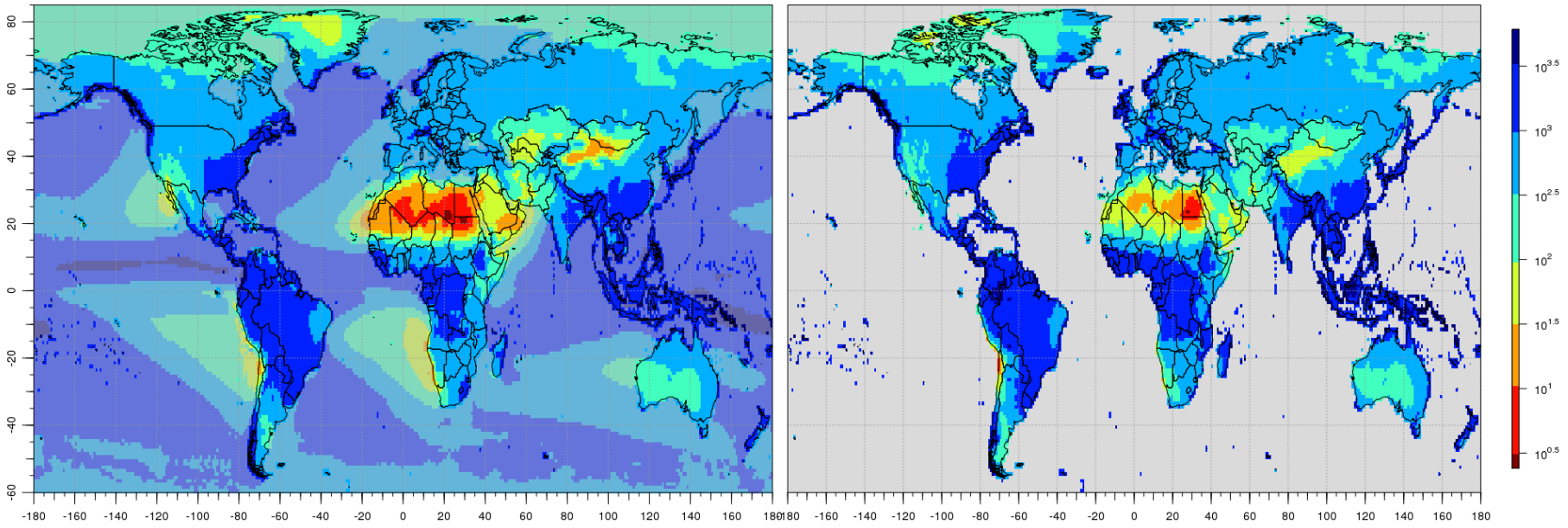
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Precipitation assessment with focus on station density, convective and stratiform precipitation



Elke Rustemeier, Markus Ziese, Andreas Becker, Anja Meyer-Christoffer, Udo Schneider, and Peter Finger

Global Precipitation Climatology Centre, Deutscher Wetterdienst, Hydrometeorology

Introduction

- Comparison ERA-20C reanalysis – GPCC monthly products
  - Full Data Monthly Version 7
  - HOMPRA Version 0.1
- Systematic differences
- Trend differences

GPCC Product
Full Data Monthly Version 7

- Monthly land-surface precipitation from rain-gauges
- Covering 1901-2013
- Gridded using modified SPHEREMAP
- New release

i.a. additional data (Indonesia, Somalia, Brazil, USA, Mexico)

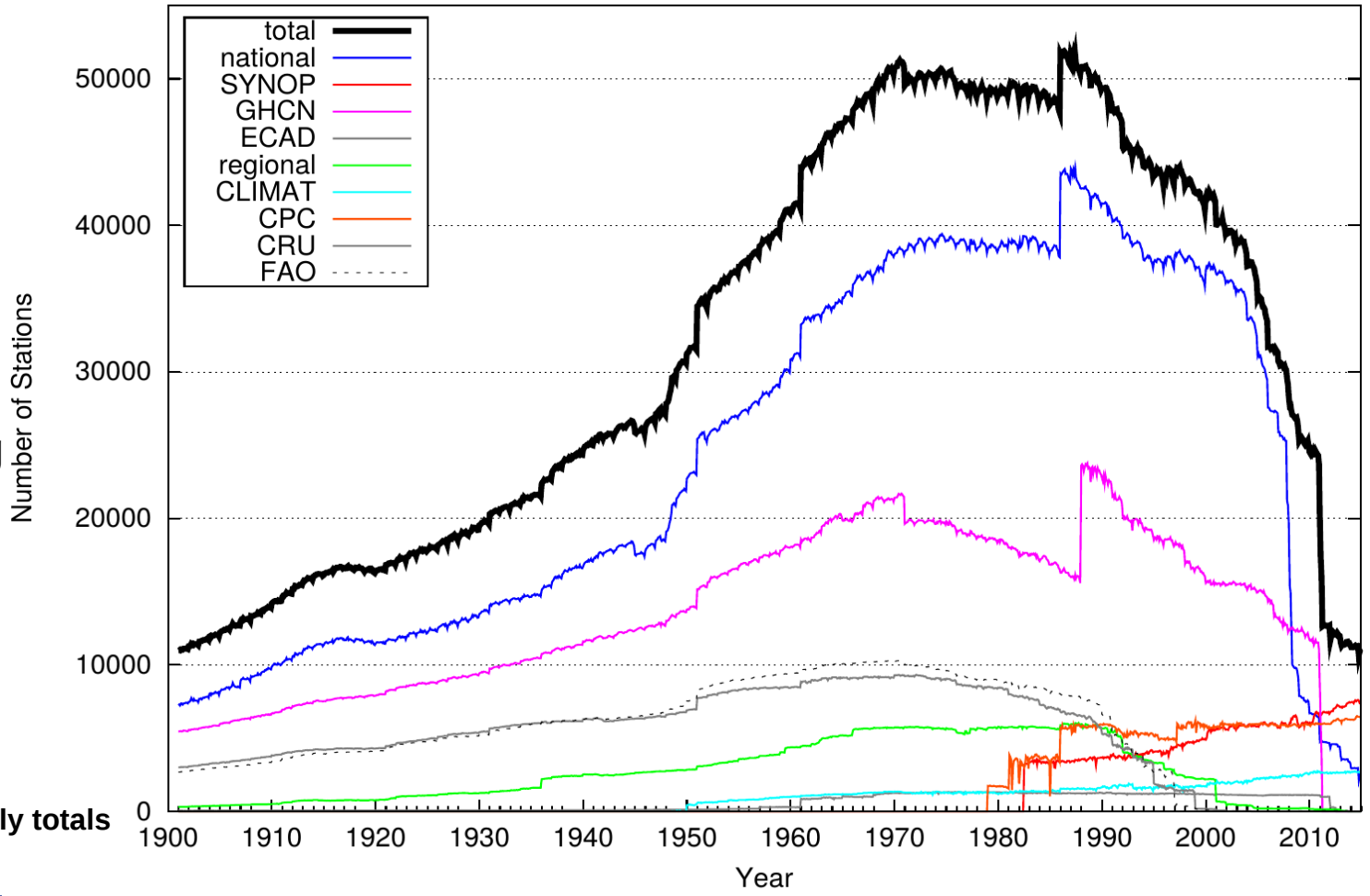
See *Schneider et al., 2014.*

GPCC Product
HOMPRA Version 0.1

- Monthly land-surface precipitation from rain-gauges
- Homogenized using 4462 carefully chosen station
- Covering 1951-2005

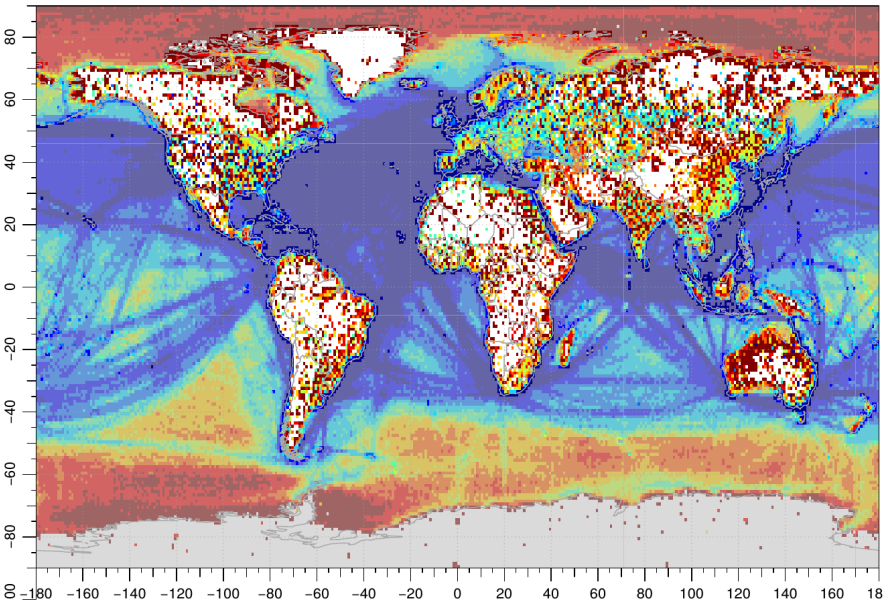
Global Precipitation Climatology Centre
GPCC Full Data Product Version 7

- In-situ data on landsurface
- Gridded analyses
1° resolution
- Interpolation of anomalies using modified SPHEREMAP

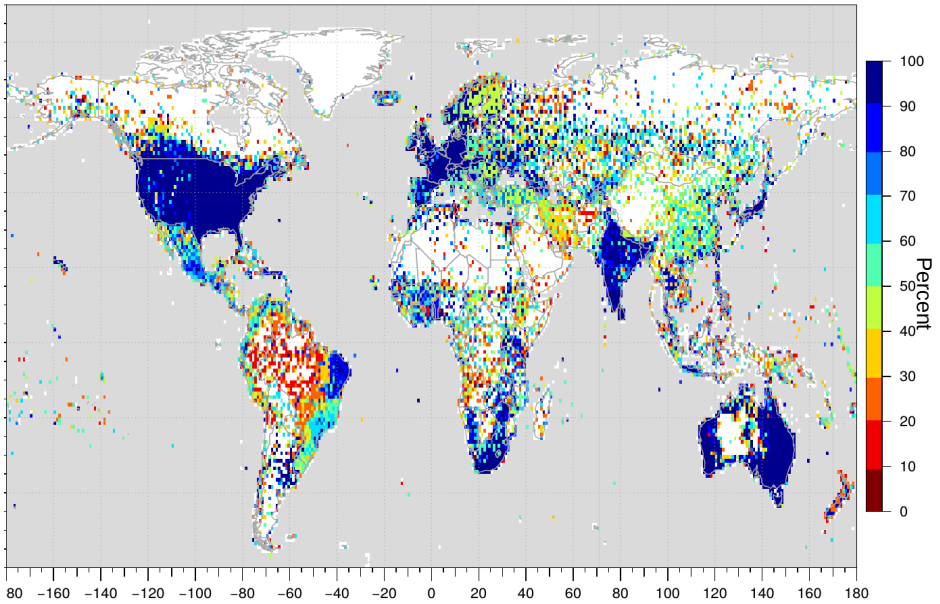


Data availability of monthly totals
Last revision 24. 4. 2015

Data base

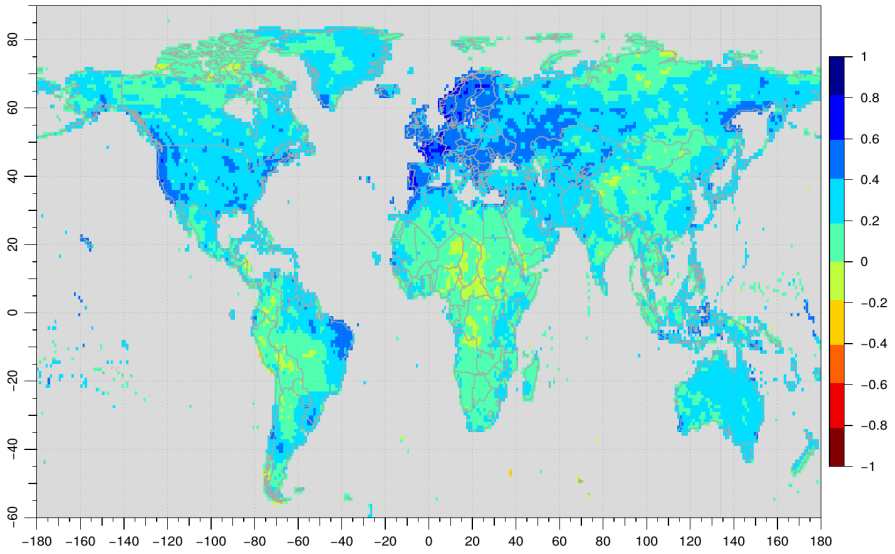


Number of surface pressure observation counts per grid box ERA-20C. Here exemplarily depicted the year 1940 (Poli et al., 2013).

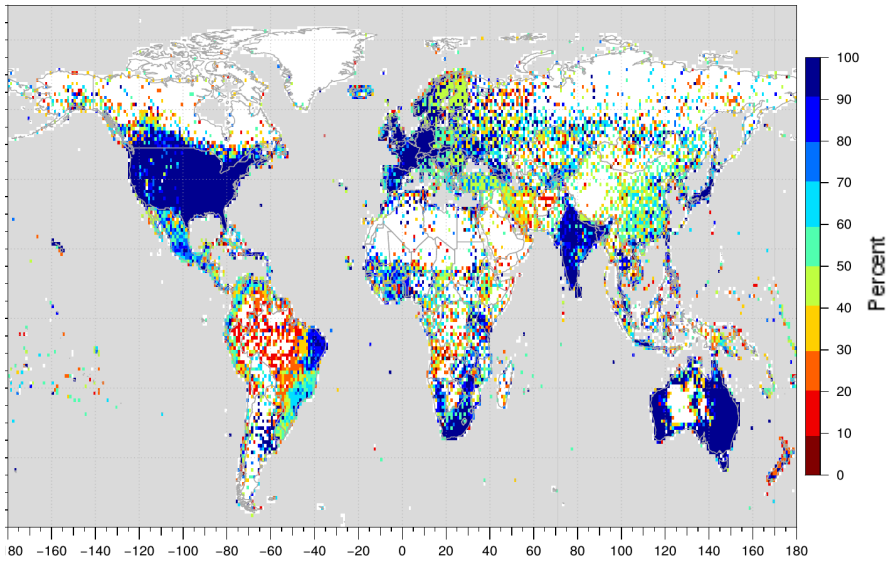


Number of precipitation series per grid for GPCC Full Data Product Version 7. Here exemplarily depicted the year 1940.

Data base

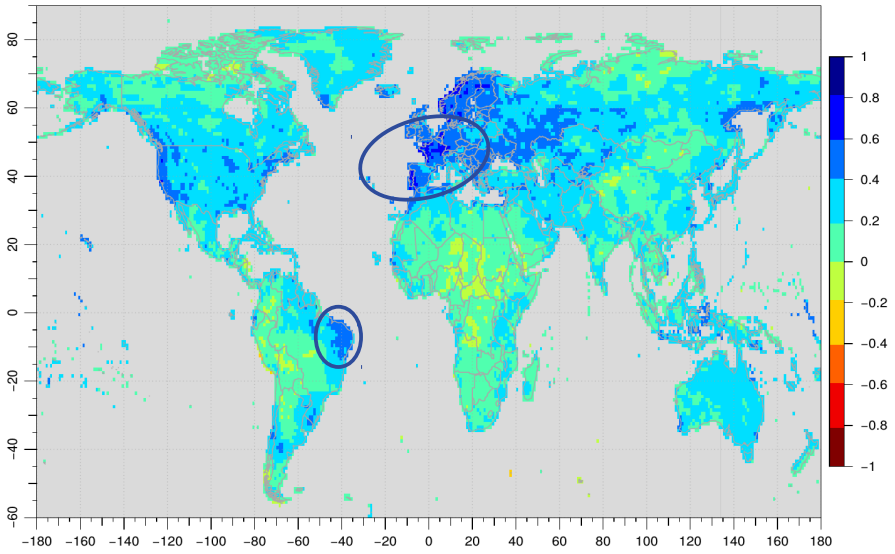


Annual Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

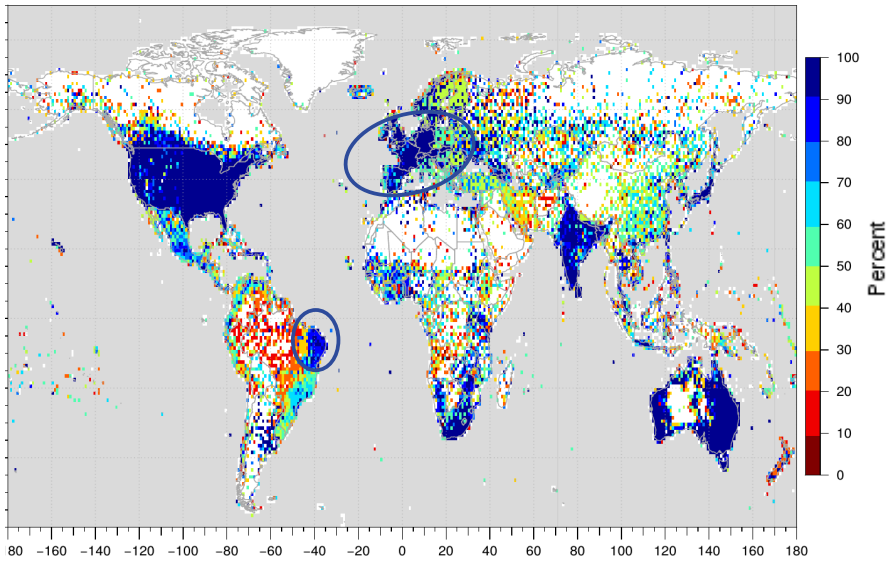


Number of precipitation series per grid for GPCC Full Data Product Version 7. Here exemplarily depicted the year 1940.

Data base

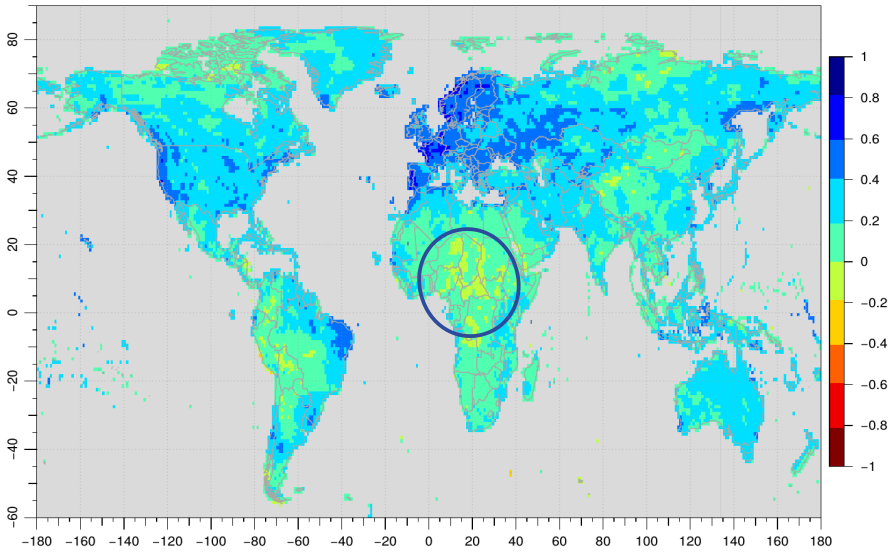


Annual Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

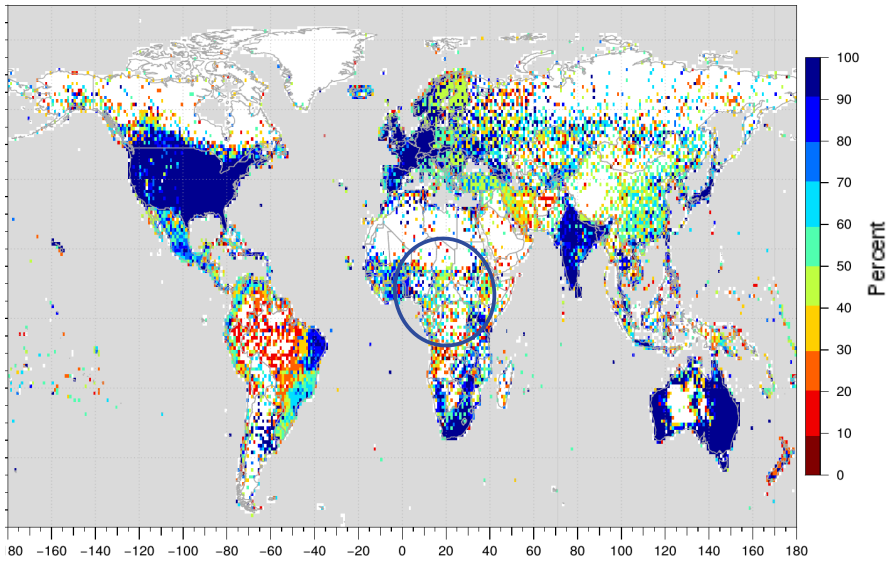


Number of precipitation series per grid for GPCC Full Data Product Version 7. Here exemplarily depicted the year 1940.

Data base

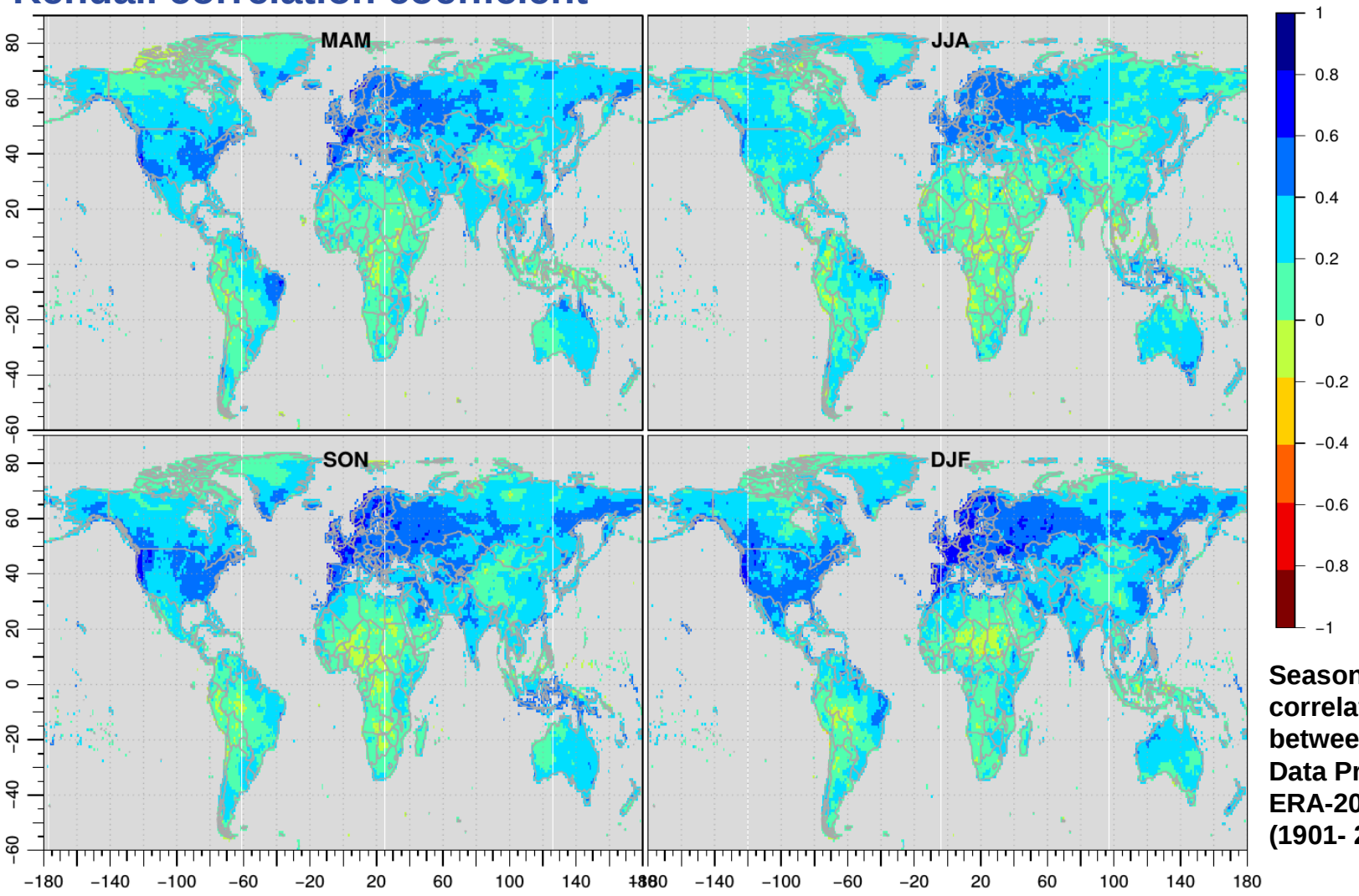


Annual Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).



