

## **Rebuttal letter review RC2**

Title: Field measurements of hydrodynamics and sediment transport at intertidal areas in the Dutch Wadden Sea

Author(s): Roy van Weerdenburg et al.

MS No.: essd-2026-75

Dear reviewer,

Thank you for taking the time to review our manuscript and the dataset. Your constructive comments and useful suggestions have helped to improve clarity and readability of the manuscript, and accessibility of the dataset. We address your comments below. Original reviewer comments are shown in black, while our responses are in *italicized blue*. Text excerpts from the revised version of the manuscript are included in *italicized red*.

Thanks again for your helpful review. Best regards, Roy van Weerdenburg

## **RC2 comments and suggestions**

### Major comments:

1. The introduction focuses heavily on sediment management and frames this dataset as a contribution to this field. In my understanding, sediment management describes the process of artificial sediment relocation or marine construction, e.g., through nourishments. I do not see how these data would be a major contribution to this. I'd suggest to focus the introduction more on the general aspects of understanding complex natural sediment transport patterns across tidal divides which would also result in a welcome shortening of the introduction.

*We agree with the reviewer that the presented dataset is not directly suited for the evaluation of sediment management strategies. In the introduction, however, we refer to the optimization of sediment management strategies primarily as a broader motivation for investigating the fundamental processes governing sediment dynamics, rather than as a direct application of the dataset itself. In our opinion, the societal relevance of the presented dataset lies in the way coastal and estuarine systems are used and modified by, or for, human activities. We therefore think reference to sediment management is fair, although that we indeed should not “focus heavily” on it.*

*In the revised version of the manuscript, we have rewritten parts of the introduction and merged the first two paragraphs into one. This has resulted in a shortening of the introduction and slight condensation of the text on sediment management. We have maintained the example of how the maintenance dredging of a tidal channel is affected by processes at larger, local, and smaller spatiotemporal scales, but refer to it as a monitoring activity rather than a management question.*

*In addition, we have removed the reference to sediment management strategies from the abstract.*

2. To my knowledge, the measurement devices were introduced reasonably and the process of collecting the observational data was presented well. I am, however, missing information about the uncertainty of the actual devices, their operating window, and potential implications on the presented dataset.

*Thanks to the reviewer's major comments 2, 3, and 4, we have changed Section 6: **Data samples** into **6: Applicability and limitations**. **Section 6.1: Potential applications** includes two of the three data samples that were already included in the previous version of the manuscript. **Section 6.2: Limitations** includes a discussion on the origin of uncertainties in the dataset, including instrument accuracy, turbidity sensor calibration, and data processing.*

3. Please elaborate the uncertainty resulting from the conversion of turbidity observations into SSC. Has the device been calibrated for suspended mud or also for suspended sand-mud-mixtures?

*The devices have been calibrated with local sediment samples. In the revised version of the manuscript we explicitly mention where the samples were taken and what the sand-mud content is. This calibration does not account for temporal changes and spatial variations in sediment composition in the field. In the revised version of the manuscript, we elaborate on the uncertainty in the turbidity-SSC conversion in **Section 6.2: Limitations**:*

*... Turbidity sensors have an upper operating limit due to signal saturation (Fettweis et al., 2019), but this limit was not reached during the field measurements. The main source of uncertainty in SSC timeseries follows from changes in the suspended sediment composition over time. The relationship between turbidity and SSC (Section 3.5) is sensitive to the sediment characteristics, as particles of different sizes, shapes, and mineral compositions scatter light differently (Downing, 2006). Optical turbidity sensors were calibrated with one type of sediment mixture. Therefore, the calibration does not reflect temporal changes and spatial variations in suspended sediment composition. Resulting SSC values (in mg/L) may therefore deviate from the actual concentrations. Changes in sediment composition may be estimated from acoustic and optic instruments deployed in parallel (Pearson et al., 2021; Lin et al., 2020), but such an analysis has not been performed yet.*

4. Section 6 includes some own analysis that extend beyond describing a dataset. For me, this was helpful to get a better grasp on the data. Still, I have to mention that such analyses do not match the scope of a data descriptor. I'd suggest to remove one example and to rename this section to "potential applications" (or comparable). Then, this section could be merged with your concluding remarks which are currently more of a summary of the paper.

