UNIVERSIDAD DE CANTABRIA

GRUPO DE ESTUDIO Y GESTIÓN DEL MEDIO NATURAL- GIMENA
DEPARTAMENTO DE GEOGRAFÍA, URBANISMO Y ORDENACIÓN DEL TERRITORIO

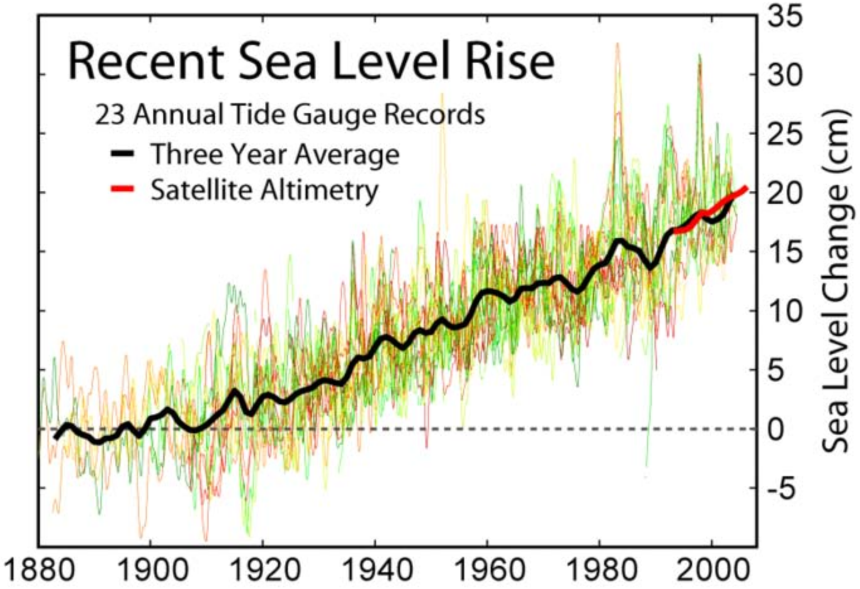
COST 733
Harmonisation and applications of weather type Classifications for European Regions

Evolution of potential flooding/erosion conditions along the coast of the Gulf of Biscay

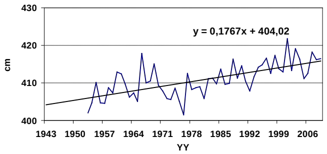
Domingo Rasilla Álvarez and Juan Carlos García Codrón

