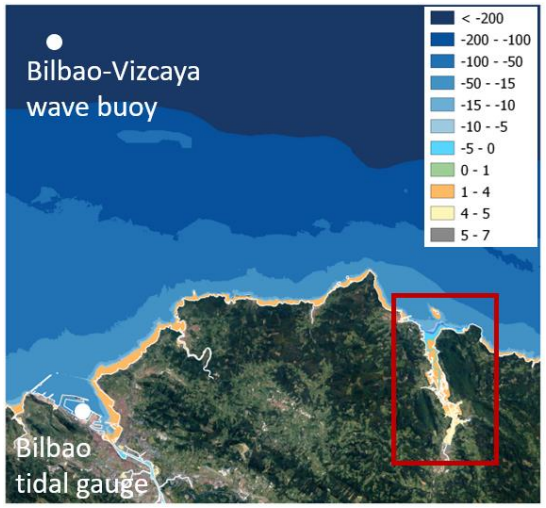
# A numerical model for estuaries: The case of the Oka estuary (SE Bay of Biscay)

Garnier, R., Townend, I., Monge-Ganuzas, M., de Santiago, I., Liria, P., Abalia, A., ... & Uriarte, A. (2022). Modelling the morphological response of the Oka estuary (SE Bay of Biscay) to climate change. *Estuarine, Coastal and Shelf Science*, *279*, 108133.

# STUDY SITE





- The Oka estuary (south-eastern Bay of Biscay) belongs to the Urdaibai Biosphere Reserve declared by UNESCO in 1984.
- The estuary is a drowned fluvial valley composed by shallow intertidal sandy and muddy flats and saltmarshes and is tidally dominated.
- Waves are a dominant influence on the enclosing spit and the ebb tidal delta.
- The ebb delta is formed by the Mundaka sand bar, a worldwide recognized surfing spot, whose morphology is the result of the morphodynamic interactions between the beach, the inlet, and the inner estuary.
- The processes that govern the morphological changes of the Oka estuary are influenced by the combined effects of tides, waves, river and wind.

