Climate change and heavy precipitating events in South-Eastern France

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Introduction

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99th quantile of daily precipitation (mm/d) in SON for the period (1989-2008)

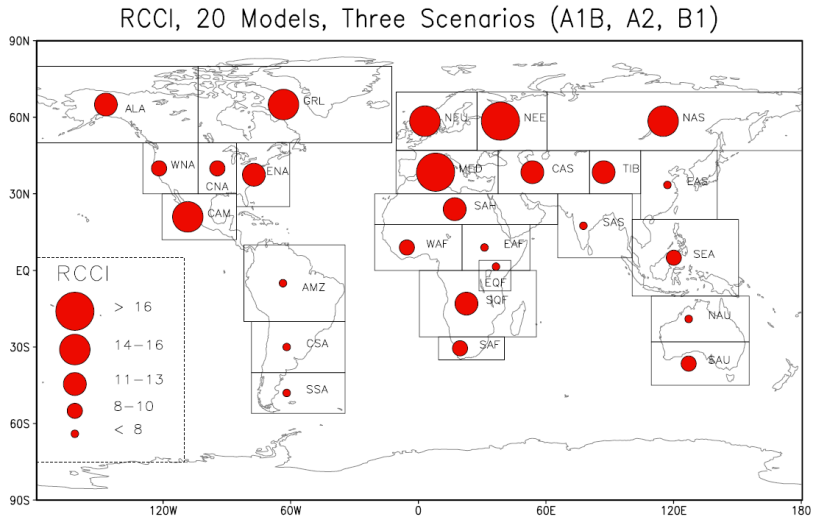
=> Heaviest rainfall occurs over southern-France and over the Alps.

Climate change hot-spots

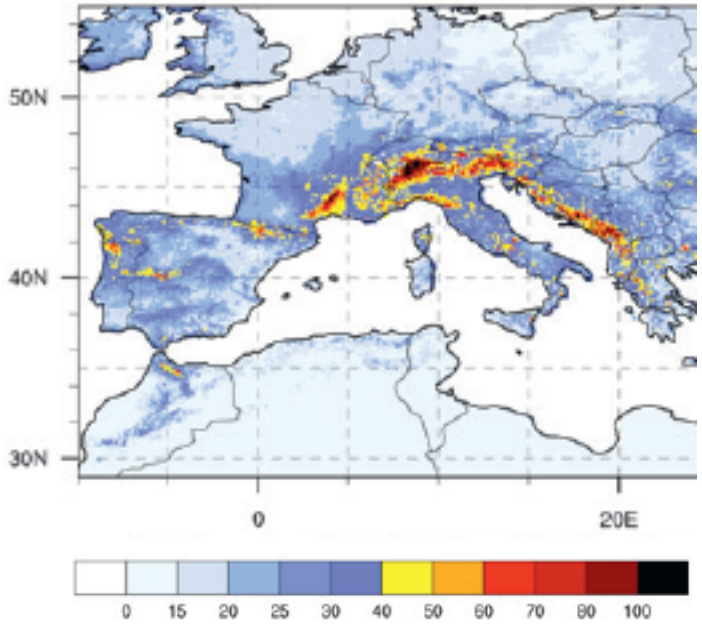
F. Giorgi[1]

Received 11 January 2006; revised 27 February 2006; accepted 17 March 2006; published 21 April 2006.

[1] A Regional Climate Change Index (RCCI), is developed based on regional mean precipitation change, mean surface air temperature change, and change in precipitation and temperature interannual variability. The



Ruti et al. 2016



The Mediterranean is known to be one of the main climate change hot-spots in the world. This region is characterized by a closed sea surrounded by mountains

Introduction

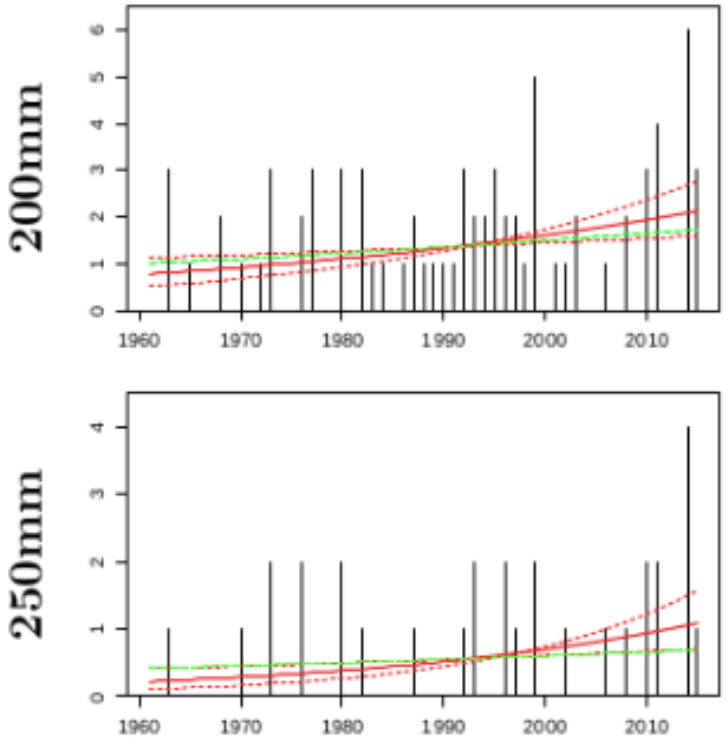
South-eastern region of France is regularly affected by events caused by intense deep convection phenomena associated with quasi-stationary systems in autumn.

Lamalou les bains – 2014

Grabels – 2014

Those events with cumulative precipitation which may exceed 500 mm/d or 100 mm/h often lead to devastating and deadly flash floods.

Introduction

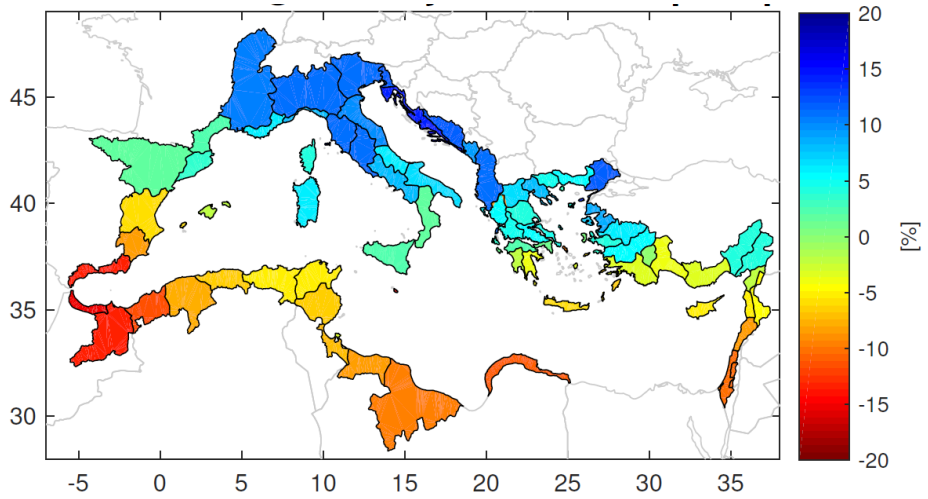


Ribes et al. 2018

=> Significant increase in number of those events between 1961 and 2015.

=> Higher increase for higher precipitation thresholds.

