Climate change and coastal areas

Addressing climate change challenges from a multidisciplinary perspective

Basque Center for Climate Change
Summer School 2013

bc3
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FOR CLIMATE CHANGE
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July 2013

1. Coastal system

2. Natural subsystem

3. Socioeconomic subsystem

1. Drivers of change

5. Impacts

5. Climate change in terms of risk

5. What we know

5. Conclusions

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Source: IPCC AR4

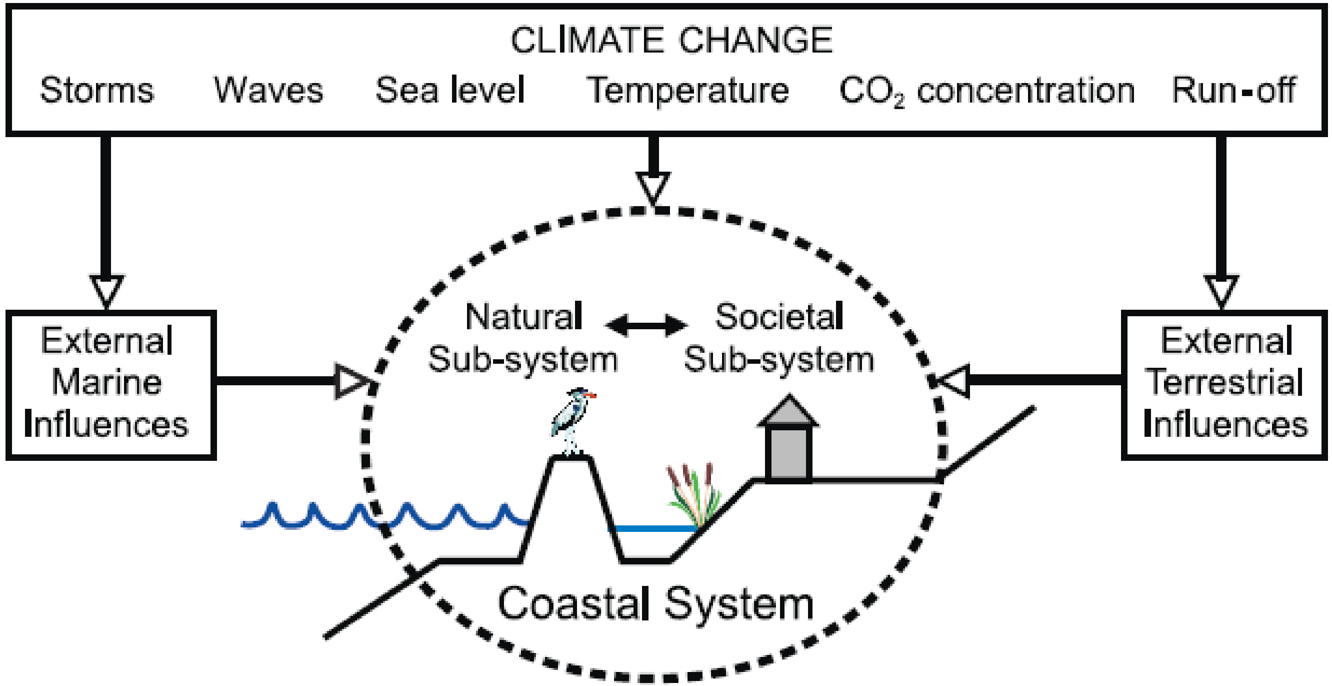
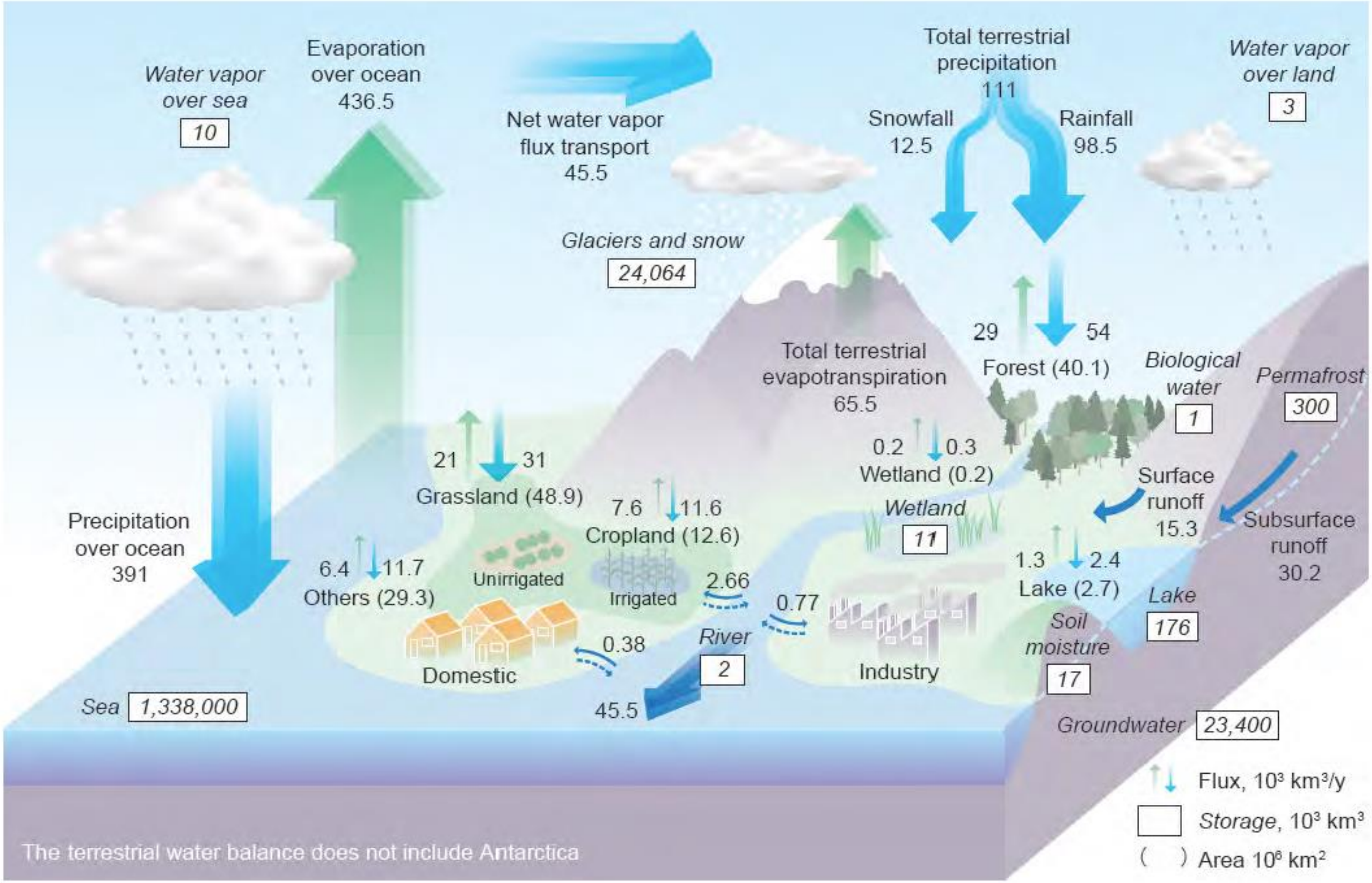
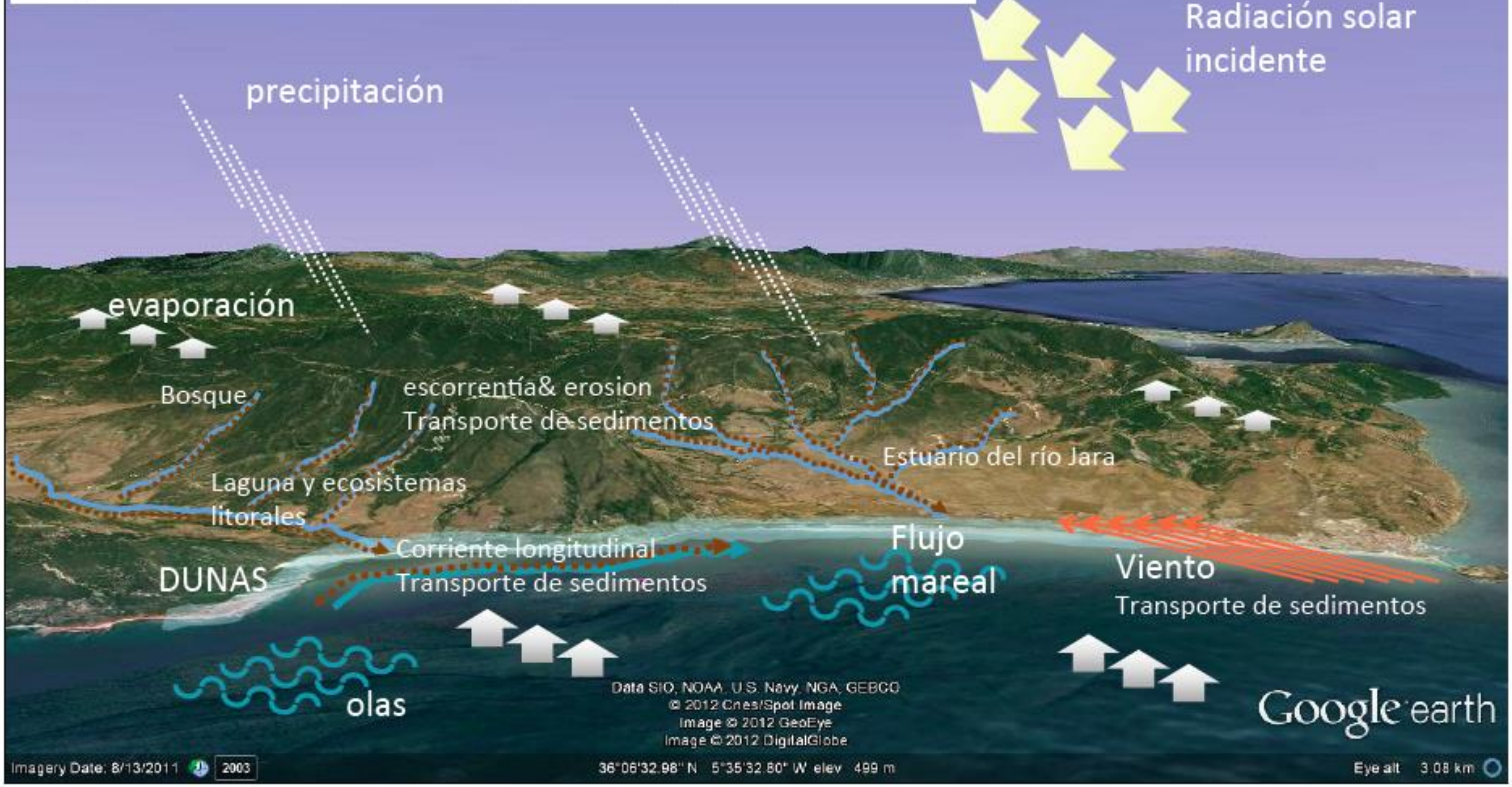


Figure 6.1. *Climate change and the coastal system showing the major climate change factors, including external marine and terrestrial influences.*



Interface between land and the ocean

Respuestas a diversas escalas espacio-temporales



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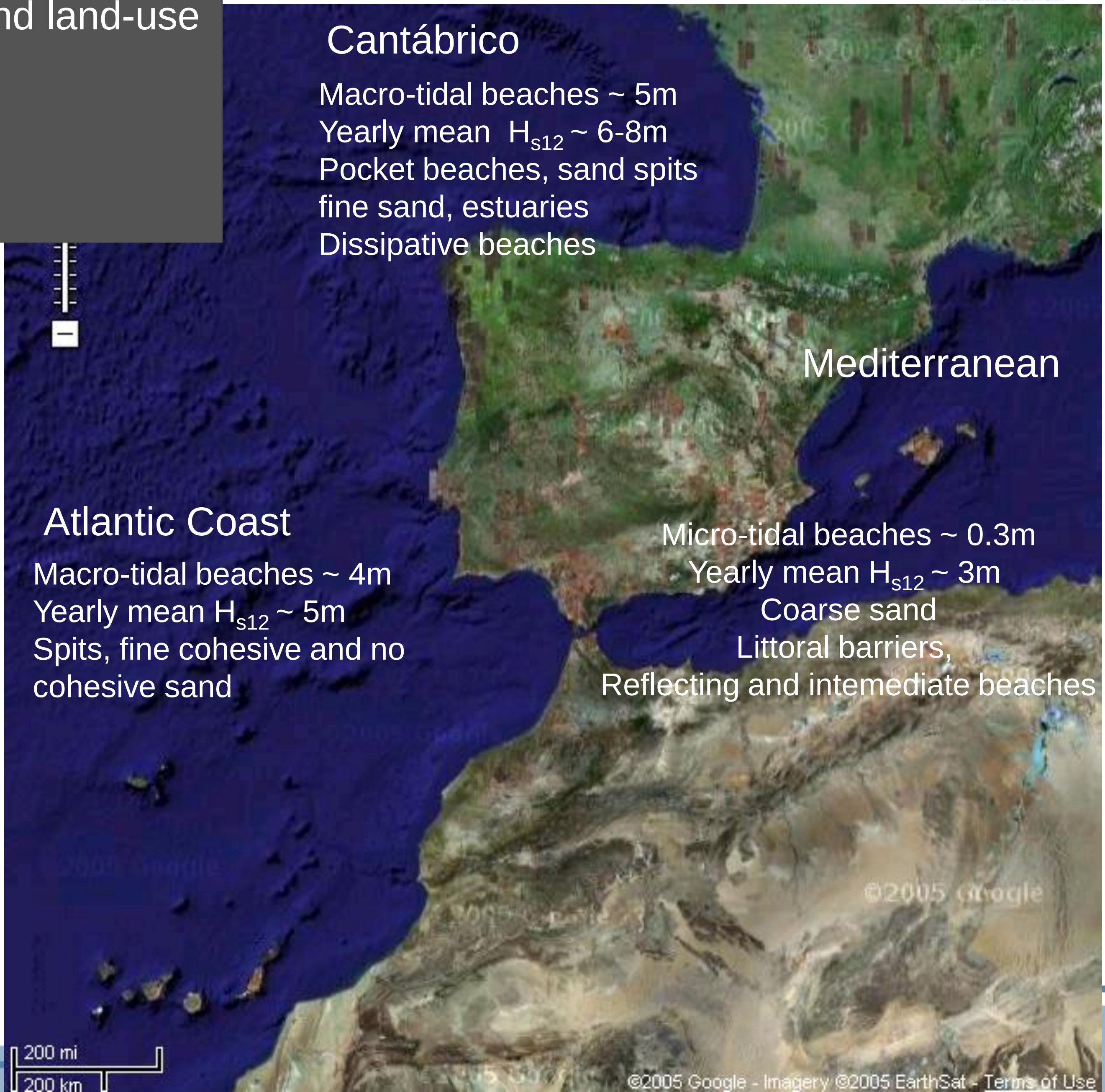
Costa española:	≈8000 km
Cantábrico:	1090 km
Galicia:	1600 km
Canarias:	1580 km
Mediterráneo:	1800 km
Baleares:	1450 km
Andalucía atlántico:	385 km

Spanish Coast:

- Wide range of processes, geology, morphology and land-use
- Shoreline: 7,860 km
- 4 wave climates
- tidal range
  0.1 m y 5.0 m



Cantábrico

Macro-tidal beaches ~ 5m
Yearly mean H_{s12} ~ 6-8m
Pocket beaches, sand spits
fine sand, estuaries
Dissipative beaches

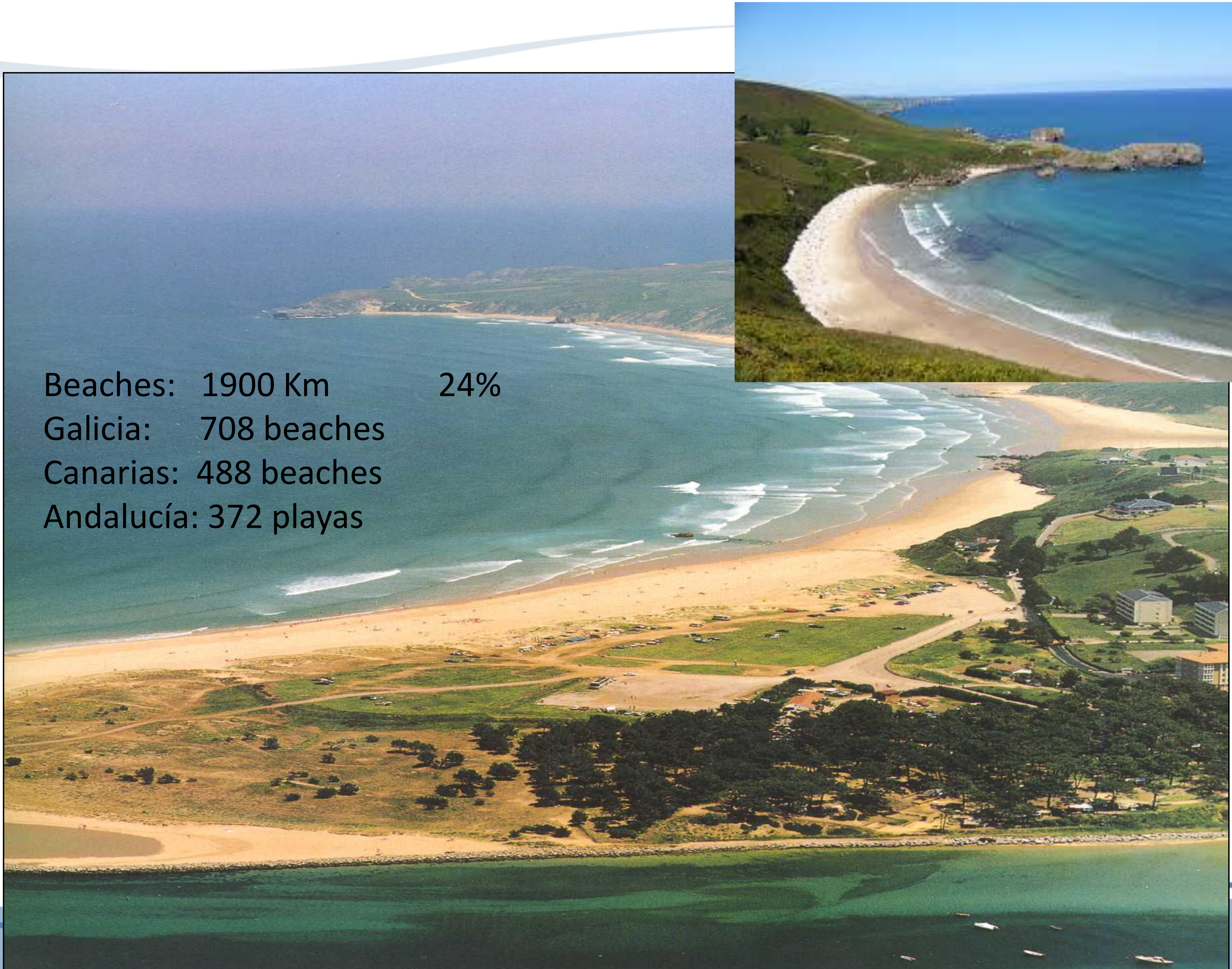
Mediterranean

Micro-tidal beaches ~ 0.3m
Yearly mean H_{s12} ~ 3m
Coarse sand
Littoral barriers,
Reflecting and intemediate beaches

