Dec 7th, 4:00 PM - 5:00 PM

Overview of Open Source Codes to Assess Environmental Effects on Ocean Wave Farms

Chris Chartrand
Sandia National Laboratories, Albuquerque, NM, ccchart@sandia.gov

Kelley Ruehl
Sandia National Laboratories, Albuquerque, NM

Jesse Roberts
Sandia National Laboratories, Albuquerque, NM

Sam McWilliams
Integral Consulting Inc., Santa Cruz, CA

Kaus Raghukumar
Integral Consulting Inc., Santa Cruz, CA

See next page for additional authors

Follow this and additional works at: https://scholarworks.uno.edu/oceanwaves

Part of the Oceanography Commons

Chartrand, Chris; Ruehl, Kelley; Roberts, Jesse; McWilliams, Sam; Raghukumar, Kaus; Porter, Aaron; and McNatt, Cameron, "Overview of Open Source Codes to Assess Environmental Effects on Ocean Wave Farms" (2017). Ocean Waves Workshop. 3. https://scholarworks.uno.edu/oceanwaves/2017/posters/3

This Event is brought to you for free and open access by ScholarWorks@UNO. It has been accepted for inclusion in Ocean Waves Workshop by an authorized administrator of ScholarWorks@UNO. For more information, please contact scholarworks@uno.edu.
Presenter Information
Chris Chartrand, Kelley Ruehl, Jesse Roberts, Sam McWilliams, Kaus Raghukumar, Aaron Porter, and Cameron McNatt

This event is available at ScholarWorks@UNO: https://scholarworks.uno.edu/oceanwaves/2017/posters/3
Overview of Open Source Codes to Assess Environmental Effects of Ocean Wave Farms

Chris Chartrand\(^1\), Kelley Ruehl\(^1\), Jesse Roberts\(^1\), Sam McWilliams\(^2\), Kaus Raghukumar\(^2\), Aaron Porter\(^3\), and Cameron McNatt\(^4\)

\(^1\) Sandia National Laboratories, Albuquerque, NM
\(^2\) Integral Consulting Inc., Santa Cruz, CA
\(^3\) Mott MacDonald, Edmonds, WA, USA
\(^4\) Mocean Energy LLC, Greensboro, MD, USA

*Corresponding author: ccchart@sandia.gov

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.

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 environmental effects.

Methods

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. SNL-SWAN has been verified against well respected wave energy models such as WAMIT, as shown in Fig. 1 [3].

SNL-SWAN and SNL-Delft3D have been designed to be run together as a coupled simulation. The coupled SNL-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.

Results

Performing a fully coupled Delft3D-SNL-SWAN model allows for an evaluation of changes in hydrodynamic and sediment transport parameters in the presence and absence of WECs in the environment. Two key parameters of importance to nearshore morphological change are maximum shear stress and bed elevation change. Fig 4 shows normalized changes in shear stress and bed elevation in the presence and absence of WECs for two wave events with the highest annual probability of occurrence at the Oregon Coast. The two cases shown are typical of summer and winter (Fig 4, normalized shear stress and Fig 5, bed elevation change) conditions on the Oregon Coast.

Changes in normalized shear stress are mainly observed in the vicinity of the WECs. Modeled bed elevation changes between the presence and absence of WECs are what may be expected due to wave shadowing in coastal transport. The presence of WECs, and the resulting wave shadowing, while minimal, results in enhanced deposition in the nearshore (<20 m water depth), followed by corresponding reduced deposition in adjacent offshore cells. These changes are on the order of 0.5% relative to baseline conditions. An increase in wave period, from 10 seconds to 15 seconds (Fig 4), is accompanied by greater changes in nearshore morphology.

Conclusions

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.

Acknowledgments

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy’s Nuclear National Security Administration under contract DE-NA0003525. This work was completed through technical support from Grace Chang, Sam McWilliams, Kaus Raghukumar, and Craig Jones of Integral Consulting, and Annie Dallman from Sandia National Laboratories.

References


Further information

Link to software and SNL-SWAN
http://snl-waterpower.github.io/SNL-SWAN/

Links to software and SNL-Delft3D
http://energy.sandia.gov/snl-delft3d-cec/
https://github.com/SNL-WaterPower/SNL-Delft3D-CEC