

# Open Boundary Condition for Application in Numerical Coastal Circulation Models

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*Introduction* Most advanced depth-resolving numerical ocean and coastal circulation models, e.g. the Princeton Ocean Model (POM) or the Finite Volume Coastal Ocean Model (FVCOM), rely heavily on predictions obtained from the numerical solution of the depth-averaged hydrodynamic equations (2DH). Thus, the accuracy of POM and/or FVCOM is intimately tied to the accuracy of the 2DH which, in turn, depends on the accuracy of the specification of 2DH boundary conditions: the topic of this paper.

*The Bottom Boundary Condition* for 2DH models is generally cast in terms of a specified bottom roughness. In coastal waters of depths allowing wind-wave motions, not resolved by the circulation model, to reach the bottom, the effects of wind-waves must be included in the specification of the bottom roughness for the 2DH model. The wind-wave effects are two-fold in that they may cause the physical bottom roughness to change, e.g. producing a wave-rippled bed, and the increased turbulent intensity associated with the strongly sheared flow within the wind-wave bottom boundary layer affects the flow resistance (or bottom roughness) experienced by the slowly varying currents predicted by the circulation model. The concept, the implications and the efficient determination of this “apparent bottom roughness”, which is the correct bottom roughness to specify for circulation models, will be briefly discussed and illustrated by example computations.

*The Open Boundary Conditions* for 2DH models, specified along segments of the lateral boundaries of the computational domain, ideally allow any motion approaching the boundary from the interior to escape to the exterior without causing any reflection back into the interior of the computational domain. The most general form of the Open Boundary Condition (OBC) is the so-called “partially clamped” (PC) OBC which depends on the specification of two parameters: (i)  $C$ , physically representing the phase velocity of the approaching wave motion; and (ii)  $T$ , a timescale for the decay of the approaching wave. For example, choosing  $T = 0$  reduces the PCOBC to the completely clamped condition, whereas it becomes the pure gravity wave radiation condition by choosing  $T = \infty$ . In this paper, we will develop a simple theoretical model for the prediction of the two parameters,  $C$  and  $T$ , needed to implement the PCOBC. The improved performance of the PCOBC when applied with our predicted parameters, rather than their recommended (default) values, is demonstrated by the results shown in Figures 1 and 2 for a simple frictionally attenuated wave propagating in a channel of finite length compared to the results obtained for an infinitely long channel for different bottom friction coefficients. Since our theoretically derived expressions for  $C$  and  $T$  are based on the linear governing equations, the limitations of our formulation, imposed by the nonlinearity of the 2DH model equations, will be examined and the results of this examination will be used to improve the performance of our formulation for strongly

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nonlinear motions. Extensions of our OBC formulation to oblique incidence and to boundaries along which the temporal variation of the free surface associated with an incident wave is specified, i.e. a “swing-door” type of OBC, will be presented.

*Acknowledgement:* The authors gratefully acknowledge the financial support of the Singapore-MIT Alliance for Research and Technology’s (SMART) Center for Environmental Sensing and Modeling (CENSAM)

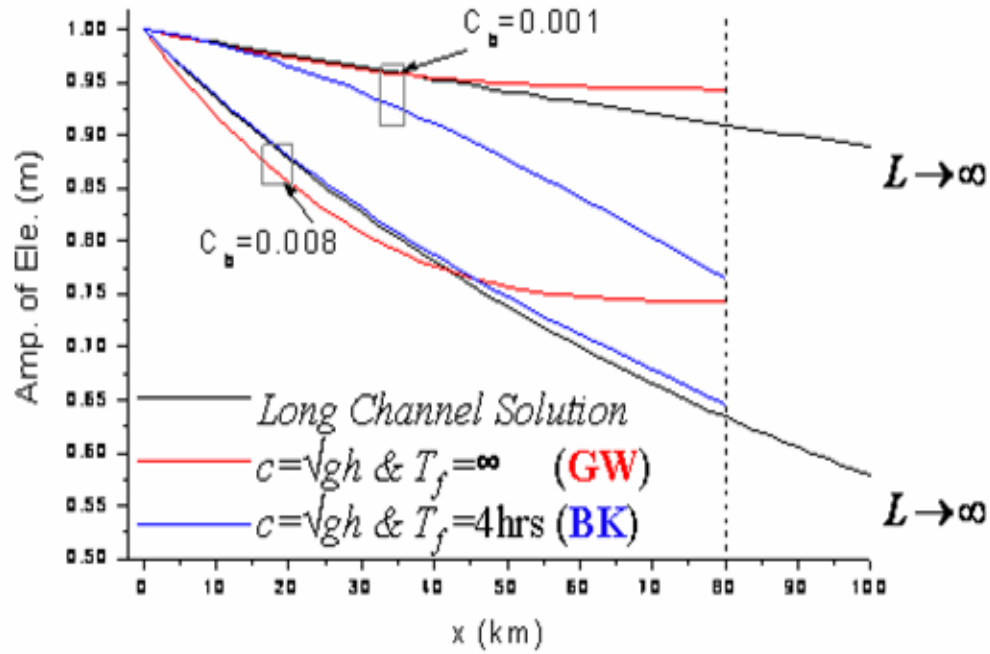


Figure 1 Elevation amplitude along 80 km long channel with *specified* OBC parameters

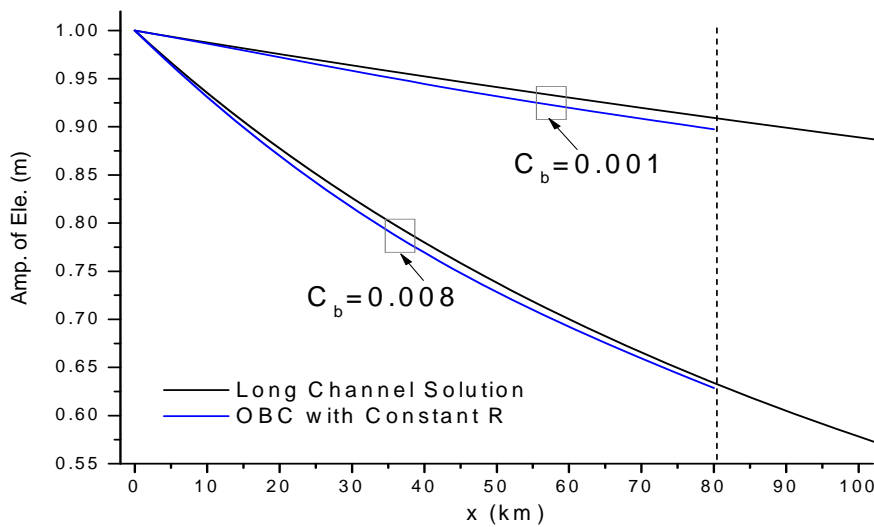


Figure 2 Elevation amplitude along 80 km long channel with *predicted* OBC parameters