RCEX: Rip Current Experiment

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LONG-TERM GOALS

The long-term goals are to understand surf zone processes related to rip current systems through field observations. Rip currents occur commonly on most beaches and dominate many. In the past decade, it is recognized that beaches with straight and parallel contours are not a stable morphologic configuration whereas more complex beaches, which support the existence of rip current morphology, are stable and more common.

OBJECTIVES

The research objectives of the proposed work focus obtaining new observations of the three-dimensional structure of the rip current system that utilize a suite of *in situ* instruments. A fleet of 30 inexpensive surf zone drifters were constructed and deployed to evaluate Lagrangian observations of rip current system for evaluating mean flow patterns, vorticity, dispersion, and diffusion. The second related effort applies a numerical model (Delft3D) to evaluate the dynamics of the rip current system and its interaction with the surface wave field and bottom topography. These new observations will be used to validate Delft3D.

The specific experimental objectives are to observe:

1) vertical structure of the rip current along the axis of a rip channel,

2) mixing and flow patterns in the rip current cell,

3) rip current pulsations and spatial variability,

4) offshore extent of rip current pulsations,

5) wave-current interaction and wave breaking patterns.

The specific numerical objectives are to evaluate:

6) wave-current interaction and the onset of breaking within a rip current,

7) wave-group forcing of nearshore circulation,

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14. ABSTRACT
The long-term goals are to understand surf zone processes related to rip current systems through field observations. Rip currents occur commonly on most beaches and dominate many. In the past decade, it is recognized that beaches with straight and parallel contours are not a stable morphologic configuration whereas more complex beaches, which support the existence of rip current morphology, are stable and more common.

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8) vortex dynamics and lateral diffusion associated with the offshore-directed rip current jet and onshore-directed wave mass flux.

APPROACH

We (MacMahan, Stanton, Reniers, Thornton, Gallagher, Brown, Brown, Henriquez, Stockel, Cowen, Wycoff, and Morrison) conducted a Rip Current EXperiment, RCEX, at Sand City, Monterey Bay, CA in April-May 2007. A combination of *in situ* Eulerian measurements, remote sensing techniques, and Lagrangian measurements were deployed. The Eulerian measurements consisted of two primary arrays: 1) a cross-shore array of co-located pressure and digital electromagnetic current meters (PUV) and ADCPs along the axis of the rip channel, and 2) an alongshore array of PUVs and Paroscientific pressure sensors (PARO; Figure 1). The two-axis current and pressure PUV sensors provide data for analyzing alongshore wavenumber-frequency spectra of the oscillatory flows, and a cross-shore array of bottom-mounted ADCP's captures the cross-shore variability in vertical structure of the currents within a representative rip channel. The cross-shore array measured the cross-shore and vertical structure of a rip current and the offshore extent of the rip current mean velocities and pulsations.

30 surf zone drifters with accurate GPS-tracking were deployed for three hours for seven different days under varying wave and tidal conditions to quantify the spatial variation in mean Lagrangian flow, vorticity, dispersion, and diffusion. High resolution velocity measurements over large area are required to map the complete cell circulation of a rip current. The GPSs after post-processing have an absolute position error of < 0.3 *m* and speed errors of < 3 *cm/s*.

Concurrent numerical model predictions of the local hydrodynamic conditions were performed to help in the deployment of the surfzone drifters and the execution of jet-ski surveys. These computations are based on the transformation of deep water directional spectra to the nearshore, including the wave groups to simulate the three dimensional infragravity time scale surfzone circulations.

Jeff Brown (University of Delaware graduate student), Rob Wyland (NPS tech), Ron Cowen (NPS tech), Jim Lambert (NPS Tech), Jon Morrison (NPS student), Jamie MacMahan constructed the surf zone drifters. MacMahan, Stanton, Reniers, Thornton, Gallagher, Brown, Brown, Henriquez, Stockel, Cowen, Wycoff, and Morrison were responsible for instrument deployment, maintenance, data archiving, removal, drifter depoyments, and bathymetric surveys.

