

COASTAL EROSION webinar

Space for Shore activities

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22 January 2021

Optical remote sensing



SAR remote sensing



HAROKOPIO UNIVERSITY

Service development



Coastal erosion experts



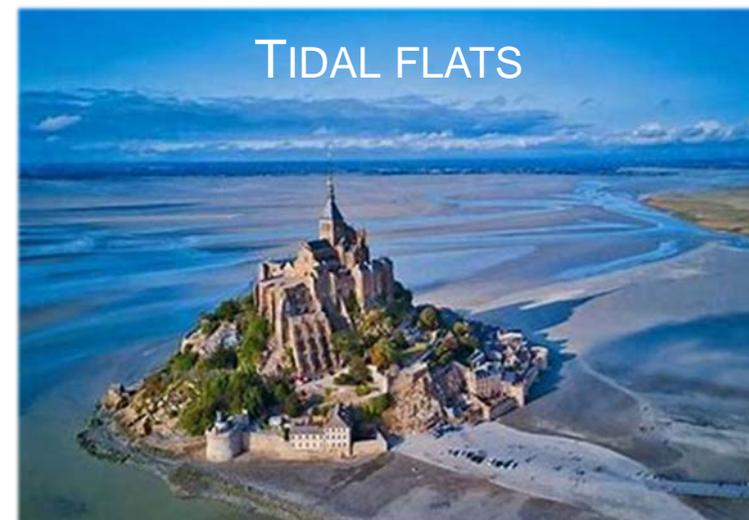
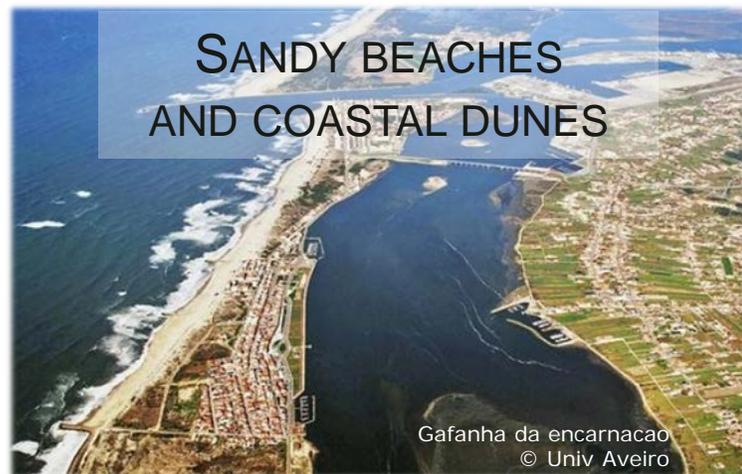
OBSERVATOIRE CÔTE AQUITAINE



A wide range of coastal geomorphology and beach landforms in Europe and around the world

- **wave forcing**, e.g. low-energy, moderate to high-energy coasts
- **tidal range** i.e. micro/macro/megatidal
- **sediment type** : sandy/muddy/rocky/shingles

Dealing with **Coastal Erosion** using Satellite Remote Sensing needs to take into account a series of indicators, not only one ! a complex problem which cannot be resumed just by extracting waterlines...



The Space for Shore ambition has also been to tackle all main coastal erosion indicators **as expressed by coastal experts and final end users** knowing that it would be very challenging to match their requirements in terms of accuracy by using decametric Sentinel-like EO datasets, but more likely with VHR (Pléiades-like).

coastal cliffs

- cliff lines (1-m accuracy)
- rock fall detection / volume of material displaced
- vertical ground movement
- nearshore bathymetry



The Space for Shore leitmotiv was to tackle all main coastal erosion indicators **as expressed by coastal experts and final end users** knowing that it would be very challenging to match their requirements in terms of accuracy by using decametric Sentinel-like EO datasets, but more likely with VHR (Pléiades-like).

macrotidal sandy beaches

- **dune foot** (*1-m accuracy*)
- **nearshore bathymetry** (*“the best possible”, better than 50 cm*)
- sandbar dynamics
- beach width
- coastal dune land cover



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microtidal sandy beaches

- **waterline and/or swash excursion upper limit** (*2-m accuracy*)
- **nearshore bathymetry** (*20-50 cm vertical accuracy*)
- **sandbar dynamics** (*10 m accuracy*)
- seabed mapping (bottom type / marine habitats)
- *Posidonia* seagrass deposits on the beaches,...

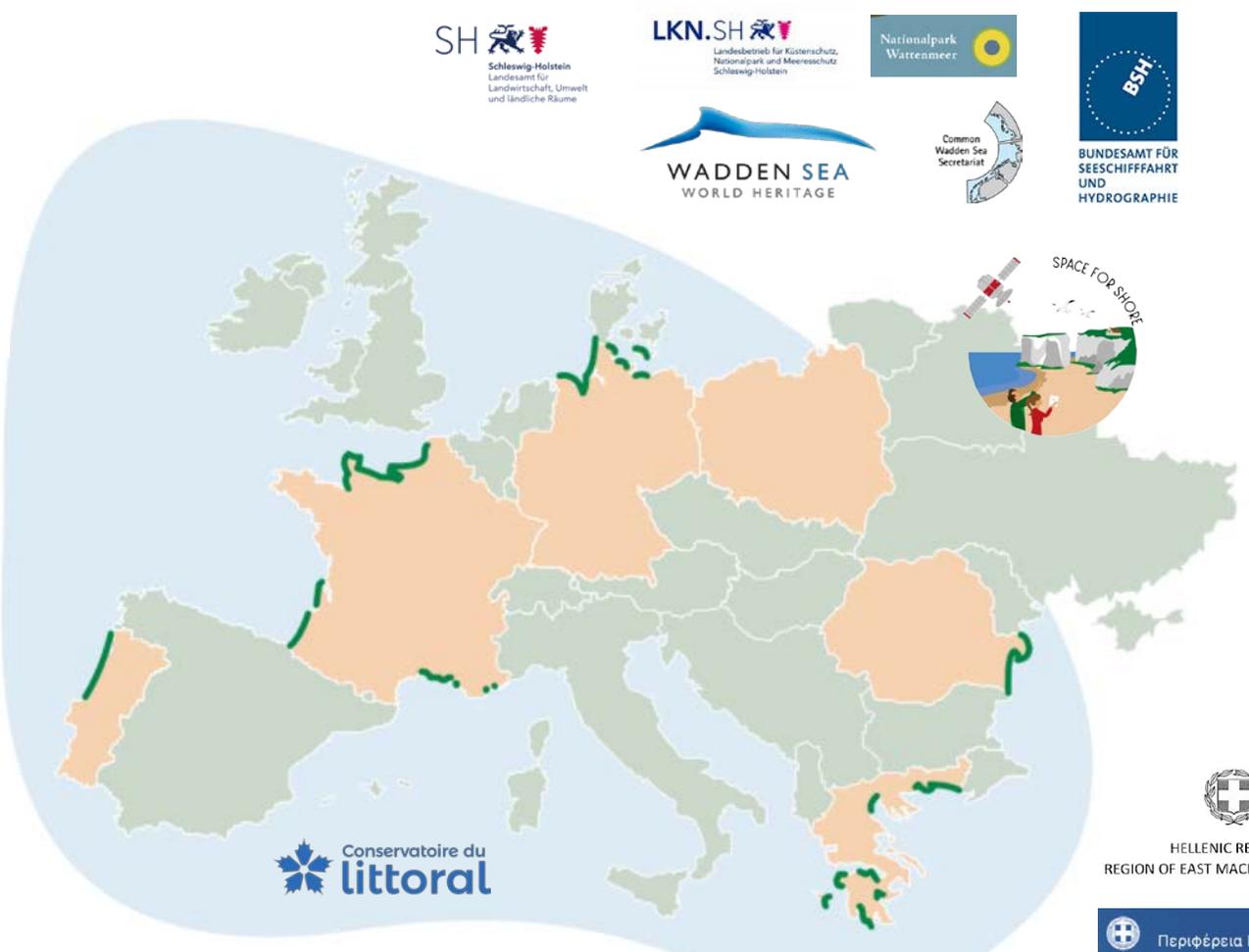


The Space for Shore leitmotiv was to tackle all main coastal erosion indicators **as expressed by coastal experts and final end users** knowing that it would be very challenging to match their requirements in terms of accuracy by using decametric Sentinel-like EO datasets, but more likely with VHR (Pléiades-like).

tidal flats

- **changes in tidal creeks and tidal channels**
(10 m accuracy)
- **sandbar dynamics** *(10 m accuracy)*





