Keynote

Wed. Nov 11, 2026 2:00 PM - 3:30 PM JST | Wed. Nov 11, 2026 5:00 AM - 6:30 AM UTC | Room A (Oshidori) (2F)

Keynotes A1

Chair: Marina Tonani, Fei Chai

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[_yrsOa95-01] Real time Bayesian inversion, prediction, and OED for tsunami early warning

*Omar Ghattas

2:15 PM - 2:35 PM JST | 5:15 AM - 5:35 AM UTC

[_yrsOa95-02] Transforming Ocean Observation into Continuous Action through Fujitsu’s Ocean Digital Twin

*Akira Karasudani[1], Akihiro Inomata[1] (1. Fujitsu (Japan))

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[_yrsOa95-03] Digital-Twin of 3D Immersive Ocean Diagnostic and Prognostic System in the Western Pacific Marginal Sea

*Jianping Gan

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[_yrsOa95-04] From Ocean Forecasting to Predictive Digital Twins: Closing the Loop from Observations to Decisions

*Ibrahim Hoteit

3:05 PM - 3:30 PM JST | 6:05 AM - 6:30 AM UTC

Discussion

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[_yrsOa95-01] Real time Bayesian inversion, prediction, and OED for tsunami early warning

*Omar Ghattas

We address real-time Bayesian inverse problems governed by time-shift-invariant wave equations, with particular focus on tsunami source inversion and forecasting, and sensor network optimal experimental design. Efforts are underway to instrument subduction zones with ocean bottom acoustic pressure sensors to provide tsunami early warning. Our goal is to create a physics-based early-warning system that employs this pressure data, along with the 3D coupled acousticâ€“gravity wave equations, to infer the earthquake-induced spatiotemporal seafloor motion in real time. The Bayesian solution of this inverse problem then provides the seafloor forcing to forward propagate the tsunamis toward populated areas along coastlines and issue forecasts with quantified uncertainties.

In the context of the Cascadia Subduction Zone, a single forward wave propagation requires ~1 hour on a supercomputer. The Bayesian inverse problem, with a billion uncertain parameters, formally requires hundreds of thousands of adjoint wave propagations; thus real time inference appears to be intractable. We propose a novel approach to enable exact solution of the inverse and prediction problems in real time. The key is to exploit the time-shift-invariance of the parameter-to-observable map, which permits FFT diagonalization and fast GPU implementation. The result is that tsunami inverse problems with a billion parameters can be solved exactly in a fraction of a second.
This fast Bayesian inversion capability is then exploited to solve the optimal experimental design problem of placement of seafloor pressure sensors to maximize expected information gain in predictive quantities of interest. Time permitting, we discuss data-driven prior construction, goal-oriented dimension reduction, and construction of fast surrogates for the nonlinear shallow water equations, which are needed for representing nearshore tsunami dynamics.

This work is joint with Stefan Henneking, Sreeram Venkat, Bowen Shi, and Yuhang Li at UT Austin, and Alice Gabriel at UCSD.

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[_yrsOa95-02] Transforming Ocean Observation into Continuous Action through Fujitsu's Ocean Digital Twin

*Akira Karasudani[1], Akihiro Inomata[1] (1. Fujitsu (Japan))

As societies face increasingly complex challenges, understanding the interdependencies among physical environments, ecosystems, infrastructure, human activities, and policies is becoming essential. Fujitsu's Digital Twin vision extends beyond the representation of physical assets to support informed decision making across social, economic, and environmental domains. Through initiatives such as Social Digital Twin and Digital Rehearsal, Fujitsu is exploring new ways to understand complex systems and evaluate actions before they are taken.

Building on this vision, Fujitsu is advancing Ocean Digital Twin technologies to make underwater environments more visible and understandable. Coordinated control of multiple underwater drones enables adaptive data collection across wide areas, while real-time sensing and rapid 3D reconstruction provide timely visibility into underwater conditions and evolving changes.

Through a hardware-agnostic approach, Fujitsu integrates multimodal data from underwater vehicles, cameras, sonar, environmental sensors, and other sources. The resulting digital representations can be continuously enriched through observation and operations, helping stakeholders improve situational awareness and make informed decisions regarding inspection, maintenance, environmental management, and other interventions. By applying Digital Rehearsal to these Ocean Digital Twin representations, stakeholders can evaluate possible interventions and their implications before actions are taken in the real environment. This creates a continuous cycle of observation, understanding, action, and learning.