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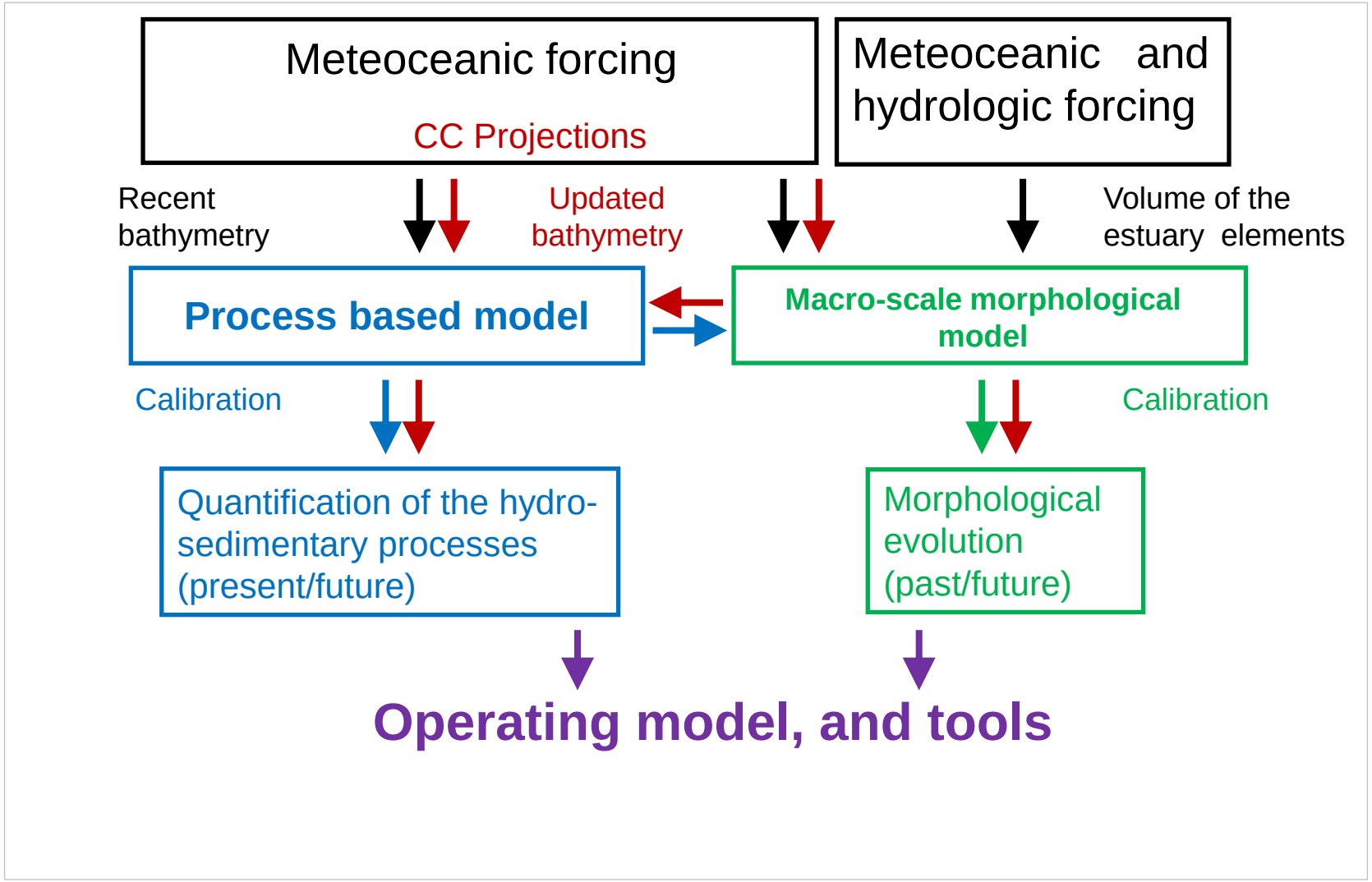
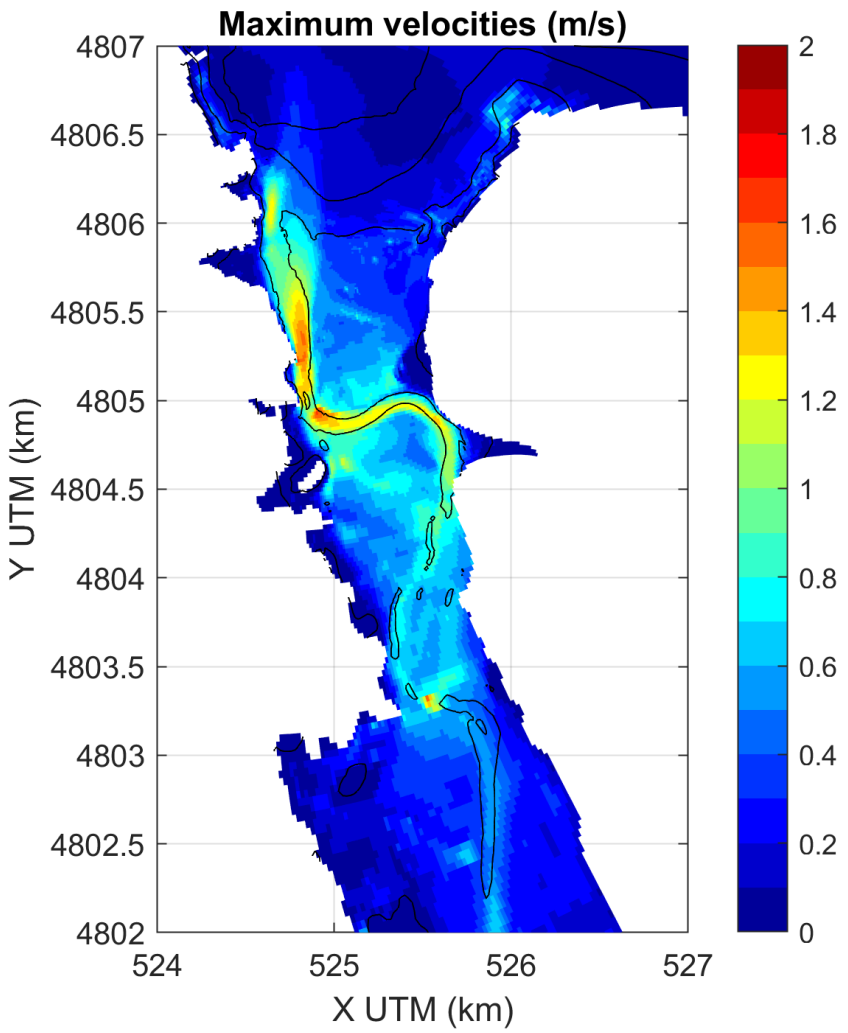
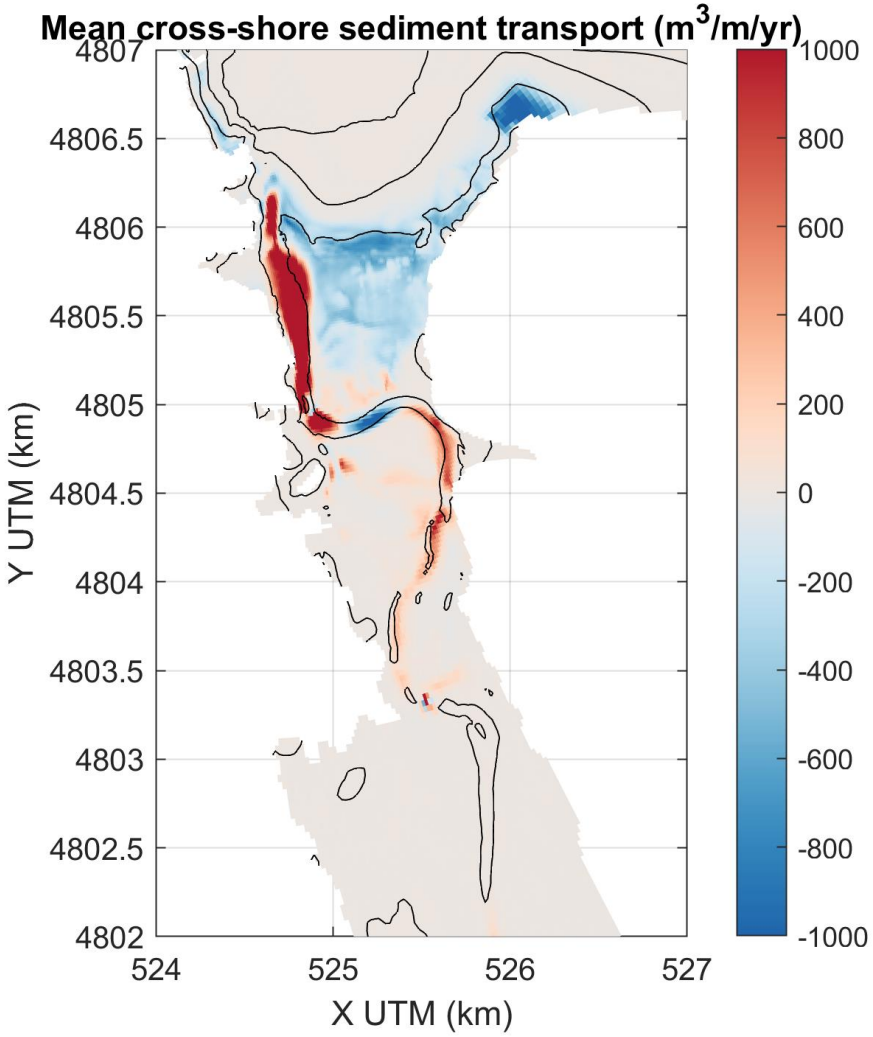
# NUMERICAL MODEL



