

**SCIENTIFIC MACHINE LEARNING AND REDUCED-ORDER MODELING  
FOR COUPLED MULTIPHYSICS SYSTEMS**

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**ABSTRACT**

Complex multiphysics systems arising in engineering, environmental sciences, and biomedical applications often require the solution of strongly coupled nonlinear partial differential equations. High-fidelity numerical simulations (e.g., CFD, FSI, thermo-fluid, and reactive transport problems) remain computationally demanding, particularly in parametric studies, optimization, uncertainty quantification, and real-time decision support.

This invited session aims to explore recent advances in Scientific Machine Learning (SciML) and Reduced-Order Modeling (ROM) for accelerating and enhancing the simulation of coupled multiphysics systems. Particular emphasis will be placed on hybrid methodologies that integrate physics-based discretization techniques (e.g., POD-Galerkin, projection-based ROMs, stabilized formulations) with data-driven components such as neural networks, operator learning methods, and surrogate modeling strategies.

Topics of interest include, but are not limited to:

- Reduced-order modeling for coupled PDE systems
- Data-driven closures for turbulence and multiscale effects
- Operator learning (e.g., Neural Operators) for parametric multiphysics problems
- Hybrid physics-informed and data-driven frameworks
- Bayesian and data assimilation techniques for inverse multiphysics problems
- Uncertainty quantification in reduced models
- Real-time digital twins for urban, environmental, and biomedical applications

The objective of this session is to bring together researchers working at the interface of computational mechanics, numerical analysis, and machine learning to discuss emerging methodologies, theoretical challenges, and practical implementations. The session seeks to foster interdisciplinary dialogue and identify promising research directions for scalable, reliable, and interpretable reduced models of coupled systems.

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