RCP8.5 Mean change in 20-year extreme precipitation



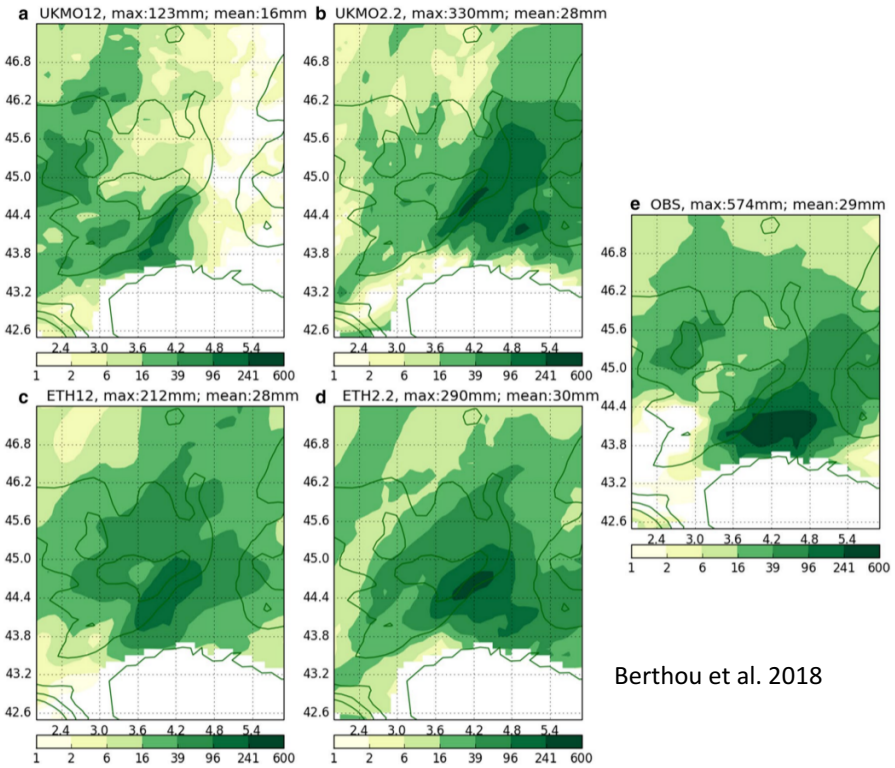
Tramblay et Somot (submitted)

The relative mean change (%) computed from an ensemble of regional climate simulations from the Euro-Cordex experiments

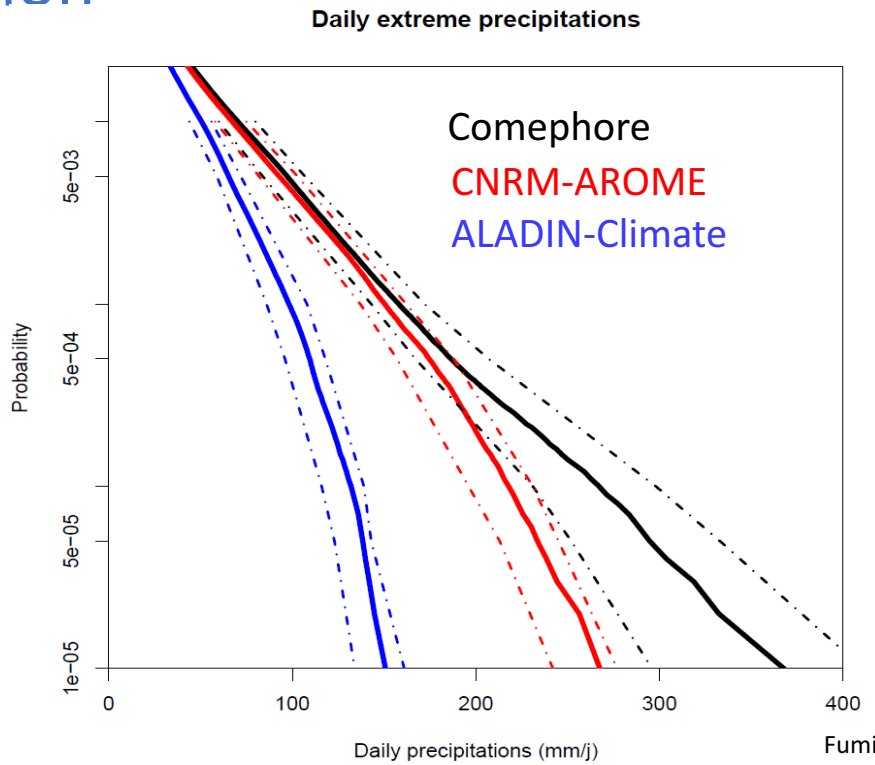
=> extreme rainfall all over south-eastern France is expected to increase.

Introduction

Studies have already shown the benefits of using CPRCM (Convection-Permitting Regional Climate Model) for the heavy precipitating events : precipitation location and accumulation are better represented with CPRCM (ETH2.2 and UKMO2.2)



Berthou et al. 2018



Fumiere et al. (in revision)

Comephore : Hourly precipitation dataset – 1km – 1997-2006

- CNRM-AROME (2,5km) is better than ALADIN-Climate (12,5km) to reproduce heavy precipitating events

- Until 200mm, CNRM-AROME simulates as much rainfall than observations

Will extreme precipitating events over the Southeast of France be more frequent and more intense in the future?

How to make a CNRM-AROME$_{41t1}$ simulation ?

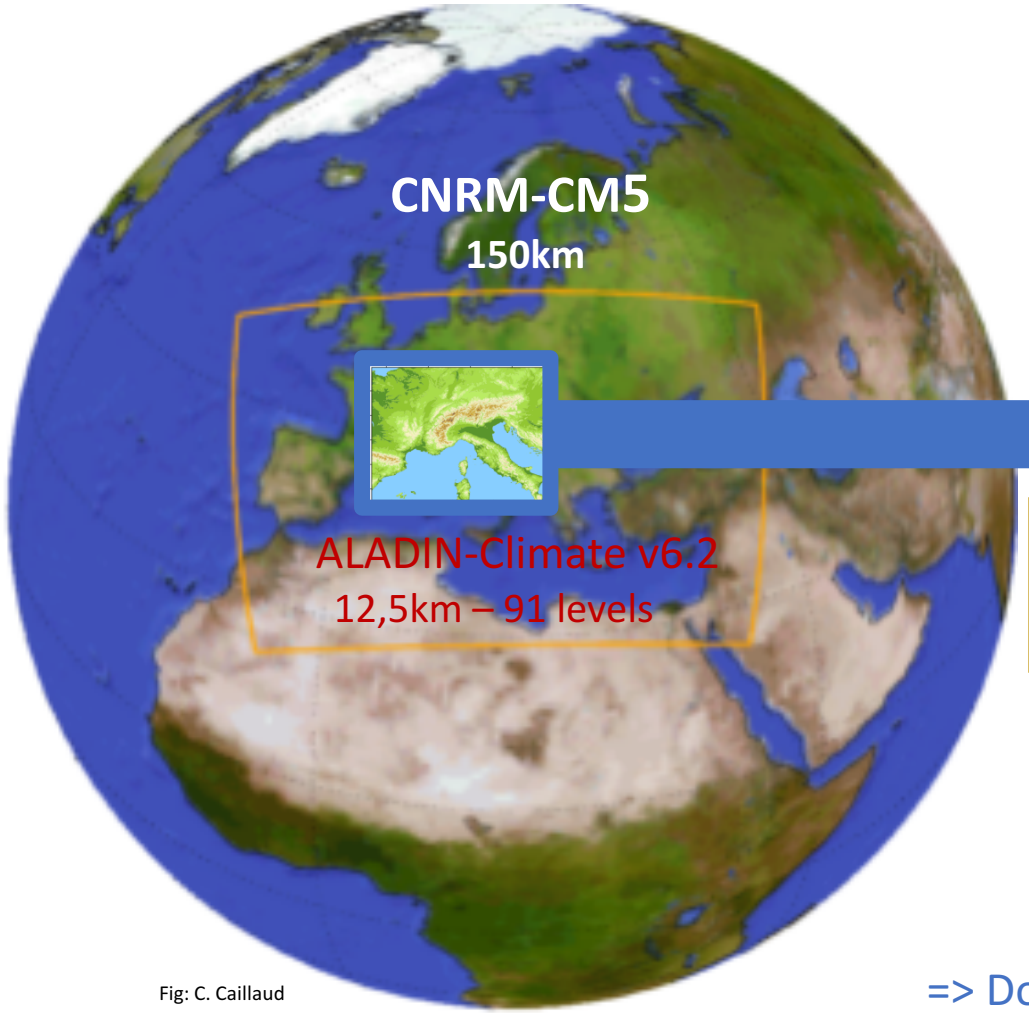
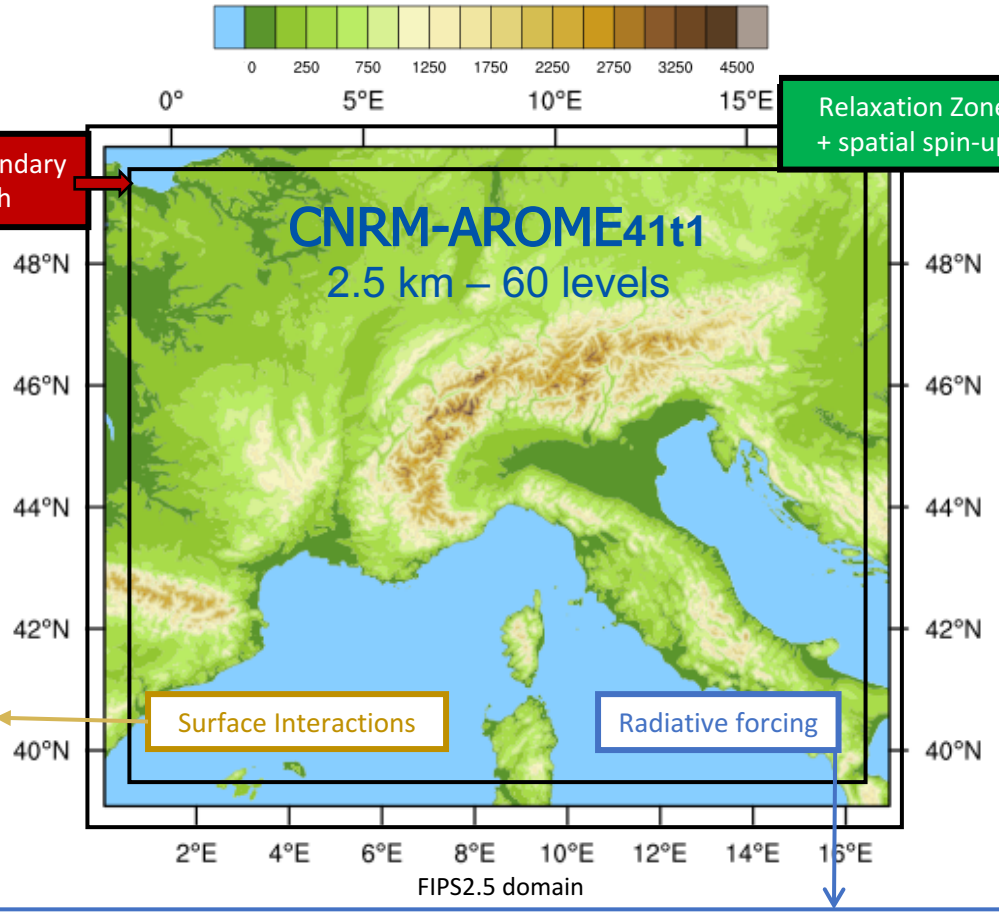