Currently, there are 5 students utilizing the dataset for Masters thesis. Two students (Jeff Brown and Jenna Brown) are from the University of Delaware and three students (Jon Morrison, Sarah Heidt, and Andrea O'Neil) from the Naval Postgraduate School. In addition Martijn Henriquez (University of Delft) will use the data obtained from the near bed observations of velocity and sediment fluxes as part for his PhD thesis to examine intra-wave sediment transport processes.

WORK COMPLETED

We successfully deployed an alongshore array of PUVs and a cross-shore array of ADCPs within a rip channel. We performed 7 drifter deployments under various wave and tidal conditions. We performed 5 bathymetric surveys over the course of the experiment. We are finalizing the data quality control and have begun efforts focusing experimental objectives.

Delft3D has been coupled to the global wave model Wavewatch III, where the freq. directional spectra from Wavewatch III are used as input to the embedded SWAN model within Delft3D to calculate the transformation of deep water wave conditions to the nearshore zone. The SWAN-derived nearshore wave conditions were subsequently used as input for the wave group modeling suite within Delft3D resulting in predictions of the three dimensional surfzone circulation patterns on the infragravity time scales and longer. Next the combined three dimensional Lagrangian/Eulerian flow field was extracted from the Delft3D flow computations and used to predict the dispersion of surfzone drifters.

Though the results are preliminary, the experiment was highly successful in providing many necessary observations for evaluating rip current dynamics.

RESULTS

Wave conditions are transformed with a nested model approach from the deep water location well outside Monterey Bay to the field site at Sand City. This transformation yields spatial and temporal maps of the nearshore wave and flow conditions in the vicinity of the measurement arrays. For instance starting on the 13th of May, the daily wave conditions are predicted for a period of 6 days as depicted in Figure 1. Closer to shore the spatial variability in wave height is caused by the wave focusing and wave breaking on the alternating rip-channel and shoal bathymetry.

