Review of “A simple approach to represent precipitation-derived freshwater fluxes into nearshore ocean models: an FVCOM4.1 case study” by Rutherford et al.

Reviewer comments in black; Responses in blue.

General comments:

This manuscript studies an important technical issue of how to represent freshwater fluxes accurately and efficiently in high-resolution nearshore ocean models. For coarse-resolution models, freshwater inputs are normally incorporated by aggregating individual contributions from various watersheds into one source and specifying it at one or two model grid points. This approach is definitely undesirable for high-resolution models in which explicit depiction of disparate spatial scales is at high priority. Using Quatsino Sound as a case study site and employing a relatively simple rain-based hydrological model, the authors perform a series of sensitivity tests to answer the two research questions they proposed. The topic is interesting and scientifically important within the geoscientific model development. The results derived here can be extended to other coastal areas and, thus, are worthy of publication. However, I would suggest the authors to clarify certain points and make some statements in the text more accurate.

We thank the Reviewer for their thoughtful comments and feedback.

Specific comments:

1) I would suggest that the title of the paper be changed to “A simple approach to represent precipitation-derived freshwater fluxes into nearshore ocean models: a case study of Quatsino Sound, British Columbia”.

This method is not unique to FVCOM. If you change to another coastal ocean circulation model, the proposed rain-based hydrological model can still be used. In the meantime, the conclusions of the paper, such as those listed in the Abstract, is only valid for Quatsino Sound.

We agree with the Reviewer that this is not unique to FVCOM; however, GMD requires that the model name be included in the title for this type of manuscript. We thus propose changing the title to:

A simple approach to represent precipitation-derived freshwater fluxes into nearshore ocean models: an FVCOM4.1 case study of Quatsino Sound, British Columbia

2) This paper only considers the very simple rain-based hydrological model. Actually, within the framework of FVCOM, a more accurate way to estimate the effect of precipitation-derived freshwater fluxes on fjord salinity dynamics can be done. In this approach, nearshore ocean model domain will be enlarged to encompass all the watersheds in the study area. Then using FVCOM's wetting and drying capability to simulate over land flow due to rain events using FVCOM's precipitation and evaporation forcing. Have the authors tried this approach? Of course, it requires a lot more computational time.

This is an interesting suggestion! While we have done some tests with wetting/drying, we have not specifically tried this approach for the implementation of freshwater fluxes into our model. The main goal of this paper is to present an approach that could be applied to other types of models and not just FVCOM; we thus feel doing further tests might be out of scope for this paper and propose potentially testing this approach in future iterations of the model. Additionally, in terms of our long-term goals, we plan to run the model for a longer period of time, and thus the computational expense of the proposed approach would likely make it disadvantageous.

Do the authors consider evaporation or evapotranspiration, in addition to precipitation?

Yes, the precipitation fields from HRDPS-1km factors in evaporation (i.e., it is precipitation minus evaporation) so it is inherently considered in our methods. We will clarify this in the text at line 157ff as follows (changes in ***bold italics***):

"Due to the lack of gauged rivers and streams, we developed a discharge proxy based on instantaneous precipitation ***minus evaporation*** from the HRDPS-1km atmospheric model for each of the 539 watersheds."

3) Lines 170-173, do you consider the freshwater falling on the surface of the numerical domain (i.e., the fjord system)? If not, the simulated salinity field will be biased.

Yes, precipitation/freshwater falling on the surface of the numerical ocean model domain is included. At line 136, we indicate which atmospheric conditions are included in the model configuration, and we will further clarify this at lines 170-173 as follows (changes in ***bold italics***):

"The proxy-calculated river discharge is illustrated in Figure 4, highlighting how much ***river and stream*** water might be missing from the model inputs if only Marble River discharge was considered."

4) Lines 228-249, the authors should give a definition of "mean" or "average" in the paragraphs here. Otherwise, it will take the readers a lot of time to try to figure that out.

We understand the confusion. First of all, we will first make sure we consistently use the same term throughout this section of the text. We will additionally include the following definition at lines 216ff: "We calculated the arithmetic mean for most model-observation comparisons, which we will henceforth simply refer to as mean values."

5) Lines 297-298, "All other sensitivity tests had metrics in between those of the Marble River Only and All Rivers simulations". This is definitely a wrong statement, which is not consistent with the numbers (e.g., Willmott Score) quoted in the text. Fig. 9 is another source to check with.

Agreed. We will change this sentence to: "All other sensitivity tests had metrics with salinity bias less than 0.4 g/kg, RMSE less than 2g/kg and Willmott Score higher than 0.8."

6) Lines 310-313, to make sure this statement is correct, you can either use the general vertical coordinate in FVCOM simulation, and/or greatly increase the number of the vertical layers. Have you tried these?

We have tried different types of vertical coordinates as well as different numbers of vertical layers in both this domain and other model domains in the region, finding

consistently overly diffusive results in all cases. We are running further tests to hopefully minimize this effect in future iterations of the model. Additionally, we realize we were not specific in our methods section – at lines 110 we specify that we use terrain-following sigma coordinates in the vertical; we will update this line to clarify that we actually do use s-coordinates (or general vertical coordinates/tanh sigma coordinate type) with DU=3.0, DL=0.0 and a sigma power of 1.0.

Technical corrections:

1) Line 128, add “on” before October 14th, 2021

Thank you for catching this.

2) Line 131, add “on” before October 14th, or (it would be better) add “at 00:00 am on October 14th”

We will correct this.

3) Line 162, delete “in each watershed”

We will correct this.

4) Line 169, Equation (3). Should it be $A_{HRDPS,j}$ the denominator and $A_{WS,j}$ the numerator?

Thank you for catching this! A_{HRDPS} should be the denominator and A_{ws} should be the numerator – it is coded correctly but we accidentally reversed them in the equation in the manuscript. This will be corrected.

5) Line 319, add “as” after “as long”

We will correct this.

6) Figure 4 caption, “in equation 2” or in equation 3?

You’re right, this should be equation 3. We will correct this.

7) Figure 6, for right-hand side panels I would suggest to change the color scale to blue color only because, I guess, no positive difference in surface salinity exists in the result.

We will modify this.

8) Figure 7 caption, is this called a histogram? I can understand that Figure 8 is called a histogram, but not this one.

This is a 2D histogram or it may also be referred to as a density heat map. 2D histograms can be used instead of scatter plots when there is a lot of overlapping data, such as in our model-observation comparisons, to indicate where there is a higher density of points. I specifically use the function (in Python) matplotlib.pyplot.hist2d to create the figures in Figure 7.

9) Figure 9, a Table may be a better choice than a Figure

We argue that a figure is quite informative, particularly for visual people. However, we understand that people process information differently and we can certainly add a table with the same information in the appendix.