Fig: C. Caillaud

Lateral and upper boundary conditions Freq:1h

Relaxation Zone : 21 points
+ spatial spin-up : 30 points



FIPS2.5 domain

Interpolated SST :
from CNRM-CM5

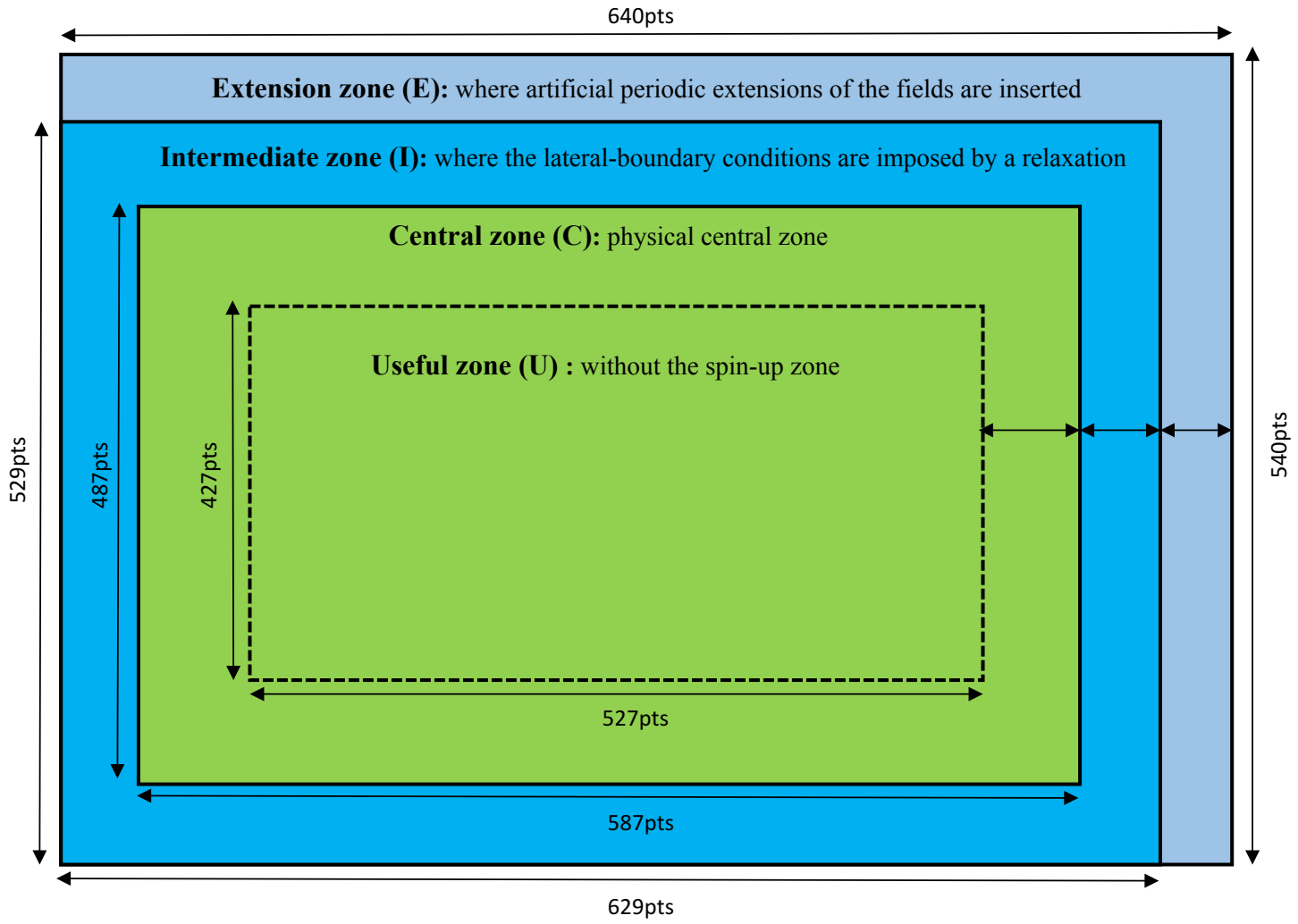
Surface Scheme :
Surfex 7.3

5 greenhouse gases :
CO_2, N_2O, CH_4, CFC11, CFC12
1 value/year/specie
(homogeneous in 2D)

5 aerosols :
Dust, Sea Salt
2D/month/specie maps (non evolutive)
Sulfates, Organic Carbon, Black Carbon
2D/month/year maps (evolutive)

=> Domain of the CORDEX-FPS Convection

Characteristics of the domain FIPS2.5



Number of points per zone :

- C+I+E+U = 345600 points
- C+I+U = 332741 points
- C+U = 285869 points
- U = 225029 points

The spin-up zone = 30 grid points
(as suggested in Matte et al. 2017)

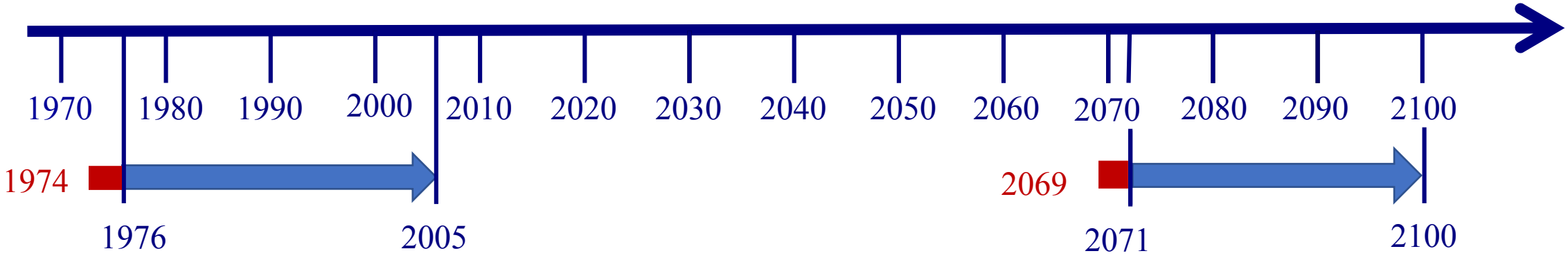
Conformal Lambert projection

CNRM-AROME$_{41t1}$ scenario simulations

The validation CNRM-AROME has been done in ***Fumière et al. (in revision)***

Information on CNRM-AROME scenario simulations:

