Variable Responses of Coastline Dynamics Controlled by Migrating Subtidal Mudbanks

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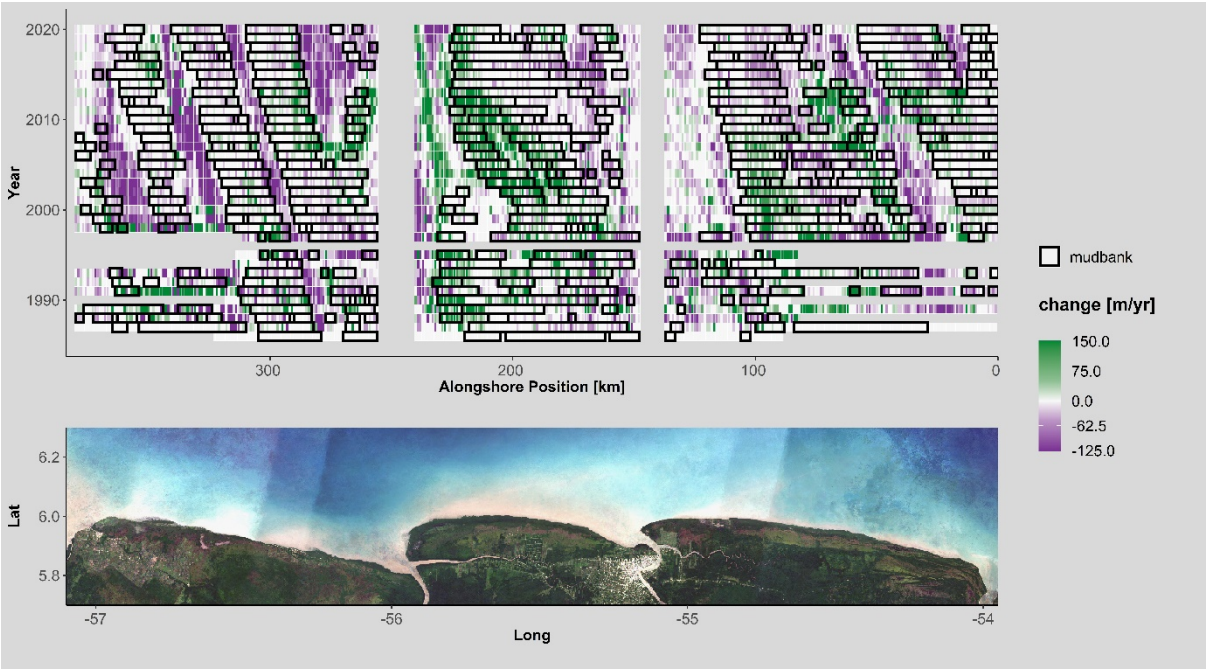
Coastal wetlands provide a livelihood for local communities and simultaneously provide services that include coastal protection, enhanced carbon storage and habitats provision for both terrestrial- and marine life. Yet, the development of climate resilient management strategies that need to account for changes that might occur in the coming decades is challenging due to the variable response of coastal ecosystems. This is because coastal ecosystems, including mangroves, wetlands and tidal flats, are directly linked to coastline dynamics, as coastlines can move seaward, when waves are low and sediment availability is high, or retreat when the opposite is true. Particularly the long-term fate of the mud dominated coastline of Suriname, part of the Guianas coastal system stretching from the Amazon to the Orinoco delta, is determined by migrating subtidal mudbanks that cause a cyclic instability of alternating erosion and progradation phases.

We present a semi-automatic remote sensing approach to quantify the influence of mudbank migration on coastline dynamics along the entire coast of Suriname. We validated our approach with high resolution drone imagery collected at contrasting locations, indicating average accuracy of changes in coastline position to be within 50 meters. This suggest we can apply our methodology on all available Landsat images between 1985 and 2020, acquired over the heterogonous and complex coastal landscapes.

The results show that regional forcing mechanisms, related to migration of six to eight subtidal mudbanks in front of the Suriname coast, have a strong imprint on local coastline dynamics with an average 25 m/yr^{-1} expansion during mudbank presence, and 8 m/yr^{-1} retreat of the coastline during mudbank absence between 1986 and 2020. More importantly, we found that not all spatial and temporal variations in the magnitude and timing of local changes can be explained by migrating mudbanks. This demonstrates the importance of incorporating changes that cannot be explained by regional forcing mechanisms in management frameworks that aim at explaining current variability and predicting future coastline changes.

Plain language summary

For the development of climate-resilient coastal management strategies in Suriname, which focus on challenges in the decades to come, it is critical to incorporate spatial and temporal variability of coastline changes. Here we use a remote sensing approach to quantify the influence of mudbank migration on local coastline dynamics, along the entire coast of Suriname between 1985 and 2020. We found that migration of subtidal mudbanks causes on average expansion of 25 m/yr^{-1} during mudbank presence, and 8 m/yr^{-1} retreat of the coastline when mudbanks has migrated further alongshore. Yet, coastal erosion can still occur when mudbanks are present and vice versa coastal aggregation may happen in the absence of mudbanks. This potentially creates a false sense of security during mudbank phases that can result in 15 years of coastal expansion, only to be followed by erosional phases that might last just as long. This demonstrates that it is essential that all coastal behaviors are included in multi-decadal management frameworks that try to explain current variability and predict future coastline changes in Suriname.



The effect of regional scaled forcing mechanisms related to migrating mudbanks on local scale coastline dynamics in Suriname between 1986 and 2020