Motivation

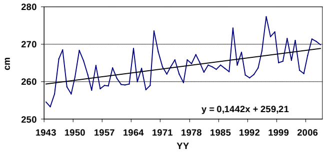
Global sea rise



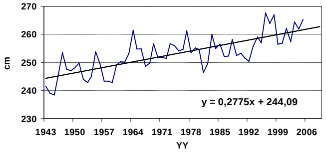
Brest



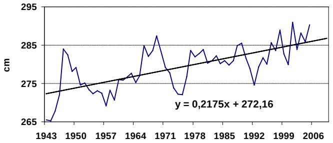
La Coruña



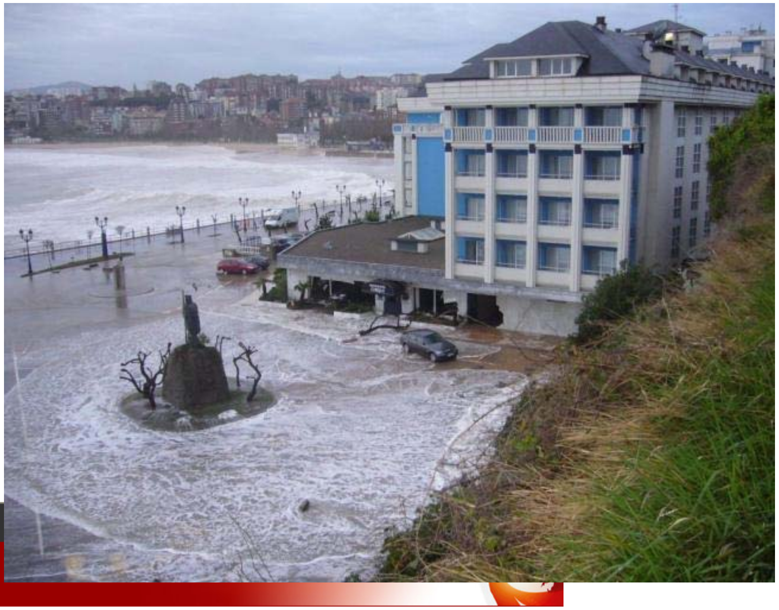
Vigo

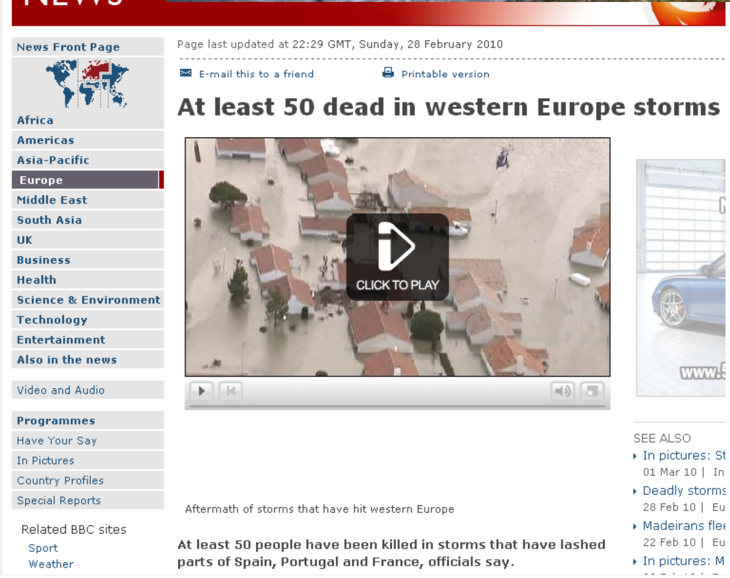


Santander



Stormy weather





Page last updated at 22:29 GMT, Sunday, 28 February 2010

At least 50 dead in western Europe storms

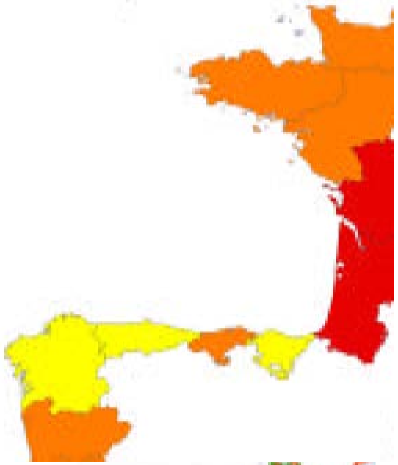
Aftermath of storms that have hit western Europe

At least 50 people have been killed in storms that have lashed parts of Spain, Portugal and France, officials say.

SEE ALSO
- In pictures: St
  01 Mar 10 | In
- Deadly storms
  28 Feb 10 | Eu
- Madeirans fle
  22 Feb 10 | Eu
- In pictures: M

Lothar/Martin	**December 1999**	**100 people killed**
Klaus	**January 2009**	**12 people killed**
Xhyntia	**February 2010**	**52 people killed**
Becky	**November 2010**	**2 people killed**

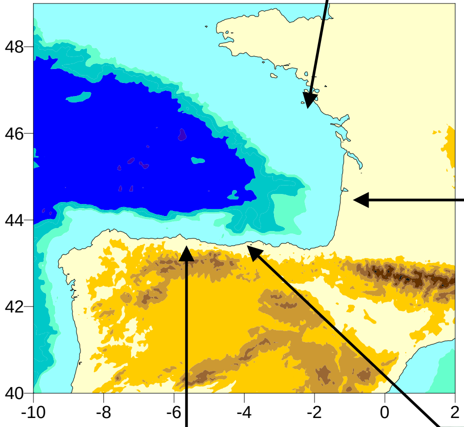
Coastal erosion



Exposure to coastal erosion:

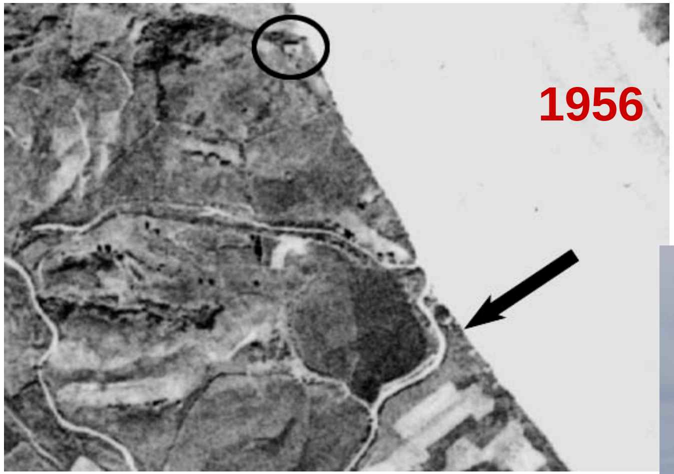
- 🟥 Very high exposure
- 🟧 High exposure
- 🟨 Moderate exposure
- 🟩 Lower exposure
- ⬜ Lack of information

- 🟥 Eroding segments
- 🟩 Stable or accreting segments

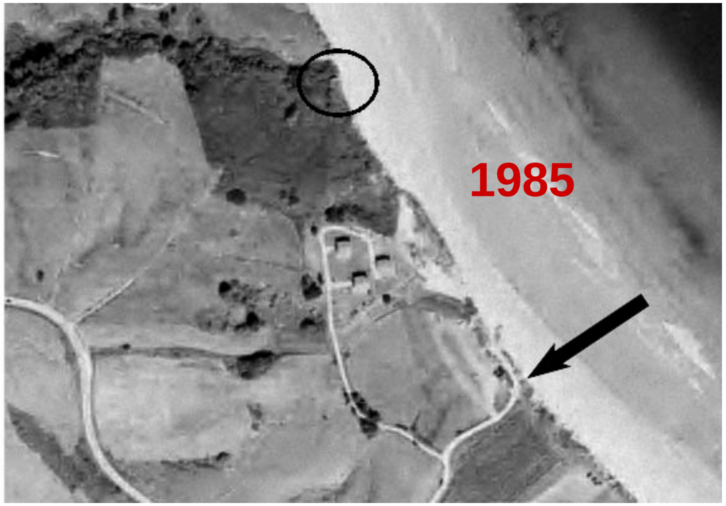


Coastal retreat

1929



1956



1985

2007

Objectives and methodology

Objetives

- **QUESTION(s) 1**:
  - Are the synoptic climatology methods suitable to highlight the diversity of atmospheric and oceanographic processes involved?
  - If statement # is fulfilled, a comparison between some preferred ones was done

- **QUESTION(s) 2**:
  - How is evolving the storm climate along the Bay of Biscay during the last decades?
  - Which is its effect on potential coastal flooding/erosion?

