EGU22-13172
https://doi.org/10.5194/egusphere-egu22-13172
EGU General Assembly 2022

Morphological effects of beach buildings: from field experiments to CA modelling

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Buildings in active aeolian environments change the morphodynamics of their surroundings. By altering the wind field and windblown sediment transport, they create patterns of deposition and erosion. These patterns can block access to infrastructure such as roads, beach entrances and buildings. They can also have repercussions for coastal safety, if buildings reduce dune growth by intercepting sediment transport into the dunes. Therefore, we examined the effects of buildings in a sandy beach environment, using a combination of field experiments and cellular automaton (CA) modelling.

Deposition and erosion patterns around buildings were examined using experiments with cuboid scale models of buildings, placed on the beach. The results show that buildings create deposition upwind of a building and in two deposition tails behind the building, with some scour along the upwind building wall and side walls. The horizontal extent of these patterns depends on the building height and the width perpendicular to the wind direction (Poppema et al., 2021). Next, scale models with square wind-facing surfaces were placed in a row perpendicular to the wind. Morphological patterns appear to depend on the building spacing. For narrower gaps, downwind deposition decreases behind the gaps, while increasing at the outside of a building group. In addition, buildings spaced less than one building width apart intercept more sediment transport, leading to more upwind deposition (Poppema et al., 2022).

Next, we include building effects in a morphodynamic CA model, to examine the effects of building on a larger beach area and longer time scale (up to 15 years). Thus far, CA models have only been used to study natural bedform dynamics. These models are based on a grid of sand slabs to represent elevation. Probabilistic rules govern the erosion and deposition of slabs, based on for instance the presence of dunes (Baas, 2007). New rules are needed to represent the sediment transport dynamics around buildings. Therefore, we added CA rules to represent acceleration of sediment (scour) and deceleration (deposition) around buildings, as well as sideward sediment transport for sediment diverted around buildings.

Comparison of model results with field experiments indicates that simulated deposition and erosion patterns show good agreement with observations. The CA model replicates the shape and location of the bedform pattern around a single building. In addition, it reproduces effects of building spacing on this pattern for building groups. Next, longer-term morphodynamics were examined with the model. These simulations show that interaction of natural bedform dynamics with morphological patterns around buildings can alter the shape, growth and migration of sand dunes.

References

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