ESTCENA
Escenarios regionales de cambio climático: Downscaling estadístico

UNIVERSITAT DE BARCELONA

GAMA
Meteorological Hazards Analysis

Impact of climate change in the mean and extreme precipitation regimes over Spain

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Climate change in the Pyrenees: vulnerability, impacts, mitigation and adaptation
FLUXPYR and OPCC Meeting, Barcelona – 5 to 8 June 2012

Objectives

To show the main results achieved at scale of all Peninsular Spain

To focus on hydrometeorological extremes in Catalonia

To show other results on the evolution of natural risks in Catalonia

ESTCENA

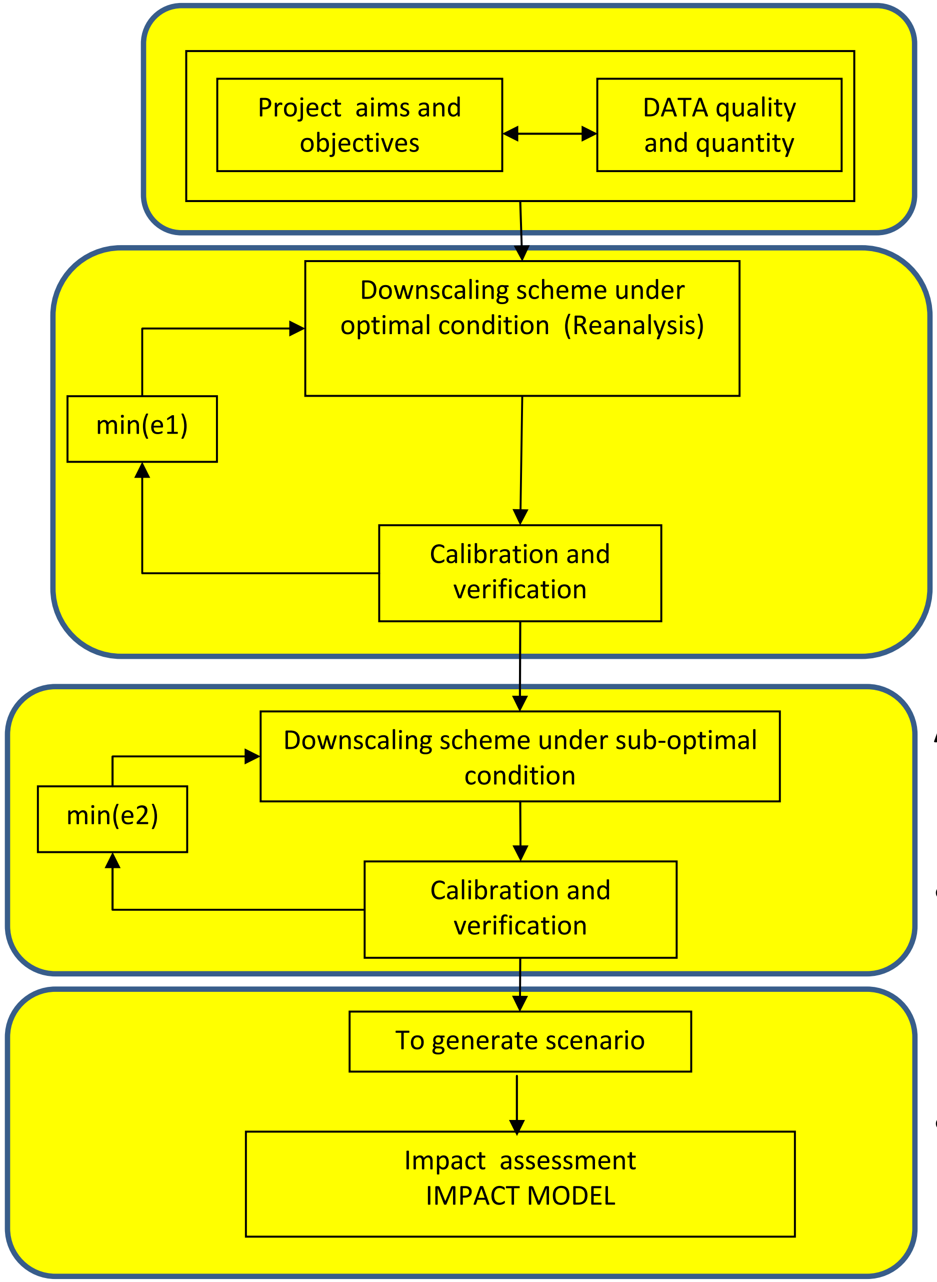
Escenarios regionales de cambio climático:
Downscaling estadístico

Project type: National project
Funding institution: Ministerio de Medio Ambiente y Medio Rural y Marino, Oficina Española del Cambio Climático
Program: Spanish R+D Program 2008-2011

Objective: to produce regional (20 km) and local (stations) scenarios for temperature and precipitation (averages and extremes) for the XXI century, at daily scale in Spain, by statistical downscaling; to focus on the uncertainty and on the robustness of the regional scenarios

September 2009-June 2012
More info: http://www.meteo.unican.es/en/projects/esTcena

STRATEGY (follow IPCC guidelines, Wilby et al. 2004)



Spain02, 1950-2008, 20kmx20km

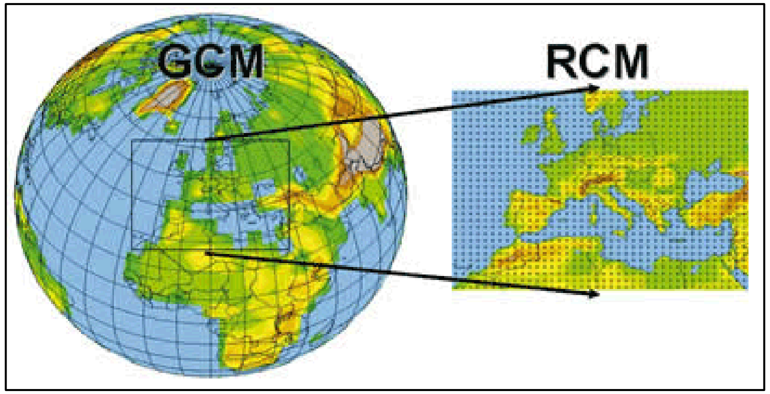
Extremes
E.g. heavy rainfall proportion (R95p /PRCPTOT) or the longest dry period (CDD)

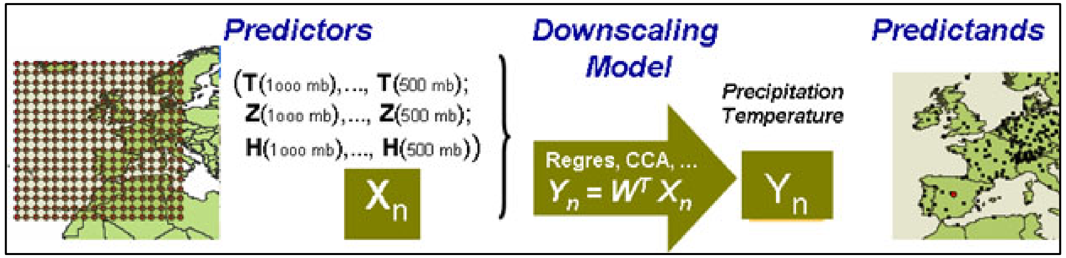
•Uncertainty
Using different scenarios, different GCM models, different downscaling methods

•Impact on Fires

Traditional approach

Dynamical downscaling	OR	Statistical downscaling
GCM		GCM
↓		↓
RCM		Statistical downscaling
↓		↓
Downscaled data		Downscaled data

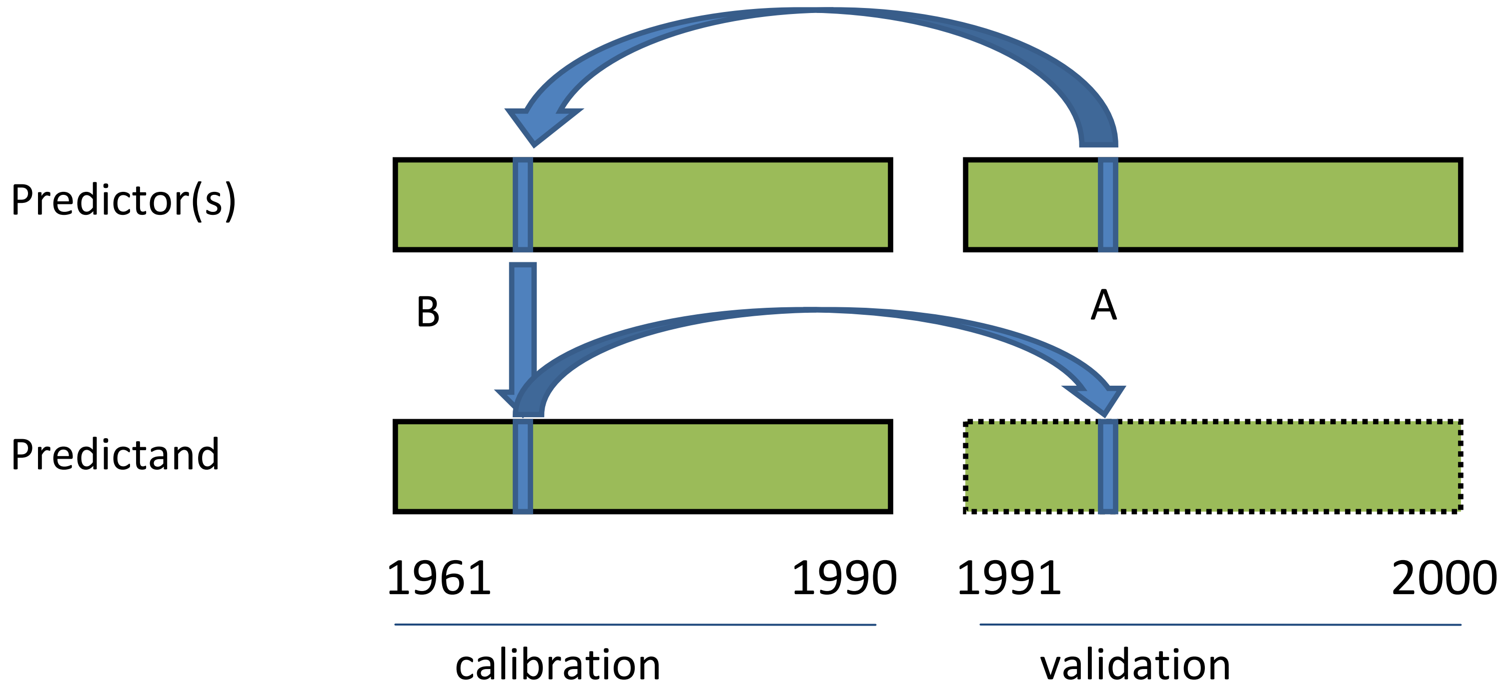




Source: UC, http://grupos.unican.es/ai/meteo/ensembles/downscaling/index.html

Analog Method

This method assumes that "analogue" weather patterns (predictors) should cause "analogue" local effects (predictands).



