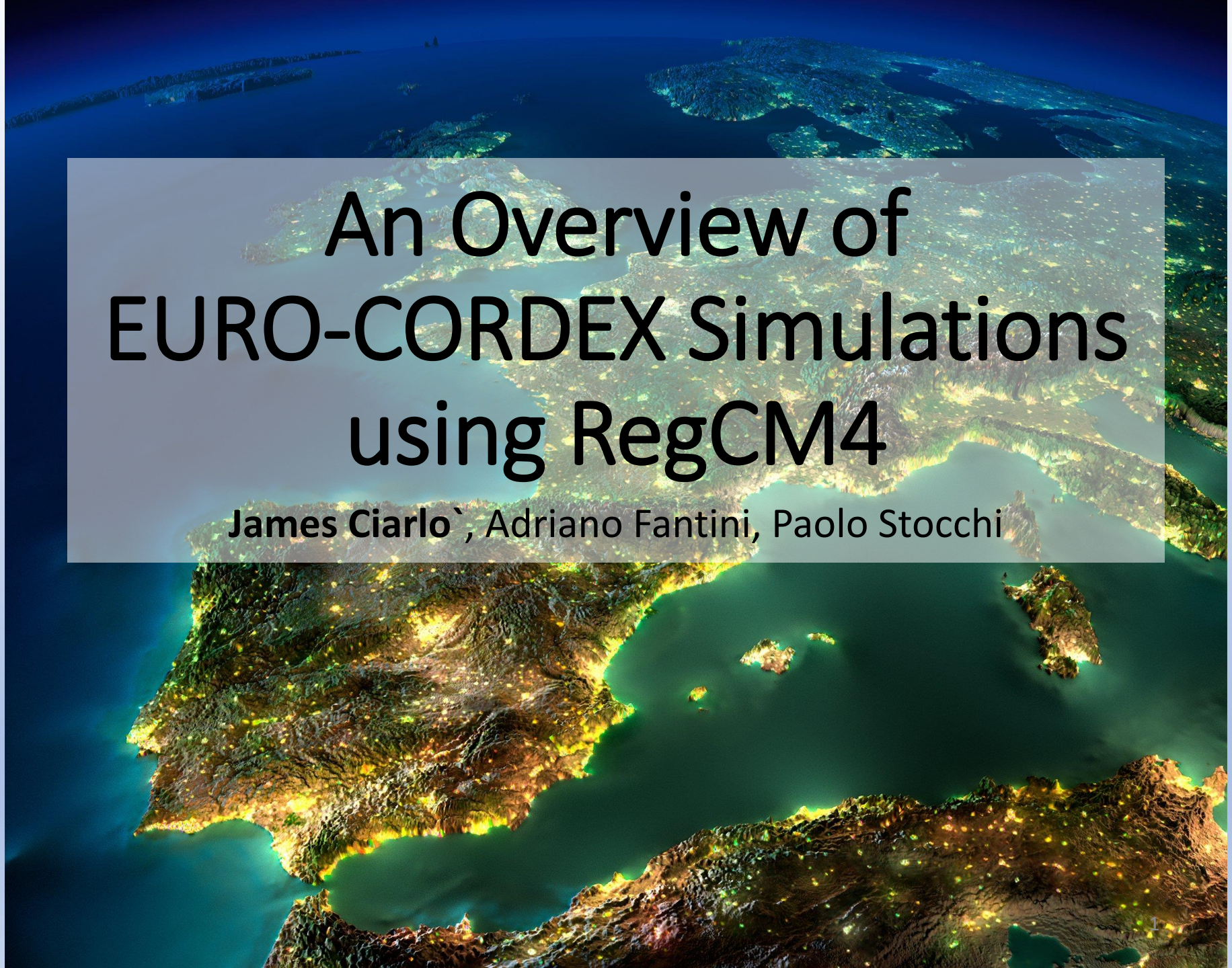


# An Overview of EURO-CORDEX Simulations using RegCM4

**James Ciarlo`**, Adriano Fantini, Paolo Stocchi

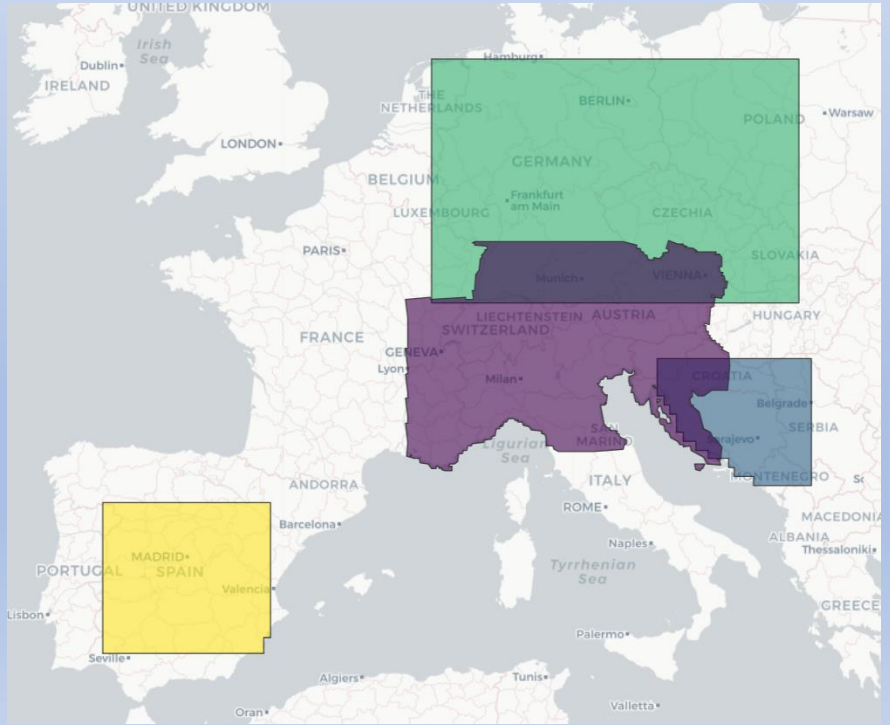
# Simulation details

- Time: 1981-2005
- **EURO-CORDEX**
  - Domain size: 530 x 530
  - Resolution: 12.0 km
- Convective Precipitation:
  - Tiedtke (1996) land and ocean
- GCM Data:
  - ERA-In & HadGEM

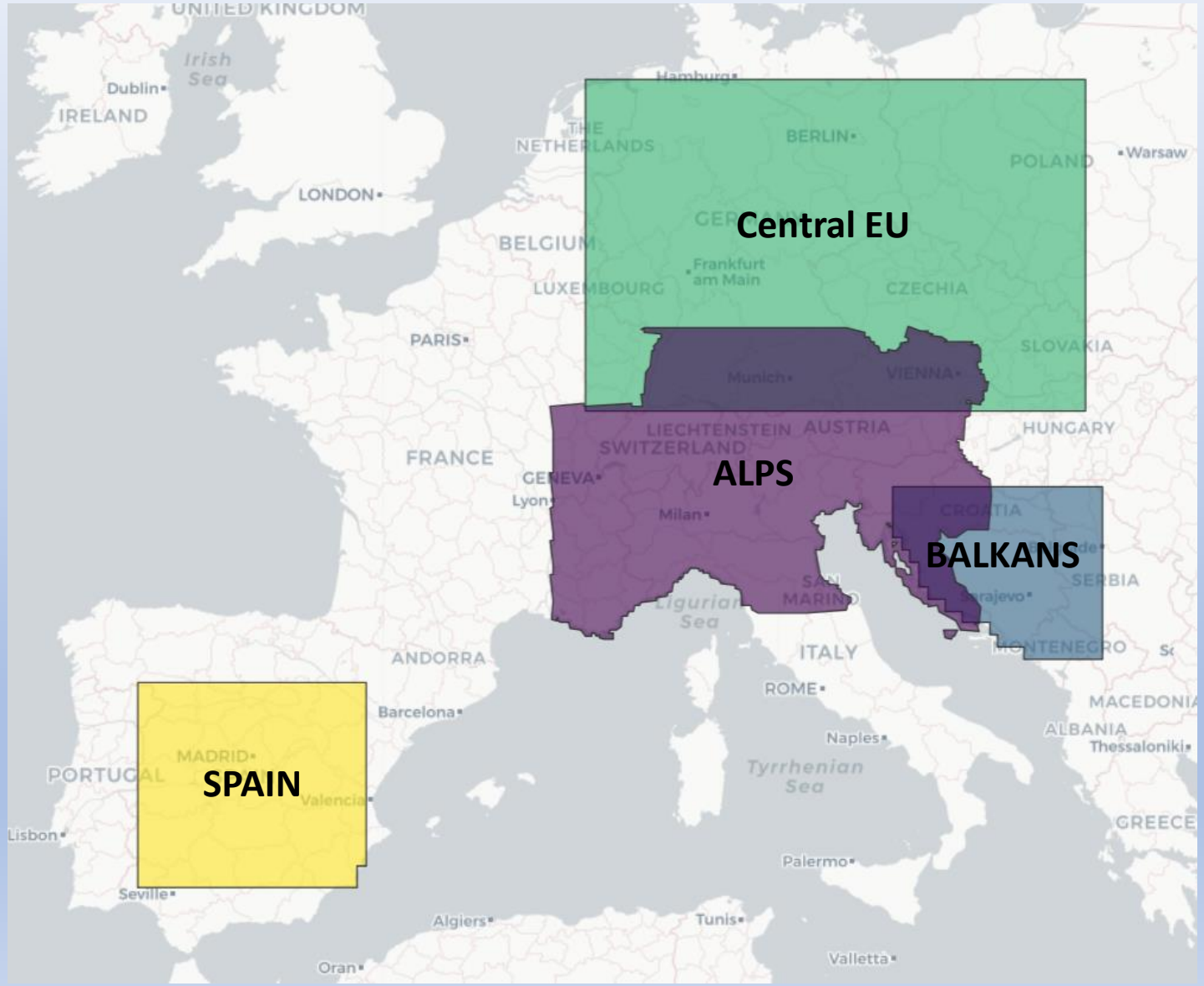
- Full Configuration:
  - obtained by testing over 120 different configurations!

# Comparative Data Sets

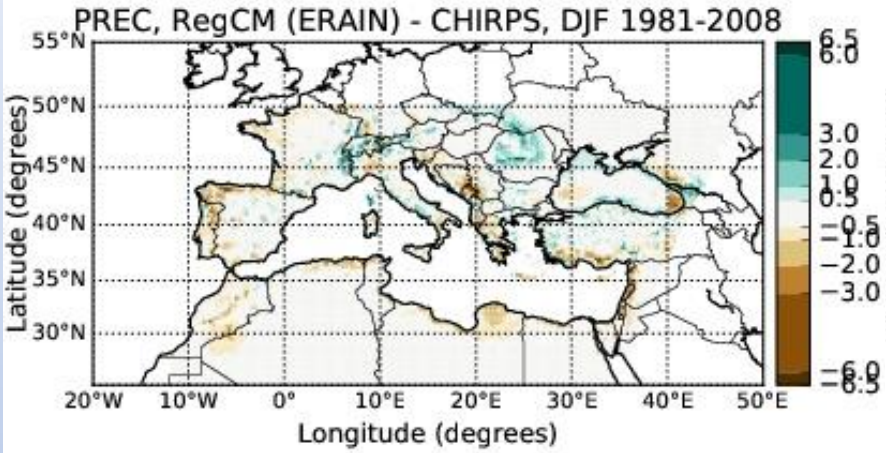
| Data-set | Resolution | Based on: | Reference |
|---|---|---|---|
| E-OBS | 0.25º | station data | Haylock et al. (2008) |
| EURO4M | 5 km | station data | Isotta et al. (2013) |
| CHIRPS | 0.05º | mostly satellite | Funk et al. (2014) |

