Analyses of added value for heavy rain fall and strong wind in convection-permitting climate simulations over Germany
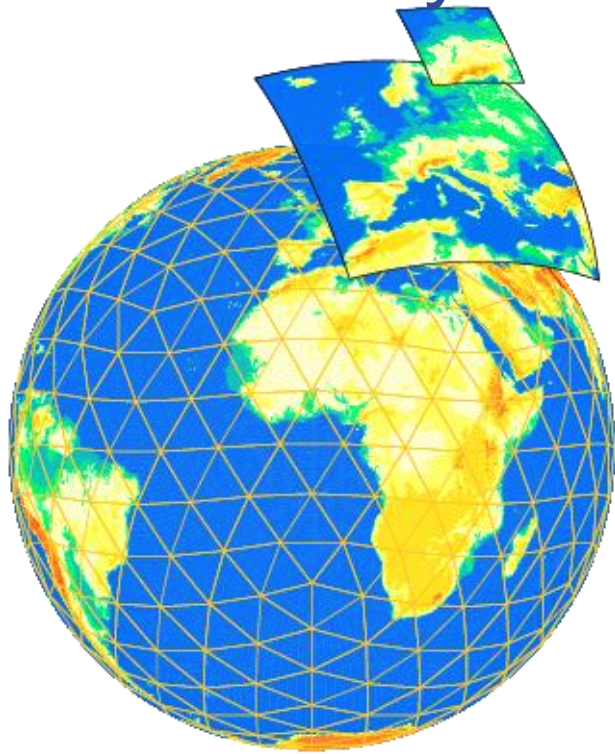
Michael Haller, Susanne Brienen, Harald Rybka, Jennifer Brauch and Barbara Früh

Deutscher Wetterdienst (DWD), Germany

CLM Assembly
21 Sept 2022

➔ **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 ERA40/ERA5 reanalysis for 1971-2019, 2020+2021 in prep.

  ➔ Hourly output (tas, sfcWind, huss …), 5-minute-data for precipitation

➔ Reference data:

Model orography

HYRAS (version 2015a, *Rauthe et al. 2013; Razafimaharo et al. 2020*)
• 1951-2015, daily data
• https://www.dwd.de/DE/leistungen/hyras/hyras.html
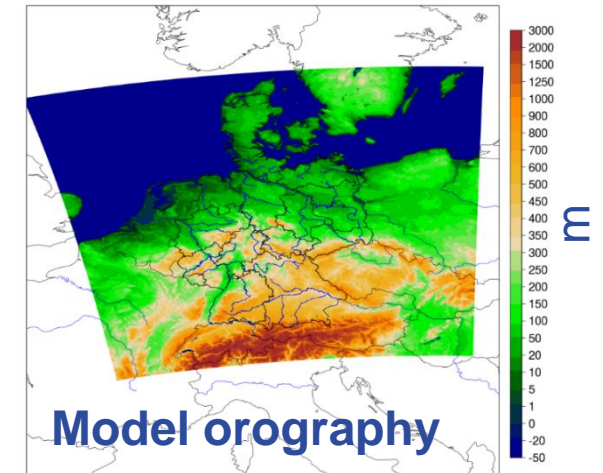
COSMO-REA6 (Bollmeyer et al. 2015)
• 1995-2015, daily data
• https://www.dwd.de/DE/klimaumwelt/klimaueberwachung/reanalyse/reanalyse_node.html