Atlantic Coast

Macro-tidal beaches ~ 4m
Yearly mean H_{s12} ~ 5m
Spits, fine cohesive and no cohesive sand

Meso tidal beaches~ 3m
Yearly mean H_{s12} ~ 6 m
Cobble beaches,
Volcanic sand



Beaches: 1900 Km 24%
Galicia: 708 beaches
Canarias: 488 beaches
Andalucía: 372 playas

Dunes

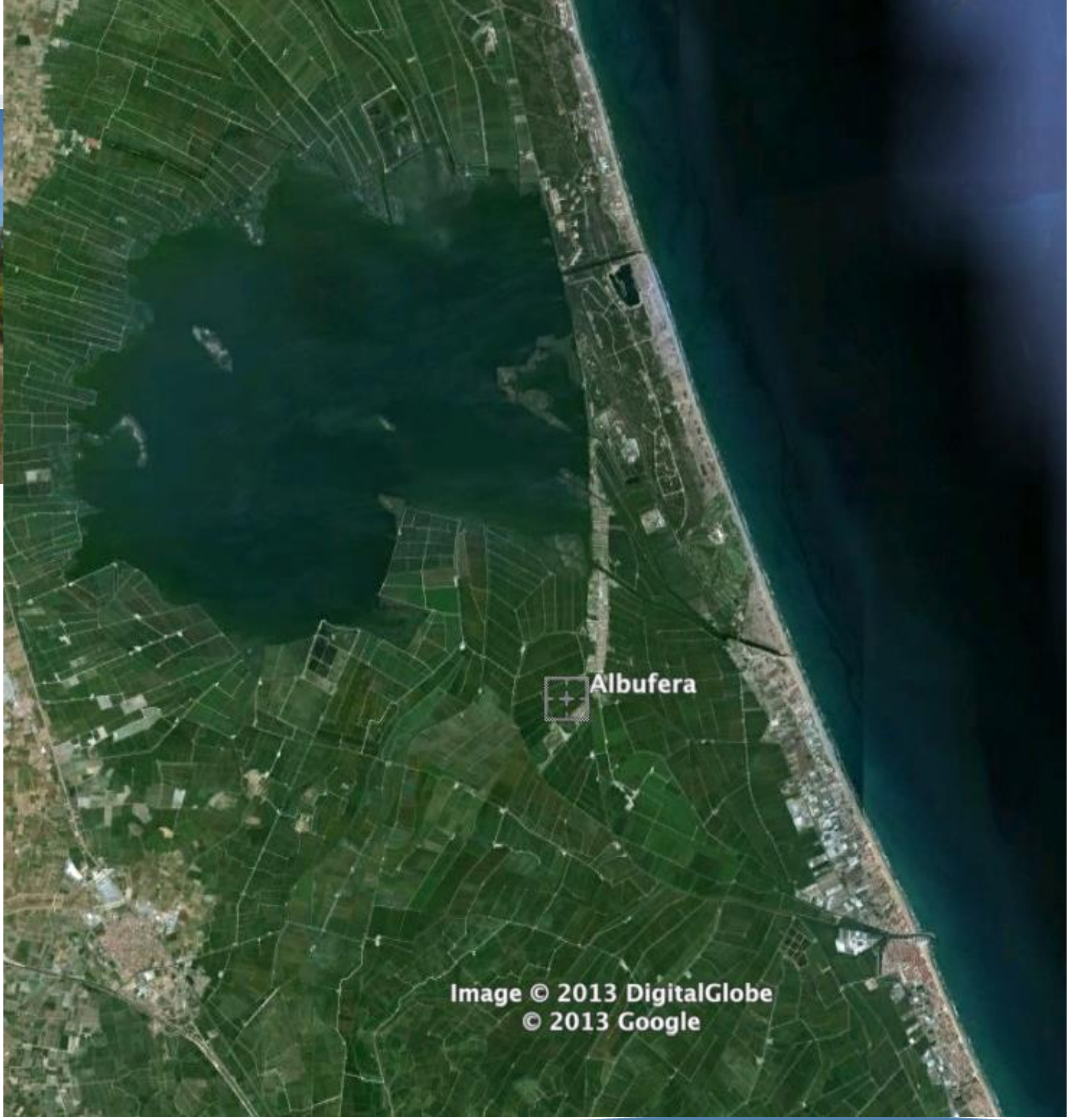
eroding
•Doñana
•Maspalomas

Cliffs

Rocky intertidal platforms


Santander Bay and spit

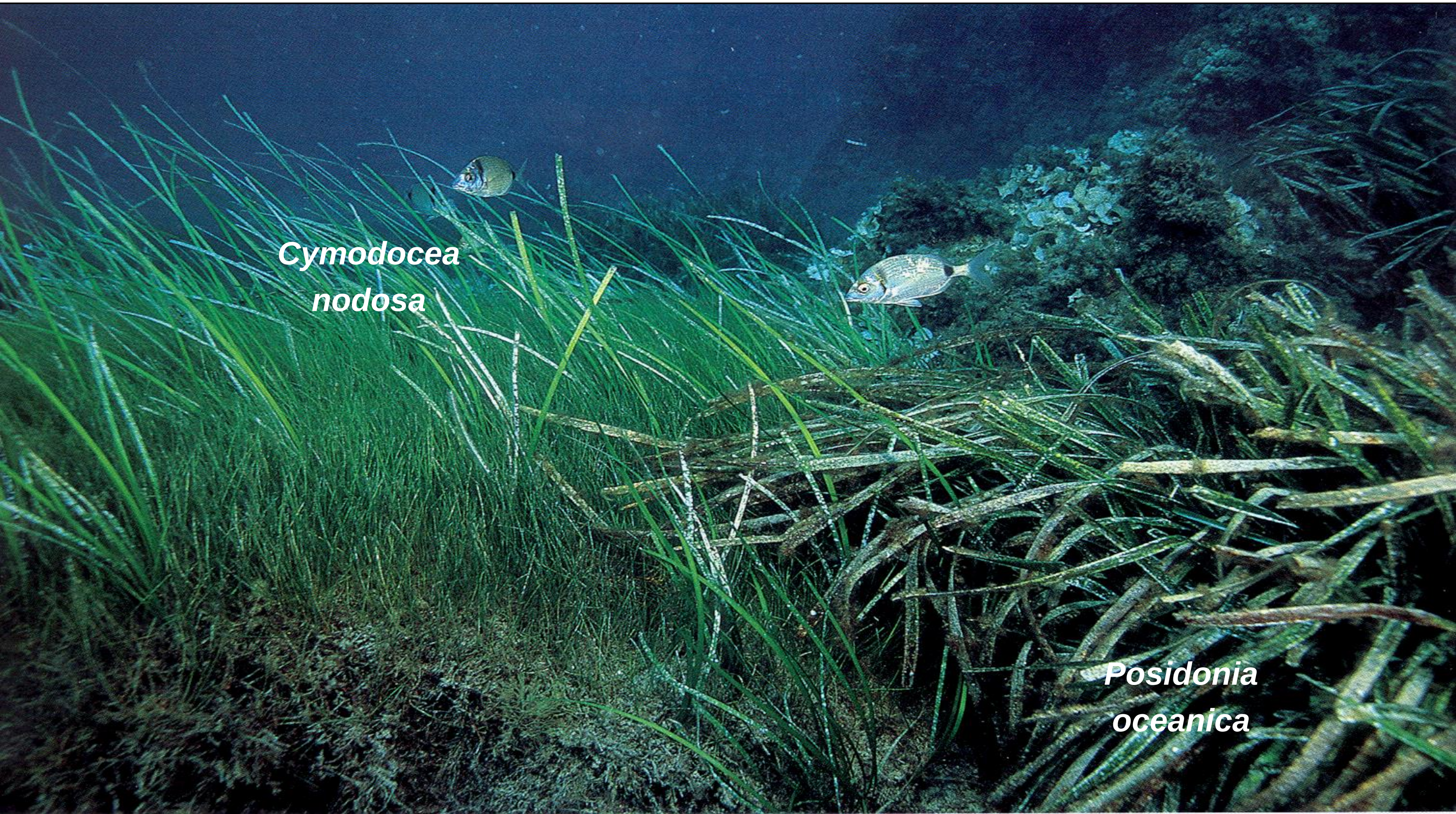
Ría de Villaviciosa



Albufera de Valencia

Coastal lagoon
Coastal barrier


Distance: 48,2 km
FOV: 45°
Terrain Elevation: 0,00 meters
Delta del Ebro


Cymodocea nodosa
Posidonia oceanica

Laminaria hyperborea kelp

Spartina Alterniflora

Macrocystis pyrifera kelp

Zostera Marina

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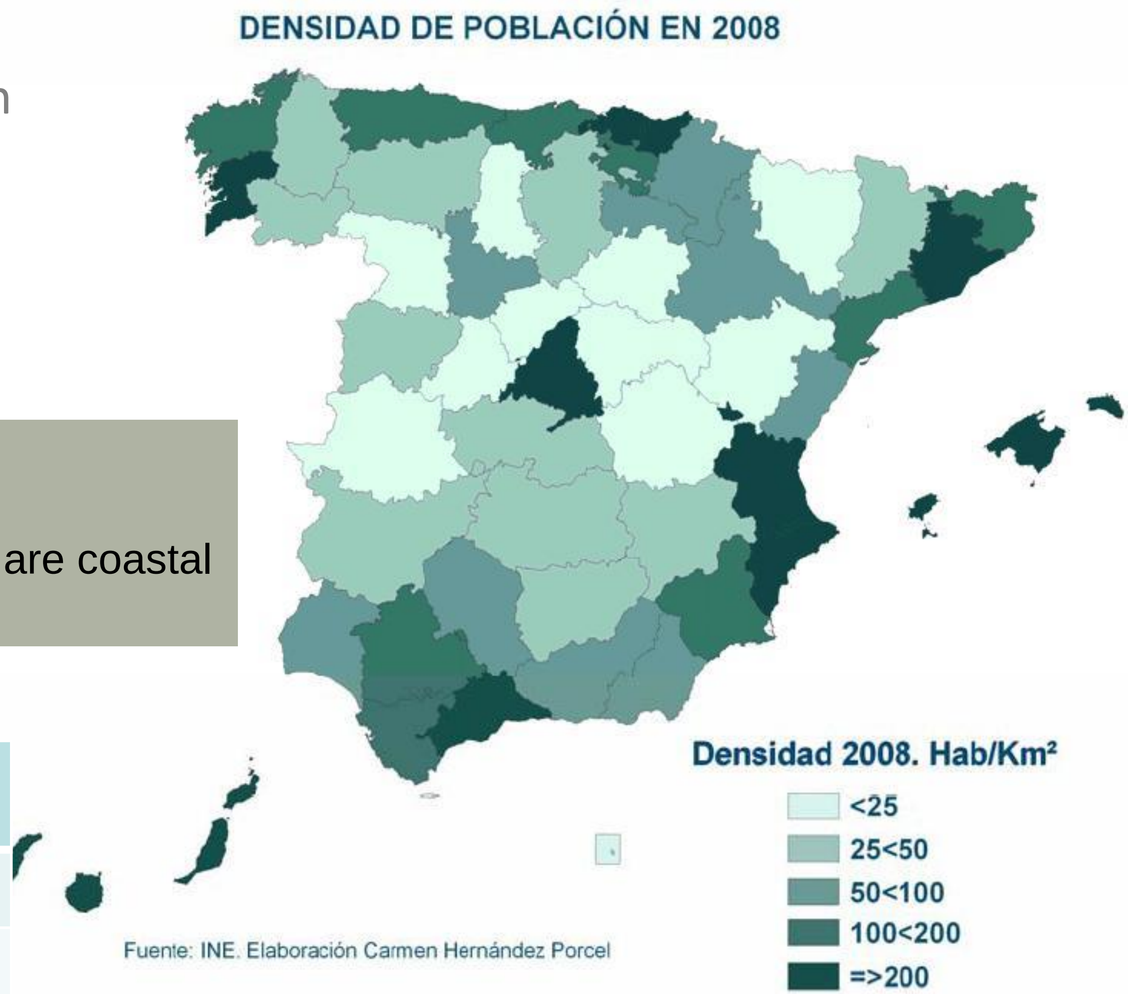
Coastal cities
44% of the total population in
7% of the total territory

National mean: 93,5Hab/km2

5 out 7 citie with the highest density are coastal cities >5000 hab/km2

City	Density (hab/km2)
Barcelona	15867
Badalona	9844
Bilbao	8559
La Coruña	6613
Valencia	5916



Med Coast

36% urban use + 11% designated for urban use

50s

LA MANGA

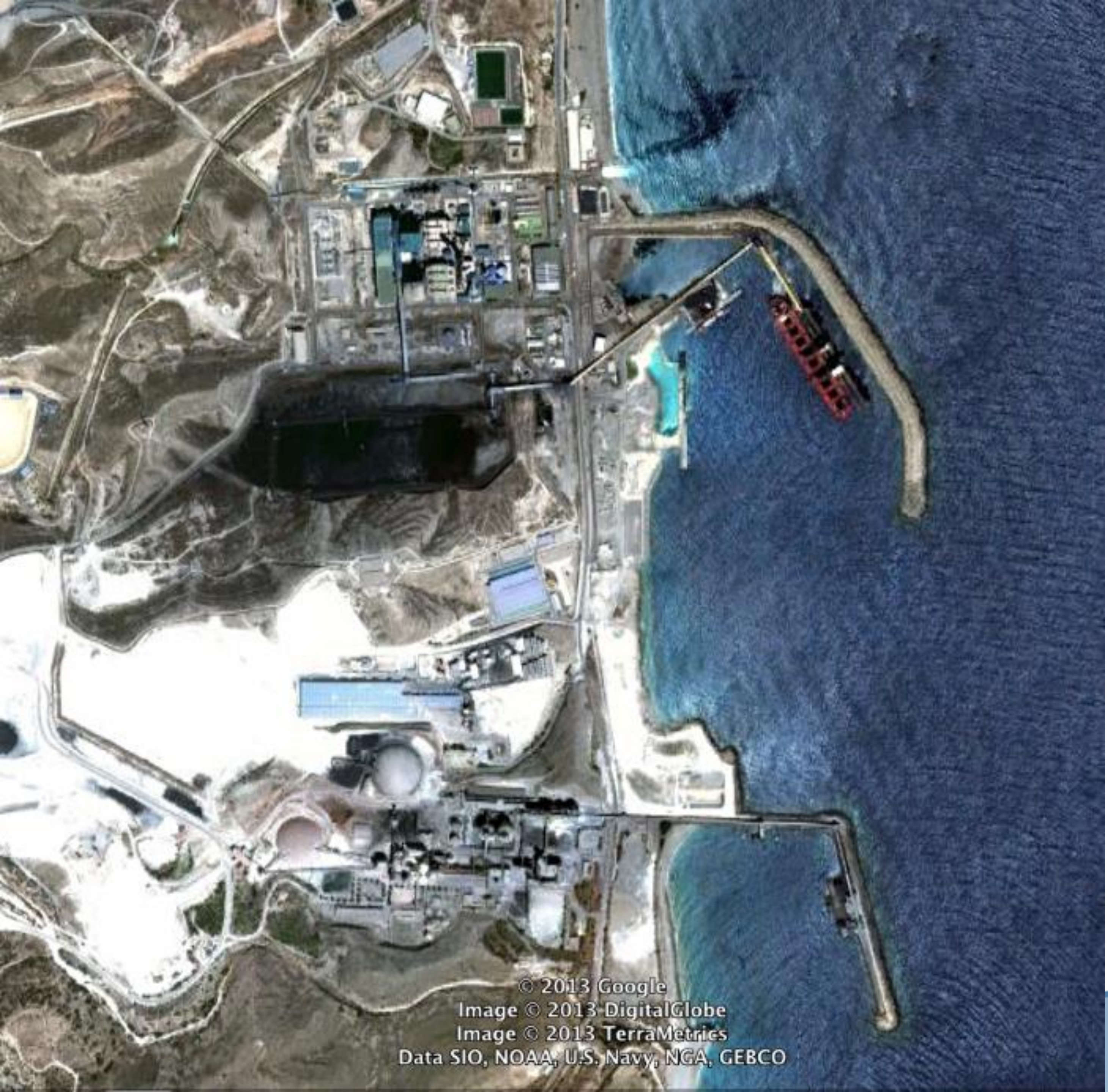
Today

Year 2000
1st km from the shoreline
Alicante: 49% urban use
Valencia: 29 % urban use
Cádiz: 32% urban use

