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Nonlinear Processes in Geophysics
Discussions
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Interactive comment on "Internal waves in marginally stable abyssal stratified flows" *by* Nikolay I. Makarenko et al.

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1) It is not clear to me how the authors relate the background shear at infinity with the wave induced shear, known to trigger Kelvin-Helmholtz instabilities. Clearly this can be done if the wave under consideration is a front wave, but in the general case some good discussion would be welcome. Also, I do not see the relevance of considering the linear stability under long-wave perturbations, since in most two-layer models for any given shear, even if very small, there exists a wave number above which the problem is unstable. This issue has been the object of recent efforts how to regularize such models (see e.g. Choi et al. 2009; Lannes & Ming 2015; Duchene et al. 2016).

We determined the background shears for each individual wave in the wave packet of

soliton-shaped waves, which rapidly reach the parallel shear of the current. This has been done on the basis of the parameters of the current immediately before the wave. This hypothesis appeared applicable because the data of measurements agree well with the chart of wave regimes in the theoretical model and the calculated profiles of wave qualitatively correspond to the observed profiles. We can consider that the wave is a front wave because it exists in a narrow channel approximately 5 km wide and 300 m deep.

In order to determine the boundary of the parametric region of the Kelvin-Helmholtz instability we used the long-wave criterion, which is formed similarly both in the linear and non-linear versions. This important property allows us to trace the "dangerous" increase in the velocity shear induced by the solitary wave. It is clear that small-scale shortwave stability has been always observed in the measurements; however, it did not induce intense wave breaking. Strong mixing started exactly at the loss of stability, which was estimated precisely from the long-wave criterion of nonlinear hyperbolicity.

Following the reviewers comments we added detailed comments and formulas to the text, and also added more references.

2) I would have liked finding a more detailed study of the homoclinic orbits for the Hamiltonian system. In particular, higher-mode ISW could have been presented and conditions for the existence of trapped cores investigated. Could the latter be related with the singularities of dïĄĺ/dx?

The authors agree that the problem on solitary waves of the higher modes and trapped vortex cores is extremely important in many applications and requires detailed research. This goal is beyond the scope of the problem reported in our manuscript. We would like to limit this publication by the analysis of the parameters of the first-mode solitary waves only, because it is strictly related to the interpretation of the data of our field studies in the Romanche Fracture Zone. In our numerical simulations we did not obtain solutions with singularities of dïĄĺ/dx, although we do not exclude the existence of such solutions for the constructed multi-parametric model. We thank the reviewer for the valuable comment and of course we plan to continue studying the qualitative properties of the solution of this Hamiltonian system.

3) For self-containedness, I would have preferred to find in para6 the density stratification and values for the background shear flow. It is not clear how the points A and B were determined to match the oceanic conditions. Also, aren't these points outside the blue region characterizing the mode-1 waves? Is the point O located along the line F1 = F2? Is the solution on Fig. 4 a periodic wave?

We significantly widened paragraph 6, and divided it into two parts. Paragraph 7 presents now the information about the density stratification and velocity. The mean velocity shear is approximately 15 cm sˆ(-1)/150 m, but it can exceed this value twice. The observed Richardson numbers are critical ∼0.25 as reported in [van Haren et al., 2014]; hence instability was revealed in the field observations. We consider that the shear is induced by the permanent inflow of bottom waters to the fracture zone through a narrow gap in its southern wall.

We added new Figure 5, which illustrates the characteristic profiles of density, temperature, and salinity in the region of our measurements. We also describe the method of determining the Froude points (F1, F2) on the basis of the field data.

The chart of wave regimes in the right panel of Fig. 2 is now given in improved colors for better visualization. The blue color shows the subcritical domain of the existence of linear waves of the first mode. The adjacent region of solitary waves of the first mode is supercritical; this narrow band is colored orange. In its turn it is bounded by the diagram of smooth bores (internal fronts), which is tangential to the spectra of linear waves at point O. Point O depends on the ratio of the depths of layers r and not necessarily belongs to the straight line F1 = F2.

The solution shown in Fig. 4 is non-periodic. The bottom station recorded irregular sequence of solitary internal waves with anomalously low amplitude dispersion. Two

very similar adjacent waves were occasionally noticed here. The wave before them has significantly smaller amplitude.

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