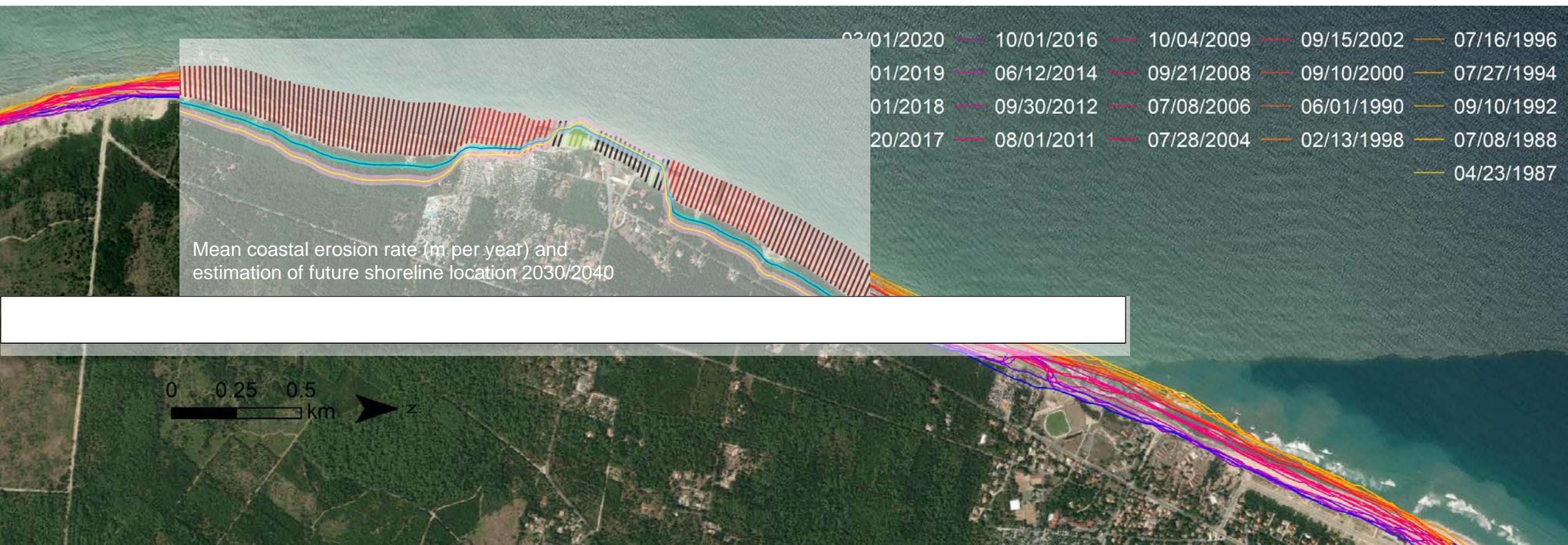
Sandy beaches and Coastal Dunes along macrotidal areas   

30 years of dune foot extracted from archives of Spot-1/2/3/4/5 and Sentinel-2



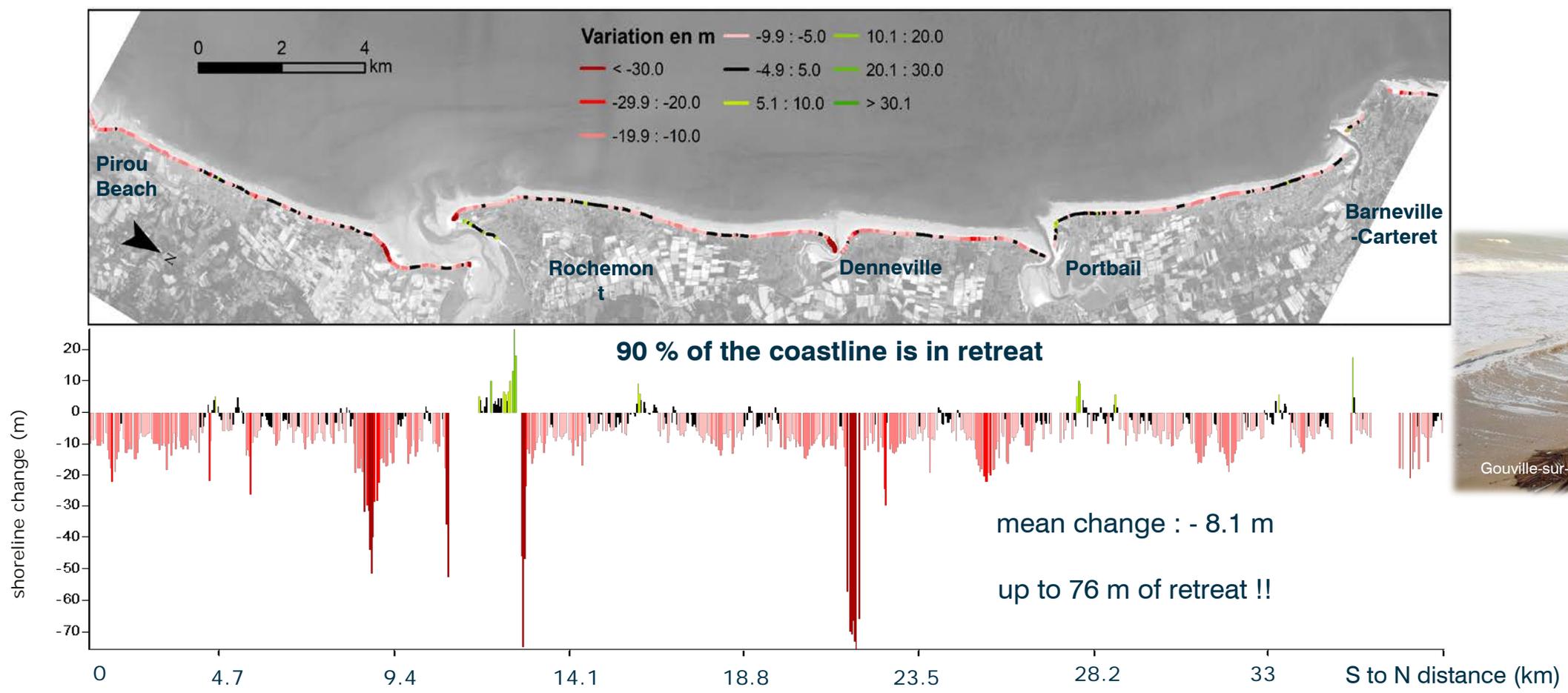
Sandy beaches and Coastal Dunes along macrotidal areas   

30 years of dune foot extracted from archives of Spot-1/2/3/4/5 and Sentinel-2 : ~ 10 m accuracy



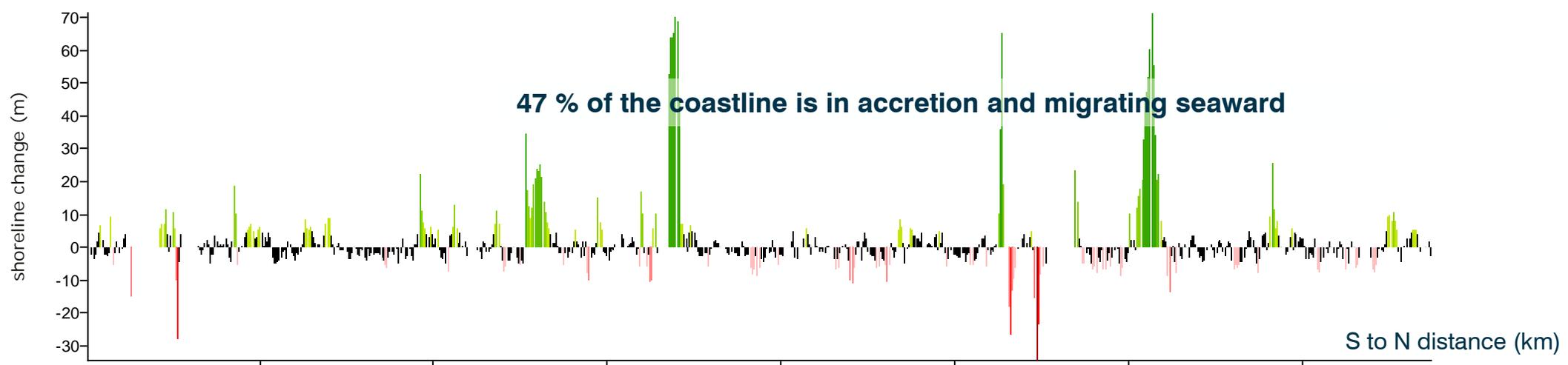
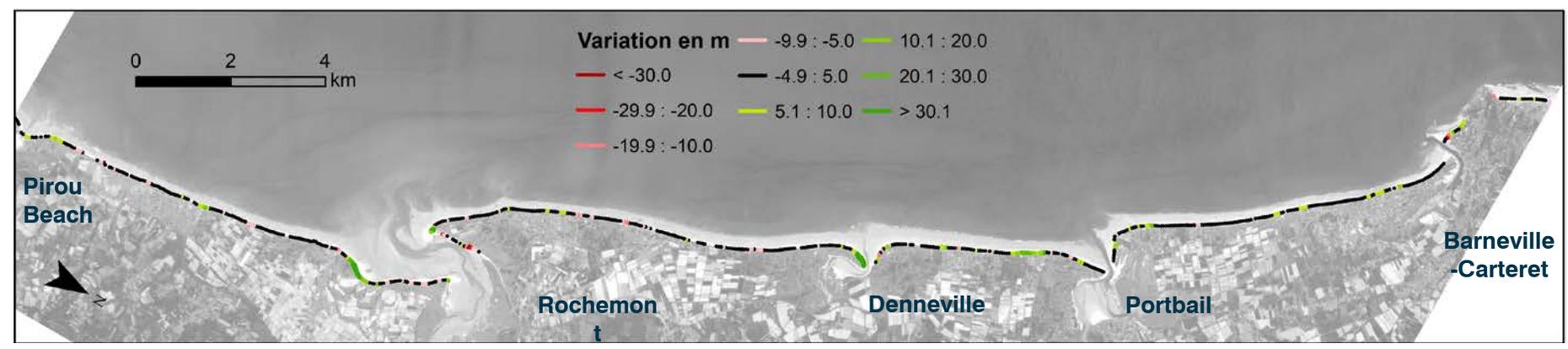
Sandy beaches and Coastal Dunes along macrotidal areas   

