"Accretion, retreat and transgression of coastal wetlands experiencing sea-level rise"

by Angelo Breda et al.

Response to the interactive comments from **Referee 1.**

The comments from the referee are shown below in italics and in blue colour. Our responses are presented below each comment in regular font. Proposed changes in the text as a consequence of the adaptation of the paper to the referee's comments are presented in italics and between quotation marks.

Referee 1

A. General comments:

The paper "Accretion, retreat and transgression of coastal wetlands experiencing sea level rise" by Breda et al. presents a novel model to simulate the effects of sea-level rise (SLR) on coastal wetlands. They have compared a conventional "bathtub" approach which is incapable of including common wetlands features like channels, transition of vegetation, or culverts, with their new modelling framework that can include these features. The models were used to simulate the resilience of four simplified representations of areas in the Kooragang wetlands, SE Australia, against SLR. The authors conclude that a bathtub approach substantially overestimates the resilience of wetlands to SLR, both in terms of sediment accretion and wetland area. They attribute the overestimation of resilience to SLR in the bathtub model to the omission of sediment transport within the domain and the influence of wetland features on the hydroperiod.

The manuscript is excellently written, presents a novel methodology and reaches substantial conclusions. The paper has managed to address one of the key limitations of previous studies on marsh retreat and SLR. The paper could be slightly improved with some minor clarifications and discussion of the model limitations (see below). All in all, the manuscript shows a significant step forward in quantifying the long-term resilience of wetlands against sea-level rise.

Answer: We thank the referee for the very positive comments and the positive assessment of the scope and contents of this study. It is our belief that these comments and detailed edits significantly improved our paper. All detailed comments are addressed below (including the minor clarifications and discussion of model limitations).

Still, the initial set-up of the different "experiments" is not yet clear to me. Figure 1 seems to suggest actual sites in the Kooragang wetland were simulated, though section 2.1 also suggests only simplified domains were used. A figure of the exact initial bottom elevation and vegetation cover in each experiment would be of great help.

Answer: In order to clarify the point raised by the reviewer, we have improved the figure with the description of the experiments. The modelling approach, data and model setup in this study are based on information pertaining to Kooragang island, where conditions similar to the layout of the different numerical experiments can be found (vegetation, tidal range, slope, infrastructure) but do not try to exactly simulate a specific point in the wetland. The configuration of the numerical experiments (or simulations as we call them now) is, however, aimed at analysing in more detail specific wetland features of the Kooragang island (culverts, channels, vegetated flats) that are likely to be present in other wetlands worldwide (as mentioned in lines L.78 to L.88 of the original manuscript). The reference to the simulations in Figure 1 within the entire wetland tries to highlight that each simulation represents conditions of specific parts of the wetland.

In order to avoid confusion, we changed the word “experiments” with the more generic term “simulations” throughout the entire document (as suggested by the reviewer in comment P3. L85). In addition, we have added a set of diagrams of each simulation layout to Figure 1. We believe this greatly improves the description of the simulations and provides a better visualization of our study.

The edited Figure 1 is presented below.