# PROCESS BASED MODEL




The process based model is composed by:

- SWAN
- DELFT3D

RESULTS: *The process based model is used to parameterise the morphological model.*

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# MACRO SCALE MORPHOLOGICAL MODEL

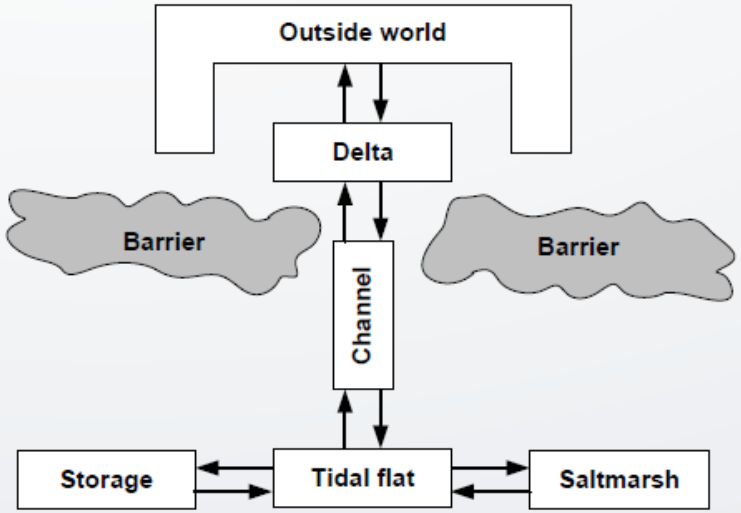
*'The modelling approach consists of a schematization of an estuary with its main morphological elements viewed at an aggregated scale.'*

Hypothesis: *'under constant hydrodynamic forcing, each element tends towards a morphological equilibrium'*

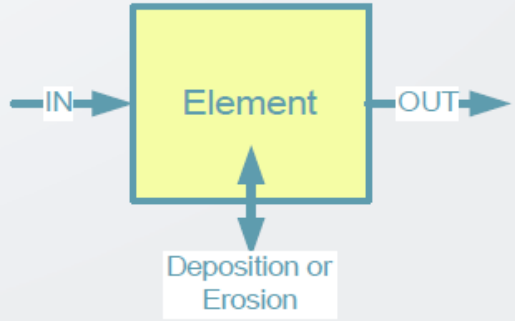
RESULTS:
*Quantify sediment exchange processes from a historical scale (order of 100 years, anthropogenic actions), to a geological scale (Holocene scale - 8,500 years).*
*Determine the state of equilibrium of the estuary*
*Determine future changes for different climate change scenarios.*

