Deltares

Enabling Delta Life

Historical shoreline positions worldwide derived from space

Period: 1984-2019

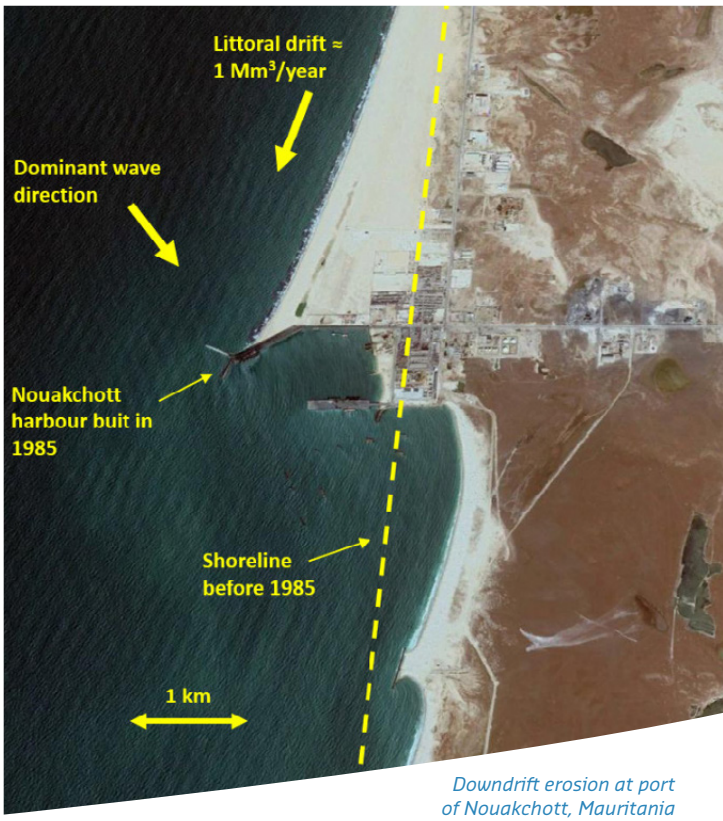
Prior to developing solutions to mitigate shoreline erosion, a comprehensive understanding of the coastal behavior is required. Robust estimation of shoreline change rates requires continuous and long-term information on shoreline position. Historically, the acquisition of shoreline data sets has been a laborious and expensive task as it involved traditional land-based surveys or the analysis of temporally sparse data collected from aerial platforms (photographs or lidar). The increasing availability, resolution and spatial coverage of satellite imagery in recent years now provide a powerful alternative to derive reliable, global scale shoreline data.

This white paper highlights the added value of the various products that can be provided based on the developed shoreline detection methods and the accompanying global data base.

Problem statement

The method commonly used to extract shorelines from satellite images in the past involved painstaking image by image analysis of series of overlapping images. Also, each satellite image had to be downloaded manually from USGS or ESA and processed on a local computer.
In-situ measurements of shoreline can be rather expensive and labor intensive limiting the frequency of such measurements in areas of interests, such as around coastal interventions as ports, protection works, land reclamations, etc. The lack of frequent surveys has led to limited understanding of shoreline behavior in the vicinity of coastal structures and in some cases resulted in unexpected damage of assets. In addition, the development of the erosion rates over time is key information when mitigating measures are considered.

The design and implementing coastal infrastructure in data poor environments requires numerical predictions



Downdrift erosion at port of Nouakchott, Mauritania

Photo: *Beach erosion at Ivory Coast (courtesy: Dano Roelvink)*

to quantify the impacts on the adjacent coast. A non-calibrated model typically comes with significant uncertainty in future shoreline positions. Here, the availability of historical shorelines allows model calibration which can greatly reduce the uncertainty in future predictions. Another key requisite when designing coastal solutions, is a comprehensive understanding of the coastal behavior. Knowing the impact of a single storm vs. a persistent long-term erosion rate can have a great influence on the optimal solution.

Solution

The increasing availability, resolution and spatial coverage of satellite imagery in recent years now provide a powerful alternative to derive reliable, global scale shoreline data. Landsat, since 1984, and Sentinel, since 2015, are examples of publicly available satellites. Up to a few years ago, the satellite images had to be downloaded and analysed locally, making efficient analysis across the world impossible.

The launching of the Google Earth Engine (GEE) platform, containing a continuously updated global satellite image archive, has enabled efficient global scale shoreline detection and has reduced image processing time to only several minutes per image.