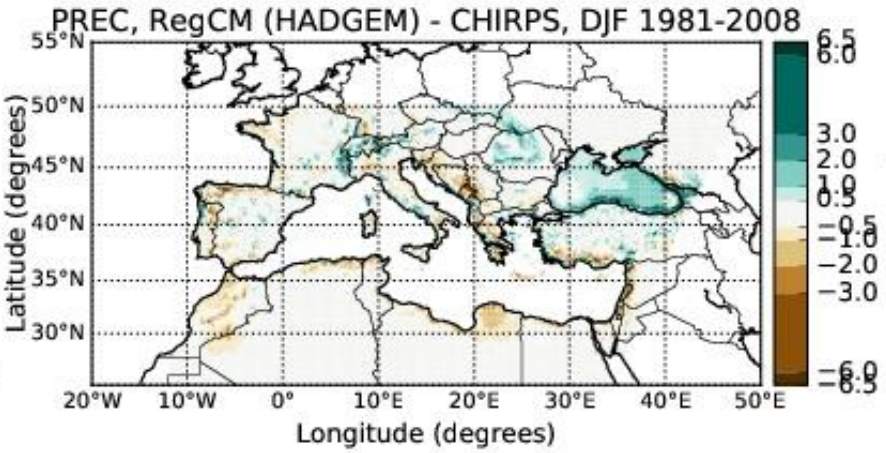


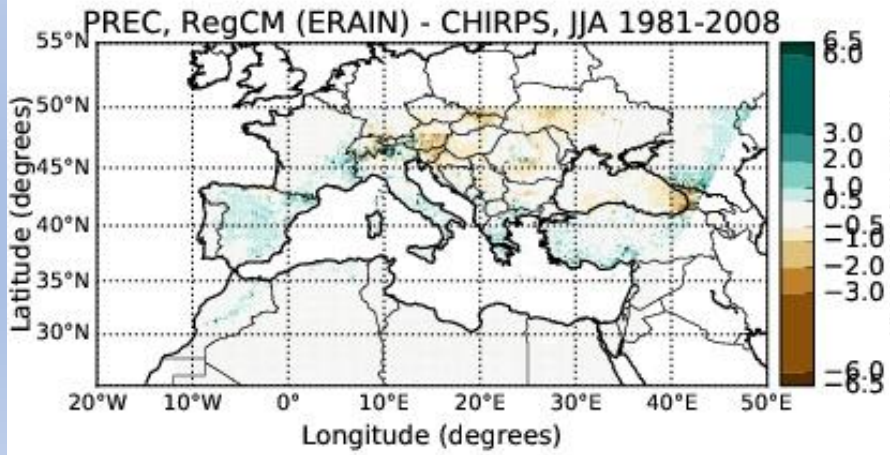
# Observation domains

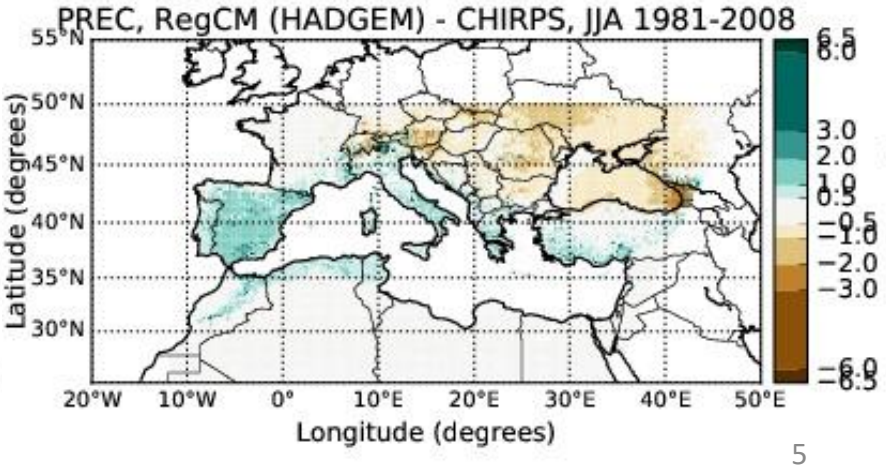


# Bias - CHIRPS

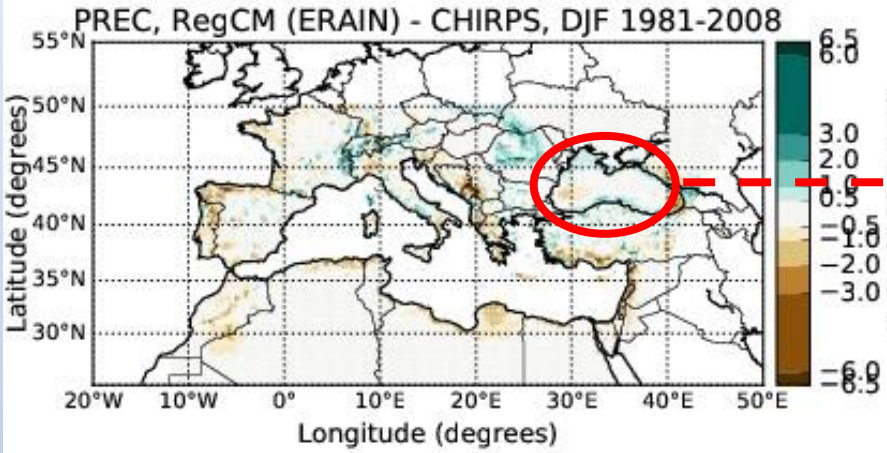

PREC, RegCM (ERAIN) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

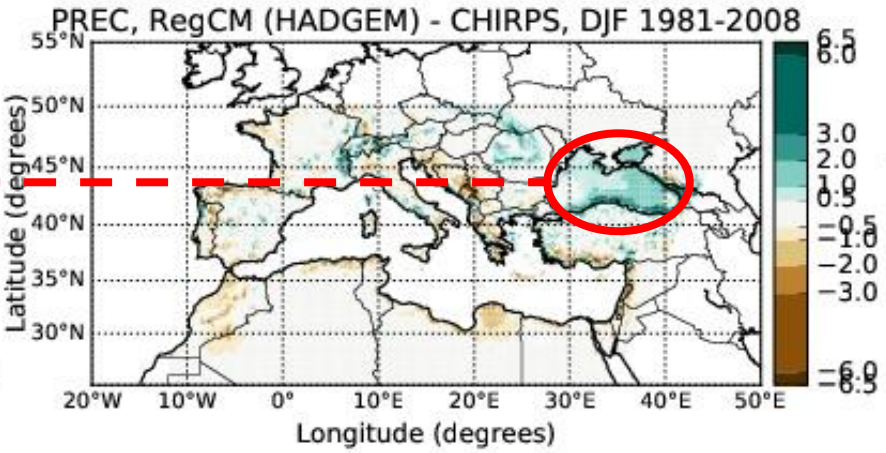

PREC, RegCM (HADGEM) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

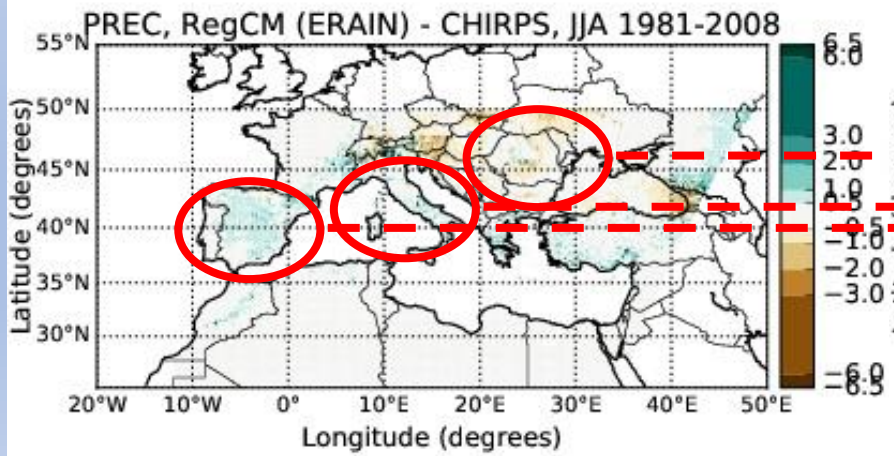

PREC, RegCM (ERAIN) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

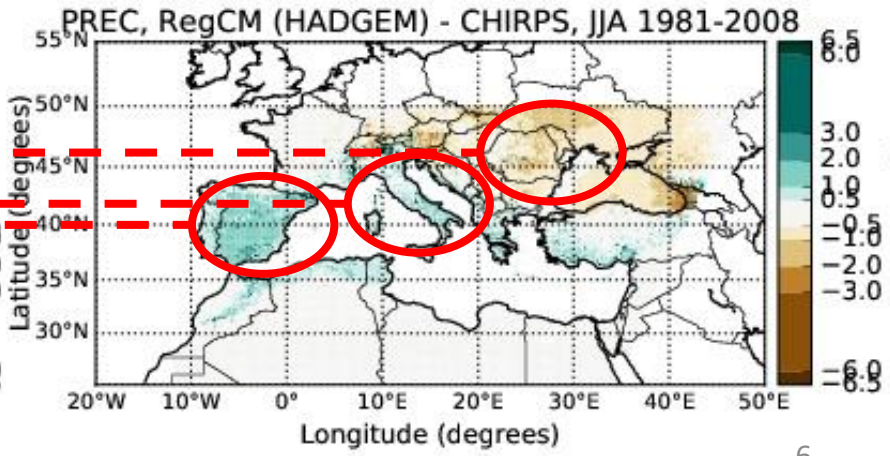

PREC, RegCM (HADGEM) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

# Bias - CHIRPS

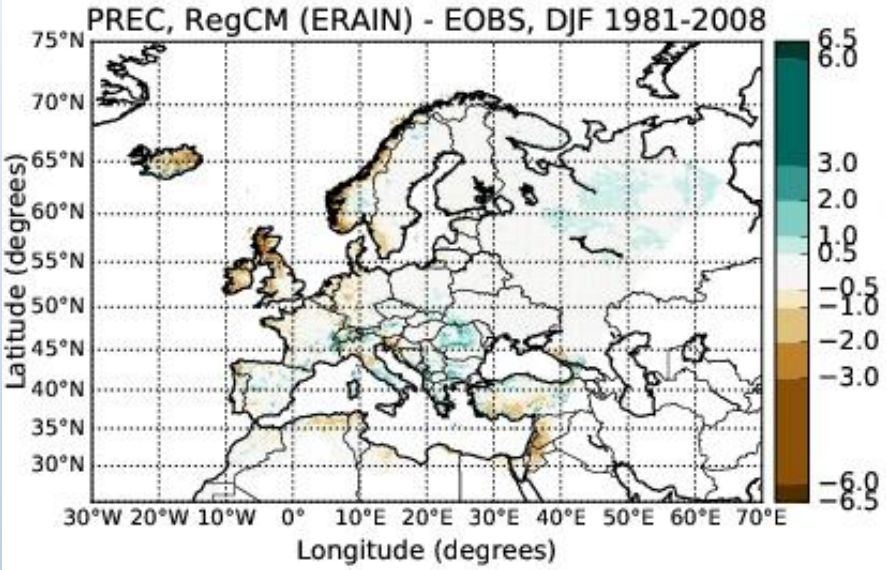

PREC, RegCM (ERAIN) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

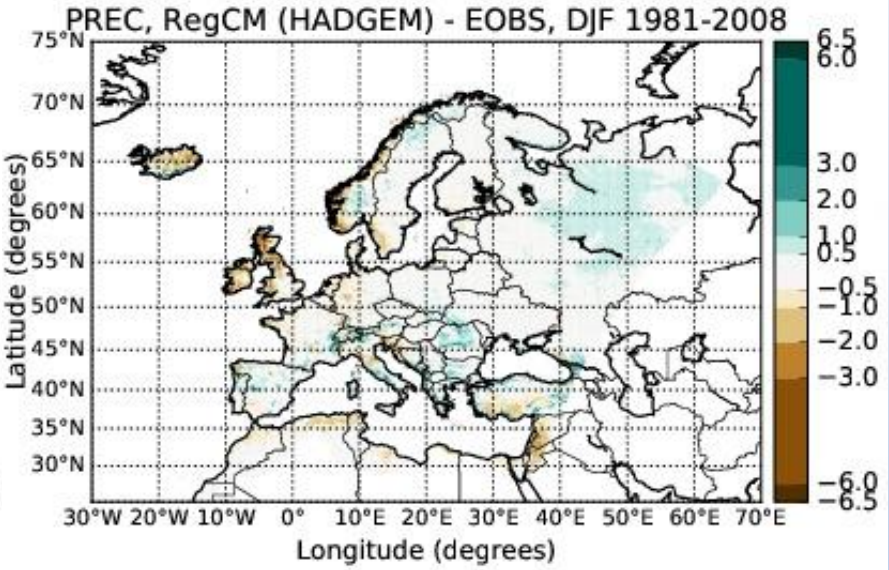

PREC, RegCM (HADGEM) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

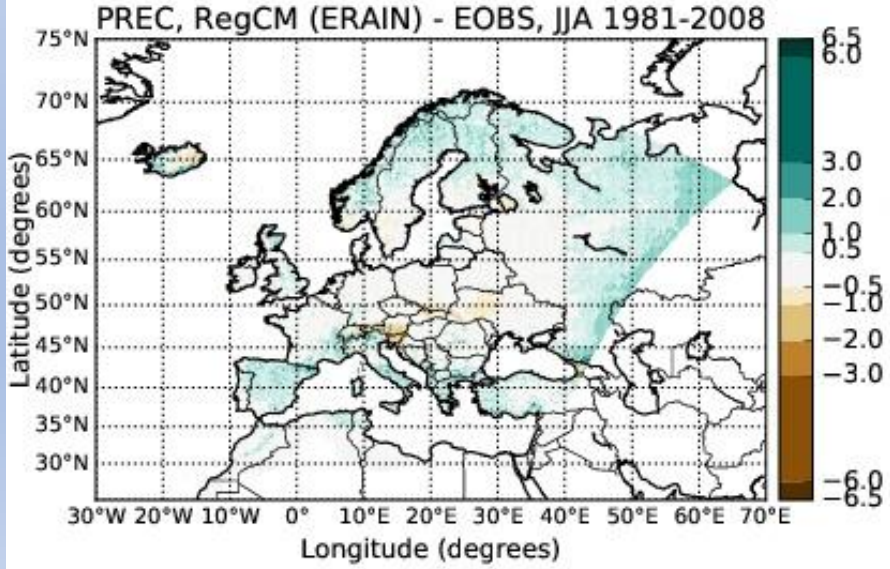

PREC, RegCM (ERAIN) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

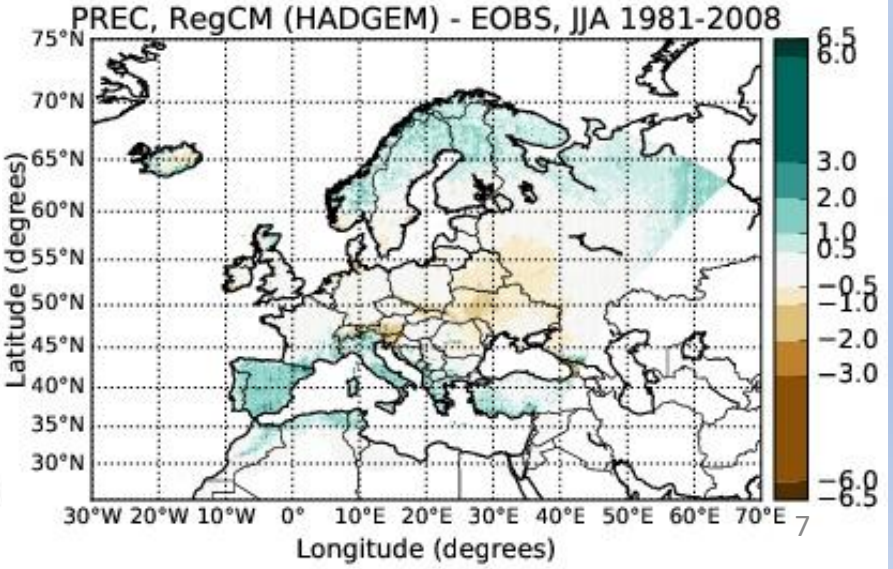

PREC, RegCM (HADGEM) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
55°N
50°N
45°N
40°N
35°N
30°N
20°W
10°W
0°
10°E
20°E
30°E
40°E
50°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

# Bias - EOBS

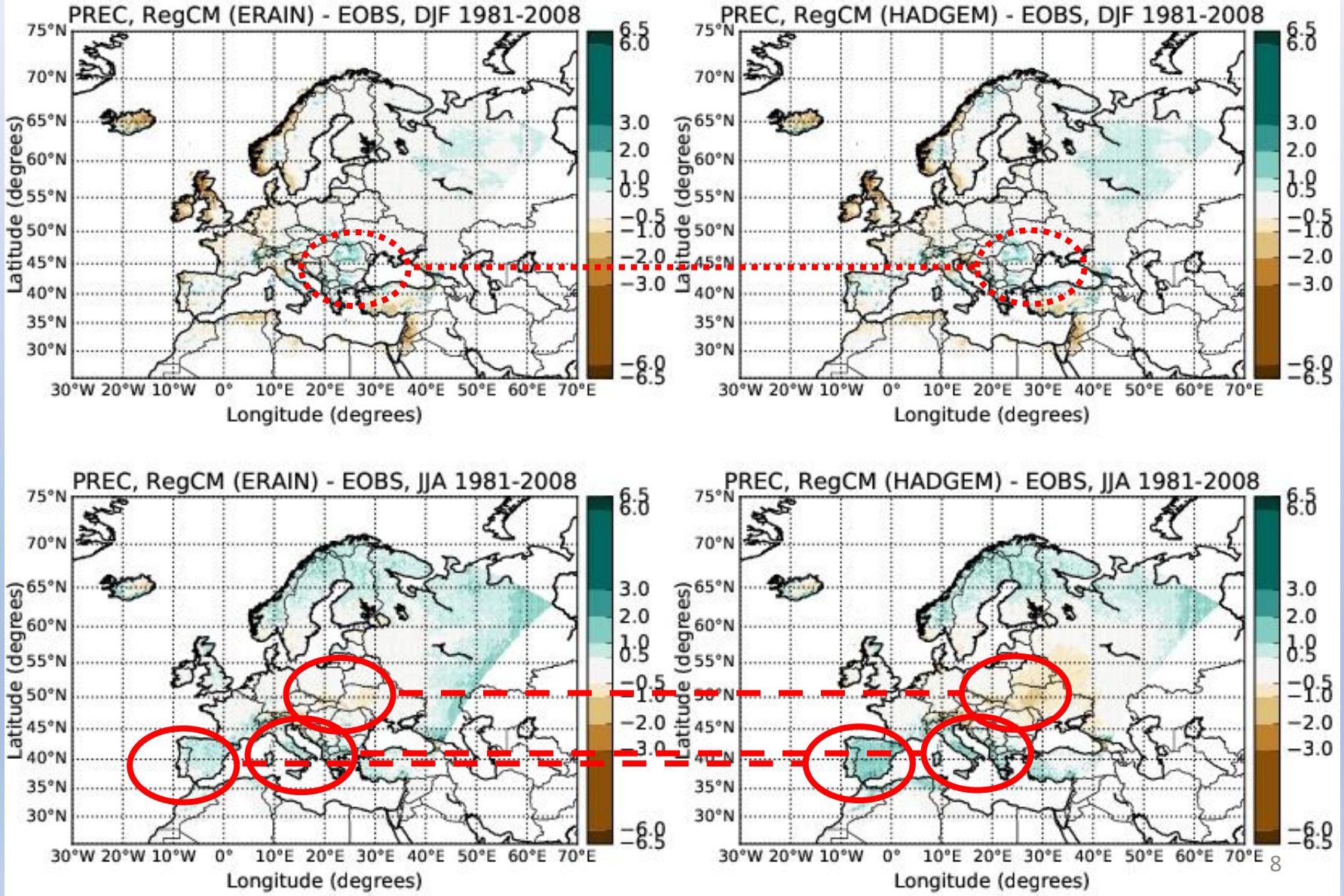

PREC, RegCM (ERAIN) - EOBS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5


PREC, RegCM (HADGEM) - EOBS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

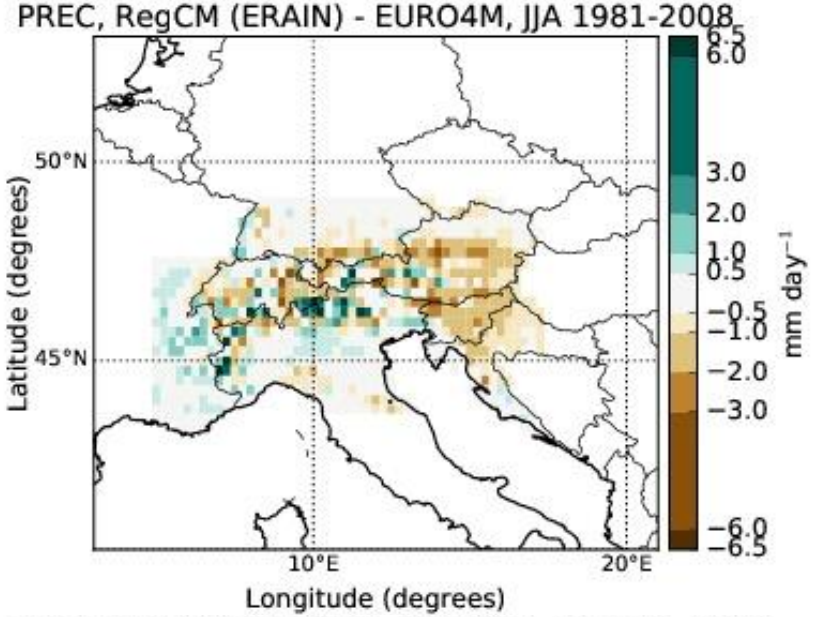

PREC, RegCM (ERAIN) - EOBS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

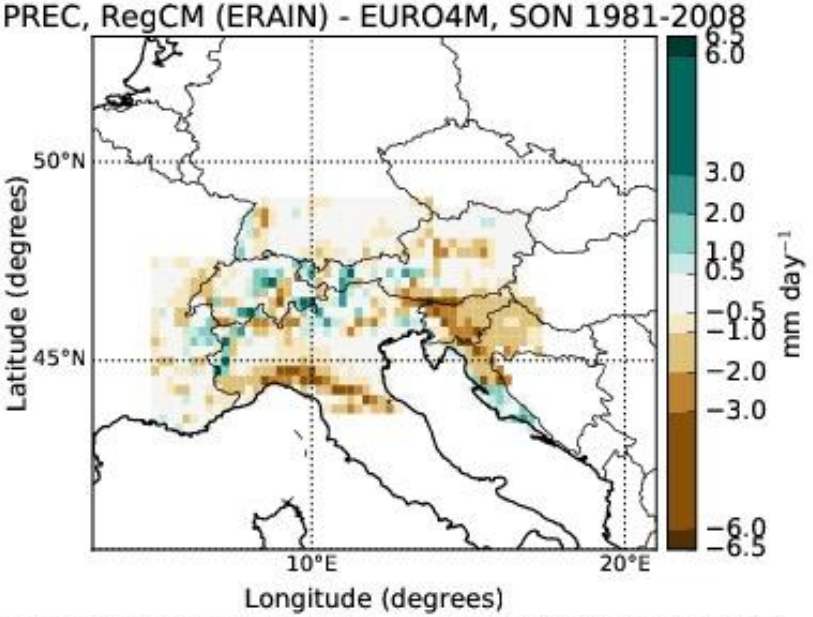

PREC, RegCM (HADGEM) - EOBS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

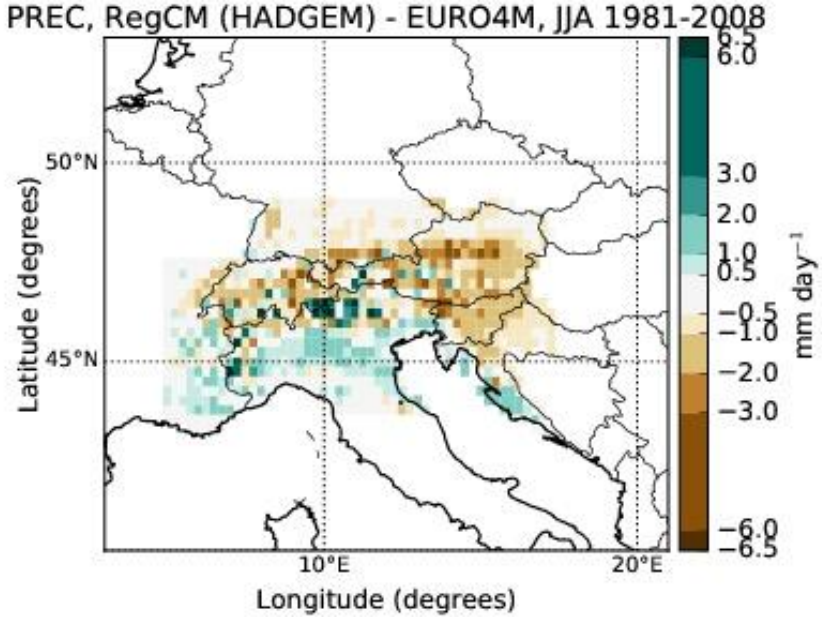
# Bias - EOBS

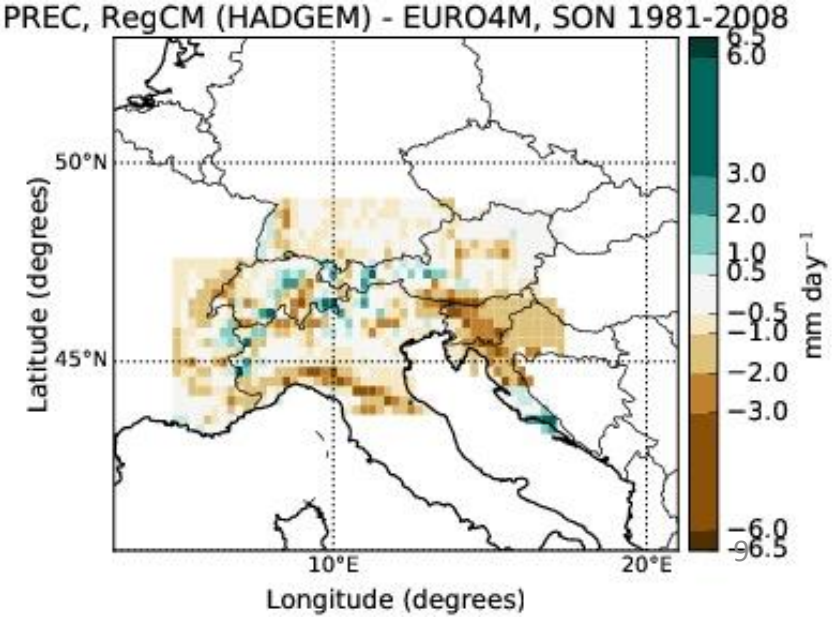

PREC, RegCM (ERAIN) - EOBS, DJF 1981-2008
PREC, RegCM (HADGEM) - EOBS, DJF 1981-2008
PREC, RegCM (ERAIN) - EOBS, JJA 1981-2008
PREC, RegCM (HADGEM) - EOBS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

# BIAS – Euro4m

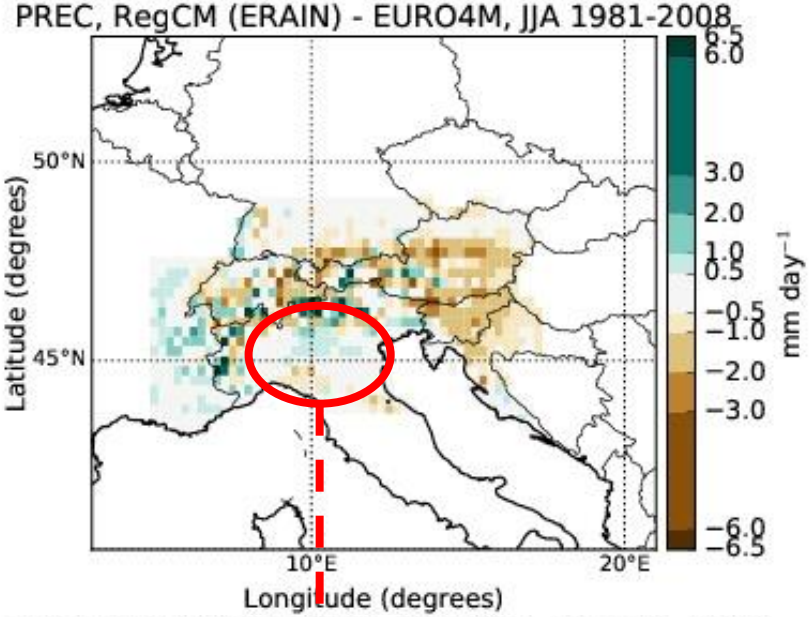

PREC, RegCM (ERAIN) - EURO4M, JJA 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

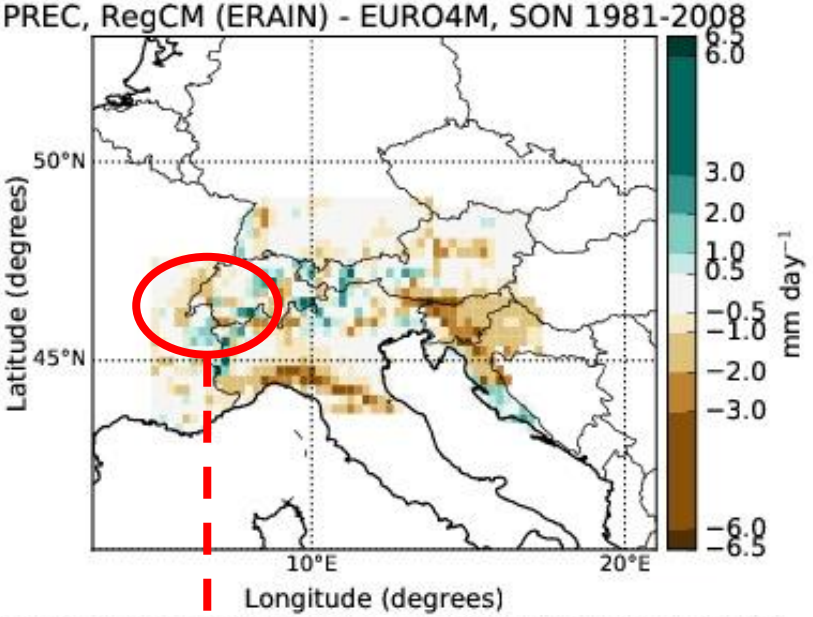

PREC, RegCM (ERAIN) - EURO4M, SON 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

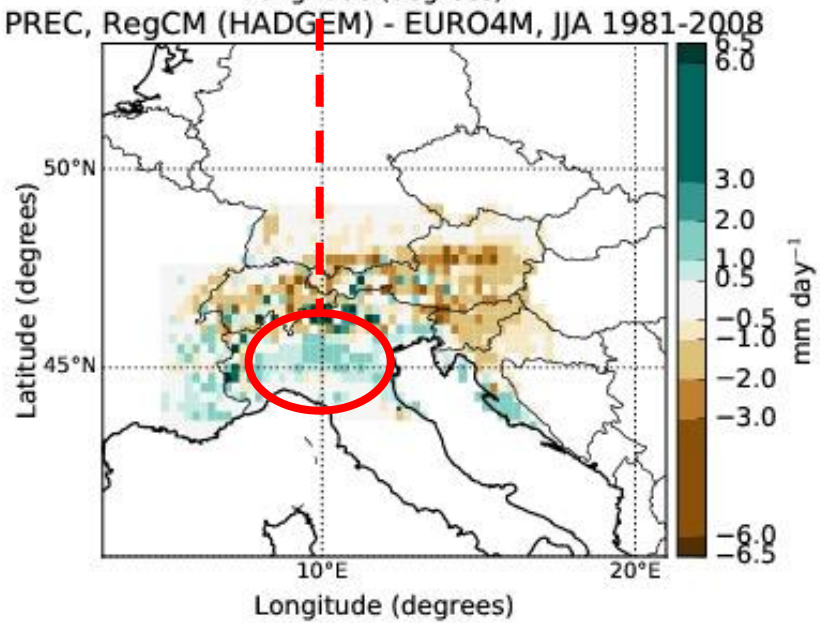

PREC, RegCM (HADGEM) - EURO4M, JJA 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

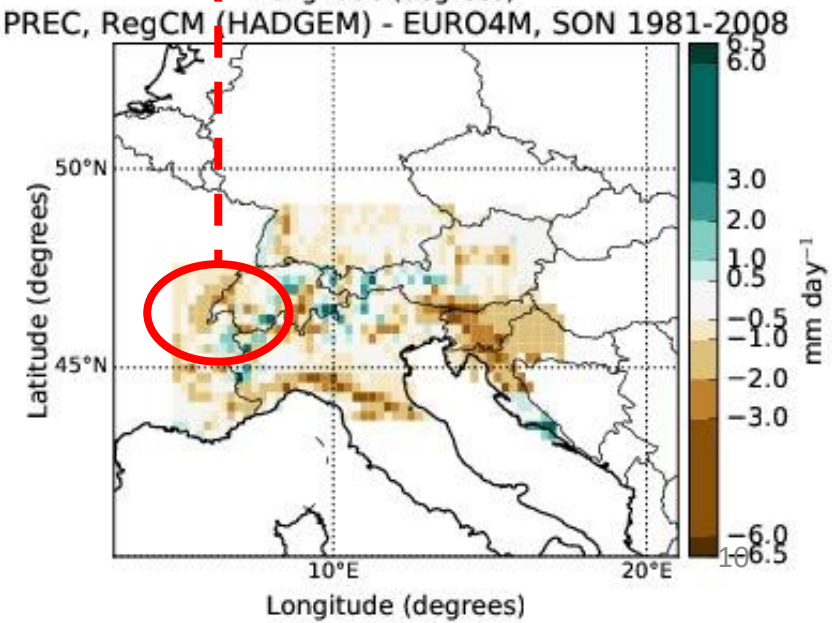

PREC, RegCM (HADGEM) - EURO4M, SON 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