This presentation introduces Fujitsu's latest Digital Twin vision and its application to the ocean domain. It will demonstrate how real-time observation, 3D visualization, and multimodal data integration can strengthen ocean intelligence and connect it with operational and societal decision making. Together, these capabilities contribute to more adaptive, resilient, and collaborative management of marine environments and infrastructure.

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[_yrsOa95-03] Digital-Twin of 3D Immersive Ocean Diagnostic and Prognostic System in the Western Pacific Marginal Sea

*Jianping Gan

The western Pacific marginal sea (WPMS), spanning from tropical to high latitude region, is the transition zone between the Southeast Asia continent and open Pacific Ocean. WPMS is one of largest marginal seas in the world, surrounded by more than 15 countries with active socioeconomical development. WPMS covers bays, estuaries, shelf seas and interlinked semi-closed seas from the south to north that actively exchanges with the open western Pacific Ocean. WPMS is undergoing changes physically and biogeochemically in responses to changing climate and human activities. These changes exhibit spatiotemporally heterogenous in the multi-scale system. Diagnoses and prognoses of the status, health, resilience and future trend of WPMS are largely determined by the sustainability of the ocean in the interlinked spheric system that composes the lithosphere (land), the hydrosphere (oceans and rivers), the atmosphere, and the biosphere (living things). It is also controlled by the multi-scale processes of unique marginal sea characteristics internally and sea-ocean exchange externally. Based on complex integration of all streaming data from observation, earth simulator, analytics, visualization, machine learning and fundamental ocean and earth science, we have developed a comprehensive digital twin system, WavyOcean (http://wavyocean.hkust.edu.hk/), to resolve multi-scale processes from coastal oceans, seas to open ocean in the WPMS. WavyOcean innovatively developed an architecture of integrated land-ocean-atmosphere earth system; high-fidelity 3D immersive, GIS-BIM integrated visualization and diagnosis, comprehensive interactive analysis toolkit, high-performance rending for large-scale data and flexible cross-platform accessibility. The system let you see the unseen ocean, provides an innovative technology to make ocean transparent, and upgrade our holistic capability for understanding, prediction and management to the ocean.

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[_yrsOa95-04] From Ocean Forecasting to Predictive Digital Twins: Closing the Loop from Observations to Decisions

*Ibrahim Hoteit

Ocean forecasting has advanced considerably over the past two decades, driven by improvements in numerical models, observing systems, satellite remote sensing, data assimilation, ensemble methods, artificial intelligence, and high-performance computing. Ocean digital twins provide an opportunity to bring these elements together within an integrated framework that combines models and observations to represent and predict the evolving ocean state and ultimately support informed decision-making. Developing predictive digital twins requires the seamless integration of numerical models with in situ observations and satellite imagery, while quantifying and propagating uncertainties and enabling optimization and decision-making in real time.

In this talk, I will discuss our experience developing integrated ocean prediction systems, with particular emphasis on the Red Sea. Ensemble data assimilation provides a framework for integrating heterogeneous observations with numerical models, quantifying uncertainties in the ocean state, and propagating them into forecasts. I will illustrate these developments through two applications. The first focuses on oil-spill monitoring and prediction, using satellite imagery for detection and atmospheric and oceanic forecasts to predict spill evolution and associated uncertainties. The second explores how environmental predictions and their uncertainties can be combined with optimization methods to design shipping routes that reduce environmental impacts, including emissions and underwater noise.

Building on these applications, I will discuss how ocean prediction systems can evolve toward operational digital twins that connect observations, prediction, and uncertainty quantification with optimization and decision-making under uncertainty. Closing this loop in real time presents significant computational and methodological challenges, and this is where AI can play an important role. AI can extract actionable information from satellite imagery, accelerate computationally demanding models, and enhance data assimilation, ensemble prediction, optimization, and decision support. I will conclude by highlighting the key challenges toward operational ocean digital twins capable of transforming observations and predictions into actionable information for real-time decision-making.

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