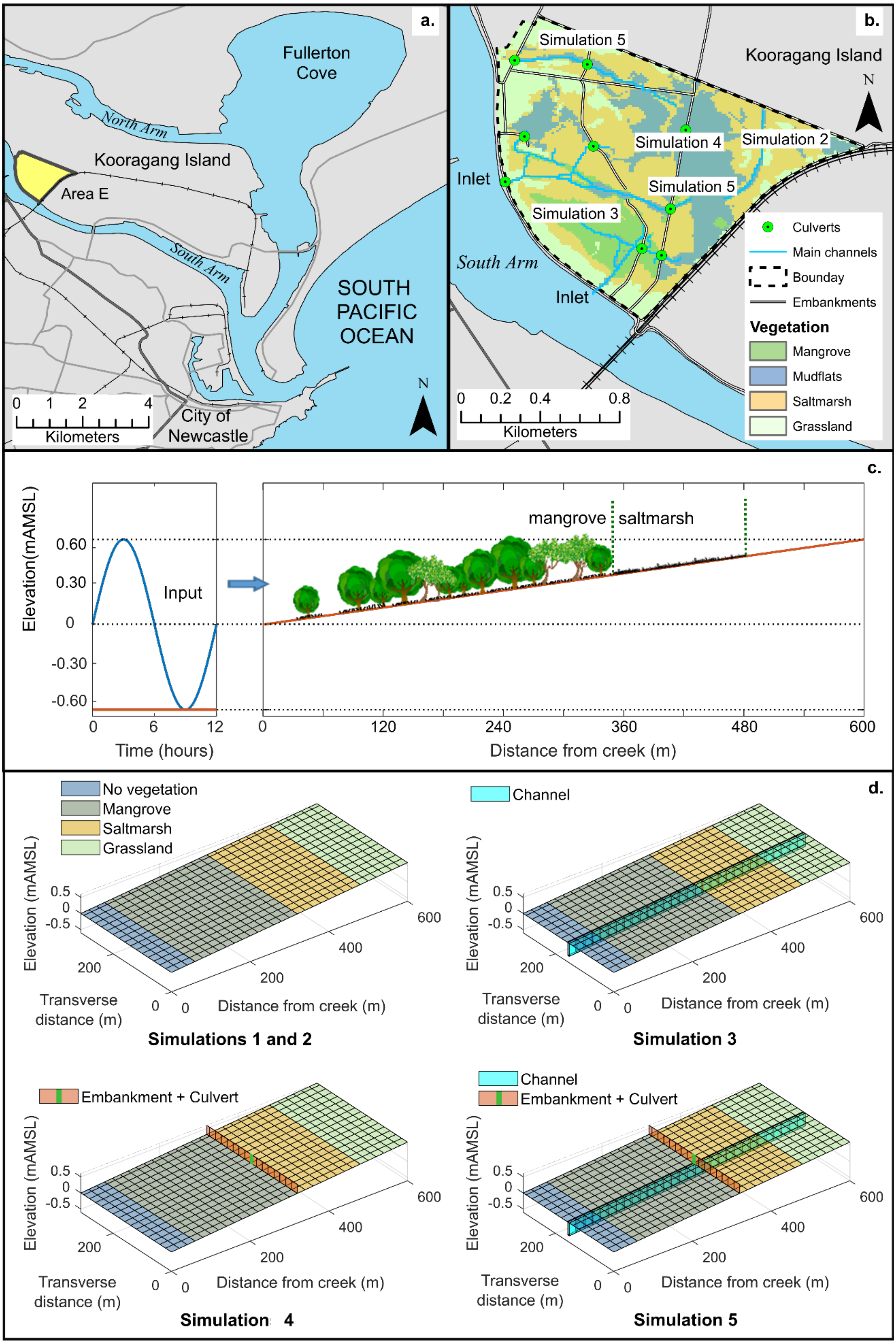


Figure 1 - Field site and areas within the site characterised by the numerical simulations: a) Area E of Kooragang wetlands, b) areas within the wetland were the simplified simulations represent the dominant processes, c) schematic longitudinal view of the domain setup and sinusoidal wave input (adapted from Rodriguez et al. (2017)), d) schematic isometric view of each simulated domain and their hydraulic features. Vegetation cover is only indicative and roughly corresponds to early stages of the simulations. Elevation unit, mAMSL, stands for metres above mean sea level.

As the authors correctly stated, the interactions between all different dynamic process in tidal wetlands are highly complex. From a modelling perspective it is perfectly reasonable to limit the amount processes included in a model. However, it does seem some discussion on the limitations resulting from this selection is missing. It would be of great value to the field and the applicability of the model if in the discussion the authors can elaborate on the limitations of their model. For example, could processes like waves, irregular storm events, soil compaction, etc. not substantially influence the results at different sites or could they still be incorporated in their model framework when needed?

Answer: We thank the reviewer for this very constructive comment. We have addressed this point by including a paragraph at the end of the discussion section detailing our model limitations. Please refer to answer of specific comments P2.L68 which includes the text for the new paragraph.

B. Specific comments:

P2.L51: What do you consider to be the entrance of the wetland? Is this the inlet or river mouth?

Answer: Thanks for pointing out that potentially confusing sentence. In the context of the sentence “inlet” is a more accurate description as this is the location for the tidal range data that we consider in our simulations (tidal signal in the Hunter river at the wetland inlet point). However, global models of wetland evolution (i.e. Schuerch et al., 2019) often consider the tidal range at the river mouth for simplicity assuming negligible tidal distorsion in the estuary (which sometimes is a good assumption).
In order to avoid confusion, we changed the word “entrance” to “inlet”.

P2.L68: Clearly not all mechanisms were included. Wave transport, sediment compaction, grazing, etc. can all be relevant for landscape features but were omitted in this study. It would be good to discuss why you think these processes were less relevant for your study-site.

Answer: The following answer also addresses the point on model limitations that the reviewer included in the general comments. We agree with the reviewer that discussing the simplifying assumptions and model limitations is important to understand the predictive capabilities of the modelling tool. The modelling framework implemented in this research extends the work of Rodriguez et al., 2017 and Sandi et al., 2018., where model limitations are described. We added a discussion of model assumptions to address this comment.
First, we changed line P2.L68 to provide a more accurate message, replacing “all relevant” by “detailed”:

“Here, we investigate how accretion and migration processes affect wetland response to SLR using a computational framework that integrates detailed hydrodynamic and sediment transport mechanisms that affect vegetation and landscape dynamics and that is efficient enough to allow the simulation of long time periods.”

Regarding model assumptions, the lack of sediment redistribution by effect of waves in the model, is addressed in lines L.221 to L.225. Kooragang island is about 8 km upstream from the estuary mouth, which has a permanent back-barrier, which strongly reduces wave energy within the estuary. Consequently, water velocities are small and erosive processes are less prominent, particularly at the location of the Kooragang island site. Wind waves are not dominant either in the river or within the wetland due to the absence of large open water areas where waves could fully develop. Soil compaction and deep subsidence do not affect the overall wetland dynamics as surface accretion and elevation change rates are similar for the study area (Rogers et al. 2006; Howe et al. 2009). Grazing or any sort of bioturbation have not been recorded as a landscape modifier in this region. Storms, on the other hand, can be an important driver for the increase in sediment supply and re-suspension of settled sediment. However, as reported from observations by Rogers et al. (2013), although storms may affect accretion dynamics over the short term (immediate erosion followed by increased deposition), they do not change the long-term trend of accretion and elevation gain rates.

Following the reviewer's comments we modified the manuscript, by adding the following paragraph at the end of the discussion section:

"The results presented in this study show generalized conditions of wetland dynamics under sea-level rise by using several simplified domains that focus on individual mechanisms affecting ecogeomorphic evolution . This approach can support a broader perspective on the potential fate of coastal wetlands in general, but some limitations arise as part of the model assumptions. As with most wetland evolution models, we did not consider soil processes other than accretion, disregarding swelling, compaction and deep subsidence. Measurements in wetlands of the Hunter Estuary show that long-term surface elevation changes are mostly due to accretion, supporting our assumption (Rogers et al. 2006; Howe et al. 2009). Another process that we did not consider was the effects of marsh edge retreat due to ocean or wind waves (Fagherazzi et al. 2012; Carniello et al. 2012), which can have a significant role in coastal wetland evolution. Most coastal wetlands in Australia are estuarine and not exposed to ocean waves, whereas wind effects in our wetland were not important due to the absence of large open water areas where wind waves could fully develop. We also simplified the tidal signal without including neap-spring cycles, which sped up computations but may have affected the results. However, preliminary tests including neap-spring tide variability showed only small differences in the initial landward edge of saltmarsh, which did not affect the accretion dynamics due to the small depths and low sediment availability in that area. Finally, our simulations did not include the effect of storms, which can influence sediment availability, water depths and velocities. We believe that in our case excluding storm effects is justifiable based on Rogers et al. (2013), who found that in these fine sediment environments storms affect accretion dynamics over the short term (immediate erosion or low accretion followed by increased deposition over the next months), but they do not change the long-term trend of accretion and elevation gain rates."

The following reference was added to the manuscript:

CARNIELLO, L., DEFINA, A. & D'ALPAOS, L. 2012. Modeling sand-mud transport induced by tidal currents and wind waves in shallow microtidal basins: Application to the Venice Lagoon (Italy). Estuarine, Coastal and Shelf Science, 102-103, 105-115.