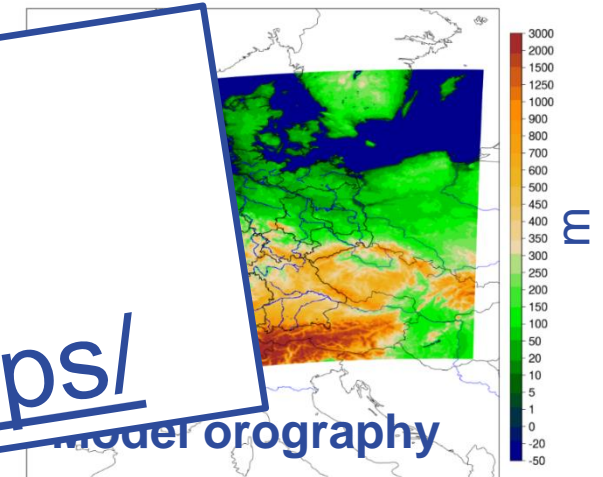**RADKLIM** (version 2017.002, *Winterrath et al. 2018*)**:**
• Gridded radar observations for Germany, calibrated with station gauges
• www.dwd.de/radklim

➜ **Convection-permitting Simulations** with COSMO-CLM5-0-16

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　➜ Time range...

➜ Re...

BMDV **Network of Experts**
Knowledge Ability Action

Model orography

Projections and Evaluation run available on ESGF: https://esgf.dwd.de/projects/dwd-cps/

HYRAS (vers... ...ahmanaro et al. 2020)
- 1951-2015...
- https://www.dwd.de/DE/leistungen/hyras/hyras.html

COSMO-REA6 (Bollmeyer et al. 2015)
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# Analytics of COSMO-CLM model simulations

- Evaluation of COSMO-CLM evaluation simulation:

  - Reference data HYRAS (precipitation) and COSMO-REA6 (wind)

- Analysis of (extreme) precipitation:

  - Added Value of high model resolution

  - Peak-over-threshold (PoT) analysis

  - Analyses for Germany and for several regions

- Analysis of changing winds and wind gusts

Regions in Germany
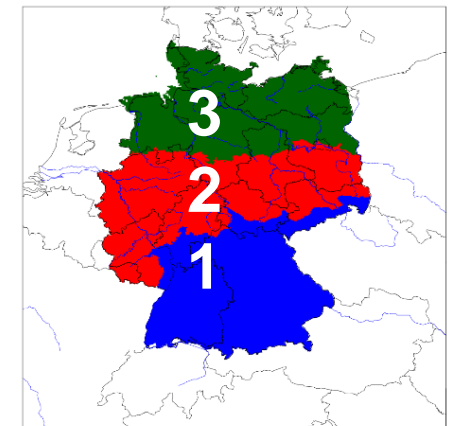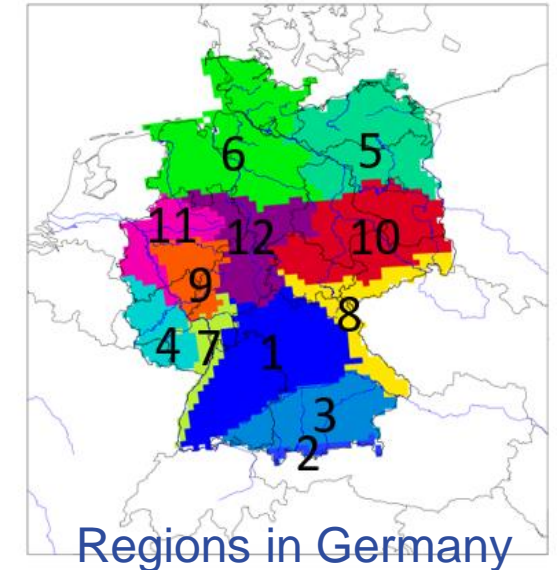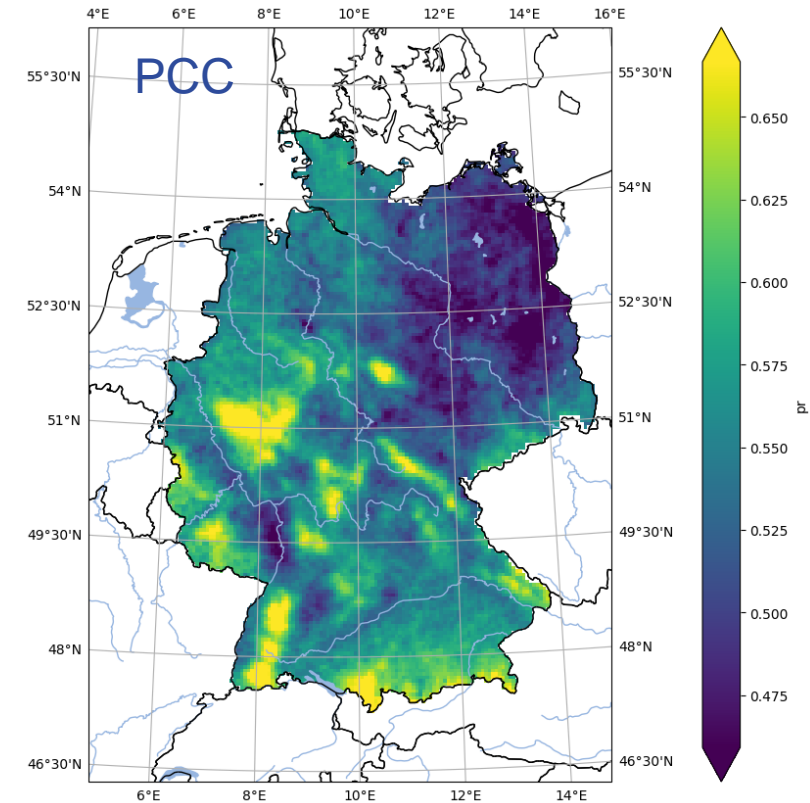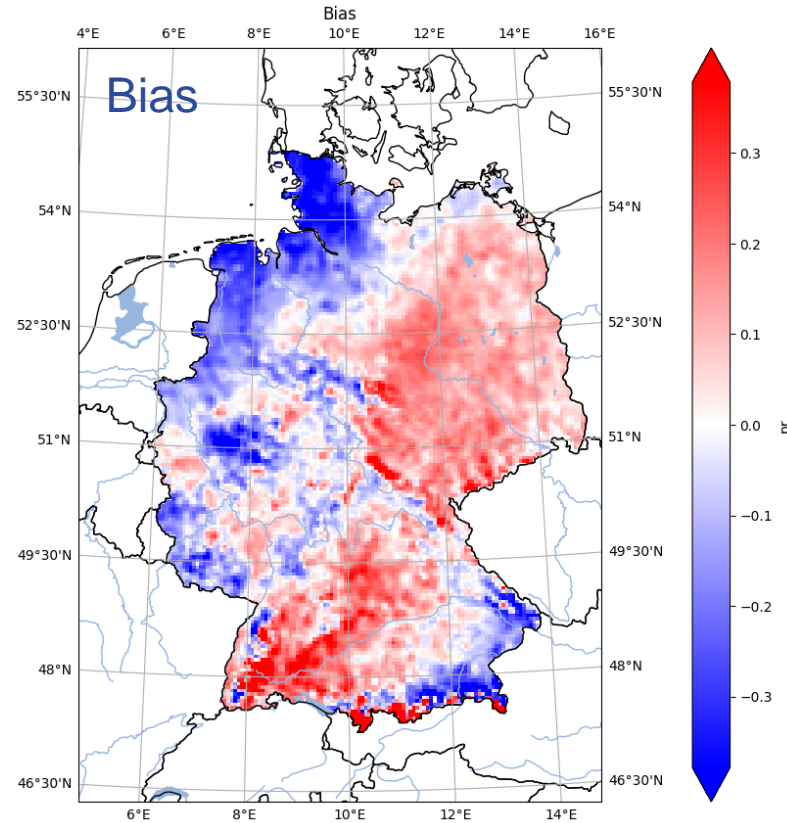
COSMO-CLM Eval-Simulation: Comparison to HYRAS data for period **1971-2000**

