Alongshore Varying Dune Retreat During Storms at a Barrier Island

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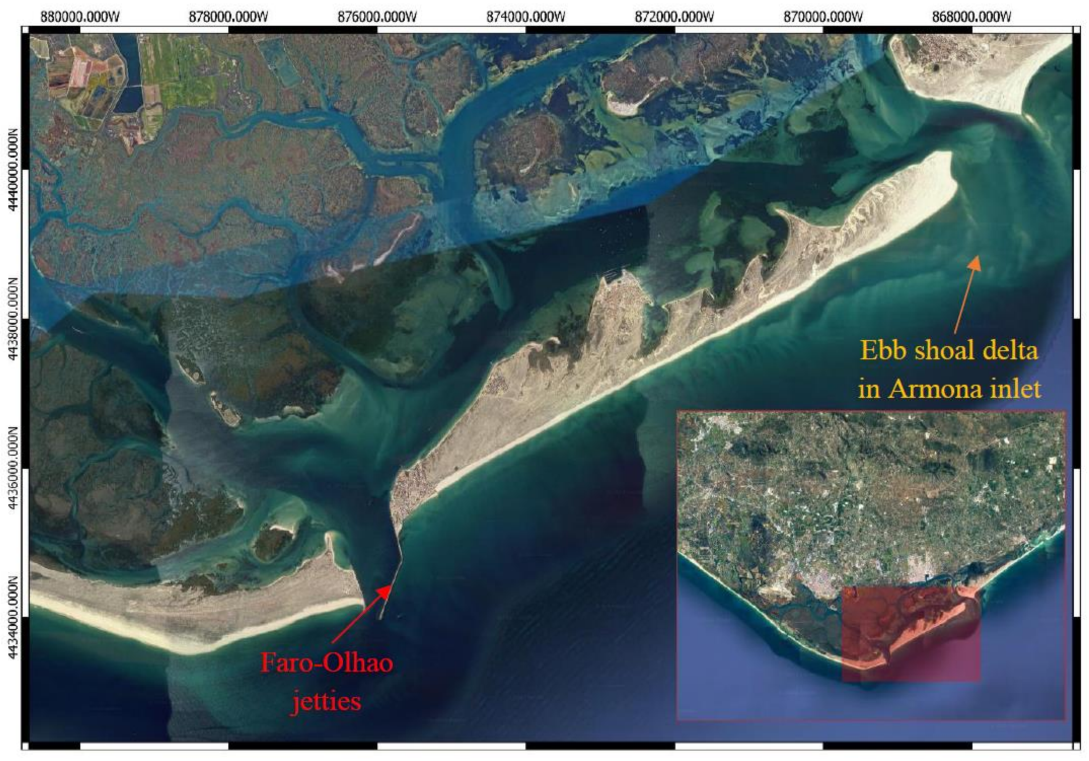
CULATRA BARRIER ISLAND



Location of Culatra Island

- Located in Southern Portugal
- Morphological evolution influenced both by natural and human interventions
- Elongation at the eastern end due to sediment supply from the Armona inlet
- Sediment starvation at the western end due to the impediment of eastward littoral drift by the Faro-Olhao jetty.

- Rubblemound and tetrapod rock armor units were used to construct the Faro-Olhao jetty resulting in a complete blockage of eastward sediment transport

