The impact of climate change on the hydrometeorological extremes in the Northeast of Spain

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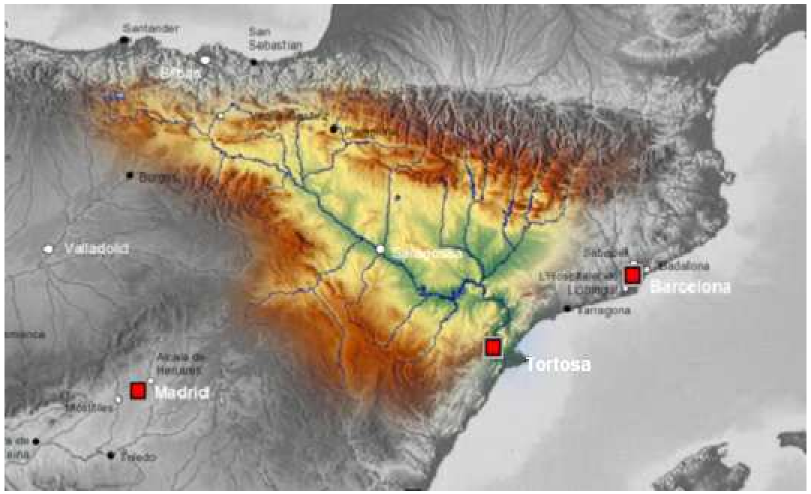
Program: Spanish R+D Program 2008-2011

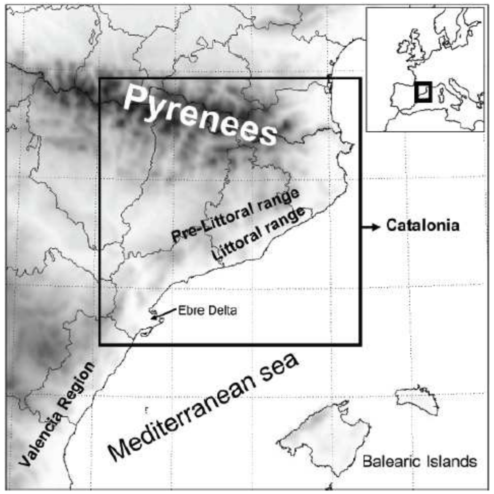
Objective: regional (20 km) and local (stations) scenarios for temperature (maximum and minimum) and precipitation for the XXI century, at a daily scale in Spain.

Start data: September 2009

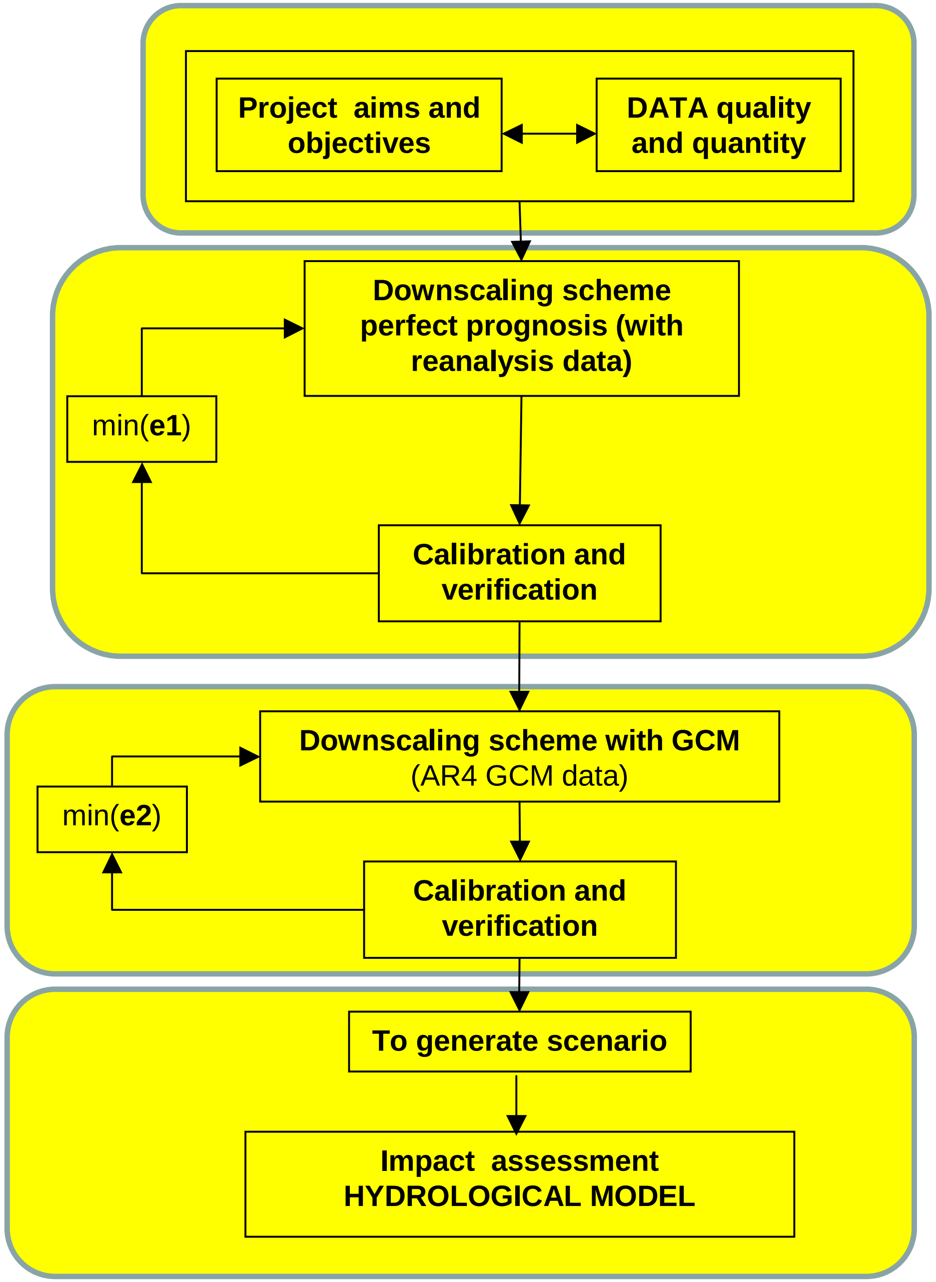
Our ultimate objectives

To generate regional scenarios with statistical downscaling in the Northeast of Spain, to focus on extremes and to analyze the impact of climate change on water resources.





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



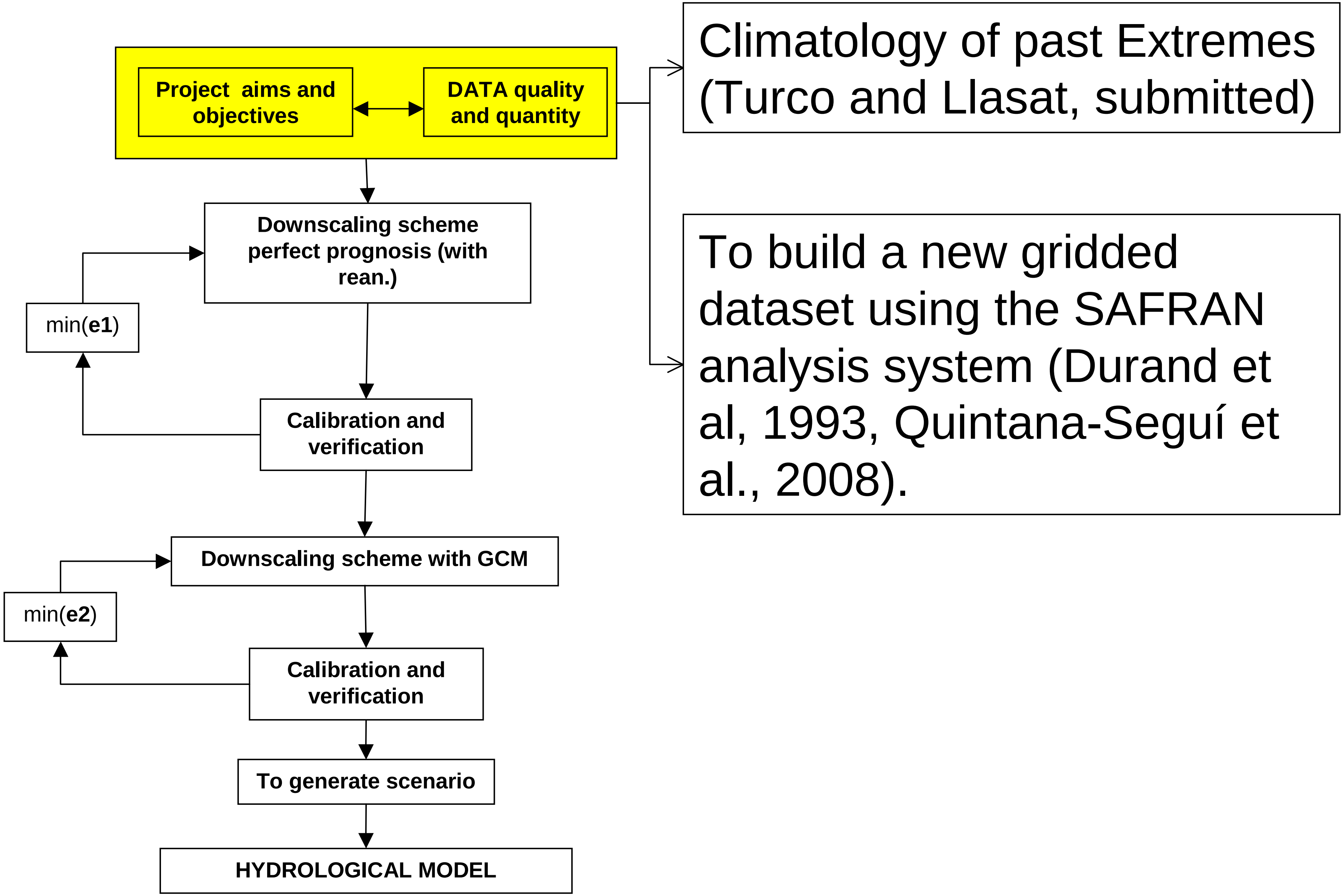
Focusing on:

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

- **Uncertainty**
  Using different scenarios, different GCM models, different downscaling method (eventually apply RCM scenarios)

- **Impact on hydrology**
  Using SURFEX to obtain future scenarios of soil wetness and runoff generation

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



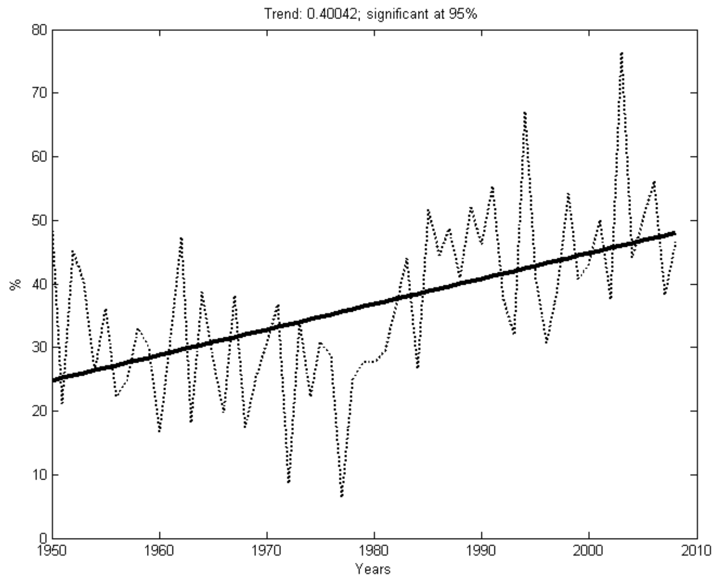
Climatology of past extremes

EXTREME INDICES ETCCDI: Expert Team on Climate Change Detection and Indices, http://cccma.seos.uvic.ca/ETCCDI

TREND SIGNIFICANCE: (Circular) Block Bootstrap (Kiktev et al. 2003) The code will be freely available in short time → http://gama.am.ub.es

TEMPERATURE: E-OBS, 01-Jan-1950 – 31-Dec-2008 (Haylock et al. 2008)
Our analysis of the temperatures in the Northeast of Spain indicates a clear signal of increase, coherent to the observed global warming (IPCC, 2007).

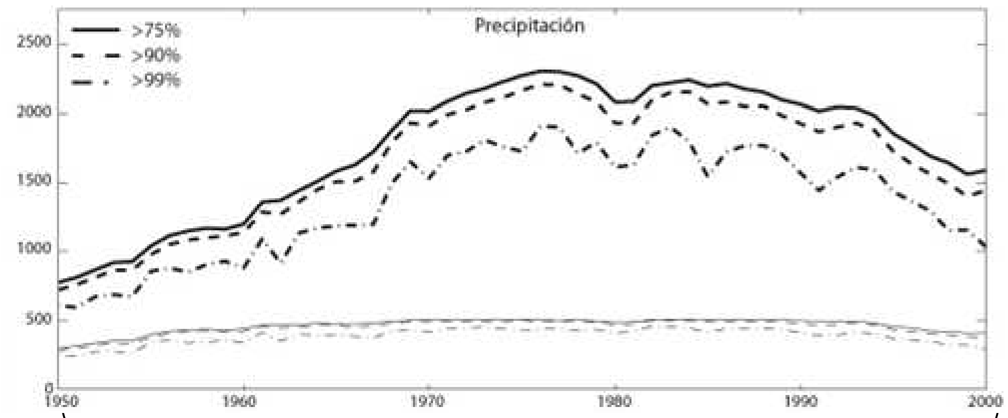
TX90p: Warm Days - Percentage of days with Tx>prctile(Tx,90)



PRECIPITATION: SPAIN02, 1-Dic-1950 30-Nov-2003 (Herrera et al. 2010)
Since a rather controversial picture appears in the studies on the precipitation trend in the NE of Spain, a greater effort has been done for this variable

PRECIPITATION

In order to analyze the influence of the length of the series as well as the departure point, 24 series have been built, shifting the starting year of the series.



Temporal variability of the number of available stations used to build SPAIN02 with at least 75, 90, and 99% of valid daily data for every year.

