THE INFLUENCE OF A CROSS-REEF CHANNEL ON CIRCULATION OVER A FRINGING REEF AT IPAN, GUAM

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Abstract

Forcing mechanisms of water circulation over a shore-attached, 400 m wide, fringing reef at Ipan, Guam with a deep (30 m), narrow (30 m) cross-reef channel are examined using current and bottom pressure measurements and a numerical model. The reef flat is shallow (0.5 m) and mostly exposed at low tide. During a 6-week deployment, the reef experienced moderate onshore winds, with an average magnitude of 2 m/s. The significant wave height measured on the fore reef ranged from 0.5 m to 2.2 m at the peak of a remotely generated wave event. Hourly mean currents on the reef flat during mid and high tides (~0.2 m/s) are directed towards the reef channel in the alongshore direction, independent of wave and wind conditions. Maximum current speeds on the reef flat reach 0.58 m/s during the wave event measured in this study. The channel flow, which is depth intensified, is always directed offshore, reaching a depth-averaged maximum of 0.72 m/s during the peak of the wave event measured in this study. Low frequency modulation of the alongshore current on the reef is significantly correlated with the alongshore sea surface height gradient. The wind stress does not play a significant role in forcing the circulation. Circulation over the reef appears to be primarily forced by wave-driven setup, modulated by the tide, which creates a sea surface height gradient between the reef flat and channel, where waves do not break and setup is low. The presence of the channel affects reef flat circulation as far away as two kilometers, a significant distance given the size of the channel and the fact that this reef lacks a back lagoon.

The numerical model suite Delft3D was used to simulate waves and circulation over the reef for comparison with the field observations. Observed tide, wind, and wave conditions for two weeks surrounding the main wave event are used to specify model boundary conditions. Model runs confirm that wind and tidal forcing results in weak flows that do not reproduce the circulation patterns observed on the reef. Runs that include waves replicate the observations made on the reef relatively well. The low frequency variability caused by changing significant wave height is captured well in the model output. The model does a poorer job replicating high frequency variability caused by tidal modulation, however. Overall, our results from both the model and observations support the hypothesis that the alongshore current on the reef flat is forced primarily by the alongshore-varying wave-driven setup between the reef flat and channel.