- Good correspondence between COSMO-CLM and HYRAS except overestimation in the North-West and in mountainous areas
- Pearson Correlation coefficient ranges between 0.4 and 0.65
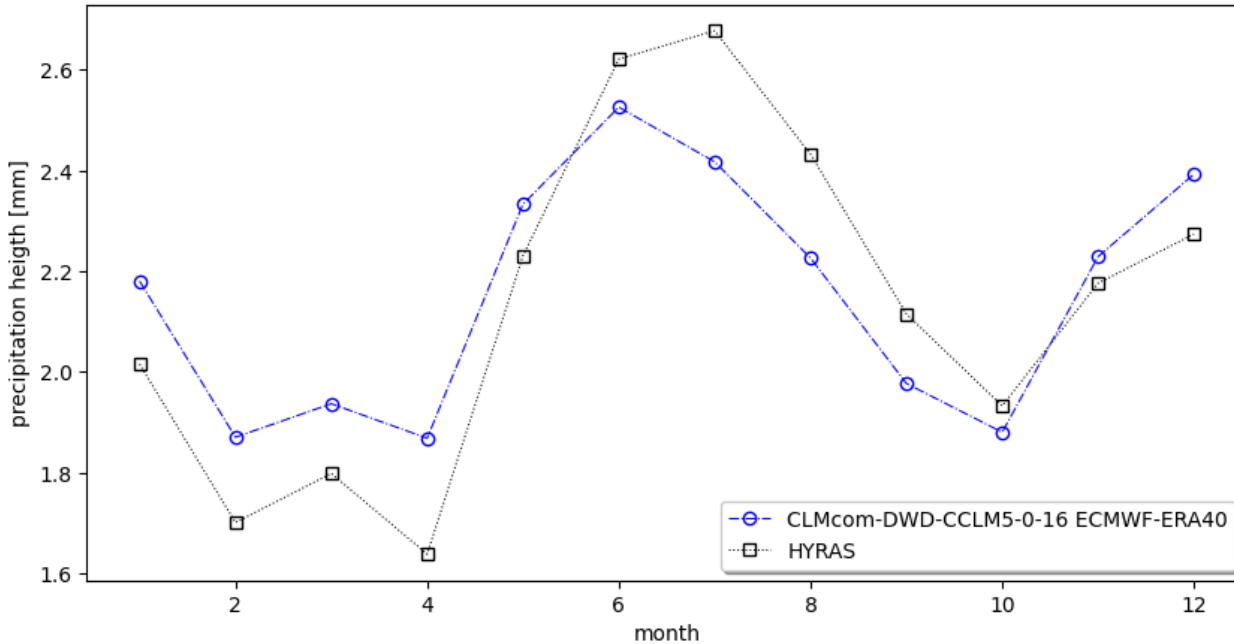
Annual cycle 1971-2015

