The structure of large events in the production mechanisms of enstrophy and strain rate in the transitioning and recirculating flow around a wing

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We investigate the properties of small-scale statistics in a transitioning shear flow undergoing large-scale strain due to the presence of a recirculating flow. The flow field is obtained from a direct numerical simulation around a NACA 0018 wing with a square wingtip profile at $Re_c = 5000$ and 10° degree angle of attack (see [1], for computational details and analysis of the main flow characteristics at $Re_c = 10^4$). We analyze the balance of the enstrophy and strain rate transport equations along two characteristic lines, see figure 1. Line A is along the cross-flow direction and intersects the recirculation zone, while B is in the main flow direction along which the flow transitions.

We also quantify and study the structure of rare large vortex stretching $\omega_i\omega_j s_{ij} > 10\langle\omega_i\omega_j s_{ij}\rangle$ and strain self-amplification events $-s_{ij}s_{jk}s_{ki} > 10(-\langle s_{ij}s_{jk}s_{ki}\rangle)$ and the circumstances under which these events occur. We find a significant contribution of the large events on the mean value of enstrophy and strain rate production (or the order of $\approx 50-60\%$). However, the fraction of the flow field over which there large events occur is less than 5%.

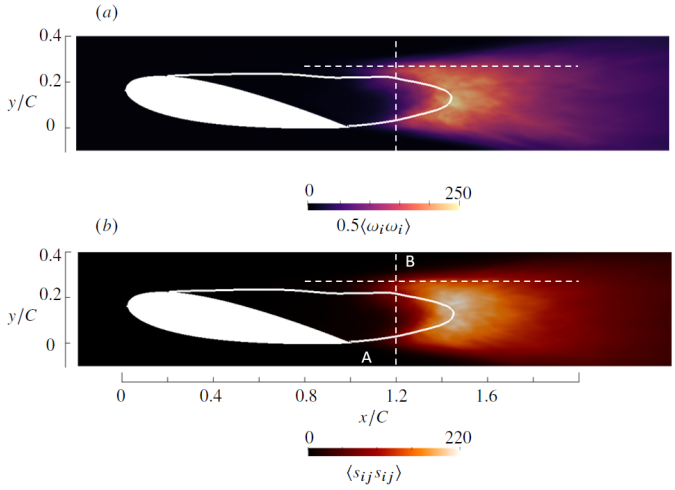

Figure 1: Contours of (a) mean enstrophy and (b) mean strain-rate of the fluctuating field. The solid white line indicates the time-average recirculation zone. Budgets of enstrophy and mean strain-rate are computed along the dashed lines A and B (line A intersects the recirculation region and the flow transitions along line B).

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[1] Bilbao-Ludena, JC. et al., *Physical Review Fluids* **8.1**