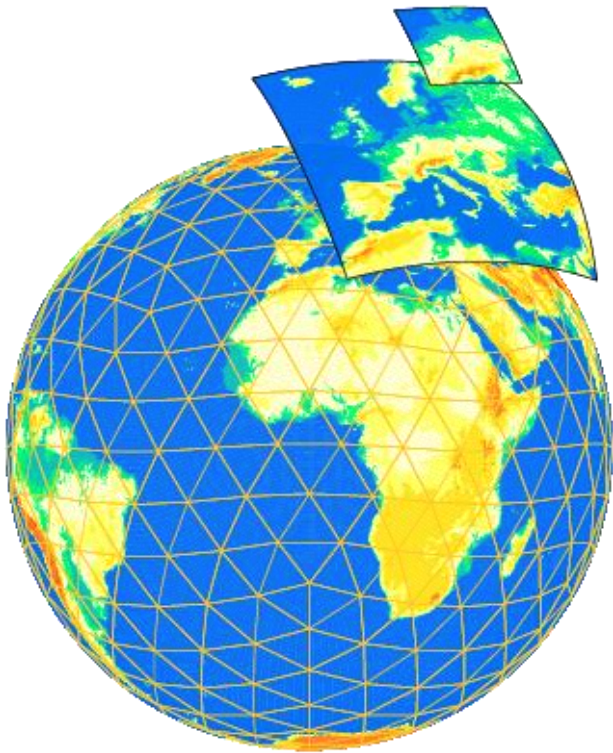


Evaluation of extreme precipitation in convection-permitting climate simulations with COSMO-CLM for Germany



Michael Haller, Susanne Brienens,
Harald Rybka, Jennifer Brauch and
Barbara Früh

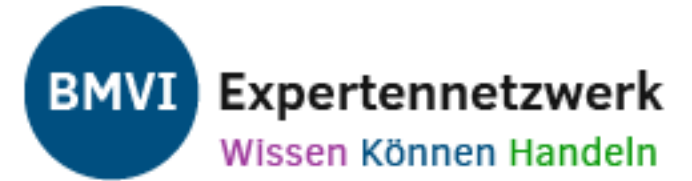
Deutscher Wetterdienst (DWD),
Germany

CLM Assembly
23 Sept 2021





- **Research project** funded by German Federal Ministry of Transport and Digital Infrastructure
- Time period 2016-2025, Phase 2 since 2020
- Goal is to
 - enhance **resilience of transport infrastructure** towards impact of **climate change** and **extreme weather events**
 - Establish **research network** between agencies
- **Climate model projections** for climate change analyses (not only) for impact studies on traffic infrastructure
- Core interest for extreme precipitation and strong wind events
- **DAS-Basisdienst** (DAS core service): Operational provider, maintenance and consulting for observation and model data



- **Convection-permitting Simulations** with COSMO-CLM5-0-16
 - 3 km grid, centred over Central Europe
 - Configuration taken from FPS-convection/CLMcom: only shallow convection parameterization, prognostic graupel
 - **Projection run** driven by MIROC-MIROC5, Intermediate nest on 12 km with COSMO-CLM4-8-17
 - Time range 1971-2000 (historical), and 2031-2060, 2071-2100 (RCP8.5)
 - **Evaluation run**, driven by ERA5 reanalysis, 1971-2019
 - Hourly output (tas, sfcWind, huss ...), 5-minute-data for precipitation

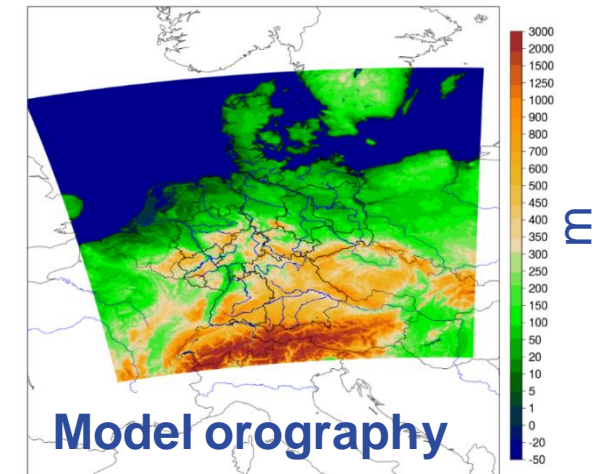
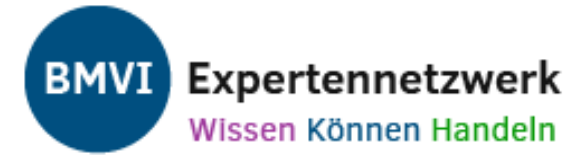
→ Reference data:

HYRAS (version 2015a, *Rauthe et al. 2013; Razafimaharo et al. 2020*):

- Gridded station observations for Germany and surrounding river catchments
- 5 x 5 km horizontal resolution, daily data
- tas, tasmin, tasmx, pr, hurs, rsds
- Time period 1951-2015

RADKLIM (version 2017.002, *Winterrath et al. 2018*):

