



Case study on regional climate projections

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- Observed climate evolutions and trends
 - Data homogeneity
 - Climate indices (mean & extreme events)

- Climate scenarios
 - Dynamical downscaling
 - Statistical downscaling

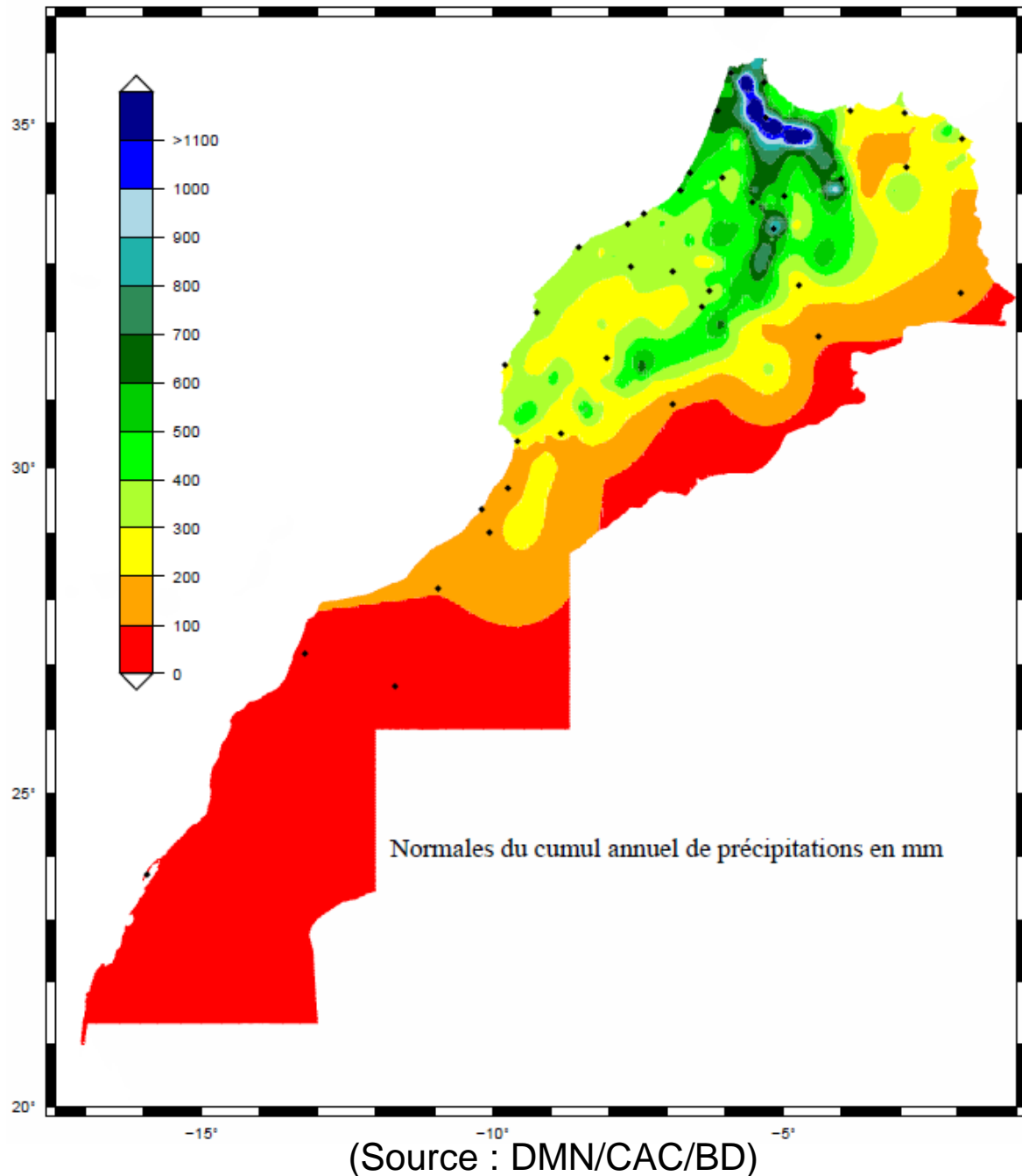
- Evaluation of future changes
 - Climate indices (mean & extreme events)

- climate varies generally from sub-humid to semi-arid

- moderate to low rainfall amounts

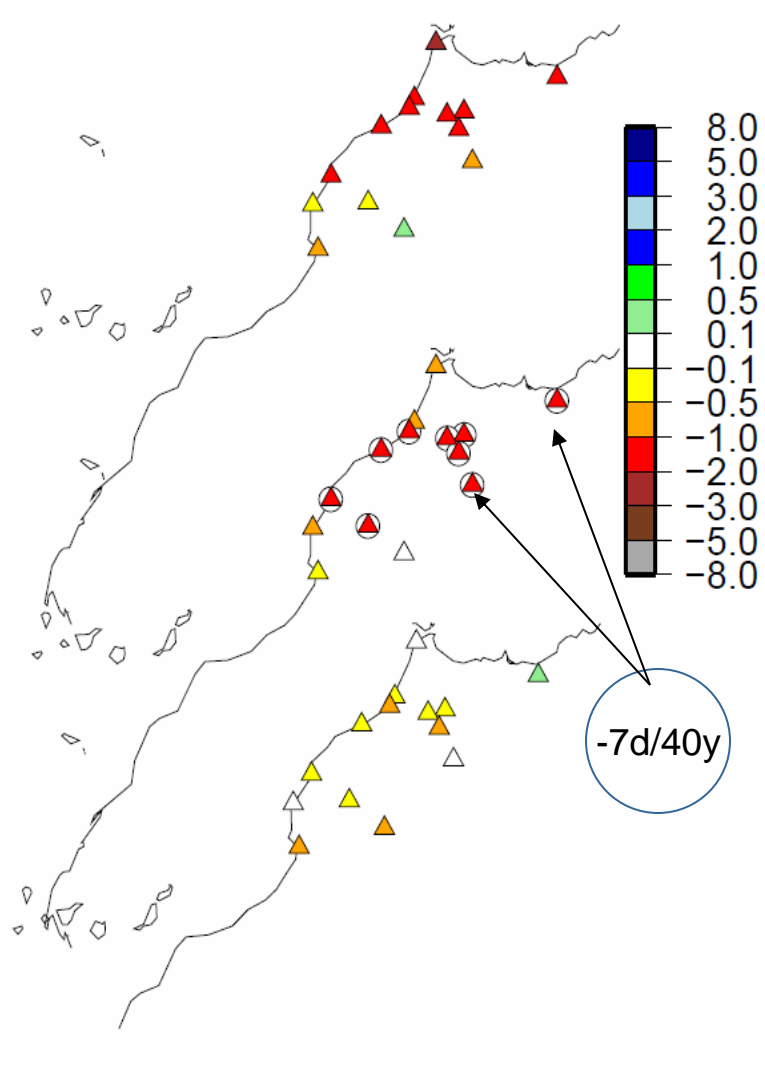
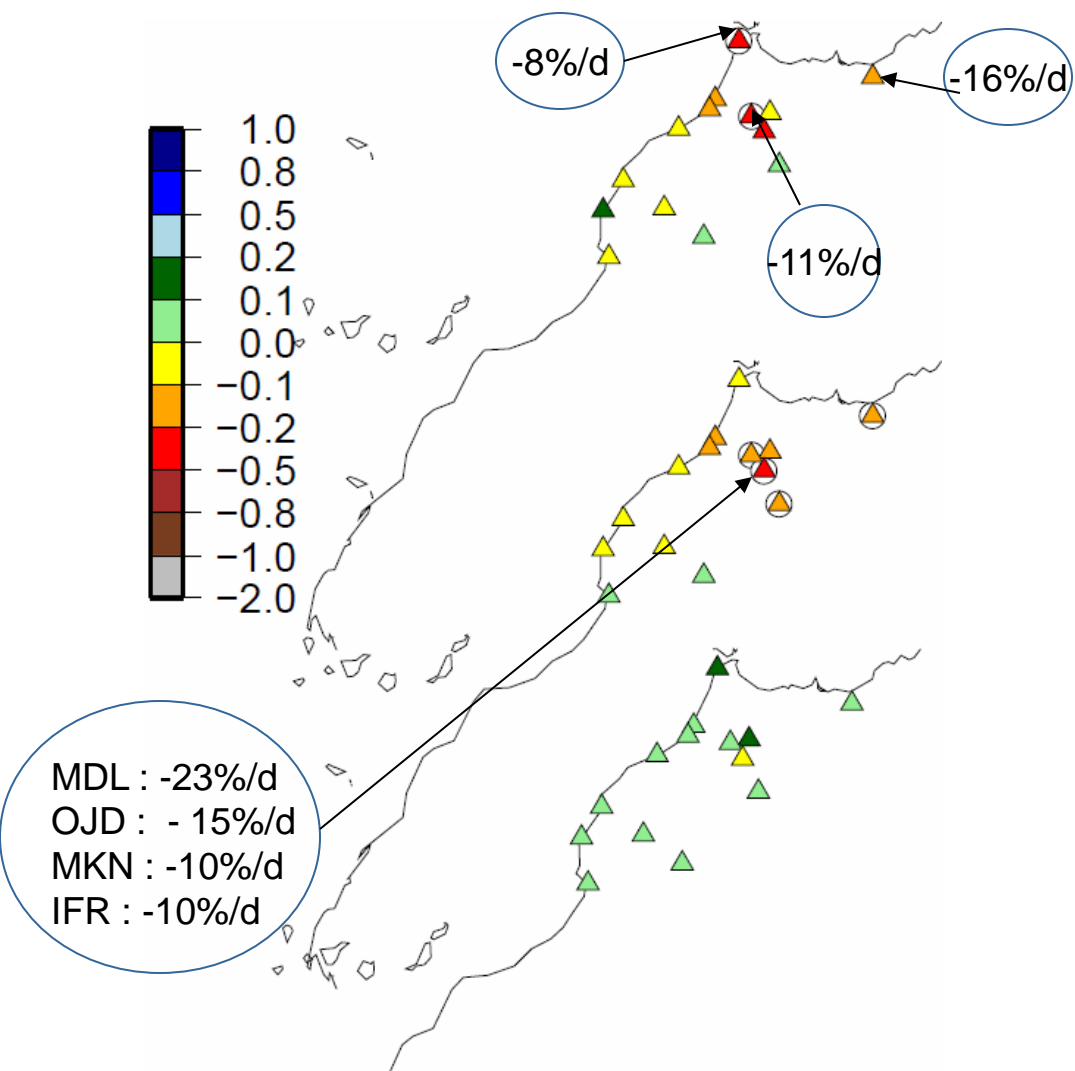
- High temporal variability

The coefficient of variation in Morocco ranges between 30% to over 70%.



Mean precipitation (mm/day per decade)

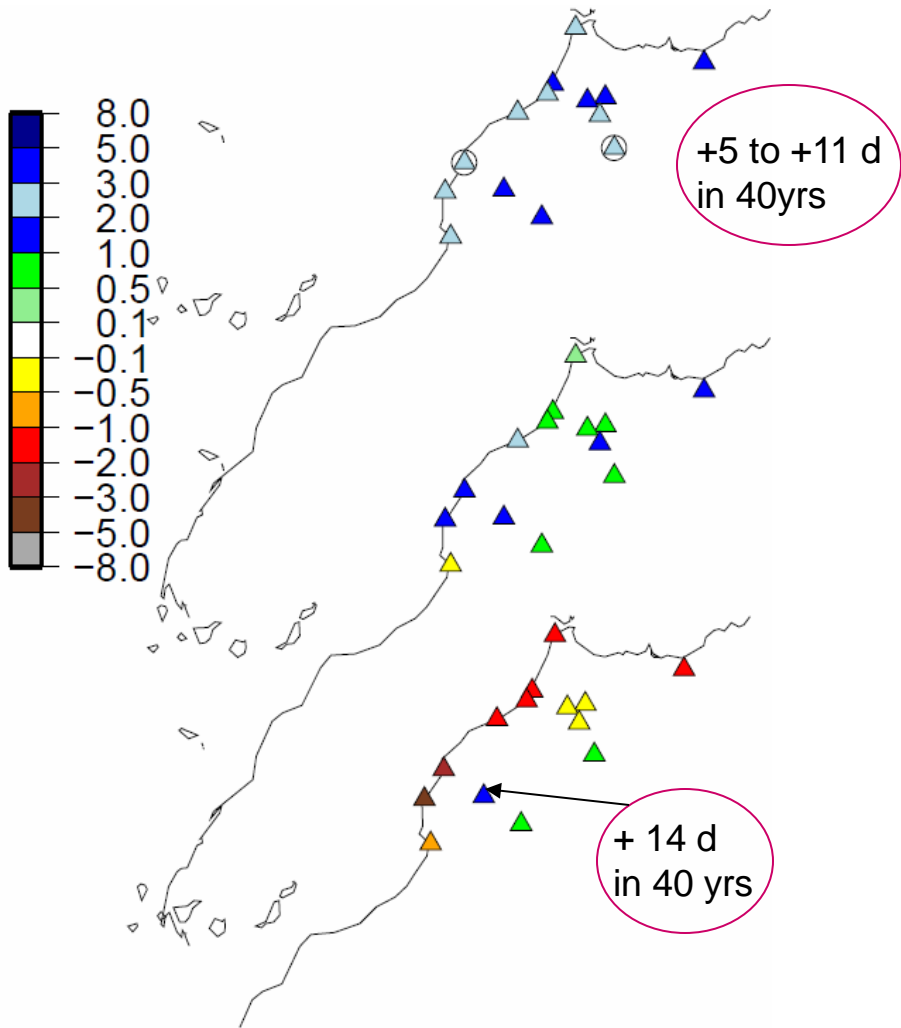
Total number of humid days (day/decade)



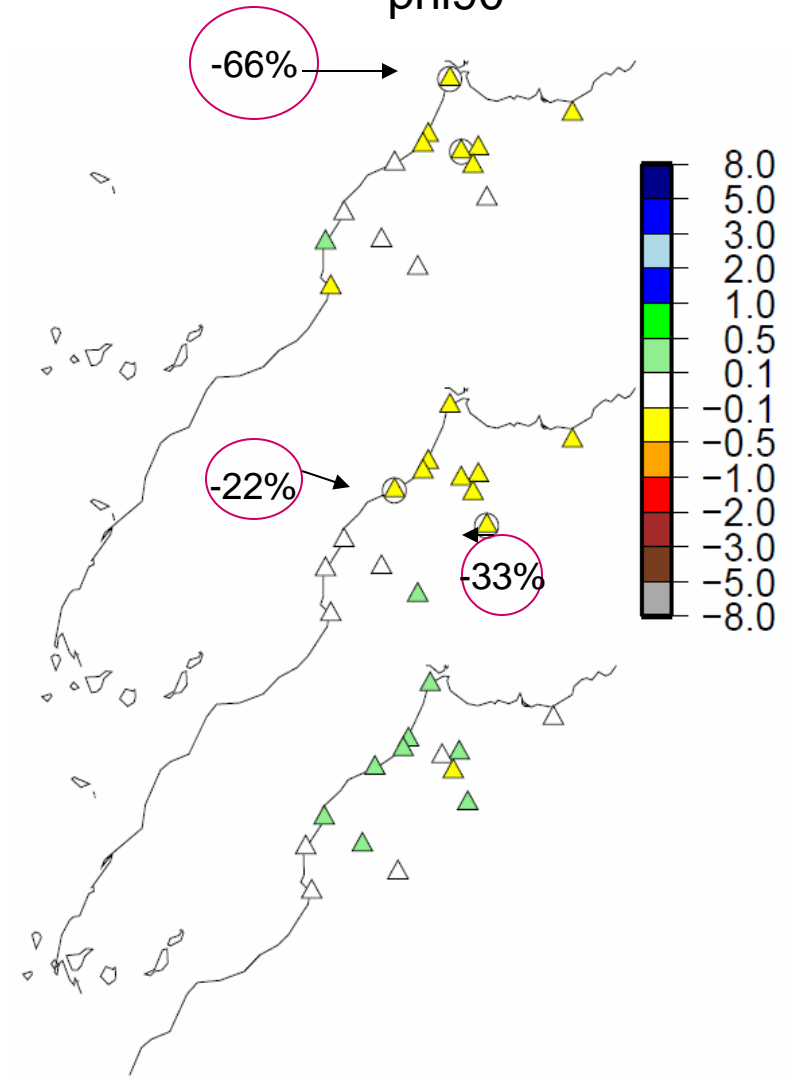
Observed trends of climate indices in Morocco (1961-2008).

