# Modeling Infragravity Waves During NCEX

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http://www.oc.nps.navy.mil/nearshore
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http://science.whoi.edu/users/elgar/NCEX/ncex.html

## LONG-TERM GOALS

The long-term goal is to develop a morphodynamic modeling capability on the time-scale of months (with a resolution of seconds) and a spatial scale of kilometers (with a resolution of meters) that can be used the predict the beach response (both hydrodynamics and beach-changes) due to changes in wave- and flow conditions with specific attention for low-frequency motions.

## OBJECTIVES

The objective of the present project is to predict the infragravity wave conditions along a complex coast for the duration of the NCEX field experiment and examine the effects of offshore edge wave reflections and infragravity wave trapping on the nearshore infragravity wave climate using 2D numerical models that allow for the spatial variability of (infragravity) waves.

## APPROACH

A research version of Delft3D is used to predict the spatial and temporal variation of the infragravity waves within the nearshore during NCEX. Although the model resolves the wave-groups and current-induced shear instabilities with a temporal resolution of approximately one second (Reniers et al, 2004), the focus of this work is infragravity waves. The cross-shore model domain starts at approximately the 20 m depth contour going towards the shoreline. The alongshore domain follows the coast for a number of kilometers, spanning the beach between the two canyons and further north of that. The model requires wave group forcing obtained from frequency-directional short wave spectra at the offshore boundary. In view of the complex bathymetry, the short wave conditions will be inhomogeneous due to wave focusing and defocusing associated with the canyon walls. To that end the inhomogeneous short wave field along the 20 m depth contour is computed with SWAN (Booij et al., 1999), utilizing the frequency-directional wave spectra observed at two CDIP buoys located offshore as input for the SWAN model. Computed frequency-directional spectra at the Delft3D boundary are then translated into spatially coherent time series of wave energy on the wave-group scale.

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To test the nearshore model performance, the computed infragravity conditions are compared to detailed measurements obtained with a combined cross-shore and alongshore array of co-located puv-sensors deployed by the NPS (Thornton, Stanton and MacMahan).

## WORK COMPLETED

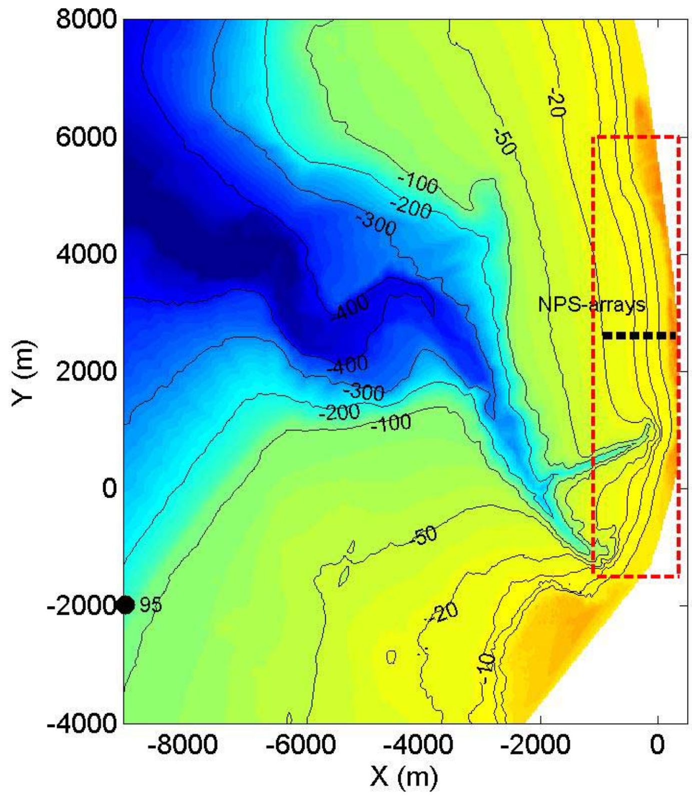


***Figure 1. Overall bathymetry, depth given in meters, used for the SWAN-computations translating the offshore sea/swell wave spectra observed at CDIP buoys 95 (indicated by the black dot) and 100 (located further offshore) toward the offshore boundary of the Delft3D computational domain (indicated by the red dashed lines). Position of the NPS-array indicated by the black dashed line.***

