SATELLITE-DERIVED SANDY SHORELINE CHANGE (1984-2020) AND PRIMARY DRIVERS IN SW FRANCE

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NTRODUCTION

Sandy shoreline erosion has become one of the biggest threats to coastal zones globally, both in developed and less developed regions of the world, which calls for improved understanding of past and future shoreline evolution and its drivers. This is true for long-term shoreline change trends but also for interannual shoreline response linked to large-scale climate patterns of atmospheric variability, which so far has been mostly explored locally based in situ monitoring program (e.g. Dodet et al., 2019).

Free-of-charge publicly available optical satellite imagery can now be used to provide short-term to multi-decadal shoreline data from the local to the global scale using different techniques (e.g., Bishop-Taylor et al., 2019), with errors typically under 10 m at microtidal beaches (Vos et al., 2019). However, on high-energy and/or meso to macrotidal low-gradient beaches satellite-derived shoreline (SDS) errors dramatically worsen (Castelle et al., 2021). In this contribution we explore if an adapted space-averaging of such uncorrected (noisy) SDS dataset can allow addressing the time- and space variability of shoreline change and their primary drivers including large-scale climate patterns of atmospheric variability.

METHOD

We address the 1984-2020 time- and space-evolution of 269 km of high-energy meso-macrotidal sandy coast in southwest France, comprising rapidly eroding and accreting sectors (Figure 1b,c), using uncertain (no tide and runup correction) SDS data using the CoastSat toolkit (Vos et al., 2019). The southwest coast of France was subdivided into boxes (Figure 1a) to which satellite images were cropped and processed with CoastSat. A total of 126, approximately 20 % overlapping, boxes were designed. All in all, a total of 104,444 individual shoreline positions along 500-m spaced transects were collected between April 12, 1984 and December 31, 2020. The shoreline trends were validated with field data collected along 41 transects surveyed along the coast over the period 2008-2019 (Nicolae Lerma et al., 2022), showing fair skill (RMSE = 1.05 m/yr and R^2 = 0.64).

We used wave data from a regional wave hindcast (see output grid points in Figure 1a), which were transformed into time series of breaking wave conditions along the coast to force an empirical longshore transport model.

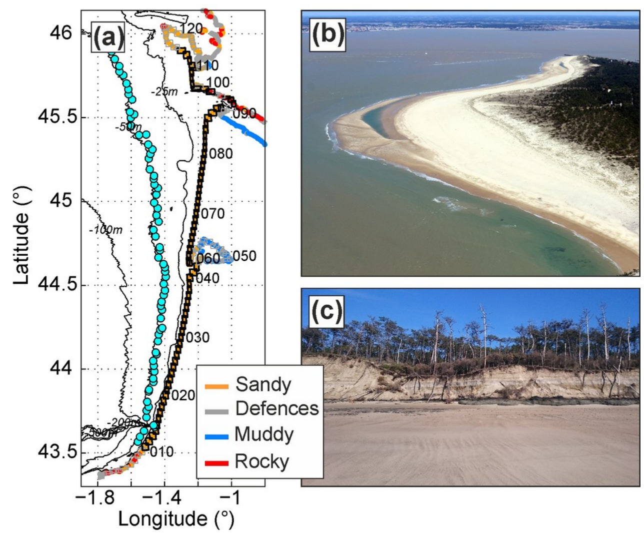

Figure 1 – (a) Location map of the southwest coast of France, with colour indicating shoreline type, and with the bathymetry contoured. The boxes (numbered) indicate Coastsat image extraction zones along the entire coast with the cyan dots indicating the corresponding wave hindcast grid points in approximately 50-m depth where wave time series were extracted. The thick black boxes show the boxes used in the present analysis. (b) accreting sector south of Cape Verdon (@Observatoire de la Côte de Nouvelle-Aquitaine); (c) chronically eroding Cape Négade where the dune has disappeared (Ph. B. Castelle).

RESULTS & CONCLUSIONS

Over 1984-2020, the shoreline eroded by 0.55 m/yr with maximum erosion (accretion) reaching 15.61 m/yr (6.94 m/yr), with the largest changes observed along coasts adjacent to the inlet and estuary mouths (Figure 2a,b). Results show that, away from ebb-tide deltas and swash bars, the long-term shoreline trend is well explained by the gradients in longshore drift computed from a regional wave hindcast and an empirical longshore transport formula.

By averaging the yearly SDS along the entire coastline, we find that interannual shoreline variability is well correlated with the winter West Europe Pressure Anomaly (WEPA), which outscores the other conventional teleconnection pattern indices. WEPA even explains more than 80% of the space-averaged shoreline variability over the recent period 2014-2020 when more and higher quality satellite images are available. A more local assessment of the links between climate indices and shoreline response shows that correlation with all climate indices dramatically drops downdrift of the large-scale estuary mouths and inlets (Figure 2c). This suggests that along this ~20 km stretch of downdrift coast, shoreline response is controlled by auto-cyclic process i.e. attributed to factors internal to the estuary mouth / inlet system. The rest of the coast is mostly controlled by halo-cyclic processes, i.e. attributed to factors external to the system which are primarily the variability in winter-mean wave height, which is well correlated with winter WEPA climate index.

Overall, we demonstrate that an adapted space-averaging of uncorrected (noisy) SDS dataset can allow addressing the time- and space variability of shoreline change and their primary drivers including large-scale climate patterns of atmospheric variability. We also advocate that such SDS analysis can be performed along any coastline in the world in order to guide future model development and application.

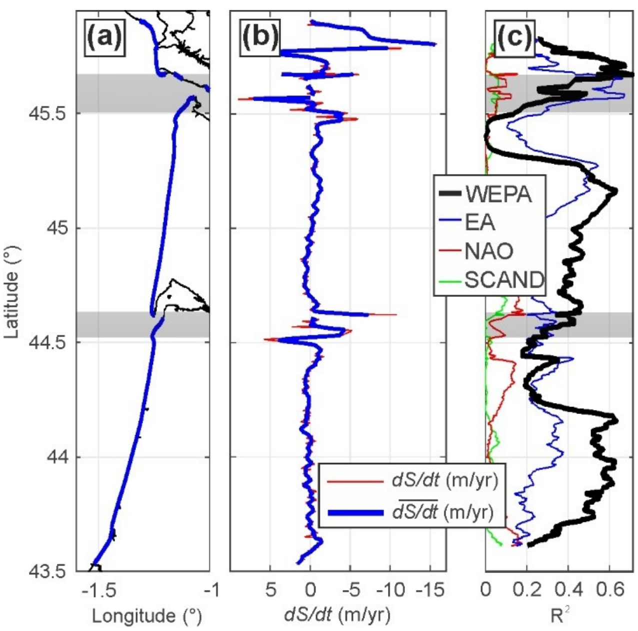

Figure 2 – (a) Shoreline sector addressed (thick blue line); (b) raw shoreline change trend (thin red) and its 2500-m moving average (thick blue); (c) coefficient of determination R^2 (1999-2020) between 10-km moving averaged yearly-mean shoreline deviation from the mean change dS/dt and the dominant climate indices in the northeast Atlantic.

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