

# Monitoring of coastal morphodynamics using satellite imagery

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## Monitoring of coastal morphodynamics using satellite imagery

Type: Method

**Project Phase:** Planning and Design

**Purpose:** Predicting coastal morphodynamics in response to interventions

**Requirements:** Python programming skills, GIS, knowledge of natural processes

**Relevant Software:** Google Earth Engine, GIS

### About

This tool aims to use observed morphodynamical changes of any coastal system during the last 30 years to predict future morphological effects to coastal interventions. This is done by the analysis of LandSat satellite imagery using Google Earth Engine. This platform enables quick selection and analysis of satellite imagery, using Google storage space and processing capacity. Since the first useful LandSat imagery was recorded in the early 1980's, over 30 years of imagery is available for every place on earth. By first assessing past morphological changes along the coast where an intervention is planned, the morphodynamical system can be understood and predictions of future effects to interventions can be better predicted. These observed changes in the past also provide a valuable dataset to test the performance of models.

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Since the mid-seventies, Earth observation satellites have been collecting data from the Earth's surface. Over the years, the quality and return frequency have improved considerably. Hence, the satellite images provide good coverage of the changes on the Earth's surface, such as urbanisation, deforestation and morphological changes in rivers and along coastlines.

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The data from many of these satellites is freely available. Until recently, the analysis of the images was difficult because of the huge amount of storage space and processing capacity necessary. However, several years ago, Google started the Google Earth Engine platform in which all freely available satellite imagery is accessible, and can be analysed using Google storage and processing facilities. This has greatly improved the applications of the satellite data. One such application is presented here, and involves the monitoring of morphological changes resulting from autonomous processes and interventions in the past.

For the Frisian coast along Lake IJsselmeer, the satellite images provide interesting information about the larger scale morphological changes in the shallow foreshore. Over this period, several interventions have been executed, such as the development of islands, sand nourishments and dams. Most of these interventions were executed in the nineties. The morphological effects have not been monitored and are therefore not clear. The analysis of satellite imagery allows us to monitor the effects of these interventions in hindsight. In addition, it allows us to determine autonomous changes in the coastal system such as coastal erosion or progradation.

The understanding of the system at a decadal scale is essential for the planning and design of new interventions. It provides insight in the speed and magnitude of expected morphological changes and therefore also provides valuable data to test model outcomes.

The tool works best in sandy coastal settings in which interventions are planned. In the case of the Frisian Lake IJsselmeer coast it was used to monitor changes in the shallow foreshore, as this foreshore is visible in calm weather conditions. In more turbid settings, the tool can be best applied to monitor changes to the sandy coast.

## How to use

Users are advised to familiarise themselves with interventions that have been carried out in the coastal area of interest in the previous decades. In addition, knowledge of Python programming is essential for using Google Earth Engine. Google earth engine is freely available, and so are the available satellite images. A google account and subscription to Google Earth engine is mandatory.

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Before continuing with Google Earth Engine, the Google earth Engine Time-Lapse video (<https://earthengine.google.com/timelapse/>) can be used to pre-assess whether the area of interest indeed shows morphodynamical changes of interest.

## Practical applications

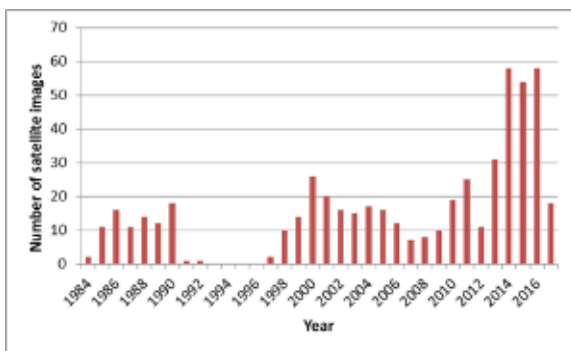
The tool was developed and applied in the Building with Nature sand motors along the Frisian IJsselmeer Coast. In this project, it was used to assess the effect of measures that were proposed during design sessions for Building with Nature measures. It contributed to the system knowledge, and exposed knowledge gaps. It also provided useful estimates of the sand transport capacity of the coastal system, which was essential knowledge to estimate the effect of interventions.

- Assessing past morphodynamical effects to previous interventions along the Frisian IJsselmeer coast
- Assessing whether a coast is naturally eroding or prograding
- Estimating sediment transport processes, magnitudes and velocities along coasts
- Building datasets to test models

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For the Frisian Coast along Lake IJsselmeer, the coastal morphodynamical changes were assessed using LandSat Imagery obtained from Google Earth Engine. The useful dataset stretched from 1984 to the present. In the area, a number of interventions were carried out to the system in the 1990's to strengthen the coast and make it more ecologically attractive. The effects of these interventions have not been monitored intensively, and therefore are unknown.

In Google Earth Engine, analyses can be performed on large satellite datasets. However, in the case of the Frisian Lake IJsselmeer coast and especially the shallow foreshore, this turned out to be a hurdle because the morphological changes observed were difficult to define using computer code, as the colour and visibility of the foreshore sediments was dependent on water depth and turbidity. Therefore, a code was written that extracts all satellite images from the area within a rectangle with less than 10% cloud cover. The images were automatically given the name of the recording date, and contained information about the exact location of the images. The images could be immediately imported into a GIS system. Interestingly, it turned out that for the period between 1991 and 1997, almost no images were available. The reason for this data gap is unknown, and appears to be specific for this location.



*Number of satellite images per year for the Frisian Lake IJsselmeer coast.*

For the entire coast, subdivided into five stretches, the differences were analysed and changes were quantified. For these guidelines, the stretch near Workum is used to show the potential of the tool. The results for the coastal stretch near Workum show several significant changes between 1990 and 2016:

- The foreshore appears to prograde by 60 and 90 m in 25 years
- South of the bended dam, the foreshore has eroded 130 m. This dam was constructed 1995 and appears to be the cause for this coastal retreat.
- The shallow sandy foreshore has prograded by 150 m to the north
- The beach near Workum has prograded 60m, probably due to sand nourishments

These changes indicate sand transport to the north. In the south, the sand supply doesn't meet the demand, and erosion takes place. The coastal stretch in between the navigation channel towards the Workum harbour and the dam is clearly affected by the construction of the dam.

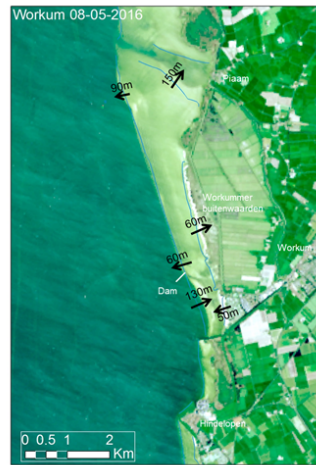
## References

>> Read more

- The Google Earth Engine is accessible at: <https://earthengine.google.com>
- The Google earth Engine Time-Lapse video can be accessed at: <https://earthengine.google.com/timelapse/>





*Satellite images of the area along the Workum coast in 30-03-1990 and in 08-05-2016.*



Observed changes of the coastal system between 1990 and 2016.

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