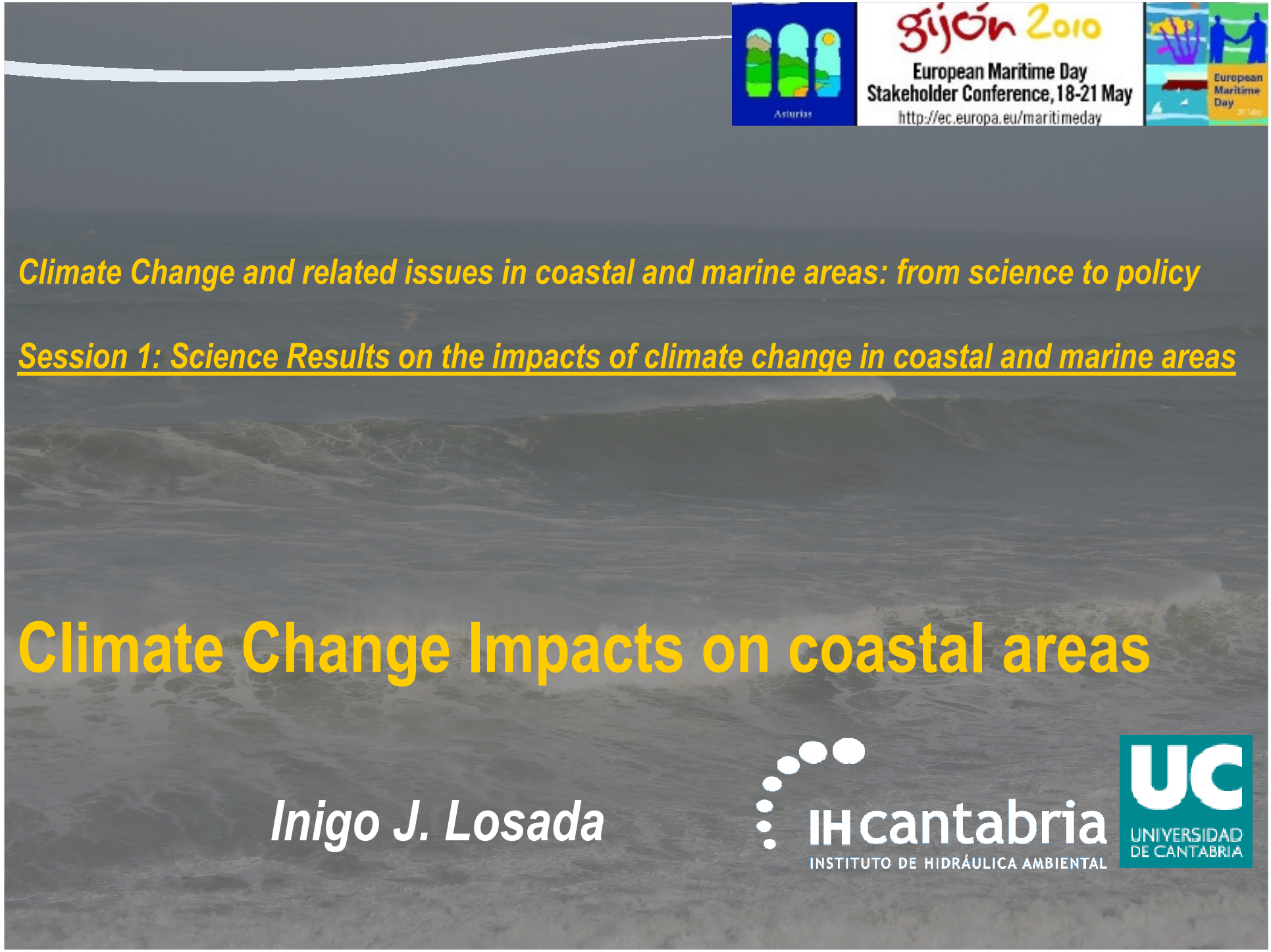

Climate Change and related issues in coastal and marine areas: from science to policy

Session 1: Science Results on the impacts of climate change in coastal and marine areas

Climate Change Impacts on coastal areas

Inigo J. Losada

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UC
UNIVERSIDAD DE CANTABRIA

C3A
Coastal Climate Change Impacts in Latin-America and Caribbean

NACIONES UNIDAS
CEPAL

C3E
Coastal Climate change impacts in Spain

GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
oecc

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1. Motivation and Objectives
2. Time and spatial scales
3. Global framework
4. Risk
5. Hazard
6. Vulnerability
7. Integration of Risk

Source: IPCC

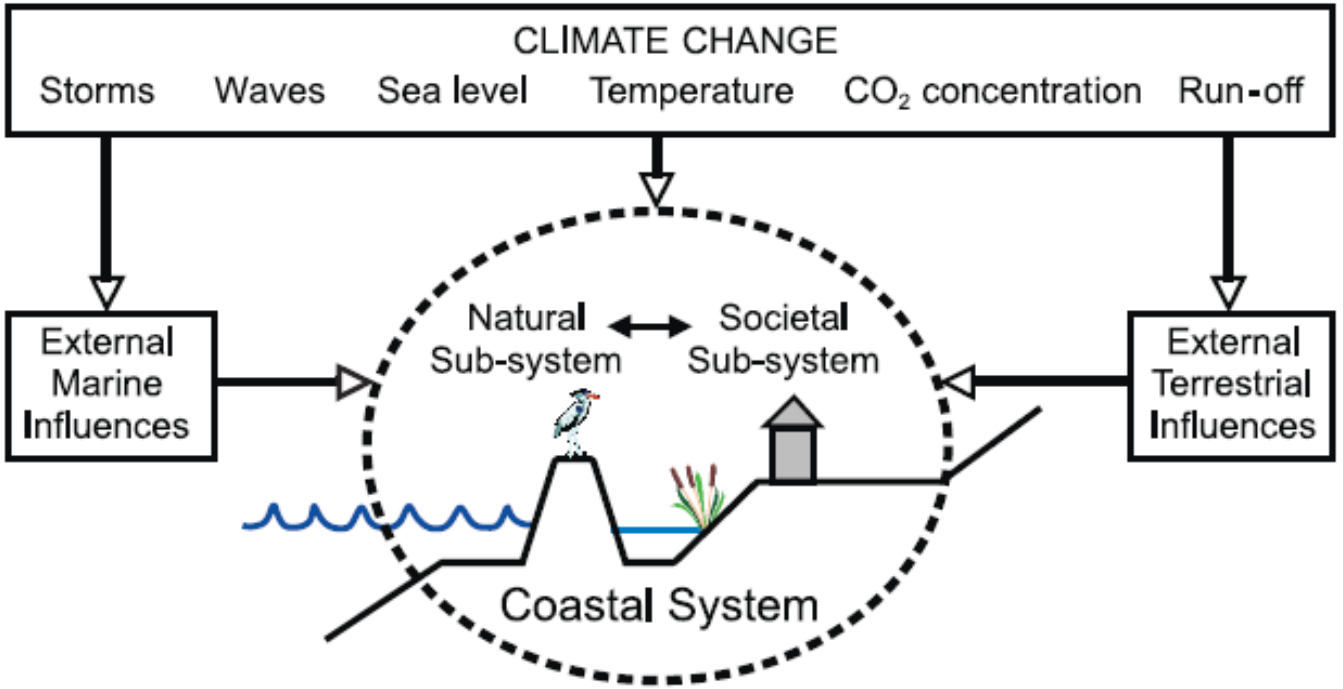


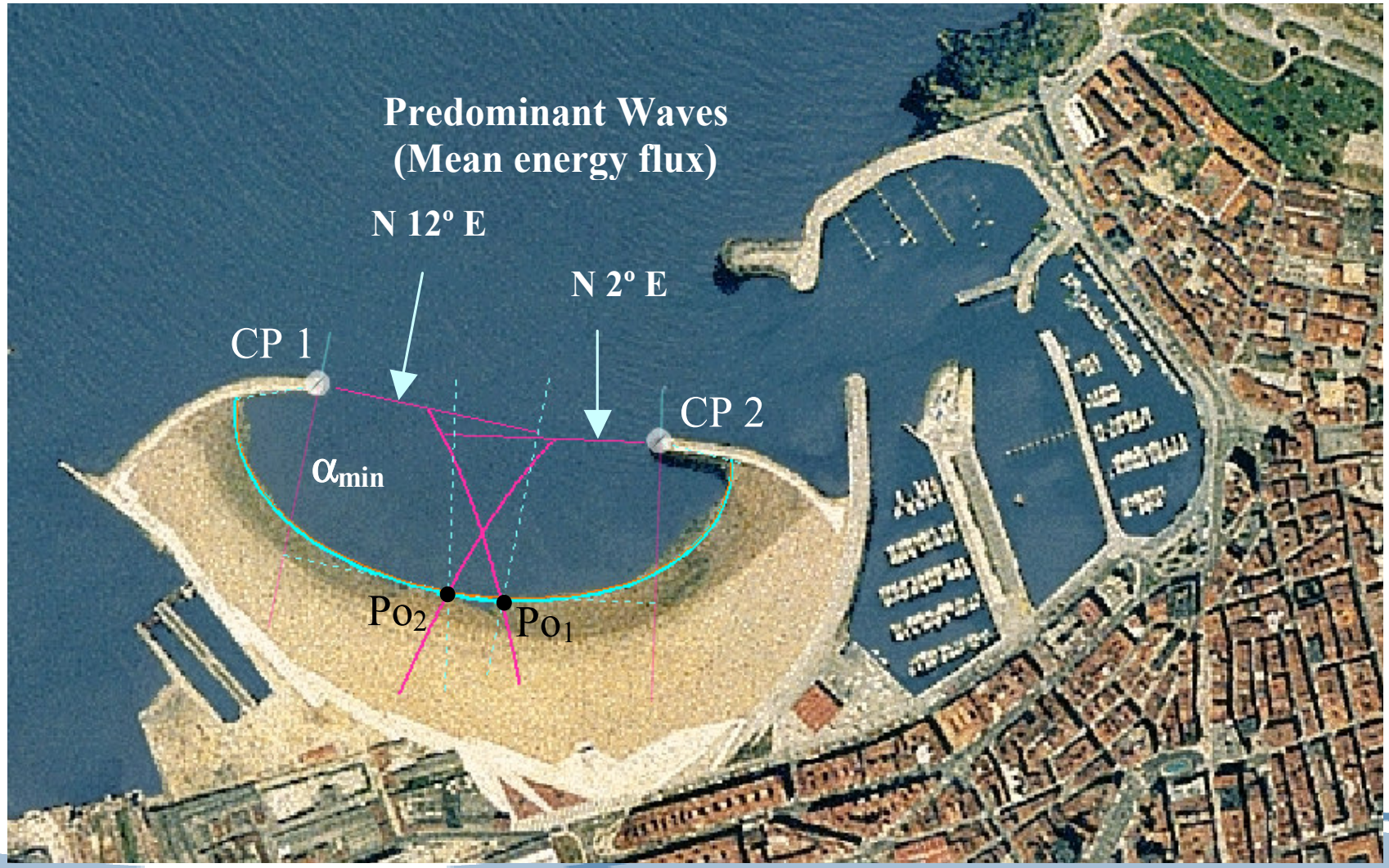
Figure 6.1. *Climate change and the coastal system showing the major climate change factors, including external marine and terrestrial influences.*

1. Motivation and Objectives

Maximum flooding level for a given sea state

1. Motivation and Objectives

Beach planform depends on the mean energy flux



1. Motivation and Objectives

Port operability

1. Motivation and Objectives

Size of the blocks

1. Motivation and Objectives

- Mean sea level is changing
- is the long-term wave climate changing ?
- is the extreme value wave climate changing ?
- is marine climate changing and how?
- what are the expected impacts on the coast (physical/socioeconomic system)?
- how can we evaluate the vulnerability?
- Can we evaluate climate change-induced risks? How?
- How do we manage risk reducing uncertainties?
- Do we have the tools to assess, implement and monitorize adaptation strategies?

