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ADVANCED MODELLING OF COUPLED COMPLEX SYSTEMS: MULTIPHYSICS, MULTISCALE, AND AI PERSPECTIVES

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ABSTRACT

Many challenges across science and engineering are inherently interdisciplinary, involving coupled complex systems with strong interdependence across multiple time and length scales. Effectively addressing these problems requires integrated modelling frameworks that can capture such multiscale dependencies. The increasing availability of data and its integration into modelling frameworks have significantly accelerated the adoption of artificial intelligence (AI), machine learning (ML), and physics-informed methods, enabling more accurate and scalable representations of complex systems. These developments are driving new opportunities for predictive modelling, discovery, and decision-making across diverse application domains. This special session aims to provide a forum for recent advances in mathematical, statistical, and computational modelling of coupled complex systems, with a particular emphasis on multiphysics, multiscale, and AI-enabled approaches. Contributions spanning a broad range of applications, including biomedical, physical, engineering, and social systems, are encouraged. Among others, applications addressing present and emerging societal challenges, particularly those related to global sustainability, resilience, and health, are especially welcome. The session aims to: (a) promote interdisciplinary collaboration; (b) advance mechanistic, data-driven, and hybrid modelling approaches; (c) highlight state-of-the-art computational and AI-based methods; and (d) support model validation through real-world applications. Topics include differential and integral equation-based models; multiphysics and multiscale methods; AI/ML and physics-informed modelling; data analytics and uncertainty quantification; and high-performance computing. Overall, this session aims to contribute to a forward-looking vision for the next generation of modelling scientists, where interdisciplinary collaboration, advanced computation, and AI-driven methodologies collectively address critical challenges in the modelling and simulation of coupled complex systems.