Towards instantaneous lift and drag from stereo-PIV wake measurements

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HIGHLIGHTS

• Wake integral methods to determine instantaneous lift and drag are discussed.
• Time-averaged wake integral estimates of lift and drag are within 30% for the current (untailored) study.
• Instantaneous forces showed poor agreement with direct force measurements, due to insufficient time-resolution and small measurement area.
• Tailored experiments should find a balance between temporal and spatial resolution as well as resolution and domain size.

ABSTRACT

In this paper we assess the applicability of wake integral methods to determine instantaneous and time-averaged forces from experimental data of simultaneous near-wake time-resolved stereo-PIV and force measurements on a rigid flat plate and membrane wings. Different expressions for time-averaged and instantaneous lift and drag are discussed. Results for the time-averaged expressions shows that even here the current data set fall short in capturing the lift and drag forces accurately with deviations of about 30%. The current data fared worse on the instantaneous force estimates. Here the fluctuations showed little to no resemblance with the time series of the force measurement, although the standard deviations are of the same order of magnitude. The main culprits were the limited time resolution of the velocity measurements and, as for the time-averaged results, the limited measurement area that did not capture the full wake. Despite these short comings of the current (untailored) data set for determining forces, a few time-averaged cases have a good match and these indicate that better and tailored experiments should be able to give better results. These tailored experiments will require a trade-off between resolution and area covered as well as a trade-off between resolution in space and resolution in time.

Fig. 1 Time-series of instantaneous lift and drag for two of the tested cases. Left: lift. Right: drag.