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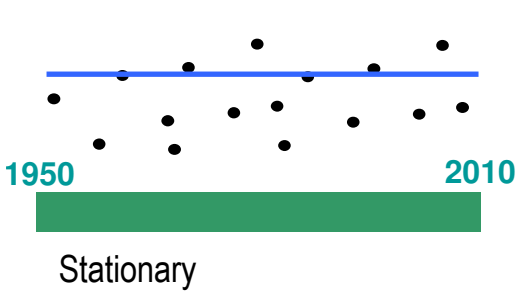
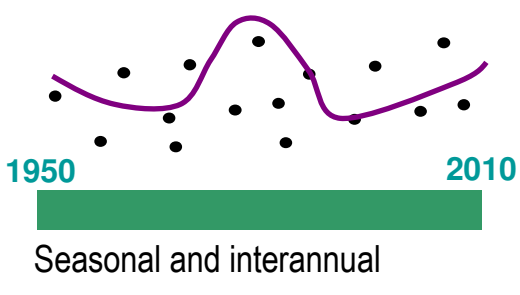
Time scales of interest

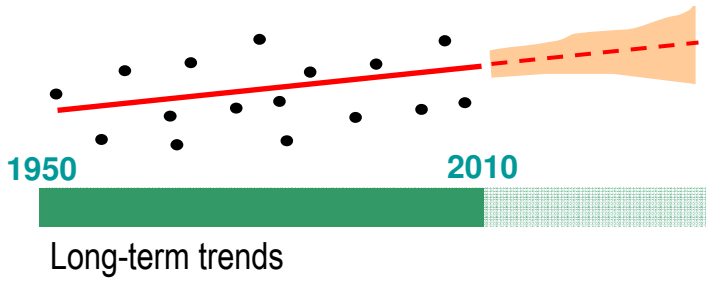
- Long-term trends and climate variability based on historical data bases



Stationary

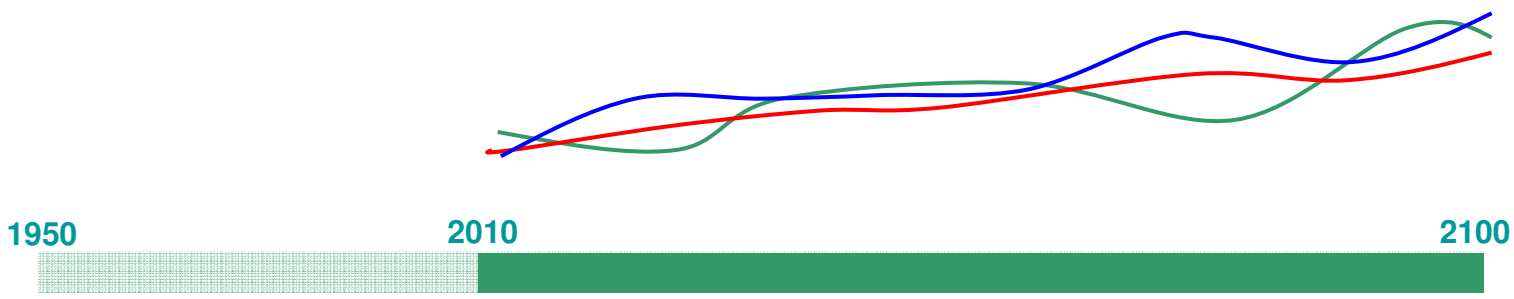


Seasonal and interannual



Long-term trends

- Projection for different IPCC scenarios using statistical/dynamic downscaling



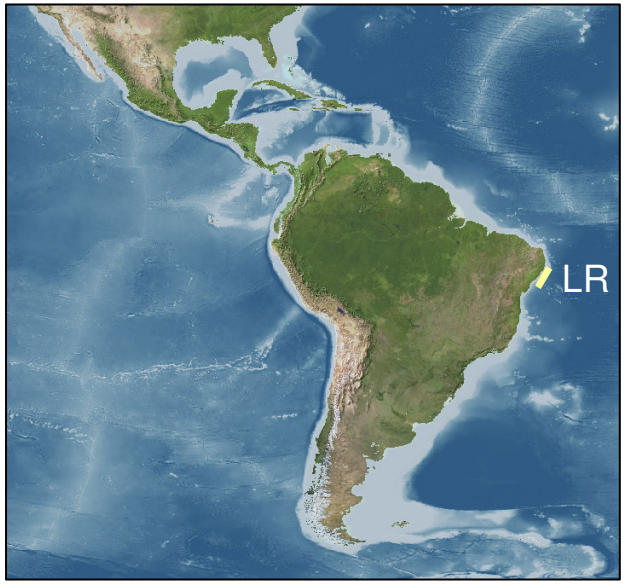
Spatial scales of interest

3 levels:

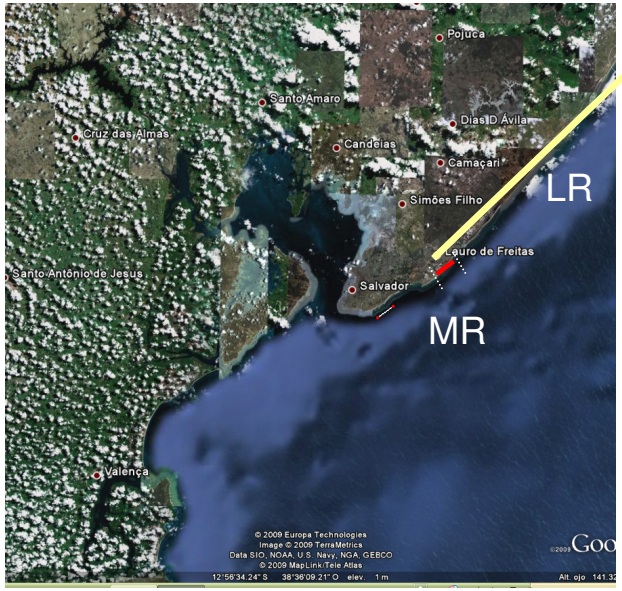
*- 0.50º ~ 50 Km = Regional Level (Low Resolution, **LR**)*

*- 0.05º ~ 5 Km = Local level (Medium Resolution, **MR**)*

*- 10 m – 100 m = "City" level (High Resolution, **HR**)*



(Southamerica and Caribbean: 250.000 Km)



Santander Bay

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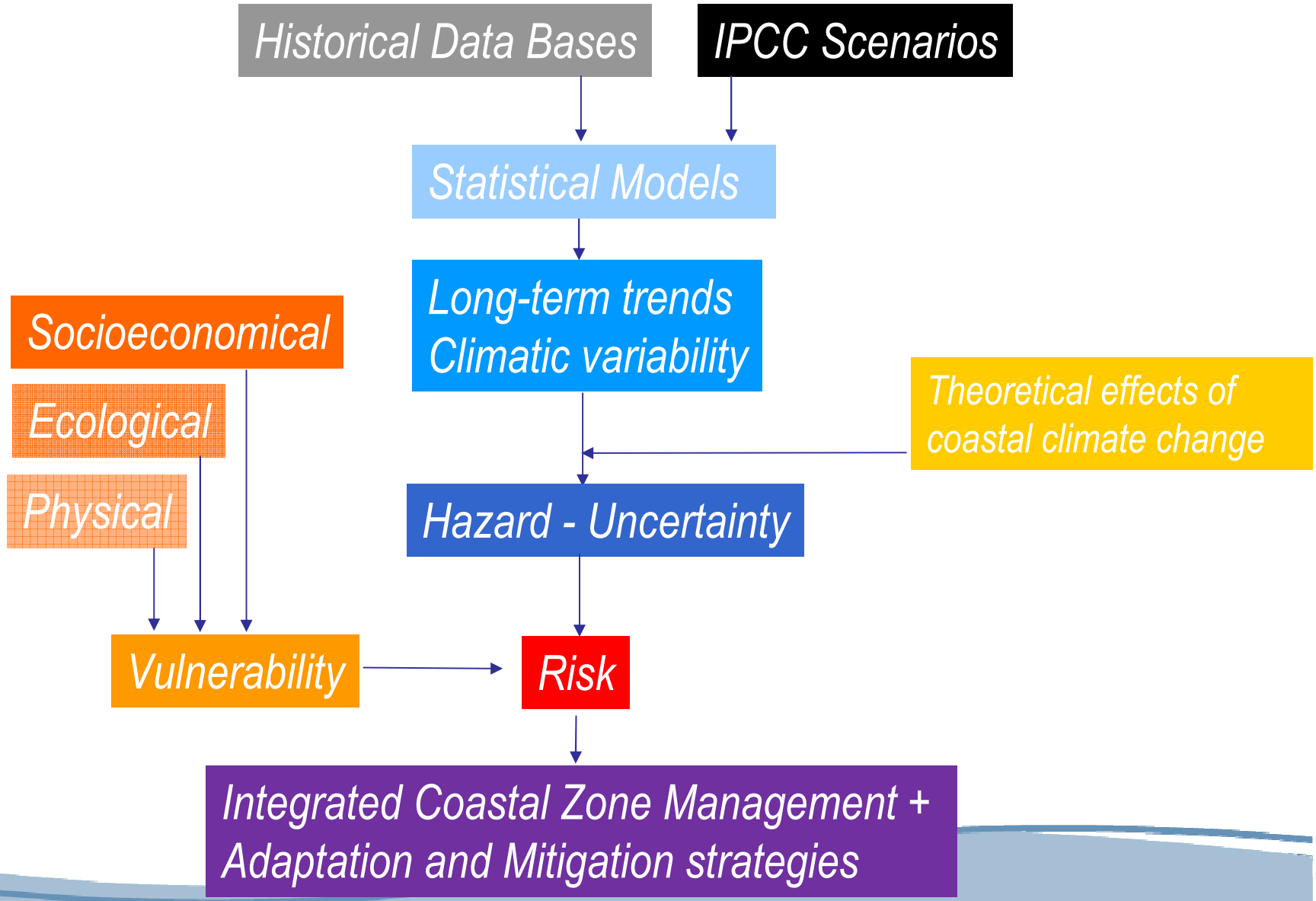
7. Integration of Risk


Historical Data Bases
IPCC Scenarios
Statistical Models
Long-term trends
Climatic variability
Socioeconomical
Ecological
Physical
Theoretical effects of coastal climate change
Hazard - Uncertainty
Vulnerability
Risk
Integrated Coastal Zone Management +
Adaptation and Mitigation strategies

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4. Risk (European Comission, Joint Research Centre)

Risk:

"The probability of harmful consequences or expected losses resulting from a given hazard to a given element at danger or peril, over a specified time period"

Hazard:

"A potentially damaging physical event, phenomenon and/or human activity, which may cause loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can be single, sequential or combined in their origin and effects".

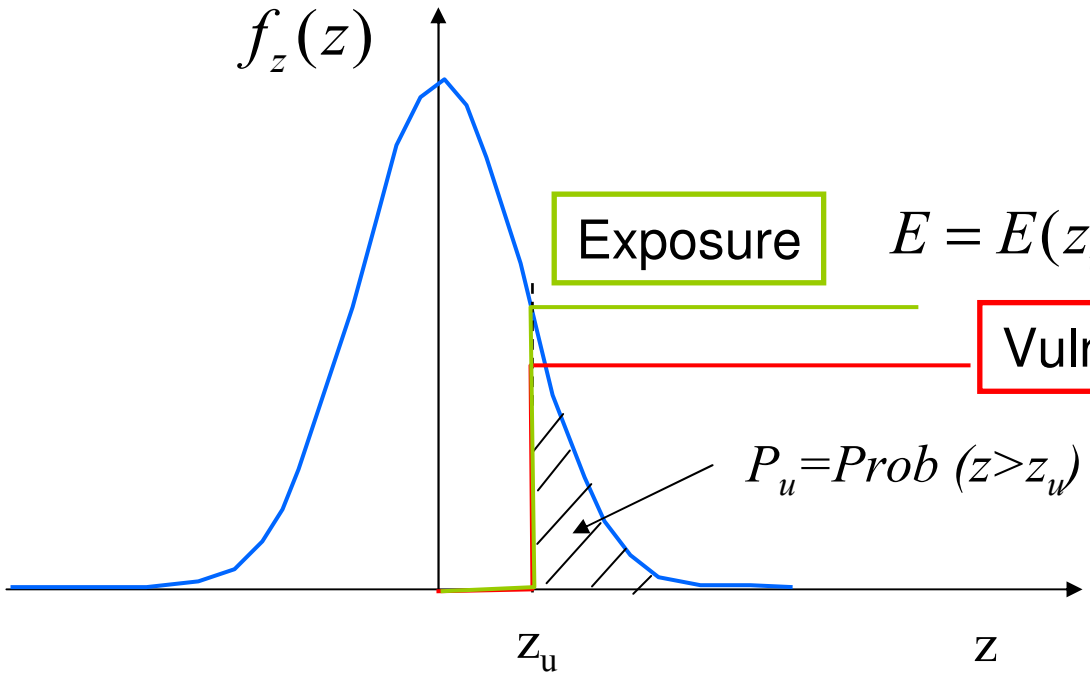
Vulnerability:

"The characteristics of a person or a group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made disaster - noting that vulnerability is made up of many political-institutional, economic and socio-cultural factors."

Figure 2: The "risk triangle" after CRICHTON (1999)

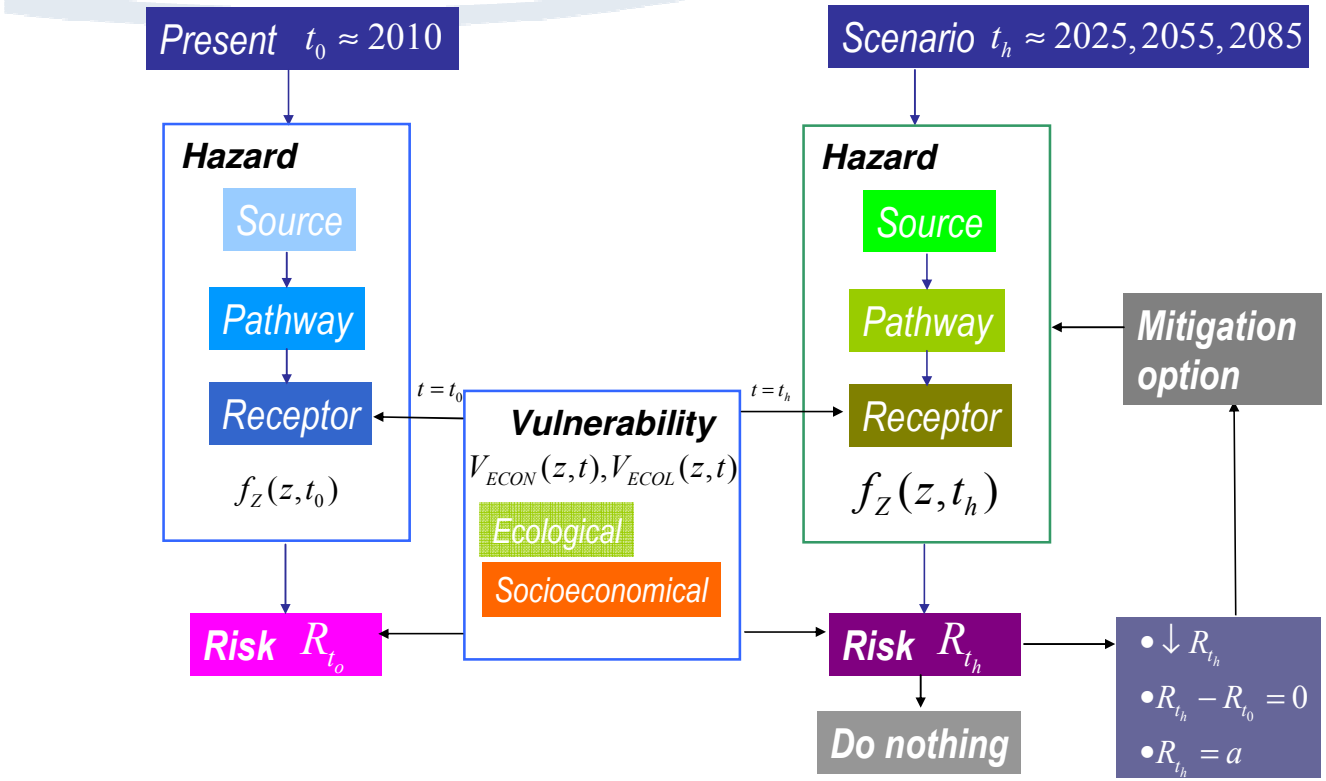
$$R_{ah} = H_{ah} \times E_a \times V_{ah}$$

