Response to Anonymous Referee #1

We are sincerely thankful to the reviewer for all the comments to our paper, especially for detailed technical comments. The remarks and authors' responses are given below.

1. **The study highlights the sensitivity of the system to the choice of the viscosity coefficient. However this finding has already been reported in Thiem et al 2011 and I am not sure where the originality lies in this paper. The paper does show that the MITgcm offers slightly improved correlation with the laboratory results than the BOM does but I do not feel this finding alone is sufficient to warrant publication in NPG.**

   Authors' Response: Nowadays many problems of fluid mechanics are being solved numerically in the framework of models for Euler or Navier – Stokes equations with the use of special software. There exists a variety of such models, all of them are quite complex, and it is not trivial to use and configure them to solve specific problems. Therefore it is necessary to have universal test problems (benchmarks) for each class of phenomena or processes modeled to help making comparison of accuracy for different models. Of course, modeling of an internal solitary wave with the help of numerical model of Navier – Stokes equations is not a new result itself. However, the results of simulations in the frameworks of different models (based on different numerical algorithms and realized with the help of different technologies) for the same equations have quite strong variations even for simplest tests. It should also be noted that there is not so many tests for the modeling of internal waves, and they are not universal for different models. That's why a comparative numerical study (comparison of the results from two models and from laboratory experiment) can be considered being of independent interest in the field of computational fluid dynamics. Moreover, the new results contain analysis of the reverse flow under the solitary wave and the investigation of trajectories of fluid particles in different vertical levels – they have a potential for studies of sediment transport in the near-bottom layer and transport properties of internal solitons with regard to passive impurities. We plan to include the obtained results into the set of benchmarks for MITgcm.

2. **The authors present some interesting and original results in section 6 and I would strongly encourage them to rewrite the paper refocusing attention on and expanding upon this aspect of the work.**

   Response: Certainly, this proposal is interesting, but it is out of scope of the present paper. We plan to devote a separate paper to these aspects of the study.

3. **I have checked back with the original papers with which the paper cites and I noticed that there may be a breach of copyright in the reproduction of figures. For example Fig 2 (a) looks like fig 4 of Carr & Davies 2006 and figures 5 & 6 look like overlays of figures from Thiem et al 2011. Can the authors clarify this please ?**

Response: We deleted Fig.2. Figures 5 and 6 use the data from **Thiem et al 2011** and are designed in the same way as in the original paper. There is the reference in the text: "The results of computations in the framework of the Bergen Ocean Model (BOM) [Thiem et al, 2011] are also presented."

4. **Page 1 Line 22: It is true all references cannot be given but some key ones should be.**

   Response: Some references are added to the models themselves and to the papers where these models were used to investigate solitary waves.

5. **Page 2 Line 2/3: I am not sure what the authors mean here. Do they mean only mode 1 waves can be supported ? Olsthoorn et al 2013 (NPG) and Brandt & Shipley 2014 (Physics of Fluids) have recently shown that mode 2 waves are generated in a similar system to the one being modelled by the authors.**

   Response: Two-layer stratification (or two-fluid system of two immiscible fluids) possesses only one mode of internal waves. This was meant in the indicated sentence. Weak disturbances of higher modes, of course, can be generated in a fluid with smoothed two-layer stratification, but the lowest mode (mode 1) is the most energetic in such a system.
   The sentence was changed in the text: "Similar stratification (slightly smoothed) is easily created in a laboratory tank […] and in a numerical tank"

6. **Line 10-14: The authors say that they are essentially repeating the work done in Thiem et al 2011 using the MITgcm but the motivation to do so is not clear. Is it to reduce the differences that occur between the BOM and the lab ? If so for what purpose?.**

   Response: The motivation of the work was rather practical, but still important: to compare the ability of different popular numerical models of Navier – Stokes equations to reproduce internal solitary waves and then to include obtained results into a set of benchmarks of MITgcm model, because there is quite poor set of tests for internal waves and no one for internal solitons, which are important. For this pupose we've choosen a numerical study having a laboratory prototype for verification, and repeated their work using MITgcm. Simultaneously, we aimed to analyze in detail the features of flow induced by internal solitary wave, and the special attention was paid to reverse flow in the bottom layer (for example, its width was not analyzed from numerical results by Thiem et al 2011) and the paths of fluid particles. Also the analysis of the opposite polarity waves is added. We are going to use these materials for future modeling of transport of inert particles during the passage of internal waves.