P2.L79: "our" implies the authors own the wetland in question

Answer: The sentence was modified to avoid confusion:

"While our results strictly apply to areas in a particular wetland in Southeast Australia, …"

P3.L85: and onwards: Consider replacing "experiments" with "simulations" as you do later in the paper. Experiments would suggest the results are from a field study rather than a numerical simulation.

Answer: As mentioned earlier, the term "experiment" was be changed to "simulations" throughout the manuscript.

P3.L104-108: Consider describing the simulations in order from 1 to 5, rather than starting with 2.

Answer: Agreed. We changed the structure of the paragraph in order to start with simulation 1.

P3.L115-119: Given that there is bound to be a storm event in the considered time period (100 years) and the seemingly large influence of these storm events on sediment supply. Should the effects of storm events not be incorporated across both scenarios to simulate accretion rates?

Answer: Indeed, it is worth mentioning that storms are potentially an important driver of changes in sediment load and accretion rates. As mentioned in the answer for comment about P2.L68, not including storm events is a limitation of our study and we plan to clarify that point at the end of the discussion (the new paragraph has been included in the response to P2.L68). However, field measurements in the Hunter estuary showed that storm events are not as significant in the long term and do not significantly modify the surface elevation change rates (Rogers et al., 2013). According to Rogers et al., (2013) storms generate high sediment loads but also high velocities, so no deposition (rather erosion in some areas) occurs on wetlands during storms. Also, the high sediment loads during storms mostly remain in the estuary and are are not completely washed out to the ocean. Those sediments in the estuary are redistributed by spring tides in the subsequent months, generating increased accretion, compensating for the storm effects and resulting in a long-term accretion dynamics largely unaffected by storms. Of course, these ideas are based on observations of one storm and may not be general, but illustrates the complexity required to incorporate the effects of storms in wetland evolution. This study focusses on the long-term effects of sea level rise, and we assume that storm effects that might cause local short-term deficits and gains in elevation would not affect the overall result. Not including such events is a reasonable simplification given the local wetland dynamics and the scope of this study.

P4.L127: Why is the model quasi-2D?

Answer: The term quasi-2D is regularly used in the hydrodynamic simulation research community and, in our case, it is used to describe a hybrid model that solves the mass conservation equation using a fully 2D scheme, and then solves the momentum conservation equation for each cell-to-cell link of the 2D grid using 1D equations in each direction. This solution scheme speeds up computations significantly and produce accurate results in wetlands. We have provided a short summary in the paper, but more detail can be found in the original model formulation (Riccardi 2000) and associated references that have previously implemented the model (Rodriguez et al., 2017; Sandi et al., 2019; Sandi et al., 2020a; Sandi et al., 2020b; Saco et al., 2019).

To better convey this message, the text in L.134 was modified to:

"In each timestep, the model solves for water elevations at every cell using mass conservation in a 2D formulation, and then it solves for discharges between cells in each direction using momentum or energy conservation in a 1D formulation."

P4.L131: 10m x 10m cells seem too large to accurately include the small channels found in wetlands. Could you elaborate how the inner channel of experiment 3 was represented in the model?

Answer: The reviewer has a point and we recognise that we did not clearly explain the implementation of the channel in our model. The inner channel is introduced in the middle transverse row of the domain but with narrower width cells compatible with the size of the channel (5m). Also, the elevation in cells representing the channel is 40 cm lower than the neighbouring tidal flat cells. Lastly, the Manning's roughness coefficient in this row is set to 0.035 (bare soil) and it remains unchanged throughout the simulation period. The roughness coefficients for each vegetation and channels were calibrated against measured water levels in Area E of Kooragang Island and compared with values from the literature (Rodriguez et al., 2017).

For clarification, in L.131 we added the following sentence:

"For cells representing channels in simulations 3 and 5, the width of the cell is reduced to 5 m and the elevation is lowered by 0.4 m."

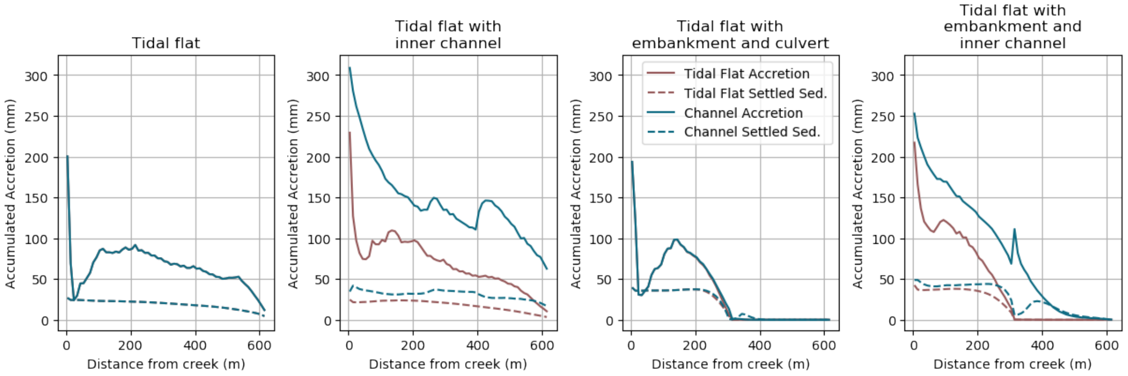
P5.L164-167: Is it assumed in the model that mangroves and marshes die and re-establish immediately when conditions change or is growth/die-off modeled through time?

Answer: Our model assumes that establishment and die-off occur every year according to the vegetation model rules. Vegetation establishment rules are entirely deterministic and vegetation is updated annualy (the eco-geomorphic time step). However, it should be noticed that these are not abrupt changes because the biomass curves for the vegetation also depend on the water conditions (water depth), and indirectly account for the gradual growth/die-off. Mature and healthy areas (highest biomass) occur at points with intermediate depths within the vegetation stripes, which are centrally located within the stripes. At the lower (seaward) stripe border biomass is lower, reflecting the “drowning” edge where some vegetation survive and other does not. At the upper (landward) stripe border the reduction in biomass reflects new-growth colonised areas with smaller size younger vegetation.