60`s

BENIDORM

Today



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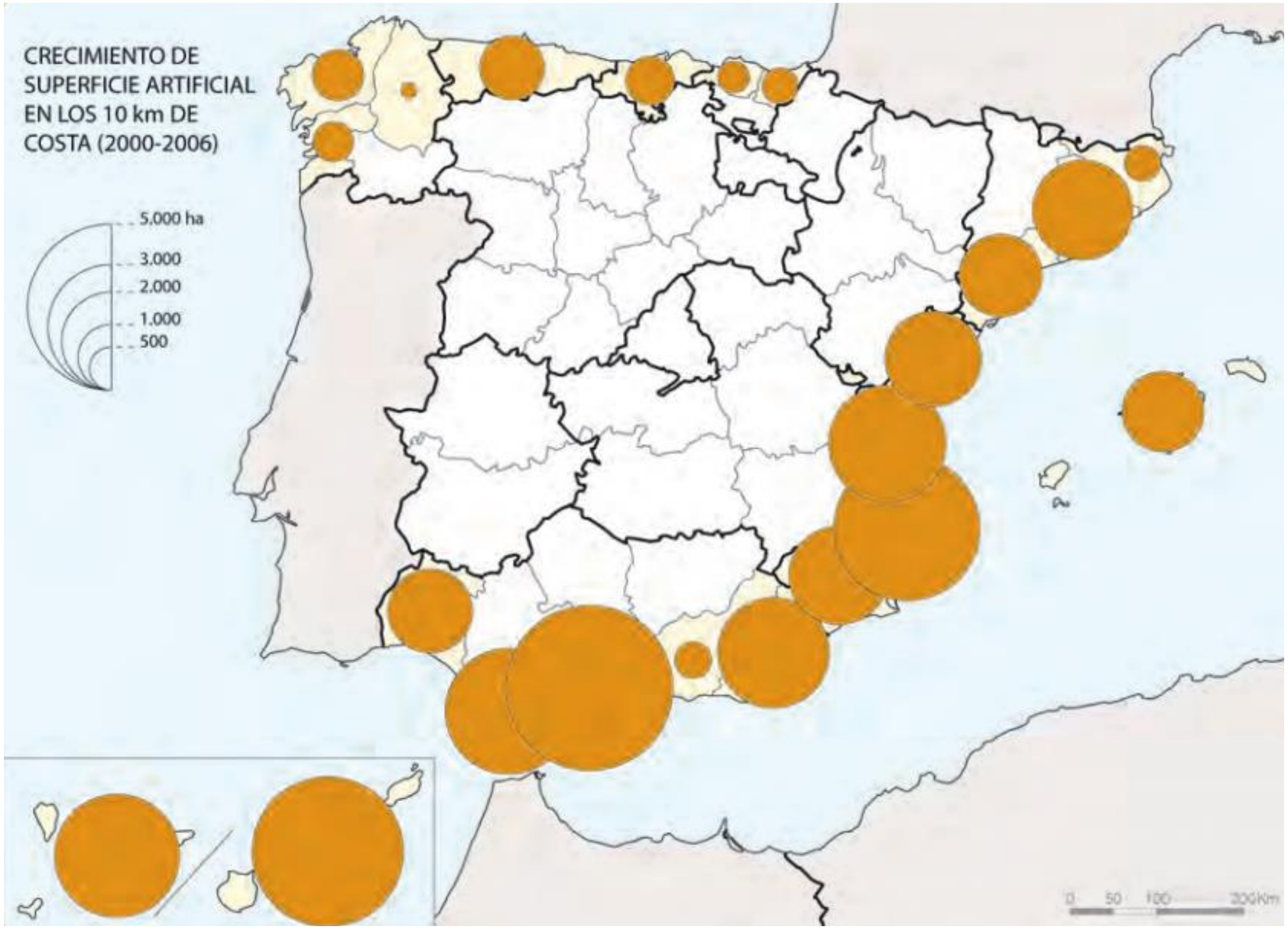
Carboneras
500 m

Cement factory
Coal power plant
Desalination plant
2 breakwaters
Aquaculture plant


CRECIMIENTO DE SUPERFICIE ARTIFICIAL EN LOS 10 km DE COSTA (2000-2006)
5.000 ha
3.000
2.000
1.000
500
0
50
100
200 Km

Maritime Transport

90% comercio externo

40% comercio interno

9.000 buques bajo bandera UE
4.000 bajo otras banderas
1200 puertos comerciales
3.500 millones de ton/año
350M pasajeros/año

EL SISTEMA PORTUARIO ESPAÑOL

El Sistema Portuario español de titularidad estatal está integrado por 46 puertos de interés general, gestionados por 28 Autoridades Portuarias. Los puertos españoles son uno de los eslabones más importantes de la cadenas logísticas y de transporte.

A través de ellos se gestionan el 60% de las exportaciones y el 85% de las importaciones, lo que representa el 53% del comercio exterior español con la Unión Europea y el 96% con terceros países. En su conjunto, la actividad del sistema portuario estatal aporta cerca del 20% del PIB del sector del transporte (1,1% del PIB español), genera un empleo directo de más de 35.000 puestos de trabajo y de unos 110.000 de forma indirecta (Ministerio de Fomento-Puertos del Estado, 2011).

En 2011, se han ampliado los puertos de Musel (Gijón) y entre las obras de ampliacion más importantes iniciadas hasta la fecha se encuentran las del puerto de Bilbao y Carboneras (Almería).

[Fuente] Ministerio de Fomento. 2011. Los puertos de interés general del Estado. Puertos del Estado. Disponible en: http://www.puertos.es/sistema_portuario/presentacion.html

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Shipyards

300 shipyards

9.000 companies

12.000 M€ benefits

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Fisheries and aquaculture

400.000 fishermen

90.000 fishing boats

6% of world fisheries

2% of world aquaculture production

Energy

-40% oil + 60% gas come from offshore sources

- Offshore wind: 2% of wind industry

  (Goal 2020: 1/3 of the total)

- Wave, tides and currents

Tourism in Spain

- 56,7 Million visitors/year (80% coastal).
- Ranked 4th by country in 2011
- Ranked 2nd by income in 2011
- 10,2% of the GPD (2010)
- 11.5% employment (2010)

EXCELTUR: Beach loading capacity 6 m2/person

Only a 30% of coastal municipalities reach higher values

324 marinas with over 107.000 berths (2005)

Valencia (10 marinas every 100 km)

Direct employment 15.000 (total 114.000)

Gross Value Added 1057 M€ (0.13% of the national GBA)

Fuente: Asociación Nacional de Empresas Náuticas

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Climatic drivers

Climate Driver	Effects
Sea Level	Submergence, flood damage, erosion; saltwater intrusion; rising water tables/impeded drainage; wetland loss and change
Storms (Tropical cyclones Extratropical cyclones)	Storm surges and storm waves, coastal flooding, erosion; saltwater intrusion; rising water tables/impeded drainage; wetland loss (and change). Coastal infrastructure damage and flood defenses failure.
Winds	Wind waves, storm surges, coastal currents, coastal infrastructure damage.
Waves	Coastal erosion, overtopping and coastal flooding.
Extreme Sea Levels	Coastal flooding erosion, saltwater intrusion
Sea Surface Temperature	Changes to stratification and circulation; reduced incidence of sea ice at higher latitudes; increased coral bleaching and mortality, poleward species migration; increased algal blooms.
Freshwater Input	Altered flood risk in coastal lowlands; altered water quality/salinity; altered fluvial sediment supply; altered circulation and nutrient supply.
Subsidence/uplift (**)	Altered coastal land surface level due to sediment compaction, glacial isostatic rebound and tectonic movement. Altered relative sea level
Ocean acidity	Increased CO2 fertilisation; decreased seawater pH and carbonate ion concentration (or 'ocean acidification')

** Non-climatic

Non-Climatic drivers

Non-Climate Drivers	Effects
Socioeconomic development	Increased exposure and vulnerability; increased flooding damages; fatalities; increased economic losses
Nutrients	Increased nutrient (i.e. nitrogen, phosphorus) loads to coastal systems resulting in degradation of coastal ecosystems by eutrophication and including hypoxia
Hypoxia	Decreased oxygen concentration (hypoxia). Serious threat to marine life and coastal ecosystems
Sediment delivery	Reduction: sediment trapping behind dams, water diversion for irrigation, and sand and gravel mining in river channels Effects on river deltas, shoreline erosion, mangroves and wetlands Increase: soil erosion due to land-use changes Delivery due to soil erosion impacts coastal ecosystems
Water diversion/ freshwater input	Induced by land-use change, water withdrawal, dam building and other engineered modifications to waterways.
Subsidence	Altered coastal land surface level due to sediment compaction subsurface resource extraction (groundwater, gas, petroleum, etc.). Altered relative sea level

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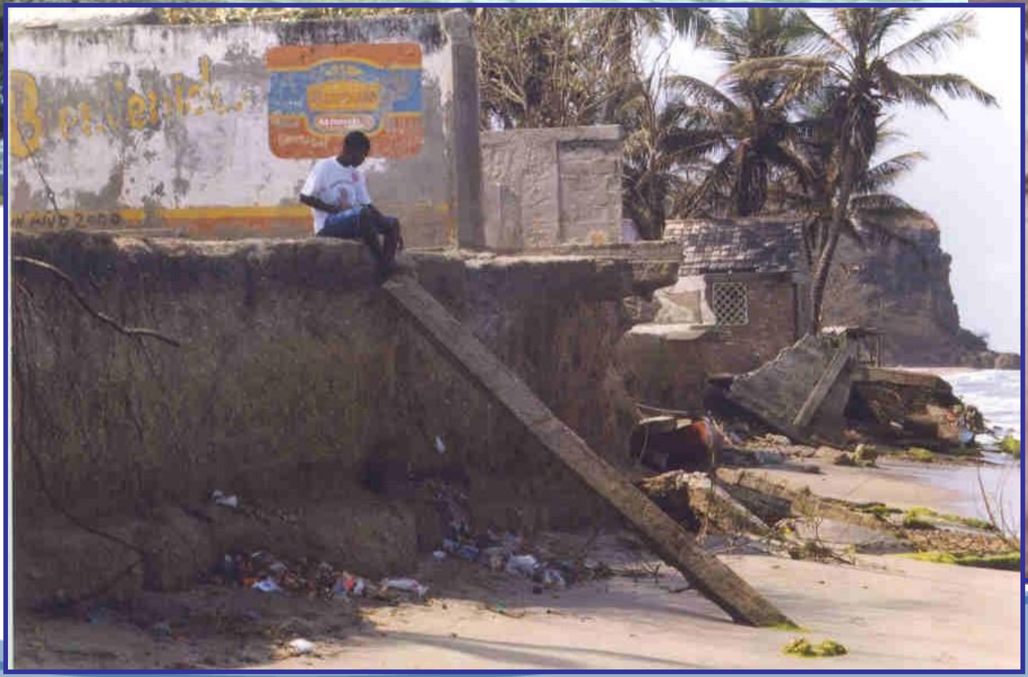
Erosion



Flooding

Impacts on coastal infrastructures

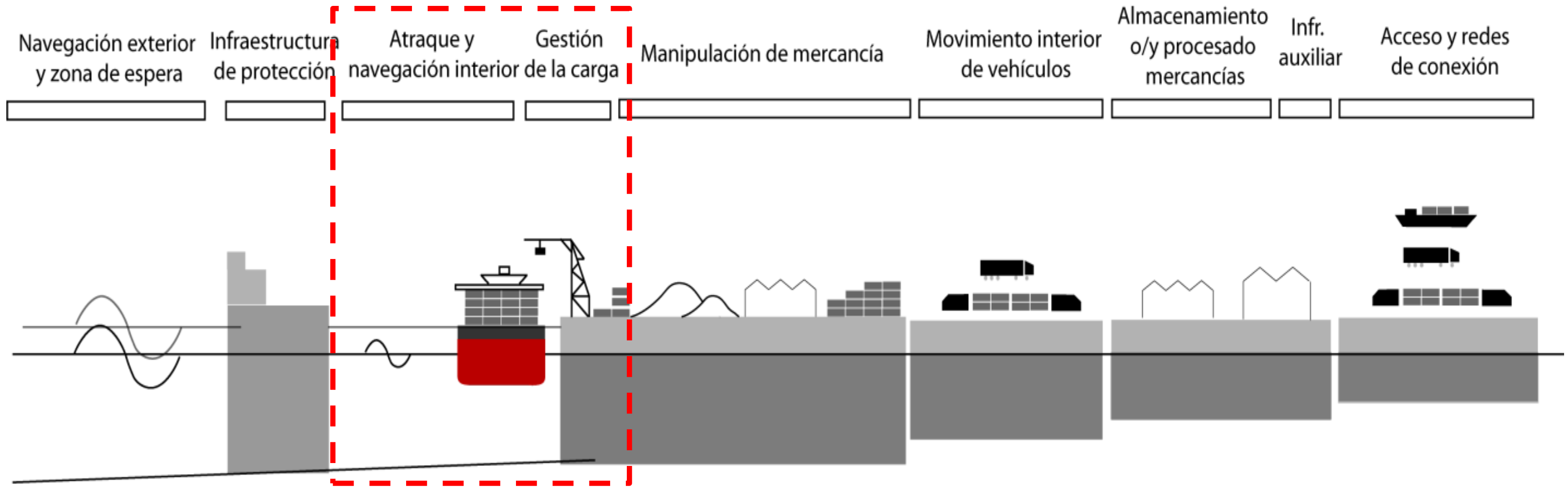
Table 3 Impacts of sea level rise, coastal floods, and storms on critical coastal infrastructure by sector

Communications	Energy	Transportation	Water and waste
Higher average sea level			
• Increased salt water encroachment and damage to low-lying communications infrastructure not built to withstand saltwater exposure • Increased rates of coastal erosion and/or permanent inundation of low-lying areas, causing increased maintenance costs and shortened replacement cycles • Tower destruction or loss of function	• Increased rates of coastal erosion and/or permanent inundation of low-lying areas, threatening coastal power plants • Increased equipment damage from corrosive effects of salt water encroachment resulting in higher maintenance costs and shorter replacement cycles	• Increased salt water encroachment and damage to infrastructure not built to withstand saltwater exposure • Increased rates of coastal erosion and/or permanent inundation of low-lying areas, resulting in increased maintenance costs and shorter replacement cycles • Decreased clearance levels under bridges	• Increased salt water encroachment and damage to water and waste infrastructure not built to withstand saltwater exposure • Increased release of pollution and contaminant runoff from sewer systems, treatment plants, brownfields and waste-storage facilities • Permanent inundation of low-lying areas, wetlands, piers, and marine transfer stations • Increased salt water infiltration into distribution systems transfer stations
More frequent and intense coastal flooding			
• Increased need for emergency management actions with high demand on communications infrastructure • Increased damage to communications equipment and infrastructure in low-lying areas	• Increased need for emergency management actions • Exacerbated flooding of low-lying power plants and equipment, as well as structural damage to infrastructure due to wave action • Increased use of energy to control floodwaters • Increased number and duration of local outages due to flooded and corroded equipment	• Increased need for emergency management actions • Exacerbated flooding of streets, subways, tunnel and bridge entrances, as well as structural damage to • Decreased levels of service from infrastructure due to wave action flooded roadways; increased hours of delay from congestion during street-flooding episodes • Increased energy use for pumping	• Increased need for emergency management actions • Exacerbated street, basement and sewer flooding, leading to structural damage to infrastructure • Episodic inundation of low-lying areas, wetlands, piers, and marine transfer stations

Sources: Horton and Rosenzweig (2010), Zimmerman and Faris (2010)

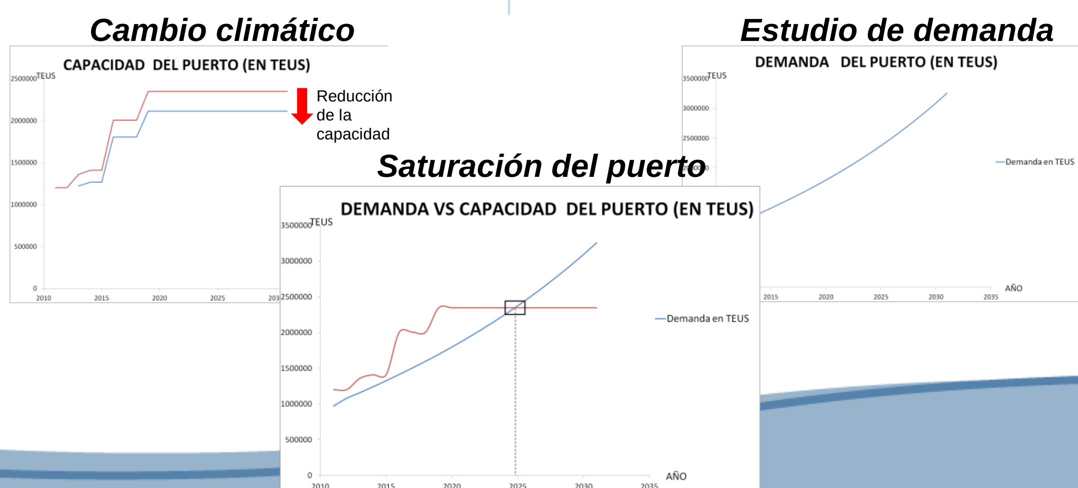
Climatic Change (2011) 106:93–127

Increased downtimes for port operation



What part of the system is critical for the port capacity?

What is the effect of climate change on this sybsystem?



