

DIGITAL TWINS FOR OCEANIC AND ATMOSPHERIC SYSTEMS

JEFFREY C. HARRIS^{*}, KONSTANTIN KUZNETSOV[†]

^{*} LHSV, ENPC, EDF R&D, Institut Polytechnique de Paris
Chatou, France

jeffrey.harris@enpc.fr and <https://sites.google.com/view/wave CFD/>

[†] GRASP Earth
Lille, France

konstantin.kuznetsov@grasp-earth.com and <https://www.grasp-earth.com/>

ABSTRACT

Digital twins are emerging as powerful tools for real-time simulation, monitoring, and predictive control of oceanic and atmospheric systems. Creating effective digital twins for such complex environments requires computational efficiency without sacrificing interpretability and accuracy. This mini-symposium focuses on advanced Reduced Order Models (ROMs) and hybrid, physics-informed machine learning approaches, offering real-time performance while preserving the critical physical characteristics of environmental processes.

Oceanic and atmospheric phenomena, characterized by multiscale and multiphysics interactions, pose substantial computational challenges, particularly for high-resolution and real-time applications. Hybrid approaches leveraging physics-informed neural networks (PINNs), dynamic mode decomposition (DMD), proper orthogonal decomposition (POD), and generative AI techniques bridge the gap between computational feasibility and physical fidelity. These methods embed domain-specific knowledge into data-driven frameworks, enhancing reliability, interpretability, and predictive capabilities of digital twins.

Target applications of interest include digital twins for offshore energy systems (e.g., wind farms, wave energy converters, oil/gas platforms), aerosol-cloud interactions in climate modeling, ocean-atmosphere coupling dynamics (e.g., hurricane forecasting, air-sea interactions), and atmospheric pollution transport. Contributions highlighting advancements in multi-fidelity modeling, data assimilation techniques, uncertainty quantification, and computational efficiency improvements are particularly encouraged.