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UNIVERSITAT POLITÈCNICA DE CATALUNYA

Coastal systems under changing meteo & climate conditions

Invited lecture

Prof. Agustín Sánchez-Arcilla (agustin.arcilla@upc.edu)

Maritime Engineering Laboratory (LIM/UPC) – Intl. Centre for Coastal Resources Res.

Catalonia University of Technology (UPC) in Barcelona

1.- The case study (CAT coast)
2.- The climatic (decadal) scale: long-term planning
3.- The storm (hourly) scale: risk management
4.- The mid-term (yearly) scale: engineering
5.- The way ahead

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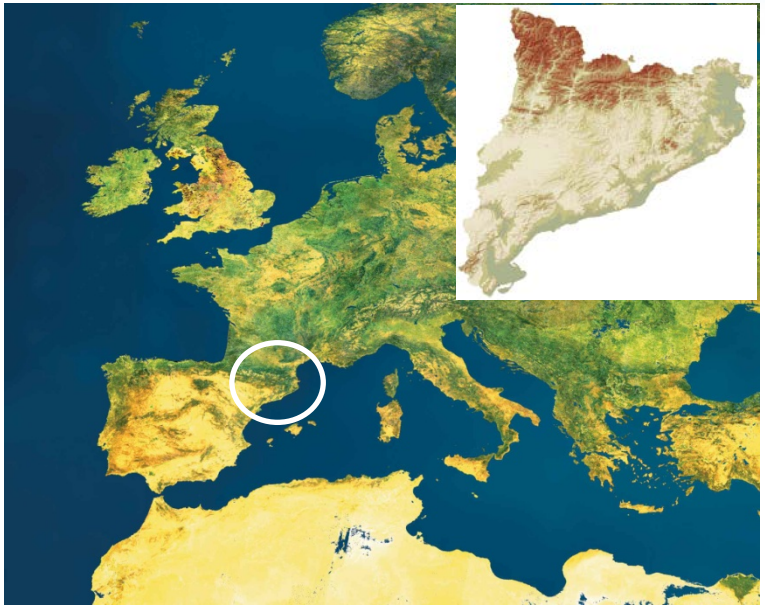
The CATALAN coast case ~ 700 km

High geo- diversity



Length ~ 700 km

Sand beaches ~ 250 km

Urban (pocket) beaches ~ 150 km

Open beaches ~ 75 km

Coastal fringe width 500 m

6.9% total area CAT - 48% total population CAT

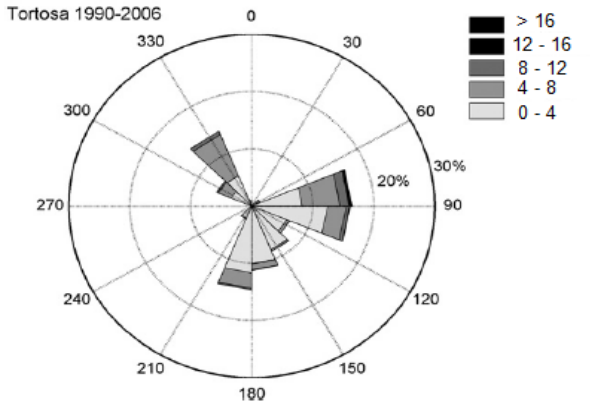
The CATALAN coast case ~ 700 km

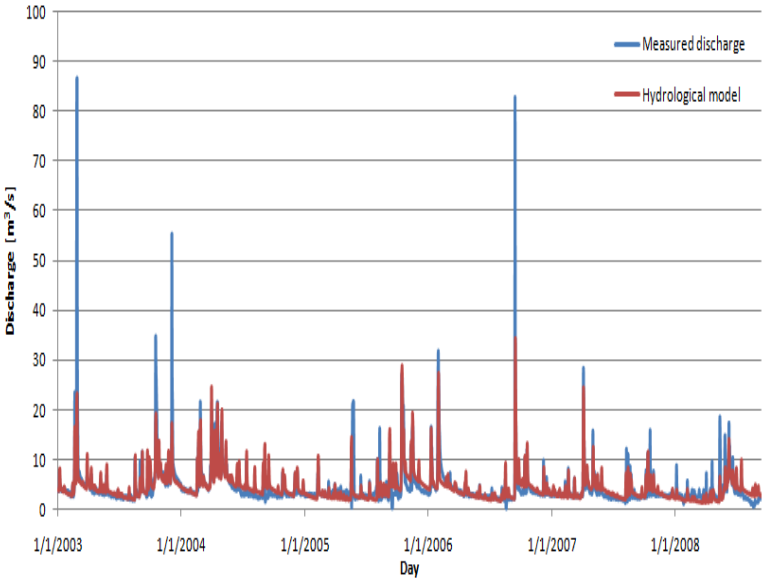
High meteo - diversity

Limited no. of extremes

Sharp gradients (prediction challenges)

26 Dec 2008 storms





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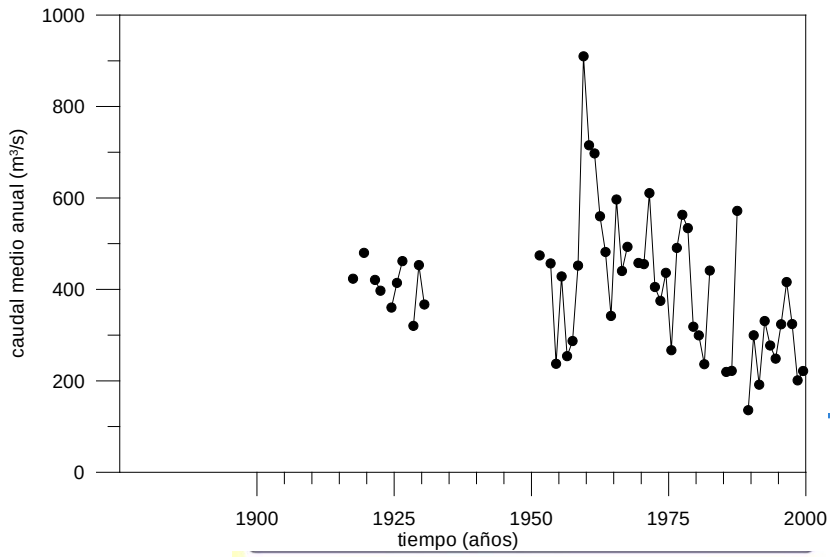
The CATALAN coast case ~ 700 km
High variability

Management signal clearly observable

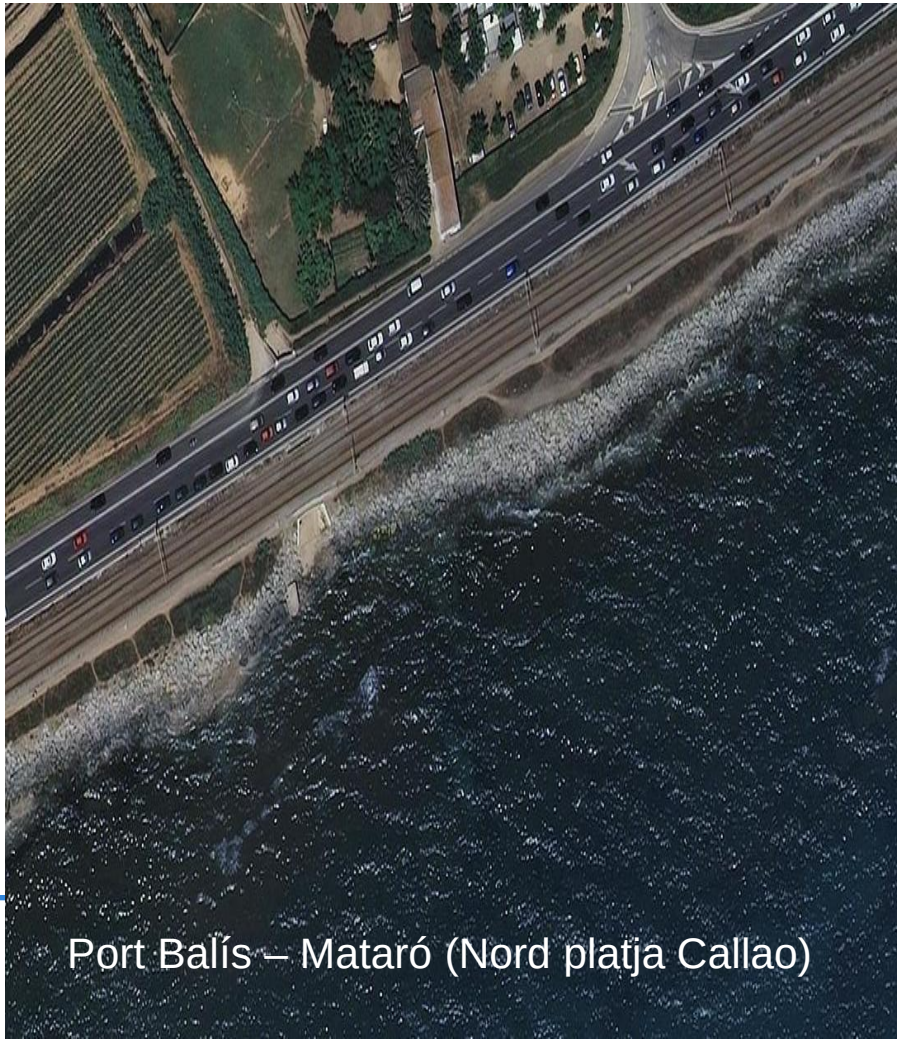
Cap Tortosa erosion > 1750 m in 43 years (40 m/y)



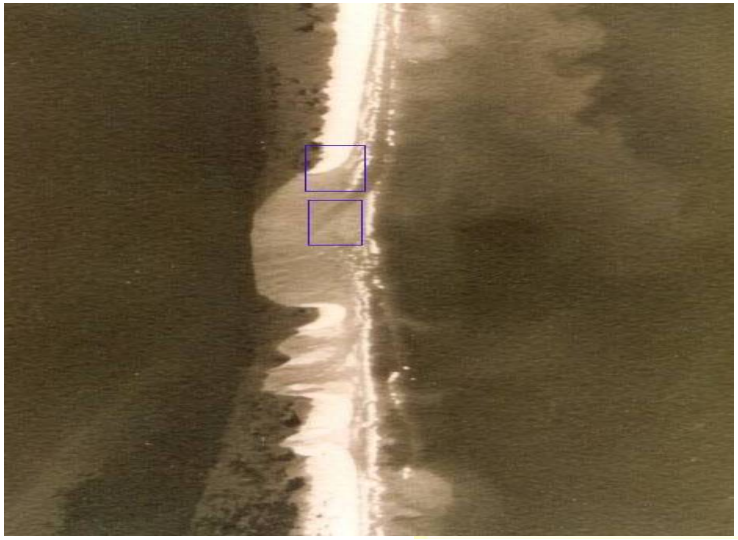
The CATALAN coast case ~ 700 km

Horizontal variability hindered (by shore rigidization)

