On the added value of the EURO-CORDEX multi-model ensemble simulations over the Iberian Peninsula

João A.M. Careto, Pedro M.M. Soares, Rita M. Cardoso

Instituto Dom Luiz, Faculty of Sciences of University of Lisbon, Lisbon, Portugal

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Objective:

What is the added value of high-resolution simulations relative to the driving lower resolution models with respect to their PDFs?

Data:

EURO-CORDEX Hindcast (0.11^{o})
Period: 1989-2008
13 Regional Models
+ ERA-Interim Reanalysis

EURO-CORDEX Historical (0.11^{o})
Period: 1971-2005
53 Regional Models
+ 13 Driving Global Models

Observations (IGD, 0.1^{o})
Period: 1971-2015
Iberian Peninsula
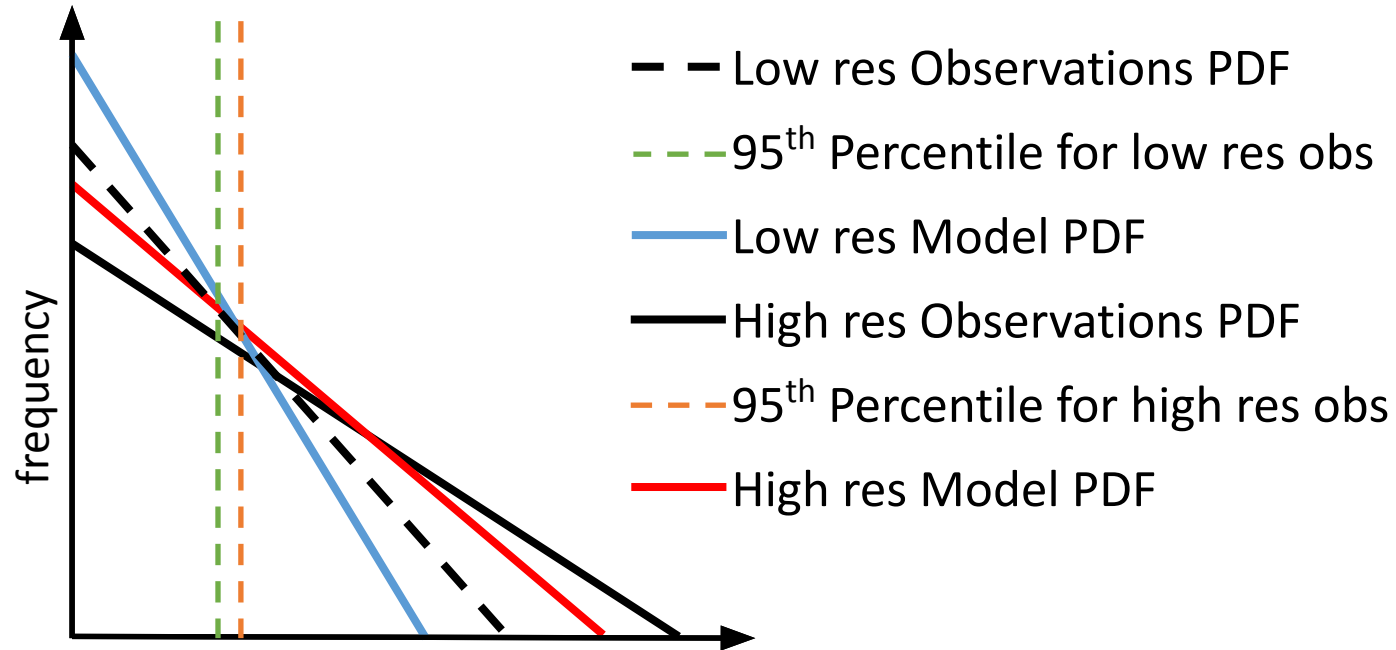Herrera et al, (2019), Doi: 10.5194/essd-11-1947-2019

Variables:

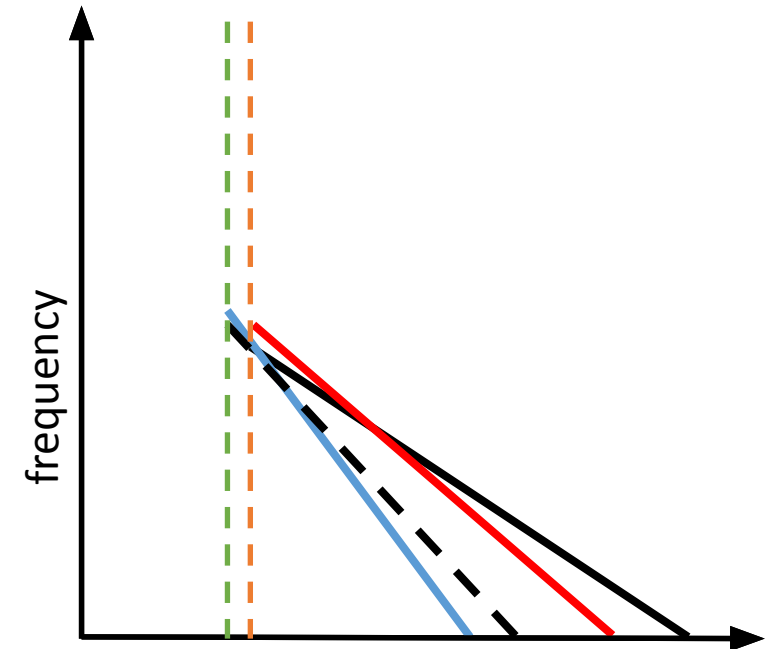- Precipitation
- Max Temperature
- Min Temperature

Methods:

1. RCMs interpolated into the 0.1^{o} resolution from observations
2. IGD interpolated into each low-res model
3. Orographic correction on temperature
4. DAVs (Soares and Cardoso, 2018)

4. Distribution Added Value (DAV)
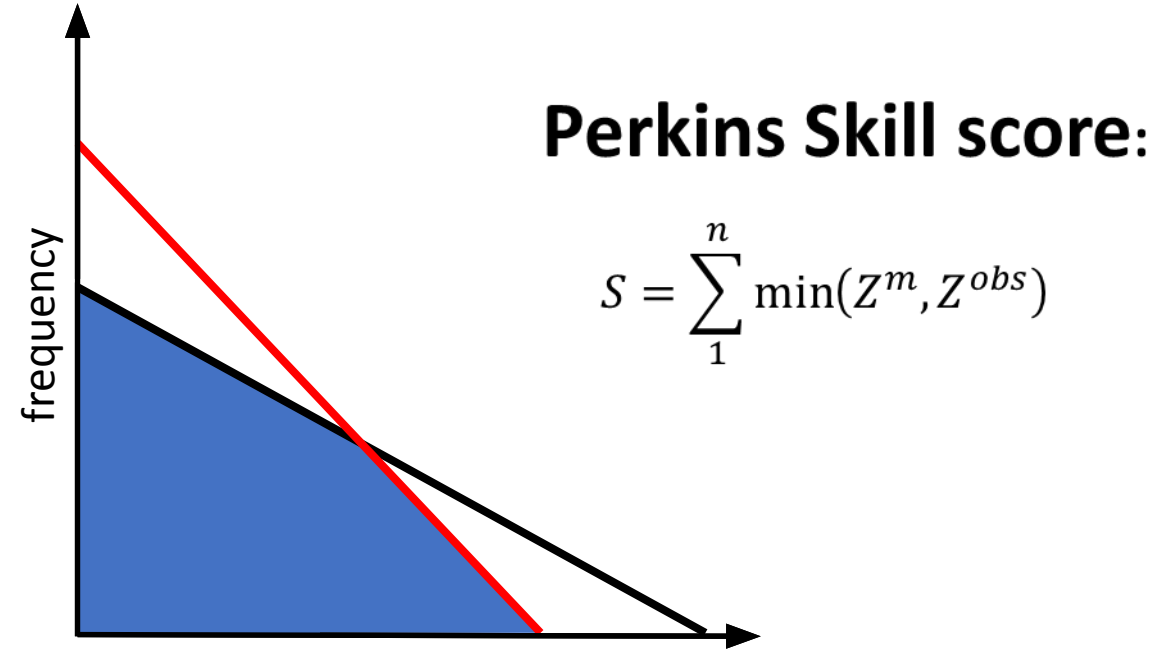
E.g.: Precipitation

E.g.: Extreme Precipitation

- - - Low res Observations PDF
- - - 95th Percentile for low res obs
— Low res Model PDF
— High res Observations PDF
- - - 95th Percentile for high res obs
— High res Model PDF

1. Create the PDFs with bins of 1 mm for precipitation and 1 °C for temperature
2. Normalization: Dividing each bin by the sum of all bins
3. Perkins Skill Score (Perkins et al 2007)
4. DAVs (Soares and Cardoso, 2018)

Perkins et al (2007), DOI: 10.1175/JCLI4253.1

Soares and Cardoso (2018), DOI: 10.1002/joc.5261

4. Distribution Added Value (DAV)

frequency

Perkins Skill score:

$$S = \sum_{1}^{n} \min(Z^m, Z^{obs})$$

Distribution Added Value:

$$DAV = 100 * \frac{S_{hr} - S_{lr}}{S_{lr}}$$

DAV > 0 -> Added Value

- Since the PDFs are normalized, the sum of each individual PDF = 1
- The similar both PDFs are, the highest the score (max value = 1)
- If the models overestimate the lower bins, then it will underestimate the higher bins
- If a dataset has no data in a particular bin, the contribution to the final score would be 0
- The contribution to the score decreases when approaching the tails of the distribution.

