English summary of the paper

Investigation of Systematic Depth Measurement Error in UAV Based Laser Bathymetry

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The full paper was published in German language in the proceedings of the 44th Annual Scientific and Technical Conference of the German Society for Photogrammetry, Remote Sensing and Geoinformation (March 13-14, 2024, Remagen, Germany) and is available at the DGPF website.

Abstract:

In recent years, UAV-based laser bathymetry has been established as an efficient measurement method for the 3D mapping of the shallow water zone of relatively clear water bodies with high spatial resolution. The achievable penetration depth of more than twice the Secchi depth often tends to be greater than with classic, aircraft-based laser bathymetry. Systematic depth deviations from independent reference measurements have, however, been repeatedly observed, with a tendency to overestimate the water depth. It is suspected that the observed effects are related to water turbidity, which means that unrealistically large refraction coefficients > n=1.4 would have to be used to compensate for the deviations in the course of refraction correction. An experiment was carried out under controlled measurement conditions in the hydraulic engineering laboratory of the TUWien in order to empirically prove the suspected correlation with turbidity.

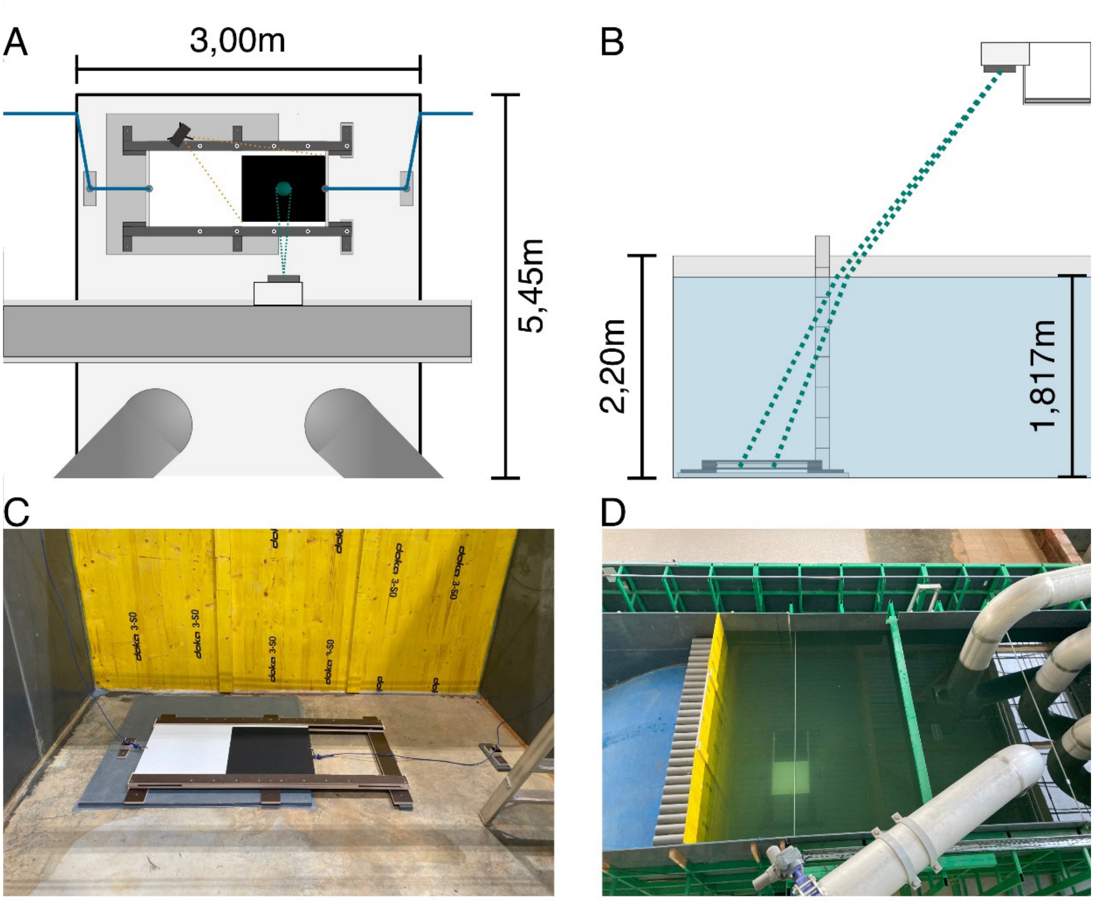

Illustration of the experimental setup from a bird's eye view.

Conclusion and future prospects:

In a controlled experiment, we investigated the assumption that water turbidity causes systematic errors in laser-based water depth measurement, with a tendency to overestimate depth. To our knowledge, this known issue has not yet been addressed in any experiment under laboratory conditions. The most important conclusion is that when analyzing waveforms using the SVB (System-Volume-Bottom) algorithm, based on exponential decomposition, a proportional deviation can actually be observed in the presence of water turbidity. This is in the order of several per cent of the measured depth.

In practice, it is therefore recommended that the water turbidity is also recorded, e.g. by measuring the Secchi depth or with the Nephelometer during laser bathymetry campaigns. With full waveform recording, which is standard for bathymetric scanners, it may also be possible to derive turbidity directly from the signal attenuation (RICHTER et al. 2021).

The evaluation of the experiment also revealed facts that are of both theoretical and practical interest and suggest further investigations. Understanding the dependence of the fluctuations and the shape of the received pulses on the FOV (field of view), especially in clear water, could, for example, prove to be essential for a more reliable detection of the water surface. Furthermore, in order to derive a possibly generally valid formula for the relationship between turbidity and error of the depth measurement, the beam geometry would have to be determined more precisely than was the case in the experiment carried out.

The determination of an additional delay effect from the measurement of the time difference of a pulse between its emission and reflection is more difficult in the turbid and therefore attenuating medium because the exact time of the reflection is always distorted by a superposition of the ground echo and the backscattering from the water column. This fact suggests an extension of the experiment, which would be based on the measurement of the transit time in the forward direction alone and therefore avoid the disturbing influence of the backscatter on the measurement.

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