Observations and Modeling of Wave-driven Extreme Water Levels on Reef-Fringed Coastlines

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Wave-driven flooding events threaten people and property on coral reef-fringed coastlines globally, and predictive tools are needed to mitigate the expected increasing occurrence of flooding as sea level rises. A majority of the currently existing nearshore wave and circulation models were developed and validated for open sandy coastlines. Consequently, these models are ill suited and perform poorly on the steep bathymetry and the large bottom roughness common to coral reefs. Although coral reefs are prevalent along low-latitude coastlines globally, a lack of hydrodynamic datasets has hindered the validation of existing models and the development of new models for coral reef environments. Recent novel laboratory and field experiments, summarized herein, have sought to address this issue. Using these datasets, we highlight the importance of both the unique morphologies of coral reefs and their bottom roughness characteristics to determining wave-driven extreme water levels. Two surfzone processes, the generation of low frequency (infragravity) waves and wave setup, are particularly important, as these components typically dominate wave runup on reef-fringed coastlines. Coasts fronted by narrow and smooth reef flats are found to be especially vulnerable to coastal flooding due to resonant amplification of infragravity waves. Alongshore uniform, shallow reefs with steep fore reef slopes are found to have the largest wave setup at the shoreline, relative to offshore wave conditions. Finally, we assess the important features of coral reefs that modify wave-driven extreme water levels and investigate the predictive skill of various classes of nearshore wave models (phase averaged, non-stationary, and phase-resolving) in reef environments.