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REDUCED ORDER STOCHASTIC MODELING AND SIMULATION OF MULTIPHYSICAL TURBULENT FLOWS

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ABSTRACT

After 80 years of Kolmogorov turbulence and almost 50 years of the advent of Direct Numerical Simulations (DNSs), the dusk of turbulent flow research seems farther than ever. Research-led application design accompanied by increasing computational power has become a norm. Despite the ability of new processors to handle faster operations, the problem of copying and moving increasingly larger amounts of data is becoming a burden (as well as later understanding it). Turbulent flow research today poses interdisciplinary challenges associated to the multiphysical nature of processes required to meet design optimization goals, or due to the formulation of physical descriptions in a very large range of scales, that is, from micrometers to astronomical units. The modeling effort required to represent such multiphysical turbulent flows demands a compromise. Thus, reduced order models become appealing. This minisymposium addresses the topic of reduced order stochastic turbulence models (SROMs).

Reliable numerical simulations have to account for the multiscale and multiphysical nature of turbulence, either by resolving it directly, or by modeling it accurately. Traditional filter-based turbulence models encounter an inherent issue here, given that complex physical interactions are not well understood. Even in simpler physical systems, some interactions are heavily dependent on the dynamics of the small scales, and these, likewise, feed back on the large scale observables. One example is combustion, in which turbulent mixing affects the reaction rates and, hence, the heat release. Another example is thermal convection and stratified flows, in which buoyancy forces drive or inhibit fluid motions on various scales. Other relevant topics concern multiphase or particle-ladden flows, among many others. This is why stochastic modeling is advantageous. On one hand, no scale reduction operation is necessary. On the other hand, physical processes can be represented by means of fluid parcel correlations in a discrete sample space, a much more consistent picture in numerical simulations. There may be different levels of fidelity within SROMs. It is the objective of this minisymposium to evaluate models of both low and high levels of fidelity, with an emphasis on low fidelity map-based SROMs. The latter resolve all relevant scales of a turbulent flow within a dimensionally reduced setting.

Recent advances on SROM formulations for multiphysical flows will be addressed, both in fundamental and applied research contexts. Coupled or hybrid filter-based SROM approaches are also addressed, as these are particularly relevant for application research. Overall, the objective is to bring together experts and stimulate the scientific exchange of an interdisciplinary research community.