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Interactive comment on "Establishing a sediment budget in the newly created "Kleine Noordwaard" wetland area in the Rhine-Meuse delta" *by* Eveline Christien van der Deijl et al.

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We thank the reviewers for taking the time to read and review our manuscript. We address each specific comment below:

Reviewer comments are bold
Author comments are in plain text
The changes in manuscript can be found in the manuscript with track changes

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Discussion paper

1 Anonymous Referee #1

The authors present results of a comprehensive study on the morphological development of a recently opened wetland, based on an extensive data set.

First of all, I completely agree with the questions raised by Reviewer 1.

For the response to these questions we refer to the document reply to review 1

The text cites a paper as to be in preparation, by the authors, which is not in the list of references. That, and conference abstracts by the authors, suggest the availability of potentially more data on SSC and current velocities at the entrance to the wetland, which are, in here, deeply missed. I guess, there is a good reason for the suspected splitting of the data set.

The paper, which was cited as to be in preparation, has meanwhile been accepted and published. Therefore, we have changed all references to this paper in the text to (van der Deijl et al., 2017) and the paper has been added to the list of references.

van der Deijl, E. C., van der Perk, M., and Middelkoop, H.: Factors controlling sediment trapping in two freshwater tidal wetlands in the Biesbosch area, The Netherlands, Journal of Soils and Sediments, pp. 1–17, doi:10.1007/s11368-017-1729-x, http://link.springer.com/10.1007/s11368-017-1729-x, 2017.

While this manuscript focuses on the medium-to-long term sediment budget since the opening of the study area , the above paper use 10-minute interval data on water level, flow velocity, and suspended sediment concentrations measured at the inlet and outlet of the study area to identify the controls on sediment trapping. The period for which

these data is available only covers the period July 2014 - March 2015 and represents only a short period since the opening of the study area. This makes this detailed data less suitable for the purpose of this study Nevertheless, we use the data and refer to the above paper in a newly added description of the water levels, discharge, and suspended sediment concentration in the channels of the study area and the inundation frequency of the intertidal flats, marshes and terrestrial zone in the area description (Section 2.1). Furthermore, we used the data for estimating the proportion of the total sediment load of the River Rhine that enters the study area (Section 2.2.4).

So, since no more information is presented here on the forcing, tide-driven dynamics, etc., the focus should be on the analysis of geospatial information. In this, I think the data source is not (yet) presented to the reader in a proper way. From the suggested high quality of MBES and LIDAR data, I had expected simply better plots, e.g., from one flat in the center of the wetland and surrounding channels, showing more details of aggradation and erosion patters.

The color scale in Fig. 1 doesn't help. The interesting elevation range, -2 m to 1 m, is essentially not resolved.

Figure 1 was included in the manuscript to show both the location of the study area and the transformation of the study area as a result of depoldering, not to derive rates of deposition at the intertidal flats. Because of the regular submergence of the intertidal flats, a complete digital elevation model based on the Lidar data of the intertidal flats is only available before the depoldering of the study area. Therefore, it is not possible to determine rates of deposition at the intertidal flats from different LIDAR datasets.

To further clarify the initial morphology of the study area after depoldering, and the division of the study area in channels, flats, marshes and a terrestrial zone, we have

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Discussion paper

added a new figure (Fig2).

Furthermore, we added a new figure to the manuscript to further clarify the sedimentation and erosion patters in the channels (Fig 4 in the revised manuscript). This new figure shows the development of channel section 1 and 3 (for location of the transects see Fig 1, which represent the morphological development of both the single channels near the inlet and outlet, and the perpendicular channels in the middle of the study area.

There are quite some simple methods around, based on gridded spatial data, e.g., the maximum bed elevation range to differentiate between more and less active regions, or, vertical dynamic trend analysis to show - what is already in the text - stagnation of morphological change with time at specific locations. The DEMs could have also been used to extract cross-sections of channels, or longitudinal transects from some channel thalweg, all means to give the reader a good impression of morphological changes. I'm just suggesting. How to proceed, and what to change, depends on the focus.