Deltares developed a shoreline detection algorithm and applied to cloud free global annual composite images using more than 1.9 million historical Landsat images. After a successful quantitative validation of this technique at multiple sites located in various geographical settings and environmental conditions, the shoreline change rates in m/yr at transects with an alongshore spacing of 500 m along the world's shoreline have been derived. This global data set is presented at shorelinemonitor.deltares.nl

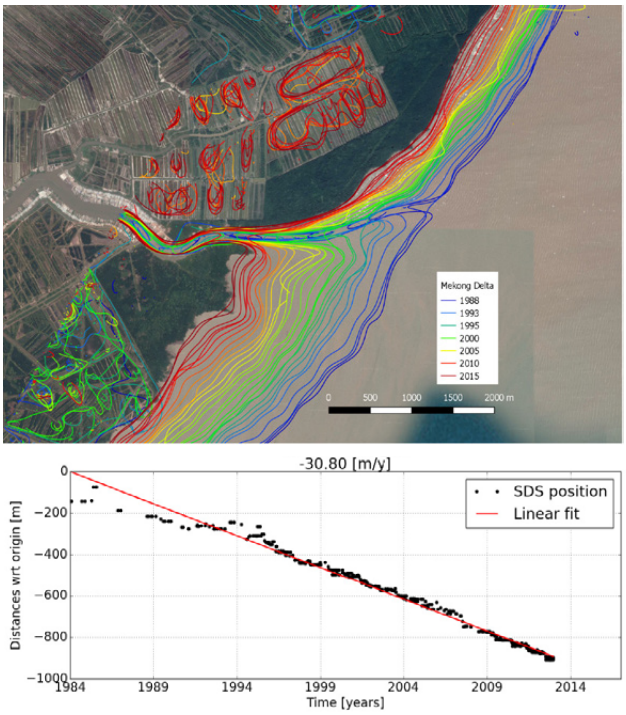


Figure 2: Annual satellite-derived shorelines between 1984 and 2016 for a river mouth in the Mekong Delta, Vietnam. The time serie represents the shoreline position along the black dotted transect, with a retreat rate of -31 m per year.

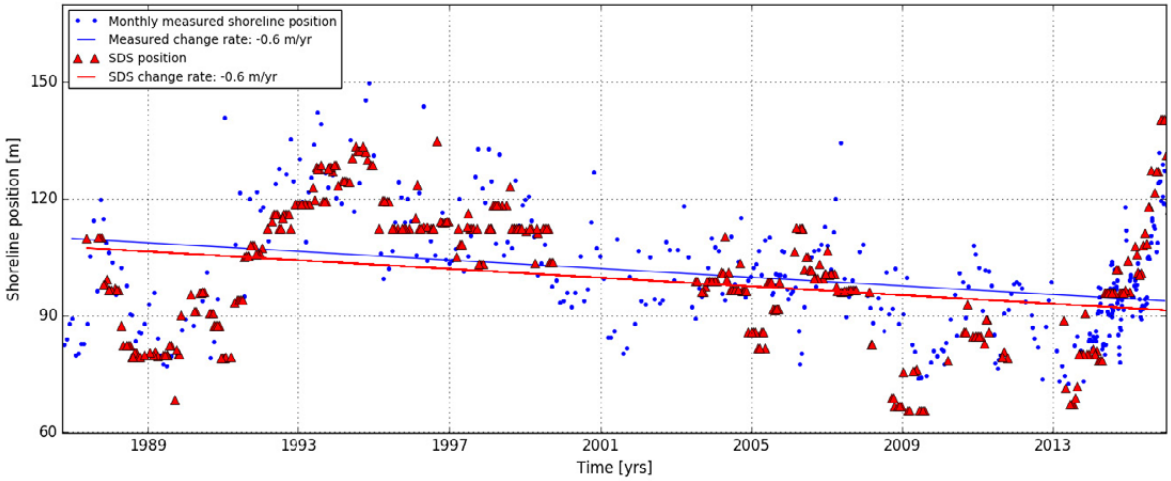


Figure 1: Validation results: a) temporal variations of shoreline positions for Narrabeen beach (blue dots indicate monthly measured shoreline positions, while the red triangles are the satellite-derived shoreline positions.