Coral bleachig due to ocean acidification

Climate system change	Organism/ ecosystem	Expected impact	Observed change	References
Increasing temperature	Seagrass	Seasonal and permanent loss of seagrass biomass with increased frequency and intensity of extreme temperatures	Increased temperatures results in a reduction in the above-ground biomass of seagrass and the disruption of the photosystem. Mass die-offs and ecosystem loss in areas exposed to prolonged extreme temperatures	Borum et al., 2005; Campbell et al 2006; Greve et al, 2003; Mayot et al, 2005; Moore and Jarvis, 2008; Najjar et al, 2010; Orth et al, 2006; Seddon and Cheshire; 2001; Seddon et al, 2000; Short and Neckles, 1999.
		Shift in community structure	Warm-water species proliferate, dominating communities in areas of low-level warming	Boudouresque et al, 2009; Ehlers et al, 2008; Francour et al, 1994; McMillan, 1984; Peirano et al, 2005; Walker, 1991
	Mangroves	Changes in species distribution and loss of habitat	Increased salinity due to higher evaporation leads to mortality and redistribution of species and reduced species richness due to variable salinity tolerance levels. Prolonged periods of extreme salinity may result in theformation of salt pan systems	Ball, 1998; Ball and Pidsley, 1995; Bertness and Pennings, 2000
	Rocky shores	Poleward shift in species ranges	The range and abundance of warm-water species are increasing, whilst those of coldwater species are diminishing	Adey and Steneck, 2001; Harley et al, 2006; Hawkins et al, 2009; Helmuth et al 2006; Nieszkowska et al, 2006
		Zonation patterns influenced by both air and sea temperatures	Reduced recruitment of fucoids and intertidal invertebrates in the littoral zone due to rising temperatures causing desiccation of propagules and suppressing growth leaving new recruits more susceptible to grazers	Hawkins et al, 2009; Helmuth et al 2006; Findlay et al 2010; Kennedy 1976; Pearson et al, 2009; Yamane and Gilman, 2009
	Kelp communities	Decline of kelp ecosystems with rising sea surface	Range and distribution of kelps is diminishing with rising temperatures due to requirements of sporophytes. Species	Adey and Steneck, 2001; Harley et al, 2006; Dayton and Tegner, 1984;

Hoegh-Guldberg and Bruno (2010)

Human-induced erosion

Eutrophication

Subsidence

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RISK = HAZARD x EXPOSURE x VULNERABILITY

The probability of **harmful consequences**, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. (UN/ISDR, 2004).

A **potentially damaging physical event**, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.
Each hazard is characterized by its location, intensity, frequency and probability. (UN/ISDR, 2004).

Inventory of people, property, systems, or other elements present in **hazard zones** that are thereby subject to potential losses. (UN/ISDR, 2004).

The **conditions** determined by **physical, social, economic, and environmental factors** or processes, which increase the susceptibility of a community to the impact of hazards. (UN/ISDR, 2004)

RISK = **HAZARD** x **EXPOSURE** x **VULNERABILITY**

RISK: Consequences

HAZARD: Dynamics → Threats (Impacts)

EXPOSURE

VULNERABILITY: Sensitivity, Resilience

Consequences: the negative effects of disaster expressed in terms of human, economic, environmental and political / social **impacts**.

Dynamics: variables and physical processes capable of generating a threat

Threats: a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Each threat is characterized by its location, intensity, frequency and probability.

Inventory of people, property, systems, or other elements present in **hazard zones** that are thereby subject to potential losses. (UN/ISDR, 2004).

Sensitivity: predisposition to be affected by physical or socio-economic changes, including damage and losses (UN/ISDR, 2004). Intrinsic quality of the exposed element.

Resilience: Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al. 2004)

Resilience: Coping Capacity, Recovery capacity

Coping capacity: the means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. (UN/ISDR, 2004)

Recovery capacity: the ability of the system to recover following a disaster.

Flooding

Low exposure, low vulnerability

Flooding

High exposure, medium vulnerability

High exposure, High vulnerability

High exposure, low vulnerability

BENIDORM

Flooding

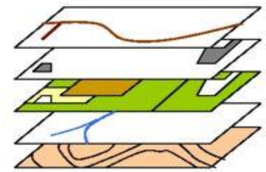
High exposure, very high vulnerability

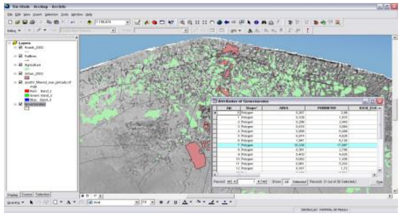
EXPOSURE	VULNERABILITY	
Exposed elements	**Sensitivity**	**Resilience**
Human exposure	Human sensitivity	Information and awareness
Environmental exposure	Environmental sensitivity	Alert and evacuation
Socioeconomic exposure	Socioeconomic sensitivity	Emergency response
Infrastructures exposure	Infrastructures sensitivity	Recovery

Tramo Analizado		Tipo del Frente Costero							
ID	Extension (m)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	1000	X							
2	1300	X							
3	1200	X							
4	1300	X							
5	360						X		
6	600	X							
7	600	X							
8	2000	X							
9	2060		X						
10	600					X			
11	1010		X						
12	1500		X						
13	1000		X						
14	1000		X						
15	1000		X						
16	1000		X						

Vulnerability indicators

+





Geographic Information System

An adequate vulnerability assessment requires an integrated and holistic approach:

How vulnerable are our coastal communities? …is about people's safety

How vulnerable are our coastal ecosystems? …is about ecological relevance and sensitivity

How vulnerable are our coastal livelihoods? ... is about income, way of life, culture and tradition

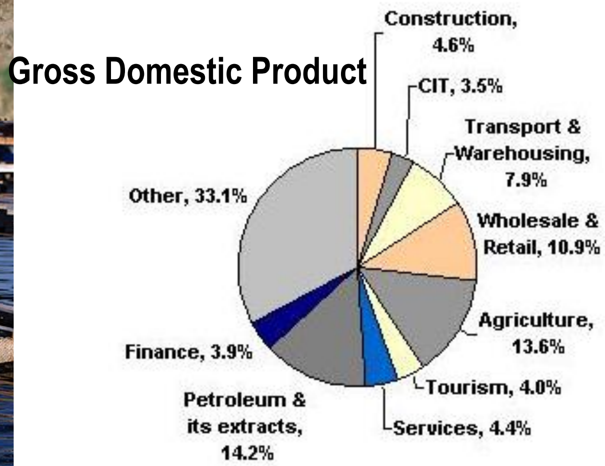
How vulnerable are our coastal economic sectors? … is about the country's economy

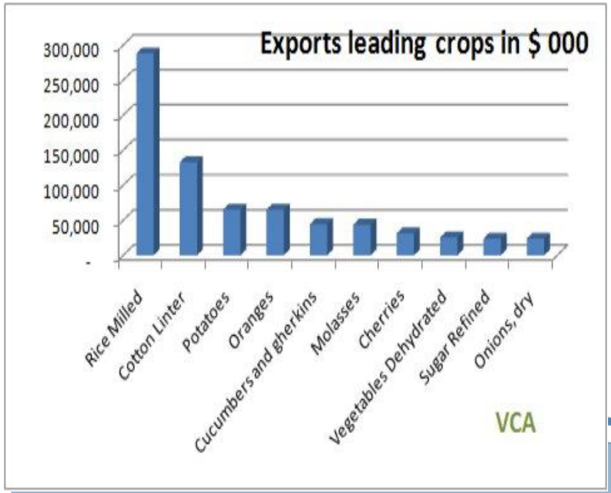
How vulnerable are our coastal infrastructures? …is about infrastructures' quality and resistance

How vulnerable are our coastal communities?

How vulnerable are our coastal livelihoods?

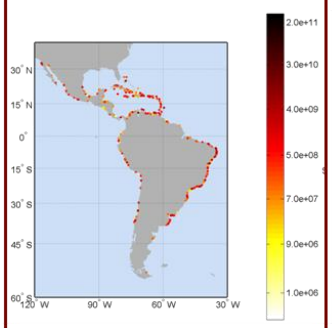
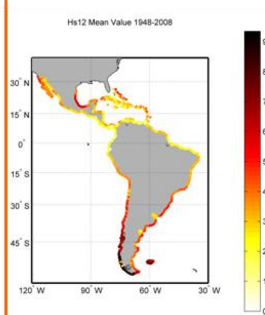
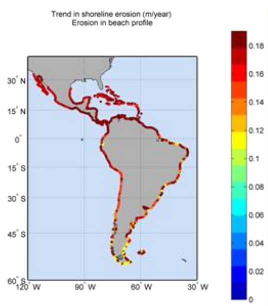
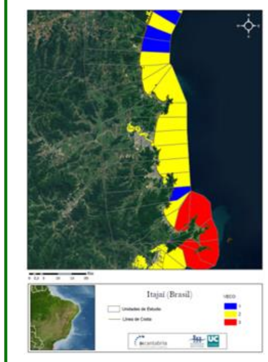
How vulnerable are our coastal economic sectors?





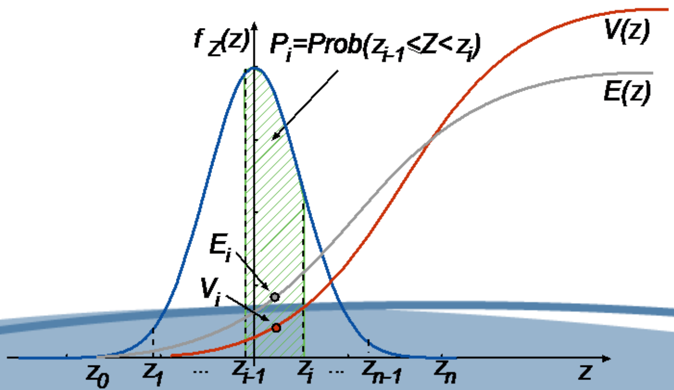
Climate Change

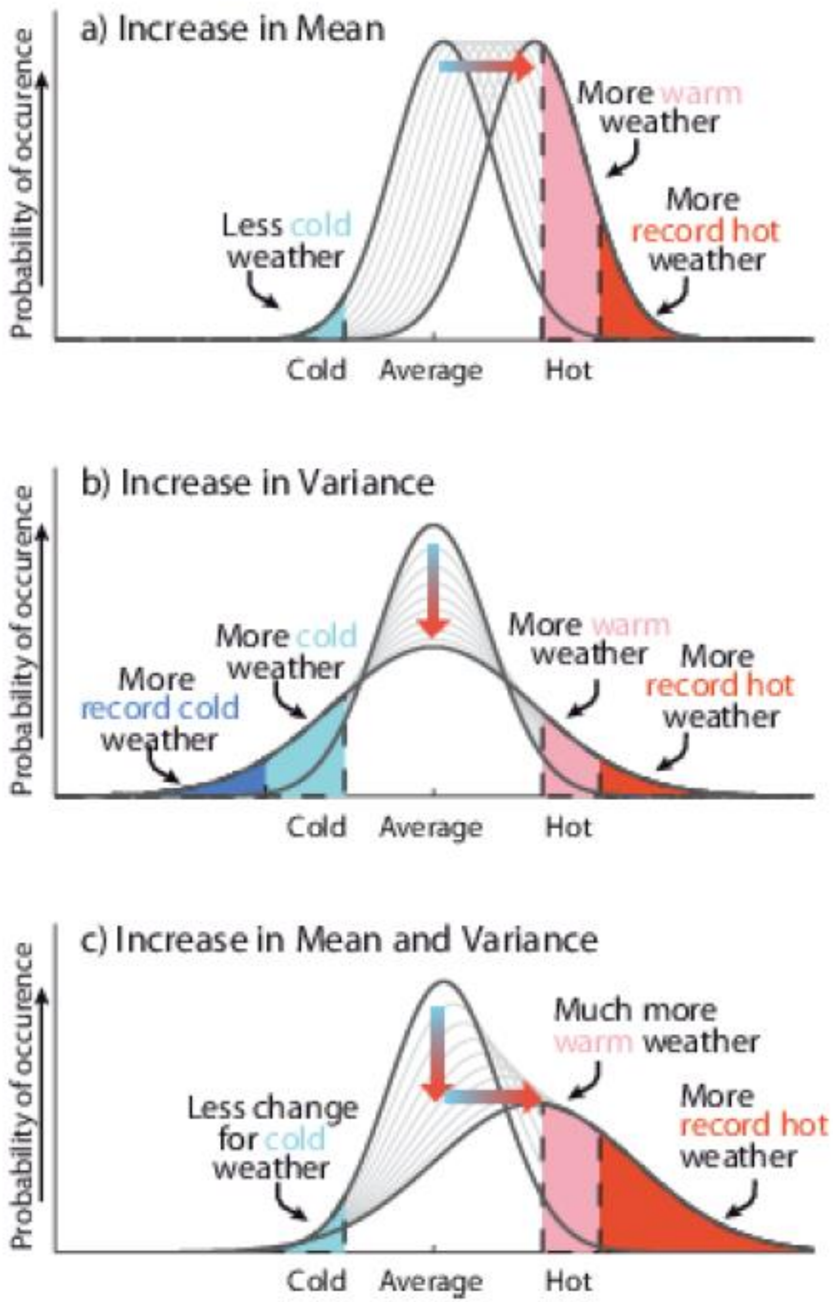
Risk Assesment Methodology

Risk	=	Hazard: Dynamics / Impacts	x	Exposure	x	Vulnerability
		 				
Scenarios		**Probability and uncertainty** **Trends**		**Coastal characteristics**		**Coastal system functions**

Beaches, ports reefs, urbanized coast, etc.

$$\underbrace{R = \int_{-\infty}^{\infty} f_Z(z)E(z)V(z)dz,}_{\text{Expected damage}}$$





a) Increase in Mean
Probability of occurence
Less cold weather
More warm weather
More record hot weather
Cold
Average
Hot
b) Increase in Variance
Probability of occurence
More record cold weather
More cold weather
More warm weather
More record hot weather
Cold
Average
Hot
c) Increase in Mean and Variance
Probability of occurence
Less change for cold weather
Much more warm weather
More record hot weather
Cold
Average
Hot

High exposure, low vulnerability

BENIDORM

For the same flooding level higher risk by increasing vulnerability and exposure

Very High exposure,
very high vulnerability

Marco general

Observations & numerical models

1. Climate drivers analysis

DTM
Indices/ geo data base
GIS

Semi-empirical fomulations
Numerical models

3. Vulnerability

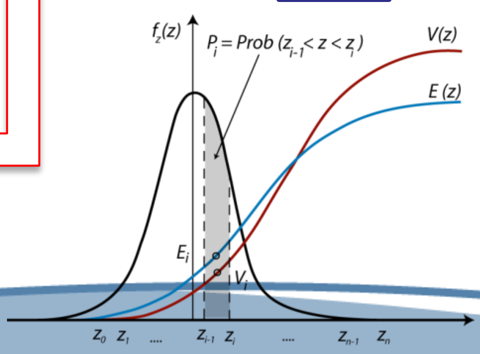
2. Impact assessment

Hazard
Exposure
Vulnerability

4. Risk assessment

5. Adaptation

Uncertainties



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Permanent vs. Extreme flooding