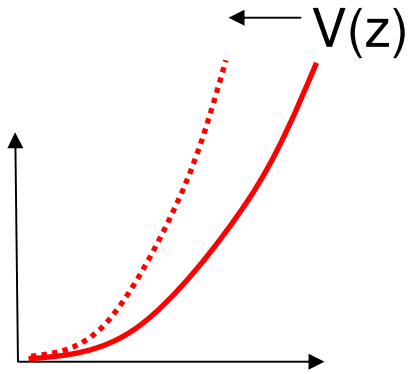
Evaluation of Risk for a given value of the Hazard z_u



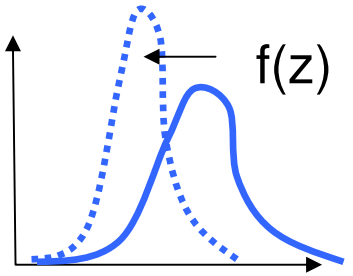
$$R \approx P_u E(z_u) V(z_u),$$

4. Risk

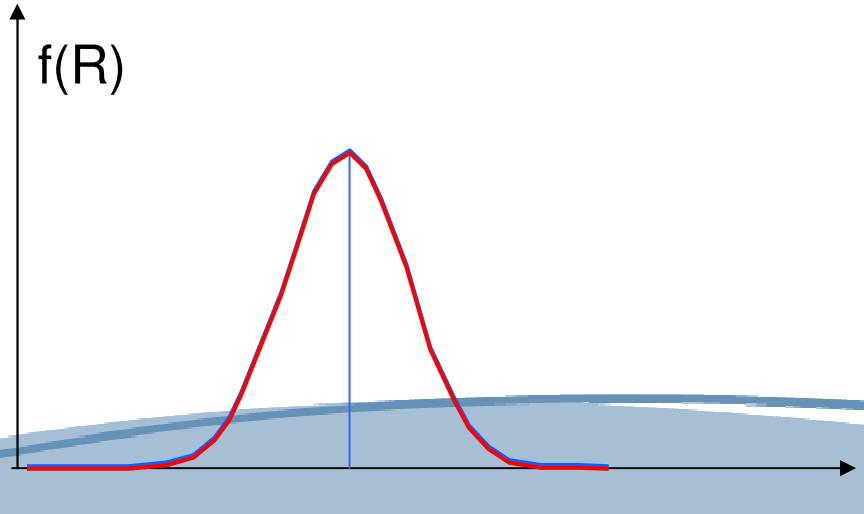




- **change vulnerability**
- **change hazard**



- $\downarrow R_{t_h}$ →
- $R_{t_h} - R_{t_0} = 0$ →
- $R_{t_h} = a$ →



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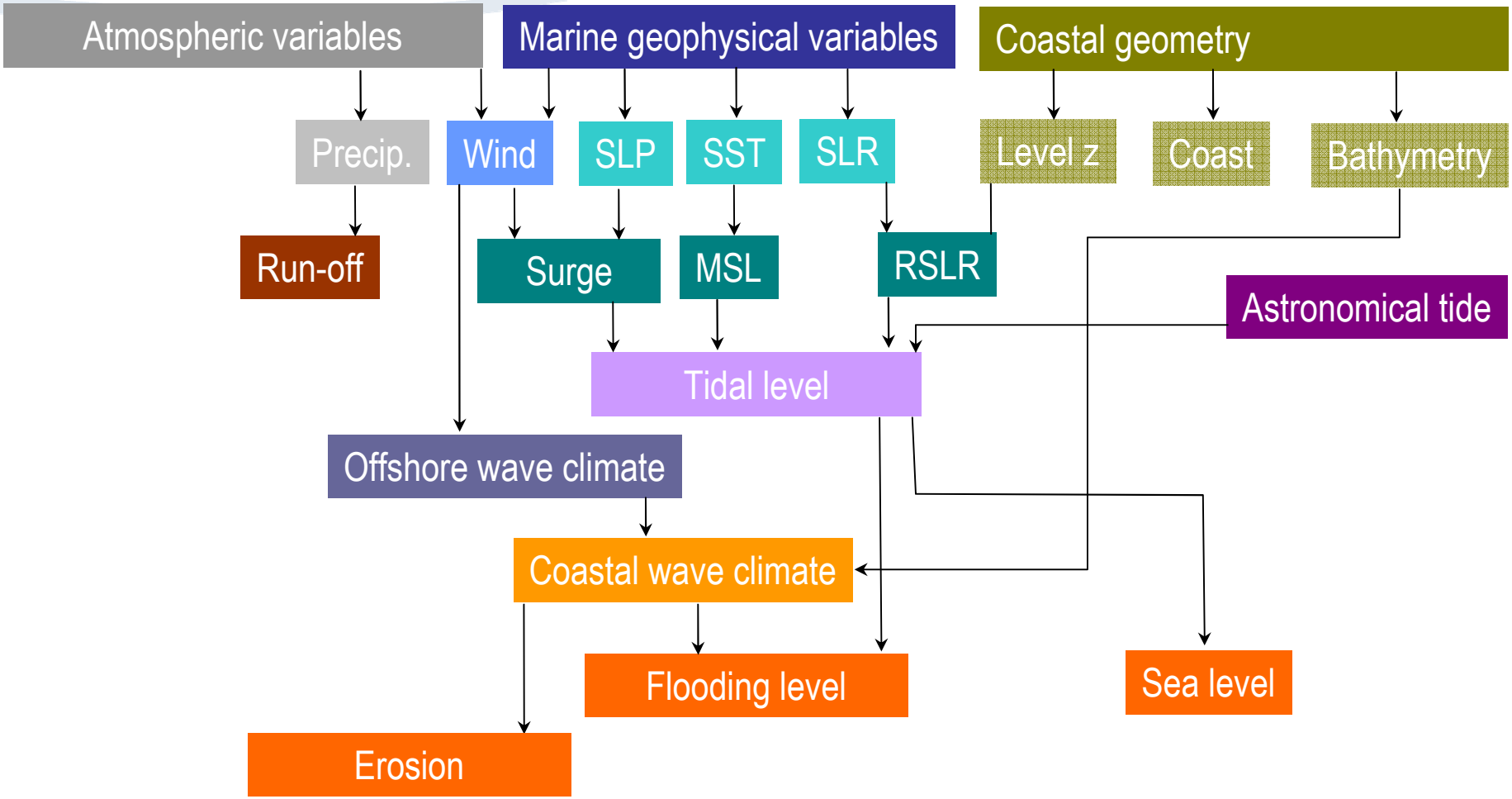
7. Integration of Risk

Identification of hazards

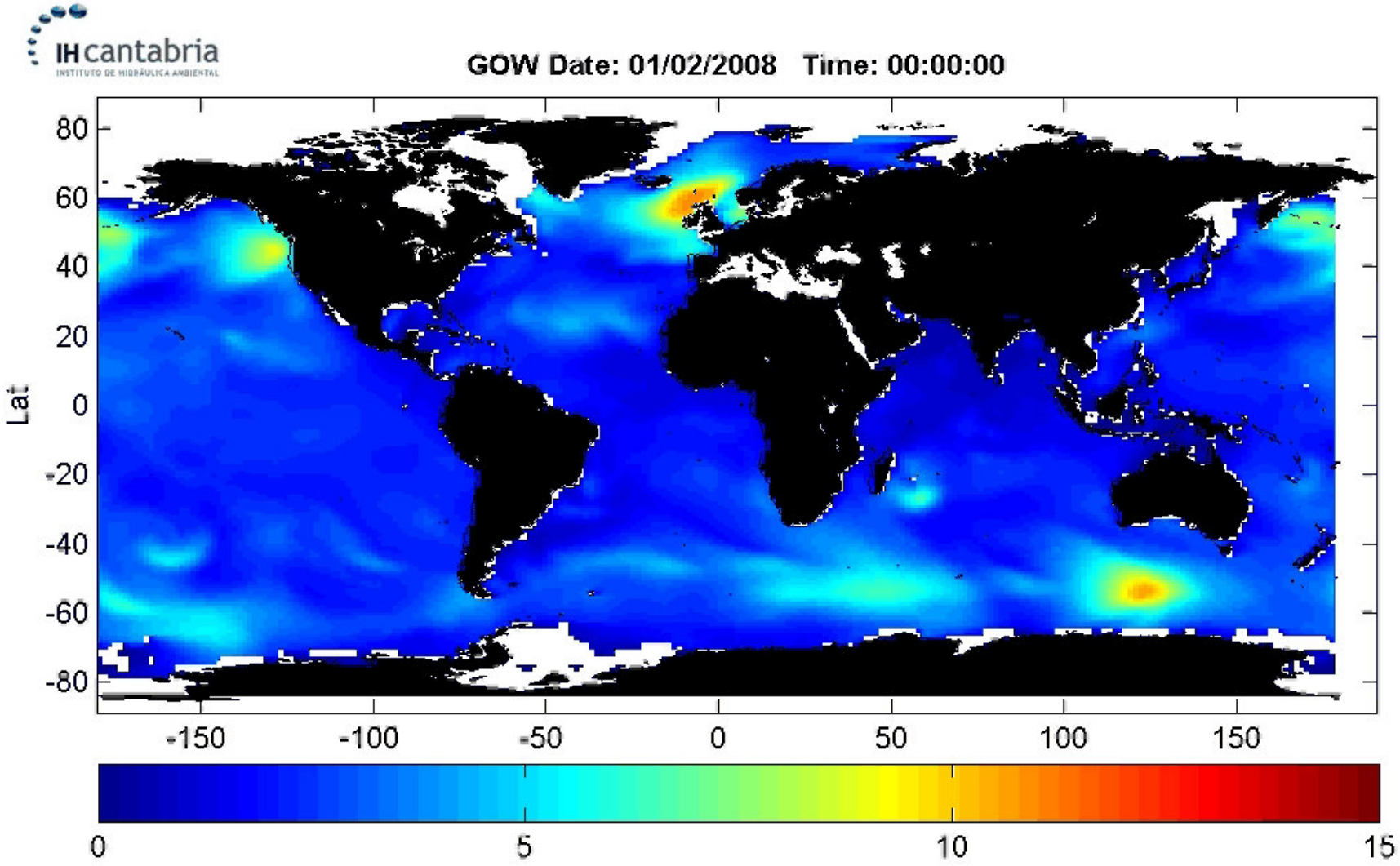


$f_Z(z)$

Probability density function of the hazard

Examples of Hazards:

