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# Quantifying measurement uncertainties in ADCP measurements in non-steady, inhomogeneous flow

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The author presents a laboratory study of fixed-platform four-beam ADCP and three-beam ADV measurements in the tailrace of a micro hydro power setup with a 35kW Kaplan-turbine and 2.5m head. The datasets discussed quantify measurement uncertainties of the ADCP measurement technique coming from non-steady, inhomogeneous flow.

For constant discharge of 1.5m$^3$/s, two different flow scenarios were investigated: one being the regular tailrace flow downstream the draft tube and the second being a straightened, less inhomogeneous flow, which was generated by the use of a flow straightening device: A rack of diameter 40mm pipe sections was mounted right behind the draft tube. ADCP measurements (sampling rate 1.35Hz) were conducted in three distances behind the draft tube and compared bin-wise to measurements of three simultaneously measuring ADV probes (sampling rate 64Hz). The ADV probes were aligned horizontally and the ADV bins were placed in the centers of two facing ADCP bins and in the vertical under the ADCP probe of the corresponding depth. Rotating the ADV probes by 90° allowed for measurements of the other two facing ADCP bins. For reasons of mutual probe interaction, ADCP and ADV measurements were not conducted at the same time.

The datasets were evaluated by using mean and fluctuation velocities. Turbulence parameters were calculated and compared as far as applicable. Uncertainties coming from non-steady flow were estimated with the normalized mean square error und evaluated by comparing long-term measurements of 60 minutes to shorter measurement intervals. Uncertainties coming from inhomogeneous flow were evaluated by comparison of ADCP with ADV data along the ADCP beams where ADCP data were effectively measured and in the vertical under the ADCP probe where velocities of the ADCP measurements were displayed. Errors coming from non-steady flow could be compensated through sufficiently long measurement intervals with high enough sampling rates depending on the turbulence scales of the flow. In case of heterogeneous distributions of vertical velocity components in the ADCP beams, the resulting errors significantly biased the mean velocities and could not be recognized by sole ADCP measurements.

For the straightened flow scenario, the results showed good agreement of ADCP and ADV data for mean velocities, whereas the ADCP data consistently overestimated turbulence intensities by a factor of 2. Reynolds stresses were in good agreement as well as were turbulent kinetic energies, apart from one measurement with outliers of up to 30%. For the tailrace flow scenario, the mean velocities from the ADCP data underestimated the ADV data by 23%. Turbulence intensities from the ADCP data were fluctuant, overestimated the ADV data by factors of up to 2.8 and showed spatial discrepancies over the depth. Reynolds stresses were only partly in good agreement and turbulent kinetic energies were over- and underestimated in a range of [-50; +30] %.