
DATA-DRIVEN IDENTIFICATION OF GOVERNING EQUATIONS FOR SHORELINE EVOLUTION USING SATELLITE-BASED OBSERVATIONS AND SINDY

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ABSTRACT

Coastal shoreline evolution is a nonlinear and time-dependent process controlled by wave climate, sediment transport, sea-level variations, river inputs, and anthropogenic interventions. Reliable identification of these dynamics is essential for erosion assessment, sustainable coastal management, and coastal infrastructure planning. Although process-based coastal morphodynamic models provide physically meaningful descriptions of shoreline change, their applicability may be limited under complex field conditions because of simplified assumptions, parameter uncertainty, and site-specific nonlinear behaviour [1]. Recent advances in satellite-based remote sensing and open-access shoreline extraction tools have enabled long-term monitoring of coastal change and increased the potential of data-driven modelling in coastal engineering [2]. This study proposes a data-driven and physically interpretable framework for identifying the governing mathematical relationships of shoreline evolution. The Antalya–Lara coastal section in Türkiye is selected as the study area, and satellite-based shoreline observations are considered together with environmental forcing parameters. The proposed methodology is based on Sparse Identification of Nonlinear Dynamics (SINDy), which discovers compact governing equations from observational data by selecting the dominant active terms from a broad candidate function library [3]. Since shoreline evolution is influenced by external forcing mechanisms, the controlled extension of this method, SINDy-c, is also considered to incorporate variables such as wave height, river discharge, and sea-level variation into the model structure [4]. Unlike black-box machine learning approaches that mainly focus on prediction accuracy, the proposed framework aims to reveal interpretable mathematical expressions that support the physical understanding of coastal morphodynamic processes. Therefore, this study presents a transparent system identification approach that bridges conventional physics-based coastal modelling and modern data-driven equation discovery.

Keywords Keywords Shoreline evolution · Coastal morphodynamics · SINDy · Equation discovery

References

- [1] Dean R.G. and Dalrymple R.A., *Coastal Processes with Engineering Applications*, Cambridge University Press, 2002.
- [2] Vos K., Splinter K.D., Harley M.D., Simmons J.A. and Turner I.L., *CoastSat: A Google Earth Engine-enabled Python toolkit to extract shorelines from publicly available satellite imagery*, *Environmental Modelling & Software*, 122: 104528, 2019.
- [3] Brunton S.L., Proctor J.L. and Kutz J.N., *Discovering governing equations from data by sparse identification of nonlinear dynamical systems*, *Proceedings of the National Academy of Sciences*, 113(15): 3932–3937, 2016.

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- [4] Fasel U., Kaiser E., Kutz J.N. and Brunton S.L., SINDy with control: A tutorial, Proceedings of the 60th IEEE Conference on Decision and Control, 3237–3243, 2021.