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# Coupling subtidal and intertidal evolution: morphodynamic processes derived from Landsat earth observations in Google Earth Engine

## A Case study at the coastal fringe of Surinam


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## Introduction

The coastal region of **Surinam** is low-lying, flat and highly vulnerable for anticipated sea level rise. At the same time, this area is essential for agriculture, fresh drinking water and human settlements. Large mud supplies from the Amazon River result in **mud banks** migrating along the coast influenced by wind- and wave dynamics. These mud banks provide excellent opportunities for mangrove **colonisation** accompanied by increased sedimentation. During **inter-bank phases** coastal erosion leads to increased erosion (Antony et al., 2010). These processes result in distinguishable, but highly dynamic **morphological units** such as Chenier's (sandy beaches), **large tidal flats**, **coastlines** and mangrove zonation.

This research focuses on utilizing remote sensing possibilities, provided by the Google Earth Engine (GEE) platform, to unravel coastal morphological responses caused by **migrating** mud banks for the entire coast of Surinam.

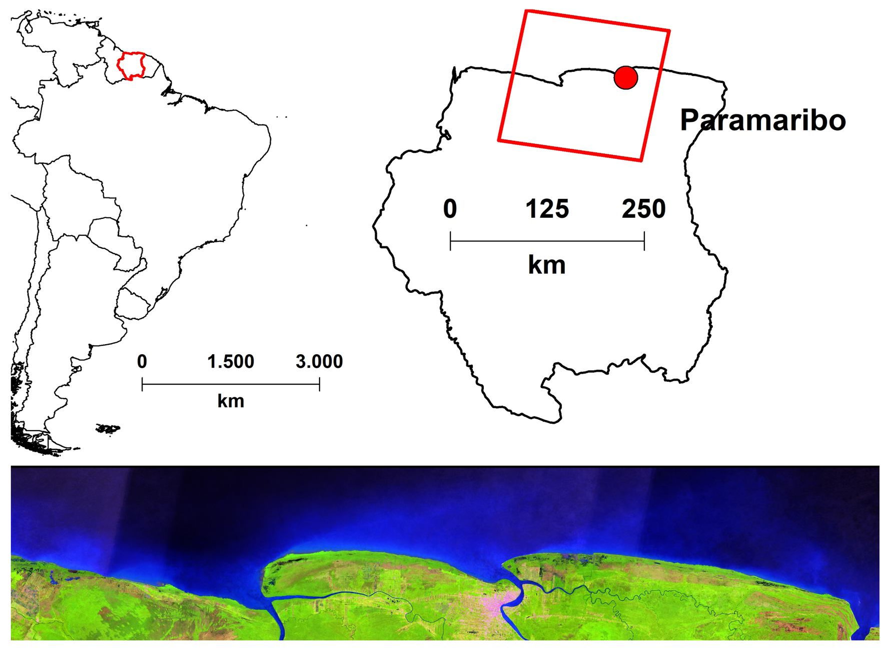


Figure 1. Coastal region of Surinam. The false colour median composite consists of Landsat observations between 2014 and 2016. RGB = swir, nir and red.

Figure 2. Intertidal mudflat, exposed during low - tide in Surinam.

## Methods

A novel automated thresholding approach (e.g. Donchyts et al., 2016), for delineating land and water based on the Normalized Differenced Water Index (**NDWI**), has been applied to separate morphological units such as the coastline and the intertidal area (Sagar et al., 2017).

A) **NDWI** values are calculated for Landsat images in image collections (either single images or image composites).

B-1) **Canny Edge detection** is applied to find relevant Land & Water pixels (Donchyts et al., 2016)

B-2) **Otsu Thresholding** is applied on the pixel histogram

C) A binary mask is created to differentiate between land and water

D) The **coastline** and **intertidal area** are defined from the binary mask + additional thresholding e.g. based on the temperature band (methods not shown here).