Offshore wave conditions measured with CDIP buoys 95 and 100, located approximately 10 km from shore (Figure 1), have been translated with SWAN to the Delt3D offshore boundary located 1 km offshore near the 20 m depth contour (Figure 1). Sea/swell wave heights and directions predicted by SWAN have been compared to additional CDIP-buoy observations closer to shore. The SWAN-spectra have been translated into coherent time series of wave group energy that are used as input for the Delft3D model. The wave transformation of sea and swell within the Delft3D model has been calibrated against measured wave transformation obtained with the cross-shore NPS-array. Comparisons of computed and measured infragravity wave heights and velocities have been made to assess the Delft3D model performance in predicting infragravity conditions within the nearshore over a complex bathymetry.

## RESULTS

To facilitate the translation of offshore frequency directional spectra to nearshore wave-group conditions over a variable topography a direct coupling is made between SWAN and Delft3D, thus automatically generating the appropriate wave group energy signals that are used as offshore boundary conditions for the Delft3D research model. This **new capability** allows for a quick assessment of the expected incident sea/swell wave conditions **and** infragravity conditions as well as the mean flow conditions within an area of complex bathymetry, given the observed frequency directional spectra far offshore, in this case at CDIP-buoys 95 (Figure 1) and 100.

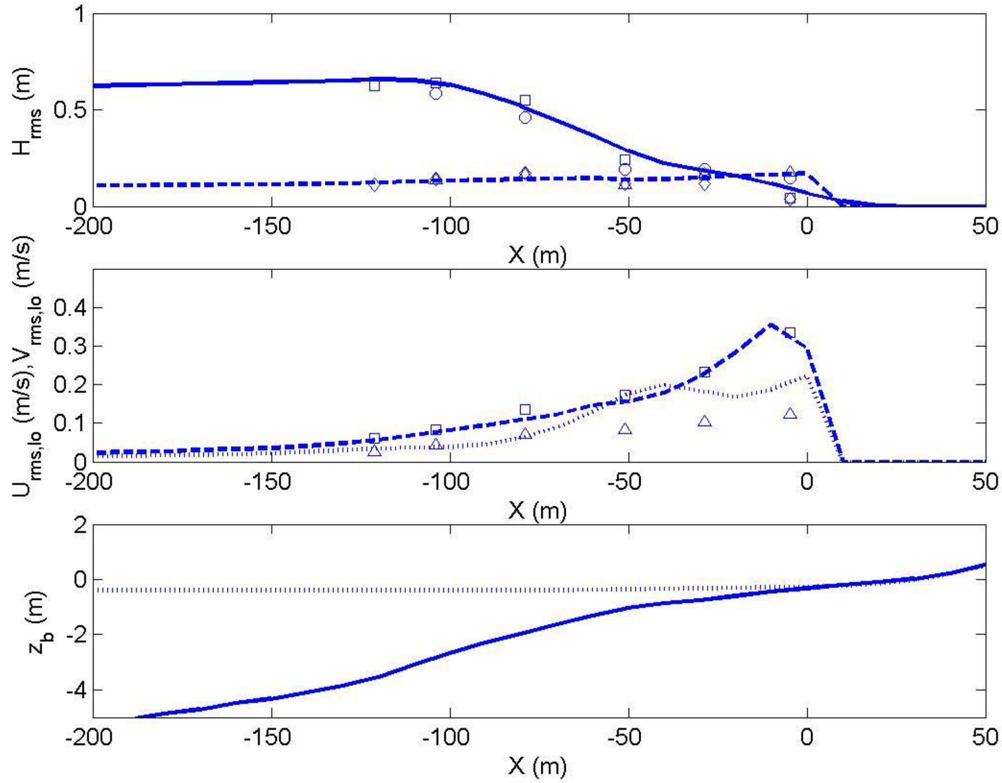


***Figure 2 Upper panel: Computed (solid line) and measured (circles and squares) incident sea/swell wave height along the NPS cross-shore transect on yearday 316, hour 8. Corresponding computed (dashed line) and measured (triangles and diamonds) infragravity wave height. Middle panel: Corresponding computed cross-shore (dashed line) and alongshore (dotted line) infragravity velocities and measured (squares and triangles respectively) infragravity velocities. Bottom panel: Bottom profile (solid line) and tidal elevation (dotted line) at the time of observation.***

