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Earth Surface Dynamics Discussions

Interactive comment on "The Influence of Dune Aspect Ratio, Beach Width and Storm Characteristics on Dune Erosion for Managed and Unmanaged Beaches" *by* Michael Itzkin et al.

Anonymous Referee #1

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The manuscript under discussion here has as major purpose to analyse dune erosion as a function of dune aspect ratio (i.e., dune height versus dune width) for storms of varying intensity and duration by simulating hydrodynamic processes, sediment transport, and morphologic change. For that, the authors create a series of synthetic dunes to run a series of sensitivity analysis.

The manuscript is well organized, easy to read and clearly presents its objectives. However, I am afraid that the outcomes from the author's experiments do not actually support their conclusions, and more important, are not the best to address the original objective. The conclusions reached by the authors overlap very well grounded facts,

namely the importance of the beach width as a major control of dune erosion, stated by several earlier works; e.g. review works (Davidson, Hesp and Miot da Silva, 2020) and works based on field observations (e.g. Burroughst and Tebbens, 2008; Charbonneau et al., 2017; Claudino-sales et al., 2008; Crapoulet et al., 2017; Galiforni Silva et al., 2019; Héquette et al., 2019; Itzkin et al., 2020; Keijsers et al., 2014; Pye and Blott, 2016), making it difficult to understand what is the actual contribution of the manuscript other than calling our attention to the fact that dunes may erode over time (usually not by a single storm), reducing their capacity to prevent overwash and inundation, depending not only on their elevation but also on their width. I believe that it would make more sense to me to call our attention to the fact that the shape of the dune, not only the aspect ratio as that might be a bit limiting indicator as the shape of a dune can vary very much, turning it very important to consider indicators that inform about the volume, in addition of course, to the elevation, as that is the key parameter that determines the impact regime, the impact can shift to overwash or inundation if a particular height is maintained over a certain width of the dune, but this is not informed by the aspect ratio. So, I would say that additional information other than only the aspect ratio would be needed to actually understand if a particular dune can cope with the impact of one or several storms if the shoreline is retreating (or if the dune is being eroded) the aspect ratio of the dune may also change, as they are all but very irregular features.

In this line, the authors state that the amount of dune erosion or the vulnerability of coastal dunes does not only depend on dune height but also on its width, as dunes can also erode by collision regimes, and thus, an aspect ratio that includes both dimensions should be used instead of only the elevation. In addition, they also state that dune erosion might be influenced by this aspect ratio. In general, I do agree with the hypothesis stated by the authors, however, I cannot fully agree with the approach used to support their statements and reinforce my concern regarding the originality of the contribution from this work. My main concern is linked to the experiments chosen by the authors, namely to the synthetic dunes used and the way the authors have decided

to create the four different configurations, which ended up having dunes with different morphologies (symmetric, non-symmetrical and with changing front dune slopes) and different distances to the shoreline that cannot be easily compared. In fact, the results suggest other factors might be more important than the dune aspect; namely the beach width, which determines the level of impact of the storm over the dune.

I will try to synthesize my concerns focusing on some statements from the abstract of the manuscript and mainly linked to the results of the experiments or simulations.

The authors state in the abstract that "low aspect ratio (low and wide) dunes lose less volume than high aspect ratio (tall and narrow) dunes during longer storms, especially if they are fronted by a narrow beach". Regarding the first part of the sentence and looking at Figure 7, where the results from the simulations are presented, it is not so obvious this affirmation as low aspect ratio dunes only erode less when using the fixed dune toe configuration (narrowing the size of the beach). The higher aspect ratios in this case are related to dunes with very steep seaward slopes resembling scarped dunes. As the authors state, and following Hesp 1988, these dunes can be more unstable and have greater probabilities of crest collapse, is all the sediment from the collapsed dune removed by the waves? Having in mind the main principles of dune/beach erosion, the amount of volume eroded should not be very different or dependent on the dune shape, but on the volume of sand that needs to be eroded as it is a response to adjust the beach profile to more energetic waves. It is not so obvious from these results that low ratio dunes erode less, as the authors change the shape of the dunes and their distance to the shore, and therefore, they cannot be easily compared anymore. In this regard, I would imagine that a more synthetic dune would help and allow direct comparisons. By a more synthetic dune I imagine something that preserves the slopes (shape) changing the ratio (even though not so realistic, a cube would make it easier). In fact, when looking again at figure 7, the lower ratio dunes are eroding more for all cases but the toe fixed one, which is due to a change in the seaward slope of the dune and not merely to a change in the ratio, as those have very very gentle slopes that

