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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "The evolution of mode-2 internal solitary waves modulated by background shear currents" *by* Peiwen Zhang et al.

Anonymous Referee #1

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1 General comments

The article presents novel numerical results describing the adjustment of a mode-2 ISW due to a background shear flow. The authors vary the center of the background shear and measure the amount of energy lost from the ISW. The authors attempt to demonstrate that this energy is radiated into three different types of waves: a leading mode-1 wave, an oscillating tail, and an amplitude-modulated wave packet. Comparison to the work of Shroyer et al. (2010) is made throughout.

The paper is well structured and contains new results that are applicable to a wide audience. However, substantial work is required to bring the paper up to an international standard. For example, there is missing literature review on mode-1 ISWs in back-

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ground currents and wave-mean flow interaction, various quantities are not carefully defined, and five cases do not suggest a fully developed study. Detailed suggestions and questions are below. I would like to see the article published, but the authors must address the following concerns.

2 Major comments

1. There are no references to similar studies of mode-1 ISWs in shear flow. Comparisons to lower mode internal waves should be made to better position this article within the literature. Suggestions include: Stastna and Lamb (2002), and Lamb (2010).

2. Other than Shroyer et al. (2010), what other references exist for mode-2 ISWs in background currents? Are there none? That seems surprising.

3. What predictions does theory make? Do the author's results match those of weakly nonlinear theory? It appears that KdV theory will apply and much can be learned by using standard techniques of KdV theory.

4. Do five cases provide sufficient information to make generalized claims about ISWs in shear flow? For comparison, Maderich et al. (2017) ran 35 cases of collisions of internal waves.

5. How were the values of the shear chosen? Were they chosen to match flow on the New Jersey shelf? What would happen if the shear was varied in terms of magnitude, or was oriented against the ISW (such that U_1 and/or U_2 were positive). What about shifting the shear upwards rather than down? What about h_s compared to h? Please add some of these cases into the article. Further motivation for the values is required.

6. How was the background shear introduced? Was it continuously increased over a short duration of time or instantaneously turned on? What was numerically done to add the shear? The first paragraph of section 2.3 does not make it clear that the ISW was generated without the presence of the background shear. Please correct this.

7. Page 7, line 4. How was the amplitude of the wave calculated? Much of section 3 discusses the change in amplitude or compares different amplitudes, but it is unclear where this came from. L is also not defined in the text.

8. What is the difference between the oscillating tail and the amplitude-modulated wave packet? To me they look identical. What are their defining features? How did you distinguish between them?

9. Page 9, lines 9-16. How does the complexity of the vorticity field imply higher energy transfer? How do you know that the energy in the radiating waves does not arise from the background mean flow? Have the authors read the literature on wave-mean flow interaction? This seems highly pertinent and must be included in the article. Lastly, how does a larger amplitude imply a higher energy? Are the authors assuming linearity? Is this applicable here? The use of the term applied (or implying) in these sentences is not justified, and begs further quantification. (see also lines 18-21 on page 11).

10. In connection to the previous comment, section 3.4 makes many of the same assumptions about how energy and wave amplitude are related. But this relation is unclear and non-trivial.

11. Page 9, lines 20-22. The consequent in the following conditional sentence does not following from the antecedent. “Based on the vorticity field shown in Fig. 6 (d), the generation of the oscillating tail and the forward-propagating long wave was continuously sustained by the energy of the ISW”. A single snapshot does

not indicate anything about the continuous evolution of the radiating waves. I suggest adding a Hovmoller (space-time) plot to show the time varying nature of the waves. However, this is only possible if sufficient time resolution is available.

12. Page 13. How are x_l and x_r defined? The authors say they are the boundaries of the integration region, but don't specify where they come from. They are critical to the discussion of the size of the wave, and the choice of definition will have a large impact in the energy values.

13. Page 20, lines 9-11. What waves are transient to the introduction of the shear, and what are persistent? Much of this article seems to consist of the initial adjustment when the background shear is introduced. What is the long time behaviour of the mode-2 wave in the presence of shear? On another note, what can be said about the generation of a mode-2 ISW while shear is present?

3 Specific comments

1. Page 3, lines 12-14. Are there references?

2. Page 4, what evidence do you have that your solution is numerically convergent or accurate? Did you conduct grid refinement strategies? How were the viscosity parameters chosen? What motivation do you have for them?

3. Page 4, line 19. Please write the equation for Δ out explicitly.

4. Figure 1. Please define the cases in the main body of the article and not in the figure caption.

5. h_{mix} and l_{mix} are not defined in the text. Just in the caption for figure 3.

6. Is a lock-release of this form applicable on a field scale?

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7. The colormap used in figures 4, 6, 8 is not good. Please change to something symmetric about a reference value. I suggest colormap 'balance' from Thyng et al. 2016. A matlab package is available for download.

8. What is being plotted in figure 4a? Is it temperature? Please make clear.

9. Text in figures 5, 6, etc. is too small and the resolution needs to be increased.

10. Put colorbars on all vorticity plots.

11. Page 10, lines 2-3. I do not see how the following sentence arises from the statement just prior to it, "Thus, the energy loss of the ISW caused by forward-propagating long waves occurs earlier than oscillating tail." I don't see how the forward-propagating wave happens earlier.

12. Figure 8. What is BLIW? Define this somewhere.

13. Page 11, line 16. Do the authors have any physical reason why "the forward-propagating long wave may not be affected by Δ"?

14. Page 13, the vertical integrals can be written as $\int_{-H}^{0}$ rather than $\int_{-H(x)}^{0}$ since the bottom topography is flat.

15. Page 13, at what time did the initial mode-2 ISW contain 146.2 KJ m^{-1}? Just before the introduction of the shear?

16. Page 13, Define EOF and give a brief overview of its applicability here. Why is it applicable while normal mode decomposition is not?

17. Can you explain the periodicity of figure 10 b? Why is it a function of distance and not time? What about the long time behaviour (when the we wave approaches $x = 0$)?

18. What are the breakdowns of the energy flux in terms of KE_f, APE_f, and W? What happens before $t = 6$T?

19. Page 15, lines 11-13. I'm still not convinced that the following is true: "the high radiating flux before 12 T indicates the generation process of the amplitude-modulated wave packet and that the relative low radiating energy flux above 12 T is caused by the generation of an oscillating tail." The authors have yet to clearly show that the amplitude-modulated wave packet is short lived while the oscillating tail is persistent.

20. Page 16, line 13. It appears that the authors haven't been rigorous enough about how the energy is transferred. Why use the word 'suggests'?

21. Table 2. Should the units be KW m^{-1}?

22. Page 17, line 8. which observations where compared? and where? Were there more than the Shroyer et al. (2010) paper?

23. Figure 15. What field is being plotted? Density? Which isopycnal is being plotted?

24. The text at times is missing articles (such as 'the') and the tense is sometimes mixed up. Please review for grammar.

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