In our response to the former comment, we already mentioned that we added a new figure (now Fig 4) to the manuscript to further clarify the aggradation and erosion patters in the channels by showing the morphological development of two channel cross-sections. Furthermore, we changed the data representation in Fig 2 in the first version of the manuscript. The maps in this figure showed the spatial distribution of the total difference in channel bed level. This figure has become Fig 3 in the revised manuscript and the maps now show the difference in channel bed level in m/year (the vertical dynamic trend) for each monitoring period.

Tja, what is the actual focus? The determination of the budget? Analysis of transport both into inside the area? Geomorphological changes of flats, banks, channels? Analysis of the sedimentology, including transport of the coarse and cohesive fractions?

I find the focus unclear and the Introduction and Discussion symptomatically unspecific, e.g., page 9 line 24: "cut bank retreat does not significantly contribute to the total sediment budget". If the paper was about the budget, why is the statement, cut banks would not contribute to that budget, followed by a detailed comparison of cut bank dynamics with literature? That is a question of the focus. The same could be said regarding sand deposition in the deeper channels.

The discussion essentially remains on the level of a comparison. In each part of the discussion, process based considerations are used to explain the situation at the specific location. Which is cool. But I asked myself at the end of each paragraph, what could be concluded from this discussion for similar geomorphological settings? I had the impression, and maybe I'm wrong, that the discussion did not lead to the conclusions.

As mentioned in the title of the manuscript, the focus of this paper is "Establishing a sediment budget in a newly opened wetland area". The rates and patterns of sedimentation and erosion are compared to those in other wetlands to discuss the relative contribution of geomorphological processes in the study area to the budget, and to derive practical implications for the management of newly created tidal freshwater wetlands.

We have made the changes in the introduction to further clarify the focus of the manuscript

In the discussion section, we compare the rates and patterns of sedimentation and erosion to those in other wetlands, and we use the process-based considerations to discuss the relative contribution of geomorphological processes to the sediment budget in our study area. To further clarify the implication of the processes to the sediment budget, each paragraph now ends with a concluding sentence. In sections 4.3 (Implications for management) and 5 (Conclusions) we refer to these conclusions to derive practical implications for the management of newly created tidal freshwater wetlands.

The exact changes in the discussion, can be found in the manuscript with track changes

The Conclusion is essentially a summary of Results. On one hand, it is said that the wetland is a trap for sediments. On the other hand, it is deduced at least for the channels that the domain is approaching some kind of equilibrium, which certainly didn't exist from the beginning. So, trapping occurs only because of the non-equilibrium state at the opening of the wetland? Which grain sizes could actually be trapped? Is it realistic that sand is transported into the wetland? If trapping was the goal (Paola et al., 2011, is cited in the Introduction), should we conclude that, to efficiently trap sediments, we would need to open new wetlands every once in a while? Ok, seriously, I find this important, as, e.g., around many estuaries we are having this discussion right now, everywhere in Europe.

We agree that this a topical and relevant discussion. We adapted section 4.3 (Implications for management) by adding reflection on current sedimentation rates and possible measures to enhance these. At the end of the section we state that conversion of polders into wetlands in deltas may be an effective strategy of delta restoration since sedimentation compensates at least partly for sea level rise and land subsidence. These management implications have also been added in the conclusions section.

So, in summary, I hope for a shorter text, with a clear focus. The plots should reflect the data quality. The Discussion should lead to the Conclusions.

To recap the response to the former comments: we have adapted and added figures, added concluding sentences in the discussion sections and we refer back to these conclusions in the conclusion.

Minor comments: P6 L7 An interesting aspect is that "channels cannot migrate freely". Any ideas what this could mean for small-scale morphodynamics and the distribution of sediments? What is that “bank protection”?

The dikes along the channels near the inlet and outlet of the study area are protected by riprap to prevent erosion. Since the outer bends have reached the riprap, further erosion is prevented. As a result, there is less sediment available for further development of the point bars at the end of the bends and the channels will become fixed.

However, the channels are not able to migrate freely due to steep banks of dikes armoured by riprap , and the average width to depth ratio of the channel has decreased from 17.9 to 15.2.

P6 L23 Any particular reason, why the term “morphodynamic equilibrium” is persistently avoided, using “equilibrium state between their geometry and the flow conditions”, instead?

We had no particular reason to avoid the term morphodynamic equilibrium, which is now used in the manuscript at P7 L26, P10 L1, P10 L9 and P13 L23

P4 L14 “whether changes . . . had been . . . years”

We have implemented this comment

P8 L17 “Yet . . . channels” example of many sentences which can simply be deleted without changing anything in the text

We have implemented this comment by deleting this sentence.