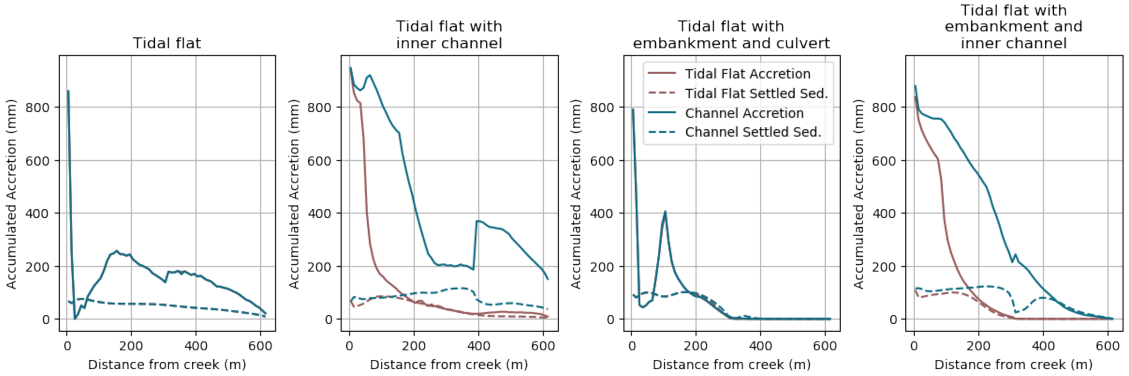
P6.L215: After solving equations 4, 5, and 6, one can solve for deposition directly following a mass balance. What is the reason for not using the deposition calculated by the sediment transport model and instead using an empirical equation?

Answer: This is a very good point. The deposition calculated in the Sediment Transport Model (STM) is a depth-averaged value over the water column and is mostly unaffected by the presence of vegetation (except for the reduction in velocity due to hydraulic resistance). This settled amount is always significantly lower than the accretion computed with the empirical equation. This is expected because the settled sediment term accounts only for the gravitational settling of sediment. Vegetation increases soil accretion through organic material incorporation into soil and sediment trapping, which are not included in the STM settling term. The overall accretion including sediment and vegetation effects is practically impossible to separate, so an overall empirical accretion equation is needed for calibration and comparison with field measurements.

We prepared the figure below (included in the supplementary material) to illustrate such situation. Even when using a considerably low settled sediment density of 0.5 Mg/m^3 (Howe et al. 2009), the highest ratio of average settled sediment over average accretion was about 50% for simulation 4 (embankment and culvert). In the other three simulations with the STM, this ratio ranged between 22% and 30%. This means that, at most, the settled sediment only contributes to 50% of the total accretion.



(a) Low sediment input (C = 37 g/m^3)



(b) High sediment input (C = 111 g/m^3)

Figure S2 – Comparing accretion (solid lines) computed with equation 10 and settled sediment (dashed lines) given by the term $S_i\varphi_i$ from equation 4. Tidal flat profiles (red lines) show conditions far from the inner channel. Channel profiles (blue lines) show results at the margin of the inner channel. Settled sediment (originally in g/m^2) was converted to mm using a sediment density of 0.5 Mg/m^3 as found in Howe et al. (2009) for restored wetlands in Kooragang Island. Results correspond to the last year of the simulated period, 2100.

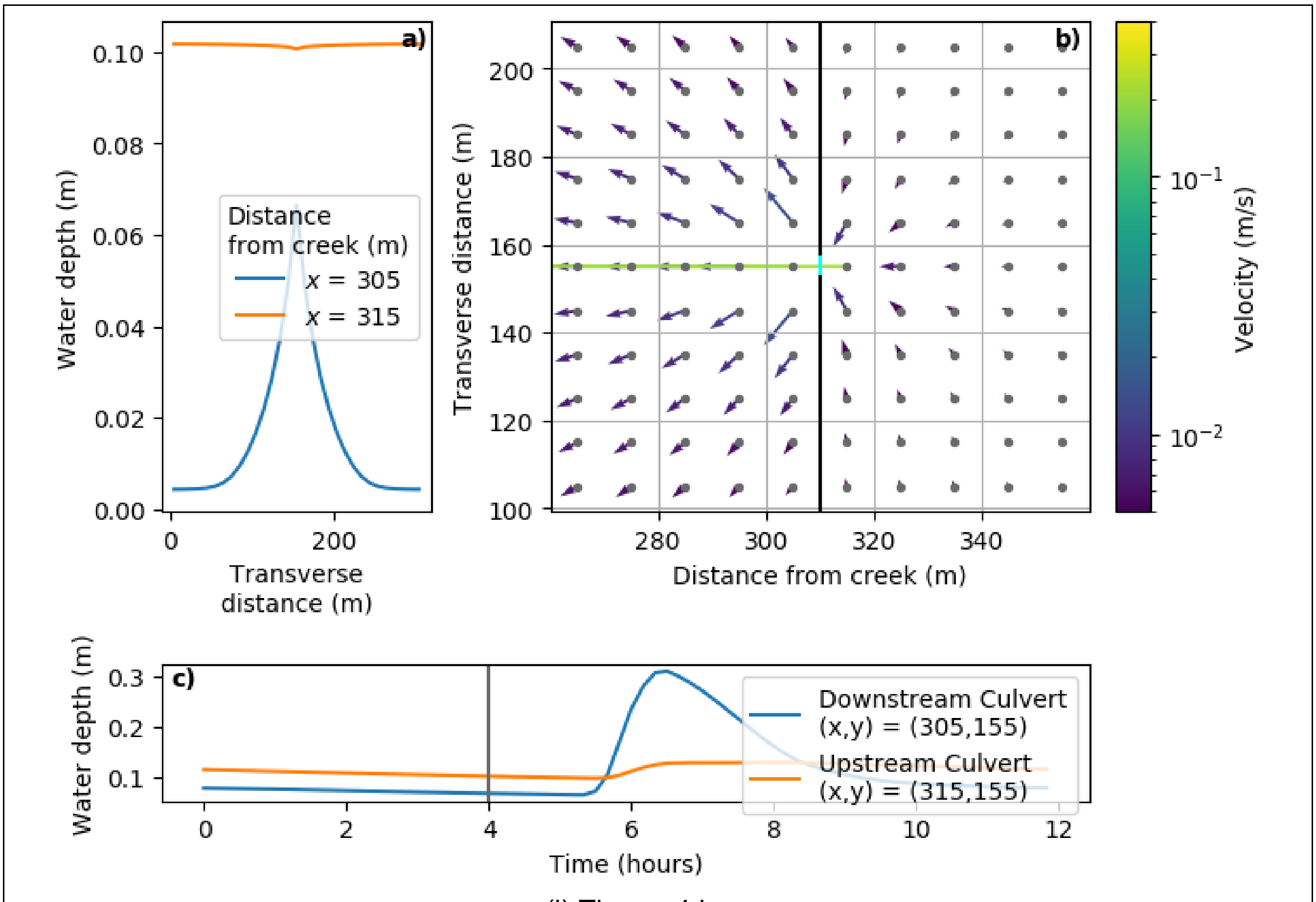
Additionally, the following text was added at the end of P5.L218:

“Although the term $S_i\varphi_i$ in equation (4) provides an amount of settled sediment that contributes to accretion, it only considers the gravitational settling of sediment and does not include many other important accretion processes associated to the presence of vegetation. The full effects of sediment and vegetation are considered in equation 10, which produces much larger accretion values (see Fi. S2 in Supplementary Materials).”

