Extreme sea levels in Guam: Incorporation of wave-driven setup and runup into the analysis of fluctuations in extreme high waters at the Ipan reef

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Abstract

Changes in mean sea levels influence the coast by affecting the height and frequency of extreme high waters. Tide-gauge records are often used to study fluctuations in the timing and severity of extreme sea levels because these records are relatively long and accessible. However, there are two main limitations to analyzing sea-level extremes using tide-gauge observations: 1) Tide gauges are often protected from wave energy, and therefore do not account for the elevation of water levels due to setup, and 2) instruments with sampling frequencies of several minutes to an hour may not correctly identify the most extreme sea level. Here it is found that sea-level extremes documented by tide gauges at Pago Bay and Apra Harbor, located in eastern and western Guam, respectively, differ significantly in height when the observations are evaluated alongside a high-frequency (1 Hz) sea-level record from Ipan that has been modified to include the influences of setup and extreme runup. The disparity between water levels with and without wave effects is especially pronounced (as high as 1.5 m) during large wave events (>2 m). Extreme high waters appear to be correlated to a surge in southwesterly monsoon winds in Apra Harbor and the passage of tropical cyclones close to (<370 km) the island in Pago Bay and Ipan. The sea-level response to the passage of a tropical cyclone over Guam does not appear to be correlated to storm intensity or proximity.