Issues with Turbulence Measurements From ADVs for Marine Energy Applications

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The Effects of Realistic Tidal Flows on the Performance and Structural Integrity of Tidal Stream Turbines (EP/J010200/1).

Abstract

Acoustic Doppler Velocimeters (ADVs) are a key tool in marine energy research. Two different commercial ADV probes (so-called downwards and side ways) and a 1D Laser Doppler Velocimeter (LDV) have been used to take velocity measurements in different flow conditions. The results showed agreement in the mean value, but highlight potential significant differences in the velocity fluctuations. It was observed that ADVs can measure accurately the standard deviation for one of the velocity components but overestimates the other two. The overestimation of the standard deviation is not constant since it varies with the both mean and turbulent flow field and therefore no simple solution can be used to remove it.

Experimental Arrangement

Experiments were performed in the high-speed recirculating water-channel at the University of Liverpool. A sideways and downwards ADV probe (figure 1 & 2) were used to measure the three velocity components sampled at 200Hz (probe A & B). The sideways probe could also be orientated downwards as shown in figure 3 (probe B - down). Measurements were taken in a uniform flow and in near wake of a Horizontal Axis Tidal Turbine (HATT). The ADV measurements were also compared against 1D-LDV results.

Figure 1 – ADV probe A.

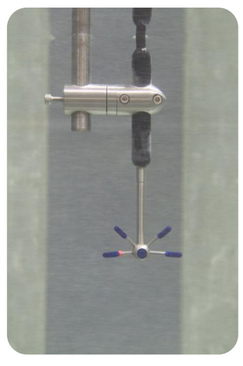


Figure 2 – ADV probe B - side.

Figure 3 – ADV probe B – down.

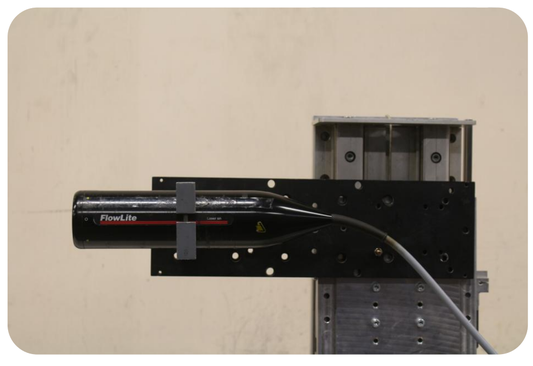


Figure 4 – 1D LDV flowlite.

Uniform Flow

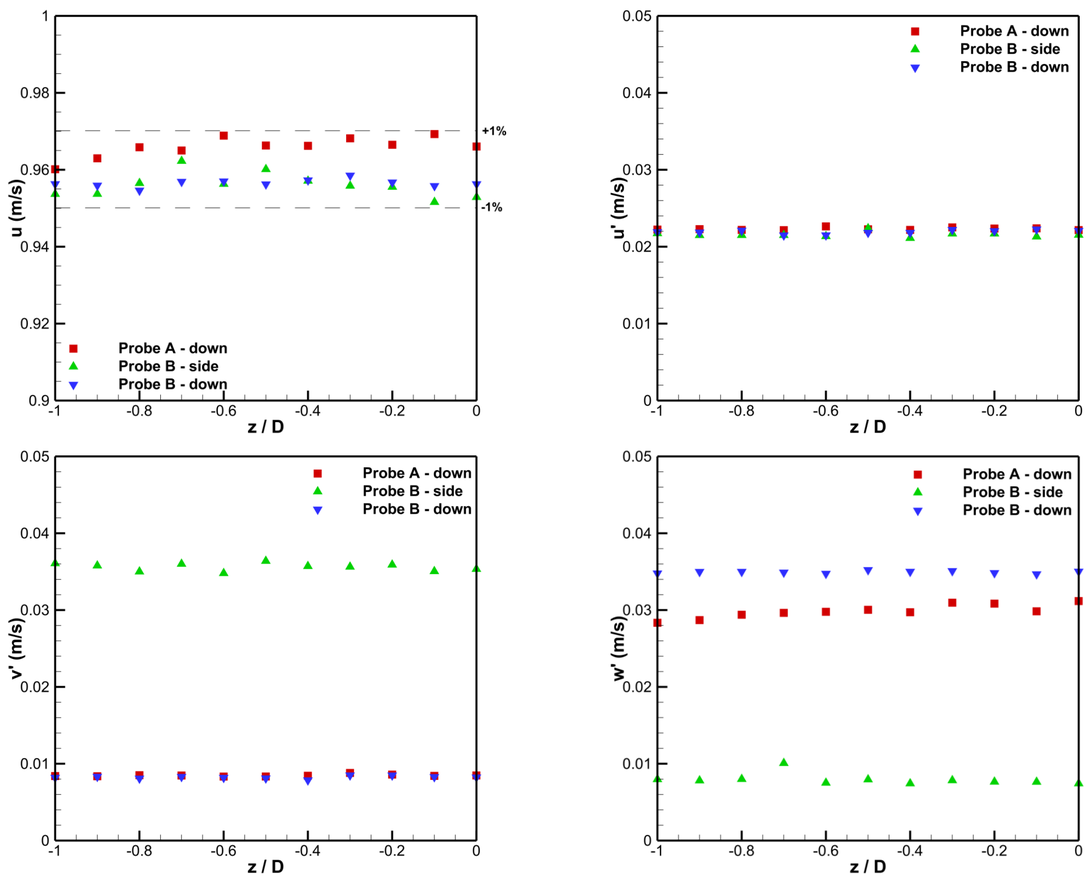
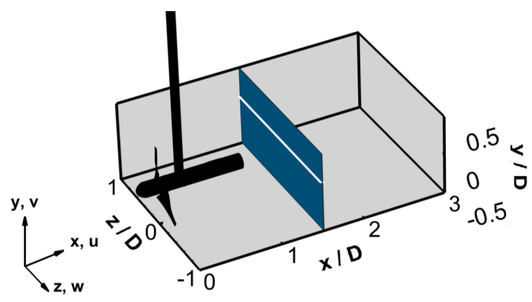
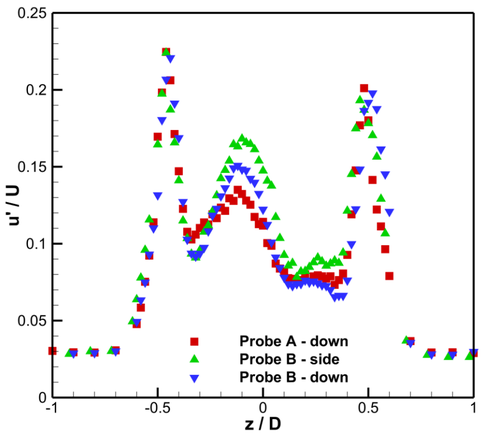
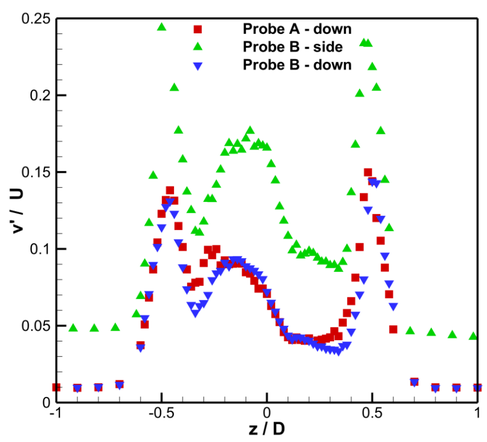