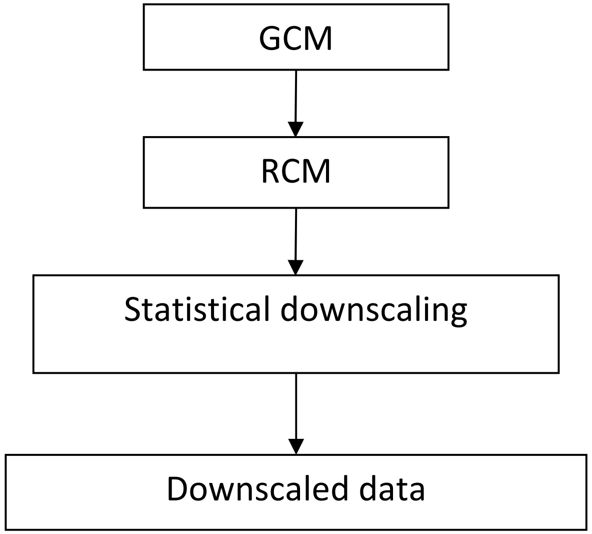
adapted from Fernández and Sáenz (2003)

Hybrid approach

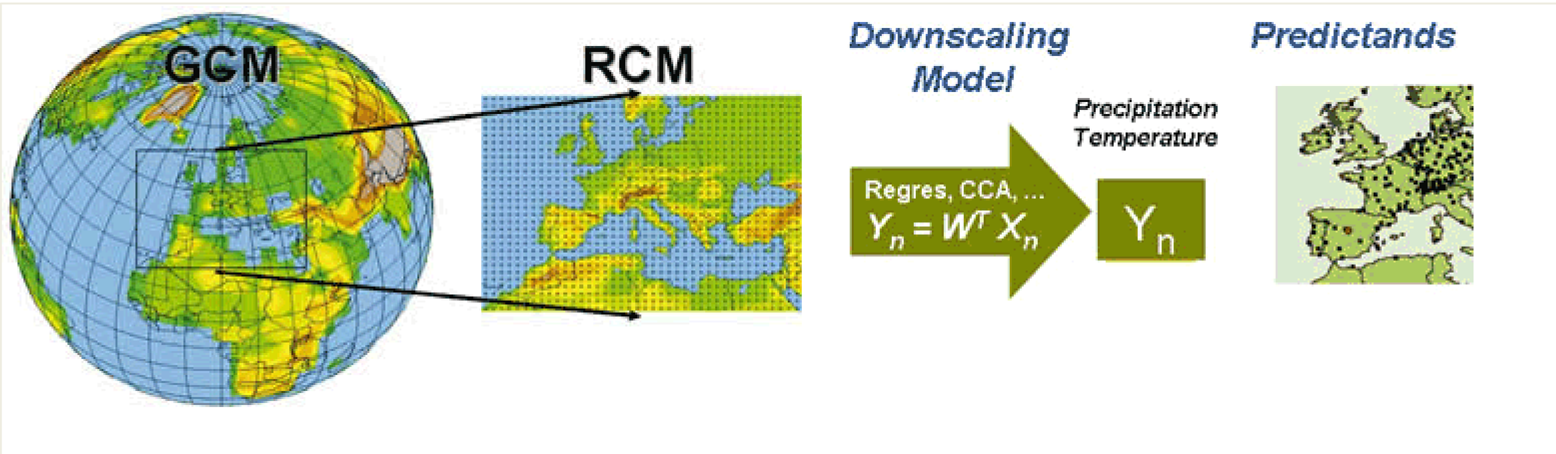
Dynamical

AND

Statistical downscaling



Model Output Statistics (MOS): the model output for the variable of interest is directly downscaled using observations or the predictions of this variable.



Maraun et al 2010, Themebl et al 2010, Piani et al 2010

12 RCM Simulations; 15 GCM-driven simulations; (ENSEMBLES project);

Table 2.1: Summary of the RCM simulations nested in ERA40 data produced for the ENSEMBLES project. The columns are the acronym used in this PhD thesis, the institution running the simulation, the model used and a reference publication.

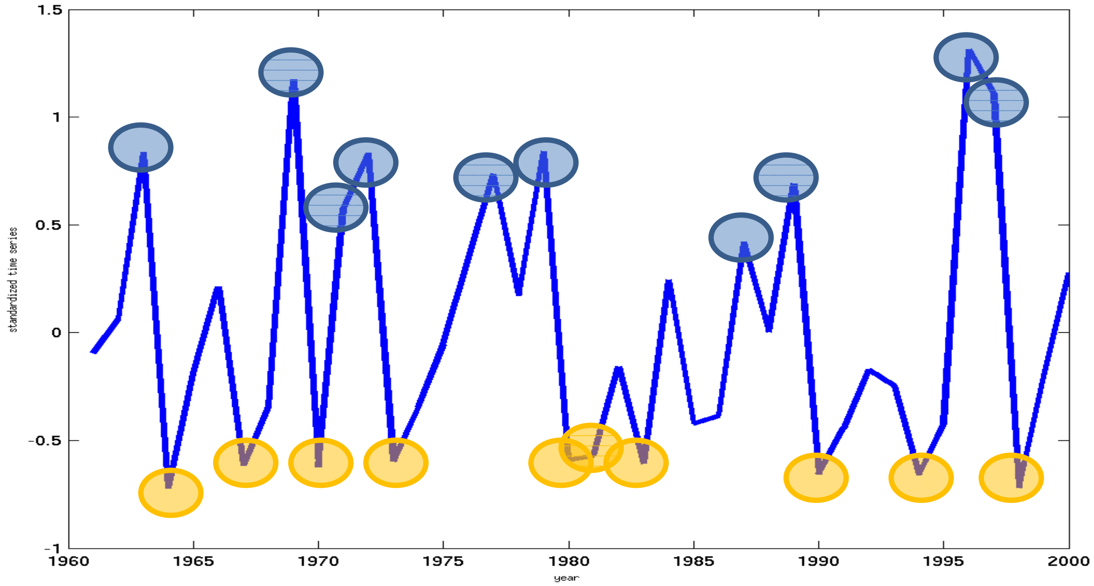
Acronym	Institution	Model	Reference
C4I	The Community Climate Change Consortium for Ireland	RCA3	*Kjellstrm et al.* (2005)
CNRM	Centre National de Recherches Meteorologiques	ALADIN-Climat	*Radu et al.* (2008)
DMI	Danish Meteorological Institute	HIRHAM	*Christensen et al.* (2008)
ETHZ	Swiss Institute of Technology	CLM	*Jaeger et al.* (2008)
KNMI	Koninklijk Nederlands Meteorologisch Instituut	RACMO	*Van Meijgaard et al.* (2008)
HC	Hadley Center/UK MetOffice	HadRM3 Q0	*Collins et al.* (2006)
ICTP	Abdus Salam International Centre for Theoretical Physics	RegCM3	*Pal et al.* (2007)
METNO	The Norwegian Meteorological Institute	HIRHAM	*Haugen and Haakensatd* (2005)
MPI	Max Planck Institute for Meteorology	M-REMO	*Jacob* (2001)
OURANOS	Consortium on Regional Climatology and adaptation to Climate Change	MRCC4.2.1	*Plummer et al.* (2006)
SMHI	Swedish Meteorological and Hydrological Institute	RCA	*Kjellstrm et al.* (2005)
UCLM	Universidad de Castilla la Mancha	PROMES	*Sanchez et al.* (2004)

Table 2.2: GCM-driven RCMs produced for the ENSEMBLES project and used in this study, with the corresponding driving GCM.

Acronym	RCM	Driving GCM	Reference
C4I	RCA3	HadCM3Q16	*Kjellstrm et al.* (2005)
CNRM	ALADIN	ARPEGE	*Radu et al.* (2008)
DMI	HIRHAM	ARPEGE	*Christensen et al.* (2008)
DMI-BCM	HIRHAM	BCM	*Christensen et al.* (2008)
DMI-ECHAM5	HIRHAM	ECHAM5	*Christensen et al.* (2008)
ETHZ	CLM	HadCM3Q0	*Jaeger et al.* (2008)
HC	HadRM3Q0	HadCM3Q0	*Haugen and Haakensatd* (2005)
ICTP	RegCM3	ECHAM5	*Pal et al.* (2007)
KNMI	RACMO	ECHAM5	*Van Meijgaard et al.* (2008)
MPI	M-REMO	ECHAM5	*Jacob* (2001)
OURANOS	MRCC4.2.1	CGCM3	*Plummer et al.* (2006)
SMHI-BCM	RCA	BCM	*Kjellstrm et al.* (2005)
SMHI-ECHAM5	RCA	ECHAM5-r3	*Kjellstrm et al.* (2005)
SMHI-HC-Q3	RCA	HadCM3Q3	*Kjellstrm et al.* (2005)
UCLM	PROMES	HadCM3Q0	*Sanchez et al.* (2004)

Validation

30 years for calibration, 10 for testing
2 experiments, test on driest/wettest period



Period	Years
Wettest	1996, 1969, 1997, 1979, 1963, 1972, 1977, 1989, 1971 and 1987
Driest	1964, 1998, 1994, 1990, 1970, 1967, 1983, 1973, 1980 and 1981

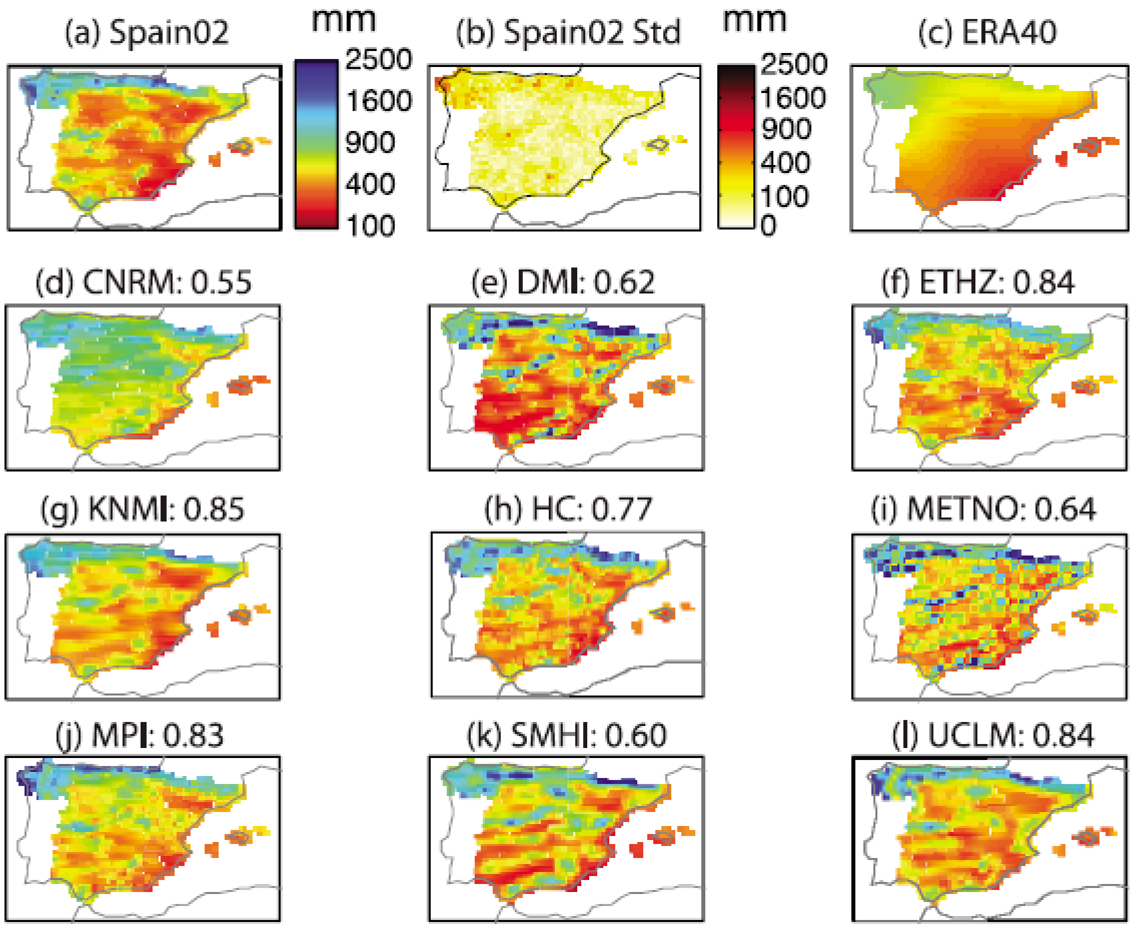
The wettest (driest) years have been identified in this way: the annual total precipitation in wet days for each point has been standardized, spatial averaged and finally sorted

Table 1: Indicators of subset of the ETCCDI precipitation indices used in this study.