## ASMITA

**A**ggregated **S**cale **M**orphological **I**nteraction between a **T**idal inlet and the **A**djacent coast




Model sediment exchange between elements

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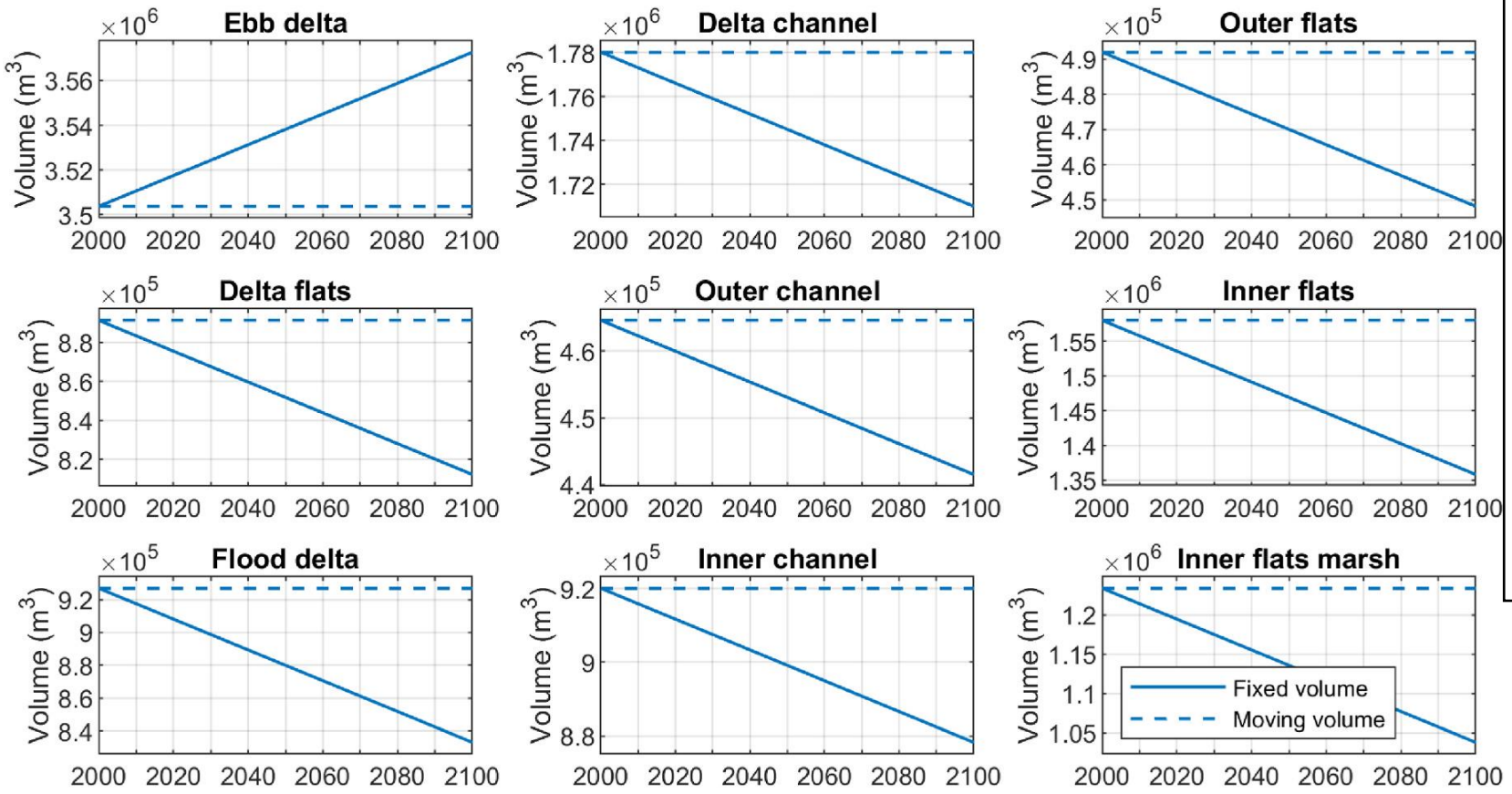
# RESULTS




Response of the Oka estuary to a linear sea level rise.

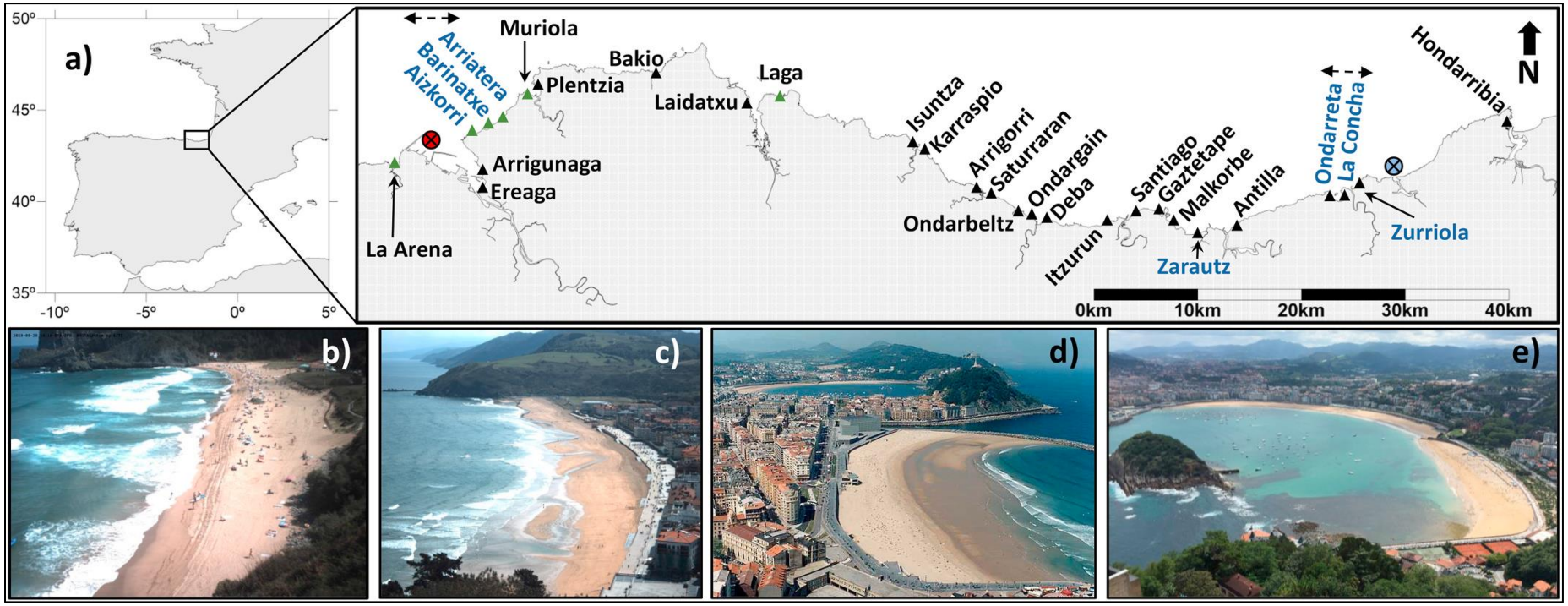
Time evolution of the fixed volume (solid line) and of the moving volume (dashed line) for the different morphological elements represented in ASMITA.