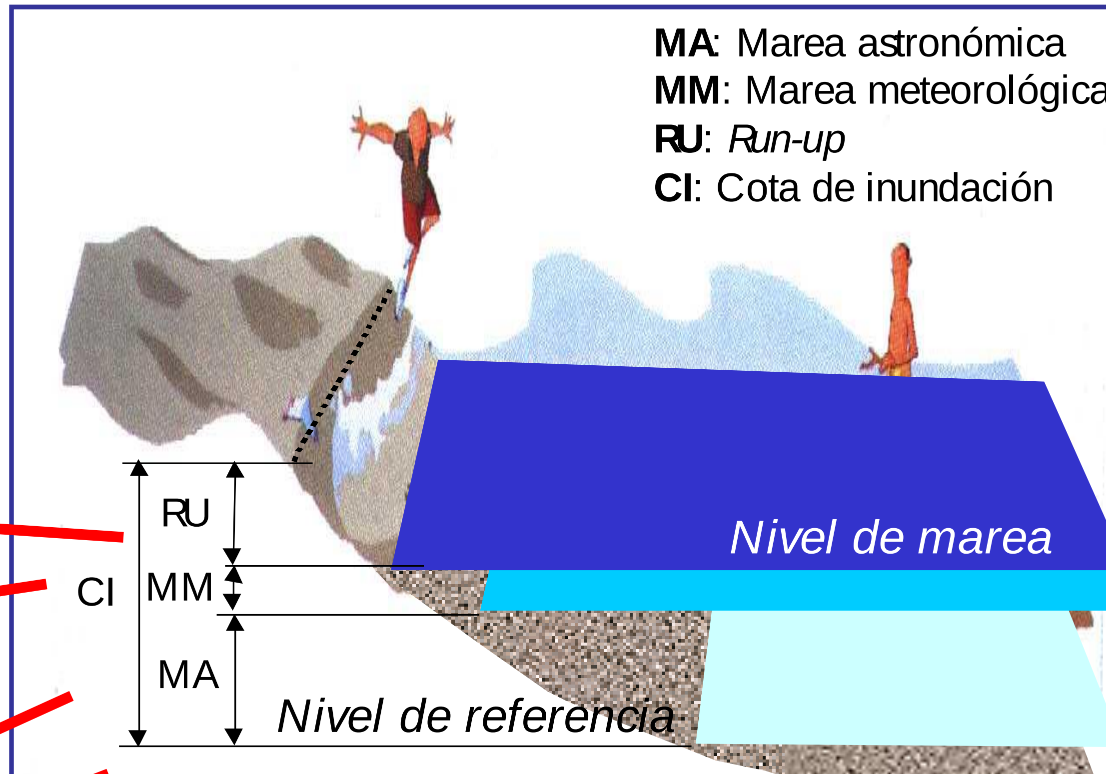
Flooding

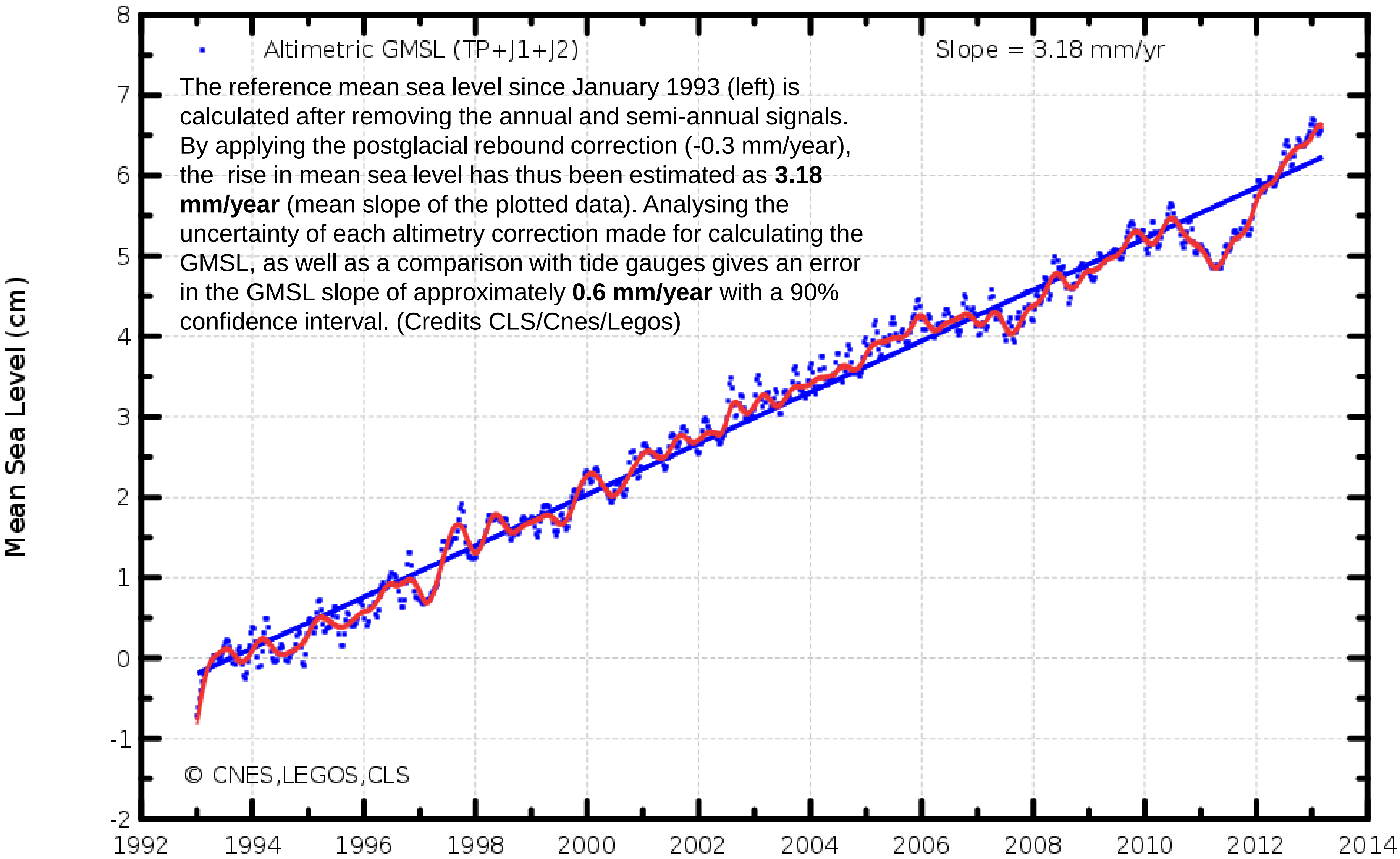
River discharge

River water level

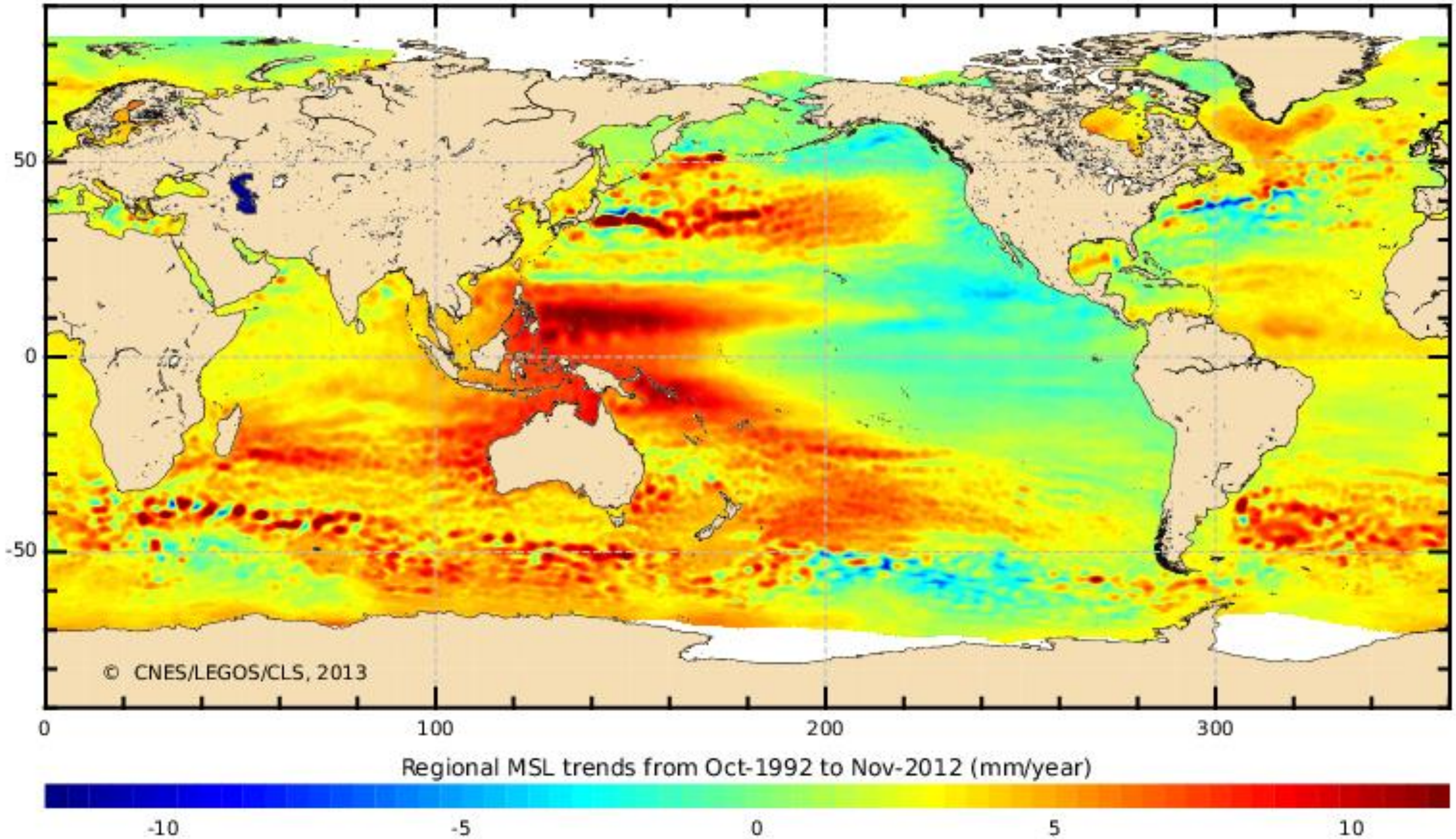
Total sea level

- Waves
- Wind
- Atm. Pressure
- Astronomical tide
- Mean sea level





Global Mean sea level



Regional sea level

IPCC (2007)

Table SPM-3. Projected globally averaged surface warming and sea level rise at the end of the 21st century. {10.5, 10.6, Table 10.7}

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a] Best estimate	*Likely* range	Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:

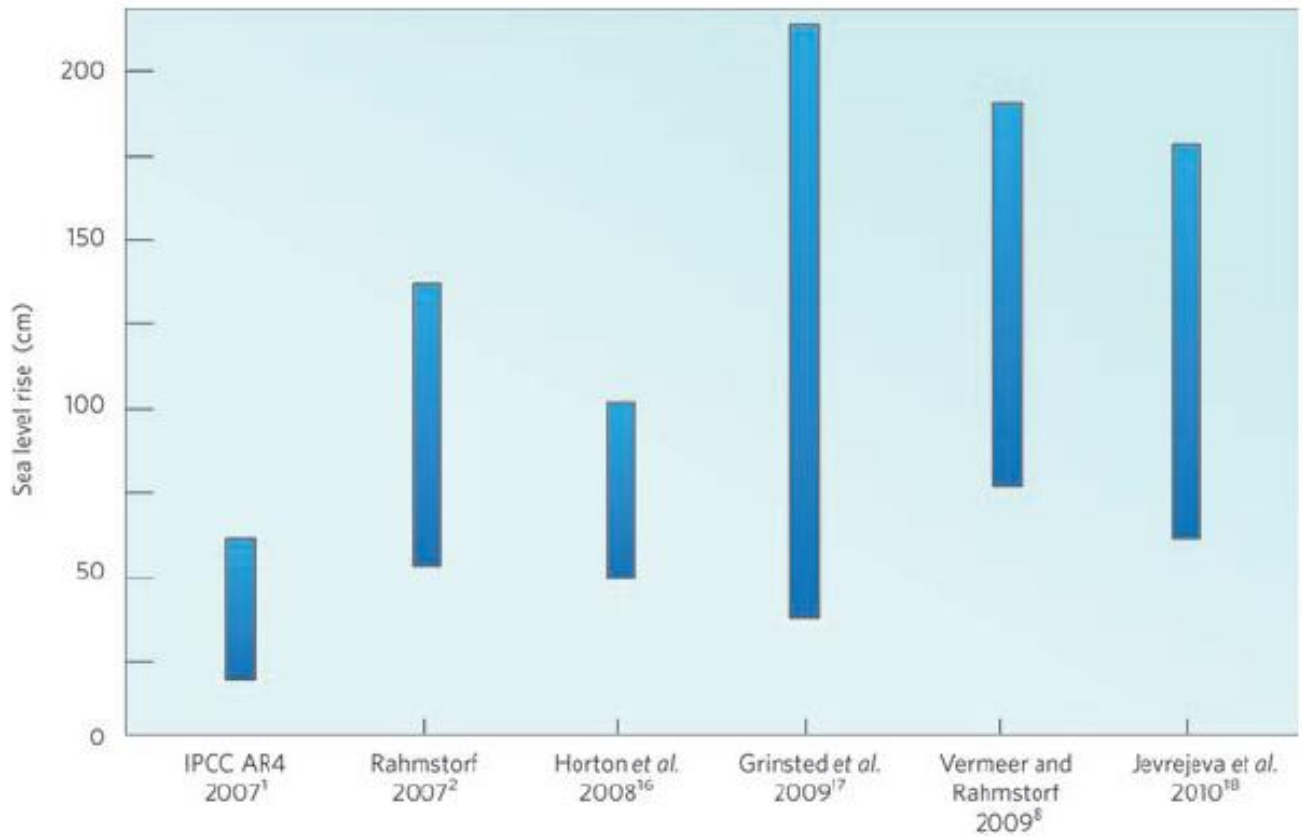
[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth Models of Intermediate Complexity (EMICs), and a large number of Atmosphere-Ocean Global Circulaion Models (AOGCMs).

[b] Year 2000 constant composition is derived from AOGCMs only.

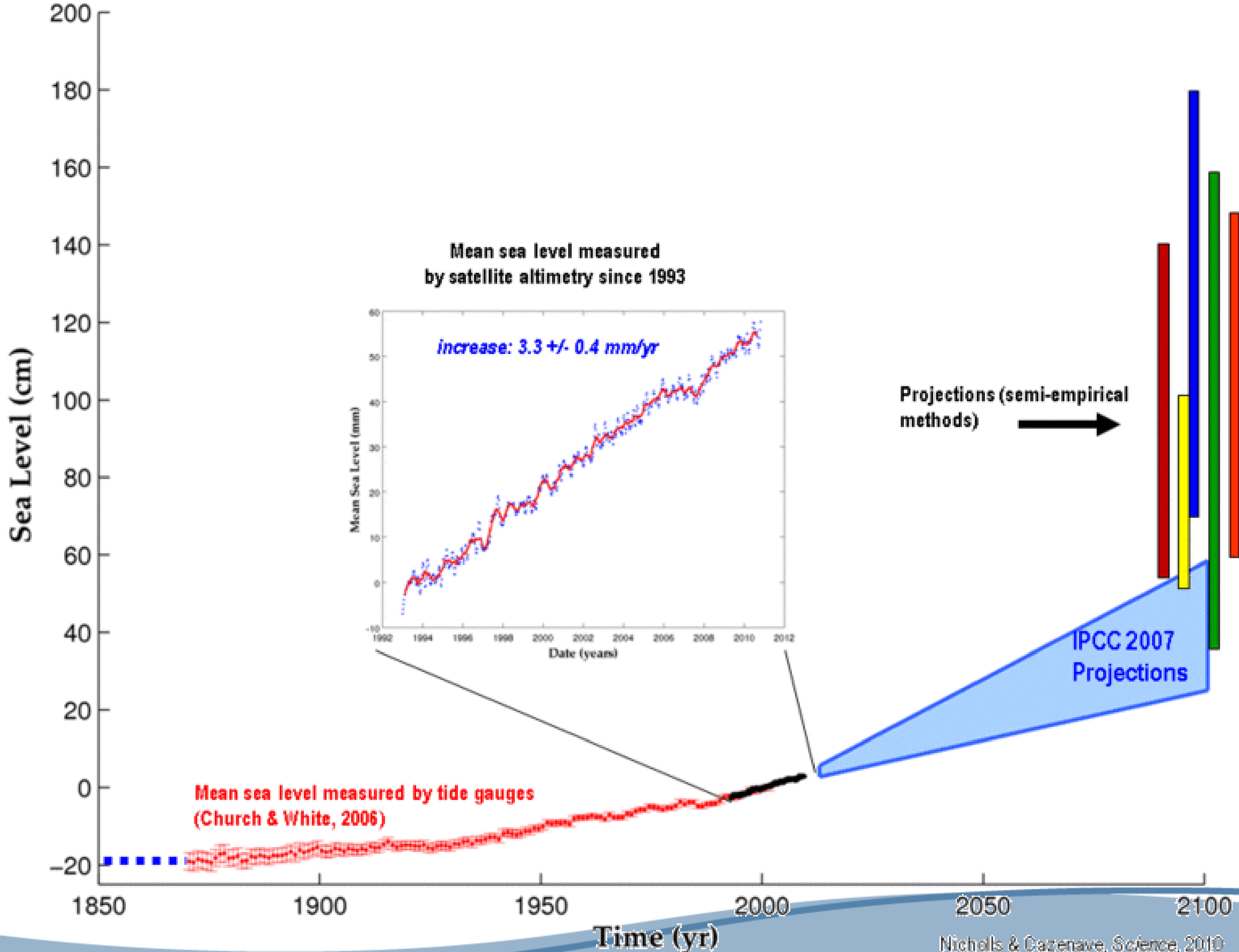
Escenarios RCP	Subida del nivel del mar (m)		
	5%	50%	95%
RCP3PD	0.36	0.57	0.83
RCP4.5	0.52	0.74	1.10
RCP6.0	0.6	0.84	1.26
RCP8.5	0.81	1.10	1.65

'abla 1. Proyecciones de nivel del mar al año 2100 para los escenarios RCP. Los resultados muestran el valor medio y los límites superior (intervalo de confianza del 95%) e inferior (intervalo de confianza del 5%). Fuente: Jevrejeva et al. (2012).