Name	**Description**	**Definition**
$PRCPTOT$ (mm)	Total precipitation in wet days	Let RR_{wj} be the daily precipitation amount on a wet day w ($RR \geq 1$ mm) in period j. Then $PRCPTOT_j$ =sum(RR_{wj}).
$SDII$ (mm/d)	Mean precipitation amount on a wet day (Simple Daily Intensity Index)	If W represents the number of wet days in period j then the simple precipitation intensity index $SDIIj$ = sum (RR_{wj}) / W.
$R95p = R95pTOT/PRCPTOT$ (%)	Percentage of precipitation due to very wet days (heavy rainfall proportion)	Let $RRwn95$ be the 95th percentile of precipitation on wet days in the base period n (1961-1990). Then $R95pTOT$j = sum (RR_{wj}), where RR_{wj} > RRwn95. The ratio R95pTOT/PRCPTOT represents the percentage of precipitation due to very wet days.
$RX5DAY$ (mm/5d)	Highest precipitation amount in five-day period	Let RR_{kj} be the precipitation amount for the five-day interval k in period j, where k is defined by the last day. The maximum five-day values for period j are $RX5day_j$ = max (RR_{kj}).
CDD (days)	Maximum length of dry spell (Consecutive Dry Days)	Let RR_{ij} be the daily precipitation amount on day i in period j. Count the largest number of consecutive days where RR_{ij} <1 mm.

But, how well the RCMs work?

Annual precipitation climatology (1961-2000) of (a) the Spain02 grid and (b) its standard error (see text). (c) ERA-40 annual precipitation climatology. Annual precipitation climatologies interpolated to the Spain02 grid of the models (d) CNRM, (e) DMI, (f) ETHZ, (g) KNMI, (h) HC, (i) METNO, (j) MPI, (k) SMHI, and (l) UCLM.



Source: Herrera et al. 2010 JGR

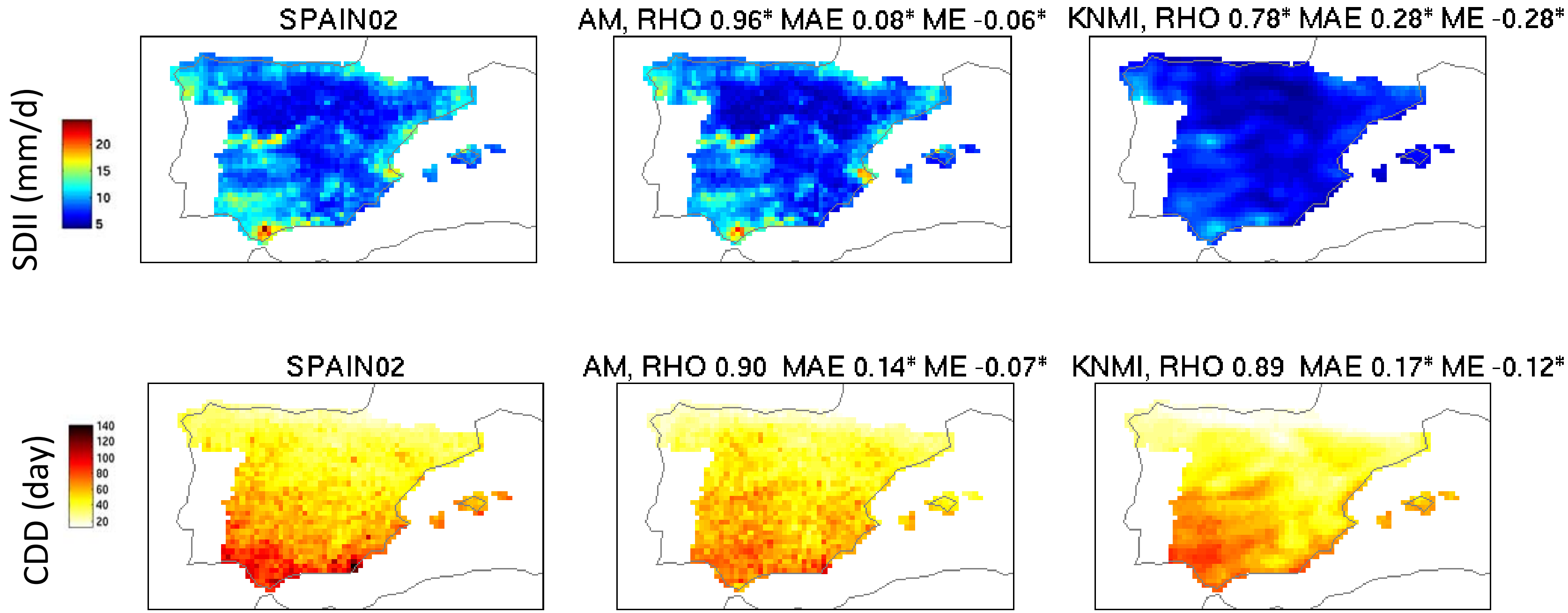
STATISTICAL DOWNSCALING: the analog method as a MOS-like downscaling for ENSEMBLES RCM-precipitation

METHOD:

- Dynamical AND Statistical downscaling
- Analog method as a MOS, using the RCM simulated precipitation as predictor

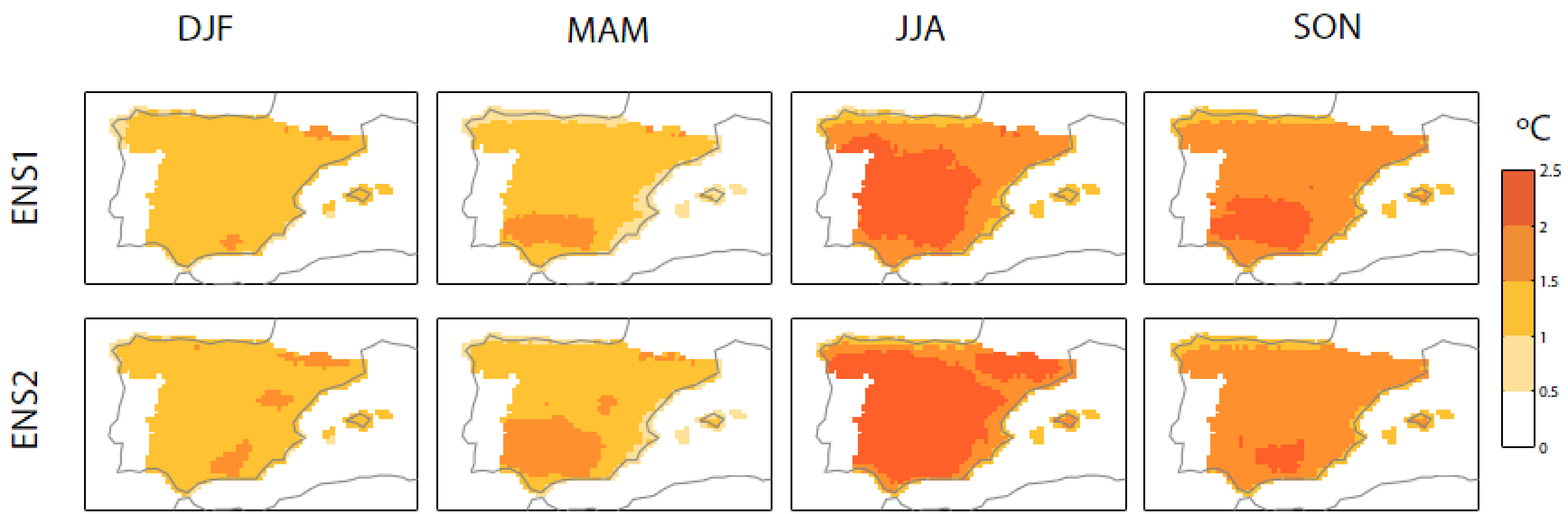
VERIFICATION:

- Overall, the MOS analog method is able to improve the reliability scores for all RCMs (10)
- It maintains the <u>spatial coherence</u> of the precipitation fields (which is very important for hydrology),
- it is <u>parsimonious</u> (so that one can assume that it is also robust) and <u>transferable</u> (since it performs well in the different climates of Spain).



MORE DETAILS --> Turco M., Quintana Seguí P., Llasat M. C., Herrera S., Gutiérrez J. M. Testing MOS Precipitation Downscaling for ENSEMBLES Regional Climate Models over Spain. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, D18109, 14 PP., 2011. doi:10.1029/2011JD016166

Temperature difference (ºC) between the baseline (1971-2000) and future (2021-2050)

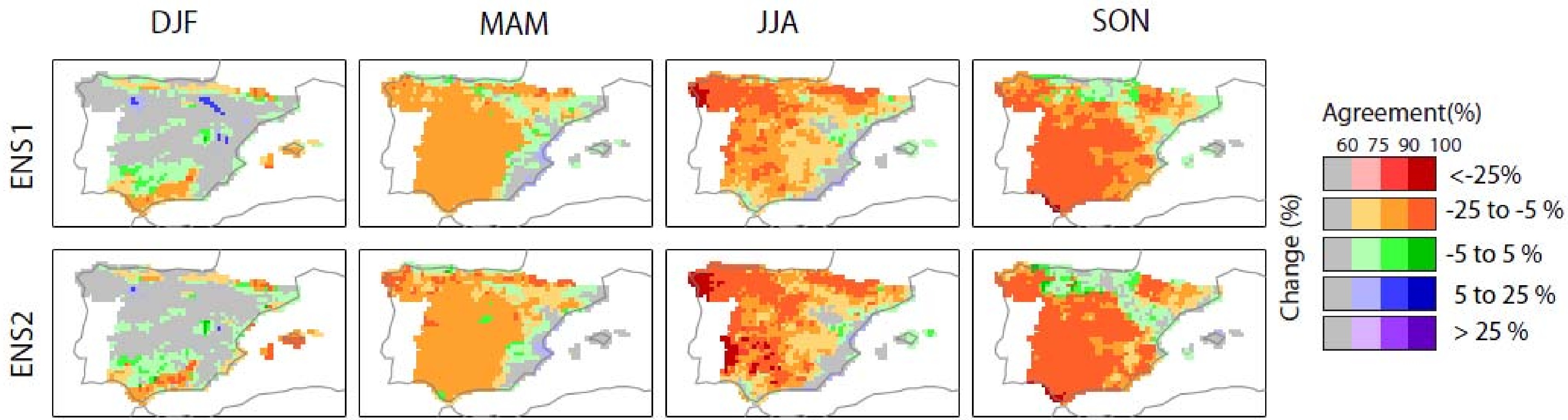


(top) the ensemble of all the available RCMs and (bottom) the ensemble of the best RCMs.

The ensemble agreement is very high: the standard deviation of the ensemble members is always around 0.5 C.

(Turco, 2012, PhD)

Precipitation change (% respect to the baseline) between the baseline (1971-2000) and future (2021-2050) periods



(top) the ensemble of all the available RCMs and (bottom) the ensemble of the best RCMs. The colour saturation level shows the percentage agreement in the direction of change among the ensemble RCMs.