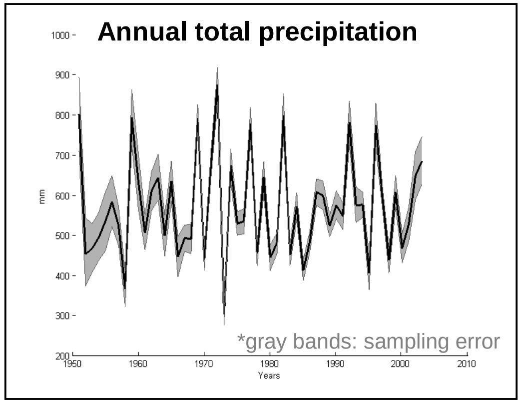
TREND PERIOD = 53 YEARS

TREND PERIOD = 52 YEARS

TREND PERIOD = ….YEARS

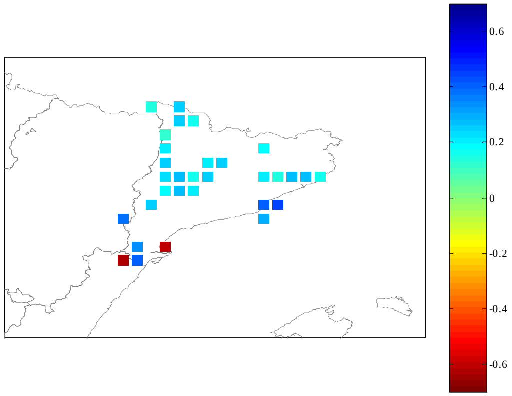
TREND PERIOD = 30 YEARS

PRECIPITATION

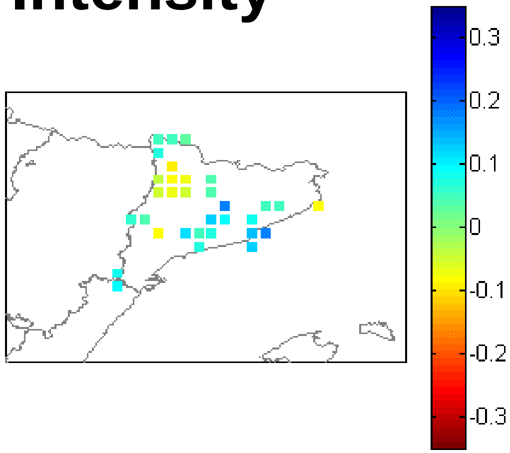


•Trend analysis: **no <u>general</u> trends**

•Local increase in longest dry period index*



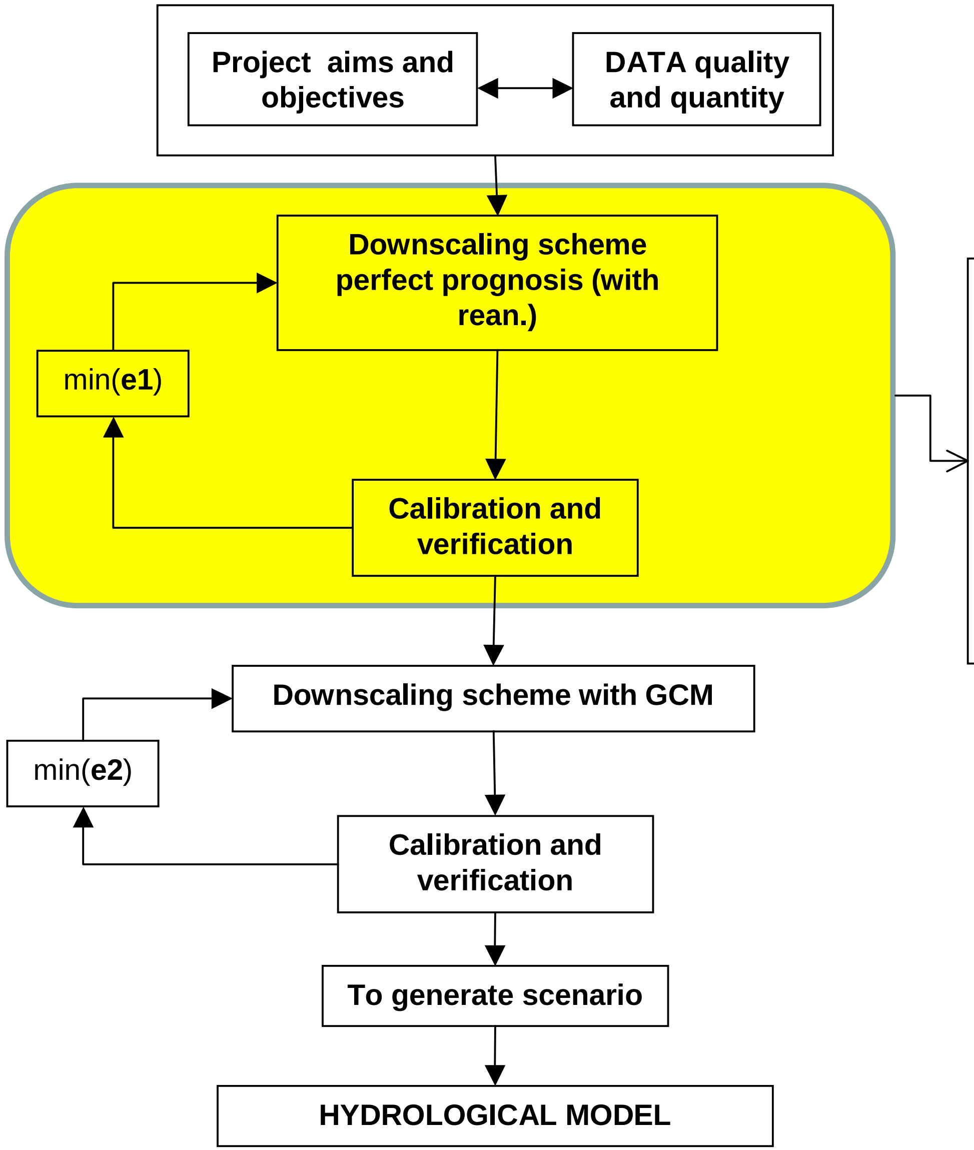
•Dipolar trend pattern of the summer series of Prec. Intensity*



•Considering **shorter length series** (between 30 and 39 years) some **seasonal trends** were found

*These trend patterns have 99% of field significance; these trends persist for all the time windows

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



- To implement the downscaling scheme
- To quantify the error 1 (assessing the strength and weakness of the SD)

Statistical methods to implement

The candidates downscaling scheme:

- **Analogues method**
  - Gutiérrez et al. 2004; Altava-Ortiz et al., 2006; Gibergans-Báguena and Llasat, 2007
- **Boé method** (has more physical understanding and maintains the spatial coherence)
  - Boé et al. (2006)
- **Other methods (quantile-mapping, method of anomaly)**
  - As in Quintana Seguí et al. 2010

Among these candidates we start with the analogues method:
Searching for a sample of past situation similar (at large scale: predictors) to the current one in the historical records

Choice of predictors

- The ideal predictor variable:
  1. Strongly correlated with the target variable
  2. Make physical sense
  3. Realistically represented by the GCM
  4. Captures multiyear variability

- Predictor variable selection is guided by:
  1. Literature review
  2. Expert knowledge of large-scale atmospheric controls of precipitation in the N-E of Spain
  3. Sensitivity test

IPCC guidelines, Wilby et al. 2004

Choice of predictors

1st step: literature review (focus on: recent studies / analogs/ daily precipitation, short range forecast: Altava-Ortiz et al., 2006, Gibergans-Baquena et al., 2007, Obled et al. 2002, Bliefernicht et al. 2007, Diomede et at. 2006, Hamill and Whitaker 2006; climate statistical downscaling: Benestad et. al, 2007, Pons et al. 2009, Timbal et al. 2001, Timbal et al. 2003, Timbal 2004, Timbal et al. 2005, Timbal et al. 2008A, Timbal et al. 2008B, Benestad 2009, Frías, 2006, Fernández et al. 2003, Matulla et al. 2008, Wetterhall et al. 2005, Wetterhall et al. 2006, Boé et al. 2007, Maurer et al. 2008, Timbal et al. 2009, Wetterhall et al. 2007, Mullan et al. 2006)

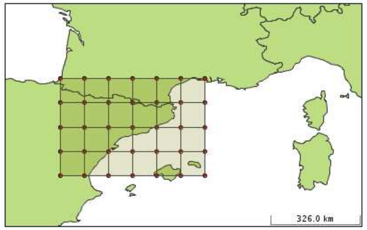
- Little consensus to the **choice of atmospheric predictor** variables, however the most commonly used predictors are:
  - Atmospheric circulation variables (MSLP, humidity, temperature, winds)
  - Precipitation
  - Geopotential is less appropriate (Zorita et al. 1995)

- In general, the choice of predictors depends on the region and season (Huth, 1996, 1999; Timbal et al. 2008) → reflecting a weakness

- Currently there is a high number of published literature but the **precipitation downscaling is still a challenge, at least in the Mediterranean regions, particularly in summer** (Maraun et al. 2010, in preparation)

First test – temperature

Domain



Obs. Data: E-OBS

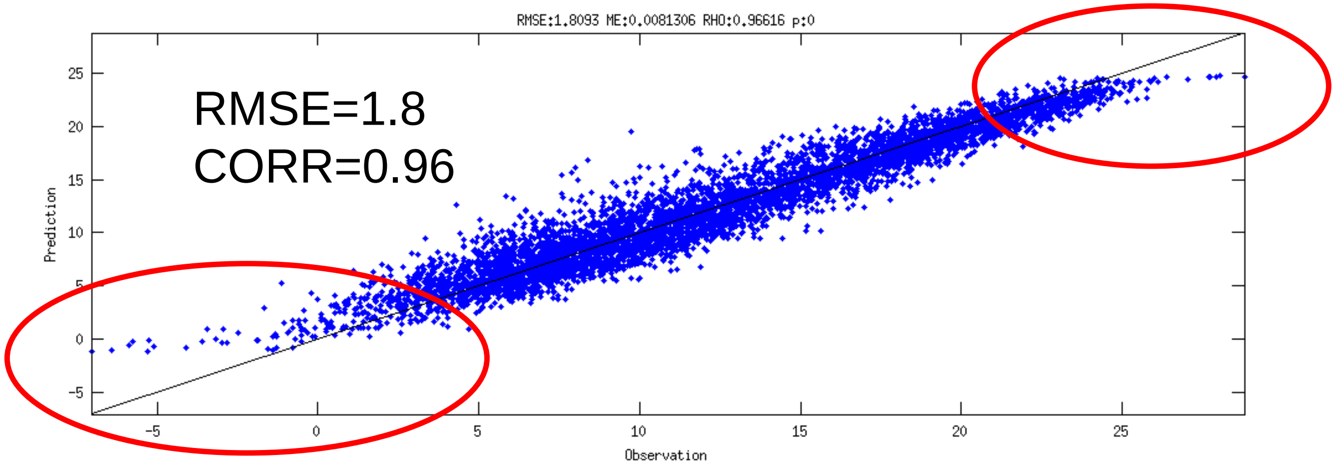
Predictor:

ERA40, slp+T850

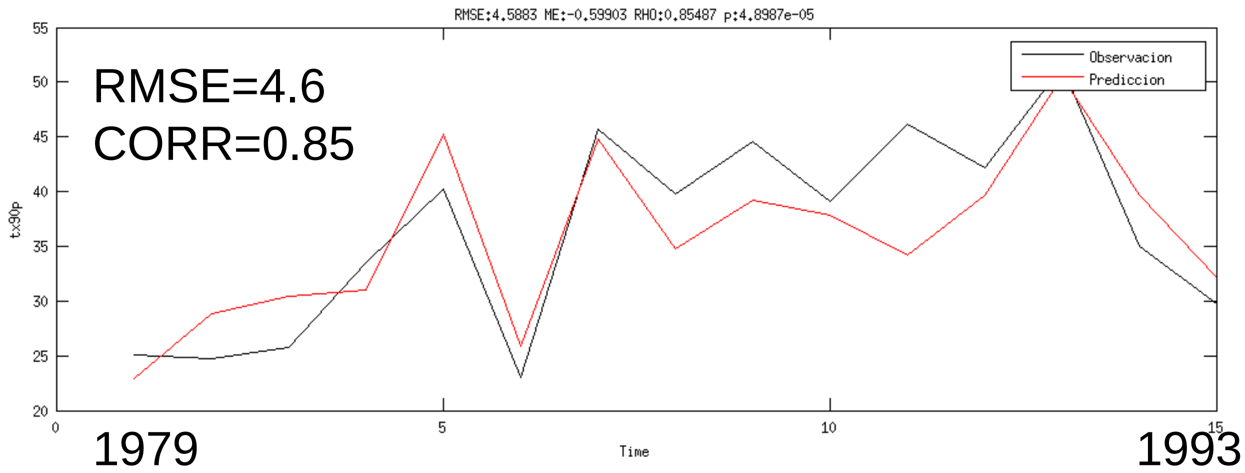
Type of regression: meanweighted

Test period: 01-Jan-1979 31-Dec-1993 STARDEXperiod
Train period: 1950-1979 and 1993-2003

<u>Most common predictors in literature:</u> slp+T850



TX90p: Warm Days - Percentage of days with Tx>prctile(Tx,90)

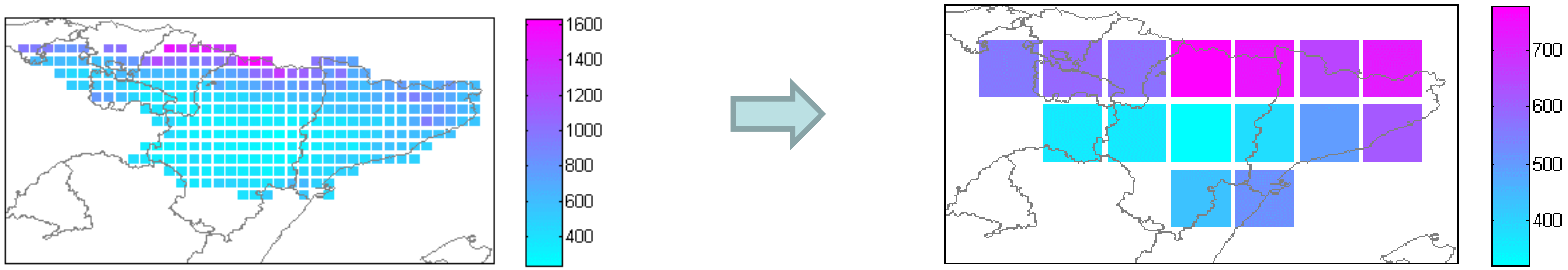


First test – precipitation

Testing with the same standard predictors the downscaled rain occurrences shows some amount of skill but an extra effort it is necessary to solve the underestimated rainfall amounts.

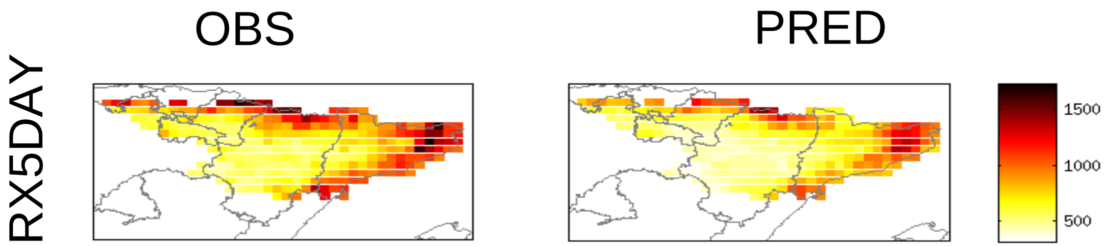
Idea:

Error1 calculated considering a <u>real</u> perfect predictor**: the aggregate SPAIN02 precipitation (20 km) at ERA40 scale (around 100 km)**



With this strategy we can answer to these questions:

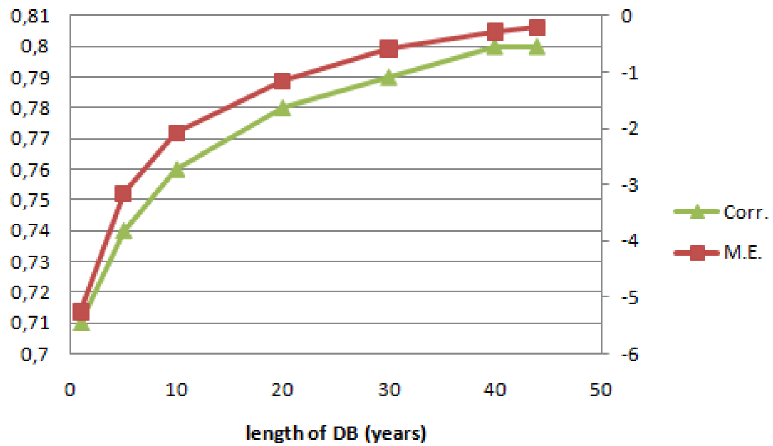
Is the method skilful for the extremes?



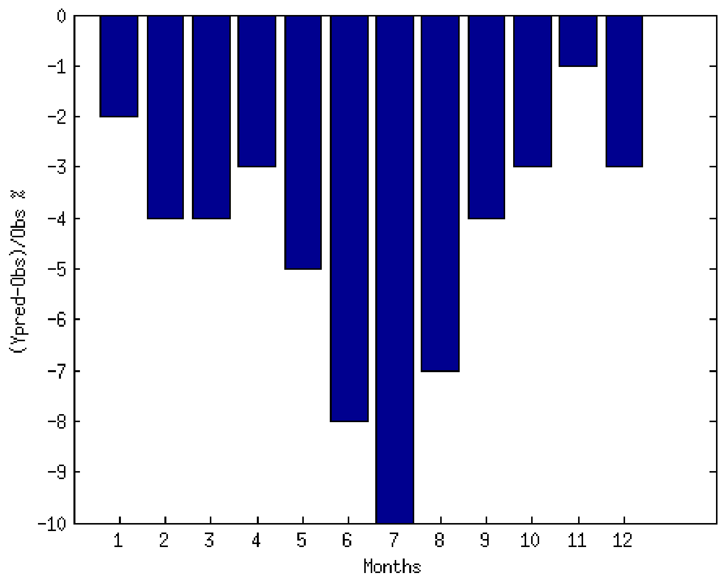
Can we improve the method (calibration)?