*Following your suggestion and after consultation with the topic editor about whether to include these analyses or not, we have kept two of the analyses in the revised version of*

*the manuscript. Also thanks to your suggestions, these analyses are now referred to as potential applications of the dataset in Section 6.*

*We have been wondering how to merge the concluding remarks into section 6, but eventually decided to maintain a separate section to summarize and close off the entire manuscript, now rewritten and named **7: Summary and outlook** instead of Concluding remarks.*

5. I suggest adjustment in storing your data and in naming to concur better with the scientific standards for netcdf (CF-conventions):
  - a. The download is quite large and takes a while. As a user, I'd like to collect "raw", "processed", and "tailored" as separate downloads.

*Thank you very much for your suggestions on how to improve the accessibility of the presented dataset.*

*In the revised version of the dataset, the folders 01\_RawData, 02\_ProcessedData, 03\_TailoredData, and 04\_Processing are available as individual folders, such that users may download these folders separately.*

- b. I do not understand why there is such a difference in file size between the zipped and unzipped netcdf files. In theory, I'd expect the netcdf files themselves to be compressed – has this been considered instead of zipping?

*In the previous version of the dataset, we only applied a default compression. In the revised version, we specified for each of the variables in the NetCDF files how it can be saved most efficiently, without losing its accuracy (see `encoding_WadSED.py` in the 04\_Processing\functions folder for details). The different way of encoding the NetCDF files has resulted in a significant reduction in file sizes, of around a factor 10, such that the remaining difference between zipped and unzipped file sizes is relatively small.*

- c. It is inefficient to make one file for each station during each campaign, I'd prefer to download the variant, e.g., "processed", of all stations of one campaign, e.g., A1-A5, in one file. This'd reduce unnecessary overlap and make your dataset much easier to work with.

*We understand the reviewer's suggestion that, for certain applications, it may be more efficient to download a specific data type for multiple measurement stations from one file. However, we have deliberately retained the original file structure due to its greater flexibility across use cases. The file organization optimized for one type of analysis (e.g., a single instrument across stations) may be inefficient for others (e.g., all instruments at a single location). In addition, the dataset is heterogeneous across measurement stations: deployment and retrieval periods differ, and measurement frequencies vary among instruments at some locations (e.g., due to differences in battery capacity). Accounting for these variations in a single uniform file would substantially increase complexity of the NetCDF files. Therefore, we consider the current structure to provide the most robust format for diverse applications.*

*For easy access to the many different files, the Winter2023-24 dataset is now also available via the OPeNDAP data service of the 4TU data repository (see <https://opendap.4tu.nl/thredds/catalog/data2/djht/485bd11f-f97e-4be9-96b2-46b1f740b8cd/1/catalog.html>). We aim to publish the Spring 2025 dataset via the OpeNDAP data service as well, but the data stewards of the 4TU repository need a few more weeks to process our request.*

- d. The files themselves have no coordinate variables. Instead, the station coordinates are stored in the global attributes. This works, but I find it unintuitive. A common NetCDF (following UGRID standards) file would use separate variables for coordinates (z, z\_bounds, projected and lon/lat) and refer to these coordinates in the variable's attributes.

*In the revised version of the processed and tailored datasets, we have included the coordinates of the measurement locations not only in the global attributes, but also as variables. The elevations of instruments were already included as variables in the previous version of the dataset.*

- e. The variables of your files would benefit from including a CF-convention standard\_name.

*We agree with the reviewer that, for the subset of standard variables, adopting CF-convention standard\_names (e.g., sea\_surface\_height\_above\_mean\_sea\_level, sea\_surface\_wave\_significant\_height, or eastward\_sea\_water\_velocity) would be appropriate. However, many variables in our dataset do not have corresponding CF standard\_names. Applying the convention only partially would result in an inconsistent metadata structure. We have therefore opted for a consistent naming approach using concise variable names that are easy to use in scripts, complemented by descriptive long\_name attributes in the NetCDF files. These long\_names allow us to provide precise, dataset-specific definitions of each variable.*

- f. Minor: The global attribute for your mail address has a typo. Consider using a more general mail-address that will remain valid for a long time. Also, I like to include the ORCID of the responsible person to ensure reachability.

