NUMERICAL AND EXPERIMENTAL INVESTIGATION OF LONGITUDINAL VORTEX OF A DELTA WING

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The flow around a delta wing with a sharp leading edge at Re_c=1M (based on the chord length c), Ma=0.155, and incidence angle α=8° was studied numerically and experimentally. The wind tunnel experiments were performed in the low-speed wind tunnel at TU Braunschweig (MUB). The measurement technique used time-resolved stereo PIV, with recording frequency f_{PIV}=3Hz.

A Large-Eddy Simulation (LES) was performed on a mesh of a total of 787 million cells. Such a fine mesh, along with a sufficiently small time step allowed to resolve the turbulent boundary layer on the delta wing surface. Data were sampled over 10 convective time units (CTUs) based on the chord length, after a transient of 10 CTUs. Simulations were performed mainly on the computing facility SuperMUC-NG. Additionally, hybrid RANS/LES simulations were performed with two interface positions for the injection of synthetic turbulence. These positions are on the delta wing, referred to as wall-modelled LES (WMLES), and in the wake of the delta wing (I2). The WMLES simulation was performed with the Synthetic Turbulence Generator (STG) of [1], where the injection is placed in the boundary layer of the delta wing. Whereas for the I2 case, the injection takes place in the already-developed longitudinal vortex.

Since the STG of [1] is formulated for boundary layer flows, its applicability to vortical flows (such as I2) is uncertain. A sensitivity study of details of the STG was performed for the I2 case to study the role of the model spectrum, and the RANS length scale (which is closely related to the turbulent kinetic energy and the dissipation of turbulence). These sensitivities were informed by the high-fidelity LES data. The STG spectrum was modified to exhibit a k-3 behavior as observed in the LES data (see Figure 1 (left)). Moreover, the integral length scale in the vortex plane was computed from the two-point correlation function for LES data (see Figure 1 (center)), which shows that the RANS model overestimates the length scale in the vortex core. To account for this overestimation, the length scale in the STG formulation was reduced.

The comparison of hybrid RANS/LES, LES, and PIV is shown in Figure 1 (right) for the spanwise Reynolds stress component (in the vortex plane). The WMLES computation gives good agreement with the wall-resolved LES. The reduction of the turbulent length scale, as indicated by the two-point correlation, significantly improves the agreement of the hybrid simulation with the reference. On the other hand, the effect of modifying the spectrum is negligible.

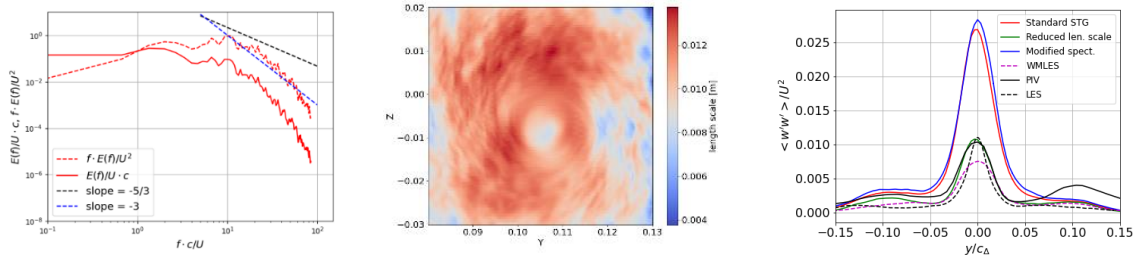

Figure 1: Turbulence spectrum (left), length scale from two-point correlation (center), comparison of hybrid RANS/LES simulations, PIV and LES for the component in the vortex plane (right)

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[1] Shur et al., *Flow, turbulence and combustion,* **93** (2014)