(Turco, 2012, PhD)

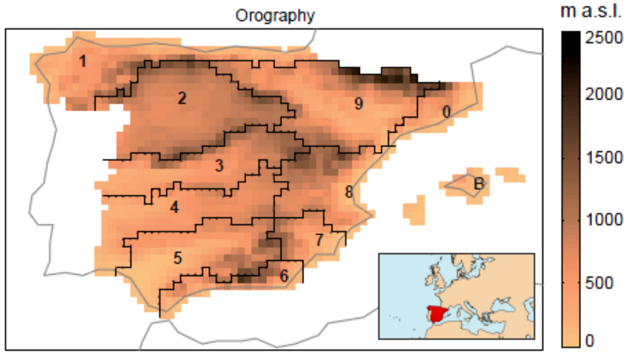
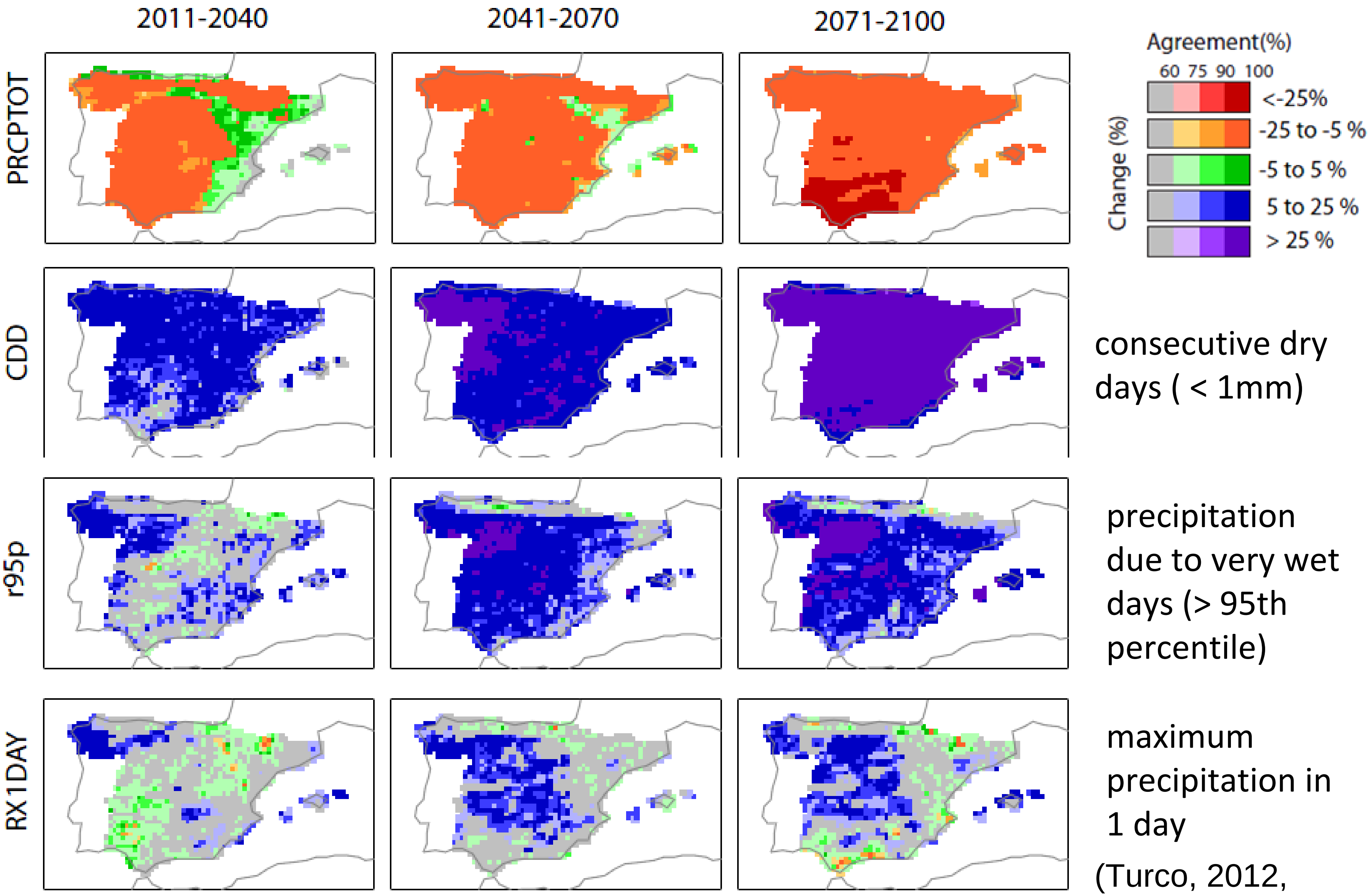


Figure 1. Area of Study and topography of Spanish Iberian Peninsula and the Balearic Islands as represented by *Spain02* at 0.2° x 0.2°, showing the main river basins: 0.Catalana, 1. Norte, 2. Duero, 3. Tajo, 4. Guadiana, 5. Guadalquivir, 6. Sur, 7. Segura, 8. Levante, 9. Ebro, B. Baleares.

Basin	Season	1971-2000 Observed (mm)	1971-2000 Simulated $_{min}mean^{max}$	2021-2050 Projected $_{min}mean^{max}$ (change %)
Sur	DJF	210	$_{83}188^{343}$	$_{-20}-5^{+13}$
	MAM	114	$_{46}128^{235}$	$_{-31}-7^{+32}$
	JJA	16	$_{5}29^{88}$	$_{-42}-5^{+51}$
	SON	144	$_{68}164^{292}$	$_{-32}-18^{+3}$
Segura	DJF	80	$_{46}98^{189}$	$_{-20}-2^{+17}$
	MAM	95	$_{53}94^{153}$	$_{-26}-1^{+36}$
	JJA	39	$_{7}37^{79}$	$_{-34}+2^{+51}$
	SON	107	$_{65}121^{182}$	$_{-22}-10^{+7}$
Levante	DJF	110	$_{62}128^{228}$	$_{-13}-1^{+13}$
	MAM	116	$_{72}132^{200}$	$_{-22}-1^{+31}$
	JJA	61	$_{12}61^{126}$	$_{-30}-3^{+37}$
	SON	150	$_{85}158^{239}$	$_{-18}-7^{+9}$
Ebro	DJF	140	$_{107}210^{350}$	$_{-17}-1^{+12}$
	MAM	163	$_{130}231^{362}$	$_{-20}-6^{+10}$
	JJA	106	$_{32}126^{232}$	$_{-36}-10^{+11}$
	SON	162	$_{126}217^{329}$	$_{-19}-5^{+9}$
Catalana	DJF	121	$_{74}139^{233}$	$_{-20}-3^{+14}$
	MAM	160	$_{107}176^{248}$	$_{-21}-2^{+17}$
	JJA	119	$_{20}106^{229}$	$_{-29}-5^{+28}$
	SON	196	$_{136}226^{366}$	$_{-30}-5^{+16}$
Baleares	DJF	139	$_{55}103^{148}$	$_{-21}-9^{+3}$
	MAM	107	$_{57}87^{130}$	$_{-22}+0^{+21}$
	JJA	39	$_{9}28^{53}$	$_{-34}+1^{+59}$
	SON	179	$_{87}151^{228}$	$_{-17}+0^{+14}$

Precipitation change (% respect to the baseline 1971-2000)



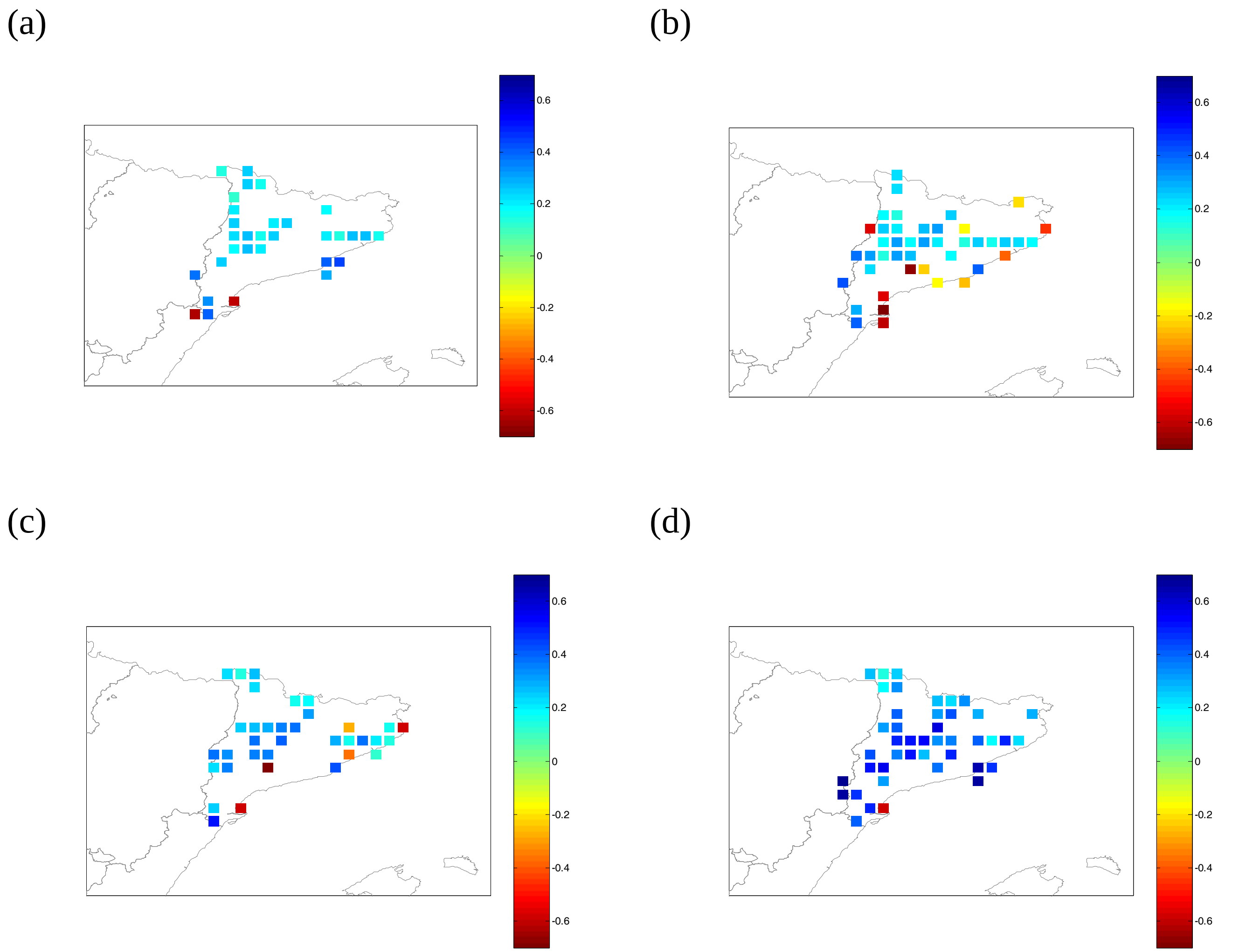
consecutive dry days (< 1mm)

precipitation due to very wet days (> 95th percentile)