Methodology

- **STEP 1**: Calculation of a coastal flooding/erosion proxy index

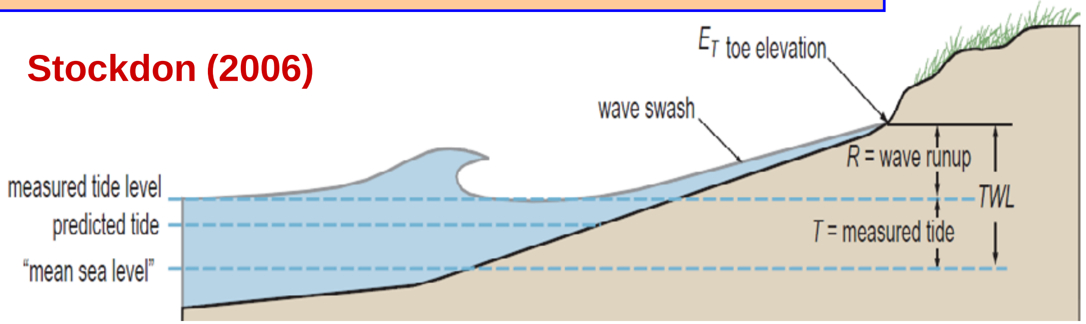
- **STEP 2**: Develop and validate a synoptic catalogue

- **STEP 3**: Combine both datasets
  - Identifying oceanographic-atmospheric links
  - Analyzing long-term evolution of forcing mechanisms

Potential flooding/coastal erosion

$$TWL = Z_T + R_{2\%}$$

Stockdon (2006)



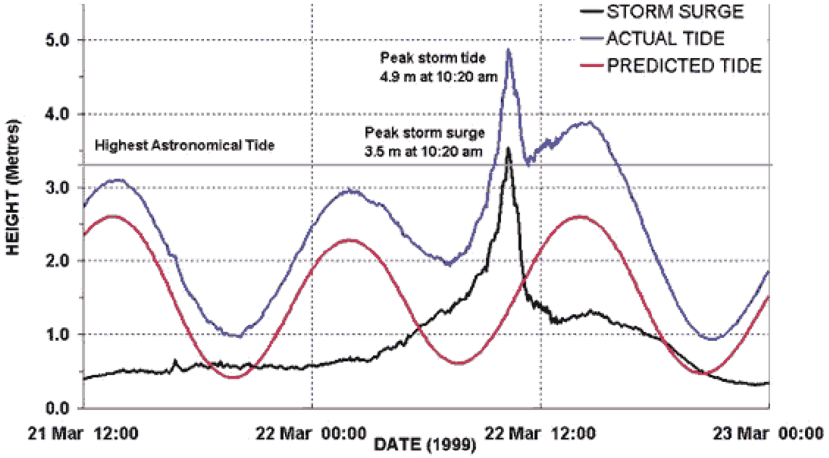
$$R_{2\%} = 1.1\left(0.35\tan\beta(H_0L_0)^{1/2} + \frac{\left[H_0L_0\left(0.563\tan\beta^2 + 0.004\right)\right]^{1/2}}{2}\right)$$

$$Zt = M_0(t) + X(t) + Y(t)$$

$M_0(t)$ = Mean sea level

$X(t)$ = Astronomical tide

$Y(t)$ = non-tidal -surge– residual-



Extreme Events:

1. > 99th percentile of meteorological forcing ($R_{2\%}$ + Y(t))

Synoptic catalogue

1. **Development: classical approach based on the combination of multivariate techniques (Yarnal, 1993; Comrie, 1996)**:
   - **Preprocessing:** original fields filtered (grid point anomalies from a 11 days moving average)
   - **PCA**
     - S-mode
     - Correlation matrix
     - VARIMAX rotation
   - **Cluster Analysis**
     - Two algorithms
       - K-MEANS (SAS procedure; 10000 random realizations, selected maximum ECV by COST733software)
       - SANDRA (1000 random realizations by COST733software)
     - Subjective number of cluster (from 4 to 15 clusters)

Synoptic catalogue

2. **Validation: Discriminant Analysis**
   - **Purpose**:
     - ⇨ k-means algorithm is sensitive to the initial partition
     - ⇨ Can be trapped within a local optima
   - **Structure of the test**
     - ⇨ Random selection of cases: 75 % for classifying, 25 % for testing
     - ⇨ Cross-validation
     - ⇨ Repeated 1000 times

3. **Validation: 2-sample Kolmogorov-Smirnov** to test the equality of the distribution of a variable under a synoptic pattern against all others (see Radan's chapter on COST733 draft report)

Validation of the synoptic catalogue

Validation of the synoptic catalogue

1. **Discriminant Analysis**
   - K-means (SAS) classifies correctly 93 %
   - K-means (COST733) classifies correctly 95 %
   - SANDRA (COST733) classifies correctly 97 %

