Response to Reviewer 3:

General comment:

The evolution of the mode-2 internal solitary waves in fluid with stratification in density and shear flow is studied numerically with use MITgcm software. It is demonstrated that initial solitary wave disturbance splits on several wave groups: forwarding-propagated long waves, amplitude-modulated wave packet (which is identified as breather) and oscillating tail behind of soliton. Such groups attenuate with distance due to transfer processes, viscosity and shear instability. Interesting moment of this study is also the difference in the location of pycnocline and shear flow. Obtained results are important for understanding processes related with mode-2 internal waves and I may recommend publishing given paper.

Response:

Thank you very much for your constructive and helpful comments, which are highly valuable for us in improving the presentation and quality of the manuscript. We have carefully read the comments and made substantial revisions accordingly. We hope you find these revisions acceptable, and we greatly appreciate your suggestions and comments. We highlight the main revisions in the manuscript, and a point-to-point response is provided below.

Question 1

In fact, the difference between oscillating tail and amplitude-modulated packet (breather) is not clear visible. For instance, the modal structure is discussed on Fig. 10, but it will be more useful to see modal structure on waves for different times. The first mode contributes in energy mainly, but what is a difference in amplitudes of modes in the pycnocline?

Response:

The related figures have been improved to clearly demonstrate the structures of the oscillating tail and amplitude-modulated wave packet. The amplitude-modulated wave packet appeared at the end of oscillating tail as steady-state envelopes *(Terletska* et al., 2016), and it could be clearly observed at the end of the oscillating tail (Figure 1). We have also added a plot to show the modal structures of waves for different times accordingly (Figure 2 and 3). Mode-1 shows the same depression or elevation on both sides of the pycnocline, while mode-2 exhibits a "concave" or "convex" nature, causing elevated and depressed amplitudes on both sides of the pycnocline simultaneously.

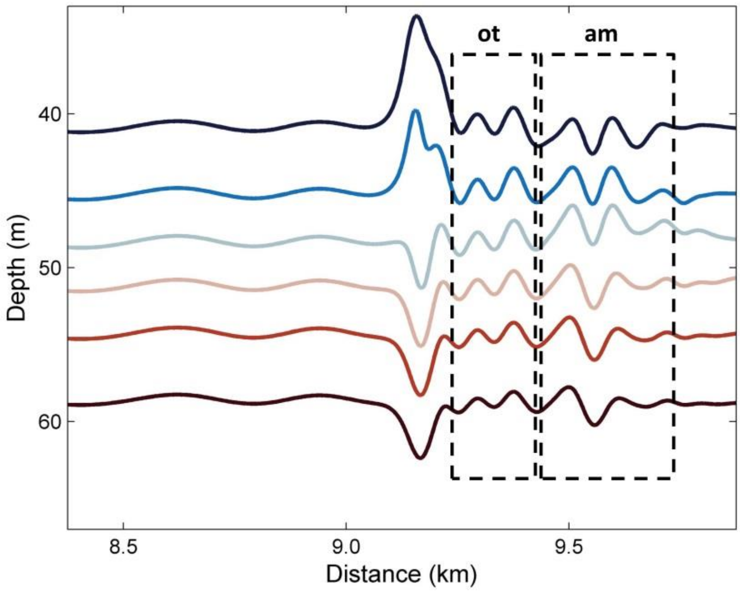

Figure 1. The evolution process of mode-2 ISW in case O5 at 14 T, where the 'ot' and 'am' denoted the oscillating tail and amplitude-modulated wave packet, respectively (see also FIigure 4(d) in the manuscript).

