An adaptation of Bruun's Rule to assess shoreline retreat due to SLR in different coastal environments and its application to the Andalusian coast (Spain).

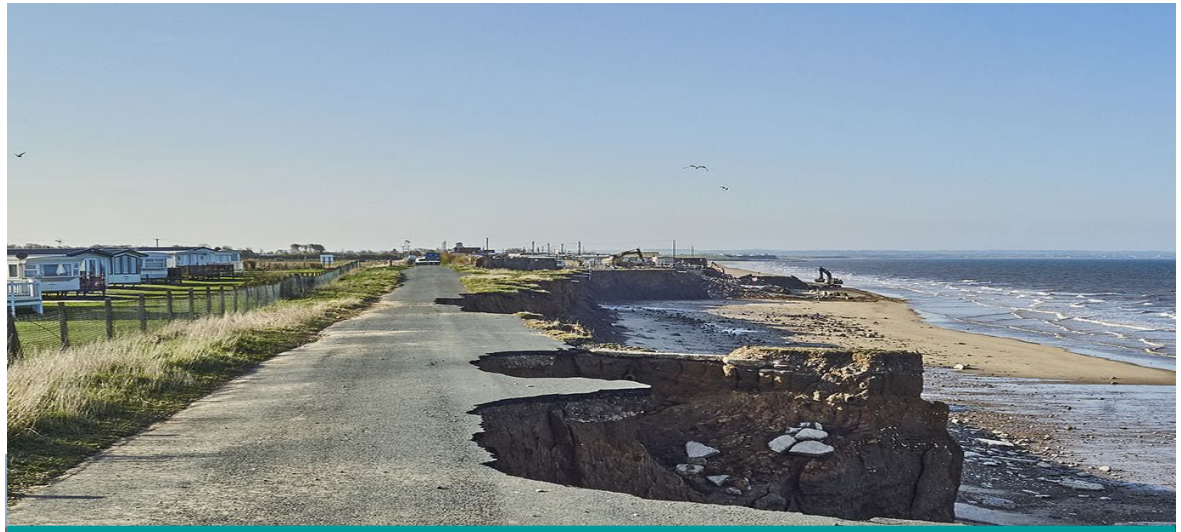
Arnau Garcia, Paula Gomes, Mauricio González, Raúl Medina, Verónica Cánovas

Affiliation: **IHCantabria**

Co-funded by the Erasmus+ Programme of the European Union

Introduction

- WHY SOULD WE STUDY SLR ?
- WHY USING THE CLASSICAL BRUUN'S RULE ?



