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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Comparing the efficiency of hypoxia mitigation strategies in an urban, turbid tidal river, using a coupled hydro sedimentary–biogeochemical model" *by* Katixa Lajaunie-Salla et al.

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nhess-2018-381: Submitted on 13 Dec 2018 Comparing the efficiency of hypoxia mitigation strategies in an urban, turbid tidal river, using a coupled hydro sedimentary–biogeochemical model Katixa Lajaunie-Salla, Aldo Sottolichio, Sabine Schmidt, Xavier Litrico, Guillaume Binet, and Gwenaël Abril Comment and replies to the reviewer 2 1. General comments This study by Lajaunie-Salla et al., presents the potential efficiency of several mitigation measures to limit hypoxia in estuarine zones based on a 3D biogeochemical modelling approach. I found this study interesting, appropriate

for NHESS, even if very site-centred and essentially descriptive. My general position is that the authors did not take advantage of the powerful tool they have developed. I listed several issues that must be addressed before further consideration. In particular, -> many hypotheses for the different scenarios are unjustified, such as using WWTP point sources time series of two different years without changing time series for other parameters (e.g. river flow), or such as considering point sources chemical composition during storm events (overflow reduction) being similar to the one observed the rest of time (would WWTP efficiency remain stable?). These issues are maybe correctly considered, but are not clearly explained in the text. -> No information on upstream C, N, P loads forcing while they could be absolutely crucial in this study. -> discussion of the results is almost absent from the manuscript, with a poor analysis of the processes involved. On the other hand, the results from the different scenarios should help stakeholders decide what are the best options to determine cost-effective measures and mitigate hypoxia in tidal zones. Therefore, I recommend major revision of this manuscript before it can be considered for final publication in NHESS. Reply: We thank the reviewer for the positive evaluation of our work and for the detailed and useful comments that contributed to greatly improve the manuscript. We took into account the reviewer's comments in order to better justify our hypotheses for the different scenarios (see also responses to comments 17 to 20). The upstream river matter loads are taken into account in our model: nitrates, ammonia, particulate organic carbon from litter and phytoplankton and dissolved organic carbon. Before answering to the specific comments by the reviewer, we would like to make it very clear that our model deals specifically with hypoxia and not eutrophication; indeed, the processes that are simulated are those who contribute directly to oxygen consumption (and supply) in macrotidal, heterotrophic estuaries: this include degradation of dissolved and particulate organic matter from various origins (freshwater phytoplankton, soil and litter material from the watershed, and treated waste water from treatment plants and untreated urban waters from sewage overflow), and nitrification of ammonia coming from urban waters as well as ammonia resulting from degradation of organic matter (using a well constrained C/N ratio for the different type or organic matter). Phytoplanktonic primary production is also simulated in the model, as a source of oxygen and biodegradable organic matter; however, because turbidity (and not nutrients) is always the limiting factor for phytoplankton growth in low salinity regions of estuaries, the model does not simulate the P cycle, and the N cycle is simulated only in terms oxygen consumption by nitrification. Finally, oxygen supply by aeration is also simulated, as well as the hydrosedimentary processes of particulate matter (deposition, resuspension and associated oxygen consumption), one of the originality of our work compared to other estuarine biogeochemical models. In order to make this clearer for readers, we will provide more details of the model description in the revised version of the MS. We will also add more discussion about the results of different scenarios that should help stakeholders to choose the best options to mitigate hypoxia zones. All the modifications proposed will be made and will send the article for correction for English before submitting the revised MS. 2. Major and technical comments Comment 1 - Lines 24-28: please consider a different order for the paper highlights, going from highest level of importance to lower levels. For instance, I'd rearrange bullet points 1-3- 2-4 Reply 1: We will change the order of highlights as suggested by the reviewer. Comment 2 - Lines 30-42: My opinion is that there is an optimum in the number of abbreviations used to maximise clarity in the text, and this optimum is outreached with the use of abbreviations for words such as WS for "watershed", ST for "spring tide", WW for "wastewater",...I recommend to remove abbreviations for the following: neap tide, spring tide, watershed, wastewater which, in the end, are not so much used throughout the text. Reply 2: As was suggested by both reviewers, we will remove the abbreviations NT (neap tide) and ST (spring tide). We will also remove the abbreviations WW (wastewater) and WS (watershed). Comment 3 - Line 45: please, include in this sentence why we should expect rising hypoxia in coastal areas, supported by references to previous studies. Reply 3: For the interest of brevity, we avoided citing a reference in the abstract, but we mention below the reasons why hypoxia will most probably rise in the future in Garonne tidal river: - an increase in

