

Parameter uncertainty in medium-term coastal morphodynamic modeling

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Abstract

Rising sea levels and anthropogenic activities are intensifying pressure on coastal zones. Process-based coastal morphodynamic models are increasingly used to forecast natural and anthropogenic beach morphology changes at various spatio-temporal scales. Such predictions are crucial for the sustainable management of coasts. However, process-based morphodynamic models contain numerous free model parameters, introducing uncertainty in predictions. Systematically exploring the parameter space has remained a challenge due to the high computational demands of these morphodynamic models. Here, for the first time we quantify parameter uncertainty of a state-of-the-art morphodynamic (2DH) coastal area model (Delft3D) by systematically varying key model parameters, utilizing the Dutch national supercomputer: SurfSara. We simulate the initial (14-month) response of the Sand Engine, an innovative mega-nourishment placed along the Holland coast with 1024 strategically chosen parameter sets. The resulting simulations are analysed using *Generalised Likelihood Uncertainty Estimation* (GLUE) to attain probability distributions of morphological evolution and its sensitivity to parameter settings. The model simulations all show an alongshore redistribution of sediment resembling what is observed. However, even simulations with similar skill reveal substantial differences in predicted morphologies (same order of magnitude as the predictions' 90% confidence interval). Our findings suggest that identifying a single optimal parameter set for coastal numerical models might be unrealistic, even for well-defined cases like large-scale coastal interventions, and that an ensemble modeling approach that quantifies parameter uncertainty is likely better suited for studies relying on morphodynamic predictions. Furthermore, we find that the magnitude of the uncertainty induced by the free model parameters is comparable to that resulting from year-to-year variations in wave climate, underscoring the importance of including both sources in uncertainty assessments.

Keywords

Parameter uncertainty, GLUE, Process-based-coastal area models, Uncertainty quantification, Coastal dynamics, Mega nourishment

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