- Extreme value distribution of flooding level
- Extreme value distribution of overtopping
- Long-term distribution of multivariate wave climate
- Long-term distribution of littoral transport
- Long-term distribution of mean energy flux direction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GOW Date: 01/02/2008 Time: 00:00:00
Lat
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60
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20
0
-20
-40
-60
-80
-150
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0
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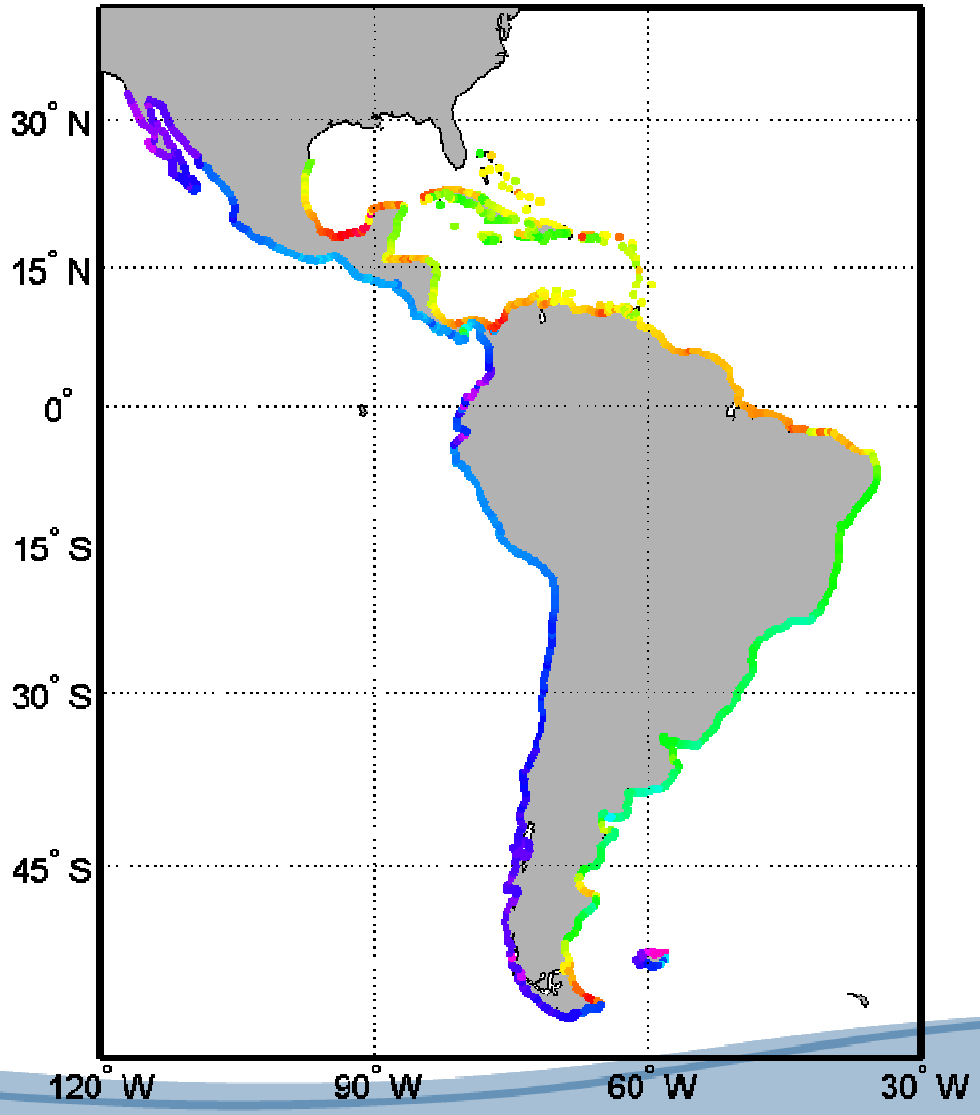
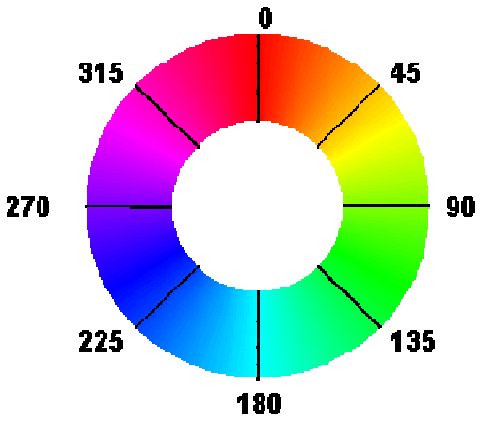
0
5
10
15

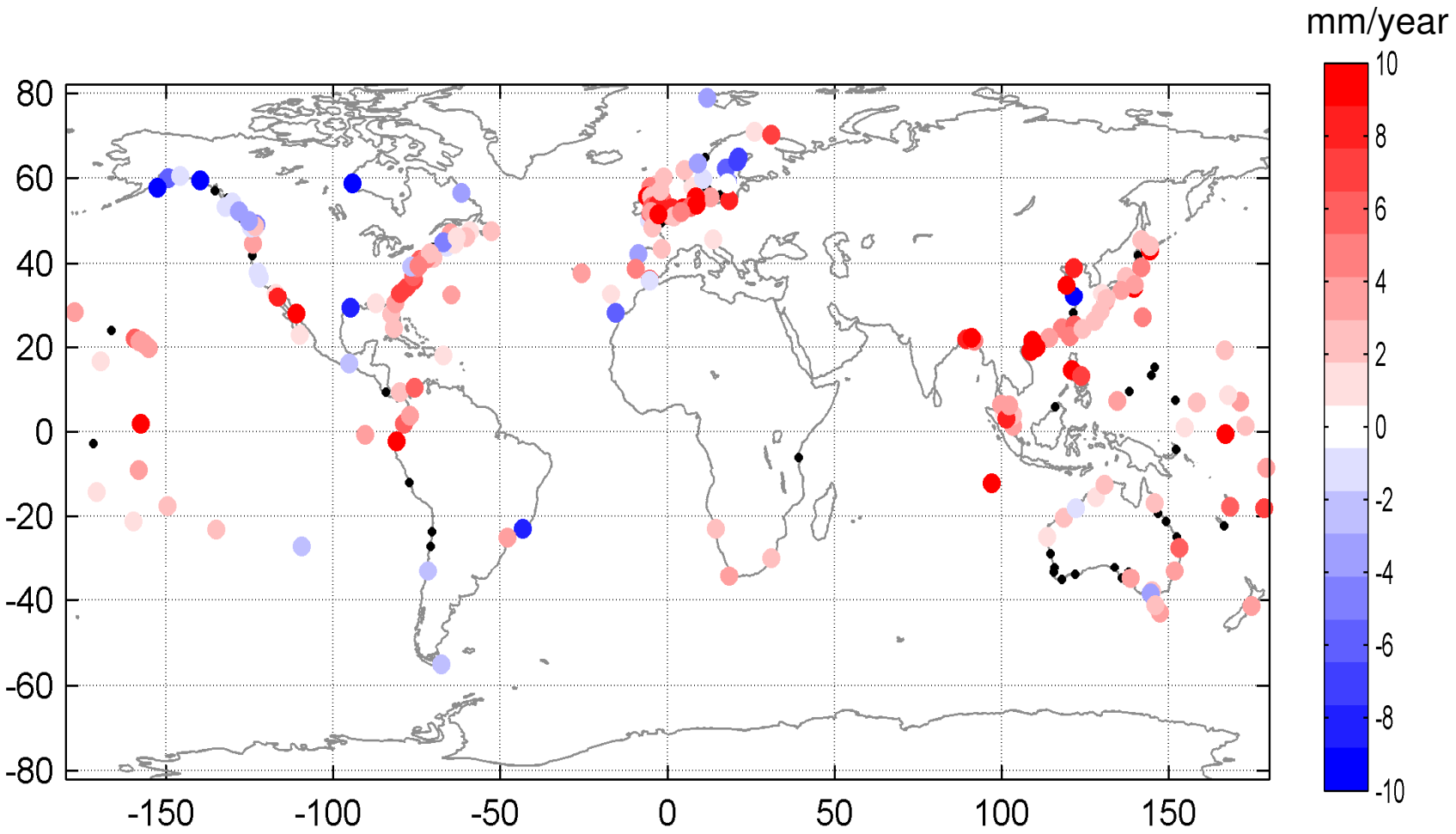
Mean Energy Flux Average Direction



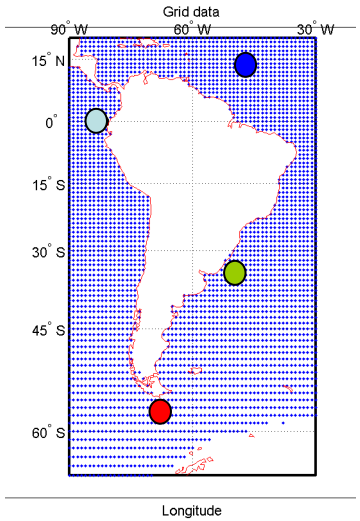


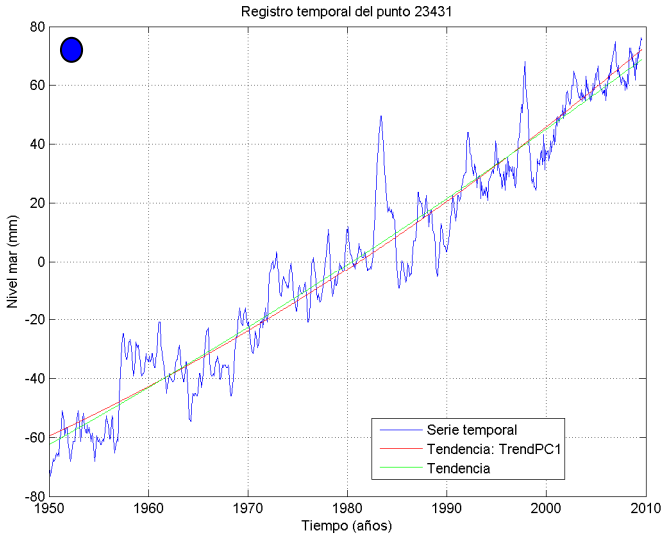
Tidal gauges

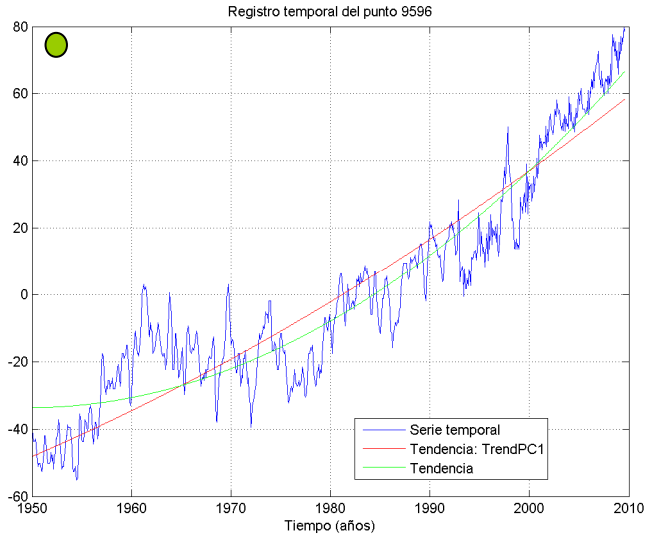
Tidal gauges. Long-term trends of extreme sea levels (Menendez and Woodworth, 2010)