Perkins et al (2007), DOI: 10.1175/JCLI4253.1

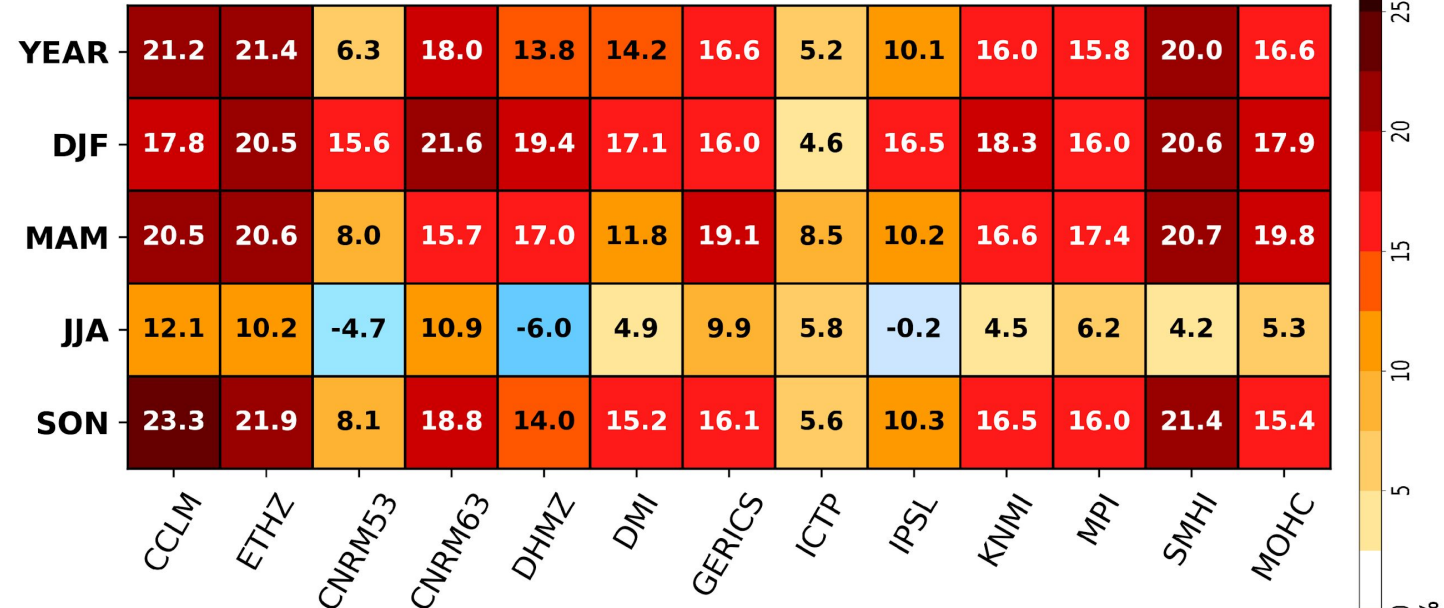Soares and Cardoso (2018), DOI: 10.1002/joc.5261
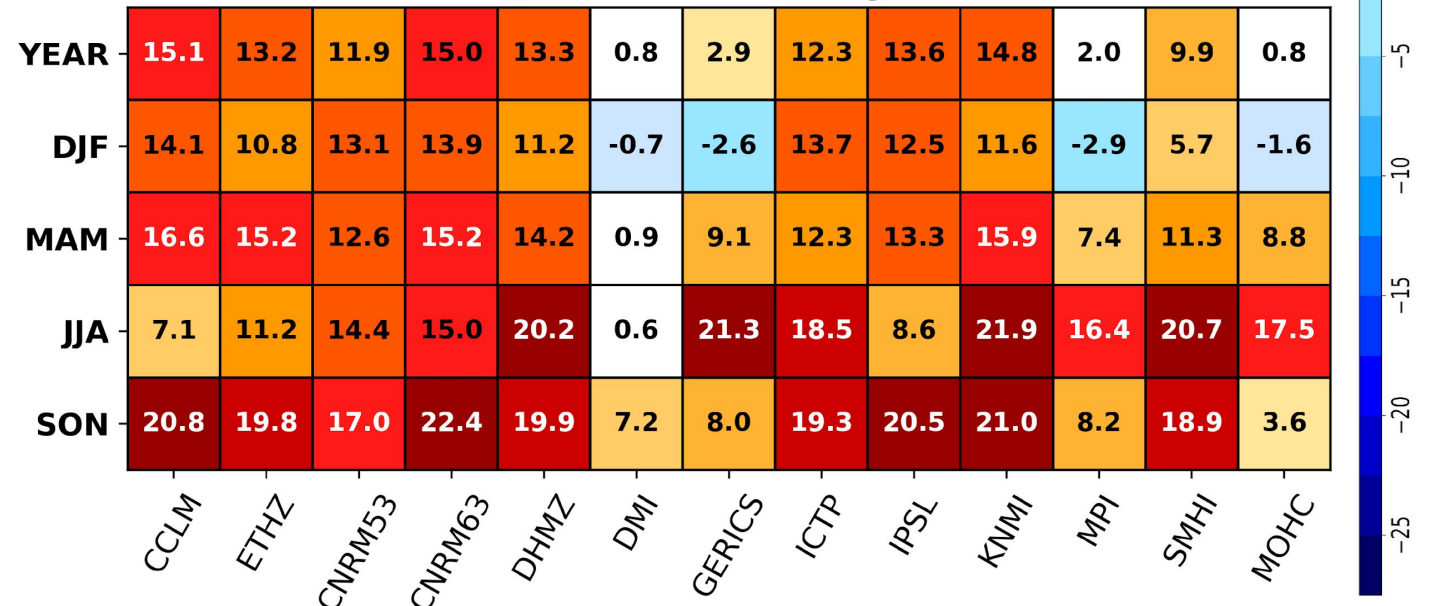
Precipitation: Hindcast
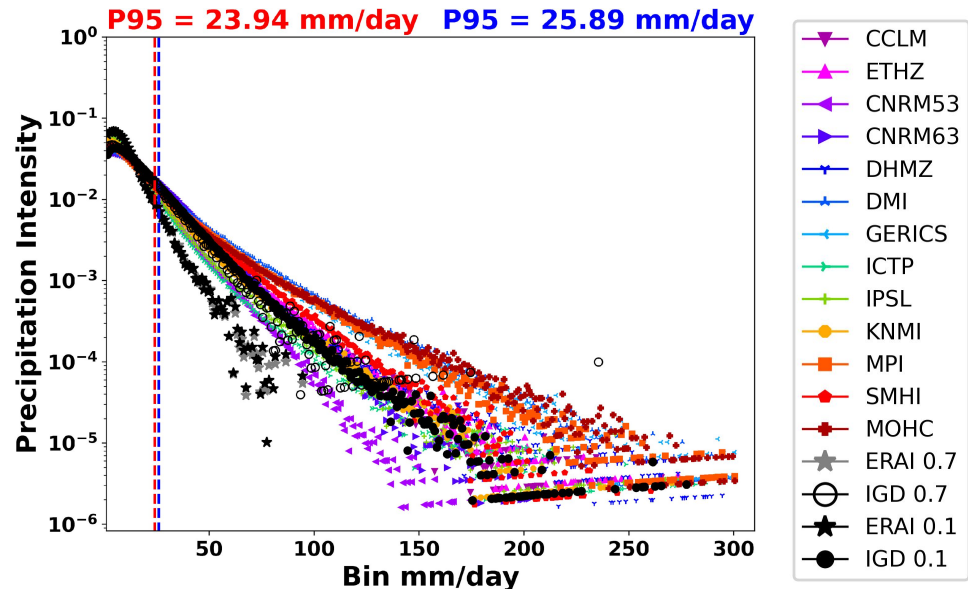
PDFs for the daily precipitation throughout the year from the Hindcast simulations (1989-2008), with ERA-Interim at 0.7° and 0.1° and IGD at 0.7° and 0.1° resolution.

- Significant added value
- Precipitation extremes within the same range.

Precipitation Intensity 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	21.2	21.4	6.3	18.0	13.8	14.2	16.6	5.2	10.1	16.0	15.8	20.0	16.6
DJF	17.8	20.5	15.6	21.6	19.4	17.1	16.0	4.6	16.5	18.3	16.0	20.6	17.9
MAM	20.5	20.6	8.0	15.7	17.0	11.8	19.1	8.5	10.2	16.6	17.4	20.7	19.8
JJA	12.1	10.2	-4.7	10.9	-6.0	4.9	9.9	5.8	-0.2	4.5	6.2	4.2	5.3
SON	23.3	21.9	8.1	18.8	14.0	15.2	16.1	5.6	10.3	16.5	16.0	21.4	15.4

Precipitation Intensity 95-100

|	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	15.1	13.2	11.9	15.0	13.3	0.8	2.9	12.3	13.6	14.8	2.0	9.9	0.8
DJF	14.1	10.8	13.1	13.9	11.2	-0.7	-2.6	13.7	12.5	11.6	-2.9	5.7	-1.6
MAM	16.6	15.2	12.6	15.2	14.2	0.9	9.1	12.3	13.3	15.9	7.4	11.3	8.8
JJA	7.1	11.2	14.4	15.0	20.2	0.6	21.3	18.5	8.6	21.9	16.4	20.7	17.5
SON	20.8	19.8	17.0	22.4	19.9	7.2	8.0	19.3	20.5	21.0	8.2	18.9	3.6