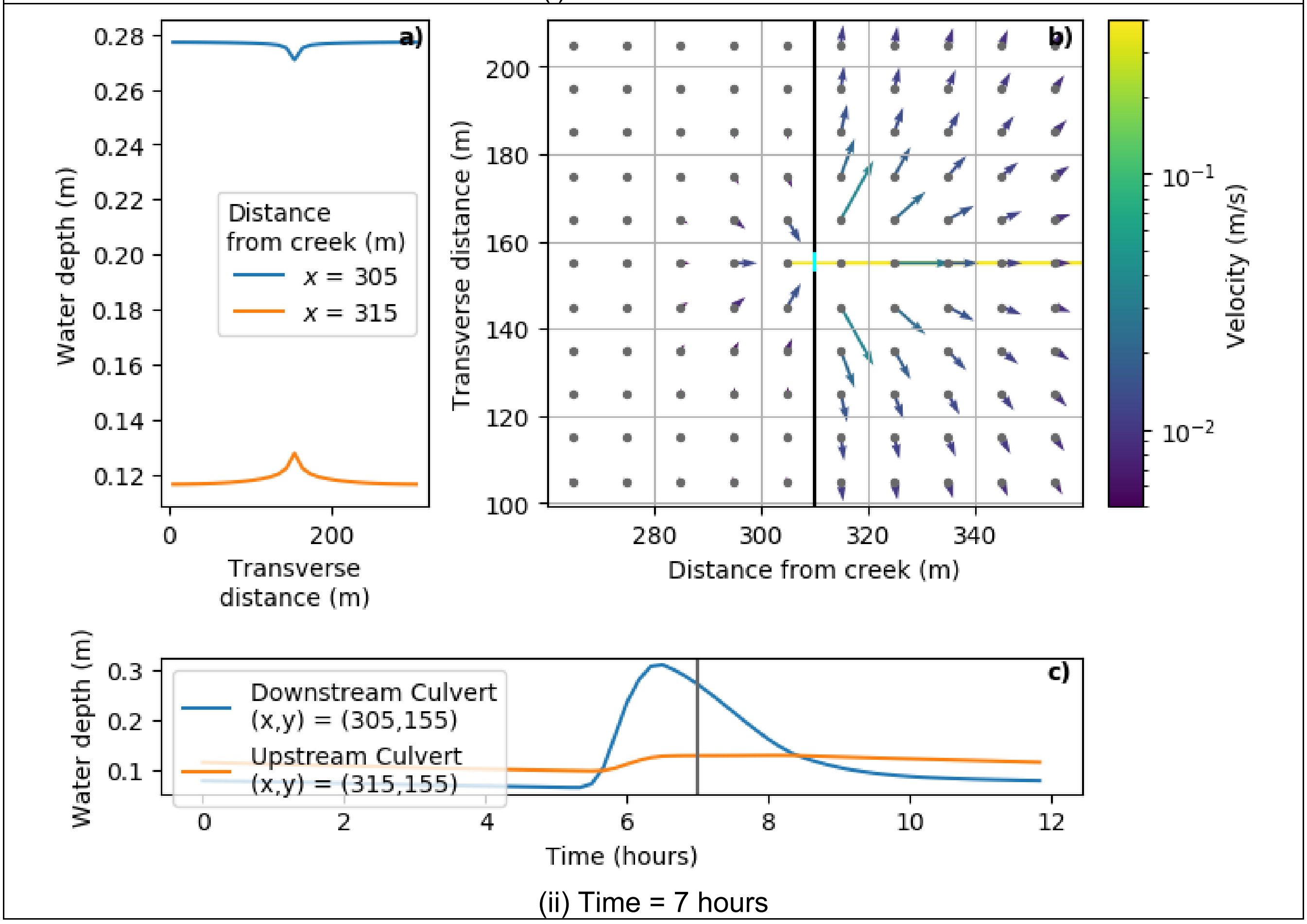
P6.L233: How was the culvert implemented? Culverts have a fixed width so I would not expect the results to be homogeneous in the transverse direction.

Answer: Again, this is a very good point. We used the culvert equation (eq 3) instead of the equation for a vegetated tidal flat (eq 2) to compute the discharge between culvert-linked cells. Equation 3 is a rather conventional culvert formulation. The culvert has a width of 0.4 m and it does produce inhomogeneities in the transverse direction, but those inhomogeneities are too small to be captured by Figure 2d (simulation with culvert).

The inhomogeneities can be seen in more detail in the figures below that show results of our model for two points in time, one during ebb flow and another during flood flow. The figures shows water levels and the velocity field at two different locations, one downstream (x=305m) and one upstream (x=315m) of the culvert (x=310m). The culvert does promote a heterogeneous flow field reflected in the velocity and also in the transverse depth profile.



(i) Time = 4 hours



(ii) Time = 7 hours

Figure R1– Hydrodynamics near the culvert. (a) water depth along cross sections near embankment, downstream at 305 m from the tide input creek and upstream at 315 m. (b) water velocity. (c) water depth time series at the cells linked by the culvert

Those inhomogeneities are in general small, but they also have a small effect when they interact with sediment and vegetation within the eco-geomorphic model. The next figure show very small transverse variations in hydroperiod and D (computed for 2050), which means that the transverse distribution of vegetation is not affected. Sediment concentration and thus accumulated accretion (from 2000 to 2050) seem to display more transverse variability. However, the maximum variability in accretion (from 4 to 8 mm in the last panel) is unable to be captured by the scale of Figure 2d, which has a range of accretion values from 0 to 200 mm.

