

Near-shore Currents in Fringing Reef Environments

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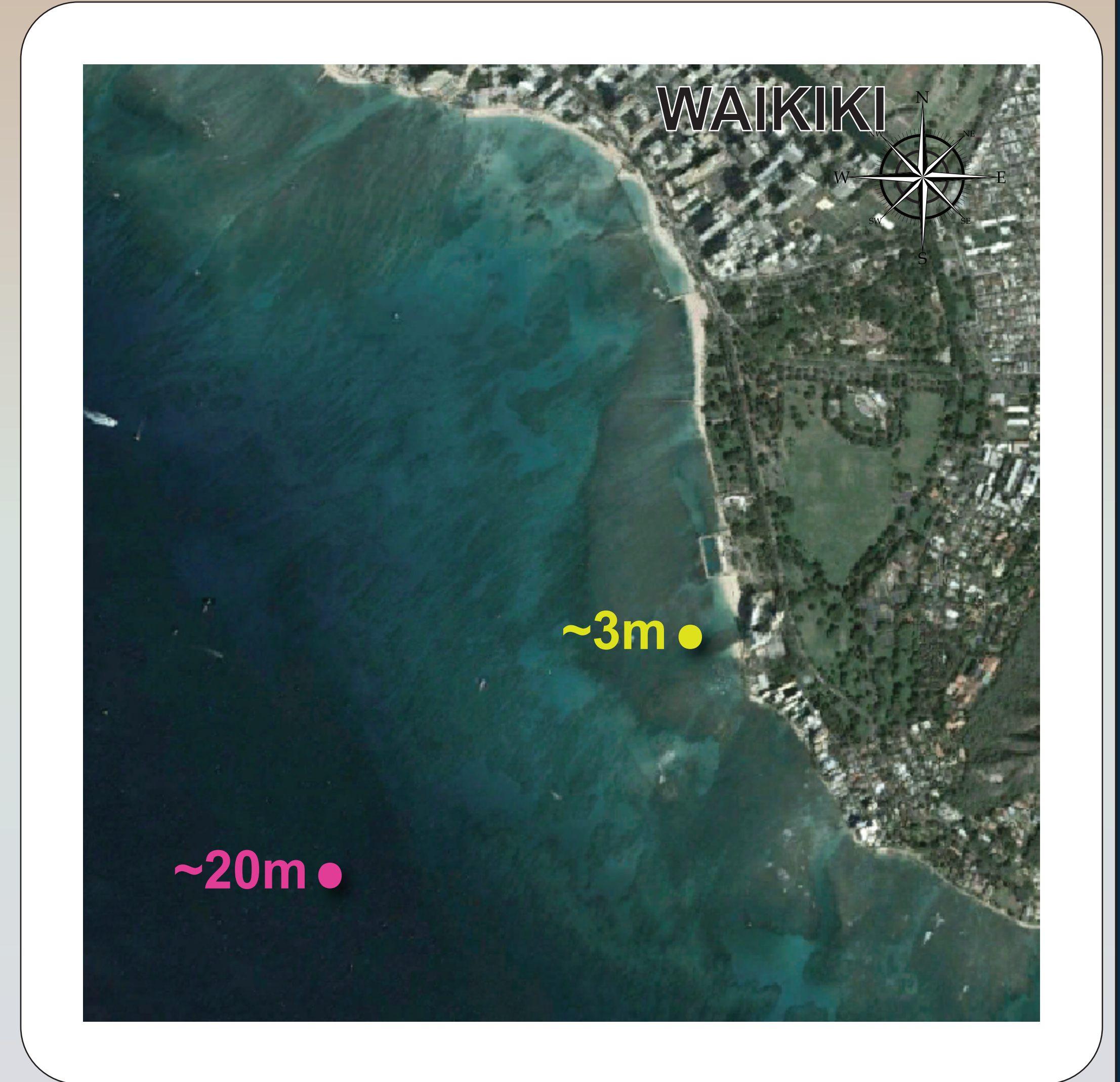


1. Introduction

Wave-induced currents are second-order processes resulting from wave transformation and breaking. These processes can be highly complex, especially along tropical coastlines in fringing reef environments. In spring of 2011, wave and current measurements were taken in the vicinity of Waikiki Beach on the south shore of Oahu, Hawaii. The Boussinesq Ocean and Surf Zone (BOSZ) model described by Roeber and Cheung (2012) is validated with current observations enabling further analysis on coastal processes associated with wave-induced currents.