*Thank you! We have tidied up the information in the global attributes in the revised version of the dataset. Although we do not know for how long the @tudelft.nl email address of Roy van Weerdenburg is going to be valid, we consider it the best email address for questions about the dataset that we can provide at this moment. Next to the email address, we have also included the ORCID of Roy van Weerdenburg to the global attributes.*

**Minor suggestions:**

1. The authors denote that their campaigns capture different periods to capture calm and rough weather with the goal of providing insights into the sediment exchange between tidal basins. I find that a summer period is a significant gap in

the dataset as both chosen periods are poor in vegetation and are characterized by cold water temperatures. Please include a statement to this limitation.

*Thank you for this suggestion. In the revised version of the manuscript, we have included a statement in Section 3.1 that our two measurement campaigns do not include summer conditions:*

*... The summer season is not captured in the two measurement campaigns, such that effects of biota on sediment dynamics that peak in summer (e.g., Van Der Wal et al., 2010) are not included in the data. ...*

2. L4: ... sediment dynamics on a tidal divide in the Dutch Wadden Sea ...

*L4-6 have been removed from the abstract, thanks to minor suggestion 4. However, the measurements were carried out not just on a tidal divide, but in channels and shoals in the back of a Wadden Sea basin. These observations provide insights that are not restricted to sediment dynamics on a tidal divide.*

3. L7: The presented dataset...

*We have changed resulting dataset into presented dataset:  
The presented dataset contains point measurement ...*

4. L4-6 and L12-16 basically mean the same thing. I'd suggest to remove L4-6.

*We have removed L4-6 and thereby the reference to sediment management strategies from the abstract.*

5. L24: You mean efficient sediment management?

*We changed effective sediment management into efficient sediment management:  
... Both sediment surpluses and deficits pose challenges to coastal functions, including flood protection, ecological value, and the accessibility of ports and waterways, highlighting the need for efficient sediment management. ...*

6. L56: ... above-mentioned campaigns already ...

*We changed While the above-mentioned data sources into Despite the regular monitoring and earlier campaigns, to also address the regular monitoring programs that are discussed in the previous paragraph:*

*Despite the regular monitoring and earlier campaigns, integrated observations of sediment transport across the larger channel-shoal system remain lacking.*

7. L67: Reserve project names for the acknowledgements

*We agree on the fact that project names should in general not be included in the manuscript. However, the presented dataset is published in an online repository as the WadSED dataset. In our opinion, it could be a helpful reference to have this name*

*mentioned in the manuscript as well. We have therefore kept this sentence in the manuscript, at the end of the introduction:*

*The dataset is published as the WadSED dataset, as the field campaigns were initiated within the WadSED project.*

8. L82: I am very sure that these papers are not in prep anymore.

*The reviewer is right to be very sure about this. The in prep. comment was relevant for another article that we were planning to refer to, but since this article is not published yet, we removed the reference to it already in the previous version of the manuscript. In the revised version, we have also removed the in prep. comment.*

9. L87: I do not agree that the Dutch Wadden Sea imported more sediment than required. If anything, sediment import has increased due to land reclamation and the closure of the Zuiderzee. Also, the Dutch Wadden Sea currently accretes too little to cope with SLR (see Pineda Leiva, et al., 2025 for reference 10.1038/s43247-025-02340-y).

*In Section 2, where we introduce the morphology of the Dutch Wadden Sea, we refer to sediment import following the closure of the Zuiderzee and Lauwerszee. Based on Wang et al., (2018), we note that this import contributed not only to channel infilling but also to the accretion of intertidal areas. At this long timescale, the imported sediment volume was more than sufficient to compensate for SLR. In our view, a detailed discussion on whether current accretion rates are sufficient to keep pace with sea level rise, although highly relevant, falls outside the scope of this introductory section. Addressing this question would require careful consideration of the associated nuances and methodological sensitivities, which we think are essential for interpreting results from studies such as Pineda Leiva et al. (2025) and others. In the revised manuscript, we have replaced the statement that the Dutch Wadden Sea has imported more sediment than required to keep pace with sea level rise into a statement that the import of large amount of sediment over the past century has led to both the infilling of channels and the accretion of intertidal areas. We think both statements have the same value in this introductory section.*

*Following large-scale human interventions in the 20th century, most notably the closure of the Zuiderzee in 1932 and the Lauwerszee in 1969, the Dutch Wadden Sea has imported large amounts of sediment, leading to the infilling of channels and accretion of intertidal areas (Wang et al., 2018; Elias et al., 2012; Colina Alonso et al., 2021).*

Also, what do you understand as extensive dredging? Please quantify.