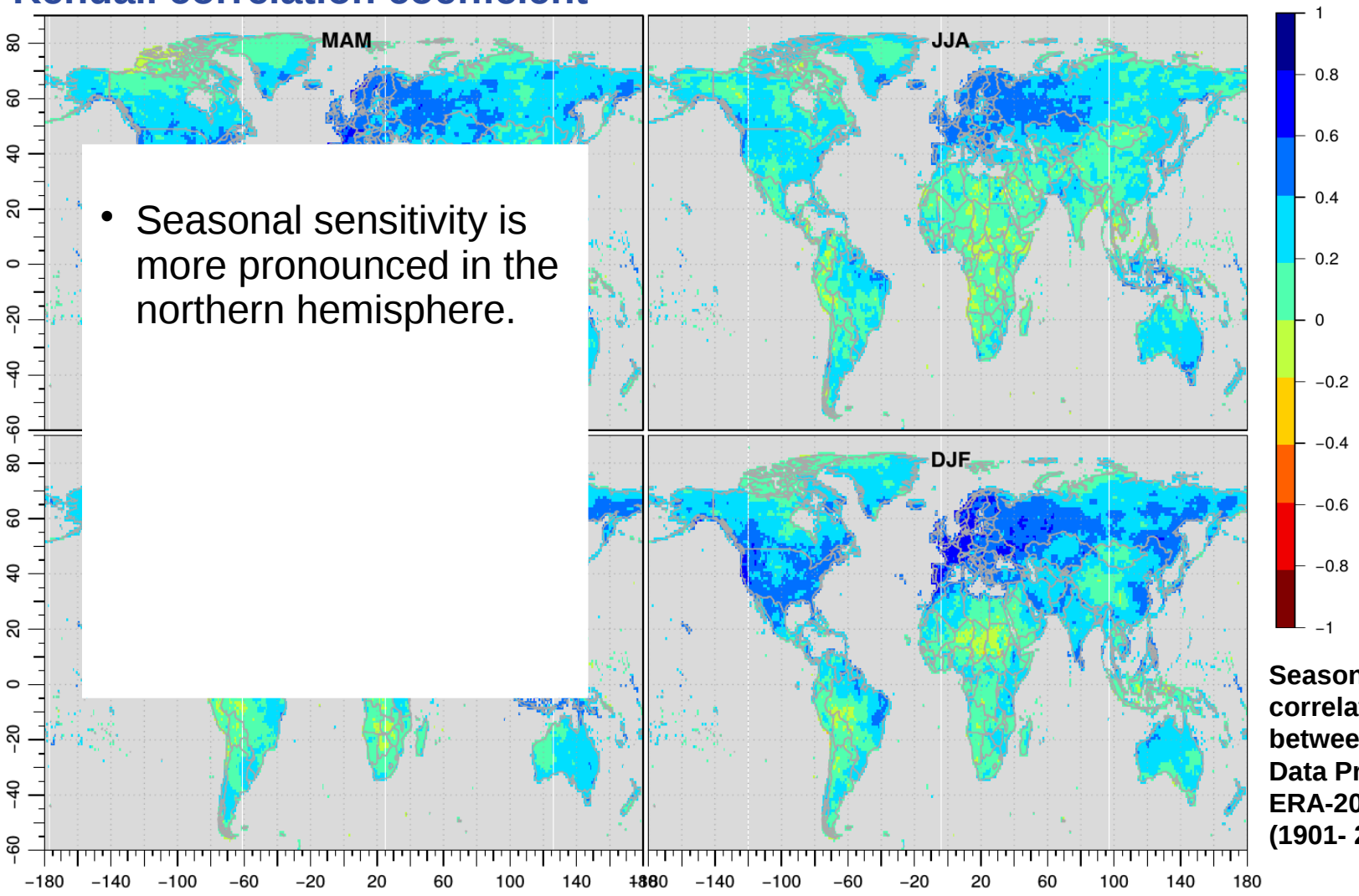
Number of precipitation series per grid for GPCC Full Data Product Version 7. Here exemplarily depicted the year 1940.

Kendall correlation coefficient



Seasonal Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

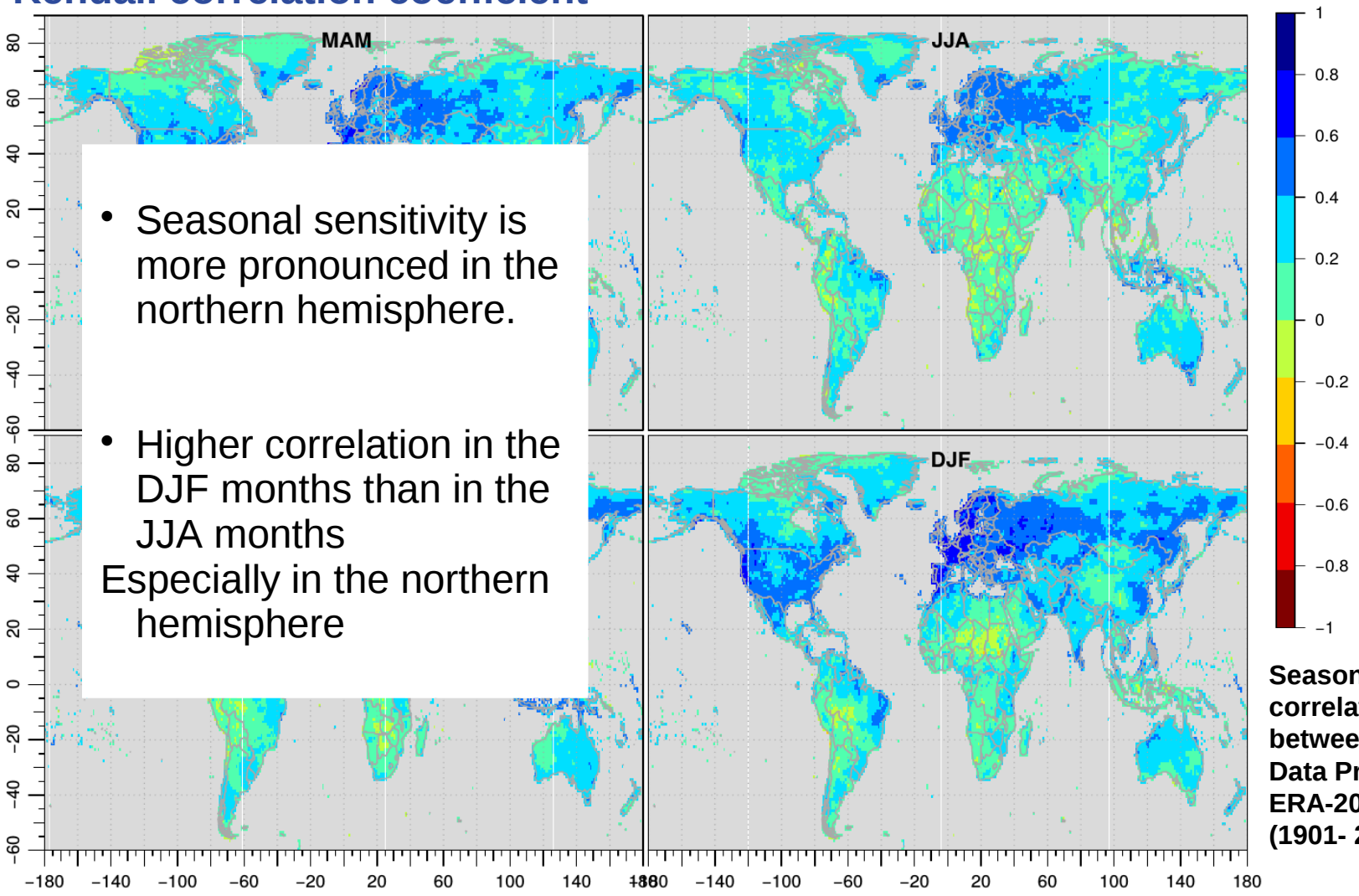
Kendall correlation coefficient



- Seasonal sensitivity is more pronounced in the northern hemisphere.

Seasonal Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

Kendall correlation coefficient



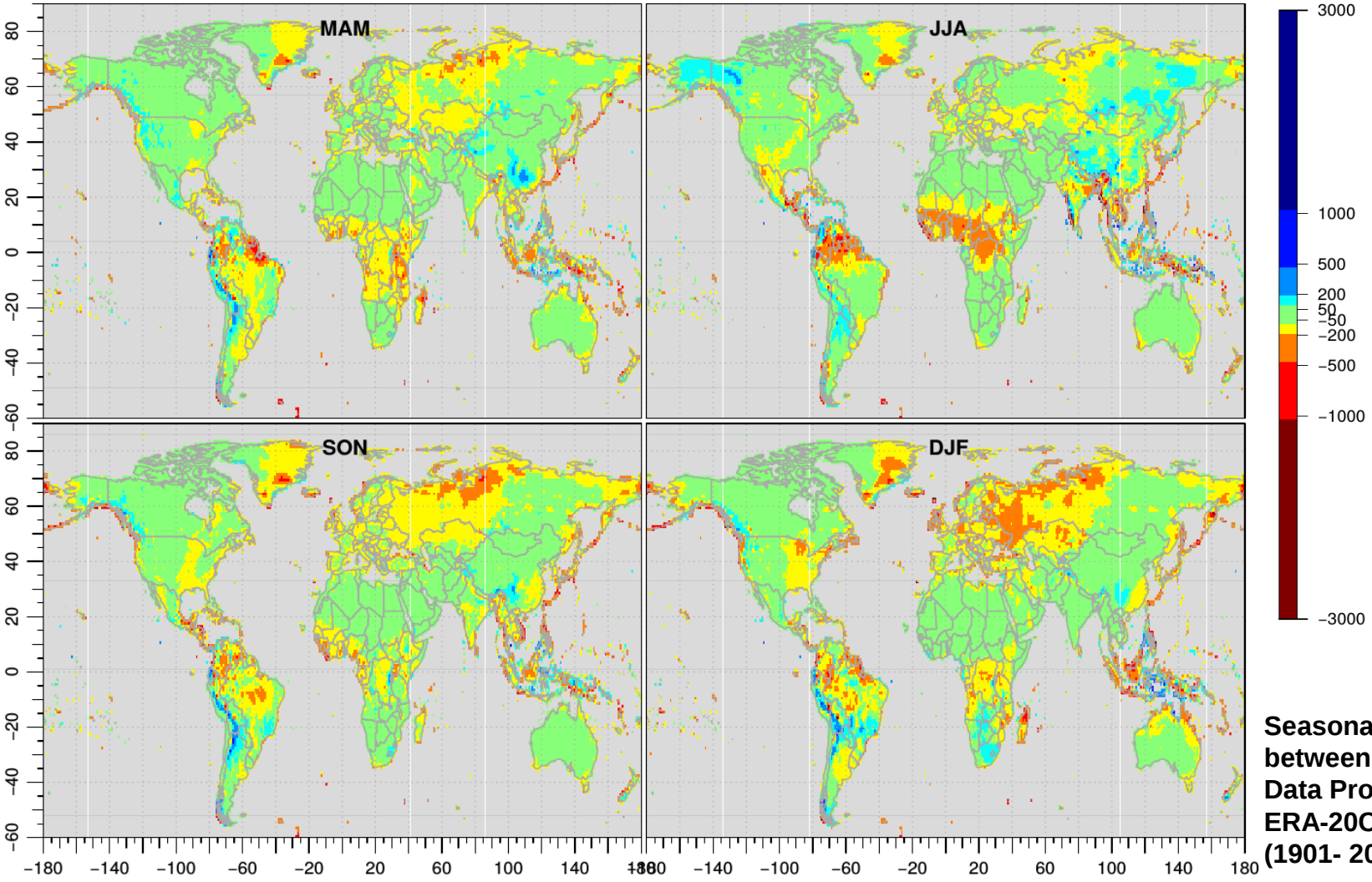
- Seasonal sensitivity is more pronounced in the northern hemisphere.
- Higher correlation in the DJF months than in the JJA months

Especially in the northern hemisphere

Seasonal Kendall correlation coefficient between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

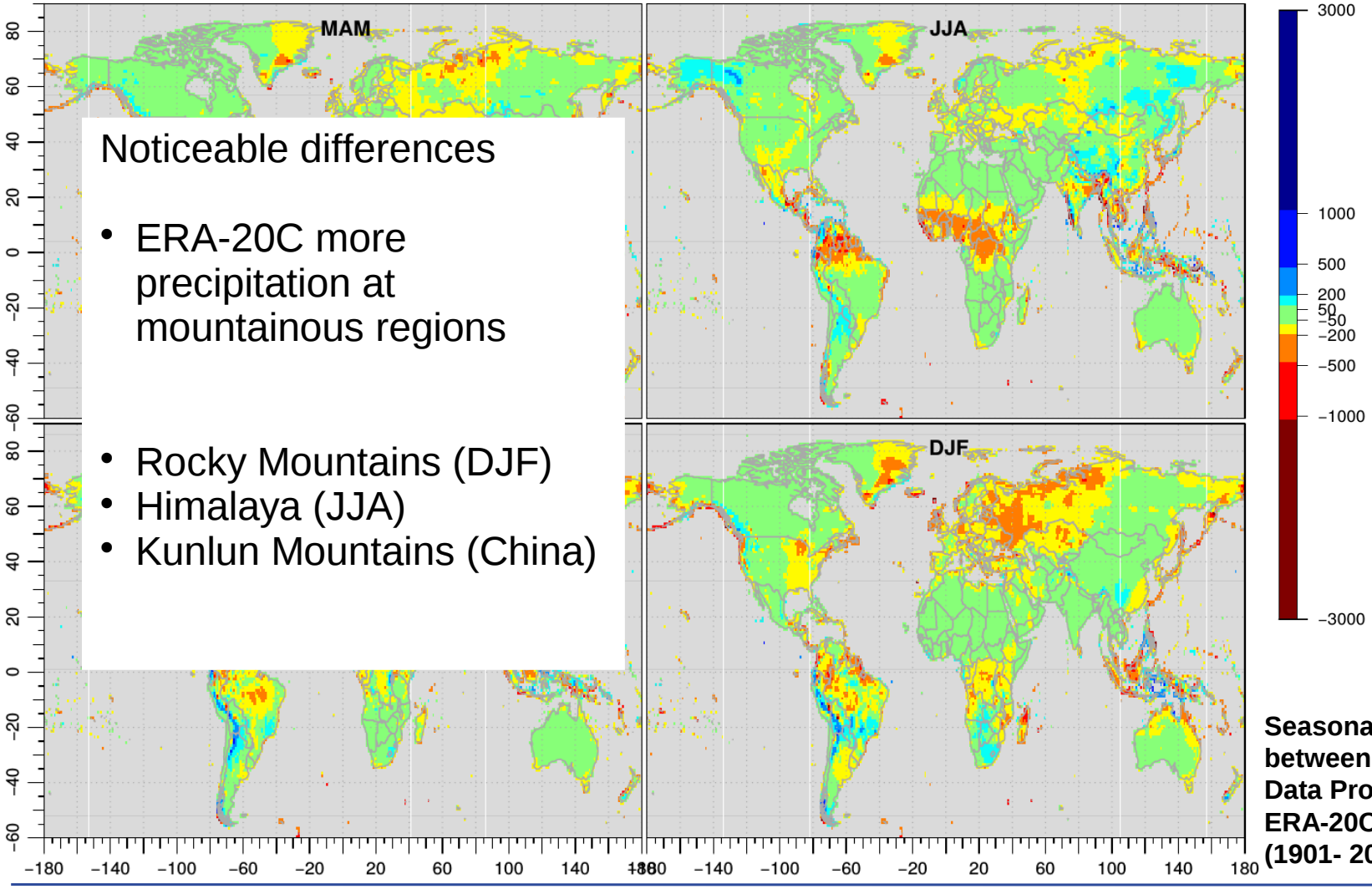
- Comparison ERA-20C reanalysis – GPCC monthly products
  - Full Data Monthly Version 7
  - HOMPRA Version 0.1
- **Systematic differences**
- Trend differences

BIAS (ERA-20C - GPCC)



Seasonal Bias between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

Bias (ERA-20C - GPCC)



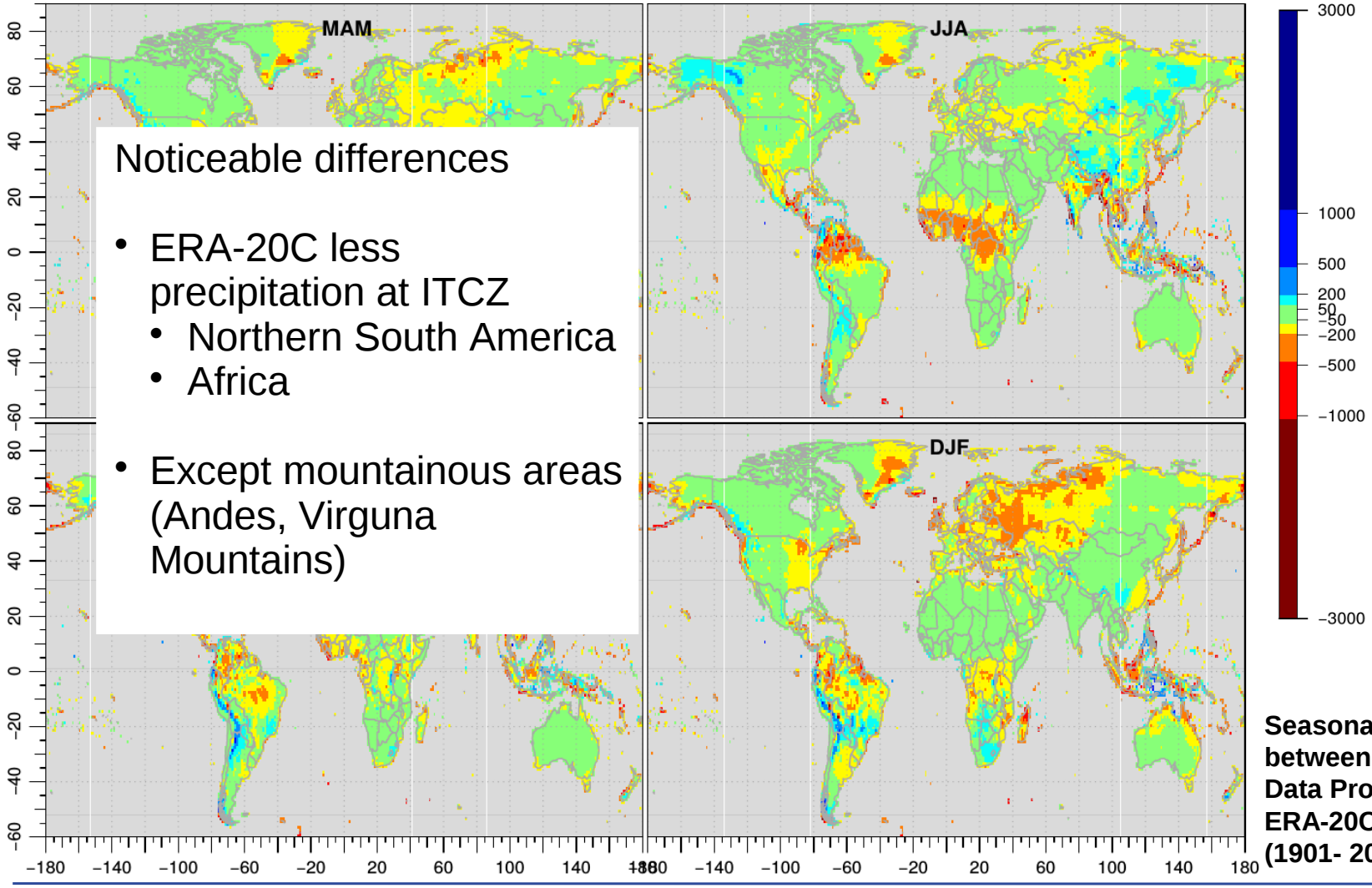
Noticeable differences

- ERA-20C more precipitation at mountainous regions

- Rocky Mountains (DJF)
- Himalaya (JJA)
- Kunlun Mountains (China)

Seasonal Bias between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

Bias (ERA-20C - GPCC)

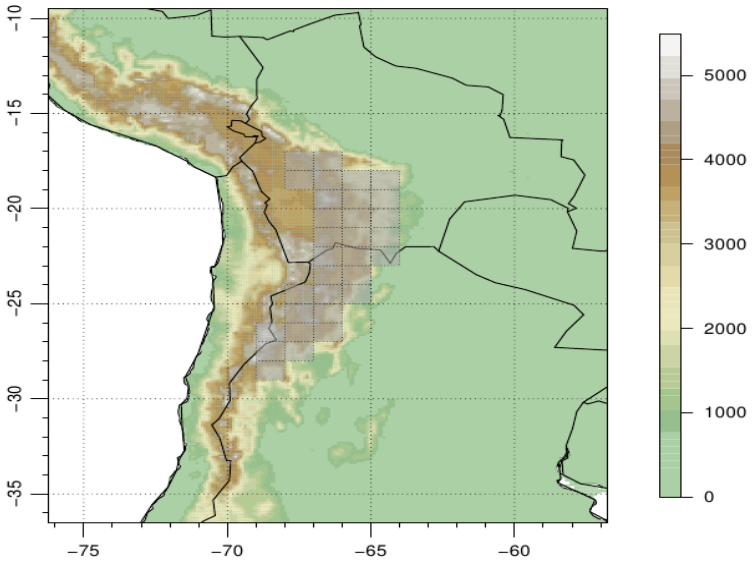


Noticeable differences

- ERA-20C less precipitation at ITCZ
  - Northern South America
  - Africa
- Except mountainous areas (Andes, Virguna Mountains)

Seasonal Bias between GPCC Full Data Product and ERA-20C reanalysis (1901- 2010).