Prior to computing the infragravity conditions the transformation of the incident wave height has been calibrated with the measured swell wave transformation observed at the NPS-array. Generally the computed incident sea/swell wave heights show a good match with the observations at the cross-shore array (upper panel of Figure 2). The corresponding infragravity wave height (upper panel of Figure 2) and infragravity velocities (middle panel of Figure 2) also compare well for the period of observation.

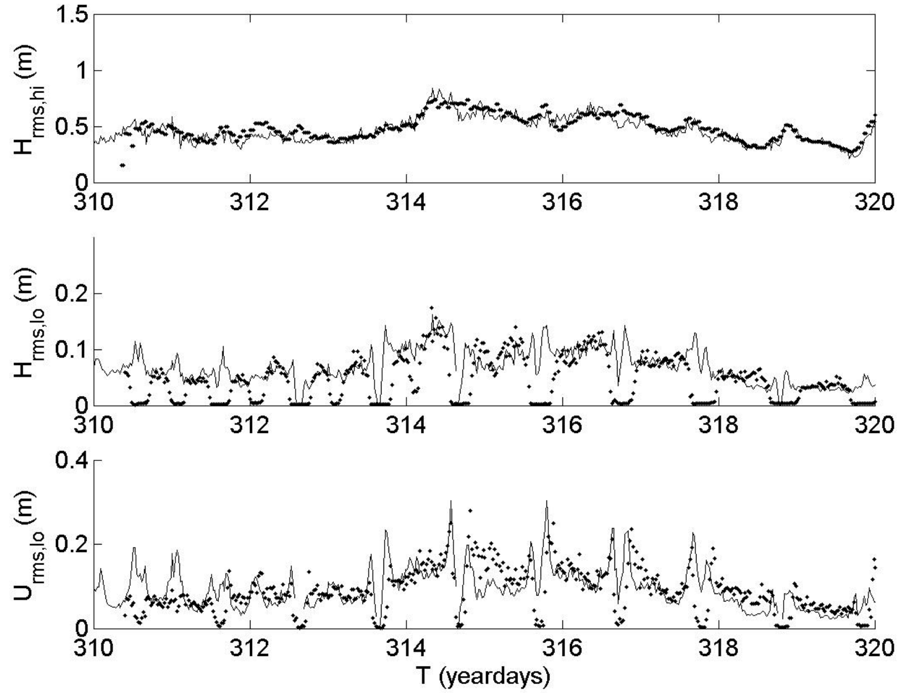


***Figure 3. Upper panel: Measured (dots) and computed (solid line) incident sea/swell wave height at puv8 located outside the surfzone at x = -125 m (see upper panel Figure 2 for location). Measured (dots) and computed (solid line) infragravity wave height at puv3 located within the surfzone at x = -50 m (see upper panel Figure 2 for location). Lower panel: Corresponding measured (dots) and computed (solid line) cross-shore infragravity velocities at puv3***.

Next the incident and infragravity wave conditions have been computed for the duration of the NCEX experiment. The comparison of computed sea and swell/wave heights shows a good match, both inside and outside the surfzone (upper panel of Figure 3). The latter result supports the approach of the combined SWAN-Delft3D modeling approach to determine the nearshore wave conditions.

In addition, comparisons of computed and measured infragravity wave heights and velocities have been made at the NPS cross-shore and alongshore array showing a favorable match throughout a number of tidal cycles (middle and lower panel Figure 3), confirming the infragravity modeling capability of the Delft3D model over a complex bathymetry.

