We would like to thank Reviewer 2 for his/her thorough review and constructive suggestions. In this response we are addressing his comments and feedback. We have numbered the reviewer's comments (**R2.1, R2.2** etc.) in order to facilitate referencing to each comment. We have added here all the changes in manuscript (shown with green). The pages and line numbers in our responses refer to the revised manuscript with track changes.

Reviewer 2

Athanasiou et al. present a framework that combines artificial neural networks and process-based modelling (XBeach) to derive estimates of dune erosion during storms on the entire Dutch coast. The approach yields a prediction skill with an RMSE of 19 m3/m, which is reasonable given the 1D-approach and the simplification of the hydrodynamic boundary conditions. The model can provide estimates of dune erosion volumes within seconds, making it a crucial new approach for assessing potential dune erosion hot spots as storms develop and hit the coast.

The authors provide a very well-written and clearly structured manuscript. The relevance and need for their work is clearly outlined in the introduction section, and reflected upon in the discussion section. The approach is detailed in an elaborate manner, making it reproducible for application of the technique elsewhere. Assumptions and limitations underlying the approach are made explicit and tested as part of the results. There is room for improvement, which is clearly addressed by the authors and this work forms a solid basis to do so. The inclusion of oblique wave incidence would be a crucial next step. As such, this work is relevant to the research field and the readers of NHESS and, after taking the comments below into account, I recommend this manuscript to be published with minor revisions.

We would like to thank the Reviewer for the positive comments.

COMMENTS

R2.1:

L84-86 A preview into the method is given here, by introducing the two-step approach with (1) a classifier and (2) a regressor. This is further elaborated in the methods section. It is unclear to me why the first step is needed if the regressor may also yield DEV=0. Please elaborate on why this choice was made.

The regressor cannot yield DEV=0, since the DEV prediction is transformed from the logarithmic scale (see Line 319: "*…and the final DEV estimation was acquired by using the exponential function on the output neuron to transform them back to real units.")* and trained only with cases that have DEV > 0 (see Lines 316-317: "*For the regression ANN only the cases where* $DEV > 0$ *were used, which comprised 79% and 77% of the total cases in the training and benchmark cases, respectively.*").

The choice of having both a classifier and a regressor had a two-fold purpose. First, after some testing we found that the classifier by itself had a better skill in estimating the binary dune erosion response, i.e. there is or there is not a dune erosion event, when compared to using a regressor that would have to estimate erosion quantities as well as non-erosion events. Secondly, the exclusion of cases with DEV<=0, during the training of the regressor, allowed for a log-transform of the DEV quantities in the training of the regression ANN, which resulted in a better model performance during prediction at different orders of magnitude of DEV (see Lines 317-318: "*The DEV values were first transformed to* $\log(DEV)$ *to ensure that during the calculation of losses, similar importance was given to minor and larger DEV cases (van Gent et al., 2007).*)".

We summarize these points in:

[Lines 272-273] : "With this 2-phase approach we ensured that overprediction for smaller DEVs was avoided and enabled the prediction of zero DEV (Verhaeghe et al., 2008)."

R2.2:
L227 Here the reader is referred to the discussion section on the impact of assuming shore normal wave-incidence for dune erosion predictions; this may lead to an underprediction of dune volumes. Please briefly mention (1-2 sentences) the implications of this here, in section 2.4, so it is clear to the reader before starting to interpret the results.

We agree and we have now added this sentence:

[Lines 229-231]: "This assumption may lead to underestimation of dune erosion when the generation of alongshore currents becomes important for sediment stirring and thus sediment transport (de Winter and Ruessink, 2017)."

R2.3:
L233-235 DEV<0 was predicted by XBeach, and the presence of newly-formed dunes is mentioned as a possible cause and deemed non-representative of the dune response. Such local accretion has been observed elsewhere, e.g. Cohn et al, GRL (2018) or Harley et al., Nature (2022), and may result from alongshore variability in pre-storm morphology. This cannot be accounted for by the 1D model used in this study, but such variations may develop during relatively small SSL, as pointed out by the authors. I feel this should be mentioned for completeness and for the translation of the model results to field observations.

This is a very relevant comment and we thank the reviewer for the references. We have now added this sentence:

[Lines 241-243]: "Additionally, local accretion can be connected with alongshore variability of pre-storm morphology (Cohn et al., 2018; Harley et al., 2022), but cannot be resolved with the 1D approach used in this study."

R2.4:
Section 4.2
I agree that including oblique wave angles would be an important next step, as storms on the Dutch are not shore-normally incident everywhere along the coast.

We agree and added this:

[Line 503]: ".. storms are not everywhere shore-normally incident along the Dutch coast ..."

R2.5:
Would this model be able to capture the response (DEV) to a storm of a dune that has not yet recovered from a previous storm? Or is this captured in the morphological inputs fed to the ANN? I.e. can this model structure deal with sequences of storms?

This is a really interesting point raised by the reviewer. In its current format the meta-model cannot directly deal with storm sequences, since the output is an indicator (DEV) and not the complete post-storm profile. Information on the new profile morphological characteristics after the 1st storm would be needed as input to make an estimate for the 2nd storm. To this end, this could be accomplished if the meta-model is updated to extract post-storm profiles (or profiles characteristics) instead of only an erosion indicator.

R2.6:
In addition to the parameters mentioned that may also be of interest and are reported in the literature, the authors may consider adding nearshore bar morphology, as observed by e.g. Castelle et al 2015 and touched upon by the authors in the introduction section. This also relates to the possible future expansion of the method discussed in L540-544.

We have now added this part:

Lines [520-521]: "In the presented meta-model, the nearshore area of the profile was only described by the nearshore slope. However, pre-storm bar morphology is of importance for post-storm dune erosion (Castelle et al., 2015)."

R2.7:
L549-550 The presented framework would be a very useful starting point for application elsewhere. Will the code be made openly available (e.g. a Jupiter notebook, or through GitHub)? If so, please include the link.

The ANN framework was developed based on the Python packages Keras and Tensorflow, which are free to use. In essence, for an application elsewhere, these packages could be employed with a new training dataset derived for the case study. To this end, it was decided not to make the code openly available, since the manuscript outlines in detail all the steps that are needed for an application elsewhere. Nevertheless, we would mention in the manuscript that the code can be provided upon request.