RECONSTRUCTION OF THE NEARSHORE SURFACE WAVE FIELD VIA ASSIMILATION OF REMOTE SENSING DATA

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Typically, phase-resolved observations of the surface wave field are limited to in situ single-point time series. Select locations and field projects may have a handful or more single-point time series, such as for example the USACE FRF "8 meter array". Recently, phase-resolved wave field observations with more spatial coverage have become available using LIDARs; however, LIDAR scan rates are only fast enough to encompass one horizontal dimension at the necessary phase-resolving sampling rates. Imaging remote sensors, such as optical cameras and marine radars, offer the possibility of full 2D reconstruction of the phase-resolved wave field. Accurate reconstructions from these sensors would essentially be equivalent to having thousands of wave gauges. Applications include short-term wave forecasting for maritime operations (e.g., cargo unloading) and high-speed navigation, as well as control schemes for wave energy converters. Moreover, realistic wave field reconstruction of nearshore wave fields would offer a very valuable new tool for investigating the time and space varying wave forcing in the nearshore.

Previous work has demonstrated that wave field reconstruction can be done successfully with pairs of optical cameras working in stereo, but only over limited fields of view (order 10^4 m^2). Marine radars sample the ocean surface over footprint areas of $O(10^6$ m$^2)$, which are large enough to capture wave group length scales. In our previous work (Simpson, 2016; Haller et al., 2017), we have developed a novel forecasting technique in which observations of the wave field from a marine radar are ingested into a data assimilating, phase-resolved wave model based on the Mild Slope Equations in order to reconstruct the surface wave field over time scales of minutes and horizontal scales of kilometers.

To date the algorithm has only been verified with synthetic data. The dataset used for assimilation was created by modeling a directional sea using the linear Mild Slope Equations then applying realistic shadowing and thermal noise to best simulate the radar characteristics. Comparisons between modeled and reconstructed surface elevations are shown in Figure 1. Time series at point locations 1-4 lie along the direction of wave propagation, approximately 400 meters apart. The computed correlation coefficients are up to 0.88.

Recently, we conducted a field experiment in Monterey Bay, CA. In this experiment we mounted the radar on a fishing boat and collected radar observations 4 km south of Santa Cruz in 50 m water depth, where an array of eight in situ wave sensors were deployed. The wave sensors are small surface profiling buoys and were deployed for 1 week; we collected spatially and temporally overlapping radar imagery for four hours. During data collection the waves were 2-3 meters in height with a 12 second period from 240 degrees. A sample post-processed radar image is shown in Figure 2 with the sensor locations indicated. The data shown are the radial component of the sea surface slope, which is estimated using a relationship between the radar intensity, height, and range (Lyzenga and Walker, 2015). In order to verify the algorithm, we reconstruct the wave field from the radial slope observations, and compare against the sensor-measured surface elevations. The goal of this work is to verify the reconstruction algorithm in a phase resolved sense against the in situ time series.

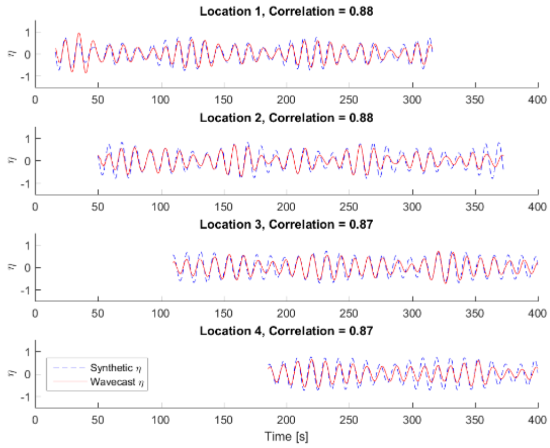

Figure 1 – Correlation of modeled and reconstructed waves from synthetic radar imagery.

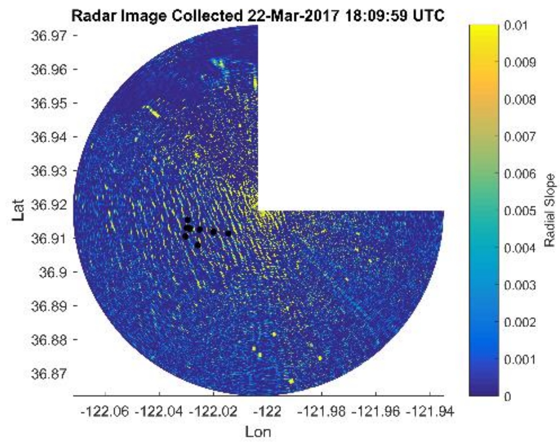

Figure 2 – Radar-estimated radial slope collected in Monterey Bay, CA.

REFERENCES

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