Horizontal/Vertical erosion (sediment scarcity)



Port Balís – Mataró (Nord platja Callao)



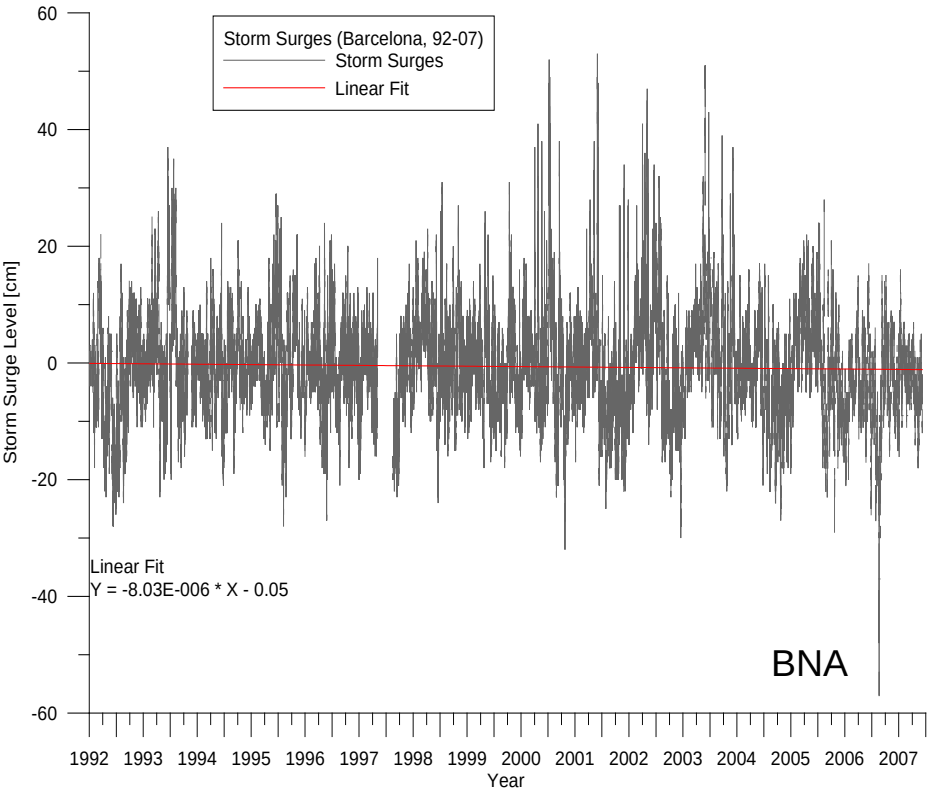
Trabucador, Delta del Ebre

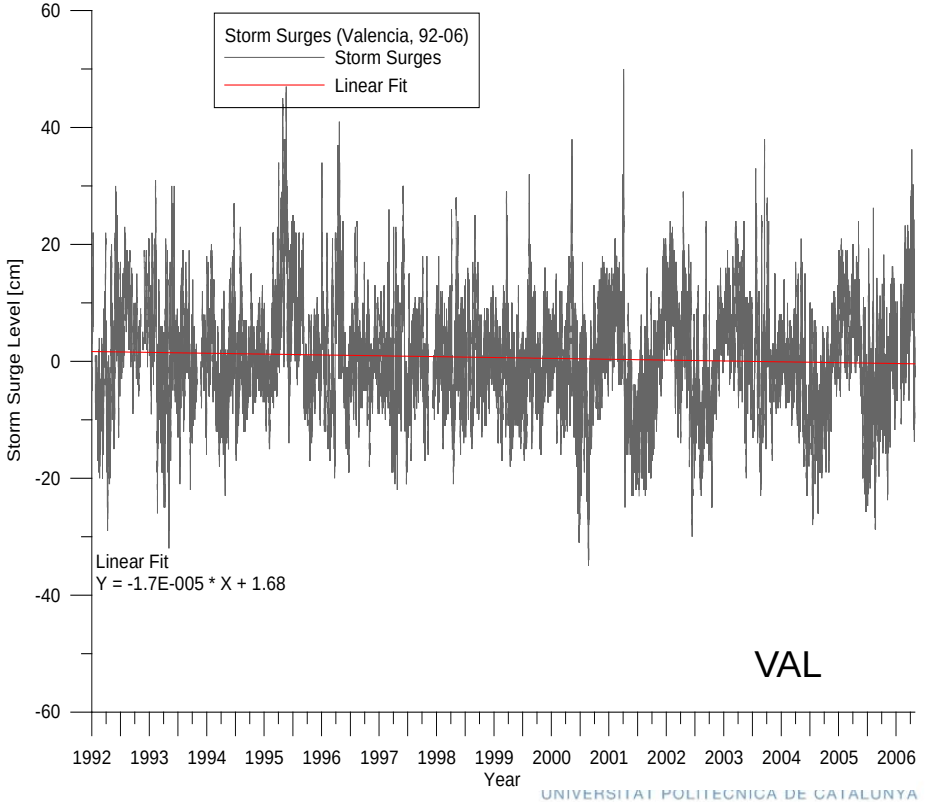
Decadal (climatic) scale drivers

Observations

Barcelona (1992-2007) & **Valencia** (1992-2006) harbours

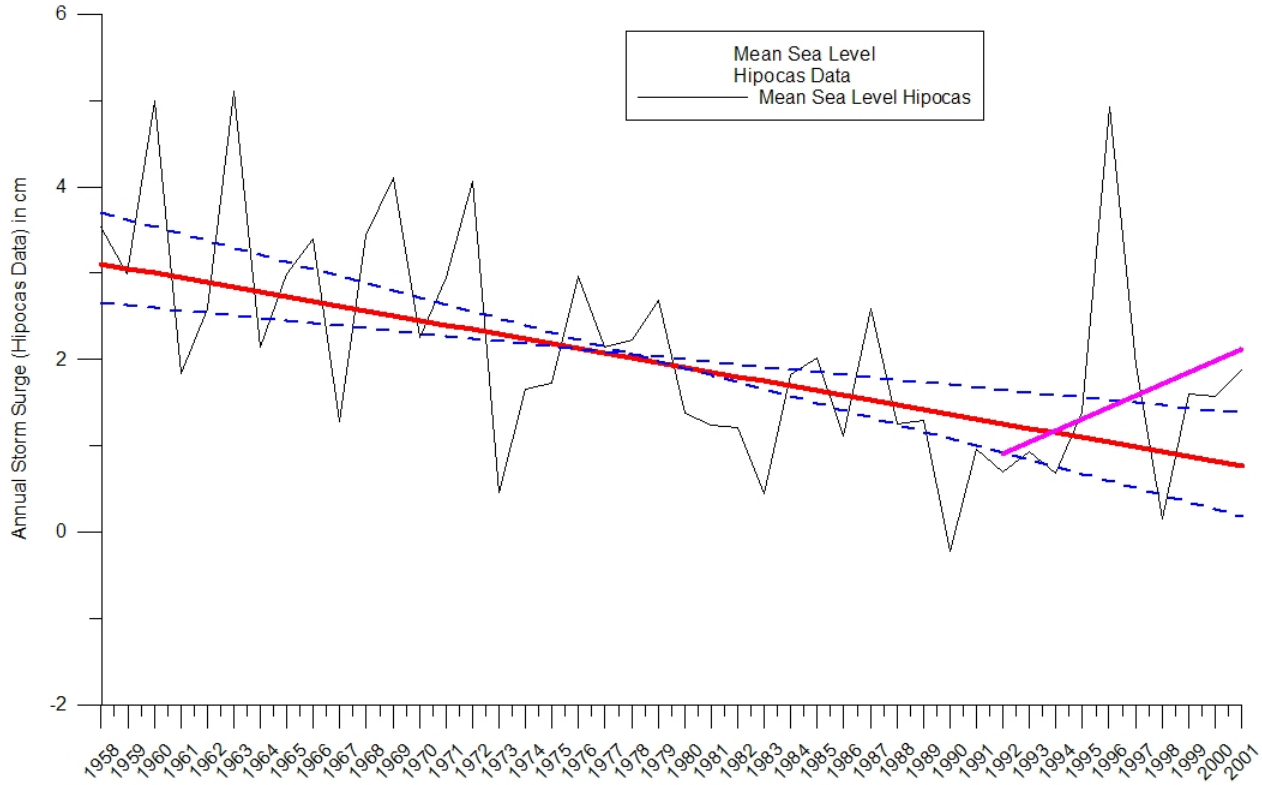
Observed trend: slight decrease of MSL (**steadiness**)