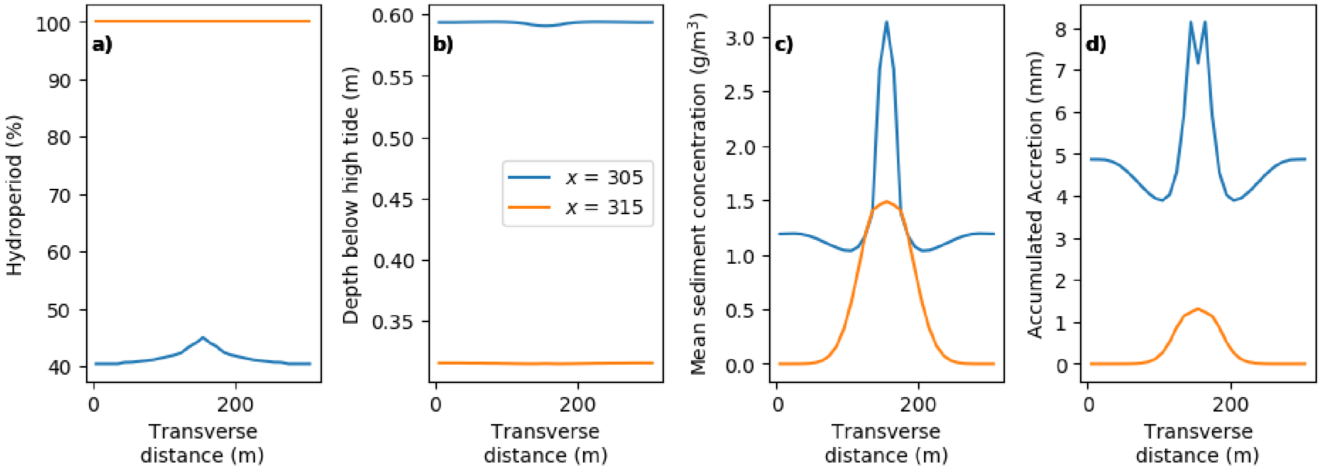


Figure R2– Model outputs at cross-sections near the embankment in the year 2050. (a) Hydroperiod. (b) Depth below mean high tide. (c) mean sediment concentration. (d) elevation change between 2000 and 2050. Culvert is located in the middle of cross-section at x = 310 m

In summary, the culvert promotes a strong reduction in the water conveyance upstream of the embankment. It also reduces the flow back to the downstream area, ponding the water over the floodplain. As sediment delivery to the upstream area is also strongly reduced, accretion rates become too low to change the terrain significantly.

P7.L241-242: I do not see mounts in figure 2a. Do you refer to figure 3?

Answer: Indeed, Figure 2a does not show two distinct mounts.

Lines P7.241-242 were modified to provide a better description of Figure 2a:

"Figure 2a shows that the bathtub experiment displays a smoother and longer transition of accumulated accretion. A slight concentration of accretion is observed at 500 m from the creek, due to the initial position of high biomass saltmarsh, …"

P10.L366: What is meant with the entrance of the wetland?

Answer: Similarly to the response to comment P2.L51, wetland inlet is a better term to use here. In the case of Sandi et al. 2019, the "entrance" corresponds to the wetland inlet from the Hunter River.

To avoid confusion, we modified this sentence to:

"Sandi et al. (2018) also reported larger wetland losses in their simulations with tidal input restrictions at the wetland inlet when compared to the case without restrictions."

P11.L403-423: This section seems to be presenting new results rather than furthering the discussion. Consider moving this part to the results section of your paper.

Answer: We appreciate the suggestion and we moved this section to the results section as suggested.

P11.L424: Do more detailed domains show a different response than your model? A comparison of your model with studies modelling more complex domains would be useful here.

Answer: This is a very good question. We are quite convinced that our simplified domain simulations are representative of more complex domains, either individually or as a combination. As an example, we have included in Figure 4 results from Rodriguez et al., (2017) and Sandi et al., (2018), that correspond to detailed simulations using a similar hydrodynamic and sediment transport (HST) formulation over an entire wetland. The accumulated accretion results for the entire wetland cases nicely fall within the range of expected values given by the simplified domain simulations. Our belief is that simulation of detailed domains represent a composition of the results found on each experiment. A comprehensive comparison using multiple domains would involve the compilation of several sets of data as well as considerable computational cost depending on the size of the domains, which is one of the reasons why we have limited the analysis to the simplified domains. However, we strongly believe that our results highlight the importance of considering a HST frameworks for the simulation of wetlands in general and significantly outperforms simplified models (bathtub).
To convey this message, we modified the last paragraph of the conclusions (L.424 onwards) as follows:.

Although the simulations carried out in this study were conducted on simplified domains, they can capture the general response of more complex domains present in real wetlands, as shown by the comparison with entire wetland results from Rodriguez et al., (2017) and Sandi et al., (2018) in Figure 4. Moreover, the features included are present in many coastal areas around the world and thus have wider implications. Our bathtub results for low sediment conditions predicting an initial increase in wetland extent early in the century and then a decrease after 2060 agree with previous bathtub model predictions (Lovelock et al., 2015b;Rogers et al., 2012;Schuerch et al., 2018). However, using the HST framework our predictions indicate that the decrease may start as early as 2030 for wetlands with tidal range close to 1.3 m (as represented in our study), over a wide range of sediment loads. We can expect that this accelerated wetland loss will affect many parts of the world, particularly in areas with micro to meso tidal range and heavily developed coasts, like eastern Australia (Williams and Watford, 1997), parts of eastern US (Crain et al., 2009), western US (Thorne et al., 2018) eastern China (Tian et al., 2016) and western Europe (Gibson et al., 2007). In these environments, attenuation can be important due to man-made structures, and transgression may be limited by development (Doody, 2013;Geselbracht et al., *2015;Kirwan and Megonigal, 2013), so we can expect a behaviour closer to that of simulations 4 and 5. On the other hand, wetlands with dense drainage networks like the Venice Lagoon in Italy (Silvestri et al., 2005), the Scheldt Estuary in the Netherlands (Temmerman et al., 2012), or the North Inlet in South Carolina, US (Morris et al., 2005), would probably behave similarly to simulation 3 and experience comparatively smaller losses of area.*

Figure 3: Please add since when the sediment was accumulating (I presume 2000) for clarity. To make comparing the plots between periods easier, please consider maintaining the same y-axis for all plots. At first glance the bumps seem to erode over time until you notice the changing y-scale.