# BIAS – Euro4m

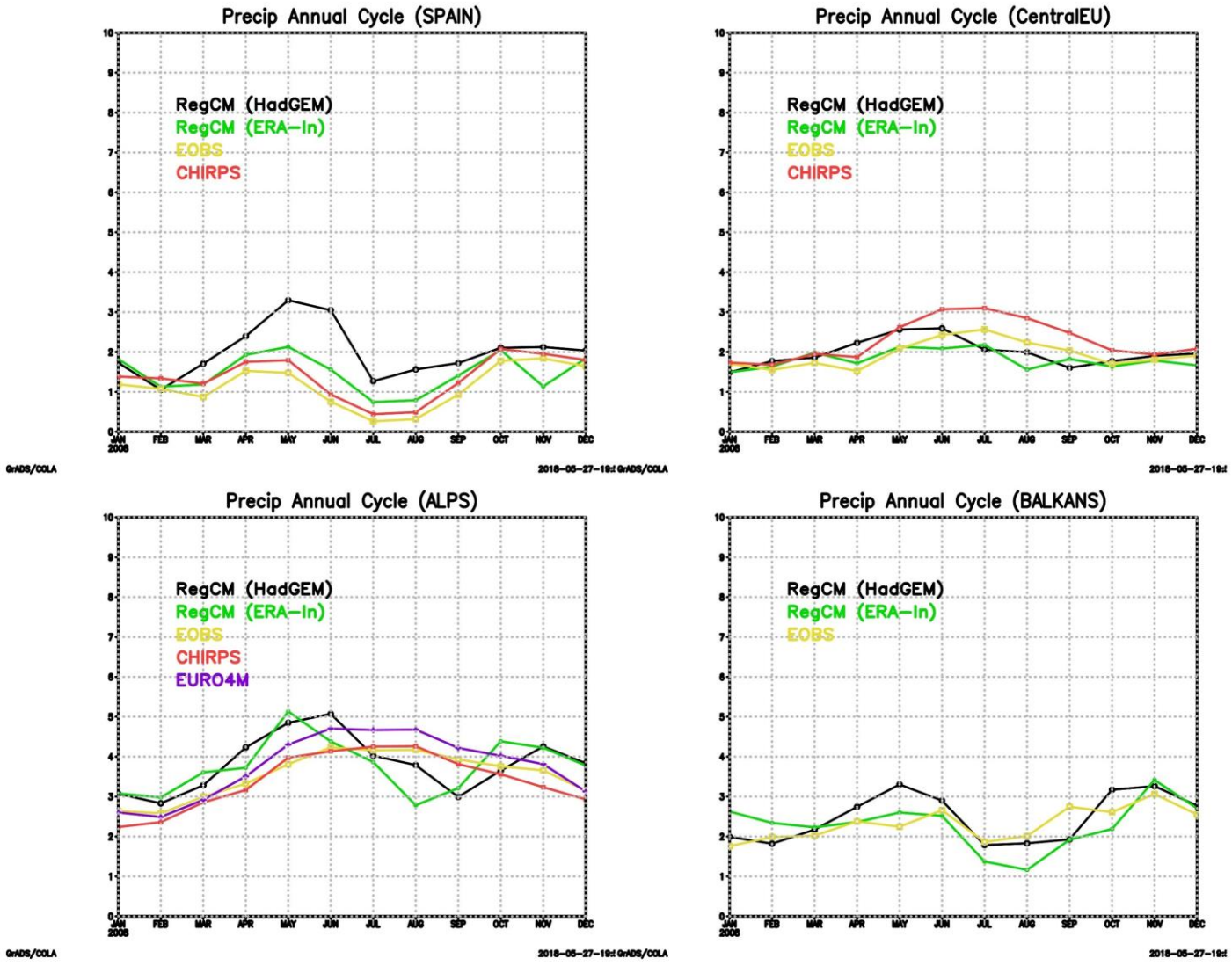

PREC, RegCM (ERAIN) - EURO4M, JJA 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹


PREC, RegCM (ERAIN) - EURO4M, SON 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

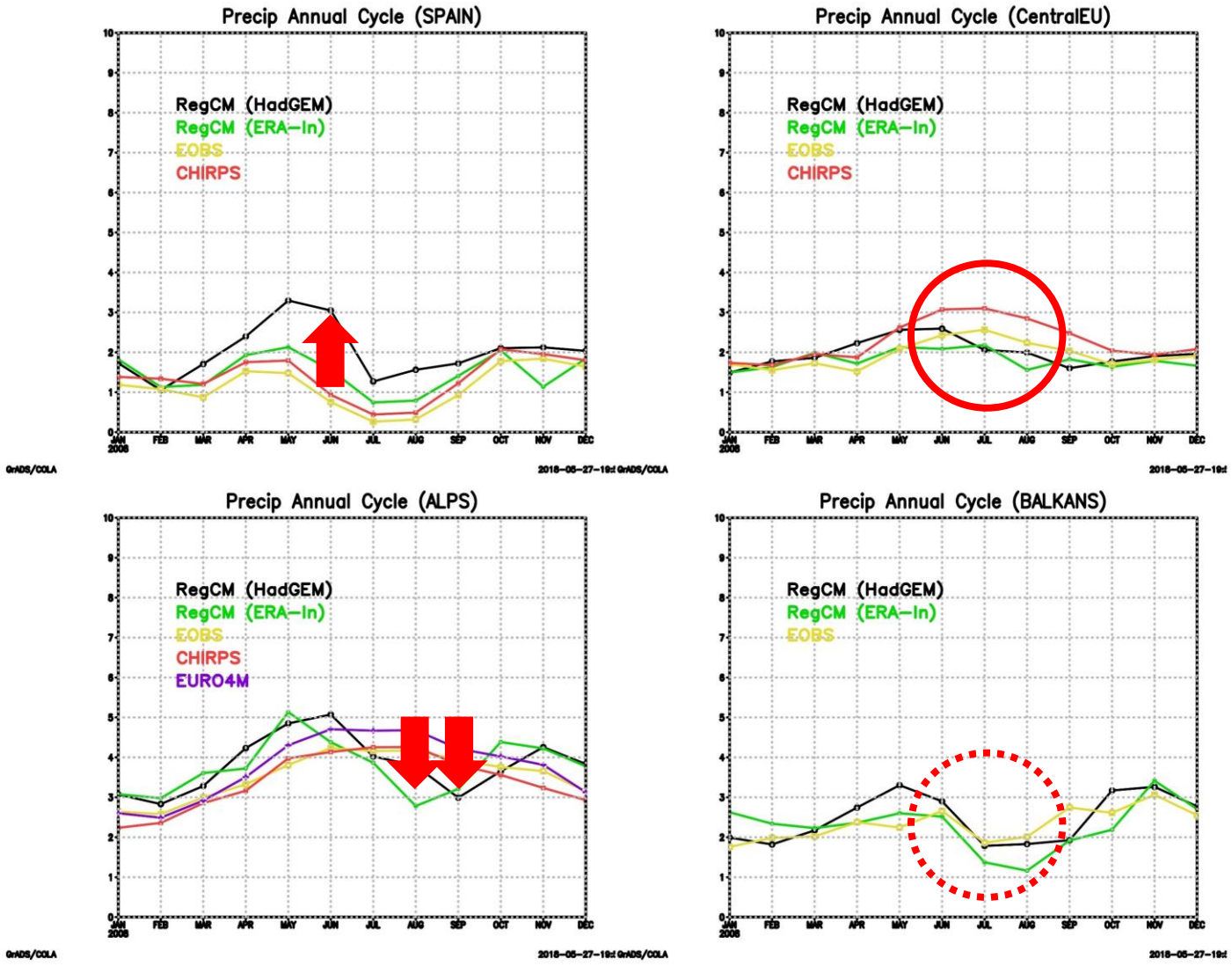

PREC, RegCM (HADGEM) - EURO4M, JJA 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹


PREC, RegCM (HADGEM) - EURO4M, SON 1981-2008
50°N
45°N
Latitude (degrees)
10°E
20°E
Longitude (degrees)
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