Notes: (i) scale on y-axis varies; (ii) the dashed line are horizontal - this means that the estuary keeps pace with the sea level rise and that a similar sedimentation is obtained in all elements; and (iii) an increase in sediment volume (ebb delta) is equivalent to a decrease in water volume (the other elements).

# A numerical model for shoreline: The case of the Basque coast (NE Spain)

de Santiago, I., Camus, P., Gonzalez, M., Liria, P., Epelde, I., Chust, G., ... & Uriarte, A. (2021). Impact of climate change on beach erosion in the Basque Coast (NE Spain). *Coastal Engineering*, *167*, 103916.

# STUDY SITE




- A total of 28 beaches, which corresponds to the official network of beaches listed by the Basque Government, along a 150 km coastal stretch located in the Basque Coast were analysed.
- The Basque Coast is characterized by its high degree of coastal anthropization; 22 out of the 28 studied beaches are urban beaches with coastal protection structures. All beaches along the Basque Coast are embayed systems laterally delimited by natural, or in some cases artificial, outcrops.

# NUMERICAL MODEL

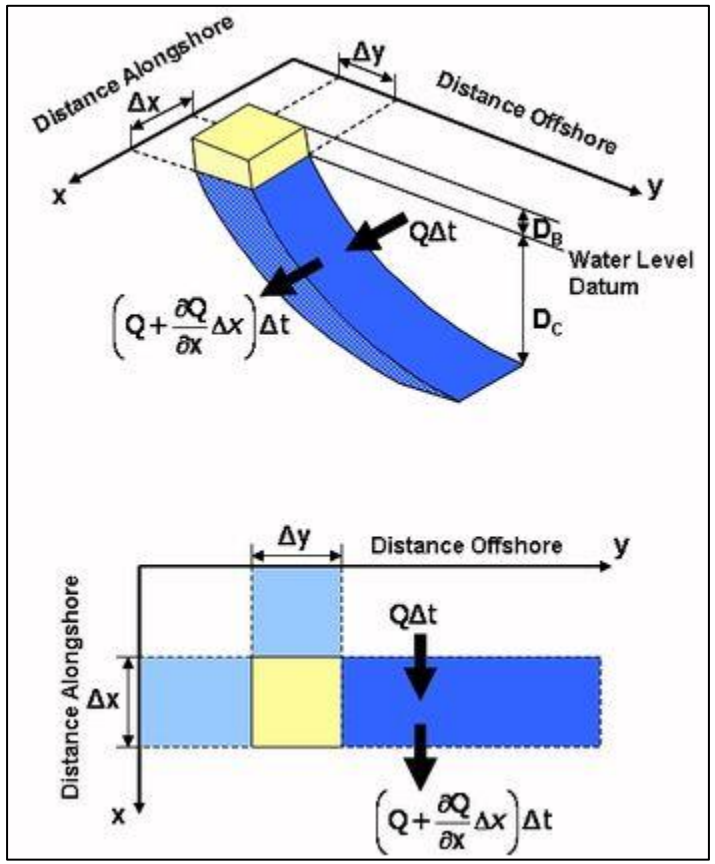
*ys* = shoreline position
*t* = time

ys,eq = cross-shore equilibrium position
kce,ca = erosion/accretion rate control parameter

$$\frac{\partial y_s}{\partial t} = \frac{1}{h_c}\frac{\partial Q_l}{\partial x} + k_{ce,ca}\left(y_{s,eq} - y_s\right)$$

