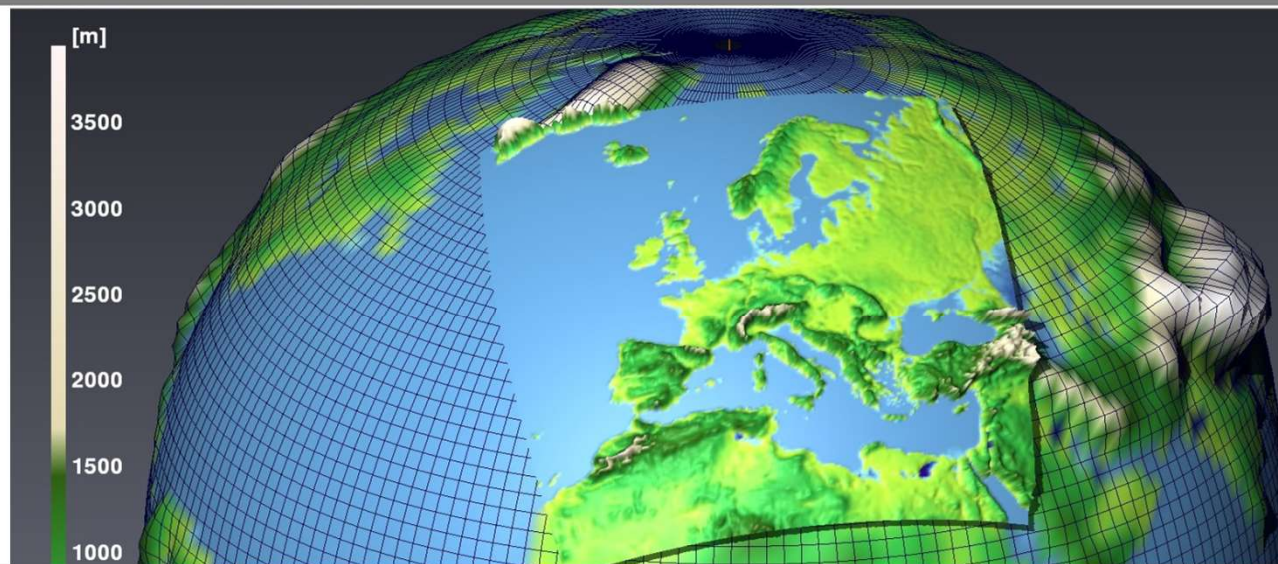# Long-term variability of European climate extremes

H. Feldmann, F. Ehmele, L.-A. Kautz, J.G. Pinto, F. Kelemen, C. Primo, B. Ahrens

Outline

- The Large CCLM Ensemble for Europe

- Evaluation

- Climate Variability of Precipitation Extremes

- Conclusions and Outlook

Large CLM Ensemble for Europe

LAERTES-EU (**LA**rge **E**nsemble of **R**egional clima**T**e mod**E**l **S**imulations for **EU**rope)

Setup: cosmo5.00_clm9, EURO-CORDEX domain (232 x 226 x 40, 0.22°)

Block	Forcing	Period	Comments	Years
1	NCEP 20CR via MPI–ESM–LR (as20ncep)	1900-2009	3 member	300
2	MPI-ESM-LR decadal hindcasts (decXXo)	1910-2009 (start years)	3 members x 100 decades	3000
3	MPI-ESM-HR historical	1900 (1960) – 2005	5 (2) members	410
4a	MPI-ESM-HR dec. hindcasts CMIP5	1960 – 2016 (start years)	5 member 57 decades	2850
4b	MPI-ESM-HR dec. hindcasts CMIP6	1960 – 2016 (start years)	10 member 57 decades	5900
	Total			**12460**

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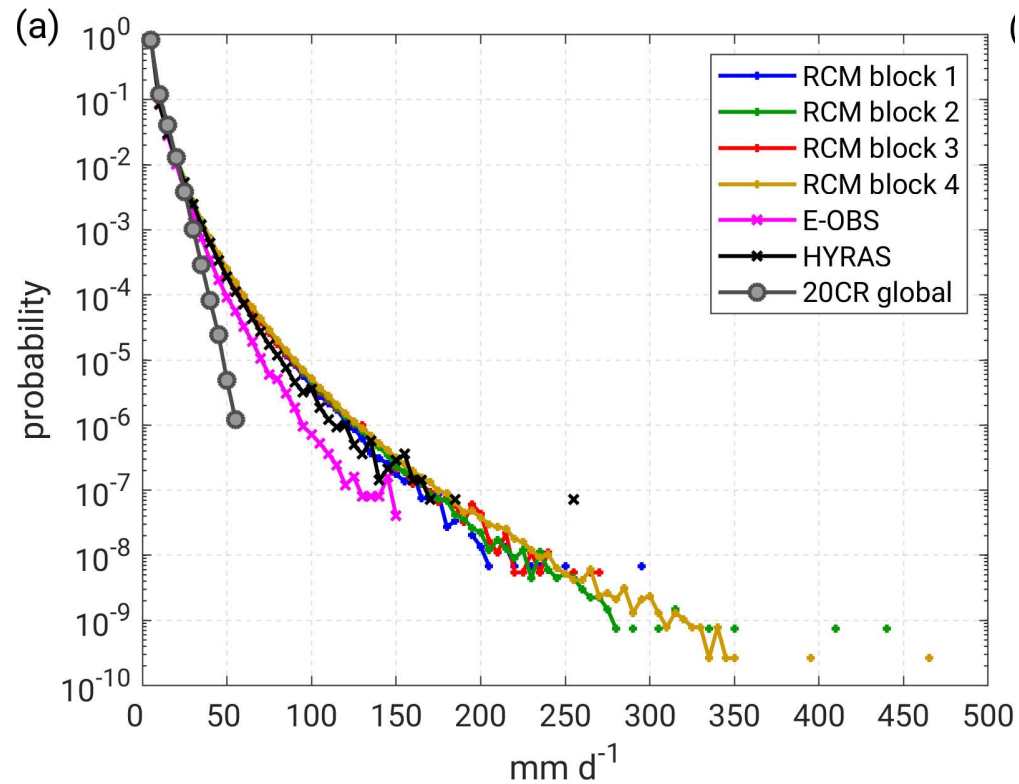# Large CLM Ensemble for Europe