Top: DJF, middle: MAM, bottom: SON

Pxcdd (j/decade)



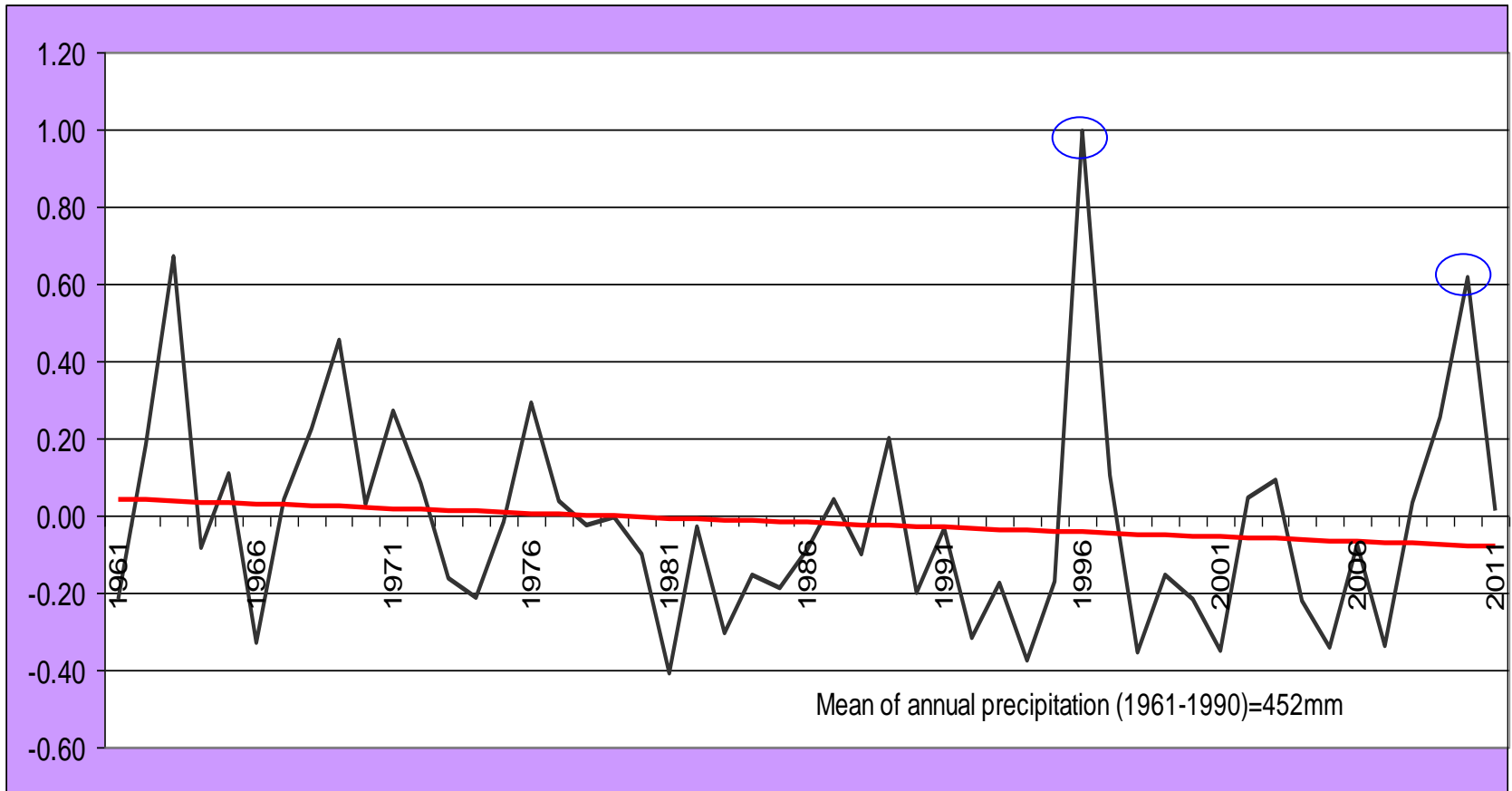
pnI90



Observed trends of climate indices in Morocco (1961-2008).
Top: DJF, middle: MAM, bottom: SON

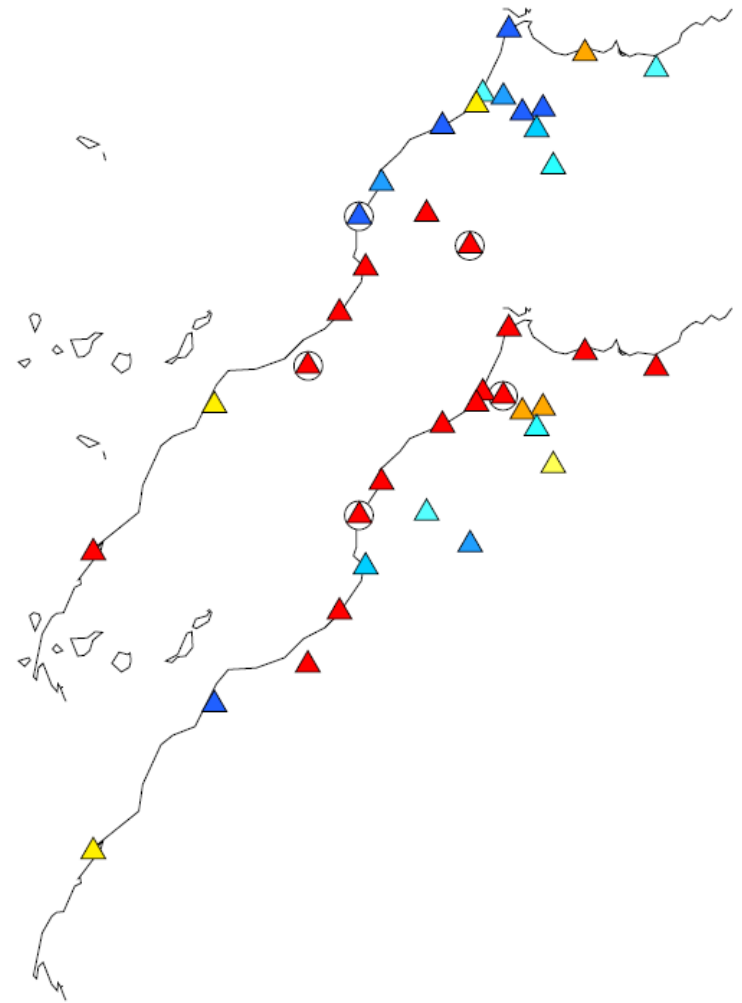
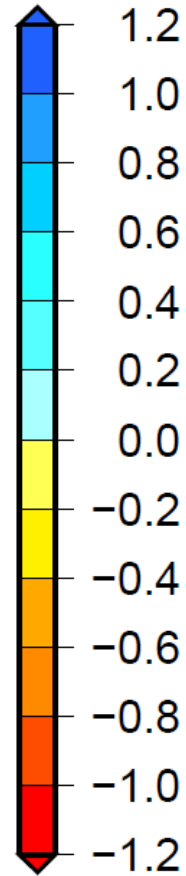
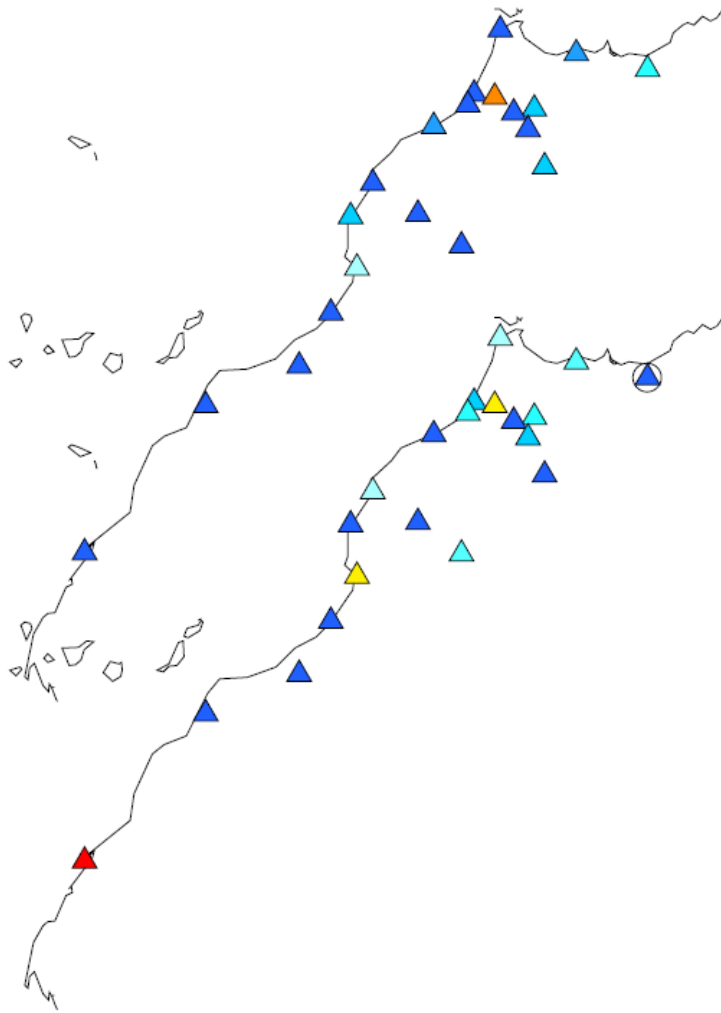
Stations	Types de climat durant 1961-1980	Types de climat durant 1981-2008	Tendances sur 1961-2008 (mm/°C par an)
Tanger	Semi-humide	Semi-humide	-0,13
Oujda	Semi-aride	Aride	<u>-0,13</u>
Kenitra	Semi-humide	Semi-aride	<u>-0,12</u>
Rabat	Semi-humide	Semi-aride	<u>-0,11</u>
Fès	Semi-humide	Semi-aride	<u>-0,10</u>
Meknès	Semi-humide	Semi-aride	<u>-0,19</u>
Casablanca	Semi-aride	Semi-aride	<u>-0,10</u>
Ifrane	Humide	Humide	<u>-0,37</u>
Safi	Semi-aride	Semi-aride	-0,07
Midelt	Aride	Aride	<u>-0,09</u>
Essaouira	Aride	Semi-aride	0,01
Marrakech	Aride	Aride	-0,05
Agadir	Aride	Aride	-0,07
Ouarzazate	Hyperaride	Hyperaride	0,01

Climate types evolution using De Martonne Index.

