also demonstrate that measurements received from the test are close to the actual water level. In addition, no TR1 data measurement were acquired at the pool bottom level.

In Config 2 (shorter distance), data received measuring distance over static water shows relatively more precise readings than the one over water with bubbles under medium ambient light. Again, both measurements illustrate high proximity to the actual water level, and no acquired data points at the bottom level of pool occurs (Graph 3).

Test on natural water - Lake Geneva

To show that TR1 can also provide stable measurements in natural, outdoor conditions, we asked one of our customers* to test our sensor in real life situations. The experiment was made above a water surface (Lake Geneva) via a TR1 sensor attached to a pole on a moving boat. The aim of this test was to examine whether TR1 performance would change in an outdoor, natural environment.

Environment and setup



Design of experiments

- 2 Distances :
  - Config 1: 60 cm between the water level and the TR1 sensor
  - Config 2: 40 cm between the water level and the TR1 sensor

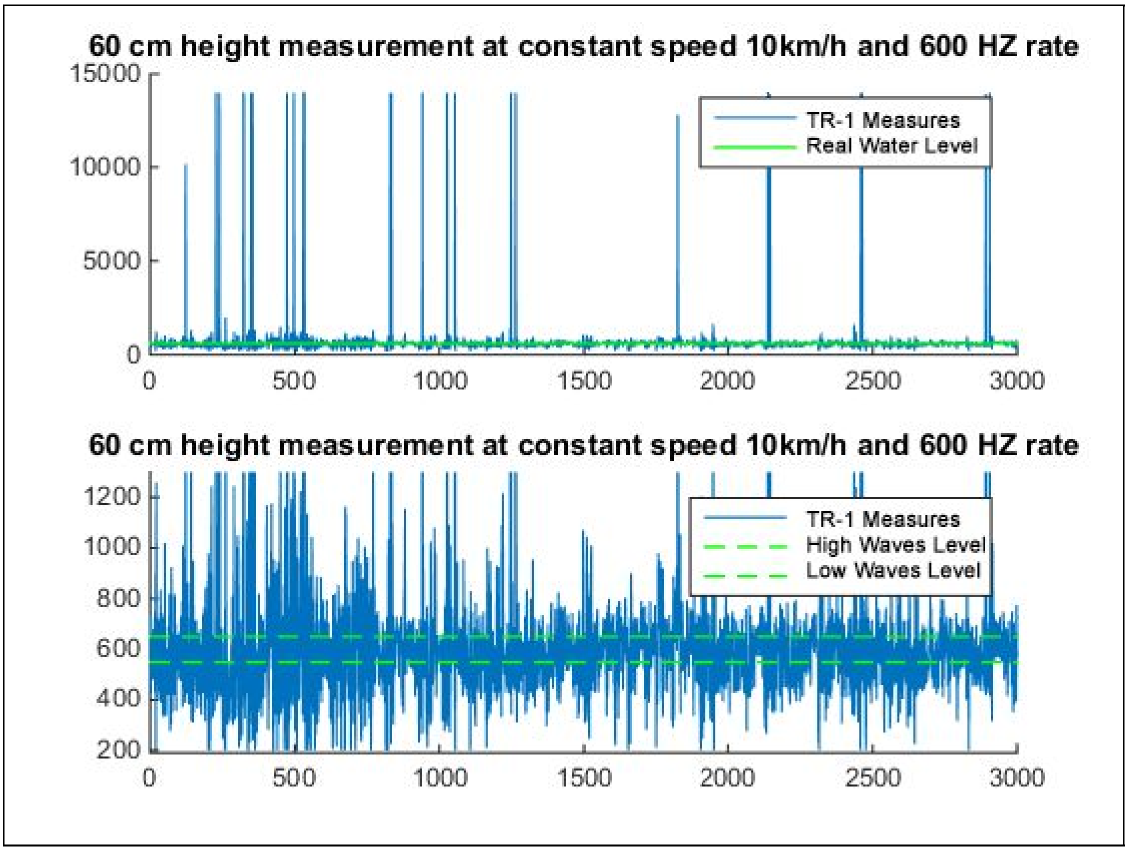
- Ambient Lights: Medium and sunny weather (no direct sunlight)