temperature decreases oxygen solubility in surface water and favors thermal stratification of the water column, which limits reaeration (Conley et al., 2009; Lehmann et al., 2014). Water warming also accelerates biogeochemical processes that consume DO (Goosen et al., 1999). - a decrease of river flow, due to a combination of climatic (lower precipitation) and anthropogenic factors (hydroelectric power dams and irrigation within watersheds) (Boé and Habets, 2014), modifies coastal estuarine circulation, sediment transport, and the transit (and then mineralization) of terrestrial organic material in estuaries (Abril et al. 1999; Howarth et al. 2000). - an increase of population and human activities enriches coastal waters with nutrients and labile organic matter from urban effluents, possibly leading to eutrophication problems (Billen et al., 2001). In the revised MS we will modify this sentence as following (see also comment 8 of reviewer 1): "Coastal water hypoxia is increasing globally due to global warming and urbanization, and the need to define management solutions to improve water quality of coastal ecosystems becomes important." Comment 4 - Lines 49-51: same as above, please, mention rising temperatures, lower summer low flows in temperate watersheds and higher nutrient loads near coastal areas due to urbanization to explain why we should expect rising hypoxia. It is good to also explain in plain language why does hypoxia occur, it makes things clear for everyone, and explains why a complex model is needed to investigate the response to different management scenarios. Reply 4: Because the Abstract section is limited in size and number of characters, we kept the abstract as is. However more explanation and references about the future hypoxia rising due to temperature, river flows decreasing or by higher organic matter and nutrient loads from urbanized area will be detailed in the Introduction section, as following: "Estuarine deoxygenation is the result of the complex interaction of environmental factors. First increase in temperature decreases oxygen solubility in water and favors thermal stratification of the water column, limiting reaeration (Conley et al. 2009; Lehmann et al. 2014) and accelerates DO-consuming biogeochemical processes (Goosen et al. 1999). Secondly, a decrease in river flow modifies estuarine residual circulation, sediment transport, and the transit and mineralization of terrestrial organic material in estuaries (Abril et al. 1999; Howarth et al. 2000). In addition, an increase in population and human activities enriches coastal waters with nutrients and labile organic matter from urban effluents, possibly leading to eutrophication problems (Billen et al., 2001). Finally high turbidity, as observed in estuarine turbidity maximum zone, limits photosynthesis (Talke et al., 2009, Diaz, 2001)." Comment 5 - Lines 67-83: First paragraph of Introduction should be reorganized with first the broader messages (e.g. "Hypoxia is a major environmental issue,...etc") narrowed down with more specific messages (e.g. "In macrotidal estuaries, the DO consumption by heterotroph processes is exacerbated by...etc"). I also think it could be more synthetic by merging several sentences together. Reply 5: We reorganized the first paragraph of Introduction as follows: "Hypoxia (dissolved oxygen (DO) concentration < 2 mg.L-1 or < 30major environmental issue: it stresses marine organisms and perturbs the functioning of coastal ecosystem (Rabalais et al., 2010; Vaquer-Sunyer and Duarte, 2008). Coastal hypoxia is a widespread phenomenon that has increased since the middle of the 20th century, due to the combined effect of climate change and local anthropic activities (land and water uses) (Breitburg et al., 2018). Due to their strategic position for migratory fishes a good oxygenation of estuarine waters is crucial in order to maintain ecological and economical services within the whole watershed (Rabalais et al., 2010). Estuarine deoxygenation is the result of the complex interaction of environmental factors. First increase in temperature decreases oxygen solubility in water and favors thermal stratification of the water column, limiting reaeration (Conley et al., 2009; Lehmann et al., 2014) and accelerates DO-consuming biogeochemical processes (Goosen et al., 1999). Secondly, a decrease in river flow modifies estuarine residual circulation, sediment transport, and the transit and mineralization of terrestrial organic material in estuaries (Abril et al., 1999; Howarth et al., 2000). In addition, an increase in population and human activities enriches coastal waters with nutrients and labile organic matter from urban effluents, possibly leading to eutrophication problems (Billen et al., 2001) . Finally high turbidity, as observed in estuarine turbidity maximum zone, limits photosynthesis (Diaz, 2001; Talke et al., 2009). In macrotidal estuaries,

DO consumption by heterotrophic organisms is exacerbated by the presence of a turbidity maximum zone (TMZ), which favors the growth of particle-attached bacteria and, to the contrary, limits phytoplankton primary production (Goosen et al., 1999). In view of the ongoing global change, it is essential to find management strategies for hypoxia mitigation. To recover or maintain a good ecological status for transitional waters is one of the objectives of the European Water Framework Directive (Best et al., 2007)." Comment 6 - Line 80: Why don't you also mention diffuse nutrient loads and primary producers biomass developed in the upstream network? Reply 6: As suggested by the reviewer we will mention this in the Introduction of the revised MS, as following (see also the comment above): "In addition, an increase in population and human activities enriches coastal waters with nutrients and labile organic matter from urban effluents, possibly leading to eutrophication problems (Billen et al., 2001)". Comment 7 - Line 81: What does "For that reason,..." refer to? Please, revise and be more specific. Reply 7: As suggested we will modify the sentence (see comment 5). Comment 8- Lines 87-92: It would be much clearer to give percentages of N and P load reduction due to these WWTP improvements or implementations. I believe this information appears in the cited papers. Reply 8: For the whole Scheldt estuary N, P and Si loads were reduced by 5.41Comment 9 - Line 141-142: The increased by how much? Why did Etcheber et al. took 110 m3.s-1 as a threshold? Reply 9: The will be detailed in the revised manuscript. The threshold of 110 m3 s-1 is the present-day low-water target flow for the lower Garonne, below which there is water replenishment. However, this target flow has rarely been reached in the past decades. Comment 10 - Line 148: which value of discharge is used as a critical threshold? This is too vague. Reply 10: As mentioned in reply 9, this will be better explained in the revised version. Comment 11 - Line 154: are these releases so "continuous"? Is there any kind of seasonality or other temporal cycles in these point sources? Reply 11: The urban water releases from WWTP are continuous whereas sewage overflow are punctual event depending on pluviometry and the management of the sewerage network. In order to avoid ambiguities in the revised MS, we will delete the term "continuous".

