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Comparison of turbulence estimation for four- and five-beam ADCP configurations

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Turbulence is a vital consideration for tidal power generation, as the resulting fluctuating loads greatly impact the fatigue life of tidal turbines and their components. Acoustic Doppler current profilers (ADCPs) are one of the most common tools for measurement of currents in tidal power applications, and although most often used for assessment of mean current properties they are also capable of measuring turbulence parameters.

Conventional ADCPs use four diverging beams in a so-called 'Janus' configuration, but more recent models employ an additional vertical beam. In this paper we explore the improvements to turbulence measurements that are made possible by the addition of the fifth beam, with a focus on estimation of turbulent kinetic energy (TKE) density.

The standard approach for estimating TKE density from ADCP measurements is the variance method. As each of the diverging beams measures a single velocity component at spatially-separated points, it is not possible to find the TKE density by a straightforward combination of beam measurements. Instead, we must assume that the statistical properties of the turbulence are uniform across the spatial extent of the beams; it is then possible to express the TKE density as a linear combination of the velocity variance as measured by each beam. In the four-beam configuration, an additional assumption regarding the magnitude of the turbulent anisotropy: a parameter ξ is introduced that characterises the proportion of TKE in the vertical fluctuations. With the five-beam configuration, direct measurements of the vertical component are available and this assumption is no longer required.

In this paper, turbulence measurements from a five-beam ADCP deployed off the coast of Anglesey in 2014 are analysed. We compare turbulence estimates using all five beams to estimates obtained using only the conventional four-beam setup by discarding the vertical beam data. This allows us to quantify the error in the standard value of ξ. We find that it is on average within 3.4% of the real value, although there are times for which it is much greater. We also discuss the Doppler noise correction in the five-beam case, which is more complex than the four-beam case due to the different noise properties of the vertical beam.