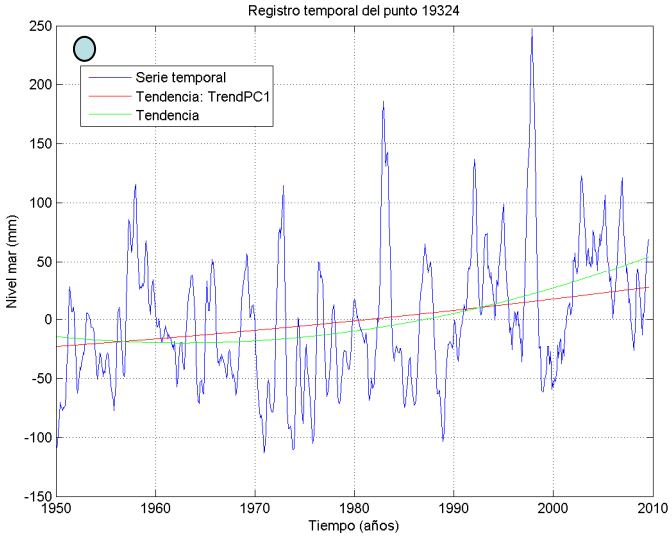


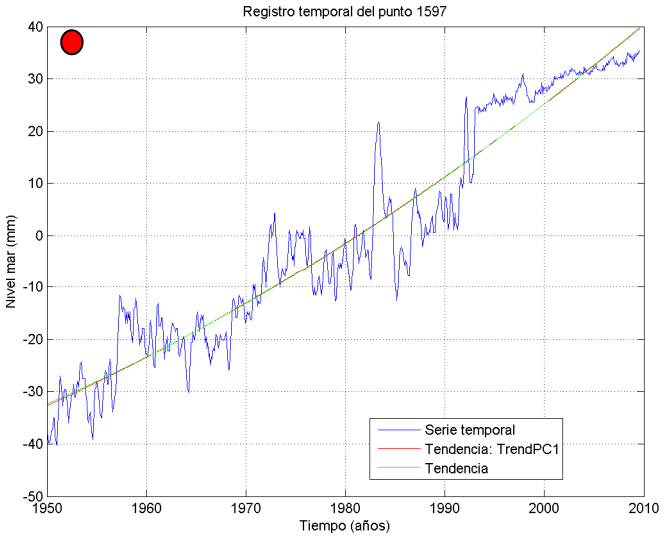
5.4. Ascenso del nivel medio del mar



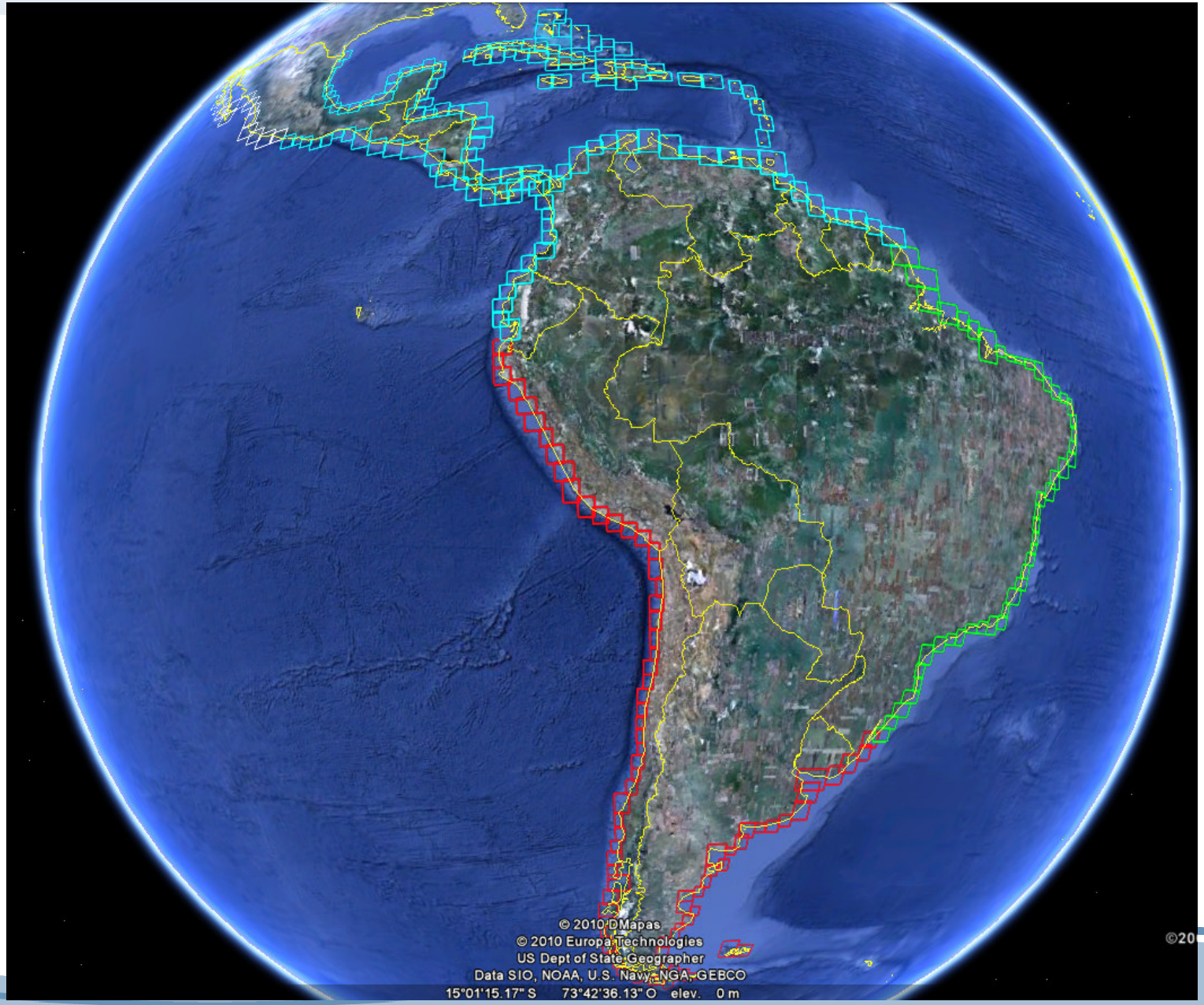








5. Hazard


© 2010 DMapas
© 2010 Europa Technologies
US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
15°01'15.17" S 73°42'36.13" O elev. 0 m

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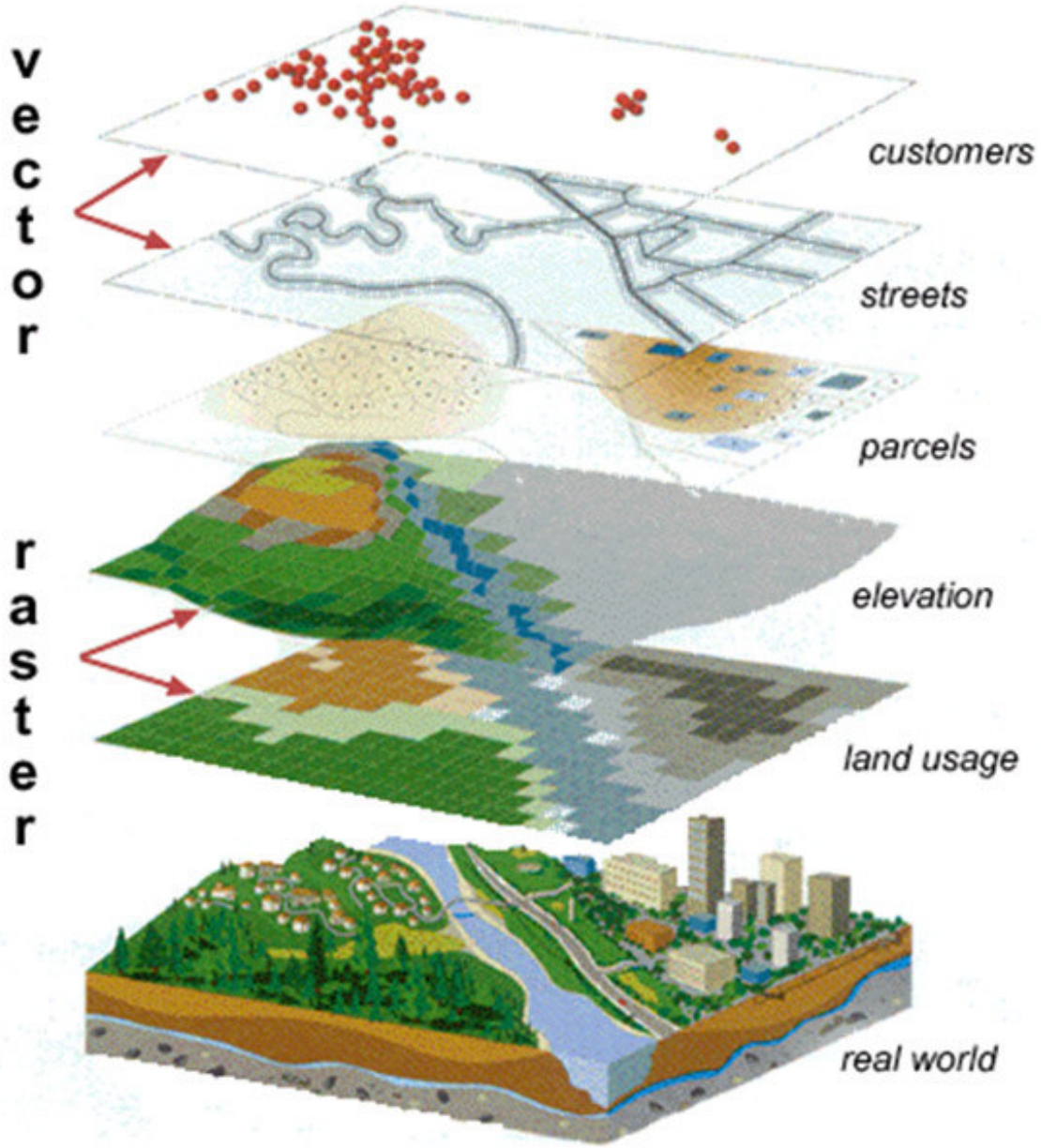
Biome (Ecosystems)

- Beach
- Mangrove
- Cliff
- Coral
- Estuary
- Delta
- Forest
- Desert
- Dunes

Socioeconomical Sectors

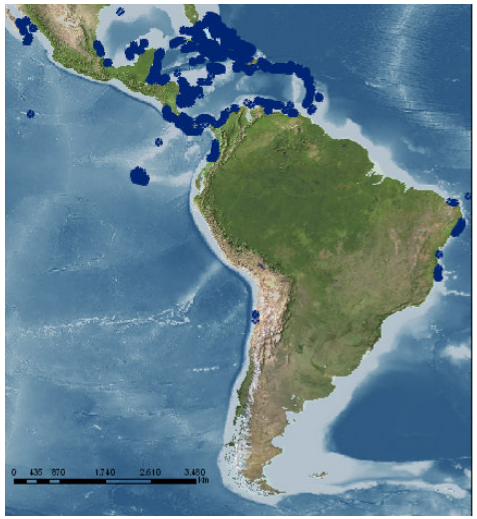
- Infrastructures
  - Wastewater and water supply networks
  - Telecommunications
  - Transport network
  - Energy network
- Industry
- Tourism
- Agriculture
- Urban
- Services
- Population

G.I.S.

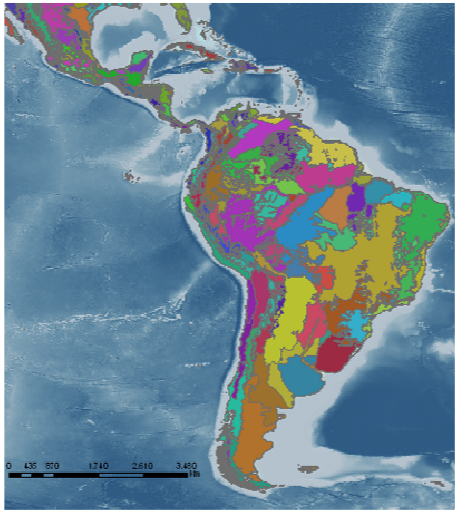

vector
raster
customers
streets
parcels
elevation
land usage
real world

G.I.S.

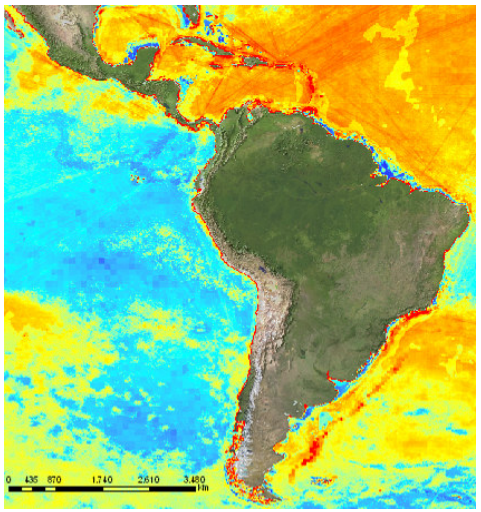
Reefs

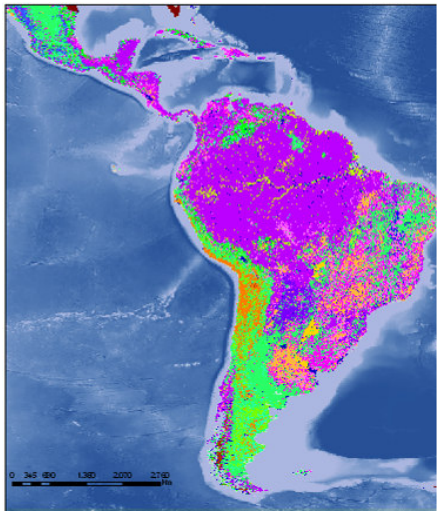


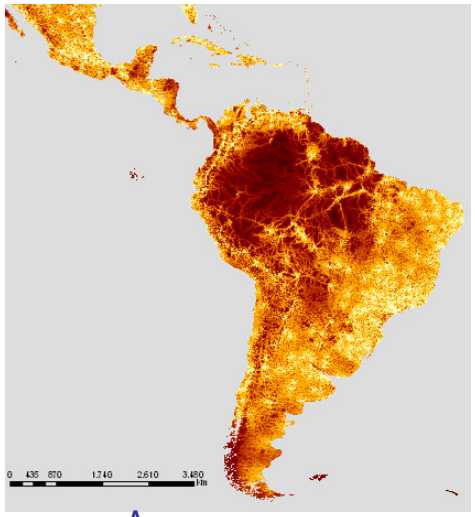
Ecosystems



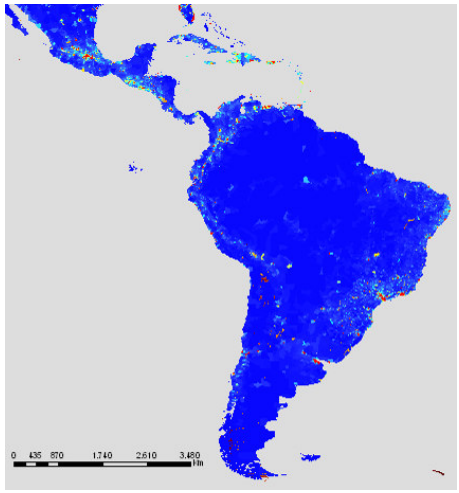
Human impacts (marine ecosystems)



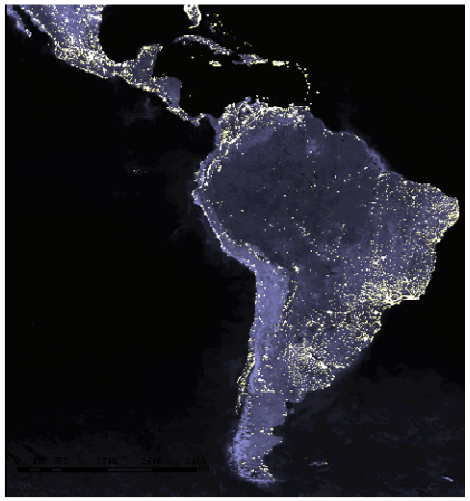




Access
(minutes to cities of 50.000 inhab.)