P9 L25 “Wind waves . . . fetch” common knowledge, not required

We have deleted this sentence from the manuscript

P10 L3 Entire paragraph: example for text with too many assumptions, for my taste, since in the end this does “not allow drawing conclusions”

We have deleted the last sentence of the paragraph so we now end with the conclusion that resuspension of sediment takes place regularly.

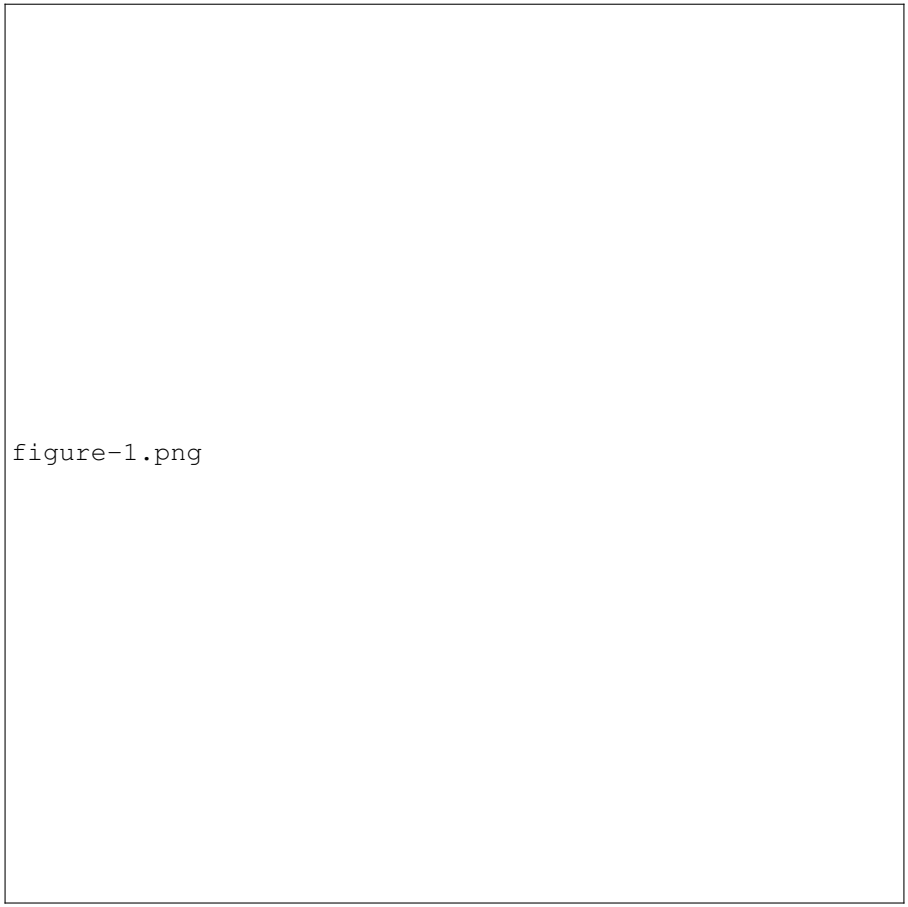

Fig. 1. The study area Kleine Noordwaard, which is located within the Biesbosch Freshwater Tidal Wetland, in the lower Rhine and Meuse delta in the southwest of the Netherlands (a and b). Elevation is shown in meters, with respect to the Dutch Ordnance Datum (NAP) for the period before (c) and after depoldering (d).