COSMO-CLM Eval-Simulation:
Time series comparison to
HYRAS data
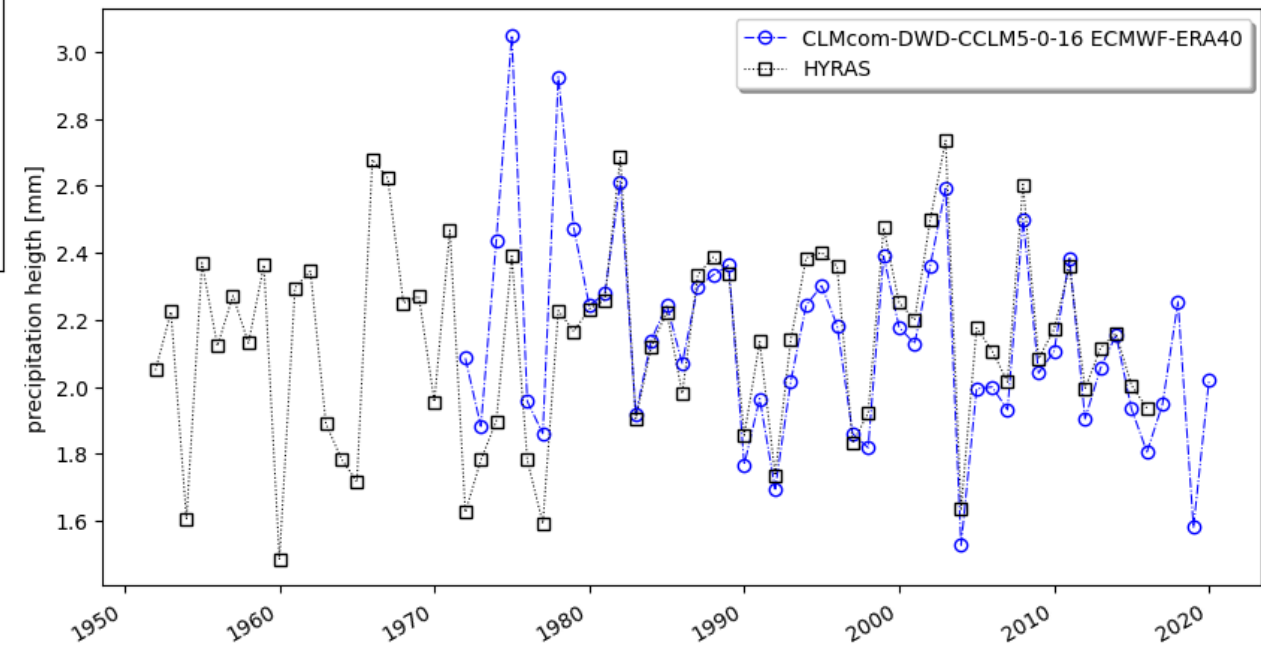
Annual mean daily precipitation 1951-2020

- Good correspondence between COSMO-CLM and HYRAS
- Small shift in annual cycle seen for summer months
- COSMO-CLM overestimation in winter, underestimation in summer