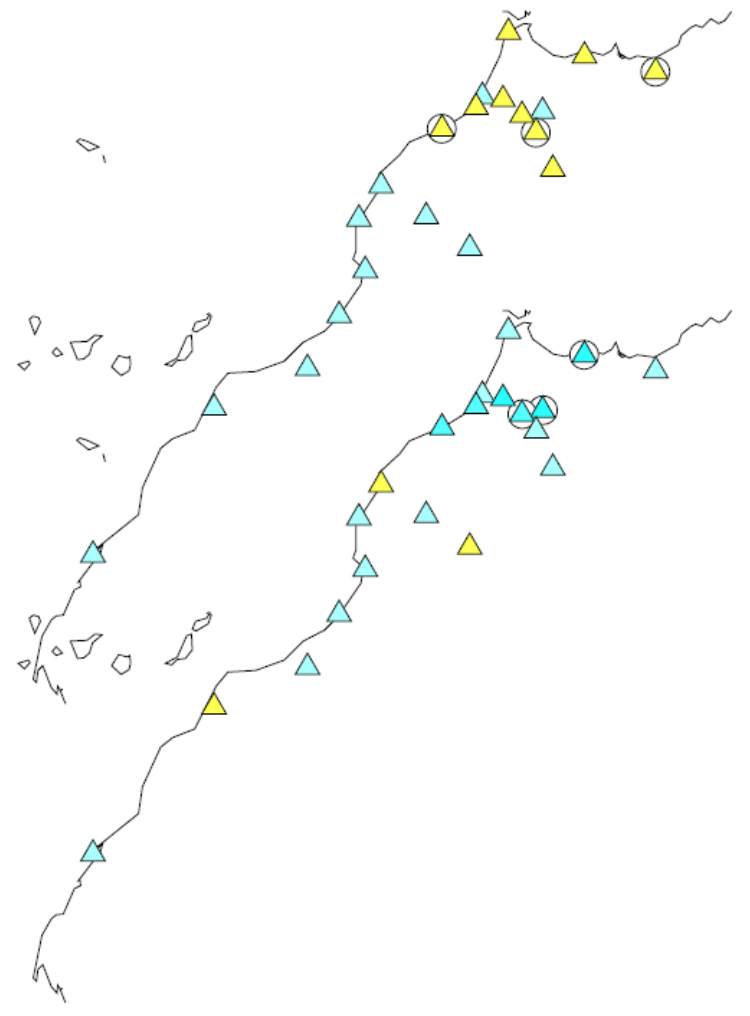
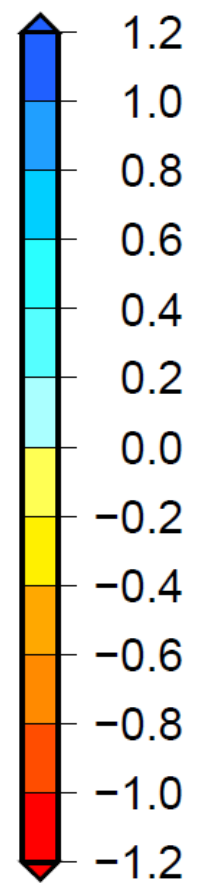
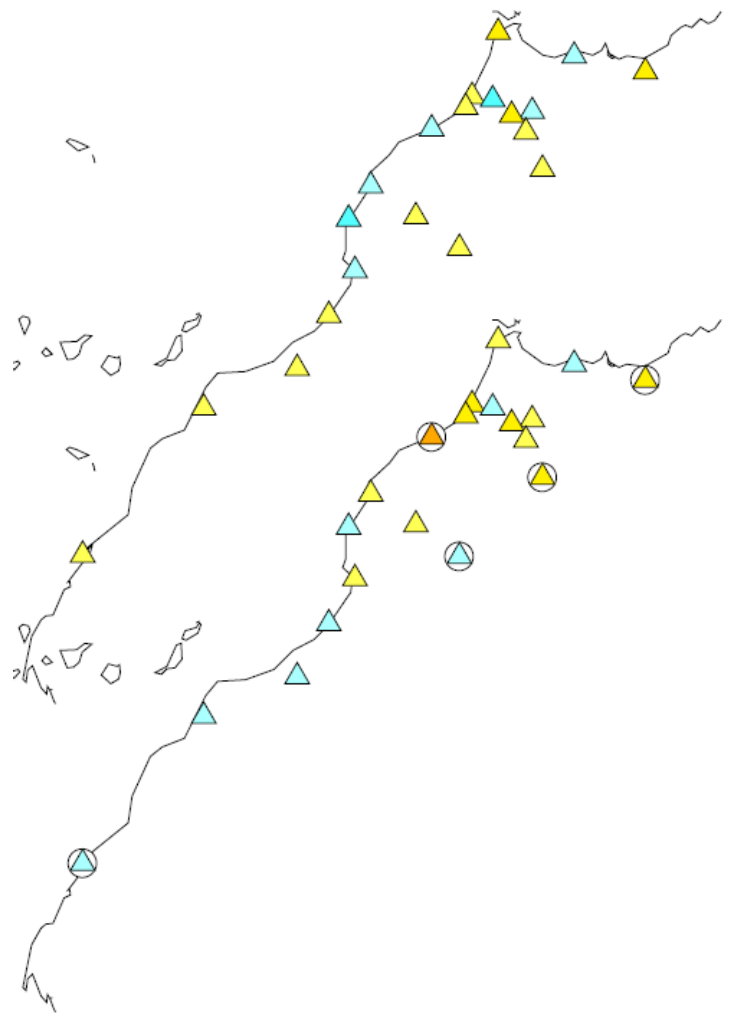


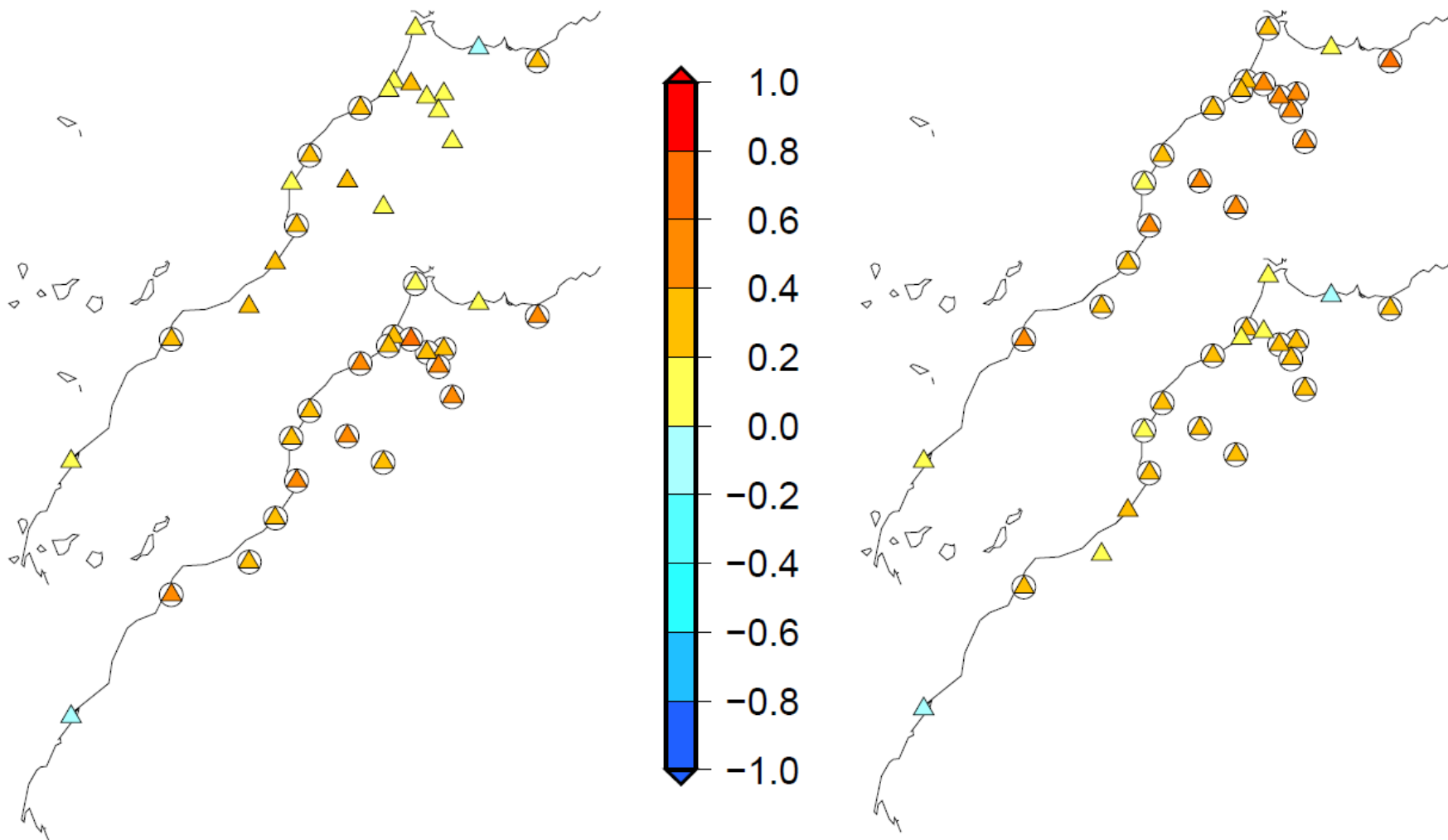
Anomalies relatives des cumuls pluviométriques annuels

Tendances de pxcdd : 1960-2012

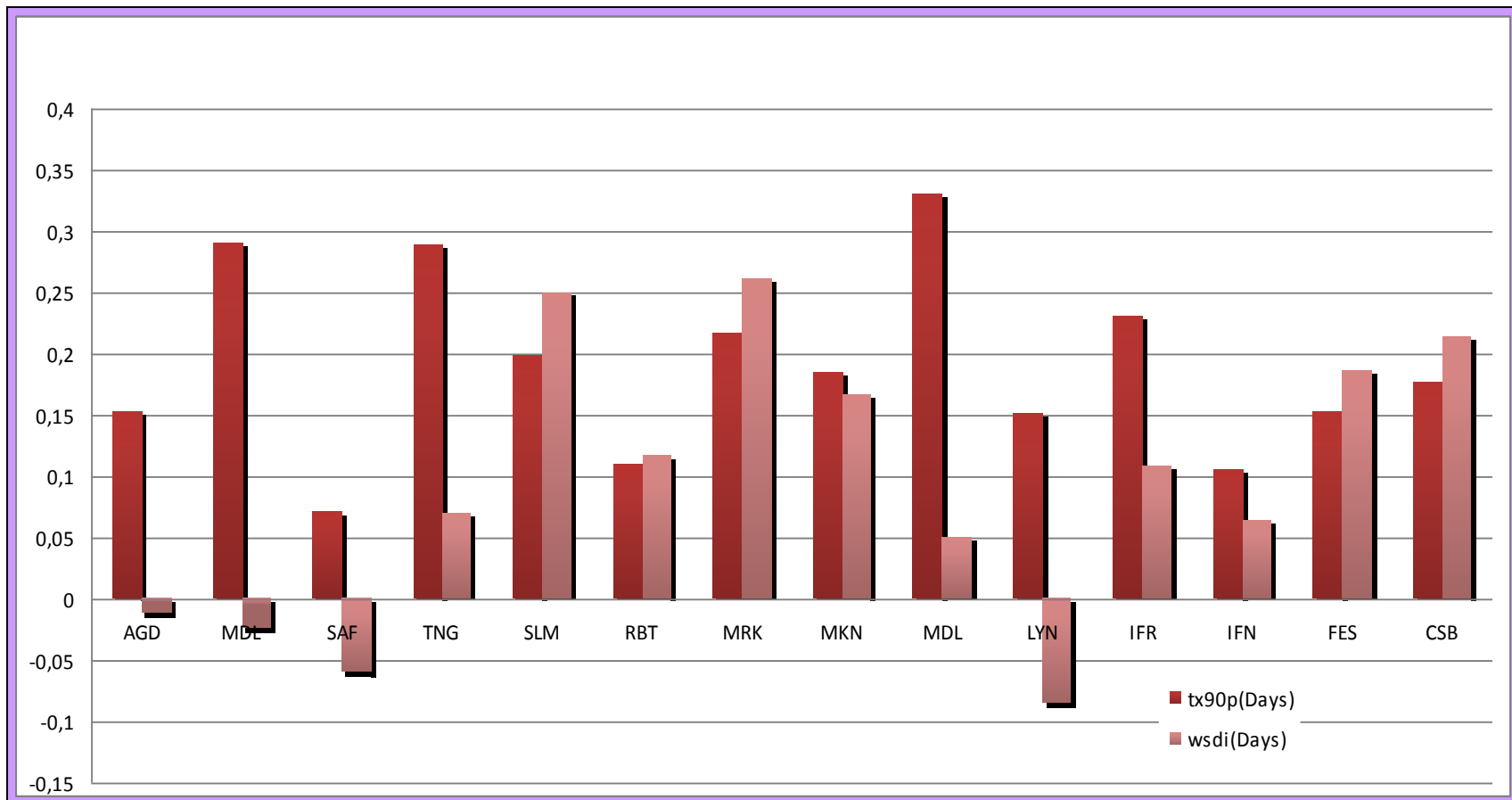


Tendances de pnl90: 1960-2012

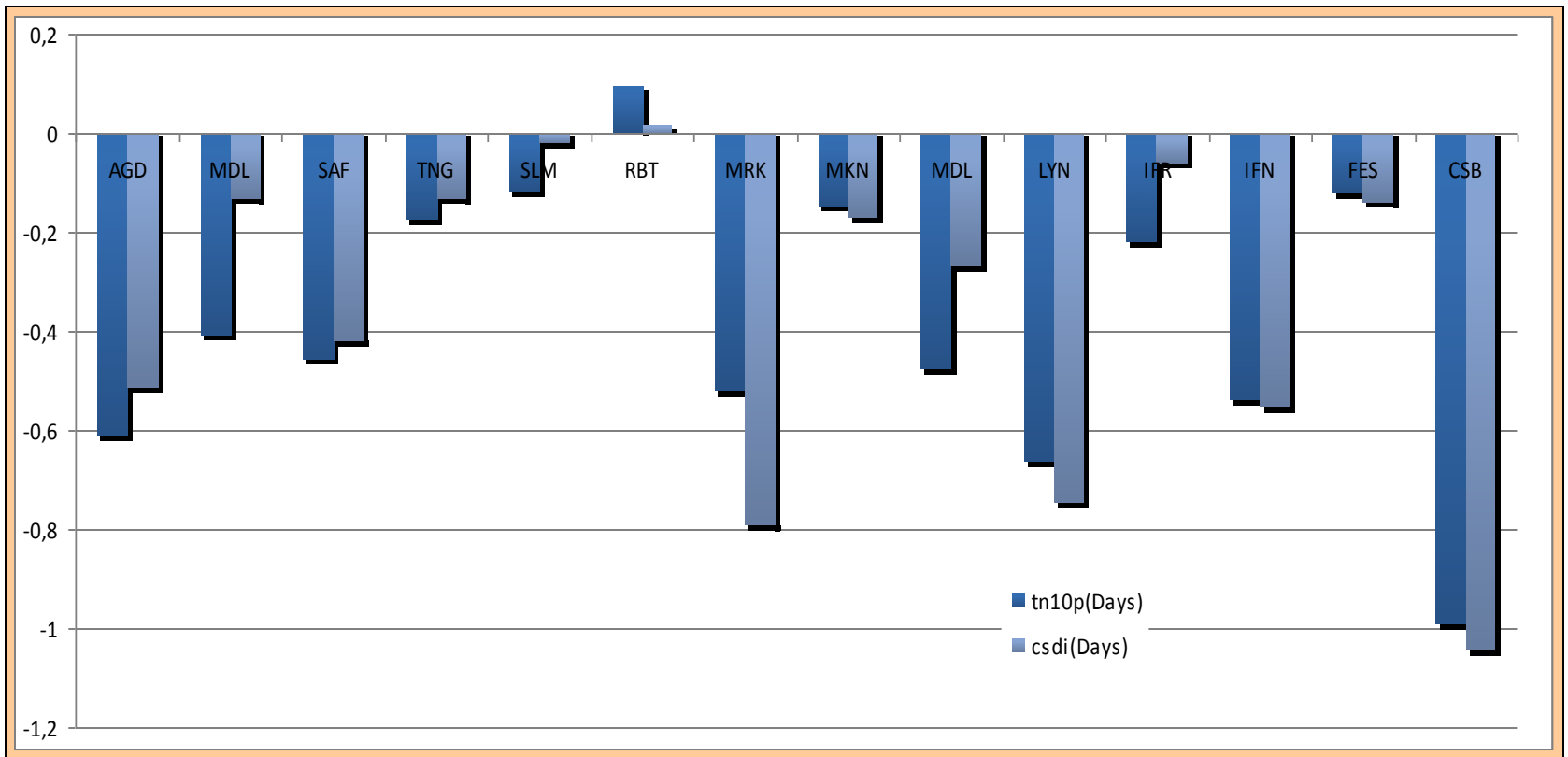




Tendances des températures (°C/décennie) : 1960-2012



Tendances des évènements extrêmes estivaux
(jours chauds et vagues de chaleurs)



