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The Assessment of Acoustic Doppler Velocimetry Profiler from a User's Perspective

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Abstract

Acoustic Doppler velocimetry profilers (ADVPs) are widely used in both experimental and field studies because of their robustness in velocity measurements. The acquired measurements offer estimates of the instantaneous flow velocity at the interrogated measurement volume and can also be further processed for the estimation of the bed surface shear stresses and turbulent kinetic energy, thus finding a wide range of applications ranging from water engineering to geomorphology and eco-hydraulics. This study aims to evaluate the performance of an ADVP in obtaining hydrodynamics measurements under fixed flow conditions, with various probe configurations. Different assessment criteria are used for the evaluation including qualitative observations as well as quantitative error metrics to assess the uncertainties in the estimation of shear stresses using log Law of the Wall and turbulent kinetic energy due to the probe configuration settings. The methodology implemented herein, for a given flow, and the suggestions presented represent a generalized hierarchical framework which can find use from practitioners and researchers alike.

Keywords: acoustic Doppler velocimetry profilers, flow velocity, shear stress, turbulent kinetic energy, turbulence.

1. INTRODUCTION

Acoustic Doppler velocimetry (ADV) is widely used as one of the most versatile and robust flow diagnostics tools for both laboratory and field studies across a range of research and applied themes spanning engineering eco-hydraulics and geomorphology. A range of specific ADV probes with varying specifications are readily available for use by professionals and researchers. ADV measures the sampling volume of a water body in the water flow via the Doppler shift caused by the reflection of the pulse transmitted from the centre transducer (the centre beam) and received by the four receiving beams (Nortek 2012; Nortek AS 2015; Kraus et al.

1994). An acoustic Doppler velocimetry profiler (ADVP), i.e. Vectrino II, has the same working principle, but enables profile measurements, which may involve interrogating more than one measurement points, at the same time. Thus ADVPs, may typically have additional parameters that the user may need to define in the probe settings, which even though desirable, may leads to increased uncertainties if there is no generally acceptable guidance to enable their optimal use.

In this work, a series of laboratory experiments have been conducted, under the same open channel flow conditions, using a profiler (ADVP Vectrino II from Nortek®) aiming to cover the full range of probe configuration combinations that can be used in practice. Flow velocities have been measured via the software Nortek Multi-Instrument Data Acquisition System (Vectrino Profiler). The probe configuration in this software contains a few indexes which have some level of dependencies which are altered to identify their impacts on the velocity measurements, velocity profile and the estimated shear stress using these measurements.

2. EXPERIMENTS AND RESULTS

The experiment has been conducted in a rectangular horizontal recirculating flume in the Water Engineering Laboratory at the University of Glasgow. The flume is 1 m wide with glassed sidewalls, and the flume bed consists of a few centimetres high layer of sand with nominal diameter from 0.5 to 2.36 mm (d_{50} = 1 mm) covering the whole flume width. The probe is joined with a vertical gauge, which enables the probe to move vertically. The velocity profiles have been taken at the same lateral location (345 mm away from the sidewall) under the exactly same flow conditions, but different probe configurations. Examples of velocity profiles of selected experiments (different probe configurations) are shown in Fig. 1 below.

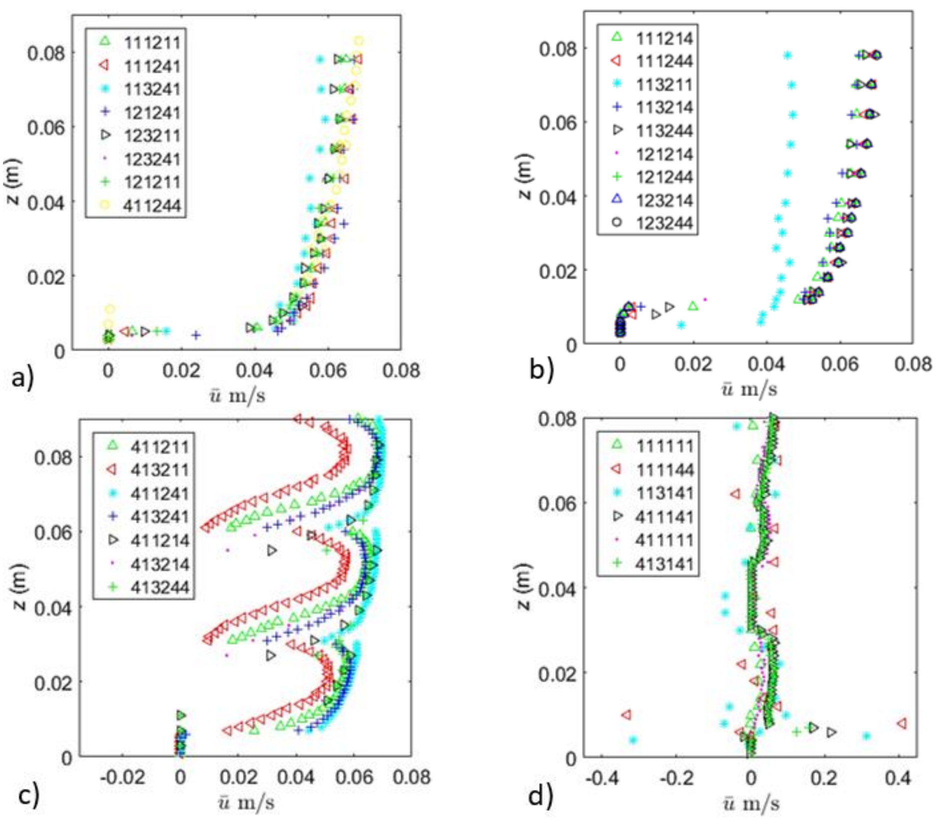

Fig. 1. Velocity profiles of selected experiments: a) "smooth" from visual check and good fit a logarithmic function, b) "smooth" from visual check, c) "curved" from visual check, and d) "random" from visual check.

3. CONCLUSIONS

Velocity profiles are taken at the same location and under the same flow condition with different probe configurations, and the result of mean velocity profile, shear stress estimated using turbulent kinetic energy and log Law of the Wall vary significantly, which clearly shows the dependency between the probe configuration and the results. Results show that overall, the accuracy of Vectrino-II is dependent on probe configurations, and this study provides a framework of preliminary test to find the best probe configuration for the given flow. The value of this research is independent of the exact software or the specific probe because it lays in the framework of optimizing the velocimetry results by tweaking the probe configuration parameters.

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