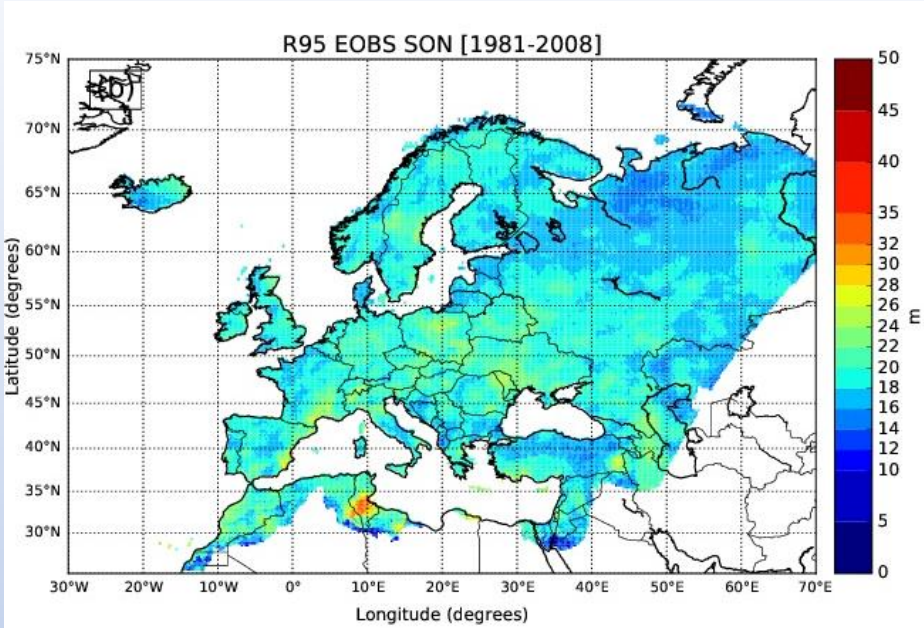
# Annual cycles

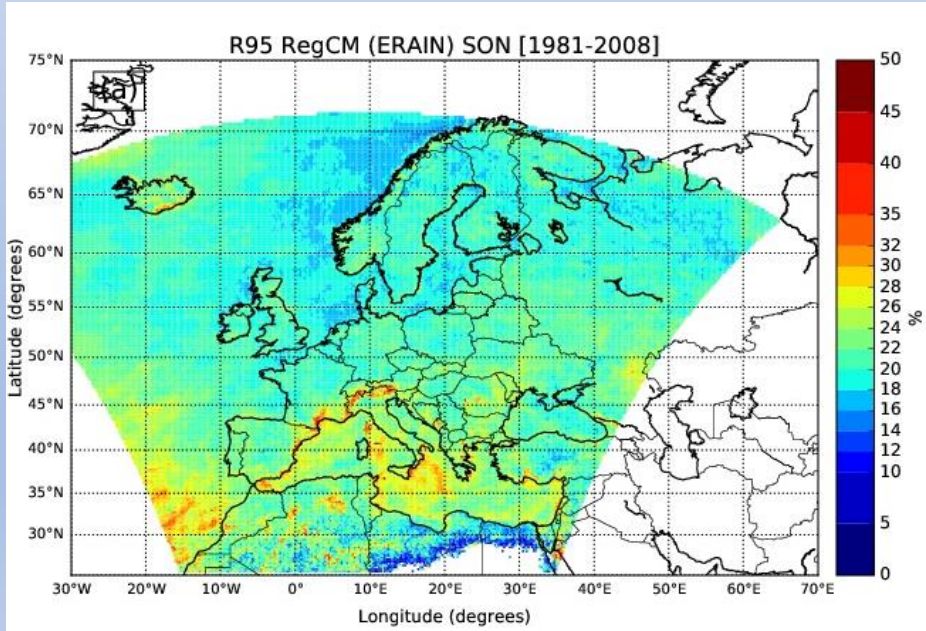


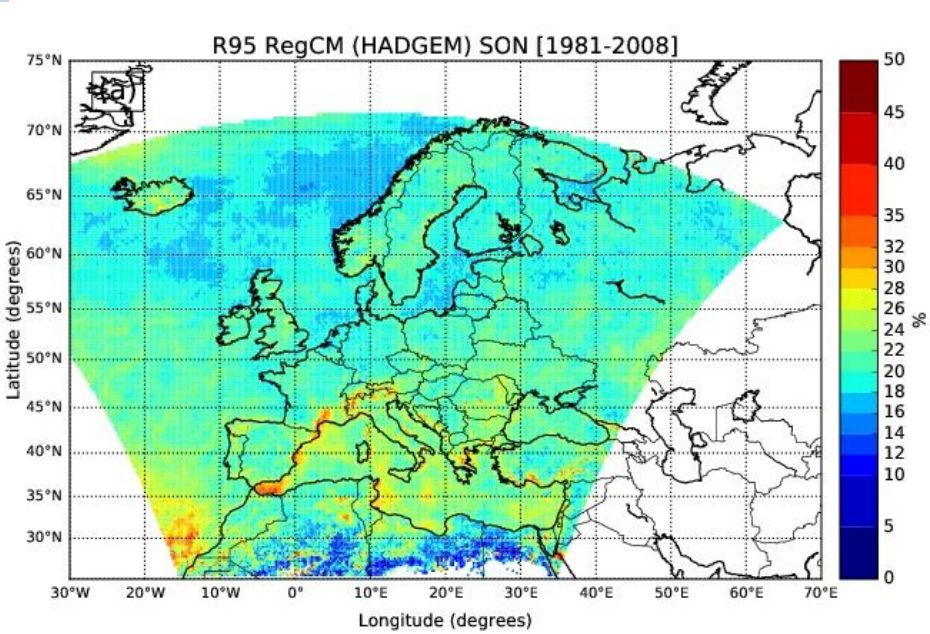
# Annual cycles



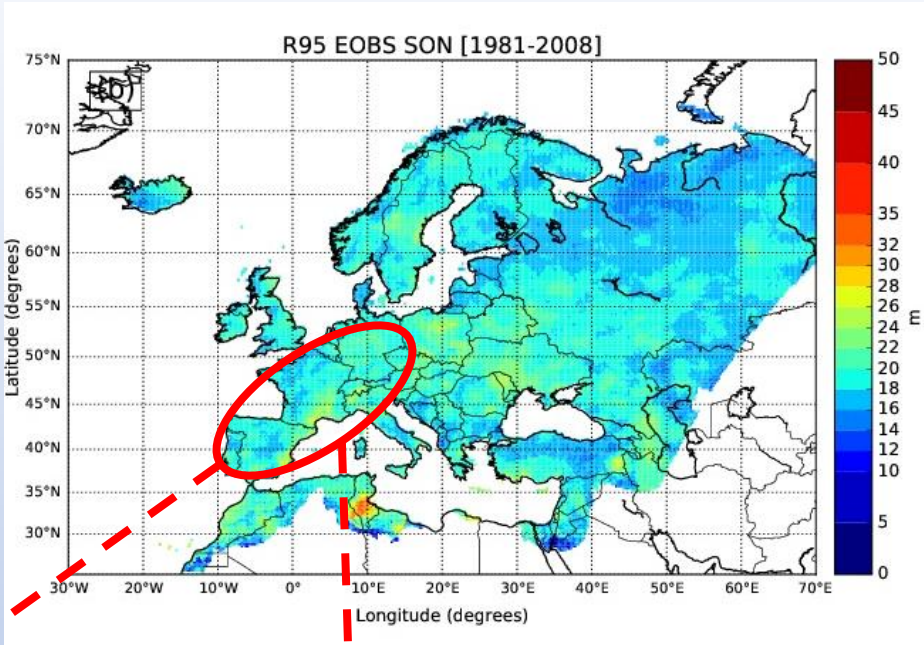
# R95 - EOBS

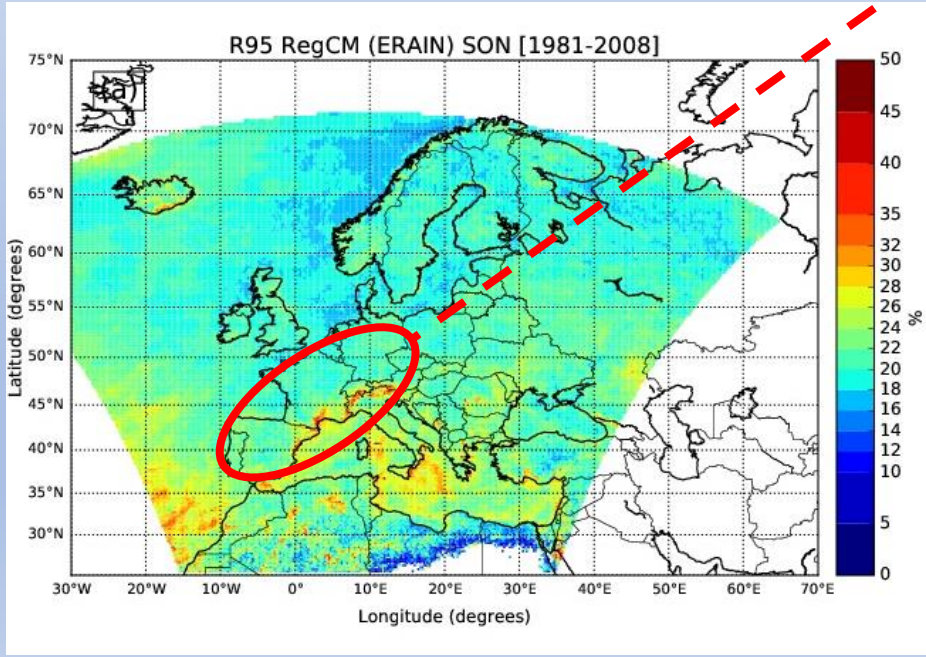

R95 EOBS SON [1981-2008]
(d)
Latitude (degrees)
Longitude (degrees)
m

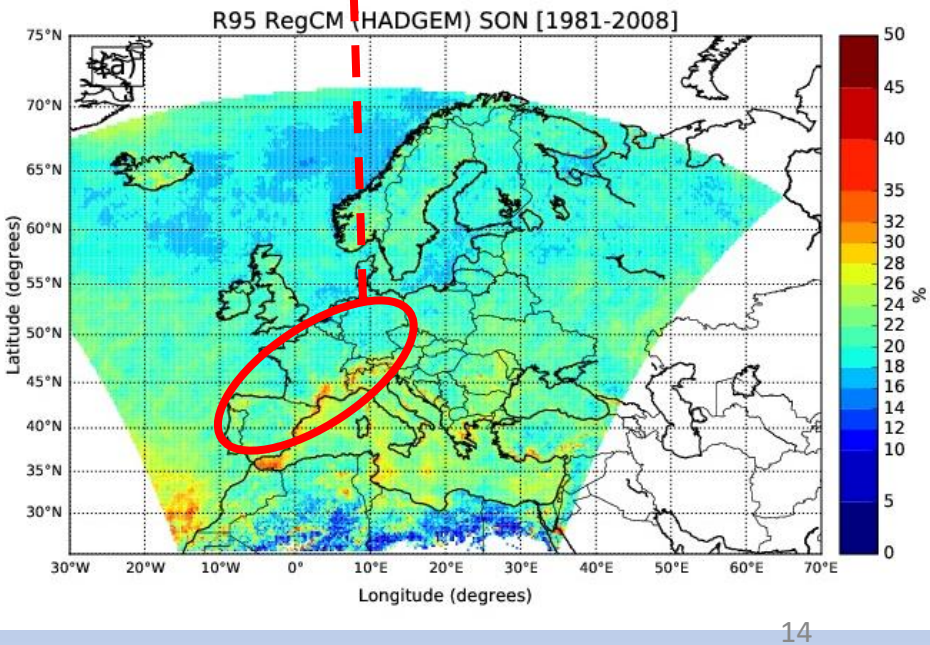

R95 RegCM (ERAIN) SON [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%


R95 RegCM (HADGEM) SON [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

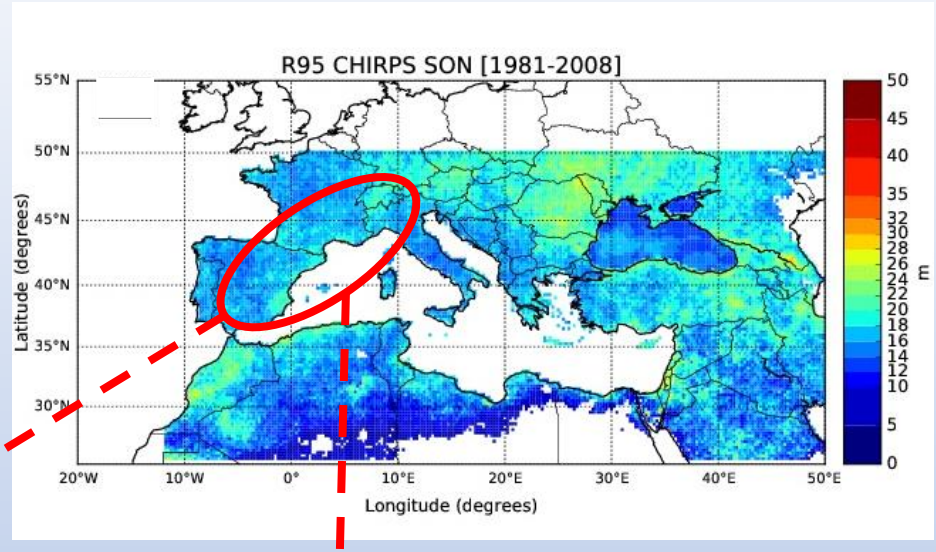
# R95 - EOBS

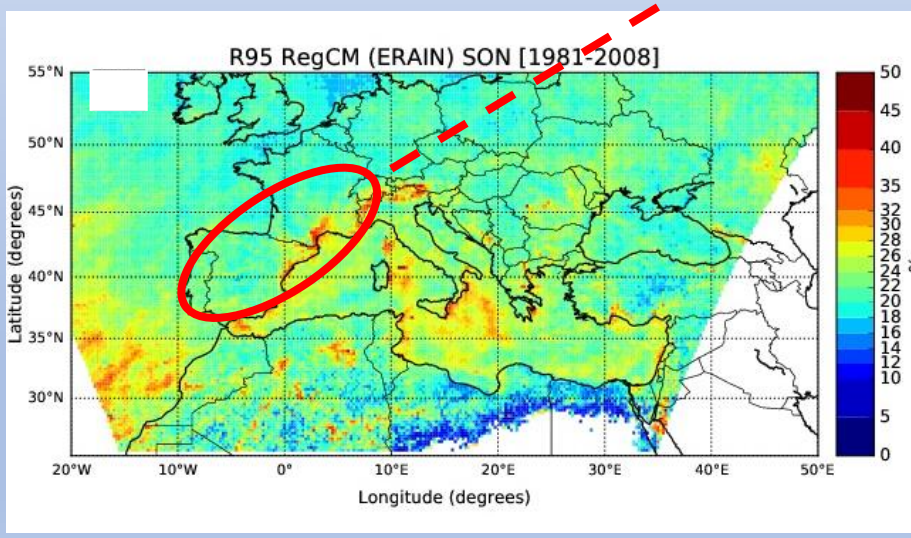

R95 EOBS SON [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

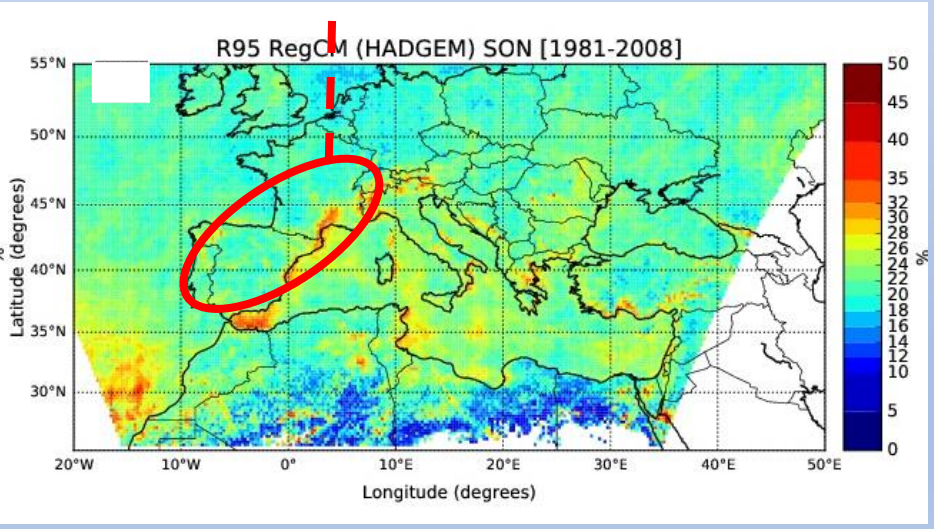

R95 RegCM (ERAIN) SON [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%


R95 RegCM (HADGEM) SON [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

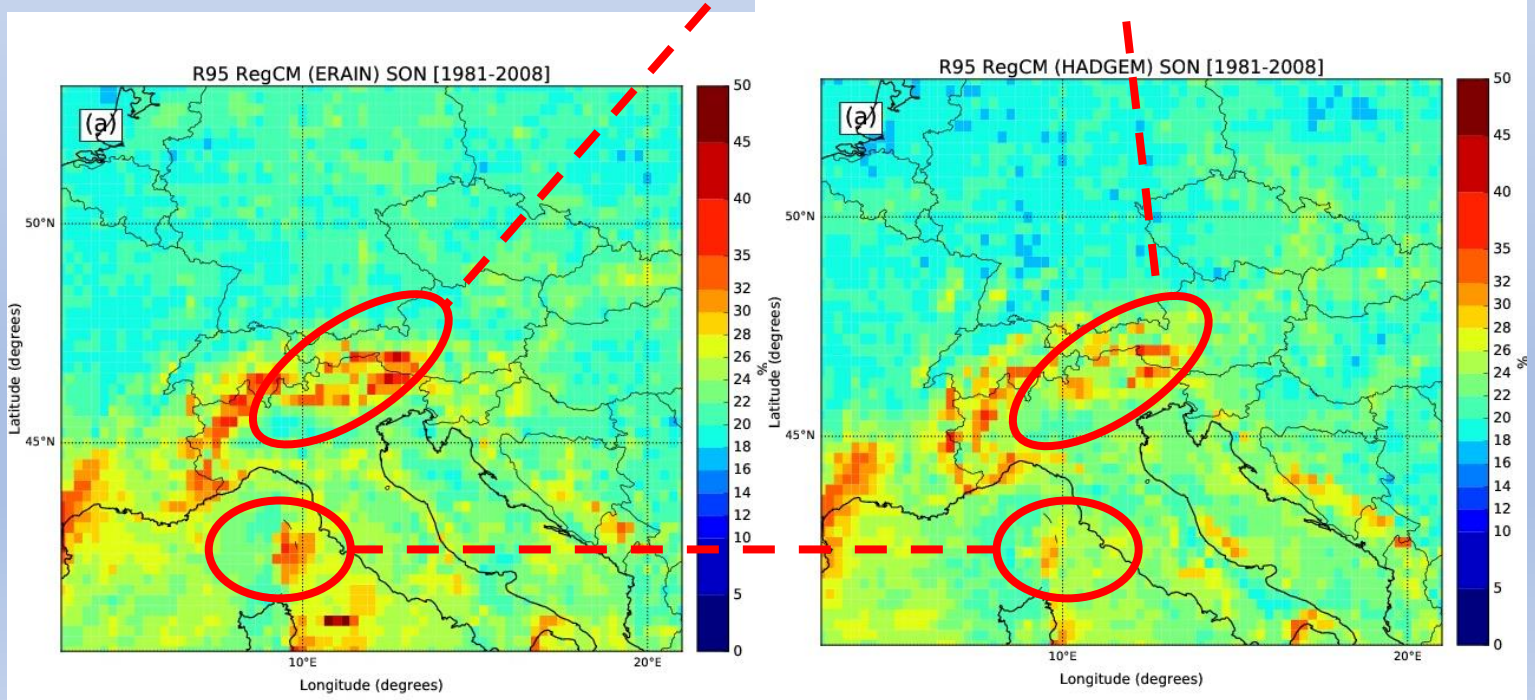
# R95 - CHIRPS


R95 CHIRPS SON [1981-2008]
Latitude (degrees)
Longitude (degrees)
mm

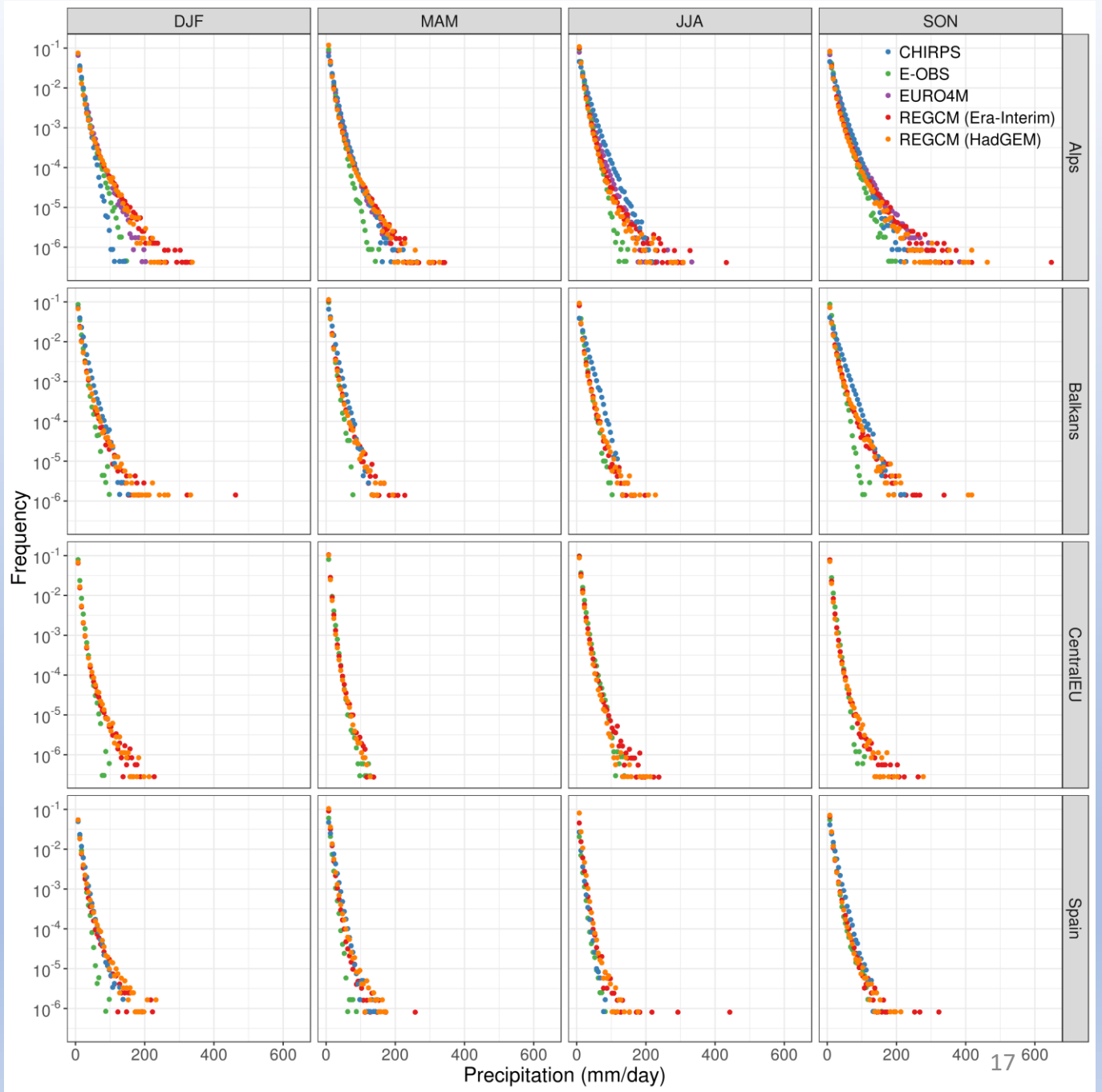

R95 RegCM (ERAIN) SON [1981-2008]
Latitude (degrees)
Longitude (degrees)
%


R95 RegCM (HADGEM) SON [1981-2008]
Latitude (degrees)
Longitude (degrees)
%

# R95 – Euro4m

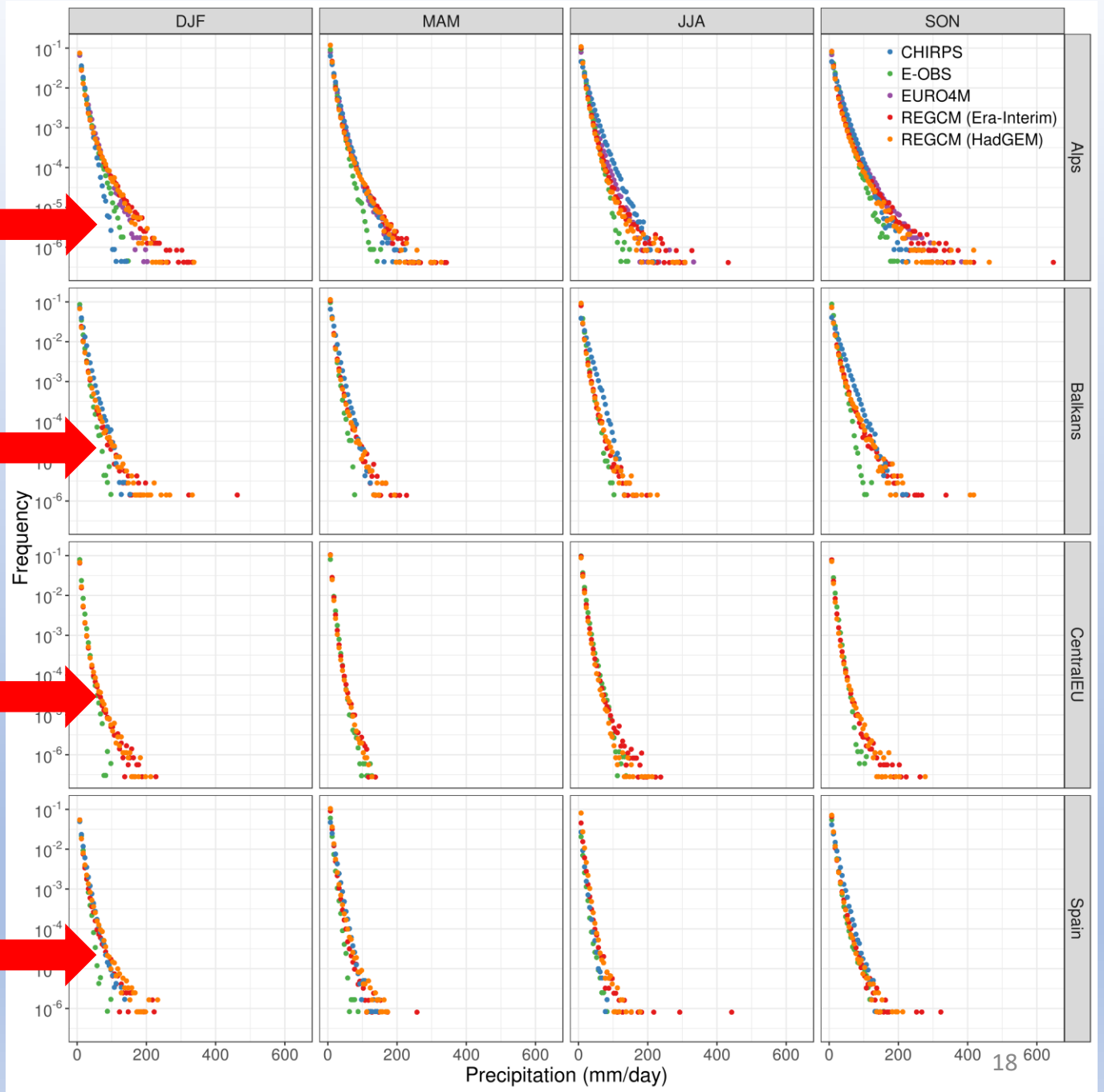

R95 EURO4M SON [1981-2008]
(b)
R95 RegCM (ERAIN) SON [1981-2008]
(a)
R95 RegCM (HADGEM) SON [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
mm
%

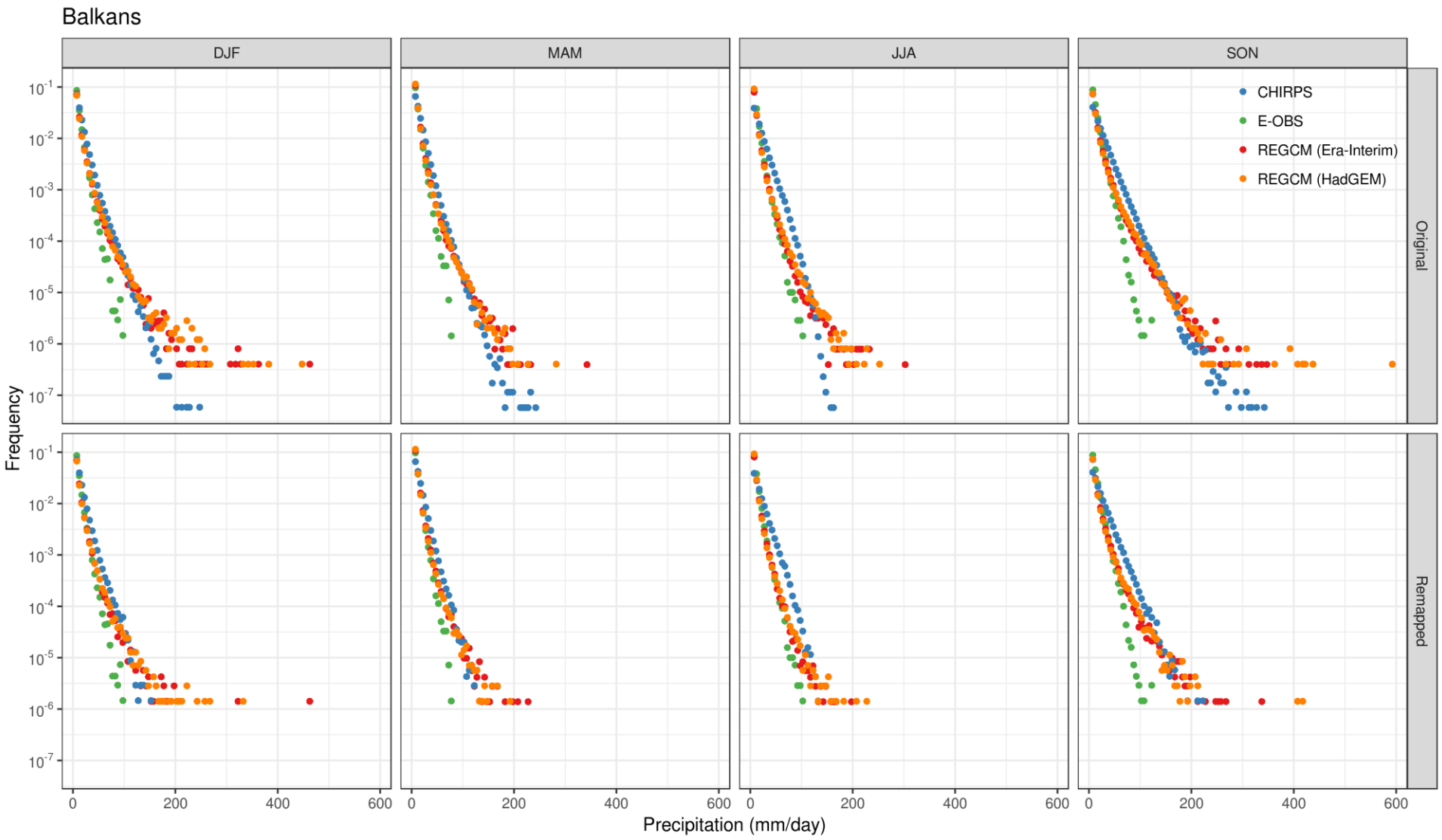
# PDFs


DJF
MAM
JJA
SON
Alps
Balkans
CentralEU
Spain
CHIRPS
E-OBS
EURO4M
REGCM (Era-Interim)
REGCM (HadGEM)
Frequency
Precipitation (mm/day)

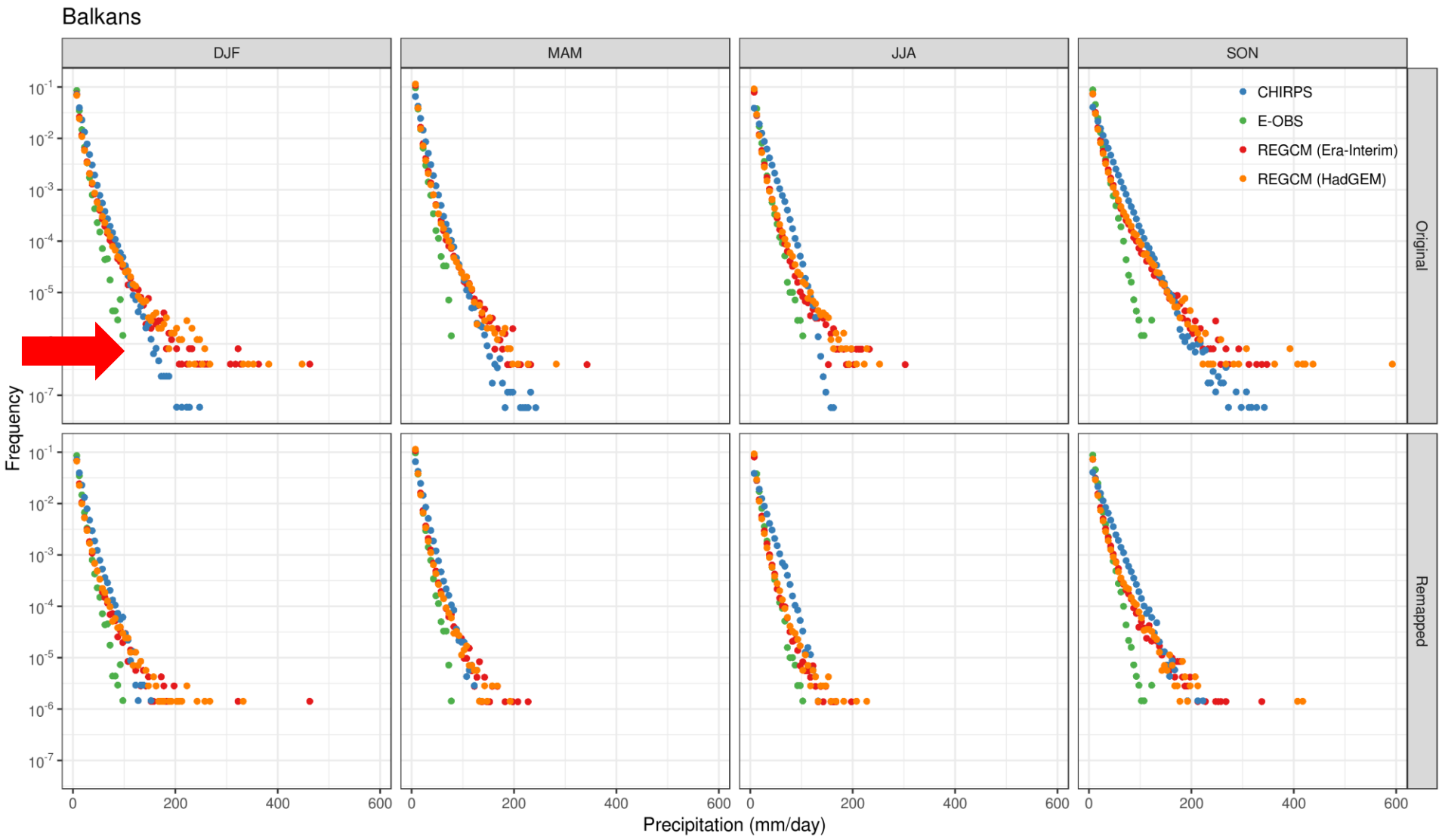
# PDFs

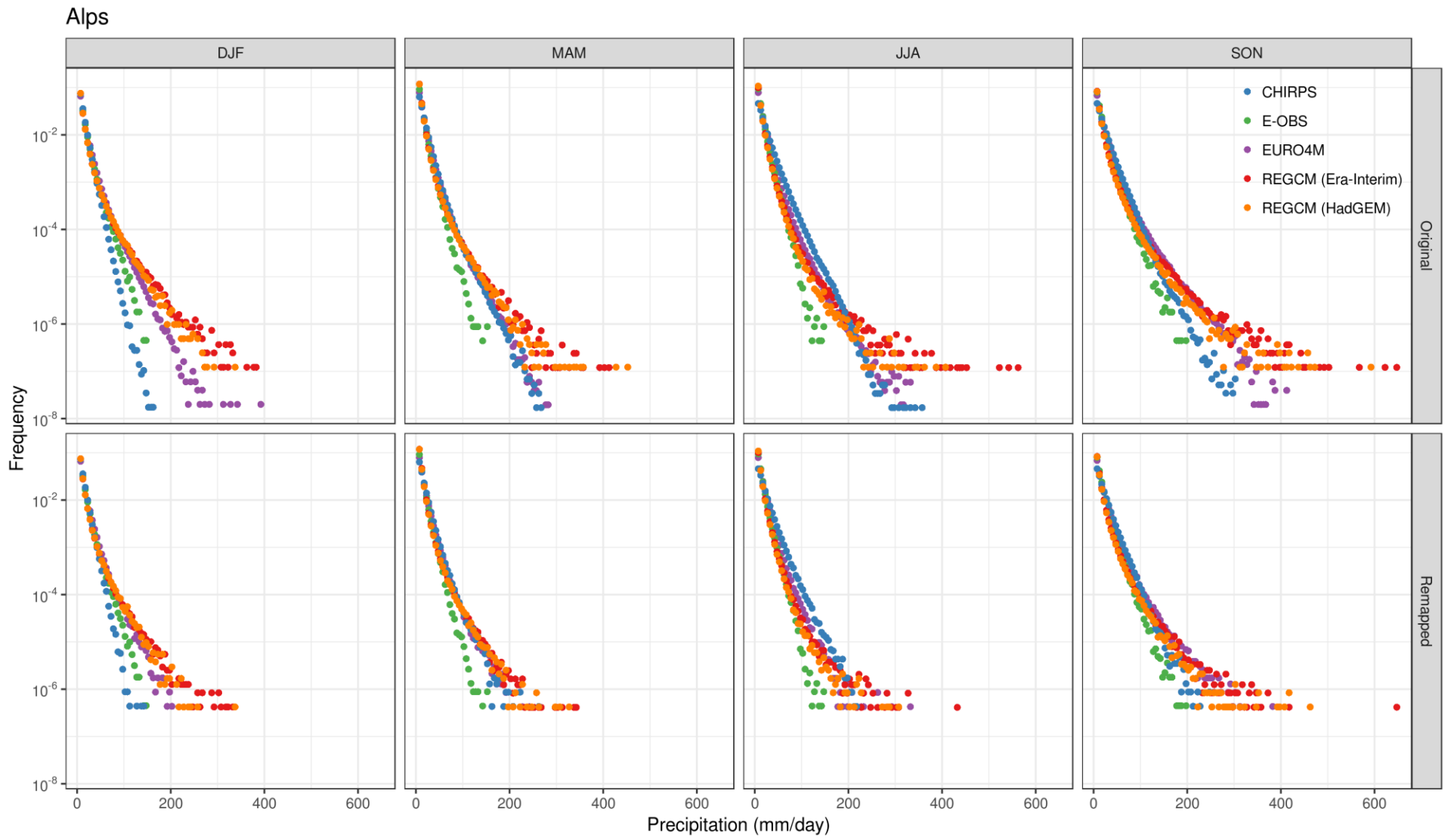
Drier E-OBS & CHIRPS!