RCPs: Representative concentration pathways



Rahmstorf (2010). Science



Sea Level (cm)
Time (yr)
Mean sea level measured
by satellite altimetry since 1993
increase: 3.3 +/- 0.4 mm/yr
Mean Sea Level (mm)
Date (years)
Projections (semi-empirical
methods)
IPCC 2007
Projections
Mean sea level measured by tide gauges
(Church & White, 2006)
Nicholls & Cazenave, Science, 2010

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Observed changes

SLR

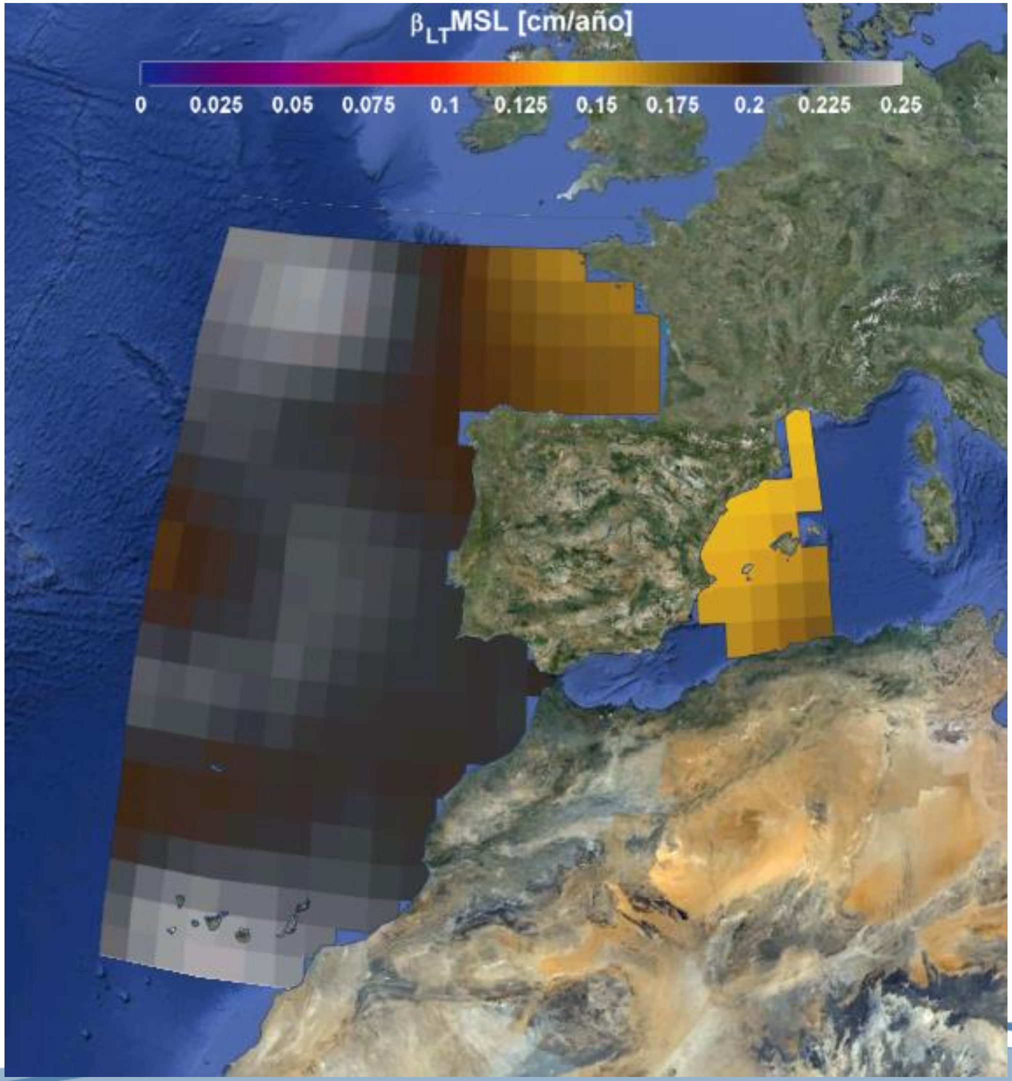
20th century:

Characteristic values

Mediterráneo: 1.5 mm/year

Cantábrico: 2 mm/year

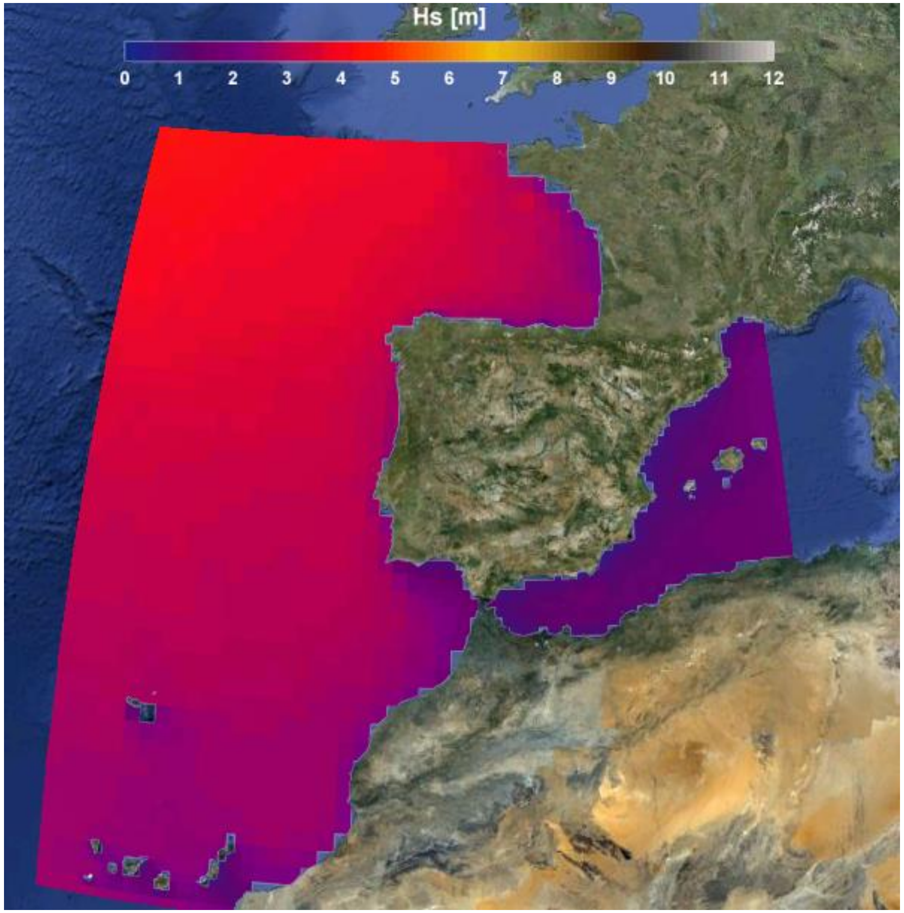
Canarias: 2.5 mm/year

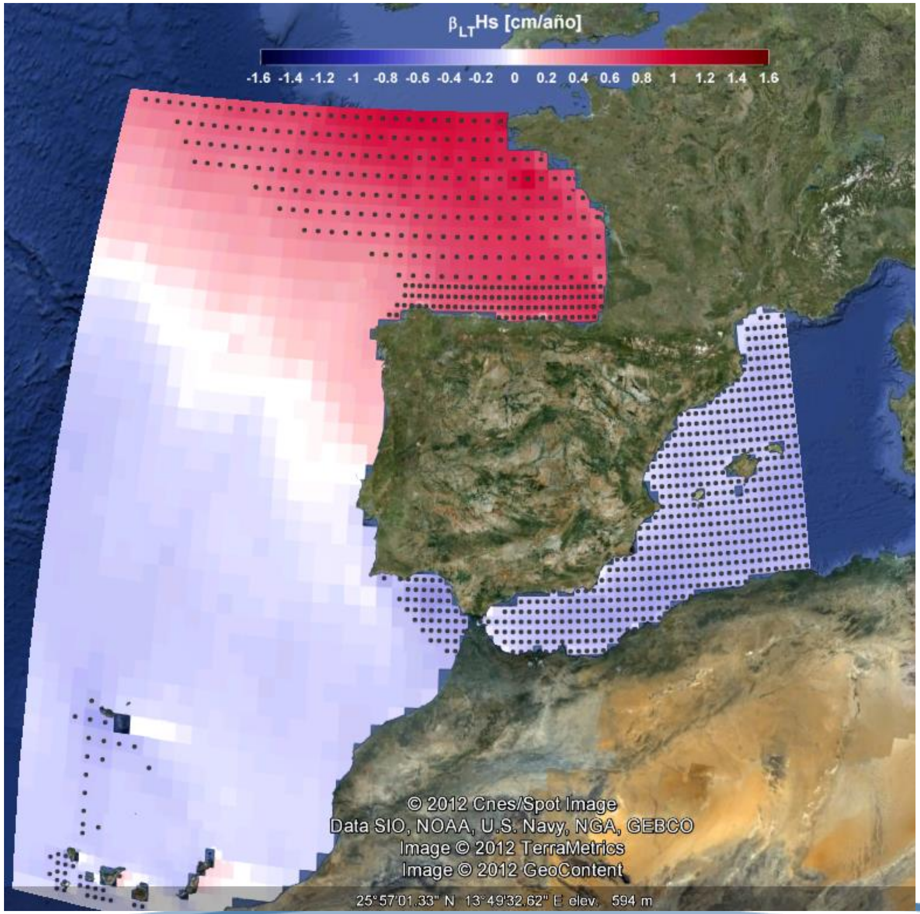


Observed changes

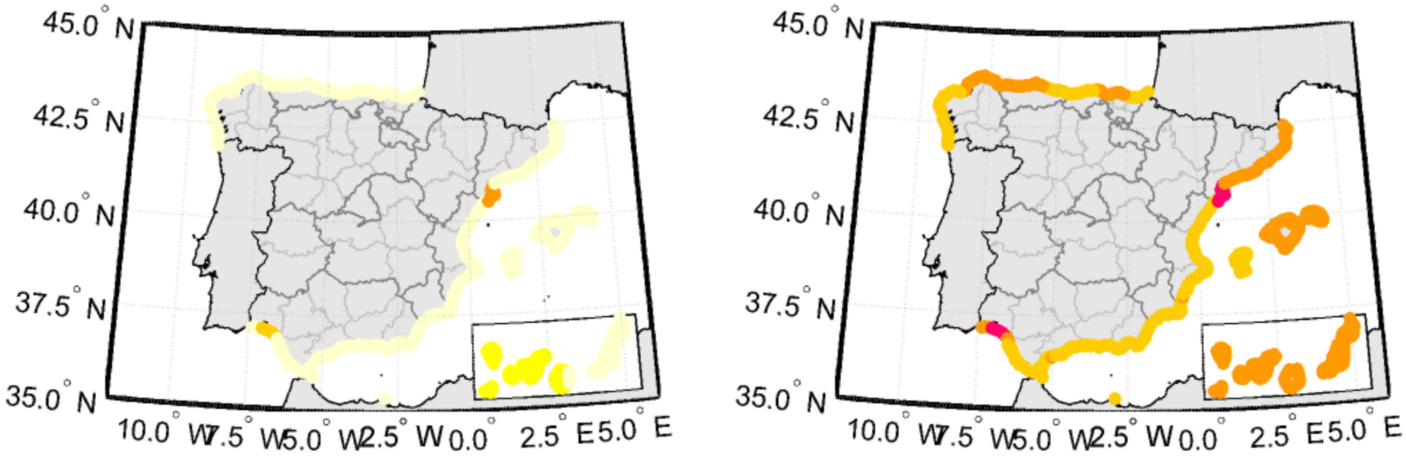
Waves: Deept water

Winter Significant Wave Height. Mean and trends (60 years)

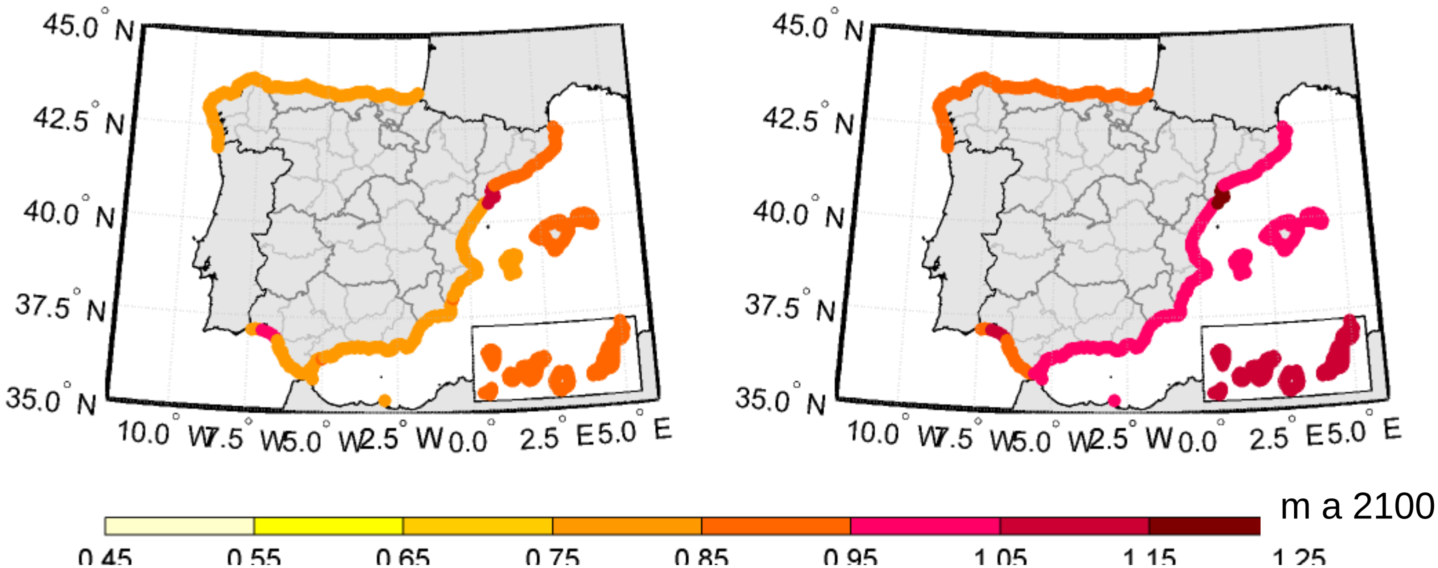




Tendencia media de invierno 1948-2008



Relative sea level projections

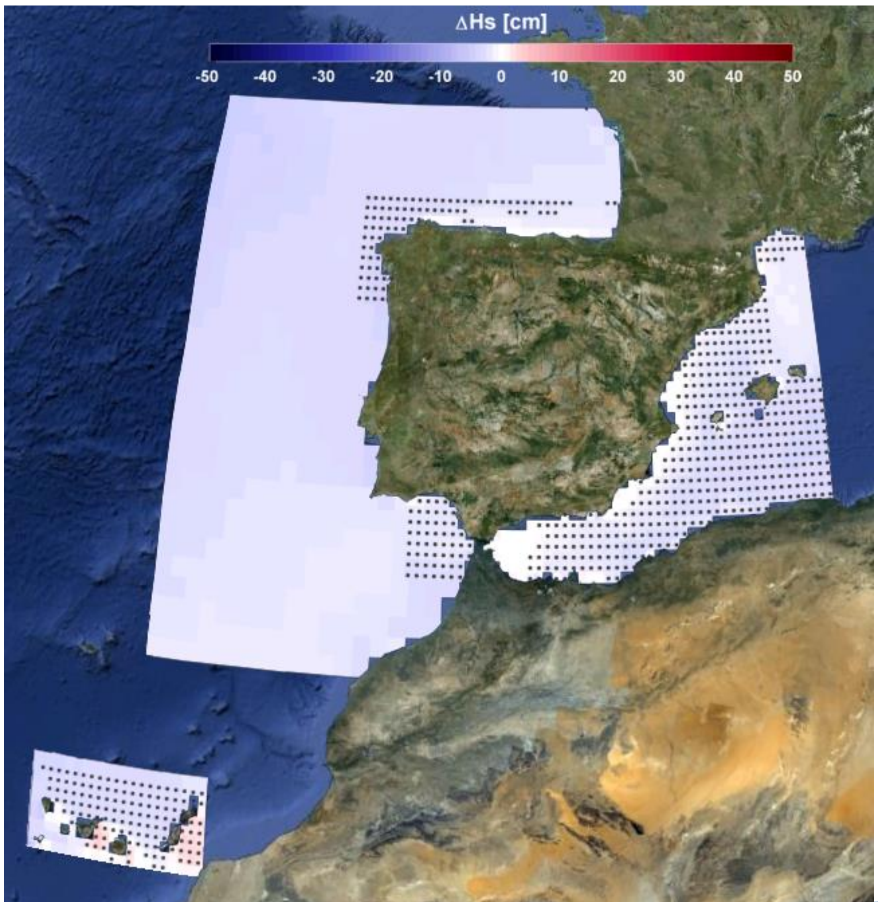


Proyecciones regionalizadas a 2100 de aumento de nivel del mar relativo para cuatro escenarios RCP3CD, RCP4.5, RCP6.0, RCP8.5 (Fuente: IHCantabria)