Decadal (climatic) scale drivers

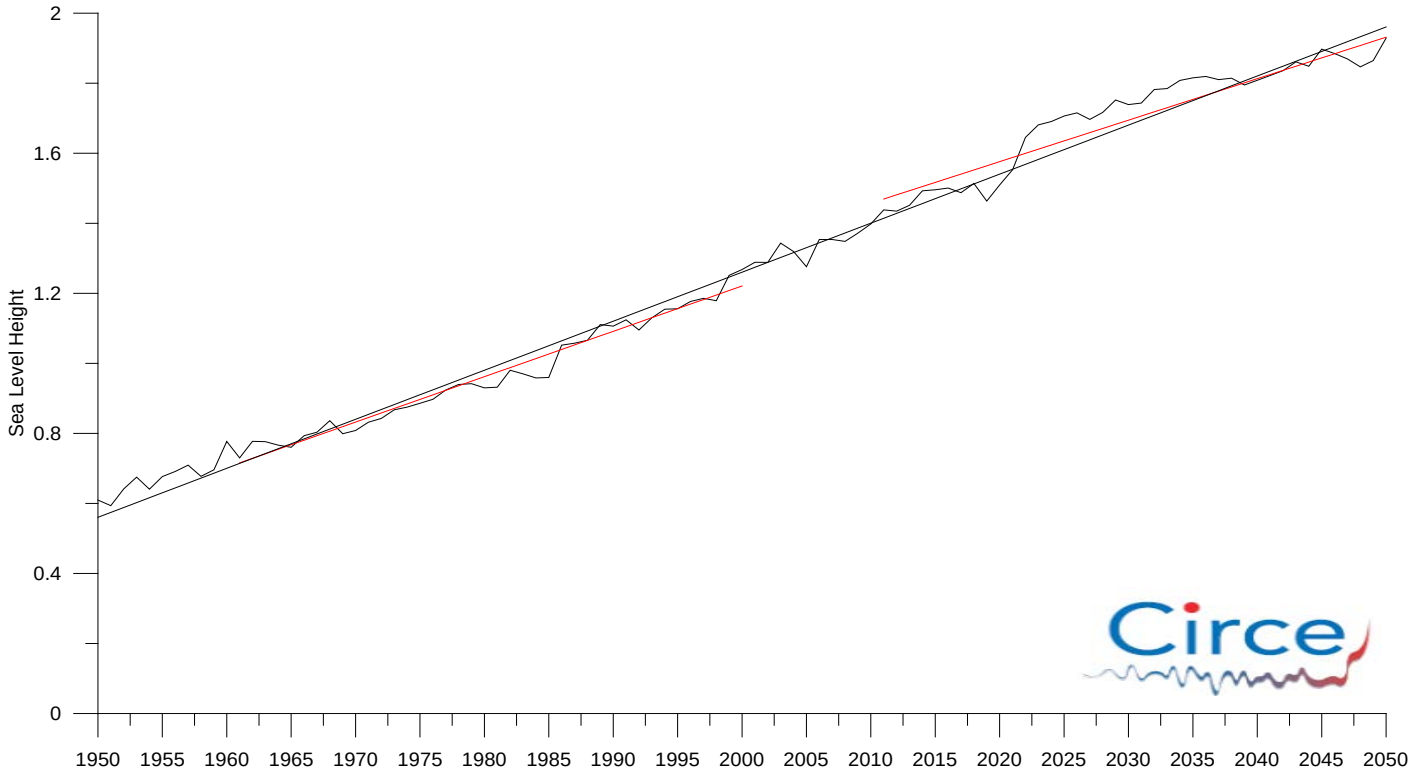
Trends may vary with interval: MSL (from hind casting) decreases from 1956-1991 and for the whole period but increases for the last decade



Ebre delta

Decadal (climatic) scale drivers

Climatic projections (CIRCE) show a clear increase of SSH for the Spanish Med coast



Simulated SSH at the Catalan/Valencia coast. The continuous line is the average series based on different simulations (1950-2050 and 1950-2060)

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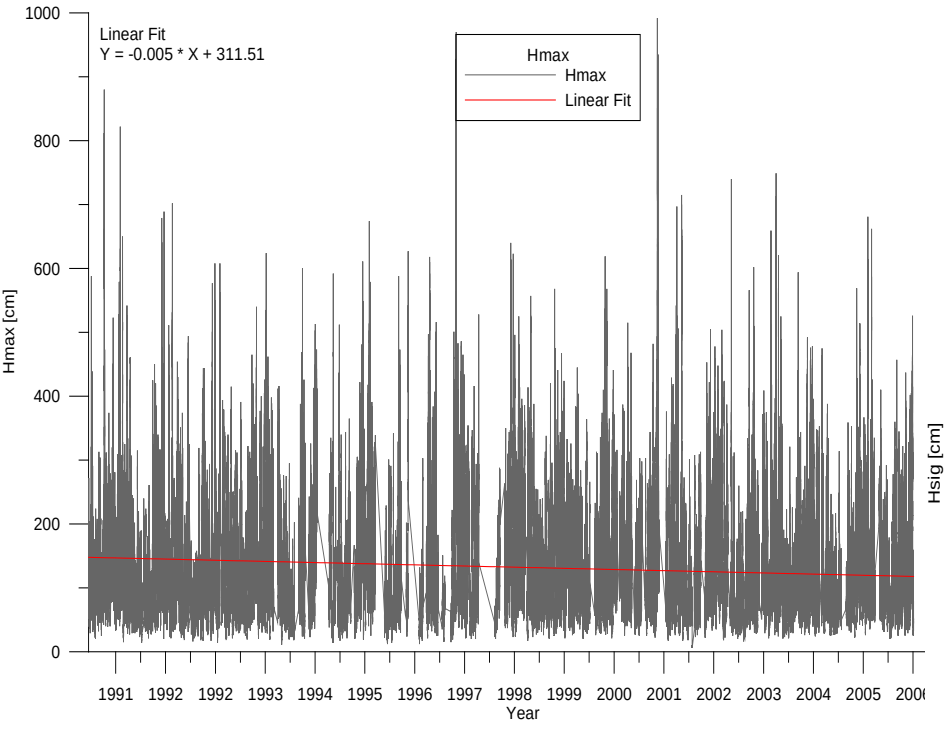
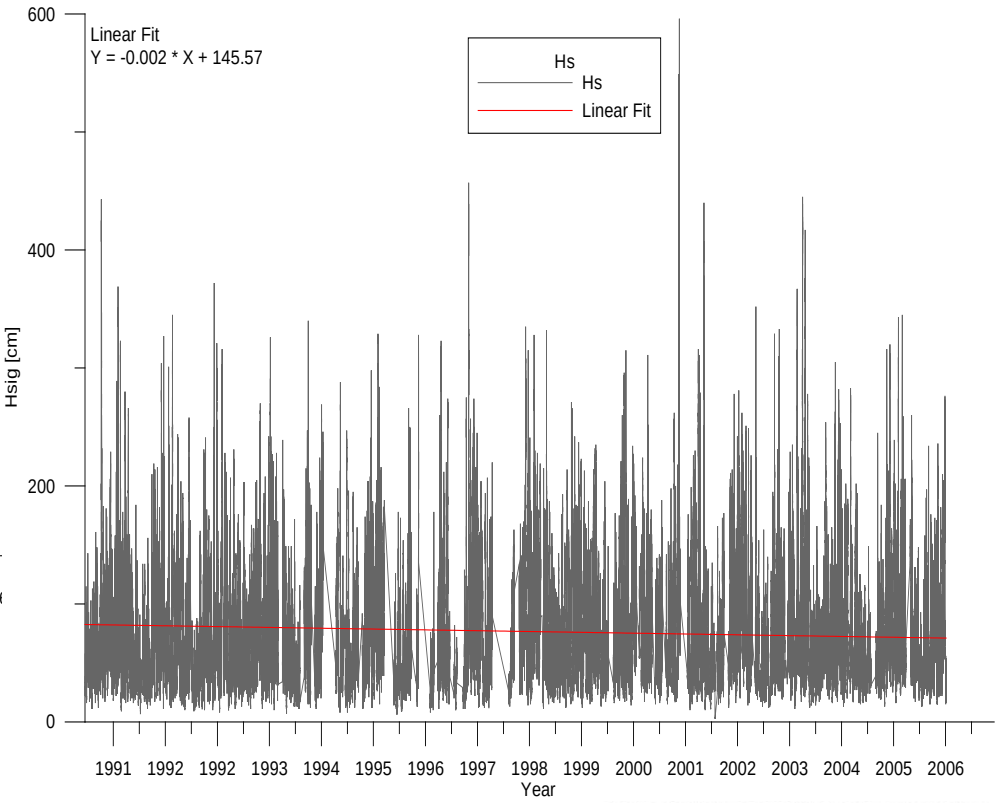
Decadal (climatic) / yearly (eng) scale drivers

Observed waves off **Ebre delta** (1990-2006)