Tendances des évènements extrêmes hivernaux
(nuits fraîches et vagues de froid)

Les moyens de Maroc Météo

les moyens de Calcul

1995
1,2 Milliards
d'opérations par seconde



2001
54 Milliards d'opérations
par seconde



2010
8300 Milliards d'opérations
par seconde

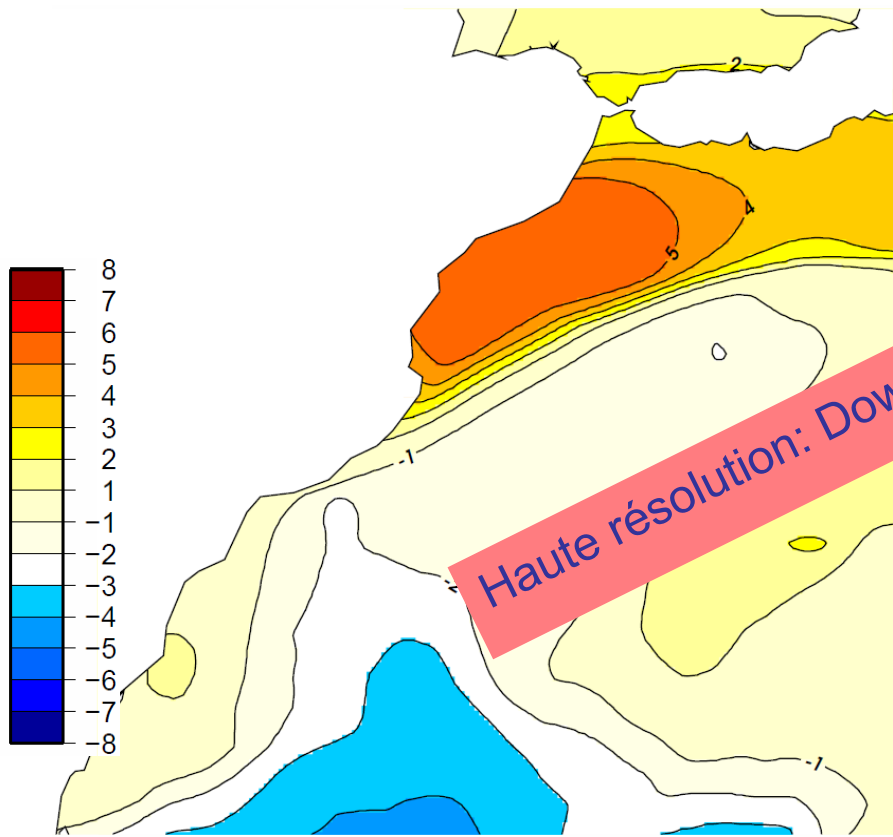


Le calculateur IBM RS6000 de la DMN

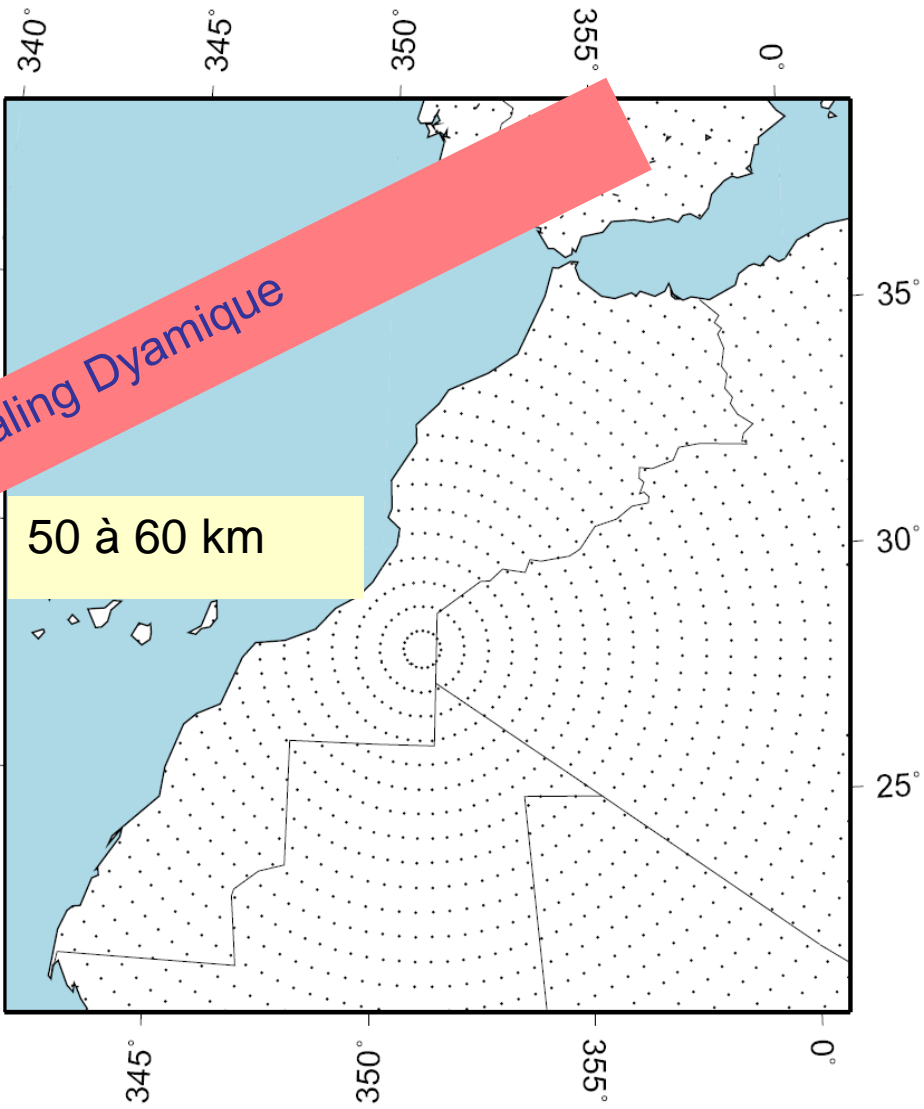


Modèles dynamique global: AREPEGE-Climat

Nombre maximal de jours consécutifs secs (en jours)



Haute résolution: Downscaling Dynamique

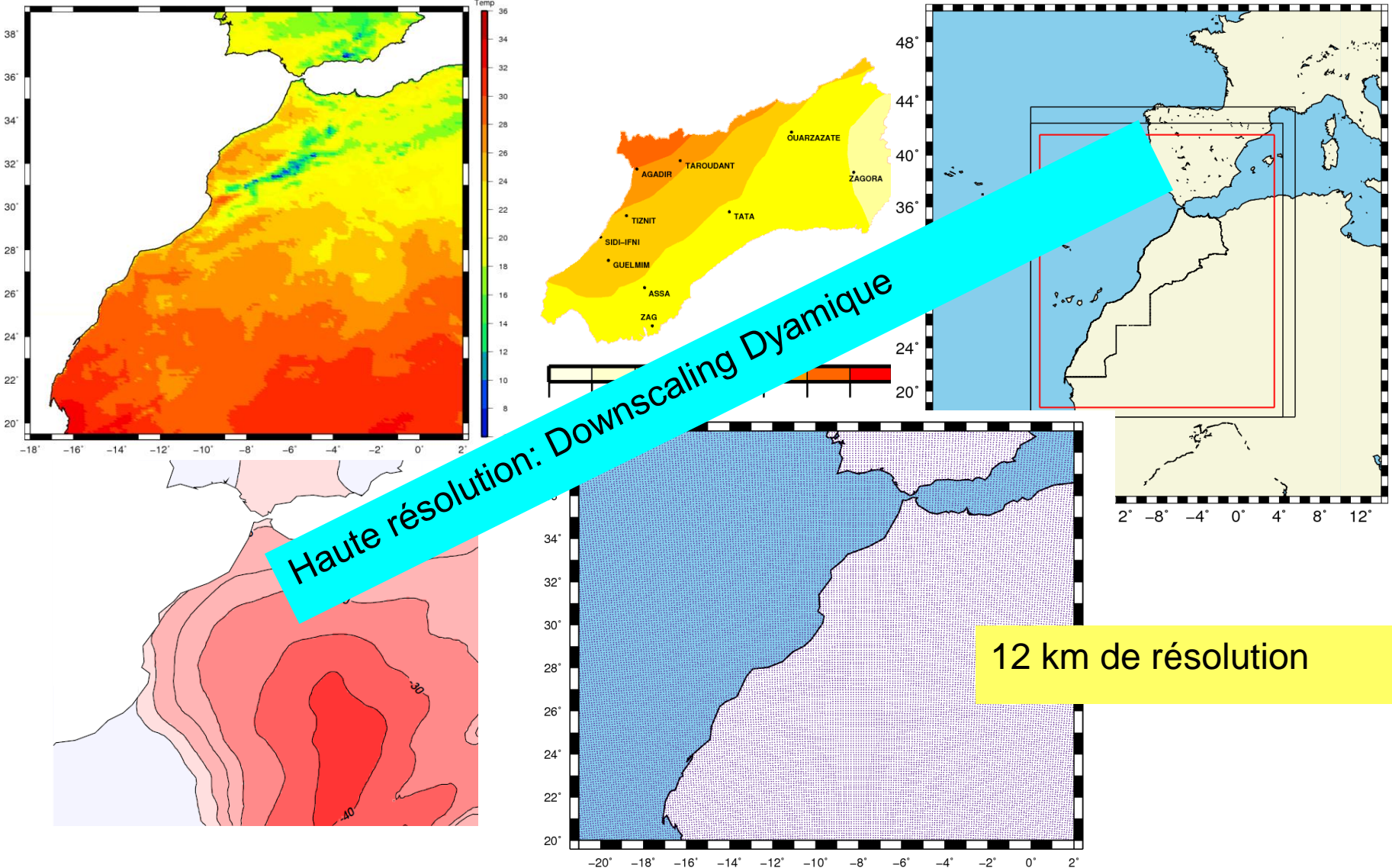


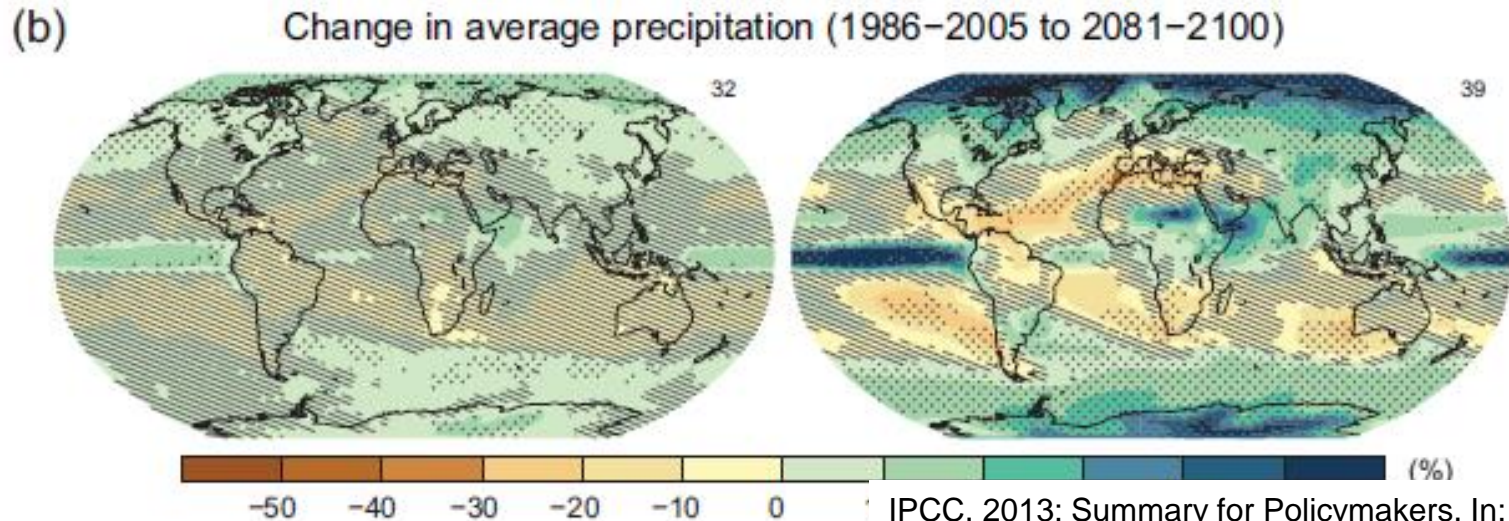
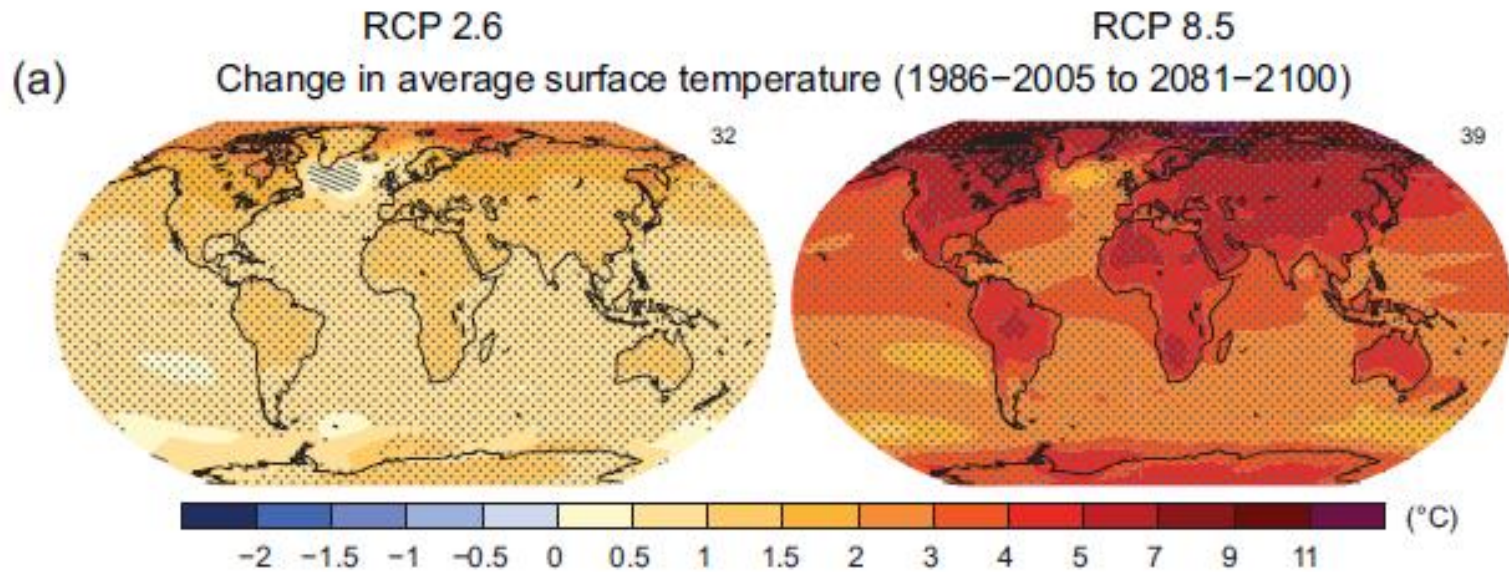
Changements futurs à l'horizon 2030 pour l'hiver étendu (octobre à mars).

