Optimum Frequency Discretization and Its Implications on Extreme Infra-Gravity Wave Runup

Luis Montoya, University of Southern California, lhmontoy@usc.edu
Patrick Lynett, University of Southern California, plynett@usc.edu

Throughout history "sneaker" waves or "king" waves (in Australia), also referred in this study as extreme infragravity (EIG) waves, have been responsible for killing several people throughout the world. Particularly on the coast of Oregon, more than 21 people have died since the year 1990 due to this phenomenon (http://www.oregonlive.com). People that are usually walking by the beach on a "nice" day are suddenly surprised and washed away by what appears to be a "tsunami-like" wave which in reality is an EIG wave.

There hasn't been much research done on EIG waves and runup so they are still poorly understood (generation mechanisms). Few studies have measured and analyzed this phenomenon (Roeber and Bricker 2015, Shimozono et al. 2015 and Sheremet et al. 2014) but come short of fully explaining how EIG waves are formed. In addition, many of these studies do not mention the input spectrum frequency resolution used in their models which is important factor in the generation of IG wave within a model.

This study reveals that the input spectrum frequency resolution plays an important role when studying IG waves and runup. Also, it shows that there is an ideal frequency resolution which can make the modeling part more accurate and efficient by capturing most of the low frequency energy transfers during the nonlinear wave interactions. It is established that runup predictions from numerical simulations that use 10 frequencies in the input energy spectrum are not the same from those that use 100 frequencies because of nonlinearity. Runup predictions are generally underpredicted when using a coarse input energy spectrum.

The Cornell University Long Wave (COULWAVE) (Lynett and Liu 2002, Kim, Lynett and Socolofsky 2009) model is used in this study because of its capabilities in predicting the dynamics and formation of IG waves and runup. To further investigate the problem 100 different configurations of significant wave heights ($H_s = 3\ to\ 12$ m) and peak periods ($T_p = 13\ to\ 22$ sec) are tested. To examine the effects of frequency resolution on extreme infragravity run-up, three different frequency resolutions are tested in the model: Δf=0.001 (coarse), 0.0001 (fine) and 0.00005 (finest) Hz.

Figure 1 shows a comparison between the maximum runup predictions from the fine frequency versus the finest. Since the bias here is closer to zero than in the other comparisons (not shown) this means that they are statistically the same. Also, the fine frequency was found to predict the highest maximum runup for 58% of the simulations compared to 36% for the finest and 6% for the coarse. Extreme runup is therefore affected by frequency resolution and convergence can be achieved using the fine resolution.

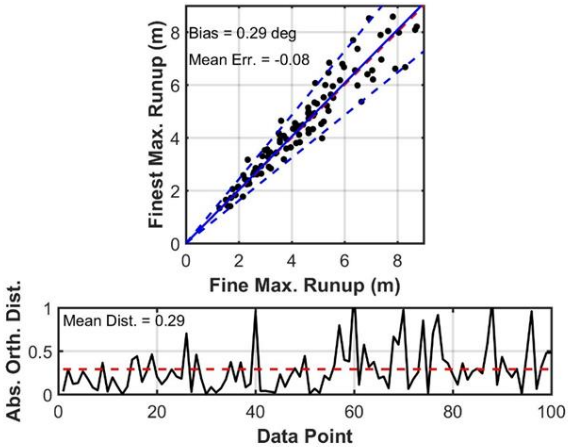

Figure 1 - Scatter plot comparing maximum fine runup versus maximum finest runup. Red dashed line is complete agreement and blue dashed lines are the 20 percent error. Bias of 0.29 degrees, mean error of -0.08 and mean orthogonal distance of 0.29. Bottom plot shows the absolute orthogonal distance of each data point to the complete agreement line. Red dashed line is the mean distance.

For high energy wave conditions, with beaches that have IG-dominated runup, in order to get numerically convergent predictions a Δf of 0.0001-0.00005 Hz is needed. This is more than 100 times smaller than what is typically used in these Boussinesq / coastal phase-resolving models. The reason for such a small Δf is because the integrated low frequency energy transfer is sensitive to a fine resolution of the interacting frequencies.

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