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Overview of open source codes to assess environmental effects of ocean wave farms (Extended Abstract)

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Overview of open source codes to assess environmental effects of ocean wave farms

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1. Introduction

The United States has a theoretical ocean wave energy resource potential of 1,594–2,640 TWh/year, enough to power between 143.5 and 237.6 million homes/year and contribute substantially to the United States' energy portfolio [1]. However, wave energy converters (WECs) are currently in the early stages of research and development at low technology readiness levels. Open ocean deployment data is from demonstration-scale projects, not from utility-scale deployments. As a result, researchers, developers, and regulators rely heavily on numerical models to understand the environmental effects of wave farms.

Preliminary numerical studies have demonstrated that small-scale deployments of ~10 WECs or less have little to no impact on the physical environment. But utility-scale wave farms may affect the near-field and nearshore wave environment, circulation patterns, and nearshore processes such as sediment transport. A suite of open source codes has been developed by Sandia National Laboratories focused on simulating the energy extraction of WECs to better understand and predict their potential environment effects.

2. SNL-SWAN

The open source code Simulating WAves Nearshore (SWAN) is developed and maintained by Delft University of Technology for modeling wave parameters in coastal areas. SWAN is a spectral code developed based on the wave action balance equation with energy sources and sinks. SNL-SWAN is a modification of the open source SWAN code to include a *WEC Module* as an energy sink that extracts energy from the wave action balance equation according to the power performance of the WEC [2]. SNL-SWAN is used to simulate and predict the effect of wave farms of varying array sizes, configurations, and with different WEC types on the wave field, as shown in Fig. 1 [3].

3. SNL-Delft3D

Delft3D, developed and maintained by Deltares, is an open source, multidimensional hydrodynamic and sediment transport model, capable of computing non-steady circulation, waves, and sediment transport phenomena resulting from forcing by tides and meteorological processes [4]. The model supports both rectangular and curvilinear grids, and multiple nesting of model grids, including a newly developed flexible mesh. Additionally, Delft3D comes with a suite of graphical tools to assist in grid-building, tidal analysis, bathymetric mapping tools, and rapid data analysis. The coupled Delft3D-SNL-SWAN (SNL-Delft3D) model allows for evaluating tidal and wave-driven circulation, including wave-current interactions that influence both nearshore circulation, wave parameters, and sediment transport.

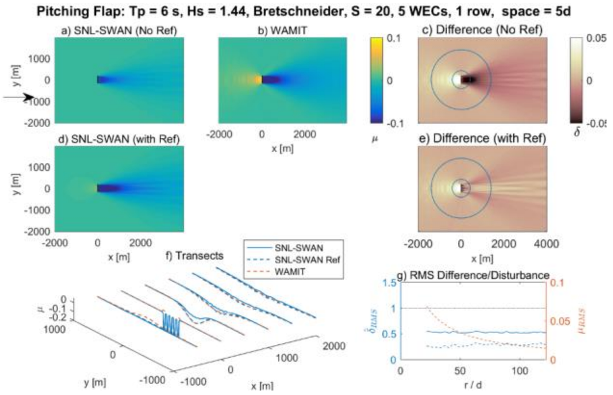

Figure 1. SNL-SWAN wave field with and without wave reflection, compared to wave field froms WAMIT

4. Environmental Effects

The development of SNL-SWAN by Sandia National Laboratories (SNL) allows users to investigate the interaction between a WEC or WEC array and the wave environment. SNL-SWAN when coupled with a hydrodynamic and sediment transport model such as Delft3D, developed by Deltares Inc, allows for the direct investigation of WEC array effects on the physical environment (e.g. waves, currents, seabed) and the associated site ecology. Ongoing development of these tools has shown how the coupling of SNL-SWAN with Delft3D-Flow can quantify the interaction between device(s) and the hydrodynamic environment at a real-world site.

5. Acknowledgment

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6. References

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