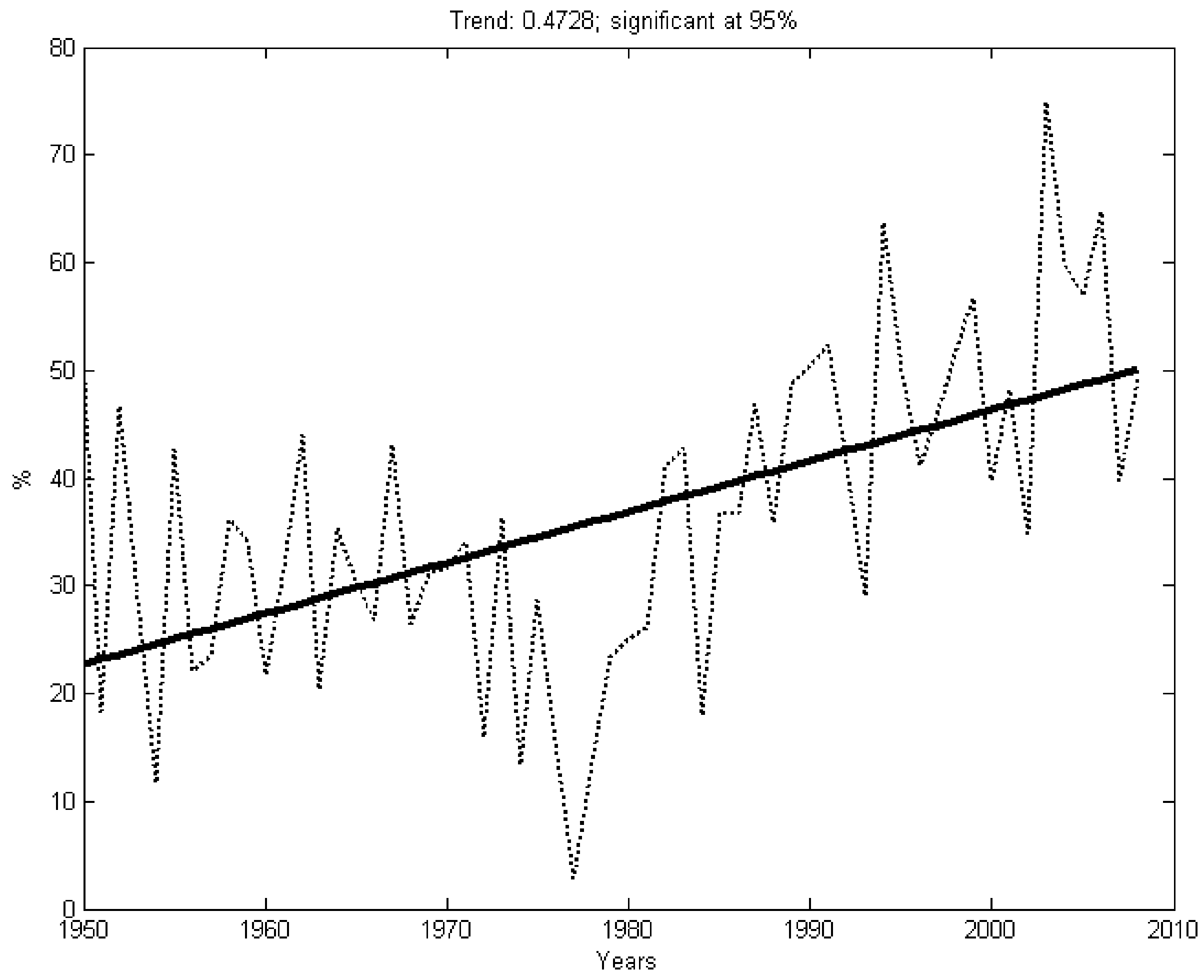
maximum precipitation in 1 day

(Turco, 2012,

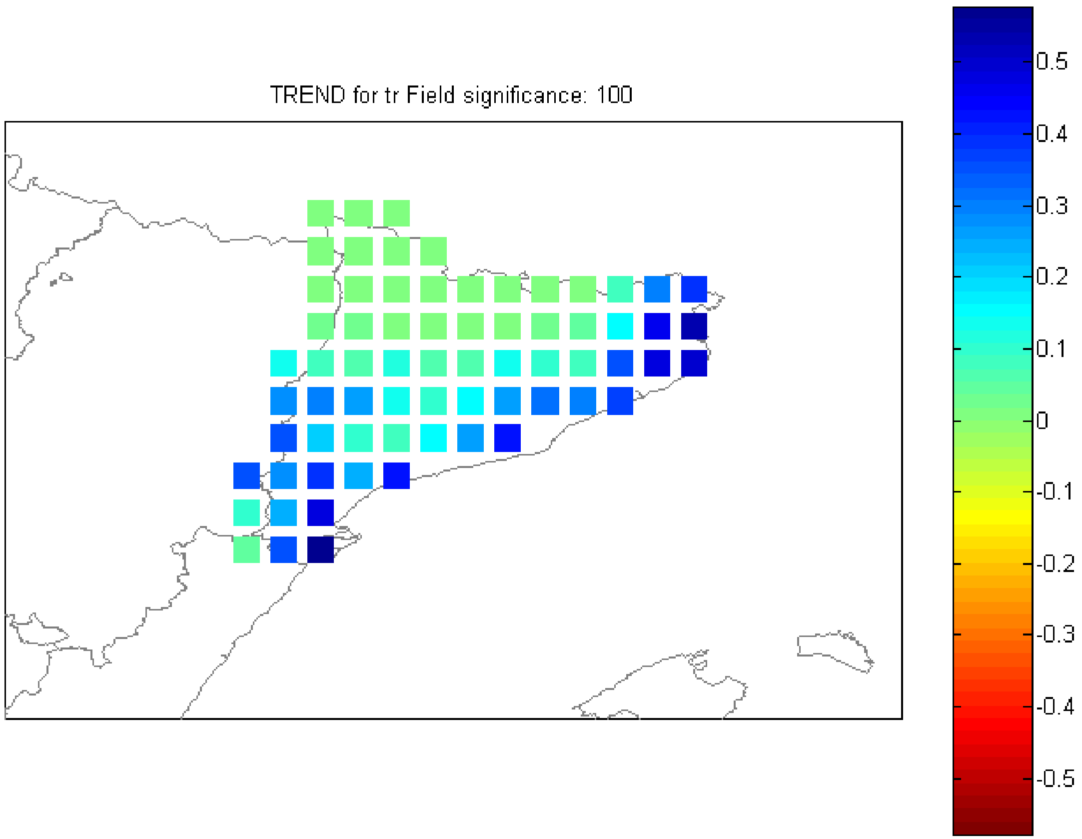

EXTREMES EVOLUTION IN CATALONIA



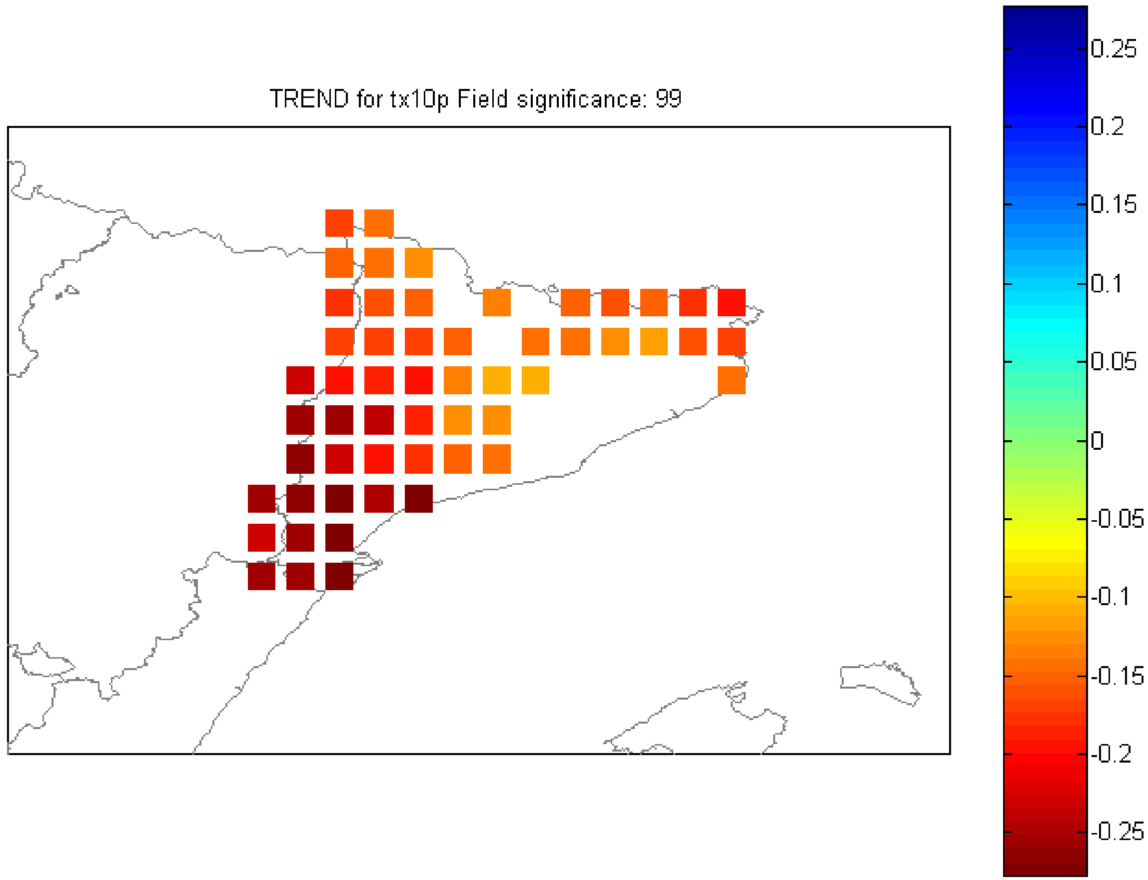
Evolution of CDD index (days/year); (a) 1951-2003, 53 years, (b) 1957-2003, 47 years, (c) 1963-2003, 41 years, (d) 1969-2003, 35 years. Significance at 99%. 30% of the territory; however, no average trend (Turco and Llasat, 2011)



Evolution of TN90p (% days with tmin<90%) (data from E-OBS, 1950-2008). Trend aprox 0,5%, significance 95%.



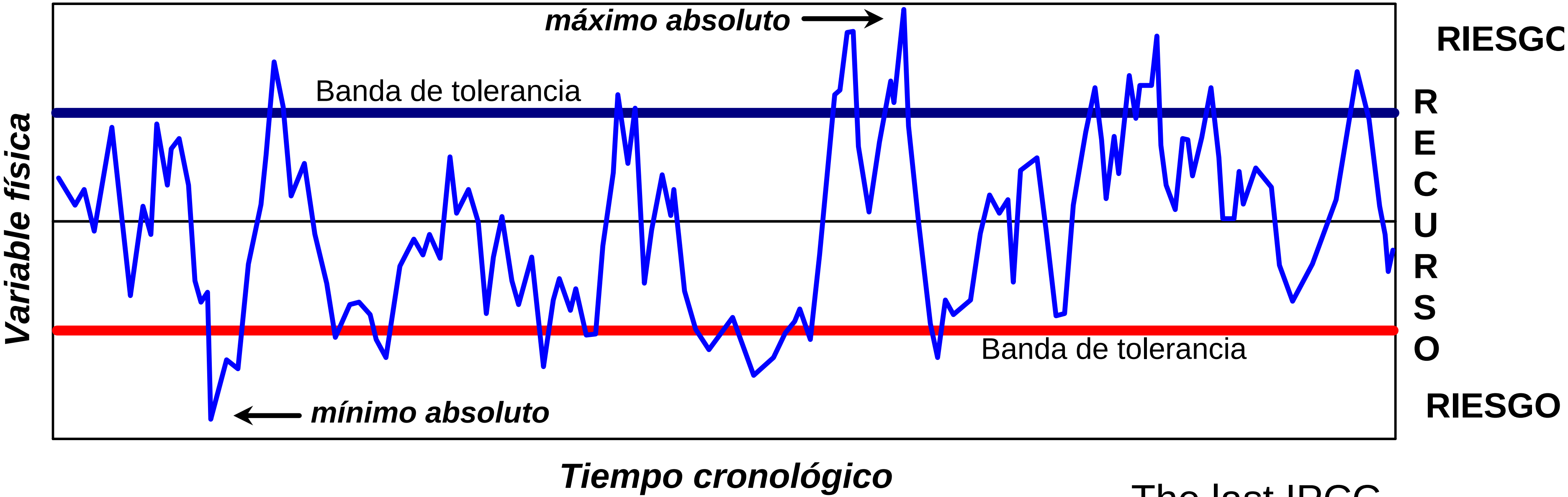
Evolution of TR20 (number of days with Tmin<20ºC); Trend>0,2% (exc: Pyrinean Region) significance 100%.