LAERTES-EU (**LA**rge **E**nsemble of **R**egional clima**T**e mod**E**l **S**imulations for **EU**rope).
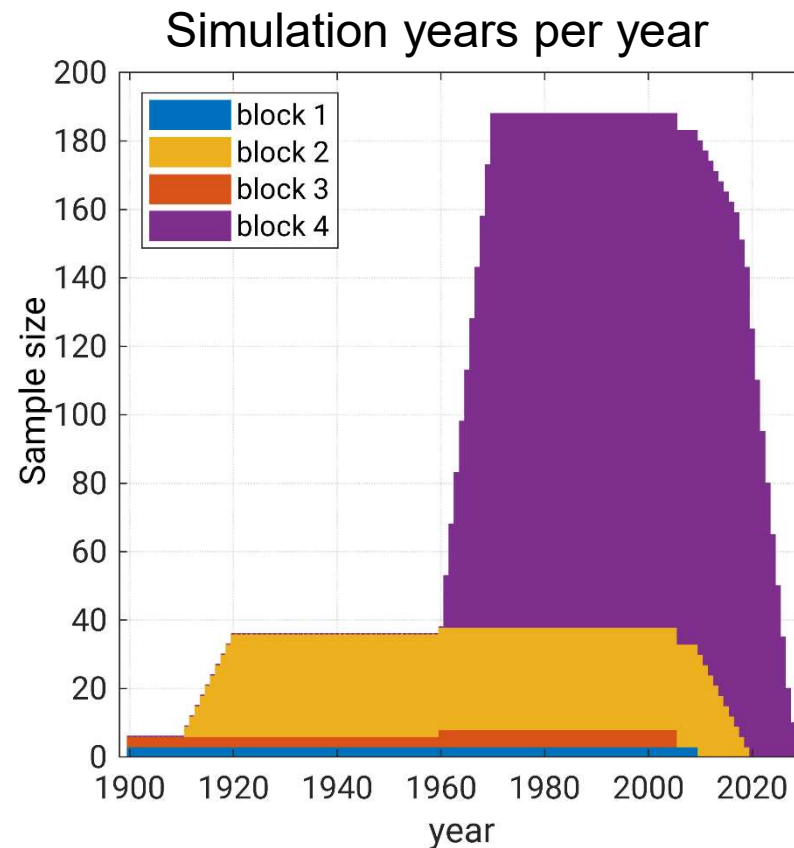
From Ehmele et al., ESD, 2019
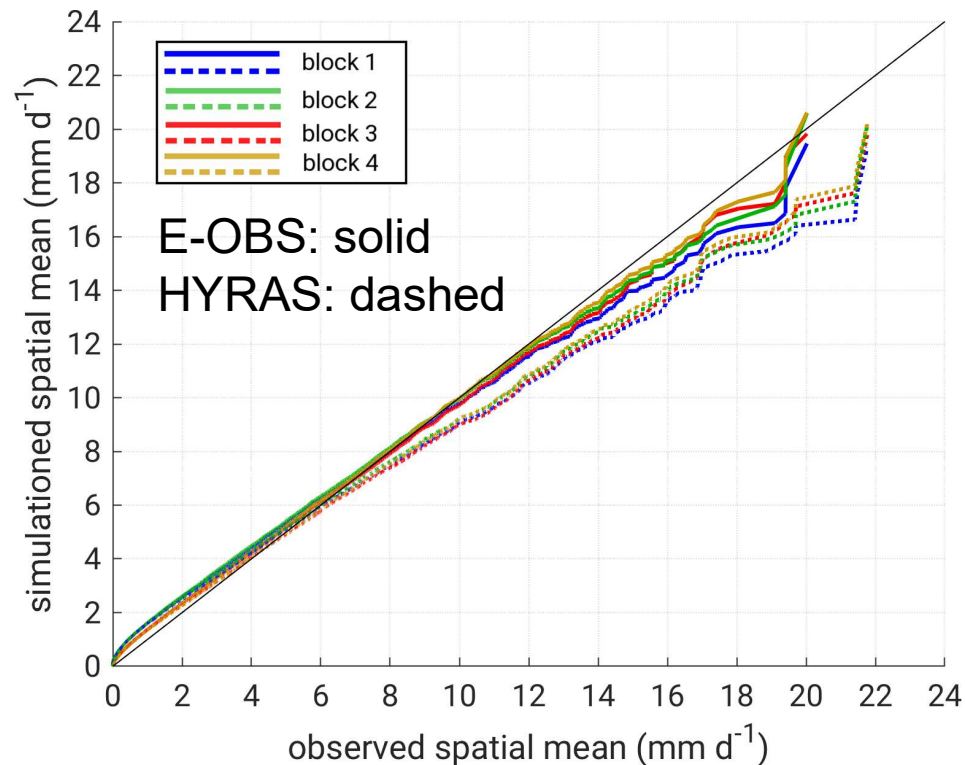
Evaluation and Consistency