Comment 12 - Lines 154-155: is this 1.5N and P point sources from Bordeaux area compare to upstream loads? This seems like a crucial information to give. Reply 12: "1.5all the year. Total N and P loads are not crucial because they do not directly impact oxygen in the estuarine turbidity maximum where these nutrient are not limiting for primary production (controlled by light). Comment 13 - Line 167: Even if description and validation of the model are extensively described in another publication, a brief description on how it performs has to be given. This would provide trust on the results for the reader's point of view. This has to be done for the reference simulation and placed at the beginning of the Results section. Reply 13: In the revised MS, we will add a brief description on how model performs have been given. This paragraph will be included at the end of "Model description" section, as following: "The model was compared with data available for the TGR and tested on the basis of three criteria: (i) the ability to reproduce the observed DO variability at a seasonal scale, (ii) the ability to reproduce the spring-neap tidal cycle, and (iii) a statistical evaluation based on the Willmott skill score (WSS, Willmott (1982)). In brief, the model performs well (WSS > 0.7) in the lower TGR around Bordeaux, and less good in the upper section (WSS < 0.5) (for details, see Lajaunie-Salla et al. (2017))." Comment 14 - Line 175: how are temporally distributed the C, N and P inputs from upstream river network? Some strong hypotheses must have been done on this part, and they have to be clarified. Reply 14: Total N and P loads from river are not crucial because they do not directly impact oxygen in the estuarine turbidity maximum where these nutrients are not limiting for primary production (controlled by light). Watershed sources include POC from litter, DOC from rivers, ammonia and nitrates (data from Etcheber et al. (2007) and Veyssy (1998)). The model also considers POC from freshwater phytoplankton and detritus (produced upstream of the turbidity maximum), for which data are from Etcheber et al. (2007), Lemaire (2002) and Lemaire et al. (2002). The temporal variability of these variables at boundary conditions (upstream) are given in table 1 of Lajaunie-Salla et al. (2017). We will add this information in the revised MS as following: "The boundary conditions of biogeochemical variables are detailed in Lajaunie-Salla et al. (2017)

and the data of organic matter and nutrients are from Etcheber et al. (2007), Lemaire (2002), Lemaire et al. (2002) and Veyssy (1998)." Comment 15 - Line 182: where did the point sources fluxes data originate from? What is the temporal frequency of this data? Which hypotheses were formulated to compute them? Reply 15: The point sources fluxes were calculated from the discharge flows and the concentration of POC, DOC and NH4 measured at different point sources. Concentrations were measured previously by Lanoux (2013): measurements were done in different points sources during dry and wet weathers. The discharge flows of points sources are recorded flow every 5 minutes by SUEZ environment the WWPT manager. We will add these informations in the revised MS. Comment 16 - Line 187: what was the level of Q recorded then? Reply 16: The mean summer Garonne River flow recorder in 2006 was 145 m3.s-1 (minimum of 54 m3.s-1) with 60 continuous days of river flow below 110 m3.s-1. In the revised MS we will add this information. Comment 17 - Line 189: is it safe to use WWTP data of another year than the one simulated in the reference with no change in other parameters like river discharge? We should expect temporal dynamics during storm events to be unrelated to discharge variations in the estuarine zone. Please, develop this aspect to justify your choice since it seems not appropriate to me. Reply 17: In fact in this scenario, we used temperature and river flow data from 2006 (with constant value between July 15 and September 30), whereas we used urban water releases data from 2014. As we mentioned, the year 2006 was a critical year from the point of view of temperature and river discharge (21-days of heat wave occurred and 60 continuous days of river flow below 110 m3.s-1). In this article, we want to demonstrate the advantage and/or effectiveness of urban water network and treatment processes improvement on hypoxia events during critical conditions. The sewage network of Bordeaux Metropolis was improved since 2011, and then we used data post-2011.We had to adjust this scenario in the model in order to account for the improvements made in the sewage network and load reduction rates, in order to reach our objectives that are to find managements solutions to mitigate hypoxia events. Comment 18 - Line 190: was it then considered that these fractions were fully treated by WWTPS? I think I understand that the volume of waste water from these wastewater SO were simply transferred to the volume of WWTP inputs into the river. Loads and volumes are very different quantities...This has to be clarified and justified: could the WWTPs absorb and treat up to 50Reply 18: The aim of these scenarios was to simulate an improvement of wastewater network by a reduction of 10 to 50- in the section of model description: "Urban wastewater discharges are included in the model with biodegradable POC and DOC and NH4 loads representative of water flowing from WWTP and from SO (concentration data are from Lanoux (2013) and flows data from SUEZ environment; Fig.1)." - in the section of scenarios description: "the increase of wastewater storage during storms. For this, a fraction of 10, 20, 30, 40 and 50Comment 19 - Line 199: why were these two locations chosen specifically? It is certainly interesting to study, but it has to be explained why and what can be expected from such a measure. Reply 19: We have chosen these two locations based on other studies, as for the Thames Estuary, where a 24-km long sewer network was constructed under the riverbed, which allows the transit of urban wastewater to the WWTP located downstream. We thus hypothesis an outfall of: (1) 21-km long (same length as in the Thames Estuary) corresponding to the position PK25 (Fig.1) where the currents are higher and could disperse urban effluents faster and (2) 11-km long corresponding to the PK15 as an alternative and less expensive solution. Comment 20 - Lines 205-206: again, these choices have to be justified. What is the basis of such scenarios? Same applies for other scenarios listed. Reply 20: We will justify these scenarios in the revised MS. Our calculations are based on the maximum stored water volume in dams of the upper Garonne River, which is 58 hm3. The three scenarios simulate variable intensities of water replenishment during the driest season, according to: - a support of 10 m3s-1 during 67 days represents a volume of water input of 58 hm3 - a support of 20 m3s-1 during 33 days represents a volume of water input of 58 hm3 - a support of 30 m3s-1 during 22 days represents a volume of water input of 58 hm3 Comment 21 - Line 220: how was this rate computed given all the different processes included? Please, detail this point, especially since this