Slight decreasing trend for both H_{max} & H_s

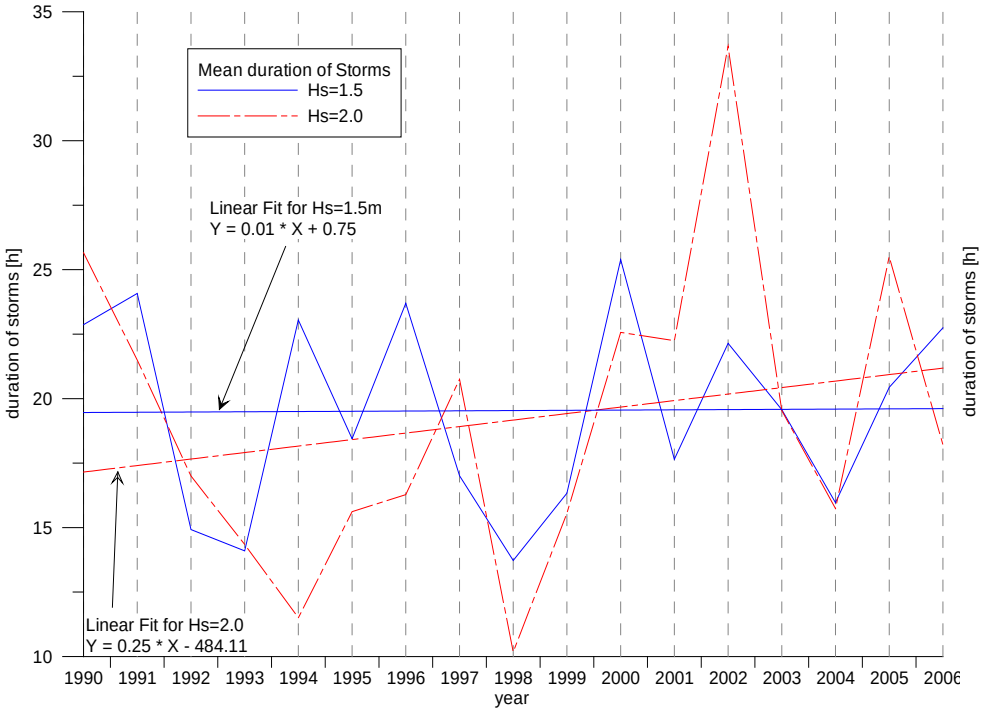


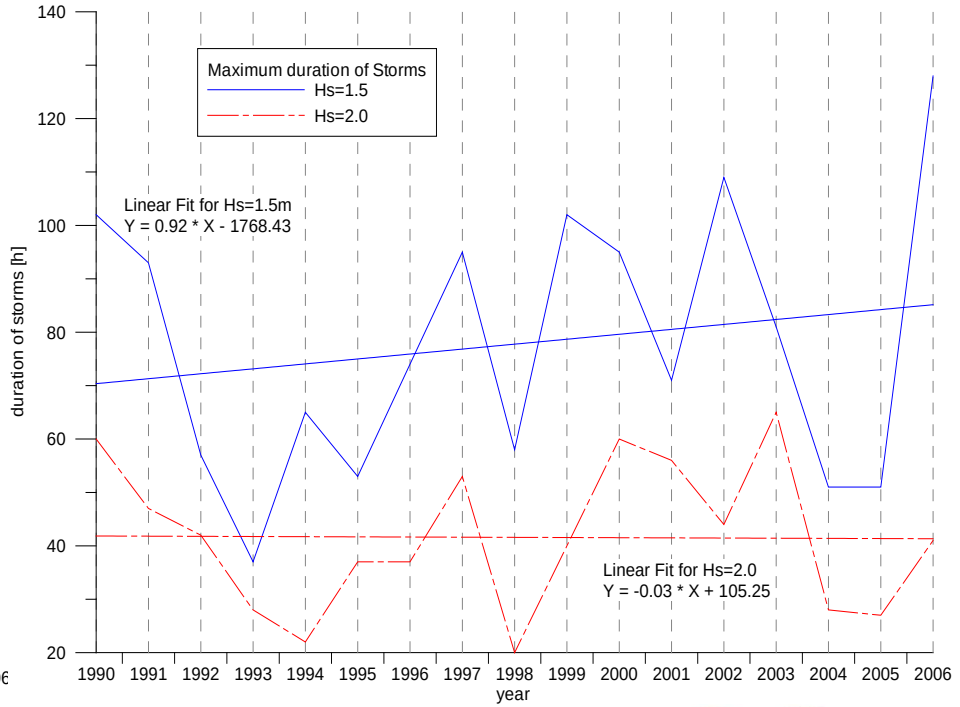


Decadal (climatic) / yearly (eng) scale drivers

Ave. duration is 20 hrs for Hs=1.5m & 19 hrs for Hs=2.0m
Increasing trend for Hs=2.0m

Max. duration is 73 hrs for Hs=1.5m & 39 hrs for Hs=2.0m
Increasing trend for Hs=1.5m





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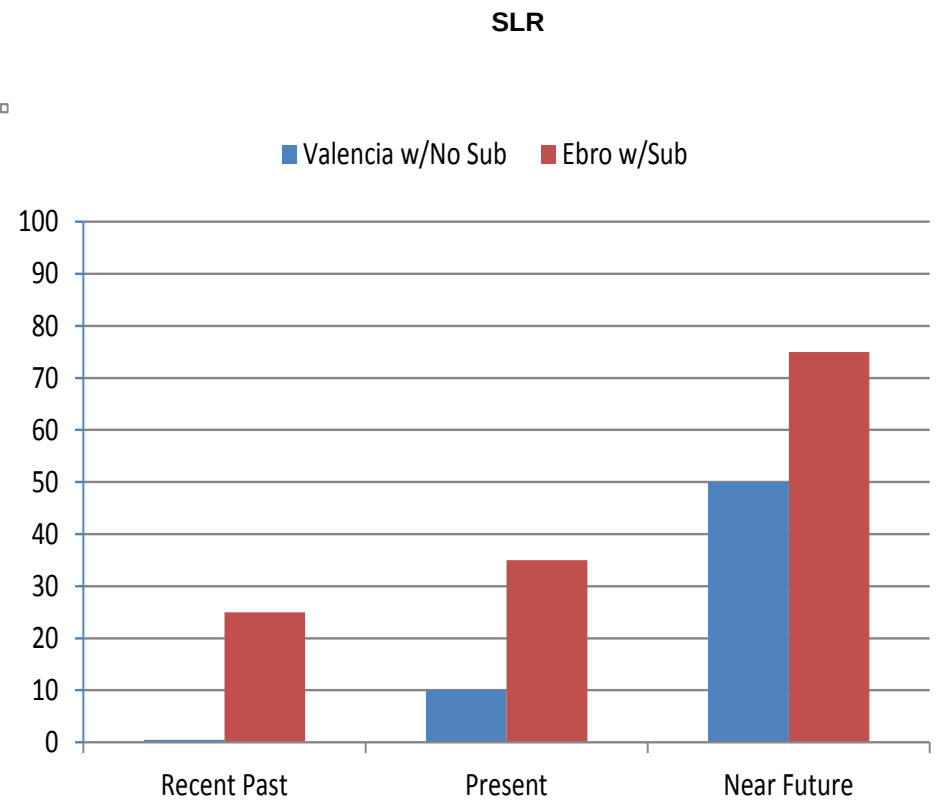
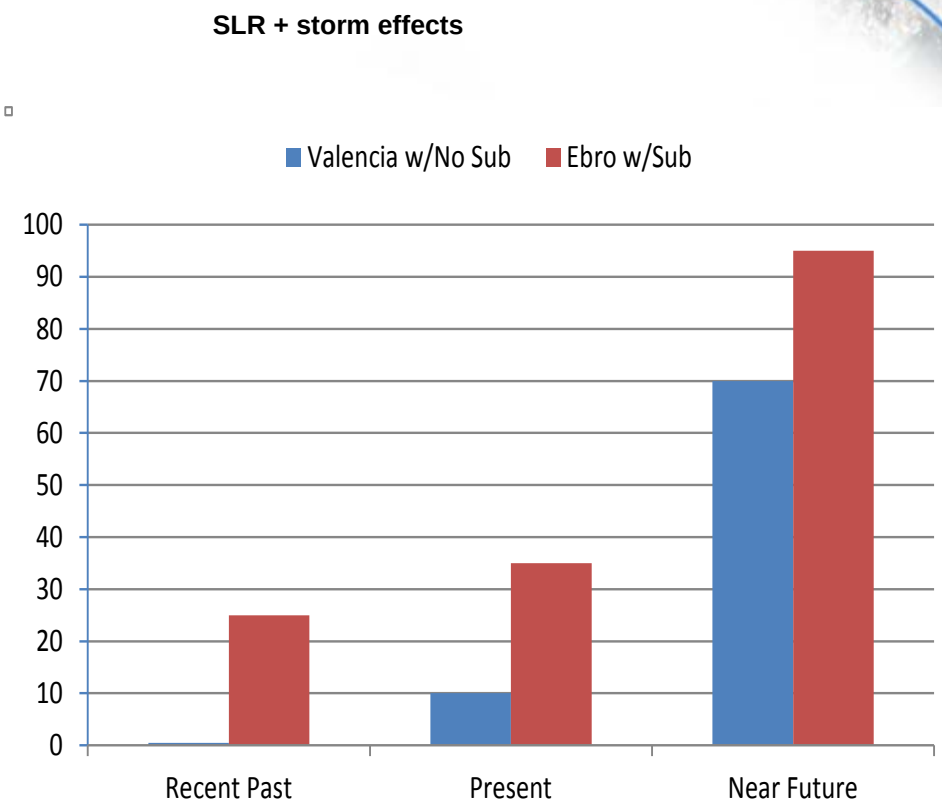
Decadal scale morphodynamic response (erosion)





Estimated shore-line erosion rates (total horizontal meters) for last century (Recent Past), present decade (Present) and by 2100 (Near Future) (Sanchez-Arcilla et al 2011)

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Storm (high τ) scale drivers

PRE-MOS

Meteo Module
WRF + ECMWF BCs

↓

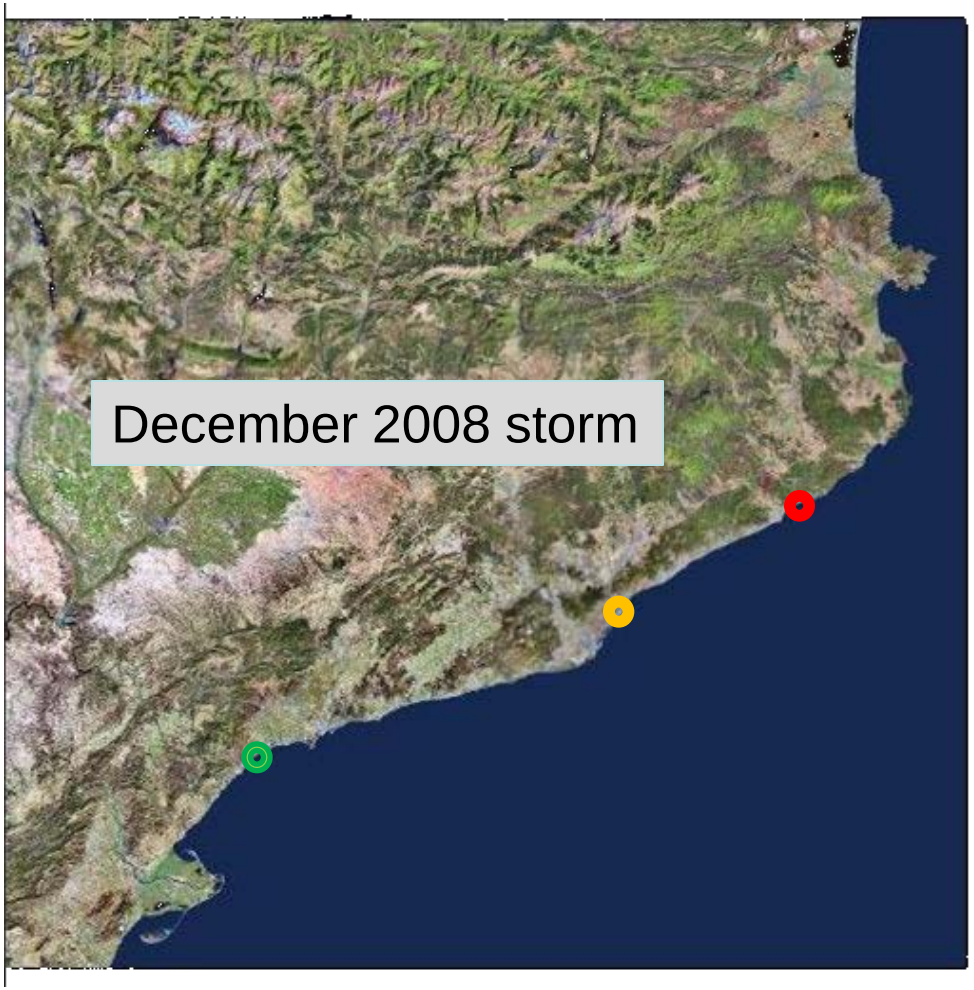
Hydrodynamic module
SWAN + ROMS

↓

Morphodynamic Module
XBEACH + DEM

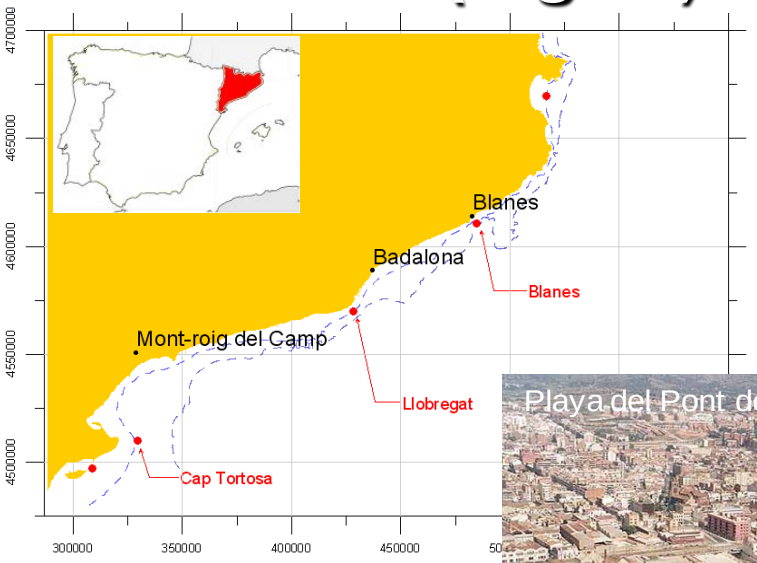
↓

Indicators Module



3 areas for calibration

Storm (high τ) scale drivers (2008 storm)