Evaluation and consistency

(a)

Intensity–probability–curve daily precipitation: RCM simulations (dry–day adjusted), observations (E–OBS and HYRAS) and global reanalysis (20CR) for Mid–Europe

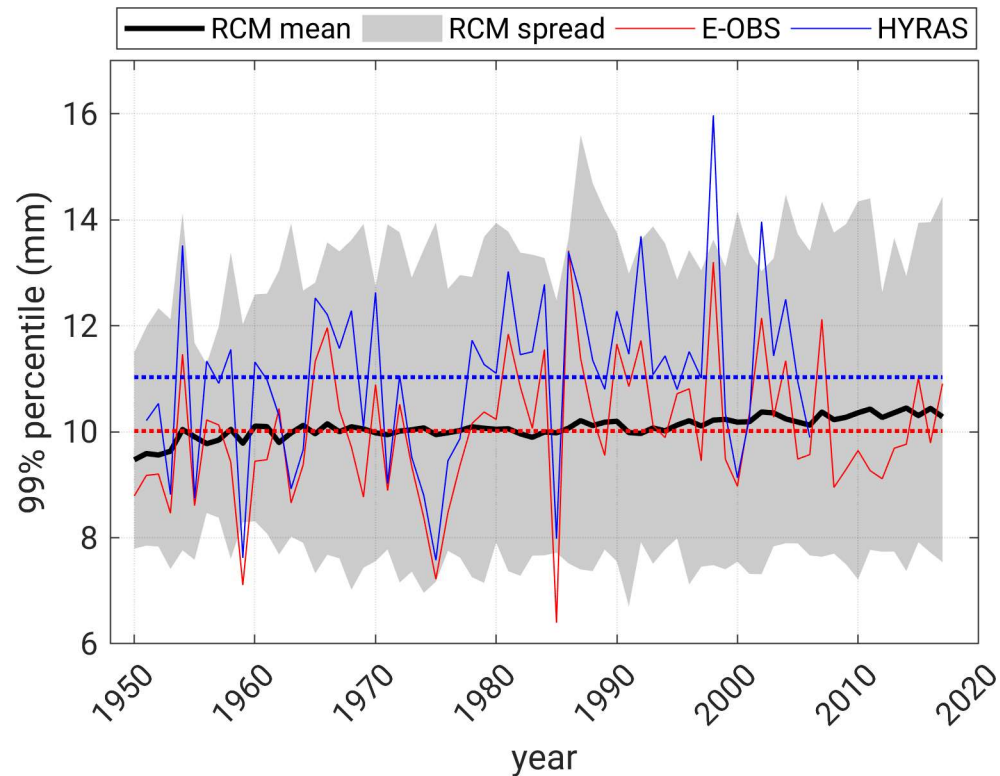From Ehmele et al., ESD, 2019

Evaluation and consistency

Quantile–quantile plot of spatial mean daily precipitation for investigation RCM simulations (data block 1–4) vs. E–OBS and HYRAS for Mid–Europe (ME).

From Ehmele et al., ESD, 2019
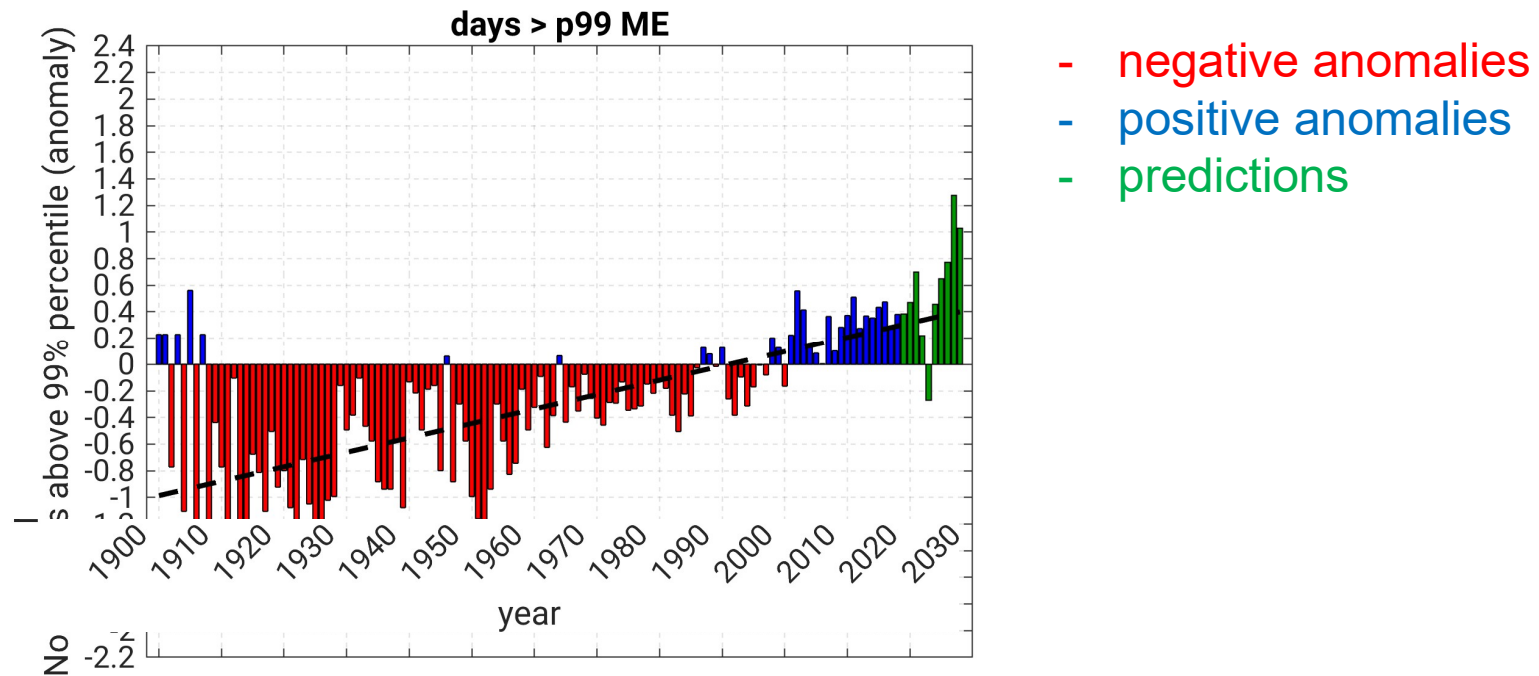
Evaluation and consistency