Short-term beach change assessment / effects of storms Ciara & Eleanor observed by Sentinel-2 (12/2019 to 03/2020)



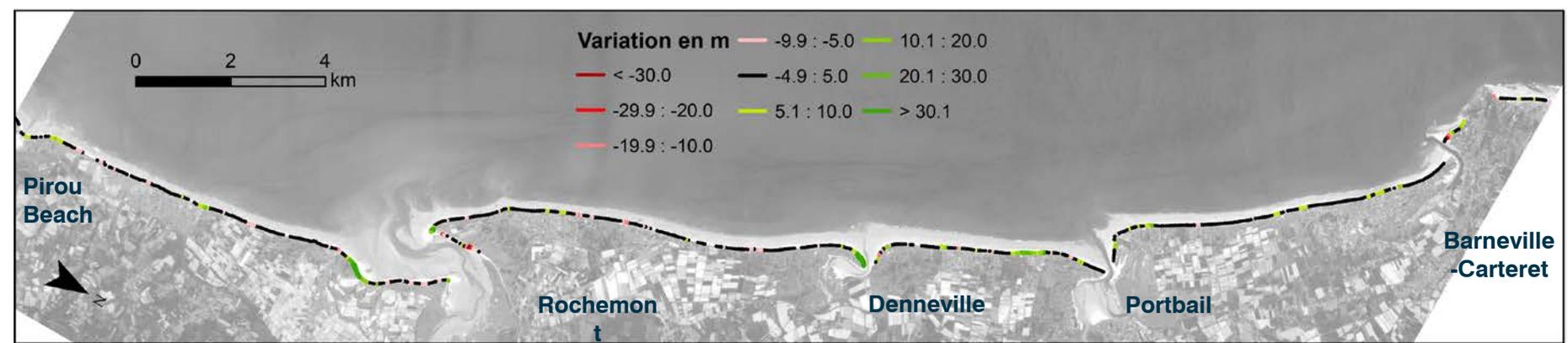
Sandy beaches and Coastal Dunes along macrotidal areas   

Short-term beach change assessment / and recovery in the following spring 2020 observed by Sentinel-2



Sandy beaches and Coastal Dunes along macrotidal areas   

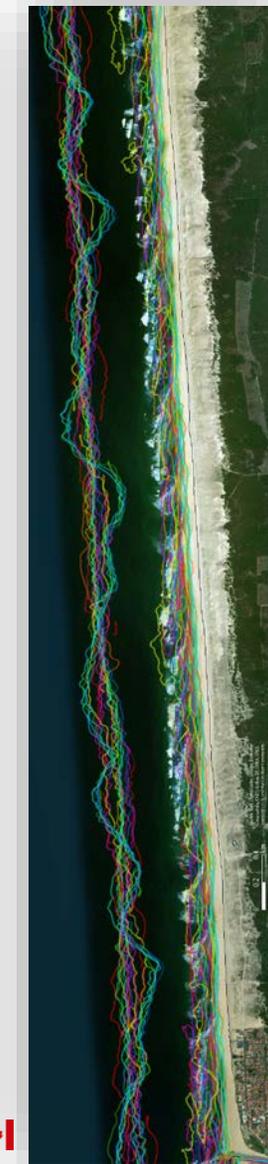
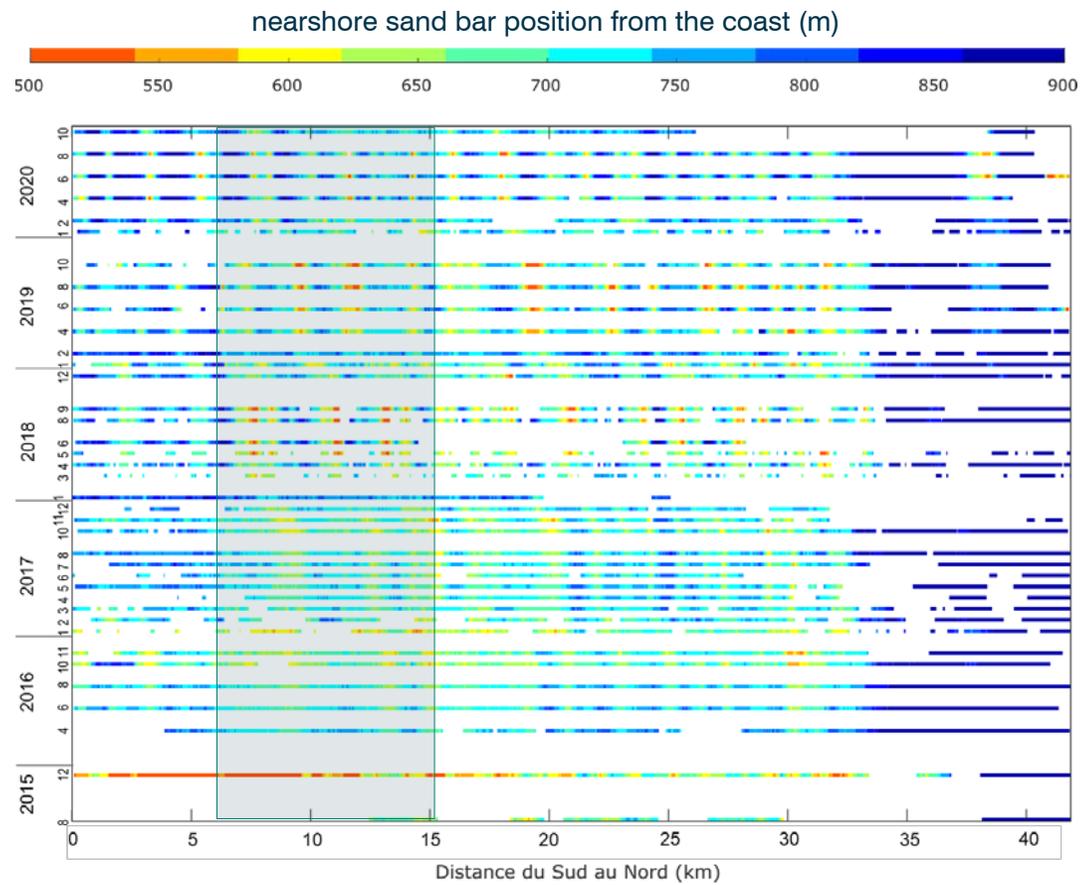
Short-term beach change assessment / and recovery in the following spring 2020 observed by Sentinel-2



*S. Costa (Univ. Caen): “Uncertainty in shoreline (dune foot) positioning of 4-5 m is not enough, but **with Pleiades we’ve been reaching relevant values of around 2m or below... Very seduced by the technique, the method and the images ! (...)** and with the ability of frequent updating by Sentinel-2, we can address the resilience of coastlines after storms !”*

Sandy beaches and Coastal Dunes along wind/wave-dominated coasts 

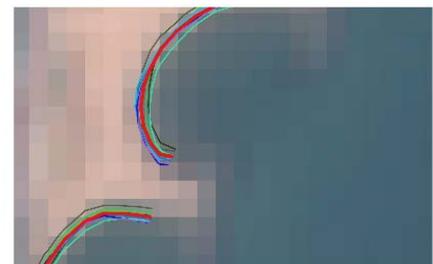
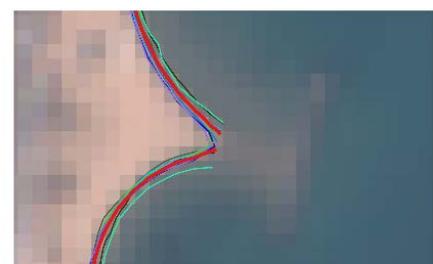
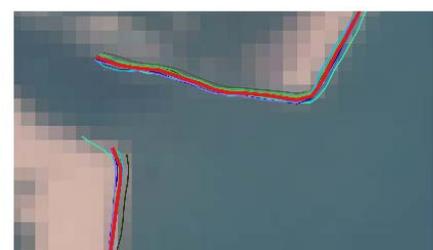
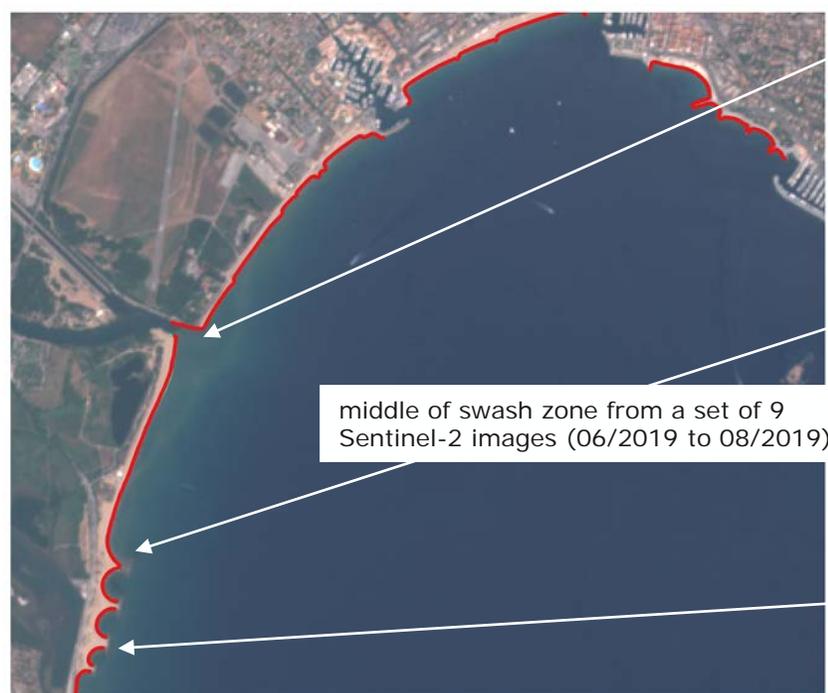
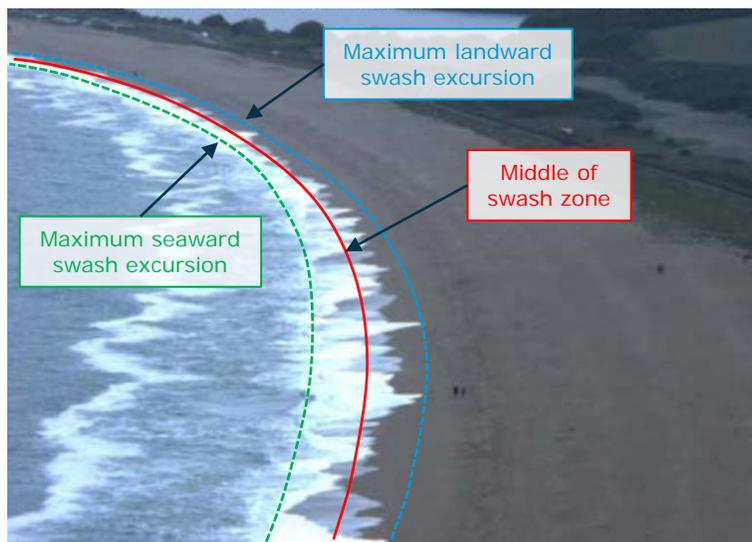
Outer sand bar migration from time series of Sentinel-2 -> **pre-storm vulnerability assessment of the beaches and shorelines**