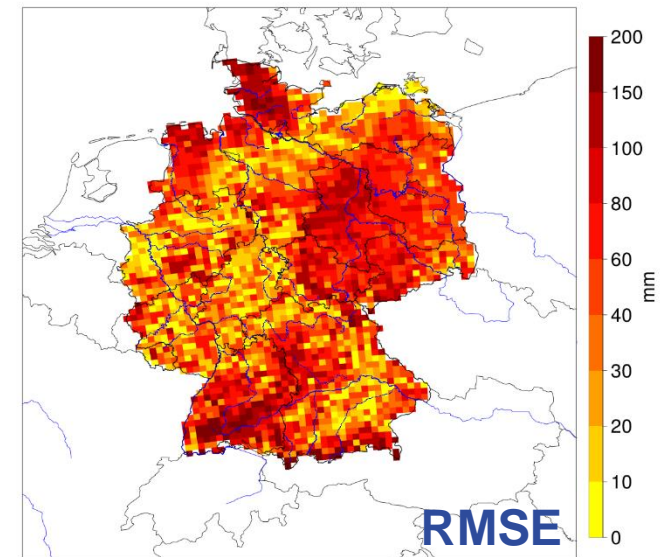
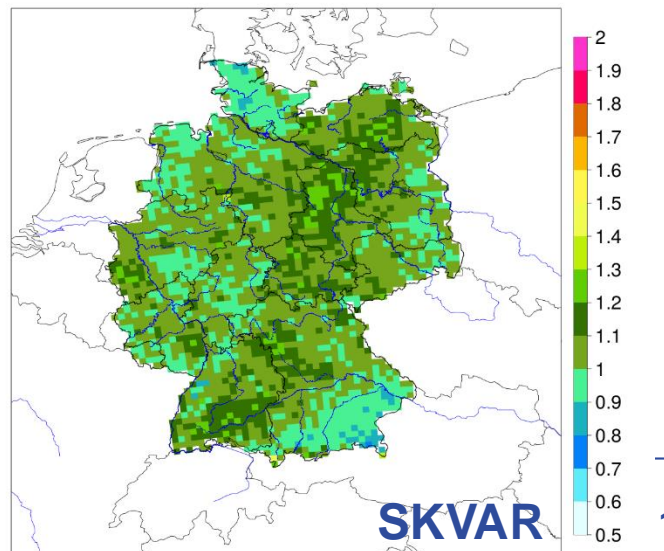
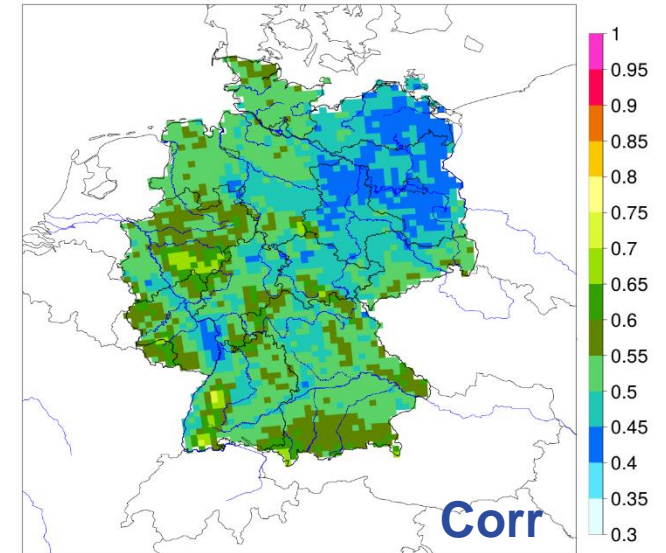
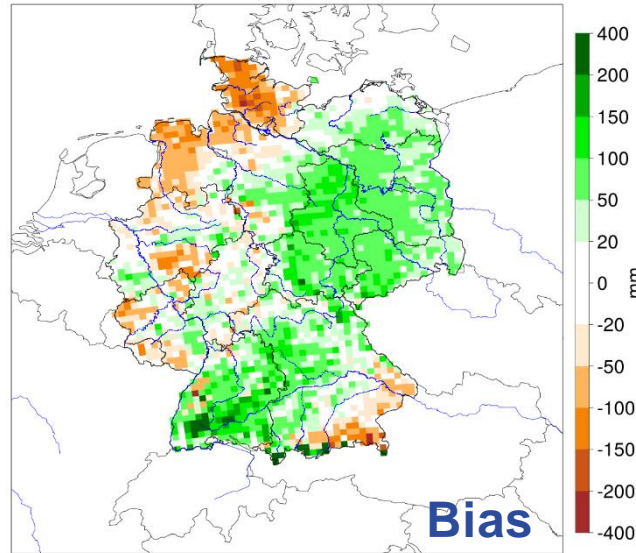
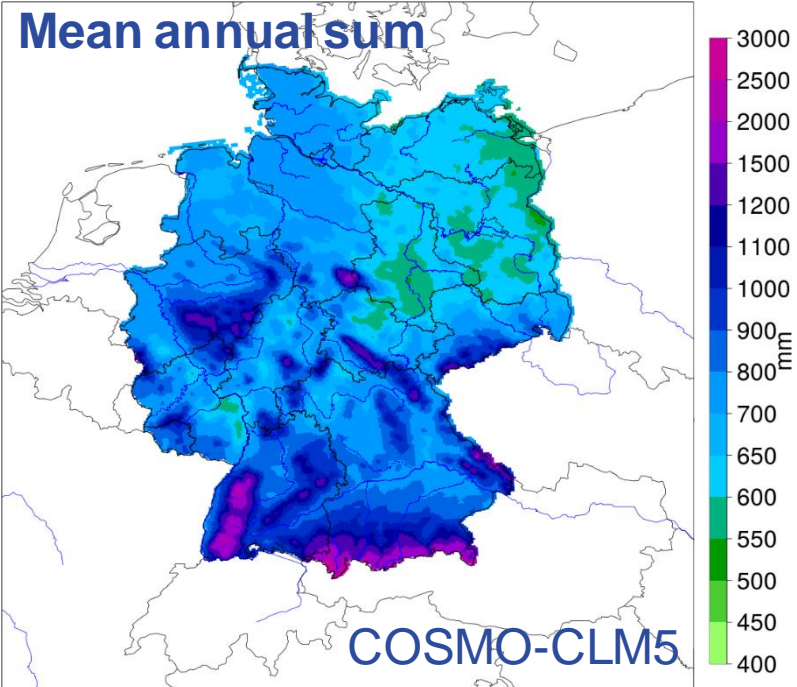
- Gridded radar observations for Germany, calibrated with station gauges
- 1 x 1 km horizontal resolution, hourly to 5 minutes data
- Precipitation and derived data products (e.g. exceedance frequencies)
- Time period 2001-2017
- www.dwd.de/radklim





- Evaluation of COSMO-CLM simulation with reanalysis-forcing:
 - Reference data: HYRAS
 - Analysis time period 1971-2000 for domain Germany
- Analysis of (extreme) precipitation:
 - Diurnal cycle of precipitation
 - Added Value of high model resolution





COSMO-CLM Eval-Simulation:
Comparison to HYRAS data for
period 1971-2000

$$SKVAR = \frac{\sigma_{mod}}{\sigma_{obs}}$$

→ Mean diurnal cycle of precipitation

→ for different seasons and different regions

→ Added value analyses

→ **DAV Index** (Soares & Cardoso, 2018)