metric is then used as a key indicator to assess mitigation measures. Reply 21: The summer average rates of biogeochemical processes impacting DO (as mineralization of organic matter and nitrification) were calculated over the area of 6.6 km^2, including the WWTP and the SO sites of Bordeaux (as shown in Lajaunie-Salla et al. (2017): Figure 1, orange area in lower panel) and over the area of 1.2 km^2 around Portets. We will add this information in the revised MS. Comment 22 - Lines 220-221: even if you refer to another publication describing extensively the model, the reader might appreciate more information on the model. This sentence mentions the concept of grid cells ("in front of Bordeaux"), but this was not mentioned before. Please, specify size of grid cells in model description, as well as time resolution. Also, it would be helpful to clearly associate Kilometric Points in the text for the river stretches chosen for further analysis. How many grid cells were used? Reply 22: As you suggested we will add more information about the model in the section 2.2, as following: "The computational domain extends from the 200 m isobath on the continental shelf to the upstream limits of the tidal propagation on both rivers (Sottolichio et al., 2000). The model is implemented for the Gironde Estuary on an irregular rectilinear grid (2421 wet cells in the horizontal), with finer resolution in the estuary (200 m x 1 km) and coarser resolution on the shelf. The vertical grid uses real depth coordinates and split into 12 layers. The tidal rivers are represented by one cell in width but are discretized vertically and longitudinally. The spatial resolution in the longitudinal direction is 1 km on the Garonne River. The model uses a finite difference numerical scheme with a transport time step of 35 s." Comment 23 - Line 225 and following paragraph: In the end, these simulations show that waste water overflow discharged during storm events have a minor impact on the estuarine hypoxia. In the data used, what is the temporal variability of the overflow versus total point sources load ratio? What is the summer average of this ratio? This would help characterize these episodic events and might show right away the priorities to stake-holders. Reply 23: The temporal variability of the overflow and treatment plants discharges and the ratio of water overflow over total point sources are represented on the Figure below. The annual and summer averages of this ratio are 12of few hours, the untreated water overflows can represent up to 98information will be added in the revised MS, as following: “Wastewater overflows represent on average 12up to 98Figure 1: Time series of wastewater discharges in m3s-1 from WWTP (green) and from SO (blue) for year 2006 (top). The ratio of SO flows over total wastewater discharges (bottom). Comment 24 - Line 238: Again, is it safe to consider loads during storm events coming out of WWTPS to have similar characteristics as the rest of the time (such as “enriched in ammonia”)?This is a critical assumption that needs solid clarification. Reply 24: The aim of these scenarios was to simulate an improvement of wastewater network by a reduction of 10 to 50Consequently, we add these overflows water volume as WWTP discharges of treated water, applying the respective POC and DOC and NH4 concentrations, because this water volume is considered as treated. In order to make this point clear, we will make the following changes in the revised MS: For these scenarios, the aim was to simulate an improvement of wastewater network by a reduction of 10 to 50then add the overflows water volume as WWTP discharges, applying the different POC, DOC and NH4 concentration, because this water volume is considered as treated. As mentioned by Lanoux e (2013), the WWTP releases treated water that contains mainly ammonia, whereas sewage overflows discharges untreated water mainly consisting of POC. Then the nitrification process will be higher for these scenarios, as more ammonia is discharged. The transfer of 50WW, with a POC concentration of 584 instead of 6333 μmol L-1, a DOC concentration of 734 instead of 1250 μmol L-1 and an NH4 concentration of 1512 instead of 214 μmol L-1 (Lajaunie-Salla et al., 2017; Lanoux, 2013). In comparison with the reference simulation, this improvement in WW treatment corresponds to a reduction of 26increase 6We plan to modify the sentence as following: “In contrast, the nitrification process is slightly increased by the reduction of SO flow (Tab.3) because the wastewater removed from SOs is transferred to WWTPs, which comprised ammonia at the difference of SOs (Lanoux, 2013). In the revised MS we will also add this information in the section 2.3 as following: “In comparison with the reference simulation, an improvement of 50corresponds to a