Yearly 99% percentile of spatial mean precipitation for ME - **ensemble mean**, ensemble spread, E–OBS, and HYRAS.

From Ehmele et al., ESD, 2019

Long-term Trends of Precipitation Extremes

Trend of Precipitation Extremes - 99th Percentile

days > p99 ME

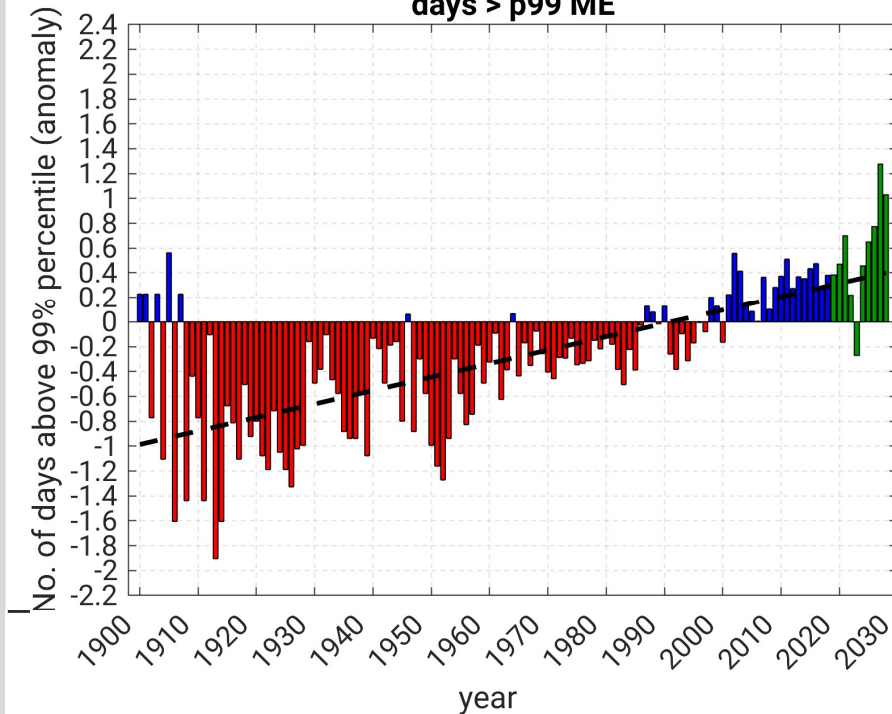- negative anomalies
- positive anomalies
- predictions

Deviation days/yr > 99% percentile compared to the climatology (1961–1990) for ME

From Ehmele et al., ESD, 2019

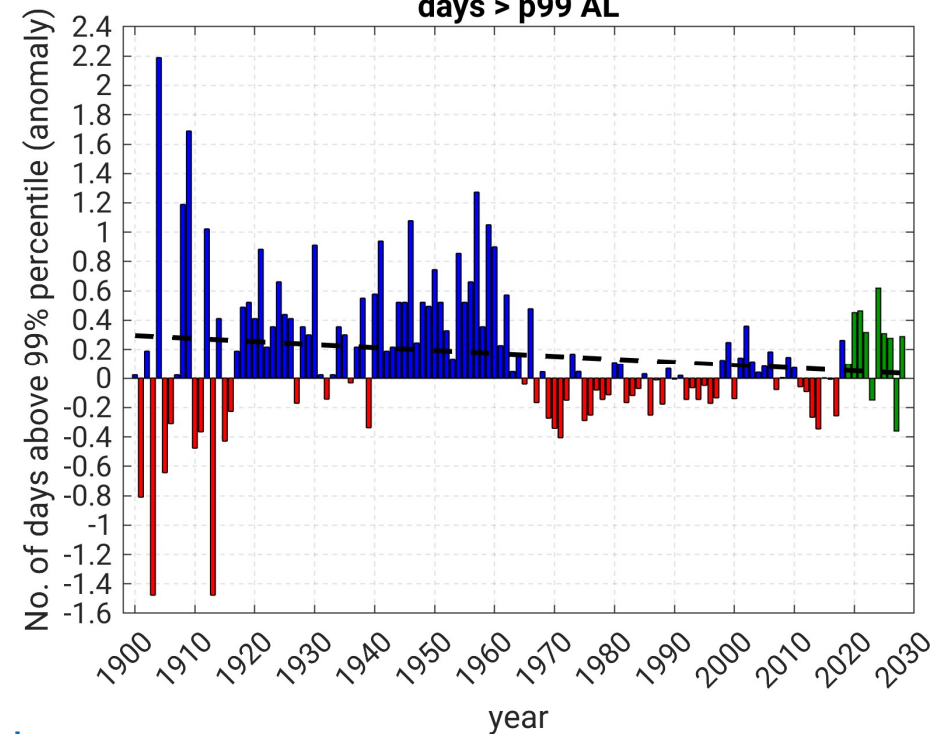# Trend of Precipitation Extremes - 99th Percentile