SANDRA (COST733)

K-means (COST733)

	1	2	3	4	5	6
1	91	7	4	7	3	3
2	1	85	2	15	1	1
3	2	1	86	4	2	4
4	2	2	8	62	3	10
5	4	4	0	8	2	81
6	0	1	0	4	91	2

K-means (SAS)

	1	2	3	4	5	6
1	4	18	90	7	21	15
2	9	72	0	1	2	34
3	3	1	0	81	4	9
4	3	5	8	9	5	37
5	78	2	2	2	1	2
6	2	2	0	0	68	3

Validation of the synoptic catalogue

Kolmogorov Smirnov test

SURGE	CP1	CP2	CP3	CP4	CP5	CP6
BREST	9,07	3,37	11,23	4,4	5,75	19,18
SABLES	6,18	2,08	8,28	2,71	4,63	17,08
BILBAO	3,99	4,19	8,65	2,98	3,68	19,45
GIJON	6,23	3,26	5,27	3,06	2,32	18,99
CORUÑA	6,33	3,10	2,83	6,56	3,77	19,87
VIGO	5,97	3,89	3,54	6,4	5,25	21,3

Tp	CP1	CP2	CP3	CP4	CP5	CP6
BREST	5,02	2,61	11,00	**1,12**	11,43	2,80
SABLES	5,18	1,98	10,78	1,21	10,72	2,81
BILBAO	5,69	3,78	10,64	2,96	12,66	1,91
GIJON	4,32	3,72	9,30	1,82	9,07	0,61
CORUÑA	4,13	2,69	9,38	**0,72**	9,26	2,66
VIGO	6,11	2,69	7,41	**0,56**	8,65	2,71

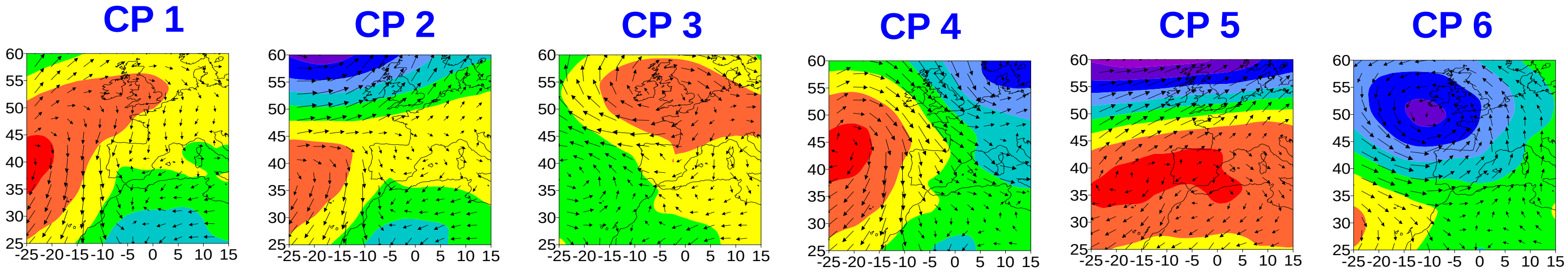
Hs	CP1	CP2	CP3	CP4	CP5	CP6
BREST	6,14	1,28	13,73	1,36	12,9	5,78
SABLES	5,14	2,77	12,03	3,06	10,47	6,10
BILBAO	2,98	2,48	14,09	6,16	10,53	1,61
GIJON	2,23	2,39	10,56	3,94	8,45	2,69
CORUÑA	1,44	1,77	8,84	**0,54**	7,79	6,42
VIGO	4,54	1,40	12,68	2,01	7,32	10,11

Oceanographic characterization

Oceanographic characterization

Average fields (SANDRA)