→ Comparison of PDFs for low and high model resolution and reference data set

→ **ETCCDI Indices:**

→ SDII

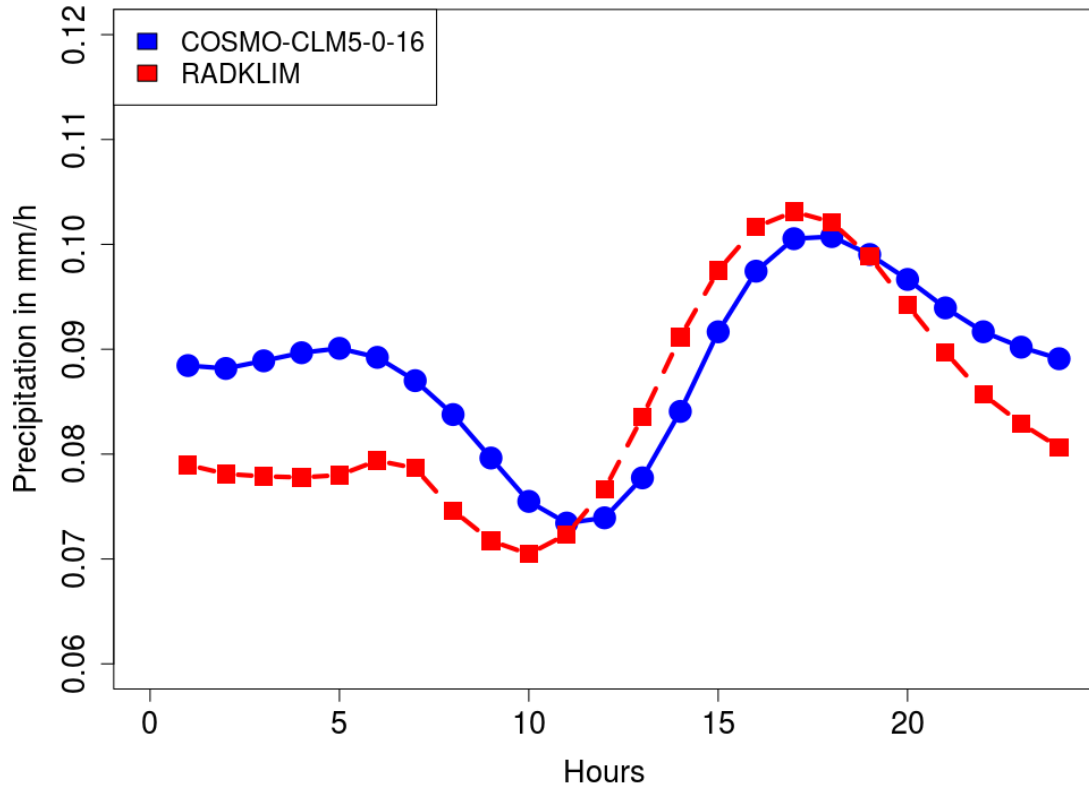
→ Precipitation intensity: mean precipitation on wet days

→ Rx1day & Rx5day

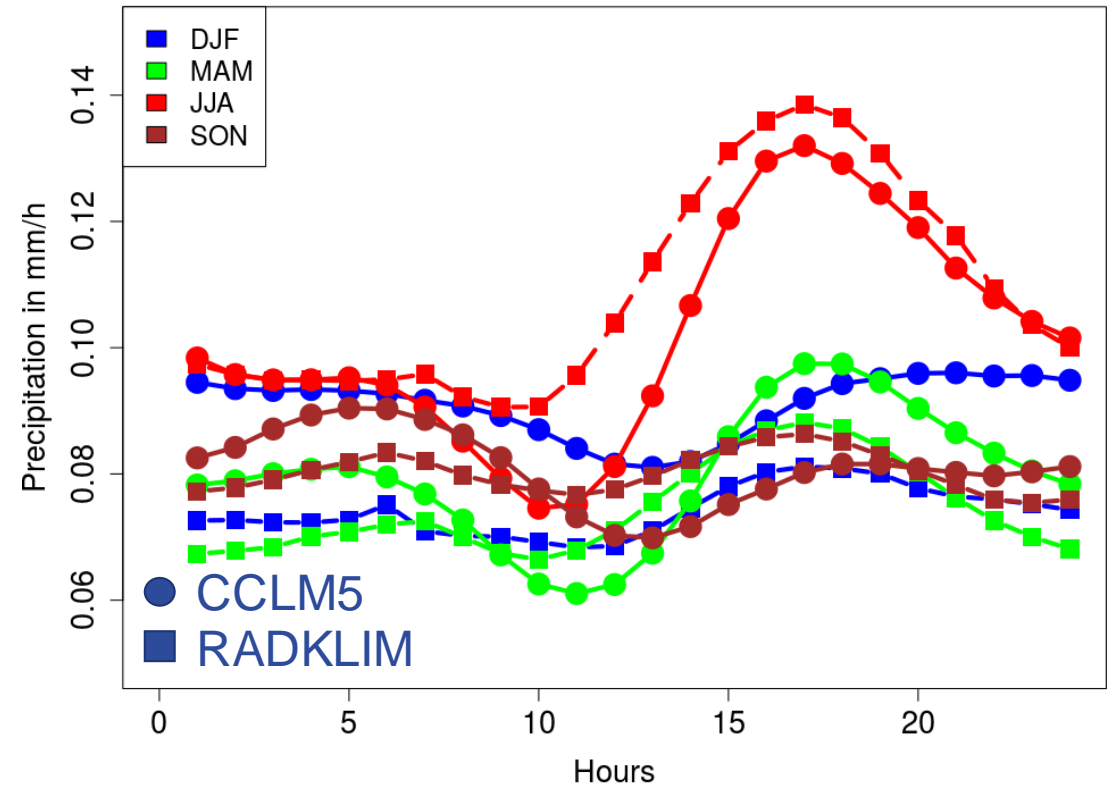
→ Mean monthly maximum over 1 day and over 5 day

→ Return periods and persistence of rain fall

$$\begin{aligned} \text{DAV} &= \text{PDF}_{\text{added value}} \\ &= \frac{\sum_1^n \min(Z_{lr}, Z_{obs}) - \sum_1^n \min(Z_{lr}, Z_{obs})}{\sum_1^n \min(Z_{lr}, Z_{obs})} \end{aligned}$$