700 µm

350 µm

170 µm

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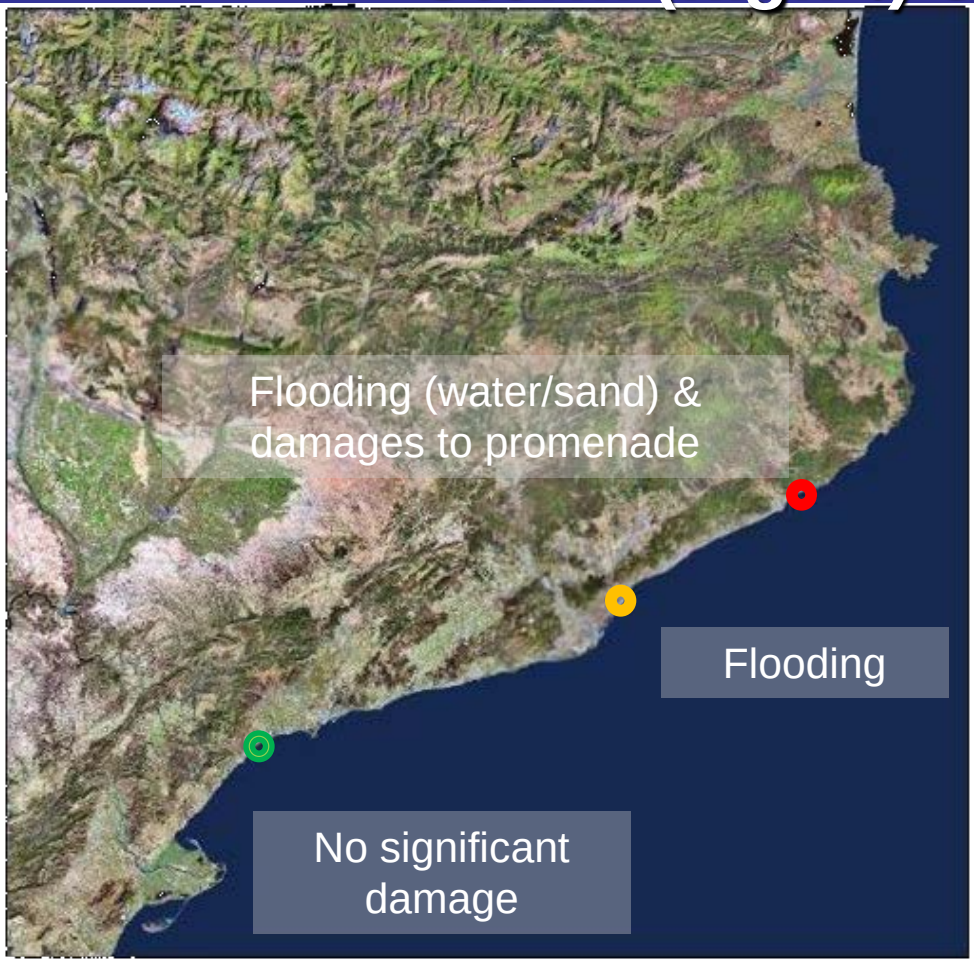
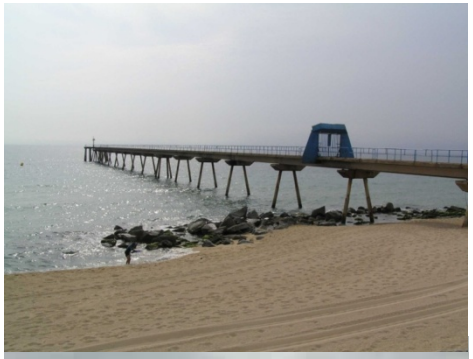
Storm (high τ) scale drivers





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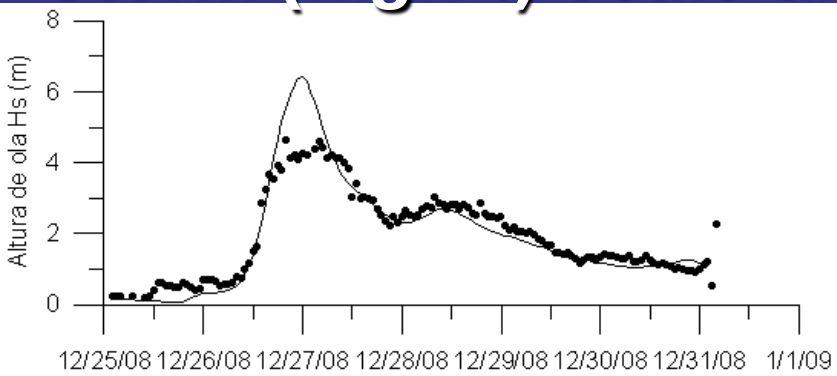
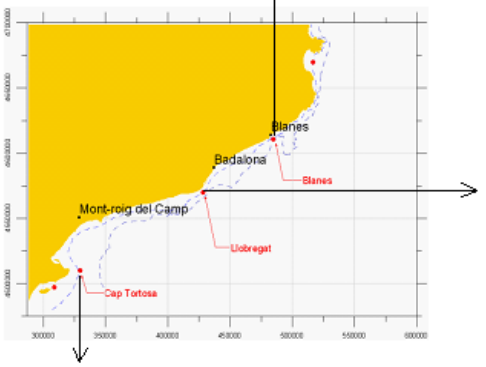
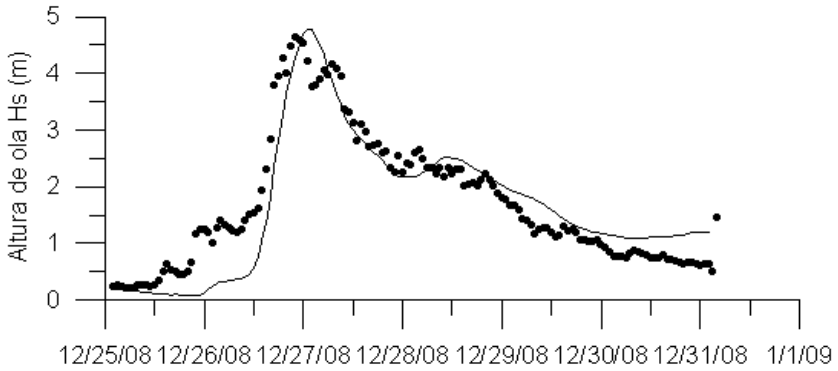
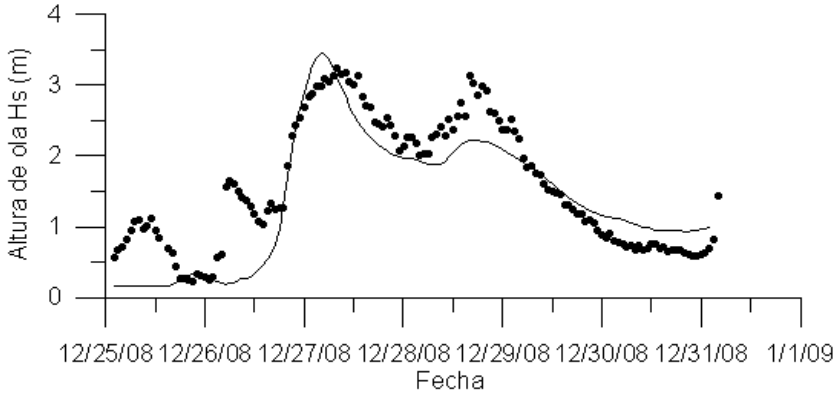
Storm (high τ) scale drivers