Projections

Waves

Annual and winter projections Hs 2040-2069 , scenario A1B



Período: 2040-2069

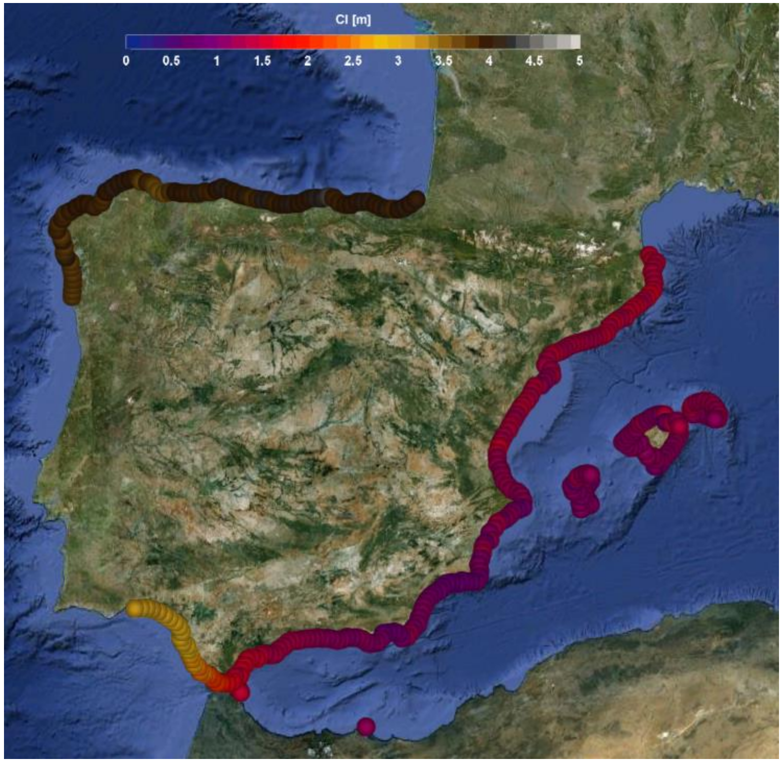
Escenario: A1B

Impacts and projected consequences

Socioeconomic system

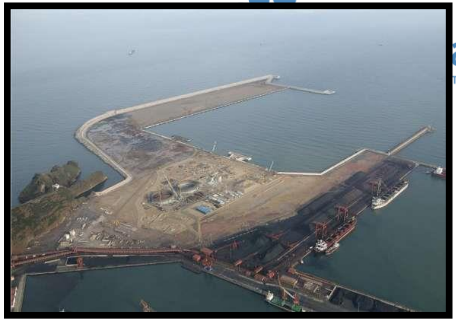
Flooding level

Flooding level (50 year return period) & absolute projected value in 2040



Año 2040

Mininum level based on historical trends



SISTEMA SOCIOECONÓMICO

Port and coastal infrastructures

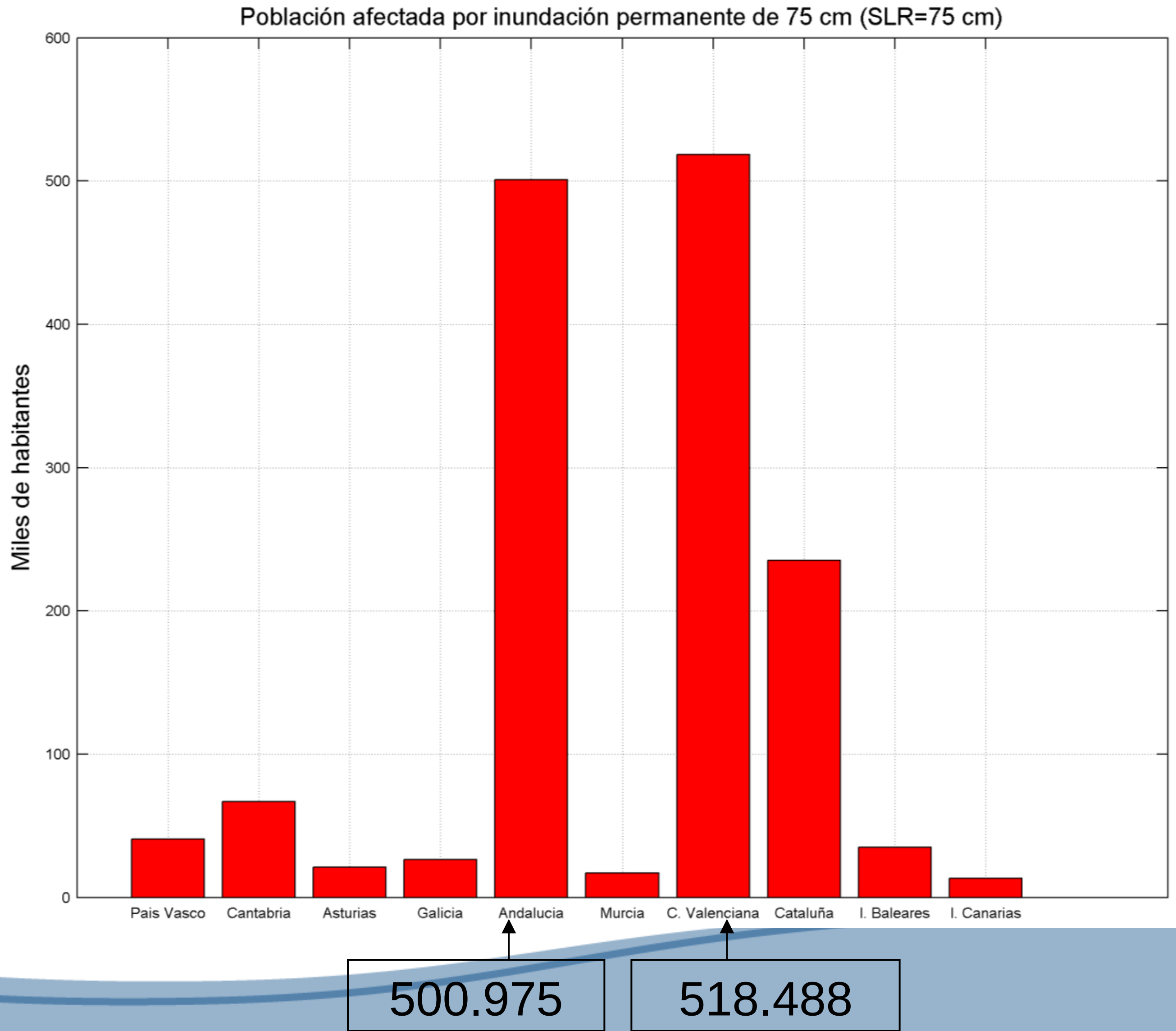
Relative change (%) in entrance operations (H_s>3 m) in 2040

Año 2040

COTA INFERIOR A PARTIR DE LAS TENDENCIAS HISTÓRICAS

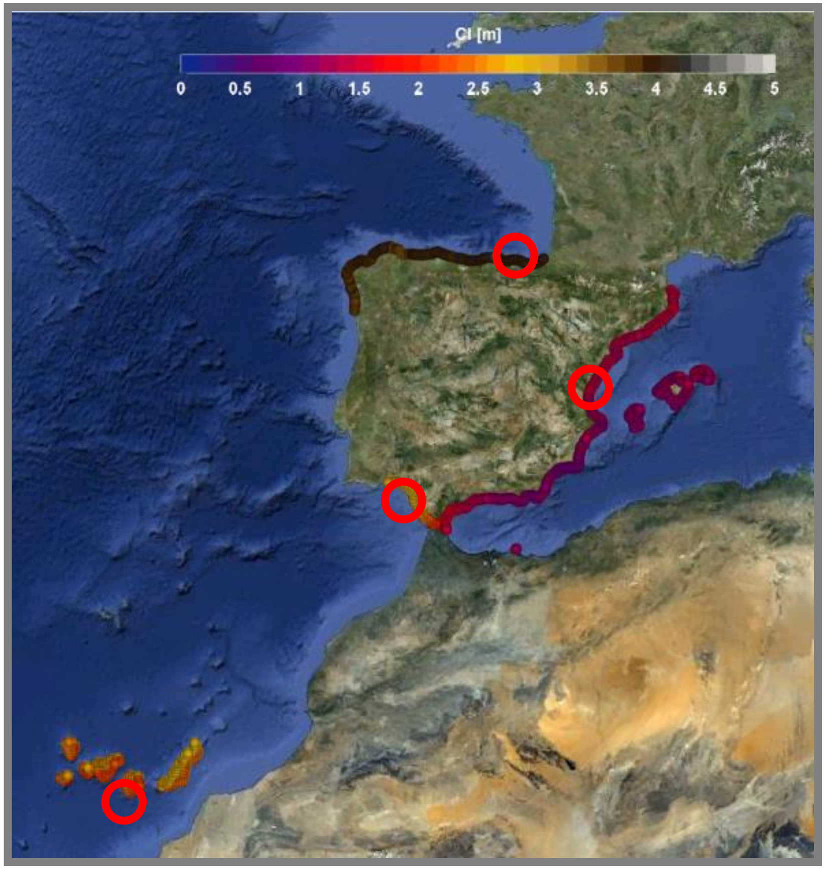
POBLACIÓN (miles de habitantes)

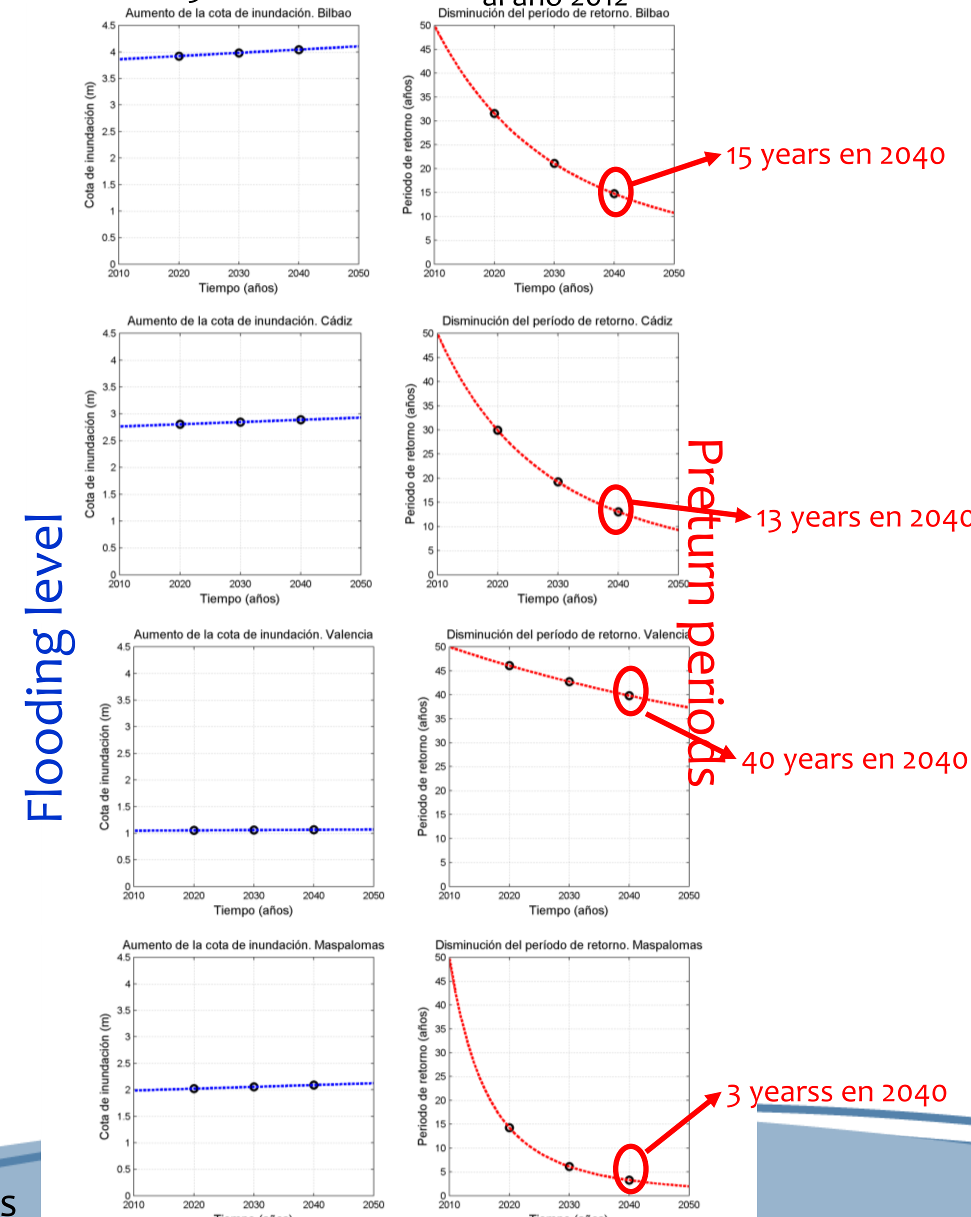
SLR=75 cm



R=50 años

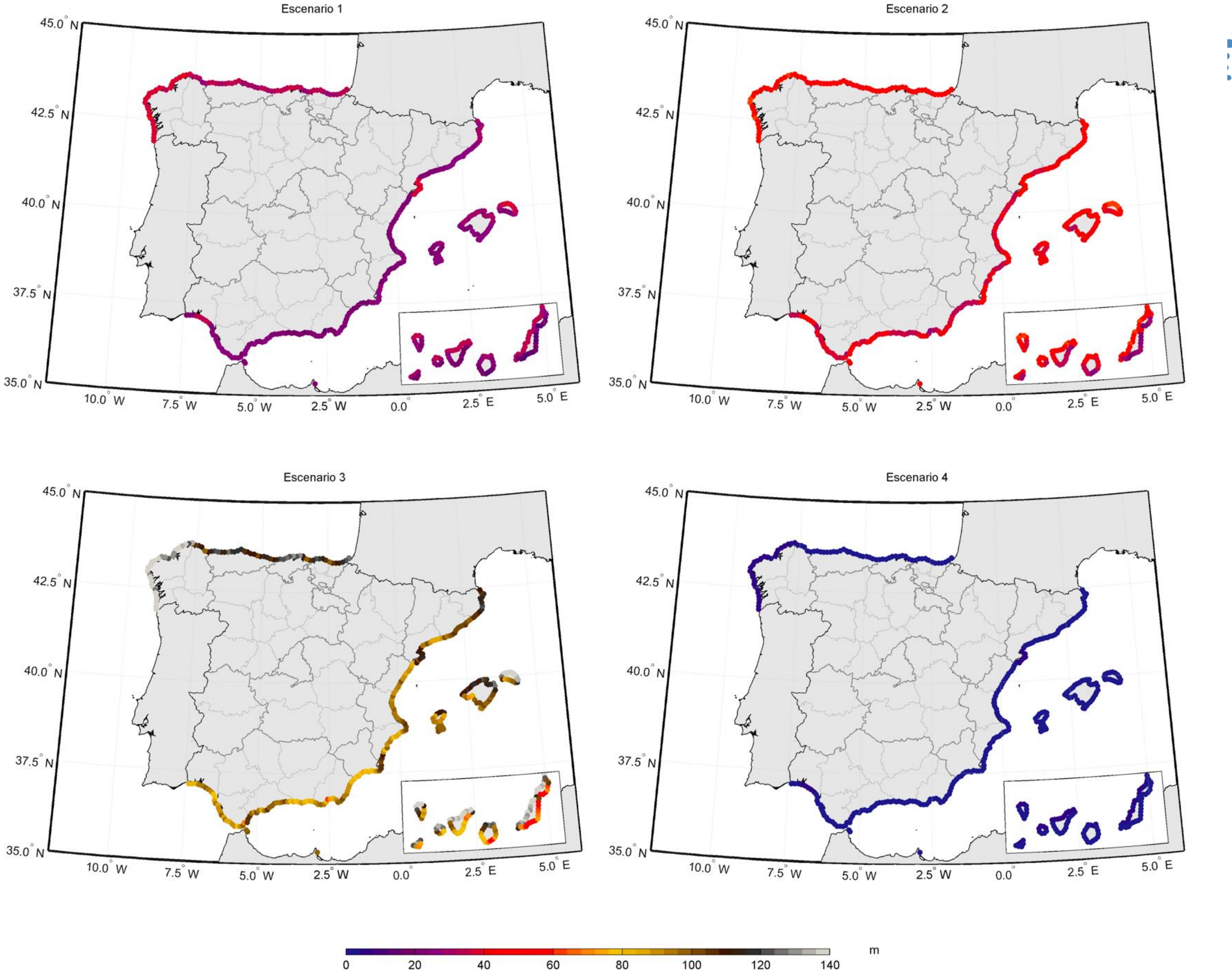
CI correspondiente al año 2012





Extreme flooding events

Based on historical trends



Escenario	1	2	3	4
Año horizonte	2100	2100	2100	2040
V. Climáticas	SNM*=50 cm	SNM=85 cm	SNM=200 cm	SNM=extrapolación tendencia

Figura 1.Proyecciones de la erosión debida a la subida del nivel del mar para los cuatro escenarios de cambio climático. Fuente: IH Cantabria.


Distance: 48,2 km
FOV: 45°
Terrain Elevation: 0,00 meters
Delta del Ebro

GOAL: Assessment of socioeconomic consequences due to climate change impacts in Deltebre for different scenarios

CLIMATE CHANGE SCENARIOS

Climate scenarios. Year 2100

Scenario 1: SLR=50 cm (RCP 3PD)

Scenario 2: SLR=85 cm (RCP 6.0)

Scenario 3: SLR=2 m (High ++)

Scenario 4: observed trends extrapolation (climate + socioeconmic) (2040)

RSLR considering (2.5 mm/year) subsidence in the Ebro Delta

Climate scenario + socioeconomic scenario. Year 2040

SLR=+4.113 cm

Población=+1%

Stock Capital:
- Urban=+2%
- Agriculture=+1%
- Industry/Energy=+1.5%
- Infraestructures=+2%

GAVpc=+2.5%

RFBDpc=+2%

Impact considered

Permanent flooding due to RSLR

Flooding under extreme events

CI_{50}+RSLR

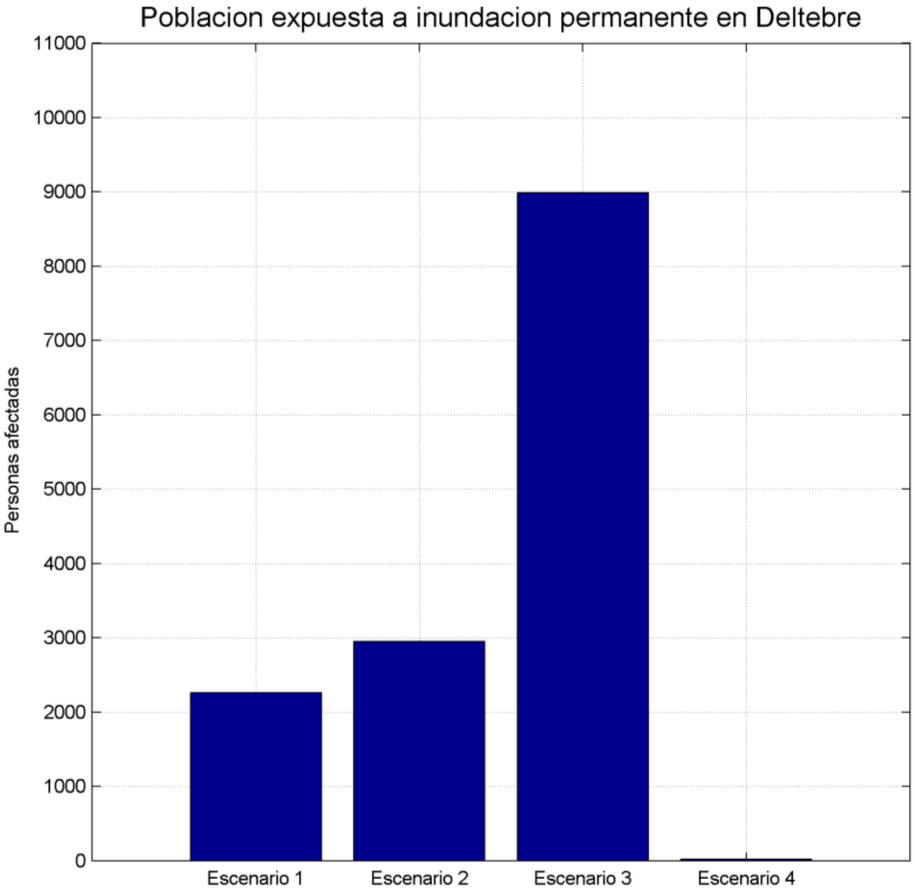
Consequences on population

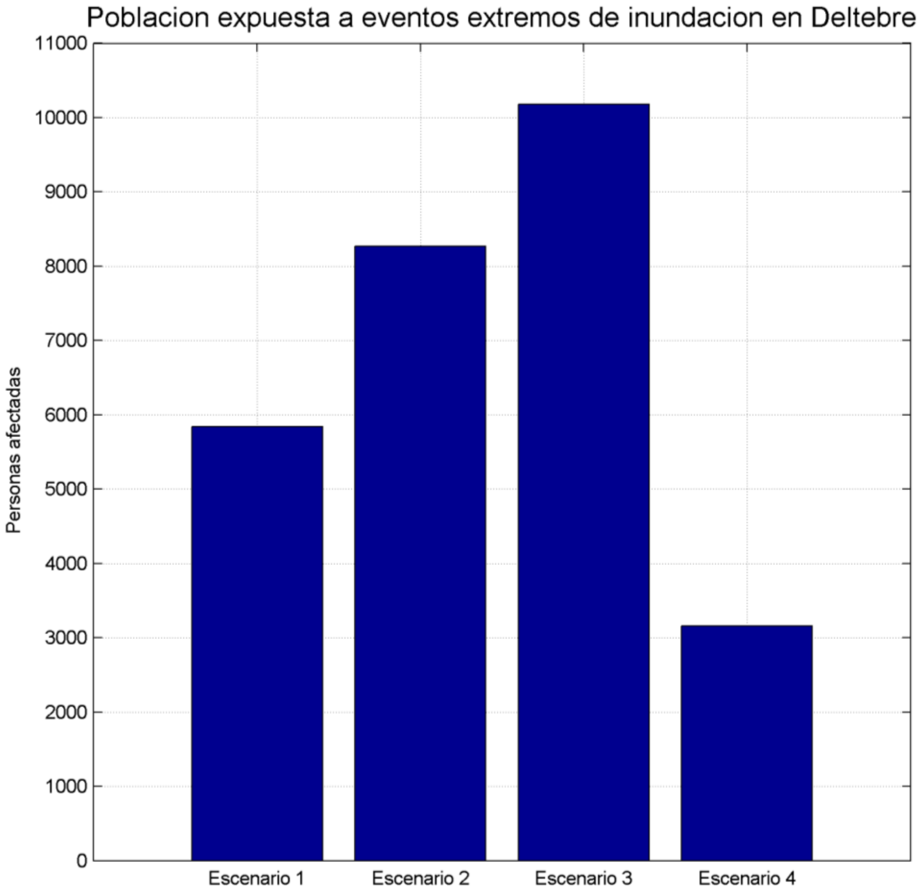
Consequences

Social:

Population affected by permanent inundation or flooding due to extremes

CONSEQUENCES ON POPULATION

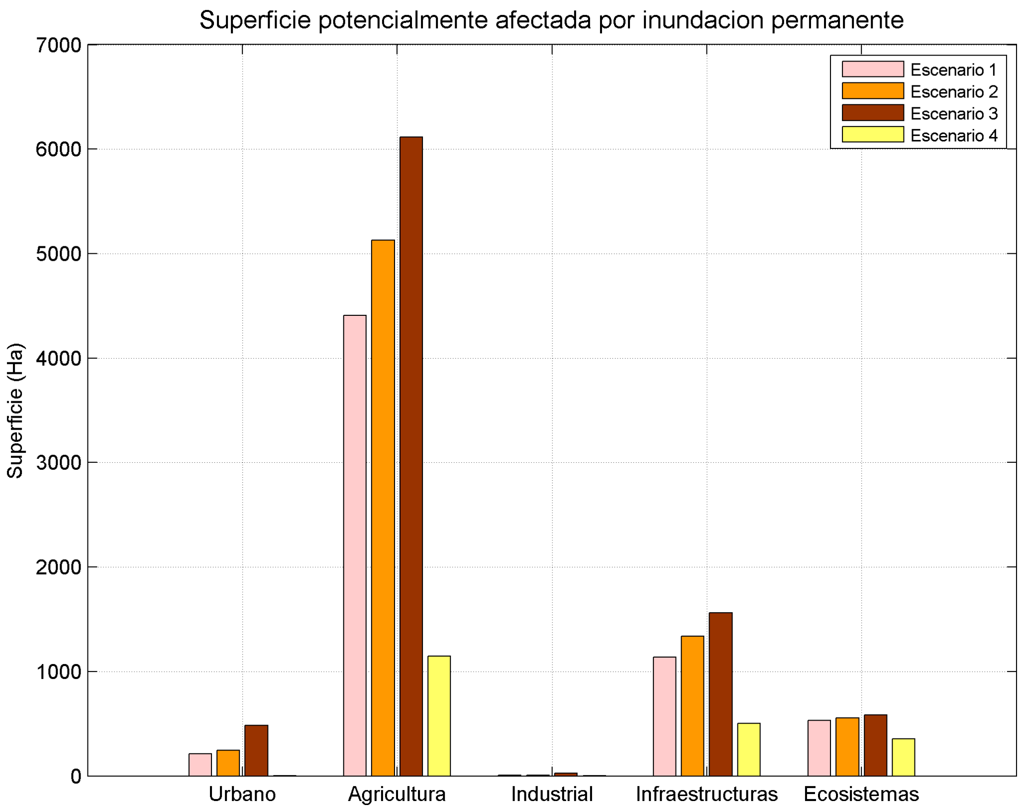




OJO: El escenario 4 incluye cambios en las dinámicas y cambios socioeconómicos al año 2040

CONSEQUENCES

PERMANENT INUNDATION



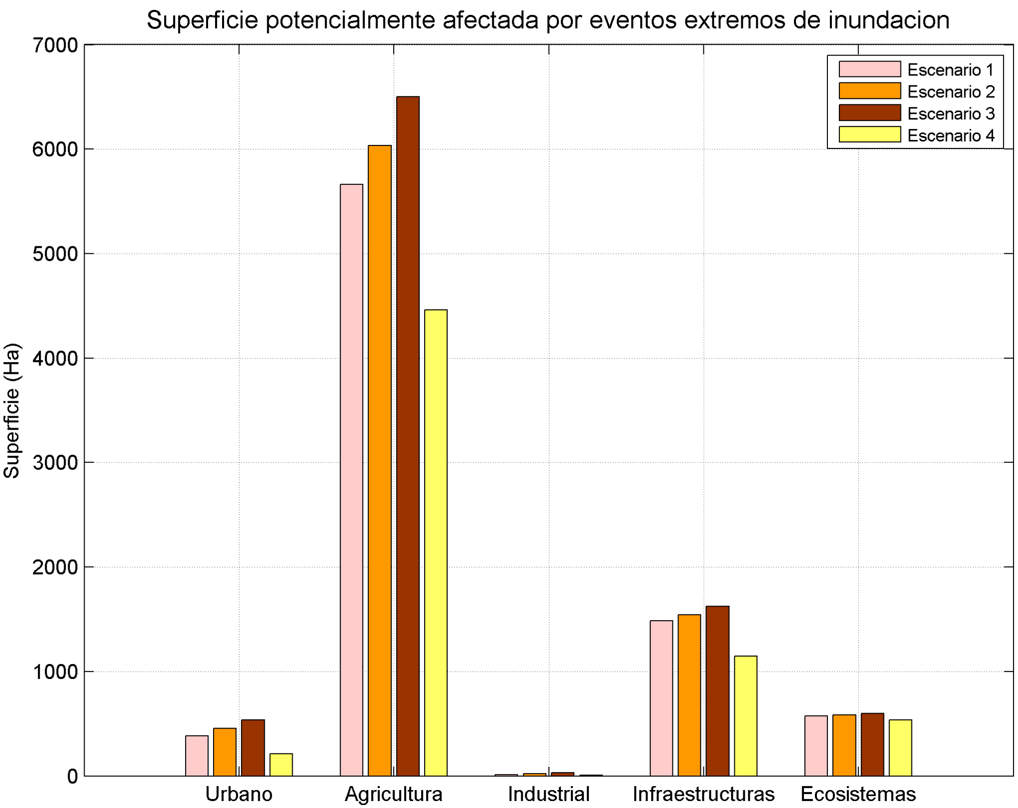
Urbano

Agricultura

Infraestructuras

Escenario 3

CONSEQUENCES UNDER EXTREME FLOODING



Urbano

Agricultura

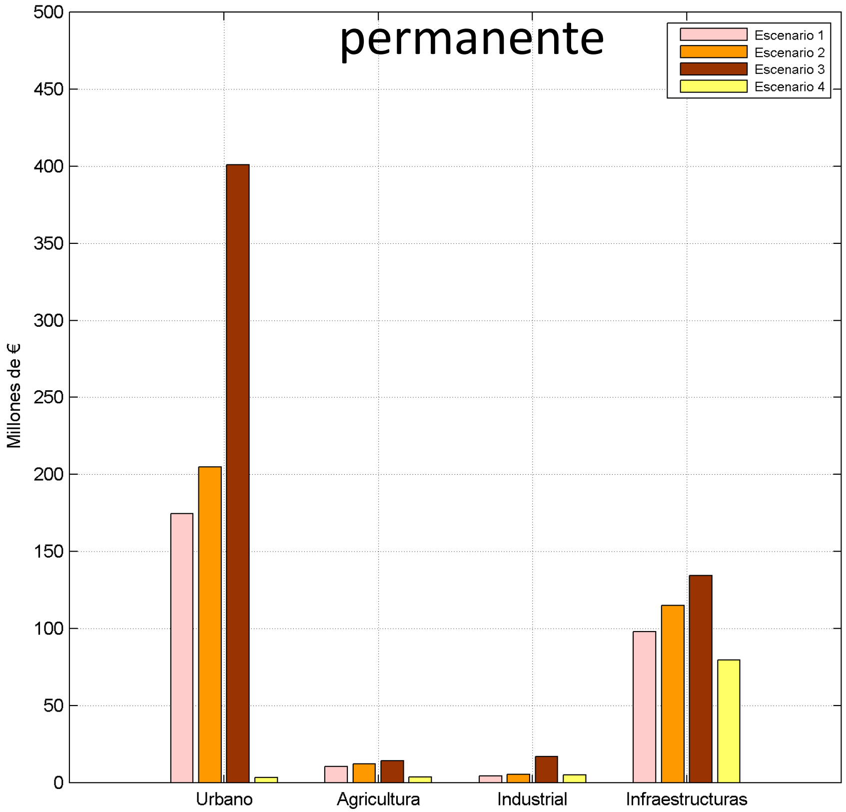
Infraestructuras

Escenario 3

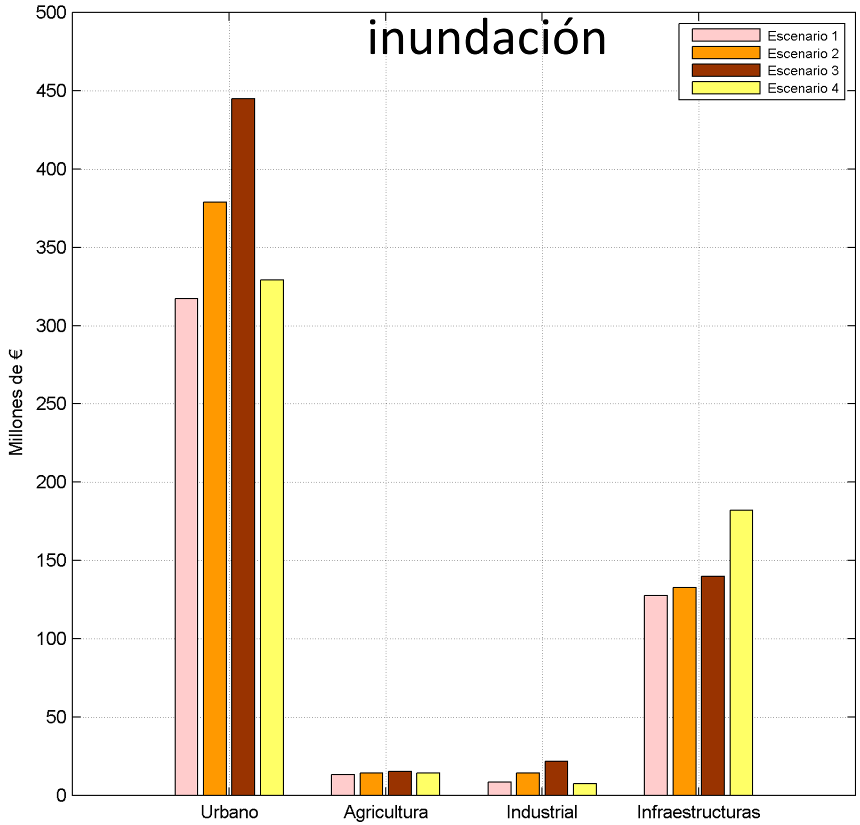
CONSECUENCIAS ECONÓMICAS

VALOR DEL STOCK DE CAPITAL PERDIDO

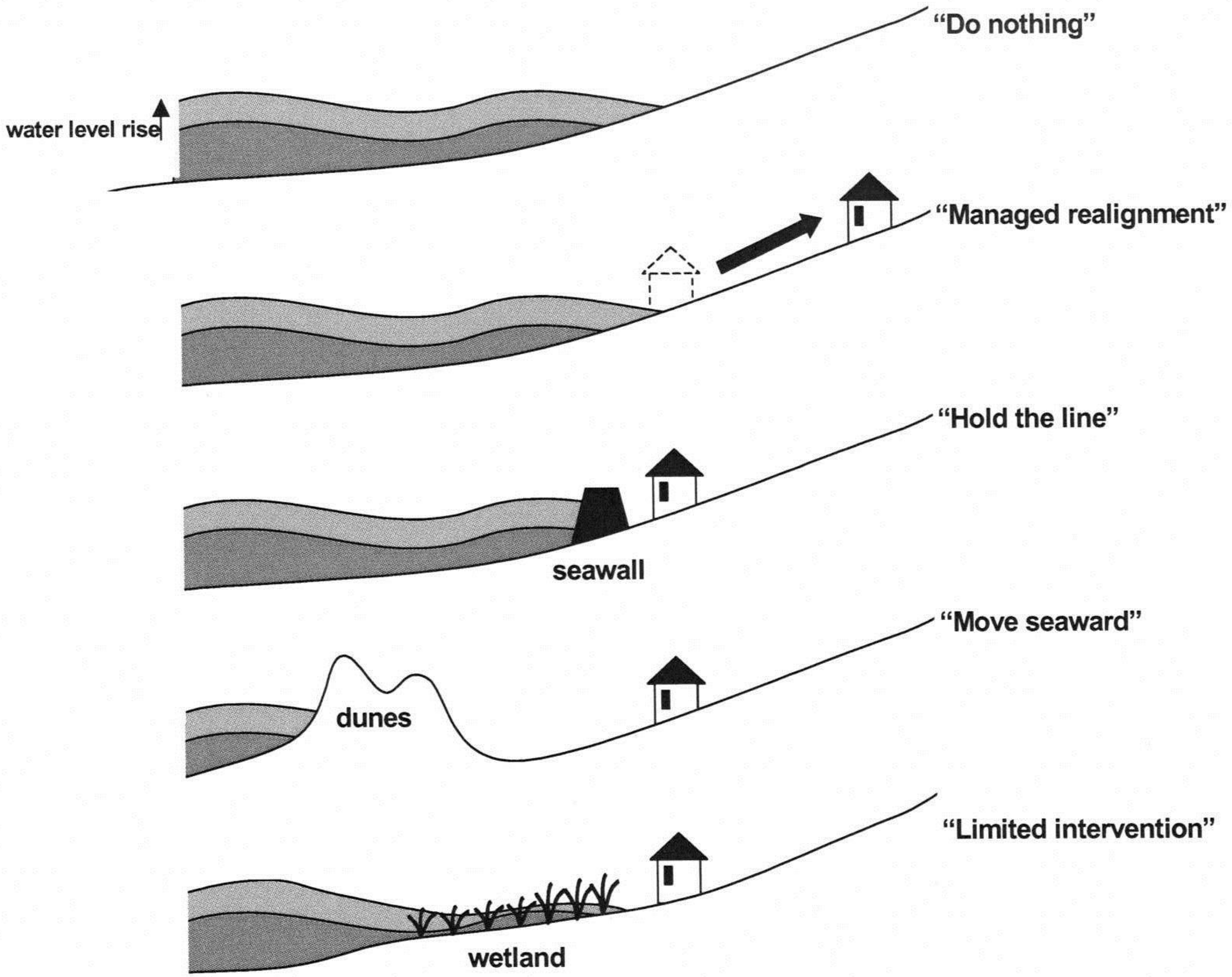
Inundación permanente



Eventos extremos de inundación



OJO: El escenario 4 incluye cambios en las dinámicas y cambios socioeconómicos al año 2040



"Do nothing"
water level rise
"Managed realignment"
"Hold the line"
seawall
"Move seaward"
dunes
"Limited intervention"
wetland

1. Coastal system

2. Natural subsystem

3. Socioeconomic subsystem

1. Drivers of change

5. Impacts

5. Climate change in terms of risk

5. What we know

5. Conclusions

Take home messages

1. Coastal areas are complex system where natural and socioeconomic subsystems coexist and interact

2. Most of the impacts observed so far can be attributed to human action

3. Climate is changing. Observations with high certainty show that climate change is and will be impacting on coastal ares. RSLR is our major problem

4. High uncertainties exist, especially when assessing impacts locally

5. Considering climate change is a must in coastal areas planning

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Take home messages

6. The lack of international agreement on mitigation strategies seems to make us think that adaptation will be a fundamental part of fighting climate change. This is especially relevant in coastal areas.

7. Limitations in climate and socioeconomic projections require taking decisions in an uncertain environment. However, we are doing better and better

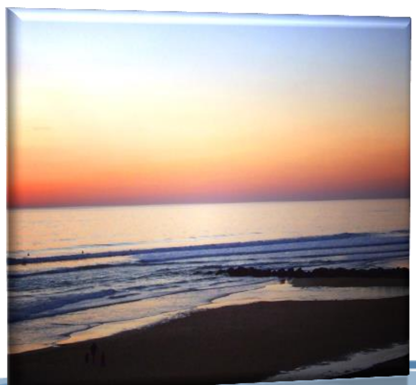
8. Flexible adaptation options and monitoring is the best option. Most of the adaptation options in coastal areas are non regret options.

Climate change and coastal areas

Addressing climate change challenges from a multidisciplinary **perspective**

Basque Center for Climate Change
Summer School 2013






July 2013