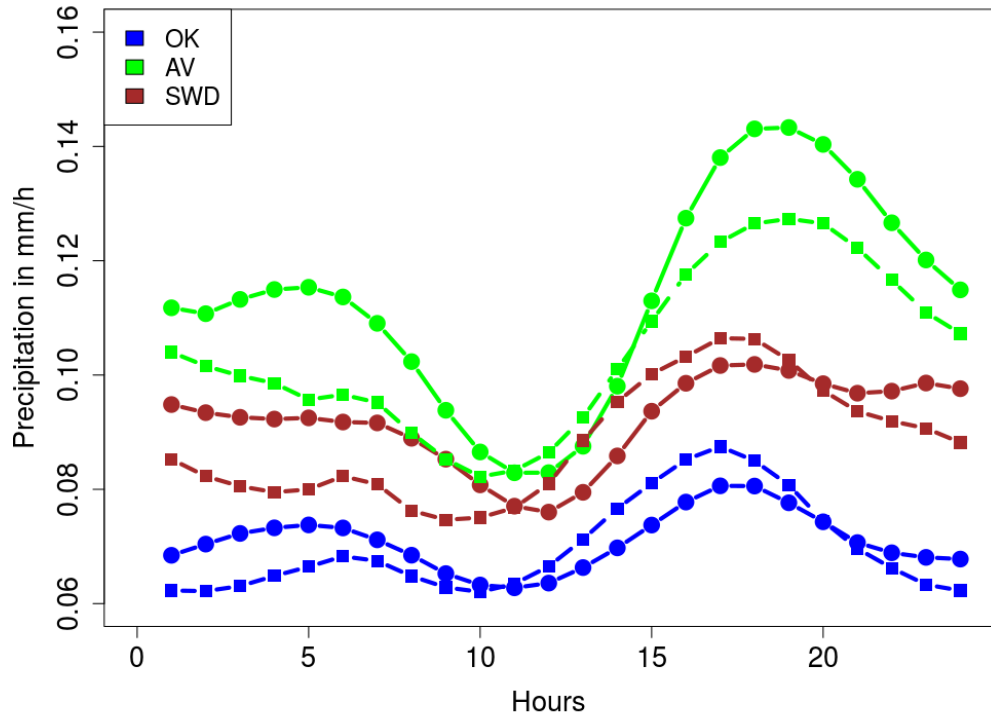


Diurnal cycle for **year** (Jan-Dec)

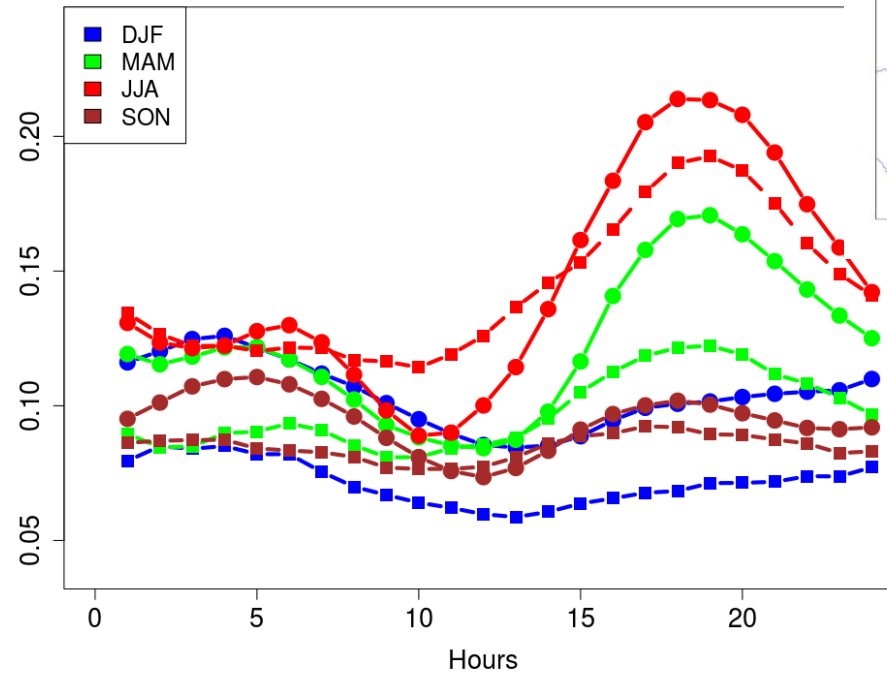


Diurnal cycle for **different seasons**

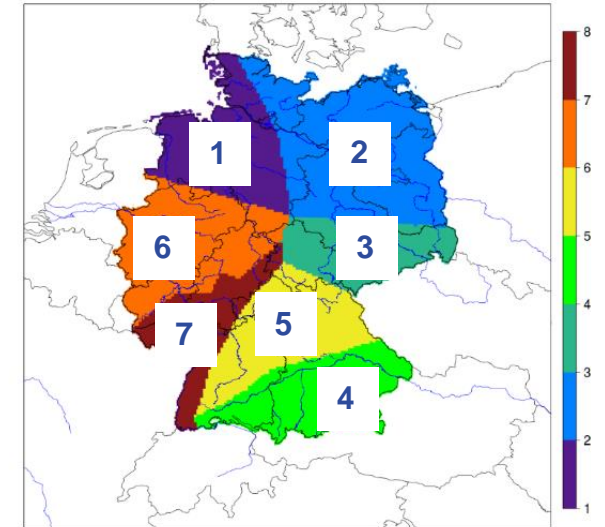
Domain: **Germany**
Time range: **2001-2017**