$Q_l$ = longshore sediment transport rate
$x$ = alongshore coordinate
$h_c$ = closure depth

## Longshore sediment transport




## Cross-shore sediment transport

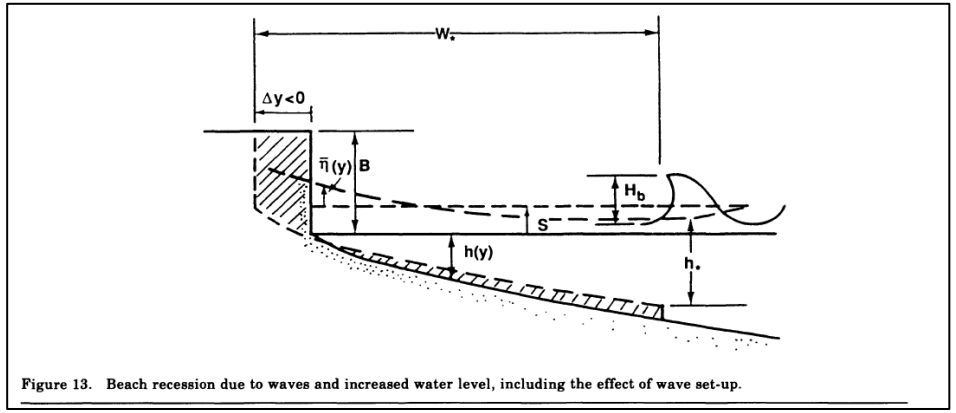
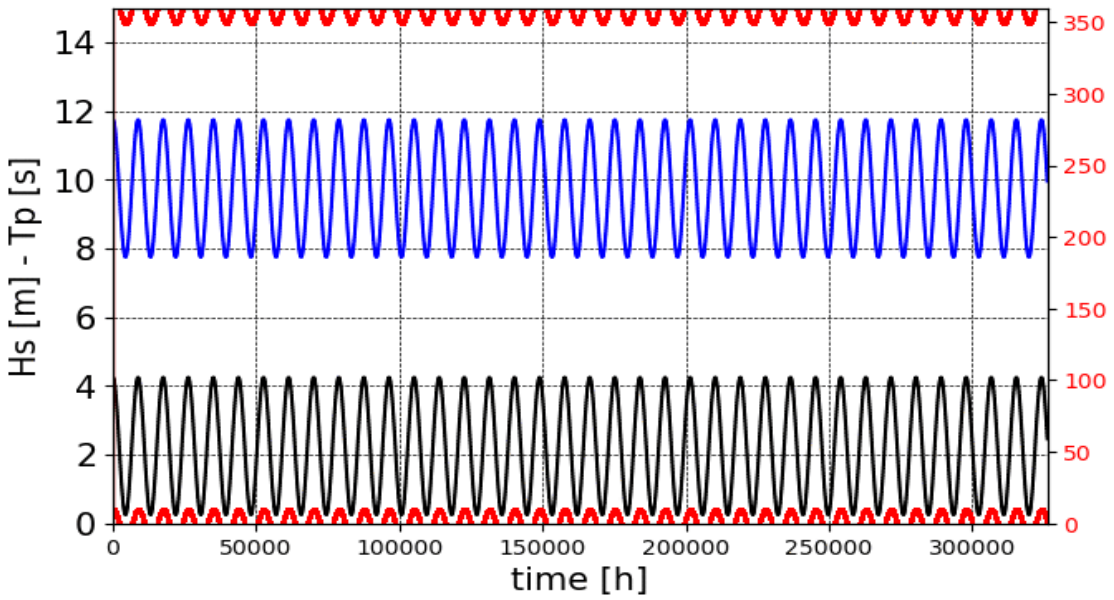
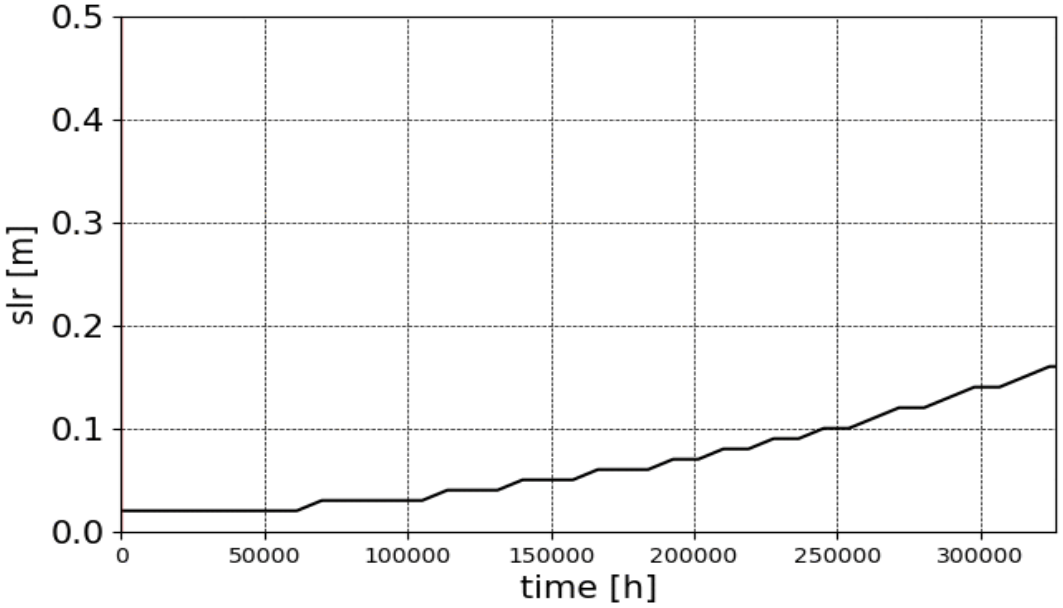