+ COASTAL EROSION AND SHORELINE RETREAT

+ EXTREME EVENTS, FLOODING, STRUCTURAL DAMAGE

+ ENVIRONMENTAL & SOCIO-ECONOMIC IMPACTS

+ VULNERABILITY AND RISK ASSESSMENT

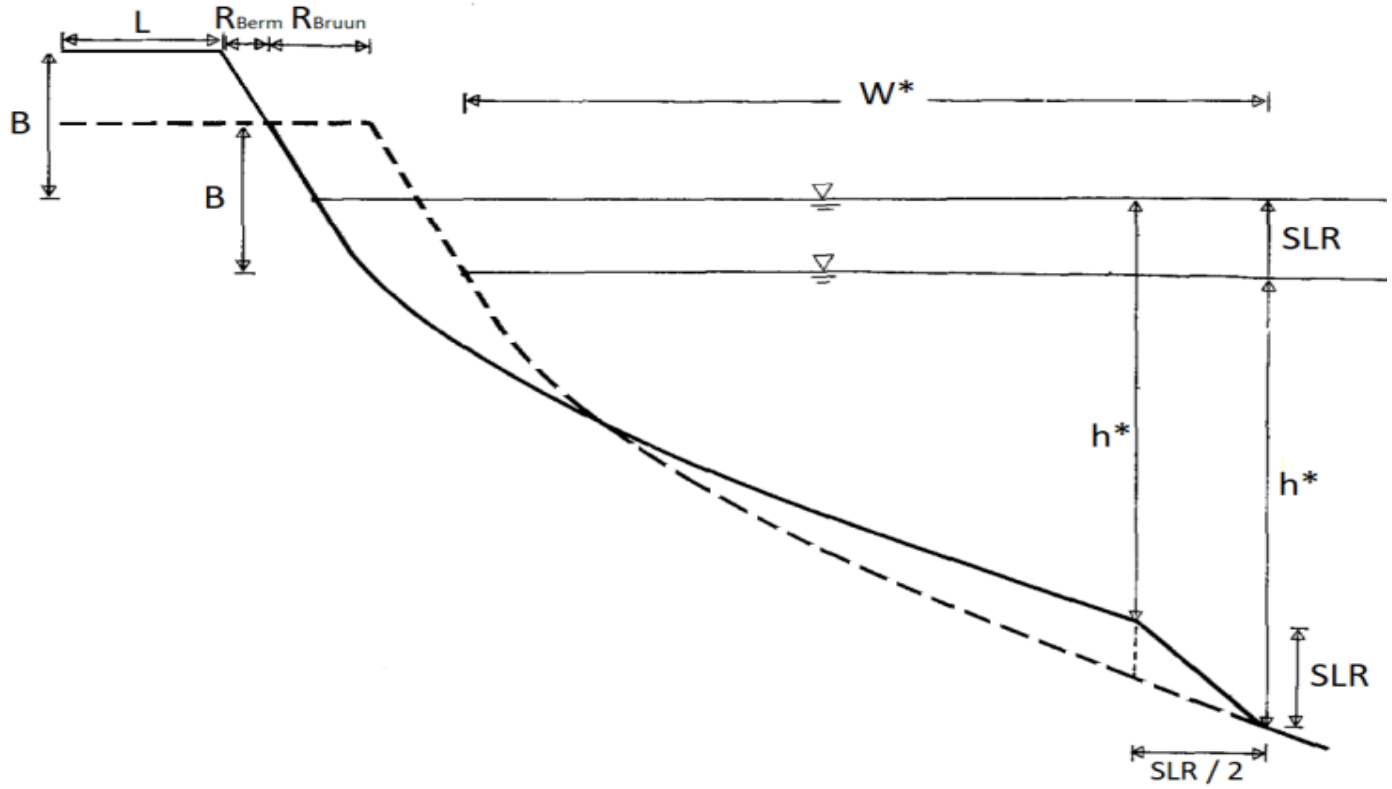
The Bruun's Rule

Assumes that the upper beach is eroded as the shore profile moves landward, and that the volume of eroded sediment is deposited offshore, resulting in a rise of the nearshore bottom which maintains a constant water depth.

EASY and SIMPLE

PRACTICAL

But it has limitations that must be concerned



Limitations

I. Only considers the sediment of submerged area. **Rosati et al., (2013)**

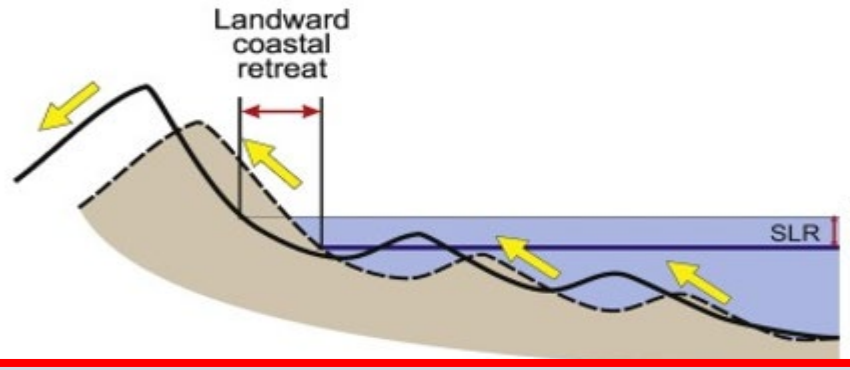
II. Also neglects the sediment needed to refill the estuaries after SLR. **Toimil et al., (2017)**