By trial and error we found:
Best regression: prc70; Best number of analogues: 30

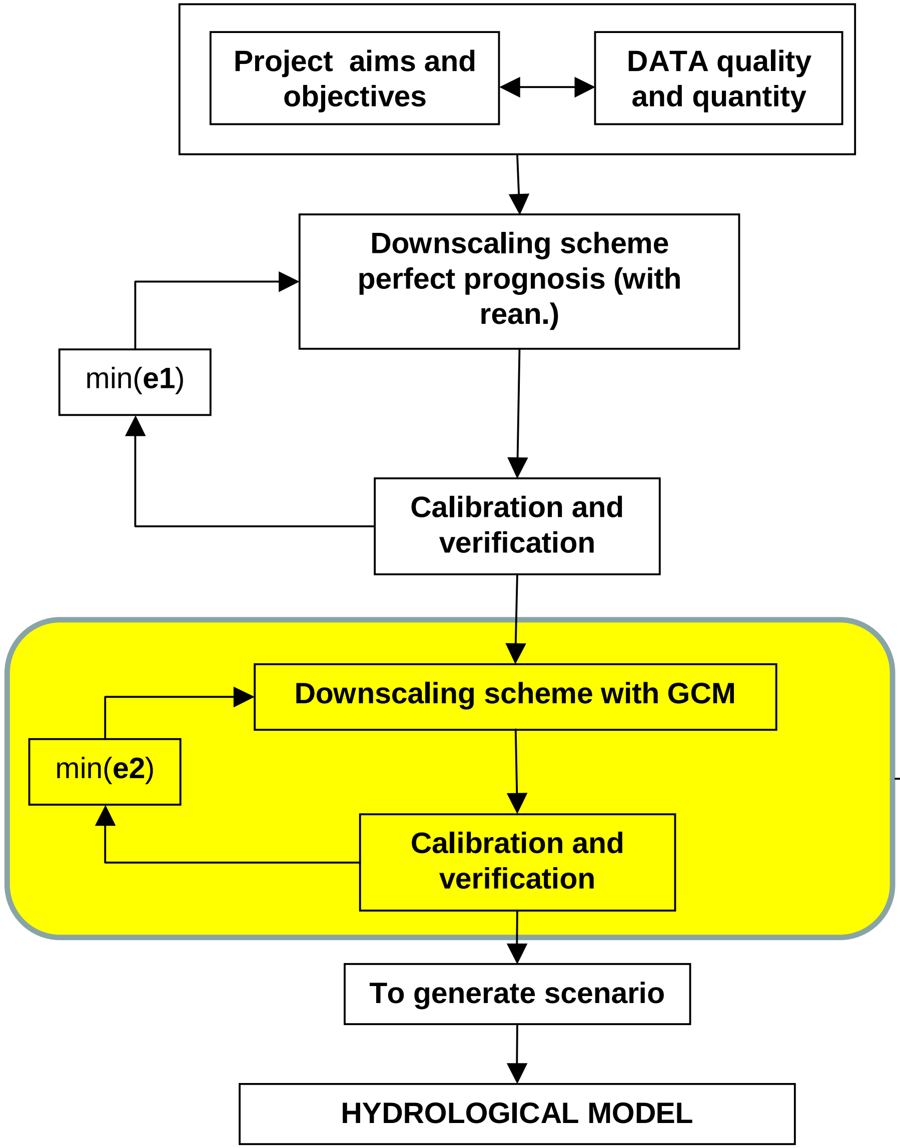
How much does the error change by increasing the length of the database?



Which is the monthly error?

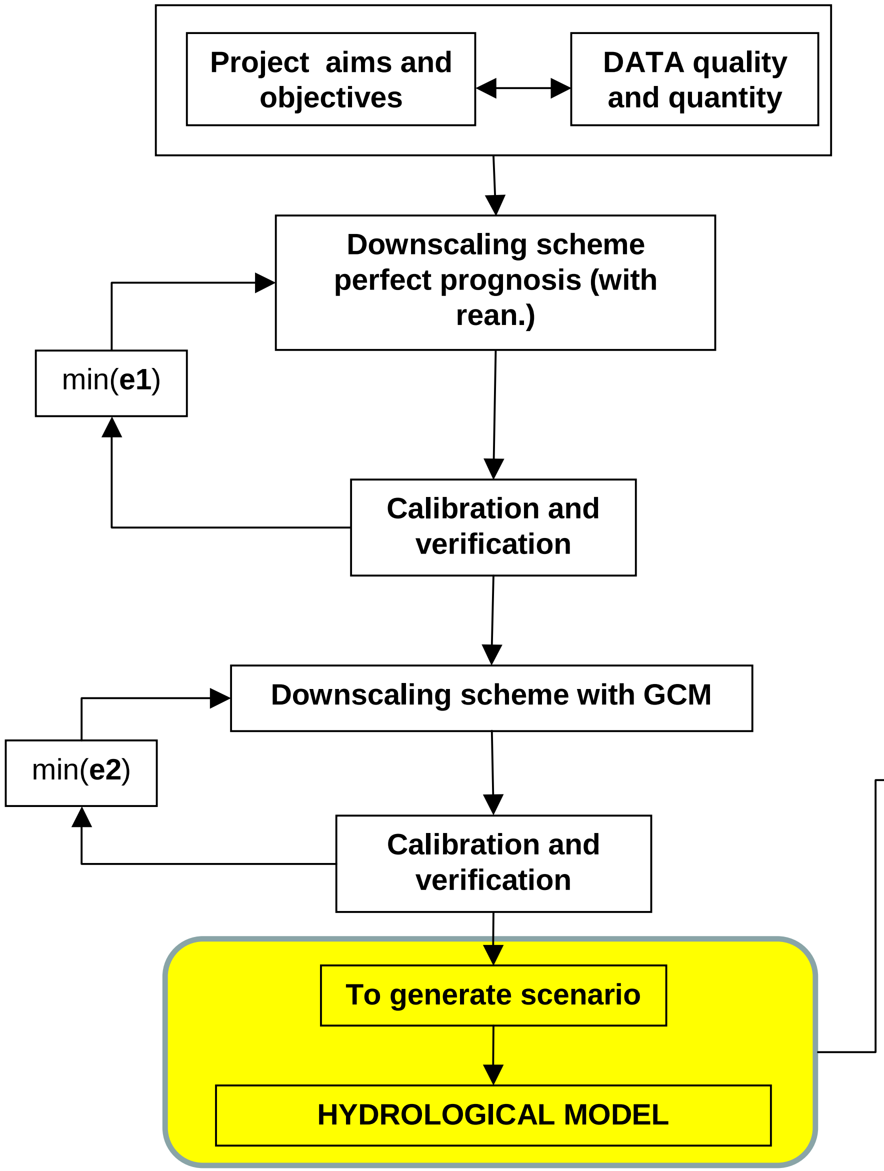


NEXT STEP



- To implement the downscaling scheme with GCM: E2=E1+Emod+Eres
- Assess the total uncertainty

LAST STEP



Using SAFRAN analysis system as observational database to apply the downscaling methods developed → to force the SURFEX surface model in the future to obtain future scenarios of soil wetness and runoff generation.

Conclusion 1/3

Trend analysis

•**Temperatures →** a clear signal of **increase**, coherent to the observed global warming (IPCC, 2007).

•**Precipitation → no general trends** were found.

- Two local trend patterns:
  - **local increase in CDD index** (around 30% of the area has an increase of around 2 days/decade
  - **dipolar trend pattern of the summer series of precipitation intensity** (in the inland part, around -0.5 mm/decade, along the coast, around 1 mm/decade.

•Considering **shorter length series** (between 30 and 39 years) some **seasonal trends** were found

Index	Year	DJF	MAM	JJA	SON
PRCPTOT	-	-	-	'Local' decrease ('70,..,'74)	'Local' increase ('70,..,'74)
R95p/PRCPTOT	-	-	-	-	-
RX5DAY	-	-	-	-	-
SDII	-	-	-	'Dipolar pattern' (*)	-
CDD	'Local' increase (*)	-	'Local' increase ('66,..,'74)	-	'General' decrease ('65,..,'74)

Conclusion 2/3

- Statistical downscaling in perfect prog, Analogues method :
  - The Analogues method shows skill in downscaling the mean and the extreme temperatures
  - The Analogues method in real perfect conditions shows skill in downscaling the mean and the extreme precipitations

Conclusion 3/3

- Next steps:
  - To build a new gridded dataset using the SAFRAN analysis system
  - To improve the implementation of the analogues method, particularly for the precipitation
  - To implement other downscaling methods in p.p.
  - To calibrate the S.D. with the GCMs
  - To generate the scenarios using SAFRAN analysis as observational database and force the SURFEX model on the Northeast of Spain