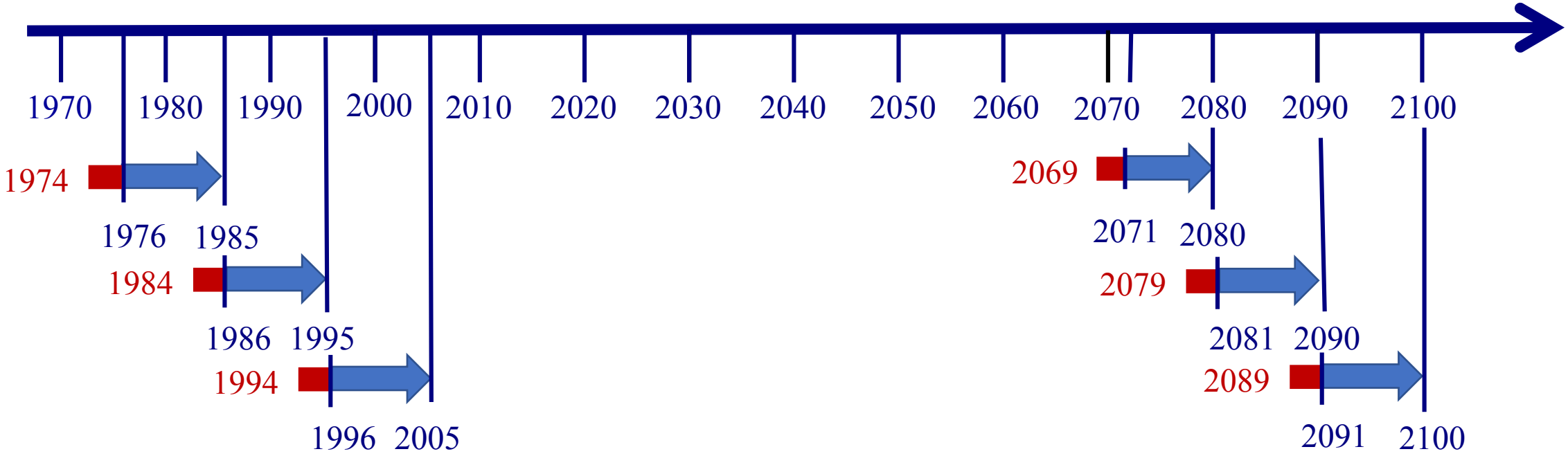
- A historical simulation : 1976 – 2005 (30 years)
- A rcp8.5 simulation : 2071 – 2100 (30 years)
- 2-years spin-up
- About 4 days per year of simulation (4 months for 30 years)



CNRM-AROME scenario simulations

Informations on CNRM-AROME scenario simulations:

- 3 simulations of 10 years for each of the two periods.
- 2-years spin-up for each simulations.
- About 54 days for 30 years

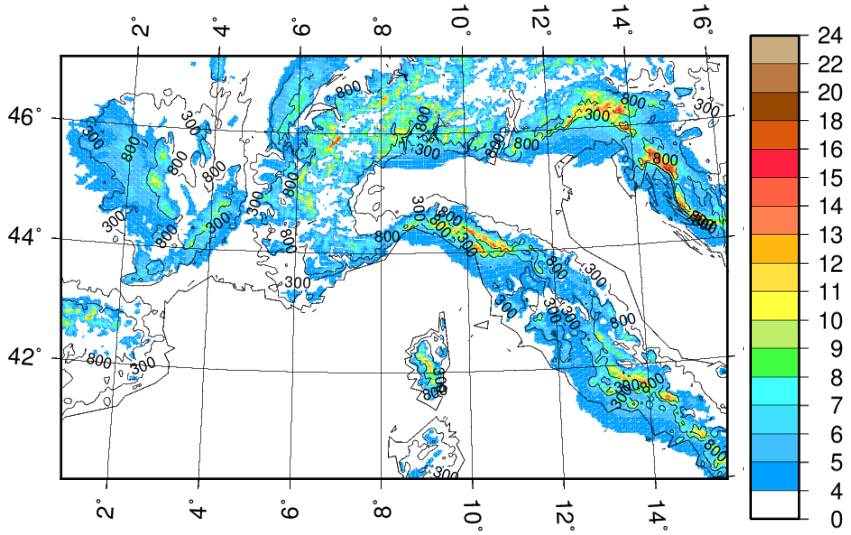


Methodology

- Focus on Daily and Hourly extreme rainfall
- During the **4 months of autumn** September – December (SOND)
- Comparing two 30-**year** periods :
    - Historical simulation : **1976 – 2005**
    - RCP8.5 simulation : **2071 – 2100**

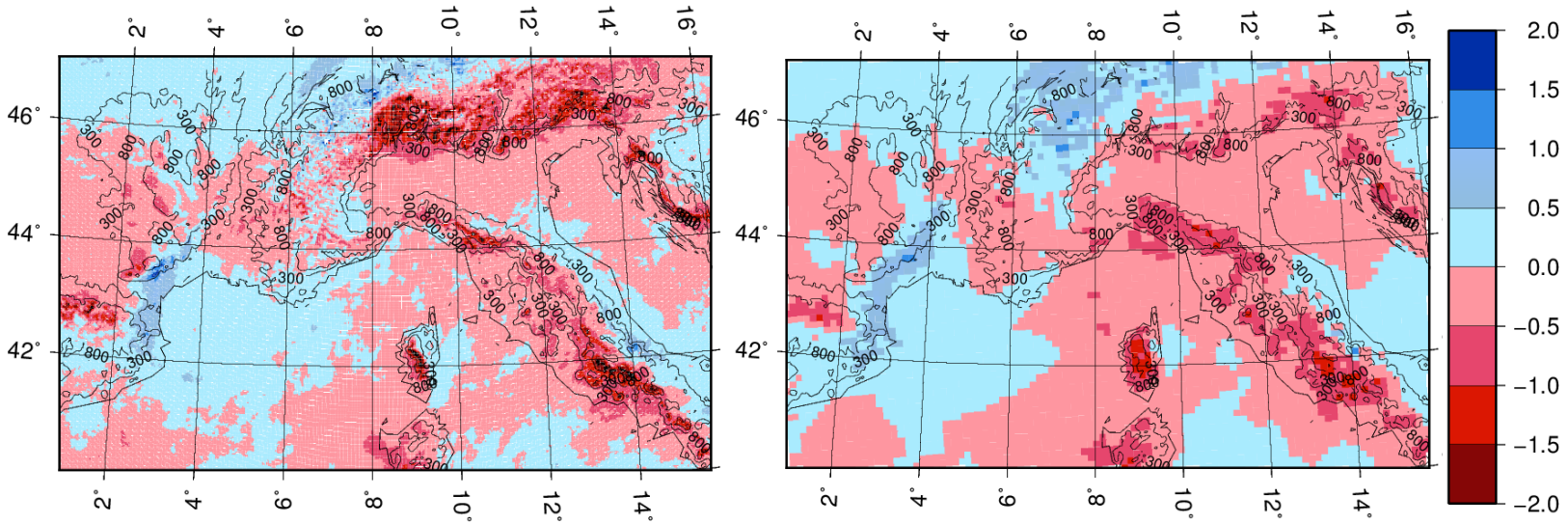
Daily mean maps

Daily mean precipitation (mm/d) with CNRM-AROME of the historical simulation



CNRM-AROME (2,5km)