Sea level pressure and wind vectors


CP 1

CP 2

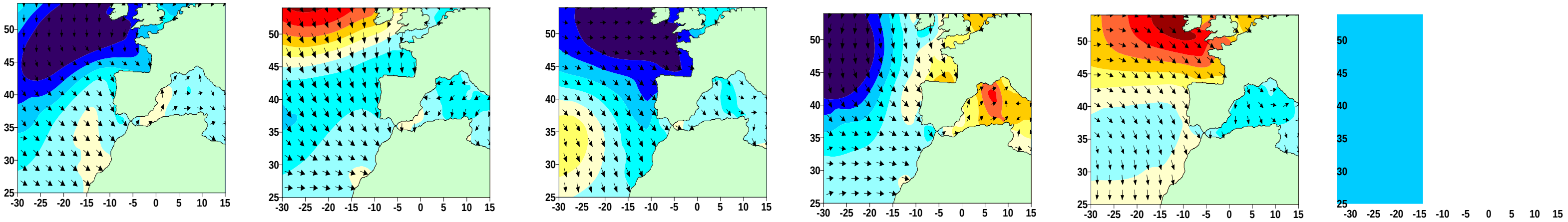
CP 3

CP 4

CP 5

CP 6

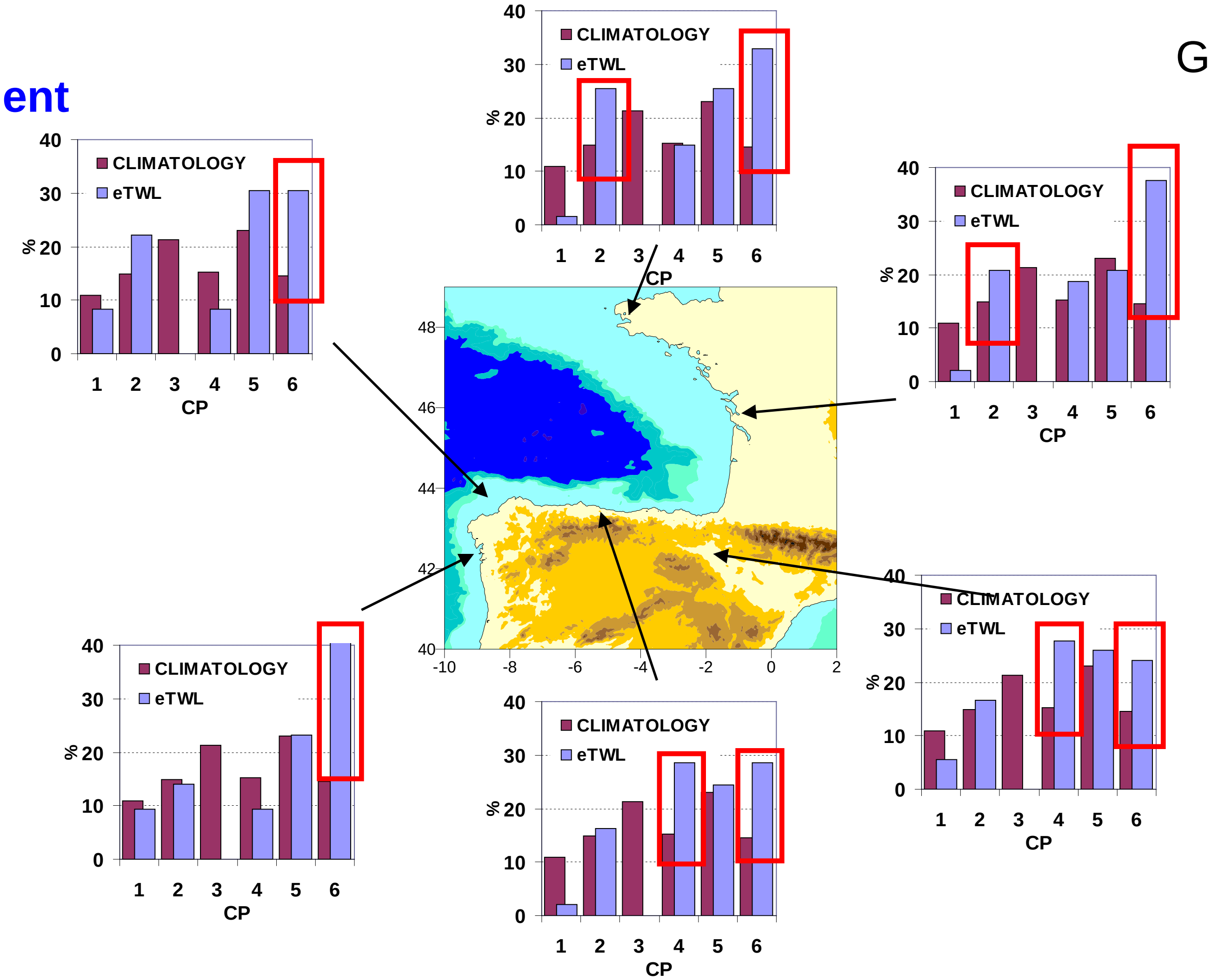
Hs anomalies and wave direction



Oceanographic characterization

Extreme (independent events)

Geographical pattern



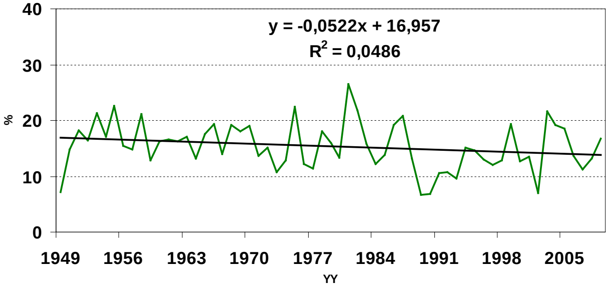
How is evolving the storm climate?

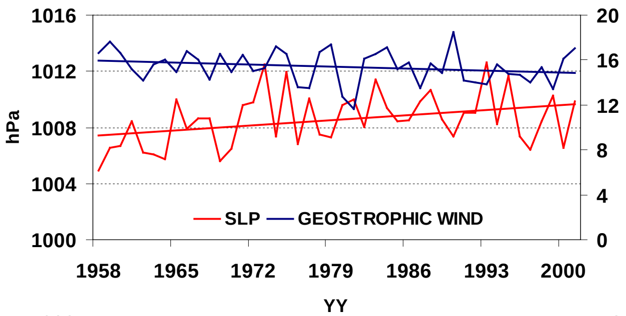
How is evolving the storm climate?

