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Prediction of beach surface moisture content with ModFlow modelled groundwater fluctuations

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Surface moisture exerts a strong control on aeolian transport from the beach toward the foredune and shows substantial spatiotemporal variability induced by tide-induced groundwater fluctuations as well as the presence and dynamics of intertidal sandbars. Here we explore groundwater-moisture dynamics on the barred beach of Egmond aan Zee using the ModFlow model to compute groundwater depth and a retention curve to relate groundwater depth to surface moisture. ModFlow is a modular finite-difference flow model, which solves the volume balance by using a groundwater flow equation based on Darcy's Law. With calibrated values for the model's free parameters based on data available at the site, ModFlow shows good skill in fitting modelled groundwater depth to measured groundwater depth. For the wet zone (close to the waterline) the root-mean-square error (RMSE)=$\sim$0.05 m and r-square=$\sim$0.96, for the intertidal zone RMSE=$\sim$0.03 – 0.05 m and r-square=$\sim$0.96, and for the back beach RMSE=$\sim$0.17 – 0.34 m and r-square=$\sim$0.53 – 0.83. The high RMSE for the back beach can be ascribed to the fact that the model has problems with capturing the groundwater overheight; modelled groundwater depth sits deeper for the dry beach compared to measured groundwater data. However, variations in groundwater induced by the tidal amplitude coincide for the modelled and measured data. When translating groundwater depth to surface moisture maps, the modelled surface moisture maps are in good agreement with TLS-derived maps at the site, and show the same surface moisture zones as the measured data does, namely: the wet zone ($\sim$18%-21%), the intertidal zone ($\sim$5%-21%) and even the back beach ($\sim$3%) is similar to measured data. Over time the intertidal zone shows the largest fluctuations, whereas the back beach and the wet zone stay rather dry and saturated, respectively. The bar-trough system perturbs this overall pattern with the bar showing moisture characteristics as the upper intertidal beach and the trough as the wet zone. We are currently, in an exploratory fashion, examining how the location and size of the sandbar affects the spatiotemporal moisture variability and how this affects the size of the beach that is potentially available for aeolian transport.