Faro-Olhao jetty

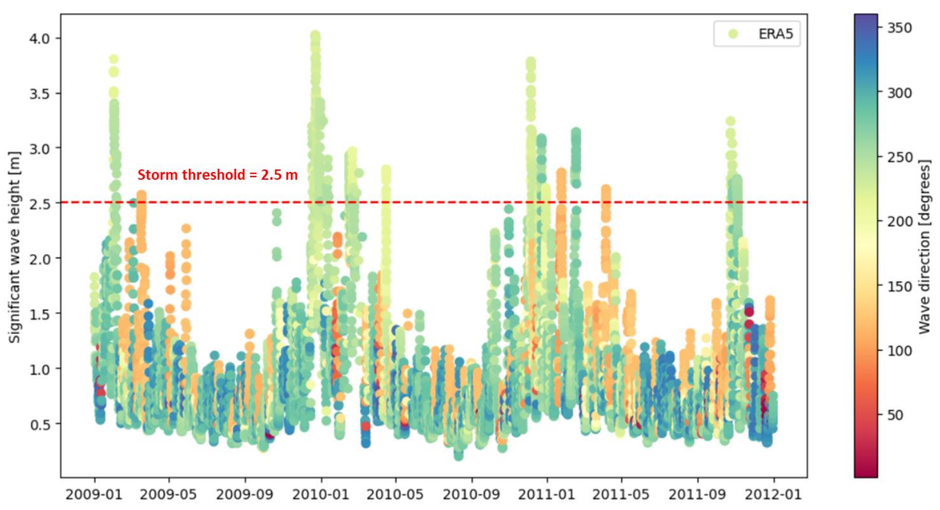
Megacusp

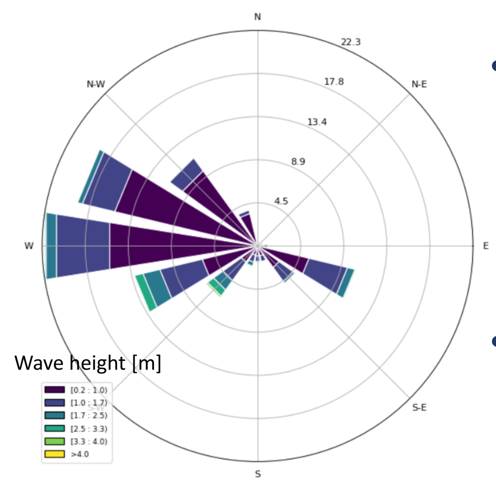
- Megacusp formation causes variability in beach width, the major factor in longshore variability of dune response to storms (Garzon et al., 2021)
- Objective: Understand the factors affecting the longshore variability of dune response to storms with the aid of fieldwork data and numerical models

OCEANOGRAPHY DATA AND WAVE PROPAGATION

Offshore waves → SNAPWAVE → Nearshore waves

(Hs, Tp, Dir, Directional spreading) | Unstructured grid with bathymetry | Alongshore gradient in wave shear stress

