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Recent Advances in Ocean Renewable Energy Modeling: Currents and Waves

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Kuykendall 209
(between HIG and Campus Center)

Monday, October 23

10:30 – 11:00 am Coffee
11:00 - 12:30 pm Seminar

Abstract

Increasing interest in power production from ocean, tidal, and river currents has led to significant efforts to maximize energy conversion through optimal design and siting and to minimize effects on the environment. Turbine-based, current-energy-converter (CEC) technologies remove energy from current-driven systems and in the process, generate distinct wakes, which can interact with other CEC devices and can alter flow regimes, sediment dynamics, and water quality. I introduce a CEC model and verify it against a two-dimensional analytical solution for power generation and hydrodynamic response of flow through a CEC tidal fence. With a two-dimensional model that accurately reflects an analytical solution, the effort was extended to three-dimensional models of three different laboratory-flume experiments that measured the impacts of CEC devices on flow. Both flow and turbulence model parameters were then calibrated against wake characteristics and turbulence measurements validating this numerical approach for simulating the impacts of CEC devices on the field. The model can be extended to future siting and analyses of CEC arrays in complex domains.

The coastal ocean represents a complex modeling challenge, intimately connected as it is to both the deep ocean and the atmosphere. The temporal evolution of oceanic processes (surface waves, flow fields, etc.) are characterized by nonlinear behavior; further, these processes are highly sensitive to external forces (e.g., changes in wind speeds) and other factors (e.g., local bathymetry and coastlines). By supervised training of machine learning models on many thousands of iterations of a physics-based wave model, accurate representations of significant wave heights and period can be used to predict wave conditions. A model of Monterey Bay was forced by measured wave conditions, ocean-current nowcasts, and reported winds. These input data along with model outputs of spatially variable wave heights and characteristic period were aggregated into supervised learning training and test data sets, which were supplied to machine learning models. These machine learning models replicated wave heights with a root-mean-squared error of 9 cm and correctly identify over 90% of the characteristic periods for the test-data sets. Impressively, forecasting wave conditions by transforming model inputs to outputs through machine-learning-specified matrix operations requires only a fraction (~1/5,000th) of the computation time compared to forecasting with a physics-based model.

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