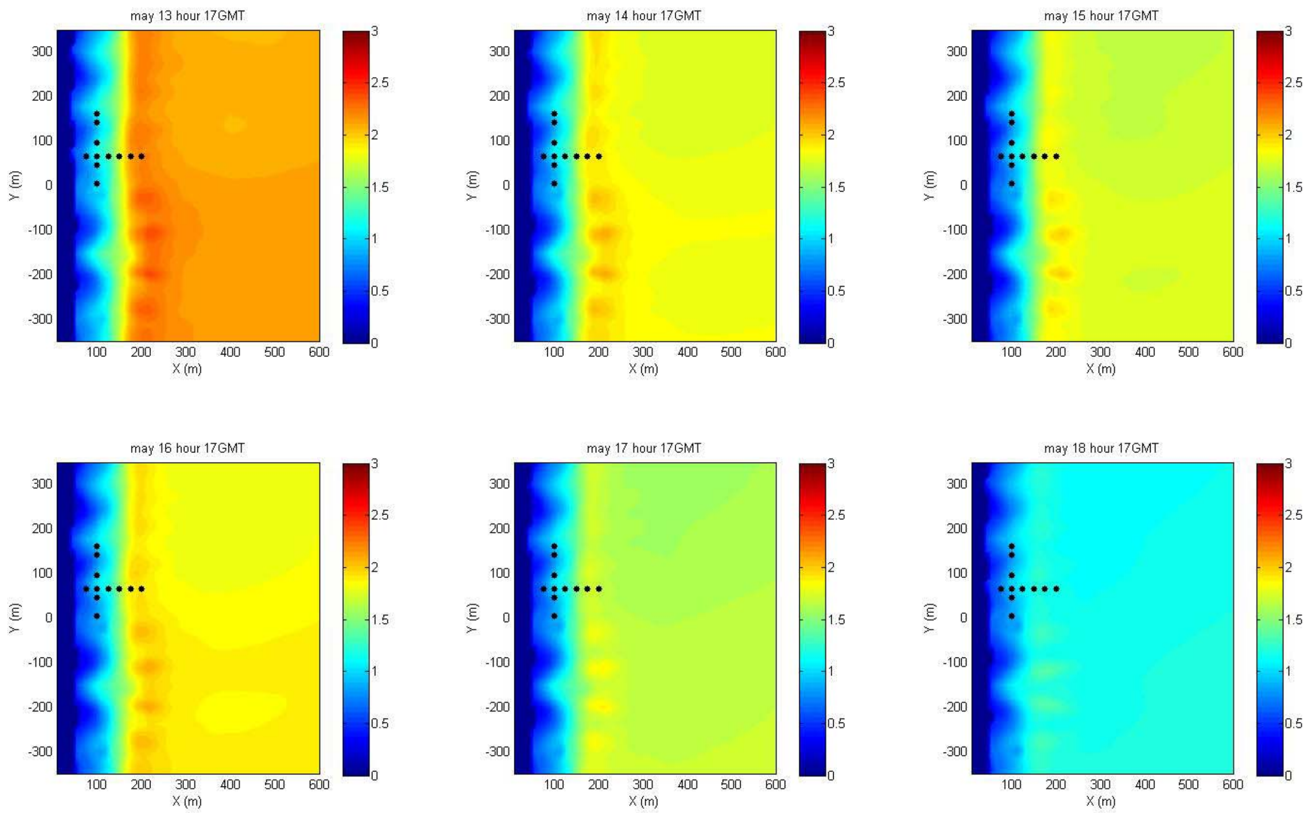

Figure 1. Predicted daily Hrms wave height at 17 hours GMT (in m indicated by the color scales) at the RCEX field site. Position of alongshore and cross-shore array sensors indicated by the black dots.

Next the transformed wave conditions are used to construct the necessary boundary conditions for the Delft3D flow module computations. The predicted mean Eulerian surface velocity field on May 13 at high tide shows a meandering of the flow superimposed on a steady longshore current (left panel of Figure 2) with oblique onshore directed flows over the shoals and offshore flows at the rip channel locations. The flow reversals close to the shore line are associated with the presence of steady surf zone eddies (e.g. at y = 200 m). Taking a cross-shore transect along the center rip channel (at Y = 60 m) shows that the flow has significant three dimensional structure in both the cross-shore flow (upper right panel of Figure 2) and the mean alongshore flow (lower right panel if Figure 1) and as a result the nearbed flow velocities (responsible for the transport of sediment particles), are strikingly different from the surface flows (responsible for the transport of drifters).