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR}$$

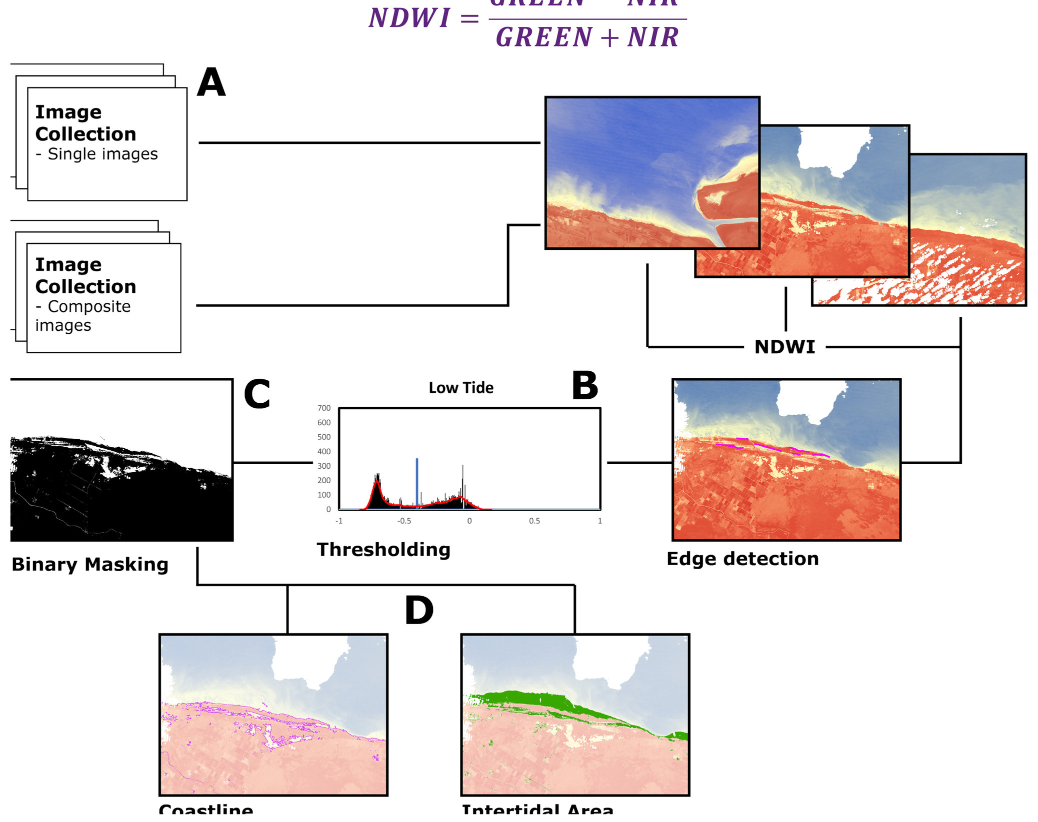


Figure 3. Schematic of the applied workflow based on Sagar et al. (2017) and Donchyts et al. (2016). The coastline and intertidal area are examples of morphological units that can be extracted from the resulting binary mask when additional steps, such as thresholding and line smoothing are applied in Google Earth Engine.

