Reply to Referee #1:

I struggled with the manuscript for many hours trying to figure out what the authors are saying, mainly because the presentation is very poor and very reader-unfriendly. My comments are divided into two categories:

We apologize for the poor presentation and greatly appreciate your helpful comments and suggestions. Our responses to the comments are as follows. The referee's comments are cited in italics.

Science:

1. I have followed Profs. Guo's and Zhang's work for years and have no doubt about Guo's modeling ability and the high quality data from Zhang's lab. The NPZD model, however, is a very simple one so ground-truthing is important. I failed to notice the comparison of field data and model results although clearly large discrepancies exist. It should also be said whether sea grasses or other plants on the bottom are important.

Thank you for your valuable feedback.

We have addressed model validation in the supplementary materials (Figure S3), which was mentioned before section 3.1. There are some discrepancies between model outputs and field observations, which likely result from mismatches in the temporal resolution of the observation data (snapshot) and model outputs (monthly mean) as well as their different time periods. However, the spatial distribution and seasonal patterns derived from both observation and modeling are consistent, indicating that the model reasonably captures the major features of ecosystem in the Toyama Bay.

Although seagrasses are present in Toyama Bay, they are not particularly significant in the eastern part of the bay, where submarine groundwater discharge predominantly occurs (Ministry of the Environment, 2008). Therefore, seagrasses and other benthic phytoplankton were not included in our model. We have clarified these aspects in the revised manuscript.

2. It is not clear why 70m was chosen as the lower limit of the SGD input. How the SGD discharge distributes within this 70m range was also not given.

The 70-meter depth limit for SGD input was determined based on prior observational studies in Toyama Bay, which indicate that groundwater discharge is primarily concentrated in the nearshore eastern regions of the bay (Hatta and Zhang, 2013). This area is characterized by the steep seabed and the localized nature of SGD, and therefore the zones deeper than 70 m have little groundwater discharge.

Additionally, because the spatial distribution of SGD discharge in this area is not distinctly defined, we assumed a uniform distribution of SGD discharge over all the grid points in this area. We have added this explanation in the revised manuscript.

3. For coastal modeling work frequently moving boundary is applied. I assume that the land boundary is not moving in this case because the tidal range is very small in the Japan Sea. It should be stated so.

Thank you for your insightful comments. We agreed and included this clarification in the revised manuscript, stating that a moving boundary is not applied because of the small tidal range in the Japan Sea.

4. Should explain the huge residual in Fig. 10.

Thank you for pointing out this issue. We assumed that the initially present nutrients represent the residual term, which are gradually replaced by the modeled nutrient sources over time. If it eventually diminishes to zero, we can judge that the initially present nutrients have been fully replaced the specified external sources of nutrients. If not, we need to define the other external sources of nutrients and make it approach zero. We have added this explanation in the revised manuscript.

5. Figures 8,9,11,12: not clear whether they are simply comparisons of SGD vs. rivers, or the ocean-side input is considered.

They are individual simulation results that do not consider ocean-side inputs. The simulations for SGD-derived nutrients only consider inputs from SGD, while those for riverine nutrients solely account for river inputs. We have added annotations to the figure captions for clarity.

Presentation:

1. It is not even clear how much SGD contributes to the study area. It is said at several places that the SGD contributes slightly more nutrients than all rivers combined to the study area. Yet, line 169 says that ...the SGD mean value of DIN loading of 26.7 g/s ...is approximately 20% of total riverine nutrient loading. Only two lines above it is said that the SGD nutrient loading is the same as rivers.

We are sorry for the misleading description. The value of 20% is for the total riverine nutrient loading into Toyama Bay. “The same as rivers” is for the nearby rivers close to the SGD sites, which represent only a part of rivers along the coast of Toyama Bay. In revision, we will delete the sentence with “is approximately 20% of total riverine nutrient loading”.

2. Figure 10. There are many symbols to use. It is not possible to differentiate red circles from pink ones.

Thank you for pointing this out. We have revised this figure to improve clarity.

3. Line 433, Should use positive tone. Instead of saying that "we paid little attention to..." should say that seasonal and short term variations will be the focus of future work.

Thank you for your suggestions. We have made this change in the revised manuscript.

4. It would help the readers if the currents are plotted when horizontal distributions of parameters are provided.

Thanks. We have included a figure showing the currents in the supplementary materials (Figure S4).

Minor points:

1. Line 37 quotes Santos et al., 2021 as summarizing the SGD-related nutrient inputs. Wilson et al. (L&O Letters, 9,4,411,2024) gave a much more comprehensive summary.

Thank you for your suggestion. We have revised the text to incorporate the more comprehensive summary provided by this literature to ensure the introduction is thorough and up to date.

2. Figure 1, state that the depth contours are in "m", and put "A, B, C, D" at the proper places.

Thanks. We have revised this figure following your suggestions.

3. Figures 4,7 and 8. The X-axis is distance, but from where?

Thank you for pointing this out. This was our oversight. The distance on the x-axis is measured from the shore and we have added the relevant explanation to the figure captions.

4. Figure 6 is about phytoplankton but the color bar gives N.

To maintain consistency, we used the raw model output data (in units of mmol N m^{-3}) to present the phytoplankton concentration.

5. Figures 7, 8, what is the unit for the color bar?

The unit for the color bar in Figure 7 is mmol N m^{-3}, while Figure 8 does not have a unit as it represents proportional values. We have provided additional clarification in the figure captions.

6. Figure 13, areas 1,2,3,4 should be A, B, C, D.

To differentiate from the labels (A), (B), (C), and (D) used in Figure 1b, we used 1, 2, 3, and 4 here to represent the four different depth areas within the blue line region near the SGD outlet locations shown in Figure 1c.

7. Line 586, "T"oyama "B"ay; should state (in Japanese).

Thank you for pointing this out. We have made this change in the revised manuscript.

Reference

Hatta, M. and Zhang, J.: Temporal changes and impacts of submarine fresh groundwater discharge to the coastal environment: A decadal case study in Toyama Bay, Japan, J. Geophys. Res. Ocean., 118, 2610–2622, https://doi.org/10.1002/jgrc.20184, 2013.

Ministry of the Environment: The 7th National Survey on the Natural Environment: Report on Shallow Marine Ecosystems Survey (Seaweed Bed Survey), https://doi.org/https://www.biodic.go.jp/reports2/6th/6_moba19/6_moba19.pdf, 2008.