Answer: Figure 3 was modified as suggested, as shown below.

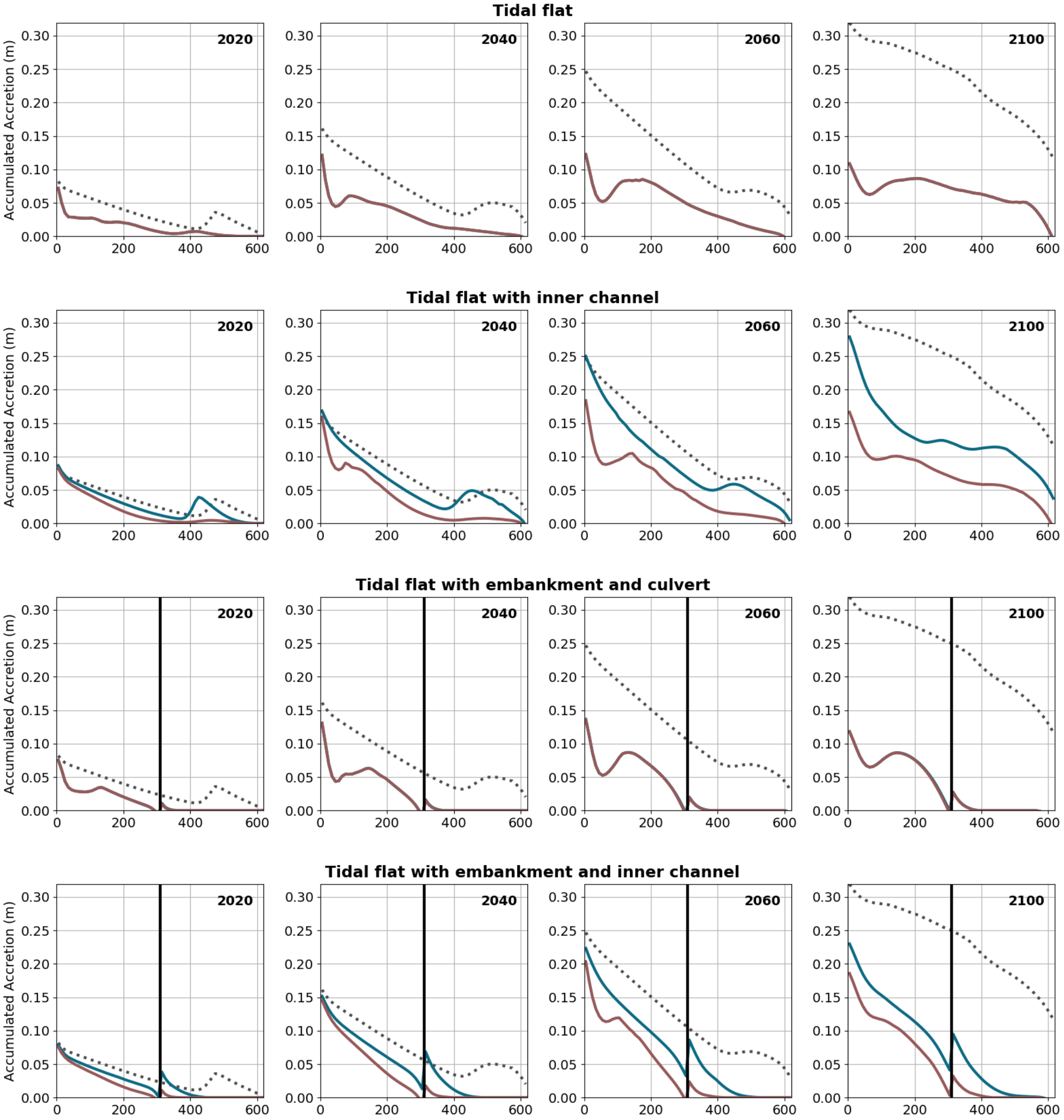


Figure 3 - Longitudinal profiles of accumulated accretion (ΔE, m) for a sediment supply of 37 g/m3. The vertical black line represents the embankment with culvert. The "channel" profile represents the elevation gain near the central channel, while the "tidal flat" profile is situated in the middle of the tidal flat. Note: simulation starts in the year 2000.

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Response to the interactive comments from **Referee 2.**

The comments from the referee are shown below in italics and in blue colour. Our responses are presented below each comment in regular font. Proposed changes in the text as a consequence of the adaptation of the paper to the referee’s comments are presented in italics and between quotation marks.

Referee 2

A. General comments:

This is an interesting manuscript that investigates how accretion and migration affect wetland response to SLR by using a numerical tool that includes hydrodynamic and sediment transport mechanisms as well as vegetation and landscape dynamics. The paper is very well written and provides important insights regarding wetland evolution under climate change conditions.

Answer: We thank the reviewer for the very positive assessment of our paper. It is also our belief that this study provides an important contribution to the ongoing discussion of wetland evolution under climate change.

B. Specific comments:

[95-105] The description of experiments is not clear. This part would be clearer if you included the reference to Fig.1c in line [103] when starting the description of experiment 2. Even so, the best thing would be to include a figure with the conditions of each experiment.

Answer: In order to improve the description of the experiments, we have modified Figure 1 including a sub-figure with the conditions of each experiment. Please notice that we replaced the word “experiment” with “simulation” throughout the manuscript (as requested by Reviewer 1) in order to better convey the idea that our results correspond to simplified domains based on general characteristics of a wetland in Australia (Area E). In the said paragraph, a reference to each simulation figure will be included when describing the simulations. The edited Figure 1 is presented below.