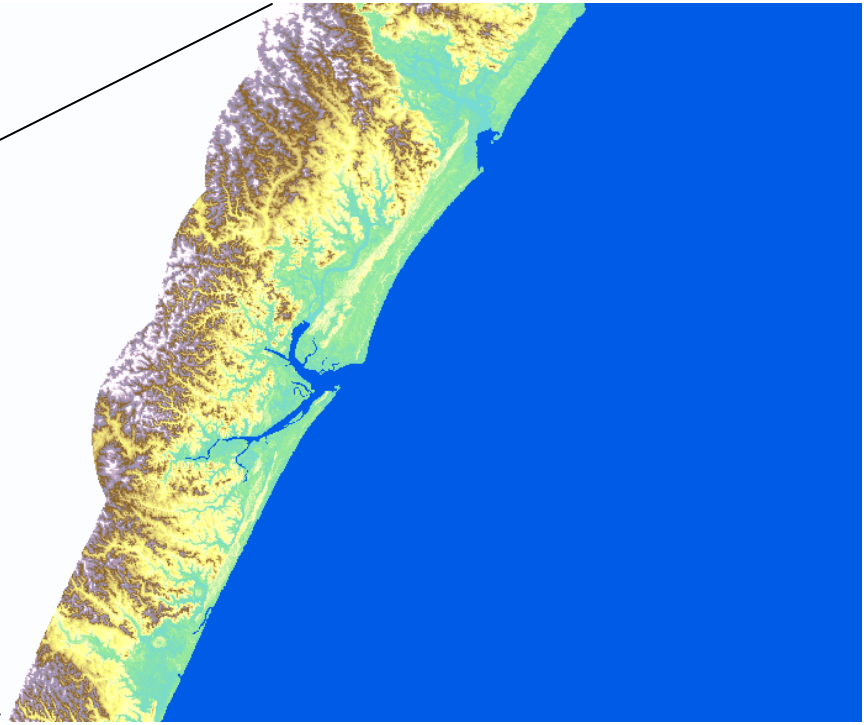
Population density



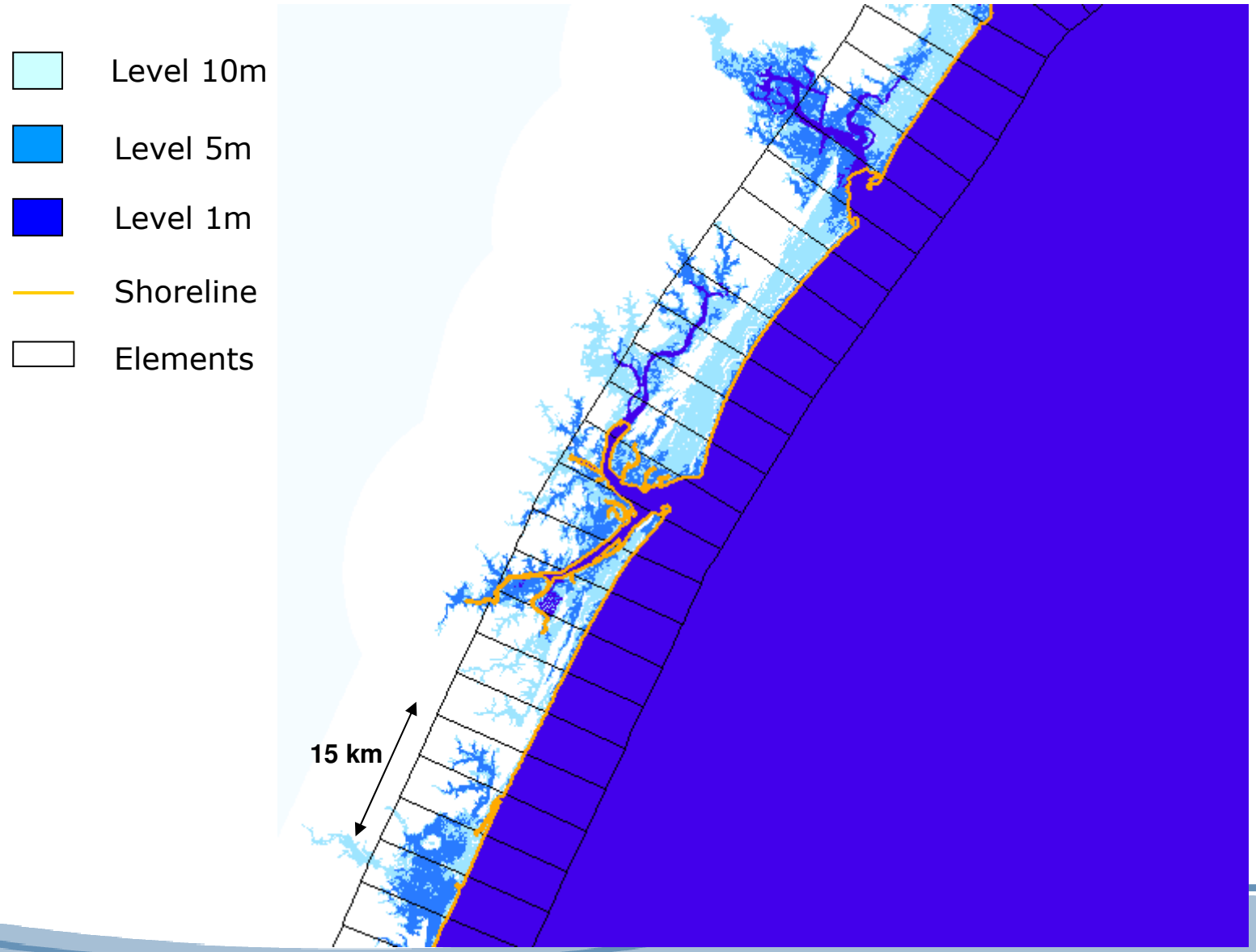
Asentamientos
(city lights)

G.I.S.

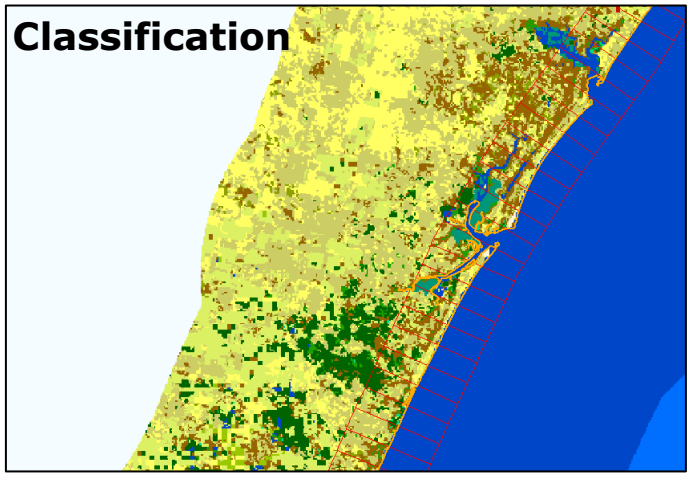
Digital Terrain Model

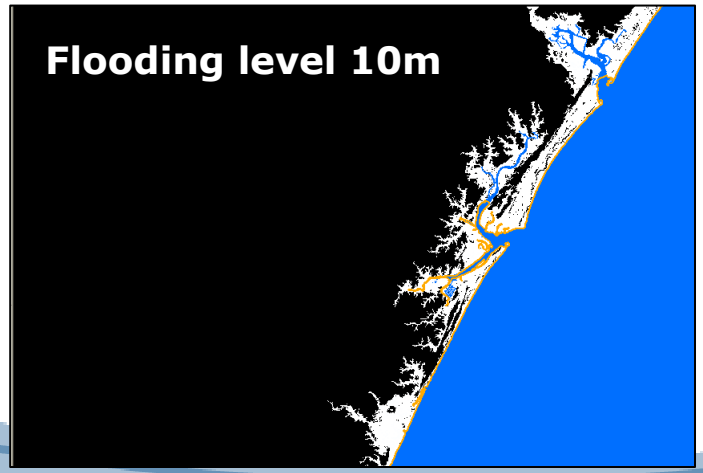


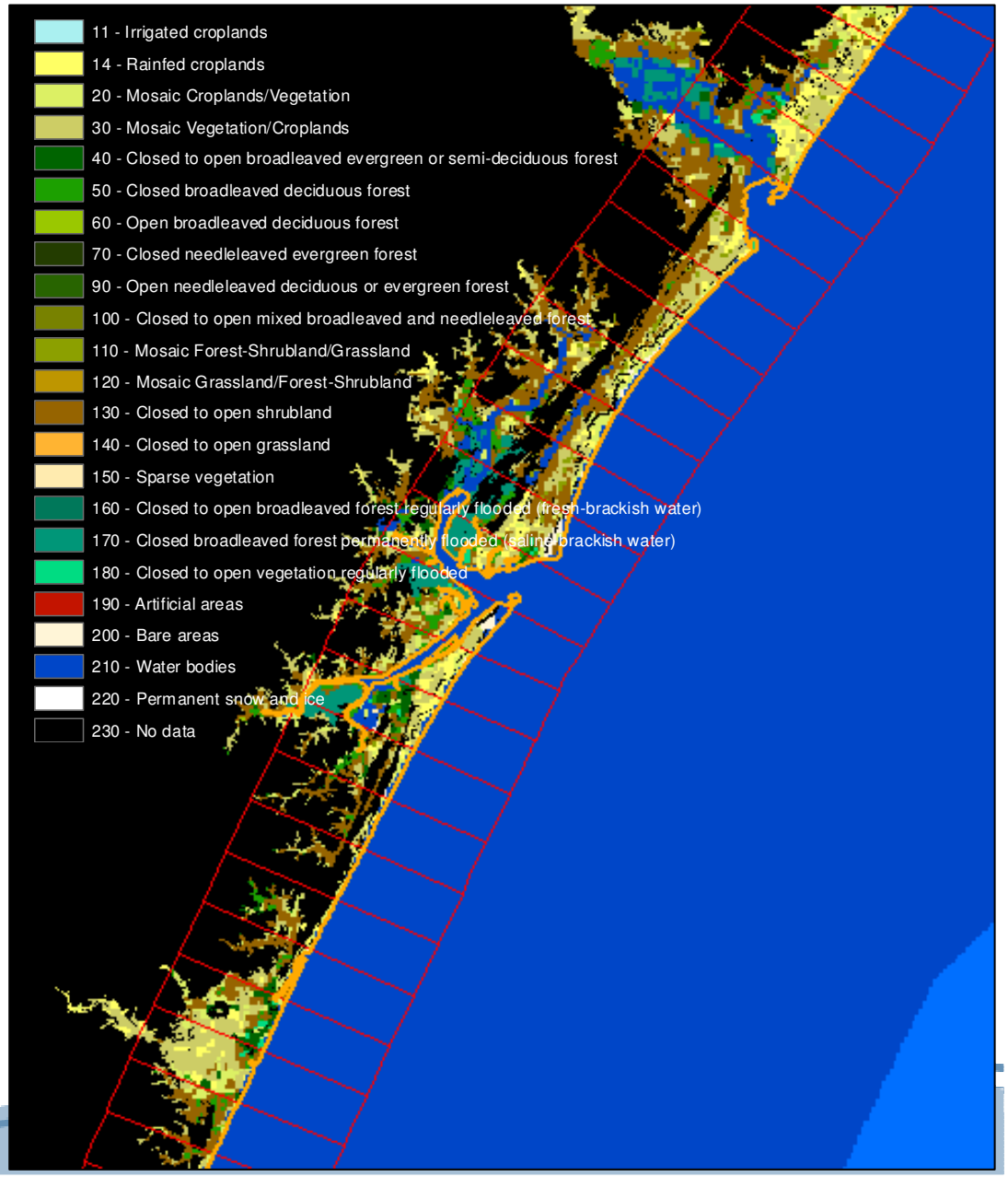
G.I.S.



G.I.S.


Classification


Flooding level 10m


11 - Irrigated croplands
14 - Rainfed croplands
20 - Mosaic Croplands/Vegetation
30 - Mosaic Vegetation/Croplands
40 - Closed to open broadleaved evergreen or semi-deciduous forest
50 - Closed broadleaved deciduous forest
60 - Open broadleaved deciduous forest
70 - Closed needleleaved evergreen forest
90 - Open needleleaved deciduous or evergreen forest
100 - Closed to open mixed broadleaved and needleleaved forest
110 - Mosaic Forest-Shrubland/Grassland
120 - Mosaic Grassland/Forest-Shrubland
130 - Closed to open shrubland
140 - Closed to open grassland
150 - Sparse vegetation
160 - Closed to open broadleaved forest regularly flooded (fresh-brackish water)
170 - Closed broadleaved forest permanently flooded (saline-brackish water)
180 - Closed to open vegetation regularly flooded
190 - Artificial areas
200 - Bare areas
210 - Water bodies
220 - Permanent snow and ice
230 - No data