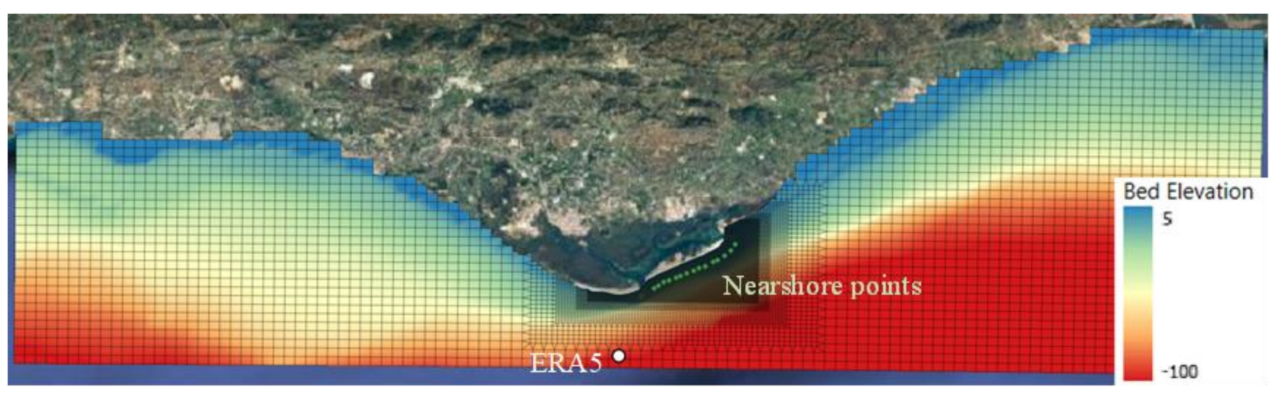




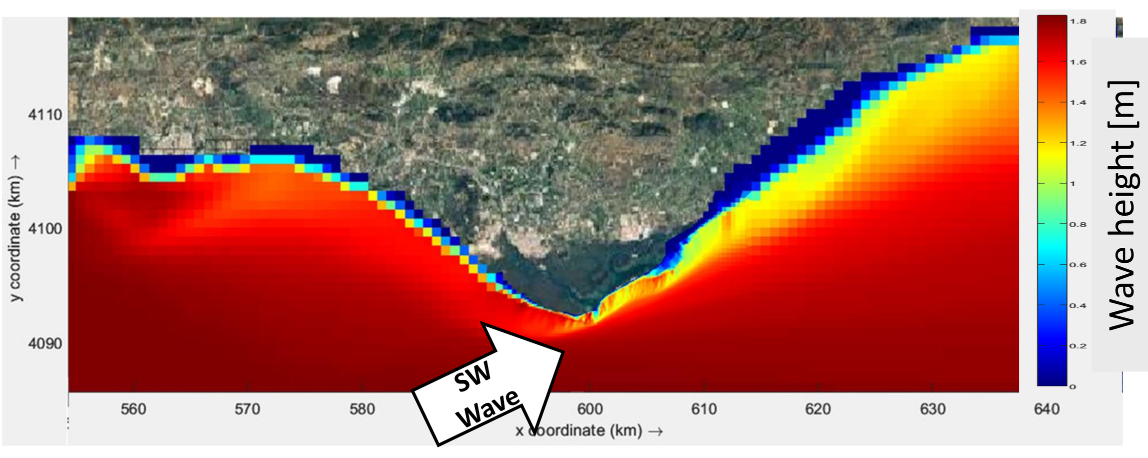
ERA5 swell and wind waves time series (left) and wave rose (right)

- The prevailing storm wave direction is from the Southwest
- The dominant wave direction is from the West

- SnapWave in stationary mode was used to propagate the ERA5 offshore waves.
- An unstructured grid with the finest resolution of 50 m was used for faster computation.



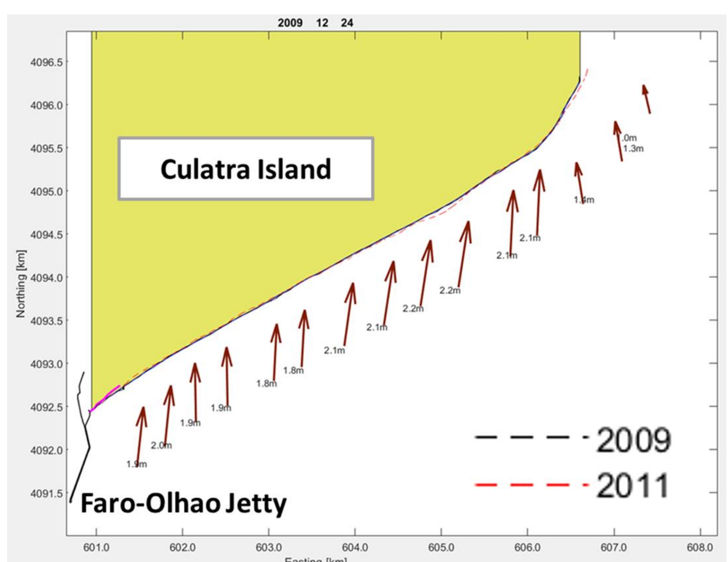
SnapWave unstructured grid with bathymetry