Sandy beaches along microtidal coastal areas 

Shoreline extraction from time series of Landsat-8 (15m), Sentinel-2 (10m), Spot-6/7 (1.5m), Pléiades (0.5 - 2m)

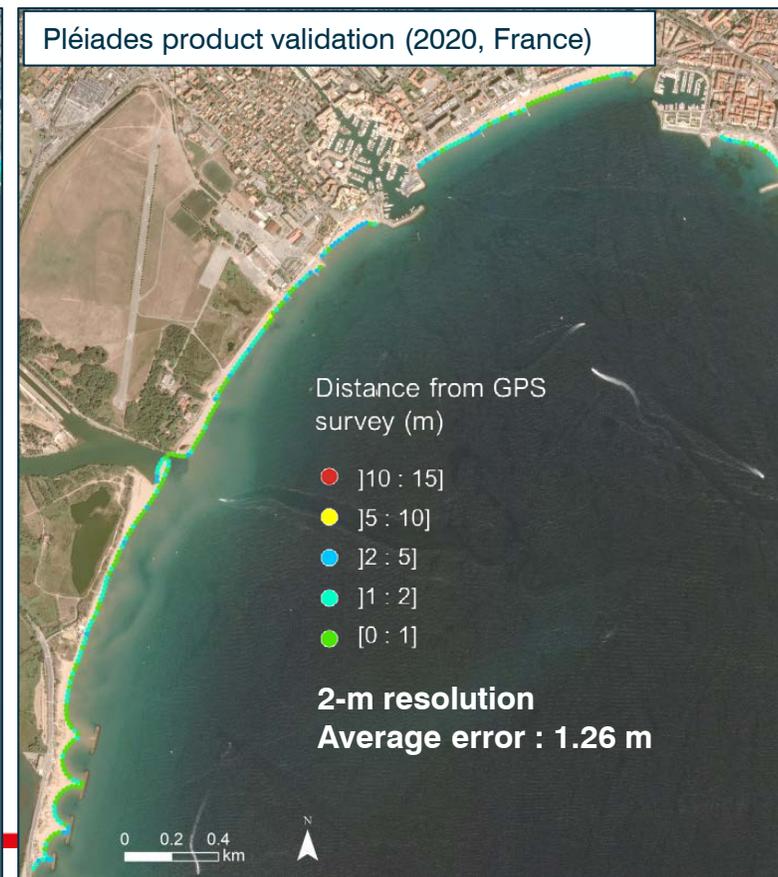
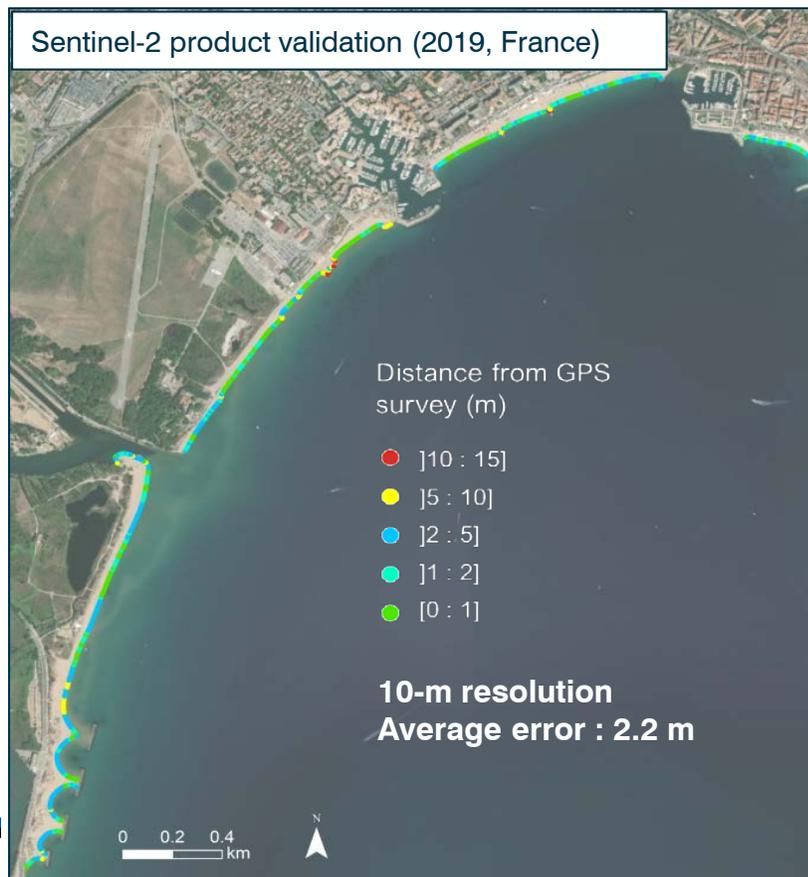
Enveloppe of successive waterlines extracted from Sentinel-2 and used to compute mean waterline at summertime and the maximum extent of swash excursion



Sandy beaches along microtidal coastal areas 

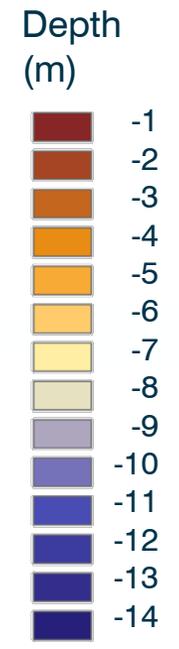
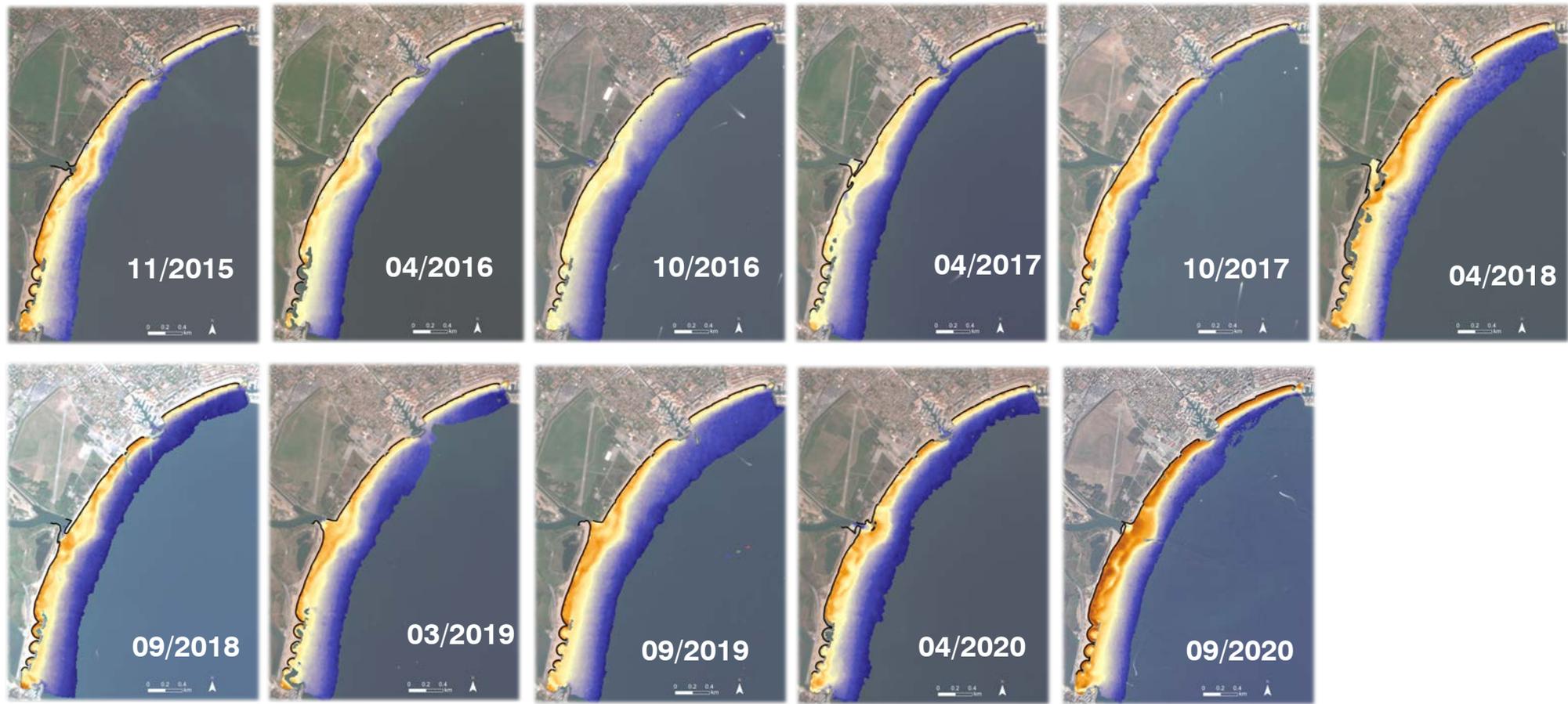
Shoreline extraction from time series of Sentinel-2 (10m) vs single-date Pléiades (2m)

