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SURROGATE MODELLING FOR COUPLED MULTIPHYSICS PROBLEMS

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ABSTRACT

Complex multiphysics systems arising in engineering, environmental sciences, geosciences, and biomedical applications are often governed by strongly coupled nonlinear partial differential equations. High-fidelity simulations, including CFD, fluid–structure interaction, thermo-fluid, thermo-hydro-mechanical, and reactive transport models, remain computationally demanding, especially when repeated evaluations are required. This is the case in parametric studies, uncertainty quantification, optimization, inverse problems, data assimilation, sensitivity analysis, and real-time decision support. This invited session focuses on recent advances in Reduced-Order Modeling and Scientific Machine Learning for the efficient, reliable, and interpretable simulation of parametrized coupled systems. Emphasis will be placed on hybrid methodologies that combine physics-based numerical formulations, such as POD-Galerkin methods, projection-based ROMs, stabilized schemes, and domain-decomposition strategies, with data-driven components including neural networks, operator learning, surrogate models, and data-driven closures. Contributions addressing the specific challenges of coupled multiphysics problems are especially encouraged. Relevant topics include stability preservation, interface treatment, loose and strong coupling schemes, constraint preservation, error estimation, uncertainty quantification in reduced models, Bayesian inference, data assimilation for inverse multiphysics problems, and real-time digital twins. Applications may span fluid–structure interaction, turbulence and multiscale flows, thermo-mechanics, environmental and urban systems, biomedical flows, energy systems, and geomechanics. The objective of the 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 aims to foster interdisciplinary exchange and identify promising directions for scalable, robust, and physically consistent surrogate models of coupled real-world systems.