Model evaluation: Wind

COSMO-CLM Eval-Simulation: Comparison to COSMO-REA6 data for period **1995-2015**
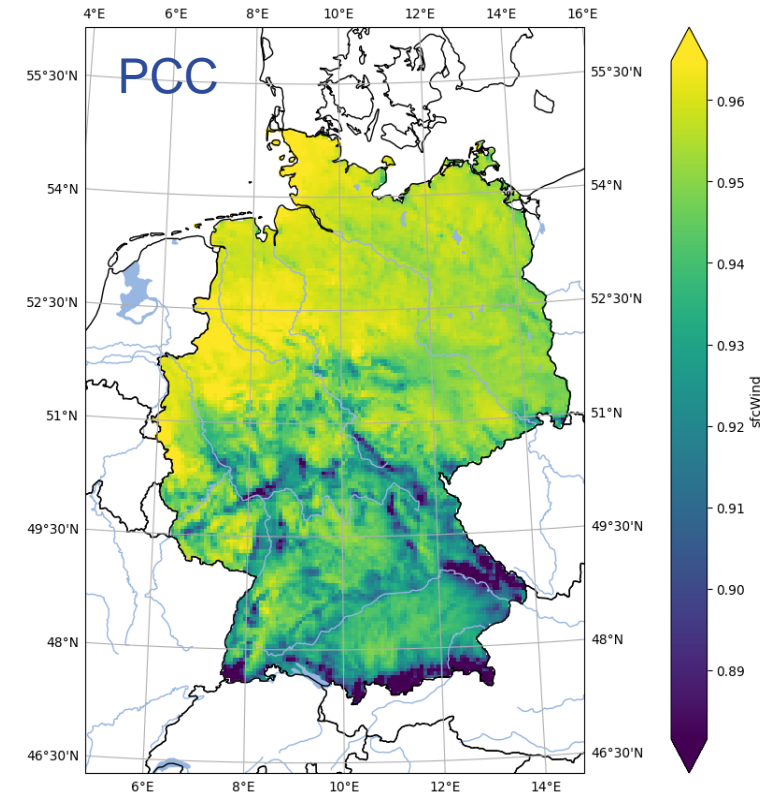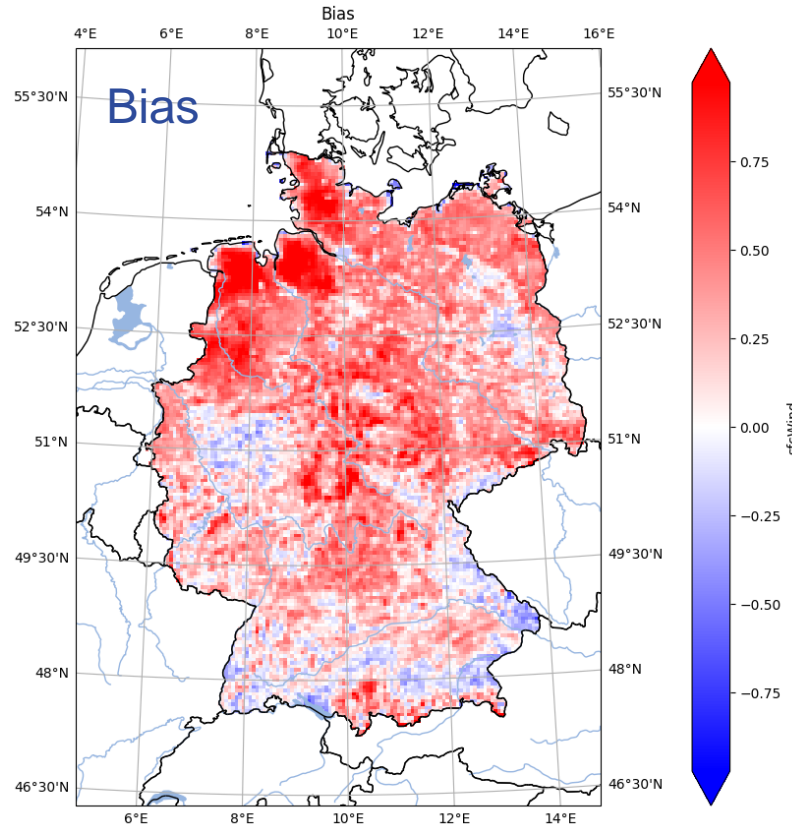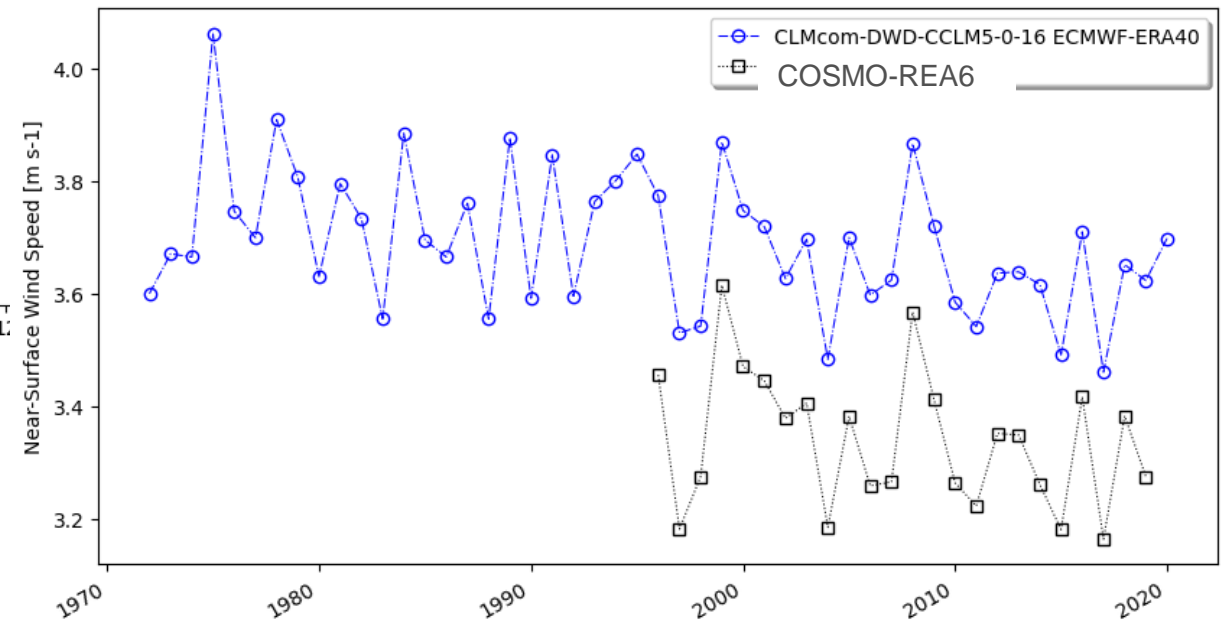