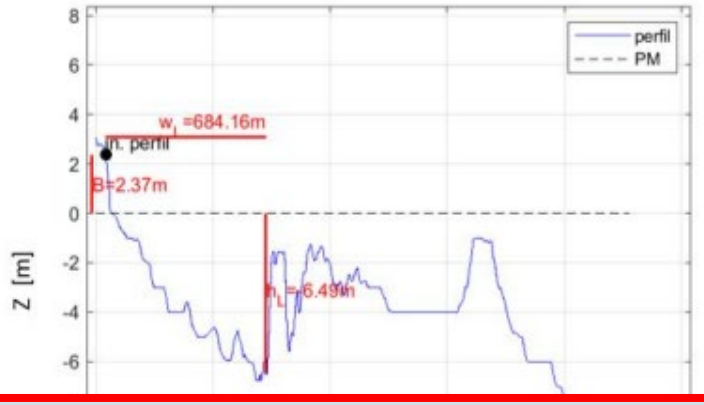
Limitations

- The classical Bruun's Rule;

III. ¿What if we had dunes morphologies backward? Does it affect to the final retreat?

IV. ¿What if we had morphologies like rocky slabs profiles or other constrained by immovable physical elements such as walls or rock cliffs?



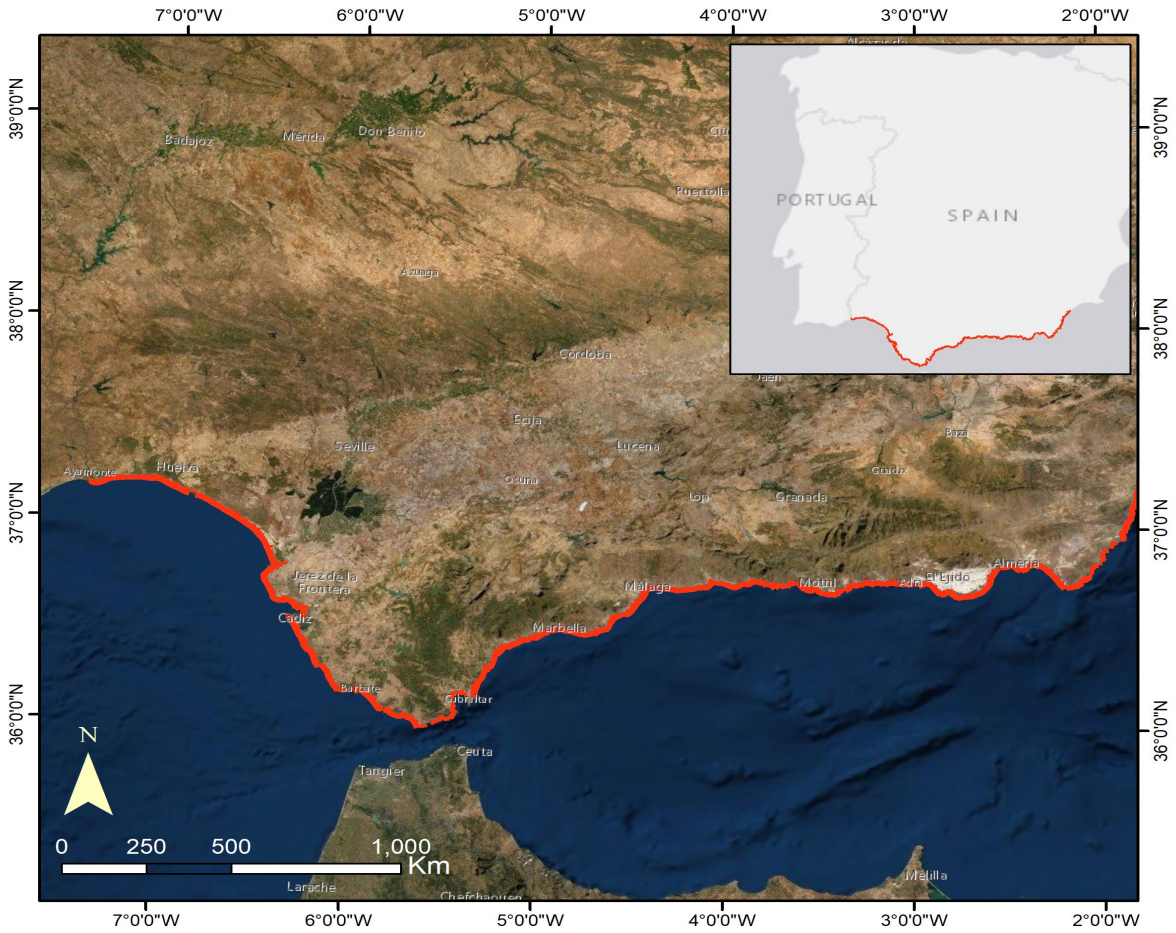


So, seems clear that a **new methodology approach** is needed to complement the Bruun's Rule, including mentioned processes and focusing on climate change timescale.