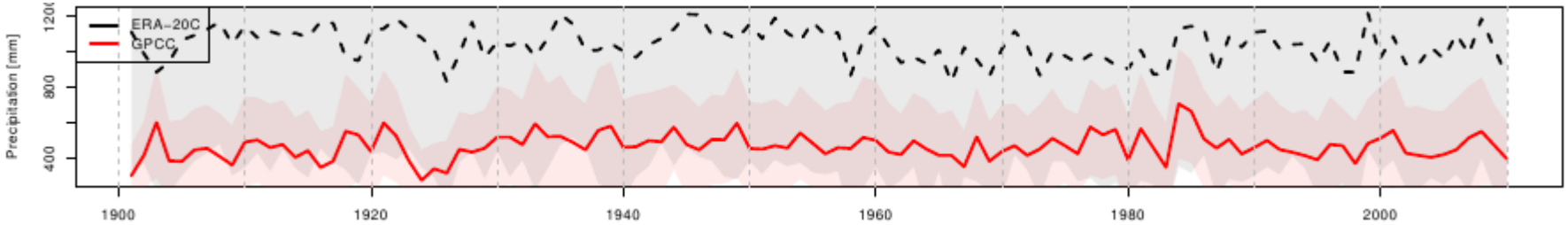
Sub-regions



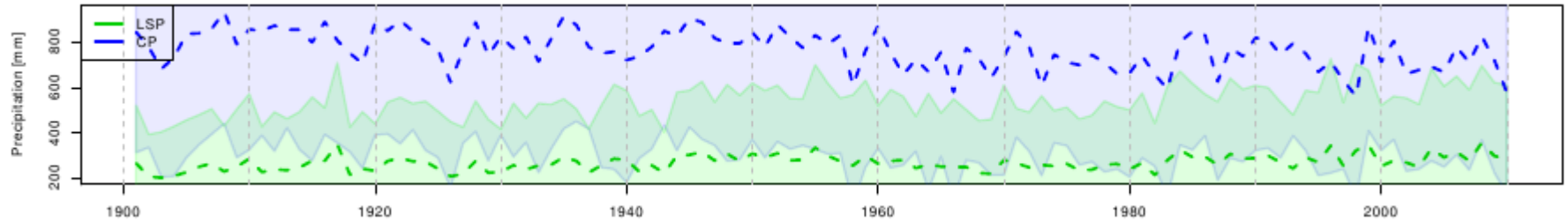
Area in the Andes

- Region that exhibits differences in the mean.
- Area with data scarcity

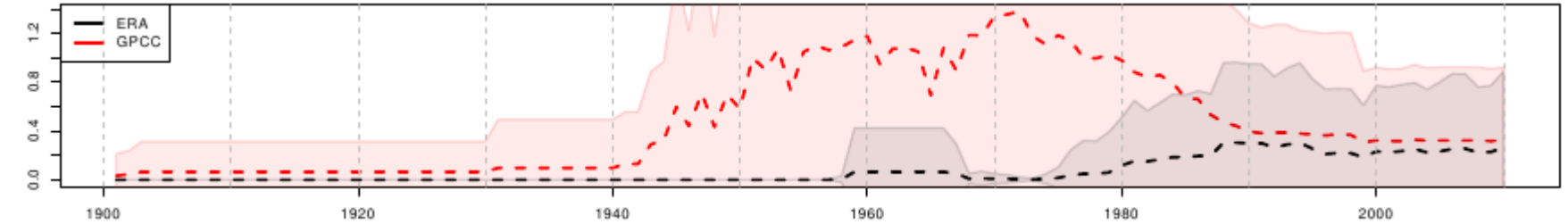
Sub-regions



Mean annual precipitation time series across an area in the Andes.
— ERA 20C — GPCC

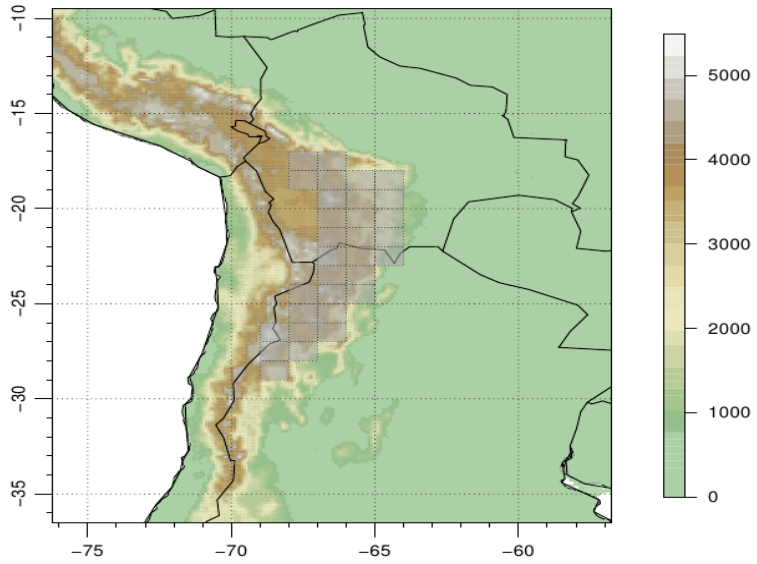


Mean annual precipitation time series across an area in the Andes.
—Convective — Large scale precipitation



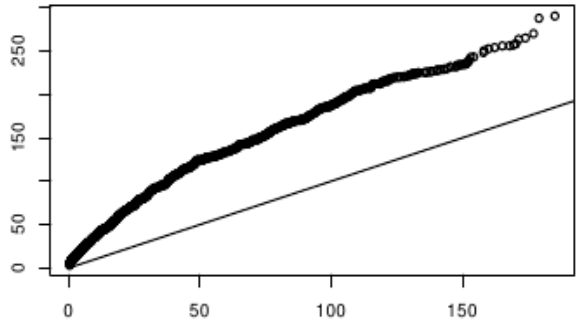
Meannumber of precipitation time series across an area in the Andes.
— ERA 20C — GPCC

Sub-regions



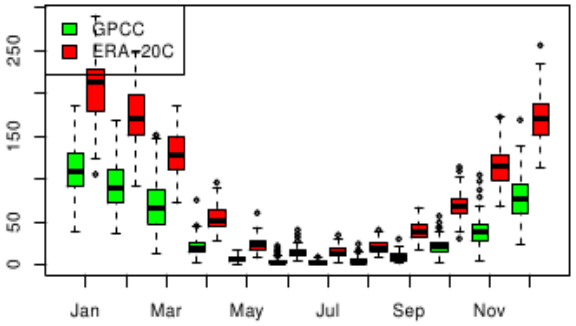
Area in the Andes

- Region that exhibits differences in the mean.
- Area with data scarcity



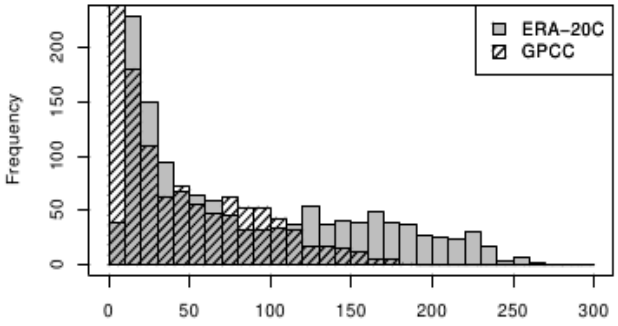
GPCC

QQ-plot of monthly totals



Box-Whisker-Plot of monthly totals

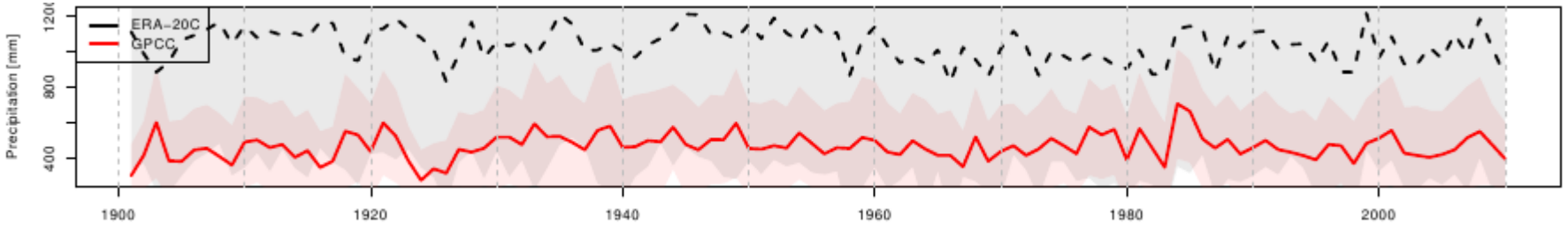
ERA-20C GPCC



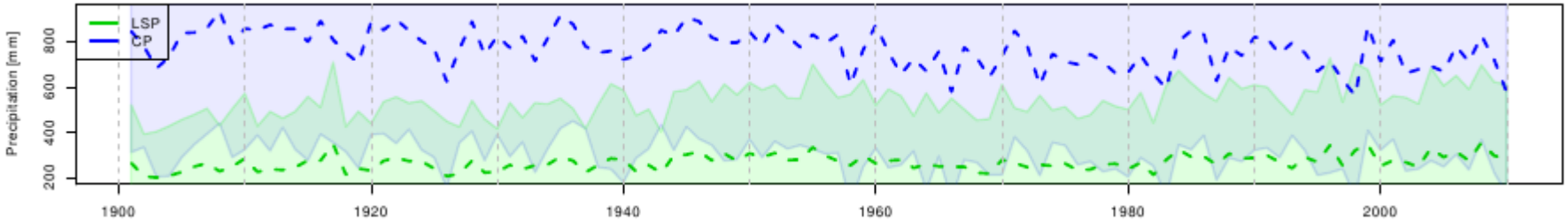
Histogram of monthly totals

ERA-20C GPCC

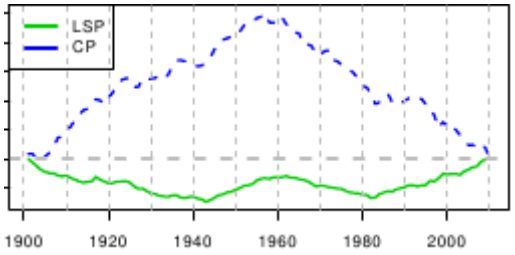
Sub-regions



Mean annual precipitation time series across an area in the Andes.
— ERA 20C — GPCC

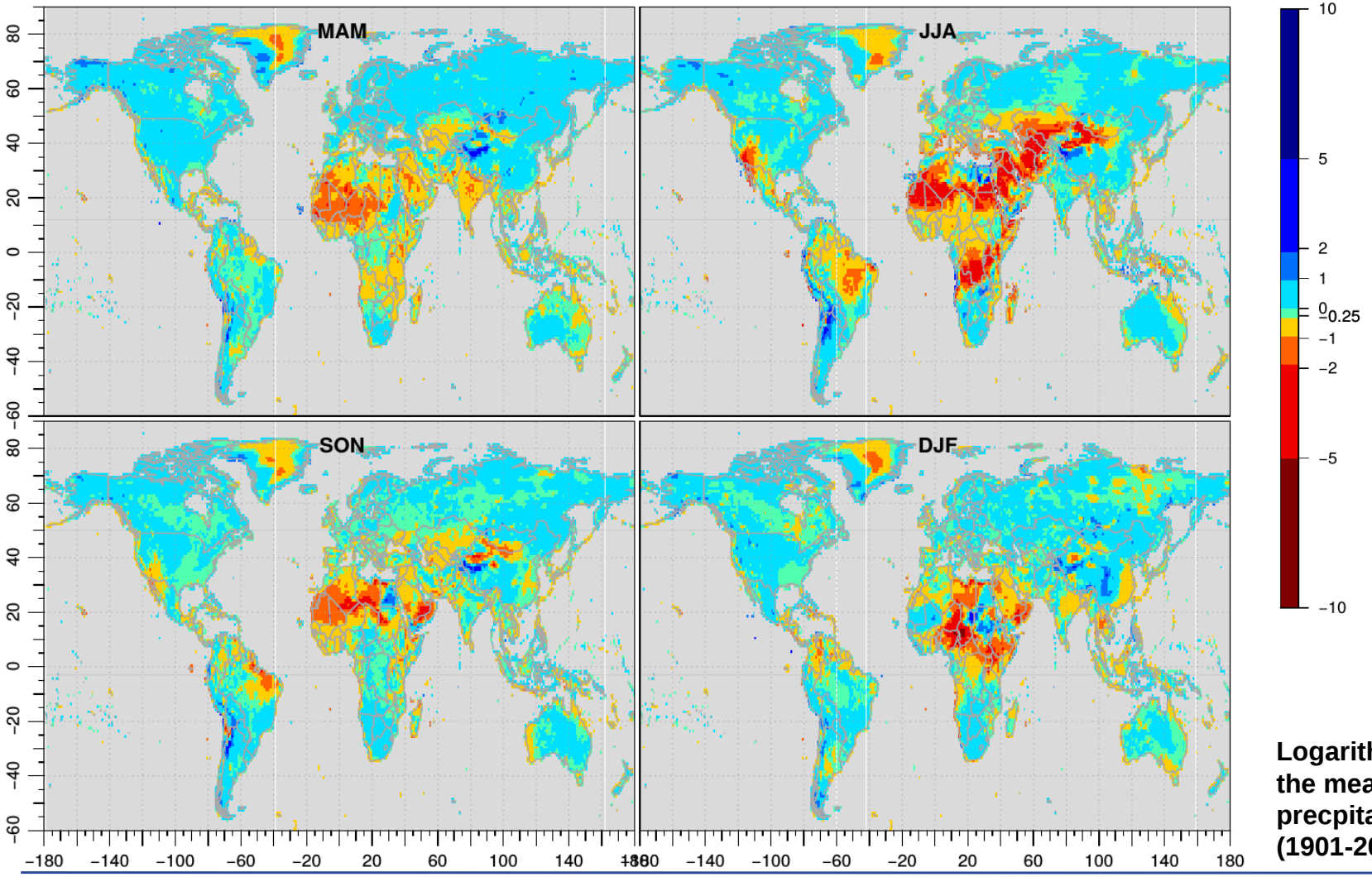


Mean annual precipitation time series across an area in the Andes.
—Convective — Large scale precipitation



Craddock test
(Cummulated sum of anomalies)
—Convective — Large scale precipitation

Logarithmic ratio [log(ERA-20C / Full Data Monthly)]



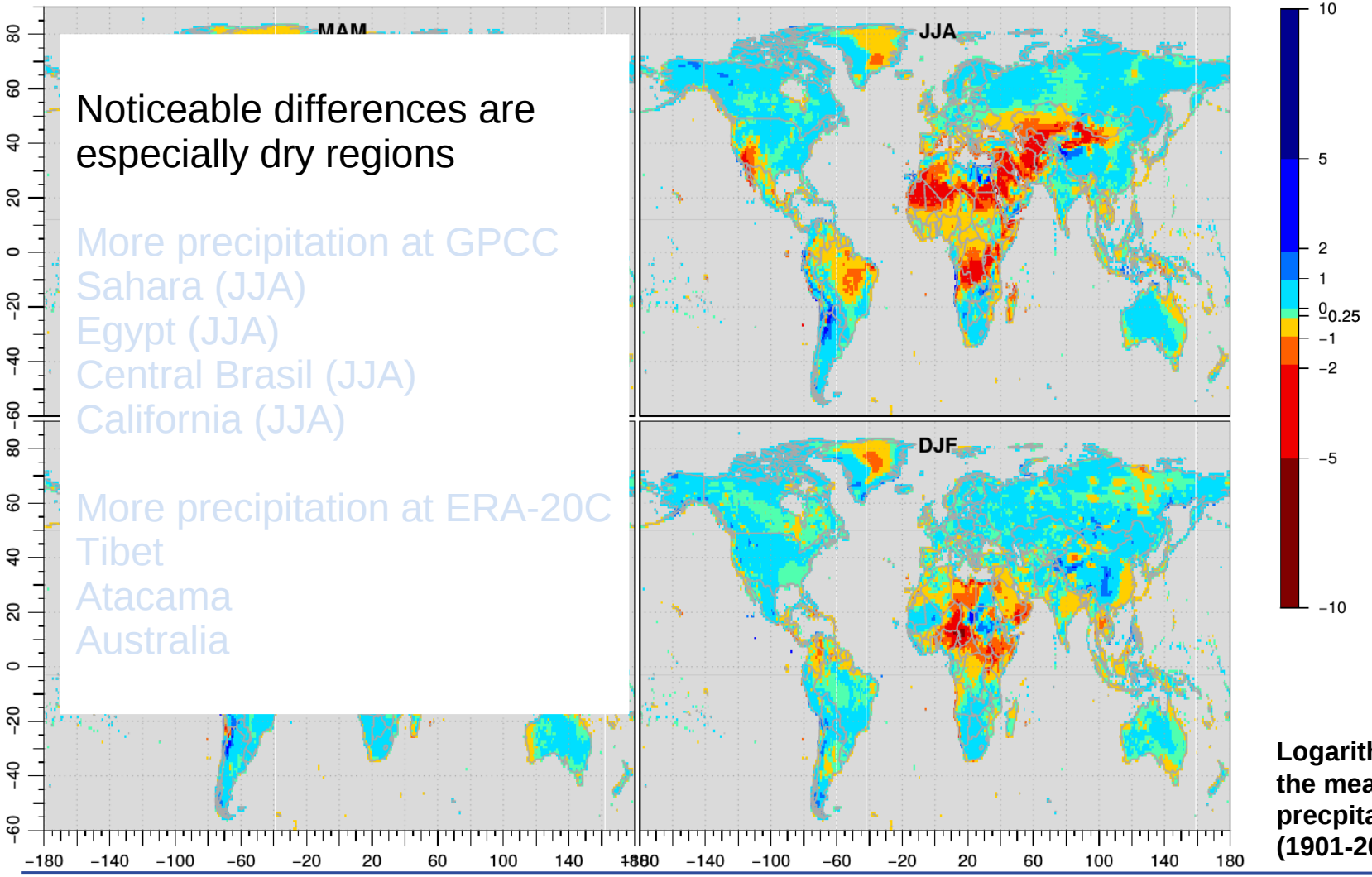
Logarithmic ratio of the mean seasonal precpitation totals (1901-2010)

Logarithmic ratio [log(ERA-20C / Full Data Monthly)]

Noticeable differences are especially dry regions

More precipitation at GPCC
Sahara (JJA)
Egypt (JJA)
Central Brasil (JJA)
California (JJA)

More precipitation at ERA-20C
Tibet
Atacama
Australia



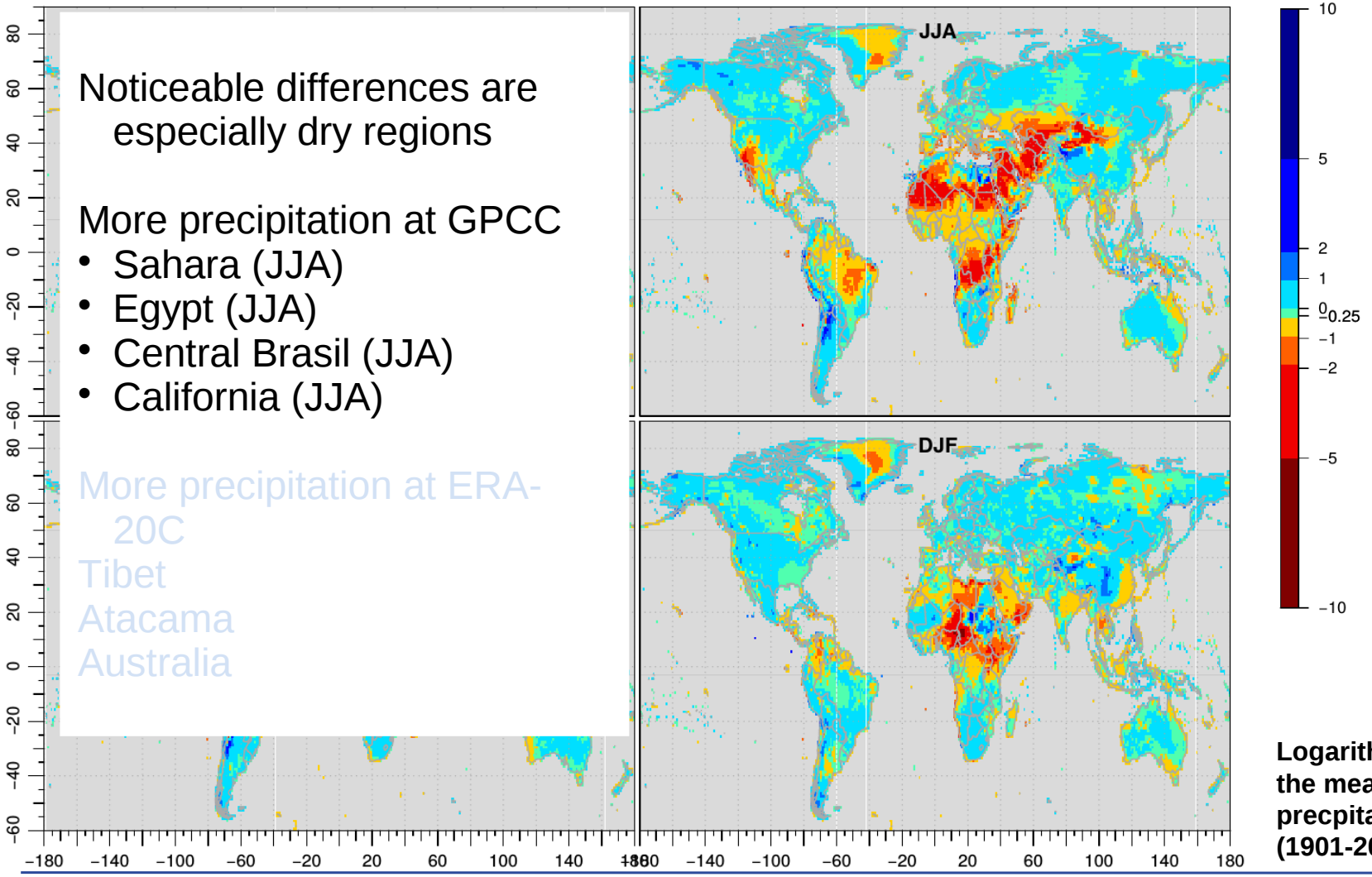
Logarithmic ratio of the mean seasonal precpitation totals (1901-2010)

Logarithmic ratio [log(ERA-20C / Full Data Monthly)]

Noticeable differences are especially dry regions

More precipitation at GPCC
- Sahara (JJA)
- Egypt (JJA)
- Central Brasil (JJA)
- California (JJA)