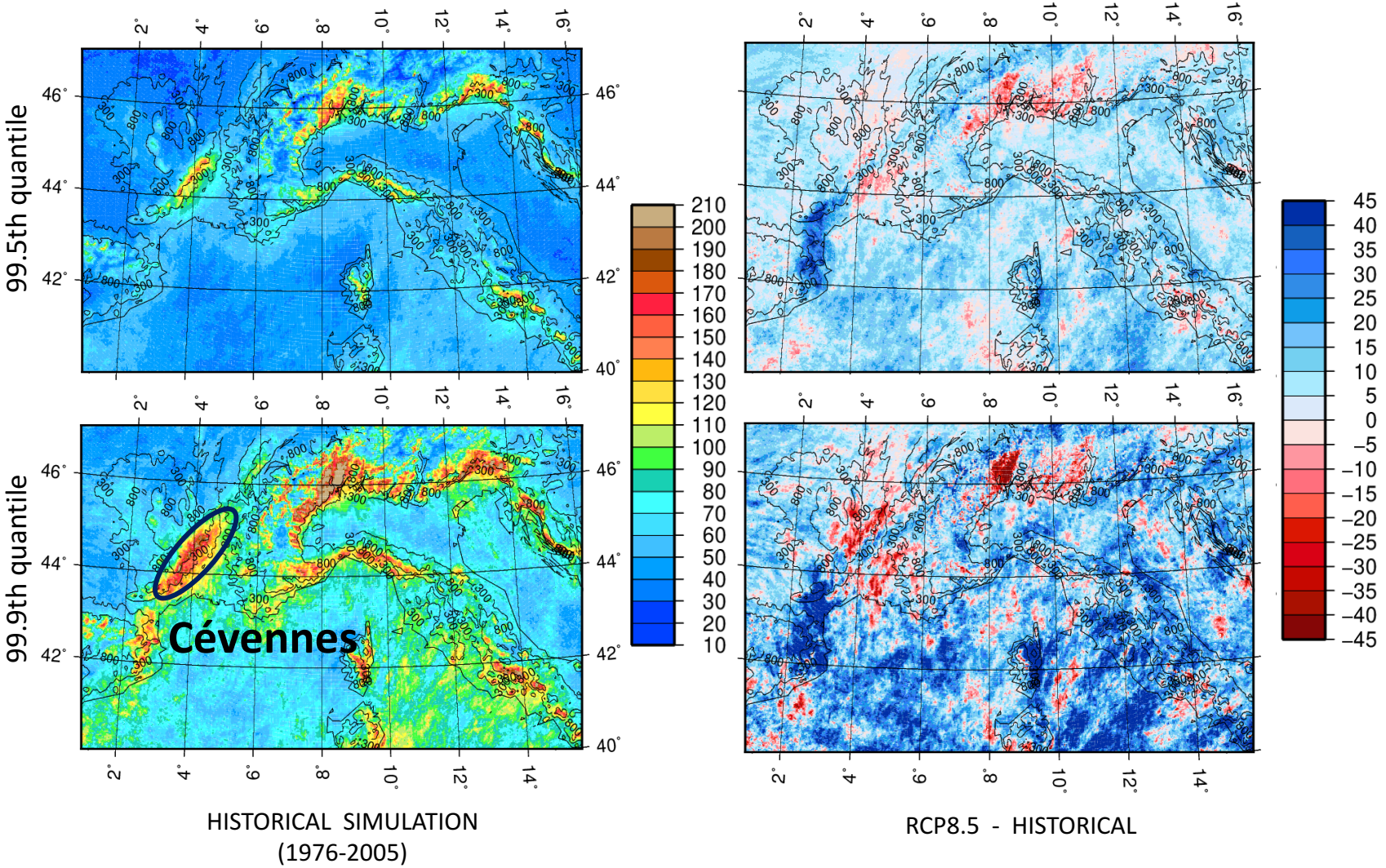
Maps of the mean precipitation differences (RCP8.5 – Historical) (mm/d)



CNRM-AROME (2,5km) ALADIN-Climate (12,5km)

- Location of the highest mean rainfall on mountains
- Similarity of the differences maps except over the Alps
- **Decrease in mean rainfall in western Mediterranean.**
- Increase in mean rainfall in the south of France.

99.5th and 99.9th daily quantile maps of CNRM-AROME

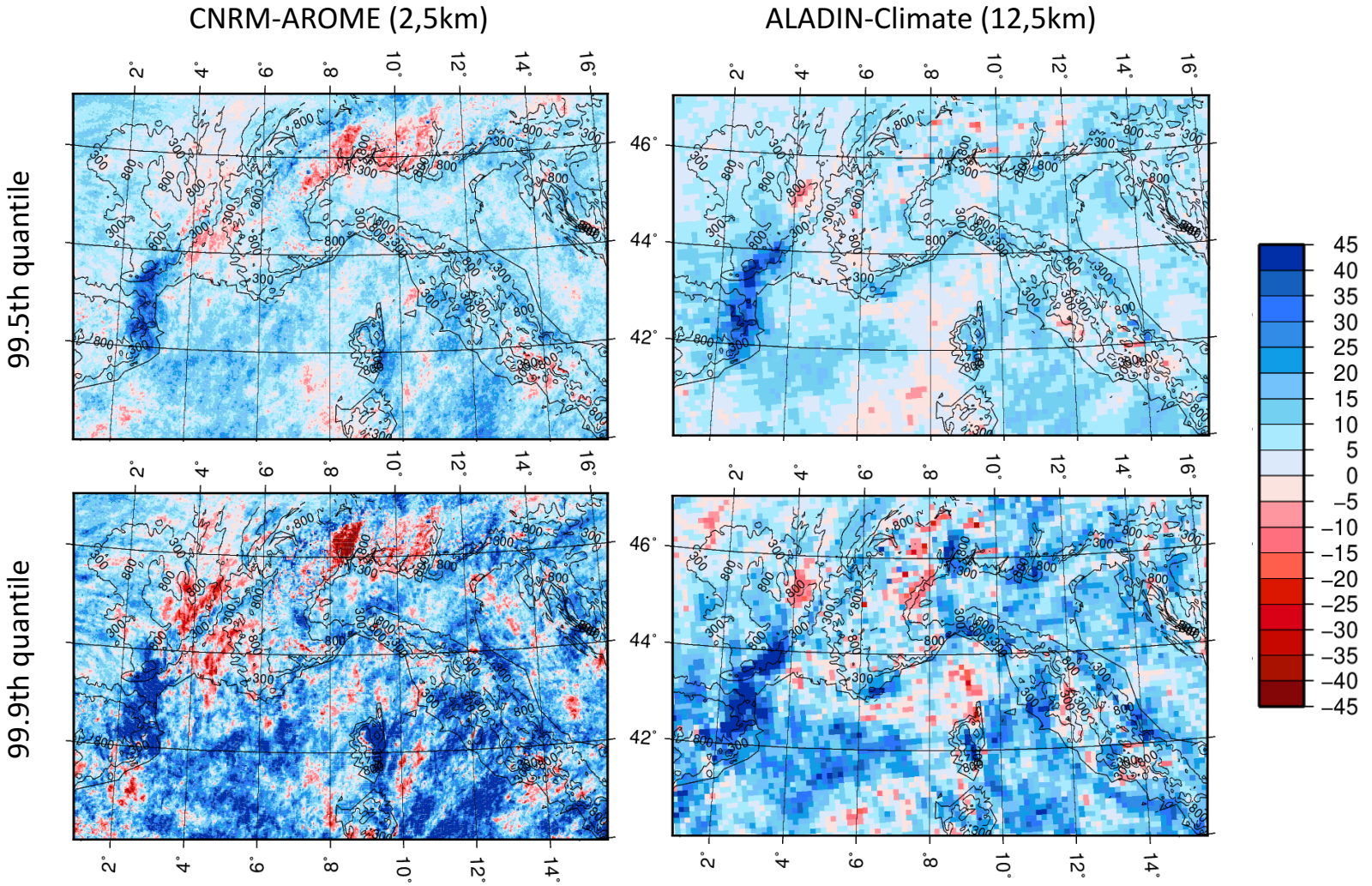


HISTORICAL SIMULATION
(1976-2005)

RCP8.5 - HISTORICAL

- Consistency of heavy rainfall location between the 99.5th and the 99.9th quantile.
- Location of intense rainfall on mountains
- Decrease in rainfall in the South of the Cevennes and in the Southern Alps.
- Increase in rainfall in the Eastern-Pyrenees and in the northern Alps.

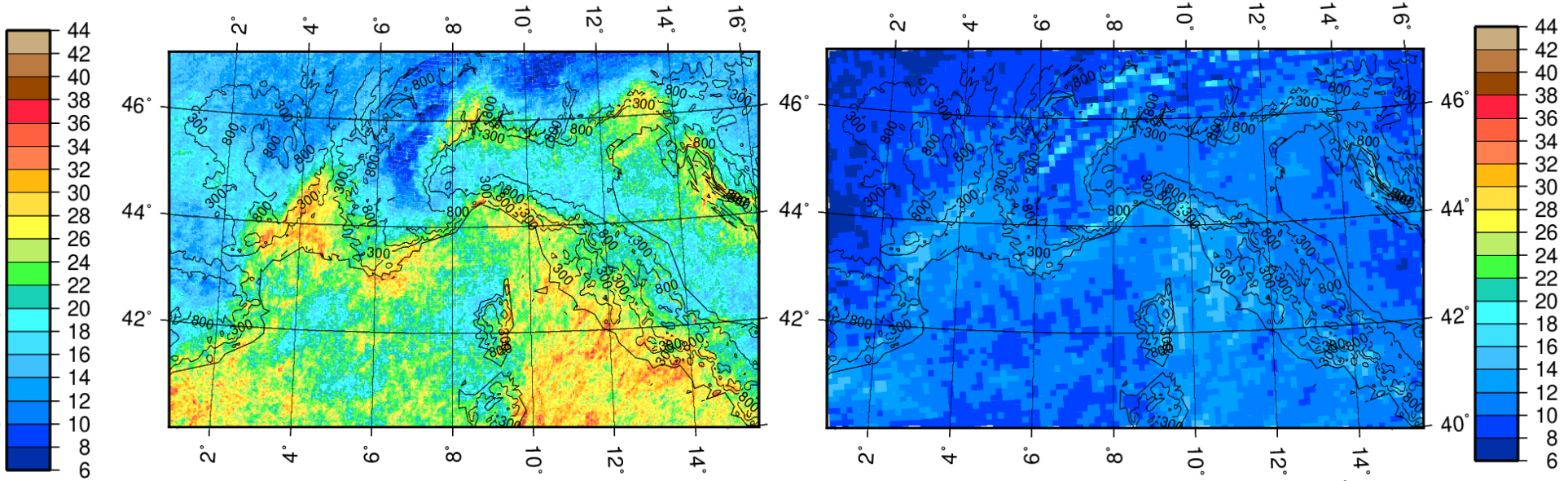
Difference between CNRM-AROME and ALADIN-Climate 99.5th and 99.9th quantile maps