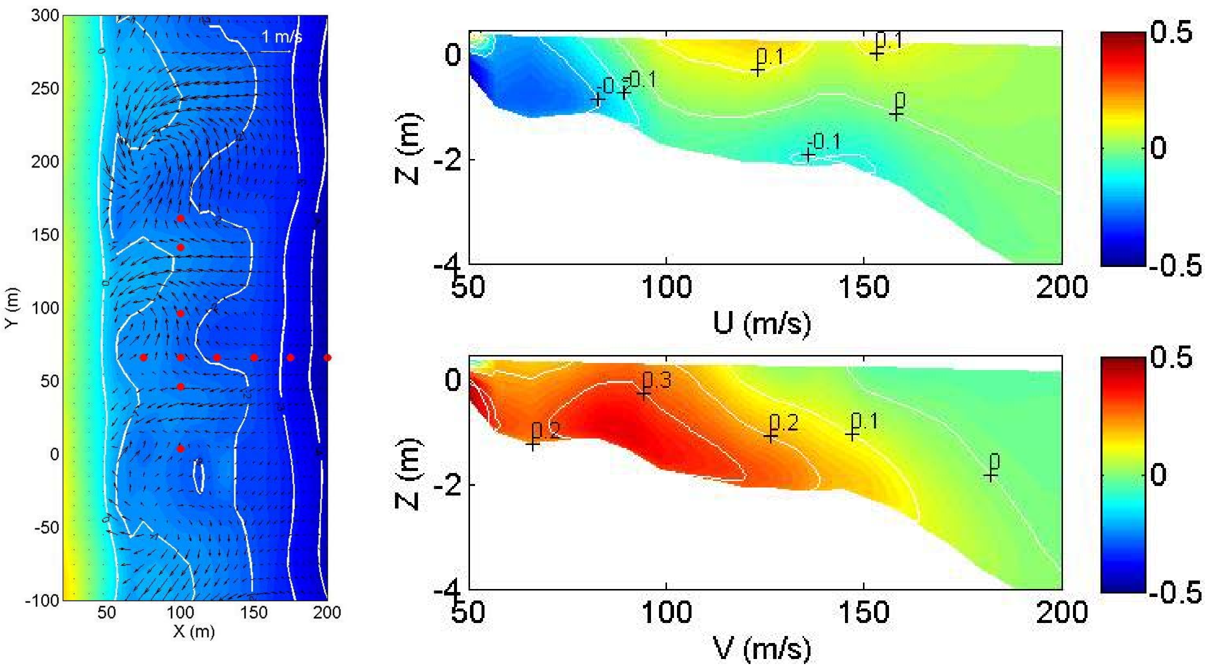

Figure 2. Left panel: Mean Eulerian surface velocities on May 13 at high tide. Position of sensors is indicated by the red dots. Right panel: Vertical distribution of Eulerian flow velocity in m/s within the rip channel at the cross-shore array location at y = 65 m for cross-shore flow (upper panel positive onshore) and alongshore flow (lower panel).

The detailed three dimensional velocity fields allow for drifter simulations. Randomly seeding the surfzone with virtual drifters and tracking their position in time results in multiple drifter trajectories (left panel of Figure 3). This shows that under these conditions the drifter are expected to remain mostly within the surfzone (with some notable exceptions around y = -100 m). Analyzing the virtual drifter results in the same way as the actual drifters in the field (MacMahan's ONR report, 2007) yields information that can be used to verify the model formulations of the mixed Eulerian/Lagrangian velocity field (right panel of Figure 3), but will in turn provide information on the reliability of the velocity fields retrieved from the more sparsely populated drifters in the field.

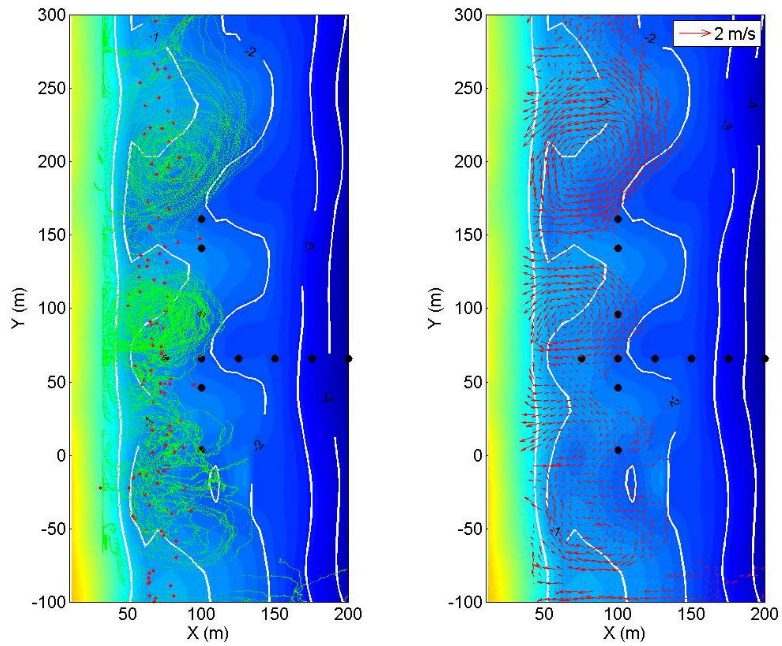

Figure 3. Left panel: Calculated drifter trajectories for may 13 at thigh tide. The initial drifter locations are indicated by the red dots. Right panel: Mixed mean Eulerian/Lagrangian velocity field inferred from the drifter velocities.

The complete model set-up allows for rapid predictions of the three dimensional nearshore flow conditions, including rip-current flows and infragravity waves, which will be compared to the detailed measurements obtained during the RCEX experiment.

IMPACT/APPLICATIONS

Comparison of model predictions with measurements of the wave and three dimensional flow conditions will result in a better understanding of the nearshore flow dynamics and subsequently improved modeling capability. In addition, the present coupling of Delft3D with a global wave model in combination with bathymetry inferred from remotely sensed nearshore observations of wave dissipation and/or wave celerity (for instance with Beach Wizard) provides a powerful tool for the predictions of the nearshore wave and flow conditions at arbitrary locations.

REFERENCES

MacMahan, yearly ONR report 2007.