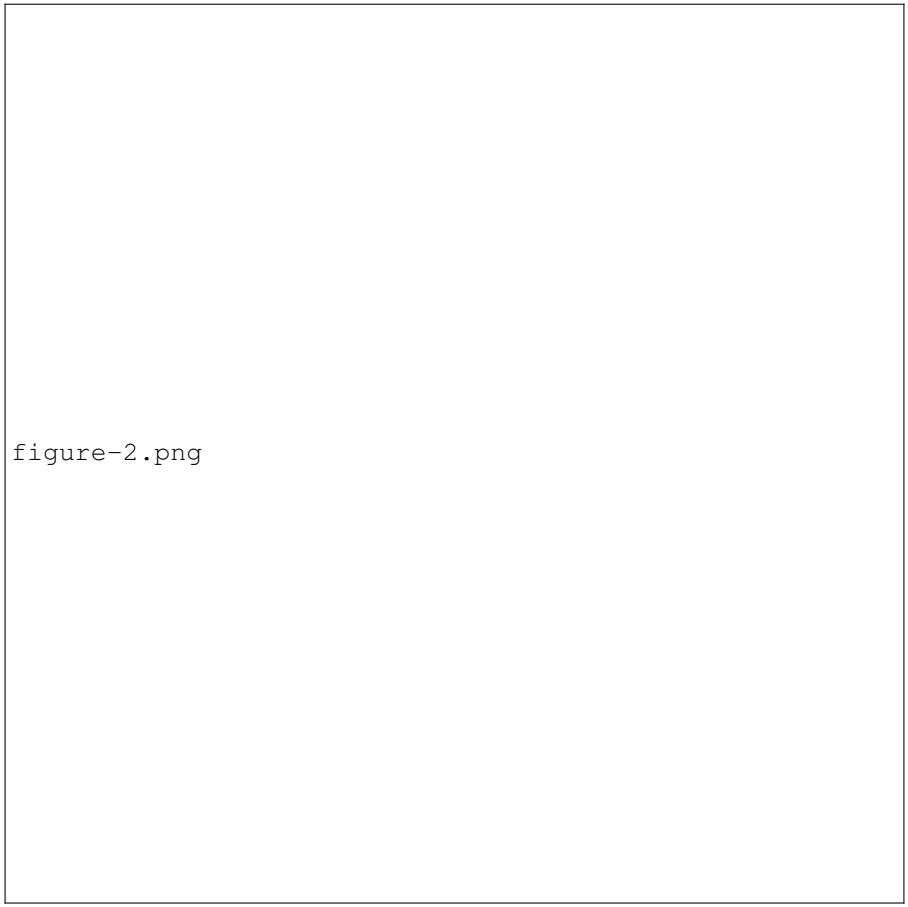

Fig. 2. Elevation of Transect A (see Fig. 1) with respect to the Dutch Ordnance Datum (m NAP) with subdivision of the area into subtidal areas, flats, low and high marshes, and terrestrial zone relative to mean low water (MLW), mean sea level (MSL), mean high water (MHW), the maximum observed water level (EHW) and the water level for a peak discharge or storm with return period of 1 year, which were used to divide the study area in.

