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Universidade do Porto
FEUP Faculdade de Engenharia

Potential Impacts of Climate Change on NW Portuguese Coastal Zones

Carlos Coelho, Raquel Silva, F. Veloso-Gomes and F. Taveira-Pinto

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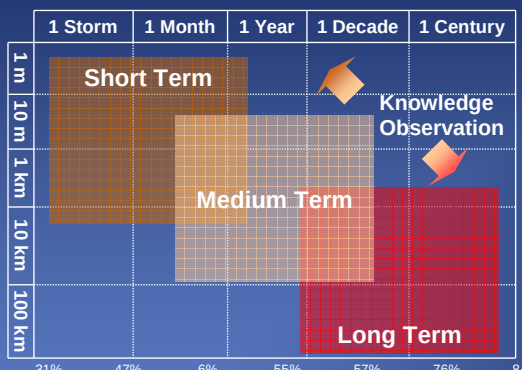
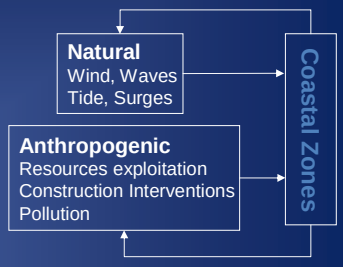
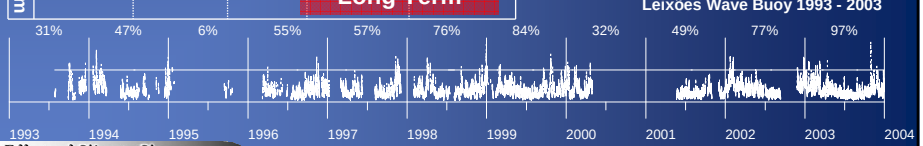
Coastal Zones

Dynamic regions responding at different temporal and spatial scales with geomorphological changes to natural and anthropogenic actions







Effects of Climate Change on the World's Oceans
International Symposium
May 19-23, 2008
Gijón, Spain

Beach Evolution

Nearshore wave and current fields
Spatial distribution of sediment transport rates
Change of bottom topography

Winds and waves
Tides and surges
Seasonal wave change

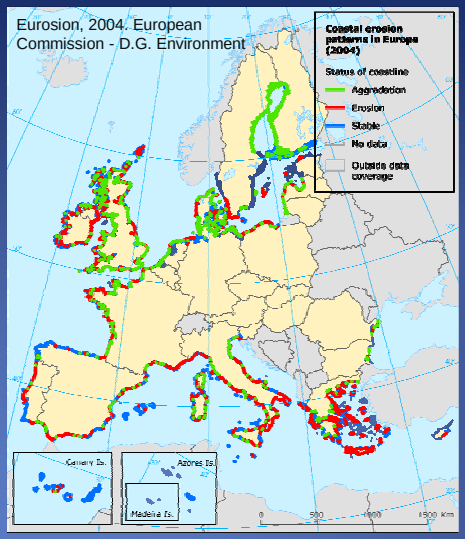
Alongshore distributions of wave height and angle
Longshore sediment transport
Sediment volumes balance
Coastline configuration change

Inter annual wave change
Surf zone bar cycle
Extreme events
Sea level change

Experience
Logical
Reasonable Considerations

Regional climate change
Coastal inlet cycle
Very extreme events

Coastal Erosion and Coastal Risk



Dynamic nature of coastal zones

Anthropogenic influences

- coastal interventions (defence and harbour structures)
- littoral occupation with dune destruction
- river sediment supply reduction (dams, dredging and fluvial flow regularization)

Effects of climate change

- effects on the wave climate with direct implications for the potential alongshore transport
- likely increase of the occurrence of extreme events (storms, droughts, changing hydrological regime may weaken the rivers sediments supply)
- the generalized acceleration of sea level rise (coastal embayment's infilling acting as sinks of sand)