Objectives

- **New model** alternative approach to the Bruun's Rule
- Relations between **SLR** and **beach erosion**, identifying all the involved parameters.
- **Long-term analysis** of shoreline retreat along the Andalusian coastline, identifying critical zones.
- Provide practical **tools** for **coastal assessment**.

- **WHY IN ANDALUSIAN COAST?**



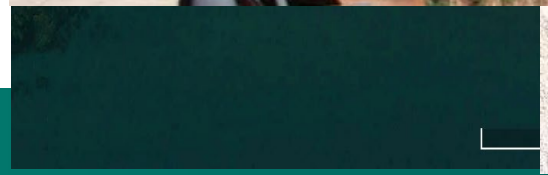
Area of interest

Built Environment
leArning for Climate
AdaptatiON

Coastal variety

Andalusia has a wide diversity of coastal morpho
and typologies clearly differentiated.

- Some examples:
  1. **Embayed beaches**
  2. **Wide open beaches**
  3. **Dune backshore beaches**
  4. **Rocky slab beaches**
  5. **Rocky beaches with cliffs**
  6. **Constrained beaches by seawalls, esplanades or other elements.**
  7. **Adjoining beaches to estuary bays**



Methodology

[R. Total = R. Profile + R. Estuarine + R. No_SLR]

[R. Profile = R. Bruun+ R. Berm]

$$R_{Bruun} = \Delta\eta \frac{W^*}{(B + h^*)}$$

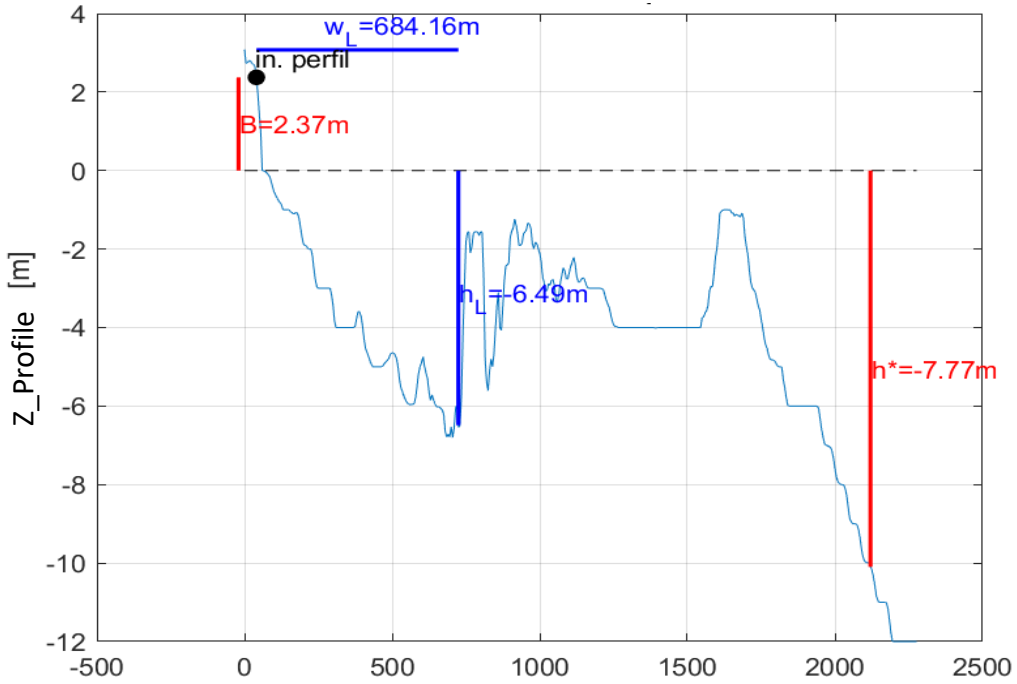
$$R_{Berm} = \Delta\eta \frac{(L - R_{Bruun})}{(B + h^*)}$$

Rosati et al., (2013)

This adaptation was proposed for profiles with a sand **dune** at the backshore:

$$R_{Profile\_d} = \frac{\Delta\eta\, W^* - (R_{Bruun} + R_{Berm} - L)\, Hd}{B + h*}$$

