Abstract Submitted
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When RANS Goes Wrong: Using PIV to Assess Ergodicity W. ETHAN EAGLE, University of Michigan — Ergodic flow, where the spatial, temporal and ensemble averages, $\bar{u}_V$, $\bar{u}_T$, $\bar{u}_N$ are taken to be equal, is a widely used assumption in turbulent flows and is useful in applications from Taylor's frozen turbulence approximation to the Reynolds decomposition $u = \bar{u} + \mathrm{u}'$. Interestingly, ergodicity is only routinely (albeit tediously) verified by CFD grid convergence studies, while experimental assessments of ergodicity that require different spatial averages $\bar{u}_V$ (an impossibility for a given probe dimension), are not undertaken. In many cases, the unverified existence of experimental ergodicity results in spurious comparisons between computed and measured mean quantities. To investigate flow ergodicity, mean flow quantities were computed from 5 sets of 100 Stereo-PIV images of a supersonic turbulent boundary layer. To evaluate a pseudo-temporal ergodicity, $\bar{u}_t$, each set was recorded at a different laser pulse timing, d_t={500ns-900ns} Spatial ergodicity, $\bar{u}_V$, was assessed using 4 interrogation window cell sizes {2^nx2^n n=3,4,5,6.} Results suggest measuring, verifying, and reporting ergodicity enhances understanding of PIV optimization and uncertainty quantification programs and is essential when PIV experiments are compared to RANS (or LES) in validation and verification exercises.

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