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Interactive comment on "Simulations and observation of nonlinear waves on the continental shelf: KdV solutions" *by* Kieran O'Driscoll and Murray Levine

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Review of

"Simulations and observation of nonlinear waves on the continental shelf: KdV solutions"

by K. O'Driscoll and M. Levine

This paper compares solutions of the KdV and eKdV (KdV plus cubic nonlinearity) using stratifications and water depths based on observations from the Middle Atlantic Bight. Two sets of simulations are done: one set uses a flat bottom and compares

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Discussion paper

solutions in different regions of parameter space. The second set investigates shoaling waves over a constant bottom slope. The eKdV model was then used to do some simulations more closely based on the observations (thinner upper layer, realistic bathymetry).

I have a number of problems with the paper and think that is requires significant revision. My basic problem is that there doesn't appear to be much that is new here other than the application to the CMO site in the Middle Atlantic Bight and that is quite a small part of the paper. The paper needs considerable polishing. Figures are in some cases hard to read and many dimensional values are given without units. It would probably benefit from being shortened and more focussed on the comparisons with observations however I am not convinced of the value of these simulations in that context. The authors make some comparisons of their results with those of Holloway et al from 30 years ago. Recent work has been done in this area using model equations that include rotation (e.g., Grimshaw and co-workers). The authors need to make a compelling argument for this set of simulations.

Comments

1. The title highlights KdV solutions with no mention of the eKdV solutions. I think it is well established by now that cubic nonlinearity is necessary to adequately model many observed solitary waves in the ocean, so if anything the eKdV equation should be mentioned in the title. Indeed, one wonders what the benefit of even considering the KdV equation is. Comparisons of the predictions of the KdV and eKdV (or Gardner) equations, as well as the RLW equation, with fully-nonlinear numerical simulations for a two-layer stratification are discussed in Lamb and Xiao (Ocean Modelling, 2014). This seems like a relevant reference.

2. Why are rotational effects not considered? The site of the observations is at mid-latitutude where rotation is going to affect the evolution of the internal tide and the amount of energy that ultimately gets transferred to ISWs. For example in Figure 10 the linear long wave propagation speed is about 0.5 m/s so waves take about

50 hours to travel 100 km. That is lots of time for rotation to affect their evolution.

3. First paragraph of page 4. Nonlinear effects can become important even without shoaling, as illustrated by the authors own flat-bottomed simulations so this should be reworded.

4. Page 5, lines 6–8. “It was originally developed in the context of internal waves by Benney ....”

5. Equations 10(b) and 10(c) are both incorrect.

6. Page 10. The introduction to section 3 repeats material from the introduction so should be deleted.

7. Page 12, line 15: For a given water depth *and wave amplitude* cubic ...”. Then on lines 16–18, whether or not the eKdV model is similar to the KdV model depends a lot on the wave amplitude. For a two layer stratification, whenever the interface gets displaced close to the mid-depth cubic nonlinearity becomes important (though if $h_1/h_2 \ll 1$ higher-order nonlinear may be needed).

8. Section 3.1.1. The cases explored in this section are not well explained. All four cases have different total depths $H = h_1 + h_2$ and different depth ratios h_1/h_2 while from what I can understand the initial wave amplitude is the same in all cases. So both the the depth ratio h_1/h_2 and the initial nonlinearity have been changed. Comparing these cases is then a bit problematic, particularly with statements to the effect that you expect one case to be more nonlinear than the other. Also, throughout ratios such as α/c and β/c are given without units. These ratios are not dimensionless. The KdV and eKdV equation have been used a lot to model internal solitary waves in the ocean. What have we learned from this set of simulations?

9. Section 3.1.2. What is new here? The general picture of the evolution of a shoaling internal tide has already been well described. What is the new contribution from this section?

10. Page 17, Line 5: there are no higher-order terms to prevent the development of solitary waves in the models used here.

11. Page 18, lines 14–15: What do you mean by 'We expect the waves to become unstable"? Do you mean your numerical solution is unstable? If so should a smaller time step be used? If a physical instability what type of instability is referred to?

12. Page 19, line 14: Do you mean the CMO line will be horizontal — lots of straight lines don't have constant h_1.

13. Page 21, lines 9–10. α/α_1 is not a dimensionless parameter.

14. Page 22, lines 3–8. Why is α_1 so much greater at the CMO site than in case A? Is it because h_1 is so much less?

15. Page 25, ine 15. Do you mean figure 16c?

16. Page 26, 2nd paragraph. Something else that could be going on is the nonlinear evolution of inertia-gravity waves that form behind internal solitary waves due to rotation. See Grimshaw et al, JPO, 2014 or Lamb and Warn-Varnas, NPG, 2015. What about multiple packets forming each tidal period because of different generation mechanisms or multiple tidal constituents?

17. Page 29, lines 8–9. The internal tide is nonlinear right from the beginning — it doesn't become nonlinear sooner as β is reduced. As β is reduced waves have to get narrower before dispersive effects become significant.

18. Page 29, line 16. I think you mean if this ratio is much larger than one.

19. Page 30, line 8. What do you mean by ’the internal tide was forced with a sech^2 wave. Don’t you mean the simulation was initialized with a sech^2 wave?

20. Figures. In general I find the font size too small in most of the figures - it is difficult to read them. In the caption for Figure 7 panels (a), (b) and (c) referred to in the text are not labeled. Figure 11 is of particularly poor quality.