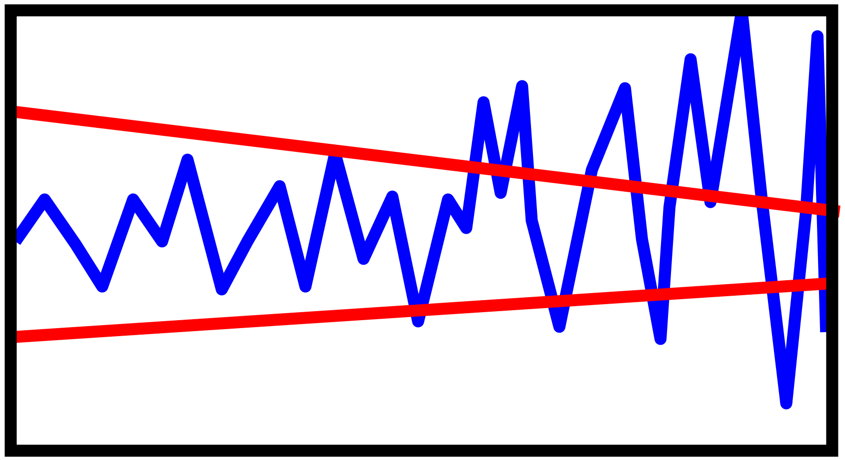
Evolution TX10p (% days with T mean<10%) (significance>99%)

NATURAL RISKS EVOLUTION IN CATALONIA (SICC, 2010)

Risk= hazard x vulnerability

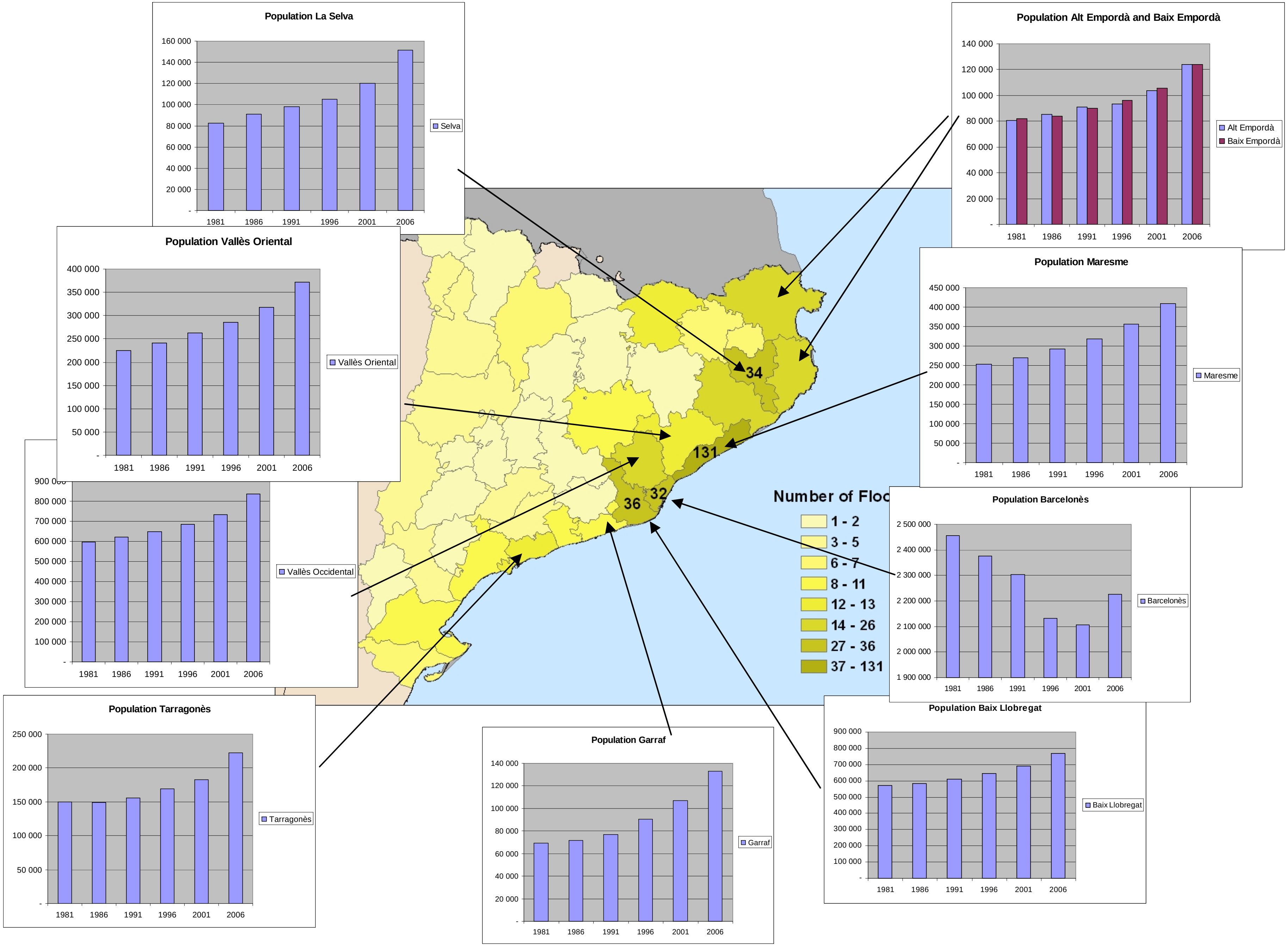


Water is a vital resource but outside the acceptable thresholds it is a risk

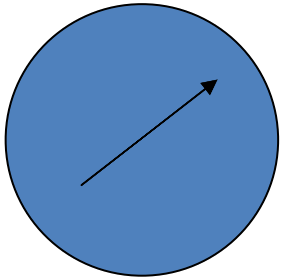


The last IPCC points to an increase of extremes

The band of tolerance seems to decrease



Population La Selva
160 000
140 000
120 000
100 000
80 000
60 000
40 000
20 000
-
1981
1986
1991
1996
2001
2006
Selva
Population Alt Empordà and Baix Empordà
140 000
120 000
100 000
80 000
60 000
40 000
20 000
-
1981
1986
1991
1996
2001
2006
Alt Empordà
Baix Empordà
Population Vallès Oriental
400 000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
-
1981
1986
1991
1996
2001
2006
Vallès Oriental
Population Maresme
450 000
400 000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
-
1981
1986
1991
1996
2001
2006
Maresme
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
-
1981
1986
1991
1996
2001
2006
Vallès Occidental
34
131
32
36
Number of Floo
1 - 2
3 - 5
6 - 7
8 - 11
12 - 13
14 - 26
27 - 36
37 - 131
Population Barcelonès
2 500 000
2 400 000
2 300 000
2 200 000
2 100 000
2 000 000
1 900 000
1981
1986
1991
1996
2001
2006
Barcelonès
Population Tarragonès
250 000
200 000
150 000
100 000
50 000
-
1981
1986
1991
1996
2001
2006
Tarragonès
Population Garraf
140 000
120 000
100 000
80 000
60 000
40 000
20 000
-
1981
1986
1991
1996
2001
2006
Garraf
Population Baix Llobregat
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
-
1981
1986
1991
1996
2001
2006
Baix Llobregat