And for the **rocky slab** beaches:



$$R_{Profile} = \frac{\Delta\eta\, Wl^* - (R_{Bruun} + R_{Berm} - L)}{B + hl*}$$

Methodology

[R. Total = R. Profile + R. Estuarine + R. No_SLR]

Toimil et al., (2017)

Estuarine bays, as well as other coastal systems analysed, tend to reset its equilibrium shape after the SLR disturbance

$$R_{Estuarine} = \frac{\boldsymbol{A_e} * (\boldsymbol{\Delta\eta} - \boldsymbol{\alpha})}{\boldsymbol{l}\,(\boldsymbol{B} + \boldsymbol{h}^*)}$$

Where;

$\boldsymbol{A_e}$: estuary area (m²)

$\boldsymbol{\Delta\eta}$: SLR (m)

$\boldsymbol{\alpha}$: Ebb tidal flats lobes growth (m)

$\boldsymbol{l}$: Length of adjoined estuarine beaches (m)

Estuarine areas and delimitations were obtained from Rediam database

Rediam

Red de Información Ambiental de Andalucía

Methodology

[R. Total = R. Profile + R. Estuarine + R. No_SLR]

Rediam

Red de Información Ambiental de Andalucía

Erosion Rates (m/year) utilized were the average rates between 2001 and 2013, with the target years set at **2050** and **2100.**

$$R_{No\_SLR} = \boldsymbol{ER} * \Delta \boldsymbol{t}_{Target}$$

	IPCC scenario	Target year
E1	SSP2-4.5	2050
E2	SSP2-4.5	2100
E3	SSP5-8.5	2050
E4	SSP5-8.5	2100

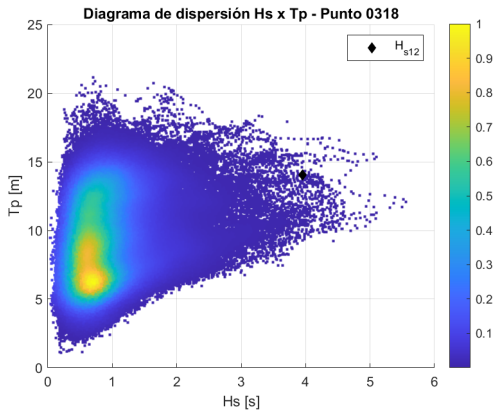
METHODOLOGY SUMMARY:

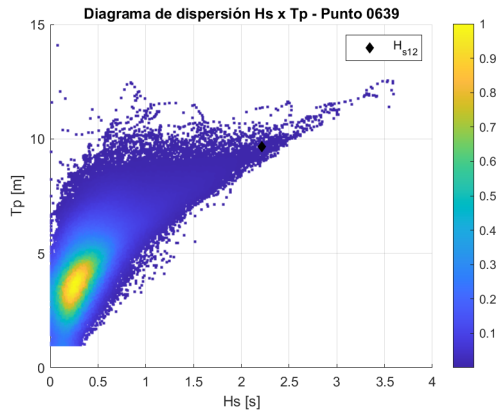
R.PROFILE
- Bruun et al., (1962)
- DUNE + CLIFF + R.SLAB (2022)