7. **Page 7 Line 4: The comparison made in figure 2 is of two different things. If I have read Carr & Davies 2006 correctly, fig 2(a) is a time series with a horizontal axis of time while fig 2(b) is in the laboratory frame and hence has a spatial horizontal axis. The authors should clarify this in their discussion.**

   Response: We are sorry for this gross mistake. The figure is removed, and the reference in the text is also deleted.

8. **Line 16: I cannot see this.**

Response: In Figure 2a (former Fig. 3a) you can see one wide (predominantly yellow) stripe reflecting the trajectory of internal solitary wave (surface wake of the soliton), and a lot of crossing it thin stripes, reflecting the trajectory of traveling short quasi-stationary surface wave of elevation generated together with internal soliton.

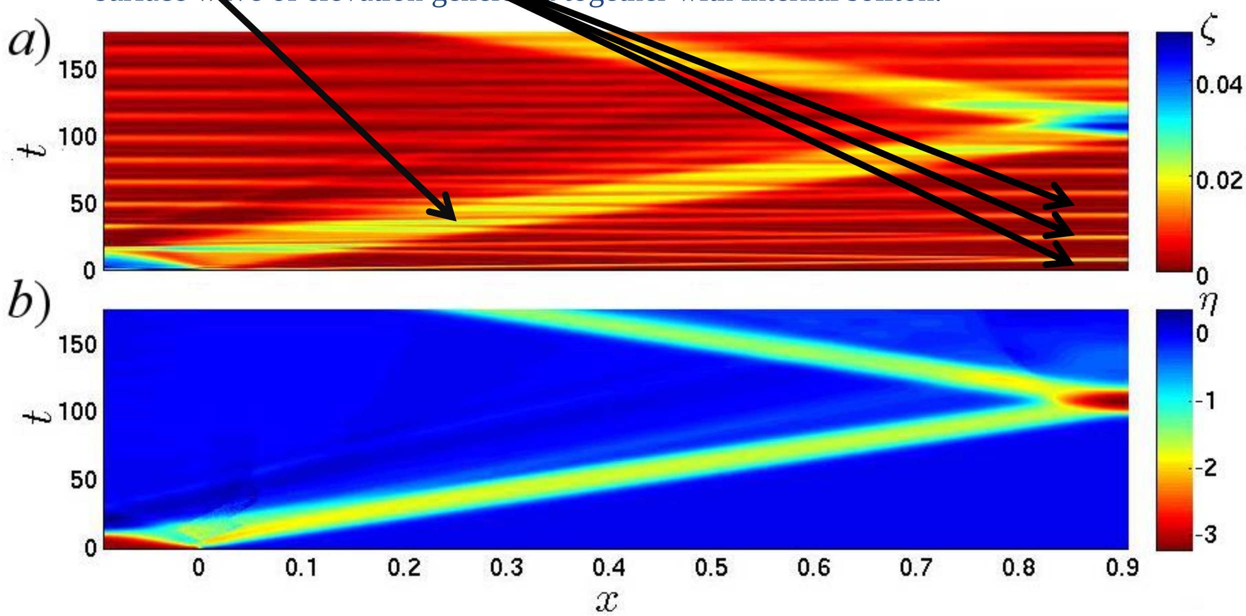

Fig. 2. *x*-*t* diagram of *(a)* free surface displacement and *(b)* pycnocline displacement

9. **Line 15: But isn't the wave considered here highly non-linear?**

Response: The wave considered here is fully nonlinear, but nevertheless the approximate theories give here reasonable predictions about the amplitude of surface wake of internal wave.

10. **Page 9 Line 15: I cannot see the numbers in fig 6a.**

Response: The remark is true, we corrected this and added the numbers.

11. **Line 22: The upper boundary condition in the laboratory is known to have a significant effect upon internal wave dynamics for example see Luzzatto-Fegiz & Helfrich 2014, Journal of Fluid Mechanics and Carr et al 2008 Physics of Fluids.**

Response: The type of the boundary condition on the surface and bottom of stratified water can noticeably influence internal wave dynamics. For example it was concluded by Grue et al. 2000, Journal of Fluid Mechanics, that surface tension can affect the intensity of internal solitary wave breaking. This can be explained by the fact of generation of shorter waves during the breaking process, which are subject to surface tension. In case of shallow water approximation (or long waves) this is justified to ignore the wind stress or surfactants at the fluid surface, unless the approximation is valid, that is until the waves are long enough.

