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A generation mechanism for rip currents

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Rip currents, which are driven by breaking waves, are widely known as a major beach hazard, accounting for 80% of surf zone rescues in the United States. As they are offshore-directed flows of the horizontal cellular circulations originating inside the surf zone, rip currents have significant influence on the development of alongshore variability in shorelines (e.g. rip embayment), setting the stage for severe erosion during storms. They can also play an important role in transport, mixing and dispersing human-induced coastal pollution into recreational waters. Theoretical understanding of their generation mechanisms, however, has not been satisfactory, in particular on beaches lacking obvious alongshore variations in either incoming waves or bathymetry. We present here a recent study on the generation of rip currents due to a hydrodynamic instability owing to the dynamical interaction of waves and currents, in a system initially alongshore uniform. The preliminary results show that for typical wave conditions and beach slopes, the instability can lead to rip current circulations with alongshore wavelength of a few hundreds of meters and growth time of a few tens of minutes. The alongshore wavelength is intrinsically determined by the instability process and does not depend on the empirical parameters in the model. Comparisons with observations of natural rip currents are made, and qualitative agreements are achieved. Because of its instability origin, the mechanism has the potential to explain the transient and sporadic development of rip currents at random locations on beaches. The importance of this hydrodynamic instability in modeling the nearshore hydro-morphodynamic system will be discussed.