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COUPLING MACHINE LEARNING MODELS FOR MULTI-PHYSICS AND MULTI-COMPONENT SYSTEMS

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ABSTRACT

Coupled problems in science and engineering increasingly involve interacting physical processes, heterogeneous data streams, and multi-component model chains that cannot be fully captured by a single predictive model. As computational models become more complex, computationally expensive, and data-rich, there is a growing opportunity to rethink how sophisticated multi-disciplinary systems can be simulated, or emulated when direct simulation is computationally prohibitive, by connecting and composing machine learning models of simpler individual components. This invited session will explore the emerging role of machine learning model coupling as a flexible framework for emulating, accelerating, and understanding complex systems across scales, components, and disciplines.

The session will cover topics such as linked statistical emulators for uncertainty quantification in multidisciplinary model chains, deep-learning-based coupling for multi-physics systems, hybrid coupling of machine learning and numerical models, and innovative divide-and-conquer strategies for decoupling strongly coupled systems to enable efficient dimension reduction and interpretation.

By highlighting both methodological advances and application-driven challenges, the session aims to position machine learning model coupling, simulator decoupling, and emulator-based recoupling as important directions for the next generation of solutions to coupled problems in computational science and engineering, with relevance to modern environmental, atmospheric, physical, industrial, and infrastructure systems that are often multi-component and multi-physics by nature.