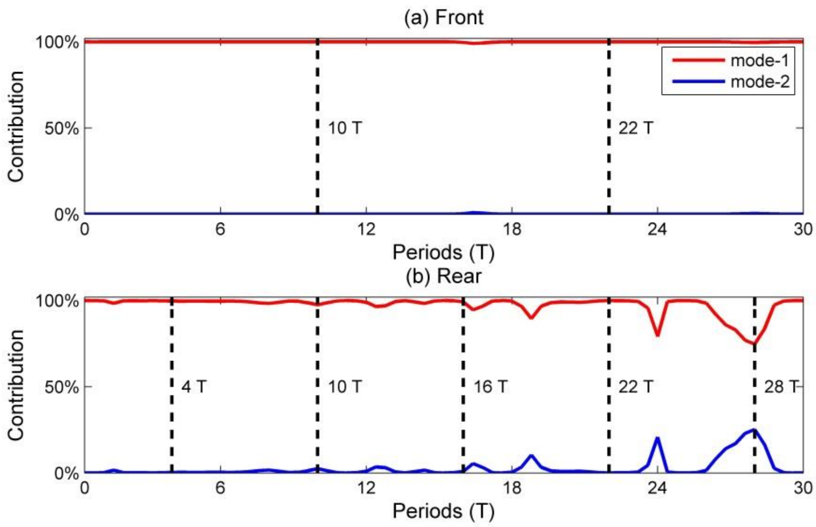

Figure 2. Percent contributions of mode-1 and mode-2 to the total kinetic energy in control experiment (case O5 with Δ = 0) from 0 to 30 T at the (a) front and (b) rear of the mode-2 ISW, the dash lines indicate the cross section where the model structures on waves shown in Figure 2.

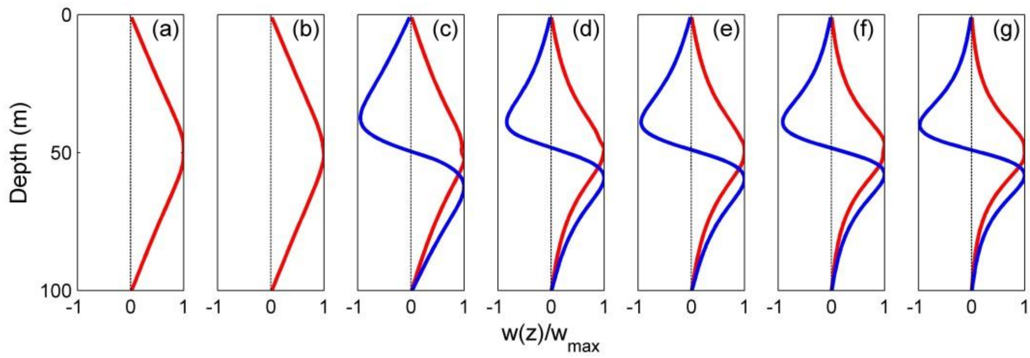

Figure 3. The model structures on mode-1 (red solid line) and mode-2 (blue solid line) waves in front of the mode-2 ISW at (a) 10 T, (b) 22 T and in rear of the mode-2 ISW at (c) 4 T, (d) 10 T, (e) 16 T, (f) 22 T and (g) 28 T for control experiment (case O5).

The related descriptions were added to the revision as follows (see also Page 18, Lines 13 – 18 in the main text):

"*The model structures of forward-propagating long wave for different times show its mode-1 nature was stable during the evolution of mode-2 ISW in the background shear current (Fig. 12 (a) and (b)). In the rear of the mode-2 ISW, the model structures of trailing waves transformed slightly with the time (Fig. 12 (c) – (g)), it shows the different in vertical structures between amplitude-modulated wave packet (Fig. 12 (c) and (d)) and oscillating tail (Fig. 12 (e), (f) and (g))*"

Question 2

What is an origin of the forward-propagating long waves? Are they generated in the initial time only?

Response:

The forward-propagating long wave was generated by the collapse of mixing induced by shear instability. This feature was generated persistently accordingly to the Hovmöller plot (Figure 4).