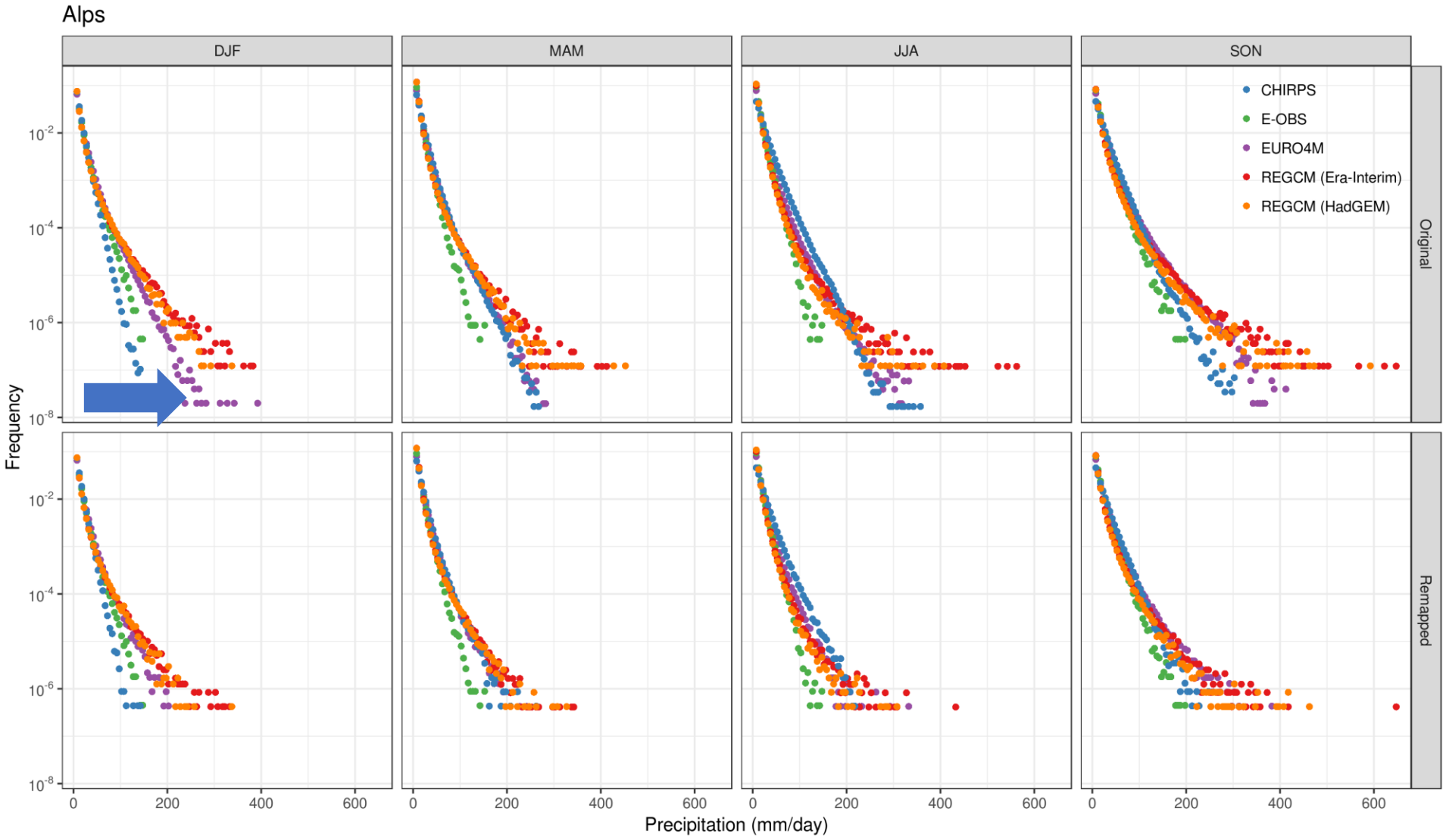

Balkans
DJF
MAM
JJA
SON
Original
Remapped
CHIRPS
E-OBS
REGCM (Era-Interim)
REGCM (HadGEM)
Frequency
Precipitation (mm/day)

# Drier extremes
# E-OBS & CHIRPS!



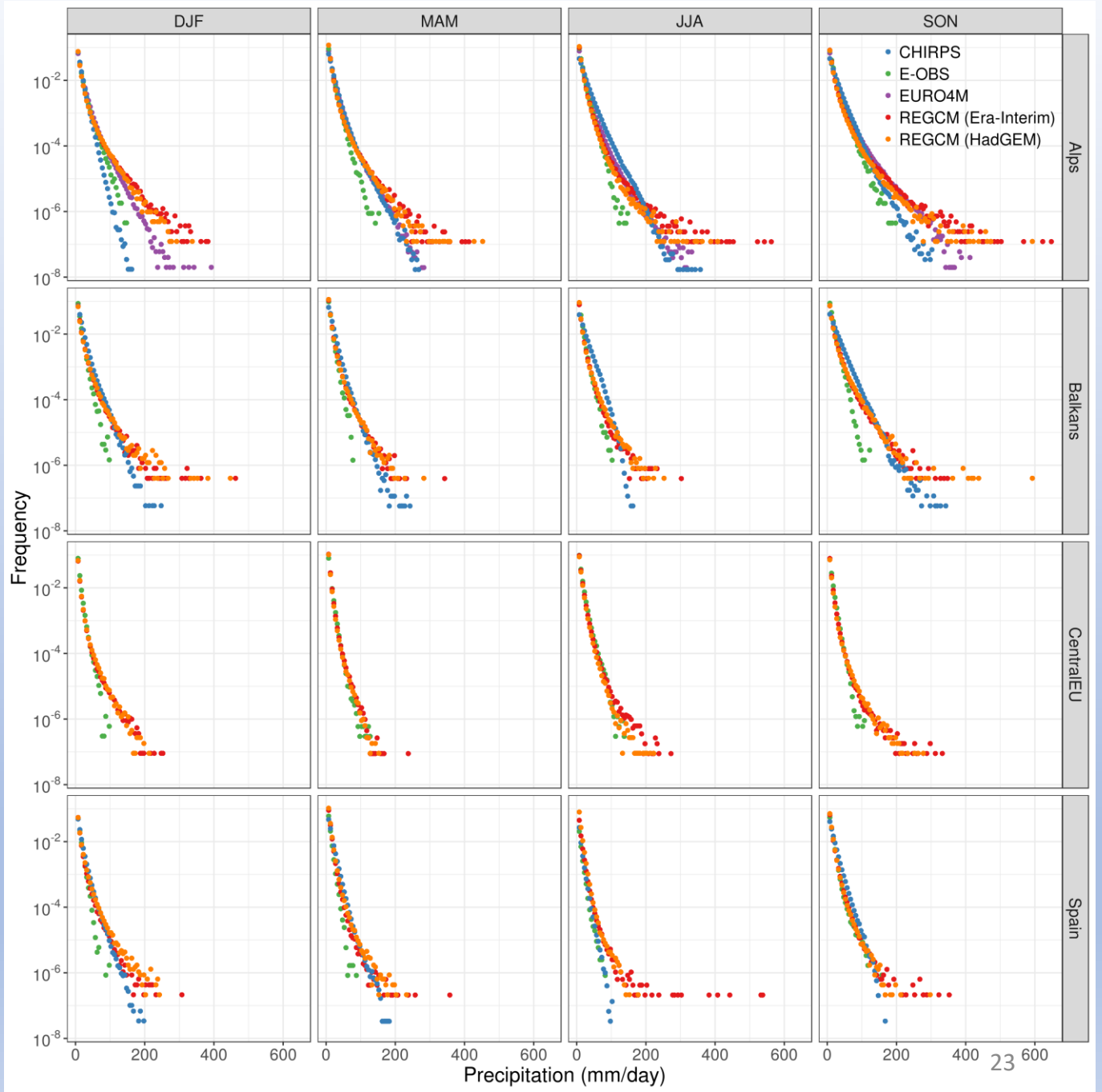

Alps
DJF
MAM
JJA
SON
CHIRPS
E-OBS
EURO4M
REGCM (Era-Interim)
REGCM (HadGEM)
Original
Remapped
Frequency
$10^{-2}$
$10^{-4}$
$10^{-6}$
$10^{-8}$
0
200
400
600
Precipitation (mm/day)

# RegCM closer to high-res EURO4M



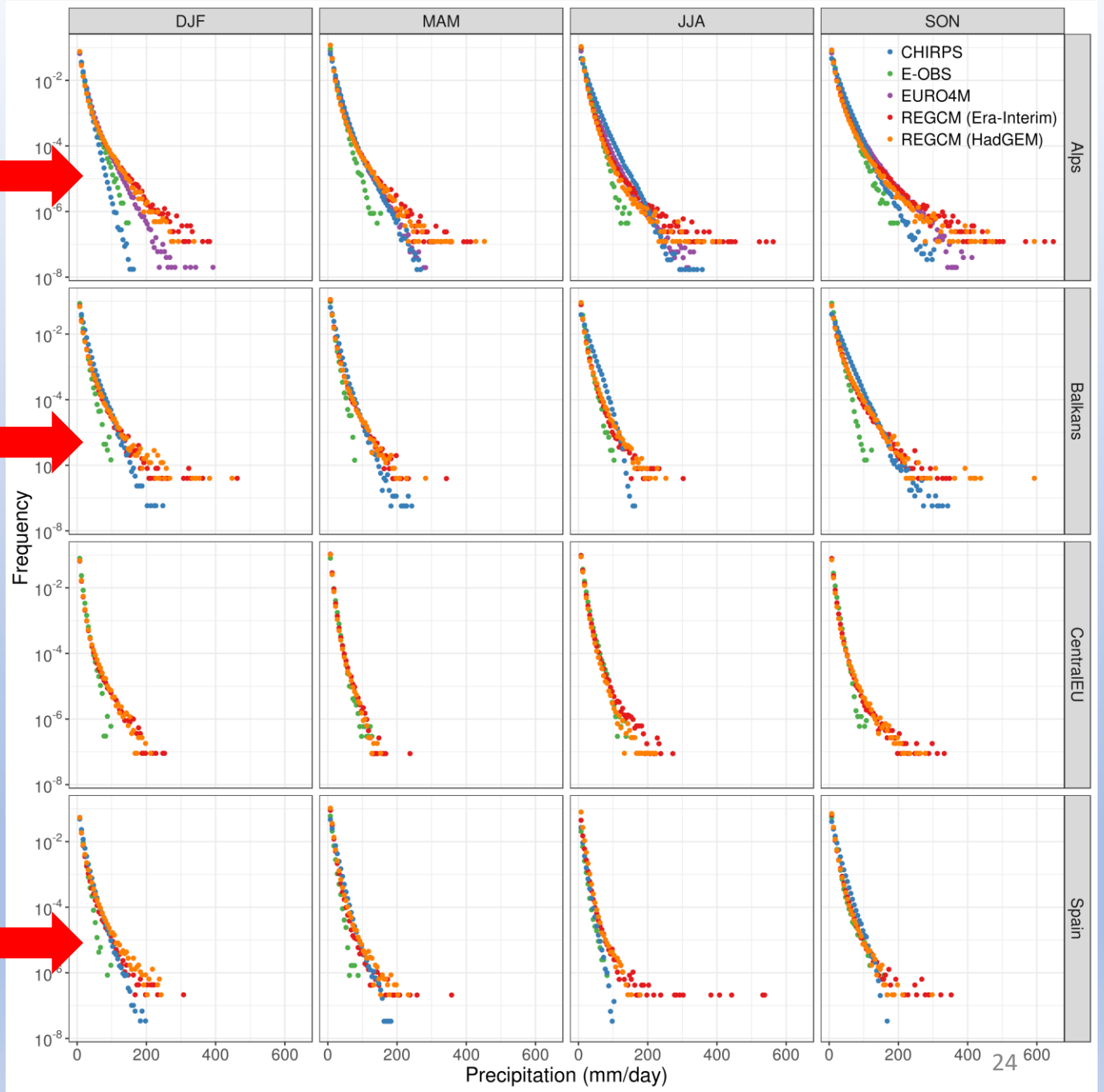
# Original data

For extremes:
Remap only when necessary!



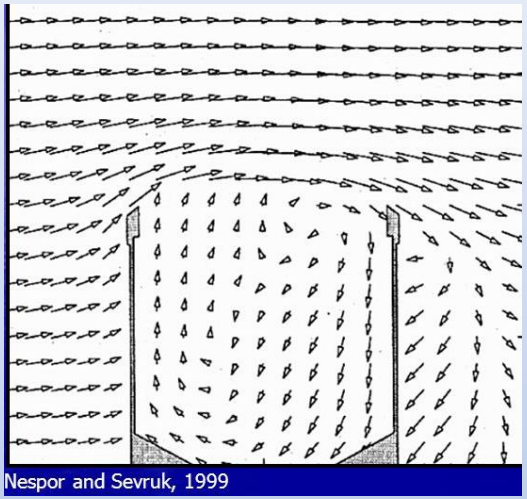
Original data

E-OBS and CHIRPS Underestimation!



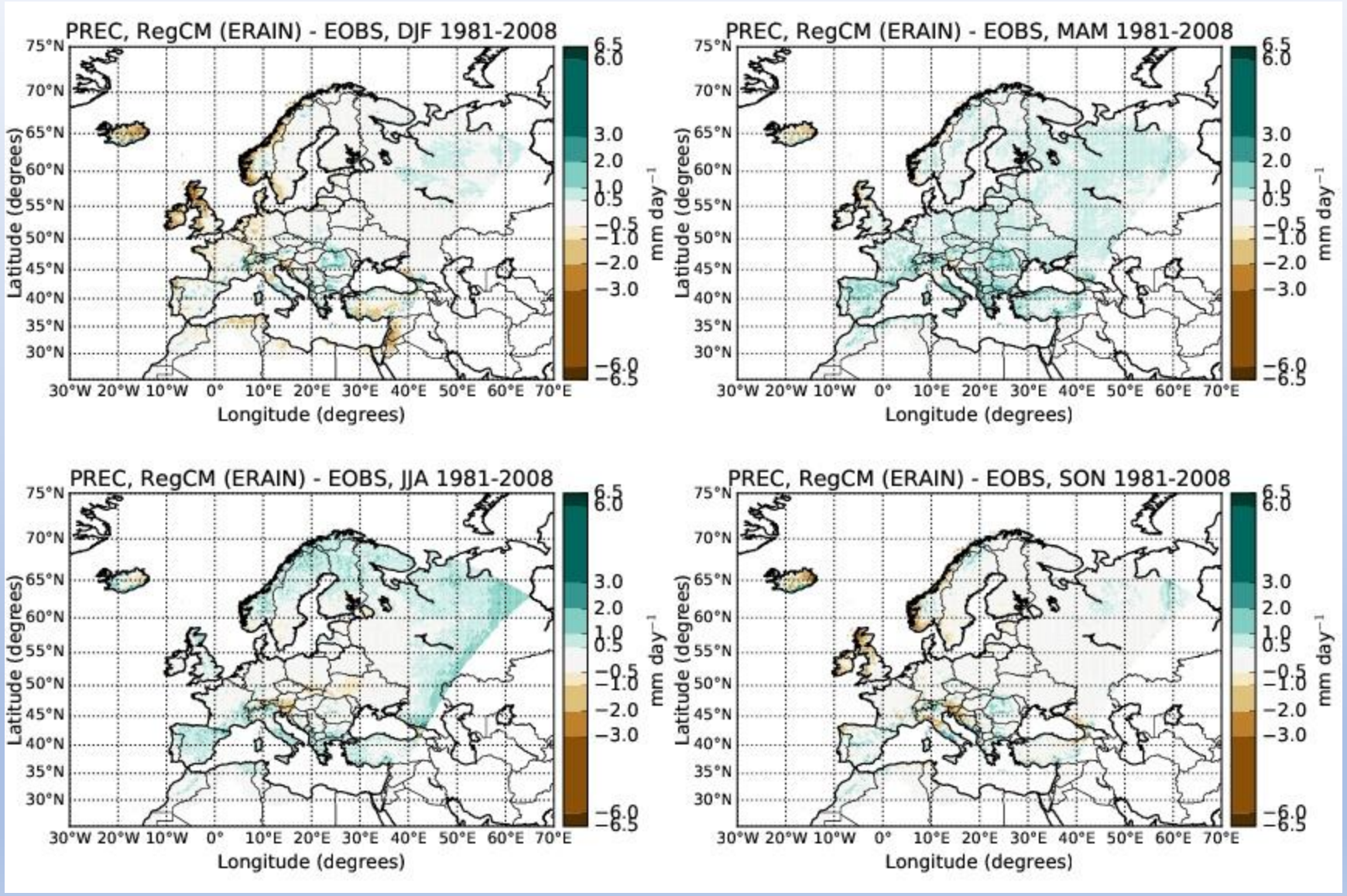
# Conclusion

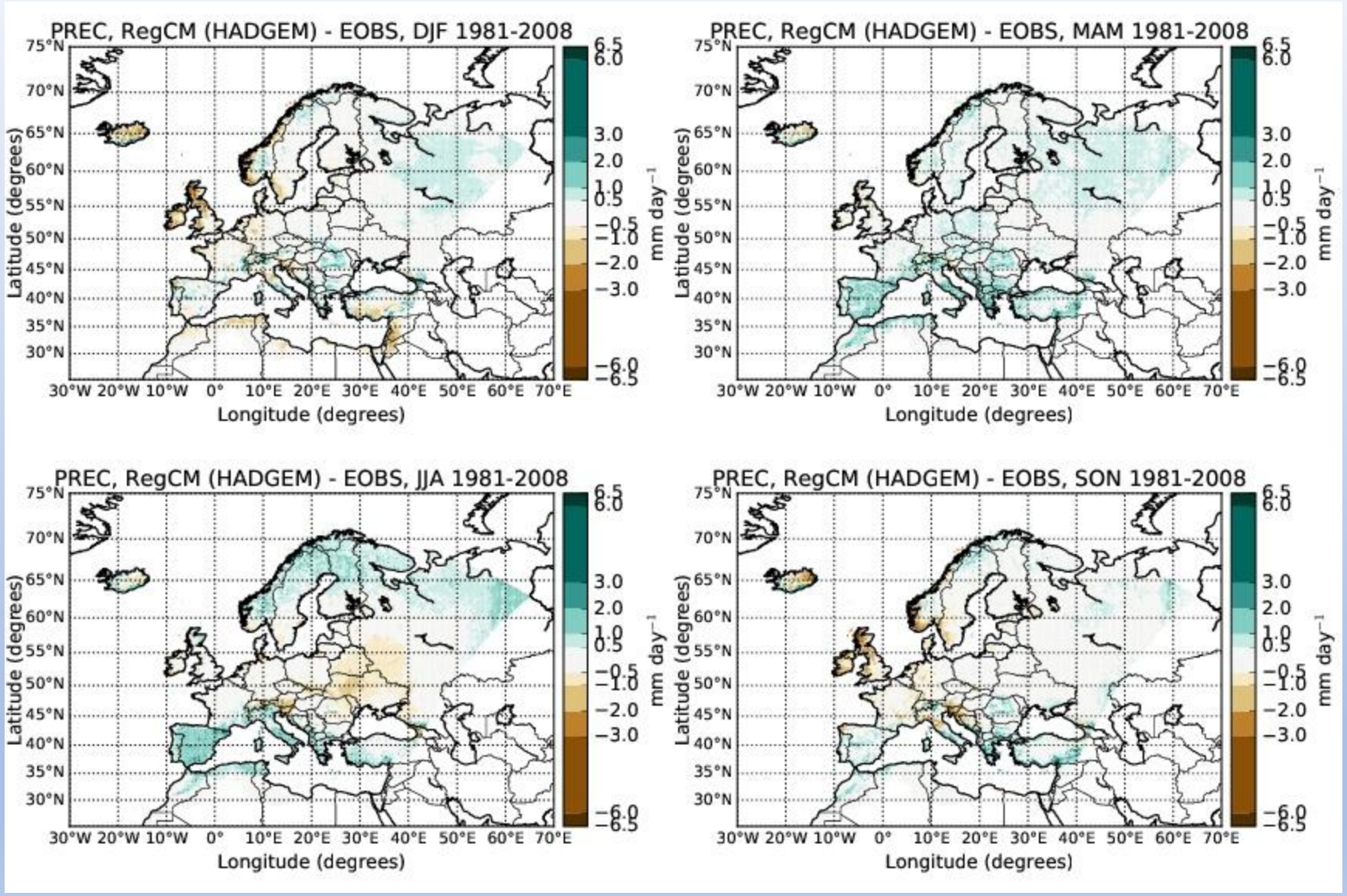
- Basic validation examples:
  - Additional high-res data for further analysis;
  - More metrics (upcoming presentations).
- Station-based Observations:
  - Underpredicted;
  - Wind-Induced Undercatch.
- HadGEM and ERA-In RegCM4 runs:
  - similar performance;
  - sufficient quality for climate projections;
  - Wetter extremes in RegCM.
    - (Possibly more prominent due to bias in observations)
- RegCM-HadGEM:
  - wetter summer in Spain and Italy;
  - drier winter in Central EU.

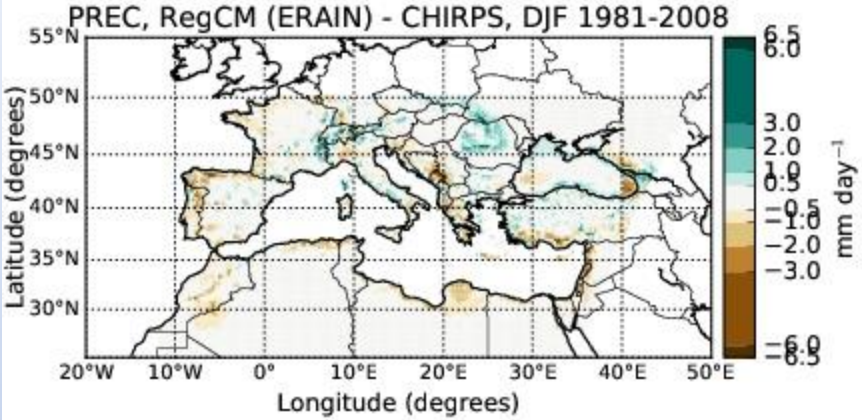

Nespor and Sevruk, 1999

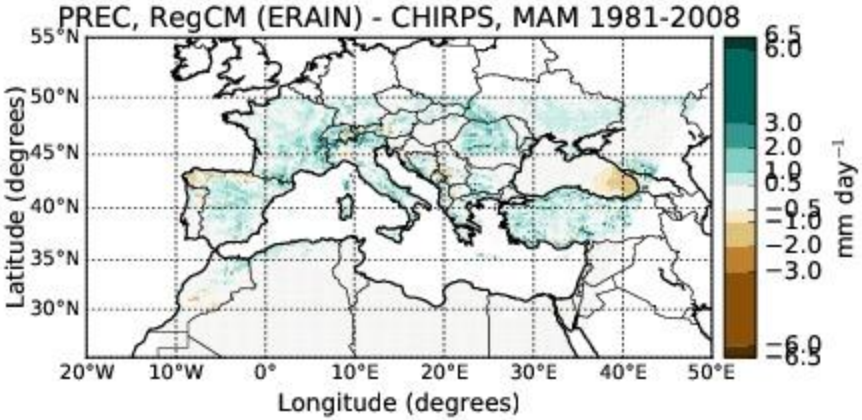
# Thank You for your attention!

