ENHANCED SHORELINE MODELLING USING DATA ASSIMILATION TO INCLUDE NON-STATIONARITY IN WAVE CLIMATES

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BACKGROUND

Coastal zone planning requires tools to predict shoreline response to changes in waves, water levels and sediment supply at time scales ranging from daily to decades. Despite the complexity of the underlying processes driving coastal change, the emergence of a range of semi-empirical models is proving to be increasingly successful at predicting shoreline response at seasonal to interannual timescales (e.g. Davidson et al., 2013). Recent improvements include the addition of processes such as longshore sediment transport and shoreline recession by SLR (e.g. Vitousek et al., 2017). But notably, in all these model formulations to-date, free-parameters are assumed to be time-invariant, relying on calibration over relatively short periods to measured shorelines and wave climate.

Adopting a time-invariant set of model free-parameters ignores the bias introduced by the training dataset and any likely future changes in beach state and forcing conditions. The alternative approach presented here allows for time-varying model parameters, with the potential to improve model predictability due to non-stationarity in the underlying forcing.

METHODOLOGY

This work makes significant advances on previous shoreline modelling efforts by considering model parameters as potential time-varying quantities, as is common in the field of hydrology (e.g. Pathiraja et al., 2016). This is achieved by adopting a suitable data assimilation technique (Dual State-Parameter Ensemble Kalman Filter, EnKF) within the established shoreline evolution model, ShoreFor (Splinter et al., 2014). The method is first tested and evaluated using synthetic scenarios, specifically designed to emulate a broad range of natural sandy shoreline behavior. This approach is then applied to an 8-year real-world shoreline dataset in the Gold Coast, Australia.

RESULTS

Analysis of synthetic cases confirms that the EnKF technique is suitable for tracking time-varying parametrizations. Application to a real world dataset (Figure 1) provides enhancement over previous time-invariant calibration methods. This overall improvement is now provided by the time-varying magnitudes of c^a, c^e, ϕ parameters and their uncertainty, resulting in higher accuracy shoreline predictions spanning the total 8-year observation period. It is anticipated that the wider application of the approach presented here will be useful for exploring parameter variability as a first step for training model parameters and empirically relating their variability to natural (and potentially future) changes in the underlying-forcing.

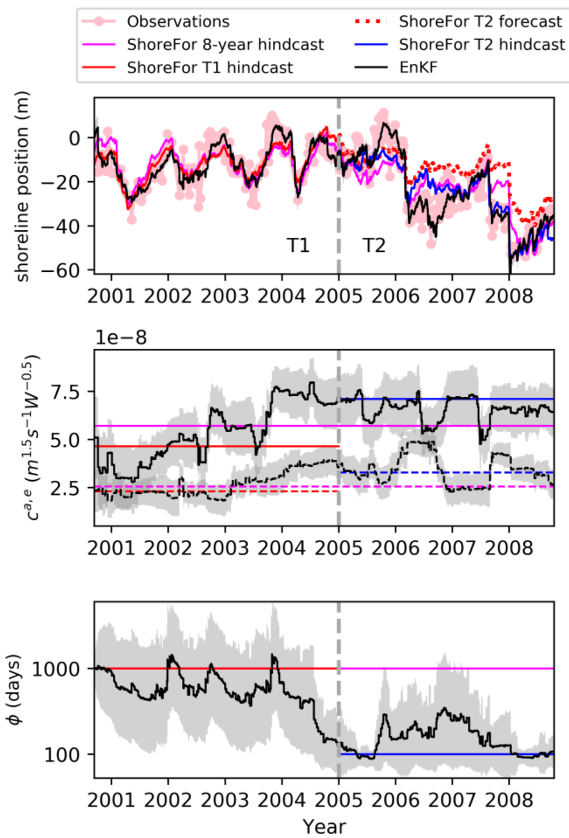

Figure 1. EnKF application to a real world dataset and comparison with previous time-invariant calibration approaches for the overall 8-yr period and for two shorter consecutive periods (T1: 2001-2004, T2: 2005-2008). Upper panel: shoreline position. Middle panel: ShoreFor c^a and c^e parameters. Lower panel: ϕ parameter.

REFERENCES

Davidson, M. A., K. D. Splinter, and I. L. Turner (2013), A simple equilibrium model for predicting shoreline change, Coastal Eng., 73, 191-202, doi:10.1016/j.coastaleng.2012.11.002.

Vitousek, S., Barnard, P. L., Limber, P., Erikson, L., and Cole, B. (2017): A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. Journal of Geophysical Research: Earth Surface , 122(4):782-806.

Pathiraja, S., Marshall, L., Sharma, A., Moradkhani, H., (2016) Hydrologic modeling in dynamic catchments: a data assimilation approach. Water Resour. Res. 52. http://dx.doi.org/10.1002/2015WR017192

Splinter, K. D., Turner, I. L., Davidson, M. A., Barnard, P., Castelle, B., and Oltman-Shay, J. (2014): A generalized equilibrium model for predicting daily to inter-annual shoreline response A generalized equilibrium model for predicting daily to inter-annual shoreline response. Journal of Geophysical Research: Earth Surface , 119:1936-1958.