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COMPUTATIONAL & DATA-DRIVEN APPROACHES FOR TURBULENT DYNAMICAL SYSTEMS

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ABSTRACT

The study of turbulence is one of the paramount areas of research in physics & engineering; in fact, it remains one of the seven unsolved Millennium Problems of the Clay Mathematics Institute. Turbulence is intrinsically chaotic and composed of a wide range of spatio-temporal scales. These flow motions naturally arise from laminar (regular) states that have a relatively simple spatio-temporal structure. However, flows typically undergo state changes, i.e., bifurcations, as the input parameters are varied. In this scenario, the flow states increase their spatio-temporal complexity successively, which leads to chaotic behaviour and ultimately fully-developed turbulence characterized by large flow fluctuations. It is thus common to find a transitional regime that involves a competition between these two extreme flow configurations. This regime is significantly important as it is widely encountered in a diverse range of fundamental and applied fluid dynamics problems, such as wall-bounded flows (e.g., Poiseuille systems), boundary layers (e.g., flow tripping in aerodynamics), and shear layers (e.g., formation of clouds over the ocean). The transition from laminar to turbulent flow can occur spontaneously, and it is a critical event that can affect the overall behavior of the fluid flow. In particular, during the transition, the flow may exhibit intermittent bursts of turbulence that are rare and unpredictable, and can have a significant impact on the system being studied. For example, coherent structures during the transition can cause large fluctuations in the drag and lift forces on objects in the flow, which can affect the stability and performance of aircraft, ships, and other vehicles. Therefore, understanding the mechanisms and dynamics of laminar and turbulent regimes, and the transition between both, is crucial for predicting and controlling fluid flow. To this end, this mini-symposium is devoted to computational methods and data-driven tools for picturing the transitional and fully-turbulent regimes based on concepts and theories from dynamical systems. This mini-symposium will enable researchers to (i) extract fundamental insight from computational methods for the analysis of chaos and turbulence, and (ii) explore state of the art data-driven tools for investigating turbulent flows.