Les moyens de Maroc Météo

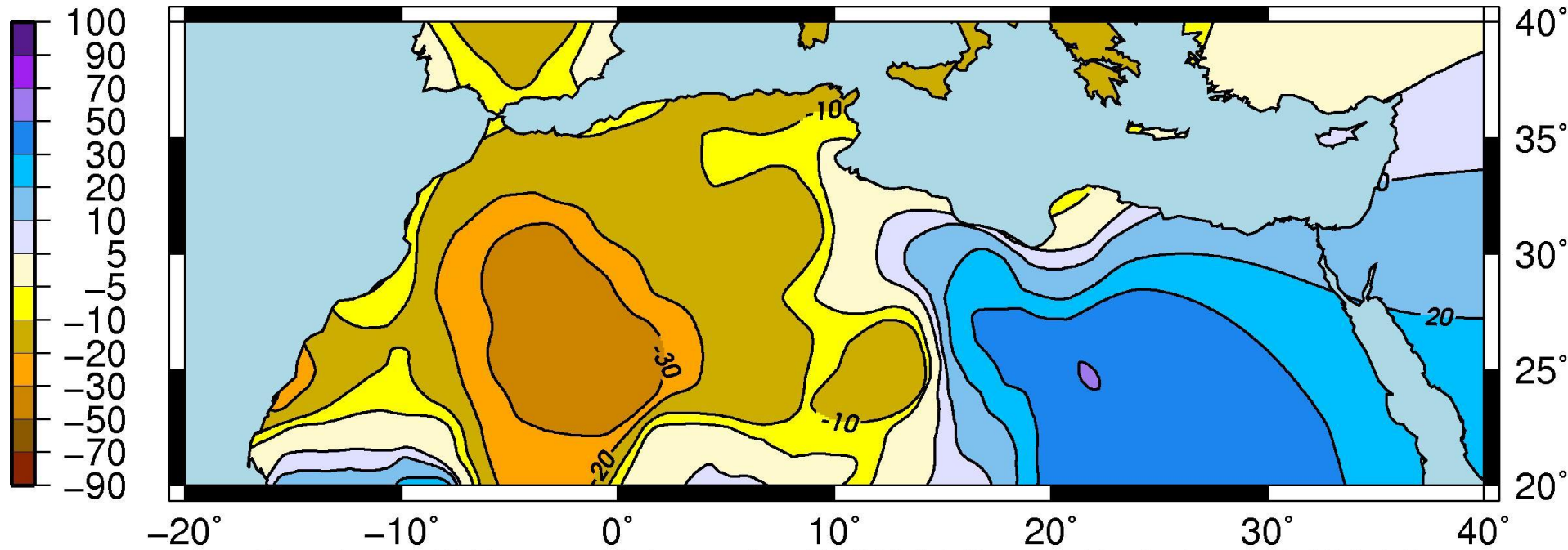
Les modèles et les outils de prévision: changements climatiques

Modèles dynamique à domaine limité: Aladin-Climat

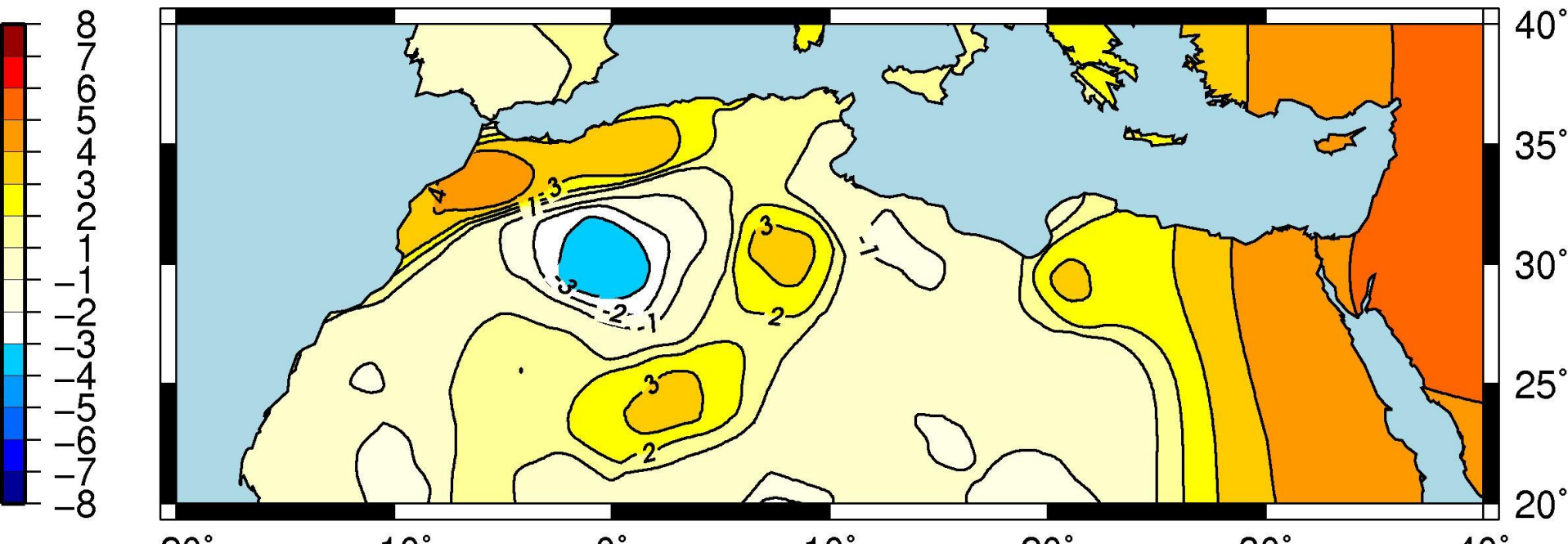


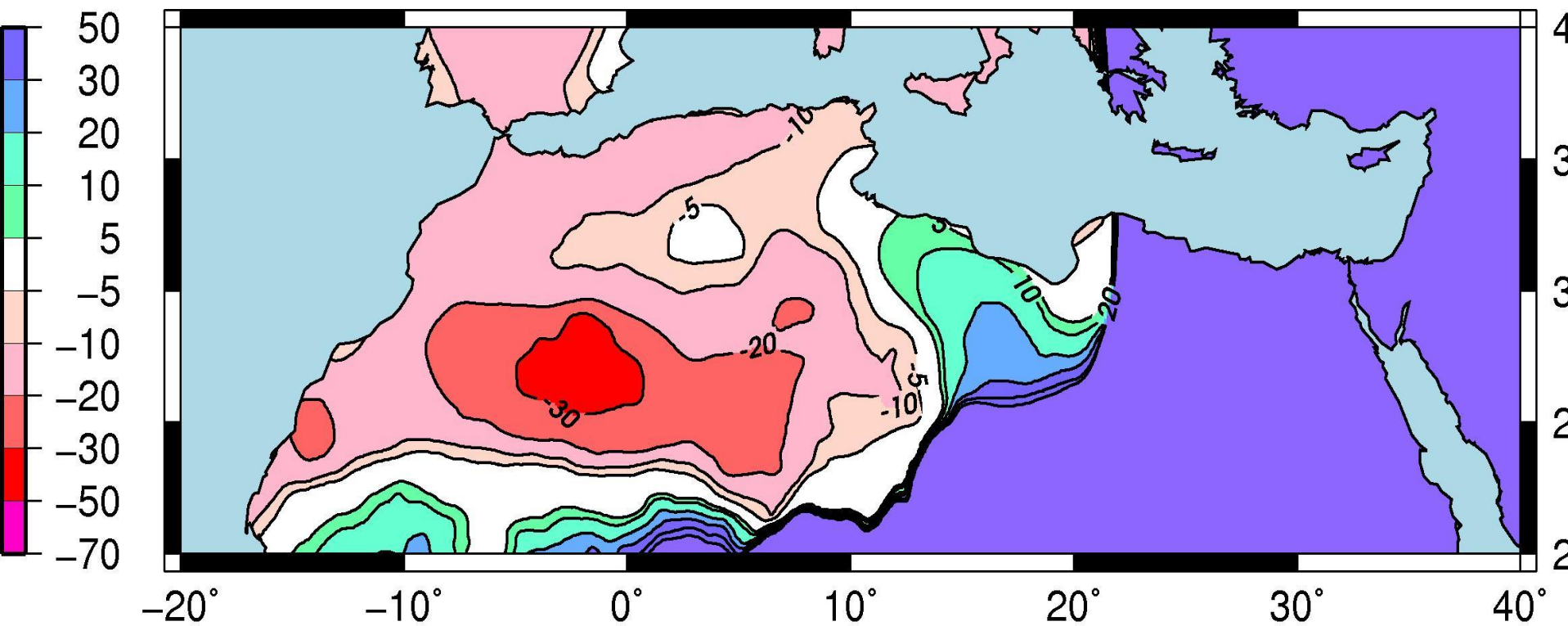


IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change



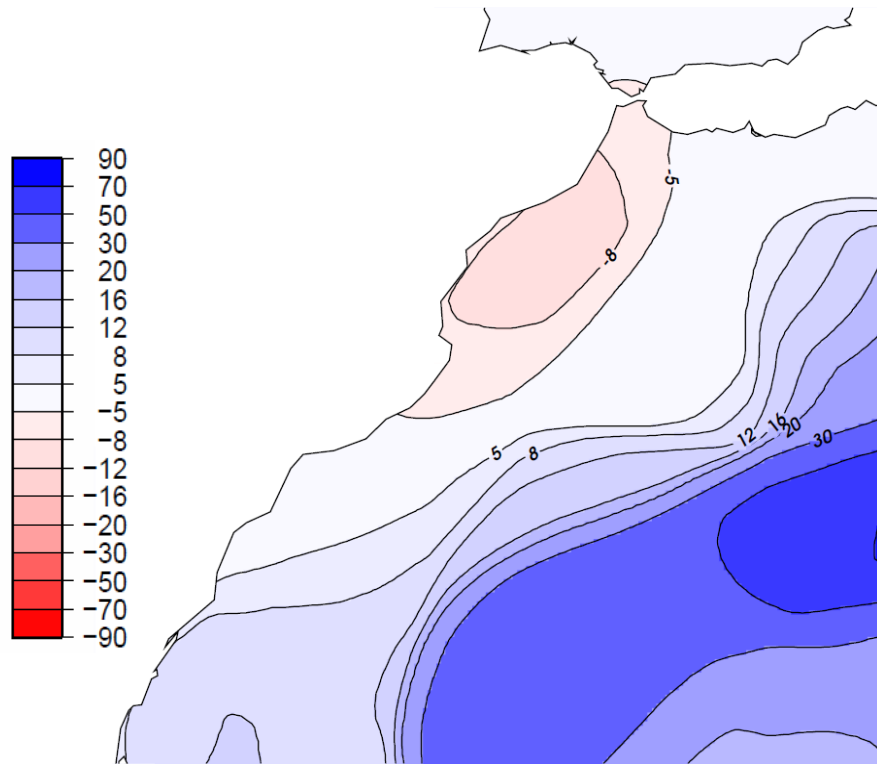
Future changes of DJF mean precipitation as projected by ARPEGE–Climate model under the scenario IPCC–A1B
 Future period 2021–2050 compared to the reference period 1971–2000. Authors: Driouech Fatima, El rhaz Khalid



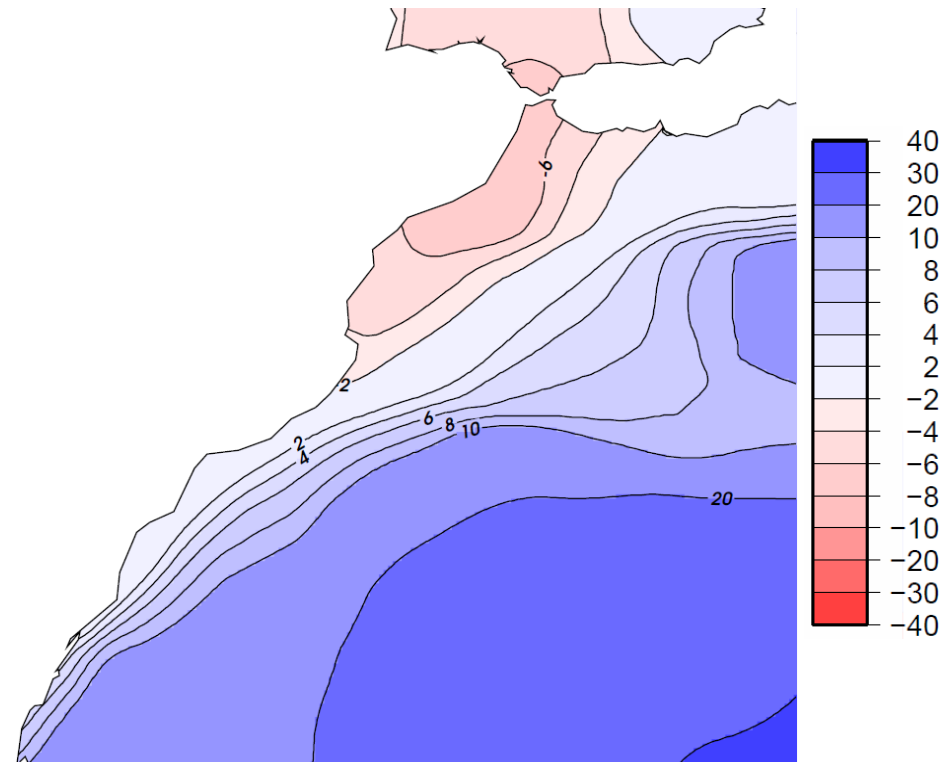


Future changes of DJF total number of high precipitation events as projected by ARPEGE–Climate model under the scenario IPCC–A1B
 Future period 2021–2050 compared to the reference period 1971–2000. Authors: Driouech Fatima, El rhaz Khalid