2. Field Program

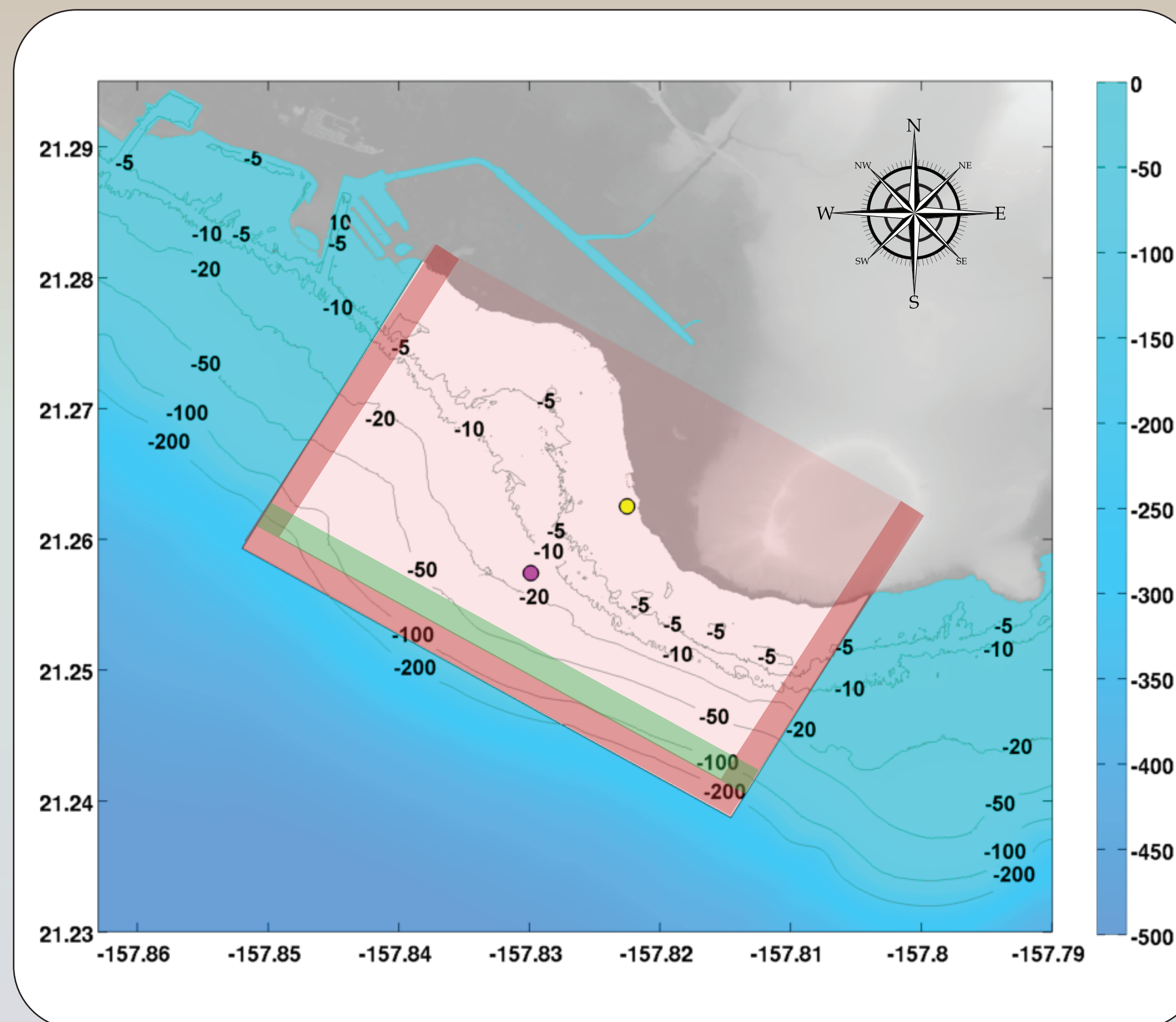
The figure on the right depicts the bathymetric complexity associated with fringing reef environments. A pressure sensor located offshore (magenta) sampled incident wave conditions for 20 minutes every hour. A current meter was placed in a near-shore sand channel located at the entrance of a small lagoon (yellow). Current measurements were taken for 1 minute every 20 minutes. The observation period over three months covers a wide range of wave and tidal conditions.