Precipitation: Hindcast

Spatial annual and seasonal DAVs for the precipitation from the Hindcast simulations (1989-2008). Only data within each point is considered.
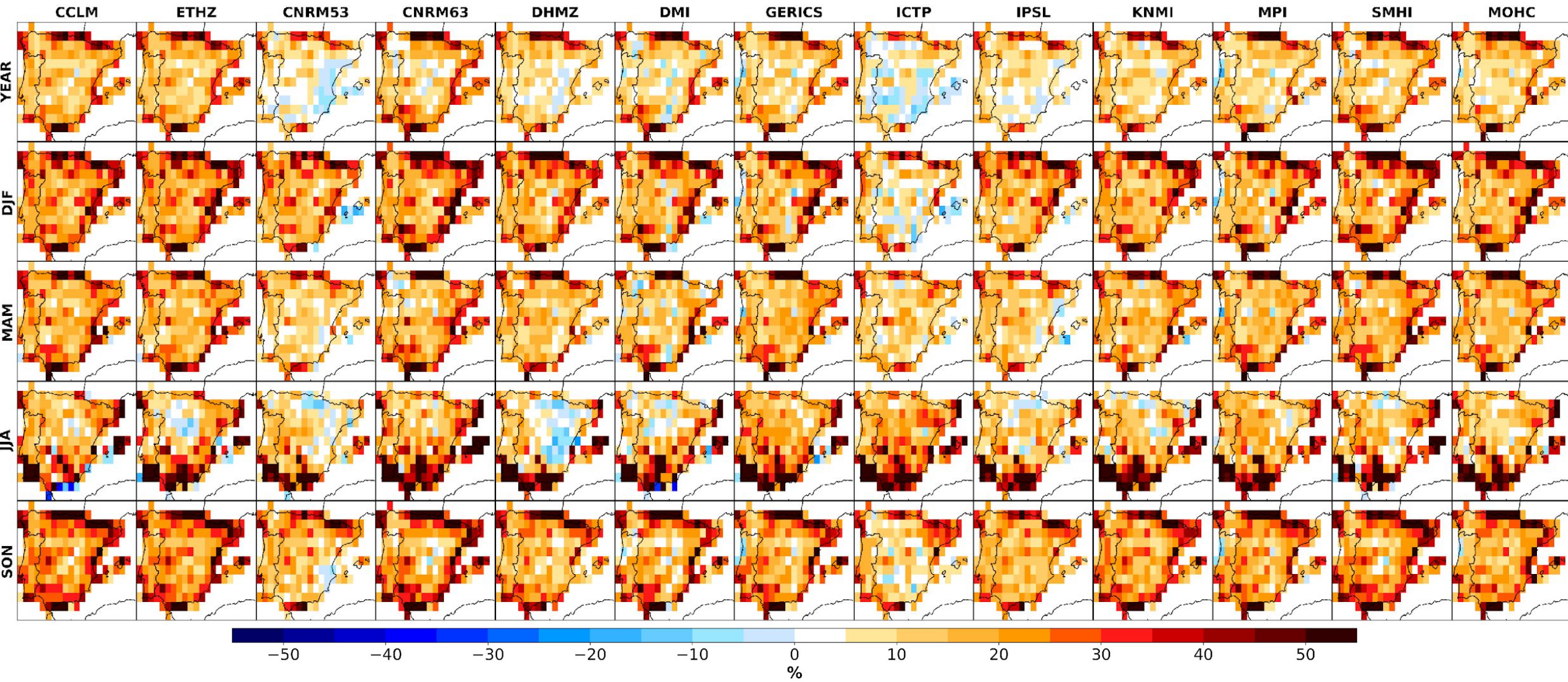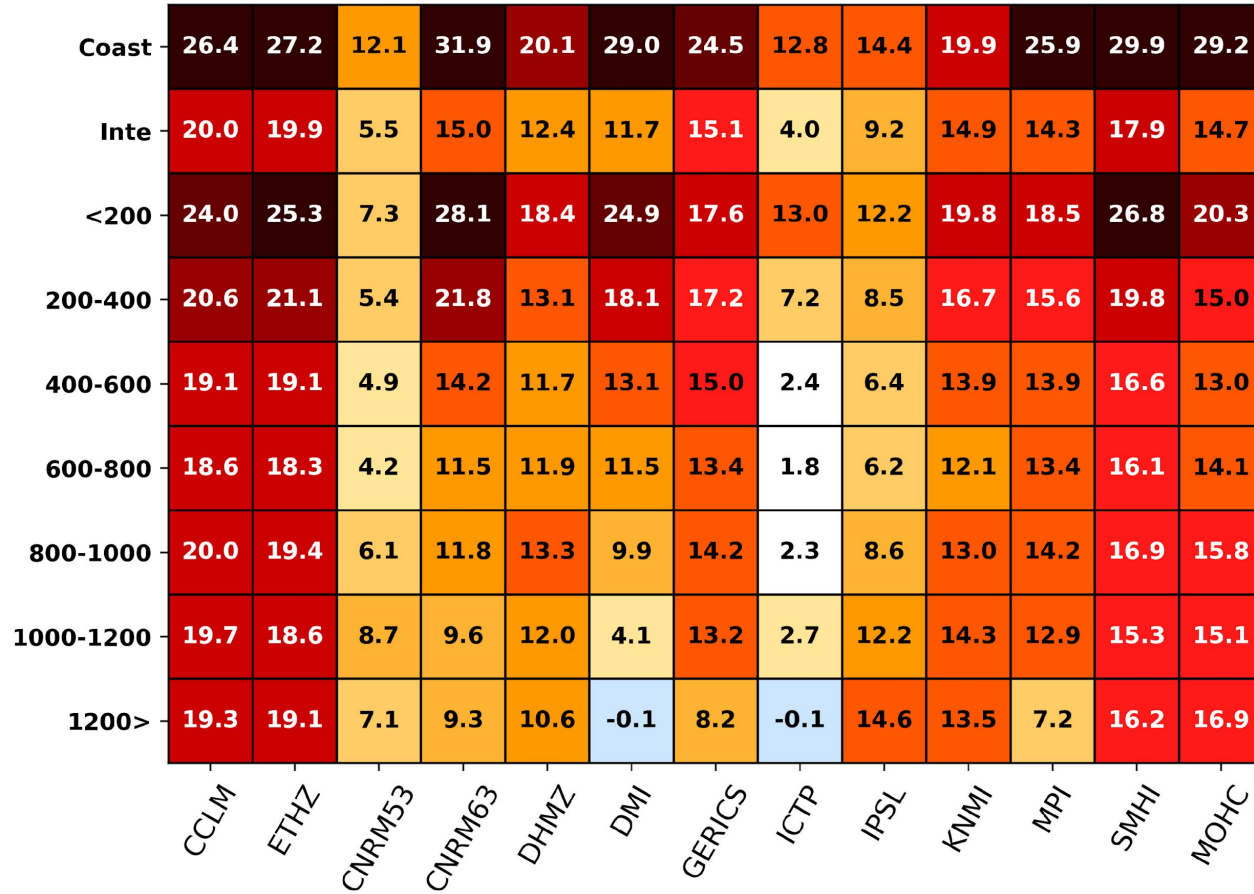
Extreme Precipitation: Hindcast

Spatial annual and seasonal DAVs for the extreme precipitation from the Hindcast simulations (1989-2008). Only data within each point and above the 95th observational percentile is considered.
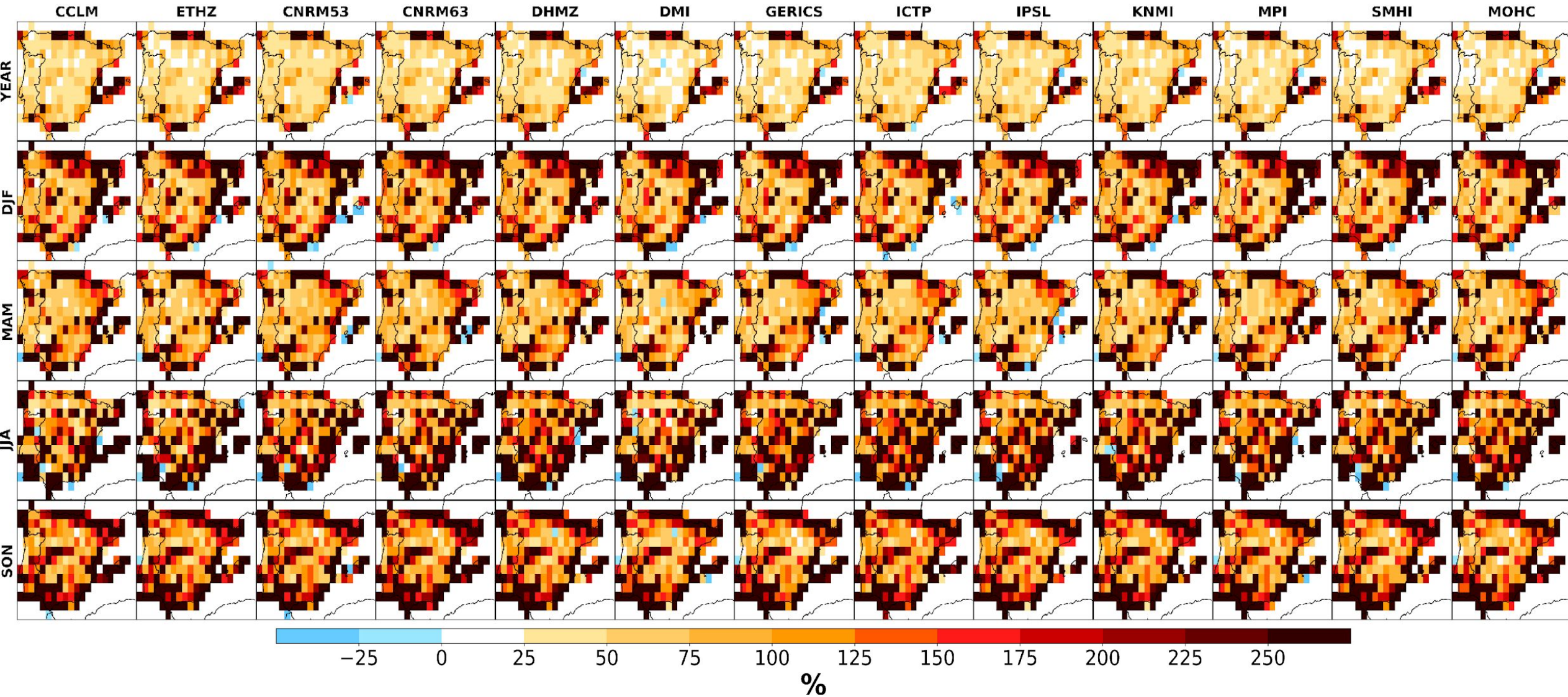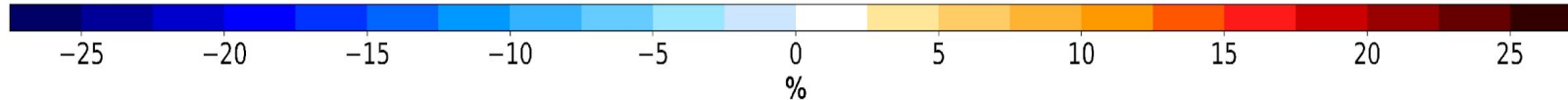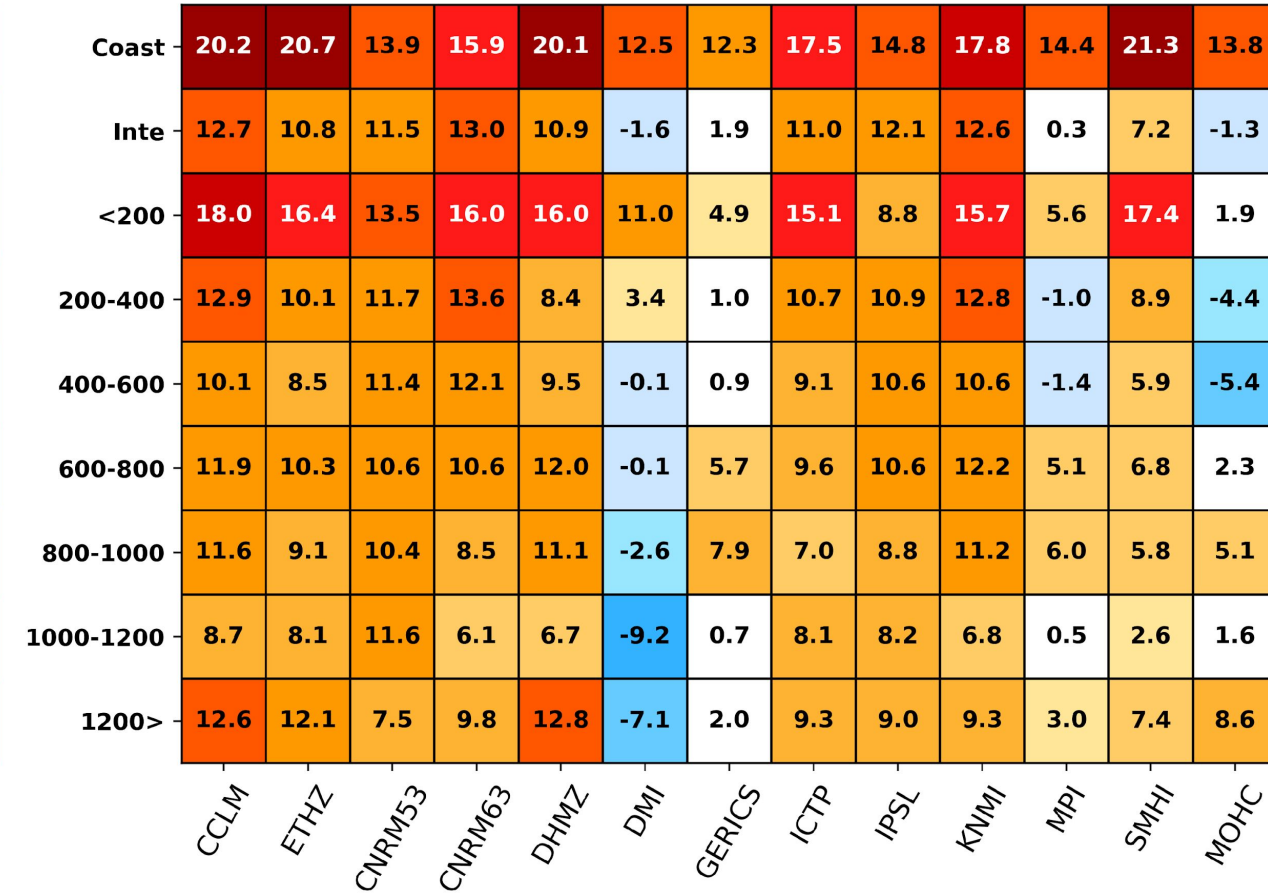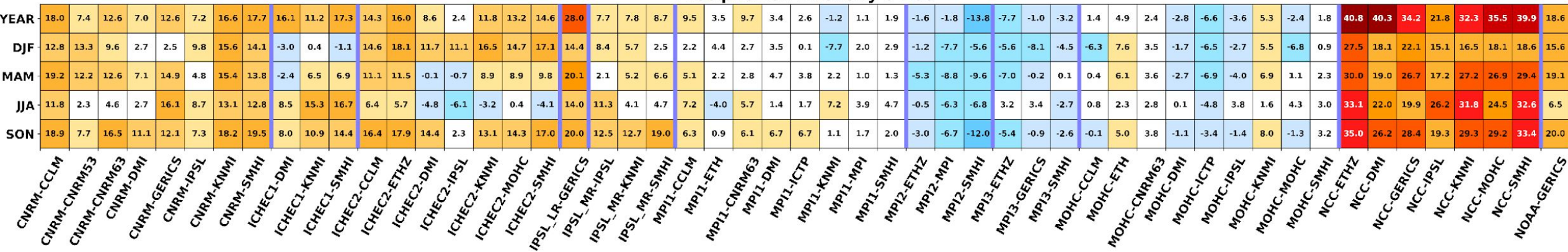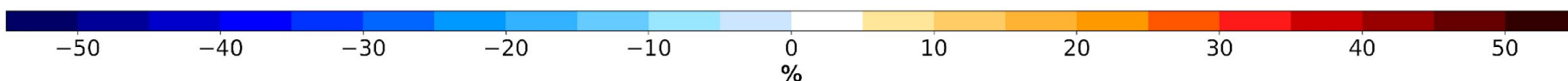
Precipitation: Hindcast Conditional

