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Wind-forced upwelling, geographical origins and numerical models

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The alongshore component of wind stress drives a shelf circulation that can lead to upwelling and/or downwelling. This component of the shelf circulation is in many places of first order importance, both from a physical and biological perspective. For many regional numerical studies however, the boundary conditions (b.c.'s) adopted to model this component of the circulation have been incorrect. Here we examine some theoretical and aspects of the circulation forced by both steady and periodic (weather-band) winds, with particular regard to the determination of correct or optimal backward (upstream) numerical b.c.'s. In both cases the analysis involves the set-up of the flow by coastal-trapped waves (CTWs) that are driven locally by the wind and/or propagate into the domain from a geographical origin. The geographical origin of the CTWs is the backward point at which the alongshore component of the wind vanishes or where friction provides a limiting effect. For steady winds, we show that the correct backward b.c. is important in getting the degree of wind-forced upwelling correct. A Flather type b.c. is adopted in a regional numerical model of the Chilean circulation, and shown (fortuitously) to reproduce the correct degree of upwelling and the geographical origin that lies 500 km north of the applied b.c. (Middleton and Leth, 2004, JGR, Vol 109). For oscillatory wind forced circulation, the importance of the geographical origin is also demonstrated. The results are examined in the context of the implementation of a numerical CTW "paddle" (driven by observations of coastal sea level), and illustrated by a number of numerical studies of Australian's shelves.