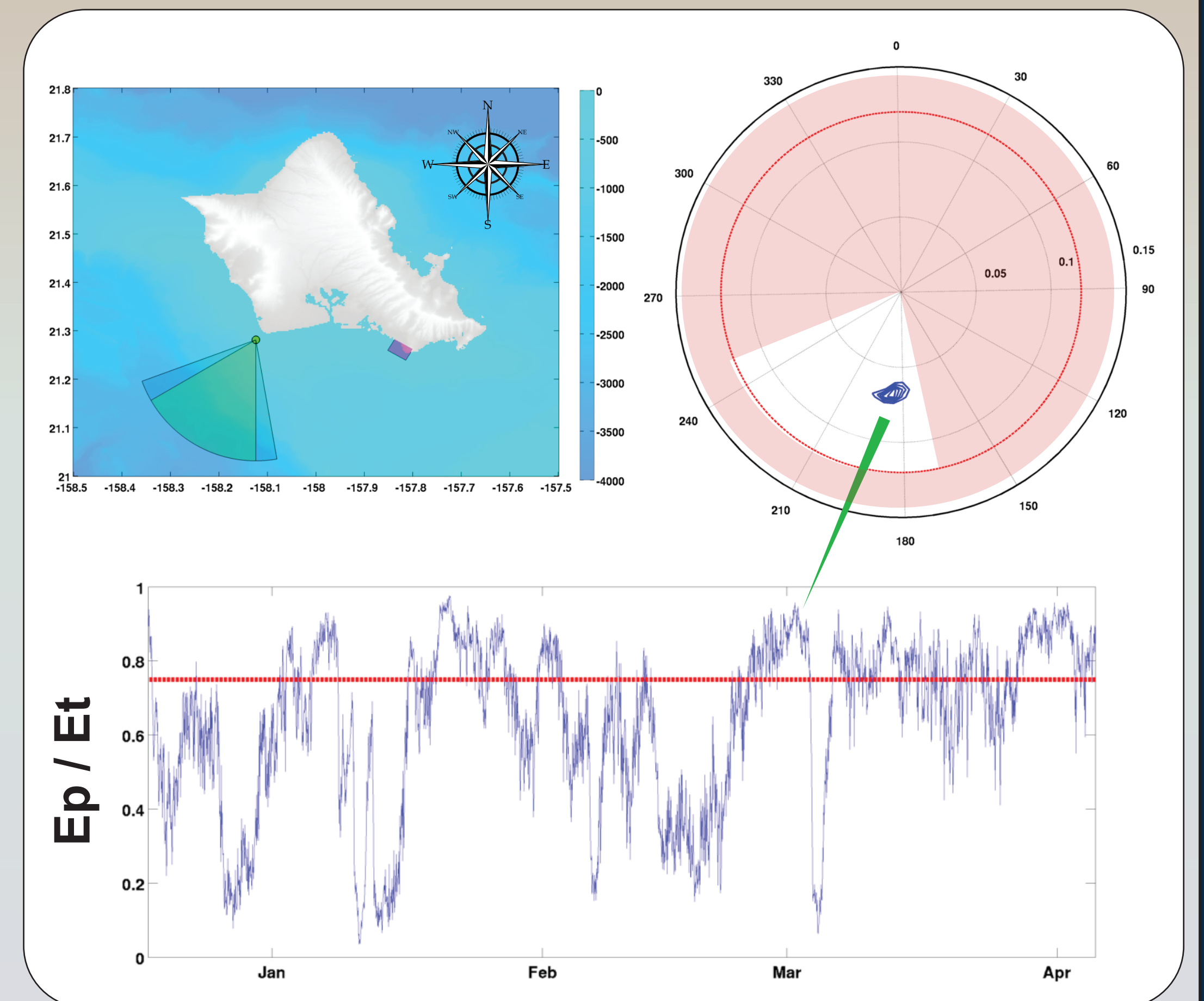
3. BOSZ

The computational domain covers 4.5 km by 3 km at 4 m resolution, resulting in ~850K grid cells. The rectangular domain is analogous to a wave basin with solid reflective walls and dissipative sponge layers (red). Waves are generated from free surface elevations of the input spectra specified at an internal wave maker using a source function (green). A local directional wave buoy was utilized to resolve the multi-modal forcing conditions to be transferred to the field site using an objective filtering approach to partition the spectra based on directional and frequency constraints.

