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We present a method for converting a time record of turbulent velocity measured at a point in a flow to a spatial velocity record consisting of consecutive convection elements. The spatial record allows computation of dynamic statistical moments such as turbulent kinetic wavenumber spectra and spatial structure functions in a way that completely bypasses the need for Taylor’s hypothesis. The spatial statistics agree with the classical counterparts, such as the total kinetic energy spectrum, at least for spatial extents up to the Taylor microscale. The requirements for applying the method are access to the instantaneous velocity magnitude, in addition to the desired flow quantity, and a high temporal resolution in comparison to the relevant time scales of the flow. We map, without distortion and bias, notoriously difficult developing turbulent high intensity flows using three main aspects that distinguish these measurements from previous work in the field: (1) The measurements are conducted using laser Doppler anemometry and are therefore not contaminated by directional ambiguity (in contrast to, e.g., frequently employed hot-wire anemometers); (2) the measurement data are extracted using a correctly and transparently functioning processor and are analysed using methods derived from first principles to provide unbiased estimates of the velocity statistics; (3) the exact mapping proposed herein has been applied to the high turbulence intensity flows investigated to avoid the significant distortions caused by Taylor’s hypothesis. The method is first confirmed to produce the correct statistics using computer simulations and later applied to measurements in some of the most difficult regions of a round turbulent jet—the non-equilibrium developing region and the outermost parts of the developed jet. The proposed mapping is successfully validated using corresponding directly measured spatial statistics in the fully developed jet, even in the difficult outer regions of the jet where the average convection velocity is negligible and turbulence intensities increase dramatically. The measurements in the developing region reveal interesting features of an incomplete Richardson-Kolmogorov cascade under development.
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