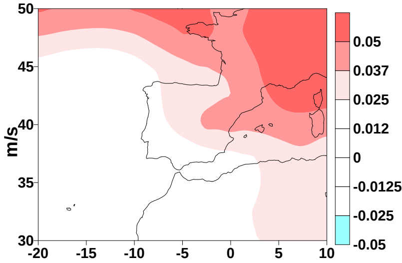
Frequency of occurrence

Within type variability

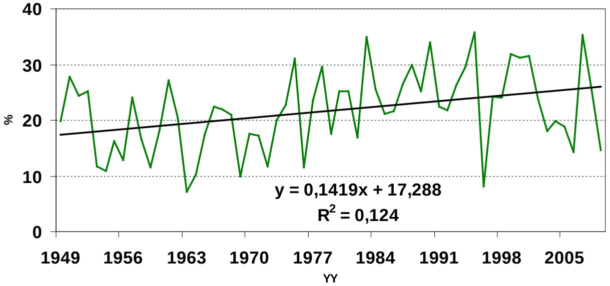
CP6

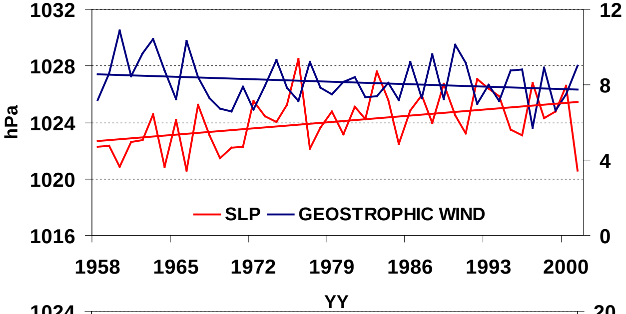


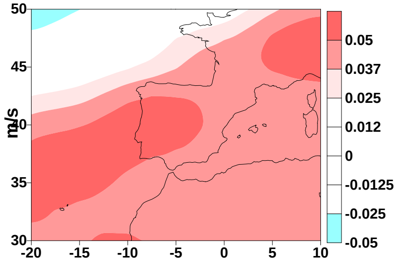




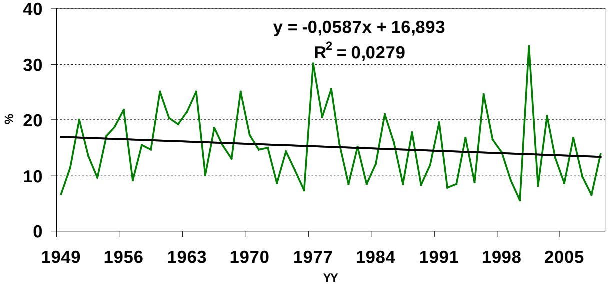
CP5

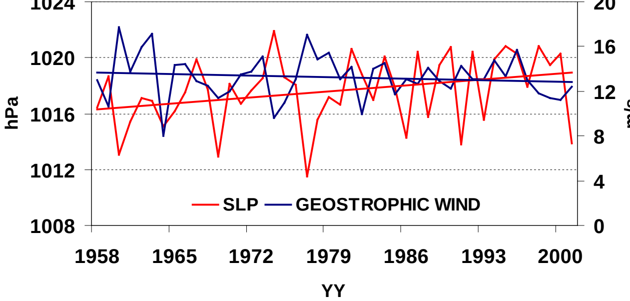


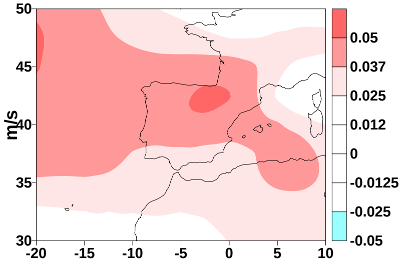




CP4



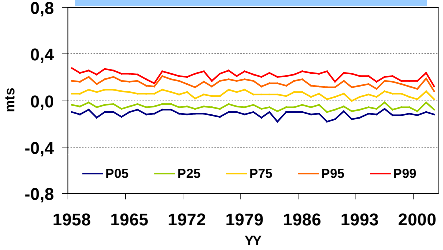




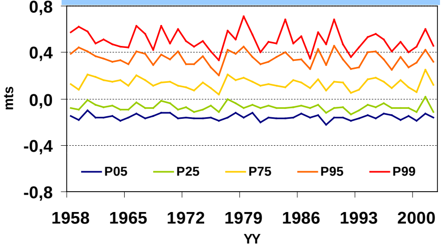
How is evolving the storm climate?