Computation Domain

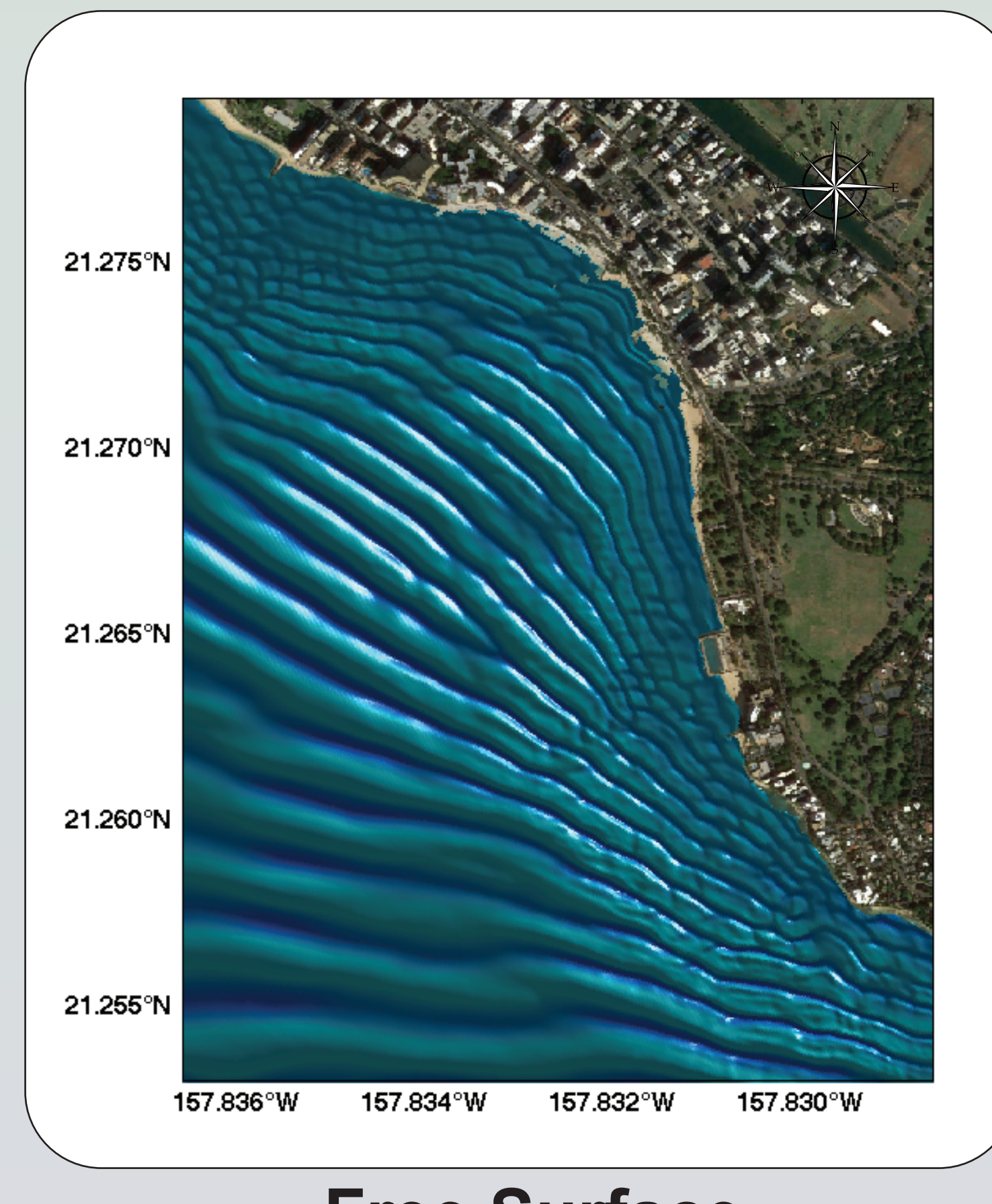
