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Three-dimensional tidal flow structure around a shallow-water island: observations and prediction of vertical transport using a finite element model

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A three-dimensional finite element model is used to investigate the formation of shallow-water eddies in the wake of Rattray Island, Great Barrier Reef, Australia. Field data (from cruises in 1982 and 2006) and observations show that stable eddies develop in the lee of the island at rising and falling tides. The water turbidity downstream of the island suggests the existence of strong upwelling that could be responsible for carrying bed sediments up to the sea surface. Using available measurements from currentmeters, the model is first validated and shows good agreement with field data in terms of the shape and strength of the recirculating flow. The water turbidity in the island's wake is tentatively accounted for by resorting to some diagnoses of vertical transport. The upwelling velocity – which is a direct measure of upwelling – is first used but fails at rendering the full dynamics of the flow. We propose to use the water age as a more appropriate diagnosis to evaluate the vertical transport around the island. The age is simply defined as the time elapsed since particles of water left the sea bottom, where the age is prescribed to be zero. We show that bottom water primarily originates at the island's tips and then recirculates in the island's wake. This could be an explanation for the presence of mud at the surface.