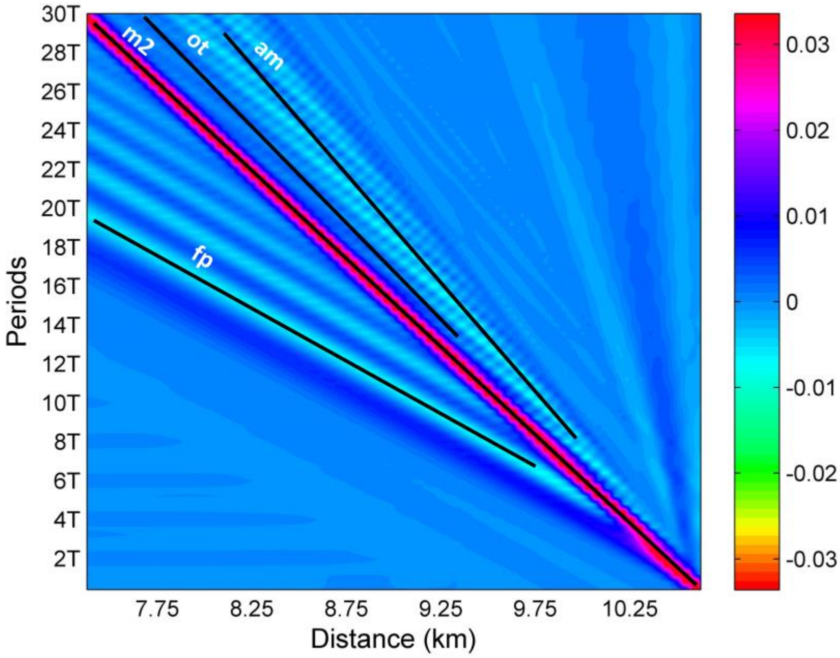

Figure 4. Hovmöller plot of horizontal velocity without background shear current at the surface. The mode-2 ISW, forward-propagating long wave, oscillating tail and amplitude-modulated wave packet are denoted by 'm2', 'fp', 'ot' and 'am', respectively. The color bar ranges from -0.034 to 0.034 m/s.

The related descriptions were added to the revision as follows (see also Page 11, Lines 1 - 3; Page 24, Lines 6 - 8 in the main text):

"*A Hovmöller plot (Fig. 6) of horizontal velocity without the background shear current at the surface was plotted (Lamb* et al.*, 2014). The forward-propagating long wave, oscillating tail and amplitude-modulated wave packet were found to propagate persistently.*"

"*Forward-propagating long waves were also observed by Yuan* et al. *(2018), who found that some small but significant long wavelength mode-1 waves appeared ahead of mode-2 ISWs. The forward-propagating long wave was generated by the collapse of mixing induced by shear instability.*"

Question 3

Usually oscillatory tail is generated behind solitary wave due to dissipation, and its energy is increased when soliton energy is decreased. Is it observed in numerical simulations?

Response:

The total energy of the mode-2 ISW and the oscillating tail in numerical simulation was calculated (Figure 5). After the generation of the oscillating tail, its energy increased, while the total energy of the mode-2 ISW decreased.

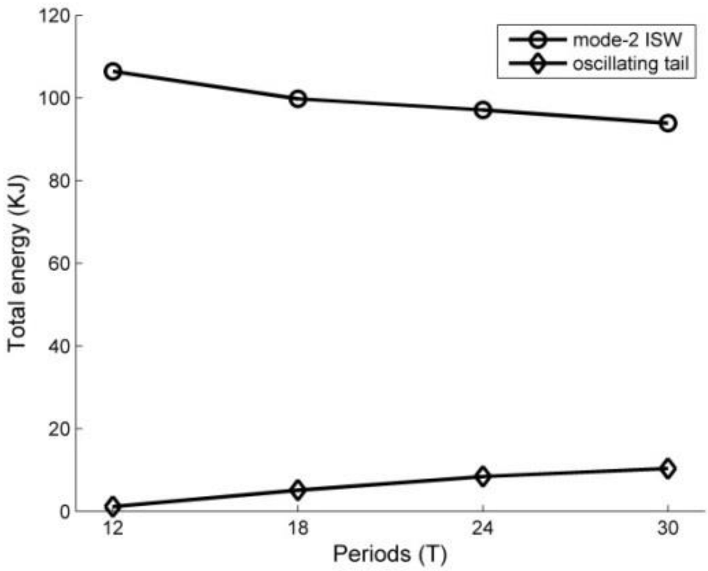

Figure 5. The total energy of the mode-2 ISW and oscillating tail in different periods.

Technical comments:

Question 1

Axis z is directed up. Looking on formulas (1) and (2) z = 0 corresponds to the fluid surface, but on Fig. 3 – to the fluid bottom.

Response:

Corrected.

Question 2

Fig. 6. There is no vorticity scale.

Response:

Added.

Reference

Terletska K, Jung K T, Talipova T, et al. Internal breather-like wave generation by the second mode solitary wave interaction with a step[J]. Physics of Fluids, 28(11): 116602, 2016.