Sentinel-2 time series used over short periods of time (~ one month) **useful to get mean waterline and the extent of swash excursion**, which are the main proxies of shoreline in microtidal coastal regions



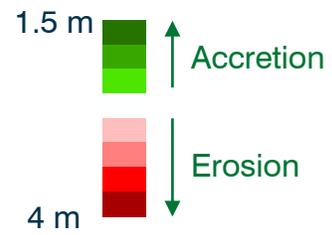
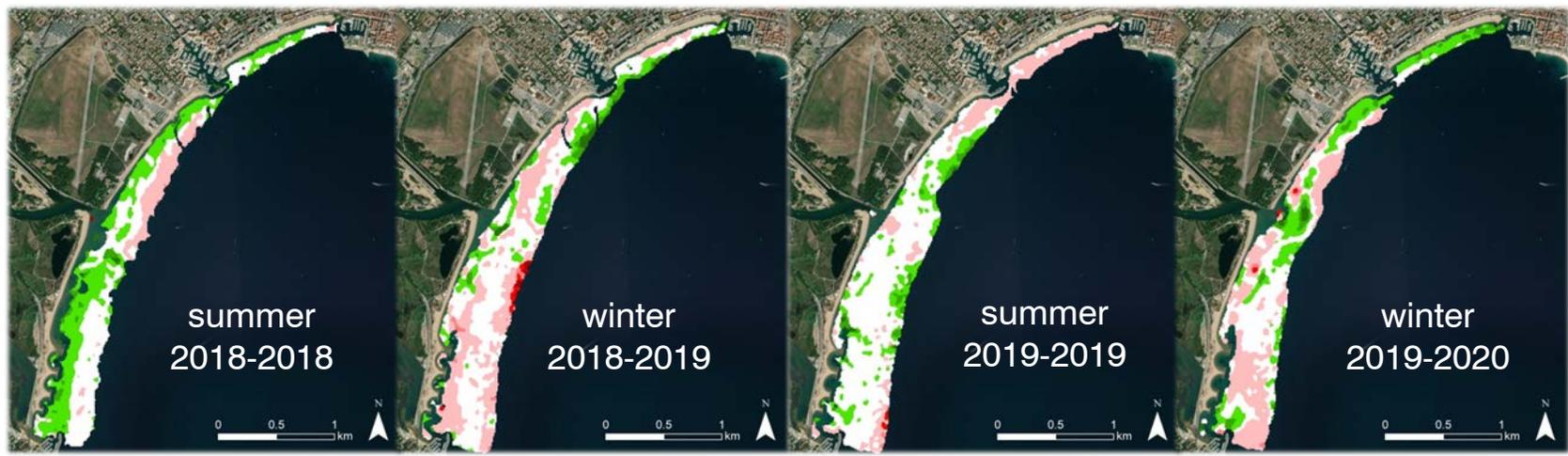
Sandy beaches along microtidal coastal areas 

Nearshore bathymetry 0-15 m water depth in Frejus St Raphael, south of France





strong seasonal coastal dynamics while in equilibrium over 5 years



Sandy beaches along microtidal coastal areas   

Shoreline extraction from time series of HR (Sentinel-2) and VHR (Pleiades-like)

Sentinel-2 time series used over short periods of time (~ one month) **useful to get mean waterline and the extent of swash excursion**, which are the main proxies of shoreline in microtidal coastal regions

+ nearshore bathymetry in routine that **enhances knowledge in coastal dynamics and beach sediment budget**

Live testimonies



Dr Fran ois Sabatier, coastal geomorphologist, lecturer at Aix Marseille University



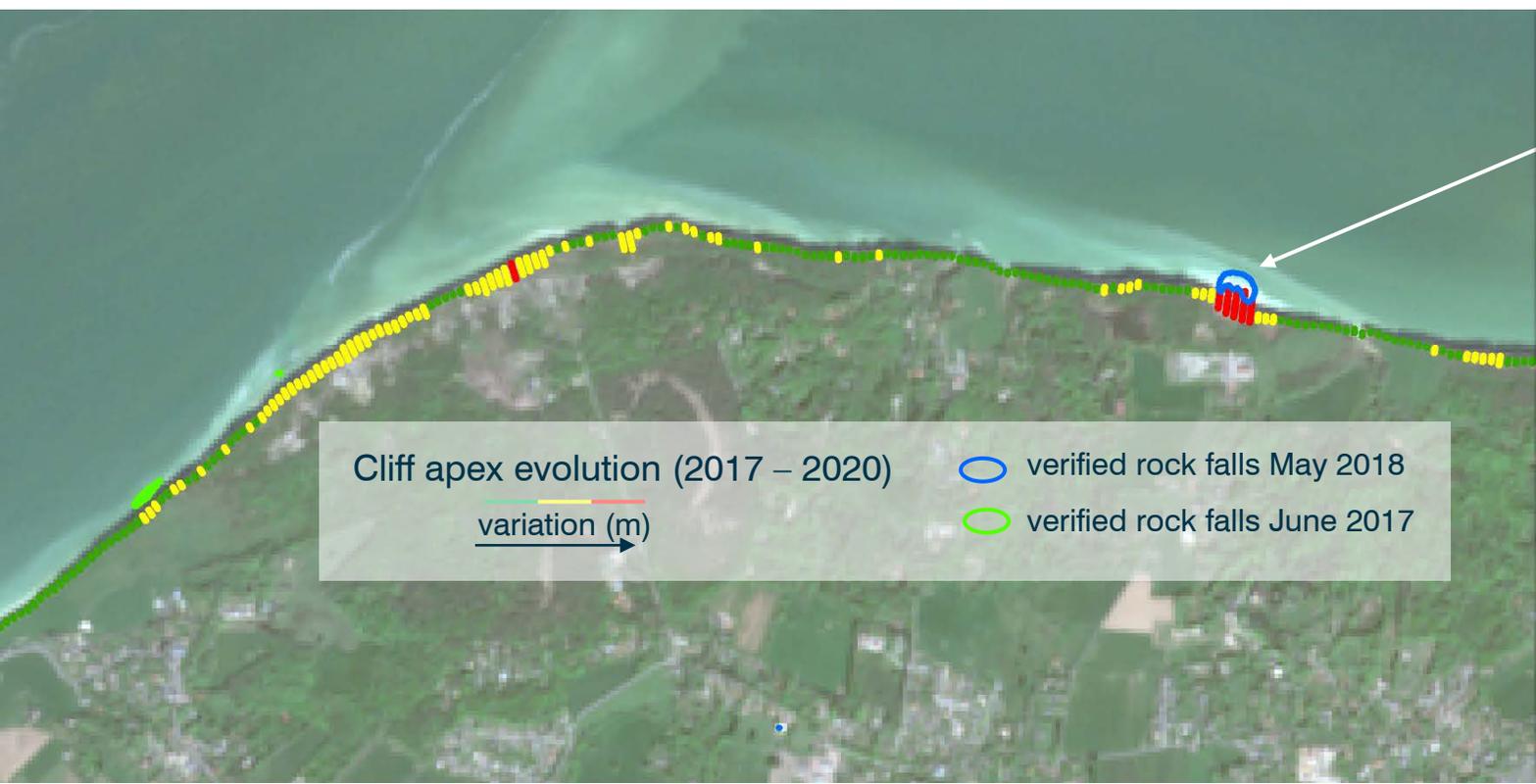
Kevin Bergeron, coastal manager at CAVEM Agglom ration Var Esterel M diterran e

