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Quantification of the uncertainty of finite-time-average approximations of infinite-time-average statistics in turbulence simulations

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— Turbulent flows are often stationary and ergodic, which means that the time average of a quantity (TKE, total drag, etc) converges to a constant as the averaging interval is increased. This infinite-time-averaged statistic is of particular interest in many problems, such as aerodynamic shape optimization. Since taking an average over an infinite time horizon is not possible in simulation, some finite-time approximation of the infinite-time-average statistic of interest is generally used in practice. The error of this approximation decreases slowly, like the reciprocal of the square roots of the averaging time. In the present work, we develop a framework to quantify precisely the uncertainty of such a finite-time-average approximation of an infinite-time-average statistic of a stationary ergodic process. In the method used, different statistical models for stationary processes have been examined to model the statistical behavior of the time series derived from the turbulence simulation. It is observed that the statistical behavior of some of these models is sufficiently representative of that of the real time series that they provide an accurate estimate of the uncertainty associated with the finite time average approximation of the statistic of interest.

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