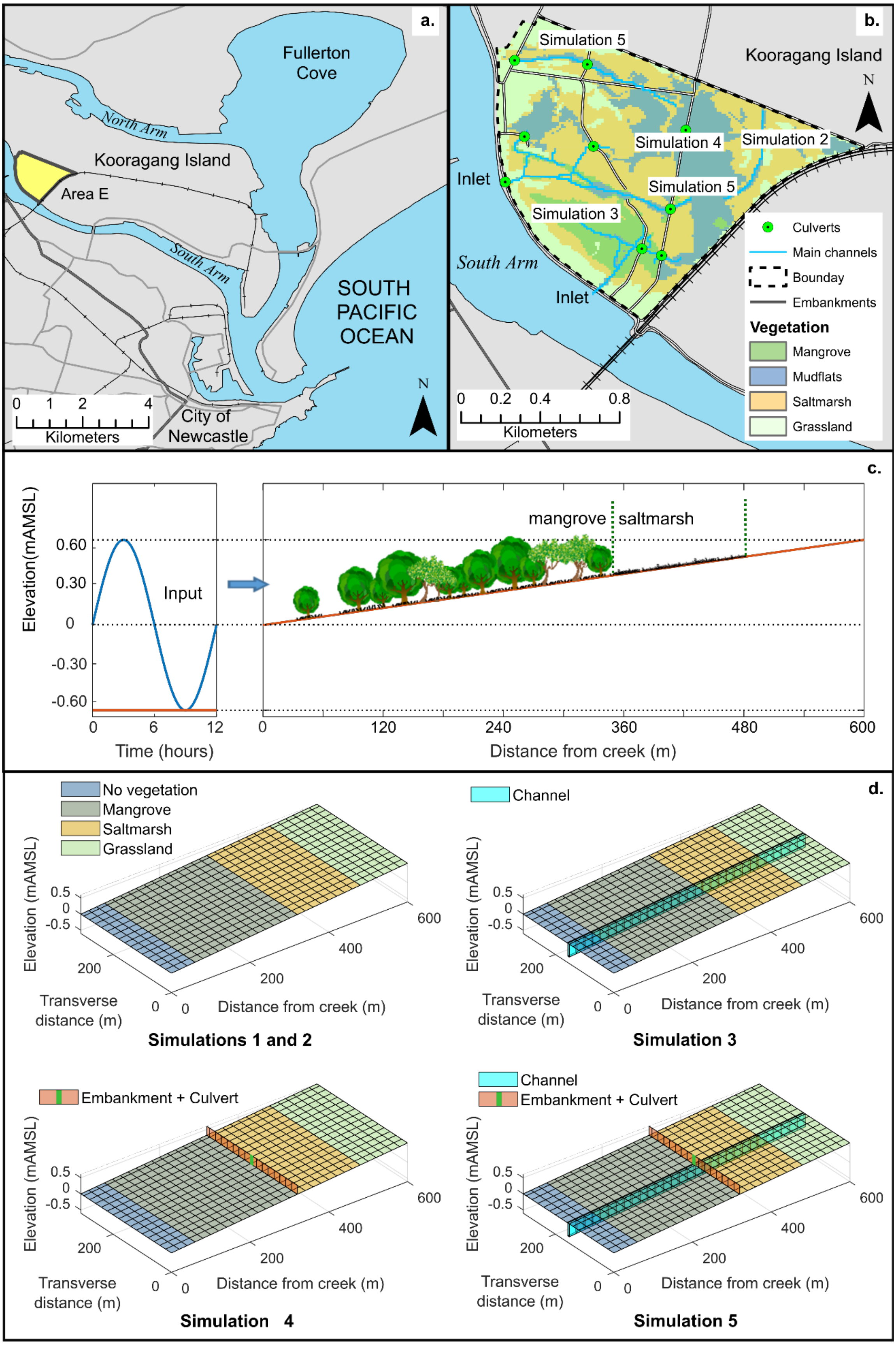

Figure 1 - Field site and areas within the site characterised by the numerical simulations: a) Area E of Kooragang wetlands, b) areas within the wetland were the simplified simulations represent the dominant processes, c) schematic longitudinal view of the domain setup and sinusoidal wave input (adapted from Rodriguez et al. (2017)), d) schematic isometric view of each simulated domain and their hydraulic features. Vegetation cover is only indicative and roughly corresponds to early stages of the simulations. Elevation unit, mAMSL, stands for metres above mean sea level.

[Discussion] Your experiments use a sinusoidal wave of constant amplitude, however the real tide often presents a neap spring tide cycle. How would your results be different if you included that variability?

Answer: We tested the implementation of a time series of water levels that included neap and spring tide variability. During this testing, saltmarsh area slightly increases landward as some areas became inundated during the highest spring tides, while mangrove areas were not affected because hydroperiod remained mostly unchanged. Such effect was only observed in the simulations without the embankment. This small saltmarsh extension did not change the overall conclusion of findings because:

1. Saltmarsh occupation reaches the upstream domain border quite early in the simulation (experiments 1-3), and most of saltmarsh loss is due to mangrove encroachment on the downstream edge. Thus in terms of total wetland area, there is no significant change of the outcomes.
2. Accretion in this increased saltmarsh area (if using neap/spring input) is negligible as both sediment concentration and water depths are too low in such high areas.

We added at the end of the conclusions the following paragraph indicating assumptions and limitations of our model:

"The results presented in this study show generalized conditions of wetland dynamics under sea-level rise by using several simplified domains that focus on individual mechanisms affecting ecogeomorphic evolution . This approach can support a broader perspective on the potential fate of coastal wetlands in general, but some limitations arise as part of the model assumptions. As with most wetland evolution models, we did not consider soil processes other than accretion, disregarding swelling, compaction and deep subsidence. Measurements in wetlands of the Hunter Estuary show that long-term surface elevation changes are mostly due to accretion, supporting our assumption (Rogers et al. 2006; Howe et al. 2009). Another process that we did not consider was the effects of marsh edge retreat due to ocean or wind waves (Fagherazzi et al. 2012; Carniello et al. 2012), which can have a significant role in coastal wetland evolution. Most coastal wetlands in Australia are estuarine and not exposed to ocean waves, whereas wind effects in our wetland were not important due to the absence of large open water areas where wind waves could fully develop. We also simplified the tidal signal without including neap-spring cycles, which sped up computations but may have affected the results. However, preliminary tests including neap-spring tide variability showed only small differences in the initial landward edge of saltmarsh, which did not affect the accretion dynamics due to the small depths and low sediment availability in that area. Finally, our simulations did not include the effect of storms, which can influence sediment availability, water depths and velocities. We believe that in our case excluding storm effects is justifiable based on Rogers et al. (2013), who found that in these fine sediment environments storms affect accretion dynamics over the short term (immediate erosion or low accretion

followed by increased deposition over the next months), but they do not change the long-term trend of accretion and elevation gain rates.”