Precipitation: Historical

Precipitation Intensity 0-100

Precipitation Intensity 95-100
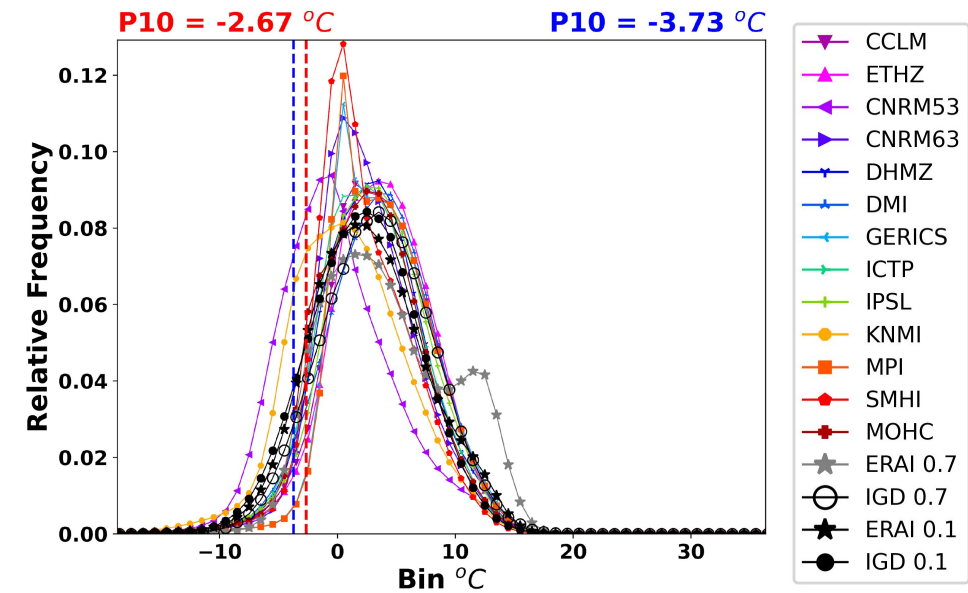
Precipitation: Historical Conditional

Min Temperature: Hindcast

Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-1.4	-0.6	-6.9	-3.6	4.4	-3.3	-2.3	2.4	3.4	1.2	-2.2	-0.9	0.6
DJF	1.6	-0.8	-11.7	2.7	6.9	2.0	-3.3	8.0	4.4	1.0	-3.6	-1.4	9.2
MAM	-3.4	-6.2	-8.8	2.6	2.8	-8.4	-5.2	5.3	1.7	-1.3	-5.6	-3.9	4.2
JJA	-13.8	-5.5	-1.4	-13.6	6.9	-17.1	-11.7	-5.1	-0.3	6.8	-11.5	4.3	-6.7
SON	-4.3	-3.1	-2.8	-0.4	7.3	-7.3	-5.0	3.4	4.1	4.5	-3.9	2.1	4.4