Mid Europe

Alps

- negative anomalies, positive anomalies, predictions

Deviation days/yr > 99% percentile compared to the climatology (1961–1990)

From Ehmele et al., ESD, 2019

Trend of Precipitation Extremes – Mid-Europe ME

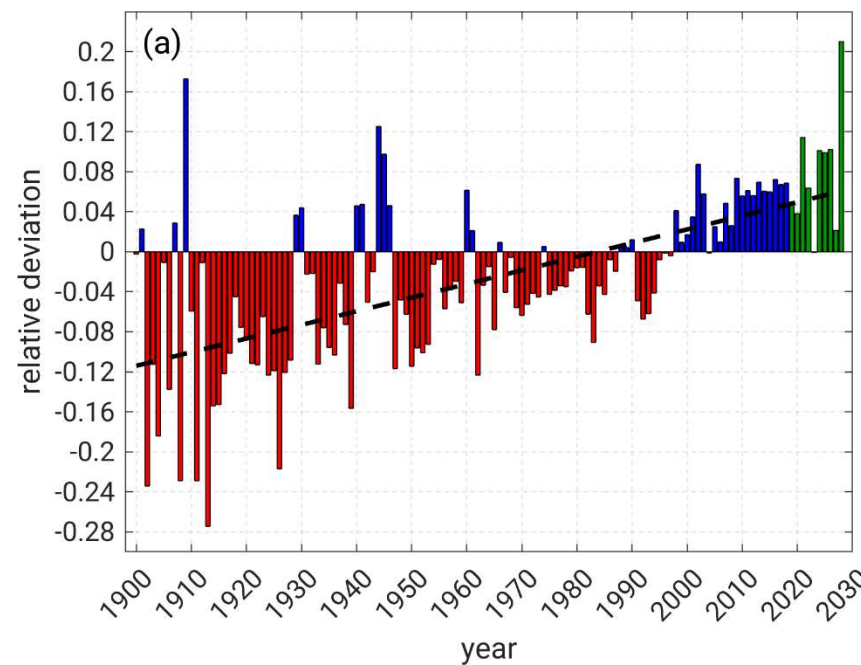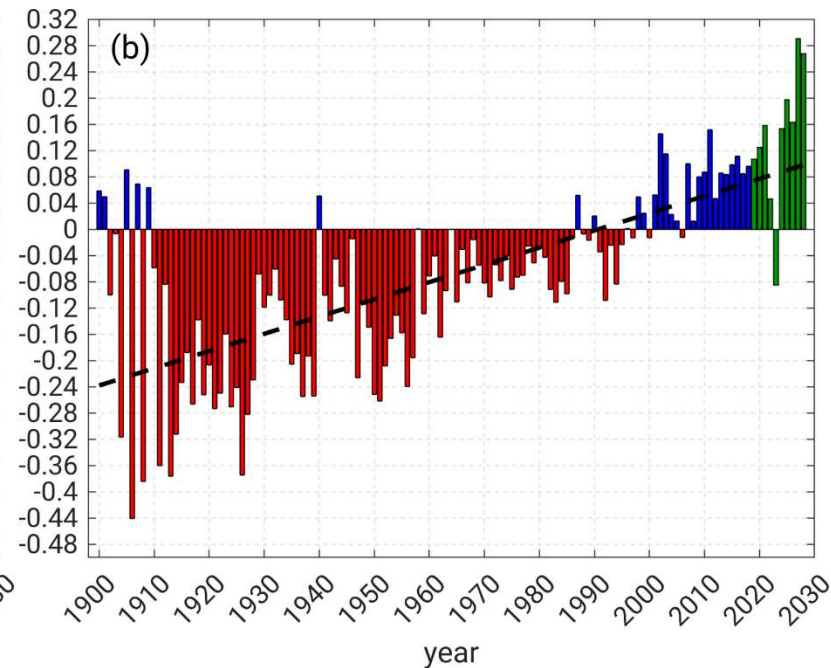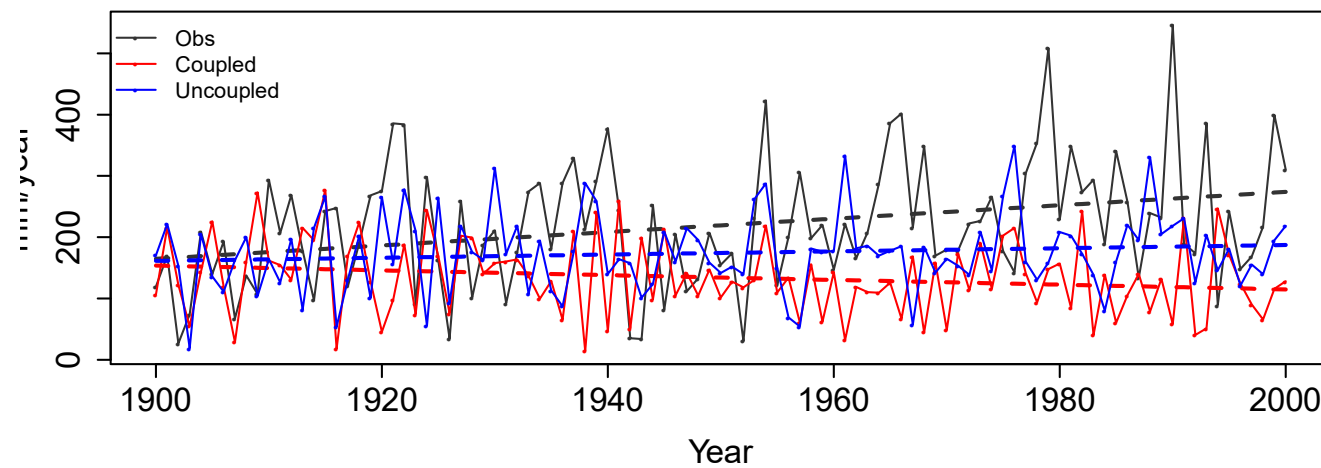R95pTOT   R99pTOT