Précipitation moyenne

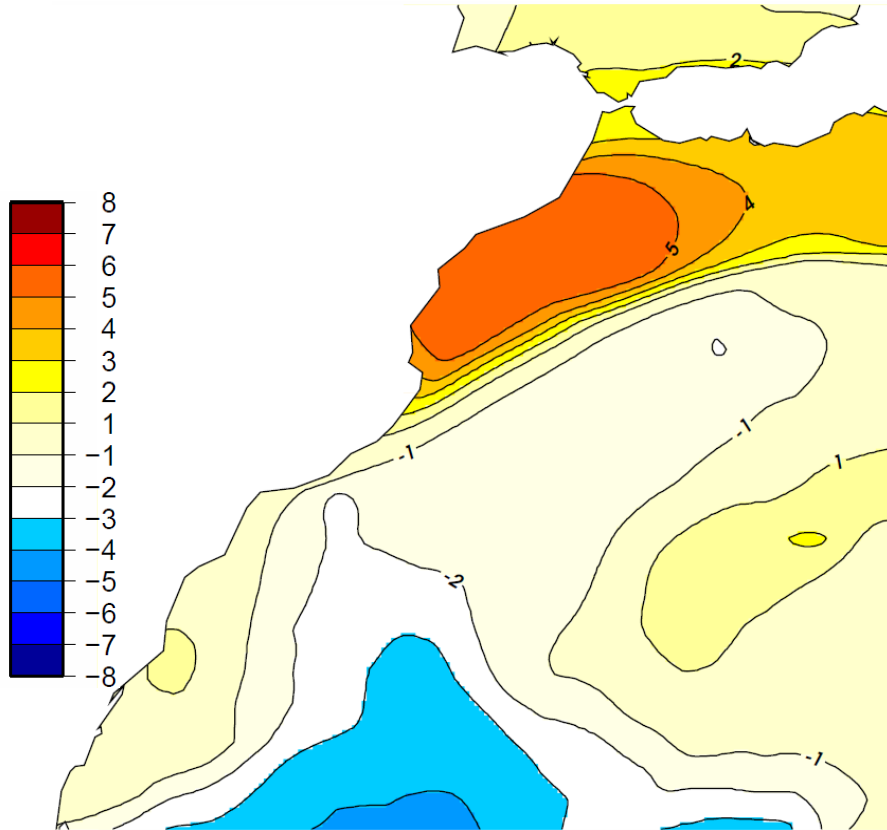


Nombre de jours humides

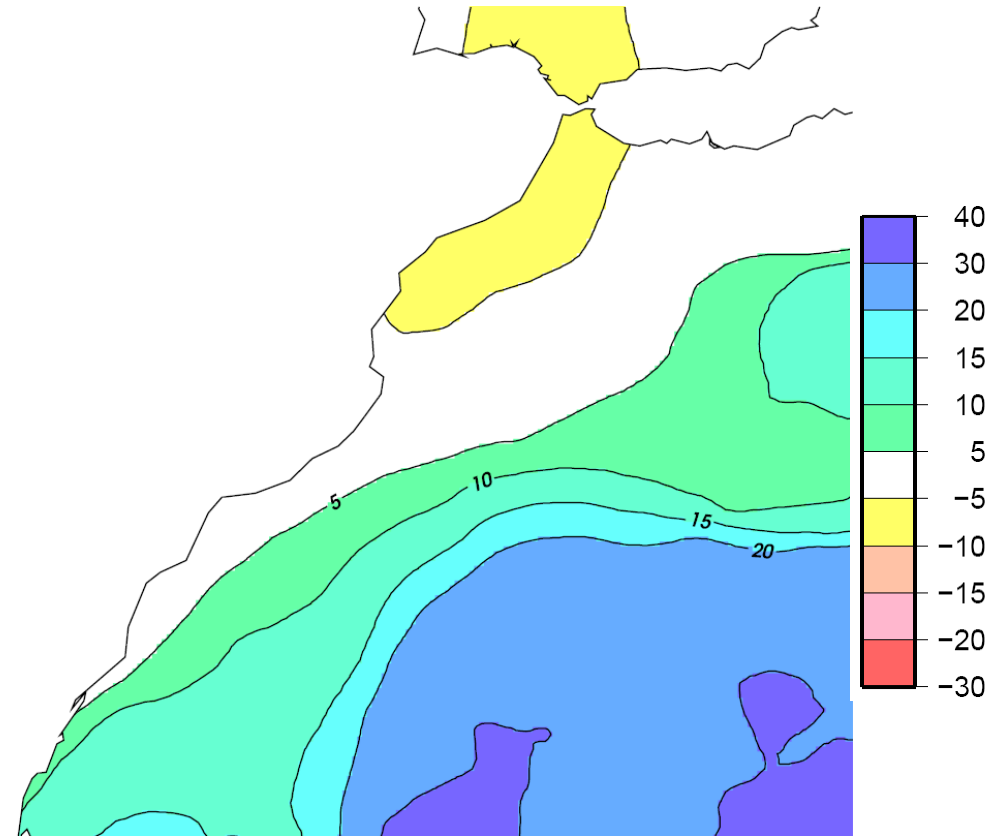


Changements (%) projetés par ARPEGE-Climat sous le scénario A1B pour l'hiver étendu (octobre à mars). 2021-2050 par rapport à 1971-2000.

Nombre maximal de jours consécutifs secs (en jours)

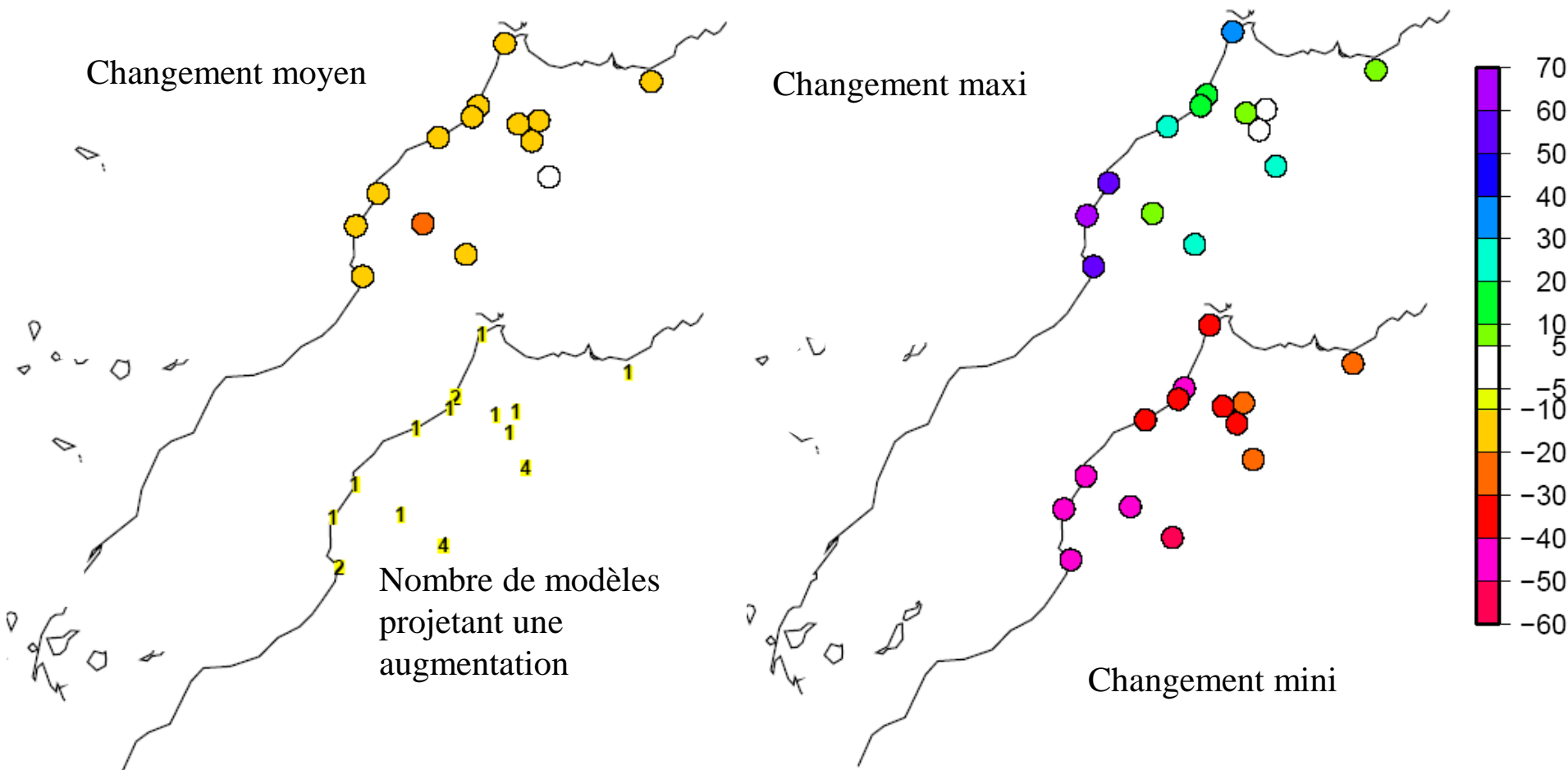


Nombre d'évènements de fortes précipitations (en %)



Changements projetés par ARPEGE-Climat sous le scénario A1B pour l'hiver étendu (octobre à mars). 2021-2050 par rapport à 1971-2000.

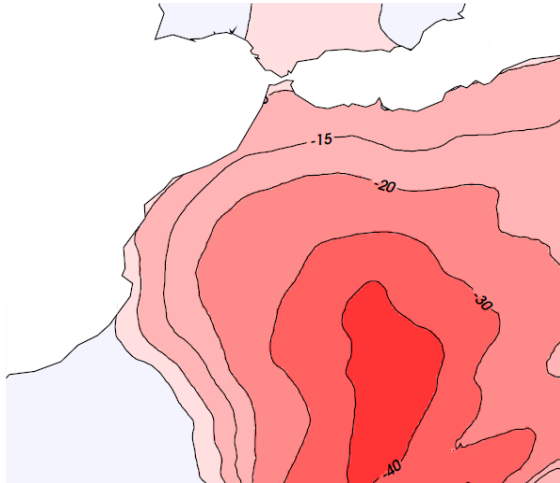
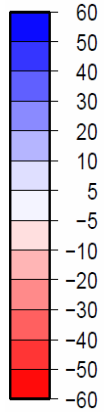
Uncertainties related to future changes for precipitation



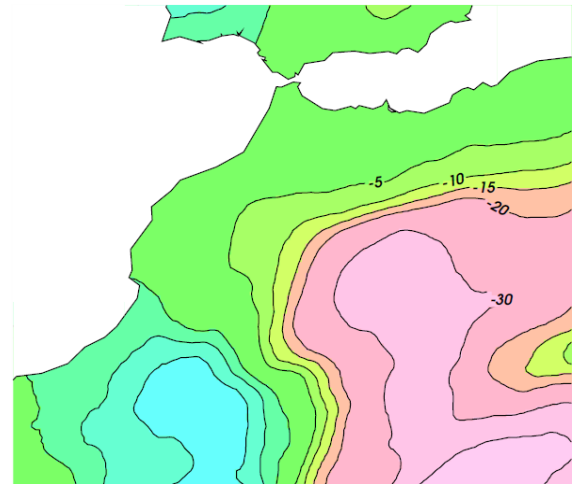
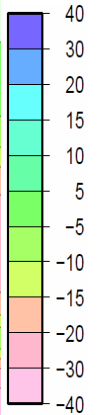
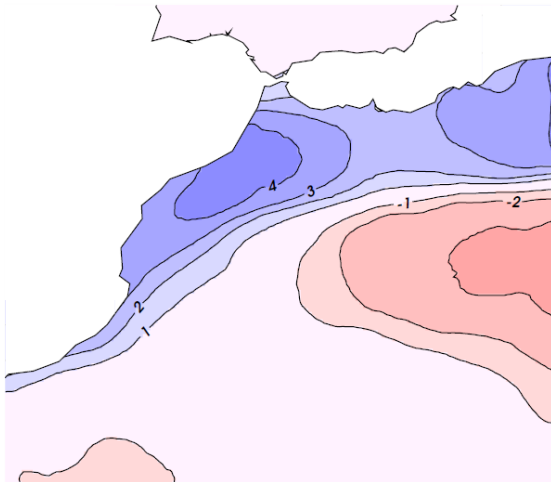
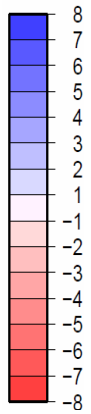
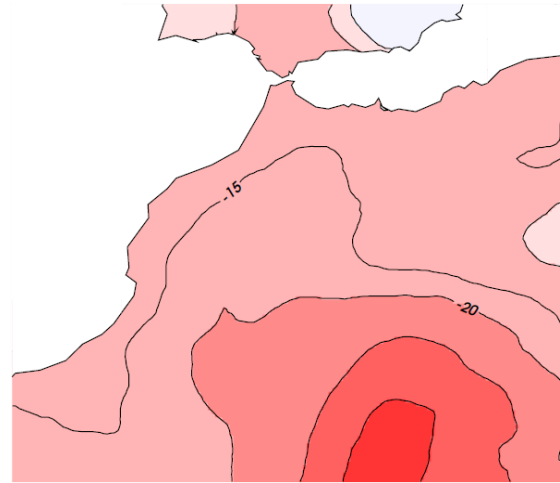
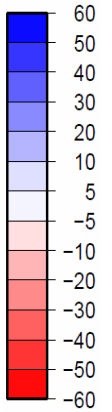
- a) Top: Mean change for mean precipitation (11 RCM) in %.
Down: Number of models giving an increase in precipitation
- b) Maximum change (top) and minimum change (down) in %
SRES A1B. 2021-2050 / 1971-2000. Winter (DJF).

