DATA-MODEL COMPARISONS OF STORM PROCESSES DURING HURRICANE HARVEY

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INTRODUCTION

During tropical cyclones, processes including dune erosion, overwash, inundation, and storm-surge ebb can rapidly reshape barrier islands, thereby increasing coastal hazards and flood exposure inland. Relatively few measurements are available to evaluate the physical processes shaping coastal systems close to shore during these extreme events as it is inherently challenging to obtain reliable field data due to energetic waves and rapid bed level changes which can damage or shift instrumentation. However, such observations are critical toward improving and validating model forecasts of coastal storm hazards. To address these data and knowledge gaps, this study links hydrodynamic and meteorological observations with numerical modeling to 1) perform data-model inter-comparisons of relevant storm processes, namely infragravity (IG) waves, storm surge, and meteotsunamis; and 2) better understand the relative importance of each of these processes during hurricane impact.

INFRAGRAVITY WAVE DYNAMICS

Field measurements of wave fields on either side of two barrier islands along the Texas Gulf coast (U.S.A) during Hurricane Harvey (2017) revealed that IG waves (0.003-0.04 Hz) were an important component of the nearshore wave field during this relatively low-surge event. IG waves were found to dominate over gravity waves during shallow flooding and overwash, consistent with the general assumption of morphodynamic models used to simulate hurricane impact (e.g., Roelvink et al., 2009). Sea-to-bay directed flow (i.e., overwash) was observed through a pre-existing and low-lying barrier-island cut for a period of 5 hours. During this time, IG energy loss across the barrier-island cut was found to be frequency-dependent, with a larger percent decrease in energy flux for the lowest frequency IG waves (47-97%), below 0.01 Hz. This dominance of low frequency (high frequency) IG energy on the seaside (bayside) of the barrier island is hypothesized to be the result of nonlinear energy transfers, energy dissipation by IG wave breaking, and wave reflection as IG waves propagated across the island during overwash.

Two Boussinesq models, namely COULWAVE (Lynett & Liu, 2002) and FUNWAVE-TVD (Shi et al., 2012), are used to hindcast IG wave generation, propagation, and energy losses during island overwash. Both models utilize the same grids, numerical resolution, and wave boundary conditions, thus allowing for an inter-comparison of different numerical solution schemes and dissipation parameters of fully nonlinear Boussinesq models. Preliminary analysis shows that the models are highly consistent in prediction of nearshore wave propagation, evolution and wave-wave interactions, as well as successful generation of IG waves during overwash. However, FUNWAVE-TVD and COULWAVE simulations diverge and generally over-predict IG wave heights through the barrier-island cut. Work is ongoing to identify the source(s) of these model differences and data mismatch as well as elucidate the role of energy dissipation and energy transfers in the observed cross-barrier transformation of IG waves during overwash.

METEOTSUNAMI GENERATION & PROPAGATION

Another key finding from the Hurricane Harvey data set was the discovery of relatively large amplitude wave motions below the IG frequency band but above known tidal frequencies (0.4-1 mHz, 17-40 minute periods) in the very nearshore and into the back-barrier during island overwash. Local and regional observations of atmospheric forcing suggest that these very low frequency wave motions may be initiated by moving atmospheric disturbances associated with radially-propagating tropical cyclone rainbands (TCRs), and can thus be classified as small-amplitude (*O*(40 cm) in height) meteotsunamis. The generation and propagation of meteotsunami by TCRs is explored using a shallow-water model supplemented with a Proudman resonance term (Proudman,1929). Model results show that meteotsunami propagation is highly sensitive to characteristics of the atmospheric disturbance including the longitudinal width and forward speed of the TCR. This combined field and numerical study identified the potential, but sometimes highly localized conditions necessary, for meteotsunami to modulate storm processes (e.g., overwash) and serve as a flood hazard during hurricane impact.

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