## Results

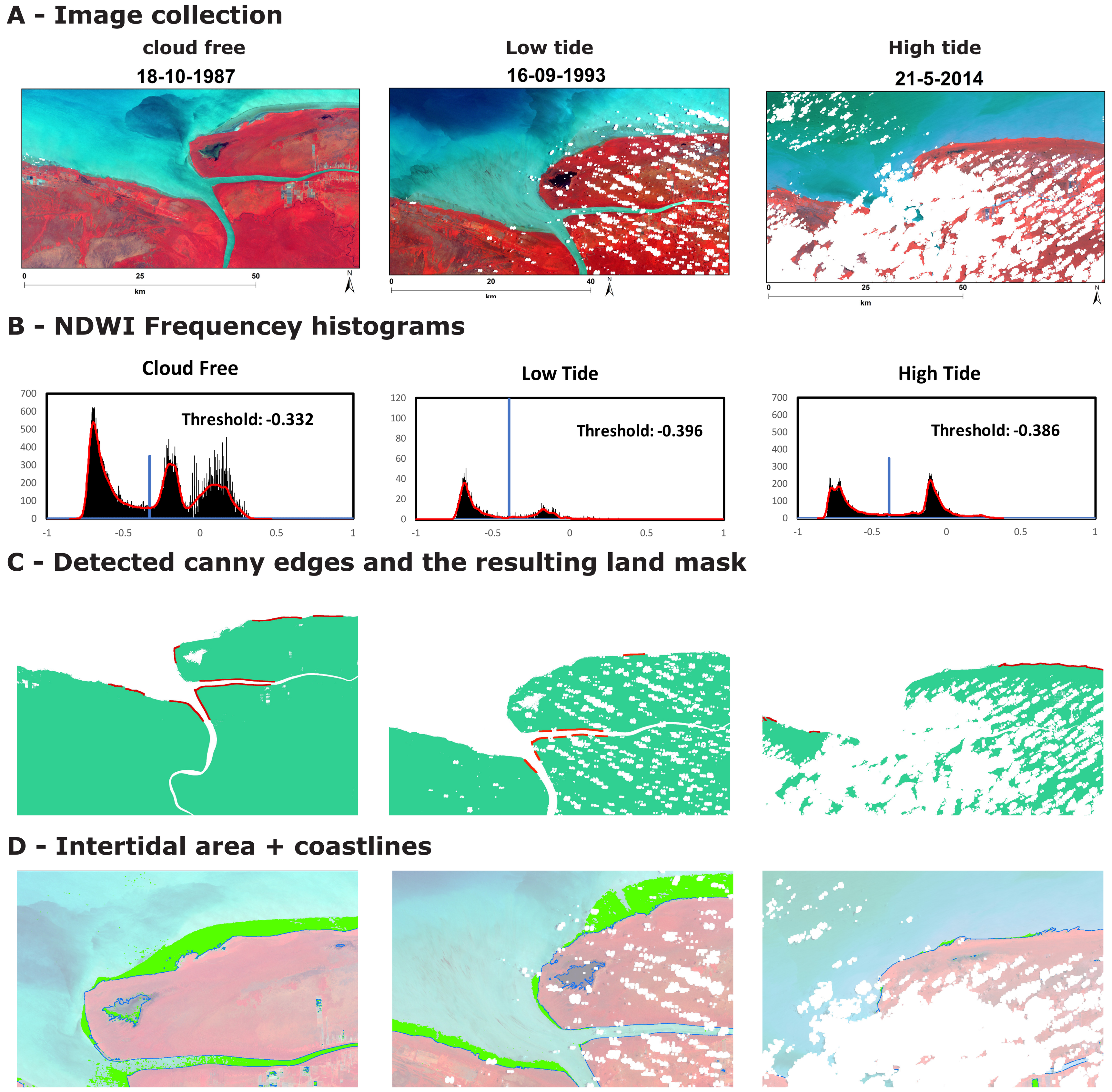


Figure 4. A) Colour infrared composites of sections of the Surinam coast. B) Index distribution for selected coastline pixels based on a Canny Edge Filter. C) Corersponding Land-water Mask and the edges that were selected in Step B. D) shows the intertidal area in green and the coastlines in blue that are resulting from the additional analysis steps (not shown here).