More precipitation at ERA-20C
Tibet
Atacama
Australia



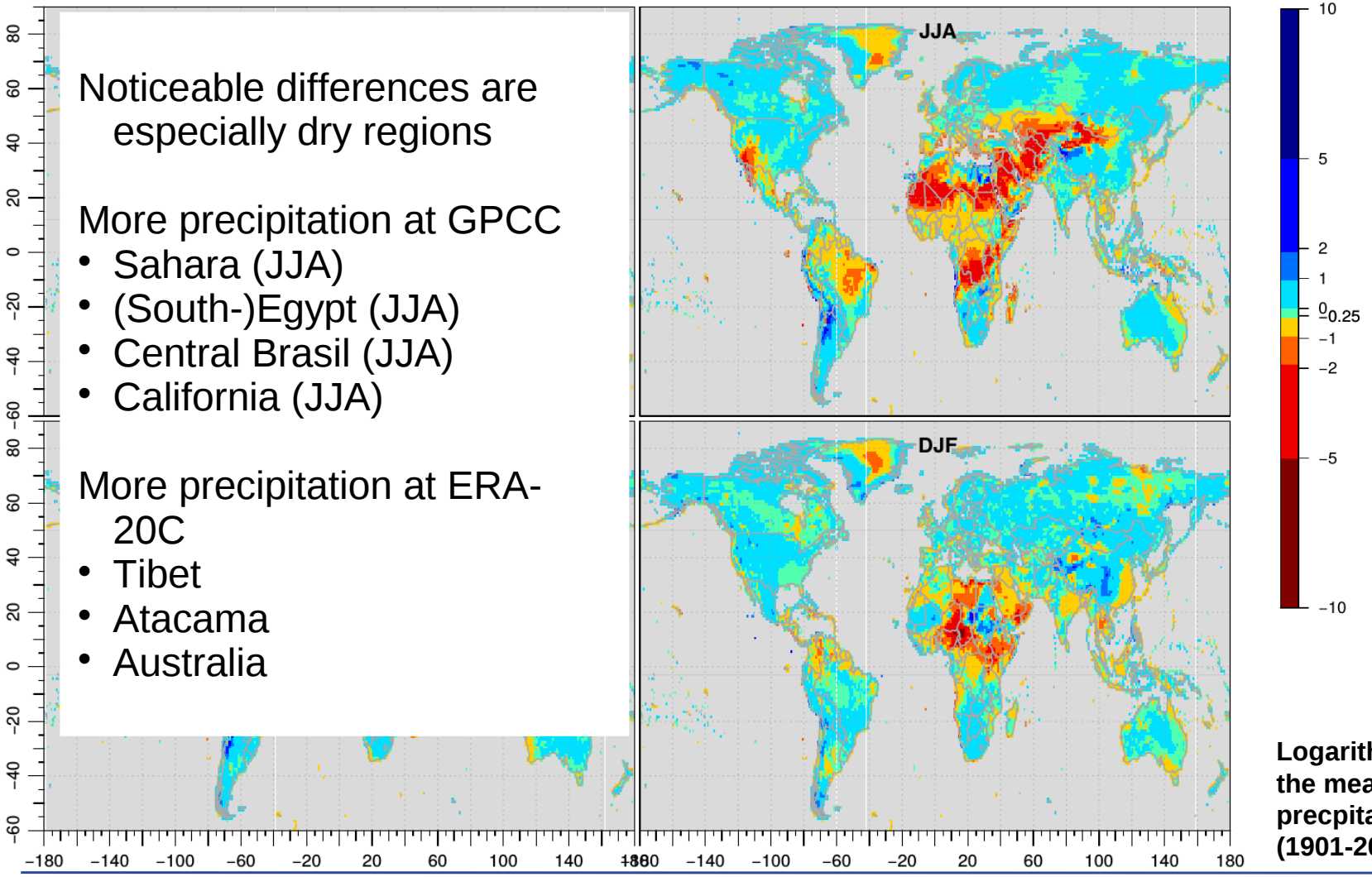
Logarithmic ratio of the mean seasonal precpitation totals (1901-2010)

Logarithmic ratio [log(ERA-20C / Full Data Monthly)]

Noticeable differences are especially dry regions

More precipitation at GPCC
- Sahara (JJA)
- (South-)Egypt (JJA)
- Central Brasil (JJA)
- California (JJA)

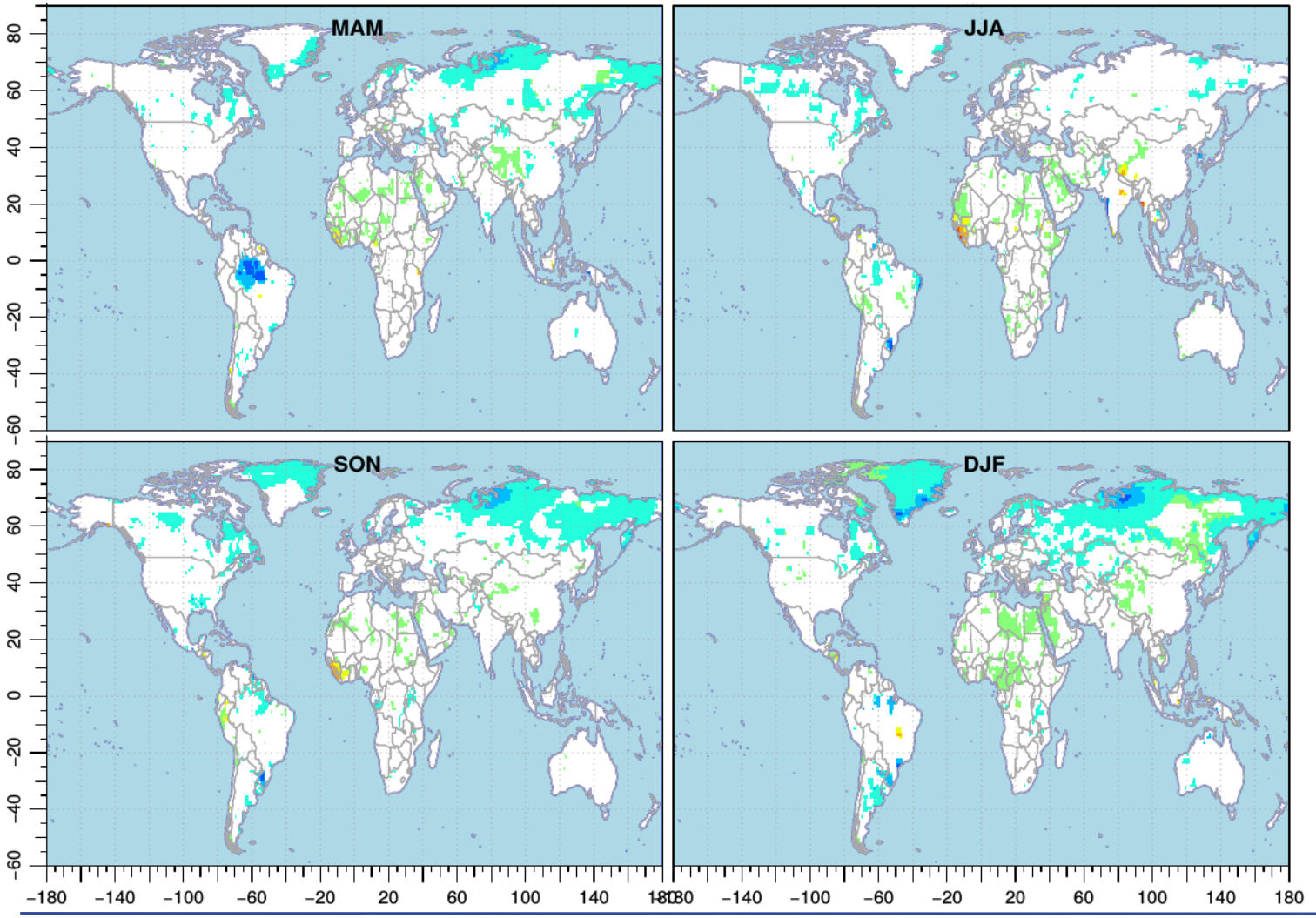
More precipitation at ERA-20C
- Tibet
- Atacama
- Australia



Logarithmic ratio of the mean seasonal precpitation totals (1901-2010)

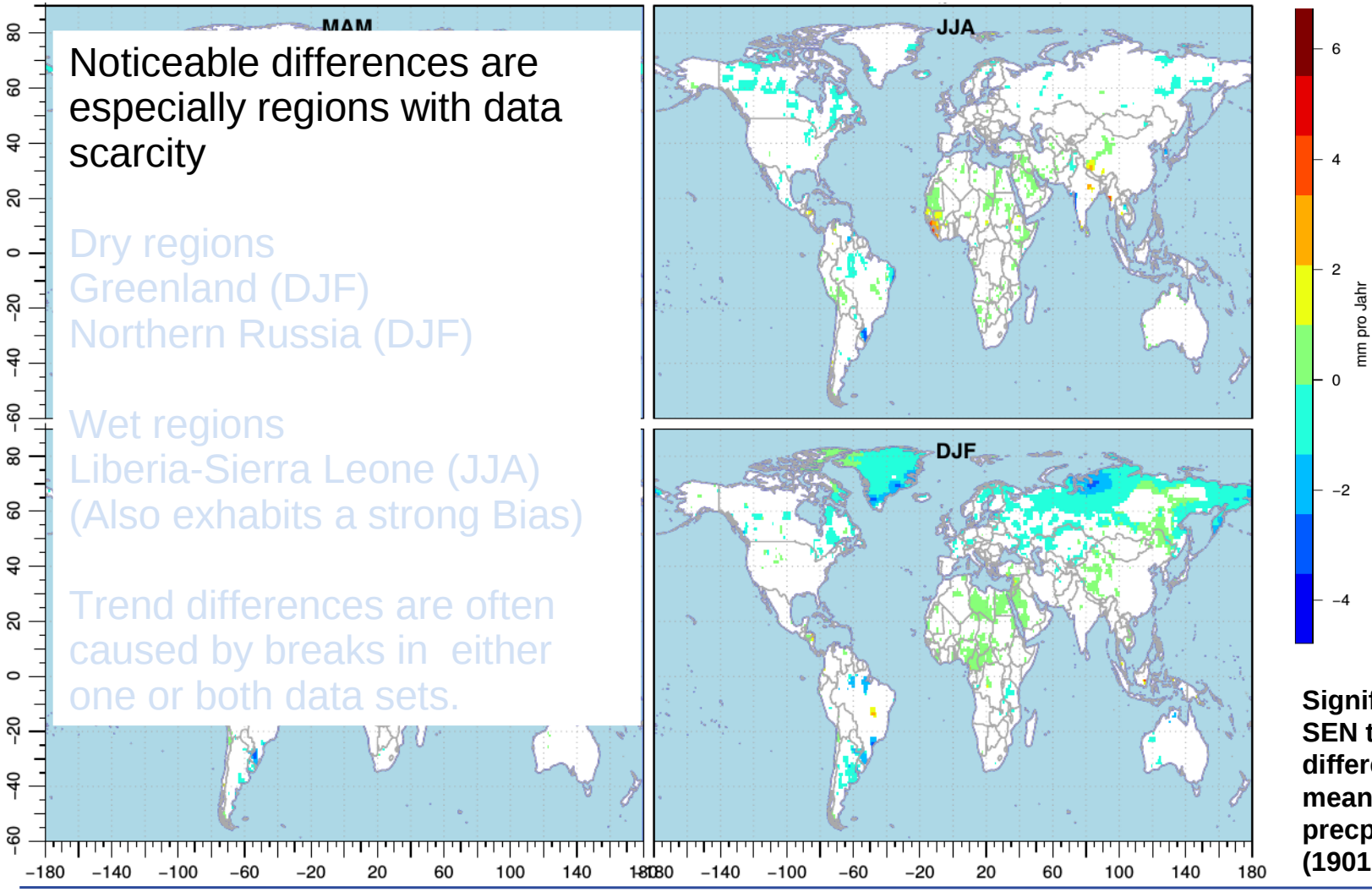
- Comparison ERA-20C reanalysis – GPCC monthly products
  - Full Data Monthly Version 7
  - HOMPRA Version 0.1
- Systematic differences
- **Trend differences**

SEN trends (ERA-20C – Full Data Monthly)



Significant (p < 0.01) SEN trends in the differences of the mean seasonal precpitation totals (1901-2010)

SEN trends (ERA-20C – Full Data Monthly)



Noticeable differences are especially regions with data scarcity

Dry regions
Greenland (DJF)
Northern Russia (DJF)

Wet regions
Liberia-Sierra Leone (JJA)
(Also exhabits a strong Bias)

Trend differences are often caused by breaks in either one or both data sets.

Significant ($p < 0.01$) SEN trends in the differences of the mean seasonal precpitation totals (1901-2010)

SEN trends (ERA-20C – Full Data Monthly)

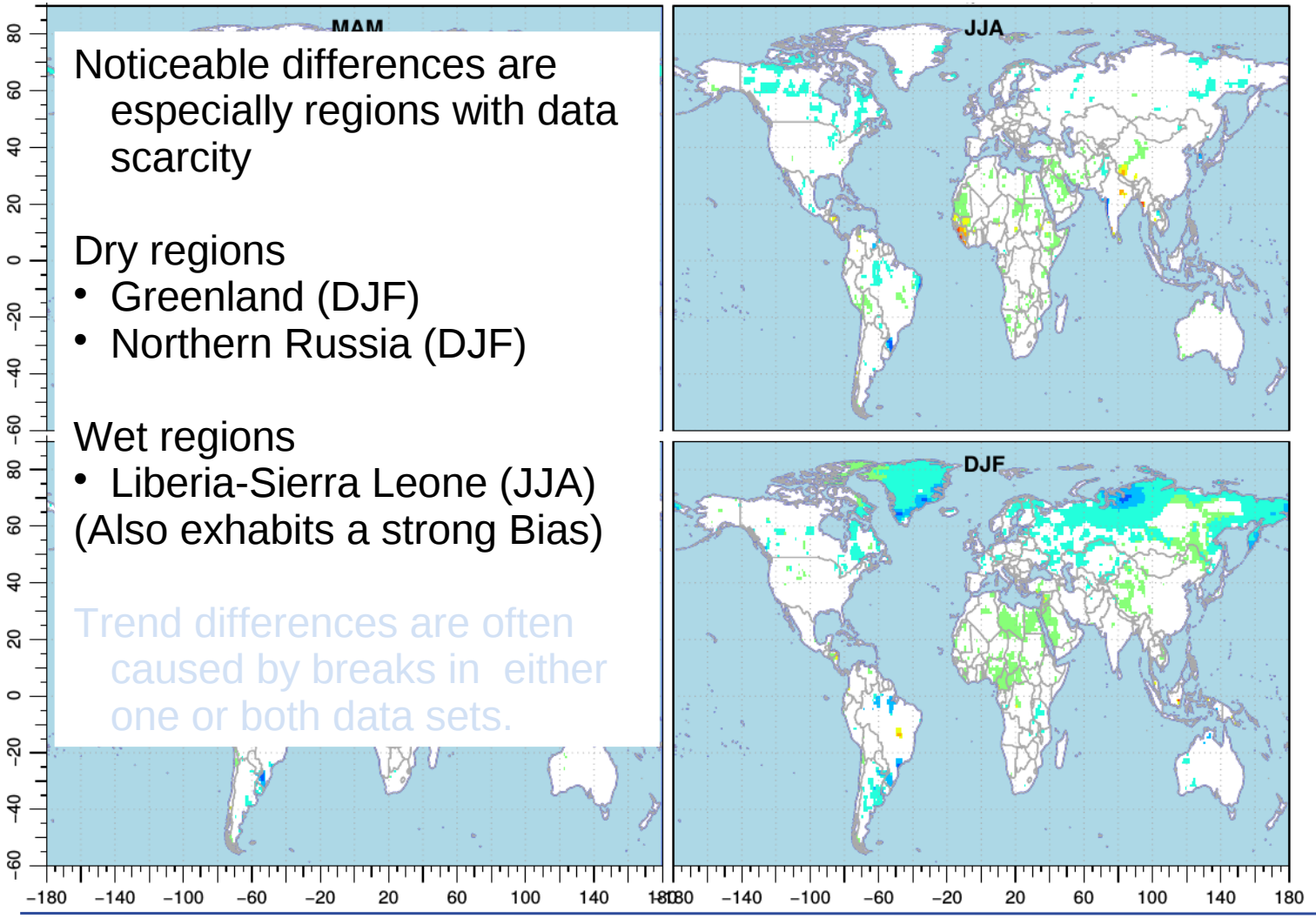
Noticeable differences are especially regions with data scarcity

Dry regions
- Greenland (DJF)
- Northern Russia (DJF)

Wet regions
- Liberia-Sierra Leone (JJA)

(Also exhabits a strong Bias)

Trend differences are often caused by breaks in either one or both data sets.



Significant (p < 0.01) SEN trends in the differences of the mean seasonal precpitation totals (1901-2010)

SEN trends (ERA-20C – Full Data Monthly)

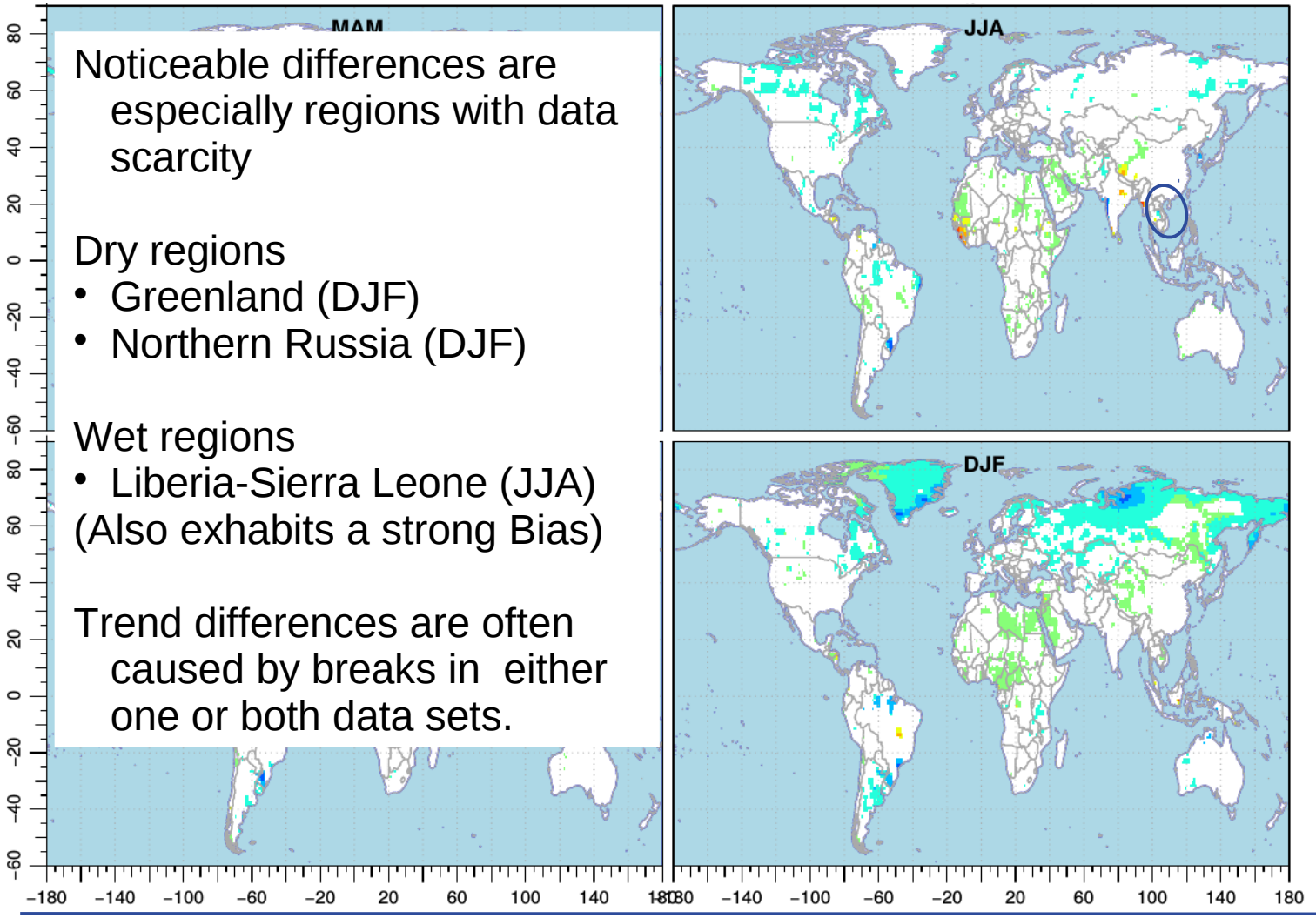
Noticeable differences are especially regions with data scarcity

Dry regions
- Greenland (DJF)
- Northern Russia (DJF)

Wet regions
- Liberia-Sierra Leone (JJA)

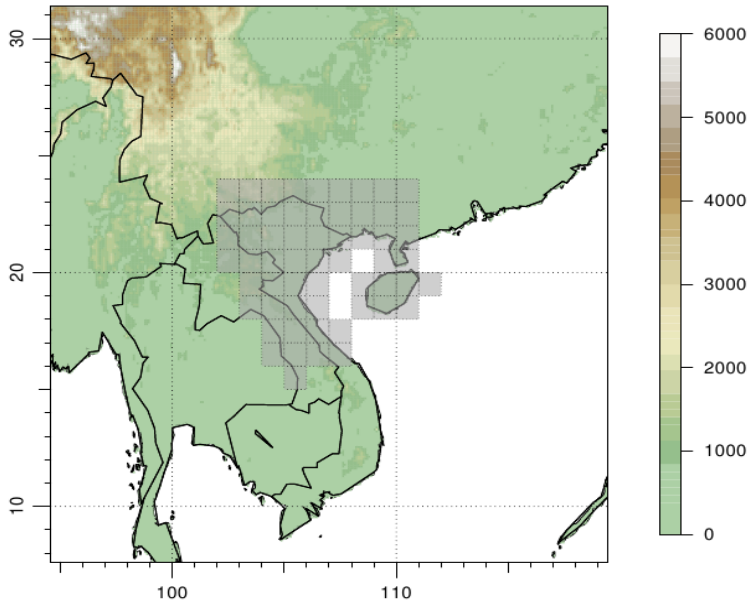
(Also exhabits a strong Bias)

Trend differences are often caused by breaks in either one or both data sets.



