EGU25-9641, updated on 14 Mar 2025
https://doi.org/10.5194/egusphere-egu25-9641
EGU General Assembly 2025

Anticipating tidal marsh collapse in river deltas

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Tidal flats, marshes, and mangroves in deltaic areas are important for biodiversity, carbon storage, and coastal flood protection. Those delta wetlands are threatened to collapse due to drowning in response to sea-level rise and subsidence. To prevent degradation, it is essential to quantify the resilience of tidal wetlands to high impact disturbances such as hurricanes, especially in densely populated river deltas characterized by high rates of sea-level rise and subsidence. Here, we show how resilience indicators rooted in dynamical systems theory can be devised using NDVI remote sensing data as input, which enables to identify relatively vulnerable wetlands in coastal areas worldwide. Specifically, the recovery rate after disturbances allows to quantify how large a disturbance a system can tolerate prior to reaching a critical threshold or tipping point, and shifting to a degraded state. We first test our methodology by hindcasting known tidal marsh collapse triggered by hurricanes. We then continue to map current-day tidal marsh resilience in several data-sparse river deltas. Finally, we interpret the resulting resilience maps using datasets of various physical forcing factors. While in-situ observations remain essential to determine site-specific thresholds for marsh collapse, our method based on globally available remote sensing and coastal oceanography data provides guidance for coastal protection efforts.

How to cite: van de Vijsel, R. C., Jonathans, T., Ashton, A. D., Ganju, N. K., and Hoitink, A. J. F.: Anticipating tidal marsh collapse in river deltas, EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, EGU25-9641, https://doi.org/10.5194/egusphere-egu25-9641, 2025.