Rocky coastlines / coastal cliffs



different strategies tested to extract cliff lines (cliff foot / cliff apex)

- machine learning algorithms applied to Sentinel-2 and Pléiades not accurate enough for cliff apex monitoring and coastal erosion assessment but of interest for automatic landslide detection



Comparison between predicted (Sentinel-2) and observed cliff apex (cliap) at Quiberville on August 28, 2015

Legend
 --- observed cliap, 2015/06/16
 --- predicted cliap, 2015/08/28

~ Overall surveyed distance: 5.93 km
 ~ Sentinel-2 resolution = 10 m
 ~ bias = 3.57 m
 ~ rmse = 11.42 m

0 500 1000 m

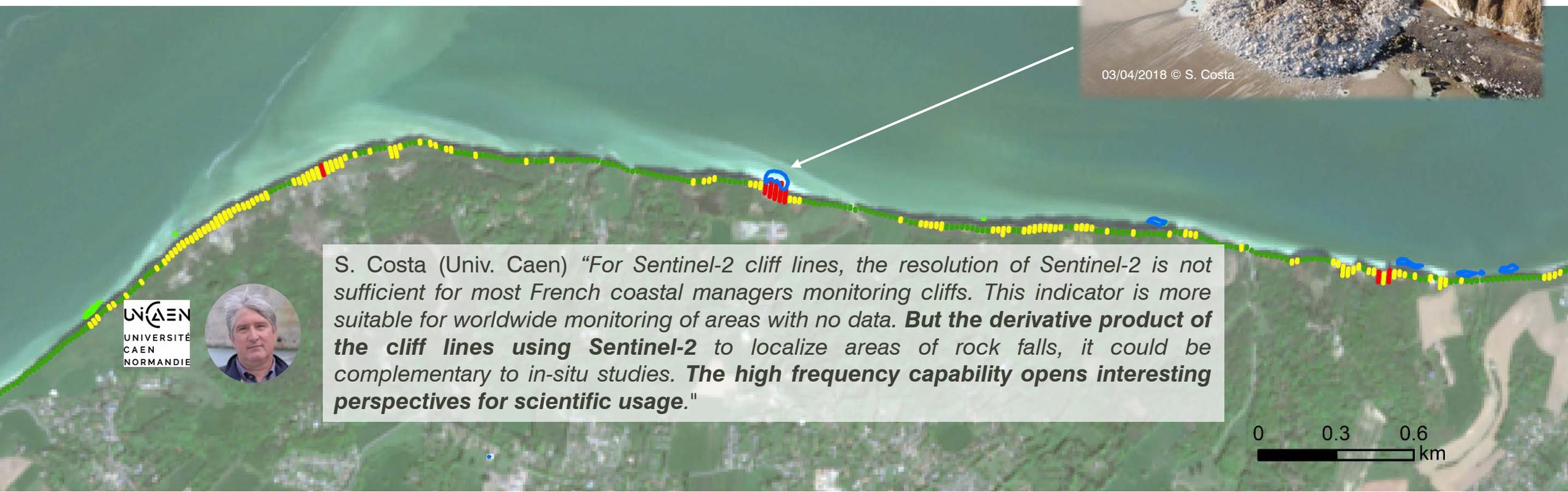


Rocky coastlines / coastal cliffs

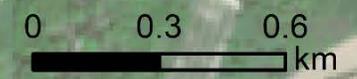


different strategies tested to extract cliff lines (cliff foot / cliff apex)

- machine learning algorithms applied to Sentinel-2 and Pléiades not accurate enough for cliff apex monitoring and coastal erosion assessment but of interest for automatic landslide detection



S. Costa (Univ. Caen) *"For Sentinel-2 cliff lines, the resolution of Sentinel-2 is not sufficient for most French coastal managers monitoring cliffs. This indicator is more suitable for worldwide monitoring of areas with no data. **But the derivative product of the cliff lines using Sentinel-2 to localize areas of rock falls, it could be complementary to in-situ studies. The high frequency capability opens interesting perspectives for scientific usage.**"*

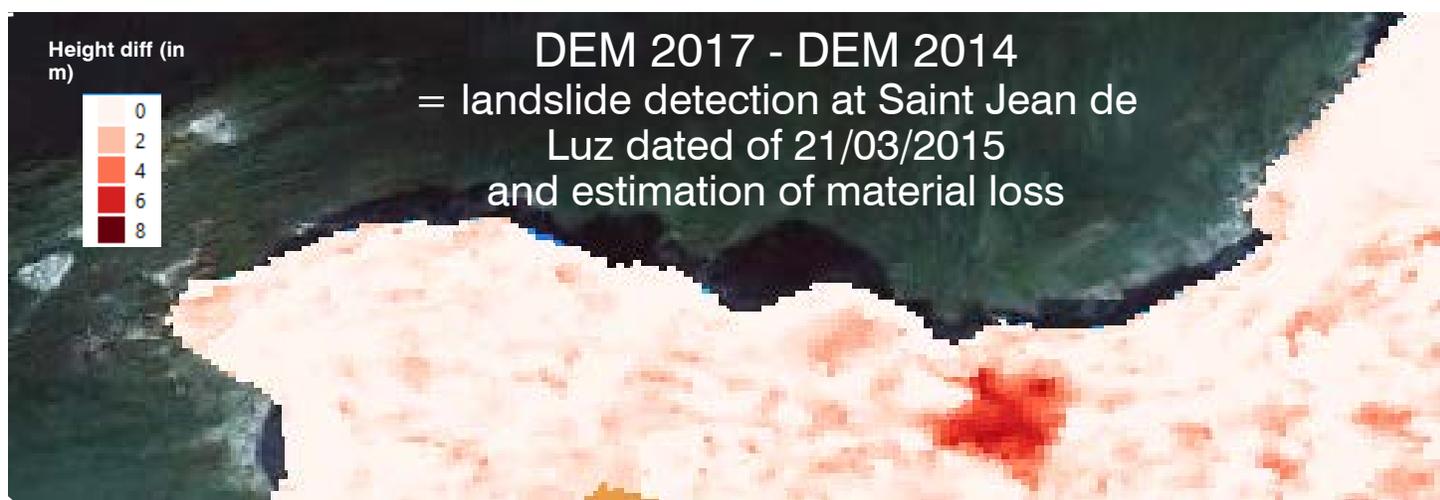
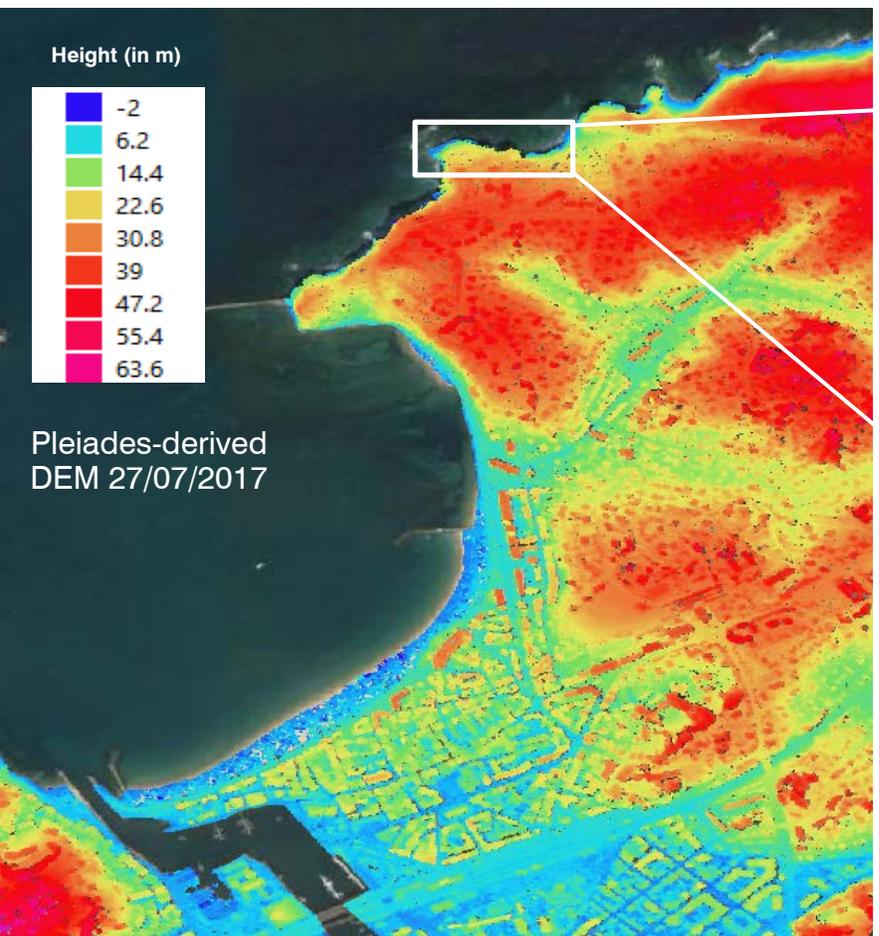


Rocky coastlines / coastal cliffs



different strategies tested to extract cliff lines (cliff foot / cliff apex)

- computing DEMs using time series of Sentinel-1 (SBAS) and stereo-pairs of Pléiades + slope detection