Wave height distribution due to SW offshore waves

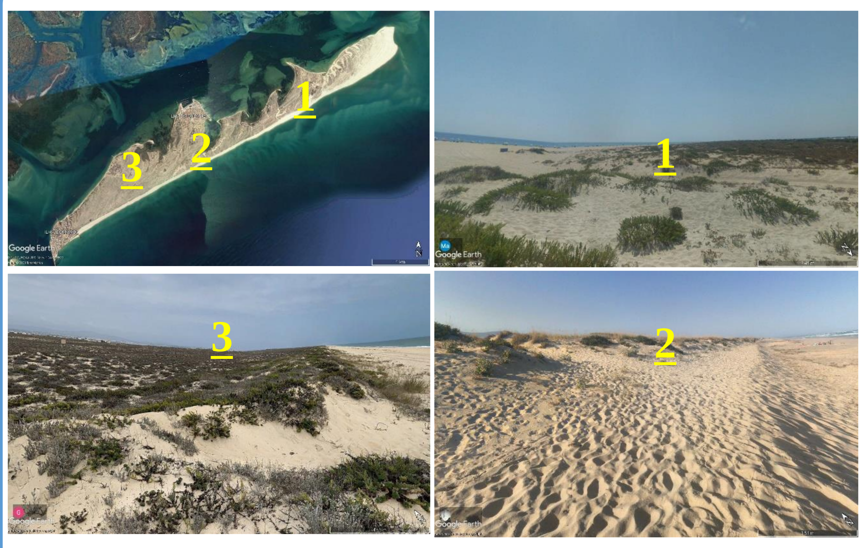
- SnapWave captures the large-scale wave refraction causing a sheltering effect at the eastern flank of Ria Formosa from Southwest waves

- The presence of ebb shoal at the eastern end causes the wave to refract resulting in alongshore variation in wave shear stress
- The presence of Faro-Olhao jetty at the western end resulted in a longshore gradient of sediment transport
- These gradients in wave shear stress and sediment transport influence the longshore variability of dune response to storms



Alongshore gradient in wave shear stress

DUNE MORPHOLOGY AND VEGETATION THICKNESS

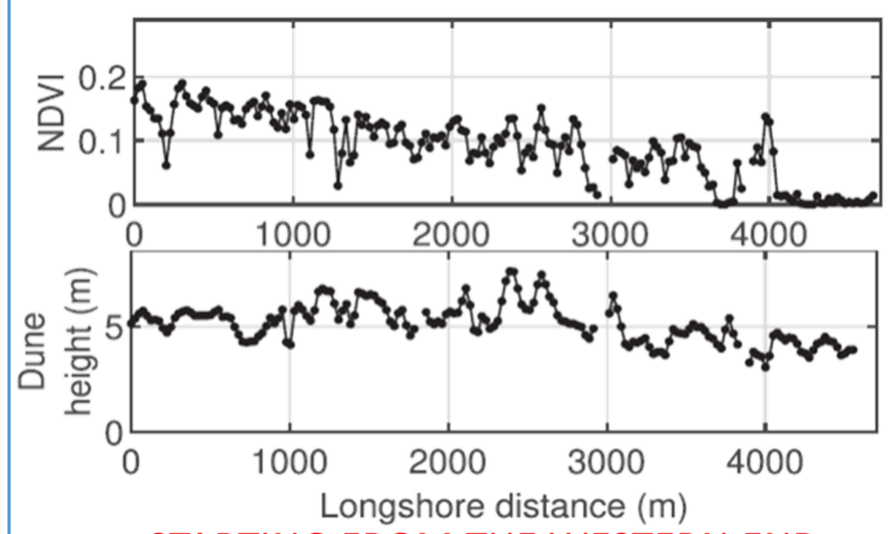


Variability of dune morphology and vegetation

- Dune morphology and vegetation thickness also influence the longshore variability of dune response to storms (Garzon et al., 2021)