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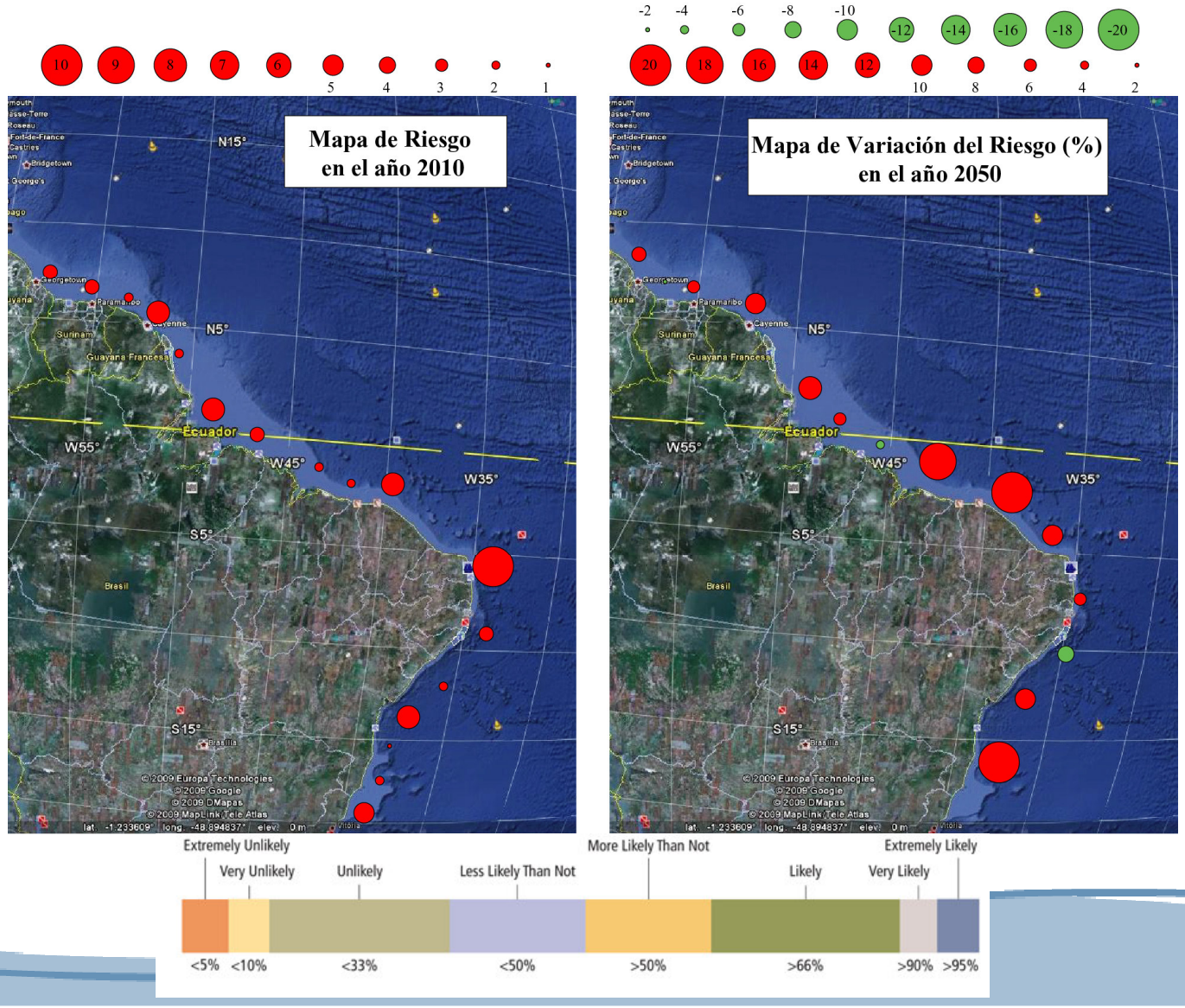
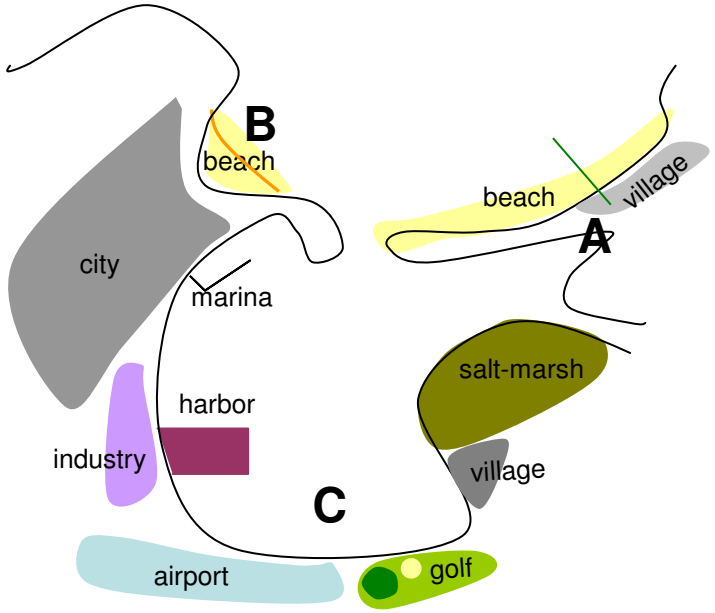
- Risk maps


10 9 8 7 6 5 4 3 2 1
-2 -4 -6 -8 -10 -12 -14 -16 -18 -20
20 18 16 14 12 10 8 6 4 2
Mapa de Riesgo en el año 2010
Mapa de Variación del Riesgo (%) en el año 2050
N15°
N5°
S5°
S15°
W55°
W45°
W35°
Ecuador
Surinam
Guayana Francesa
Brasil
Georgetown
Paramaribo
Cayenne
Bridgetown
Fort-de-France
Castries
Roseau
Basse-Terre
Brasília
Vitória
© 2009 Europa Technologies
© 2009 Google
© 2009 DMapas
© 2009 MapLink/Tele Atlas
Extremely Unlikely
Very Unlikely
Unlikely
Less Likely Than Not
More Likely Than Not
Likely
Very Likely
Extremely Likely
<5%
<10%
<33%
<50%
>50%
>66%
>90%
>95%

City-Urban Scale

Identification of local hazards

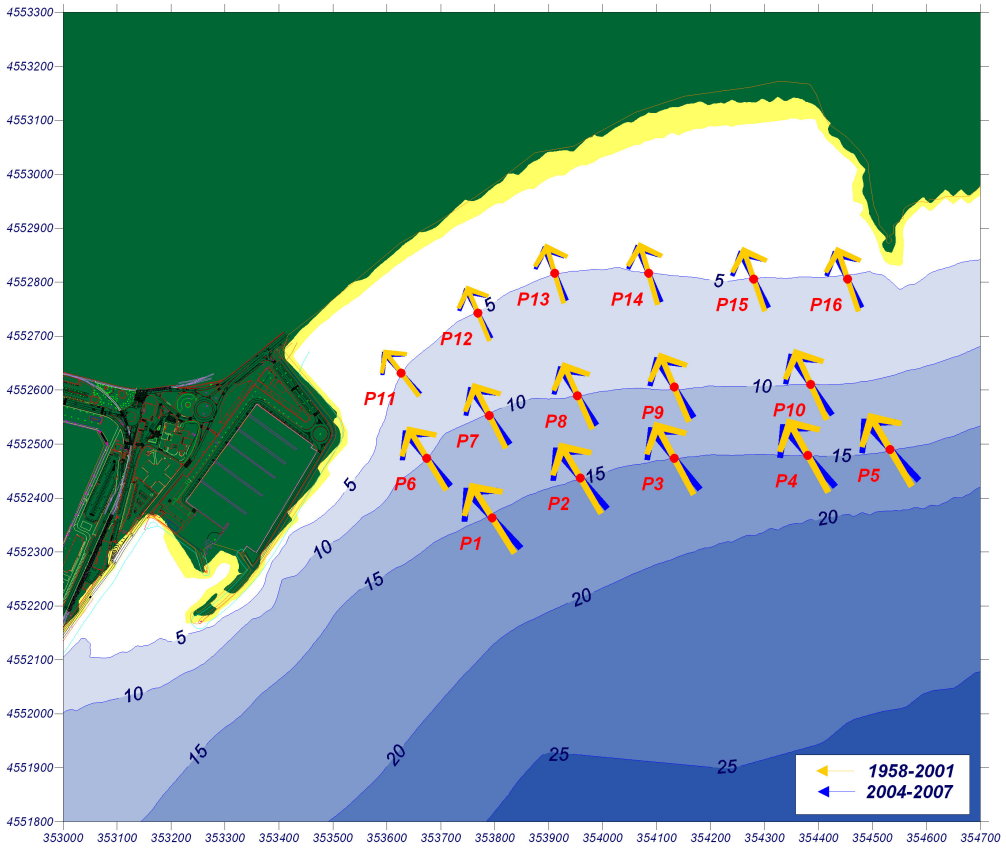


$f_Z(z)$

Probability density function of the hazard

Examples of Hazards:

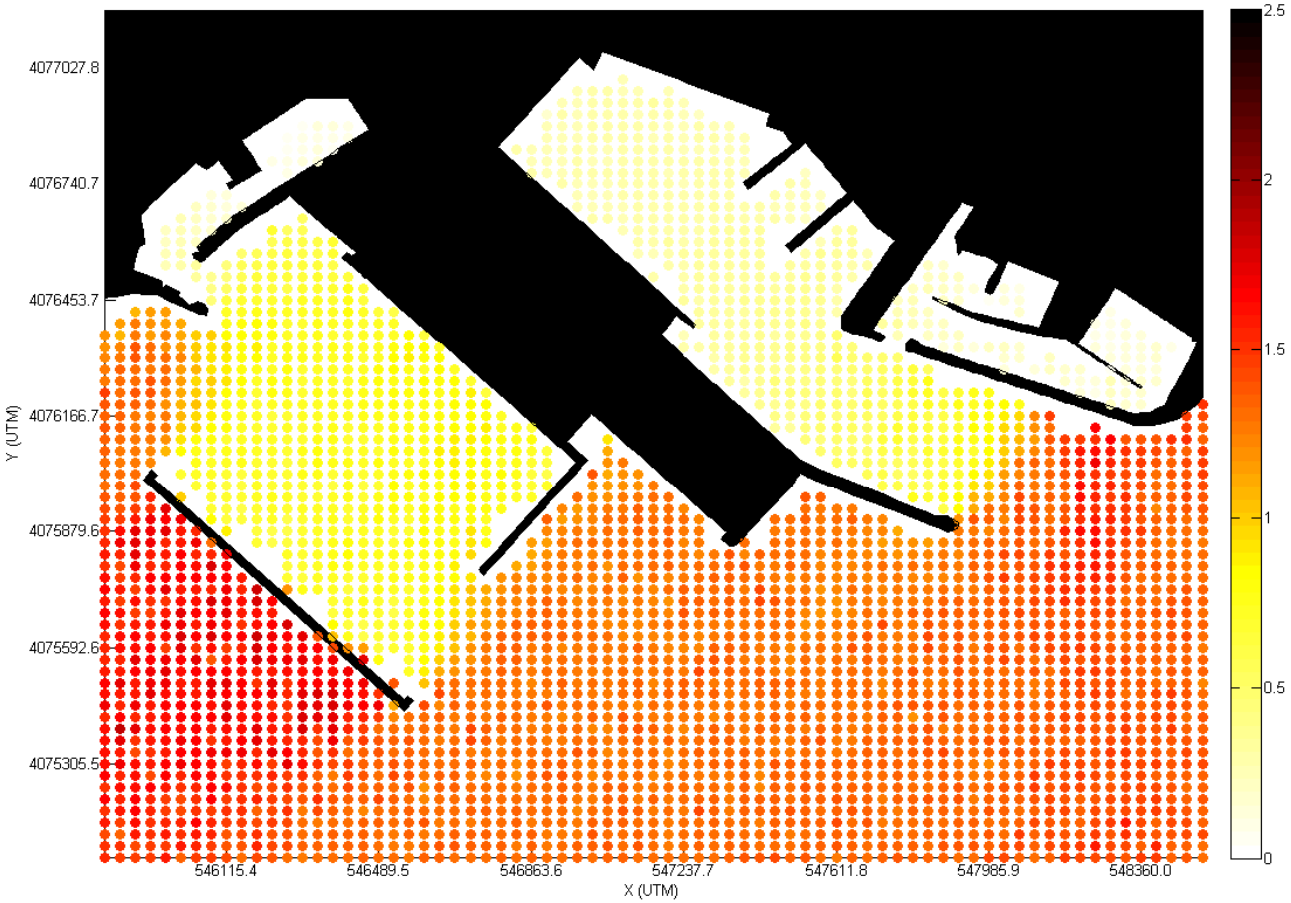
- Extreme value distribution of flooding level **A, C**
- Extreme value distribution of overtopping **A**
- Long-term distribution of multivariate wave climate **A**
- Long-term distribution of littoral transport
- Long-term distribution of mean energy flux direction **B**



El Milagro Beach (Tarragona)

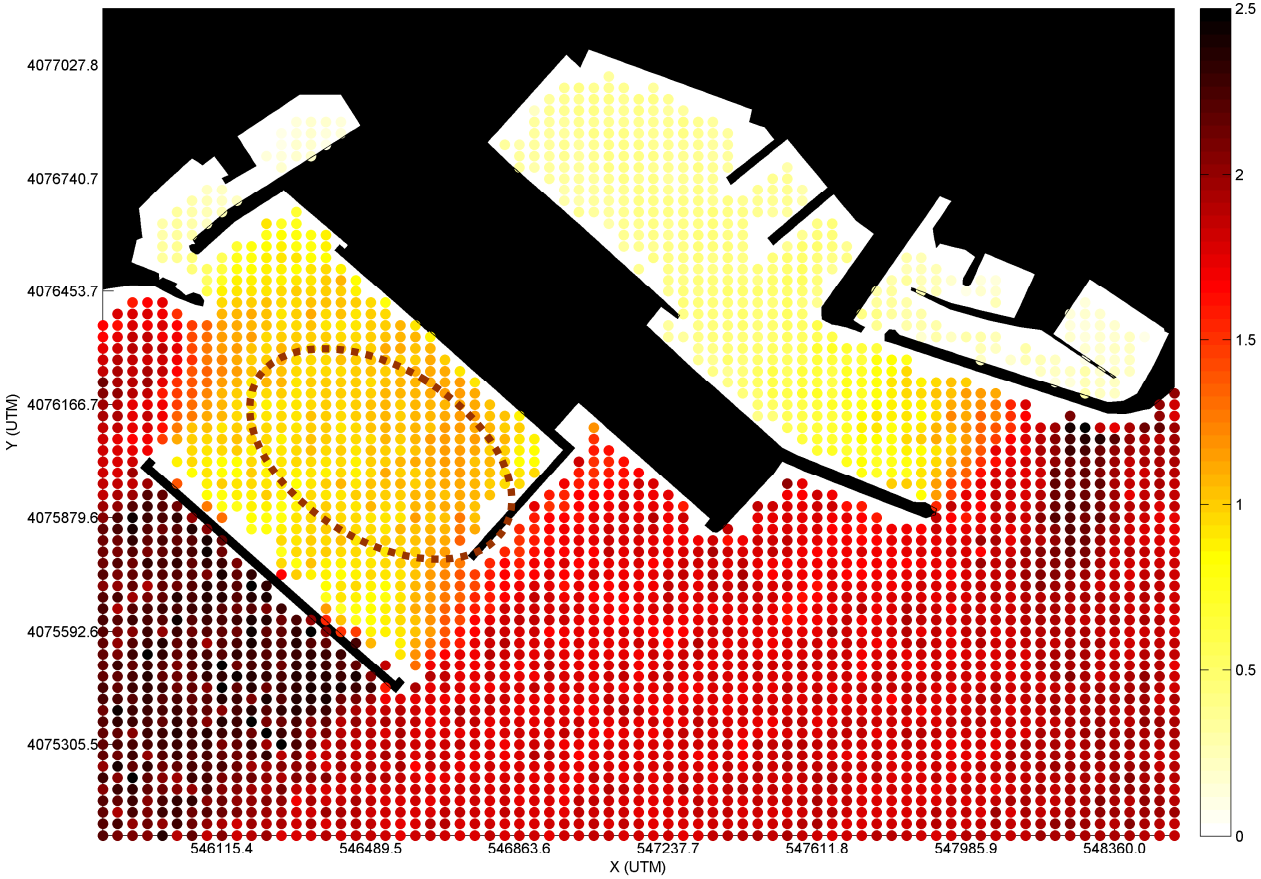
Shoreline variation due to changes in wave direction based on observations