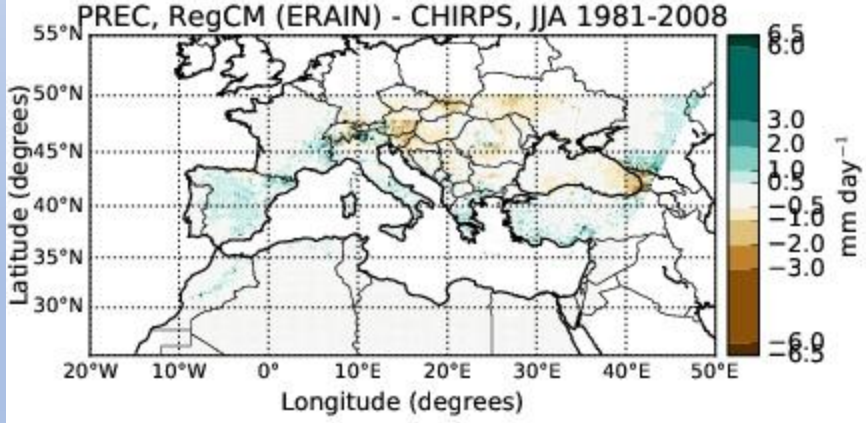
Email: jciarlo@ictp.it

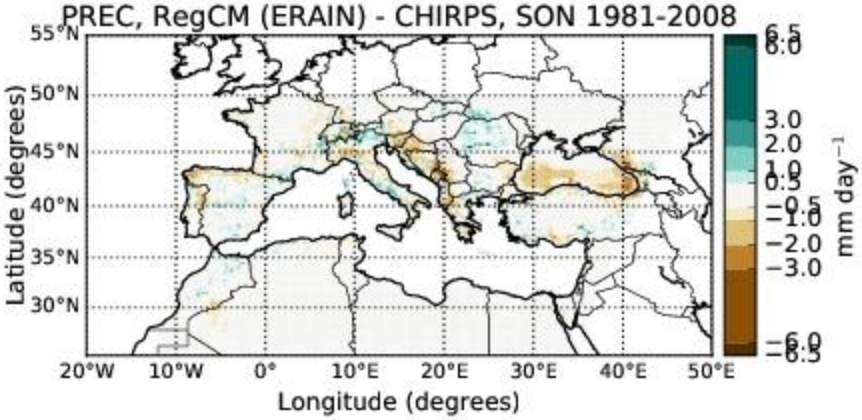

PREC, RegCM (ERAIN) - EOBS, DJF 1981-2008
PREC, RegCM (ERAIN) - EOBS, MAM 1981-2008
PREC, RegCM (ERAIN) - EOBS, JJA 1981-2008
PREC, RegCM (ERAIN) - EOBS, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

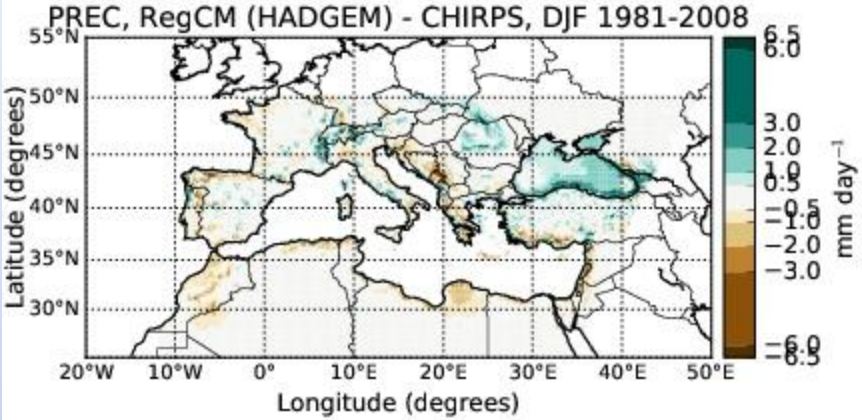

PREC, RegCM (HADGEM) - EOBS, DJF 1981-2008
PREC, RegCM (HADGEM) - EOBS, MAM 1981-2008
PREC, RegCM (HADGEM) - EOBS, JJA 1981-2008
PREC, RegCM (HADGEM) - EOBS, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹
75°N
70°N
65°N
60°N
55°N
50°N
45°N
40°N
35°N
30°N
30°W 20°W 10°W 0° 10°E 20°E 30°E 40°E 50°E 60°E 70°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5

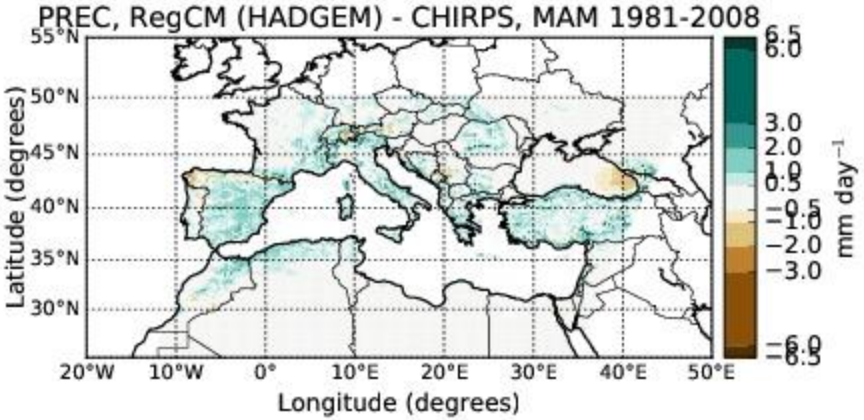

PREC, RegCM (ERAIN) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

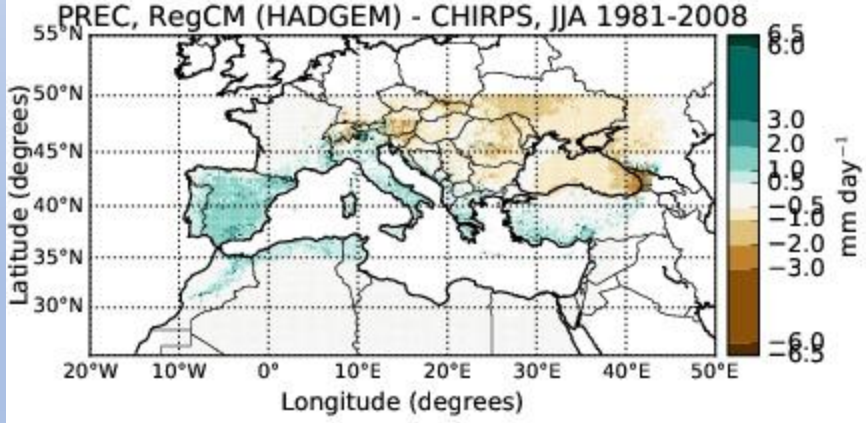

PREC, RegCM (ERAIN) - CHIRPS, MAM 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

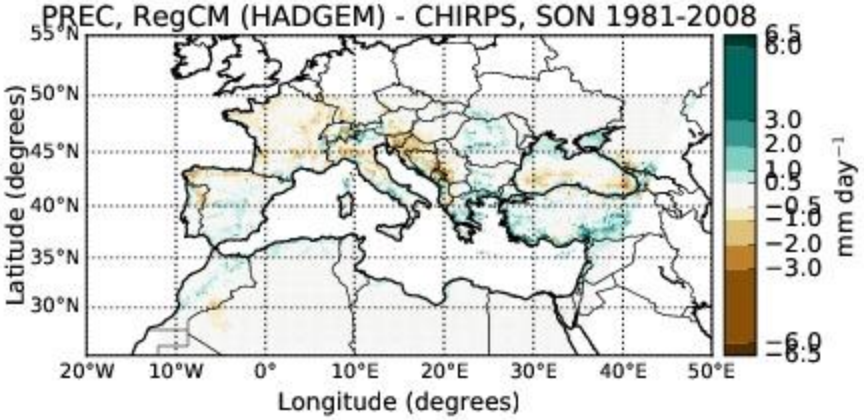

PREC, RegCM (ERAIN) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

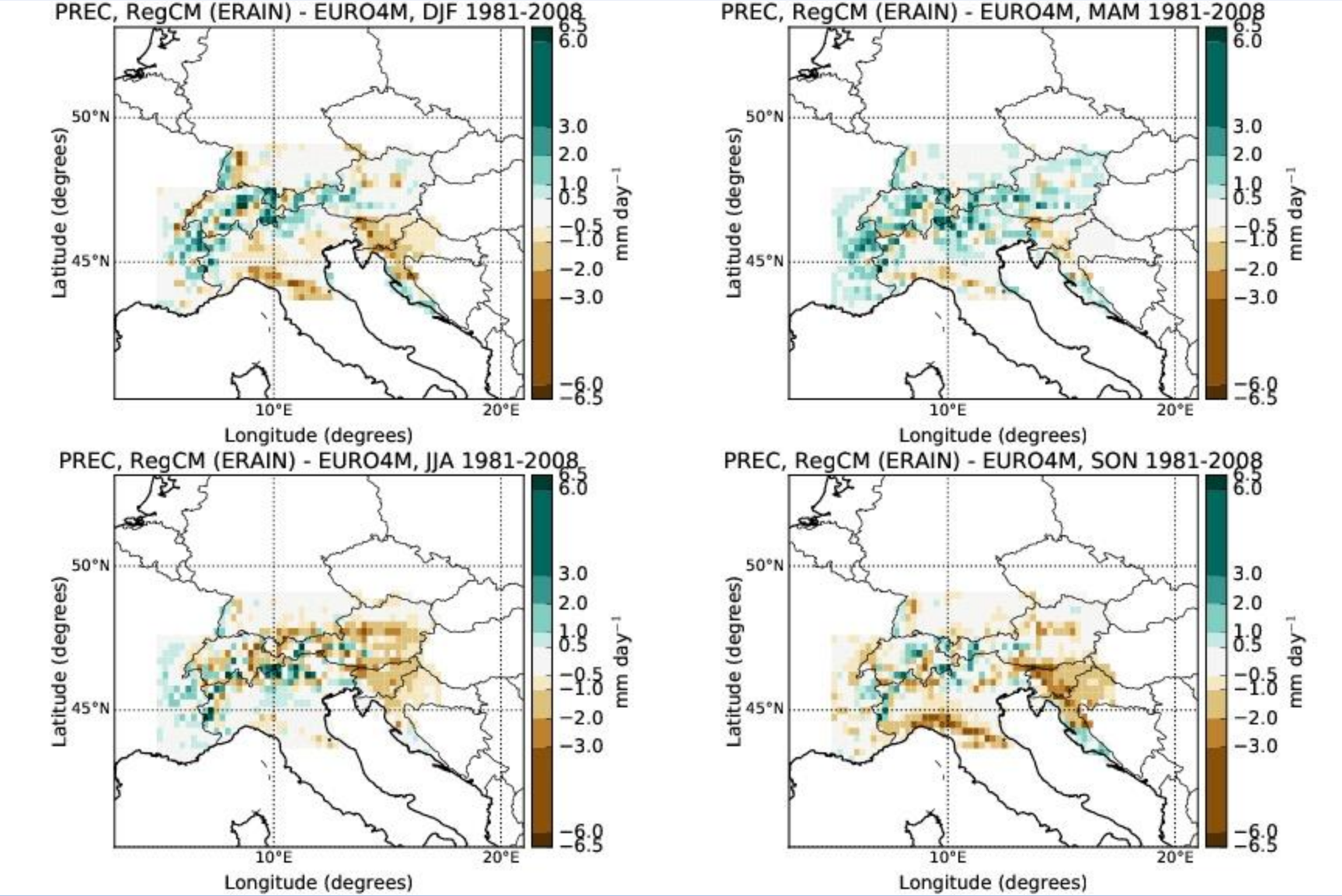

PREC, RegCM (ERAIN) - CHIRPS, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

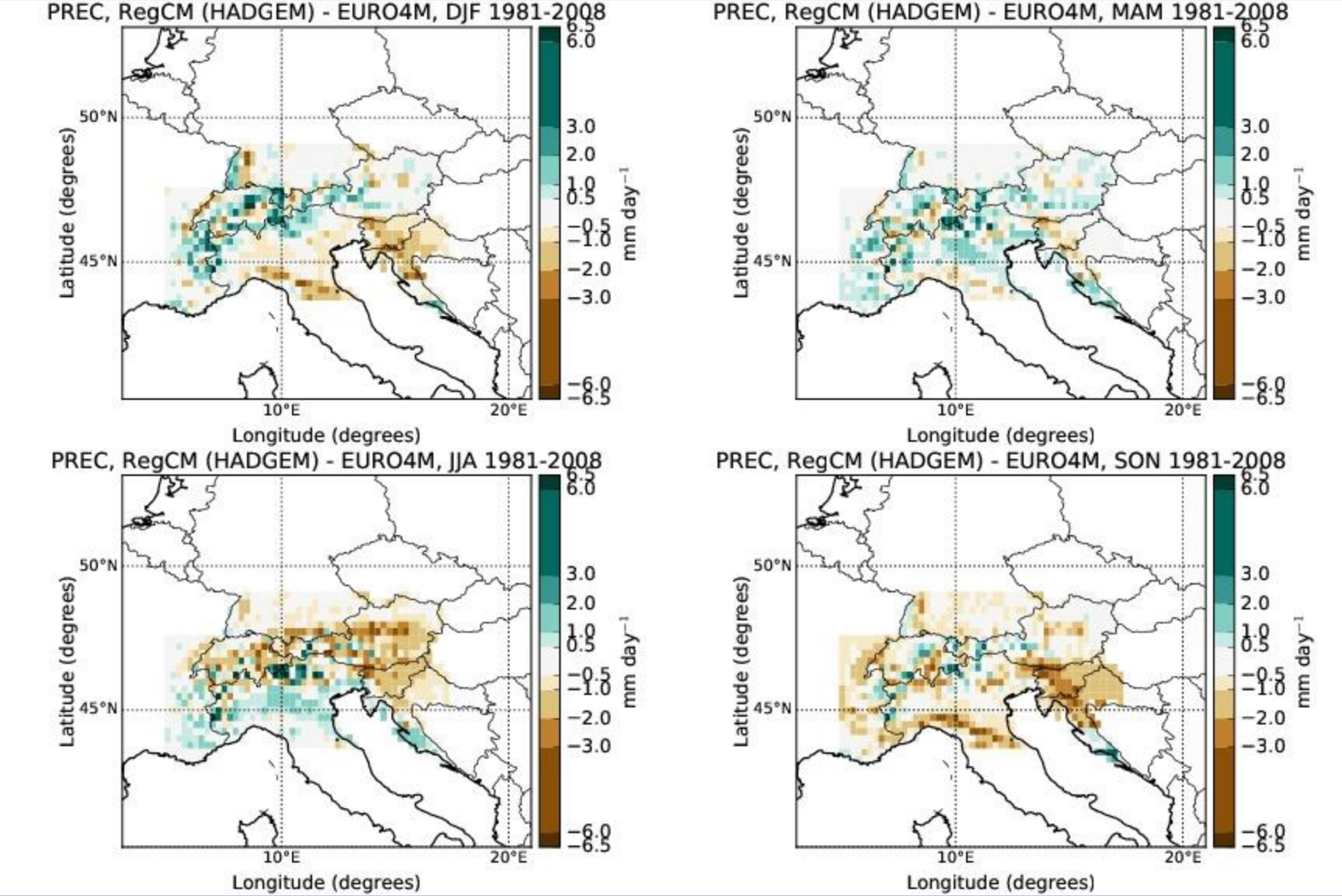

PREC, RegCM (HADGEM) - CHIRPS, DJF 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

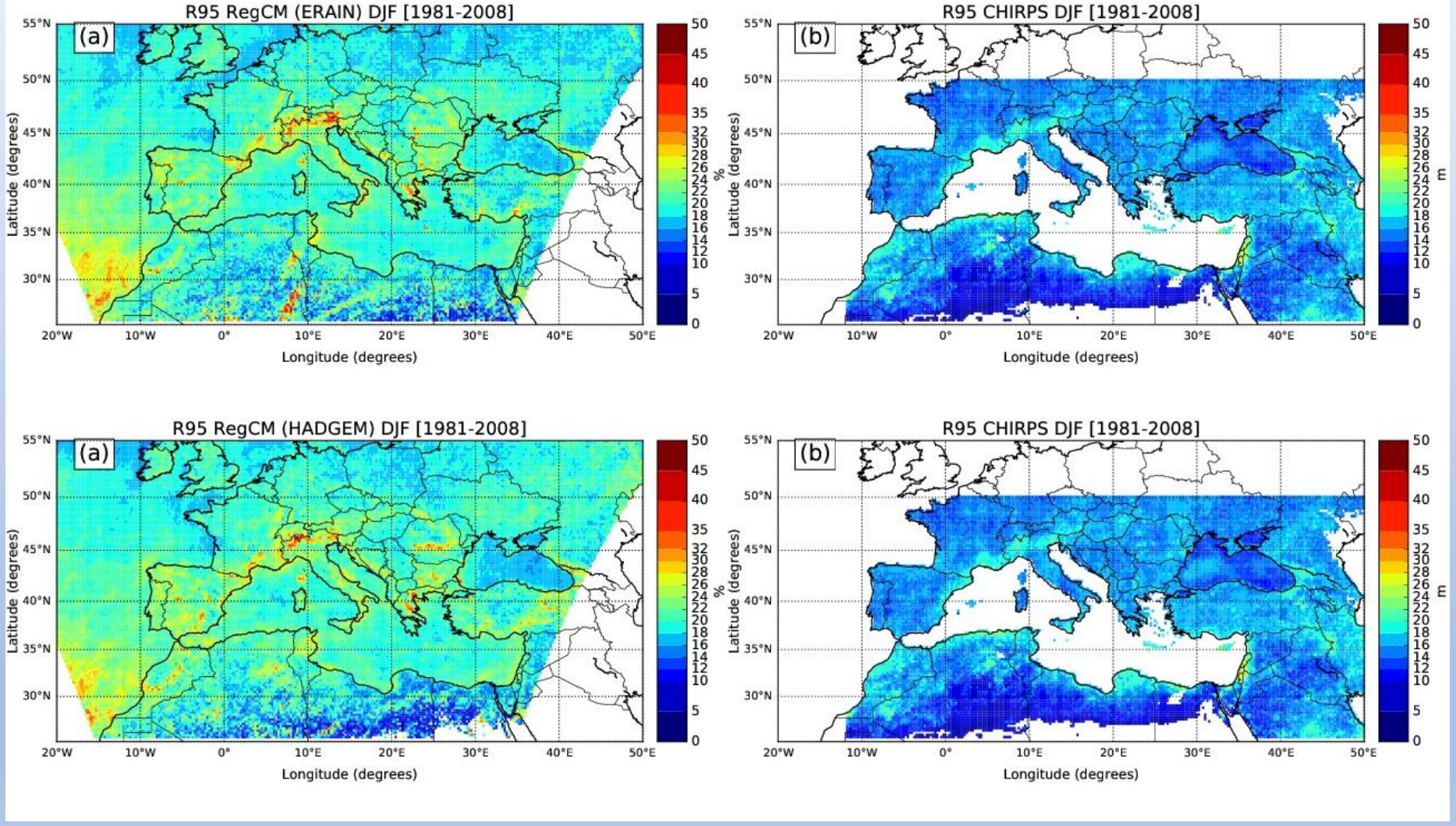

PREC, RegCM (HADGEM) - CHIRPS, MAM 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

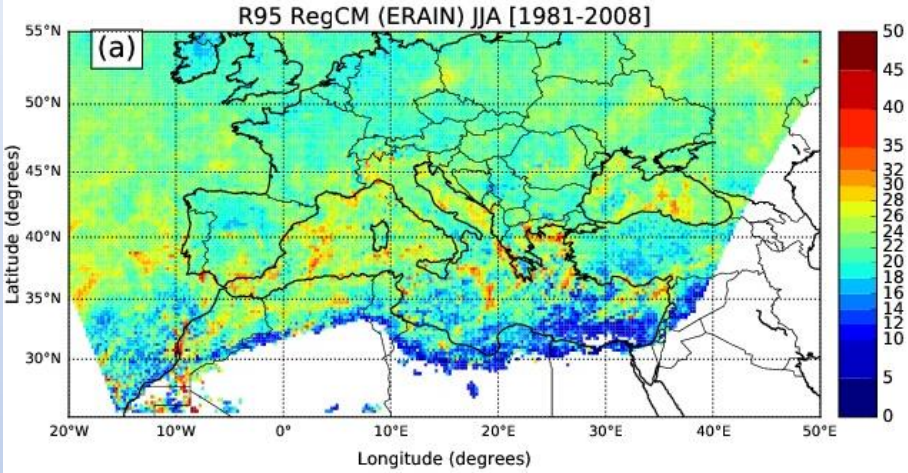

PREC, RegCM (HADGEM) - CHIRPS, JJA 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

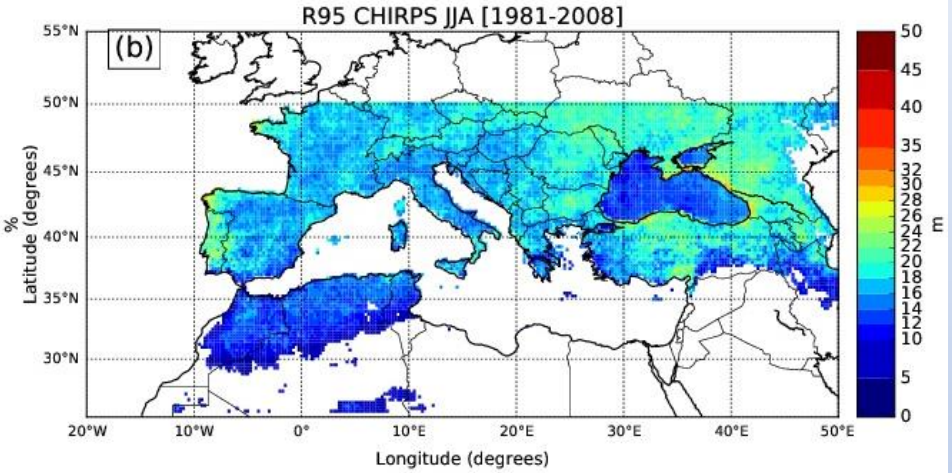

PREC, RegCM (HADGEM) - CHIRPS, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
mm day⁻¹

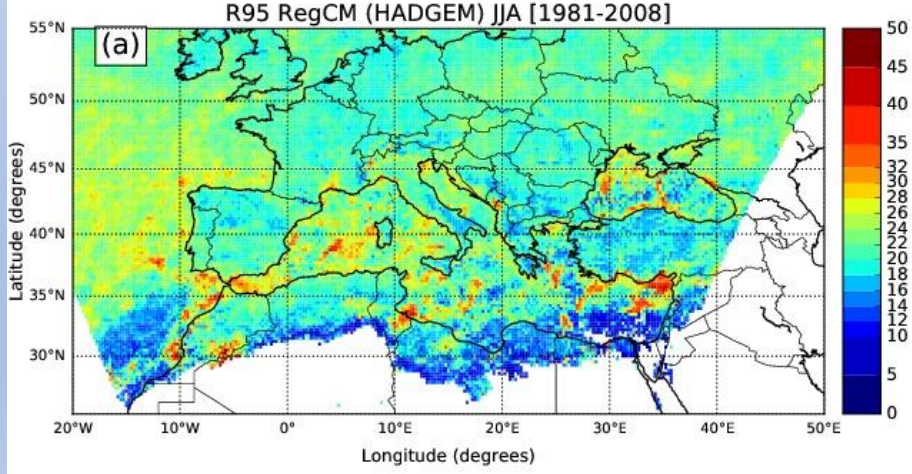

PREC, RegCM (ERAIN) - EURO4M, DJF 1981-2008
PREC, RegCM (ERAIN) - EURO4M, MAM 1981-2008
PREC, RegCM (ERAIN) - EURO4M, JJA 1981-2008
PREC, RegCM (ERAIN) - EURO4M, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