RCP8.5 - HISTORICAL

- Similarity between both models
- Major difference over the Alps between ALADIN-Climate and CNRM-AROME.
- ALADIN-Climate simulates an increase in rainfall in the south of the Cevennes compared to CNRM-AROME.
- Both models simulate an increase in intense rainfall in the Eastern Pyrenees.
- Increase in extreme daily rainfall in the western Mediterranean.

99.99th hourly quantile maps of the historical simulation

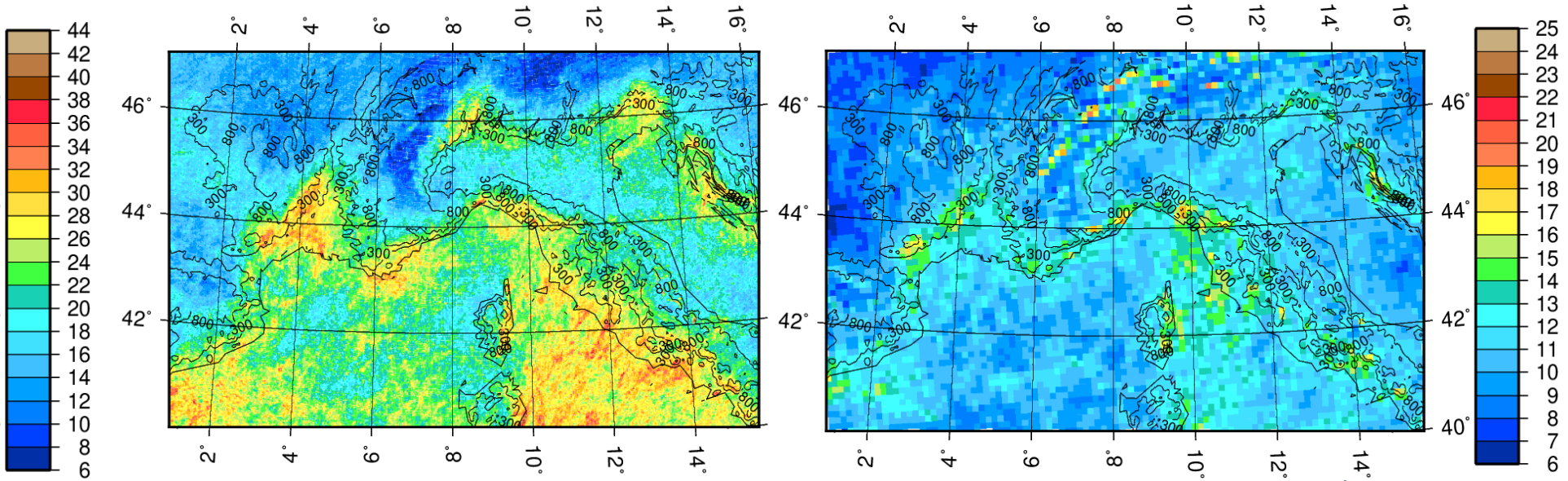


CNRM-AROME (2,5 km) (mm/h)

ALADIN-Climate (12,5 km) (mm/h)

- CNRM-AROME simulates its most intense rainfall on mountains especially over the Cevennes
- Cumulative precipitation of CNRM-AROME is more important

99.99th hourly quantile maps of the historical simulation

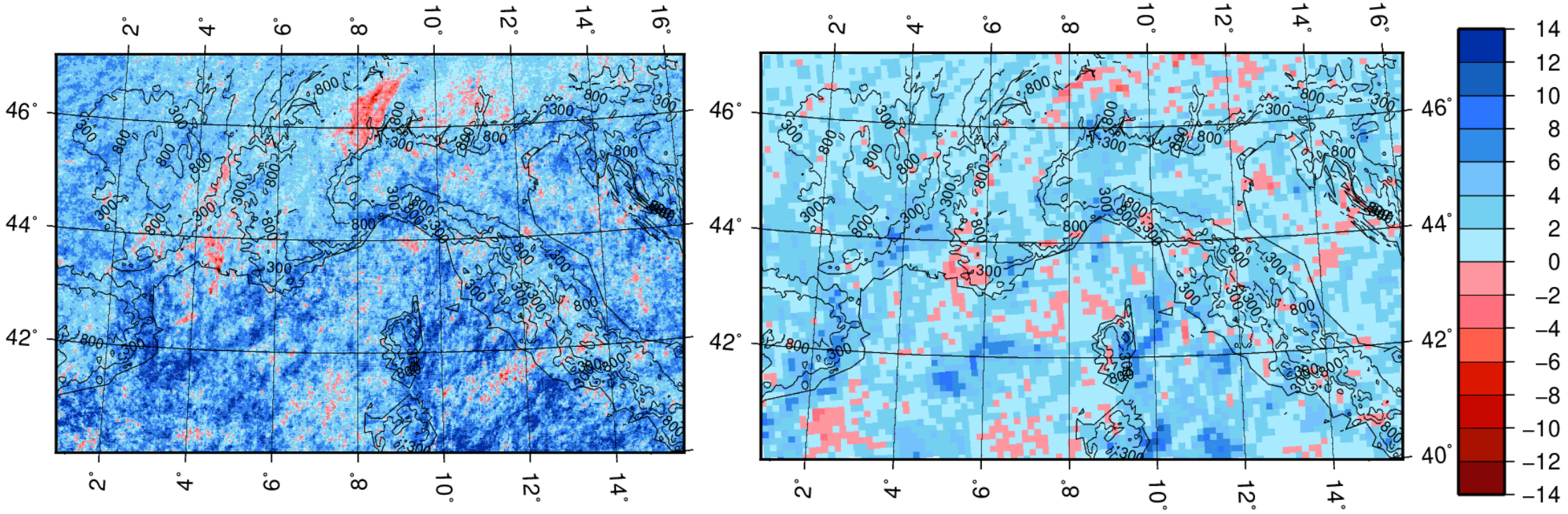


- ALADIN-Climate also simulates intense rainfall over the Cevennes even if they are weaker

Differences 99.99th hourly quantile maps (RCP8.5 - Historical)