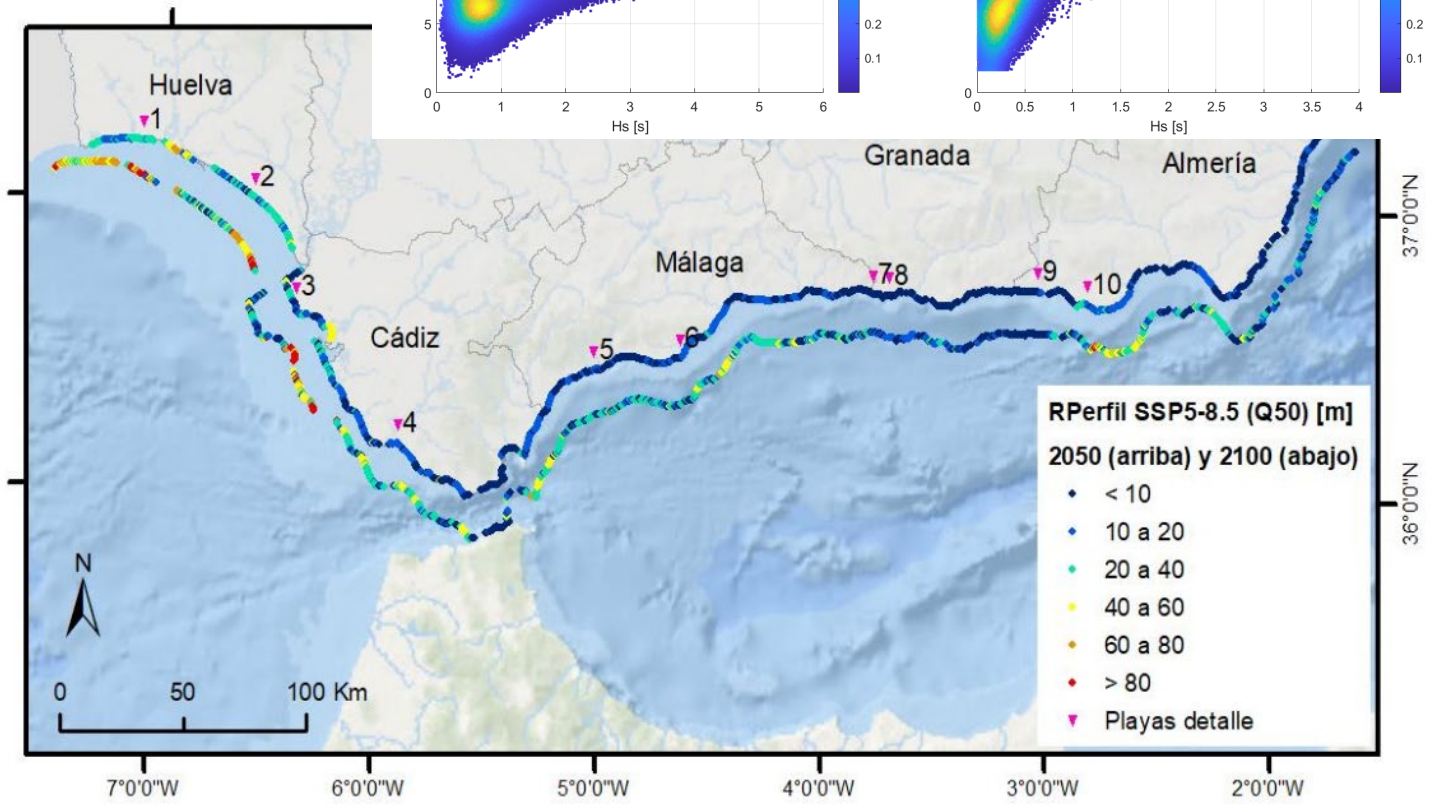
R.ESTUARINE
- Toimil et al., (2017)
- Shorelines → REDIAM

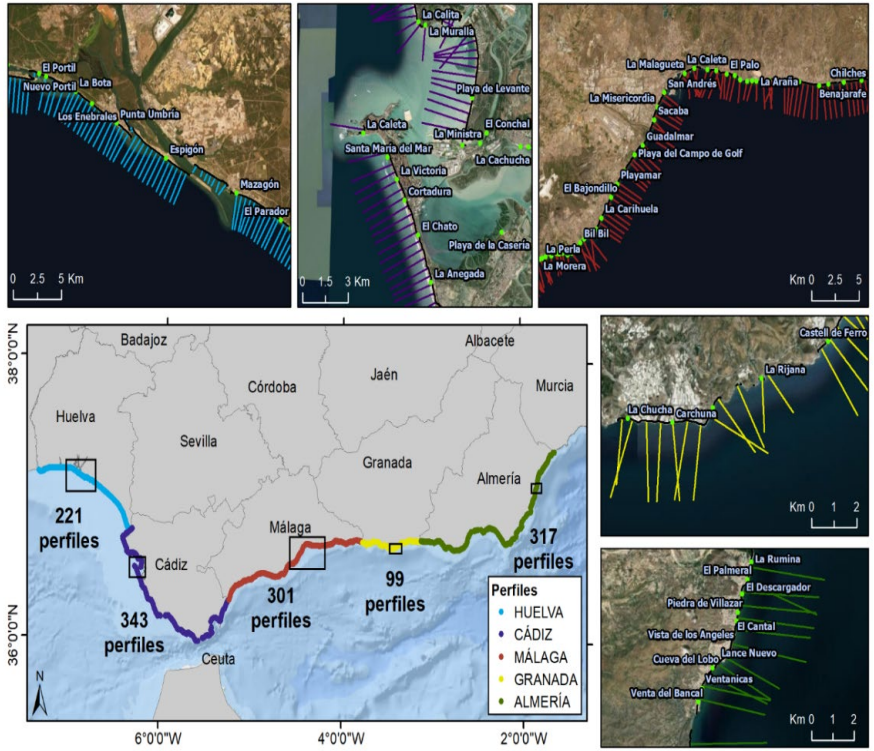
R. No_SLR
- Erosion rates → REDIAM
- Target years (2050 y 2100)