*The extensive dredging reaches 2-3 million m<sup>3</sup>/year for channels in the Dutch Wadden Sea (excluding the Ems estuary). We have added this information to the final sentence of Section 2:*

*At present, extensive dredging is carried out to maintain the fairways to the barrier islands and the North Sea (2-3 million m<sup>3</sup>/year in the Dutch Wadden Sea excluding the*

*Ems estuary and port maintenance dredging), reflecting the generally high sediment availability in the system.*

10. L92: I am unsure if the term “morphological units” is broadly understood. You could also consider defining tidal divides.

*Thanks to both reviewers' comments, we have removed the term morphological units from Section 3.1, to focus our introduction on the sediment exchange processes at two different spatial scales.*

11. F3: I assume the axes refer to %? Please label the axes.

*Yes, the axes indeed refer to %. In the revised version of the manuscript, we have added these labels to the figure. Figures are scaled compared to the previous version to apply the same axes in each of the three windows.*

12. F3: It looks like wind speeds >20 m/s were rarely reached. Re-allocating your bins in the diagram would add much more information to the reader.

*Thank you for sharing your suggestions for improvements to our figures. Indeed, wind speeds > 20 m/s were rarely reached. We changed the bin size from 5 to 4 m/s, such that the windroses provide more information in the wind classes that are frequently observed.*

13. L146: Add numbers to the exceptionally high water level  
We have added the maximum water level to Section 3.2:  
*The resulting water levels in the Dutch Wadden Sea (3.19 m NAP at Nes; Figure 4) were the highest since 2006.*

14. L167: Introduce the abbreviation “NAP”  
*In the revised version of the manuscript, we introduce the NAP abbreviation the first time it appears in the manuscript, which is in Figure 1.*

15. T3: %OM and %CaCO<sub>3</sub> are N/A for A2 to A4. Please elaborate.  
*Only the samples that are collected during the Spring 2025 campaign are analyzed with the TGA701 Thermogravimetric Analyzer, as discussed in Section 3.4. The %OM and %CaCO<sub>3</sub> for locations A2-A4 therefore remain unknown.  
For clarity, we have in the revised version of the manuscript also included this explanation in the caption of Table 3.*

16. L290: Specify if these data are open or disclosed data.  
*In Section 5, we have limited ourselves to regular monitoring programs that provide open datasets, available via online data portals or via scientific (data) publications. Although the SUBES dataset is not yet publicly available, we have decided to include it in the manuscript because we expect the dataset to be published in the near future.*

*We have now included at the start of Section 5 that the section is about open datasets.*

*The analysis and interpretation of this dataset can be complemented by several supplementary open datasets obtained through regular monitoring programs in the Dutch Wadden Sea, ....*

17. L291: Specify how these SSC were sampled (calibrated turbidity sensors or water samples?)

*These SSC measurements are obtained by collecting water samples. We have added to Section 5 that suspended sediment concentration are monitored through monthly to bimonthly water sampling.*

18. L294: The online form of RWS is mentioned for the second time here.

*The form to request data obtained by the long-term water quality monitoring program and bathymetric surveys is different from the online portal to request water level observations. So, although these two forms look similar, they are different. We expect the direct links to these forms to be useful for users (outside of the Netherlands) who are not familiar with the different data platforms of Rijkswaterstaat, and decided to keep both links in the manuscript.*

19. F11, F12: Please use color-deficiency compliant colormaps such as cmocan or cmcramer.

*Thank you for providing your guidance on the use of color-deficiency compliant colormaps. We have changed the colormap in Figure 11 to one of the colormaps in the cmcramer collection. The original Figure 12 is not included anymore in the revised manuscript, thanks to changes after one of your major comments.*

20. L335: Remove extensive

*We have removed extensive from the manuscript.*