Significant (p < 0.01) SEN trends in the differences of the mean seasonal precpitation totals (1901-2010)

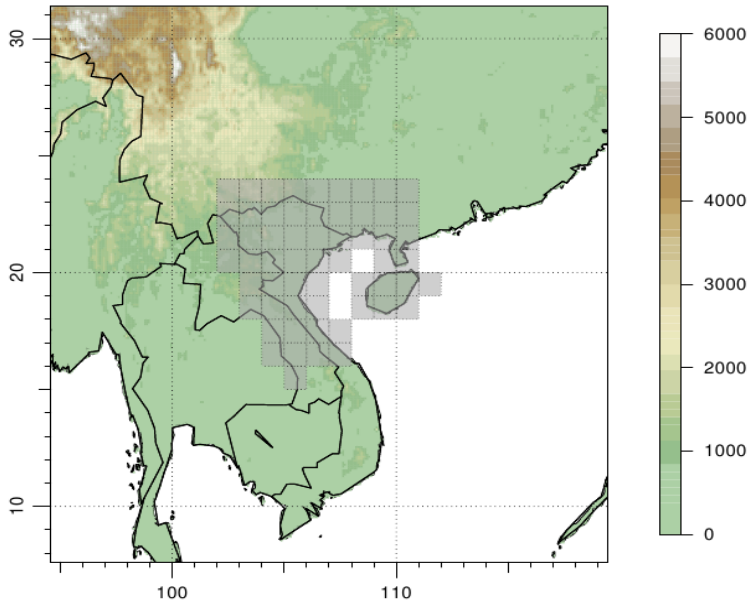
Sub-regions



Area in South-East Asia

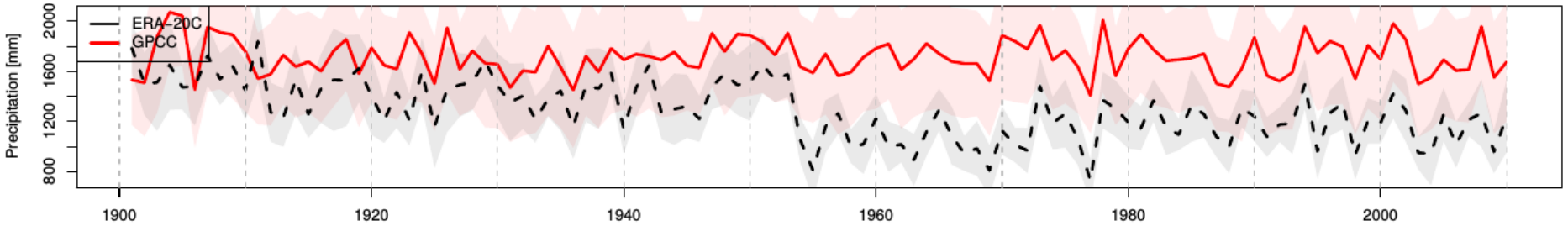
- Region that exhibits differences in the trends.
- Area with data scarcity

Sub-regions



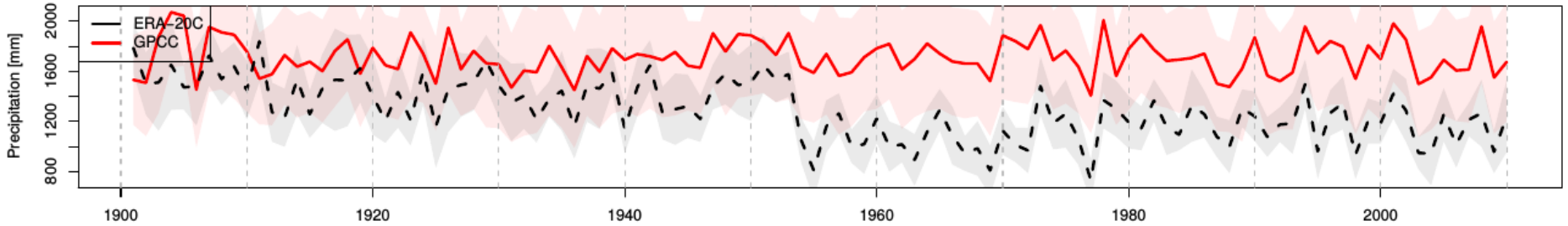
Area in South-East Asia

- Region that exhibit strong differences in the trends.
- Area with data scarcity

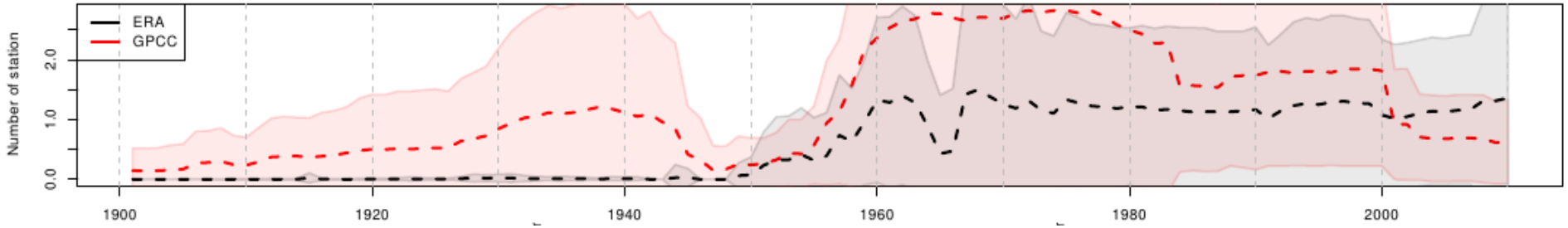


Mean annual precipitation time series across an area in South-East Asia as indicated on the map on top.
— ERA 20C — GPCC

Sub-regions

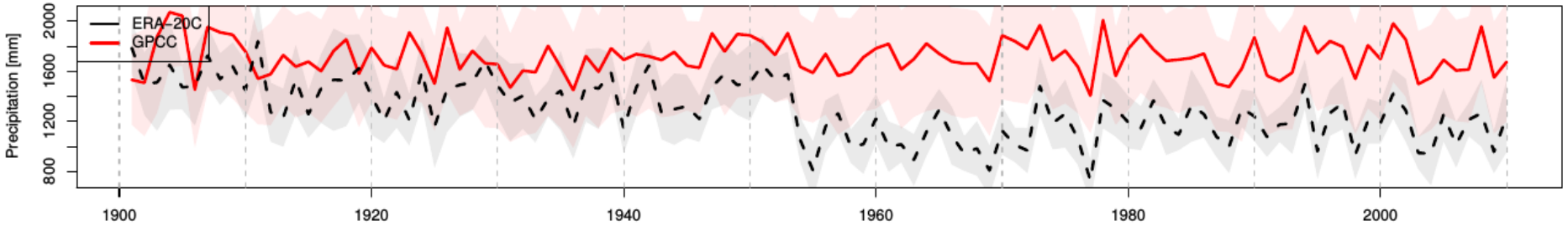


Mean annual precipitation time series across an area in South-East Asia.
— ERA 20C — GPCC

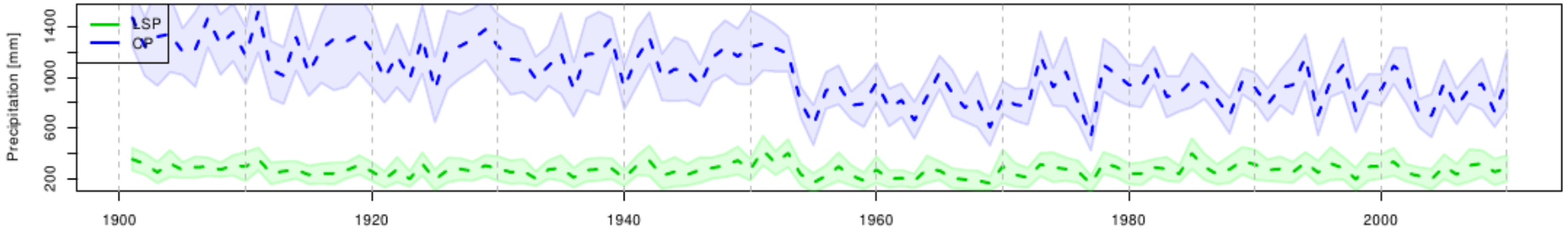


Mean number of time series across an area in South-East Asia.
— ERA 20C — GPCC

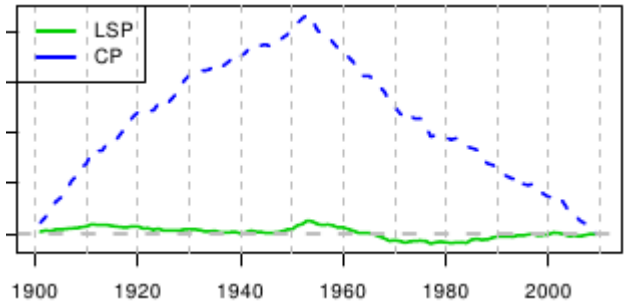
Sub-regions



Mean annual precipitation time series across an area in South-East Asia.
— ERA 20C — GPCC



Mean annual precipitation time series across an area in South-East Asia.
—Convective — Large scale precipitation



Craddock test
(Cummulated sum of anomalies)
—Convective — Large scale precipitation

SEN trends (ERA-20C – Full Data Monthly)

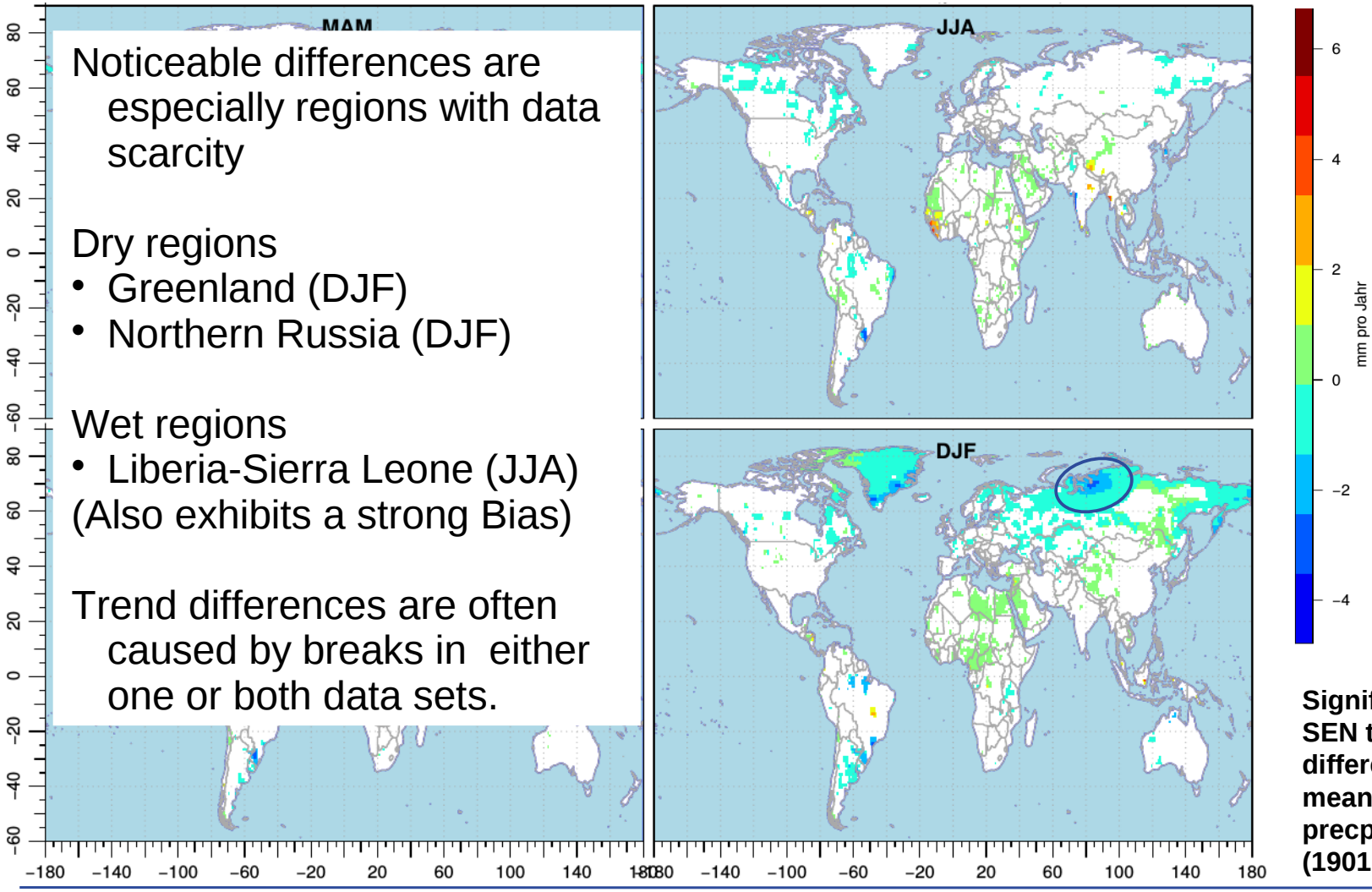
Noticeable differences are especially regions with data scarcity

Dry regions
- Greenland (DJF)
- Northern Russia (DJF)

Wet regions
- Liberia-Sierra Leone (JJA)

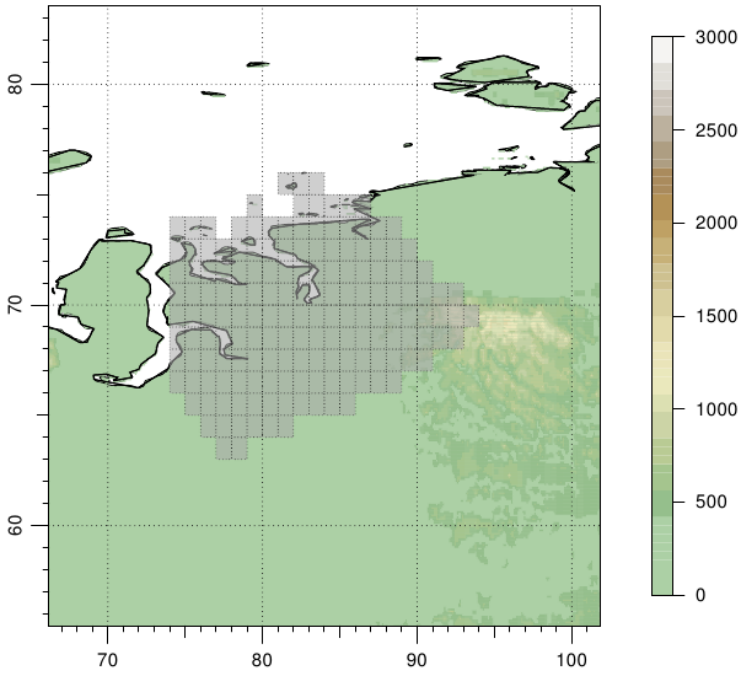
(Also exhibits a strong Bias)

Trend differences are often caused by breaks in either one or both data sets.



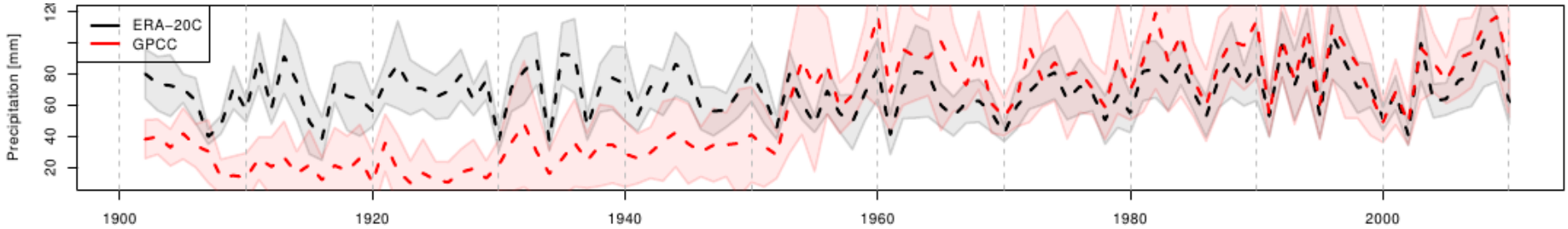
Significant (p < 0.01) SEN trends in the differences of the mean seasonal precpitation totals (1901-2010)

SEN trends (ERA-20C – Full Data Monthly)



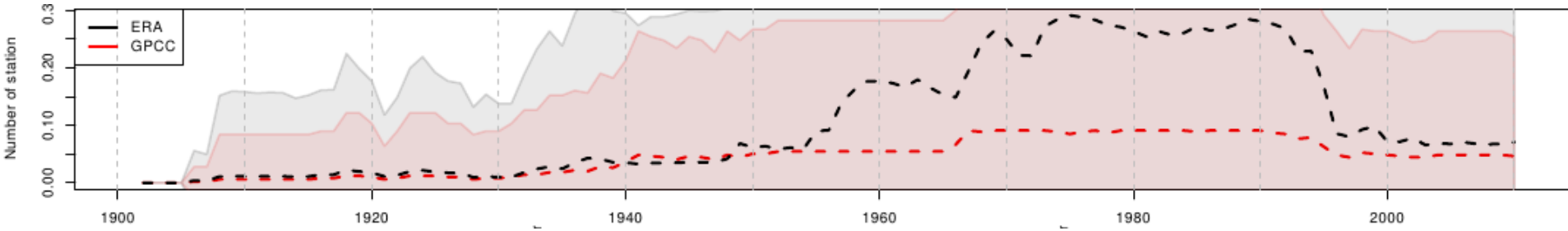
Area in northern Russia

- Region that exhibit strong differences in the trends.
- Area with data scarcity

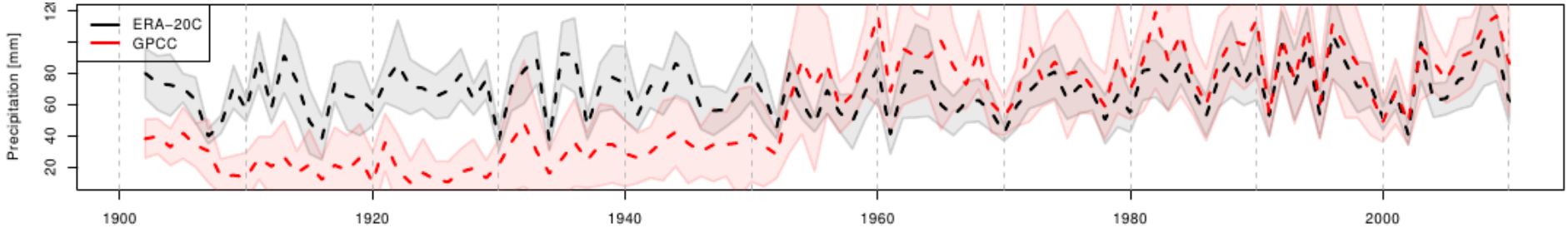


Mean DJF precipitation time series across an area in Northern Russia.
— ERA 20C — GPCC

SEN trends (ERA-20C – Full Data Monthly)

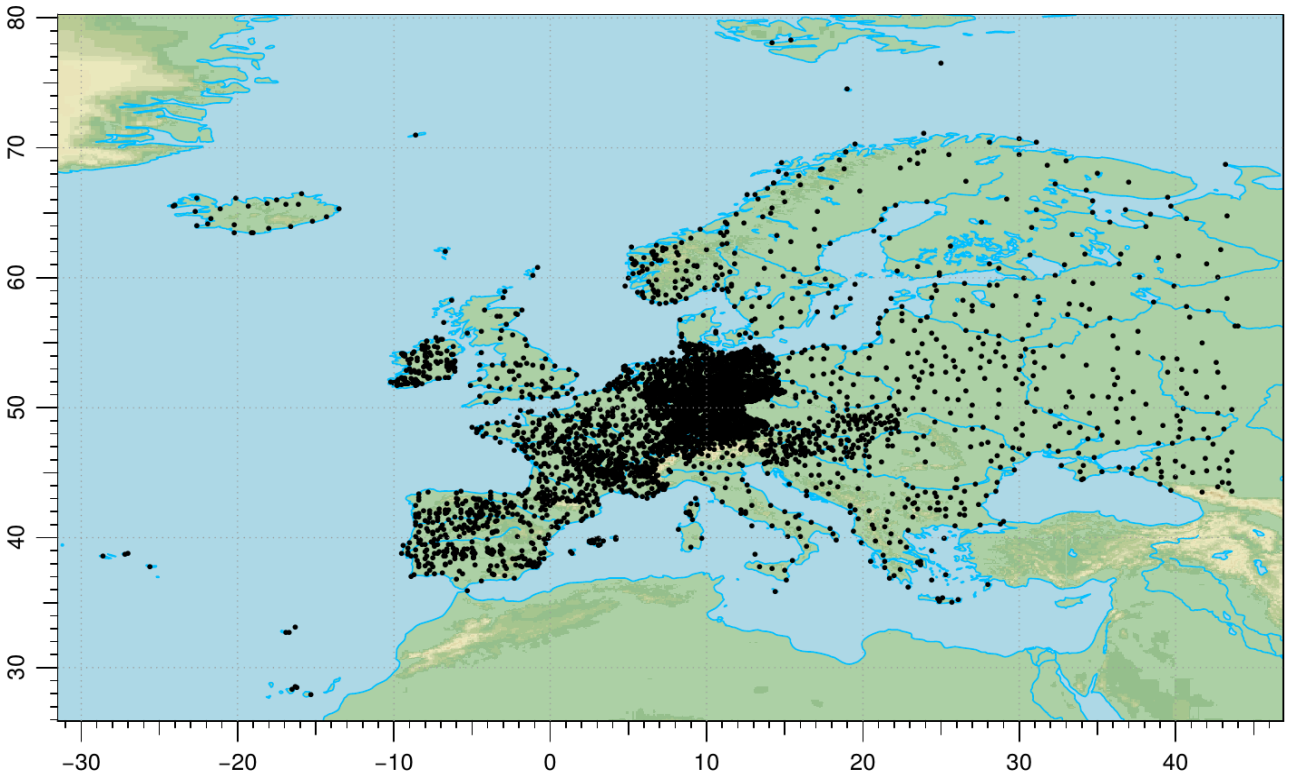


Mean DJF number of time series across an area in Northern Russia.
— ERA 20C — GPCC



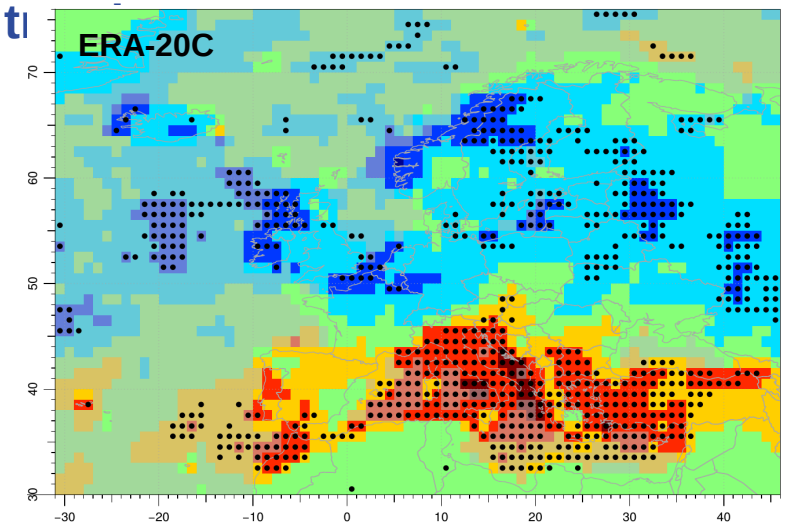
Mean DJF precipitation time series across an area in Northern Russia.
— ERA 20C — GPCC

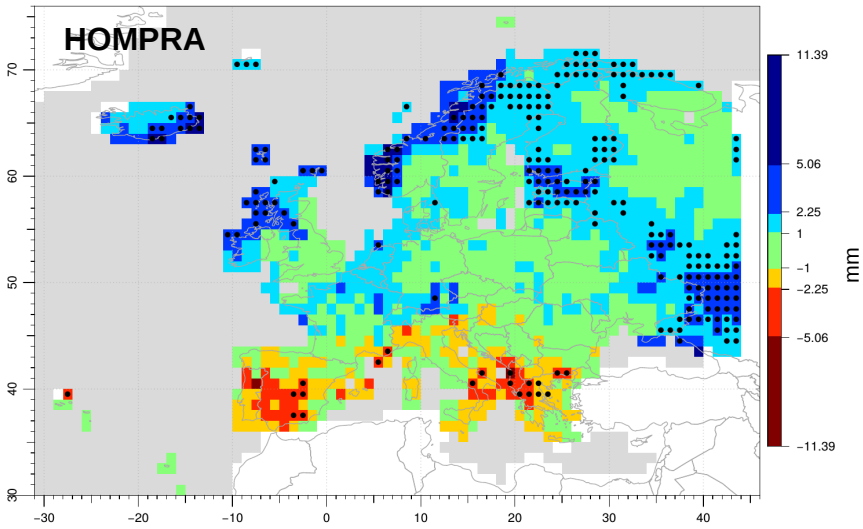
GPCC HOMPRA Europe Version 0.1



- Monthly land-surface precipitation from rain-gauges
- Homogenized using 4462 carefully chosen station
- Covering 1951-2005