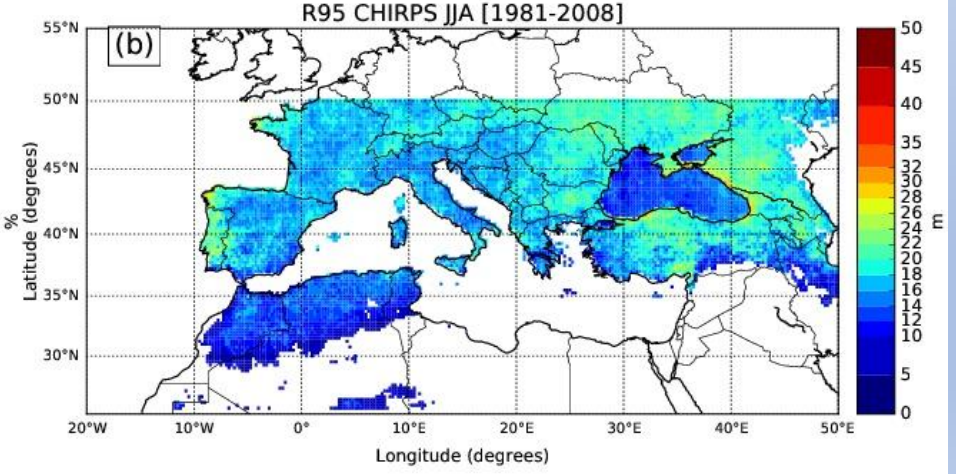

PREC, RegCM (HADGEM) - EURO4M, DJF 1981-2008
PREC, RegCM (HADGEM) - EURO4M, MAM 1981-2008
PREC, RegCM (HADGEM) - EURO4M, JJA 1981-2008
PREC, RegCM (HADGEM) - EURO4M, SON 1981-2008
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
6.5
6.0
3.0
2.0
1.0
0.5
−0.5
−1.0
−2.0
−3.0
−6.0
−6.5
mm day⁻¹

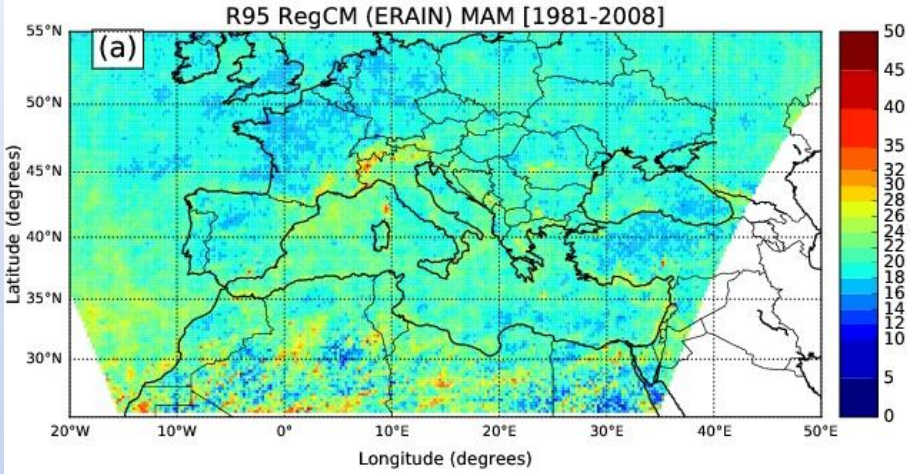

R95 RegCM (ERAIN) DJF [1981-2008]
(a)
R95 CHIRPS DJF [1981-2008]
(b)
R95 RegCM (HADGEM) DJF [1981-2008]
(a)
R95 CHIRPS DJF [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
%
m