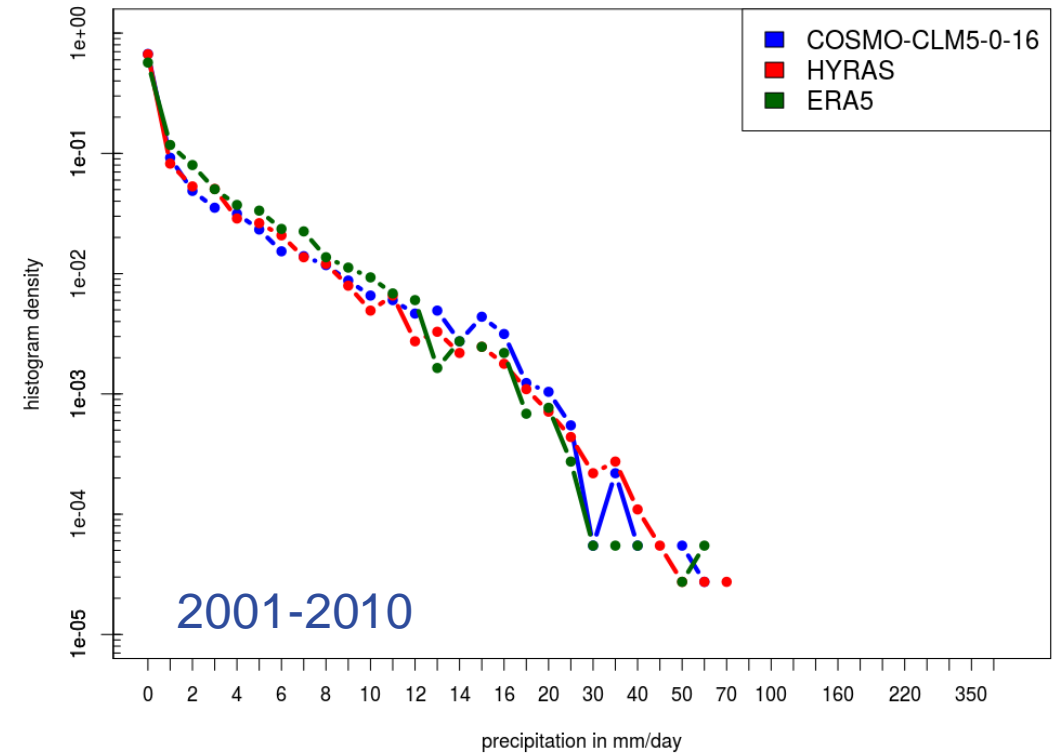
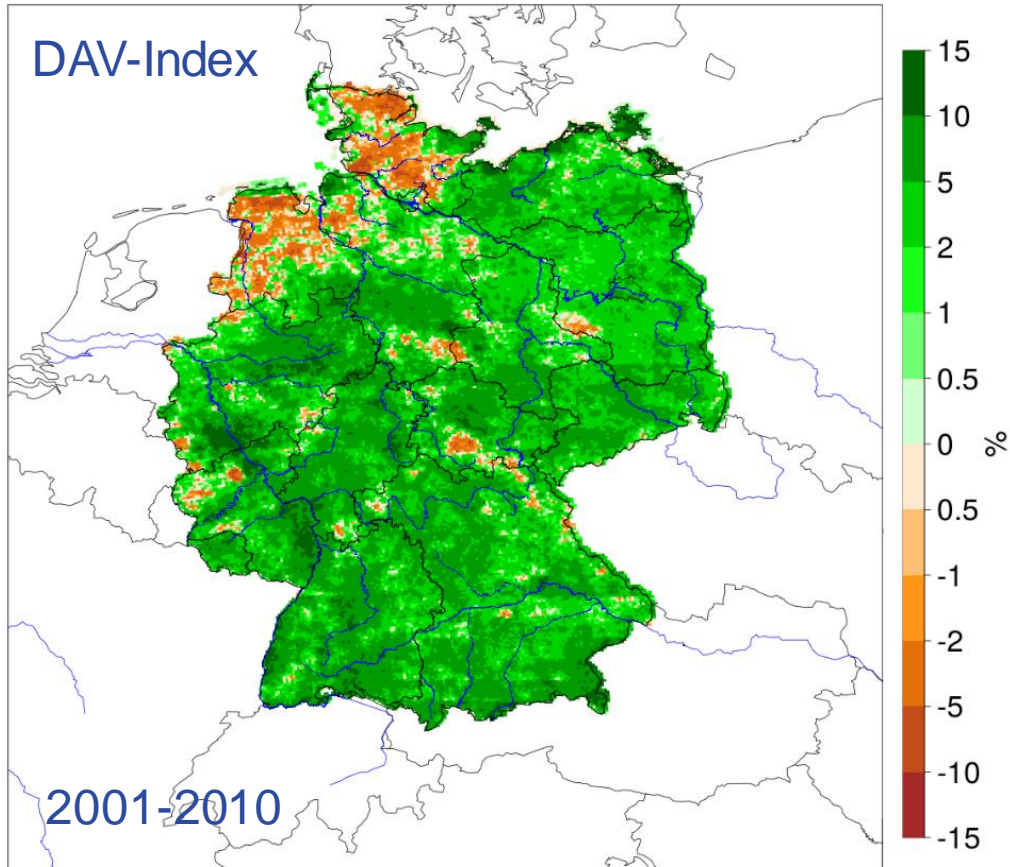
3 regions (2,4,7), for year (Jan-Dec)



1 region (4), different seasons

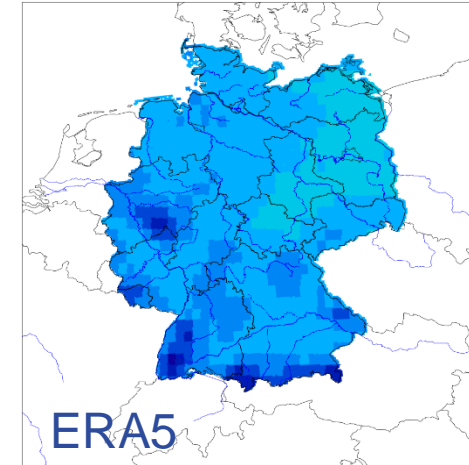
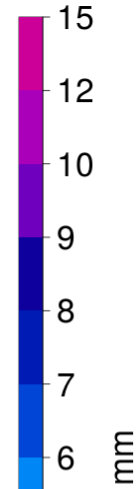
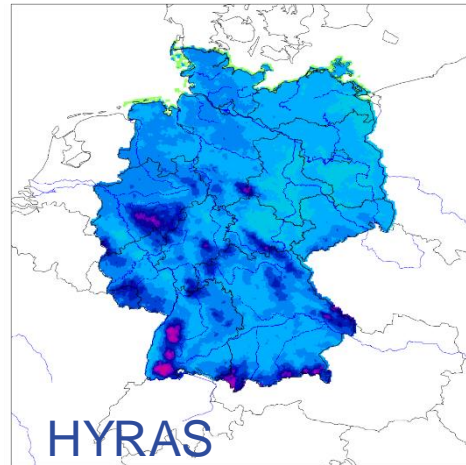
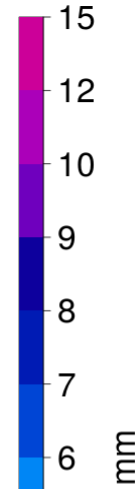
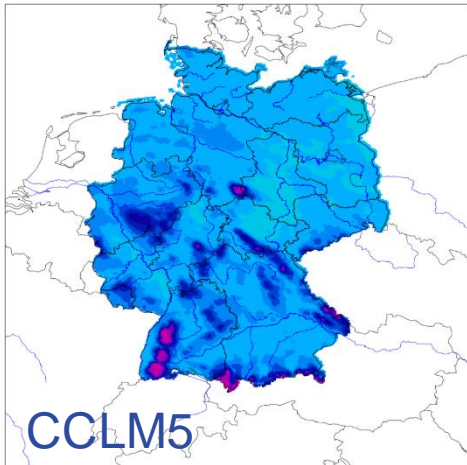