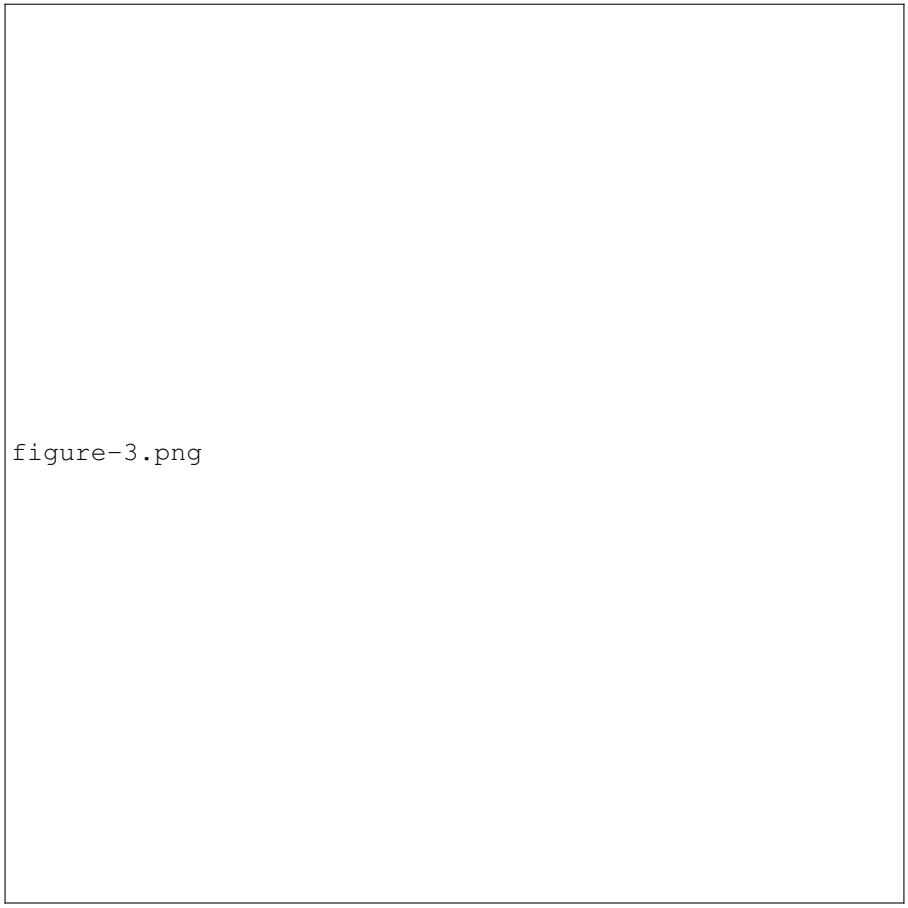

Fig. 3. The difference in channel bed level and the cumulative channel bed volume for each monitoring period. The cumulative channel bed volume is shown along a N-S transect starting from the Spiering polders (purple in Fig. 1). The budget of the Wassende Maan (blue in Fig. 1) is added at once at the second black line. The channel in the southwest of the study area was dredged in the monitoring period 2012-2015. The dredged area is excluded in the analysis and not shown in the cumulative channel bed volume.

C11

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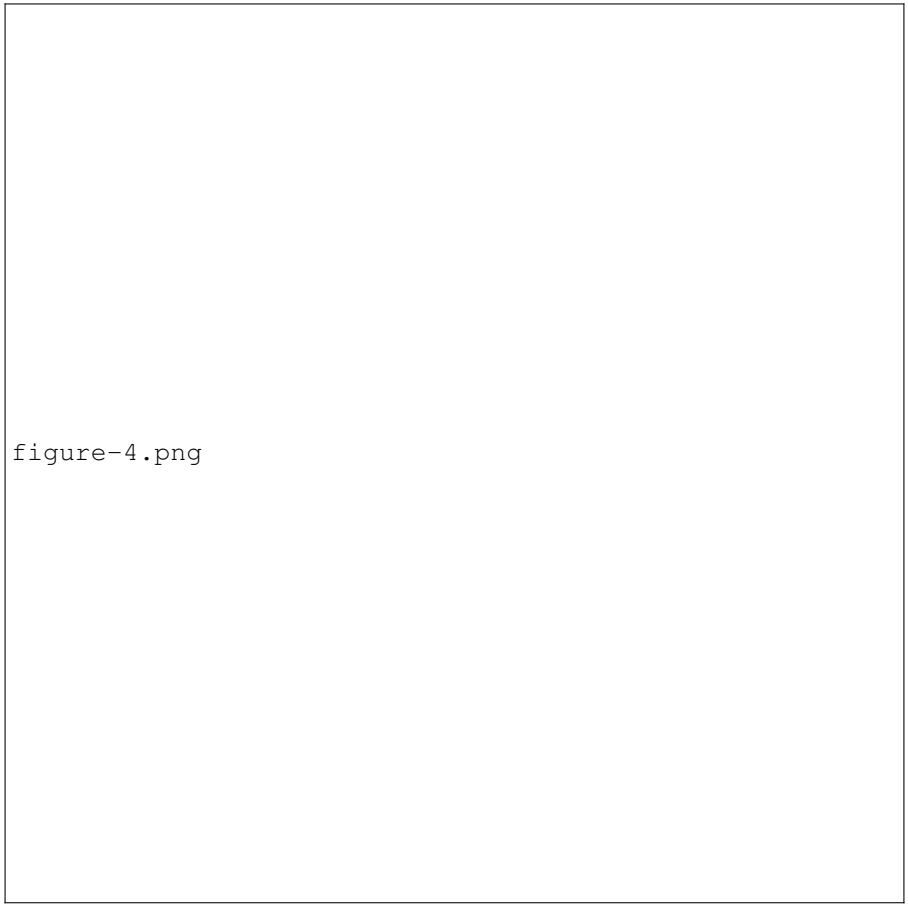

Fig. 4. Bed level of channel section 1 (a) and 3 (b) for all monitoring campaigns. (see Fig. 1 for the locations of the cross sections)