Effects of 3D current structure on 2D horizontal circulation in surf zone flows

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Recent advances in numerical simulation of surf zone flows have provided a growing wealth of information on the three dimensional (3D) structure of these flows. Simulations with wave-resolving models have verified earlier predictions of the importance of the spatial structure of individual breaking wave events in determining the scales of horizontal flow structures in the turbulent surf zone. Purely wave-averaged models are known to under- predict the breakdown of coherent current patterns such as shear waves in a number of observed cases, thereby suppressing the transition to a quasi-2D turbulence field and it's subsequent evolution through inverse cascade effects. The additional incorporation of quasi-3D effects in 2D models, or the application of a full 3D wave-averaged model, improves knowledge of the vertical structure of mean flows but further suppresses the transfer of energy to small scale eddies. In contrast, wave-resolving, 2D Boussinesq models such as FUNWAVE are able to predict the spatial structure and energetics of smaller scale flow structures, since the spatial pattern of breaking and wave energy decay is resolved. These models have also been shown, however, to over-predict mixing effects in comparison to results derived from dye or drifter studies. In this presentation, we use the 2D Boussinesq model FUNWAVE and the 3D non- hydrostatic model NHWAVE to carry out detailed simulations for several data runs from the Sandyduck experiment. These cases are chosen to fall in the range of wave conditions where 2D wave-averaged models fail to predict the evolution of a turbulent current field. We examine the effects of including 3D structure on apparent horizontal mixing, and we examine the generation and persistence of the 3D vorticity field in order to examine the importance of the two horizontal components (neglected in Boussinesq modeling) and their role in organized coherent structures. We also examine the structure of the dissipation of organized wave energy during wave breaking, in order to address the proper spatial distribution of dissipation-related forcing in wave-averaged models.