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Estimating Uncertainties in Statistics Computed from DNS¹

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University of Texas at Austin — Direct numerical simulation (DNS) of turbulence is a critical tool for investigating the physics of turbulent flows and for informing and developing engineering turbulence models. For instance, flow statistics obtained from DNS are commonly used as “truth data” for the calibration and evaluation of turbulence models. Thus, like experimental data, uncertainty estimates are a necessary component of the reported output. In DNS, uncertainties in the computed statistics arise from two sources: finite sampling and the discretization of the Navier-Stokes equations. Here, we apply estimators for both sources of error. Finite sampling errors are estimated using the “effective sample size,” which accounts for the fact that the instantaneous data are correlated. Discretization errors are estimated using data from simulations with varying time step and mesh spacing. The performance of these estimators is tested for several statistics using DNS of turbulent channel flow at low Reynolds number ($Re_\tau \approx 180$).

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