- negative anomalies, positive anomalies, predictions

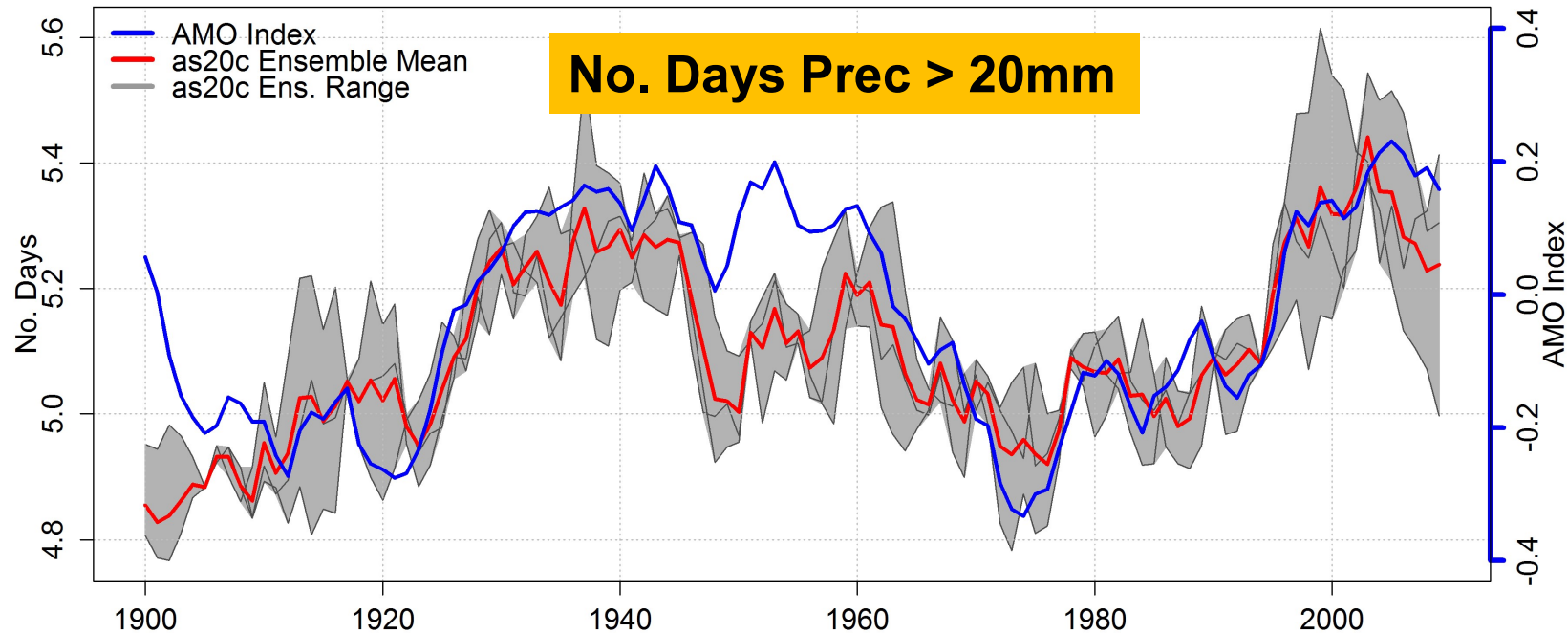Deviation days/yr > 99% percentile compared to the climatology (1961–1990)

