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ADVANCED COMPUTATIONAL METHODS FOR FREE-SURFACE WATER WAVES

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ABSTRACT

Free-surface water waves are central to a wide range of engineering applications, including coastal, offshore, naval, and environmental engineering. Accurate and efficient numerical models are essential for predicting wave–structure interactions, coastal flooding, sediment transport, and wave breaking. The continued development of computational methods for free-surface flows is a major research focus in academia and industry. Model fidelity is typically determined by the governing equations, ranging from depth-averaged shallow-water models to nonlinear potential flow and viscous Navier–Stokes formulations. A key challenge lies in designing robust and efficient numerical discretizations that resolve complex geometries, nonlinear interactions, and multiscale dynamics. This mini symposium aims to bring together researchers working on developing advanced computational methods for free-surface water waves. Topics of interest include high-order discretization techniques such as spectral/hp element methods [1] and discontinuous Galerkin methods. Emerging paradigms, such as data-driven and physics-informed machine learning [2], are of particular interest due to their ability to embed physical laws into learning frameworks, enabling improved data efficiency, better generalization in data-scarce regimes, and real-time or reduced-order predictions. These approaches are promising for applications including wave-structure interaction, coastal flooding forecasting, inverse problems (e.g., parameter estimation and sensing), and surrogate modelling of high-fidelity simulations. The goal is to foster discussion across methodological boundaries and application domains, highlighting recent advances and identifying future directions in modelling free-surface flows for water waves.

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