Figure 5 – ADV mean and fluctuating velocity results in a uniform flow.

Turbine Near Wake (ADV)







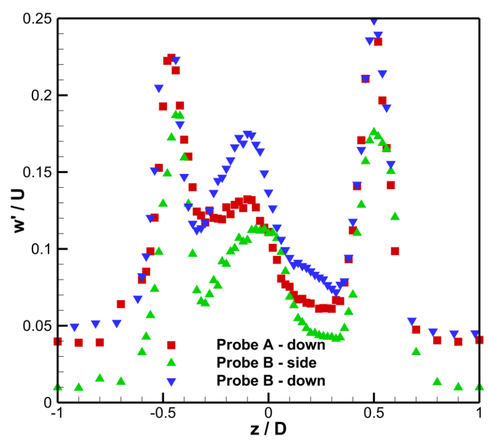


Figure 6 – ADV results in the near wake of the turbine (1.5D downstream)

Turbine Near wake (ADV & LDV)

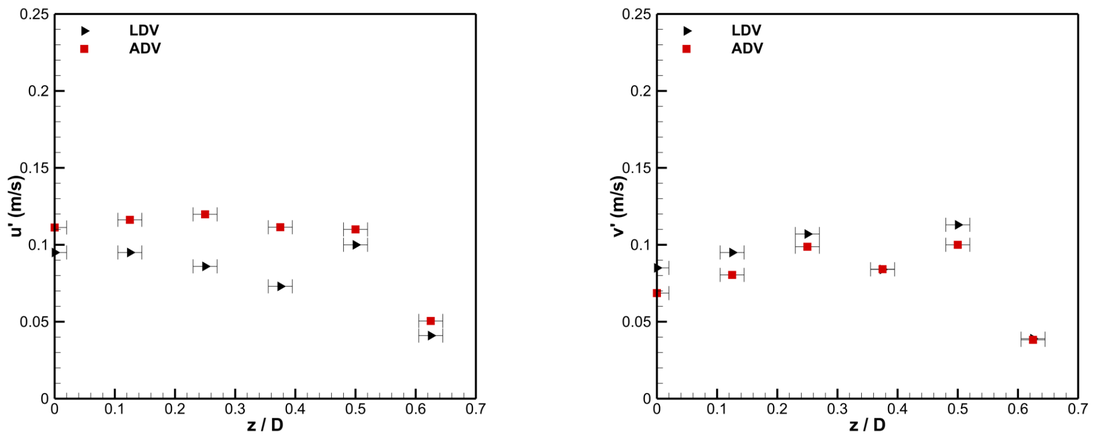


Figure7– ADV wake results compared with LDV

Conclusions

- ADVs provide an easy method to measure the mean velocity accurately.
- ADVs can accurately measure the fluctuations in one of the velocity components and this is dependent on the orientation of it's control volume.
- Although there are inherent uncertainties in ADV results they still provide a relevant set of data qualitatively.

References

Voulgaris G, Trowbridge JH. Evaluation of the acoustic Doppler velocimeter (ADV) for turbulence measurements. J Atoms Ocean Technol 1998;15(1, Part 2):272-89

Khorsandi B, Mydlarski L, Gaskin S. Noise in Turbulence Measurements Using Acoustic Doppler Velocimeter. J Hydraul Eng 2012;138(10):829-939