$$NDVI = \frac{RNIR - RR}{RNIR + RR}$$

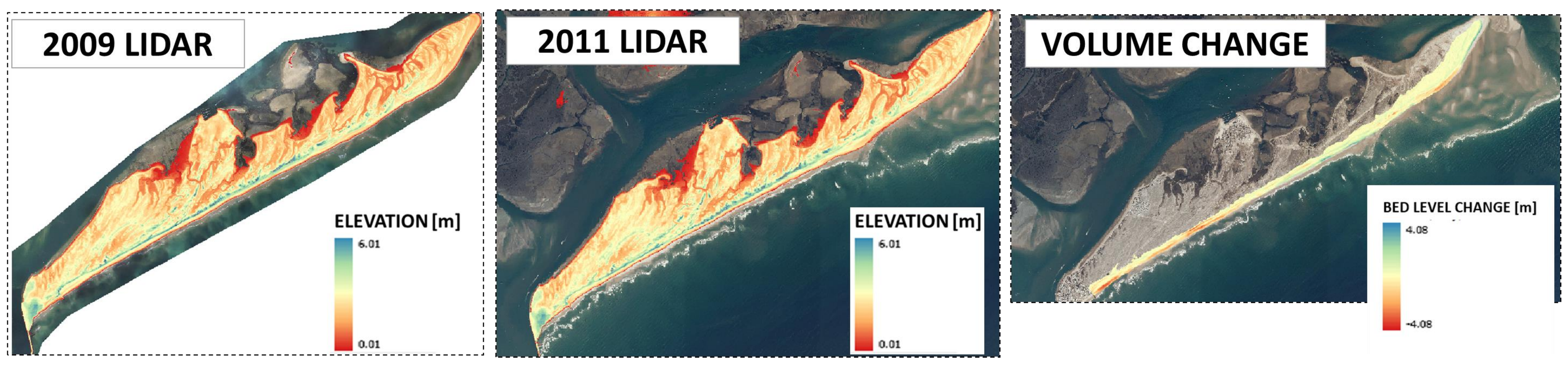
Vegetation thickness quantified by NDVI



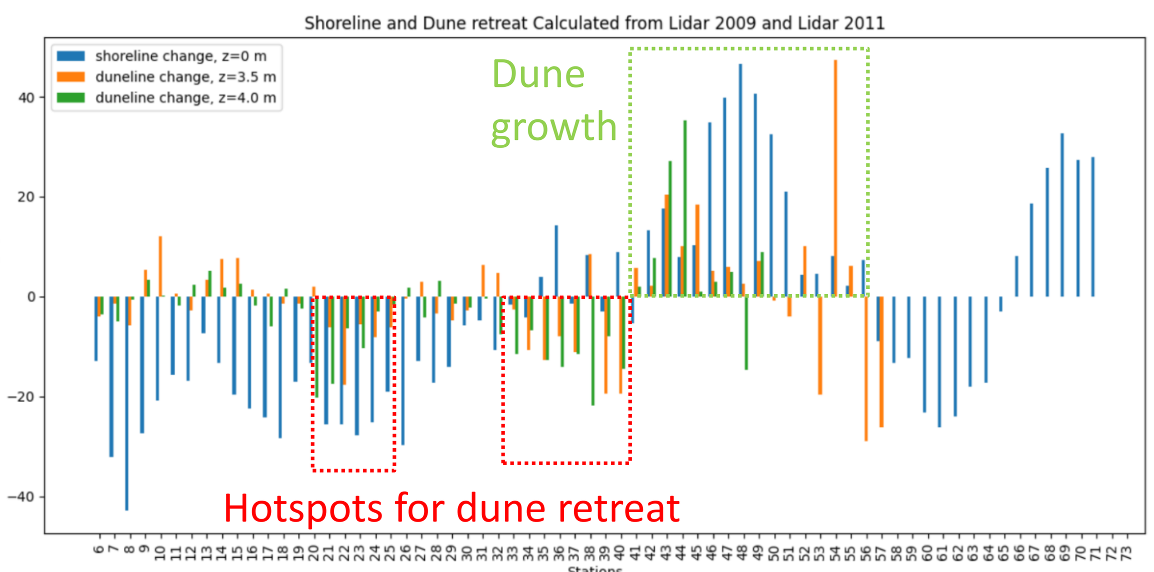
Longshore variability of dune and vegetation

- NDVI: RR is the multispectral red band and RNIR represents the near-infrared band of the multispectral imagery at each pixel
- A minimum NDVI threshold of 0.10 is used to classify the presence of vegetation
- The start of the vegetation was assumed to be the dune line
- The dune height varies around 4 to 8 meters alongshore