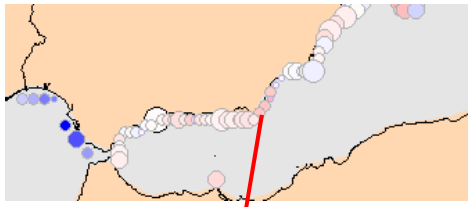
95% percentile of significant wave height
Port operations



Yellow/white dots: below non-operation wave height threshold

95% percentile of significant wave height





Long-term trends of wave climate at 2050

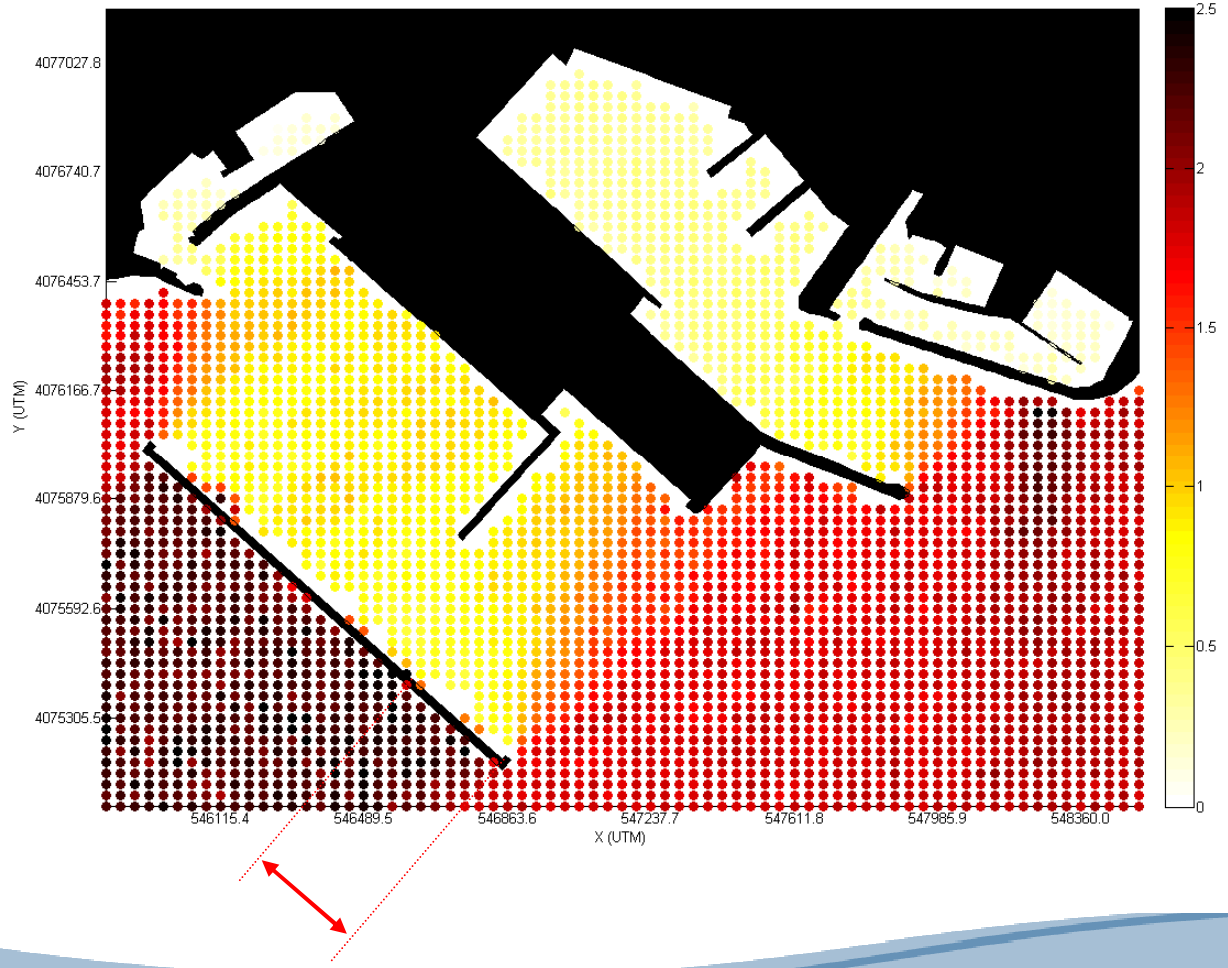
ΔH=30 cm

sea level rise at 2050

$\Delta \eta$=15 cm.

Reduction of harbour operation time
200 hours/year
Losses 0.5M€/year

Adaptation



Objective: reestablish current situation

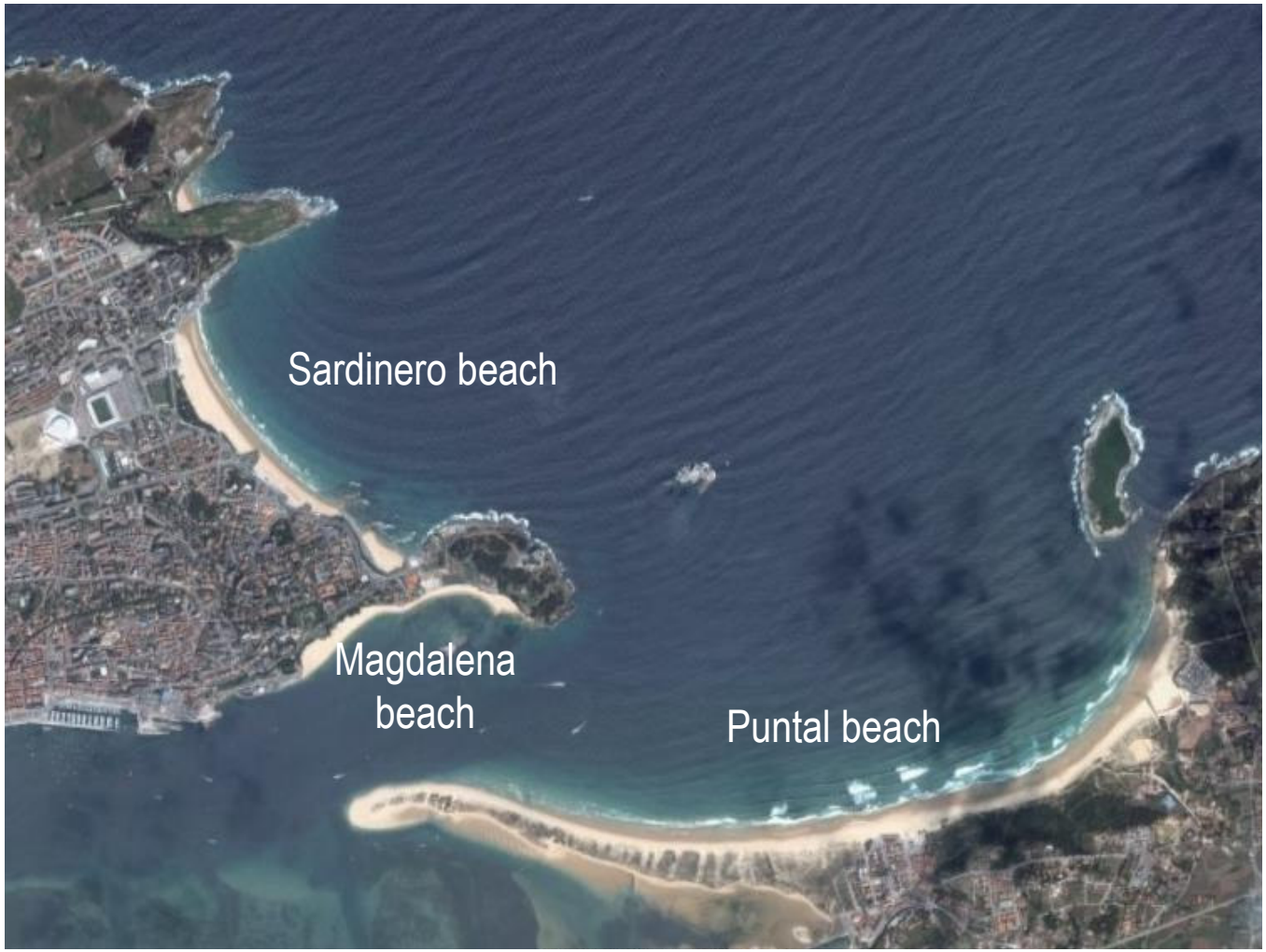
Action: Increase vertical breakwater length caissons

200 m length
15 m wide
25 m vertical

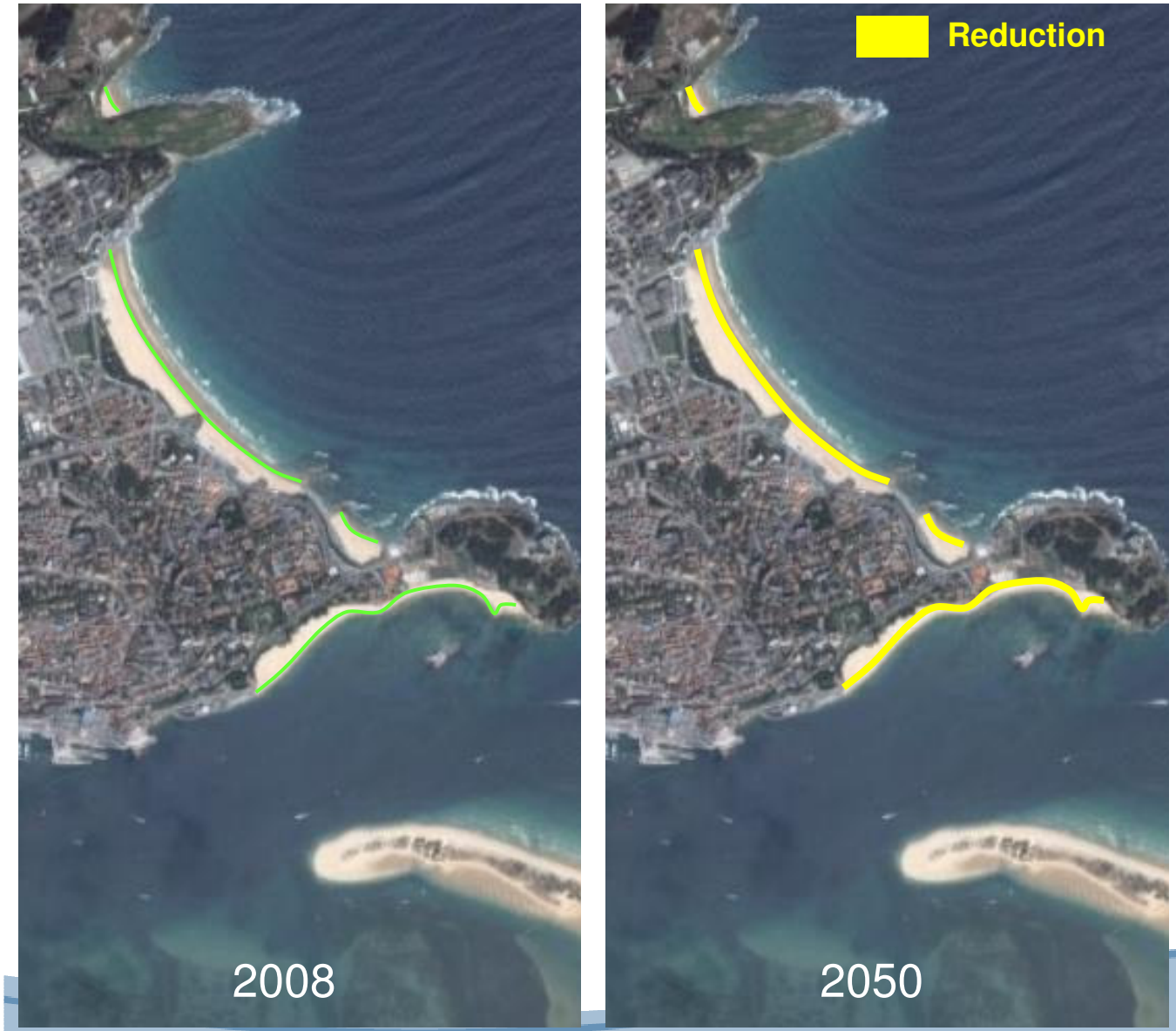
60 €/m3

Adaptation cost: 4.6 M€

Beaches



Adaptation



Shoreline retreat at 2050 = 8 m

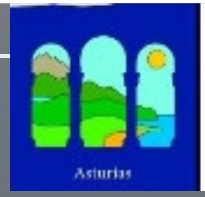
Impact: Reduction of 30% beach surface
20.000 users loss

Objective: reestablish current situation

Action: Beach nourishment

8 m x 2500 m x 10 m
Sand 20€/m^3

Adaptation cost: 4 M€



gijón 2010
European Maritime Day
Stakeholder Conference, 18-21 May
http://ec.europa.eu/maritimeday

Climate Change and related issues in coastal and marine areas: from science to policy

Session 1: Science Results on the impacts of climate change in coastal and marine areas

Climate Change Impacts on coastal areas

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