Min Temperature Frequency 0-10

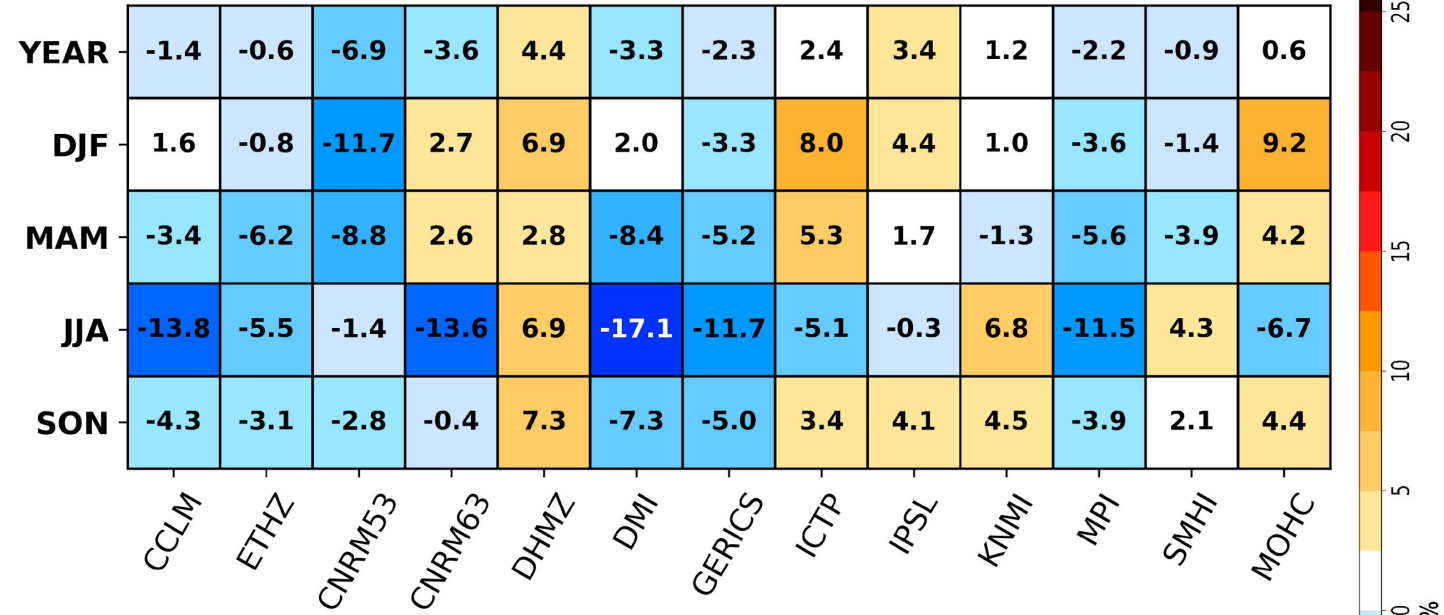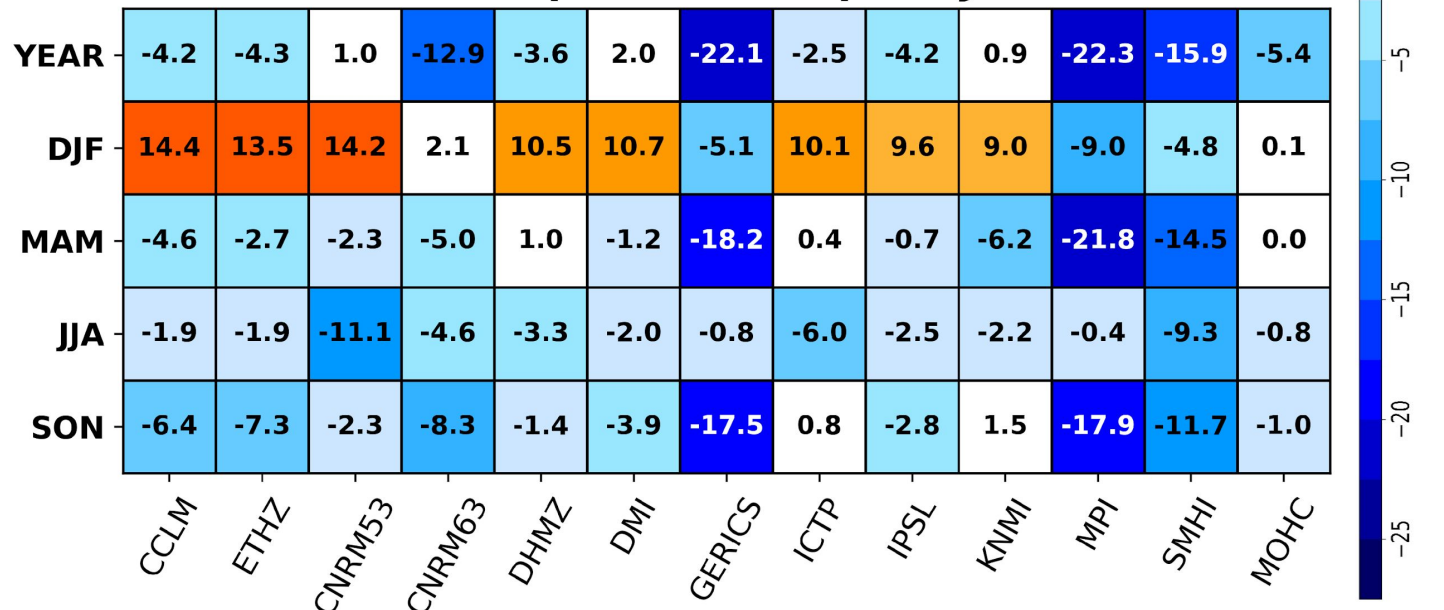|	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-4.2	-4.3	1.0	-12.9	-3.6	2.0	-22.1	-2.5	-4.2	0.9	-22.3	-15.9	-5.4
DJF	14.4	13.5	14.2	2.1	10.5	10.7	-5.1	10.1	9.6	9.0	-9.0	-4.8	0.1
MAM	-4.6	-2.7	-2.3	-5.0	1.0	-1.2	-18.2	0.4	-0.7	-6.2	-21.8	-14.5	0.0
JJA	-1.9	-1.9	-11.1	-4.6	-3.3	-2.0	-0.8	-6.0	-2.5	-2.2	-0.4	-9.3	-0.8
SON	-6.4	-7.3	-2.3	-8.3	-1.4	-3.9	-17.5	0.8	-2.8	1.5	-17.9	-11.7	-1.0

- The PDF follows a normal distribution, small changes on the mean and std affect the score
  - Losses due to overestimation of the frequency for bins around 0 °C
  - Extremes: the 10th percentile in winter is too low. During summer there is no snow.

Min Temperature: Hindcast

DJF

P10 = -2.67 °C   P10 = -3.73 °C

Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-1.4	-0.6	-6.9	-3.6	4.4	-3.3	-2.3	2.4	3.4	1.2	-2.2	-0.9	0.6
DJF	1.6	-0.8	-11.7	2.7	6.9	2.0	-3.3	8.0	4.4	1.0	-3.6	-1.4	9.2
MAM	-3.4	-6.2	-8.8	2.6	2.8	-8.4	-5.2	5.3	1.7	-1.3	-5.6	-3.9	4.2
JJA	-13.8	-5.5	-1.4	-13.6	6.9	-17.1	-11.7	-5.1	-0.3	6.8	-11.5	4.3	-6.7
SON	-4.3	-3.1	-2.8	-0.4	7.3	-7.3	-5.0	3.4	4.1	4.5	-3.9	2.1	4.4

Min Temperature Frequency 0-10

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-4.2	-4.3	1.0	-12.9	-3.6	2.0	-22.1	-2.5	-4.2	0.9	-22.3	-15.9	-5.4
DJF	14.4	13.5	14.2	2.1	10.5	10.7	-5.1	10.1	9.6	9.0	-9.0	-4.8	0.1
MAM	-4.6	-2.7	-2.3	-5.0	1.0	-1.2	-18.2	0.4	-0.7	-6.2	-21.8	-14.5	0.0
JJA	-1.9	-1.9	-11.1	-4.6	-3.3	-2.0	-0.8	-6.0	-2.5	-2.2	-0.4	-9.3	-0.8
SON	-6.4	-7.3	-2.3	-8.3	-1.4	-3.9	-17.5	0.8	-2.8	1.5	-17.9	-11.7	-1.0

- The PDF follows a normal distribution, small changes on the mean and std affect the score
  - Losses due to overestimation of the frequency for bins around 0 °C
  - Extremes: the 10th percentile in winter is too low. During summer there is no snow.

Min Temperature: Hindcast

MAM

P10 = 1.85 °C   P10 = 0.69 °C

Legend: CCLM, ETHZ, CNRM53, CNRM63, DHMZ, DMI, GERICS, ICTP, IPSL, KNMI, MPI, SMHI, MOHC, ERAI 0.7, IGD 0.7, ERAI 0.1, IGD 0.1

Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-1.4	-0.6	-6.9	-3.6	4.4	-3.3	-2.3	2.4	3.4	1.2	-2.2	-0.9	0.6
DJF	1.6	-0.8	-11.7	2.7	6.9	2.0	-3.3	8.0	4.4	1.0	-3.6	-1.4	9.2
MAM	-3.4	-6.2	-8.8	2.6	2.8	-8.4	-5.2	5.3	1.7	-1.3	-5.6	-3.9	4.2
JJA	-13.8	-5.5	-1.4	-13.6	6.9	-17.1	-11.7	-5.1	-0.3	6.8	-11.5	4.3	-6.7
SON	-4.3	-3.1	-2.8	-0.4	7.3	-7.3	-5.0	3.4	4.1	4.5	-3.9	2.1	4.4

Min Temperature Frequency 0-10

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-4.2	-4.3	1.0	-12.9	-3.6	2.0	-22.1	-2.5	-4.2	0.9	-22.3	-15.9	-5.4
DJF	14.4	13.5	14.2	2.1	10.5	10.7	-5.1	10.1	9.6	9.0	-9.0	-4.8	0.1
MAM	-4.6	-2.7	-2.3	-5.0	1.0	-1.2	-18.2	0.4	-0.7	-6.2	-21.8	-14.5	0.0
JJA	-1.9	-1.9	-11.1	-4.6	-3.3	-2.0	-0.8	-6.0	-2.5	-2.2	-0.4	-9.3	-0.8
SON	-6.4	-7.3	-2.3	-8.3	-1.4	-3.9	-17.5	0.8	-2.8	1.5	-17.9	-11.7	-1.0

- The PDF follows a normal distribution, small changes on the mean and std affect the score
  - Losses due to overestimation of the frequency for bins around 0 °C
  - Extremes: the 10th percentile in winter is too low. During summer there is no snow.

Min Temperature: Hindcast

SON

P10 = 2.9 °C   P10 = 1.74 °C

- The PDF follows a normal distribution, small changes on the mean and std affect the score
  - Losses due to overestimation of the frequency for bins around 0 °C
  - Extremes: the 10th percentile in winter is too low. During summer there is no snow.
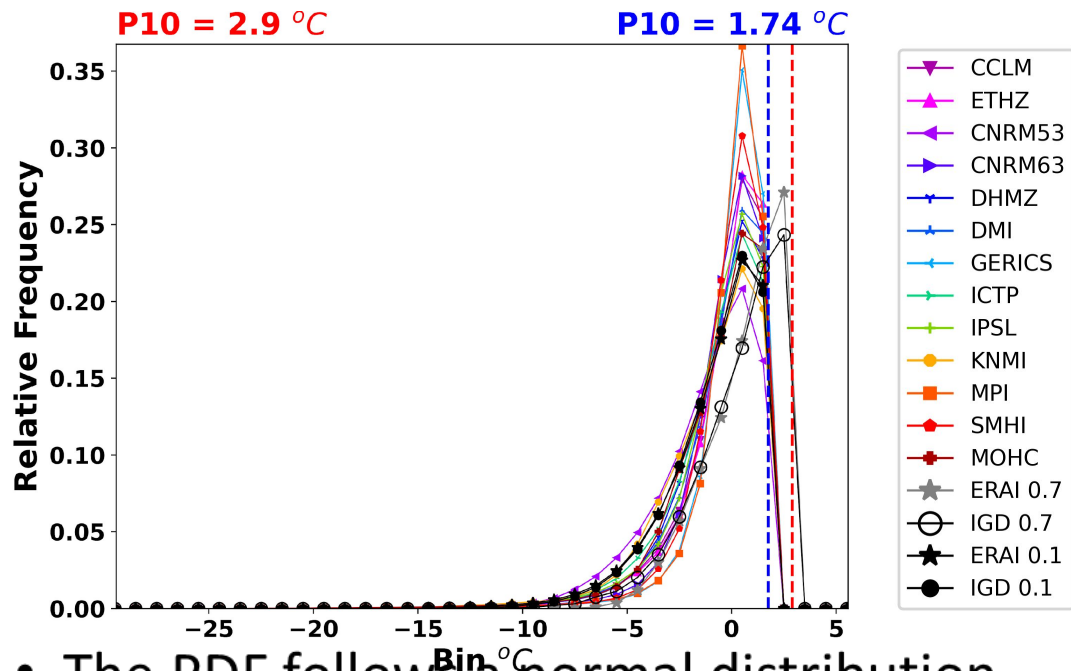
Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-1.4	-0.6	-6.9	-3.6	4.4	-3.3	-2.3	2.4	3.4	1.2	-2.2	-0.9	0.6
DJF	1.6	-0.8	-11.7	2.7	6.9	2.0	-3.3	8.0	4.4	1.0	-3.6	-1.4	9.2
MAM	-3.4	-6.2	-8.8	2.6	2.8	-8.4	-5.2	5.3	1.7	-1.3	-5.6	-3.9	4.2
JJA	-13.8	-5.5	-1.4	-13.6	6.9	-17.1	-11.7	-5.1	-0.3	6.8	-11.5	4.3	-6.7
SON	-4.3	-3.1	-2.8	-0.4	7.3	-7.3	-5.0	3.4	4.1	4.5	-3.9	2.1	4.4

