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INTERDISCIPLINARY CHALLENGES FOR POST-EXASCALE FLUID DYNAMICS

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ABSTRACT

The complex nature of turbulent fluid flows implies that the computational resources needed to accurately model problems of industrial and academic relevance are virtually unbounded. Computational Fluid Dynamics (CFD) is therefore a primary driver for the world's most powerful supercomputers. These simulations have the potential for massive societal impact, including more efficient energy use, better healthcare delivery, and improved climate models.

Extreme-scale CFD poses several cross-disciplinary challenges, including algorithmic issues in scalable solver design, handling extreme-sized data via compression and in-situ analysis, and ensuring resilience and energy awareness in both hardware and algorithm design. To address the complexities of real-world geometries, modern solvers must leverage robust iterative methods coupled with scalable preconditioners. This requires innovative approaches to iterative and multilevel methods to maintain algorithmic efficiency across billions of unknowns. As we move toward post-exascale architectures, these hurdles are amplified by the shift to massively parallel GPU systems. Overcoming this requires streamlining inter-processor communication and adopting mixed-precision techniques to maximize throughput without sacrificing accuracy.

The wide range of these topics makes post-exascale CFD relevant to a wider HPC audience, extending well outside the traditional fluid dynamics community. This minisymposium aims to bring together HPC experts and domain scientists to discuss current and future challenges and facilitate international collaboration.