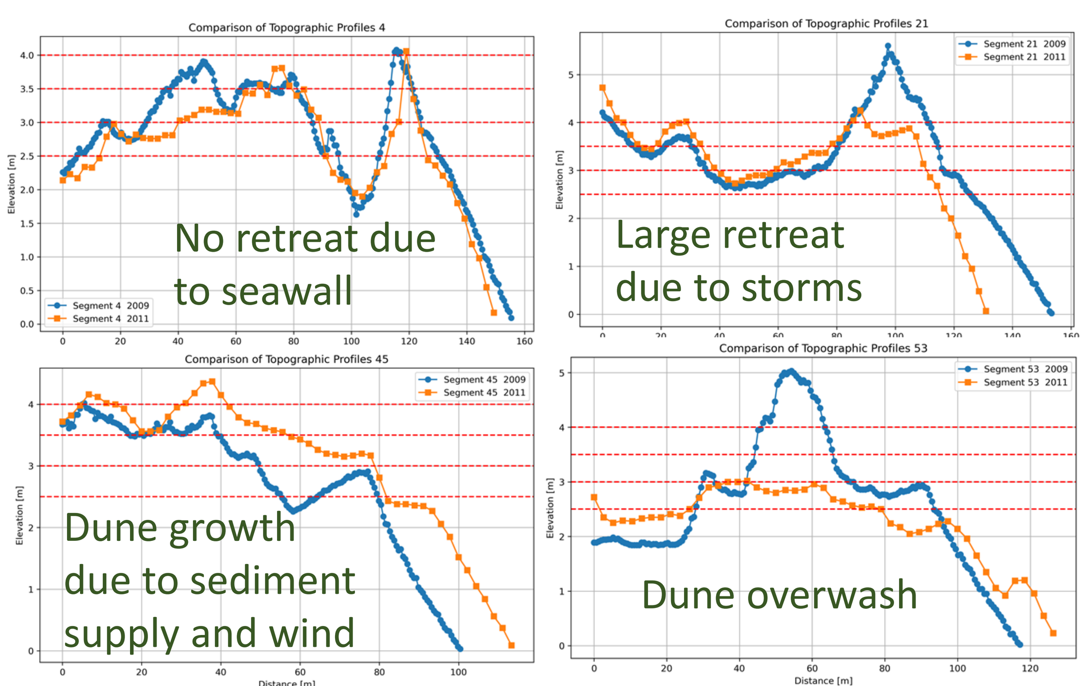
MORPHOLOGICAL DATA ANALYSIS



Digital Elevation Model (DEM) for 2009 (left) and 2011 (middle) and Volume Change (right)



Duneline change (negative is retreat and positive is accrete)



Profile classifications based on the driving mechanism

- Volume change was calculated using DEM's
- Retreat was calculated assuming the dune line is at elevations 3.5 m and 4.0 m
- Hotspots for retreat due to storms were identified
- Three distinct areas emerged: profiles 1-5 (protected by seawalls), 6-42 (linear barrier island with dune retreat from 2010 storms), and >43 (curved barrier island affected by inlet and wind, undergoing recovery with berm and dune formation)
- Instances of dune overwash were observed near the inlet
- We aim to capture this dune longshore variability using numerical models.

CONCLUSION

- A preliminary investigation of factors affecting the longshore variability of dune response to storms was conducted such as (i) initial morphology, (ii) wave energy and incidence angle, and (iii) dune morphology and vegetation.
- SnapWave effectively captures the alongshore variation in wave shear stress along the island.
- Morphological data such as LIDAR 2009 and LIDAR 2011 give information on the hotspots for erosion and other relevant processes such as dune growth due to wind and sediment supply, and dune overwash along the barrier island.
- Dune morphology and vegetation thickness were quantified from fieldwork data and satellite images (NDVI).

REFERENCES

Garzon, J. L., Costas, S., & Ferreira, O. (2021). Biotic and abiotic factors governing dune response to storm events.

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