Communauté D'AGGLOMERATION PAYS BASQUE
EUSKAL HIRIGUNE Elkargoa



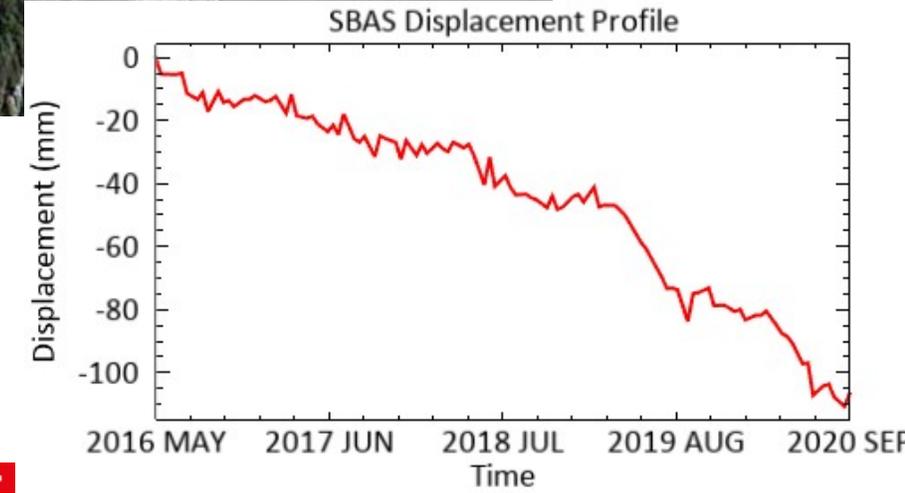
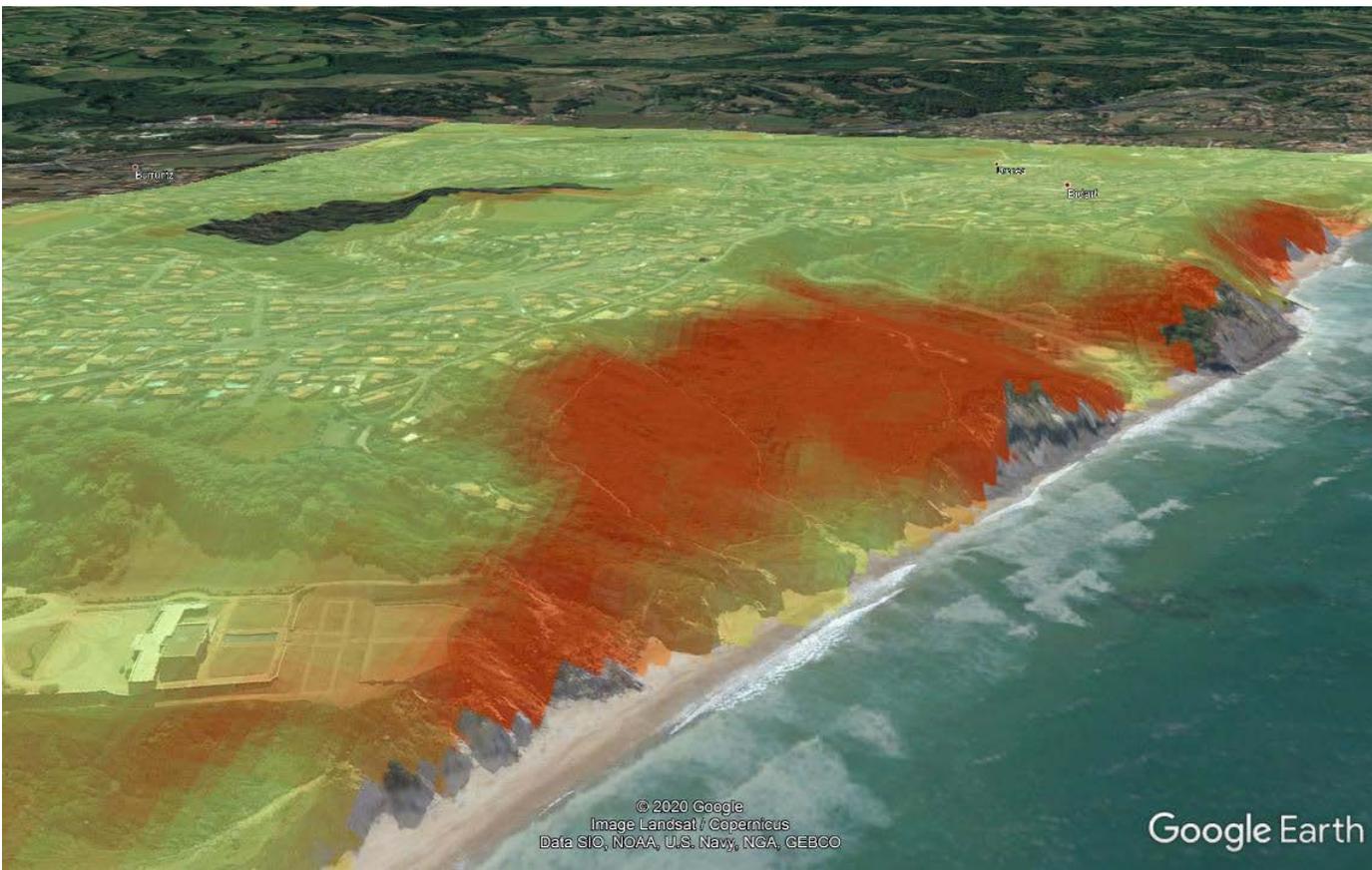
Caroline Sarrade, CAPB Agglomération Pays Basque *"The use of the Pleiades-derived cliff lines products might be very interesting for future projects."*



Rocky coastlines / coastal cliffs



SAR interferometry : new evidence of coastal cliff subsidence to be used as early warnings of sudden landslides !



Demonstrated capability of Earth Observation to assess coastal erosion issues all around European coastlines following the requirements expressed by a representative set of coastal managers in 5 member states

Earth Observation provides **affordable, easy-to-update, flexible and multi-scale** products for shoreline and coastal erosion monitoring

- high frequency (monthly) Sentinel-derived information about beach state (shoreline / nearshore bathymetry / beach morphology)
- seasonal / yearly updates of shoreline positioning (archive + VHR) supporting effort in knowledge augmentation of coastal change

Next is to move towards **a Space for Shore service** serving operational issues for shoreline planning

-  pre-storm vulnerability supporting beach nourishment operations
-  early-warning coastal landslide
-  coastal conservation



- Adaptation to Climate Change



Photo Credit: World Bank/Vincent Tremeau.

Saint Louis, Sénégal © World Bank

- Adaptation to Climate Change
- Conservation of exceptional coastal landscapes and biodiversity reservoirs (mangroves, coastal dunes, coastal wetlands...)



Mangrove in French Guyana © C. Proisy



Challenges Innovation Copernicus

 Ce programme est financé par la Commission Européenne dans le cadre du programme FPCUP - Caroline Herschel