reduction of 26Comment 25 - Line 245 and following paragraph: Can we consider that, if relocating point sources further downstream could help solve hypoxia in the estuarine zone it would significantly increase coastal eutrophication? This point is, to my view, absolutely crucial: are we not simply moving the problem to a different place and environment? Please, address this point in the Discussion based on available literature. Reply 25: The reviewer is right when she/he asks if coastal eutrophication could be favored by relocating urban discharge downstream; in other terms, if solving the problem of hypoxia could create another problem by increasing the load of nutrient (specifically nitrogen) to the coastal zone; however, this question is relatively complex, because it depends on the overall capacity of the urban and estuarine system to remove nitrogen by denitrification, and this capacity is not necessarily linked to the place where wastewater is released more or less downstream. Indeed, as clearly exemplified with the case of the Scheldt estuary (Billen et al., 2005; Soetaert et al., 2006), hypoxic conditions in the water column will potentially promote anoxic conditions and denitrification in the surface sediment (and fluid mud; Abril et al. 2000). This means that resolving the question of hypoxia with any of the solutions tested in this work (not necessarily relocating the point source downstream, but all management that limits hypoxia like maintaining freshwater discharge or treating larger volumes of urban WW), with in theory increase the total N load (mainly as NO3) to the coastal zone. This has been clearly shown for the Scheldt estuary since the pioneer work of (Billen et al., 1985). In fact, the solution to mitigate estuarine hypoxia and coastal eutrophication at the same time consists in realizing denitrification in WWTP, which is not the case in Bordeaux at the moment. Comment 26 - Line 274 and following paragraph: Is there a big difference if we release the water from the upstream depending on the tidal variations? Do we want to flush the water (when tidal current goes downstream) or dilute estuarine zone (when tidal current goes upstream)? Would this make any difference? Reply 26: We tested simulation with water release during neap tides and spring tides. Water release during neap tides is not significant, because hypoxia occurs during spring tides as highlighted by Etcheber et al. (2011); Lajaunie-Salla et al. (2017); Lanoux et al. (2013). This information will be added at the end of the section 3.2 of the revised MS, as follows: "Other scenarios of LTS during neap tides were made (no presented here) but were not significant because hypoxia events occur during spring tides (Etcheber et al., 2011, Lanoux et al., 2013, Lajaunie-Salla et al., 2017)." Comment 27 - Line 296 and following paragraph: Generating such an event would increase water velocity and would likely erode river bed sediment, remobilizing nutrients and generating more turbidity. Does the model take this into account? I see nothing on the watersediment processes in the study. Please, clarify this aspect and justify your choices. Reply 27: Erosion of river bank is not an issue here in the Garonne tidal river, because tidal current are naturally very strong (up to 2.5 m s-1 during maximum flood) and changing the river discharge will not impact these maximum values. A certain amount of the deposited particulate organic matter can be resuspended when the bottom shear stress exceeds the erosion threshold. However, not all the organic matter is always resuspended, this depends if the erosion rates is sufficiently high. When all the OM stored in the deposited mud has been eroded, bed stress cannot resuspend more material. On a neap-spring time scale however, all of the deposited material is eroded and no long-term burial occurs in the model. The model considers a constant seabed oxygen consumption that is based on POC degradation rate, 10 times slower than in the water column. Moreover, NO3-or NH4+ benthic fluxes are not computed in the model. This model result is consistent with earlier field and experimental work (Abril et al., 1999, 2000, 2010). In fact, the seabed in the Gironde turbidity maximum is composed of a layer of fine sediment (fluid mud) of variable height that is regularly resuspended depending to the tidal amplitude and water currents, as described by the model. Below this layer, consolidated sediments have larger grain size and lower organic carbon content and likely contribute very little to the total oxygen consumption. Concerning the fluid mud layer, which is suboxic and where denitrification and Mn reduction are the major respiratory pathways, experimental work (Abril et al., 2010) have shown that anaerobic carbon remineralisation rates are slow (in the range of 0.5-5 μmol L-1 h-1), even if the sediment concentration