Hydrodynamics: Hs

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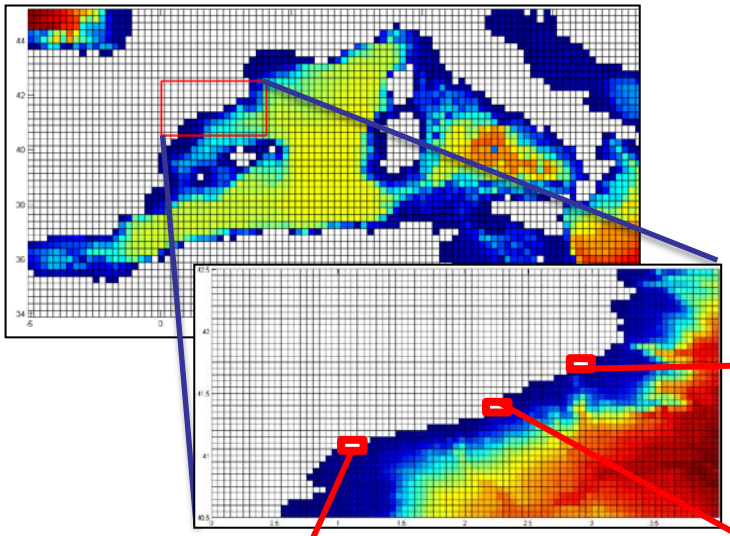
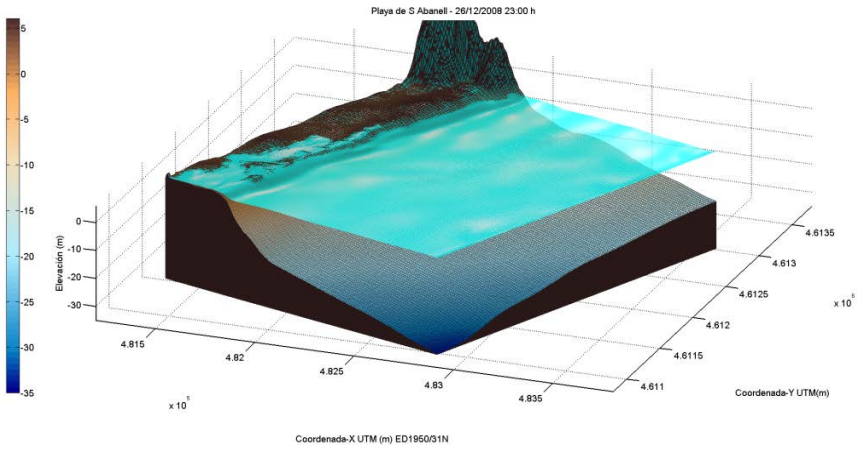
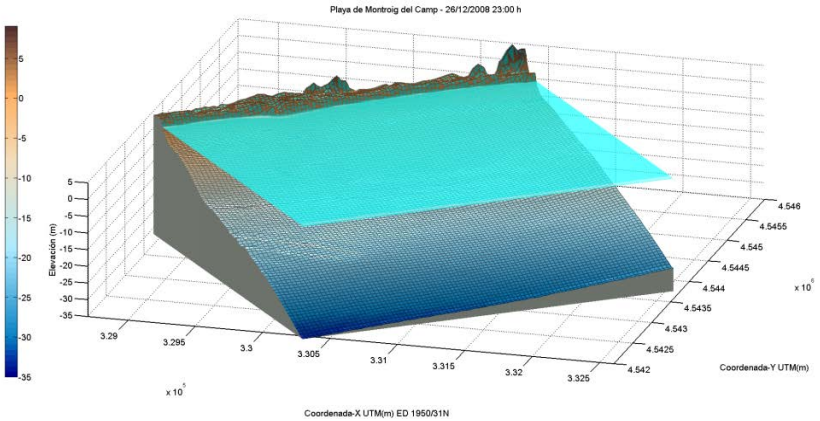
Storm (high τ) scale response (2008 storm)

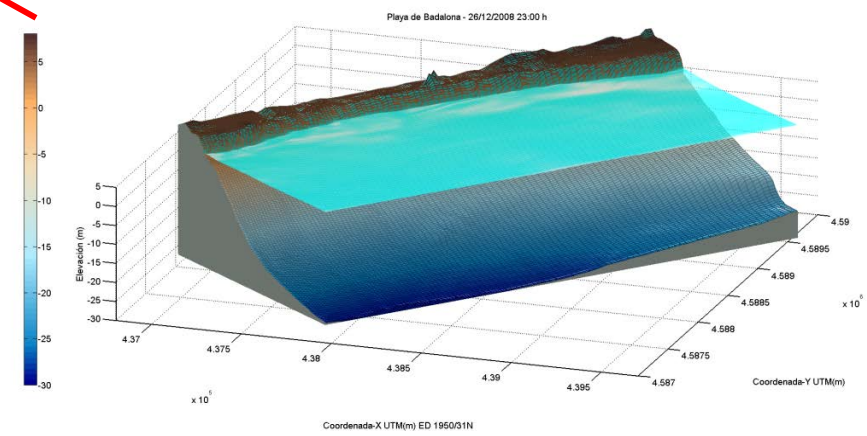
Morphodynamic module XBEACH

Local meshes (grandma $\rightarrow$ mom $\rightarrow$ daughter $\rightarrow$ grand daughter)









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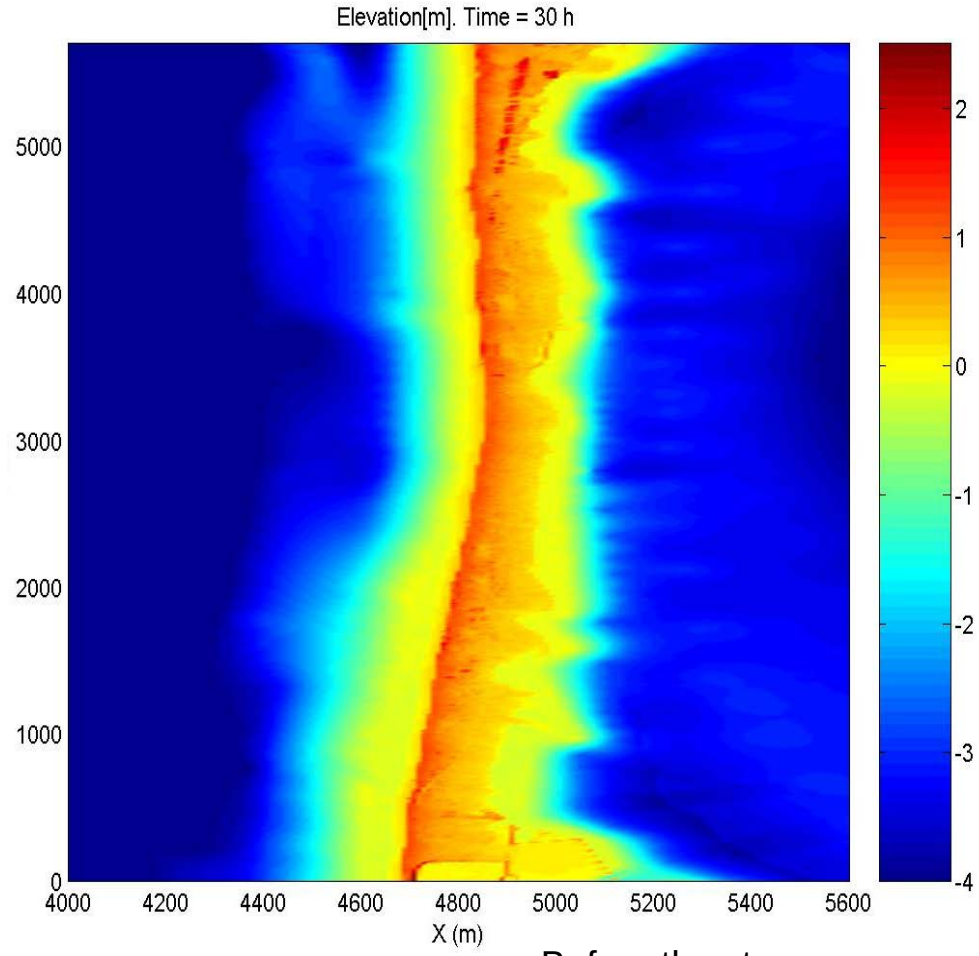
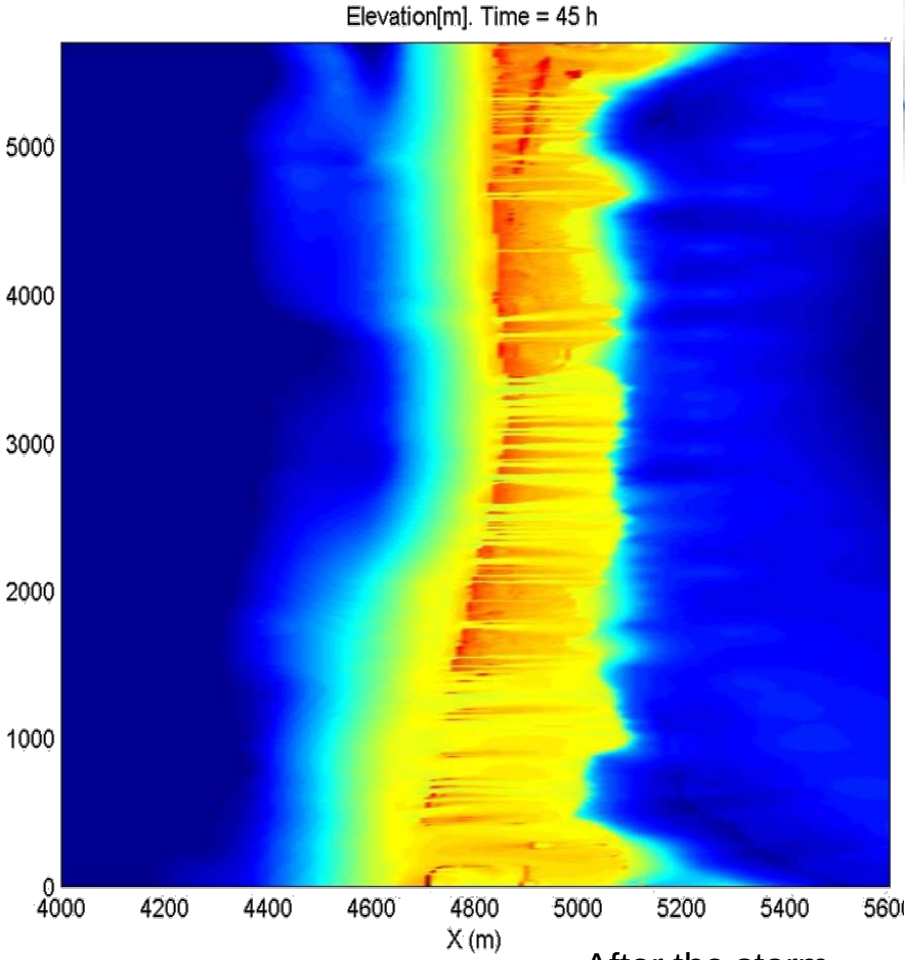
Storm (high τ) scale response (2001 storm)



Before the storm



After the storm

Breaching fan deposits (simulated and observed) contribute to maintening the unit (link to longer term scales)