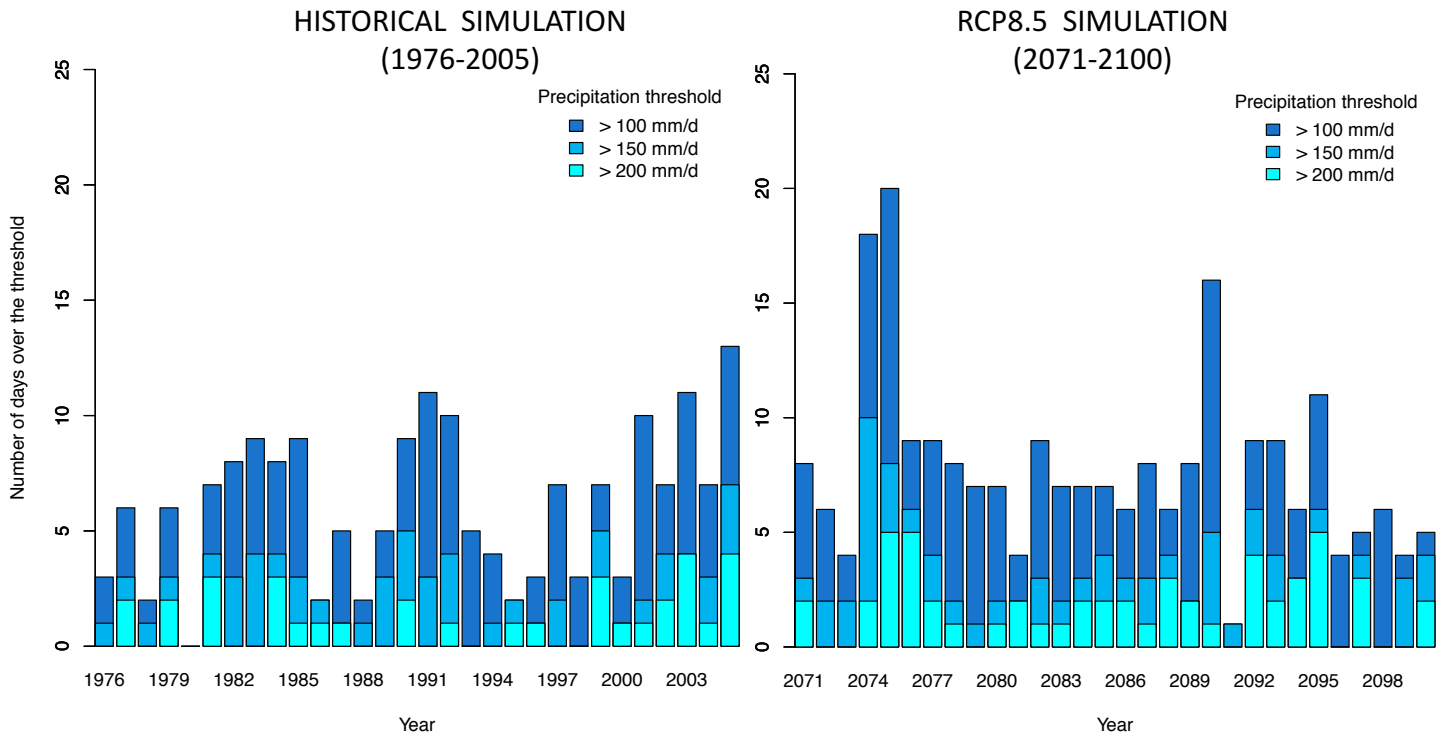
CNRM-AROME (2,5 km)

ALADIN-Climate (12,5 km)



- Similarity between the two differences maps
- Increase in intense rainfall all over the Mediterranean
- Increase in intense rainfall in the Eastern Pyrenees
- Decrease in extreme rainfall on lowlands in the south of the Cevennes with CNRM-AROME

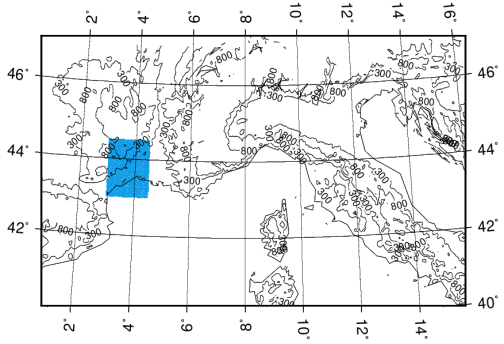
Number of days with heavy rains over the Cevennes



Number of days over thresholds of 100, 150 and 200 mm/d for each year of the the historical et RCP8.5 period

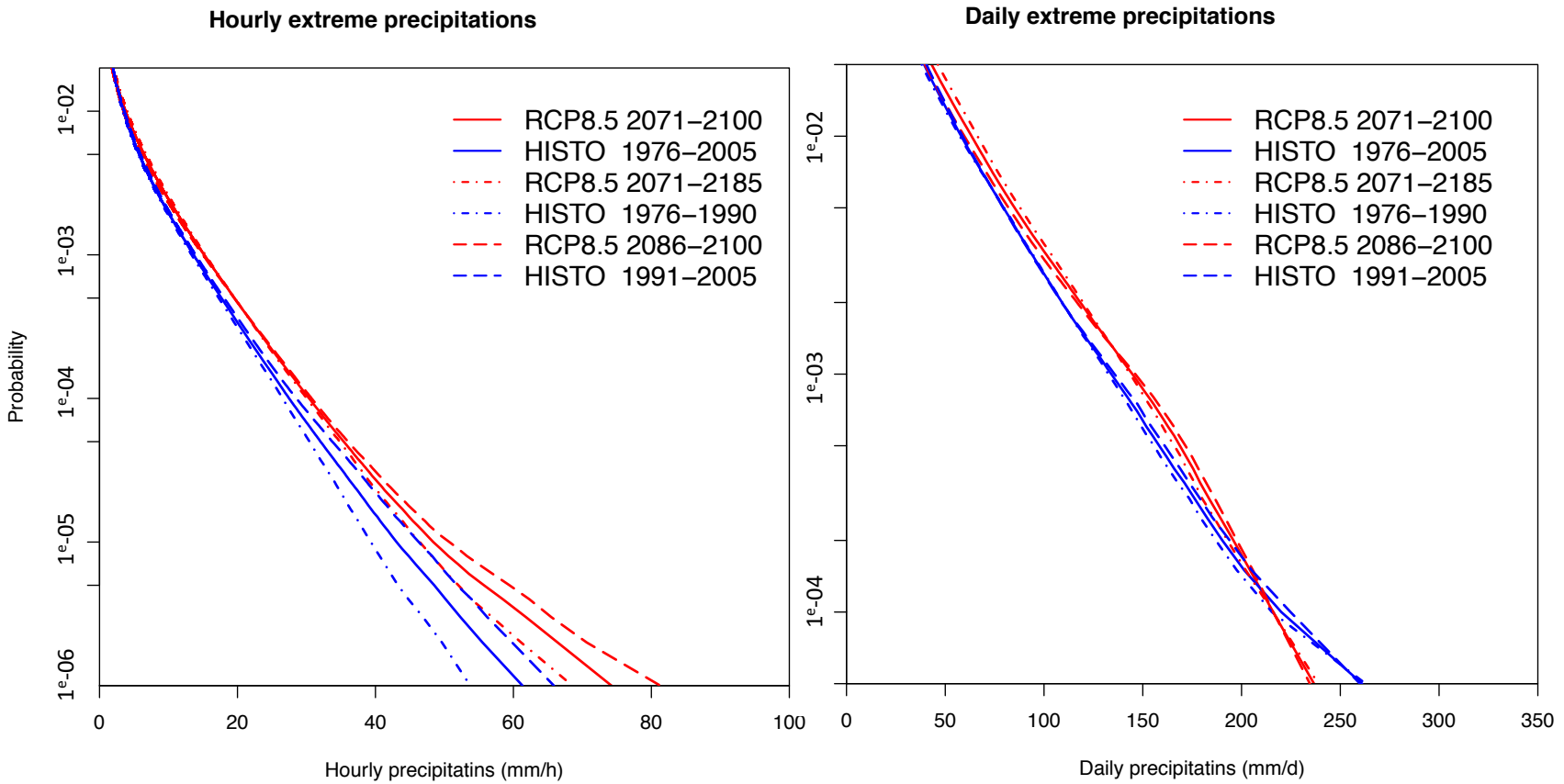
Simulation		HISTORICAL mean (1976-2005)	RCP8.5 mean (2071-2100)	Significance Test : T-test	Increase
Threshold	>1 mm/d	94	91	Significant	-4%
	>100 mm/d	6,1	7,8	Significant	27%
	>150 mm/d	2,5	3,4	Significant	33%
	>200 mm/d	1,1	1,8	Significant	58%

Mean of the number of days over thresholds of 100, 150 and 200 mm/d every year for the historical and RCP8.5 simulations.



- Strong inter-annual variability
- The t-test shows that the differences in mean precipitation for each threshold between the two simulations are significant.

Daily and hourly extreme precipitation over the Cevennes.



- Increase in extreme hourly rainfall in the future over the Cevennes.
- Increase in daily rainfall and daily heavy rainfall until the threshold of 230mm/d.
- Decrease in extreme events (+230 mm/d) over the Cevennes.