User stories

Governments

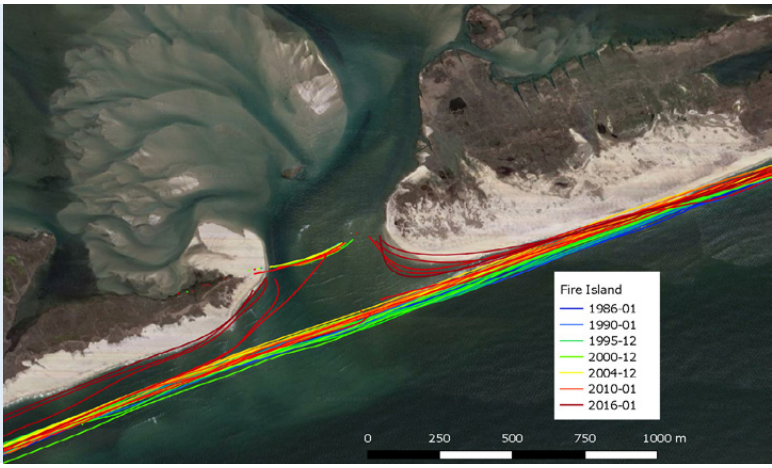
Governments could use the data base to support the following activities:

- Planning of infrastructure
- Development of Adaptation strategies
- Aid funding
- Awareness

Municipalities & cities

Cities or municipalities could use the data to develop their strategies related to:

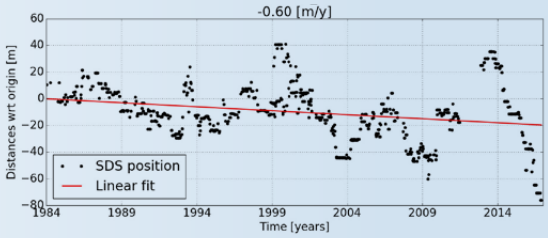
- Coastal management
- Nourishment strategies
- Planning of infrastructure



House owners / Insurance companies

House owners could assess them selves how their beach has changed and use the data for simple extrapolation of the historic trend to assess the future changes.

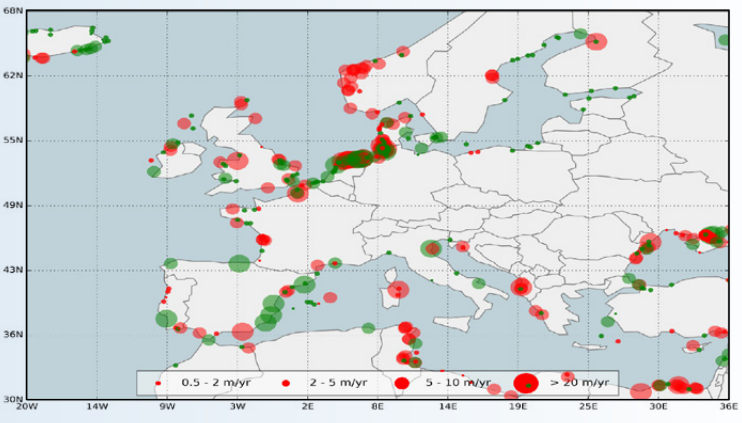
- Awareness



Institutes or banks

Other research institutes of regional banks could use the data for:

- National Assessments on State of the Coast
- Future land loss assessments
- Post-storm impacts on coastal areas



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Data services

The following data services can be provided; see table below for details:

1. Shoreline change trends
2. Annual shorelines
3. Monthly shorelines
4. National assessments
5. Coastal vulnerability
6. Operational mode

Data service	Product name	Resolution		Period	Charges / tasks
		Temporal	Spatial		
1	Coastline trends and annual shoreline positions (T)	Single trend value Annual	per 500 m per 500 m	1984 - 2016	Free accessible
2	Annual shorelines (C)	Annual	30 m alongshore	1984 - 2016	Upon request
3	Monthly shorelines (C)	Monthly	30 m alongshore	1984 - 2018	Upon request
4	National or regional assessments 'State of the Coast'	Monthly	10-30 m alongshore	Historic	To be discussed
5	Coastal vulnerability assessment in view of Climate Change	Monthly	10-30 m alongshore	Future based on trend extrapolation	To be discussed
6	Operational (storm impact)	Daily	10 m alongshore	near-future	To be discussed

T = Transect level (500 m spaced) C = Continuous alongshore

Combining with other data sets

Deltares has recently opened up more data services to the general public which can be viewed, inspected and downloaded from the Deltares portal for free. Data sets covering global forecasts of water levels, currents, river discharges, wind, waves and bathymetry can be found here. The data sets in the portal will further increase over time and we are open to host your (global) data set as well.

Global Data Viewer

In Summary

This white paper presents a new high-resolution global data set on historical shorelines since 1984. Using satellite imagery, the need for labor-intensive shoreline surveys or image-by-image analysis greatly reduces and save both time and money. Various end-users can benefit from the various data services that this technological development provides. Free available observations from space allow great insight in the behavior of our coast in the past, now and in the future.

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Deltares is an independent institute for applied research in the field of water, subsurface and infrastructure. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. Deltares is based in Delft and Utrecht.