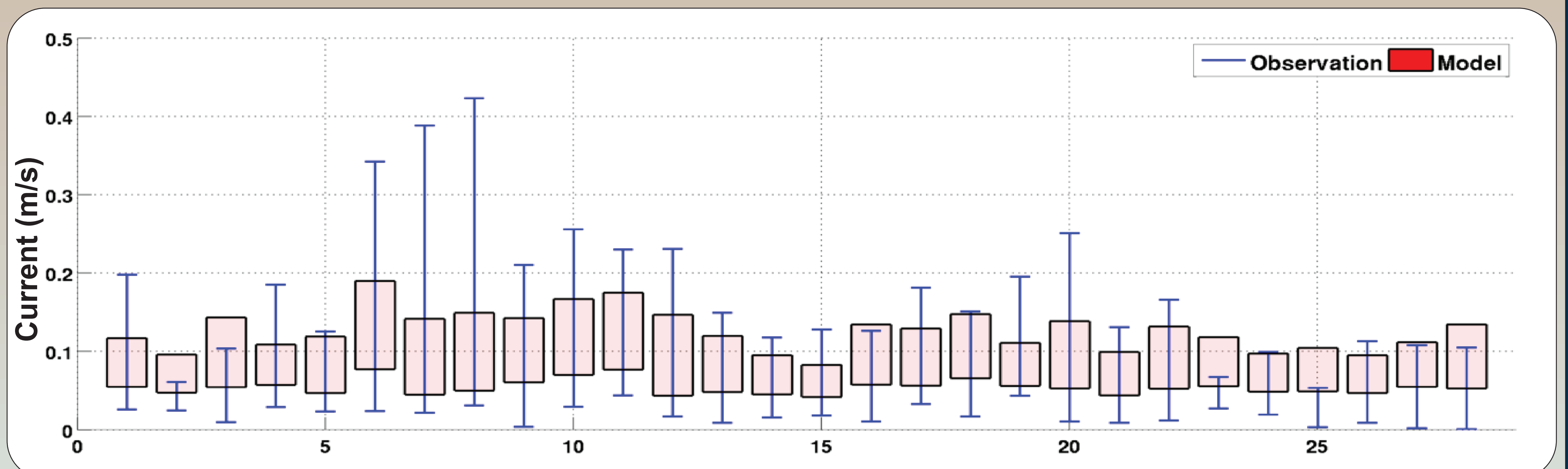