exceeds 100 g L-1 (Abril et al. 2010). Reduced species (mainly NH4+ and Mn(II)) build up in the fluid mud, but reaching relatively modest concentrations (respectively 30 and 10 μmol L-1). Owing to the height of the fluid mud layer (max 10estuary occupied by the fluid mud pools, it was concluded that the oxidation of inorganic reduced species during resuspension events had a negligible effect on the water column oxygenation even at spring tide (Abril et al. 1999). In the revised version, we will mention these facts as following: "In TGR, tidal current are naturally very strong and the additional river flow will not strengthen erosion of river bank." Comment 28 - Line 344: If we expect lower low flows with longer summer droughts, can we really hope to "reduce water use for agricultural practice"? Reply 28: This is a political choice to be made, we can only suggest it to stakeholders. Comment 29 - Line 349: Do we actually know enough to determine which one of the proposed management decisions would be the best? Could your whole approach be transformed into a simple decision-tree to help local stakeholders take actions? This relates to the pre-diction capacity of the model used. A model can sometimes show good reproducible results (strong validation) but low prediction capacity under clearly different conditions. This has, to my view, to be discussed. Reply 29: Our approach does not include cost, nor political choices such as agriculture versus urban investments. Comment 30 - Line 351: In the end, would this combined approach have the best efficiency to effective cost ratio? Reply 30: As we said previously our approach does not include cost, and then we are not able to assess the best efficiency to effective cost solution. 3. Minor comments Line 24: "limit" instead of "limits" Reply: We will correct as suggested. Line 49: "Future climate conditions..." instead of "The future climatic conditions..." Reply: We will correct as suggested. Line 81: remove space before comma Reply: We will correct as suggested. Line 86: "suffering from" instead of "undergoing"? Reply: We will correct as suggested. Line 88: "...in the 1980s" instead of "in 1980s" Reply: We will correct as suggested. Line 89: same for "in 1990s" Reply: We will correct as suggested. Line 96: EPA also exists in the US and other countries. It is confusing since cases in Europe are presented just above, but examples in Canada and Japan are mentioned afterwards...Please be more specific. Reply: In the revised MS we will add information about cases in US. Line 100: “sewer network” instead of “outfall”? Reply: We will correct as suggested. Line 136: what is “PK”? Non-French speakers might not know it refers to “Point Kilométrique”. Please, use a different term such as KP for Kilometric Point. Reply: As suggested, we will change this annotation for “KP” to mean “Kilometric Points” Line 137: please, include Pauillac position in the river reach to compare with “from PK25 to PK-70” in the previous sentence, even if it is clear on Fig. 1. Reply: During low river flow, the TMZ is located between the PK25 and the PK-70, or from Bec d’Ambes to La Reole city, i.e. upstream of Pauillac. We will add this information as follows: The position of the TMZ varies seasonally: during low river flow, it is present in the Tidal Garonne River from PK25 to PK-70, i.e. upstream of Pauillac (Fig.1).” Line 137: “around Pauillac (Fig.1) downstream the Gironde Estuary” instead of “around Pauillac (Fig.1) at downstream of the Gironde Estuary” Reply: We will correct as suggested. Line 141: “Since the mid-80s,” instead of “Since mid 80s,” Reply: We will correct as suggested. Line 143: “Such a decrease” while you mention an increase just above... Reply: In this sentence, we mention that the river flow decreases, whereas in the sentence before we mention that the numbers of days with a river flow below 110 m3s-1 increases. We will modify the sentence in the revised as following: “A decrease in the Garonne flow limits the re-oxygenation of TGR waters with welloxygenated freshwaters and favours the upstream advection and the concentration of TMZ (Lajaunie-salla et al., 2018).” Line 152: “Part of the sewage system” instead of “The part of the sewage system” Reply: We will correct as suggested. Line 167: “validation” instead of “avalidation” Reply: We will correct as suggested. Line 170: “The biogeochemical model resolves extensively the processes that...” in-stead of “The biogeochemical model includes all the processes that...” Reply: We will correct as suggested. Line 180: “uses” instead of “use” Reply: We will correct as suggested. Line 181: where were the meteorological data measured? Reply: The meteorological data were measured in Pauillac station and temperature data from Bordeaux station. We will add this information as following: “The biogeochemical model uses measured

water temperature from Bordeaux station (MAGEST network; Etcheber et al. (2011), https://twitter.com/Gironde$_{M}$*agest*), *windandincidentlightintensityfromPauillacstation(Mt*
pleasecorrectEnglishinthissentence.Reply : Wewillmodifythesentenceasfollowing :
“The16scenarioswererunover10months, fromtheJanuary1toOctober31.″Line228 :
“thelargeststormevents″or“thelargestsewageoverflowevents″insteadof“thelargestsewage
Wewillmodifythesentenceassuggested.Line235andelsewhereinthetext :
“thecontributionofWWTPmatterdegradation...″.ItbringsconfusiontorefertoWWTPsouth
Wewillmodifyassuggestedandreplace“thecontributionofWWTPmatterdegradation″by“the
thissentenceisunclear.Please, clarify.Reply : Weagreewiththereviewer, andwilltakeintoacc
“Incontrast, thecontributionoftreatedurbanmatterdegradationfromWWTPandnitrificati
16waterdischargeisreducedby50increaseisduetothetransfertoWWTPsofthewastewaterren
please, findamoreexplicitnamefor“urbanmatters″.Reply :
Wewillmodify“urbanmatters″by“urbaneffluents″.Line259 :
clarifythechangesinthedownstreamsectionundersuchcondition.Reply :
Wewillclarifythissentenceasfollowing : “Withthedownstreamrelocationofurbandischarge
“diluted″insteadof“reduced″Reply : Wewillcorrectassuggested.Line301 :
Please, clarifywhatdecreasesbyspecifyingtheunitsafter“6.6to1.6″Reply :
Thewaterhalf−renewaltimesisexpressedindays.WewillmodifythesentenceintherevisedM
“Waterhalf−renewaltimesarelessthan1dayinPortets, anddecreasefrom6.6to1.6daysinBor
isitoneortwoweeksthen?Accuratenumberswouldhelp.Reply :
Here, anintenseSTSof400m3s−1isnotabletomaintaingoodlevelofoxygenallsummerlonginP
“IntenseSTS(400m3s−1)isnotabletomaintaingoodlevelofoxygenallsummerlonginPortets.
“threshold″insteadof“thereshold″, “degradationis″insteadof“degradationis″Reply :
Wewillcorrectassuggested.Line338 : addareferencetothisexpectedpopulationgrowthReply :
WewilladdthereferenceabouttheexpectedpopulationgrowthLine342 :
couldyouprovideanestimateofsuchacost?OrgiveexamplesconsideringwhatisdonefortheTha
FortherevisedMSwewillgiveanestimationofsuchcost.Line343 :
whatcanofenvironmentalimpactareyoumentioning?Please, clarify.Reply :
Here, wewantedtomentiontheimpactofoutfallconstructionontheecosystem.Wewillmodifyt