12. Line 18-20: I am not sure what the authors mean here about the reverse flow smoothing the horizontal flow.

Response: We mean that reverse flow affects the tail of internal solitary wave in the lower layer of fluid. This can be seen from the difference of the rear level of u-disturbances in Fig. 5a, and the horizontal profile of the disturbance becomes more symmetrical about its extreme:

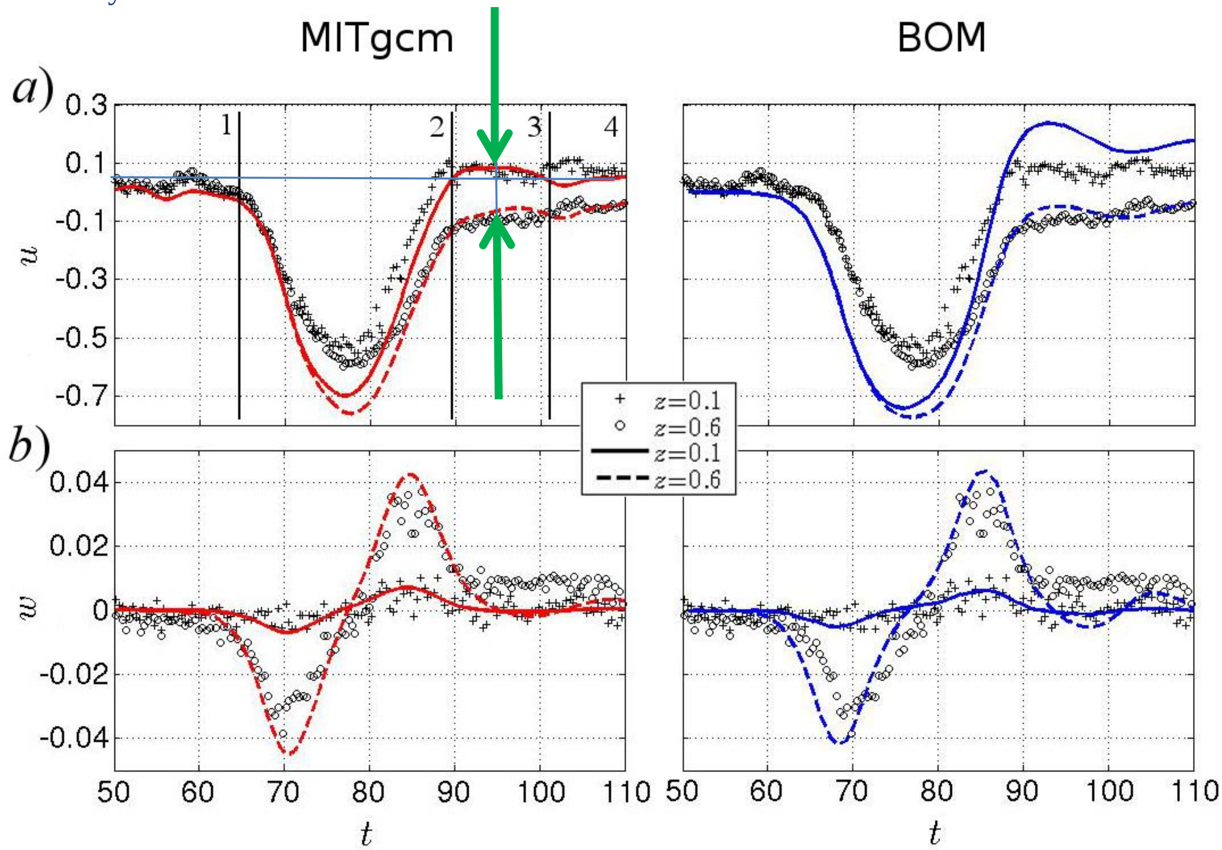

Fig. 5. (*a*) Horizontal and (*b*) vertical near-bottom velocities at $x = 0.66$, measured in the laboratory experiment (symbols) and in numerical MITgcm and BOM models (lines) at a depth of $z = 0.1$ (symbol «+» and the solid curve) and z = 0.6 (symbol «○» and the dotted curve)

13. Page 5 Line 5: I am not sure exactly what the authors mean here

Response: We changed the description of viscous terms in such a way:

"Viscous forces were introduced as the additional term in the momentum equation:

$$\vec{D}_{\vec{v}} = A_h \frac{\partial^2 \vec{v}}{\partial x^2} + A_v \frac{\partial^2 \vec{v}}{\partial z^2}, \qquad ()$$

where $v = v(u, w)$ is the velocity vector, Laplacian viscosity coefficients A_h and A_v are in general implied to be different (Table 2)."

Technical Corrections – Done.