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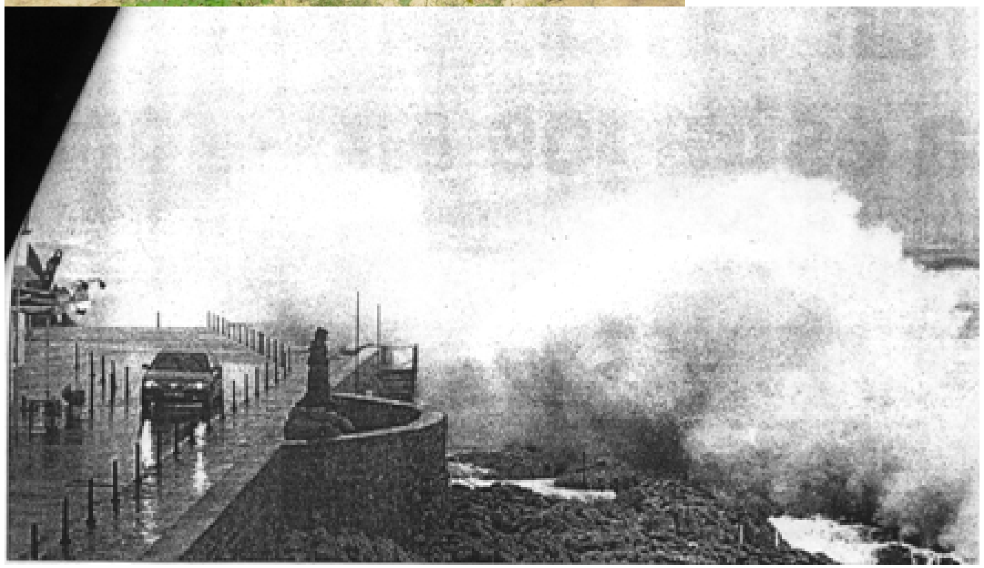
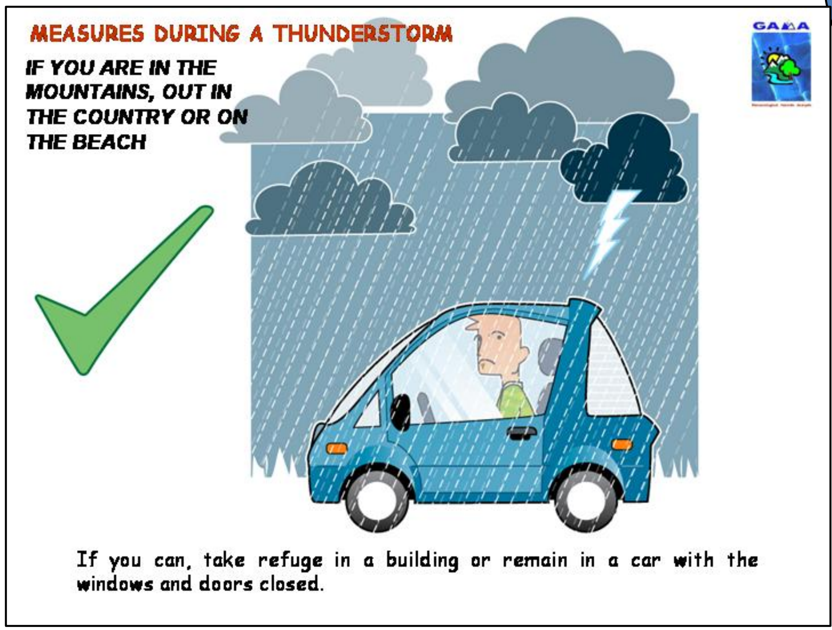
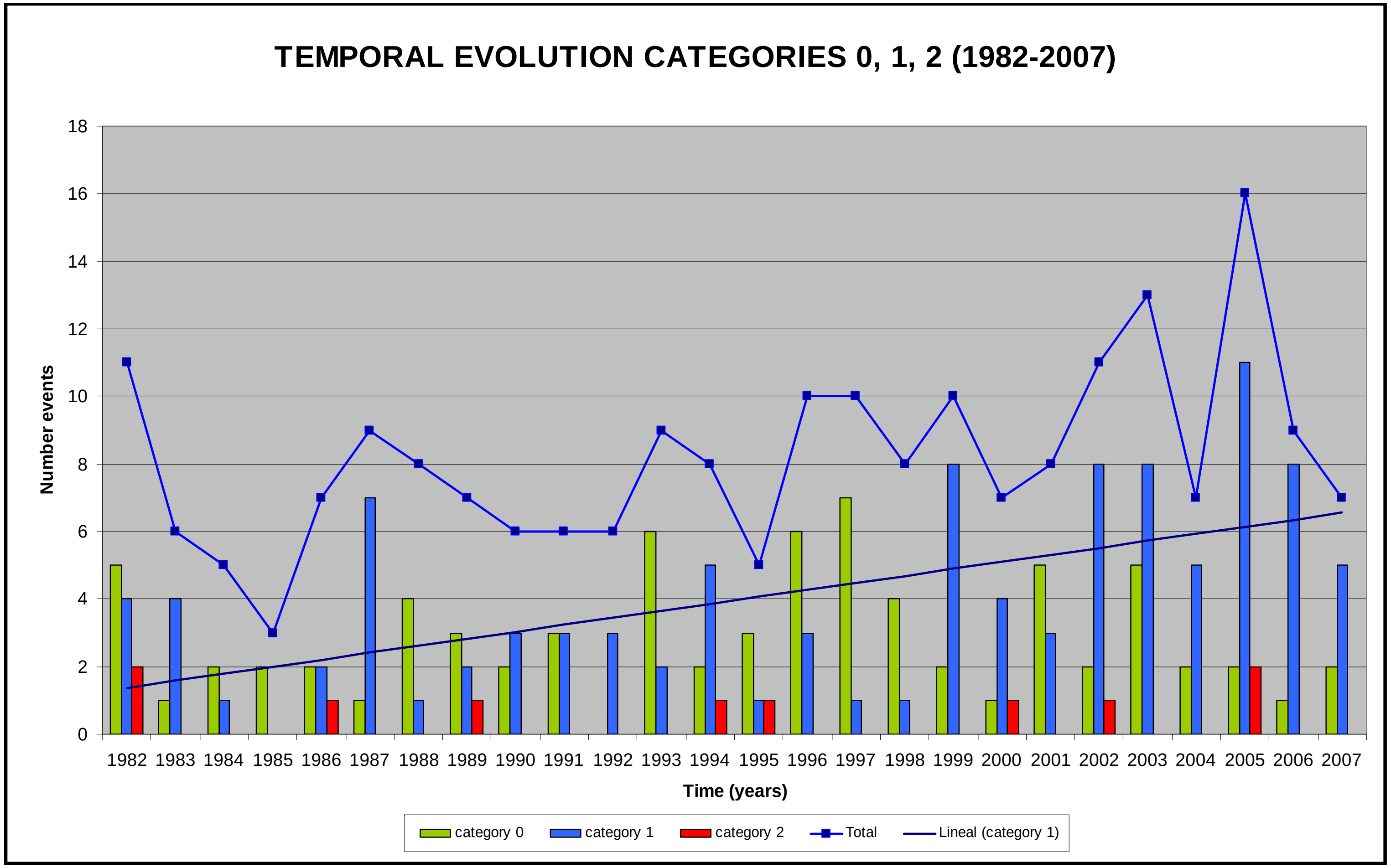
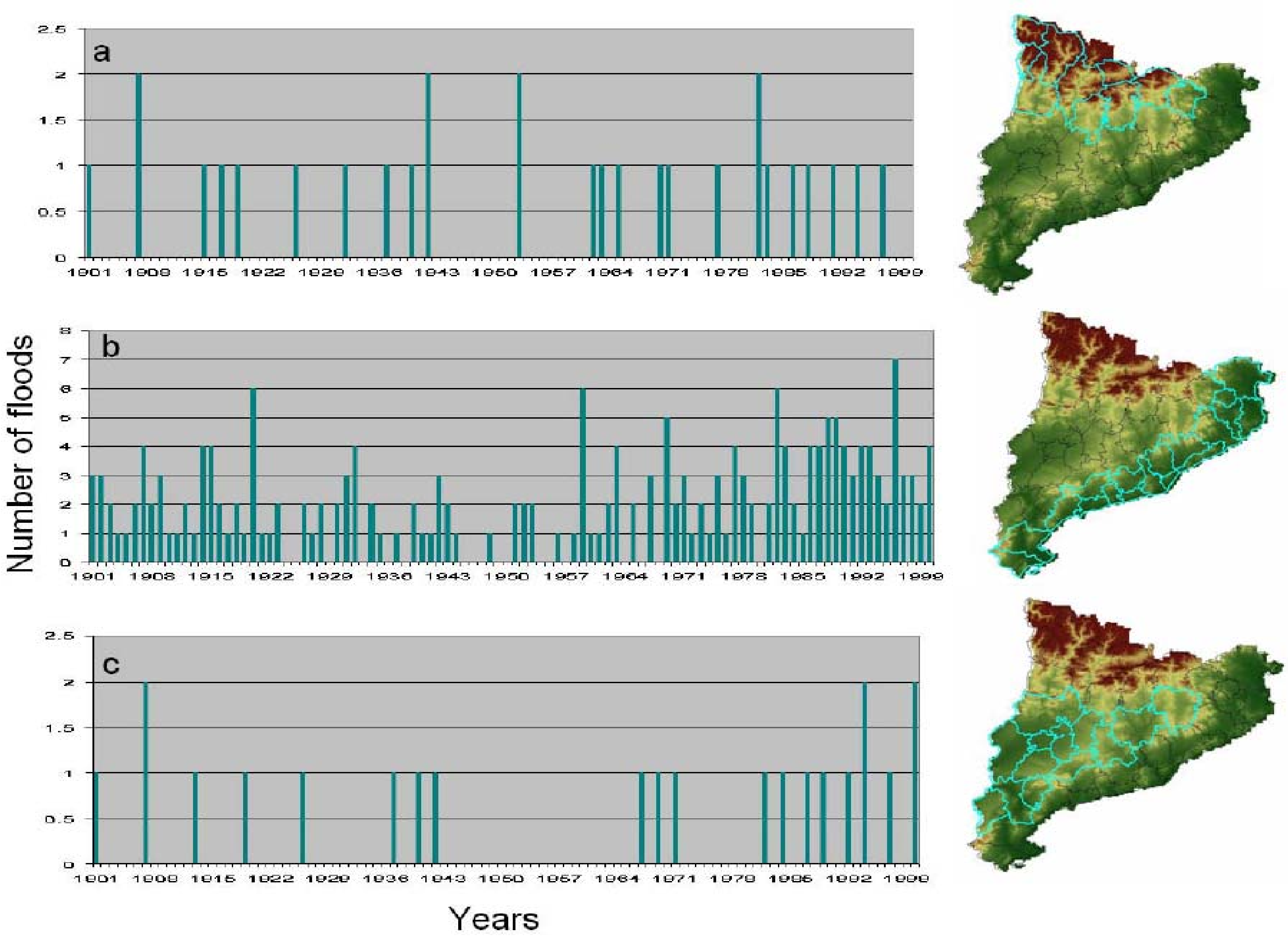



MEASURES DURING A THUNDERSTORM
IF YOU ARE IN THE MOUNTAINS, OUT IN THE COUNTRY OR ON THE BEACH
If you can, take refuge in a building or remain in a car with the windows and doors closed.