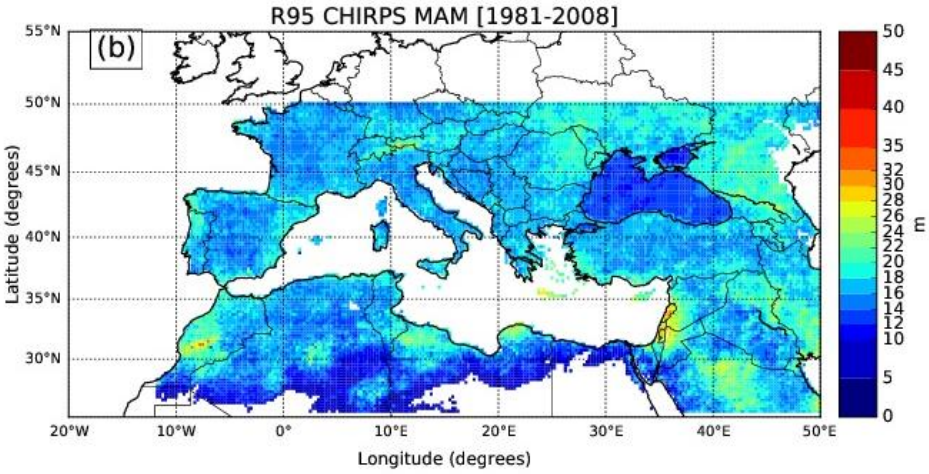

R95 RegCM (ERAIN) JJA [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

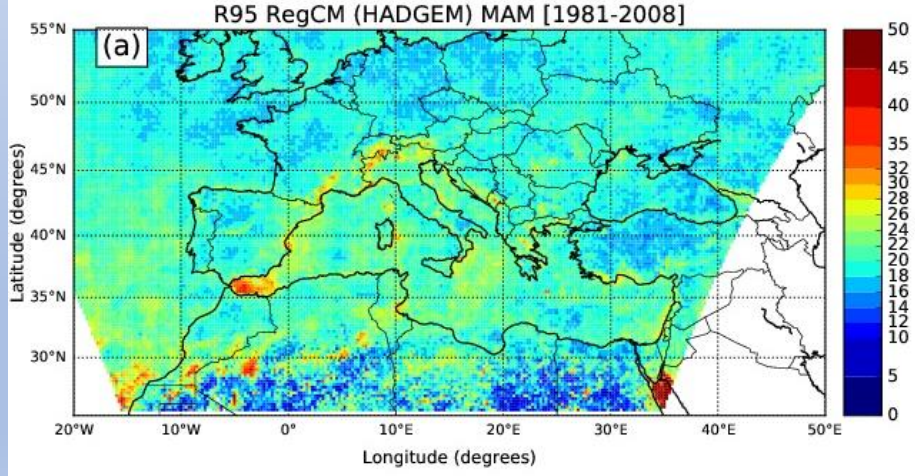

R95 CHIRPS JJA [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

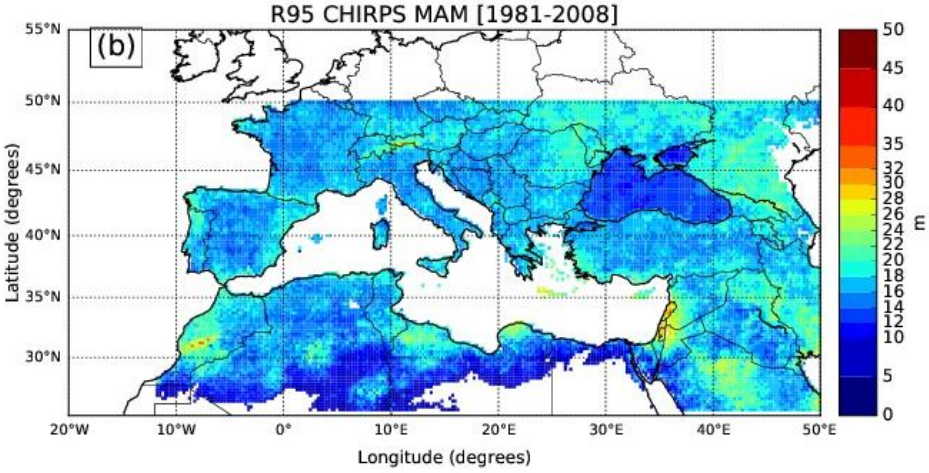

R95 RegCM (HADGEM) JJA [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

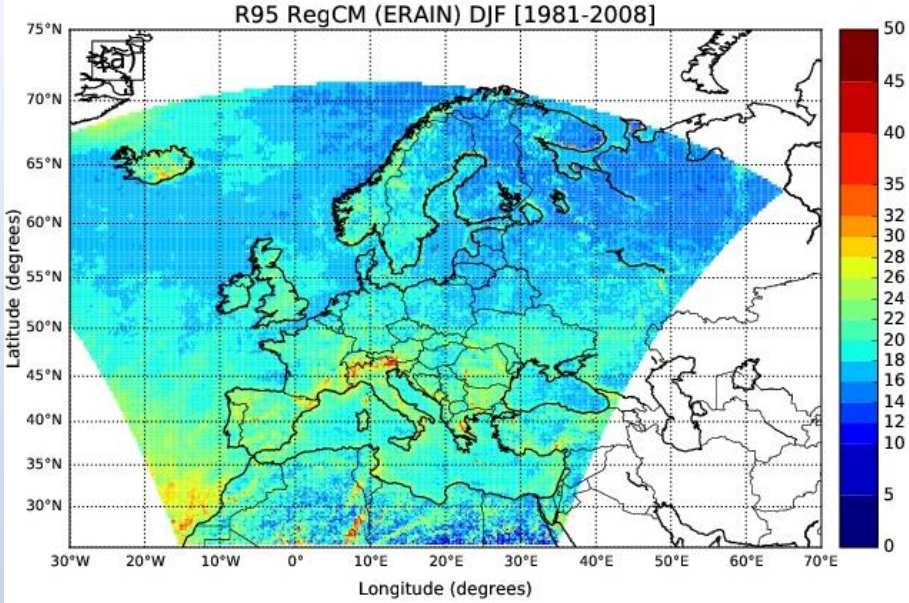

R95 CHIRPS JJA [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

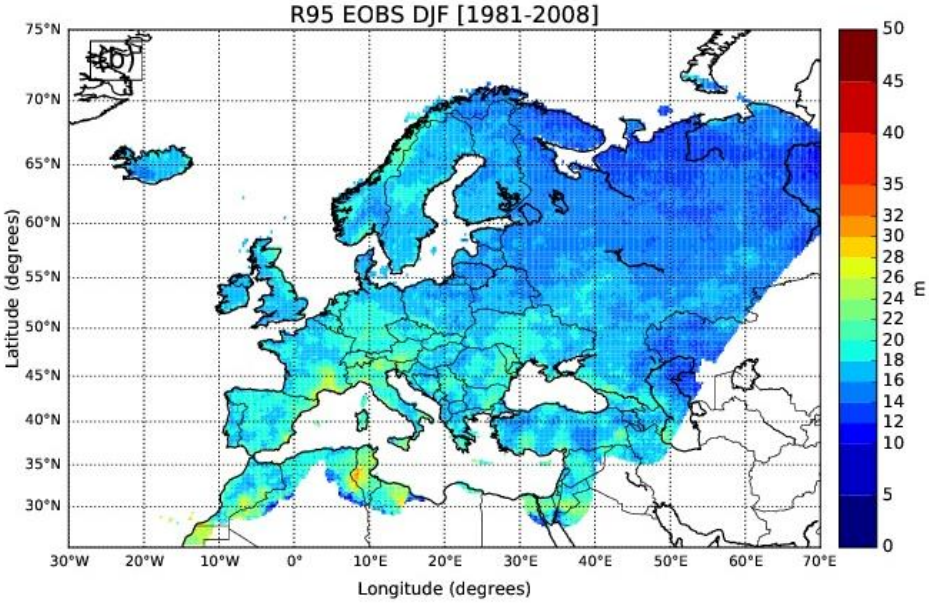

R95 RegCM (ERAIN) MAM [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

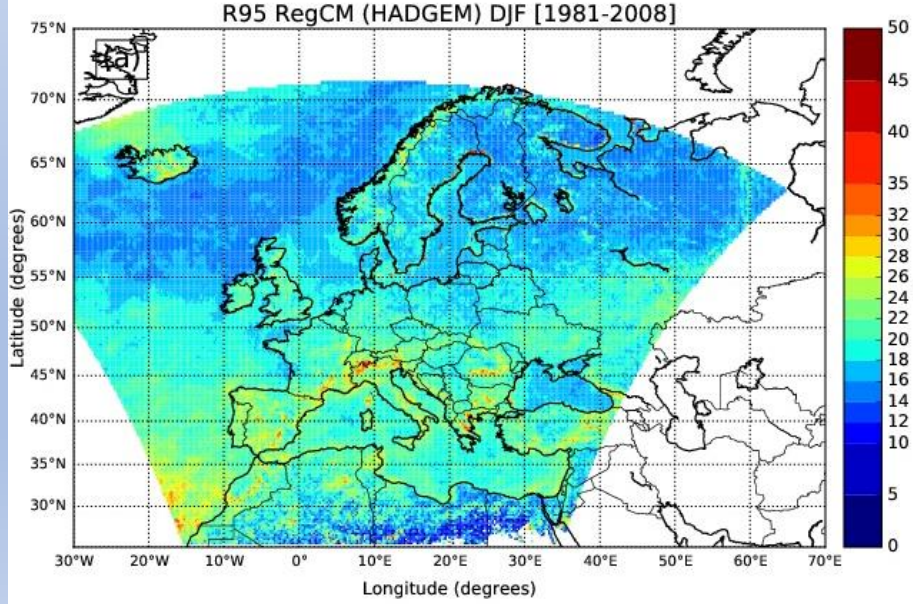

R95 CHIRPS MAM [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

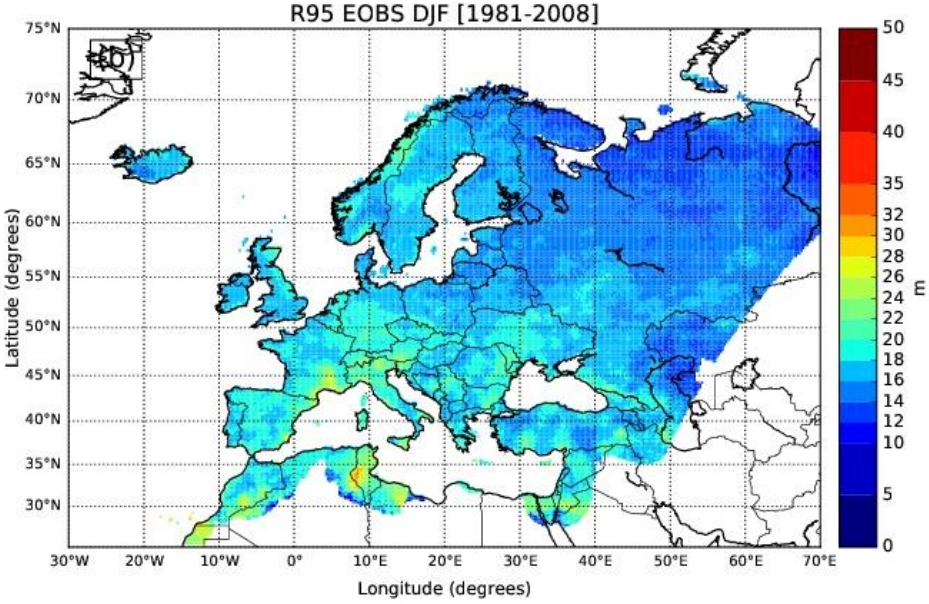

R95 RegCM (HADGEM) MAM [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

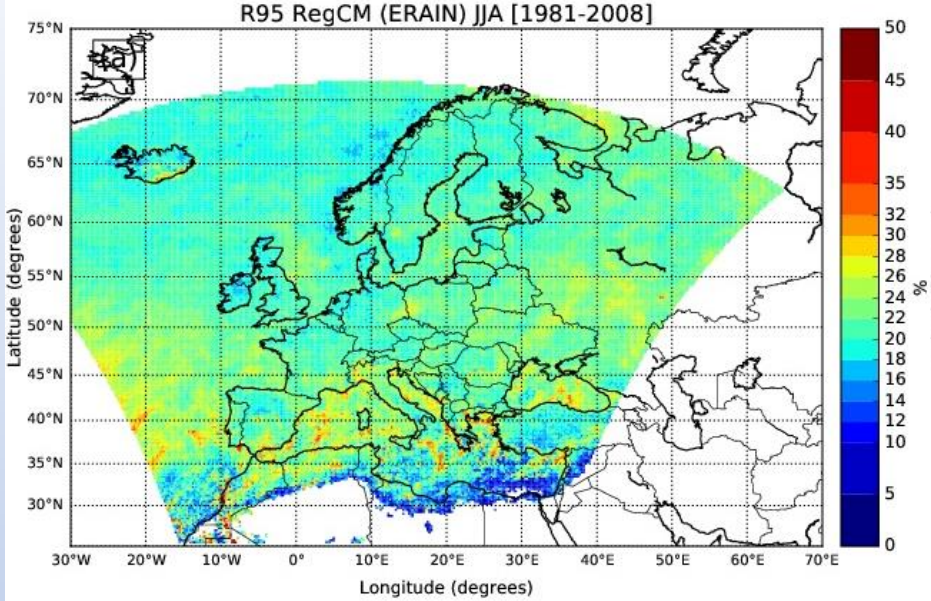

R95 CHIRPS MAM [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

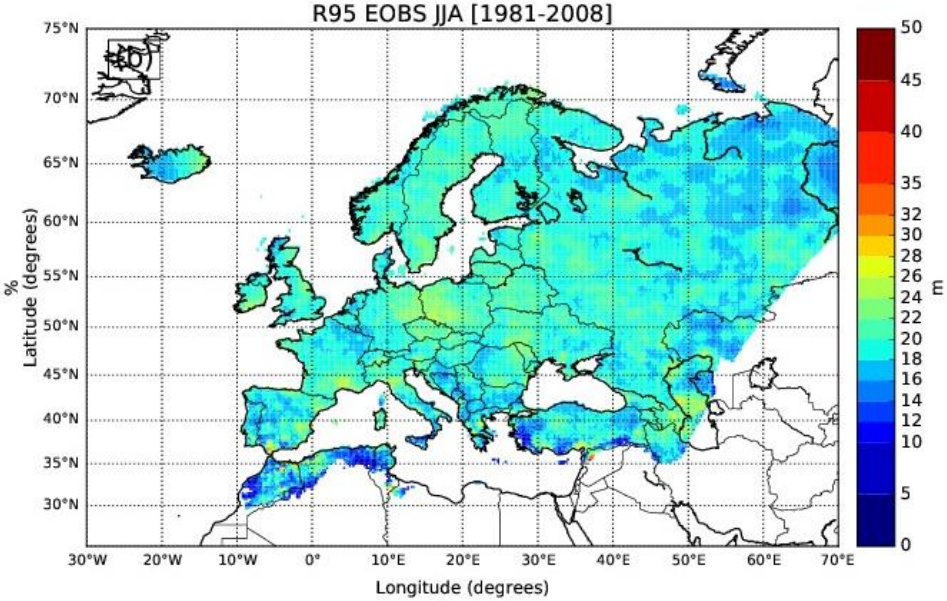

R95 RegCM (ERAIN) DJF [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

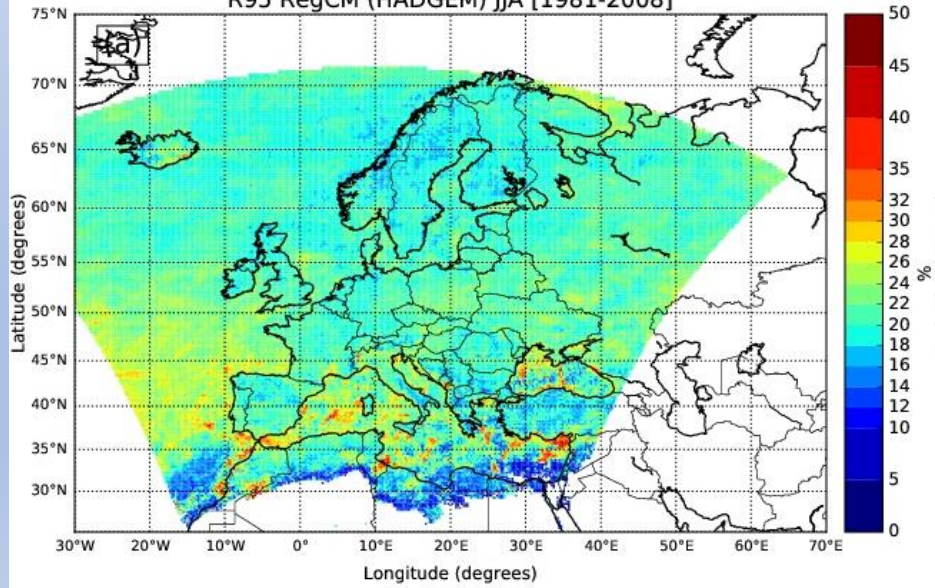

R95 EOBS DJF [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

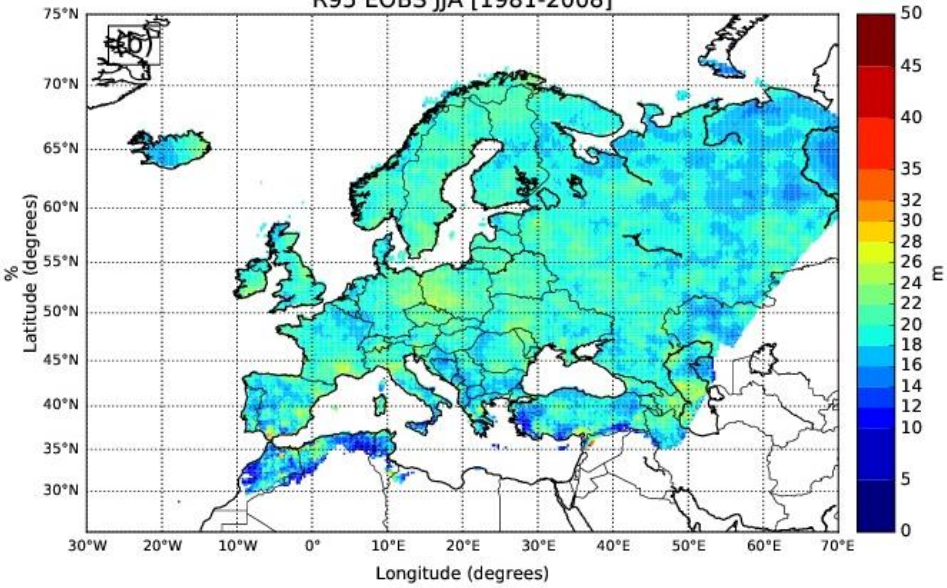

R95 RegCM (HADGEM) DJF [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

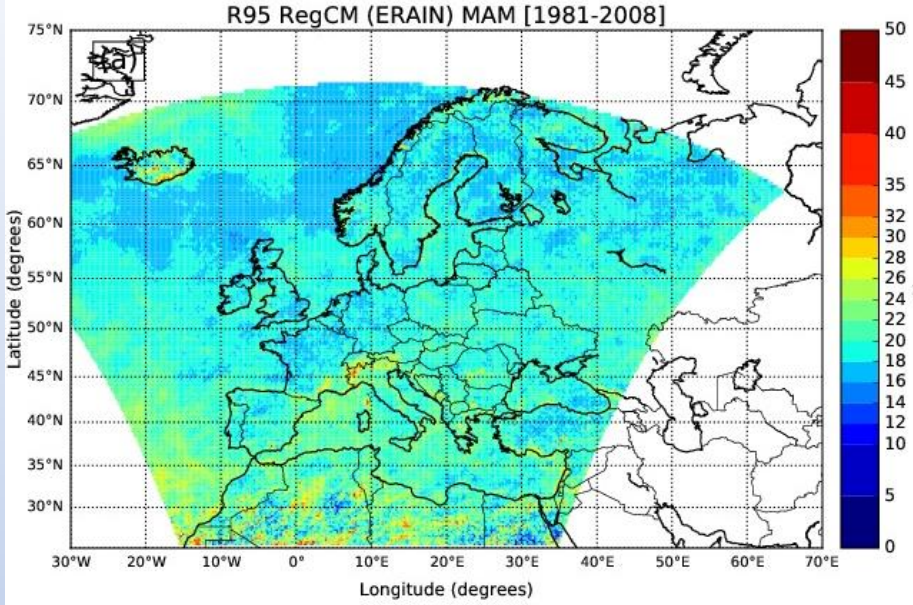

R95 EOBS DJF [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

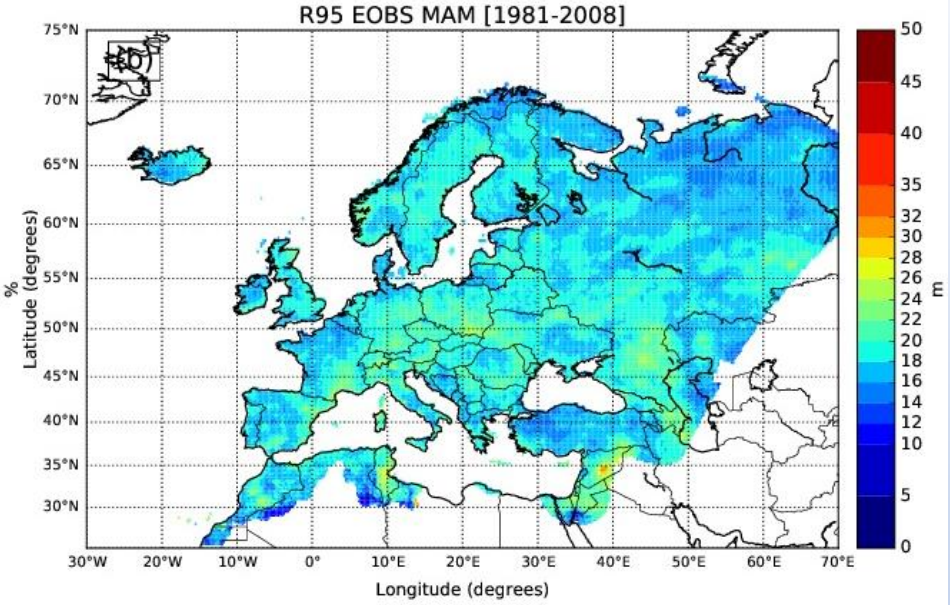

R95 RegCM (ERAIN) JJA [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

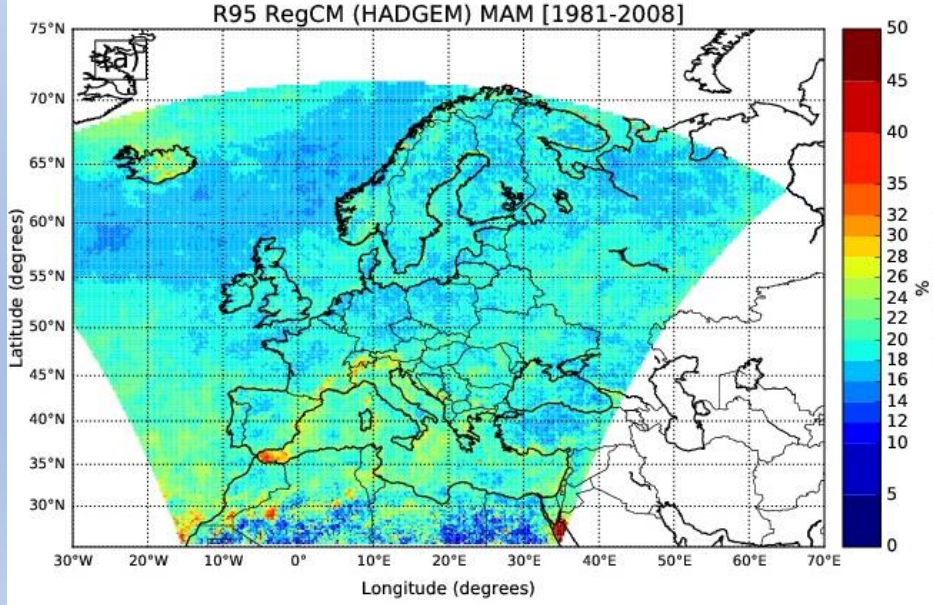

R95 EOBS JJA [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

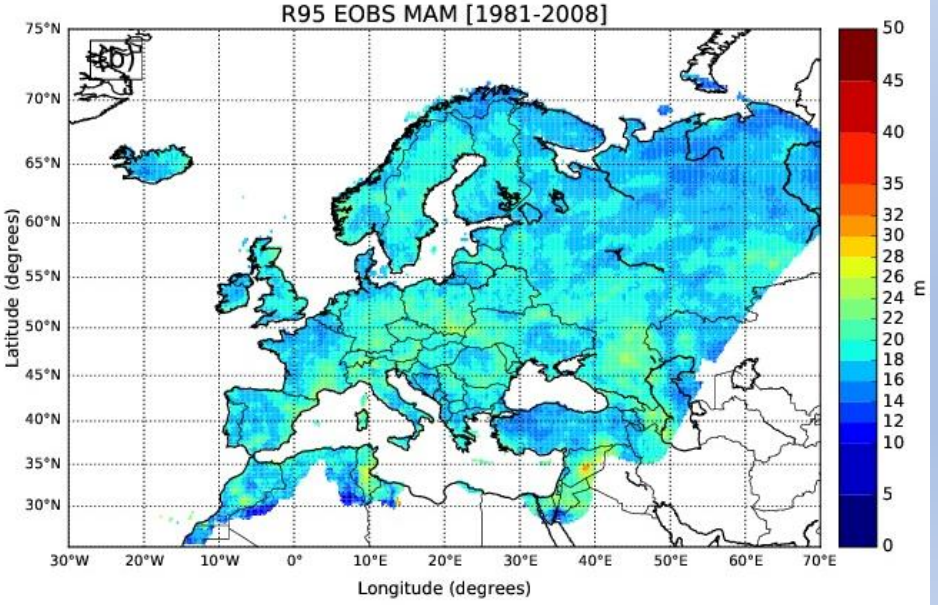

R95 RegCM (HADGEM) JJA [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

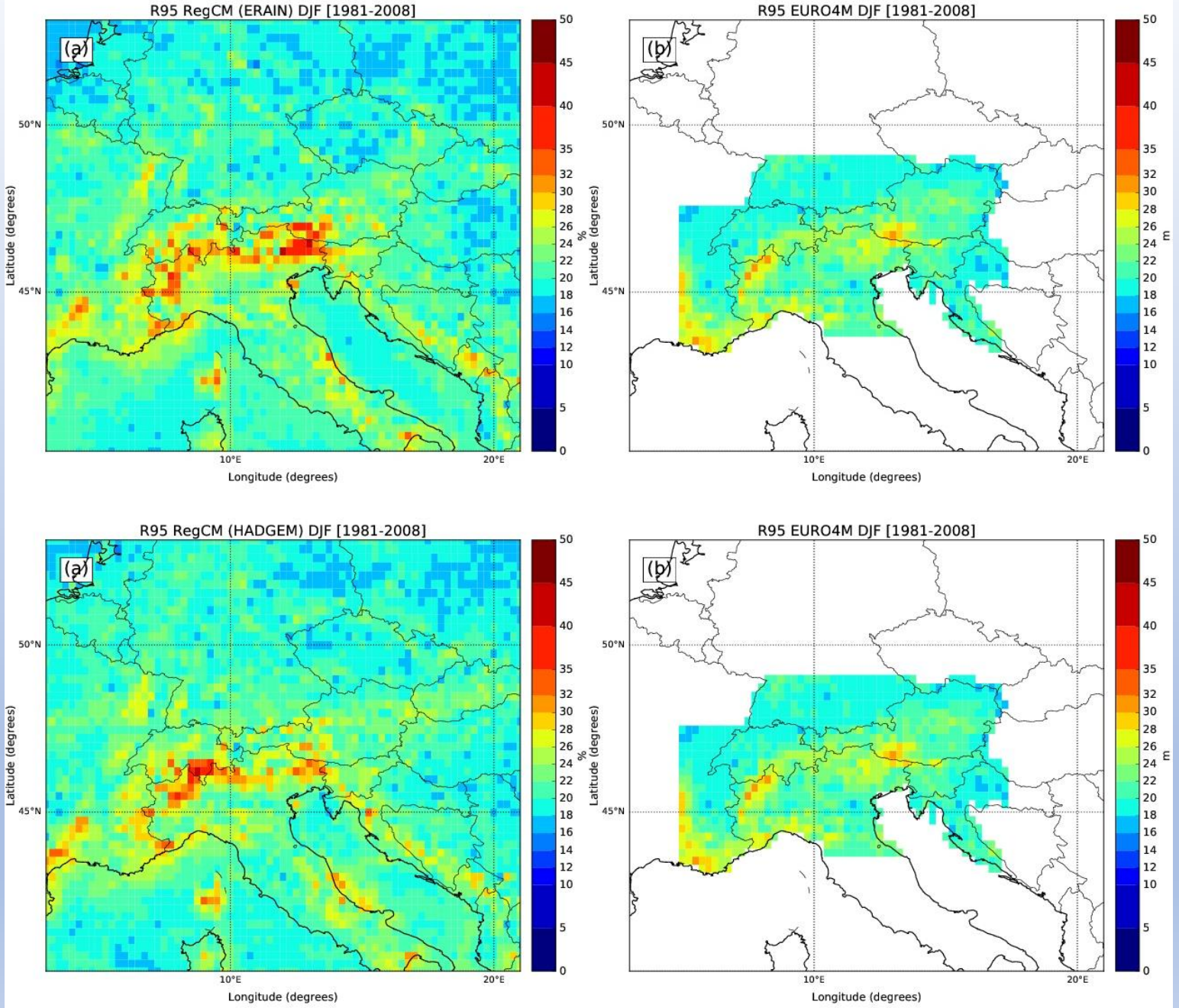

R95 EOBS JJA [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

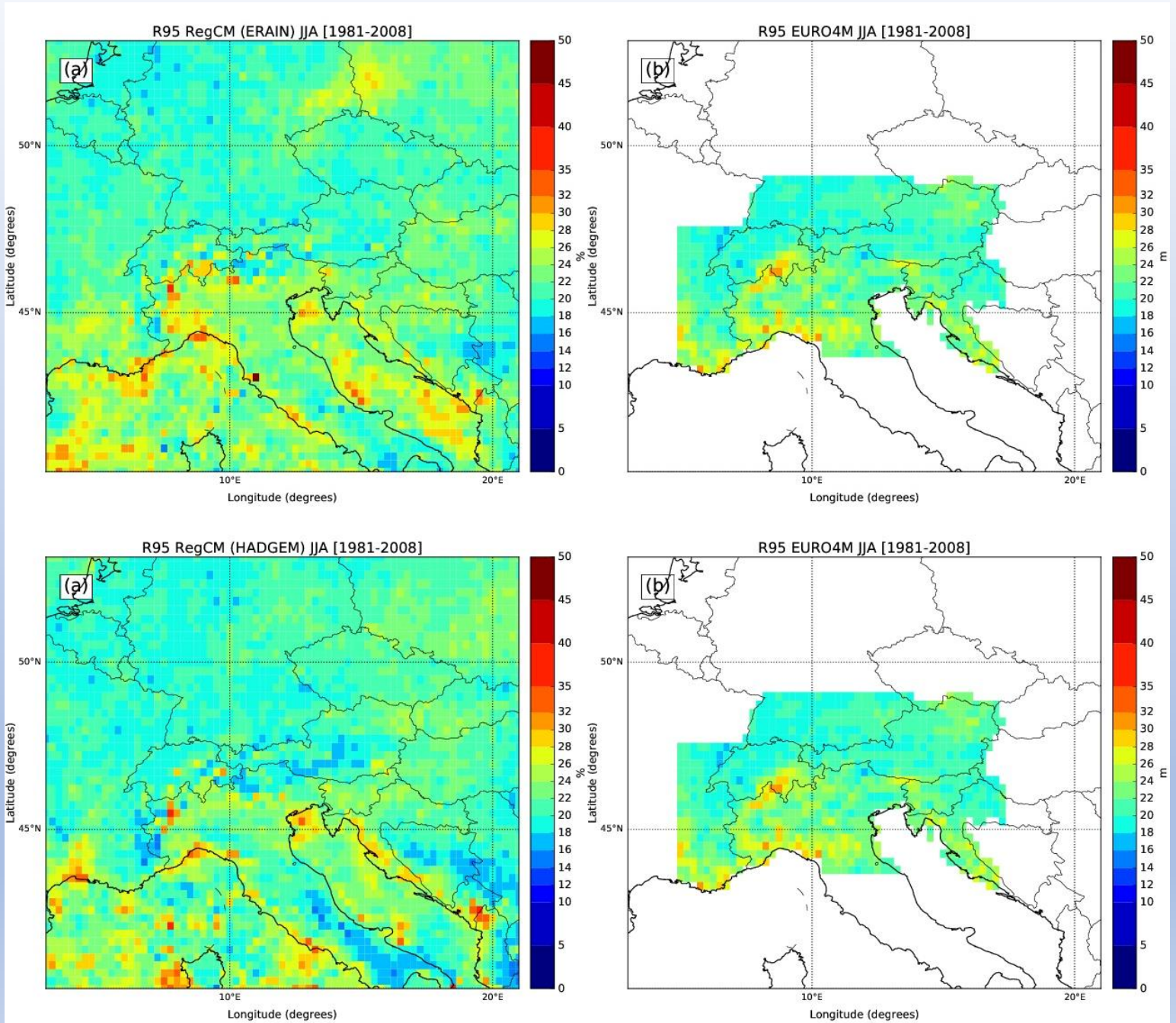

R95 RegCM (ERAIN) MAM [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%

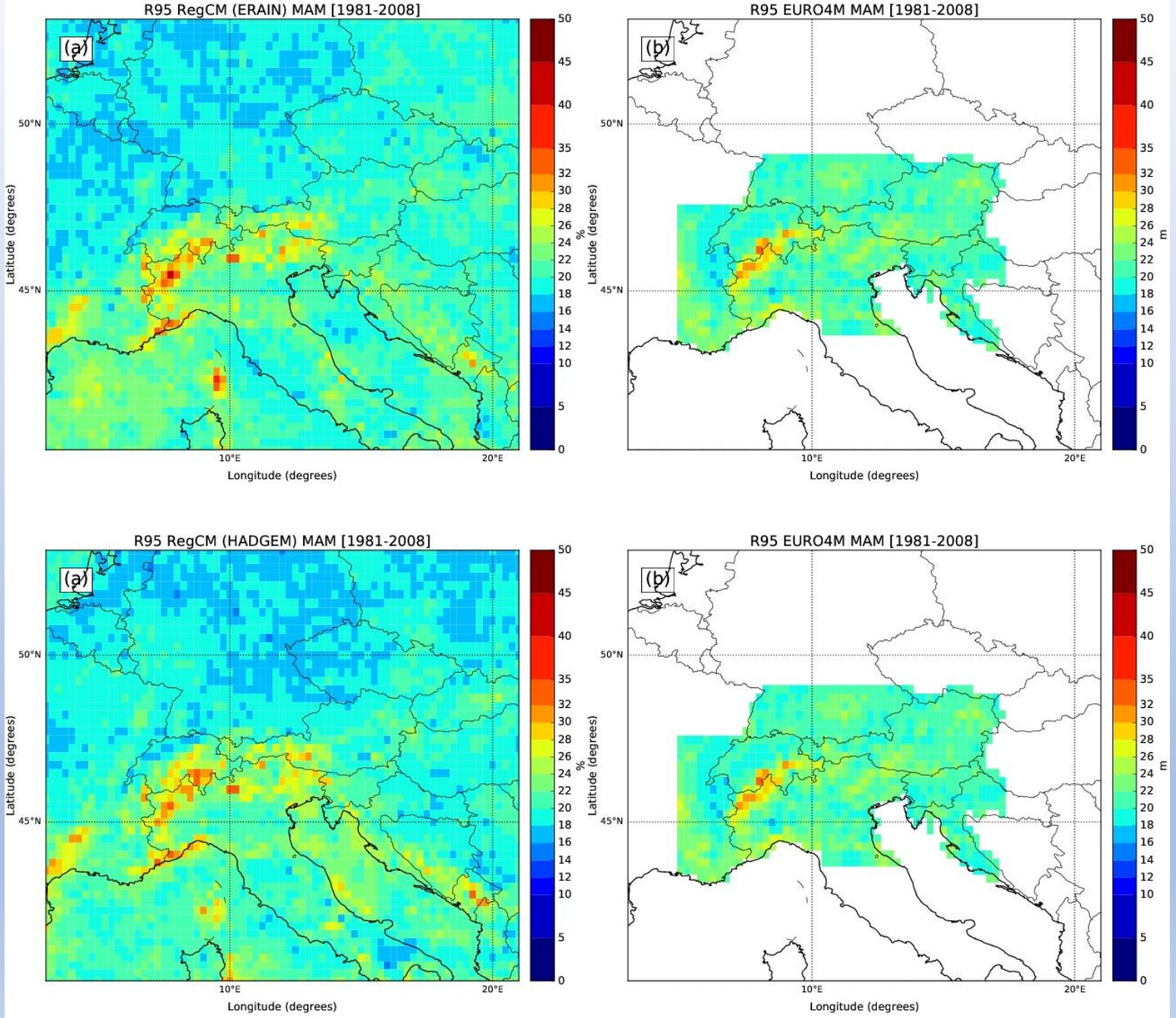

R95 EOBS MAM [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m

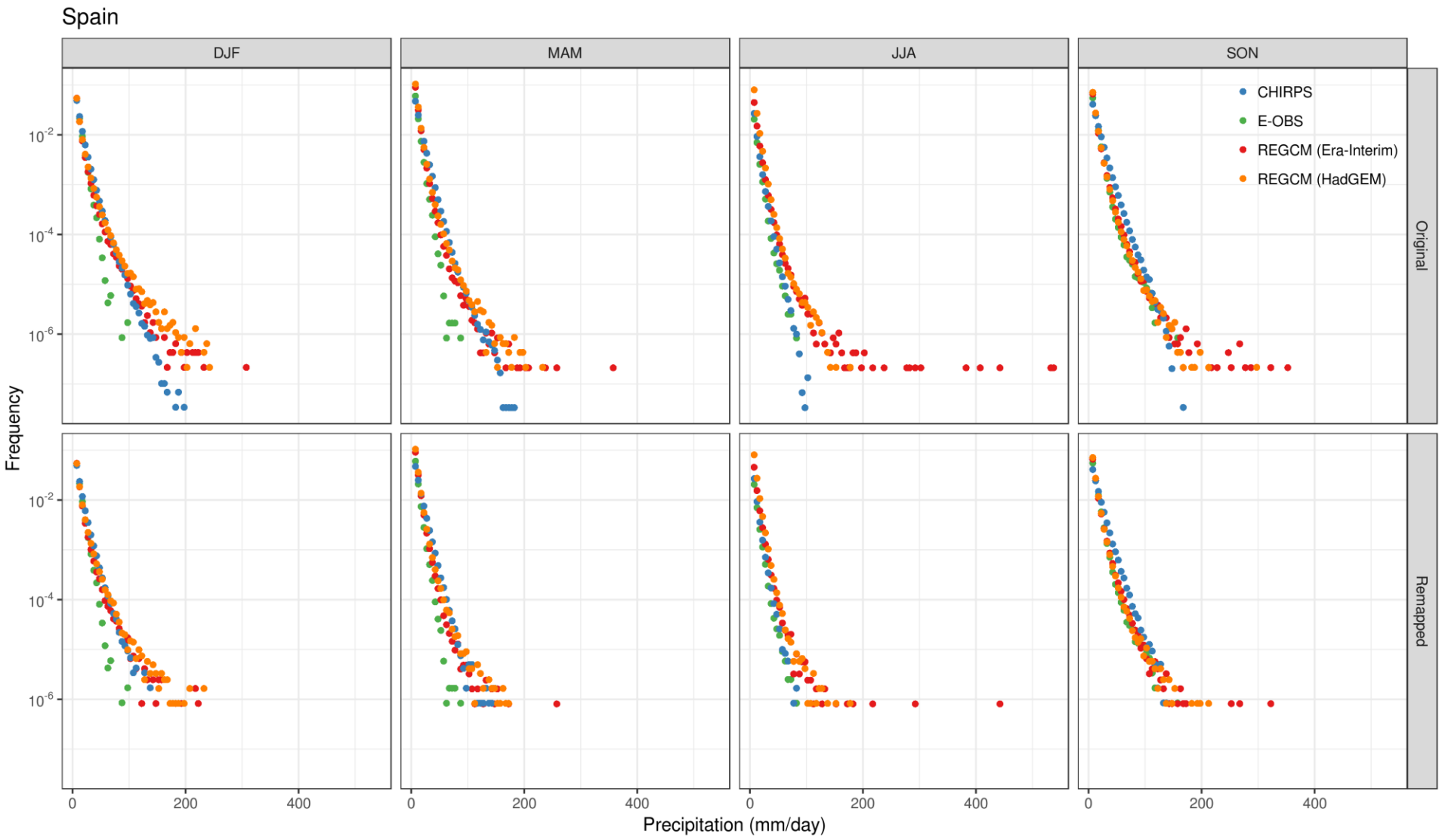

R95 RegCM (HADGEM) MAM [1981-2008]
(a)
Latitude (degrees)
Longitude (degrees)
%


R95 EOBS MAM [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
m


R95 RegCM (ERAIN) DJF [1981-2008]
(a)
R95 EURO4M DJF [1981-2008]
(b)
R95 RegCM (HADGEM) DJF [1981-2008]
(a)
R95 EURO4M DJF [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
%
m
0
5
10
12
14
16
18
20
22
24
26
28
30
32
35
40
45
50


R95 RegCM (ERAIN) JJA [1981-2008]
(a)
R95 EURO4M JJA [1981-2008]
(b)
R95 RegCM (HADGEM) JJA [1981-2008]
(a)
R95 EURO4M JJA [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
%
m
0
5
10
12
14
16
18
20
22
24
26
28
30
32
35
40
45
50


R95 RegCM (ERAIN) MAM [1981-2008]
(a)
R95 EURO4M MAM [1981-2008]
(b)
R95 RegCM (HADGEM) MAM [1981-2008]
(a)
R95 EURO4M MAM [1981-2008]
(b)
Latitude (degrees)
Longitude (degrees)
50°N
45°N
10°E
20°E
%
m
0
5
10
12
14
16
18
20
22
24
26
28
30
32
35
40
45
50


Spain
DJF
MAM
JJA
SON
CHIRPS
E-OBS
REGCM (Era-Interim)
REGCM (HadGEM)
Original
Remapped
Frequency
$10^{-2}$
$10^{-4}$
$10^{-6}$
0
200
400
Precipitation (mm/day)