Hot-wire measurements in the near-wake of a 3D bluff body

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Hot-Wire Anemometry (HWA) is often used in complex turbulent flows due to its ease of operation. Despite its superior temporal and spatial resolution compared to laser-optical measurement methods, its weaknesses in complex flows are well-known, such as its directional ambiguity for high-flow angles and back-flow in particular. Therefore, the application of HWA should be restricted to flow regions without 3D mean flows and backflow. In this context, the knowledge about potential backflow-regions stems either from previous studies or from *ad hoc* measures of the mean velocity profile.

A hot-wire probe placed in recirculation regions can nonetheless yield wake statistics that seemingly appear meaningful, due to the complex interplay of rectified streamwise velocity signals and high-flow angles as demonstrated in Fig. 1a. This figure compares the mean streamwise velocity read from a single wire (SW) and an X-wire (XW) probe in the near-field wake region of a 3D bluff body compared to Prandtl tube and laser-Doppler velocimetry (LDV) measurements. There is very good agreement among these measurement techniques for $|y/H| > 0.5$ while clear deviations are visible in the centre of the wake. Since LDV can resolve backflow it provides a reliable reference in this region. It can be seen that the Prandtl tube measurements contain a clear indication of a backflow region with kinks in the mean velocity profile. In contrast, both HWA measurement profiles (SW and XW) suggest a flow field which is far from exhibiting backflow. With only access to the HWA data, however, the user would seemingly assume that the measurements were clearly taken even downstream of the recirculation region, which is, however, not the case.

One further example of the severity of biased measurements is given in Fig. 1b depicting the percentage of instantaneous outliers (points outside the angular calibration maps) for an XW probe as a function of streamwise/wall-normal position in the near wake, i.e., downstream the bluff body. Even when the measurement location is placed downstream of the recirculation region, which extends to approximately $x/H = 1.3$, HWA results misestimate the velocity deficit within the wake, particularly when the calibration is limited to the often used range of ± 30 degrees.

The present work aims to study in detail the characteristics of HWA data obtained in wakes with the goal to extract an indication about possible rectification errors directly from the data and without the need to asses other measurement techniques.

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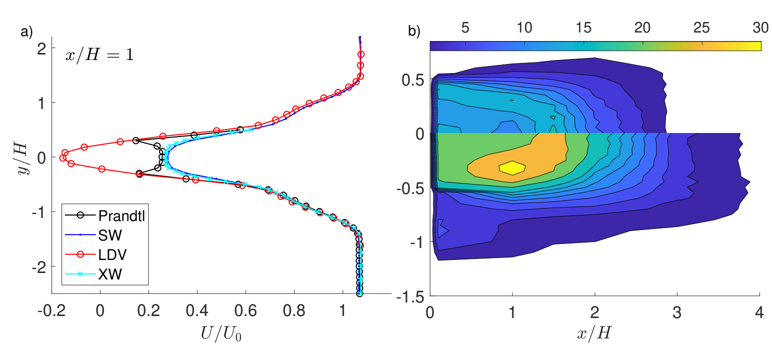

Figure 1: a) Comparison of measured mean streamwise velocity profiles at $x/h = 1$ by means of SW, XW, Prandtl tube and LDV. b) Percentage of outliers for XW calibration maps covering flow angles up to ± 45 (top) and ± 30 (bottom).