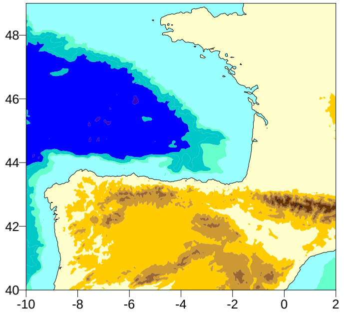
Storm surges

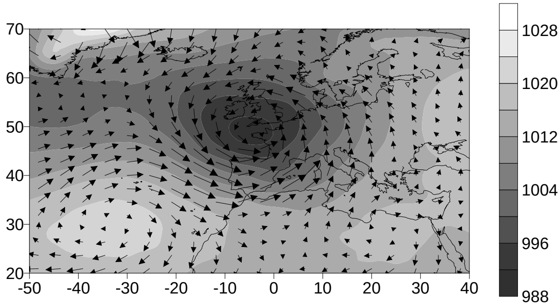
La Coruña



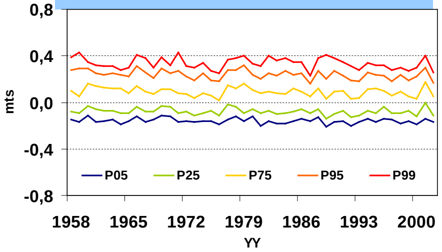
Brest



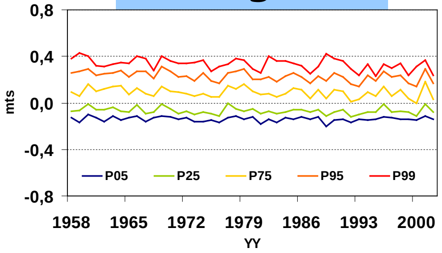




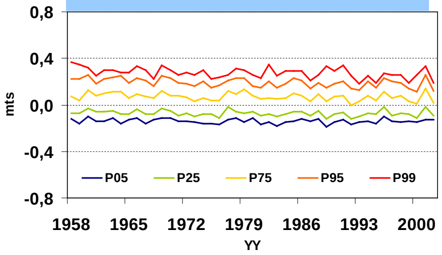
Sables Olonne



Vigo



Santander

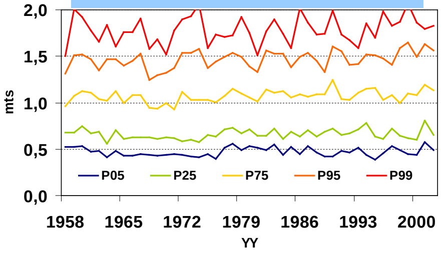


	P05	**P25**	**P75**	**P95**	**P99**
BREST	-0,12	-0,13	-0,12	-0,18	-0,18
SABLES OLONNE	-0,22	-0,20	-0,26	-0,26	-0,22
SANTANDER	-0,18	-0,22	**-0,31**	**-0,45**	**-0,43**
CORUÑA	-0,22	-0,20	**-0,30**	**-0,46**	**-0,46**
VIGO	-0,11	-0,21	-0,29	**-0,47**	**-0,42**

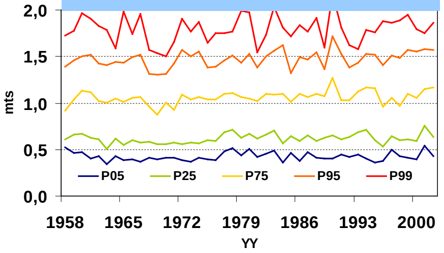
How is evolving the storm climate?