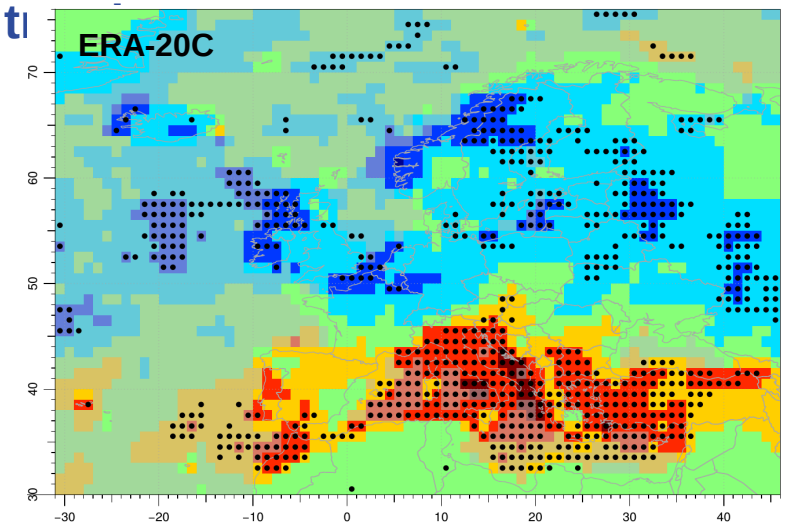
Annual t

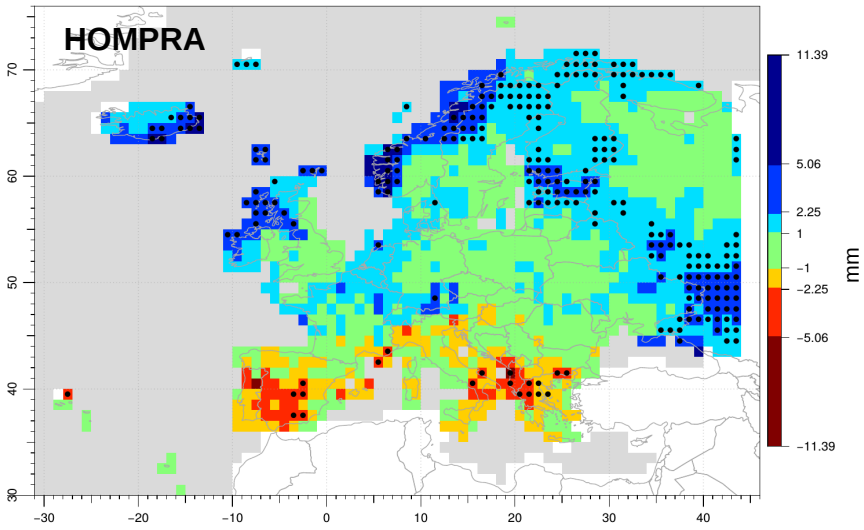


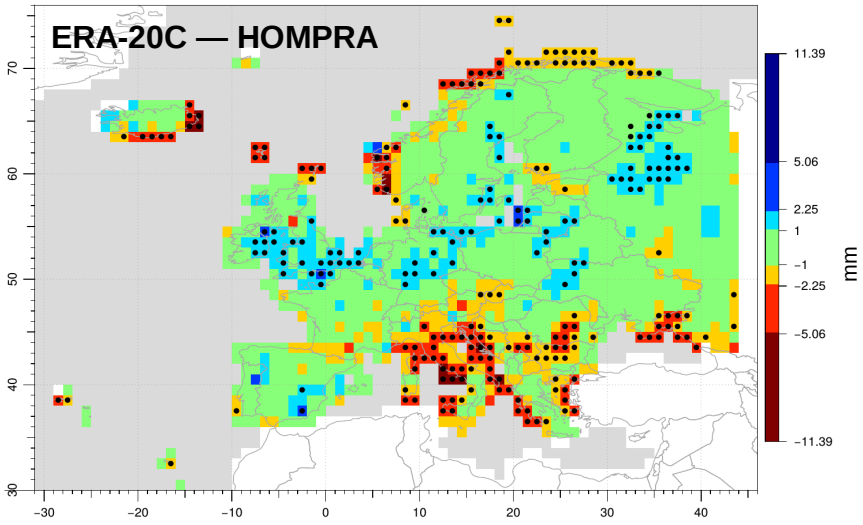


- Similar structure
- ERA more trends than HOMPRA

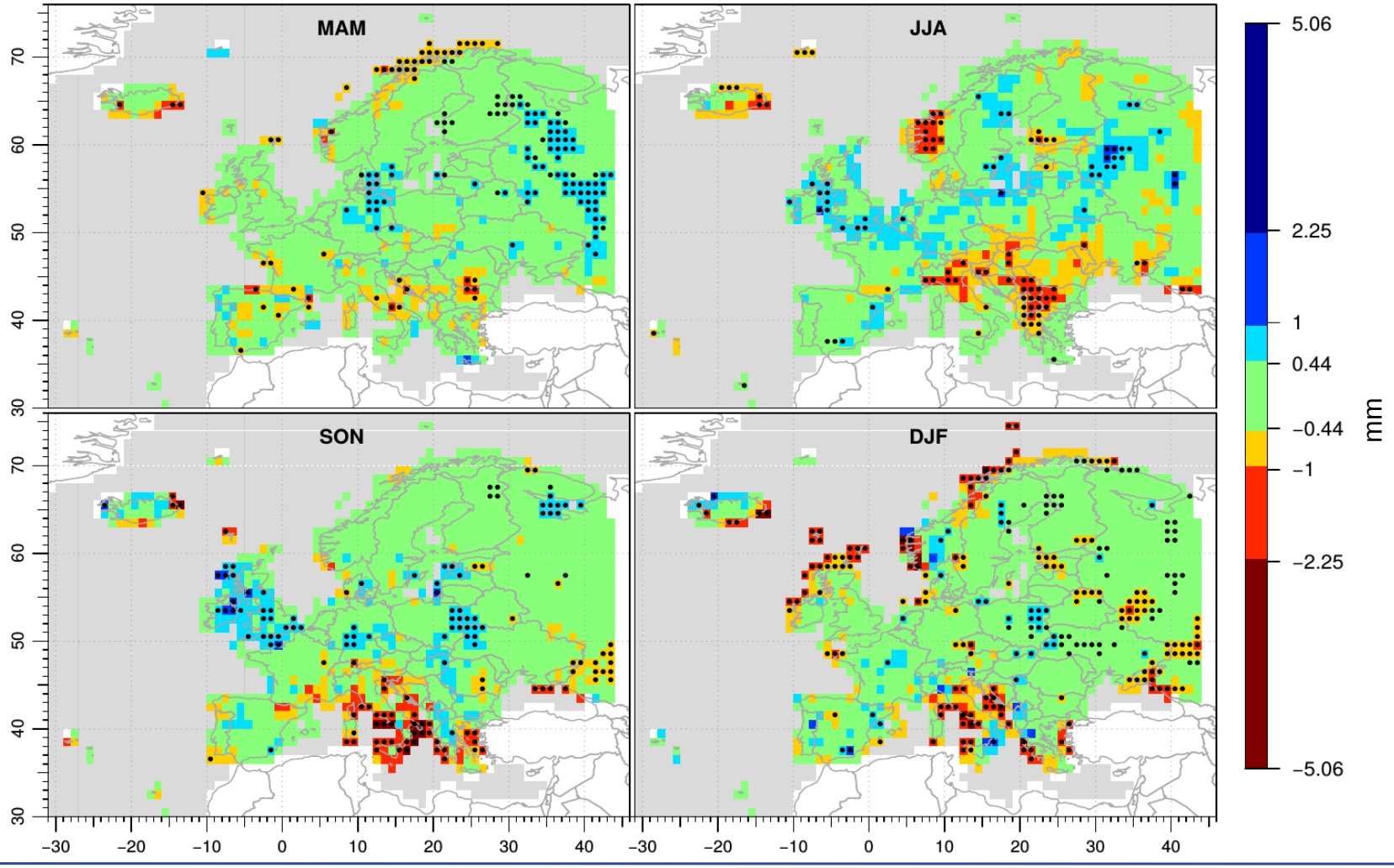
Annual t


ERA-20C
70
60
50
40
30
−30
−20
−10
0
10
20
30
40


HOMPRA
70
60
50
40
30
−30
−20
−10
0
10
20
30
40
11.39
5.06
2.25
1
−1
−2.25
−5.06
−11.39
mm


ERA-20C — HOMPRA
70
60
50
40
30
−30
−20
−10
0
10
20
30
40
11.39
5.06
2.25
1
−1
−2.25
−5.06
−11.39
mm

Seasonal trend (ERA-20C — HOMPRA)



Conclusions

- Largest differences are found in regions with **data scarcity** in time and/or the area.
- **Seasonal sensitivity** is more pronounced in the northern hemisphere.

Assessment of the contingency table as Heidke Skill Score (HSS), hit and false alarm rate and frequency bias confirm this.

- Strong biases are also found in **mountainous regions** (ERA-20C shows more precipitation than GPCC).
- **Trend differences** often go along with **breaks** in the time series in either one or both of the data sets.
- Breaks in ERA can also be found in convective precipitation
- **Trend comparisons in Europe** show that trends in ERA-20C are stronger than in HOMPRA, but show the same spatial structure.

Prospectives

Evaluation on daily scale with GPCC Full Data Daily Version 1 (1988-2013)

- of convective and large scale precipitation
(in areas with high station density)
- ETCCDIs (Klein Tank et al., 2009)

Better understanding of precipitation BIAS
Including additional parameters

- Large scale and convective precipitation
- Wind direction and force
- Orographie

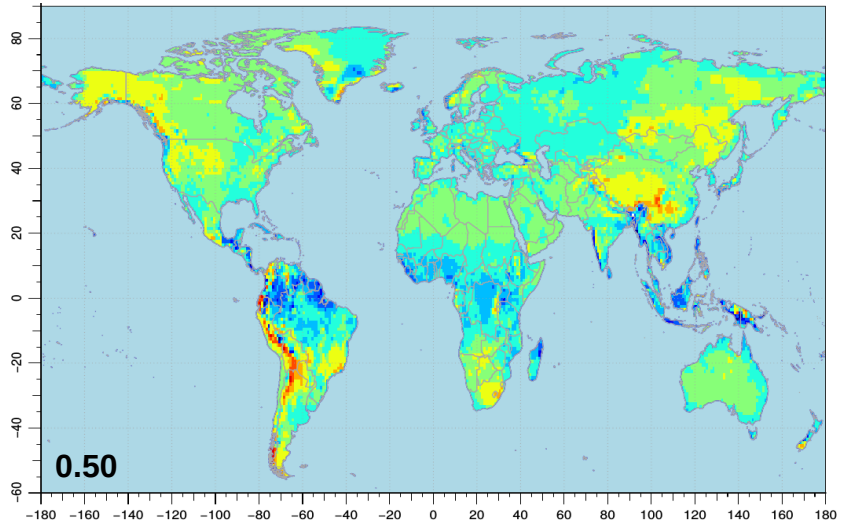
Thank you for your attention!

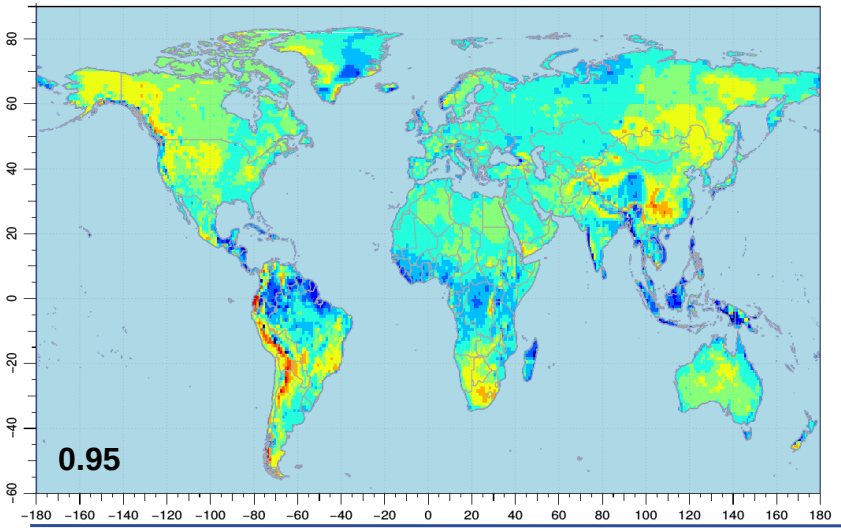
Poli P., H. Hersbach, D. Tan, D. Dee, J.-N. Thépaut, A. Simmons, C. Peubey, P. Laloy-aux, T. Komori, P. Berrisford, R. Dragani, Y. Trémolet, E. H´lm, M. Bonavita, L. Isaksen and M. Fisher (2013): The data assimilation system and initial performance evaluation of the ECMWF pilot reanalysis of the 20th-century assimilating surface observations only (ERA-20C), ERA Report Series 14, http://www.ecmwf.int/publications/library/do/references/show?id=90833.

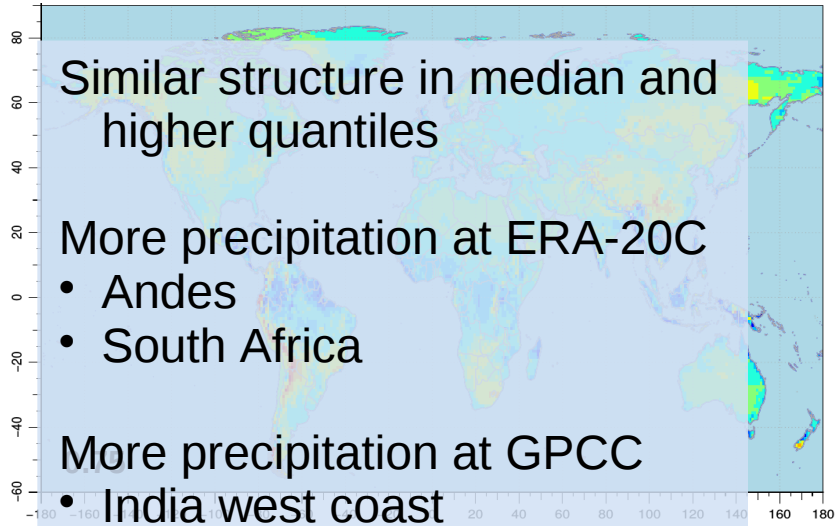
Schneider U., A. Becker, P. Finger, A. Meyer-Christoffer, M. Ziese, B. Rudolf (2014): GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle, Theoretical and Applied Climatology 115.1-2 (2014): 15-40, DOI: 10.1007/s00704-013-0860-x.

Legates, D.R. (1987): A climatology of global precipitation. Publ. in Climatology 40 (1), Newark, Delaware, 85 pp.

Difference of temporal quantiles (ERA-20C - GPCC)



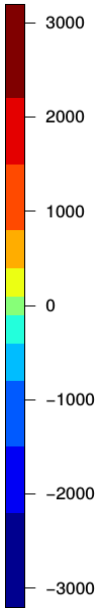




Similar structure in median and higher quantiles

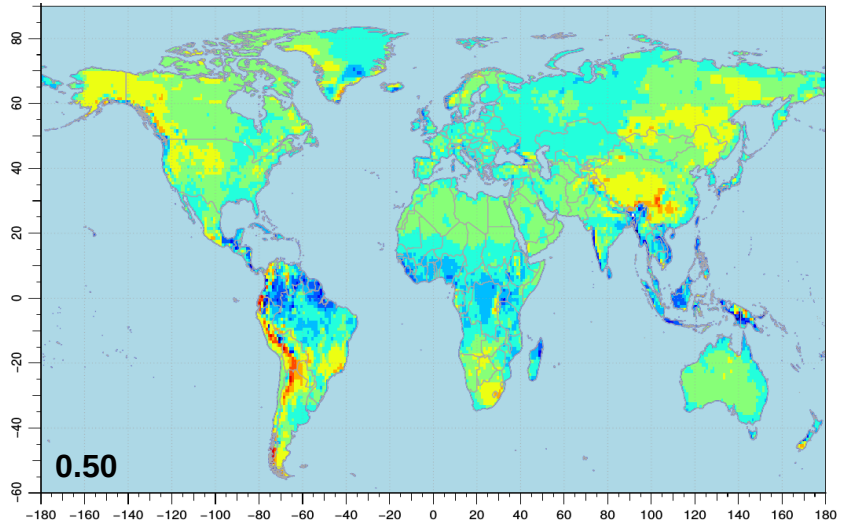
More precipitation at ERA-20C
- Andes
- South Africa

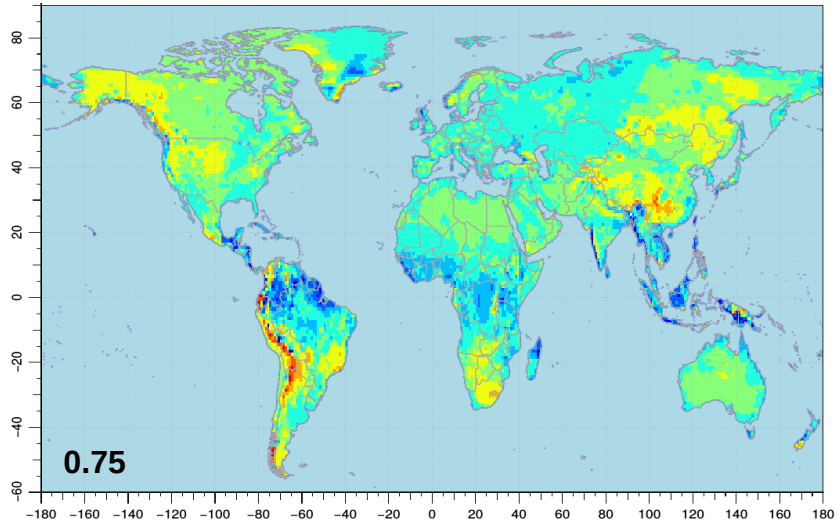
More precipitation at GPCC
- India west coast
- Africa ITCC

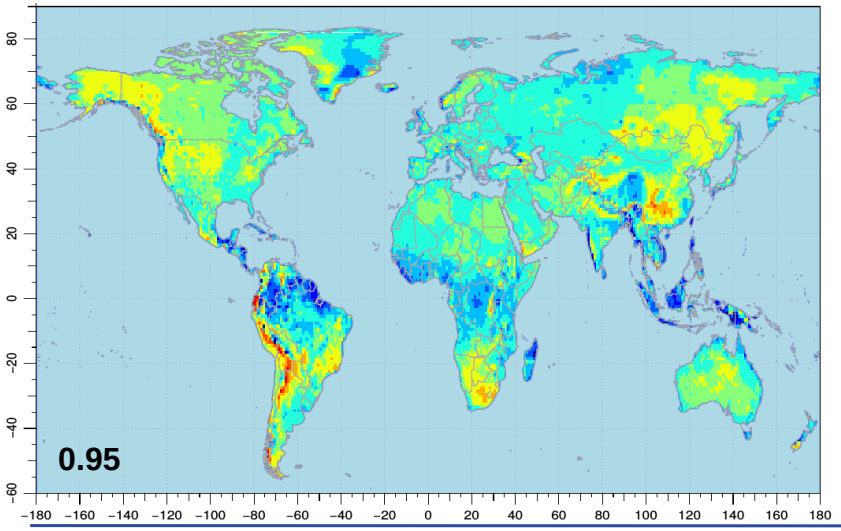


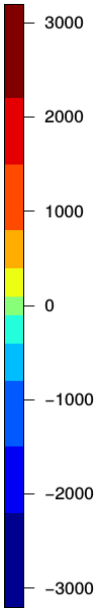
Differences of the annual temporal precipitation quantiles (1901-2010)

Difference of temporal quantiles (ERA-20C - GPCC)



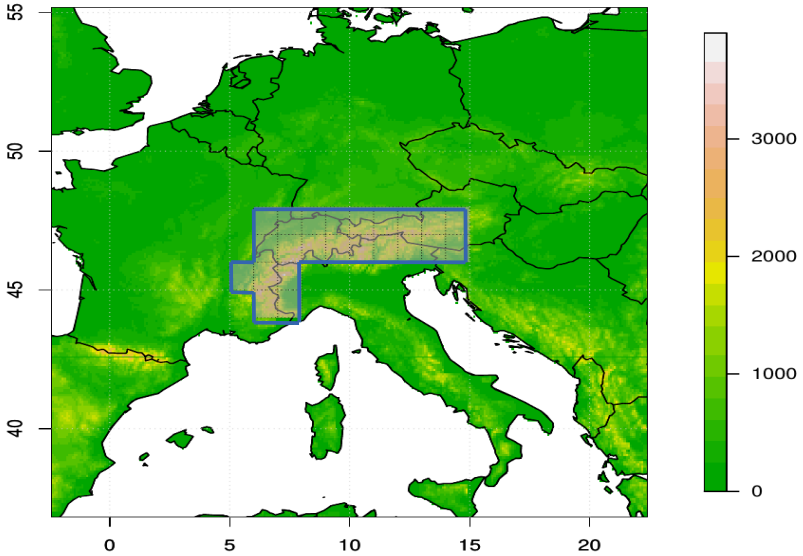






Differences of the annual temporal precipitation quantiles (1901-2010)

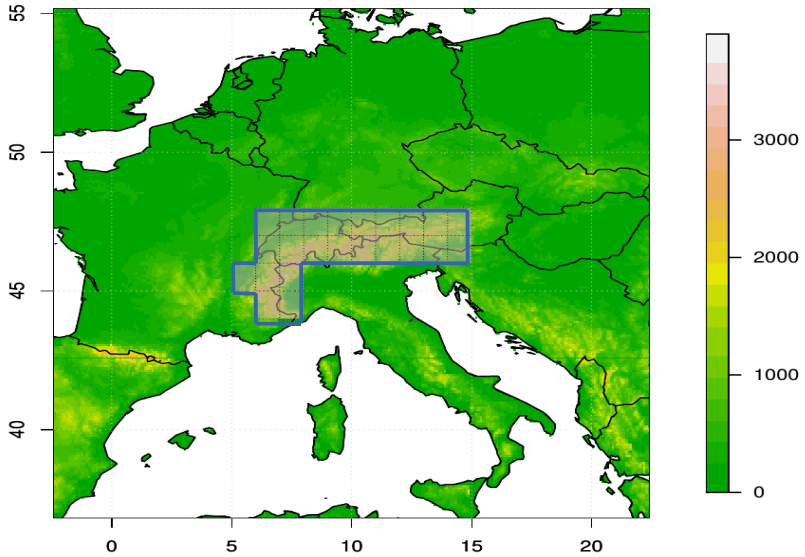
Sub-regions



Region that exhibits especially **good agreement** in the global scores

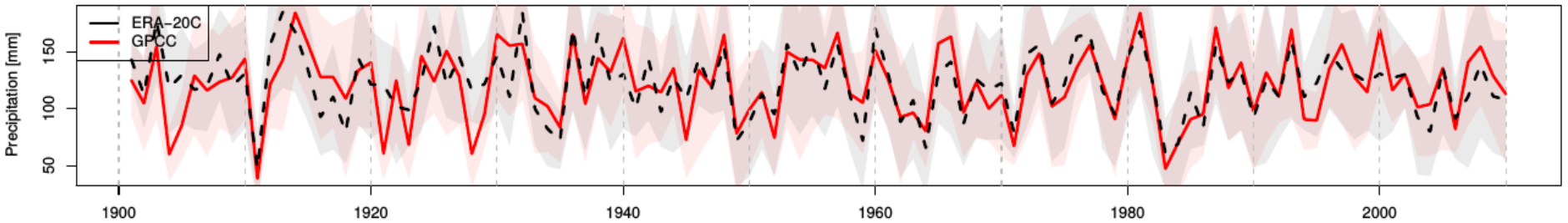
- High correlation
- Area with many stations
- Difficult mountainous region