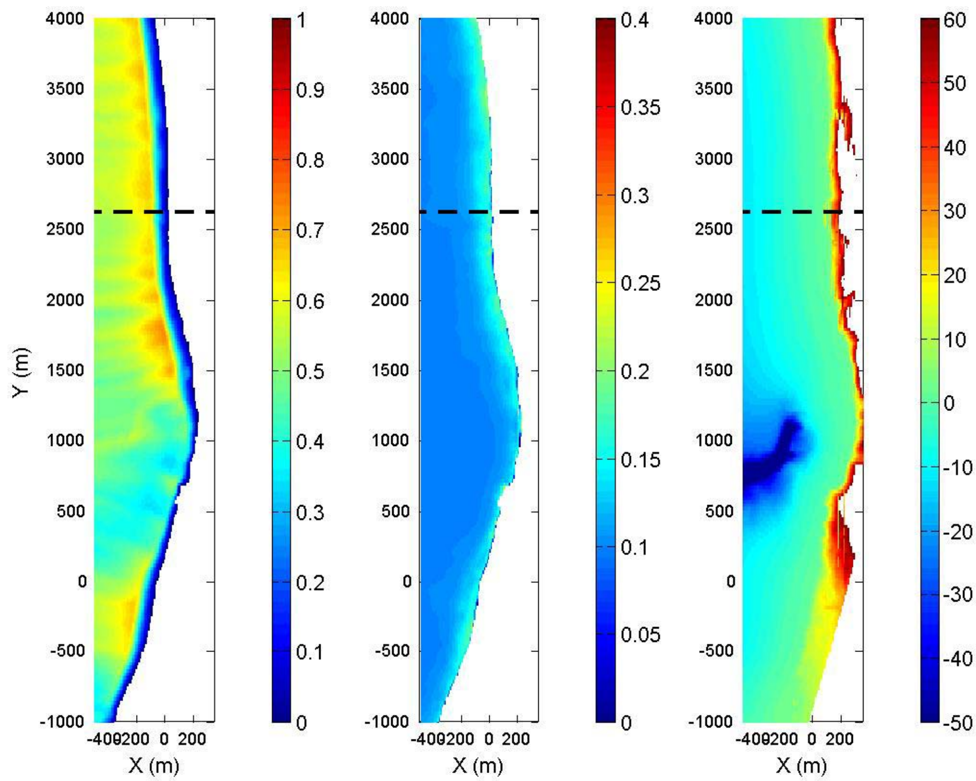


***Figure 4. Left panel: Delft3D computed incident sea/swell wave height in meters for yearday 316, hr 8, showing the (de-)focusing effects associated with the canyons resulting in a strong alongshore variability with the highest waves at Blacks Beach (Y~1800 m). Middle panel: Corresponding computed infragravity wave height in meters that shows a much milder response to the presence of the canyons without apparent focusing. Right panel: Corresponding bathymetry, depth in meters, showing the close proximity of the La Jolla canyon to shore. Position of the NPS cross-shore array indicated by the dashed black line around Y = 2600 m.***

The spatial variability in the bathymetry due to the close proximity of both Scripps and La Jolla canyons (Figure 1) results in an inhomogeneous incident sea swell wave height (left panel of Figure 4), with maximum wave heights observed at Black's beach (around Y = 1800 m). In contrast the corresponding infragravity wave height shows relatively little alongshore variability, suggesting the canyons are not (de-)focusing the infragravity energy as is the case for the incident sea/swell.

## IMPACT/APPLICATIONS

The research is expected to lead to an improved modeling capability of infragravity conditions within the Delft3D modeling package, which is important in view of sediment transport and related morphodynamic response. The model can be used to make a quick assessment of the expected sea/swell wave conditions and concurrent infragravity and mean flow conditions within a nearshore area with complex bathymetry.

## RELATED PROJECTS

The work presented here is part of a collaborative effort with Ed Thornton and Tim Stanton of the Naval Postgraduate School. For additional info see http://science.whoi.edu/users/pvlab/NCEX/vert_structure.html. The calibrated SWAN-Delft3D model will be used within the Beach Wizard project to assimilate remote sensing observations of wave dynamics for bathymetric estimates.

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