“Moreovertheenvironmentalimpactonecosystemofsuchconstructioncanhinderthissolution.
“purposes"insteadof“practice"Reply : Wewillcorrectassuggested.Line357 :
Pleaseremove“tomaintainthebestwaterqualityaspossible"Reply :
Wewillcorrectassuggested.Line368 : “theriverwater"insteadof“waters"Reply :
Wewillcorrectassuggested.4.SpecificcommentsonTablesonFiguresTable1 :
abbreviationsintheTablemustbedefined(asafootnoteorinTablecaption)Reply :
Assuggestedwewilldefineabbreviationsasfollowing : “Qref :
riverflowof2006; QG/D : riverflowofGaronneandDordogne; QWW :
wastewaterflow; SO : sewageoverflow"Figure2 :
Presenting2aand2bwithlogaxiswouldhelpthereader.Withthecurrentgraph, itisnearlyimposs
axisinonefigure.Reply : Inordertoidentifybettertheriverdischargesandpointsourcesvalues
TimeseriesofGaronneRiver(black)andDordogneRiver(grey)flowofthereferencesimulatio
1), wastewaterdischarges(WWTP + SO)foryear2006(green)and2014(blue)(be, m3s −
1).ComparisonofsimulatedDOminevolution(overtidalcyclein(c).ThecontributiononDOcon
TotalNandPloadsfromriverarenotcrucialbecausetheydonotdirectlyimpactoxygenintheestu
ratioofurbantowatershedinputsofcarbonandnitrogeninFigure34 :
AlmostnouseismadeofthespatialdistributionsofDOinthetext.Itisapitysincetheyshowverycl
verticaldistributionseemsquitehomogeneous.whatistheinterestof3Dmodellinginthiscase?C
Assuggestedbythereviewer, morediscussionwillbeaddintherevisedMS.ThepointP1, P2andP
Whatistheinterestofshowingdielcycles?Wouldn'titbemoreinstructivetoextractfromthesetim
Asrecommendedbythereviewer, wewillmodifythefiguretoshowthesimulatedDOminoverthe
Timeseriesofriverflow(top, m3s−1), DOmin(overtidalcycle)atBordeaux(middle, Portets(b
1(c, fandi).Bluelinerepresentsthesimulationofreference.Figure6 :
Almostnouseofthisfigureismadeinthetext.Irecommendextractingmetricsthataremoreinfo
Assuggestedbythereviewer, morediscussionwillbeaddintherevisedMS, inordertohighlightst
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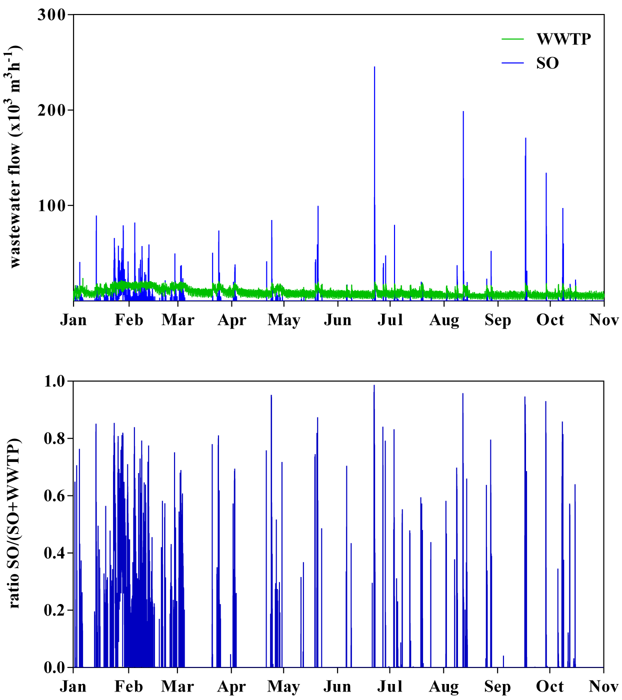
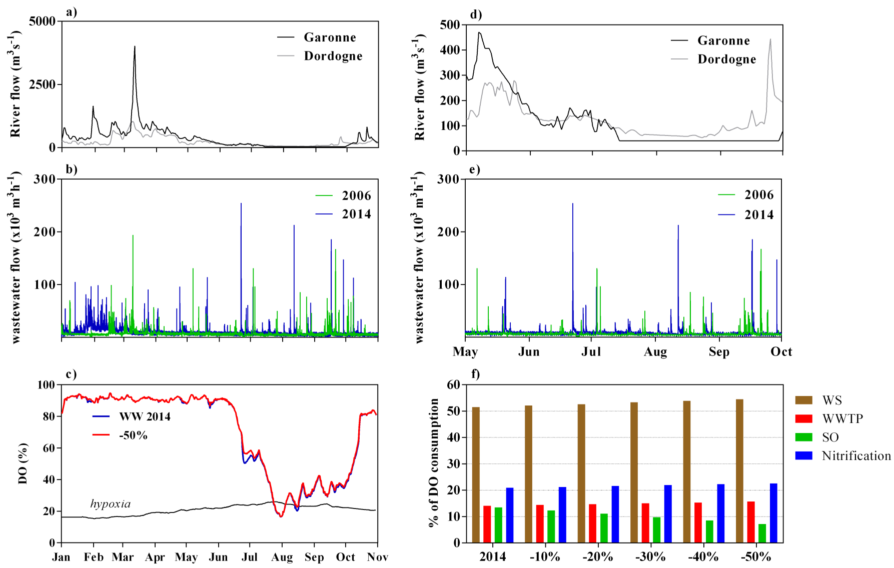


