



## Water Surface Elevation Maps

A New Tool for Water Resources Engineering

### Summary:

We have developed a new drone payload, which can measure water surface elevation (WSE) in meters above mean sea level at very high spatial resolution and very high accuracy in rivers, streams, lakes and wetlands. The payload was designed for standard UAV platforms and water surface elevation can be mapped efficiently along long stretches of rivers and streams.



*The new water surface elevation drone payload*

### The payload:

The payload consists of a differential global navigation satellite systems (GNSS) unit, a gimbal and a 77 GHz radar ranging unit. The GNSS unit records the exact position of the UAV platform and the ranging unit provides the distance (range) between the UAV platform and the water surface. Subtracting the range from the elevation of the platform, we calculate the water surface elevation. The

radar ranging unit delivers full waveform data, i.e. returned power for a sequence of 1024 range bins. The water surface is easily identified in the waveform as the bin with the highest return power. Each range bin corresponds to 3.6 cm, but waveform analysis allows for an accuracy higher than the bin resolution.

Accuracy of WSE measurements	3 cm
Recommended flight height	30 m
Recommended flight speed	2-3 m/s
Number of range bins	1024
Range bin resolution	3.6 cm
Radar ranger frequency	77 GHz
Sampling rate of the radar ranger	5 Hz
Typical along-track resolution of WSE dataset	0.5 m
Survey time for 1 km river stretch	ca. 10 min
Processing time for 1 km river stretch	ca. 10 min

*UAV-borne water surface elevation surveys: Technical specifications*

### Applications:

The drone payload can be used to efficiently map WSE along rivers and streams and over wetlands and lakes. Applications include

- River maintenance – WSE profiles along rivers reveal backwater effects and conveyance changes caused by, for instance, aquatic vegetation.
- Hydrodynamic modelling – WSE profiles along rivers can effectively constrain spatially distributed Manning/Strickler roughness coefficients.
- Groundwater – WSE profiles along rivers provide reliable boundary heads in systems where aquifers and surface water bodies are in hydraulic contact.
- River discharge estimation – The slope of the WSE provides information about the local Manning/Strickler roughness and can inform river discharge estimation algorithms.

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**Technical reference:** Bandini, F., Sunding, T.P., Linde, J., Smith, O., Jensen, I.K., Köppl, C.J., Butts, M., Bauer-Gottwein, P.: [Unmanned Aerial System \(UAS\) observations of water surface elevation in a small stream: comparison of radar altimetry, LIDAR and photogrammetry techniques](#). *Remote Sensing of Environment*, Volume 237, 2020, Article 111487