● CCLM5
■ RADKLIM



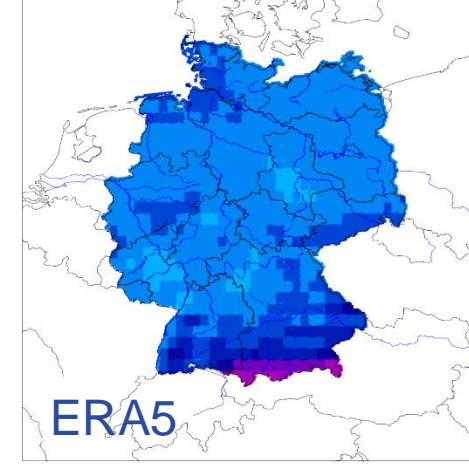
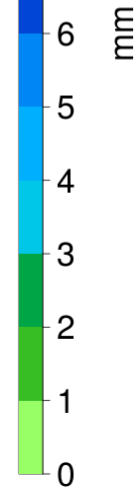
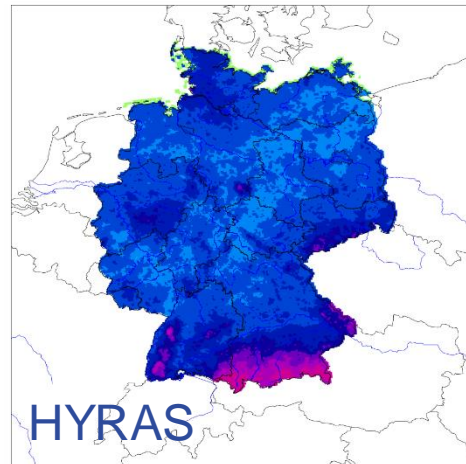
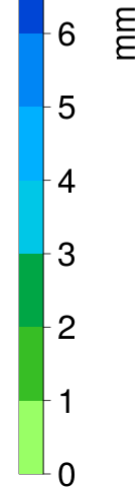
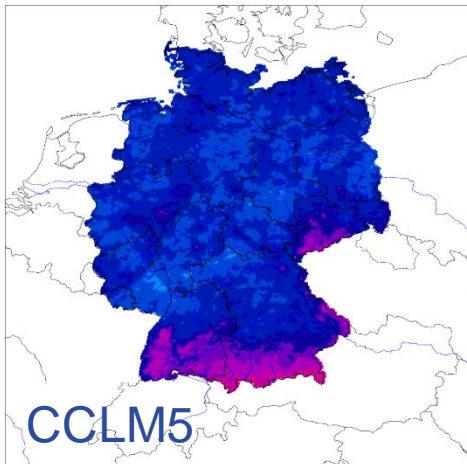
$$\begin{aligned}
 \text{DAV} &= \text{PDF}_{\text{added value}} \\
 &= \frac{\sum_1^n \min(Z_{lr}, Z_{\text{obs}}) - \sum_1^n \min(Z_{lr}, Z_{\text{obs}})}{\sum_1^n \min(Z_{lr}, Z_{\text{obs}})}
 \end{aligned}$$

Comparison of HoKliSim-De and ERA5, after Soares & Cardoso (2018), Perkins et al. (2007)