Sub-regions



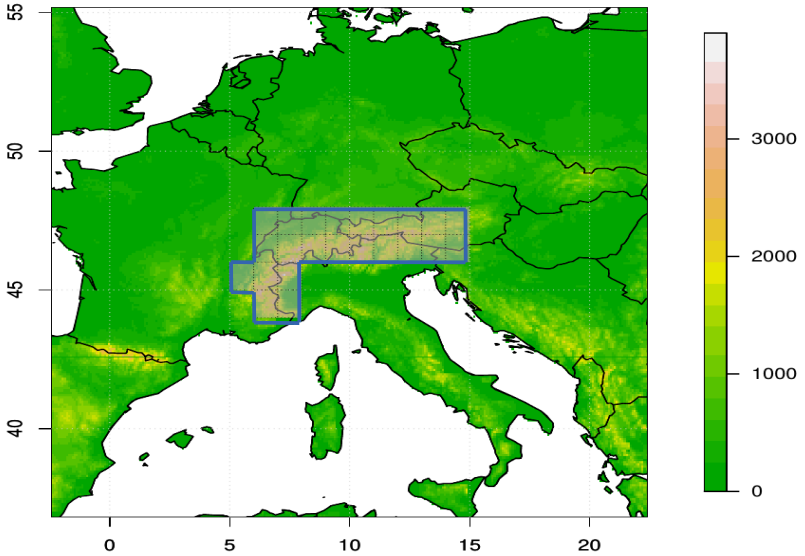
Region that exhibit especially **good agreement** in the global scores

- High correlation
- Area with many stations
- Difficult mountainous region

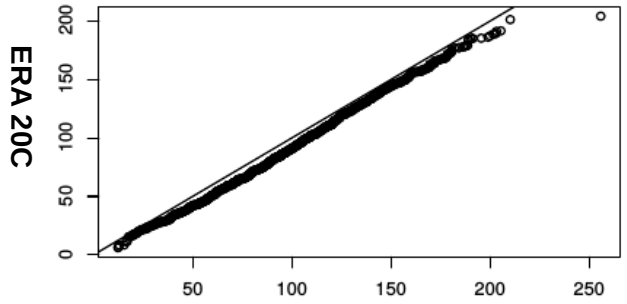


Mean July precipitation time series across an alpine area as shown on the map.
— ERA 20C — GPCC

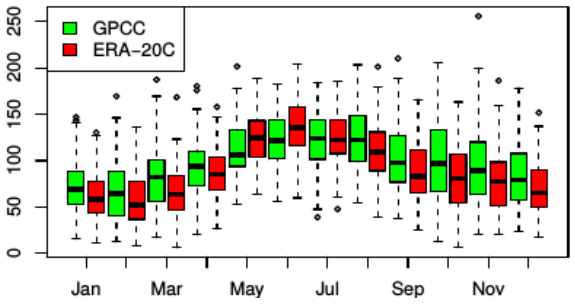
Sub-regions



- Region that exhibit especially good agreement in the global scores
- Example of an area with high correlation
- Area with many stations

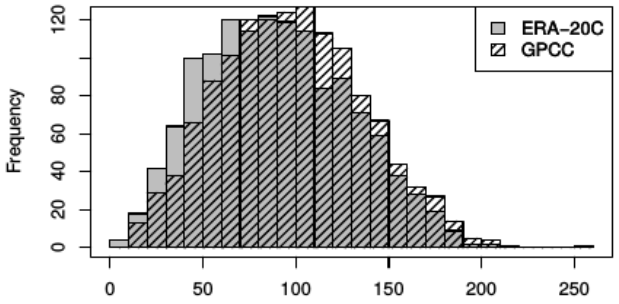


QQ-plot of monthly totals



Box-Whisker-Plot of monthly totals

ERA-20C GPCC



Histogram of monthly totals

ERA-20C GPCC

ERA-20C

- Based on the ECMWF forecast model IFS version Cy38r1 with a spatial resolution of about 125 km
- Spanning 1900-2010
- Surface forcings are the same as will be in the final product
- Only surface observations are assimilated namely marine winds and pressure

→ This allows comparison with independent, not assimilated data.

See *Poli et al., 2013*

GPCC Product
Full Data Daily Version 1

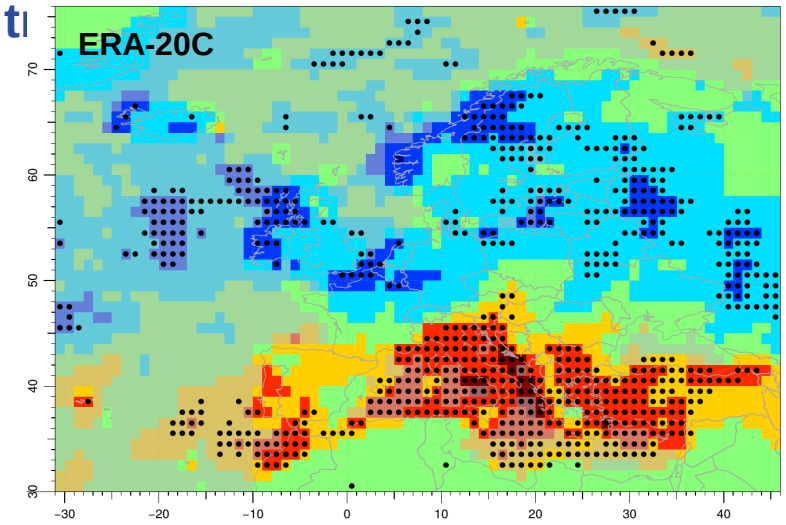
- Daily land-surface precipitation from rain-gauges
- Spanning **1901-2013**
- Gridded using modified SPHEREMAP
- New release

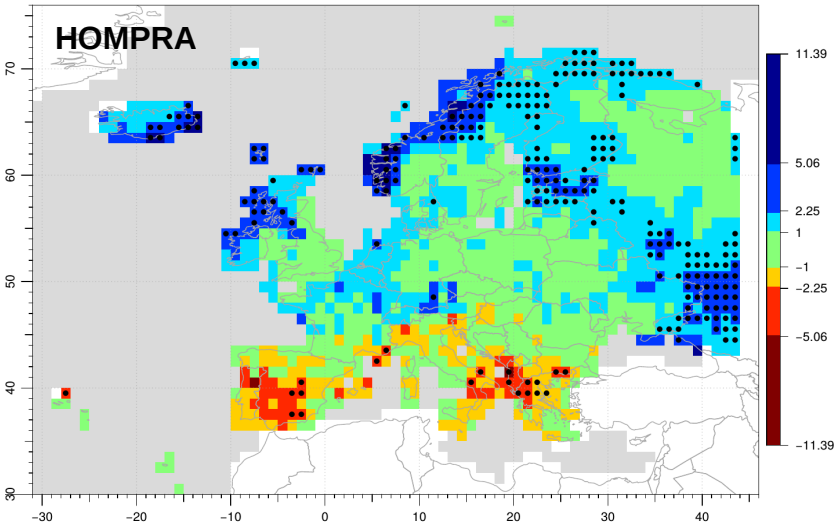
See *Schneider et al., 2014.*

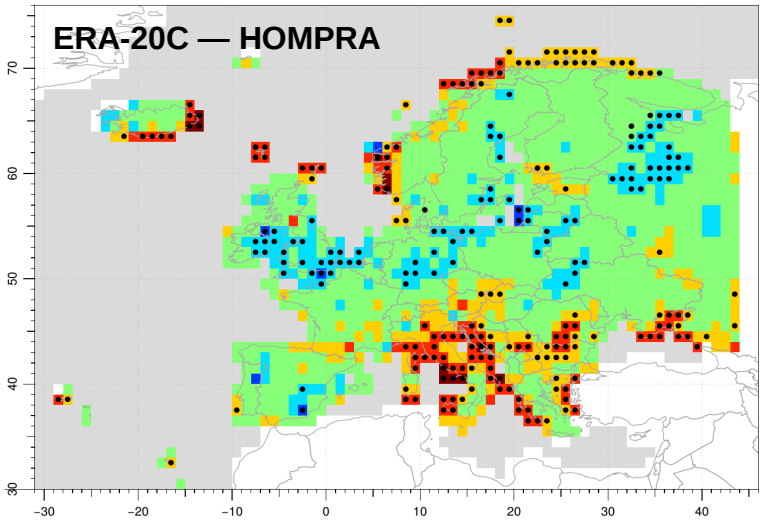
Corrected for systematic errors applying Legates correction *(Legates, 1987)*