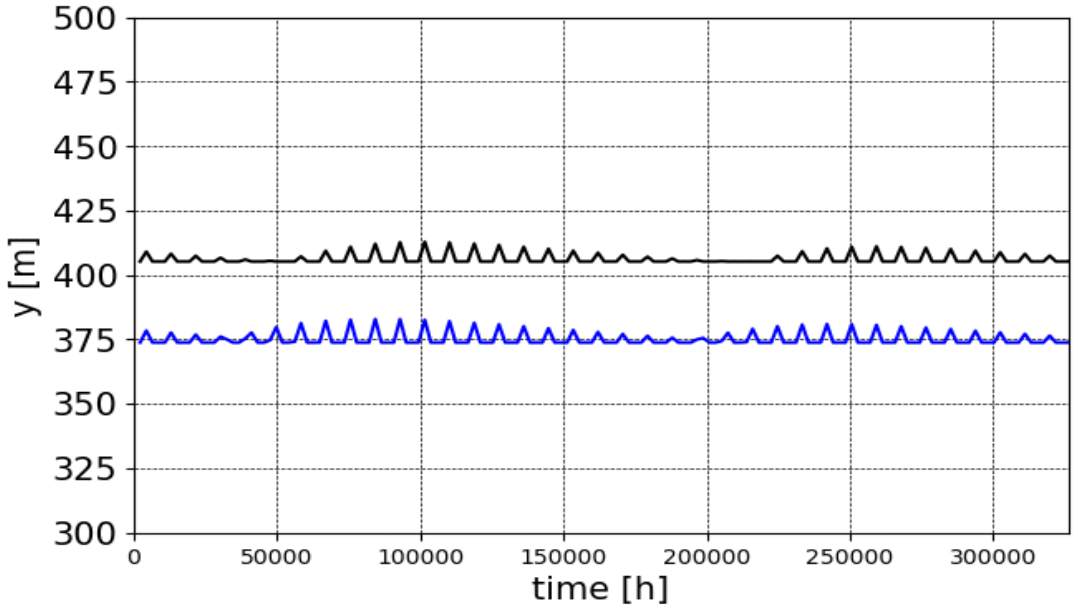

Figure 13. Beach recession due to waves and increased water level, including the effect of wave set-up.

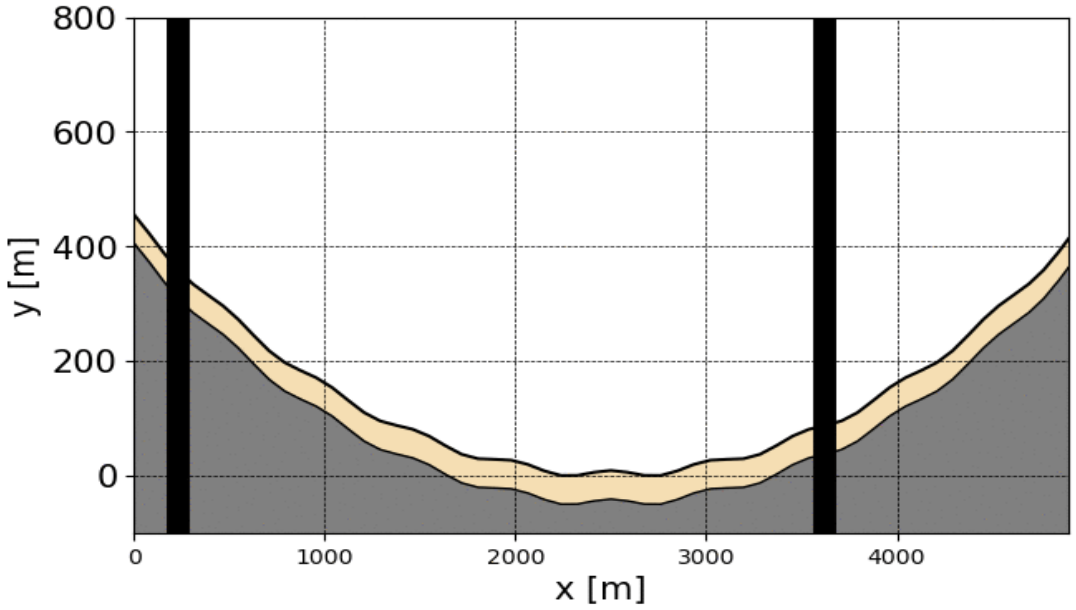
Dean, R. G. (1991). Equilibrium beach profiles: characteristics and applications. *Journal of coastal research*, 53-84.

