TRIDIMENSIONAL TRANSIENT RIP CURRENTS IN A WAVE-RESOLVING MODEL

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Flash rips and surf eddies are transient horizontal structures of the order of 10-100 m, which can be generated in the absence of bathymetric irregularities. They are traditionally evaluated in a depth-averaged setting which involves intrinsic horizontal shear instabilities and the direct generation of vorticity by short-crested waves. In this article, we revisit the processes of surf eddy generation with a 3D wave-resolving model (CROCO) and provide a plausible demonstration of new 3D nonhydrostatic instability and turbulent cascade. We first present a quick overview of a compressible free-surface approach suitable for nearshore dynamics. Its ability to simulate the propagation of surface gravity waves and nearshore wave-driven circulation is validated by laboratory experiments. Next, we present a real world application from Grand Popo Beach, Benin, forced by waves with frequency and directional spreading. The generation of surf eddies by the 3D model differs from depth-averaged models, due to the vertical shear associated with shallow breaking waves. In this case, the eddy generation from both horizontal shear instability and the breaking of short-crested waves is hindered, the former by stretching the alongshore current and the latter by inhibiting the inverse energy cascade. Instead, the vertical shear flow is subjected to forced wave group variability and Kelvin–Helmholtz type instability at an inflection point. Primary and secondary instabilities generate spanwise and streamwise vorticity connecting small-scale eddies to larger horizontal surfzone structures. Streamwise filaments, appearing as 5 m wide ribs or mini-rips, can extend beyond the surfzone but with moderate energy. The timescale associated with the mean shear-induced turbulence is several times the wave period and suggests an intermediate range between breaker-induced turbulence and large-scale surf eddies.

Reference:

Marchesiello P., F. Auclair, L. Debreu, J.C. McWilliams, R. Almar, R. Benshila, F. Dumas, 2021: Tridimensional nonhydrostatic transient rip currents in a wave-resolving model. Ocean Modelling, 163, 101816