Dear editor, dear authors,

The manuscript under consideration for publication in *NHESS* assesses the effects of the managed realignment of Meshketh Out Marsh in the Ribble Estuary (UK). The study uses numerical modelling scenarios to estimate impacts on water levels, inundation extent, inundation duration, and flow velocities during multiple historic storm events. The authors run several model configurations to isolate the contributions of different compound flooding drivers. Finally, they increase the water level time series to provide insights into the impacts of various future sea level rise scenarios.

The novelty of this study lies in estimating the impact of the managed realignment project on estuarine-scale hydrodynamics. The authors focus primarily on extreme events, for which they isolate the different components of compound flooding and quantify their respective contributions. In addition, they investigate the effects of tidal dynamics and highlight the amplification of low water levels resulting from the managed realignment.

The study is conducted using an existing Delft3D-FLOW numerical model that has been developed, validated, and applied in previous peer-reviewed studies, providing a strong foundation for the present work. Overall, I consider the manuscript suitable for publication in *NHESS* after revision, with particular attention given to clarifying the research scope, improving readability, and updating the future sea level rise scenarios.

Major comments:

Research scope

The research scope is currently prone to ambiguity, as it is unclear which specific "gaps" are referred to in line 73. In the preceding section (lines 54-72), the authors introduce several issues, including the effectiveness of managed realignment (MR) under climate change, the impacts of MR during compound flooding events, the limited evidence base for MR, complex governance arrangements, financial barriers, and limited social acceptance. It remains unclear whether the study aims to address all of these challenges, which would be overly ambitious, or only a subset of them. A clear definition of the research problem and scope is essential to guide the reader and to ensure that the objectives, methods, and conclusions are appropriately aligned.

From the results section, it becomes clear that the authors focus on the impact of managed realignment (MR) on estuarine hydrodynamics during selected storm events as well as under non-storm conditions. However, the rationale for this specific focus remains insufficiently explained. Managed realignment is typically implemented to achieve multiple objectives, such as reducing flood risk, enhancing coastal protection, and promoting ecological benefits. In the introduction, the authors refer to both "coastal defence" and "coastal protection" as motivations for MR, whereas the stated objective of the study is to "investigate changes in estuarine dynamics."

The term *estuarine dynamics* can refer to a wide range of physical processes but is typically associated with the interaction between freshwater and saline (tidal) water within an estuary. These processes include mixing, stratification, and density-driven circulation, which are key controls on phenomena such as salt intrusion and sediment transport. In contrast, *coastal defence* and *coastal protection* generally refer to measures aimed at reducing coastal flood and erosion risks, often through engineered structures such as dikes, levees, and seawalls.

The study does touch upon estuarine dynamics by describing the impacts on tidal dynamics in Section 3.2. Furthermore, on page 24, it becomes apparent that embankments or levees are present in the study area and currently restrict the landward migration of salt marshes. However, given the spatial resolution of the model, it is unlikely that these relatively small-scale features are represented with sufficient accuracy. Moreover, the potential effects of managed realignment (MR) on the performance of these embankments, and on other coastal defence structures in the area, are not discussed in the results.

If the primary focus of the study is estuarine dynamics, I would argue that the modelling approach has important limitations. The applied depth-averaged (2D) model configuration is unable to represent three-dimensional density-driven processes, such as stratification and gravitational circulation, which are often fundamental components of estuarine dynamics. As a result, the scope of the conclusions regarding estuarine dynamics should either be more clearly constrained or supported with a justification of why a 2D approach is sufficient.

Alternatively, if the focus is on coastal defence or coastal protection, the study appears limited in its ability to assess the effectiveness of MR as a flood management measure. The representation of embankments and other engineered structures is not described in sufficient detail, and their interaction with the MR scheme does not appear to be evaluated. Consequently, it is difficult to determine how the reported hydrodynamic changes translate into changes in flood risk or coastal protection performance.

In addition, the presented results primarily focus on hydrodynamic conditions within the estuary itself, such as water levels, inundation characteristics, and flow velocities. In contrast, flood risk assessments typically focus on impacts in landward, flood-prone areas, with outcomes expressed in terms of flood extent, damages, asset exposure, or the number of people affected. The manuscript would therefore benefit from a clearer explanation of how the analysed hydrodynamic indicators relate to the broader objectives of managed realignment and to the societal benefits that such schemes are intended to provide.