Min Temperature Frequency 0-10

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-4.2	-4.3	1.0	-12.9	-3.6	2.0	-22.1	-2.5	-4.2	0.9	-22.3	-15.9	-5.4
DJF	14.4	13.5	14.2	2.1	10.5	10.7	-5.1	10.1	9.6	9.0	-9.0	-4.8	0.1
MAM	-4.6	-2.7	-2.3	-5.0	1.0	-1.2	-18.2	0.4	-0.7	-6.2	-21.8	-14.5	0.0
JJA	-1.9	-1.9	-11.1	-4.6	-3.3	-2.0	-0.8	-6.0	-2.5	-2.2	-0.4	-9.3	-0.8
SON	-6.4	-7.3	-2.3	-8.3	-1.4	-3.9	-17.5	0.8	-2.8	1.5	-17.9	-11.7	-1.0

Min Temperature: Hindcast

JJA

P10 = 10.45 °C   P10 = 9.25 °C

Legend: CCLM, ETHZ, CNRM53, CNRM63, DHMZ, DMI, GERICS, ICTP, IPSL, KNMI, MPI, SMHI, MOHC, ERAI 0.7, IGD 0.7, ERAI 0.1, IGD 0.1

Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-1.4	-0.6	-6.9	-3.6	4.4	-3.3	-2.3	2.4	3.4	1.2	-2.2	-0.9	0.6
DJF	1.6	-0.8	-11.7	2.7	6.9	2.0	-3.3	8.0	4.4	1.0	-3.6	-1.4	9.2
MAM	-3.4	-6.2	-8.8	2.6	2.8	-8.4	-5.2	5.3	1.7	-1.3	-5.6	-3.9	4.2
JJA	-13.8	-5.5	-1.4	-13.6	6.9	-17.1	-11.7	-5.1	-0.3	6.8	-11.5	4.3	-6.7
SON	-4.3	-3.1	-2.8	-0.4	7.3	-7.3	-5.0	3.4	4.1	4.5	-3.9	2.1	4.4

Min Temperature Frequency 0-10

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
YEAR	-4.2	-4.3	1.0	-12.9	-3.6	2.0	-22.1	-2.5	-4.2	0.9	-22.3	-15.9	-5.4
DJF	14.4	13.5	14.2	2.1	10.5	10.7	-5.1	10.1	9.6	9.0	-9.0	-4.8	0.1
MAM	-4.6	-2.7	-2.3	-5.0	1.0	-1.2	-18.2	0.4	-0.7	-6.2	-21.8	-14.5	0.0
JJA	-1.9	-1.9	-11.1	-4.6	-3.3	-2.0	-0.8	-6.0	-2.5	-2.2	-0.4	-9.3	-0.8
SON	-6.4	-7.3	-2.3	-8.3	-1.4	-3.9	-17.5	0.8	-2.8	1.5	-17.9	-11.7	-1.0

- The PDF follows a normal distribution, small changes on the mean and std affect the score
  - Losses due to overestimation of the frequency for bins around 0 °C
  - Extremes: the 10th percentile in winter is too low. During summer there is no snow.

Min Temperature: Hindcast

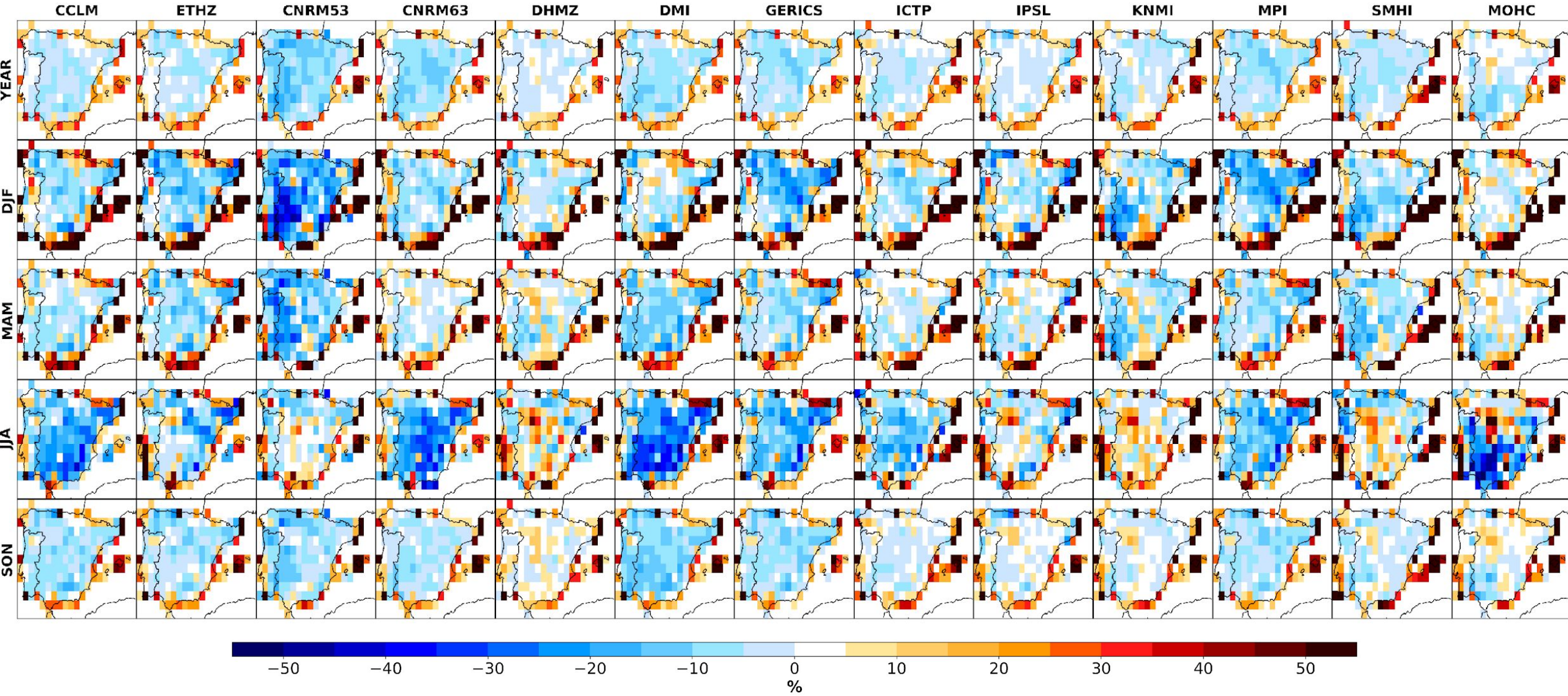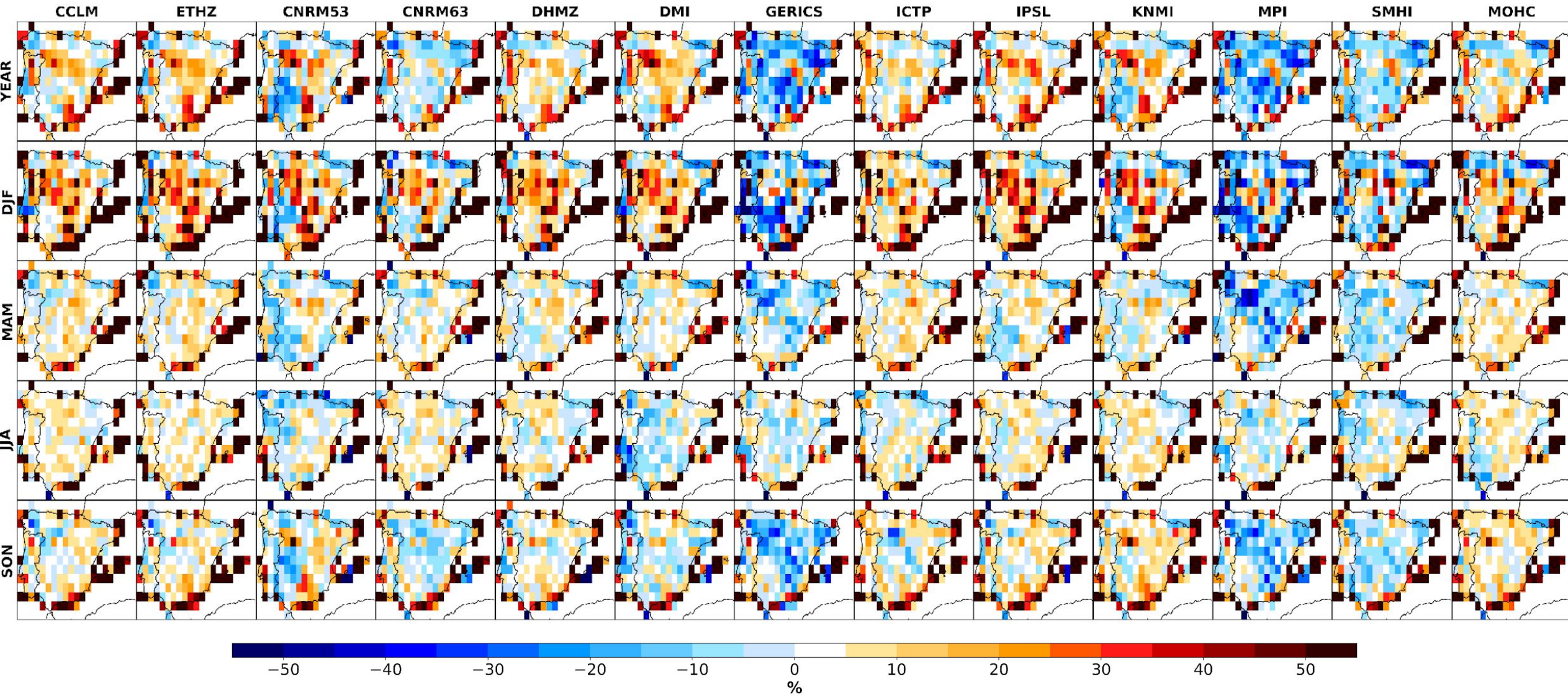Spatial annual and seasonal DAVs for the min daily temperature from the Hindcast simulations (1989-2008). Only data within each point is considered.
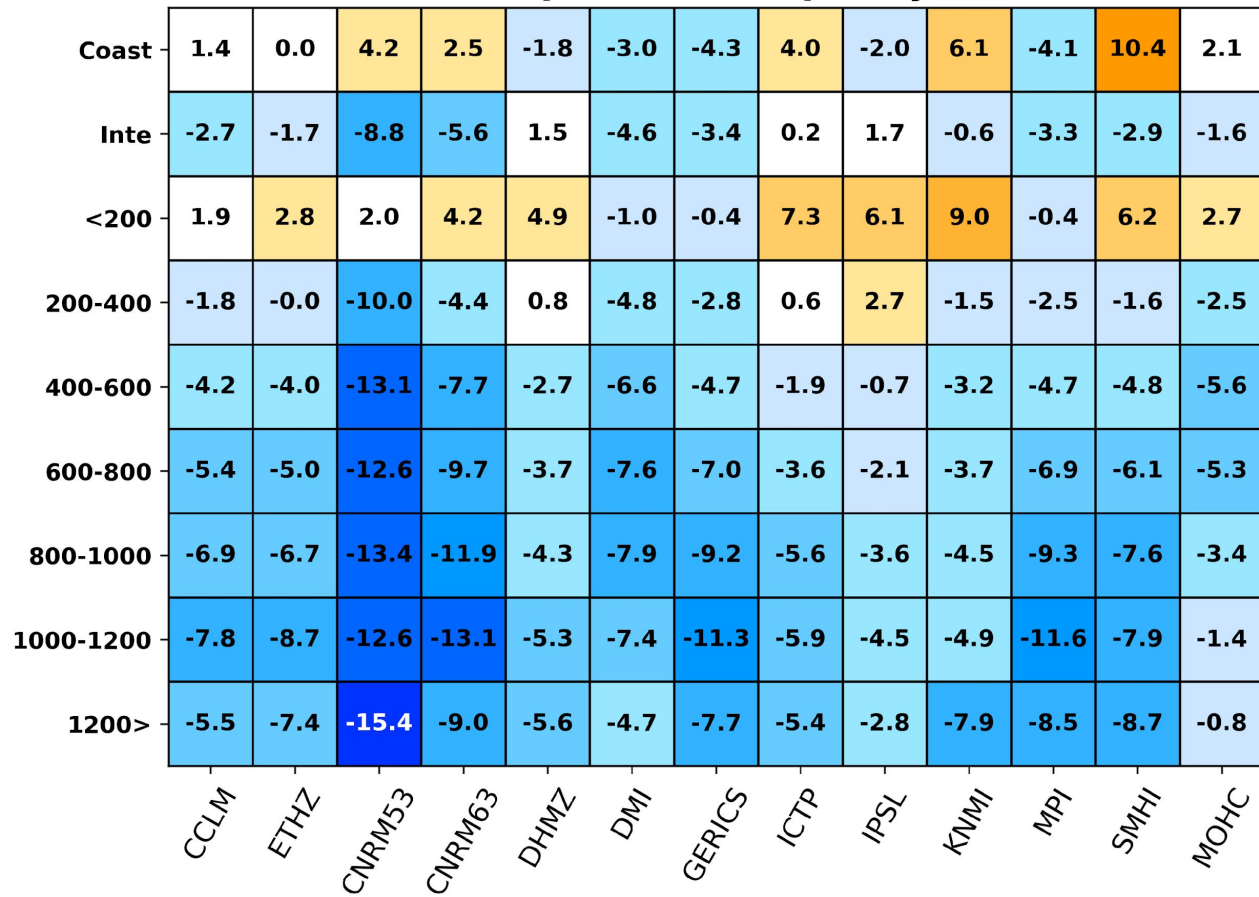
Min Temperature: Hindcast