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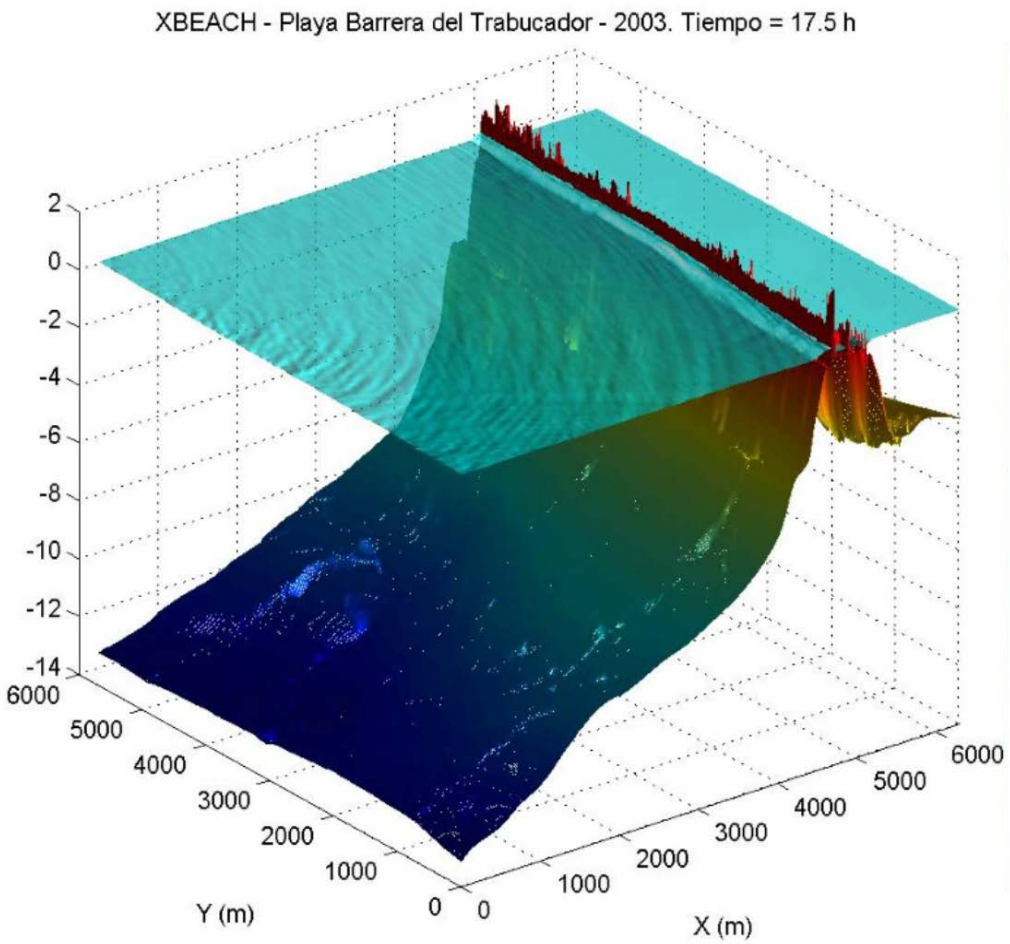
Storm (high τ) scale response (2001 storm)



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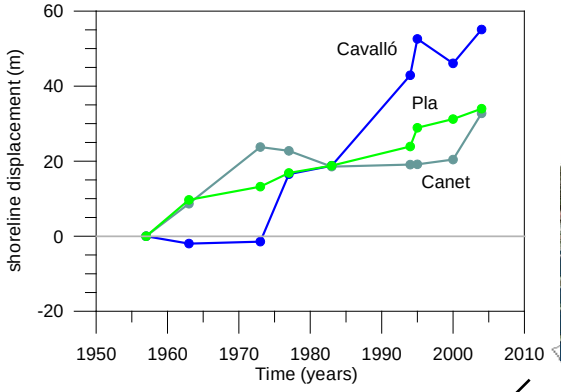
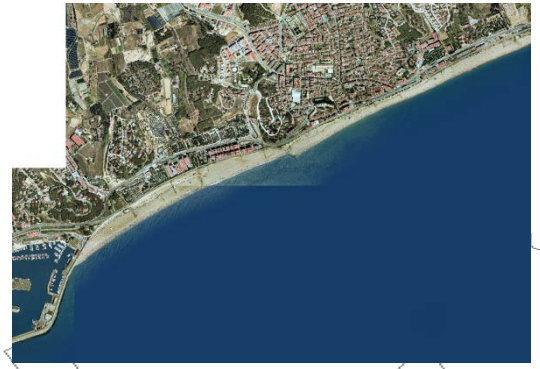
Mid-term (engineering) scale: observations

Ave. mid-term shoreline evolution (m/y) for the period 1995-2004
Cell: Port d' Arenys - Port de Blanes

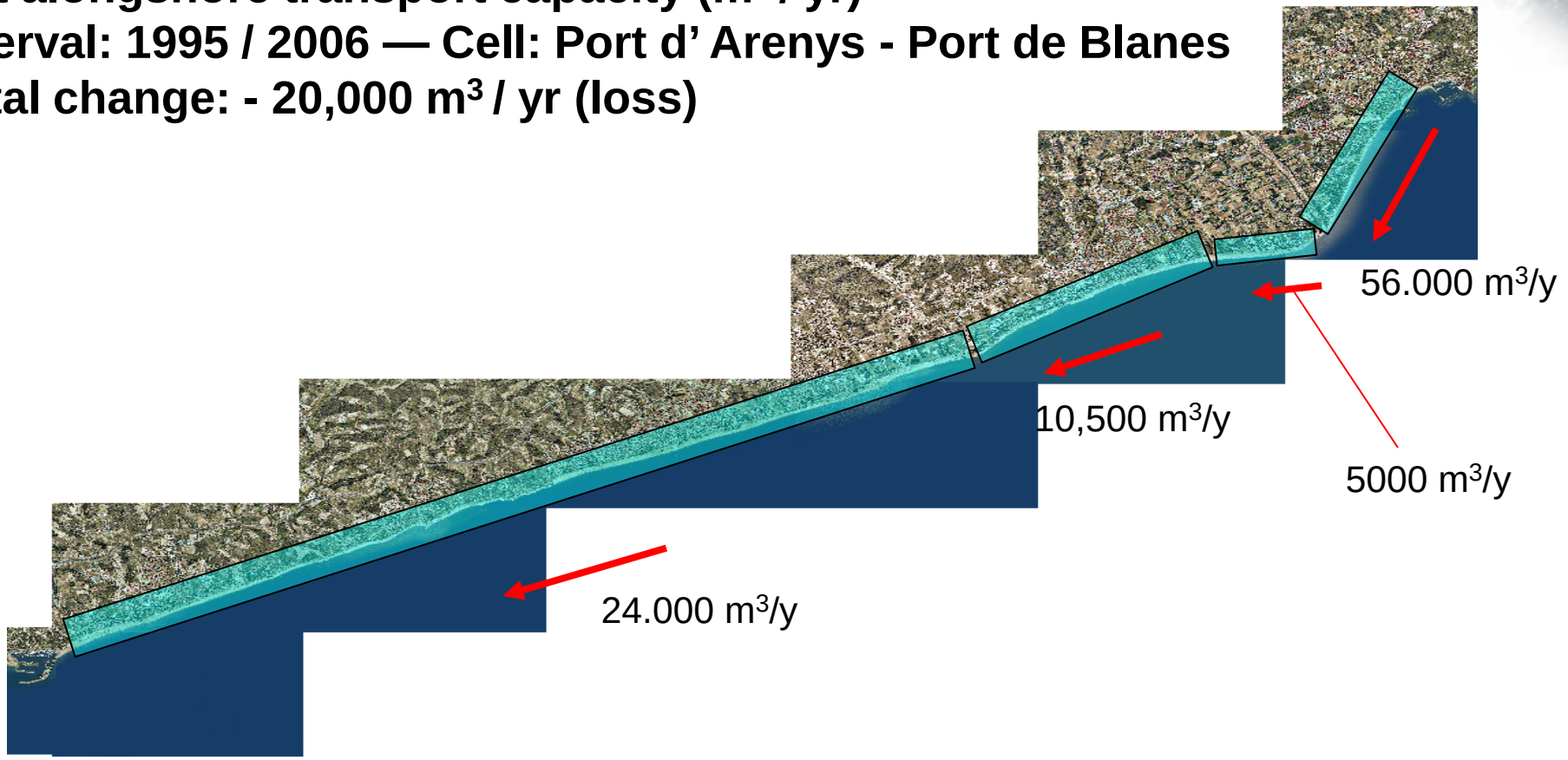




Llibre Verd Costa Catalana

Mid-term (engineering) scale: calculus

Net alongshore transport capacity (m^3 / yr)
Interval: 1995 / 2006 — Cell: Port d' Arenys - Port de Blanes
Total change: - 20,000 m^3 / yr (loss)



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Mid-term (engineering) scale: modelling

