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Short-term forecasts and scaling of intense events in turbulence[1]

DIEGO A. DONZIS, U. Maryland, K.R. SREENIVASAN, ICTP, Italy; U. Maryland — Turbulence at high Reynolds numbers is replete with strong fluctuations in vorticity, dissipation and other features of small-scale motion, which can be thousands times their respective mean values. The understanding of these extremes is important for intermittency theory and reacting flows, but also for other extreme events such as strong earthquakes. Using direct numerical simulations of isotropic turbulence at up to $R_\lambda \approx 400$ we explore the extent to which extreme events can be predicted dynamically through a precursor. We study the evolution equation of vorticity to show that advection dominates when vorticity peaks in a fixed frame of reference. The growth of squared-vorticity during large excursions follows a universal power-law with a single exponent when normalized by the proper timescale. This description is shown to be consistent with multifractal models. Large viscous contributions are identified as precursors for intense vorticity, forming a reasonable basis for forecasts on short timescales that can be estimated simply by a suitable combination of viscosity and large-scale velocity. Definitive forecasts are shown to be possible if this information is supplemented by the sign of different terms in the vorticity equation. Implications for other intermittent quantities are briefly mentioned.

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