- Graphs used:
  - Same scale
  - Made with 3000 distance measurements

Test Results

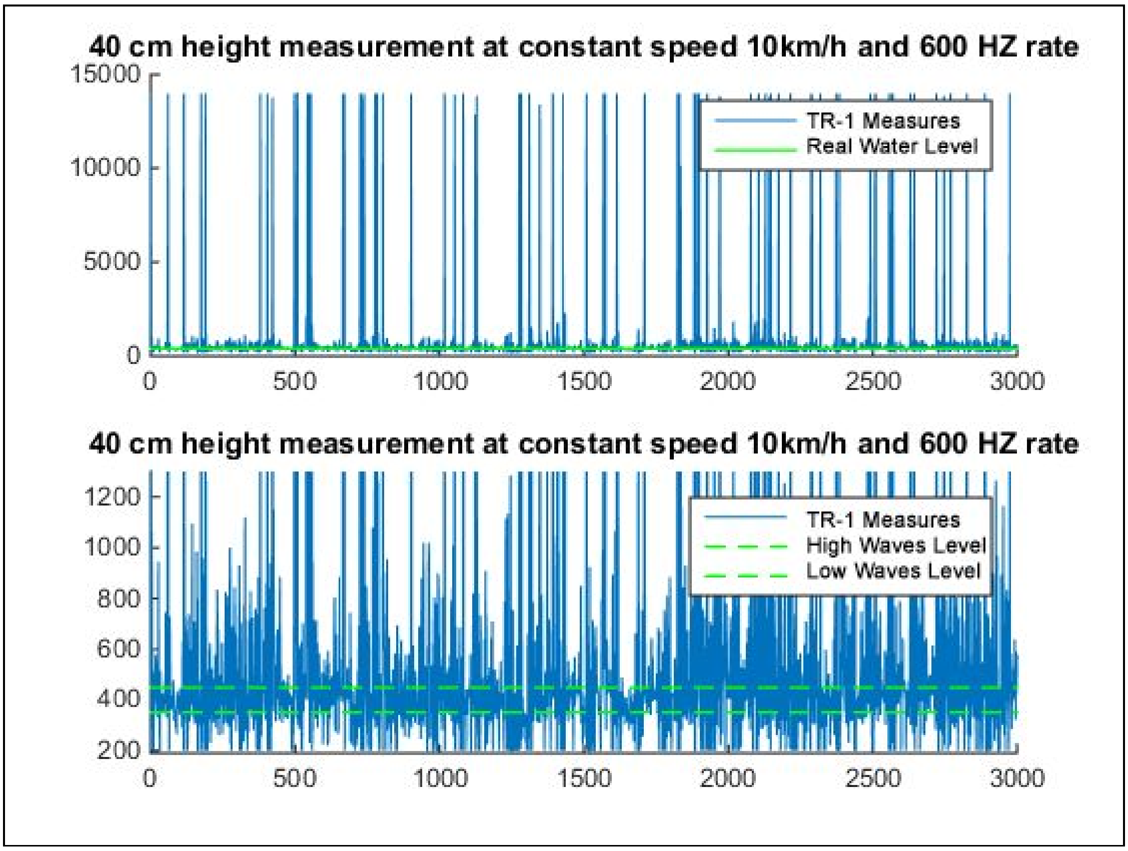
Config 1: longer distance

- **Real Water level: more or less 60.00 cm from TR1 (but with waves)**
- **Ambient Light: Medium = Sunny weather (no direct sunlight)**



Config 2: shorter distance

- **Real Water level: more or less 40.00 cm from TR1 (but with waves)**
- **Ambient Light: information not recorded**



* Many thanks to Valentin Mottier of Ecole Polytechnique Fédérale de Lausanne (EPFL) for the test data graphs and images.

Conclusion

In Config 1 (longer distance), Graph 4 illustrates that statistics correspond with measurements taken 60 cm above water with waves. With minor readings (errors) going deeper than the surface level of water, the test proves that TR1 is able to detect and measure the distance to the water surface with waves and without direct sunlight, while at a speed of 10 km/h.

In Config 2 (shorter distance), as the distance between the TR1 and water surface decreases (40 cm), more measurements can go through the surface level of the water (errors). Despite that, when the measurements do go through the water surface, the readings reach the maximum range of the sensor, which then allows the user to filter these errors easily from the real water level values when working with the data.

The results show that most measurements from the TR1 are correct and the errors are very clear. This means that the TR1 can be used reliably above water with some filters to exclude error readings.