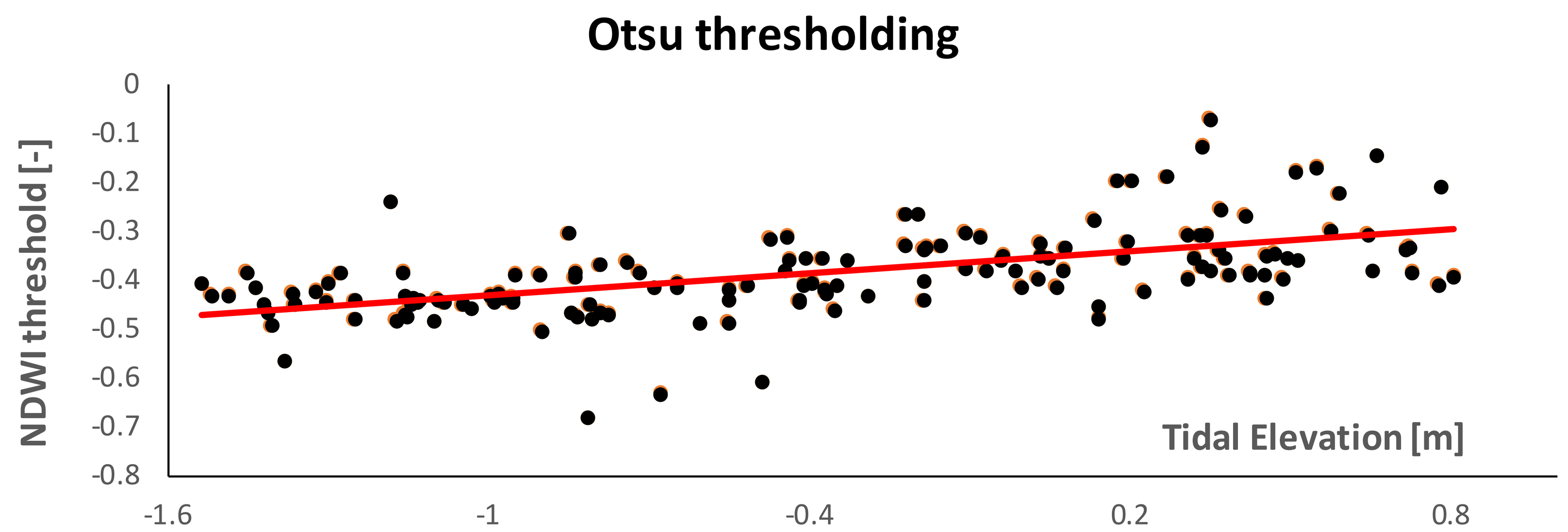


Figure 5. Predicted tidal elevation and calculated threshold values for the available landsat scenes at the study location. The thershold value is expressed in NDWI index and indicates the value that is used to differentiate between land and water as is explained in step B and C of the workflow.