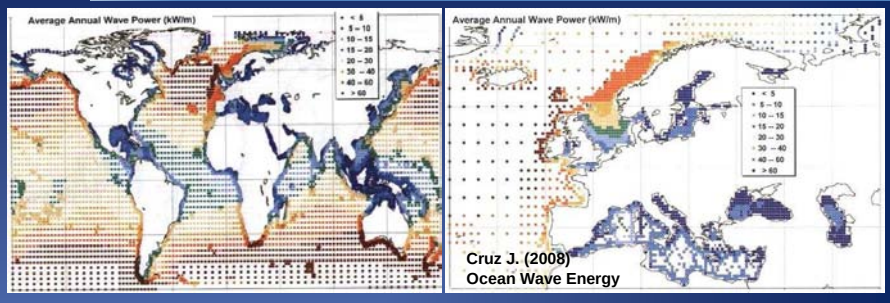
Coastal Planning and Management

Coastal erosion and natural coastal dynamics may cause serious damage, endangering people and assets in littoral urban fronts. Climate change, with consequent sea level rise and storminess regime changing, results in higher risk of flood and erosion in the sea-land interface at medium to long term.

To minimize impacts, it is necessary to understand the various processes involved and assess different scenarios for coastal evolution prediction (medium to long term).

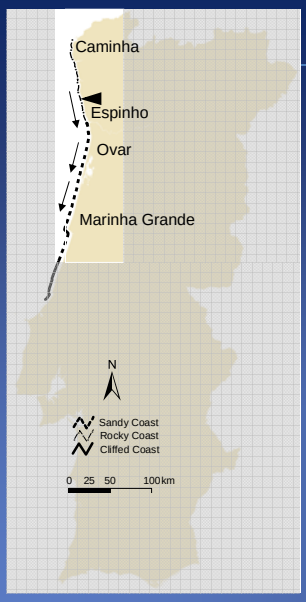
It is increasingly more important to make available to decision makers vulnerability and risk analysis maps (as a recommendation from EU) and coastal evolution numerical models for plans conception and coastal engineering solutions selection for erosion control.

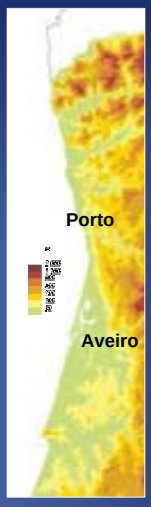
Portuguese NW Coast



Wave regime: NW, H_s ~ 2-3 m, T_m ~ 8-12 s
Winter storms: NW, H_s up to 8 m, persisting for up to 5 days
Potential alongshore transport: mainly due to the wave action, ~ 1-2 Mm^3/year, southward directed
Tide regime: semi-diurnal, tidal range 2-4 m (spring tides)
Mean sea level: +2 m (CD)
Main morphological features: Low rocky coasts, sandy shores backed by dunes, cliffed stretches, Douro estuary, Aveiro Lagoon
Sediment sources: Douro River and coastal erosion (1.8 Mm^3/year->0)

Portuguese NW Coast





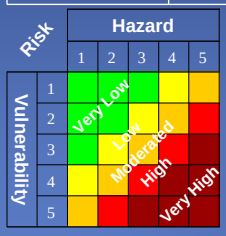
Major cities: near estuaries and lagoons, Porto e Aveiro

Leixões harbour

Affected by erosion, with a coastline retreat tendency in several stretches, along which there are already several coastal protection structures but yet with some natural and beautiful stretches