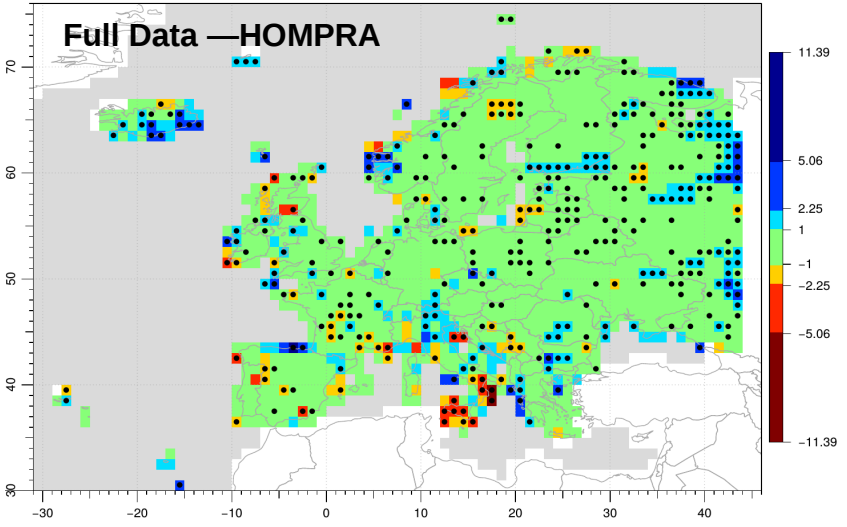
Annual

t

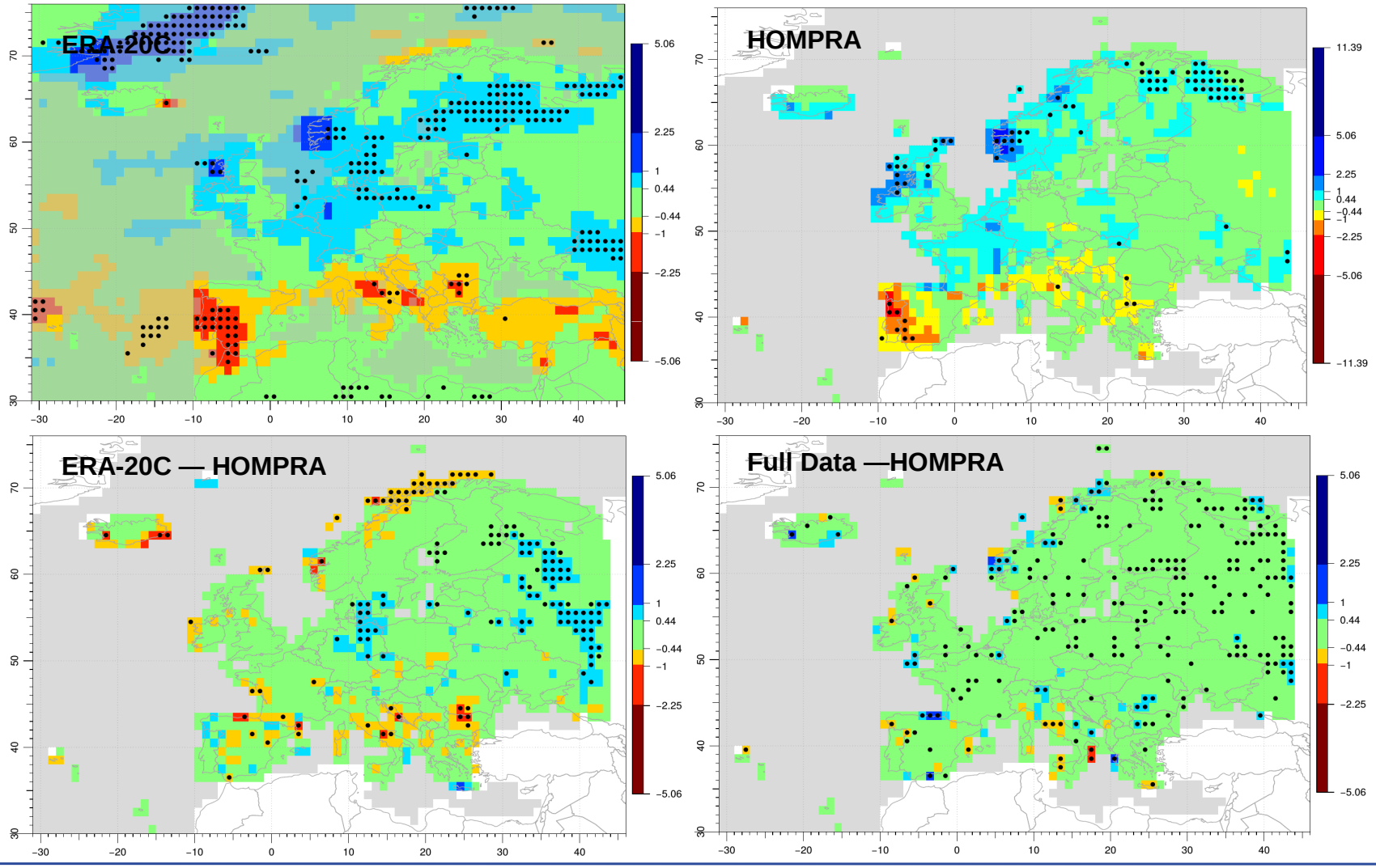

ERA-20C


HOMPRA
11.39
5.06
2.25
1
−1
−2.25
−5.06
−11.39

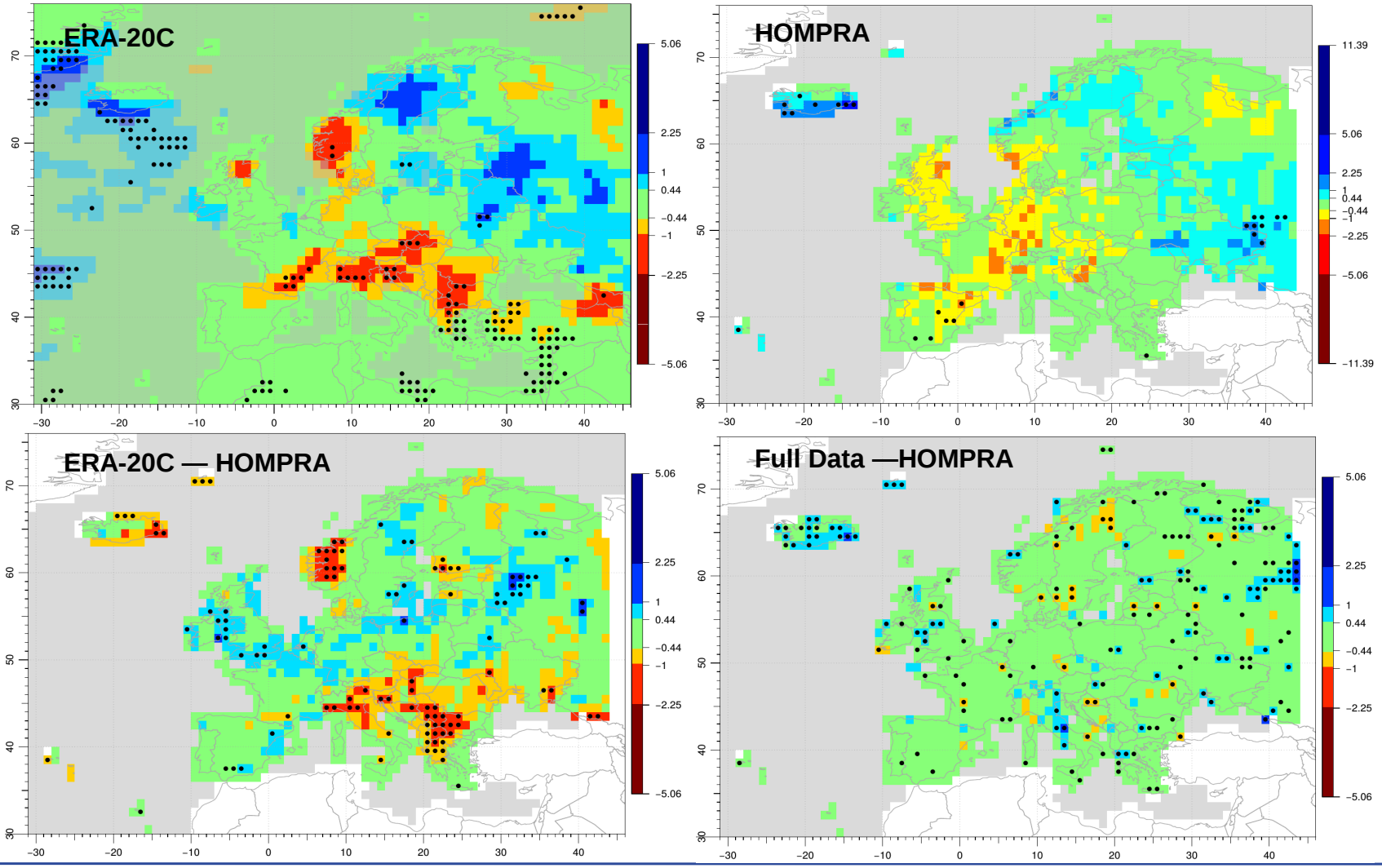

ERA-20C — HOMPRA


Full Data —HOMPRA
11.39
5.06
2.25
1
−1
−2.25
−5.06
−11.39

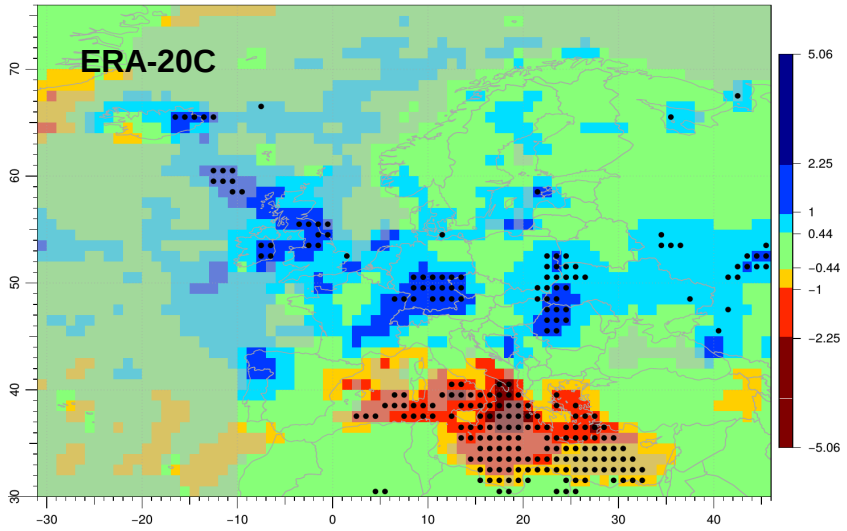
Seasonal trend

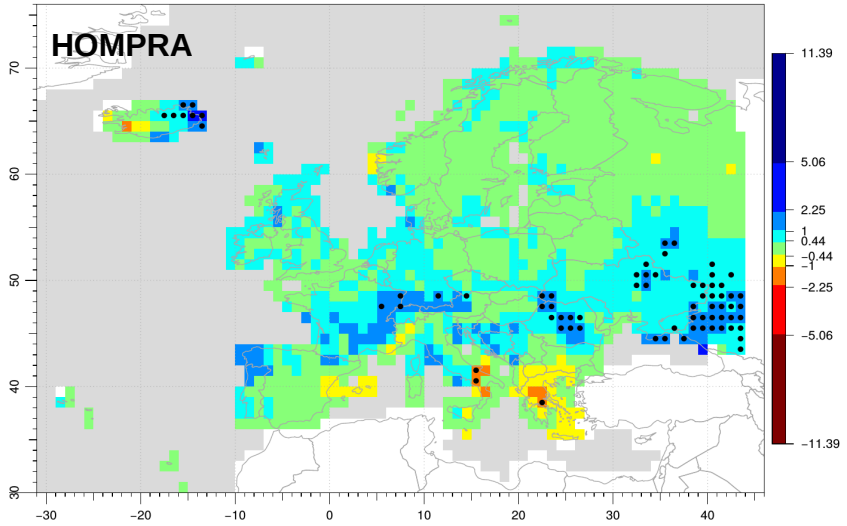


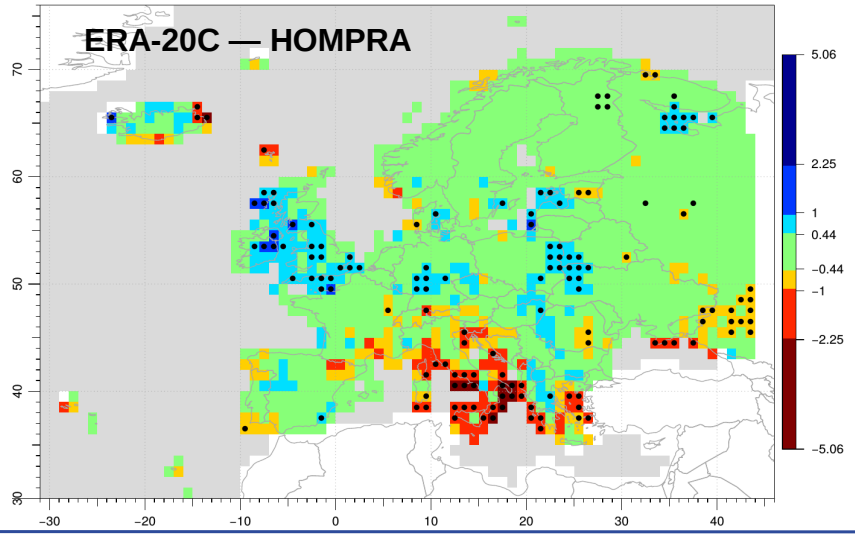
Seasonal trend

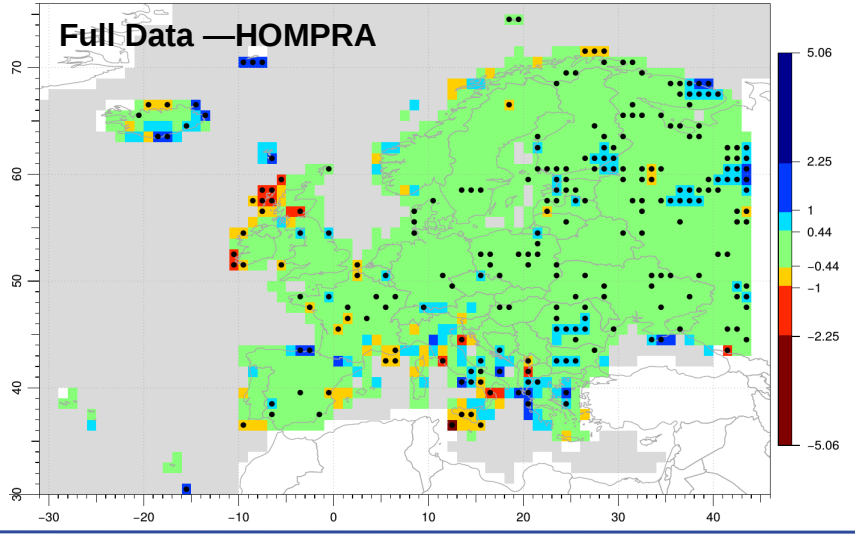


Seasonal trend

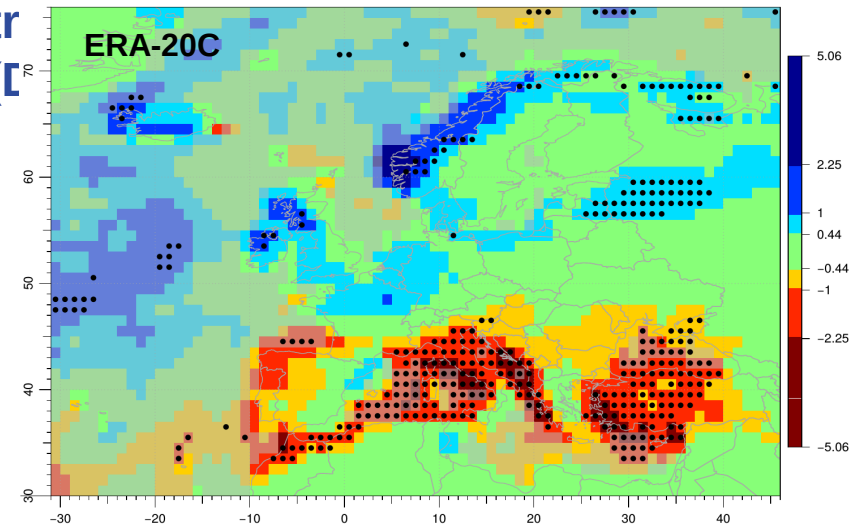


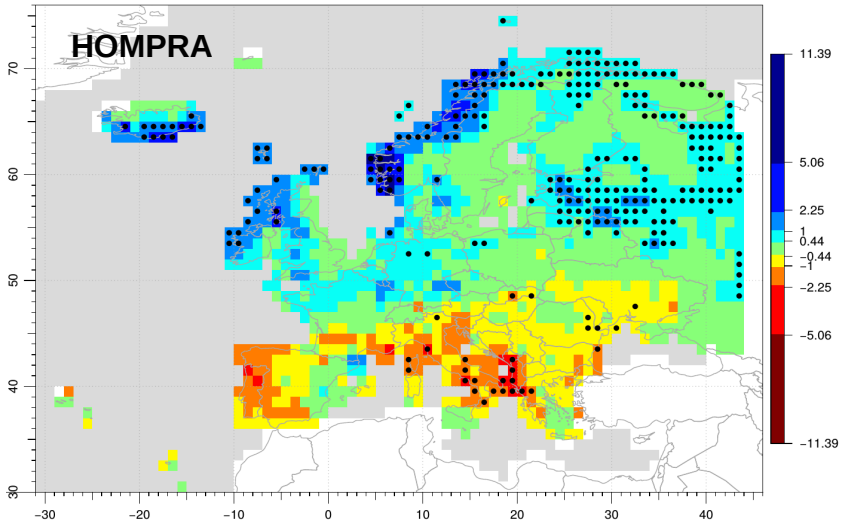


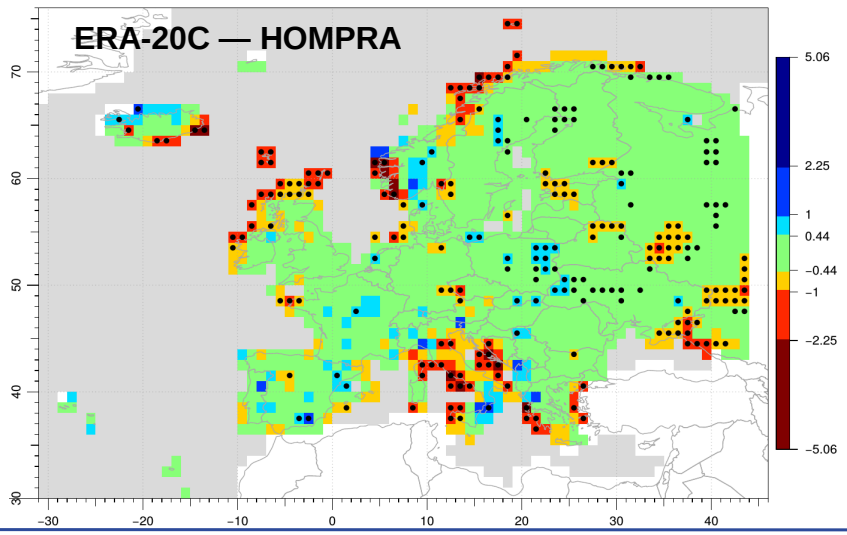


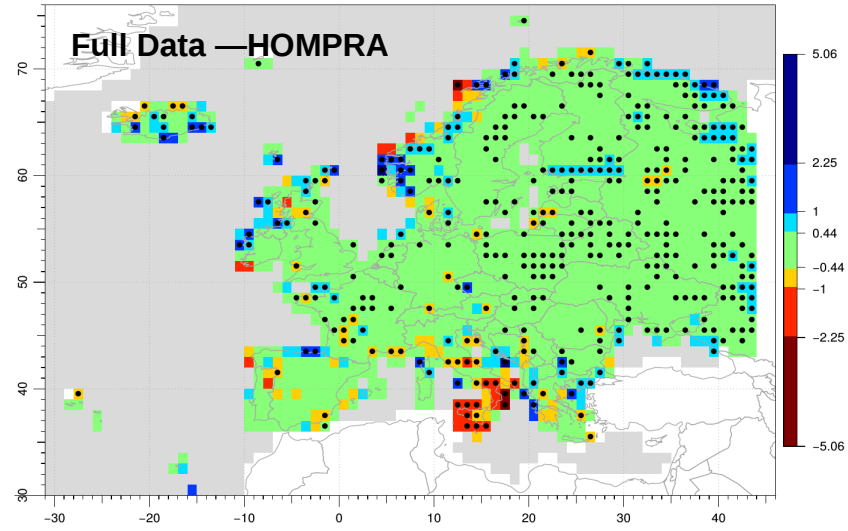


Seasonal
tr
(D

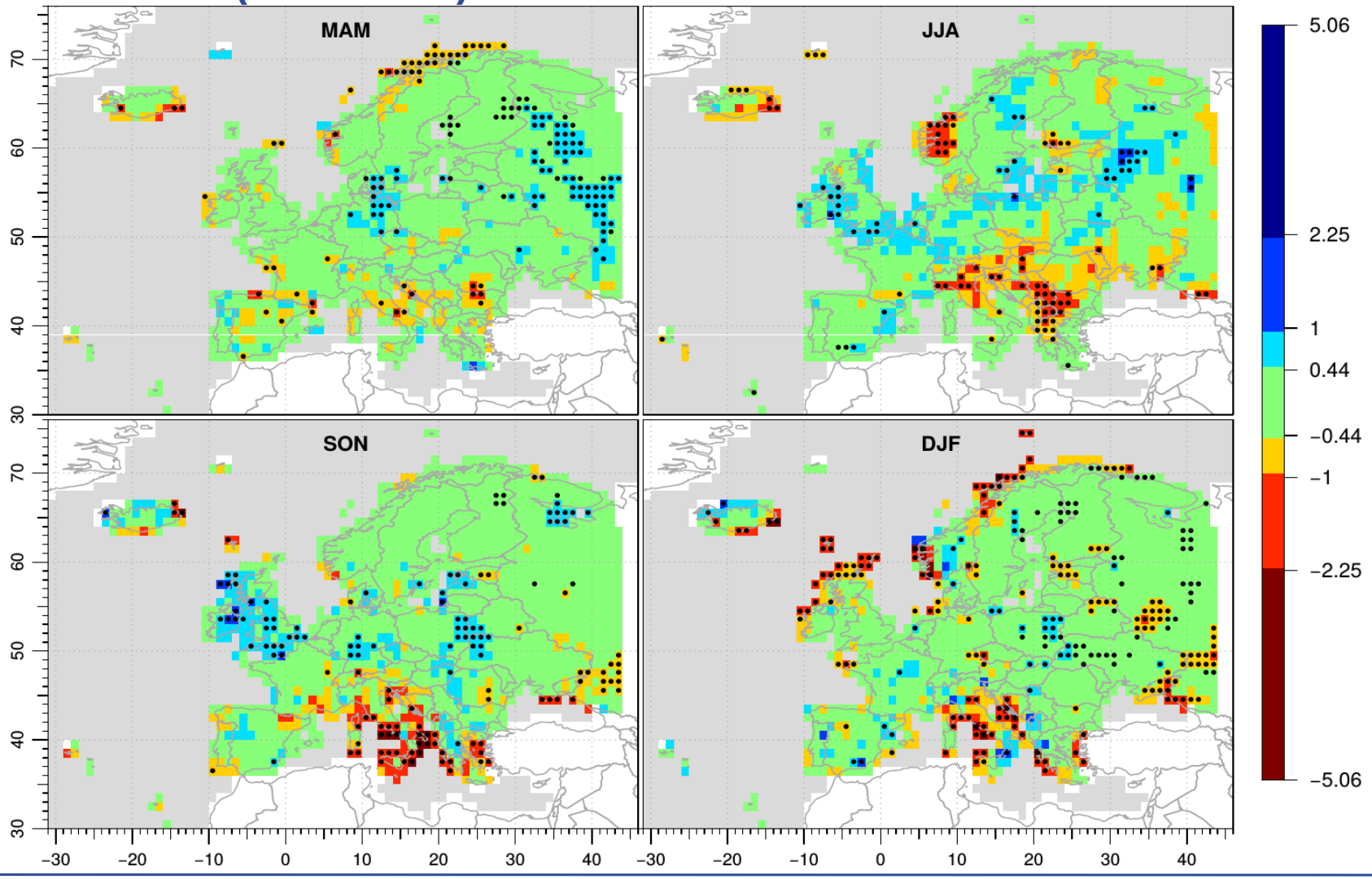


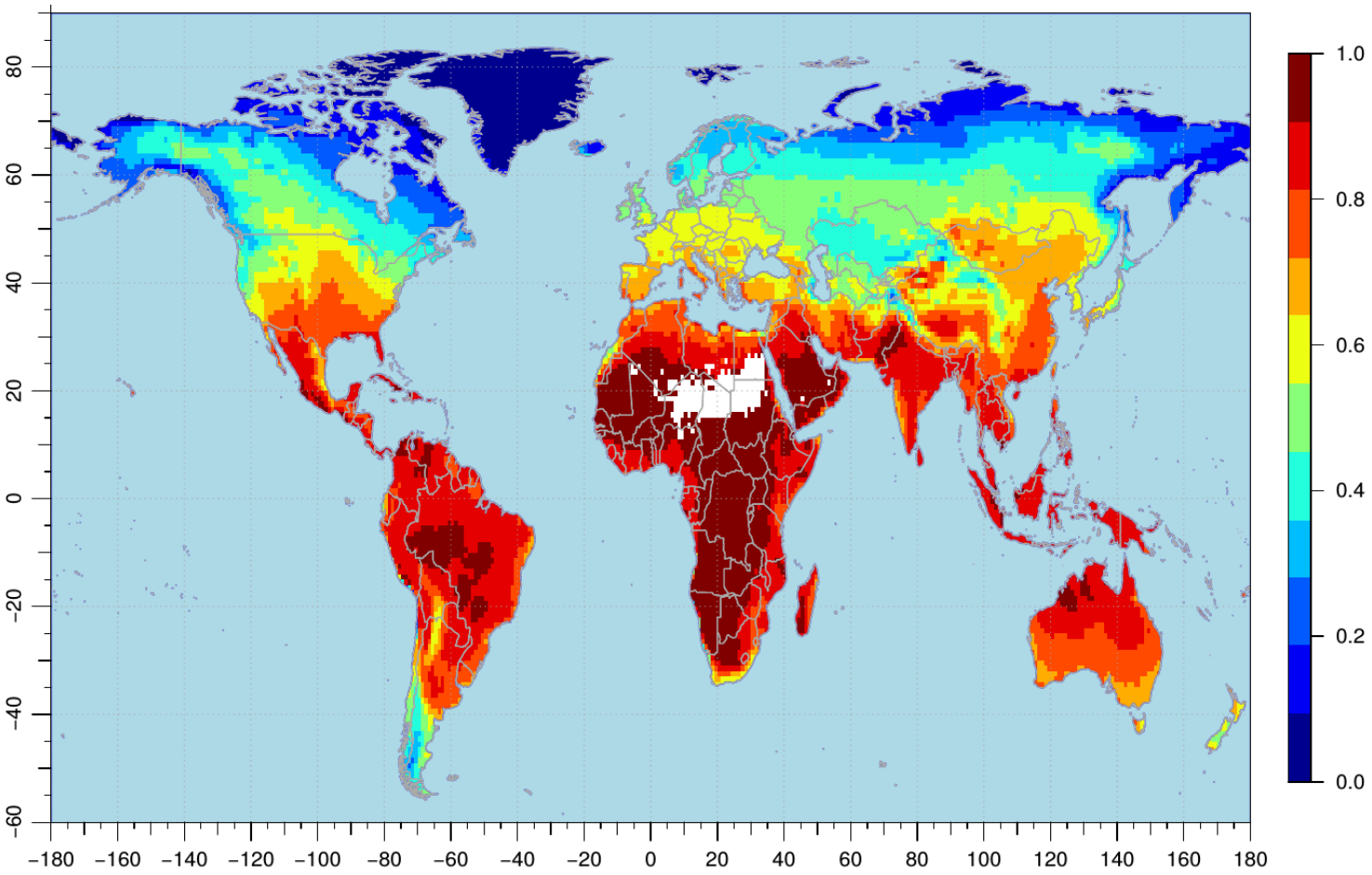




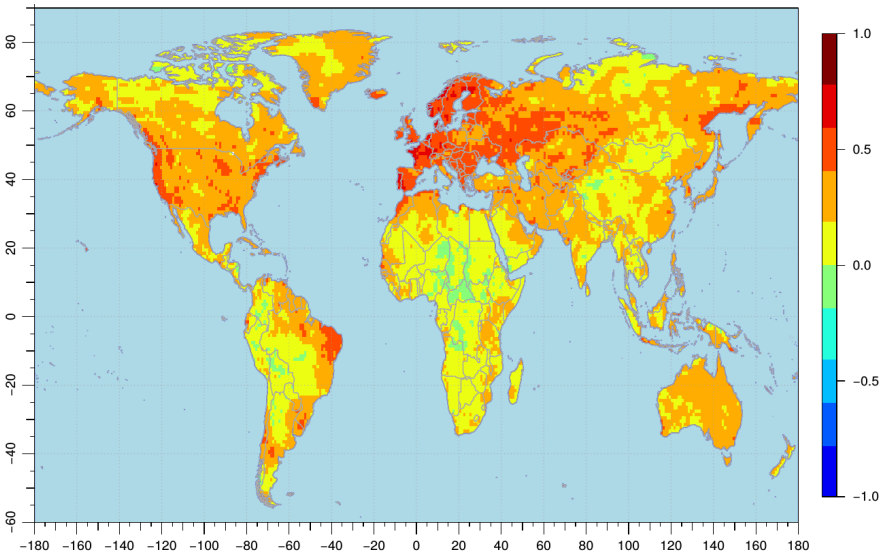


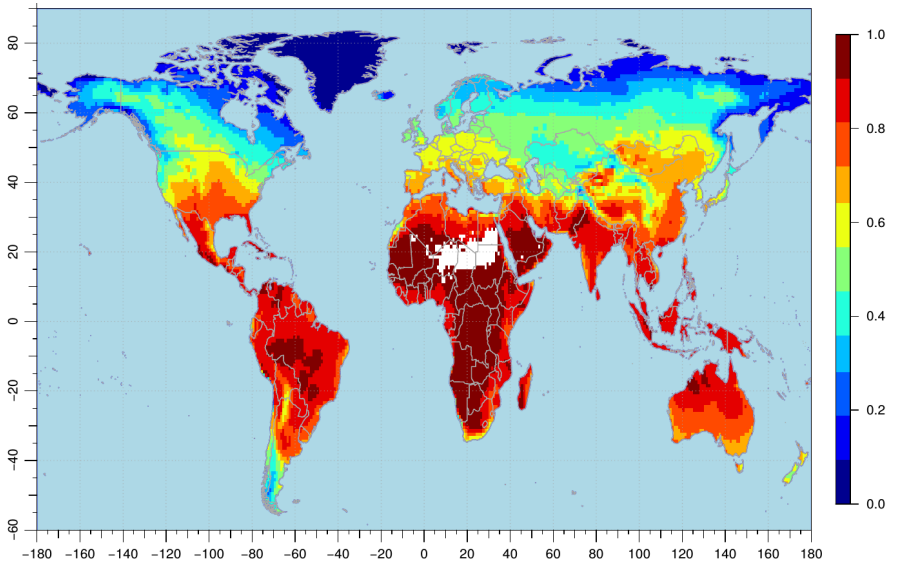
Seasonal trend (ERA - HOM)




80
60
40
20
0
-20
-40
-60
-180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180
1.0
0.8
0.6
0.4
0.2
0.0

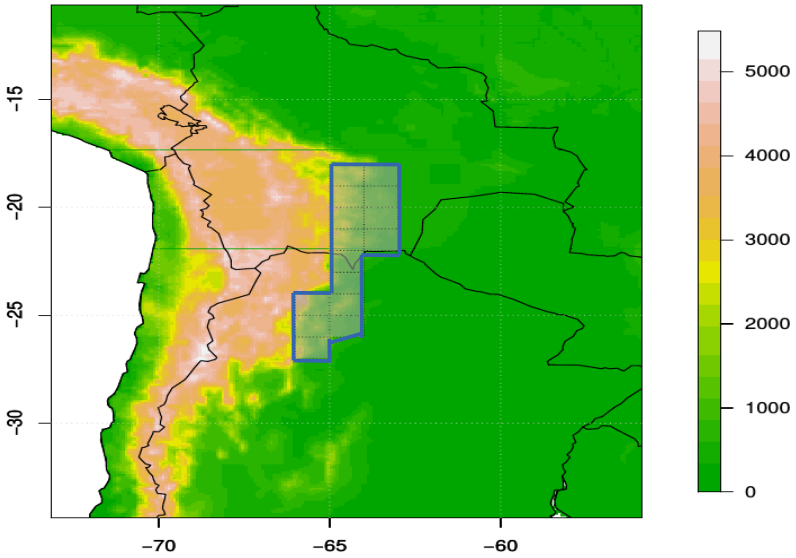
Kendall correlation coefficient

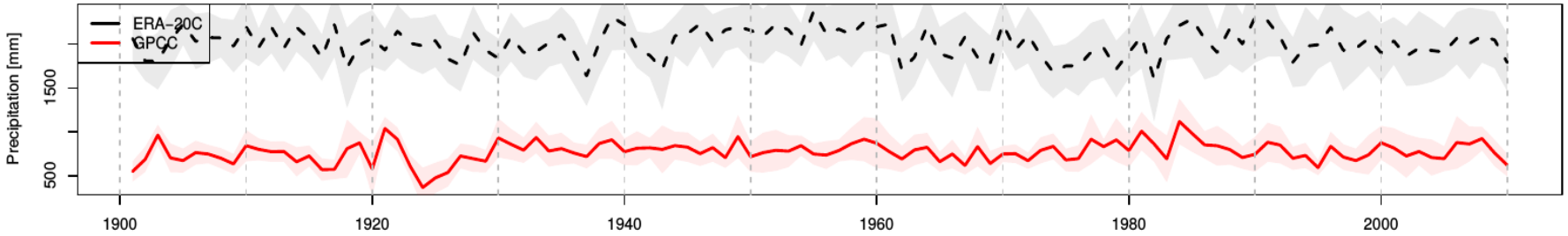




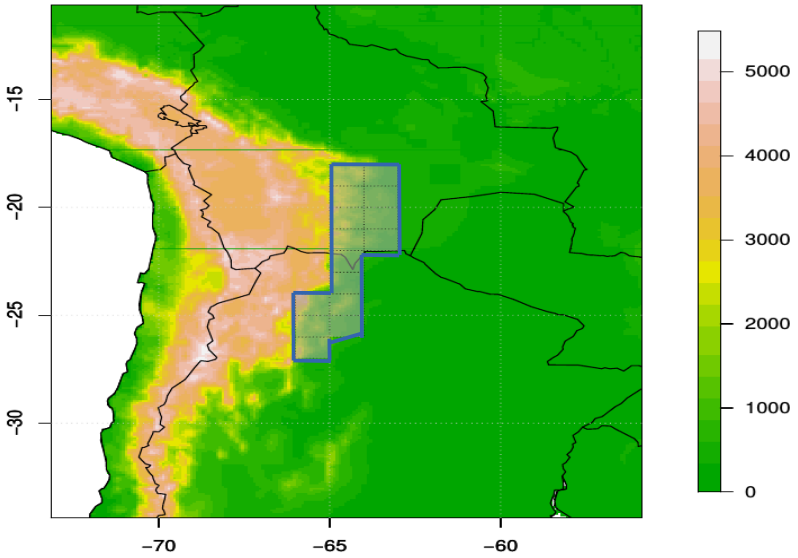
Kendall correlation coefficient
Annual totals 1901 - 2010

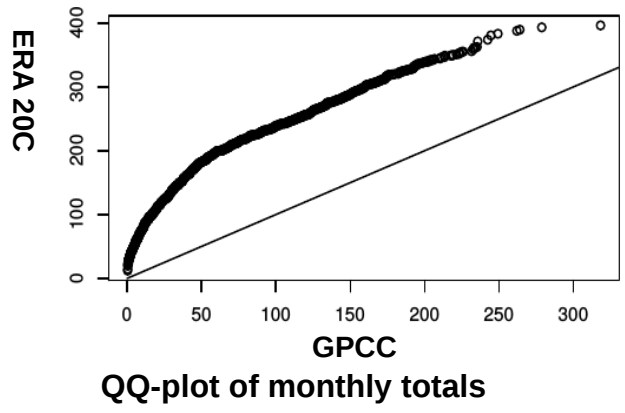
Convective – Large scale



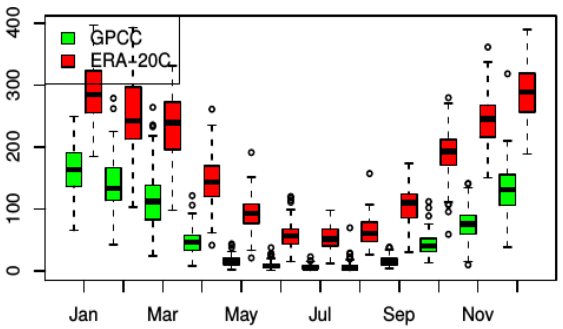


Mean annual precipitation time series across an area in South-America as indicated on the map on top.
— ERA 20C — GPCC



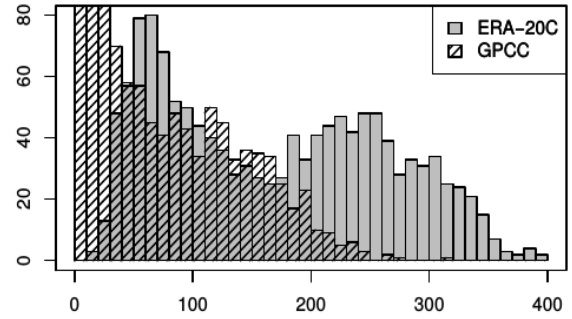


QQ-plot of monthly totals



Box-Whisker-Plot of monthly totals

ERA-20C GPCC



Histogram of monthly totals

ERA-20C GPCC