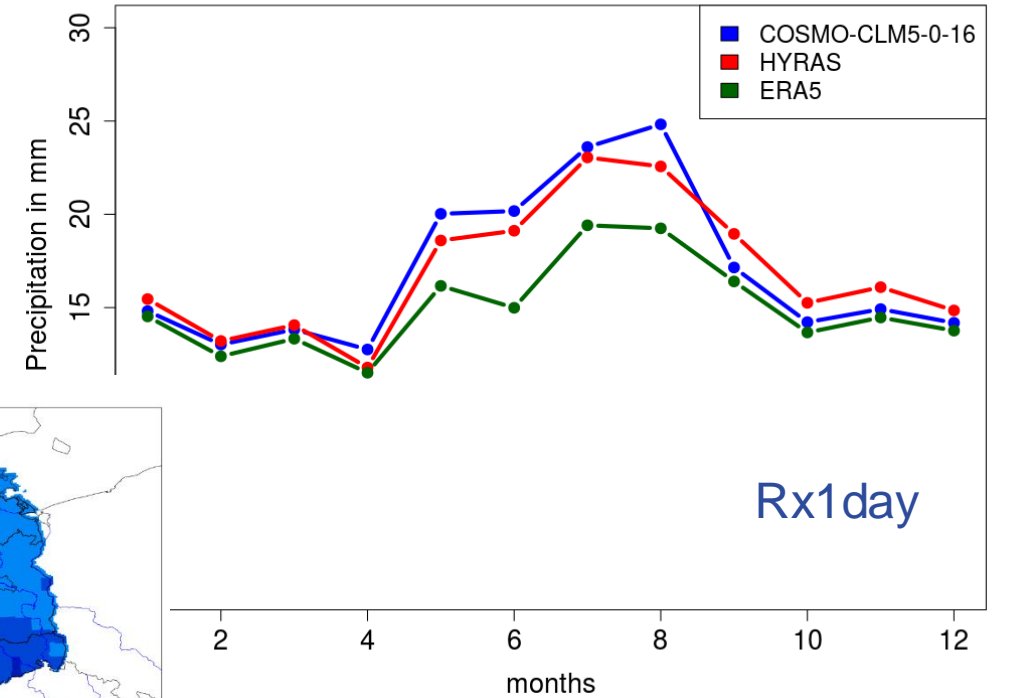
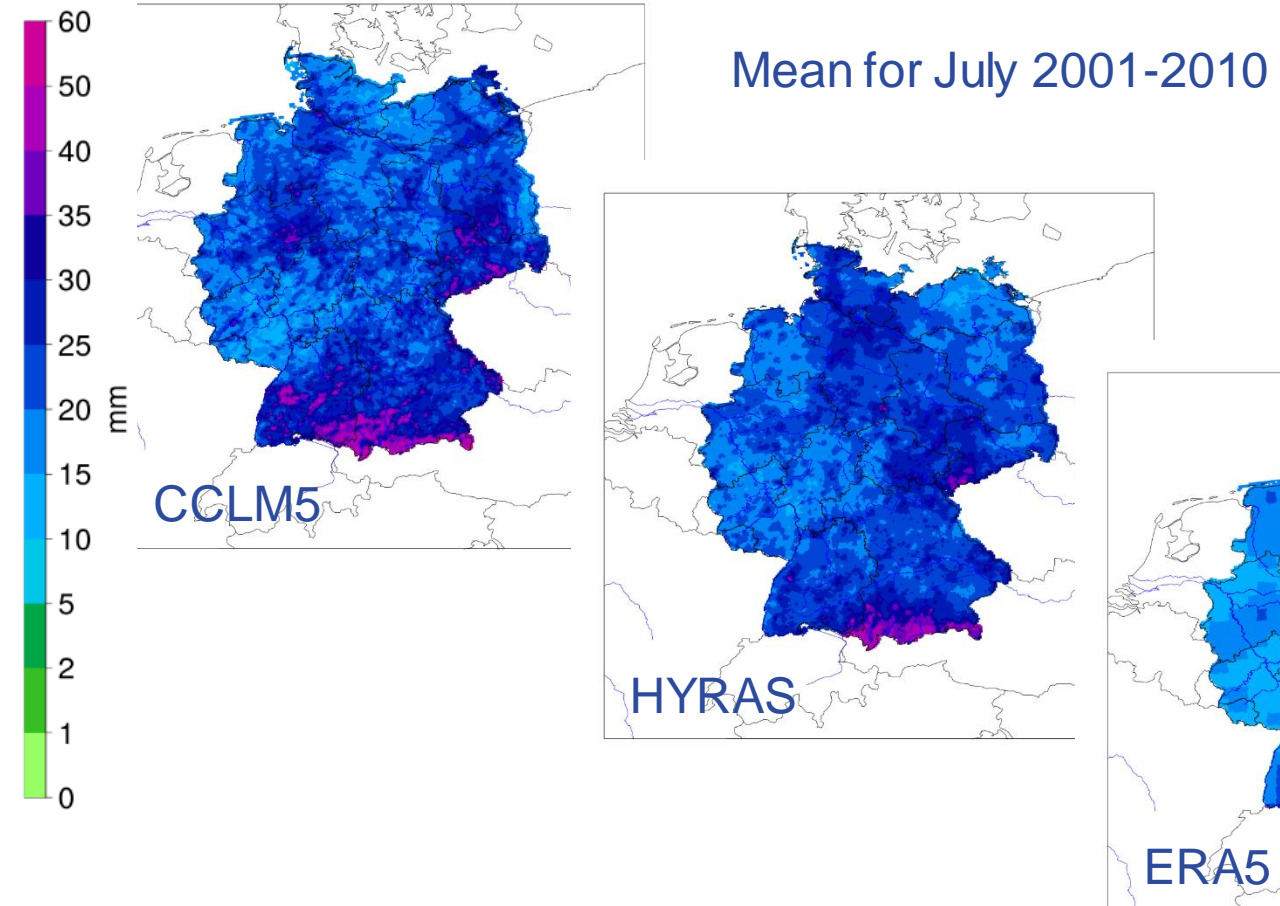