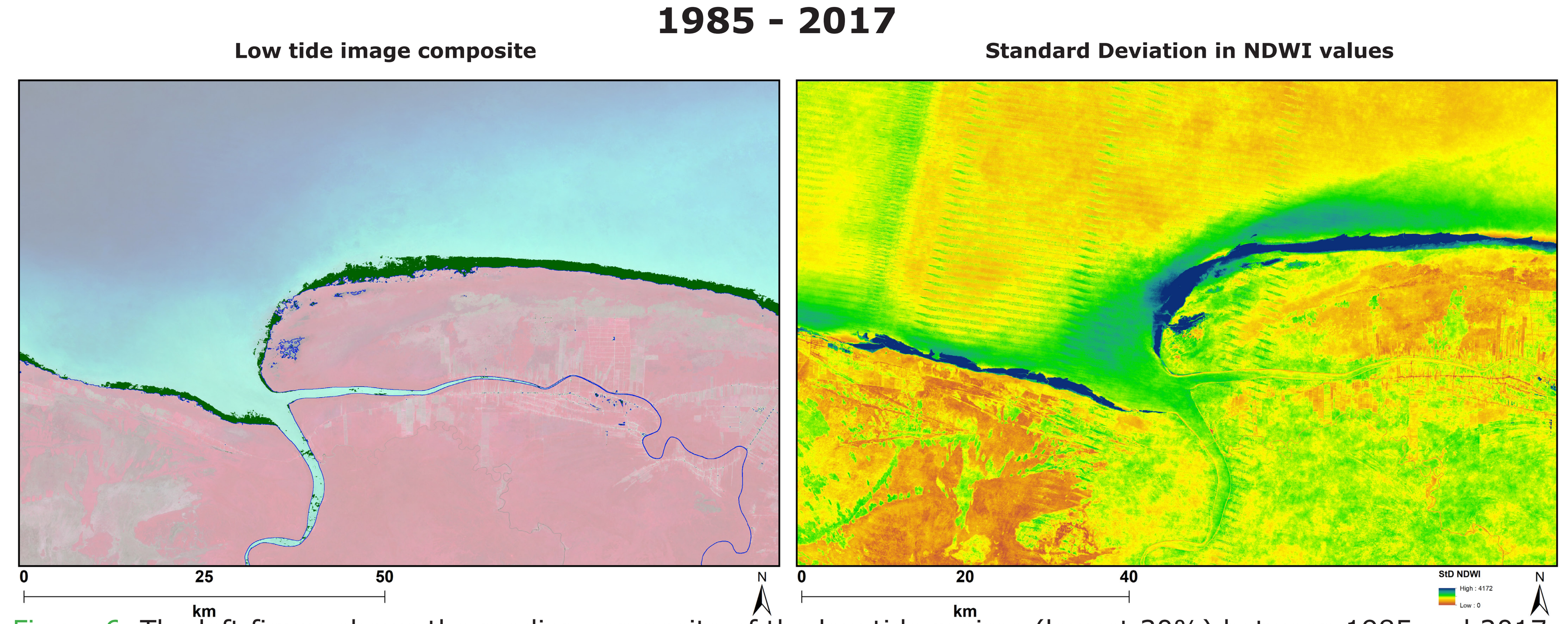


Figure 6. The left figure shows the median composite of the low tide regime (lowest 30%) between 1985 and 2017 with the extracted coastline and intertidal area. The right figure shows the standard deviation in all NDWI values between 1985 and 2017 highlighting morphodynamic activity in a coastal region (sagar et al., 2017).

## Conclusion

- Dynamic **Otsu thresholding** results in significantly different values that are used to differentiate between land and water for individual images (figure 5). This potentially reflects the effect of image characteristics, like tidal elevation, cloud cover, sensor type and others, on the spectral signal.

- Scene based (dynamic) thresholding for NDWI images allows to differentiate between land and water and has become available with the processing power of Google Earth Engine (figure 5). This allows the detection of morphological system components such as coastlines and intertidal areas despite differences in tidal elevation or cloud cover during image acquisition.

- Only applying Otsu thresholding, based on the NDWI index, is insufficient to differentiate between **intertidal area** & waters with **high sediment concentrations** in South America. Additional thresholding, for example based on temperature, provides a way forward.

- The standard deviation in NDWI (figure 6) highlights the potential pitfall of using **median composite images** in highly dynamic coastal environments. Scene based derivation of system components can overcome these problems.

## Lookout

- The differentiation between water and intertidal area, based on a average water temperature as shown in the results, requires more testing before it can be applied for all images.

- In order to analyse coastal dynamics on seasonal or annual time scales it is necessary to aggregate image based observations of morphological units rather than aggregating spectral information.

- Explore the possibilities to extract more morphological units such as Chenier's by applying the same method with the NDVI vegetation index as input.

- With the scene based definition of morphological units, such as the intertidal area it becomes possible to define pure end-member classes that can be used in a spectral unmixing approach. This will allow us to delineate less homogeneous subtidal mud banks.


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**Refrences**

Donchyts, G., Baart, F., Winsemius, H., Gorelick, N., Kwadijk, J., & Van De Giesen, N. (2016). Earth's surface water change over the past 30 years. Nature Climate Change, 6(9), 810.

Sagar, S., Roberts, D., Bala, B., & Lymburner, L. (2017). Extracting the intertidal extent and topography of the Australian coastline from a 28 year time series of Landsat observations. Remote sensing of environment, 195, 153-169.

Anthony, E. J., Gardel, A., Gratiot, N., Proisy, C., Allison, M. A., Dolique, F., & Fromard, F. (2010). The Amazon-influenced muddy coast of South America: A review of mud-bank–shoreline interactions. Earth-Science Reviews, 103(3-4), 99-121.



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