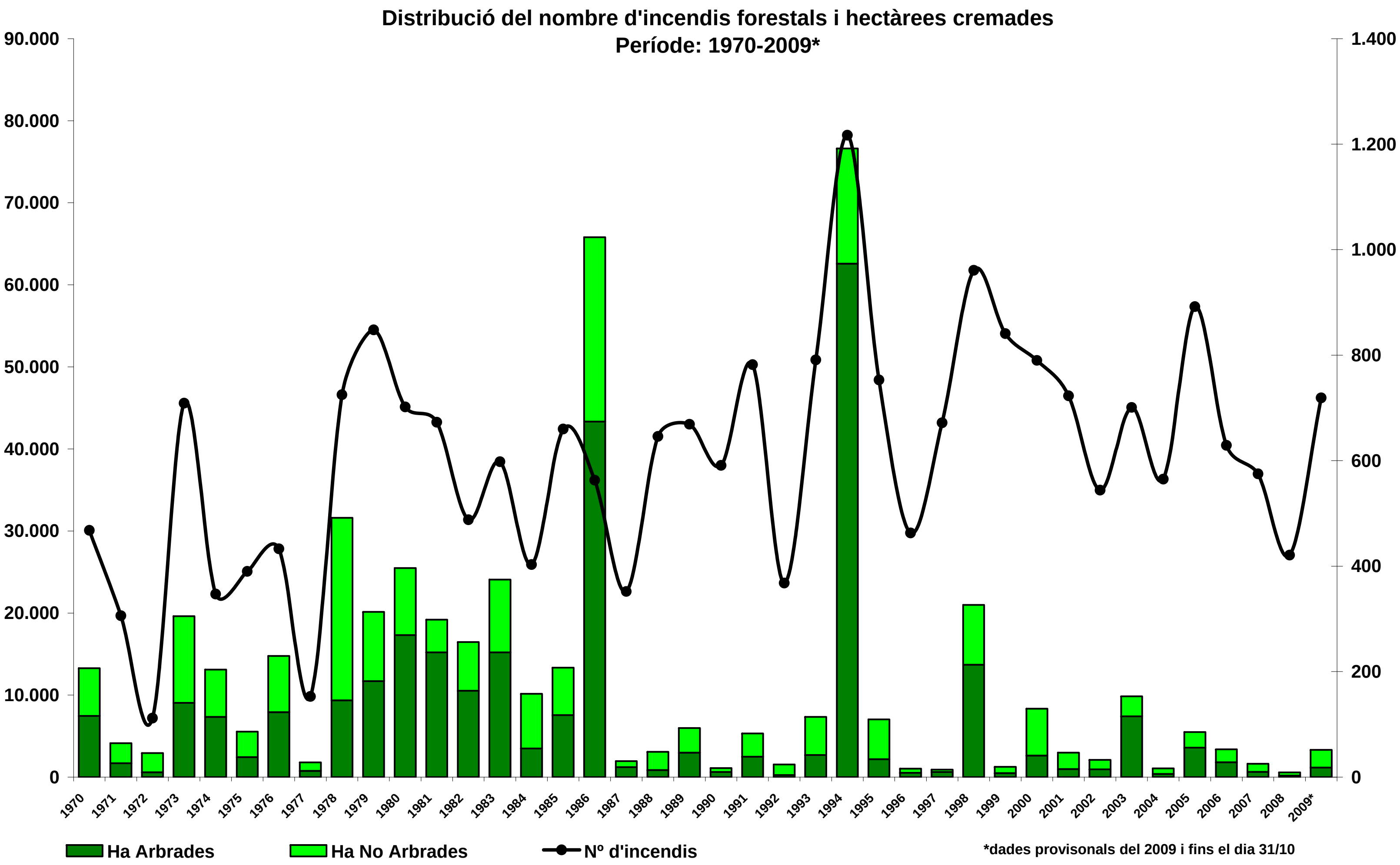

30
RIERADES
RIADAS
FLOOD
INONDATION
FLUTGEFAHR
ALLUVIONES



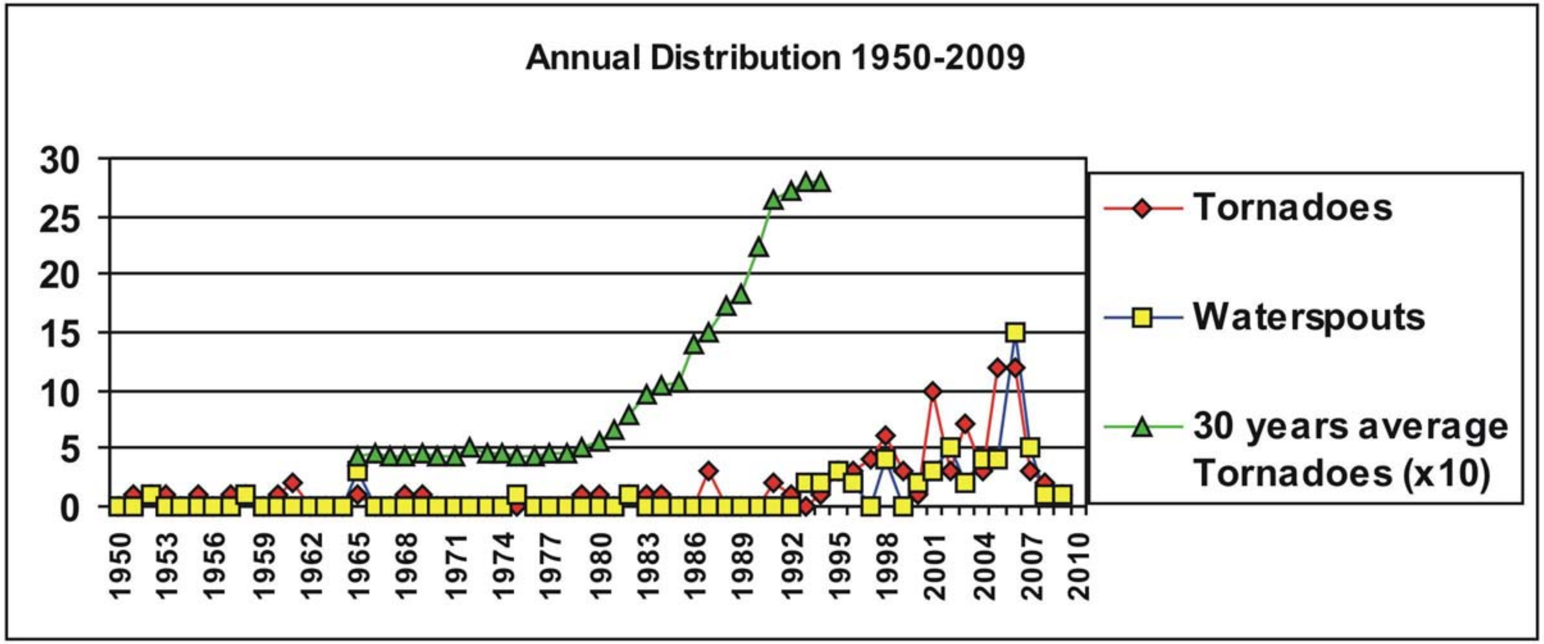
1982-2007; ordinary floods (0); extraordinary (1); catastrophiques (2).



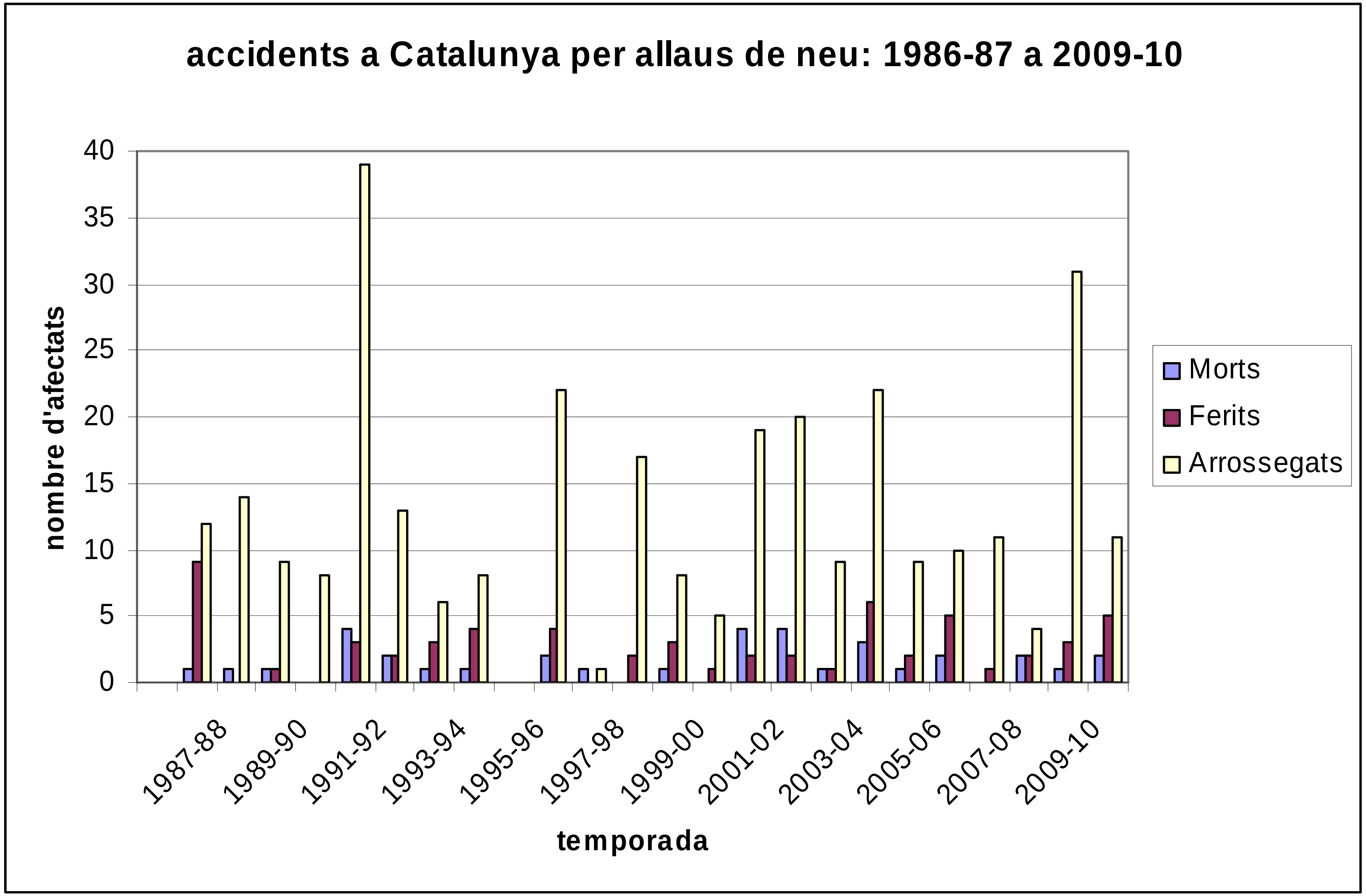
Evolució de les inundacions a Catalunya pel període 1901-2000
(Barnolas i Llasat, 2007)



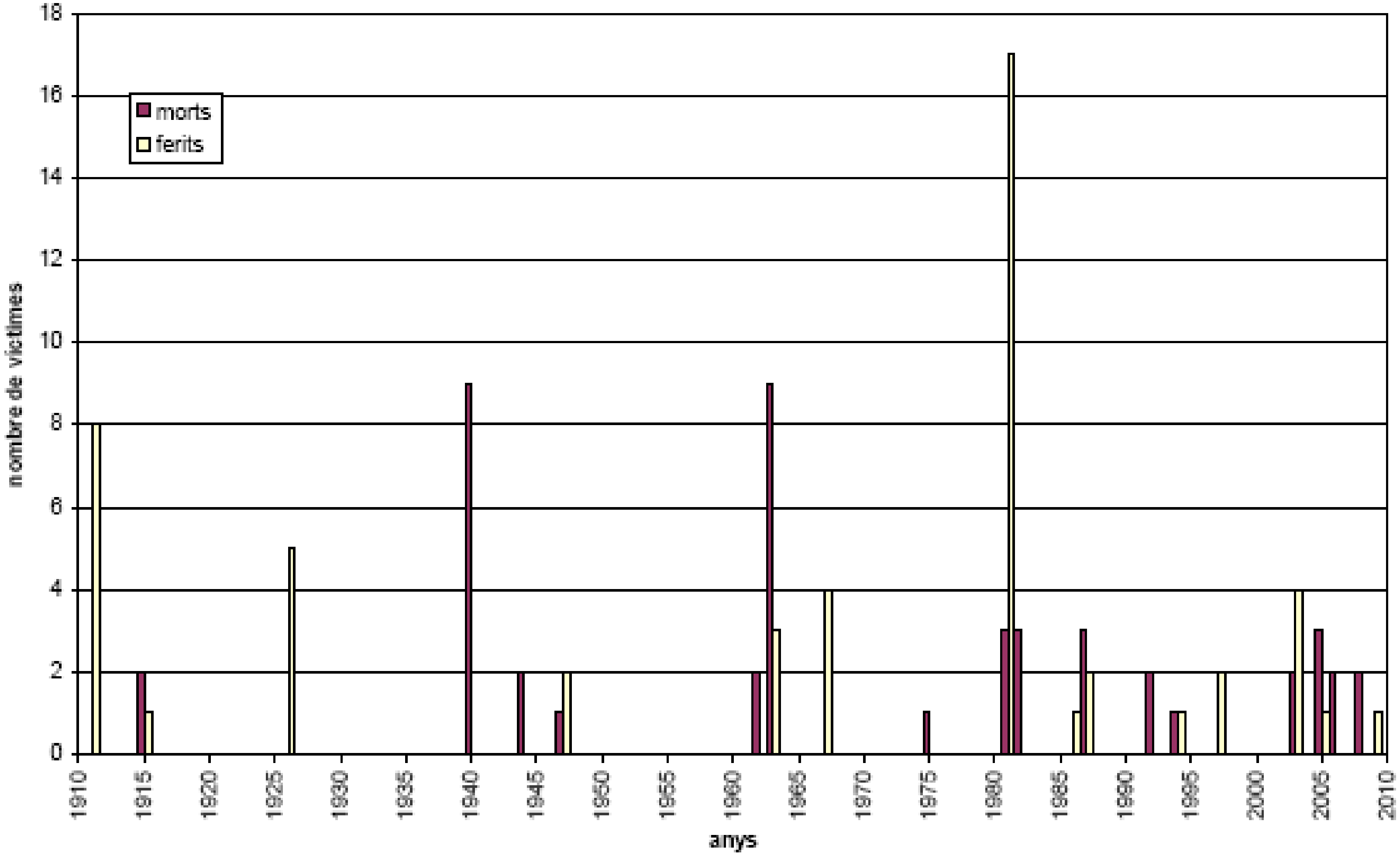
Evolució de l'activitat de foc a Catalunya (1 gener 1970-31 d'octubre 2009). Cortesia del Servei de Prevenció d'Incendis Forestals. Departament de Medi Ambient i Habitatge. Generalitat de Catalunya).



Evolució dels tornados i mànegues



Nombre d’afectats per allaus a Catalunya entre les temporades 1986-87 i 2009-10. D’aquesta darrera les dades corresponen fins al mes de març de 2010. No es disposa de dades de la temporada 1995-96.



Mapa dels terrenys susceptibles d'esllavissades de Catalunya

Today

“Corpus Christi” tradition

25 July 2012, Faculty of Physics, 11 a.m.
Climate Change in a Mediterranean environment (Catalonia): Precipitation extremes, regional scenarios, impacts on forest fires
PhD: Marco Turco

http://gama.am.ub.es blog GAMA: gamariesgos.wordpress.com; facebook; twitter