Spatial annual and seasonal DAVs for the extreme min daily temperature from the Hindcast simulations (1989-2008). Only data within each point and below the 10th observational percentile is considered.
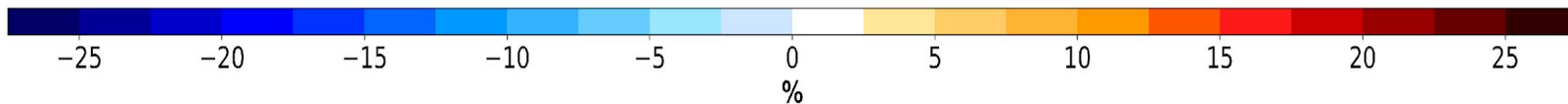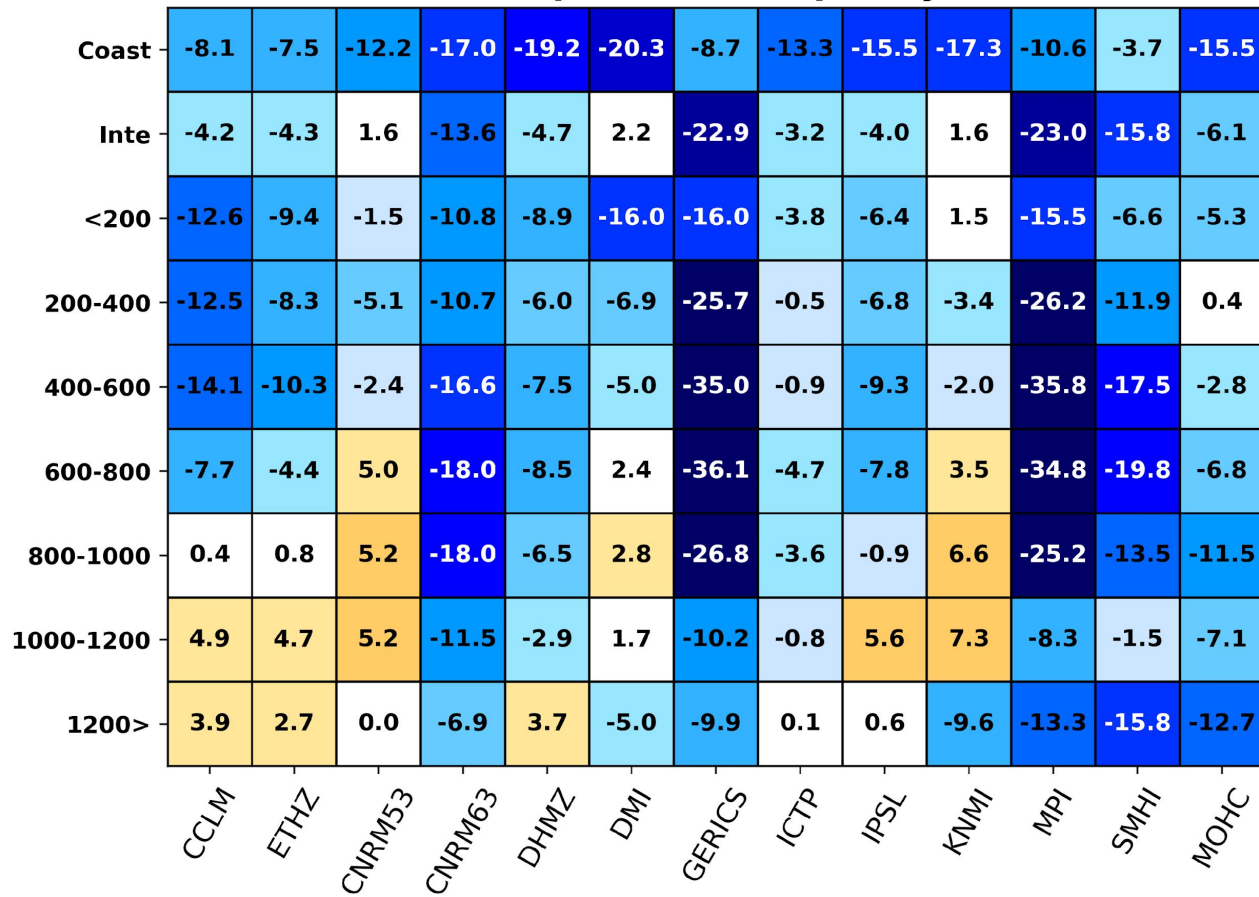
Min Temperature: Hindcast Conditional
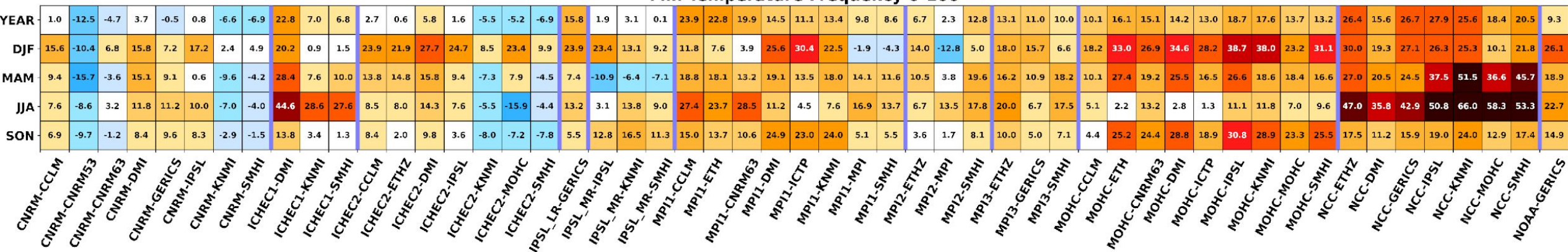

