

Interactive comment on “Exploring the contributions of vegetation and dune size to early dune building using unmanned aerial vehicle (UAV)-imaging” by Marinka E. B. van Puijenbroek et al.

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Thank you for your comments and the helpful feedback, which will help us improve both clarity and impact of the MS. Below we provide a point-by-point response to the comments, including their consequences for the MS.

Reviewer comments are indicated with open bullet points, whereas our response is indicated with a dash.

Kind regards, also on behalf of all co-authors

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Marinka van Puijenbroek

Summary: This is a very interesting piece of work that assesses the relationships between vegetation and dune morphology based on UAV surveys. The authors successfully follow the contributions of vegetation and dune morphology to dune development on a large beach in the Netherlands. A truly interesting part of this study is the fact the dune growth is determined in summer and winter by dune size and vegetation respectively. I believe the paper is a valuable contribution, and I think it should be published after the authors have clarified/reviewed a few points. I have no issues with the work per se in terms of the statistical analyses applied to relate dune volume with both vegetation species and characteristics. However, I have some moderate comments regarding the analysis of the UAV acquisition and processing.

Moderate comments

o There are only 5 ground control points used which are not homogeneously located in the investigated study site (e.g. not in each corner and middle of the site). Thus, my concern is that the sum of error from data acquisition to DTM generation is likely to be above 5cm. Also the error of the DSM for each survey is likely to be different due to difference of weather conditions and survey acquisition. I would suggest the authors to report the error of the DSM of each survey.

- Thank you for calling attention to this aspect. We set out to calculate three potential sources of error: 1) the vertical error associated with the use of photogrammetry, 2) the error involved in performing multiple campaigns and 3) the relationship between NDVI and vegetation biomass. Concerning 1) The vertical error of the DTM ranged between 0 – 20 cm. This value did depend on the distance to the ground control marker, further from the marker the higher the vertical error. This vertical error means for the dune volume that there will be an error in dune volume between 5 – 12 % depending on the vertical error. Concerning 2), the repeatability of the photogrammetric reconstruction was on average 3 cm. We do not expect the vertical error error to affect our results

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however, since the measurement error is random in nature and not systematic making explanatory variables less significant rather than more significant. The third point is discussed in the comments below.

- We will add information on the accuracy of the photogrammetry reconstruction to the results and discuss the implications of the accuracy of the photogrammetric reconstruction for our results in our discussion.

- We will include in the supplementary data 1) graphs of the frequency distribution of the vertical error, 2) the relationship between distance of the ground control marker and the vertical error, and 3) a graph on the repeatability of the photogrammetric reconstruction. In the supplementary data we also included two tables of the deviation of the dune volume for different vertical errors and information about the dense point cloud for the different mapping campaigns.

- o Unfortunately no field vegetation height surveys are reported to be carried out during the UAV flight. Could the authors report the error of vegetation height extracted by the difference between DSM and DTM? I would expect a difference between summer and winter since the vegetation binding is likely to be higher for the latter.

- Unfortunately we did not measure the vegetation height during our mapping campaigns and can therefore not report the error of the vegetation height. The maximum vegetation height calculated in our study is most likely an under-estimation, because the during photogrammetric reconstructions outliers are removed. During winter the maximum vegetation height will most probably be lower, partly because in the field the vegetation height is lower. The NDVI signal is also lower and this will also result in a lower maximum vegetation height, especially for the dunes covered with *Elytrigia juncea*, since their NDVI signal is very weak in winter.

- We did relate the summed NDVI per dune with the biomass of the vegetation per dune (see response earlier comment). We did not find a significant relationship between the NDVI and the biomass on a dune, but this was partly due to the low sample size.

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Biomass also includes vegetation parts such as stems and litter, and these parts do not contribute (much) to the NDVI signal, which could explain the absence of a correlation. We will add this result to our manuscript.

o I would suggest the authors to be critical about the limitations of their technique.

- We agree that it is important to be critical about the limitation of the UAV monitoring, and therefore we will add a paragraph to the discussion, which discusses how the accuracy of the DTM could affect our results.

o I think that it would be nice if the authors present the DTM, DEM and orthomosaics for each survey in a Figure. This could help further to support the analysis.

- We agree, and will include a graph with the DTM, DSM and orthomosaic for each mapping campaign in a figure in the supplementary material.

Minor comments:

o In the abstract, some result values should be added to support the interpretation of the findings. I would not suggest to have biogeomorphology as a keyword because it is not mentioned in the text of the manuscript.

- We will add some result values in the abstract and remove biogeomorphology as a keyword.

o I would suggest to modify Figure 1 by: adding a ground picture where dunes, and vegetation could be visualized and locating the foredune.

- We will add a ground picture of the area, unfortunately there is no photograph from which we can clearly indicate the foredune.

o The methodology section is quite long. I would suggest to have a separate study site section. Also I think that it would be easier for the reader to have a figure of the workflow of the methodology.

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- We will add a title above the study site section. We will add a figure with the workflow of our methodology.

o Could the authors justify the thresholds used to define the dunes in lines 184-185.

- We will add this sentence to justify the thresholds used to define dunes: The 5 cm threshold is the minimum that can be accurately derived from the images and corresponds with visual estimates of nebkha dune foot; Pixels above 5 cm indicated sand deposition, and a slope of 15° has been earlier identified by Baas et al (2002), as the slope for a shadow dune.

o Authors said that there are 11 blocks landward from the foredune in line 236 . However only 10 blocks could be seen in Figure 2.

- There are 11 blocks landward from the foredune, however in our figure 2 one block was cut off by the edge of the figure. We will change figure 2 to show all the blocks.

o In Figure 4, the markers for seaward and landward cannot be differentiated. They should not be the same.

- We will change the markers for the seaward and landward situated dunes, so that they can be differentiated.

o I truly enjoyed the discussion part. I checked the references and found them all correct and found them all correct (i.e. references cited in the text are in the list and vice versa). The manuscript is well written. I could not find grammatical errors or awkward sentences that would distract me as a reader. On the contrary, the text is easy to follow. I believe the manuscript should proceed to publication after the revision outlined above. UAV systems are becoming more and more accessible to a wider community and hence I believe contributions such as the one outlined in this paper will be welcome by a number of other coastal researchers.

- Thank you for your comments, we are glad you liked our discussion.

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