Conclusion

- *Daily rainfall :*
  - Decrease in mean rainfall except over the Cevennes, the Eastern Pyrenees and over the northern Alps.
  - Increase in extreme daily rainfall all over the domain except over the southern Alps in the future
  - Maximum increase in extreme daily rainfall over the eastern Pyrenees.
  - Increase in extreme daily rainfall except for very extreme daily rainfall

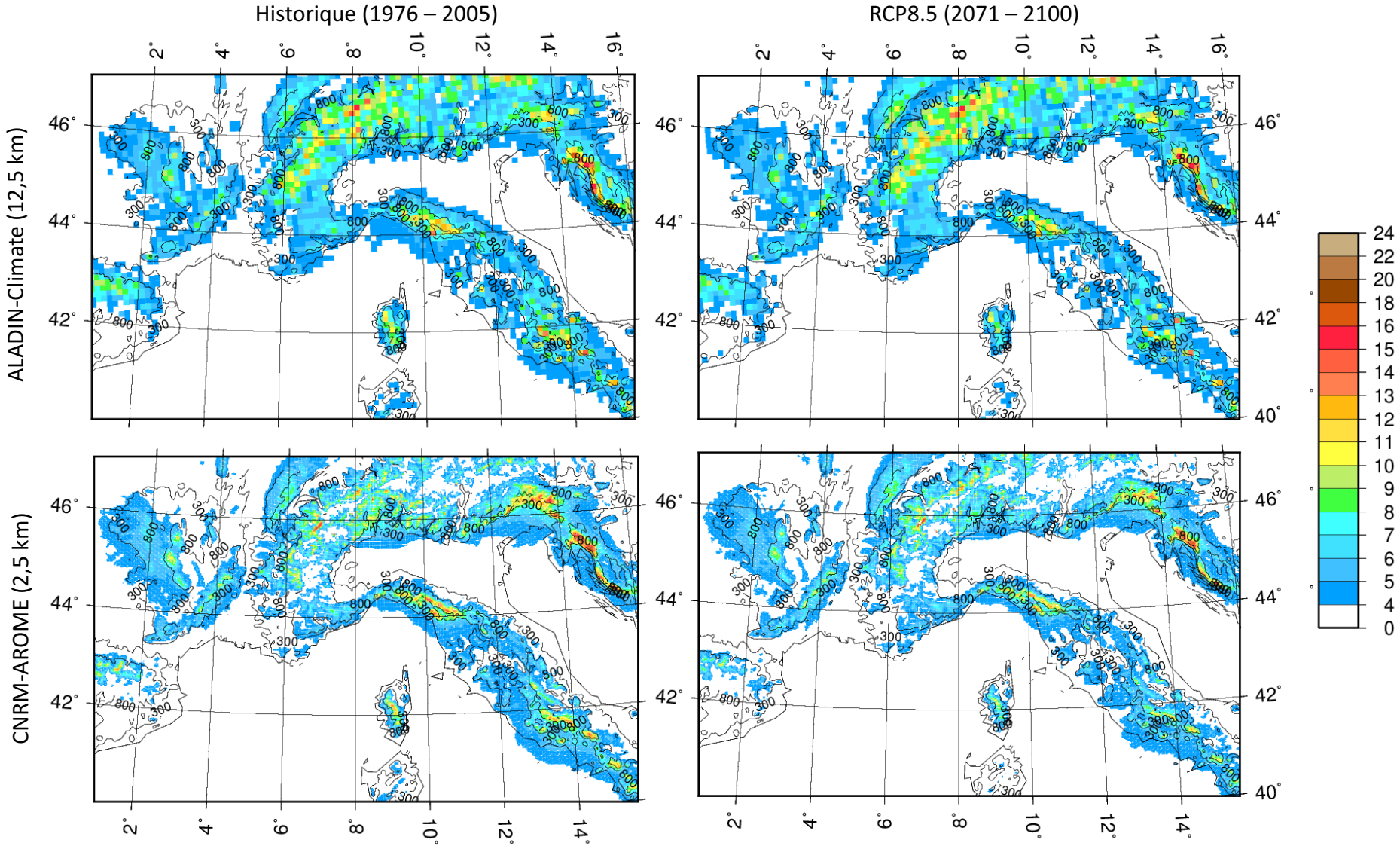
- *Hourly rainfall :*
  - Increase in extreme hourly rainfall all over the Mediterranean
  - Maximum increase in extreme hourly rainfall over the eastern Pyrenees.
  - Increase in extreme hourly rainfall over the Cevennes in the future.

*=> **In the future**, **events** might be **more intense** but shorter or less stationary*

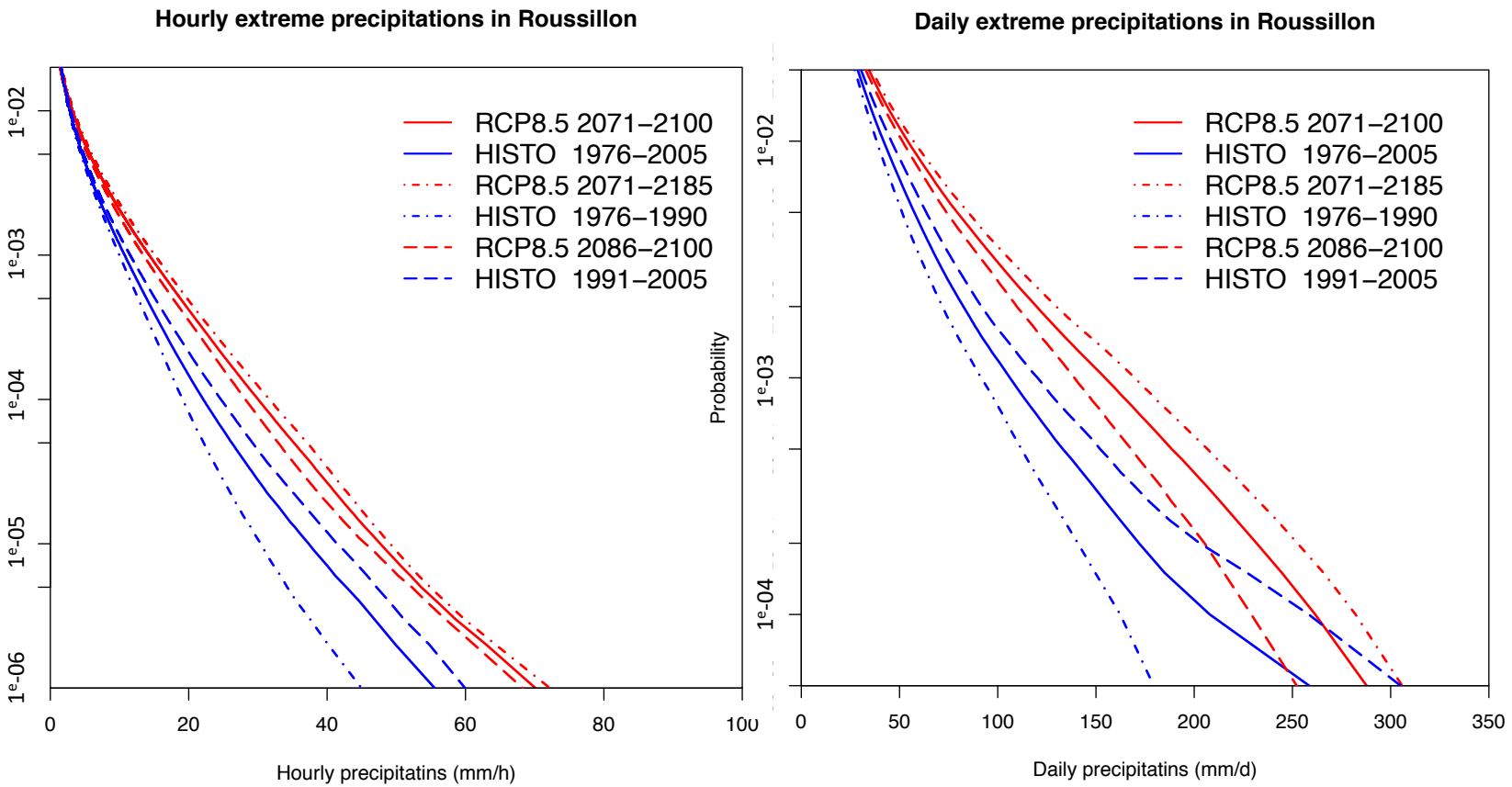
- Use of the CORDEX-FPS multi-model ensemble to increase the robustness of the results

Thanks to WCRP and NCAR for their financial support

Daily mean maps



Daily and hourly extreme precipitation in the Eastern Pyrenees



- Increase in extreme hourly rainfall in the future in the Cevennes.
- Increase in daily rainfall and daily heavy rainfall
- Strong influence of a very extreme with a daily cumulation very important during the historic period in Eastern Pyrenees in 2000

Perspectives :

- Add a statistical analysis (bootstrapping method).