Financé par

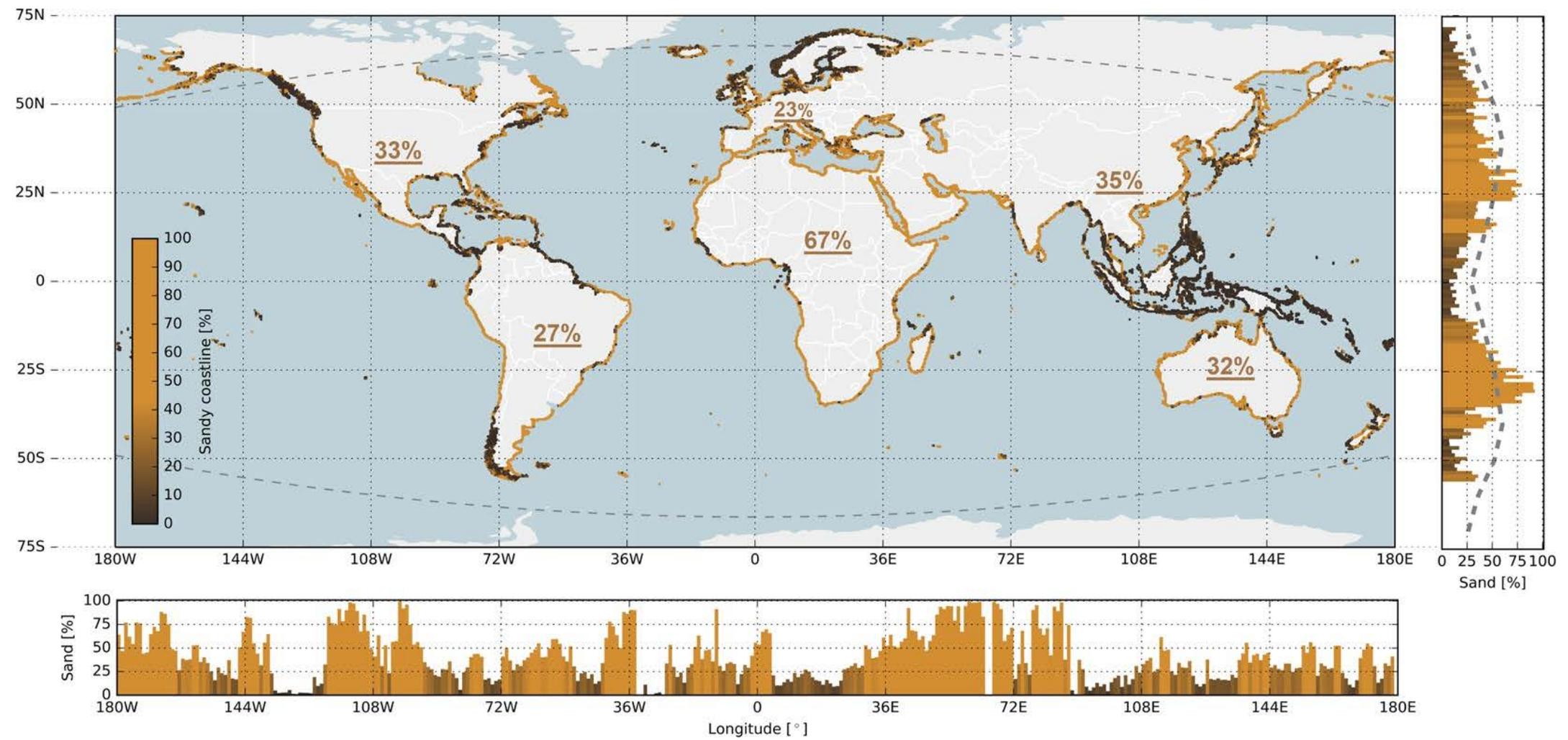


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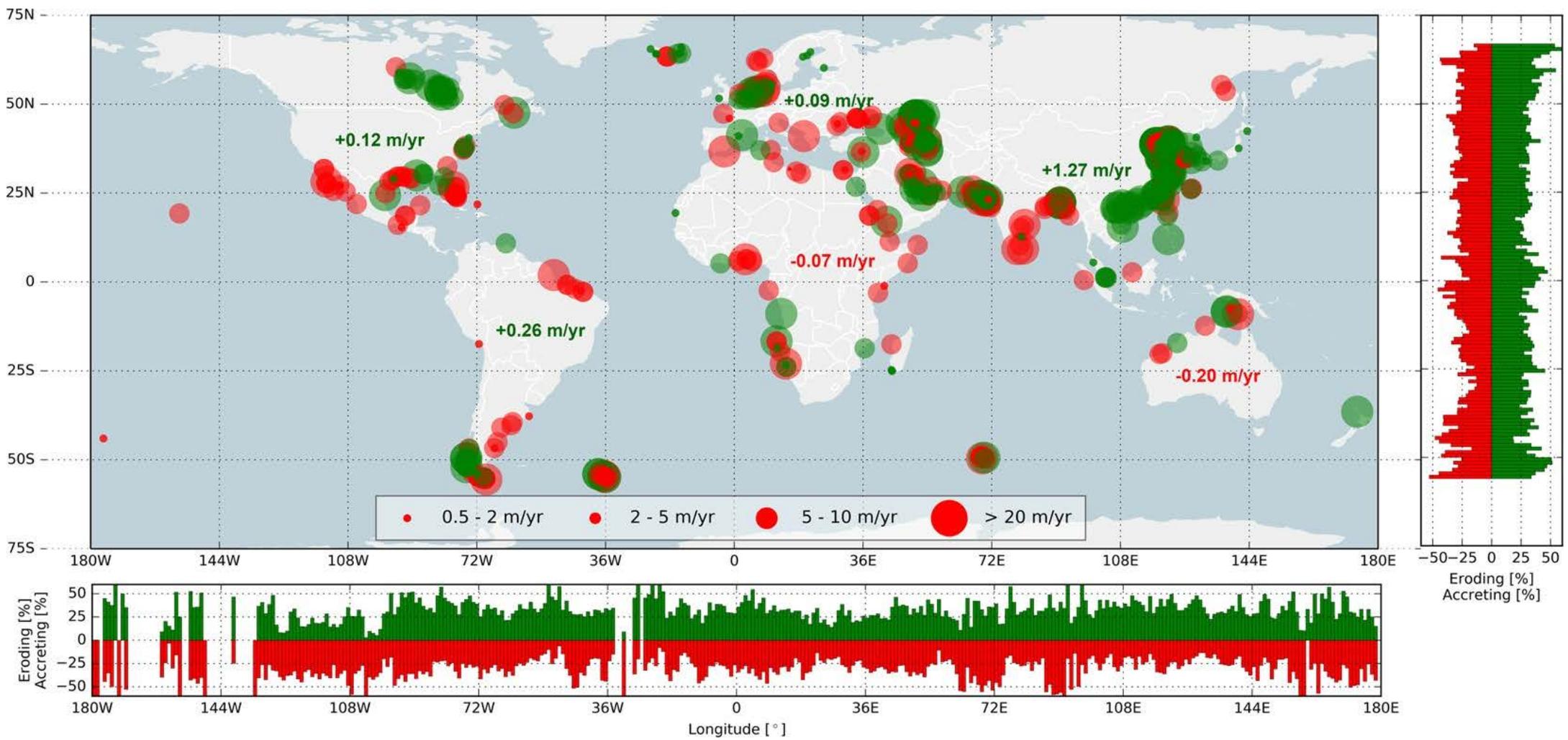
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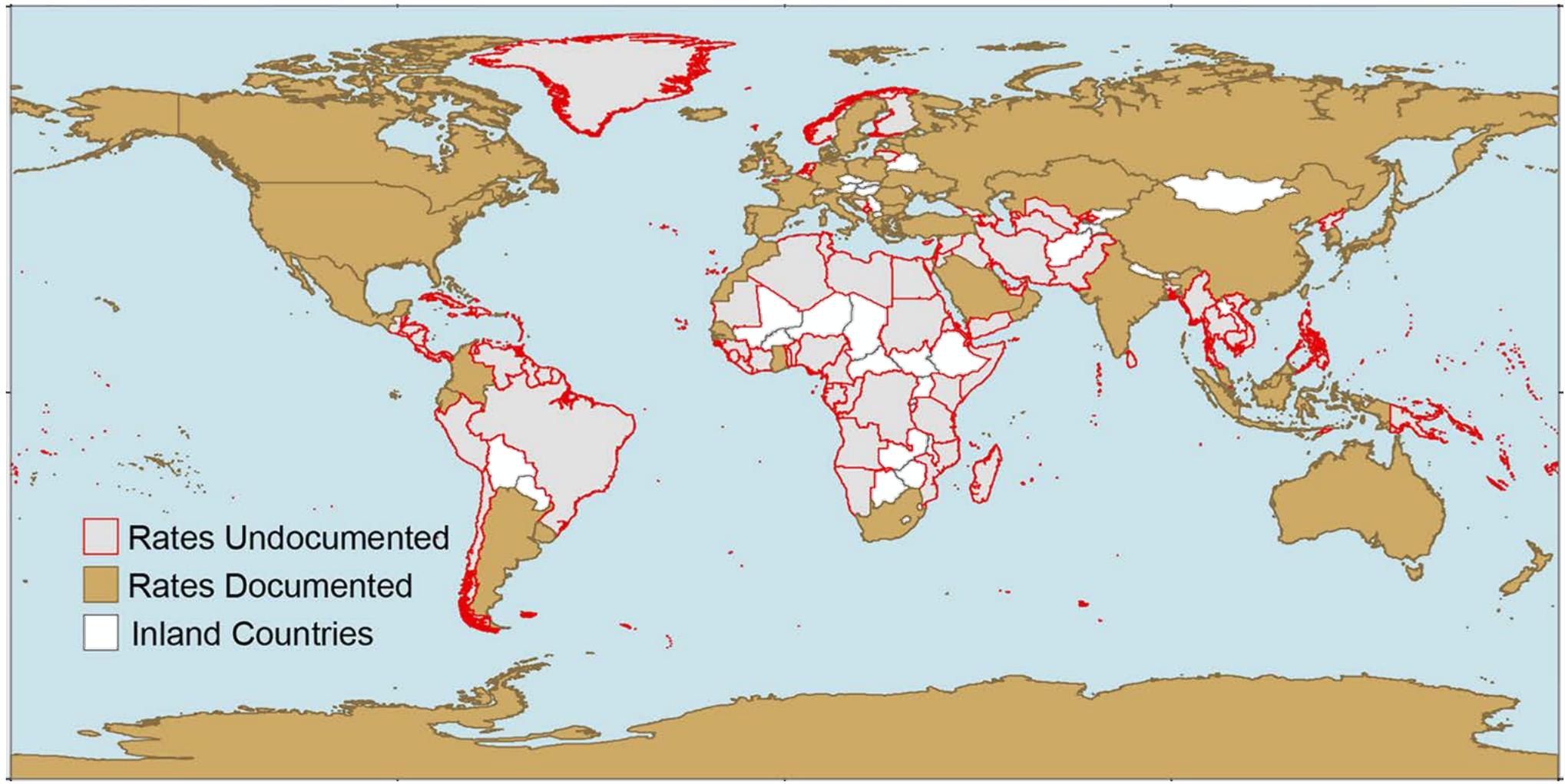


Luijendijk, A., Hagenaars, G., Ranasinghe, R. *et al.* The State of the World's Beaches. *Sci Rep* **8**, 6641 (2018). <https://doi.org/10.1038/s41598-018-24630-6>





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Young & Carilli, 2018 (*Earth Surface Processes and Landforms*)





Prof. Dano Roelvink, IHE Delft, senior scientist at Deltares

Thank you for your attention

and do not hesitate to contact us for any comment or interest in the Space for Shore products



contact details info@i-sea.fr

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Our relays in European regions