Min Temperature Frequency 0-100

	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
Coast	1.4	0.0	4.2	2.5	-1.8	-3.0	-4.3	4.0	-2.0	6.1	-4.1	10.4	2.1
Inte	-2.7	-1.7	-8.8	-5.6	1.5	-4.6	-3.4	0.2	1.7	-0.6	-3.3	-2.9	-1.6
<200	1.9	2.8	2.0	4.2	4.9	-1.0	-0.4	7.3	6.1	9.0	-0.4	6.2	2.7
200-400	-1.8	-0.0	-10.0	-4.4	0.8	-4.8	-2.8	0.6	2.7	-1.5	-2.5	-1.6	-2.5
400-600	-4.2	-4.0	-13.1	-7.7	-2.7	-6.6	-4.7	-1.9	-0.7	-3.2	-4.7	-4.8	-5.6
600-800	-5.4	-5.0	-12.6	-9.7	-3.7	-7.6	-7.0	-3.6	-2.1	-3.7	-6.9	-6.1	-5.3
800-1000	-6.9	-6.7	-13.4	-11.9	-4.3	-7.9	-9.2	-5.6	-3.6	-4.5	-9.3	-7.6	-3.4
1000-1200	-7.8	-8.7	-12.6	-13.1	-5.3	-7.4	-11.3	-5.9	-4.5	-4.9	-11.6	-7.9	-1.4
1200>	-5.5	-7.4	-15.4	-9.0	-5.6	-4.7	-7.7	-5.4	-2.8	-7.9	-8.5	-8.7	-0.8

Min Temperature Frequency 0-10

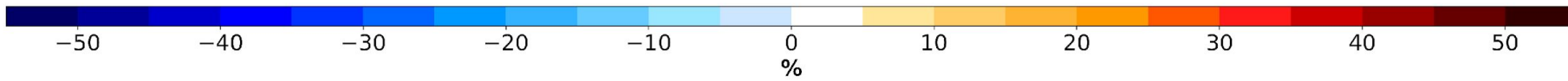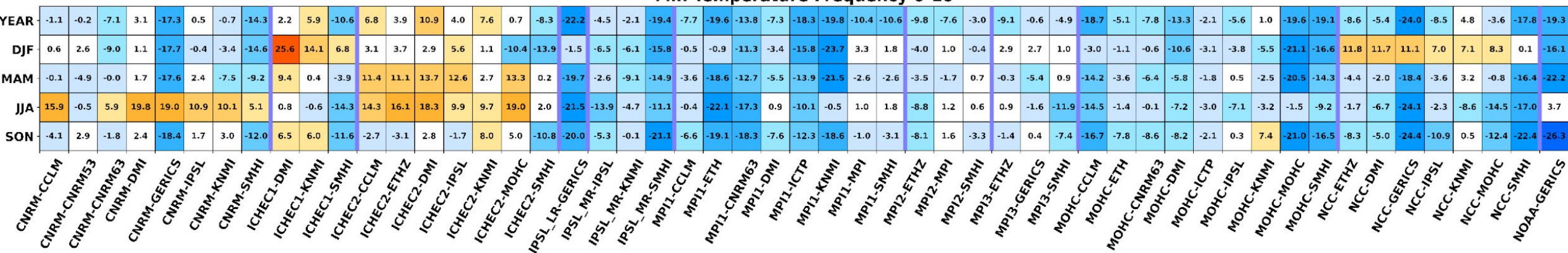|	CCLM	ETHZ	CNRM53	CNRM63	DHMZ	DMI	GERICS	ICTP	IPSL	KNMI	MPI	SMHI	MOHC
Coast	-8.1	-7.5	-12.2	-17.0	-19.2	-20.3	-8.7	-13.3	-15.5	-17.3	-10.6	-3.7	-15.5
Inte	-4.2	-4.3	1.6	-13.6	-4.7	2.2	-22.9	-3.2	-4.0	1.6	-23.0	-15.8	-6.1
<200	-12.6	-9.4	-1.5	-10.8	-8.9	-16.0	-16.0	-3.8	-6.4	1.5	-15.5	-6.6	-5.3
200-400	-12.5	-8.3	-5.1	-10.7	-6.0	-6.9	-25.7	-0.5	-6.8	-3.4	-26.2	-11.9	0.4
400-600	-14.1	-10.3	-2.4	-16.6	-7.5	-5.0	-35.0	-0.9	-9.3	-2.0	-35.8	-17.5	-2.8
600-800	-7.7	-4.4	5.0	-18.0	-8.5	2.4	-36.1	-4.7	-7.8	3.5	-34.8	-19.8	-6.8
800-1000	0.4	0.8	5.2	-18.0	-6.5	2.8	-26.8	-3.6	-0.9	6.6	-25.2	-13.5	-11.5
1000-1200	4.9	4.7	5.2	-11.5	-2.9	1.7	-10.2	-0.8	5.6	7.3	-8.3	-1.5	-7.1
1200>	3.9	2.7	0.0	-6.9	3.7	-5.0	-9.9	0.1	0.6	-9.6	-13.3	-15.8	-12.7

%

Min Temperature: Historical

Min Temperature Frequency 0-100

Min Temperature Frequency 0-10
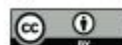
Min Temperature: Historical Conditional
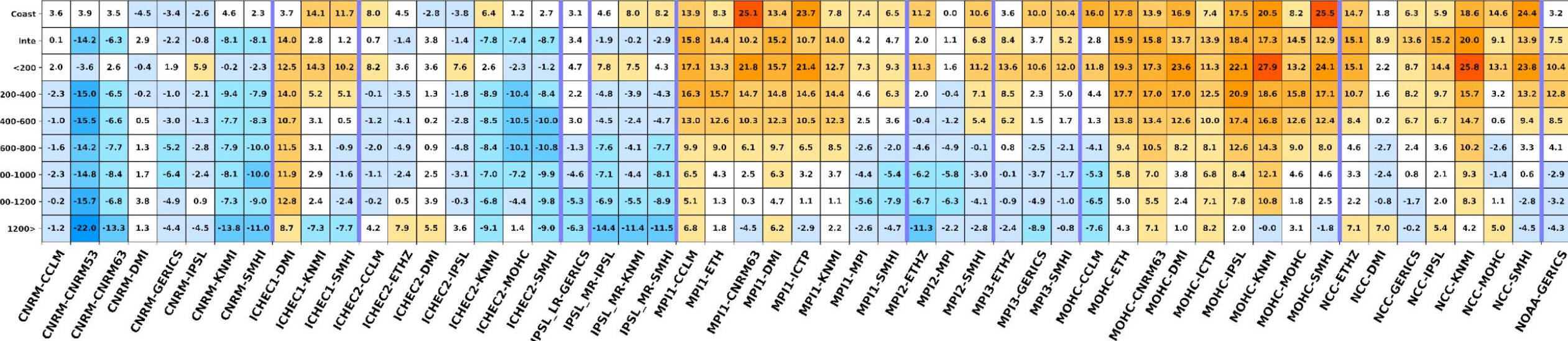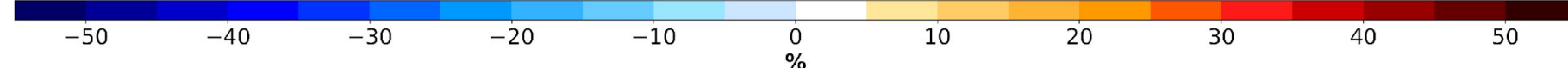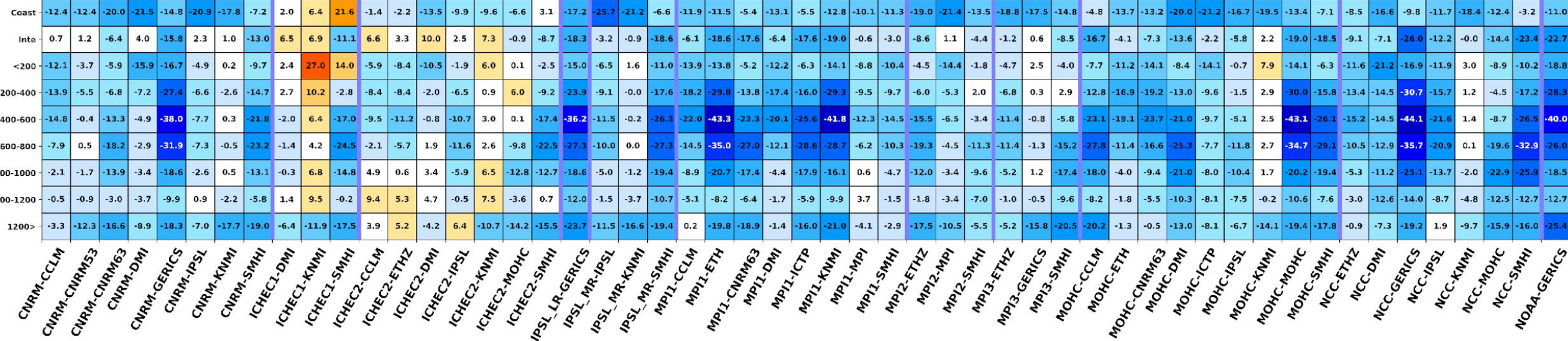
Added value of the EURO-CORDE...
the Iberian Peninsula revisited. Part...

João António Martins Careto[1], Pedro Miguel Matos S...
Jose Manuel Gutiérrez[3]

5 [1]Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lis...
[2]Meteorology Group. Dept. of Applied Mathematics and Comput...
[3]Meteorology Group. Instituto de Física de Cantabria, CSIC-Univ...

Corresponding author João A. M. Careto (jacareto@fc.ul.pt)

10 Faculdade de Ciências da Universidade de Lisboa, Campo Gran...

1749-016 Lisboa, Portugal

Added value of the EURO-CORDEX high-resolution downscaling over the Iberian Peninsula revisited. Part II: Max and Min Temperature

João António Martins Careto[1], Pedro Miguel Matos Soares[1], Rita Margarida Cardoso[1], Sixto Herrera[2], and Jose Manuel Gutiérrez[3]

5 [1]Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa, 1749-016, Portugal
[2]Meteorology Group. Dept. of Applied Mathematics and Computer Science. Universidad de Cantabria. Santander, Spain.
[3]Meteorology Group. Instituto de Física de Cantabria, CSIC-University of Cantabria, Santander, Spain.

Corresponding author João A. M. Careto (jacareto@fc.ul.pt)

10 Faculdade de Ciências da Universidade de Lisboa, Campo Grande, Ed. C8 (3.01)

1749-016 Lisboa, Portugal

Thanks!