Results









A total of 1281 profiles along the coast

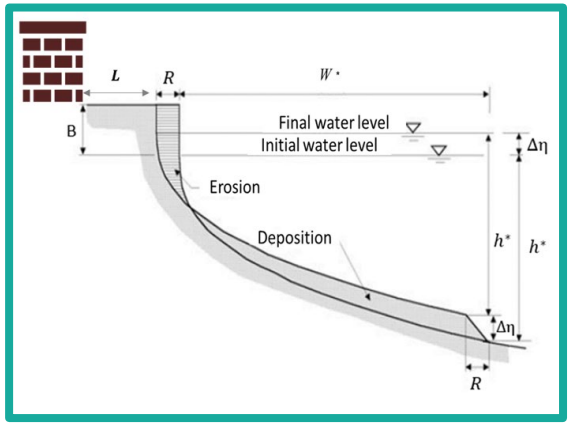
~ 1 profile for every 500m

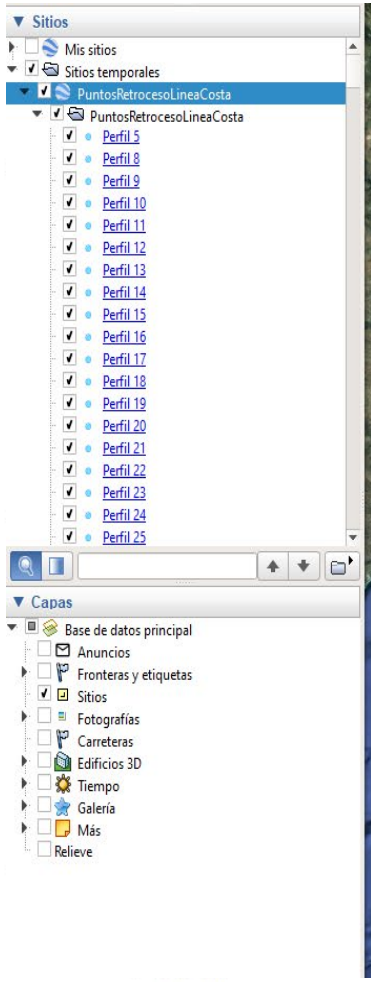
Results

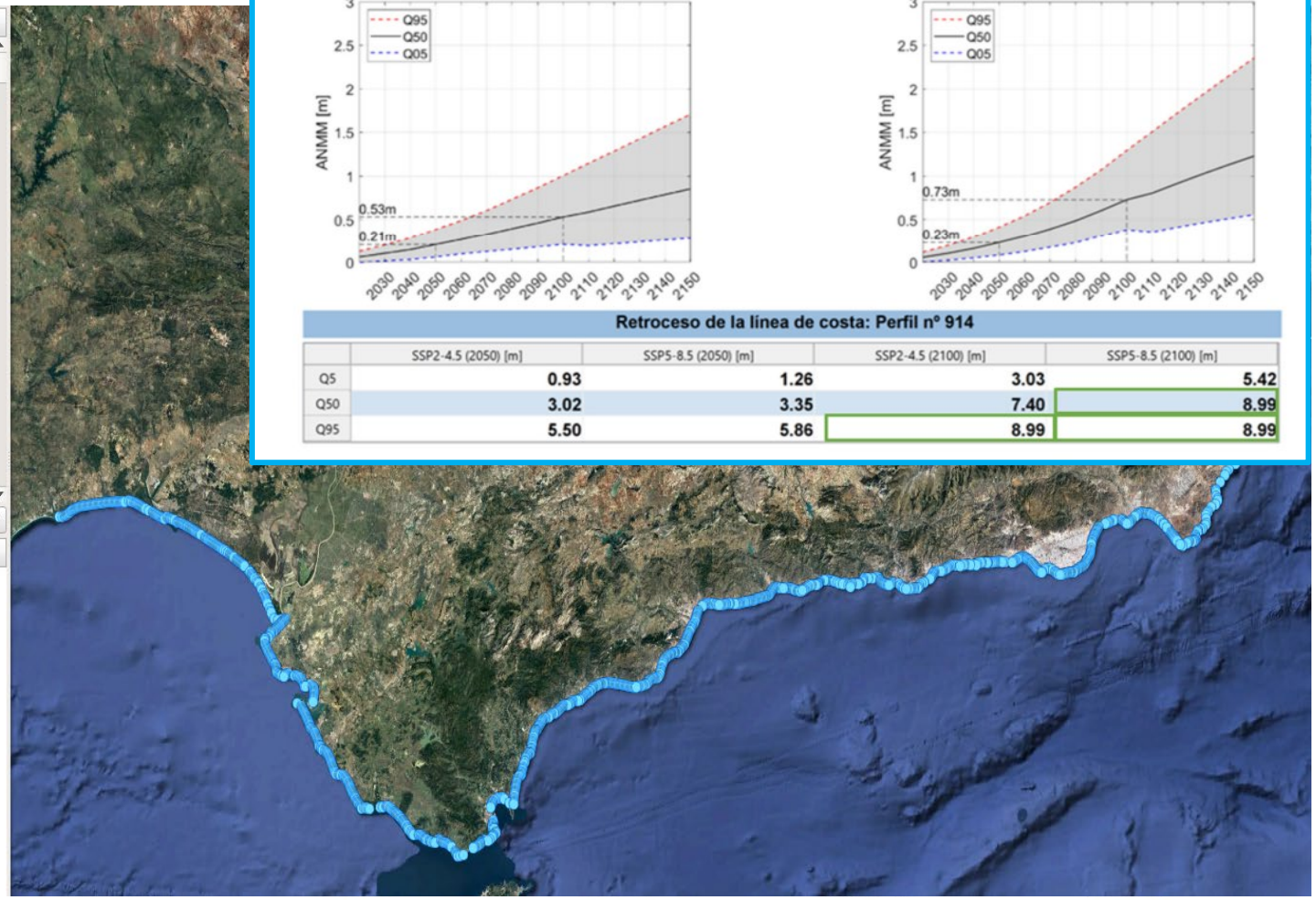
Atlantic part has more risk of erosion than Mediterranean region, except for Almería (SW).

Products obtained:

- **Kmz file**
- **Erosion calculator**







Perfil 914

RETROCESO DE LA LÍNEA DE COSTA DEBIDO AL CAMBIO CLIMÁTICO CALCULADO CON MODELOS DE BRUUN ADAPTADOS	
Provincia	GRANADA
Fondo	Perfil de arena
Trasdós	Muro o acantilado

Proyecciones de aumento del nivel medio del mar (ANMM) según IPCC-AR6

Retroceso de la línea de costa: Perfil nº 914

	SSP2-4.5 (2050) [m]	SSP5-8.5 (2050) [m]	SSP2-4.5 (2100) [m]	SSP5-8.5 (2100) [m]
Q5	0.93	1.26	3.03	5.42
Q50	3.02	3.35	7.40	8.99
Q95	5.50	5.86	8.99	8.99

Conclusion

- This **simple** and **new** method.
- Based on empirical equilibrium model.
- Useful for identifying erosion **hotspots** and estimating the long-term changes in relation to CC.

Acknowledgments

- **REDIAM** & **CAGPyDS** for providing data and support.

Rediam
Red de Información Ambiental de Andalucía

Junta de Andalucía
Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible

Thank you for your attention

1. Main authors

Arnau Garcia[1], Paula Gomes[1], Mauricio González[1], Raúl Medina[1], Verónica Cánovas[1]

arnau.garcia@.unican.es

Affiliation: IHCantabria