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Gaining "insight" by blurring one's "sight"

HUSSEIN ALUIE, University of Rochester

Coarse-graining (CG), which is equivalent to observing flows through eyeglasses of varying strength, provides a powerful yet intuitive approach to analyze and understand multiscale flows. This is because it allows for resolving the dynamics simultaneously in scale and in space, at every instant in time, and without requiring assumptions of homogeneity or isotropy, making it ideal to probe complex non-canonical flows that are unsteady, inhomogeneous, anisotropic, and multi-phase. With examples from plasma, oceanic, and variable-density flows, I will illustrate some of the advantages CG has over traditional tools such as Reynolds averaging, structure functions, and Fourier analysis. I will discuss a new method based on CG to extract the spectrum, including that of non-quadratic quantities such as kinetic energy in variable density flows, self-consistently, which the Fourier spectrum and the wavelet spectrum cannot. I will also discuss the emergence of new invariants in MHD and in compressible turbulence which can be unraveled by the proper scale-decomposition based on CG. Finally, I will present a generalization of CG to spherical domains, allowing for the analysis of scale-processes in oceanic flows from satellites.