Spectral Partitioning

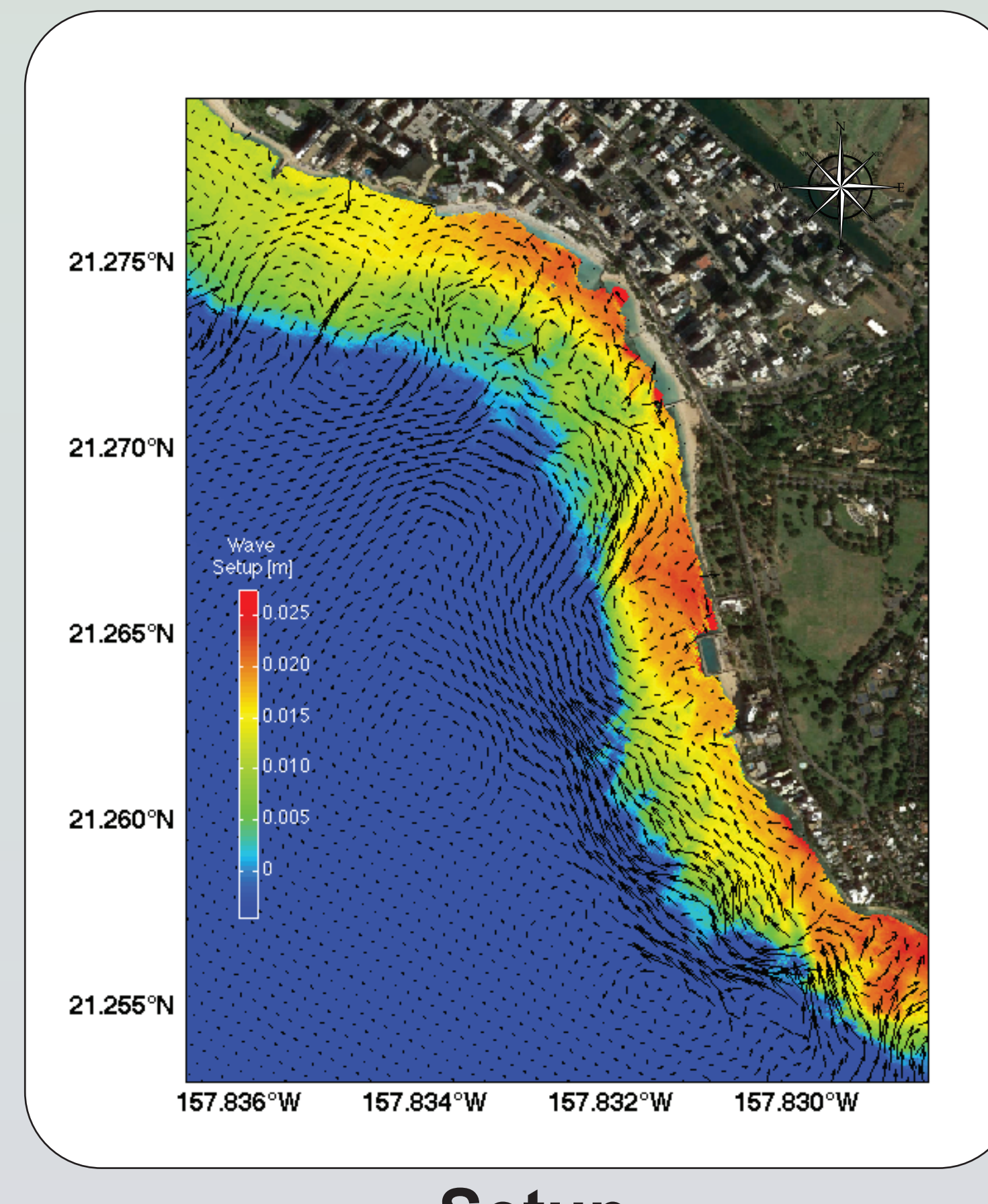


4. Results and Discussion

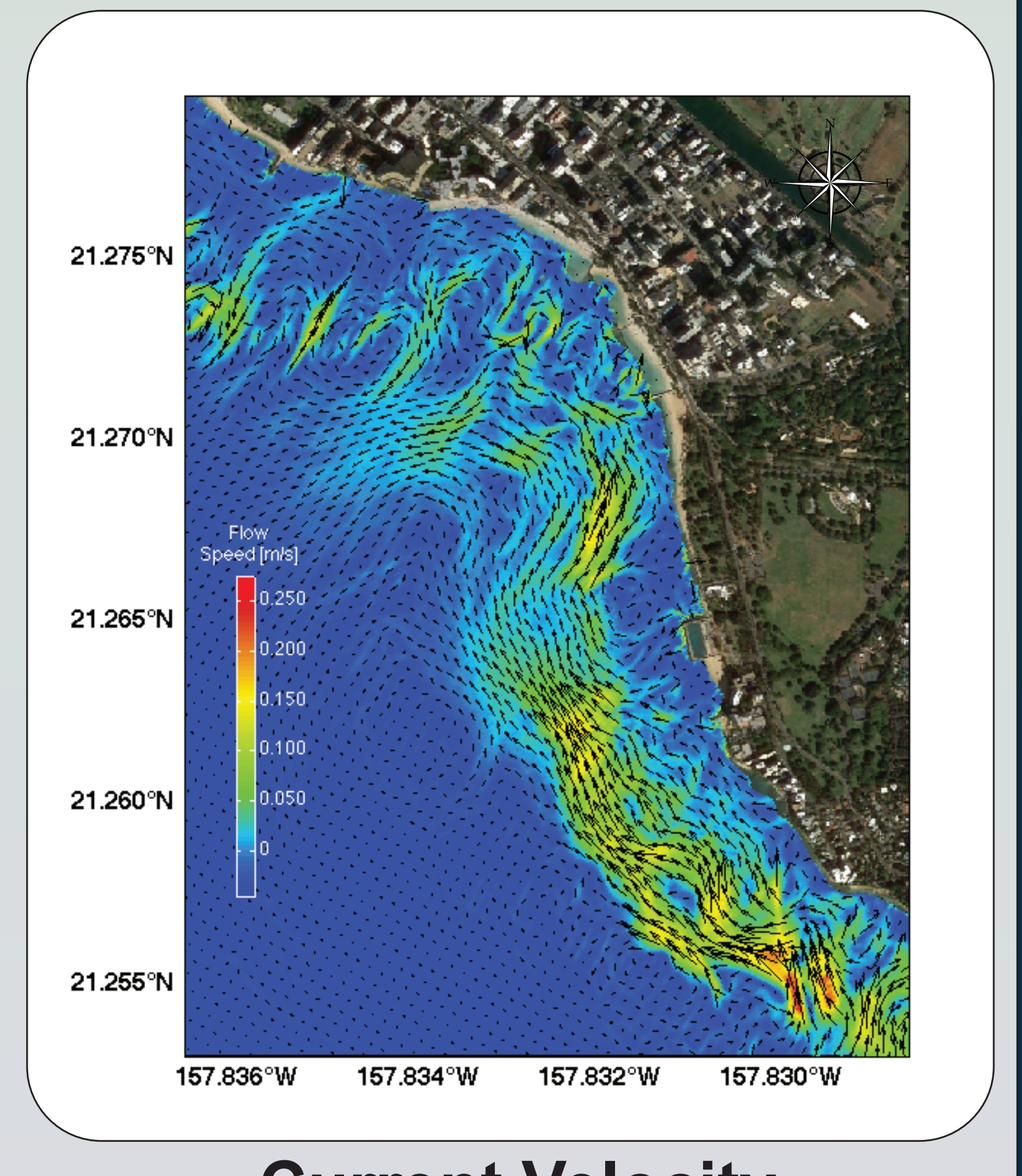
To isolate wave driven currents, all model runs were conducted during slack tide. The one-minute averaged flow speeds from the model and measurements show consistent agreement within a large envelope indicating the presence of infra-gravity waves. Showing sufficient validation, the spatial circulation patterns through out the domain. The bathymetry dictates the focusing and intensification of the near-shore momentum flux driving wave setup. Energetic wave breaking over the reef face builds the setup over the shallow reef flat. The phase averaged flow velocity is smallest in areas with large setup and it is highest over the reef face. In the particular case shown, the free surface depicts refraction and wave breaking along the reef edge as oblique incident waves travel from south to north.



Free Surface



Setup



Current Velocity

5. Concluding Remarks

BOSZ reproduces the general circulation pattern over a complex reef system with small-scale features such as narrow channels. This study demonstrates that under weak to moderate wave forcing conditions the strongest phase averaged current velocities occur in areas of wave breaking. The bathymetry appears to topographically govern the flow patterns whereas gradients in the wave setup have little influence.

6. References

Roeber, V., Cheung, K.F. (2012). Boussinesq-type model for energetic breaking waves in fringing reef environments. Coastal Engineering, 70(1), 1-20.