Thank you for your attention

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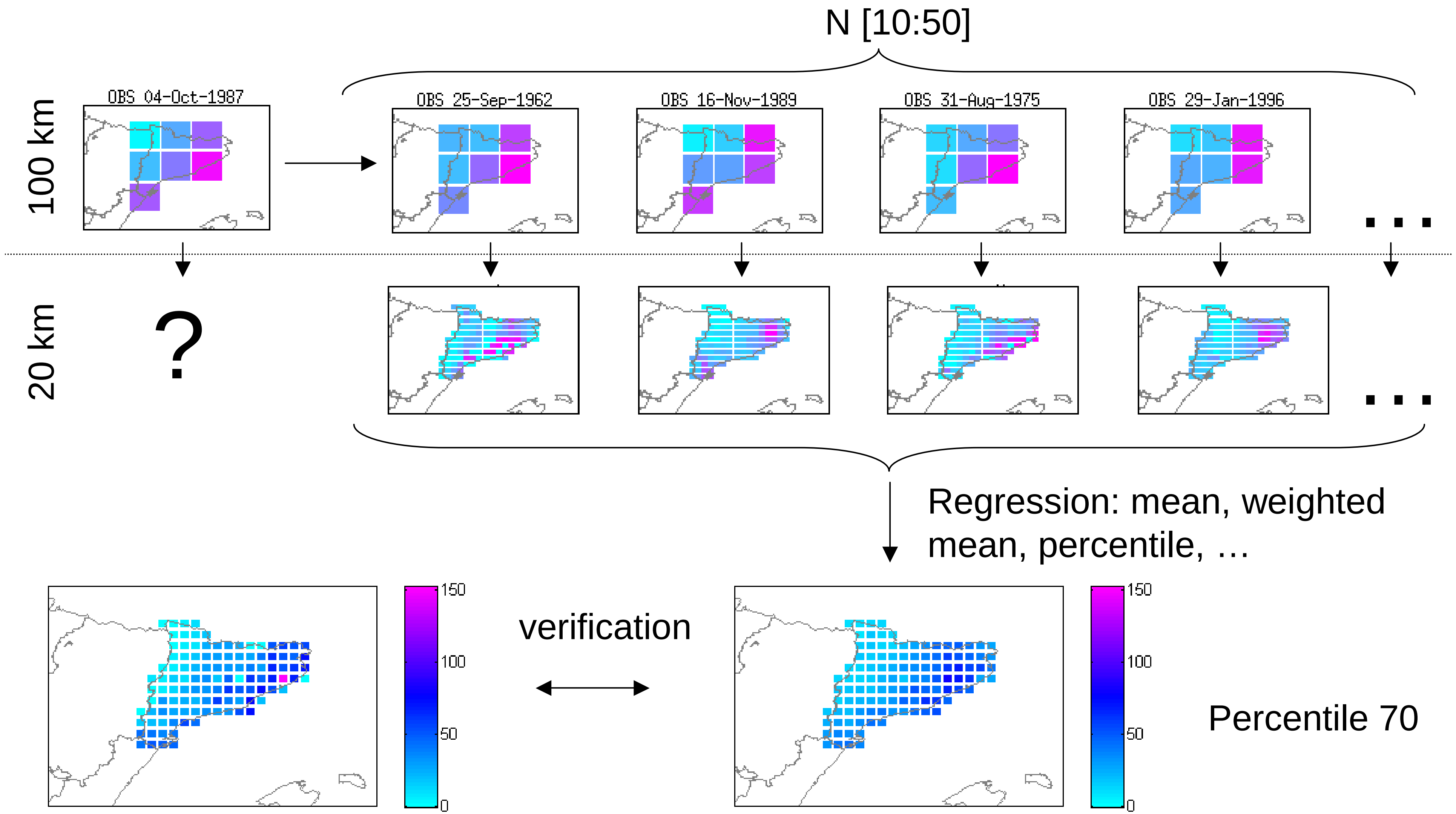
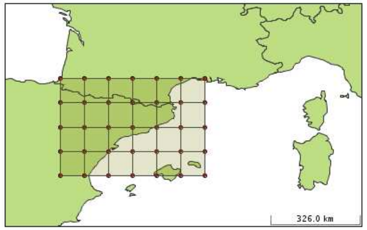
Extra slides

Analogues method



First test – Mean temperature

Domain



Obs. Data: E-OBS

Number of analogs: 30

Type of regression: meanweighted

Test period: 01-Jan-1979 31-Dec-1993 STARDEXperiod

Train period: 1950-1979 and 1993-2003

<u>Searching for the best predictors</u>

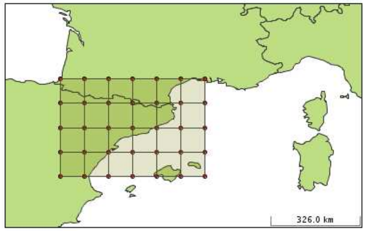
(Simple greedy search) from this list:

Predictors: (var-level-time)
Geopotential-500-00
Geopotential-500-12*
Geopotential-1000-00
Geopotential-1000-12
V velocity-500-00
V velocity-500-12
U velocity-500-00
U velocity-500-12
Temperature-500-00
Temperature-500-12
Temperature-850-00
Temperature-850-12
Temperature-1000-00
Temperature-1000-12
Relative humidity-700-00
Relative humidity-700-12
MSLP-0-00
MSLP-0-12

*Smaller grid including a temporal component can be better (Gutiérrez et al., 2004, Pons et al. 2010)

First test – Mean temperature

Domain



Obs. Data: E-OBS

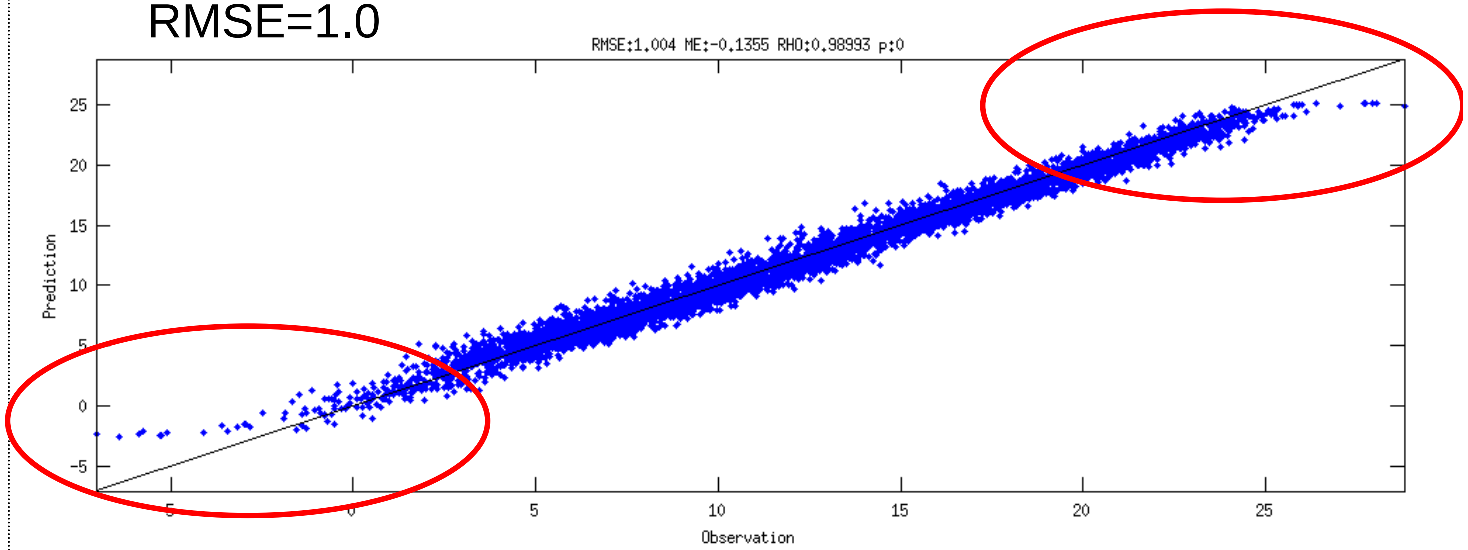
Number of analogs: 30

Type of regression: meanweighted

<u>"Best" predictors</u>

'Z'	[500]	[12]
'T'	[850]	[12]
'T'	[1000]	[0]
'T'	[1000]	[12]

