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Wave-Measuring Performance Characteristics of Spoondrift Spotter

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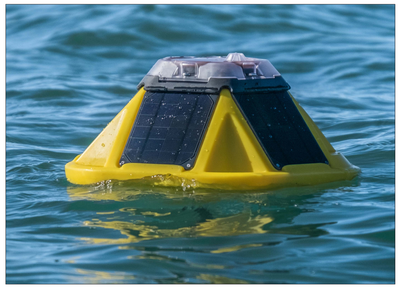
Spoondrift Spotter represents a state-of-the-art wave measurement buoy developed by Spoondrift (www.spoondrift.co) and supported by funding from the Advanced Research Projects Agency – Energy (ARPA-E). A low-cost buoy platform like Spotter enables a range of new applications. For instance, coherent arrays of Spotters can support adaptive tuning of marine and hydrokinetic energy devices. In general, the availability of high-fidelity wave measurements can help support wave assessments for a variety of commercial, military, operational, academic, and recreational users.

Technical Details

Spoondrift Spotter is an embedded wave measurement device integrated in a web-based application for real-time data access. The Spotter device consists of a compact (15-in. diameter) and lightweight (12 lb) wave measurement buoy that samples 3-dimensional displacements at 2.5 Hz and calculates wave statistics (e.g., spectra, wave heights, periods, directions). Spotter is constructed from marine-grade plastics and is solar-powered so that battery life is unlimited. Due to its small size, Spotter can be deployed from small vessels, either free-drifting or moored (see www.spoondrift.co).



The Spoondrift Spotter wave measurement buoy

In the present work, we use data collected with Spotter beta prototypes. The moored Spotters were tethered to the seafloor with a lightweight inverse catenary mooring.

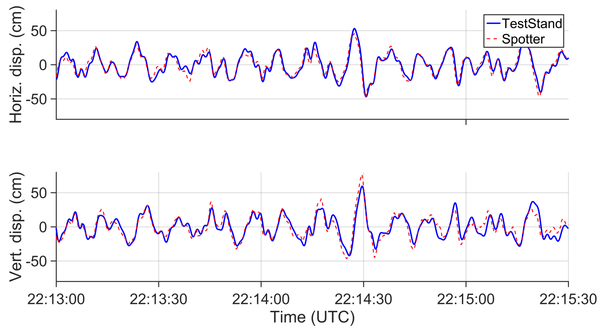
Deterministic Data Validation

Deterministic validation of Spotter is achieved by means of a purpose-built, motion-controlled validation stand. The stand specifications are as follows:

- Programmable to simulate both monochromatic and random waves
- Capable of maximum wave heights of 1.8 m and wave periods ranging from 3 to 25 s.

A custom-built 2-dimensional wave validation stand features two orthogonal arms and a programmable motion controller.

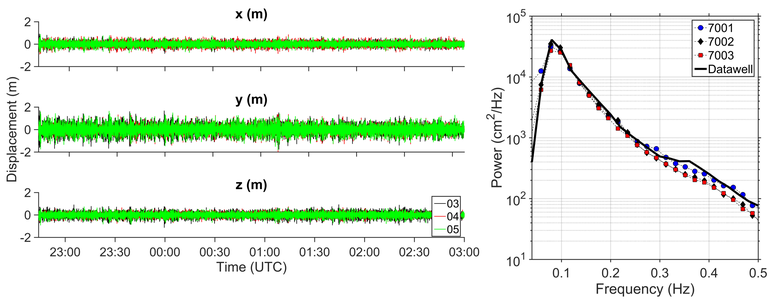
Comparisons between validation stand motion and Spotter measurements for a realization of a JONSWAP spectrum for fully developed seas show excellent agreement for both horizontal and vertical displacements (see figure below).