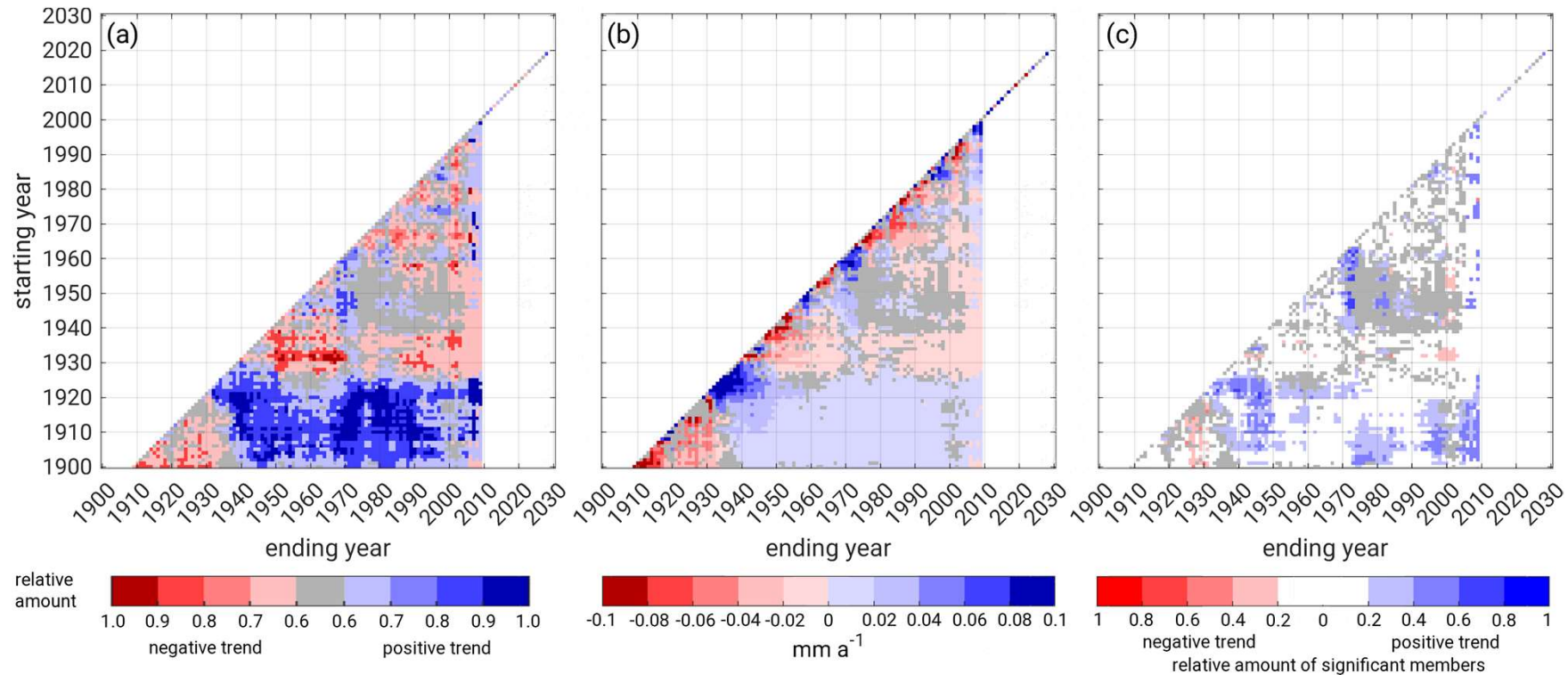From Ehmele et al., ESD, 2019

R95p in Hohenpeißenberg

From Primo et al., GMDD, 2019

Multi-decadal variability of heavy precipitation over Europe

No. Days Prec > 20mm

as20c ensemble: downscaling of the MPI-ESM assimilation runs (3 member)
AMO: Kaplan

Long-term variability

Trend analysis 99Pctl for ME with (a) the relative amount of members of LAERTES-EU with a positive or negative trend; (b) the trend in mm per year averaged over the members from (a), and (c) relative amount of members from (a) that have a significant trend; cases with no distinct number (less than 60 %) of members with same trend sign are marked in gray
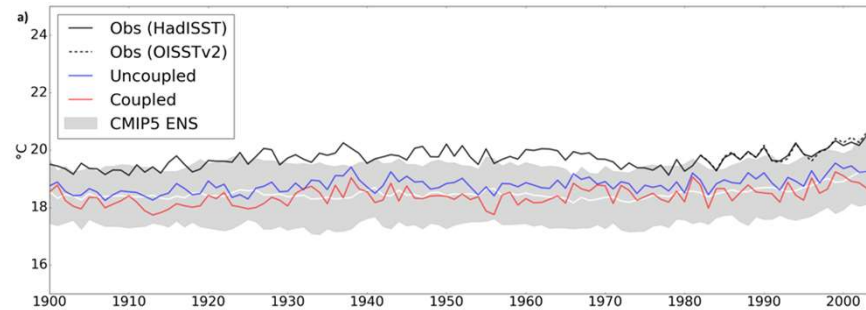
From Ehmele et al., ESD, 2019

Sources of Trend and Variability Pattern
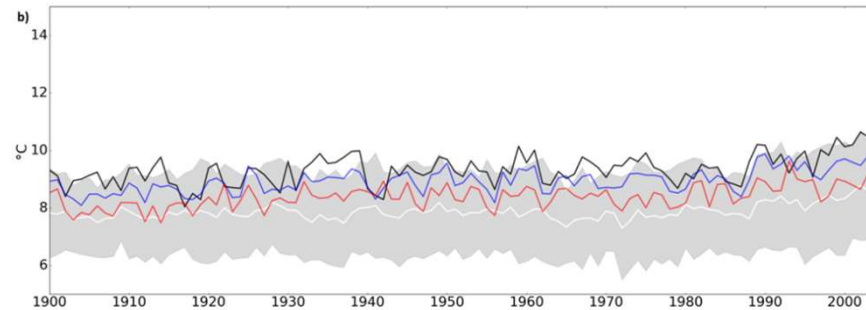
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SST Trends in the Mediterranean, Baltic- and North Sea

Mediterranean Sea

Baltic- and North-Sea

SST annual means coupled simulation (CCLM-NEMO), atmosphere-only CCLM simulation compared to observations (HadISST/OISSTv2) and ensemble mean (white line) and spread (shaded area) from CMIP5 simulations.