RMSE=1.0



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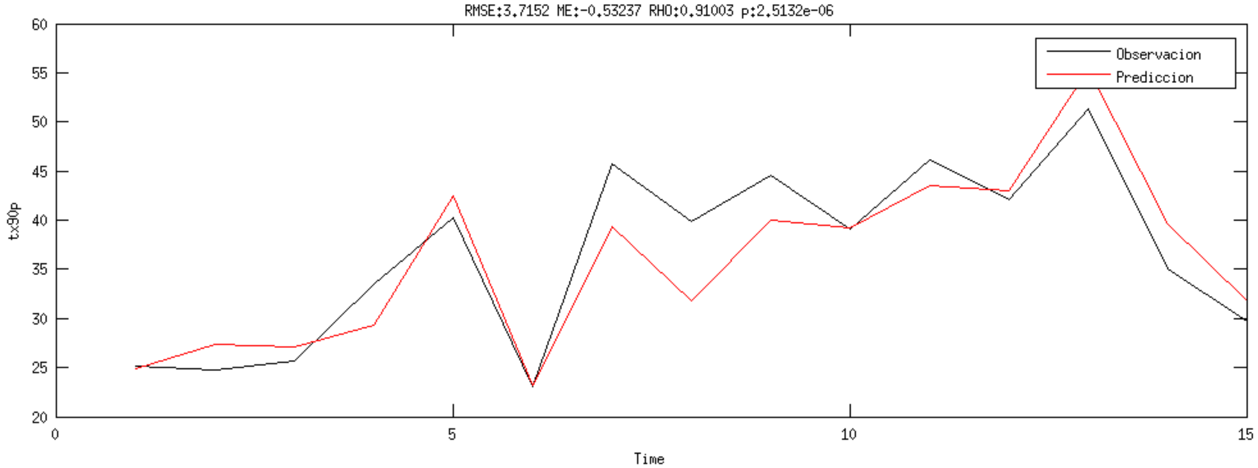
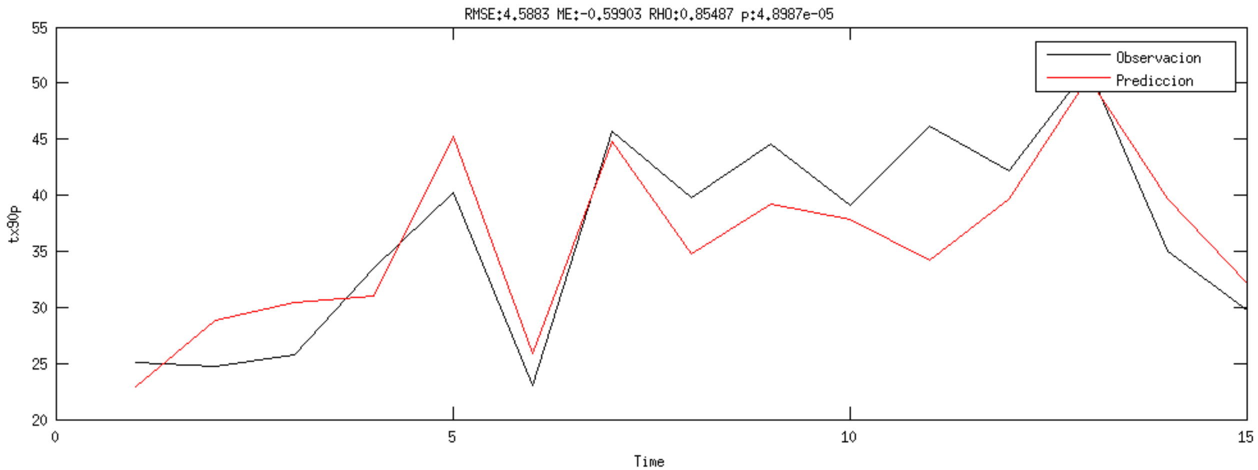
BEST PREDICTORS



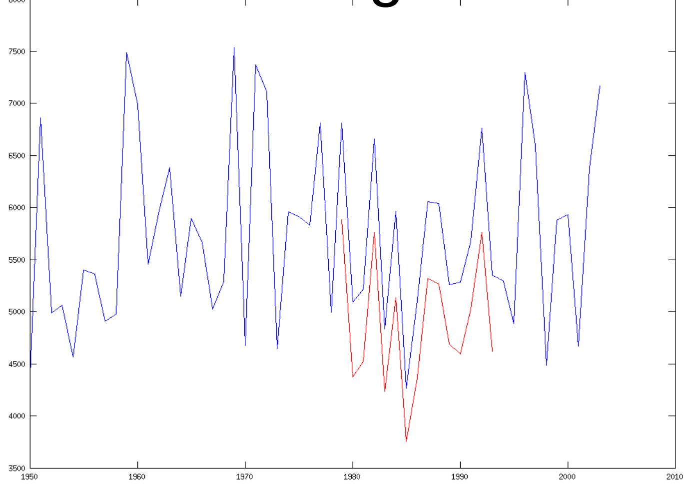
SLP+T850



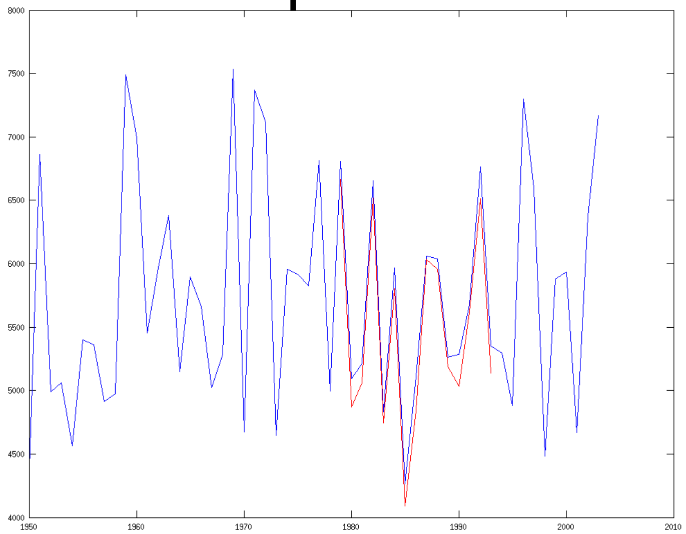
1979 1993

Best regression:

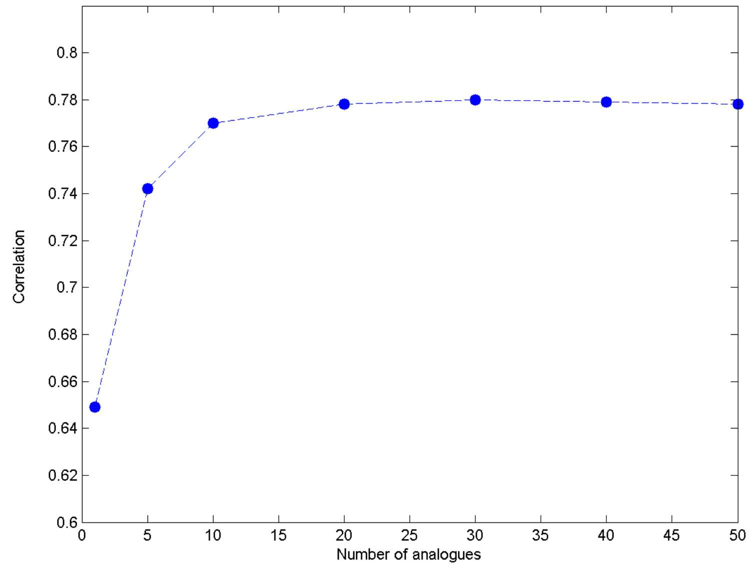
Weighted mean



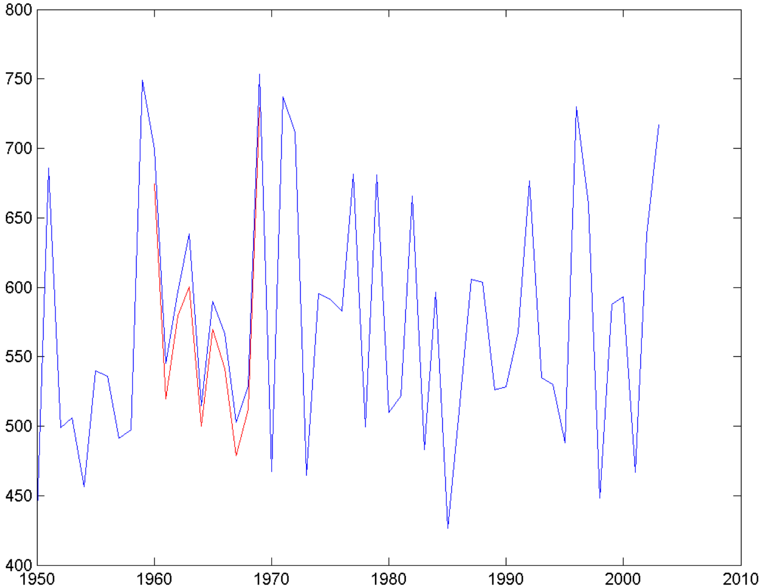
prc70

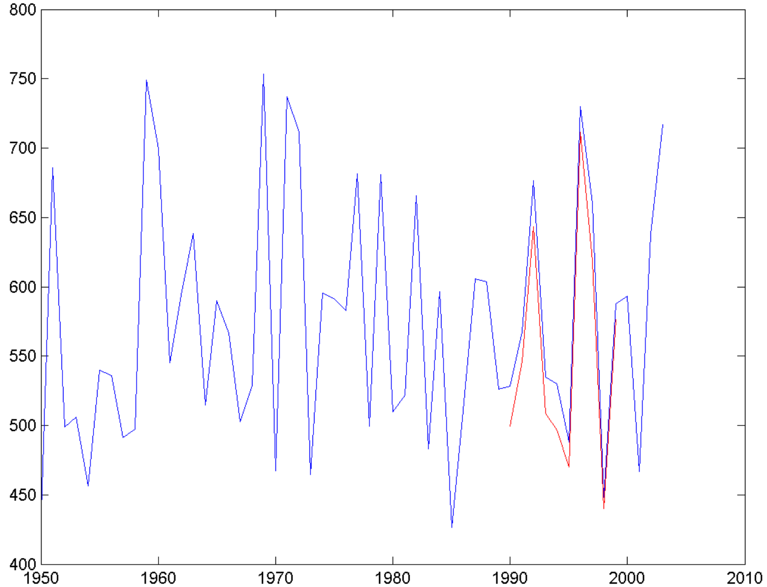


Best number of analogs:



Error F(Ttest)



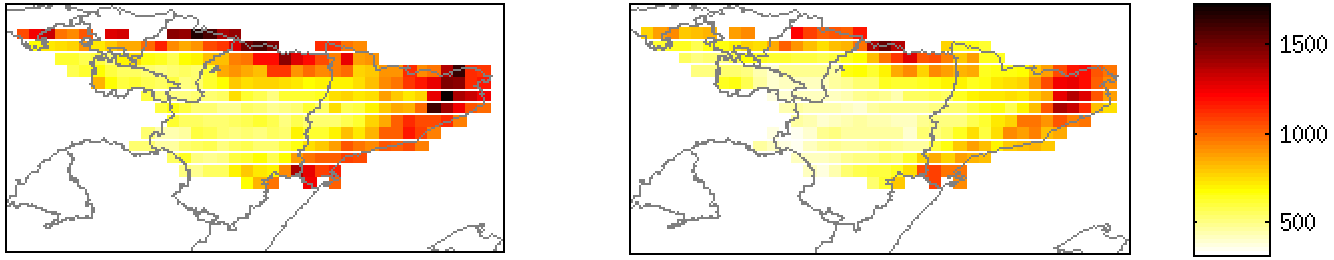


Extremes

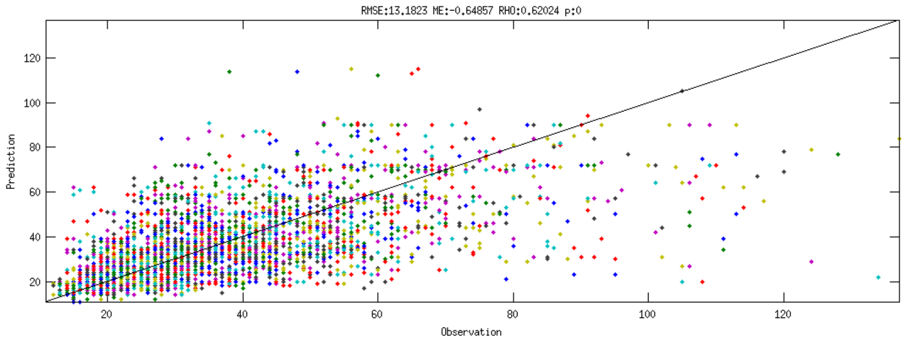
RX5DAY

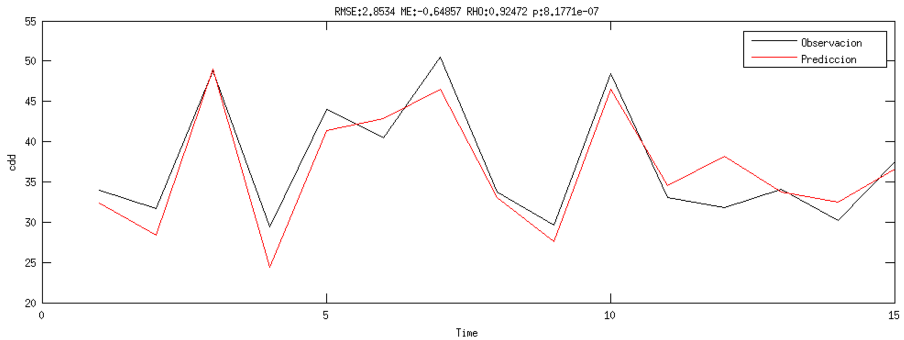
OBS

PRED



CDD





1979 1993

With the upscaled SPAIN02 as a predictor this implementation can be considered a **benchmark**:

- is the method skilful for the extremes?
- Is there room to improve the extremes?

Short Range Forecast

LOCATION	METHOD	PREDICTOR	PREDICT AND	REFERENCE
Catalonya	AM, 2 two selection criteria (proximity, correlation)	Geop 1000, 850, 500	P	Altava-Ortiz et al., 2006
Catalonya	AM + radiosounding, different selecrion criteria tested, pi=Ni/Na	Geop 1000, 700, 700/1000 thickness	P	Gibergans-Baquena et al., 2007
France (parts of Italy and Catalonya)	AM, Teweless-Wobus score, consider the seasonal effects, medium domain size, numam: 50, Q20, Q60, Q90	Geop 1000, 700 at 00 and 24 UTC	P	Obled et al. 2002
Rhine basin	AM, euclidean distance (1), the Pearson correlation (2) and a combination of both measures (3); numam: 30	geop 1000, 700 MFLUX 700 (SHUM x UWND)	P (Q95)	Bliefernicht et al. 2007
Italy (Emilia Romagna)	AM, euclidean distance and S1 score	Geop 500, 850, Q700, W 700	P	Diomede et at. 2006
USA	AM, euclidean distance	P (256 km)	P (32 km)	Hamill and Whitaker 2006

Climate Statistical Downscaling

LOCATION	METHOD	PREDICTOR	PREDICTAND	REFERENCE
Scandinavian region	Multiple regression analysis	Large scale precipitation+slp	Pm	Benestad et. al, 2007
Northern Spain	AM, Euclidean distance, mean of the 30 corresponding historical observations	Z500, Z1000,T500,T850,RH 850 (12 e 24)	annual number of snow days	Pons et al. 2009
Australia	AM, Euclidean distance, sensitivity test of AM to several internal parameters	MSLP, T850	TM, Tm	Timbal et al. 2001
Western France	AM, Euclidean distance, sensitivity test of AM to several internal parameters	MSLP,T850, PWTR	T, P occurrence	Timbal et al. 2003
Australia	AM, Euclidean distance, sensitivity test of AM to several internal parameters	PWTR, MSLP	Winter and spring P	Timbal 2004
Australia	AM, Cfactor	MSLP, large-scale rainfall	P	Timbal et al. 2005
Australia	AM, Cfactor	MSLP, PWTR	P	Timbal et al. 2008A

LOCATION	METHOD	PREDICTOR	PREDICTAND	REFERENCE
West Australia	AM, Cfactor	MSLP, Q859, U850	P	Timbal et al. 2008B
Oslo	AM+correction through PDF predictions	Monthly T2m P, SLP	P (Q<0.975)	Benestad 2009
Iberian P. + Scandinavian P.	CCA+AM (weighted average of 2 best AN)	SLP, GEOP500	Pmonthly for DJF	Frías, 2006
Northern Spain	AM serching in the CCA space	SLP	Pmonthly for DJF	Fernández et al. 2003
California, European Alps	AM, sensitivity test of AM to several internal parameters	SLP, Q700	P	Matulla et al. 2008
Central Sweden	AM, Teweles-Wobus score	SLP	P	Wetterhall et al. 2005
China	AM, Teweles-Wobus score Train: 1961-1978 Test 1979-1993 (as in STARDEX)	SLP	P (stardex indeces)	Wetterhall et al. 2006
Seine basin (France)	WT and conditional resampling	Geop500	P	Boé et al. 2007
Western USA	AM, focus on daily skill, numan: 30	Anom(P)	P	Maurer et al. 2008
Australia	Generalization of AM	A lot of combination in funxtion of season/zone/predictands	T, P	Timbal et al. 2009
Central Sweden	4 SD (AM)	MSLP	T, P	Wetterhall et al. 2007
New Zealand	AM, bootstrap	MSLP and SST anomalies	Monthly Terciles of T, P	Mullan et al. 2006