



Dune foot position and dynamics:

The key indicators to anticipate erosion hazard along macrotidal beaches

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An exhaustive review of end-users' requests



HOW	Revisit	Horizontal accuracy
France	2-4/year; 1/week in emergency	1 m
Greece	1-10/year	n/a
Portugal	2/year; post-storms	1 m

WHY Monitor the dune foot as the main indicator of shoreline variations of macrotidal sandy beaches.

High-frequency monitoring of major storm events, and/or Spring high tide levels, and/or for specific beach morphological patterns.

Need a post-storm emergency map of the shoreline retreat.



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Open-source spatial data with precious morphological details : the example of a multispectral Sentinel-2 image in Normandy (Cotentin) – 05/07/2018

Visually not so obvious to delimitate the dune foot position...

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Method

- For the dune foot extraction, approach based on supervised classification:
 - Detected limits:
 - □ Seaward limit of vegetation
 - □ Seaward limit of the slope-induced shadow of dune
- For the dune foot extraction, using very high resolution spatial data, approaches based on textural analysis and DEM extraction.
- Statistical estimation of changes in dune foot position:

Distance of change in [m]







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Space for Shore - Final Meeting

Area of change in [m²]

Databases exploited

SPOT-1/2/3/4/5 (resolution 10-20 m)

Pléiades (resolution 2 m)

AIRBUS DEFENCE & SPACE



Worldview-2 (resolution 0.3-0.5 m)

Sentinel-2 (resolution 10 m)

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D'ÉTUDES SPATIALES









Demonstration areas and periods

New Aquitaine Region 62.5 km alongshore 1987 - 2020 KO Yearly & Seasonally 85 products Normandy Region 40.5 km alongshore 2017 - 2020 Seasonally S 15 products





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Product display

High frequency to analyse both long-term trends and short-term variability of the dune foot dynamics ...



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Product display



High frequency to analyse both long-term trends and short-term variability of the dune foot dynamics ... and apprehend the future!



Product display

Dune foot evolution – When storms significantly erode in one season



Validation experiments







Validation of the dune foot extraction by comparing with position measured on field

0.1

Distance from validation data (m)

0.0 - 5.0

5.1 - 10.0 10.1 - 20.0

> 20.1

Control points generated along the satellite-derived dune foot

every 20 m

Measured change rates compared to published in-situ change rates

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Validation results

		i			i	
	Satellite		Validation dataset			Mean
Site		Date	Туре	Source	Date	absolute
				Ource	Date	error (m)
North Medoc (New Aquitaine, France)	SPOT 2	07/16/1996			1998	8.9 m
		07/28/2004			10/29/2016	15.3 m
	SPOT 4	09/30/2012				10.2 m
	SPOT 5	10/04/2009			- 10/30/2016	9.2 m
		06/12/2014		OCA -		5.6 m
	Sentinel-2	10/01/2017	GPS	BRGM	10/04/2017	84 m
					10/07/2017	0.4 111
		04/2018			10/23/2018	10.6 m
	Sentinel-2	10/01/2018			- 10/24/2018	9.6 m
Cotentin (Normandy, France)	Sentinel-2		Lidar	ROLNP		
Aveiro (Portugal)	Sentinel-2	03/21/2018	GPS	Aveiro Univ.	03/13/2018	
					_ 03/20/2018	16.5 m
	Pléiades	03/12/2014			04/14/2014	9.6 m

Changes rates close to GPS data survey

	Satellite	Date of change	١	Mean		
Site			Туре	Source	Date	absolute error (m)
North Medoc (New Aquitaine, France)	SPOT - Sentinel-2	2012 - 2020	GPS	MEDOC Atlantique - CASAGEC	2013 - 2020	0.8 m/yr
	Sentinel-2	Winter 2019 - 2020			2019 - 2020	1.66 m



Much finer precision with VHR spatial data!



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Approval from scientists





S. Costa (LETG/Caen Univ.): "Margin of error of 4-5m is not enough, but with Pleiades we reach relevant values of around 2m. Very seduced by the technique, the method and the images! "



A. Robinet (BRGM/OCA): "Regarding georeferencing, acquire **a database of GPS points is necessary** to rectify the image positioning where the products will be produced."

A. Nicolae-Lerma (BRGM/OCA): " **Some reservations about the practicability of this tool** "; " **Lots of international opportunities** but no doubt also **interesting on several sites in New Aquitaine** "





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Users' requirement achievement level

	Horizontal accuracy		Revi	sit	Production area	
	Requested	Achieved	Early request	Produced after POC	Requested	Achieved after POC
France	1 m	9.5 m (Sentinel-2) 9.8 m (SPOT)	2-4/year; 1/week in emergency	Yearly from 1987 to 2015; 2/year until 2020	New Aquitaine (Biscarosse & Arcachon Lagoon inlet)	North Medoc
	-	-	-	Seasonally 2017 – 2020 / events	-	Cotentin
Greece	n/a	-	1-10/year	-	Peloponnese	-
Portugal	1 m	16.5 m (Sentinel-2) 9.6 m (Pléiades)	2/year; post- storms	-	Aveiro Region (Northwest Coast)	-

Beyond these results, using VHR images over a highly textured coastal dune area, we reached accuracy values below 2 m for almost 90% of the evaluated points

And dune foot change accuracy of the order of 1 metre !

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Dune foot too small to be detected with S2 & limited Third Party Mission data

End-users' testimonies

Convinced in indicators extracted from very high resolution satellite imagery



V. Mazeiraud (Medoc Atlantique):" Interest in the satellite approach [...], on highly dynamic sectors based on highly accurate images"

"We will consider the integration of the Pléiades-derived dune foot positions"

Convinced in the complementarity of field monitoring with spatial observations for the analysis of dune erosion



V. Mazeiraud (Medoc Atlantique):" Interest in the **satellite approach**, in addition to traditional methods, or even to go beyond the possibilities of conventional approaches by integrating the analysis of satellite data for monitoring changes, hazards and projections."

Critical about the dissemination of the results without providing the necessary contextualization for careful and fair interpretation.



V. Mazeiraud (Medoc Atlantique): "You should **consider the activities of the territories** (e.g., the sand beach renourishment). You must be very careful to calculate trends very precisely."

A useful tool to anticipate the macrotidal coastal sustainability to future hazards

UNIVERSITÉ CAEN NORMANDIE



S. Costa (Univ. Caen): "With the ability to revisit satellite imagery, we can address the resilience of coastlines after storms."

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ESA's expectation achievement level

Semi-automated dune foot extraction with accuracy below the pixel size.

Long-term trend (33 years) analysed over several tens of kilometers (>60 km).

→ Made possible thanks to a large open-source spatial datased available with high resolution



Significant change rates of the dune foot dynamics measured during stormy seasons.



The accuracy of the dune foot position extracted from high resolution images remains limited for coasts with low dynamics.



Efficient for coastal areas with well-developed dunes covered by vegetation and showing relatively narrow dune face with respect to the image resolution. \checkmark

Efficient for detecting coastal dunes with contrasted texture.

Accuracy sufficient to monitor and prevent expected coastal changes induced by climate change.





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