WWTP
SO
wastewater flow (x10^3 m^{3}h^{-1})
300
200
100
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
ratio SO/(SO+WWTP)
1.0
0.8
0.6
0.4
0.2
0.0

Fig. 1.



a)
Garonne
Dordogne
River flow (m^{3}s^{-1})
b)
2006
2014
wastewater flow (x10^3 m^{3}h^{-1})
c)
WW 2014
-50%
hypoxia
DO (%)
d)
e)
f)
% of DO consumption
WS
WWTP
SO
Nitrification
2014
-10%
-20%
-30%
-40%
-50%

Fig. 2.

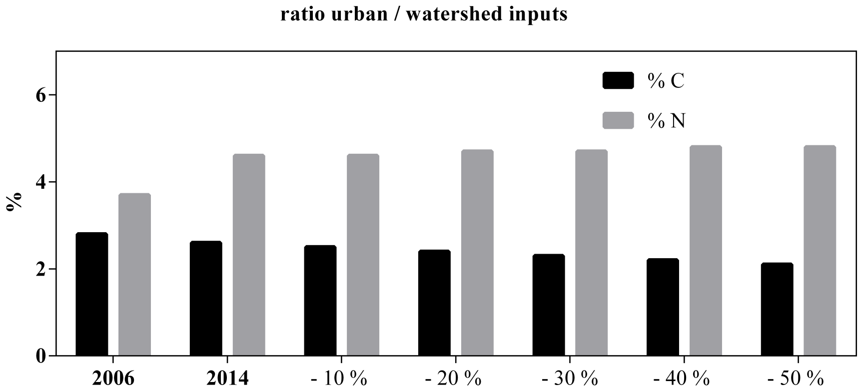

ratio urban / watershed inputs
% C
% N
%
6
4
2
0
2006
2014
- 10 %
- 20 %
- 30 %
- 40 %
- 50 %

Fig. 3.

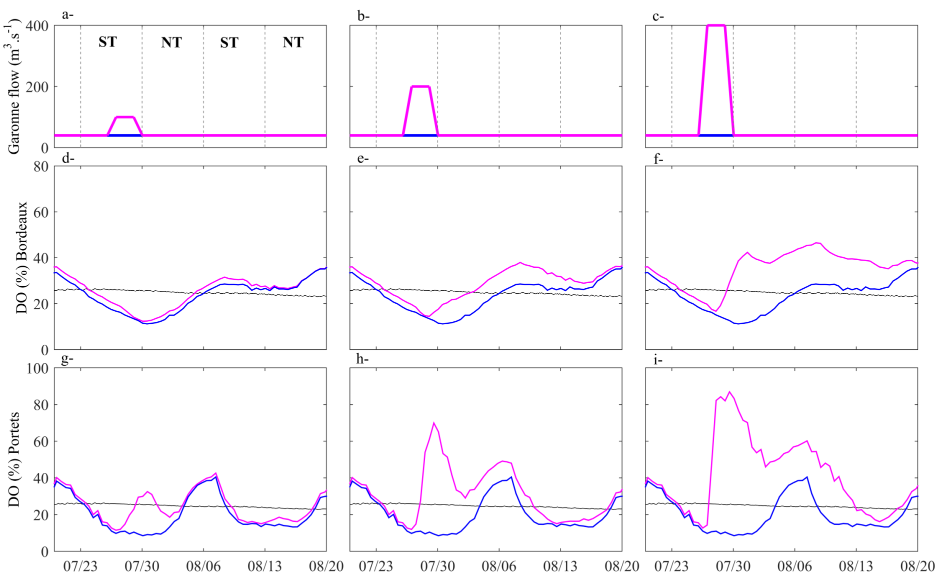

a-
b-
c-
ST
NT
ST
NT
Garonne flow (m³.s⁻¹)
DO (%) Bordeaux
DO (%) Portets
d-
e-
f-
g-
h-
i-
07/23
07/30
08/06
08/13
08/20

Fig. 4.