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Comment on bg-2021-164

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Referee comment on "Nutrient transport and transformation in macrotidal estuaries of the French Atlantic coast: a modelling approach using C-GEM" by Xi Wei et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-164-RC1, 2021

Review of Wei et al. BG 2021-164

It is always very interesting to test the knowledge we have about natural systems by translating them into equations in mathematical models. This allows first to test the validity of the equated processes and second to build scenarios according to environmental changes. This manuscript presents results of nutrient retention in estuaries of the French Atlantic coast obtained with a mathematical model entitled C-GEM.

Macrotidal estuaries are complex transitional environments. Modeling nutrients in these systems is a challenge, because the biogeochemical processes are numerous and complex and the physics of estuaries alone is the subject of complex 3D models. Here the choice was made to build a simplified one-dimensional physical model coupled with biogeochemical reactions involving dissolved N, P and Si compounds, as well as suspended particles. This model is applied to 7 estuaries of different sizes and the model outputs are compared to the available data for the tested period. The model could be criticized for being too simple (1-D), but the biogeochemical part is relatively complete and in the end the results are promising. This 1-D approach is a sufficiently precise step to obtain interesting results. I have a few remarks that concern the validation of the model, the tidal cycles, and points of detail described below.

Line 40: It is conventional to write that estuaries, and more generally water bodies, are facing increasing anthropogenic impacts. For European estuaries, it would have been fair to write this in the late 1990s. Since then, there have been major efforts to improve water quality. Nitrate and phosphate levels are much lower today than 30 years ago. It would be more accurate to write something like "despite efforts to improve natural water quality since the 2000s, estuaries remain receptacles for nutrients and contaminants..."

Table 1. I am a little confused to see that the Dordogne watershed is included in the third row of the table and not in the second. The same goes for the Nive, I suppose, in the Adour column. In general, this 3rd row (Estuary basin area) should be better explained or its name should be changed

Section 2.3.1: In this manuscript, the model is a black box and it is necessary to consult the articles of Volta et al. to know the details of the modeled processes. For example, I tried to see how the interactions between SPM and phosphates were accounted for, but I could not find this information. Wouldn't it be appropriate to put the model elements in an appendix?

Line 177. The time resolution of the model is hourly and daily depending the parameter. However, the input data to the model does not have this resolution. Here, it is stated that the data was linearly interpolated to obtain the temporal resolution of the model. Could you give some indication of the frequency of acquisition of the measurements of the Naiades data set?

Table 3 : concentrations unit in µmol/L, and in Table 4, units in mg/L

Table 4 : the value of SPM concentration of the Dordogne is very high : it is not representative of the Dordogne river. It is most likely a value from a station located in the tidal estuarine part of the Dordogne river. The Dordogne is a river with many upstream dams: SPM concentrations are low until the tidally influenced zone is reached. It would be interesting for readers familiar with these estuarine systems to give the names of the stations used to define the river mixing end-members.

page 12 and Fig 3. The model results are compared to values measured along the estuaries at two contrasting dates, one during a period of high tributary discharge and the other during a period of low discharge. However, one date, for example January 15, 2015, is a 24-hour period when there were 2 tidal cycles. For these macrotidal estuaries, it is likely that the timing of the tide plays an major role in the spatial distribution of the different compounds described here. However, I did not see when this tidal cycle effect was discussed. Do the model outputs correspond to a time of high tide? low tide? For an estuary the size of the Gironde, a given time corresponds to different moments in the tidal cycle upstream and downstream. This would need to be discussed.

Line 295 "…donwstream of the confluence with the Dordogne tributary". This sentence implies that the Dordogne is a source of material for the Gironde estuary at the confluence. This ignores the reality of the environment. The Dordogne and the Garonne meet in the estuarine zone. At the confluence, the waters of the two rivers are very efficiently mixed by the tide: mixed waters of the Garonne and the Dordogne rise largely upstream of the confluence, up to the dynamic tidal limit, located on both rivers more than 70 km from the confluence (e.g. Parra et al., Continent Shelf Res 19, 135-150, 1999)

For some parameters shown in Figure 3 (and Fig S1), only the data from the river mixing end-member and the data from the marine mixing end-member are shown. There is no data in the estuarine part: we can therefore not talk about model validation here (e.g. the bottom graphs for the Loire). For the Adour, there is only one control point. Is it a point taken at high tide or low tide?

Generally speaking, most of the control points are located either at the level of the marine end-member or in the zone where the salinity is close to zero. There are not many control points in the salinity gradient area. This makes it difficult to claim that the model calibration is robust.

line 344: data expressed in % saturation would allow a more direct visualisation of O2 consumption

Figure 4. Simulated and measurement of salinity are important information that is missing here. Indeed, it is stated in line 316 that the stations were chosen in such a way that they are not too influenced by the marine boundary. But these stations should not be strongly influenced by the river boundary as well. Indeed, according to figure 3, all stations in figure 4 are in the area where the salinity is close to 0.

Here again the question of the tide comes up: for the selected stations what is the variation of the concentrations during a tidal cycle in summer, in winter, during spring tides or neap tides? This aspect is not discussed here. Measurements on tidal cycles probably do not exist, but can the model simulate them? If not, this role of the tide should still be discussed.

section 3.2.1: in this paragraph I found it difficult to know whether reference was made to flows from estuaries or river flows into estuaries.

In line 361 and in table 8, the flow results are given with 2 decimal places. Is this level of precision justified?

Line 373: “They accounted for about 80% of the total water discharge from all the estuaries on the French Atlantic coast and 83% of the total watershed areas on the French Atlantic coast, and hence a similar proportion of the nutrient fluxes.”: The missing 20% are represented by small rivers with small estuaries. As a result, this 20% certainly has a lower nutrient retention rate than the average of the estuaries studied here. Thus, the contribution to the nutrient flow to the Atlantic coast of this 20% is probably higher than 20%.

Are the nutrient import data in Table 8 and Figure 7 direct outputs from C-GEM? It is not clear to me

Table 7; TP values do not take into account the P associated with inorganic particles.

However, some of this P is desorbed in the salinity gradient, so that an estuary can become a source of DIP (e.g. Deborde et al. 2007 L&O 52, 862-872). Is this reaction taken into account in the model?

Fig. 7: This figure shows average calculations of retention rates and residence times at the annual scale. For me, an annual average is meaningless and does not explain the relationship between the two parameters. It would be more interesting to compare these two properties in flood and low water periods. The relationship should certainly be better and the processes that go with it should be easier to explain.

Line 472 : simulations do not resolve the tidal cycles.

line 481 to 486: I have the impression that we are going in circles in this paragraph.

line 503: perhaps it should be recalled here that the link between water residence time and nutrient retention is a known phenomenon for lakes, wetlands or dams and that it is this principle that leads to the restoration or construction of wetlands

The first paragraph of section 4.3 should be included in the introduction

I hope that my comments and considerations will make it possible to better highlight the quality of the results of this modelling, which has interested me greatly