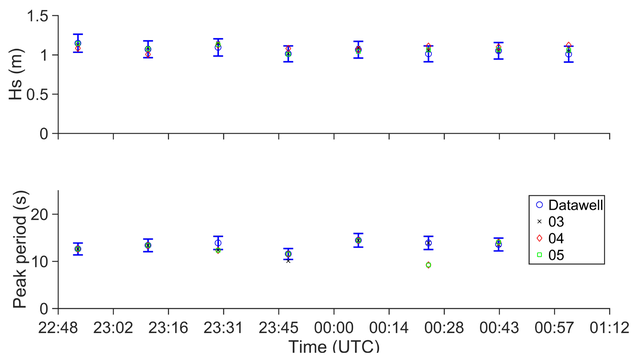
Comparison of vertical *(top)* and horizontal *(bottom)* displacement time series with validation stand controlled motion experiment.

In-Water Statistical Data Validation

To validate Spotter-derived wave statistics, a series of field tests was conducted in Waimanalo Bay, Oahu. During these experiments, several Spotter prototypes were deployed alongside a Datawell DWR-G4. Spectrally derived quantities such as significant wave height, peak period, mean direction, and directional spread were all in excellent agreement (see figure right below).



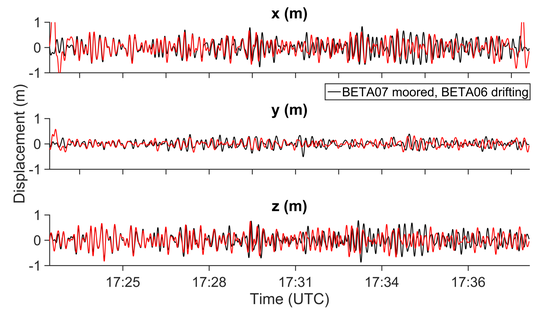
Displacement time series *(left)* and wave spectra *(right)* compared to Datawell measurements in Waimanalo, Oahu.

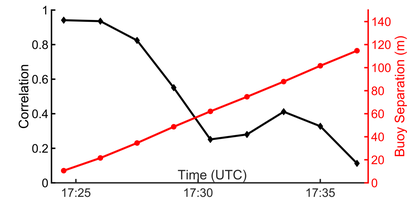


Significant wave height *(top)* and peak period *(bottom)* compared to Datawell measurements in Waimanalo, Oahu.

In-Water Drift and Distance Tests

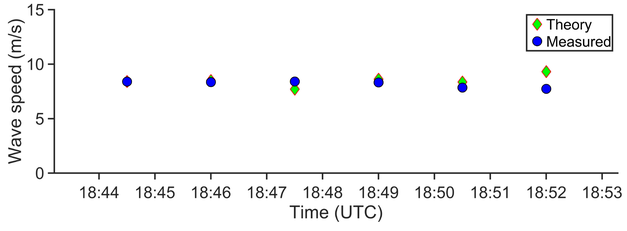
A series of drift and distance tests was conducted in April 2017 in Half Moon Bay, California. During the experiment, Spotter BETA07 was moored in 35 m water depth, while Spotter BETA06 was allowed to drift freely. During the drift test, the Spotter BETA06 was repeatedly allowed to drift for 15 minutes, beginning with a 1 m separation from the moored Spotter BETA06. The correlation between the observed surface elevation by each of the Spotters was calculated every 3 minutes with a 1.5-minute overlap between segments. The wave field significantly decorrelates when horizontal separations exceed 40 m (~2 wavelengths at the peak period).





Time series of measured displacements during drift tests *(above)*. Correlation of 3-minute segments and buoy separation *(left)*.

Spotter BETA06 and BETA07 were subsequently moored 116 m apart. From the time lag of maximum correlation, we calculated wave speeds at the peak of the spectrum and compared them to predictions from linear wave theory (see below). The agreement is excellent.



Wave speeds calculated using 3-minute data segments on two Spotters 116 m apart.

Conclusions and Future Work

Spoondrift Spotter is a robust platform capable of providing high quality deterministic wave measurements. Future work includes coherent processing of Spotter array data and the expansion of the Spotter's platform to make acoustic and other oceanographic measurements.

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