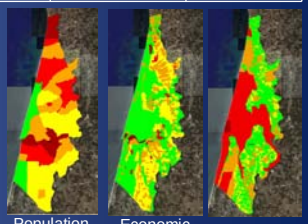
Vulnerability and Risk Analysis

Hazards Parameters	Very low	Low	Moderated	High	Very High
	1	2	3	4	5
Population Density (inhabitants/km^2)	< 100	≥ 100 and < 200	≥ 200 and < 350	≥ 350 and < 500	≥ 500
Economic activity (settlements)	Without edification or economic activity	Rural zones with agricultural activities	Urban zones with associated economic activities	Industrial zones	Zones of specific equipment
Ecology	Non classified	National Agricultural Reserve	National Ecological Reserve	Ecological protected zones	Natural parks
Cultural and historical values	Non existent	Non classified	Traditional activities and edifications	Regional historical edifications	National historical monuments



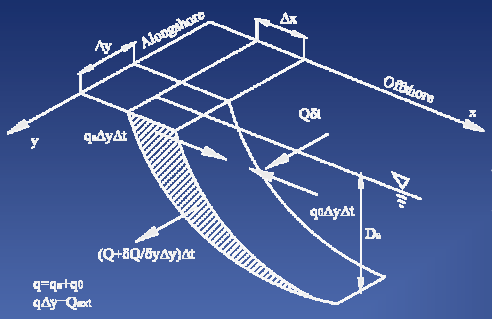
Vulnerability Map

Hazards Maps



Population Density | Economic activity | Ecology

Long Term Configuration Model



Continuity Equation

$$\frac{\partial V}{\partial y} = \left(\frac{\partial Q}{\partial y} - q\right) dt$$

$$q = q_s + q_0$$

The variation of the volume of sand is the same as the variation of sediments in transport added (or subtracted) of eventual external sediment sources (or sinks)

$$\Delta V = (\Delta Q - Q_{ext})\Delta t$$

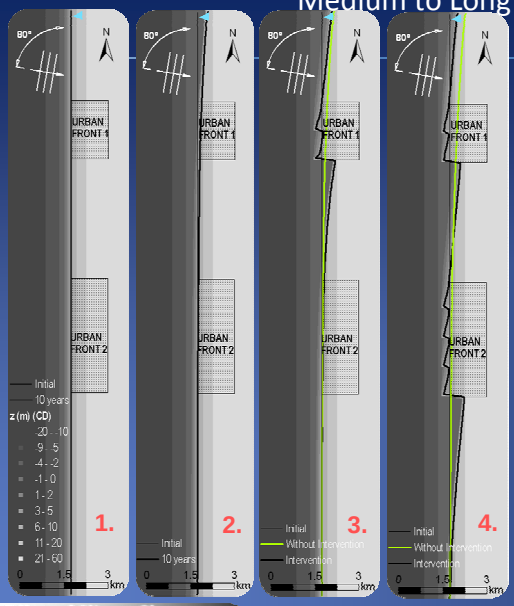
The variation of the volume of sand is uniform over a elementary alongshore beach length and represents a bottom variation of the active beach profile, between closure depth and the wave run-up limit

Profile down drift from a groin under persistent erosion

Profile up drift from a groin under persistent accretion

$$\Delta z = \frac{\Delta V}{(active\ \ width)\,\Delta y}$$

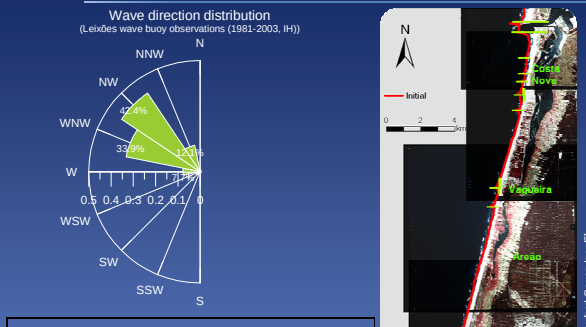
Medium to Long Term Scenarios Evaluation
Generic Tests