# NUMERICAL MODEL

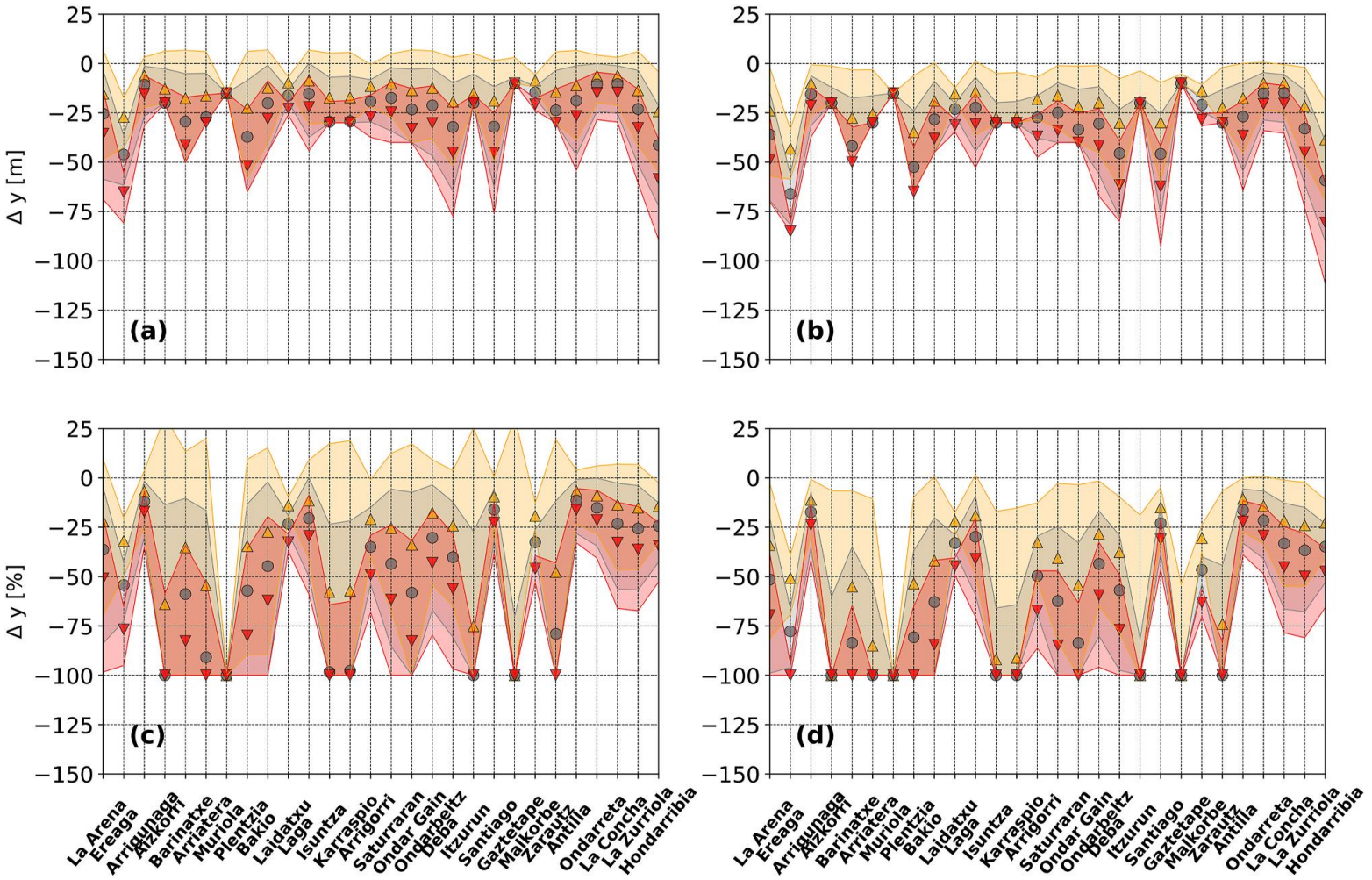


# RESULTS




Shoreline retreat due to short- and long-term processes by the year 2 100. a) Shoreline retreat under RCP 4.5 scenario. b) Shoreline retreat under RCP 8.5 scenario. c) Erosion and accretion percentages under RCP 4.5 scenario. d) Erosion and accretion percentages under RCP 8.5 scenario. Yellow upward triangle and yellow shadow zone: Triangle represents the mean value and shadow zone represents the uncertainty band (1st to 99th percentile values), associated with short-term processes, using the 5th percentile of the RCP SLR. Grey circle and grey shadow zone: Circle represents the mean value and shadow zone represents the uncertainty band (1st to 99th percentile values), associated with short-term processes, using the 50th percentile of the RCP SLR. Red downward triangle and red shadow zone: Triangle represents the mean value and shadow zone represents the uncertainty band (1st to 99th percentile values), associated with short-term processes, using the 95th percentile of the RCP SLR. Beaches are ordered in the x axis from West to East. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

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