Multi-decadal Variability over Europe
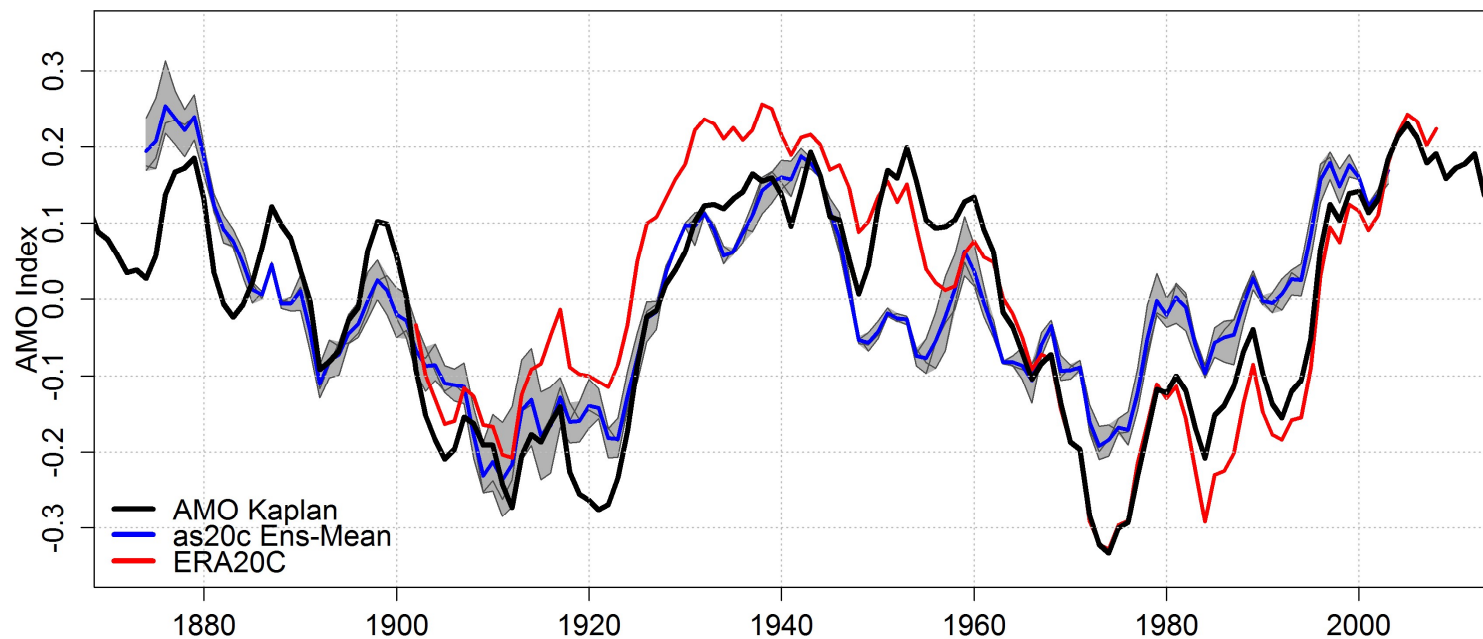## Centennial Downscaling Simulations

Donwscaling over Europe with CCLM5 (EUR-0.22° grid); period 1900 – 2010

- **NCEP 20CR Re-analysis** via MPI-ESM-LR assimilation runs (3 member)
- **ERA20C**

- **(Decadal Hindasts 1925 – 2009 3 members** forced by MPI-ESM-LR)
reference data: HadCRUT4, ERA-20C NCEP 20CR ens. mean

AMV Index (Kaplan), ERA20C, as20ncep Ensemble - 5yr means

Further Information

- 3 Publications on the topic of long-term climate variability using these simulations
  - Ehmele, F., Kautz, L.-A., Feldmann, H., and Pinto, J. G.: Long-term Variances of Heavy Precipitation across Central Europe using a Large Ensemble of Regional Climate Model Simulations, Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2019-47, in review, 2019.

  - Kelemen, F.D.; Primo, C.; Feldmann, H.; Ahrens, B. Added Value of Atmosphere-Ocean Coupling in a Century-Long Regional Climate Simulation. Atmosphere 2019, 10, 537.

  - Primo, C., Kelemen, F. D., Feldmann, H., and Ahrens, B.: A regional atmosphere-ocean climate system model (CCLMv5.0clm7-NEMOv3.3-NEMOv3.6) over Europe including three marginal seas: on its stability and performance, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-73, in review, 2019.

Conclusions and Outlook

- The large CLM ensemble provides a data set to investigate very extreme precipitation events in Europe
  - This will be a topic for the ClimXtreme project SEVERE
- The data sets indicate long-term trend and variability pattern with stronger extremes of Middle Europe
  - The evaluation is difficult due to lack and inhomogeneities of the observation data sets
- The suggested mechanism are:
  - The warming trend of the oceans, causes stronger evaporation and higher atmospheric moisture.
  - The Atlantiv Multidecadal Variability pattern modulates the lng-term variability of extreme precipitation over Europe

Thank you for your attention

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