do not make easy to identify which is the actual location of the dune toe (or transition to the beach). So, from what is shown here, high ratio dunes are not "specially" losing more volume of sand when the beach is narrow as the authors state, but "only" when the beach is narrow, otherwise they almost don't lose sand. The latter results from the fact that the other configurations (fixed crest and heel) present wider beaches and so, they may enter the collision regime later, or not at all. The authors also suggest that this affirmation mostly applies to longer storms. However, from figure 7f, j, g, k, we see that the erosion increases over time also for low aspect dunes if the configuration of the dune is different, so, again, the problem of comparing dunes with different shapes and distance to the shore does not help interpreting the outcomes of this work, and to assess the role of the ratio.

Also in the abstract, the authors affirm: "During more intense storms, low aspect ratio dunes experience greater erosion as they are more easily overtopped". I see again a problem when comparing dunes with different shapes and distances to the shoreline. The affirmation sounds totally logic to me as the amount of volume needed to erode depends on the magnitude of the storm, and as stated by previous authors: "one of the most significant factors affecting the magnitude of spatial and temporal change to a foredune during an erosion event is the height of the mean water level during the storm (Davidson, Hesp and Miot da Silva, 2020 and references therein)", and in fact this is the main factor that the authors assess when changing the magnitude of the event, the water level. However, when looking again at figure 7 (namely 7i), high and low aspect ratios share maximum volume loses, and in fact the main difference with fig.7e, is the fact that a higher water level reaches the low aspect ratio dune crest more easily than low water levels. Conversely, low aspect ratio dunes for the configurations other than the fixed toe one, are more vulnerable because their toe is closer to the shoreline when compared to the high aspect dunes, which are far from the shore in the crest and heel fixed configurations, which in turn makes it difficult to compare volumes of erosion.

Still in the abstract, the authors state that in managed scenarios (by managed dunes,

they refer to those sites where a fenced dune is constructed seaward of the existing natural dune) a fenced dune effectively prevents the natural dune behind from experiencing volume loss. Again, this is what should be expected as having a fenced dune implies in their case that the shoreline is again seaward and distant from the toe of the natural dune, resembling a wide backshore. Yet, the authors mention that the volume loss can be reduced up to 50%, which is a number that depends on their experiments, as if they have built a larger fenced dune it would be greater, also if instead of using the toe fixed they had used the crest or heel fixed configurations, that % would increase. So, again, it is not clear the point/contribution of the authors as these are well grounded ideas/facts usually used for the managers to design the actions to take.

In this line, the authors also state: "a wide beach offers the greatest protection from erosion in all circumstances regardless of dune morphology or storm characteristics". This is again, the expected result, so, are the authors trying to convince the readers that XBeach can simulate erosion? And yet, this is again something that many examples in the literature have demonstrated. Finally, and yet in the abstract, the authors end saying: "in maintaining wide beaches and dunes, the protection offered in the short-term must be considered against long-term detrimental effects of potentially limiting overwash fluxes, which are critical to maintaining island elevation as sea level rises". This idea is developed at the end of the discussion section. From what I understand, a nourished beach, if using the adequate sediments, could provide the needed sediments for the dune to cope with sea-level rise as that is the regular mode dunes grow vertically. The authors claim that maintaining large beaches would prevent rollover and thus, the natural adaptation of the barrier to sea-level rise. Here, I cannot agree with the authors because barriers, if sediment input is enough (so they maintain their beach, even if artificially) can adapt by adapting the vertical elevation of the dune feed from the abundant sediments of the beach, and not only through rollover, right? I see more the problem of being able of maintaining large beaches with the adequate sand and in terms of costs. In this context, if sea level rises, so will the nourished beach berm and thus the dune, unless winds are not efficient anymore, which seems not to be the

case in the future. Therefore, I would recommend the authors to better explain what the actual message is that they try to highlight here and to state what is their opinion about the possible coupled adaptation of the dune in that context.

More specific comments: Regarding the introduction, I would expect here that the authors present the main factors controlling the magnitude of dune erosion by storms, as this will be the main point of discussion, also considering the scales of change, from a single storm to a series of storms or the time-scale of relevance for managing would be interesting. In relation to the methods, they mention that the effect of the configuration of the beach, namely the beach slope, will be also assessed, however, this is not thereafter clearly evaluated. In line 281, I would add here the importance of the width of the dune to the impact of storm groups also.

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