Future effects of managed realignment

The future effects of managed realignment (MR) are strongly linked to the morphological development of the restored area. Once formerly reclaimed agricultural land is reconnected to the sea, sediment deposition may occur, leading to increases in bed elevation over time. These morphological changes will, in turn, affect local hydrodynamics. Moreover, the morphological evolution of the site will influence the extent to which salt marshes can persist and adapt under rising sea levels.

The authors acknowledge the importance of these processes but do not incorporate them into their modelling framework. For a study that aims to assess the future effects of managed realignment, this represents a significant limitation. The future scenarios presented in the manuscript are based solely on modified water level boundary conditions and implicitly assume a static morphology.

Consequently, the future scenario analysis, in its current form, provides little meaningful insight into the long-term effectiveness of the managed realignment (MR) scheme. By assuming a static morphology, the analysis neglects the very processes that are expected to govern the long-term evolution of the site following realignment, namely sediment accretion, channel adjustment, and marsh development. As a result, the projected hydrodynamic responses under sea level rise are unlikely to be representative of future conditions and may even be misleading. The future scenarios therefore cannot be considered a robust assessment of MR performance under climate change.

This limitation is fundamental rather than minor and should be reflected accordingly in the scope, interpretation, and conclusions of the manuscript. To support any claims regarding the future effectiveness of the MR scheme, the authors should explicitly account for morphological evolution, either through the sediment transport and morphological updating modules available in Delft3D or by evaluating a range of plausible morphological trajectories. Without such analyses, the future scenario results do not provide a sufficiently sound basis for drawing conclusions about the long-term impacts of managed realignment under sea level rise.

Readability and figures

The manuscript is a lengthy read. In particular, the Results section could benefit from a substantial condensation as it is rather repetitive. I can imagine the struggle of the authors to communicate all the scenarios that they have performed. I would encourage the authors to present the results at a higher level of abstraction, focusing on the key messages.

At present, the manuscript contains a large number of maps that often convey similar information and add considerably to the length of the paper without proportionally increasing the scientific value. While these figures may be useful as supporting material, many of them are more appropriate for an appendix or supplementary information. The main manuscript should instead focus on a limited number of figures that synthesise the results and highlight the most important conclusions. A substantial restructuring of the Results section would considerably improve readability and help readers better understand the scientific contribution of the study.

Minor comments:

Title: Given the scope of the study I would suggest to make clear that the focus is on flooding or hydrodynamics. For example: ".. under present-day and future compound <u>flood</u> events".

Line 24: introduce meteorological drivers here.

Line 48: ..in a more sustainable way. (compared to what?).

Line 55: Consider adding "that have unintended negative effects" to circle back to the title.

Lines 73-82: Worth mentioning "Flooding" and/or "modelling" here.

Line 83: "Section 2, the Ribble Estuary..". To prevent "Section 2. Section 3".

Line 89: Quite some abbreviations throughout the manuscript. Is that really necessary?

Line 90: No space between the value and the unit (applies to many place in the manuscript)

Section 2.1 A clear satellite image with annotations of the site would be helpful.

Line 104 and 107: Different vertical reference levels used. Please align.

Line 111: Please include the exact version that you used for the simulations.

Line 121: With the ~20 m resolution, how many grid cells are used to cross-river.

Line 147: Would be convenient to include the stations in the overview map of the area.

Line 176: What is the vertical reference level here?

Line 193: I think you meant 0.67 m.

Figure 2: fontsize too small.

Table 1 and Table 2: possible to merged these tables into a single table?

Section 3.1 I would start the paragraph with "For the three storms.. (line 205)".

Line 226: remove "on".

Line 227 – 231: addresses inundation time, thus fits better paragraph 1 of Section 3.2.

Figure 3: figures and font size way too small.

Line 243-244: I think you can omit the definition of MHHW and STR here.

Line 250: Not very strong to open a sentence with "Fig 6. shows.."

Line 259: remove "once the MR is in place"

Line 262: remove "it".

Line 274: change "on" to "at"

Line 328: The author refer quite a number of times to the Review article Temmerman et al., 2023. I would encourage the author to cite the original research articles.

Line 339: Example of passive writing style. You could rewrite it to: "The success of MR as a NbS to reduce flooding in coastal areas requires.."

Line 352: “Previous studies”, but you only cite a single study. “A previous study showed..”

Line 359-361: Cut into multiple sentence.

Line 375: That the water level increases in the MR is intended. What about the water level in flood prone landward areas?

Line 400: Good to include the presence of coastal structures in the Introduction.

Line 408: Rewrite