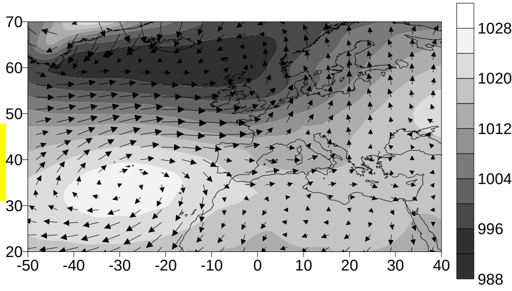
Wave Run up

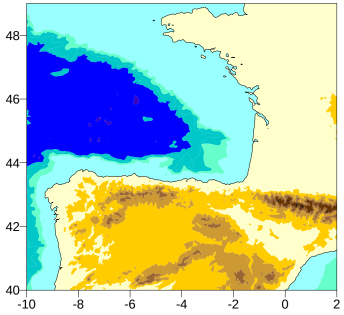
La Coruña



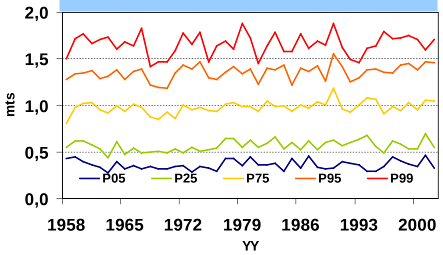
Brest



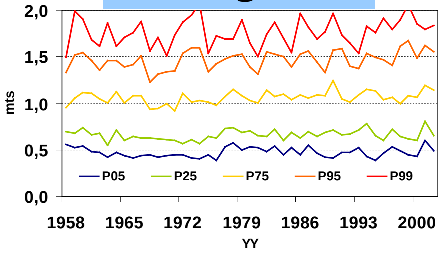




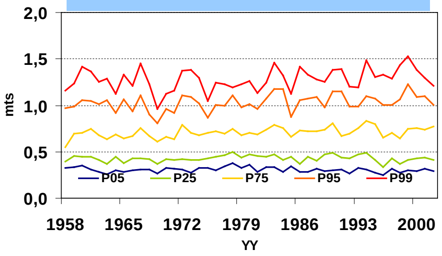
Sables Olonne



Vigo

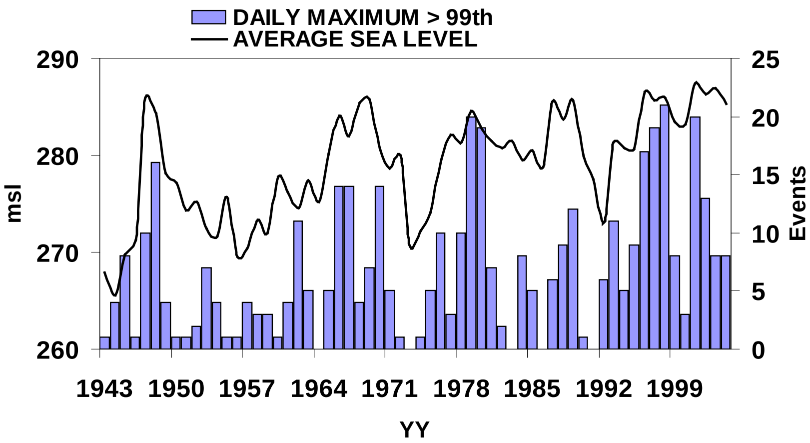


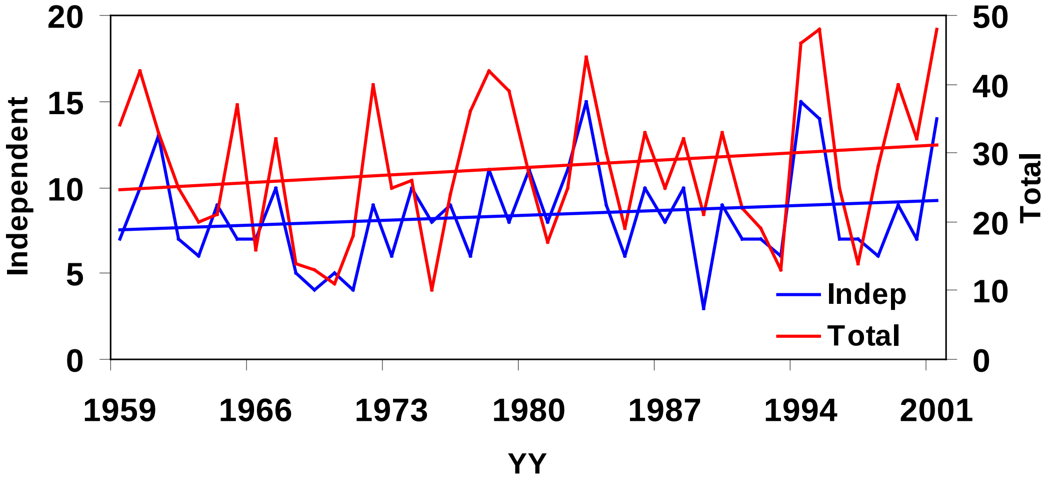
Santander

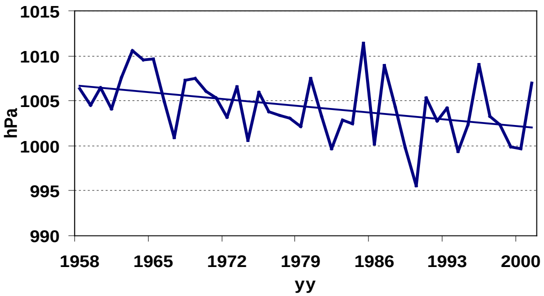


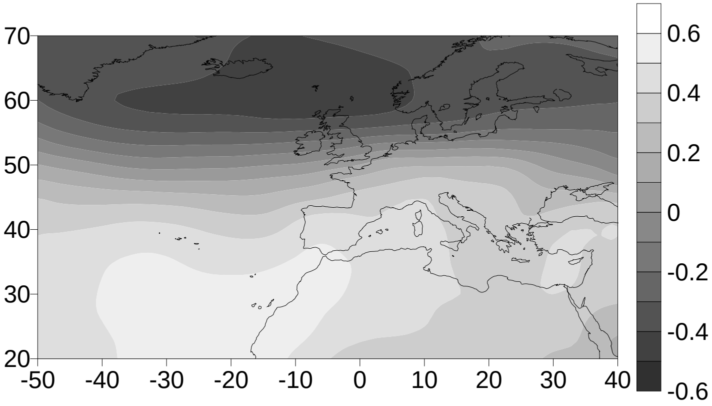
	P05	P25	P75	P95	P99
BREST	0.07	0.29	**0.39**	**0.36**	0.12
SABLES OLONNE	0.08	0.24	**0.38**	**0.38**	0.09
SANTANDER	-0.17	0.06	**0.46**	**0.35**	0.29
CORUÑA	0.08	0.22	**0.38**	**0.39**	0.20
VIGO	0.07	0.21	**0.37**	**0.37**	0.21

Effect on potential coastal flooding/erosion









Conclusions (1)

QUESTION 1:

- Synoptic climatology methods are suitable:
  - Storm surges: lows tracking close to the region (inverse barometer effect)
  - Wave activity: need of long fetches (diversity of lows)
- K-means and SANDRA (COST733 software) offer almost similar results
  - Preprocessing ¿enhances K-means? ¿weakens SANDRA?
  - SANDRA computing intensive

Conclusions (2)

- **QUESTION 2**:
  - Reduction of storminess
    - Less storms
    - Weaker storms (more southerly component)
  - Paradox effect on potential coastal flooding/erosion
    - Reduced regional storminess (storm surges) has been balanced by the effect of distant storms (waves)
    - The inclusion of actual sea levels (astronomical tides –semi diurnal- plus long-term trends) means more eTWL by storm (persistence)

I would like to thank my colleagues from COST733 action, who provided the COST733 software and many instructive talks about synoptic classification

Thanks for your attention