1983

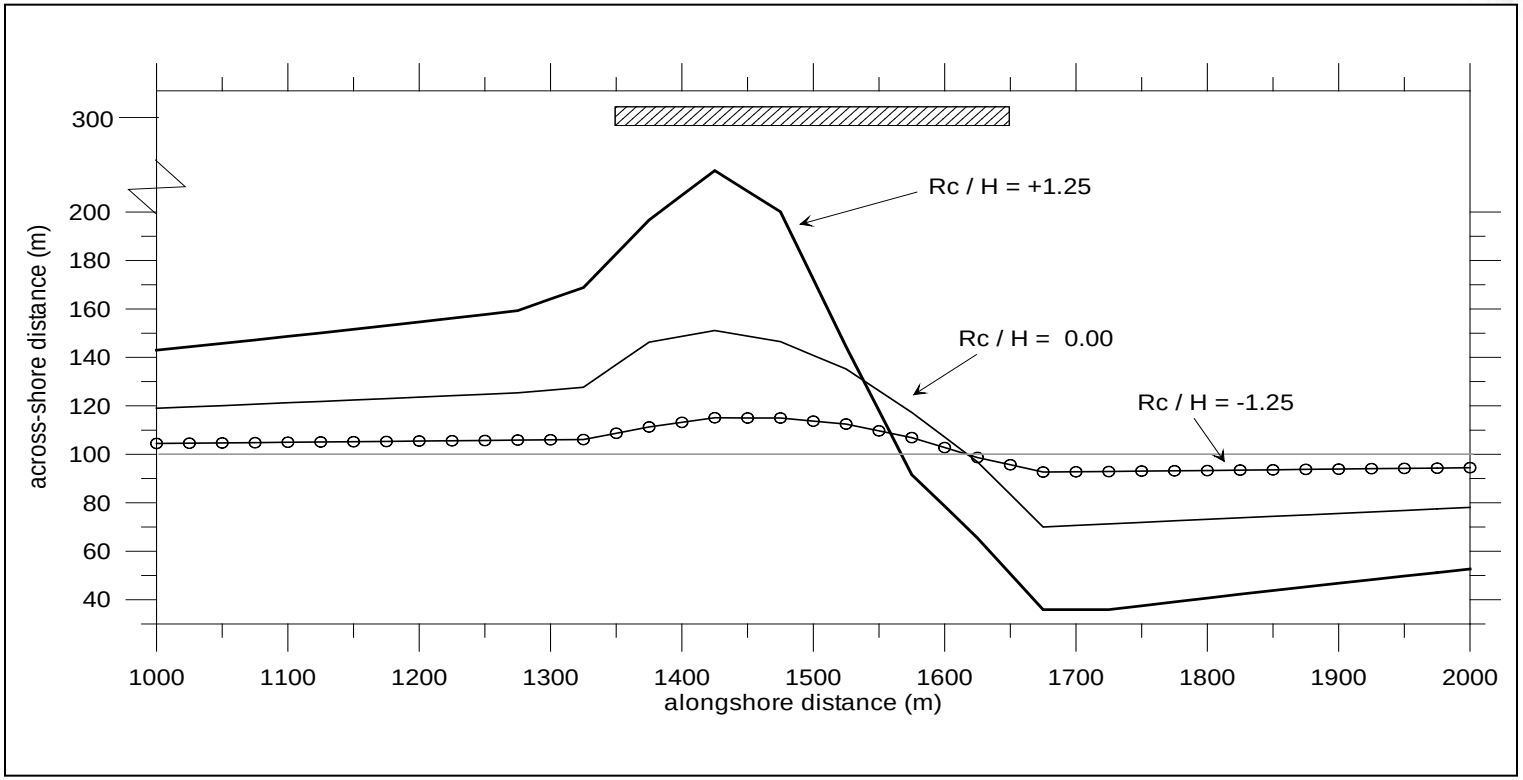
2001

Roca de Gaià

Altafulla beach
Tarragona, Spain

Loss > 200.000 m3 in 10 years

Mid-term (engineering) scale: modelling



Computed shoreline with a one-line numerical model (BEACH_1L) behind a detached low-crested breakwater. Salient development as a function of freeboard for oblique wave incidence.

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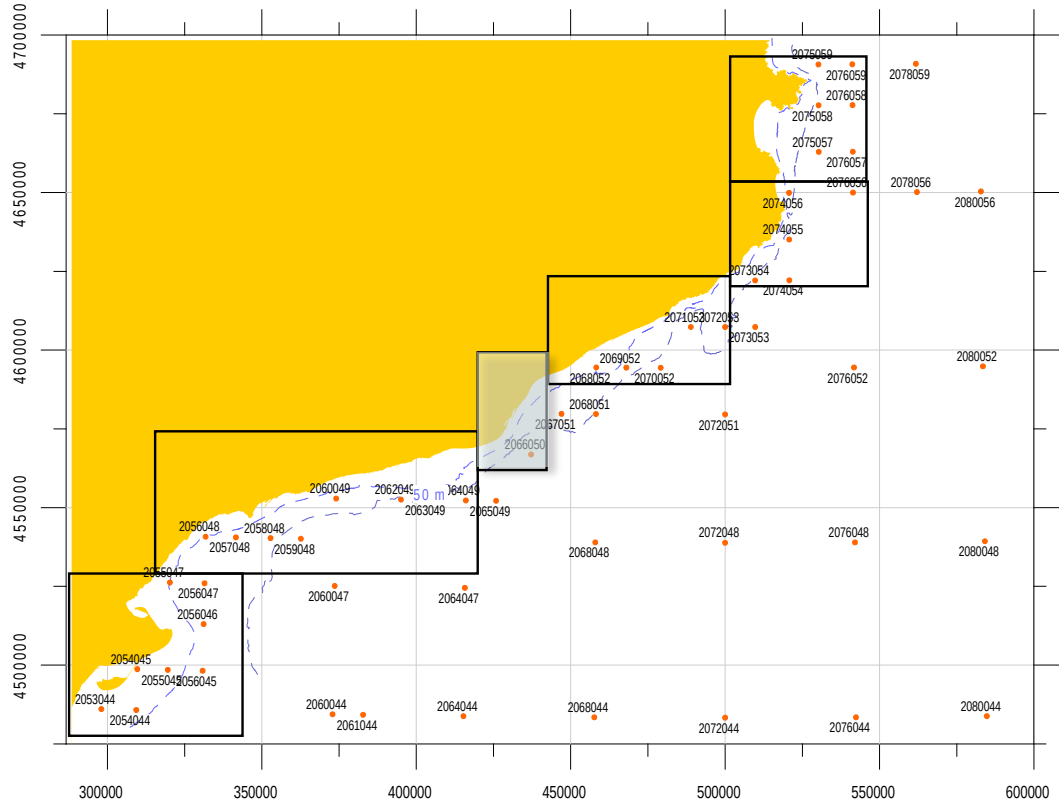
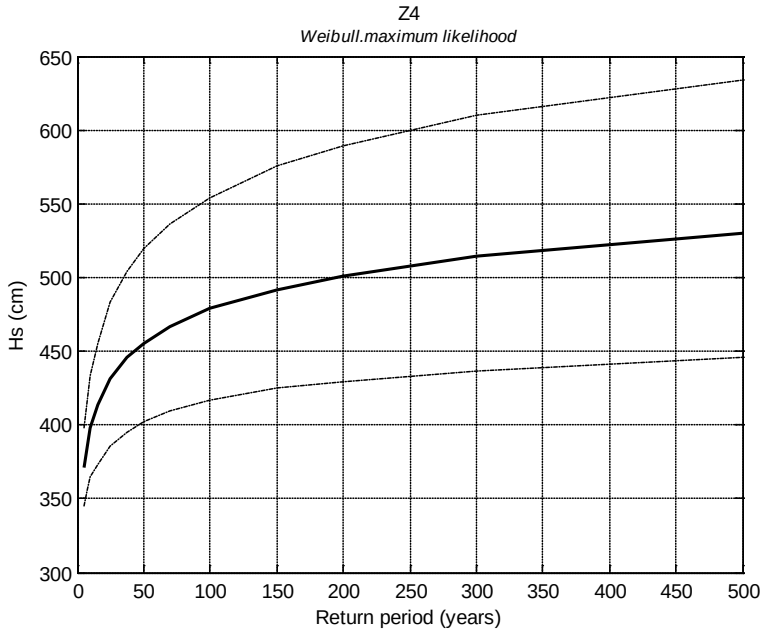
The way ahead: predict with uncertainties

- ✓ Select the "right" time scale
- ✓ Make explicit the uncertainties





PDF from observed data

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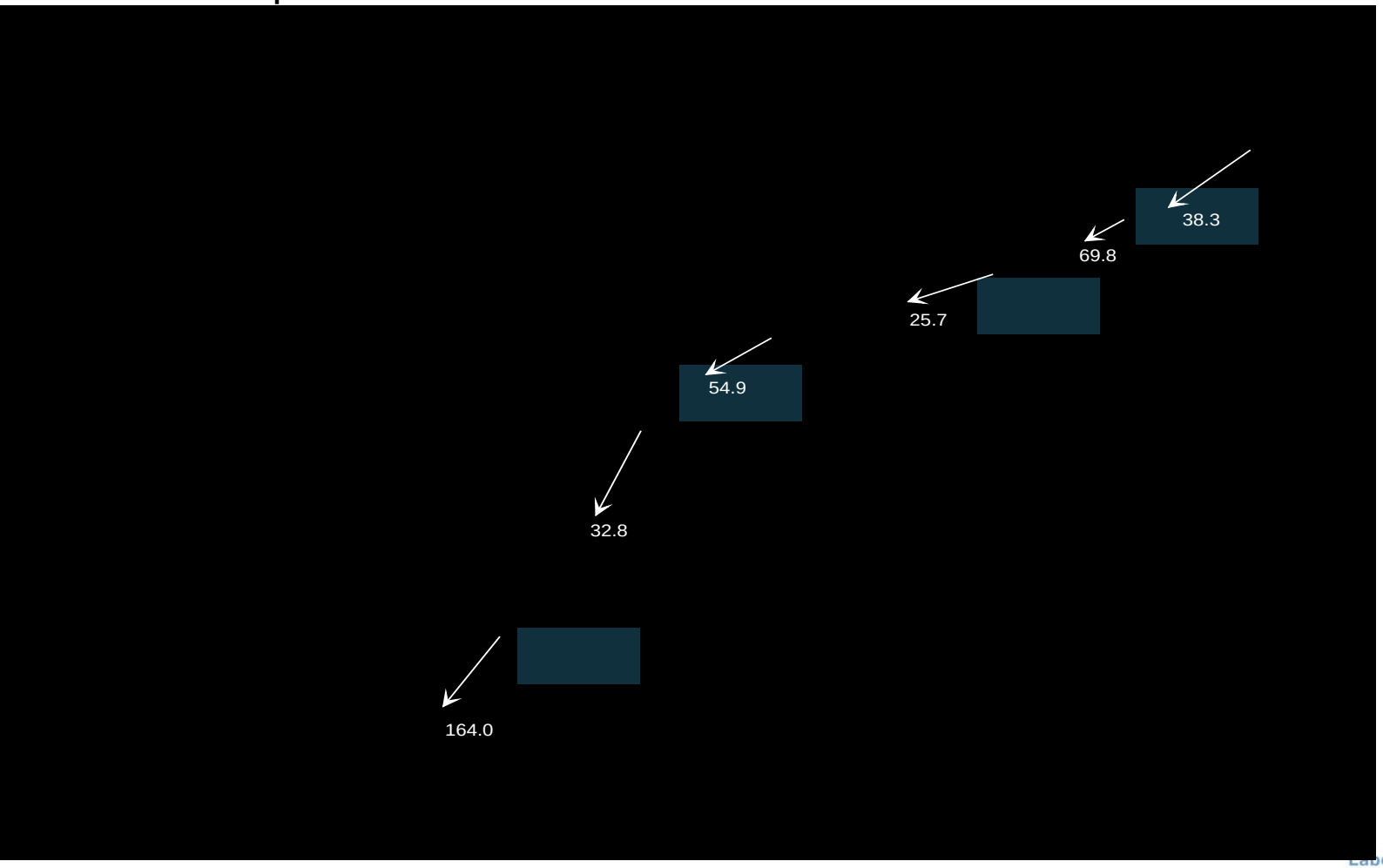
The way ahead: predict with uncertainties

- ✓ Potential transport ≠ Actual transport
- ✓ Make explicit the uncertainties



The way ahead: predict with uncertainties

- ✓ Uncertainties in BCs
- ✓ As a function of t-scale

GRACIES !