Aladin-Climate

Précipitation moyenne (en %)



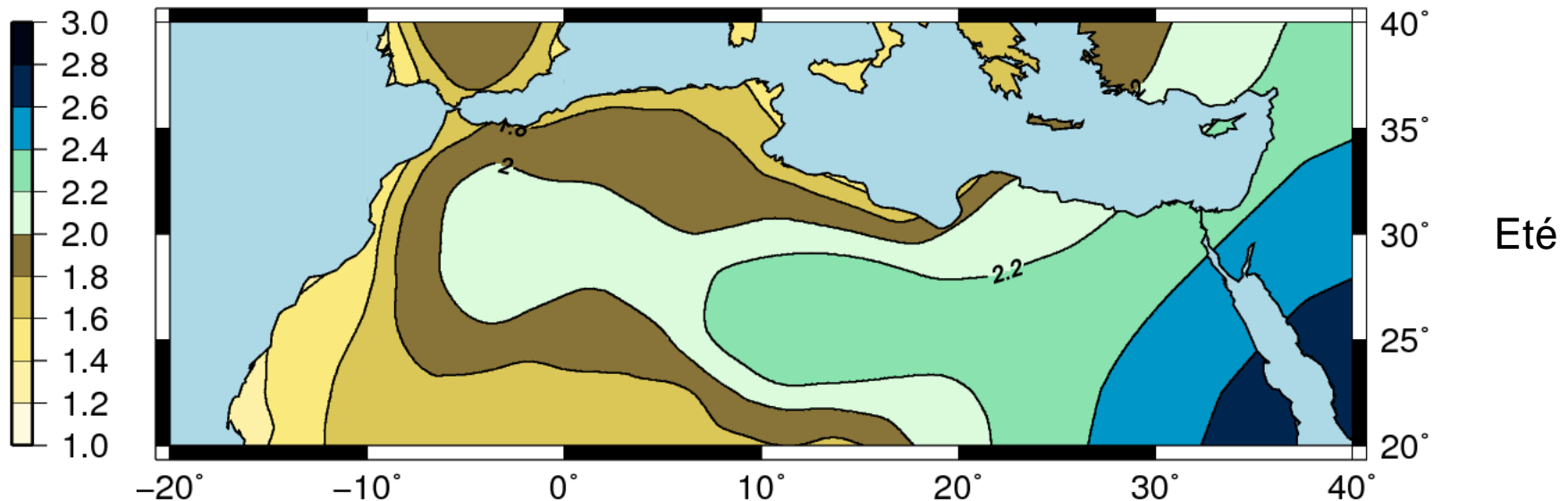
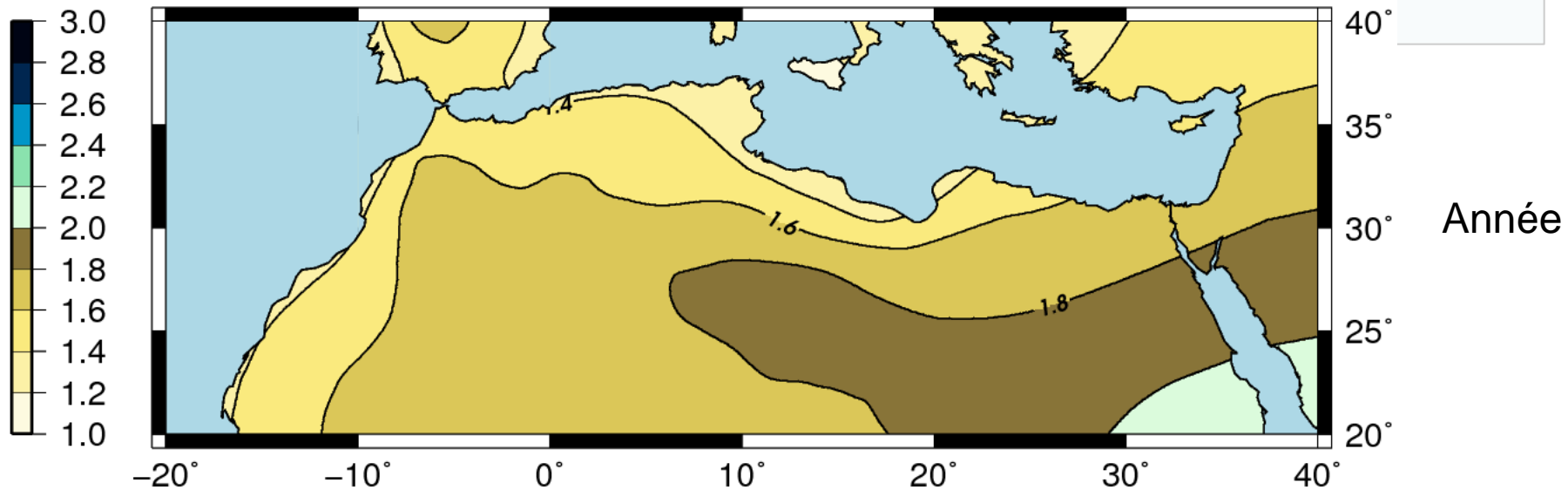
Nombre de jours humides (en %)



Nombre maximal de jours consécutifs secs (en jours)

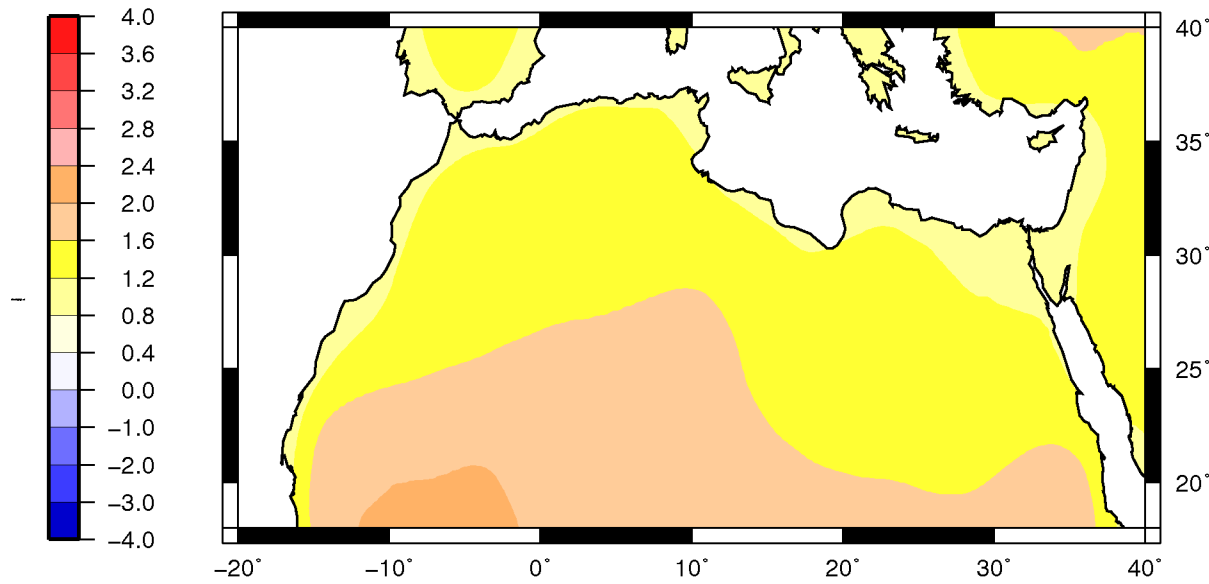
90ème centile calculé sur le long terme (en %)

Volet Changements climatiques: Changements futurs

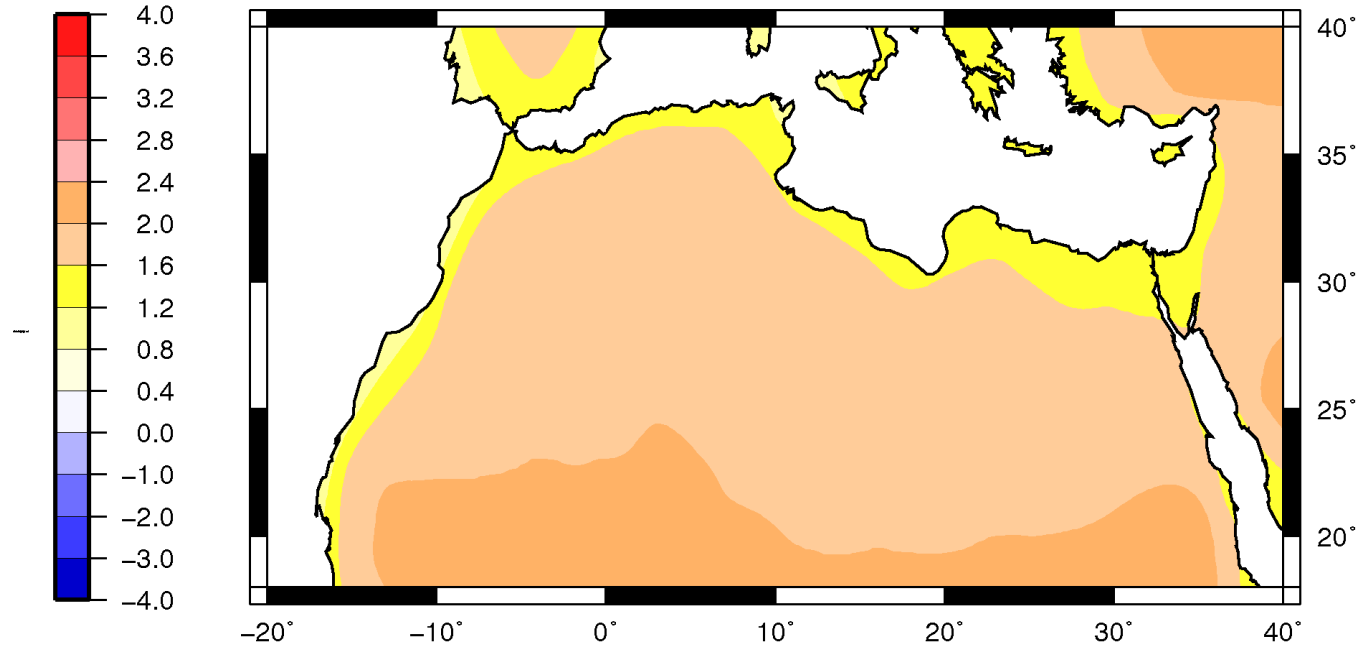


Changements projetés par ARPEGE-Climat pour la température moyenne.
Scénario A1B. 2021-2050 par rapport à 1971-2000. (en °C)