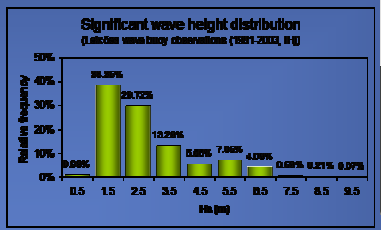


Waves: H_S = 2.0 m, T_{Hs} = 9.34 s
Tides: MSL = +2.0 m (CD)
Bathymetry: 8 x 20 km² regular
Dean equilibrium profile
(d_{50} = 0.3 mm, m = 2/3, A = 0.125)
Emerged beach slope 3%
Longshore Transport: CERC
Active Profile: Hallermeier; Ruggiero
BC: extrapolated from neighbours

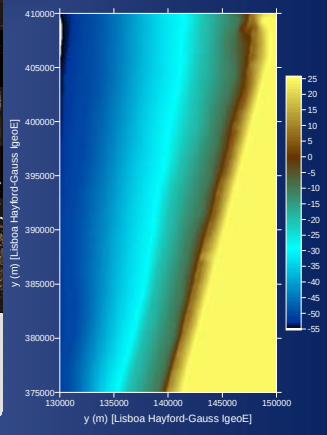
1. Uniform linear beach in equilibrium; sediment supply at north (Douro river in its natural regime 1.8 Mm³/ano)
2. 50% sediment supply reduction - 10 years simulation
3. Protection of the northern settlement with 2 groins - 4 years simulation
4. Protection of the southern settlement with 4 groins - 10 years simulation

Medium to Long Term Scenarios Evaluation
Application to South Aveiro Coastal Stretch





Computational grid
(Bathymetry: nautical chart (IH 2000);
Topography: aerial survey (IGP 1998))
20 x 35 km² regular (50 x 100 m²)



Medium to Long Term Scenarios Evaluation
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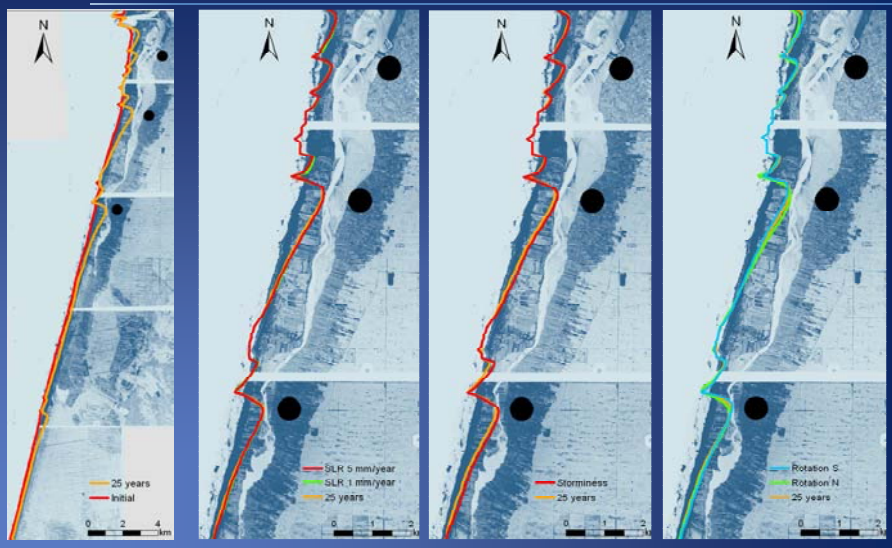

Conclusions

The Portuguese NW Coast suffers from a continued high sedimentary deficit that is primarily due to Douro River sediment supply reduction. Under the present critical state, the generalized sea level rise, due to climate change, will have significant importance only at longer term.

The preferable solution to the erosion problem would be artificial sand nourishment, but this solution is not feasible due to the high amounts of sediments in deficit and the costs involved. A solution may be achieved through the construction of coastal defense structures to protect urban sea fronts and the passive acceptance of erosion in intermediate stretches.

Vulnerability and risk analysis maps (as a recommendation from EU) are under construction and coastal evolution numerical models (LTC) are being improved and applied to help in plans conception and coastal engineering solutions selection for erosion control.

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