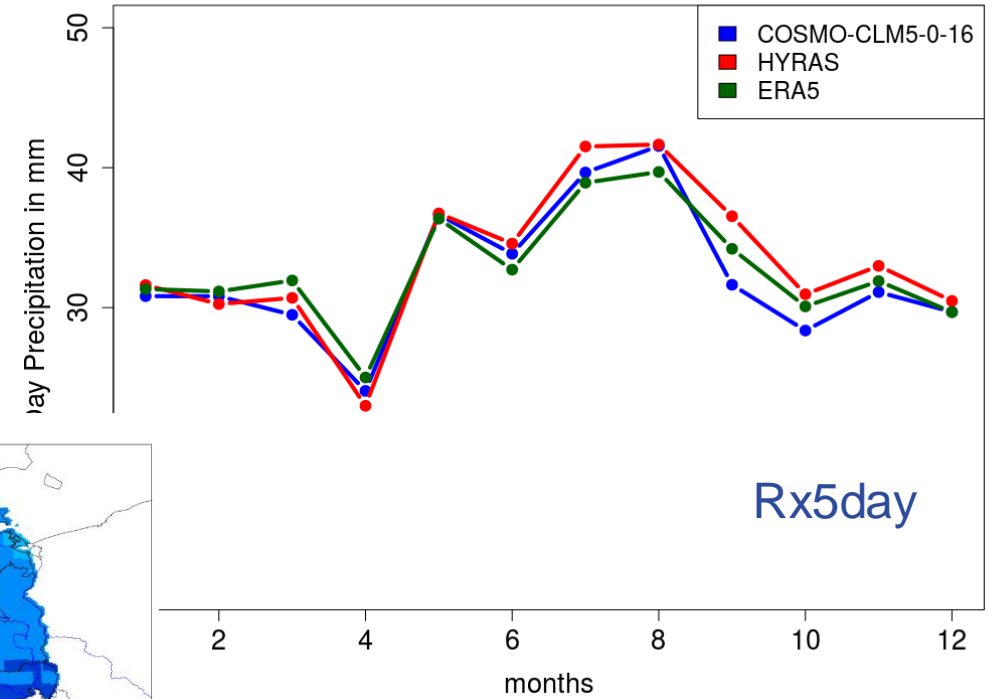
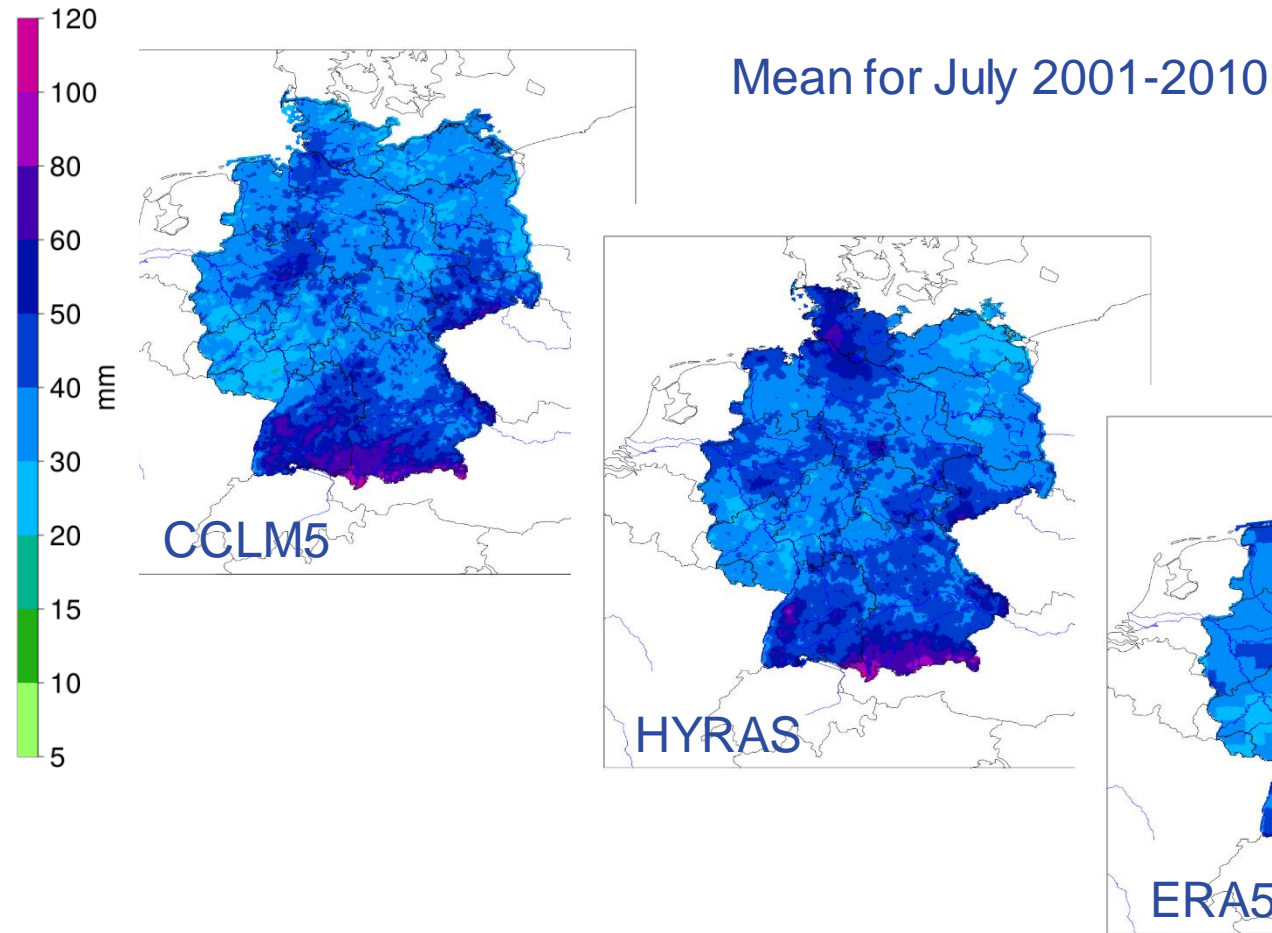
DJF

Time period 2001-2010

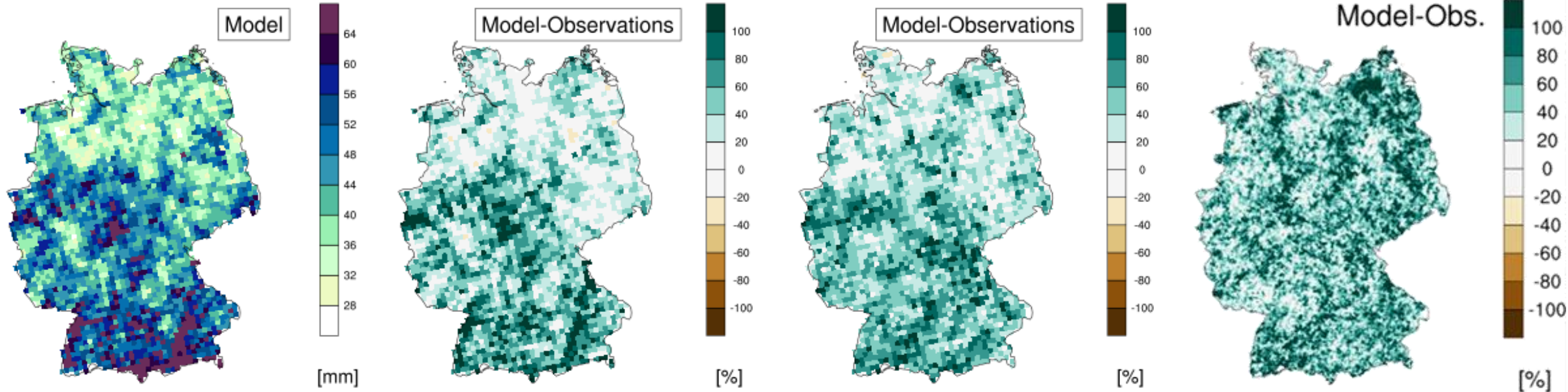


JJA





D=3h T=30a



**COSMO-CLM EUR-11
Historical run**

**COSMO-CLM GER-0275
Historical run (remap)**

**COSMO-CLM GER-0275
evaluation run
2000-2019**

Persistent rain fall (D=3 hours) and Return periods (T=30 years)

- No Added Value of higher resolution in comparison to EUR-011 simulation (only slightly better for 24 h)
- Too much rain in high-res simulation, especially for short events
- Dependence on reference data: RADKLIM and KOSTRA show differences

- COSMO-CLM Simulations with 3km grid resolution for 30-year periods
 - CMORized, will be published on ESGF
 - Data Evaluation for core variables temperature, precipitation and wind, still ongoing
- Good correspondence to reference data...
 - Positive added value in comparison to coarse reanalysis data
- ...but
 - Overestimation of very extreme precipitation and on short time intervals (1-3h)
 - Overestimation of night-time precipitation (most pronounced in winter time)

- Continue with extreme precipitation analyses
- Analyses of extreme wind events
- For next simulations: switch from COSMO-CLM to ICON-CLM