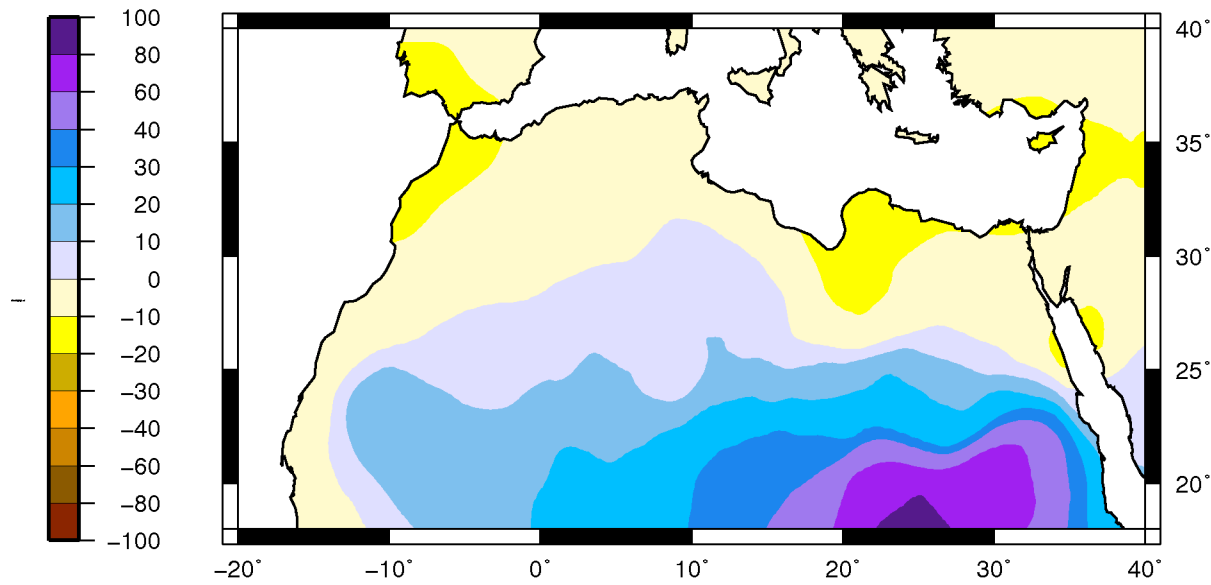
Température moyenne



KNMI_rcp85
Annuel
Horizon 2030

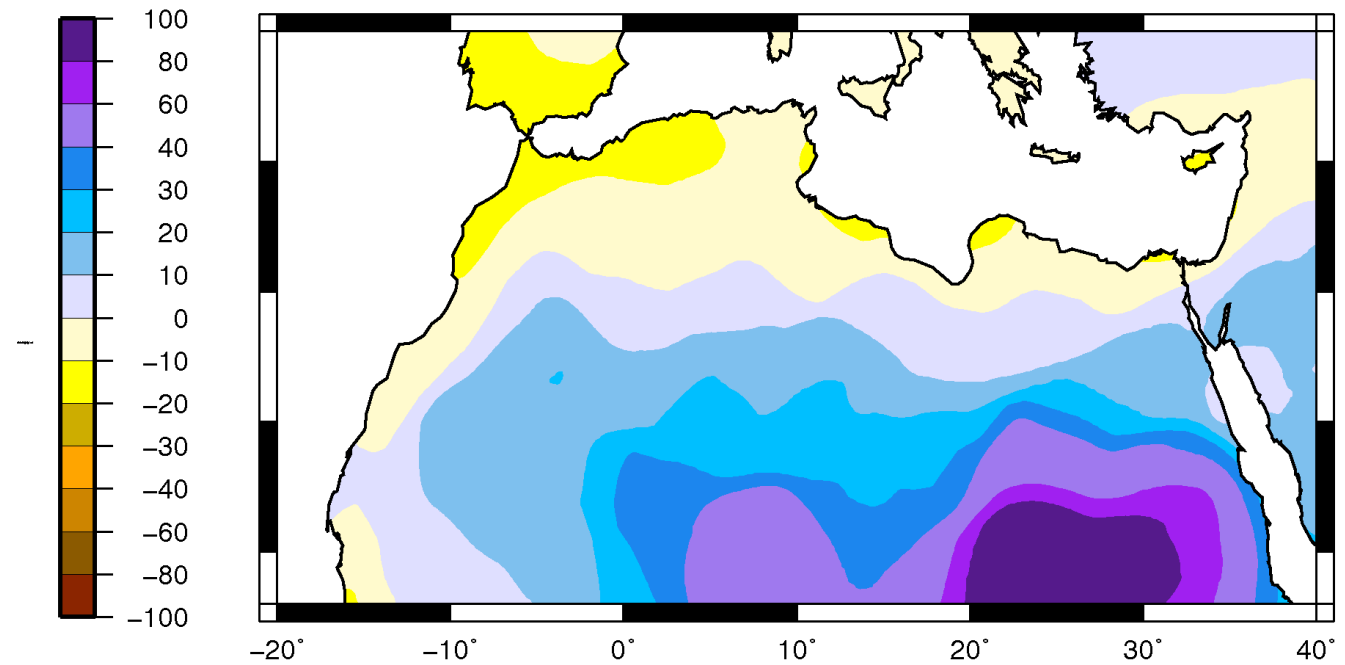


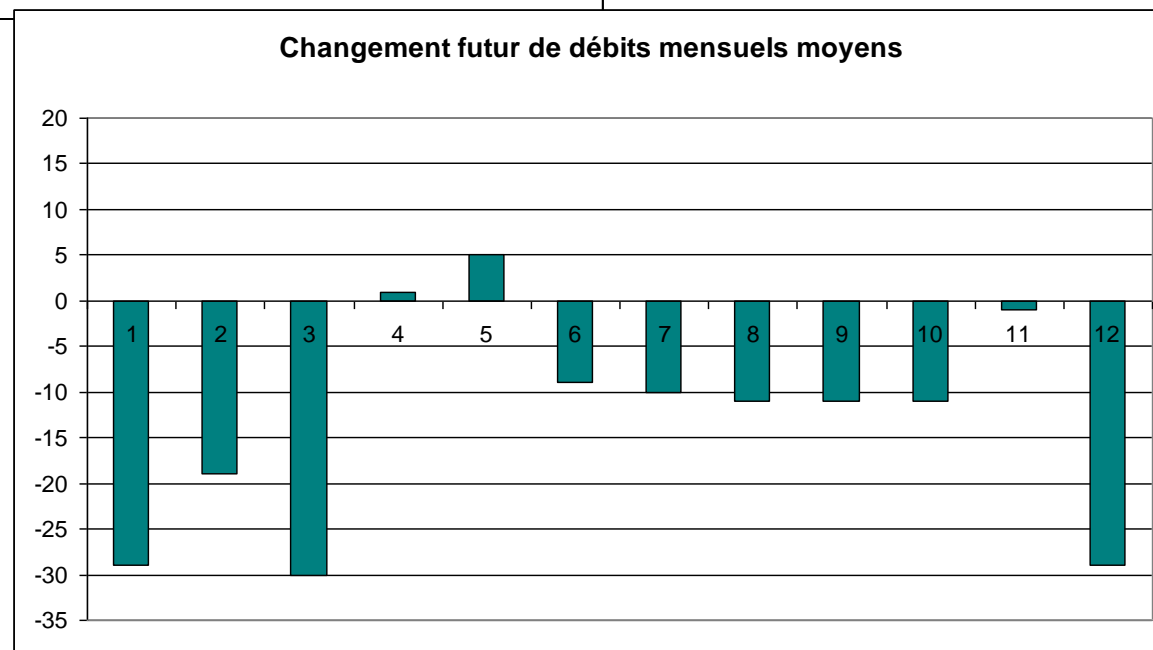
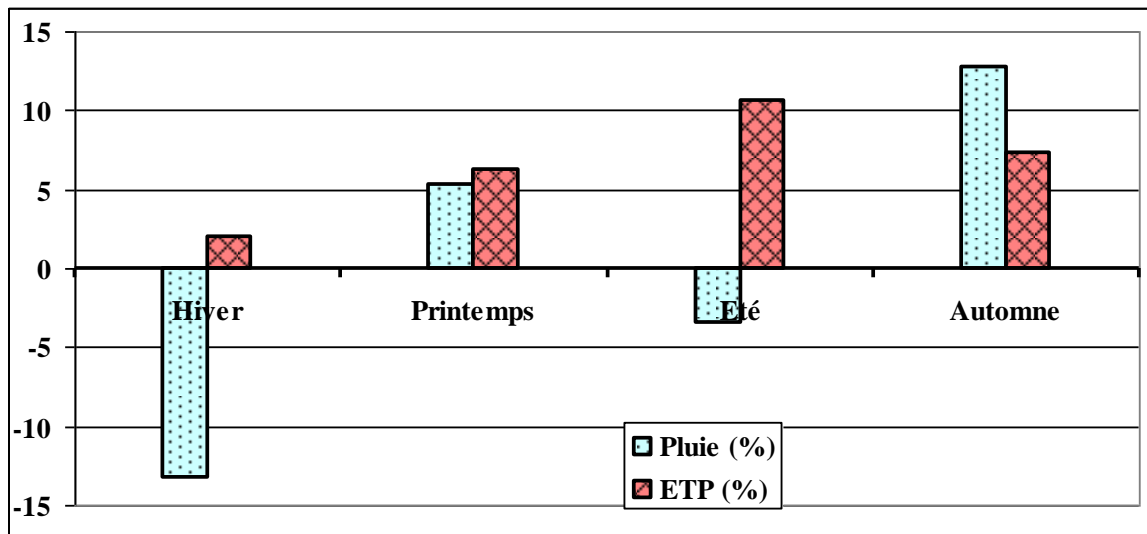
Précipitation



CCCma_rcp45
Annuel
Horizon 2030

CCCma_rcp85
Annuel
Horizon 2030

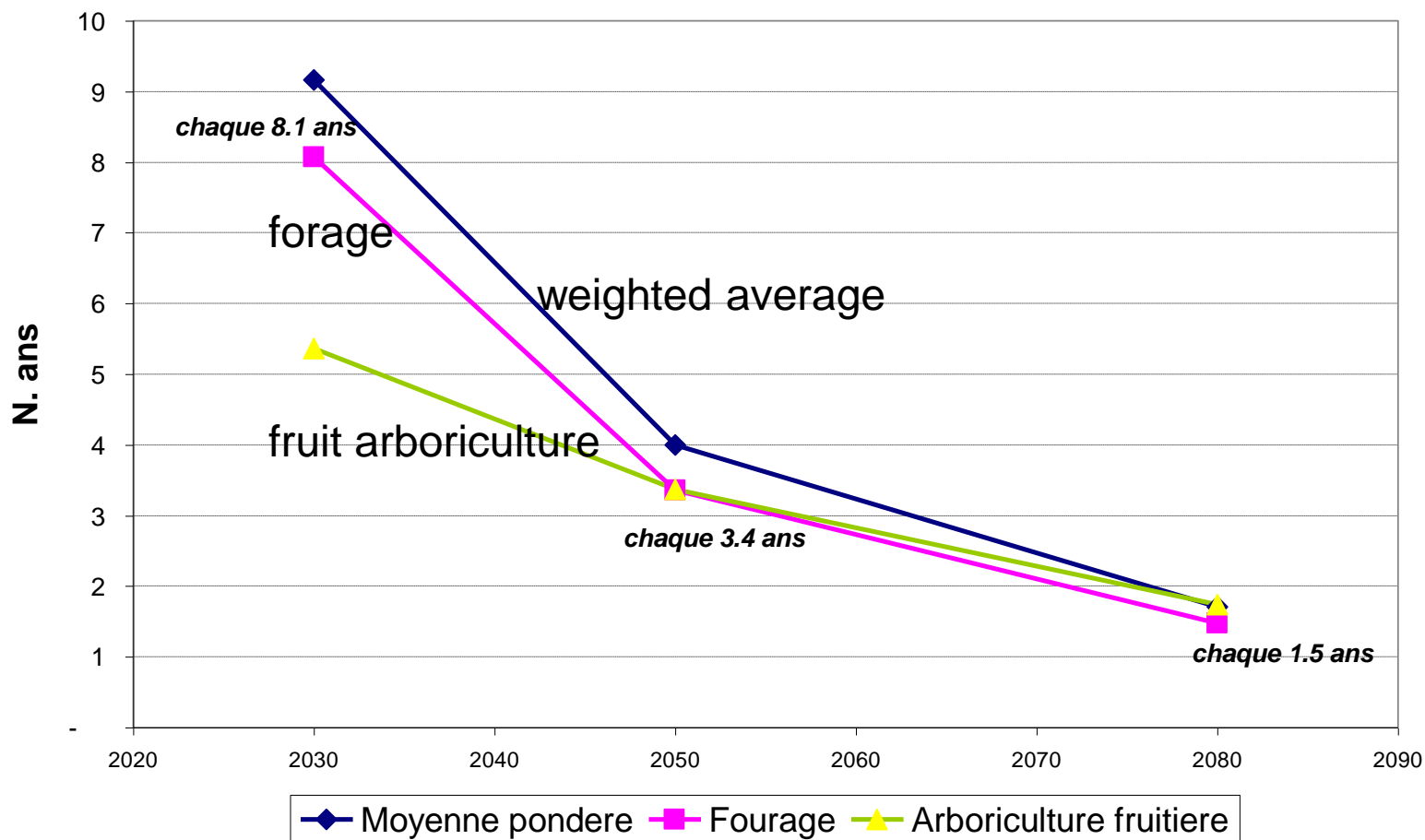




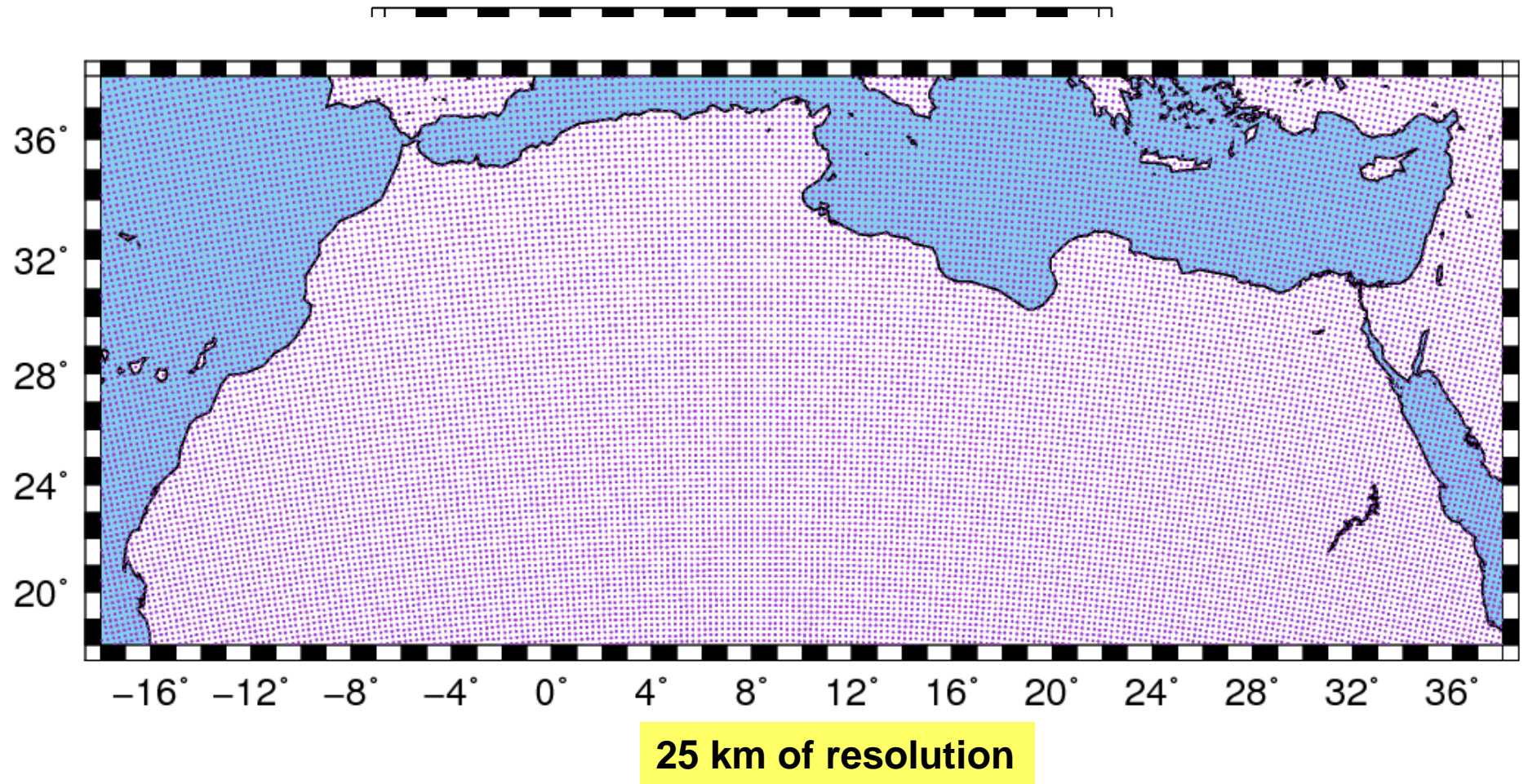
Variation des débits mensuels moyens au niveau de la Moulouya entre le futur et le présent 2021-2050 par rapport à 1971-2000. Scénario A1B.

Impact of climate change on crops in Morocco at current technology level : Increase of low Yield frequency

Future return periods of yields with 10 years return period in the current climate



Avec remerciements à T. ElHaïrech



Possible future work: Climate Scenarios for the North African RCC region



Avec Remerciements