- Good correspondence between COSMO-CLM and COSMO-REA6
  - Except the North-West part where differences > 0.75 m/s
- Very high correlation coefficient (> 0.9 in most areas)

Annual cycle 1995-2018

Annual means 1971-2019
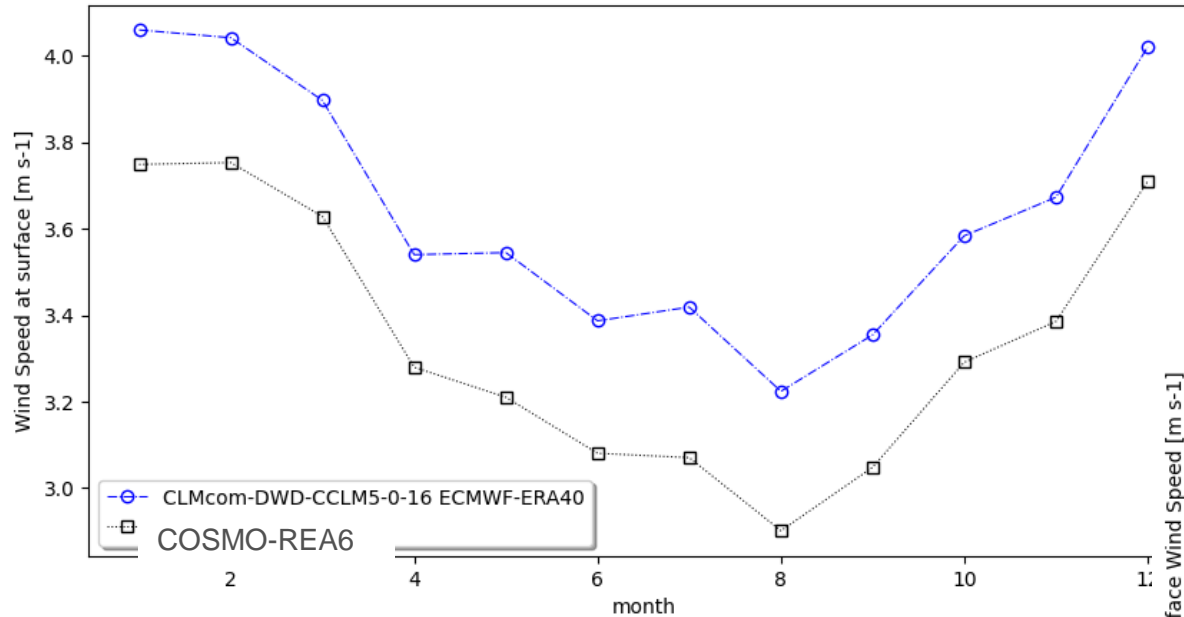
- Good correspondence of annual cycle and long-term annual means
  - Systematic shift of ≈ 0.3-0.4 m/s

➜ **Hourly data:**

  ➜ **Mean diurnal cycle of precipitation**
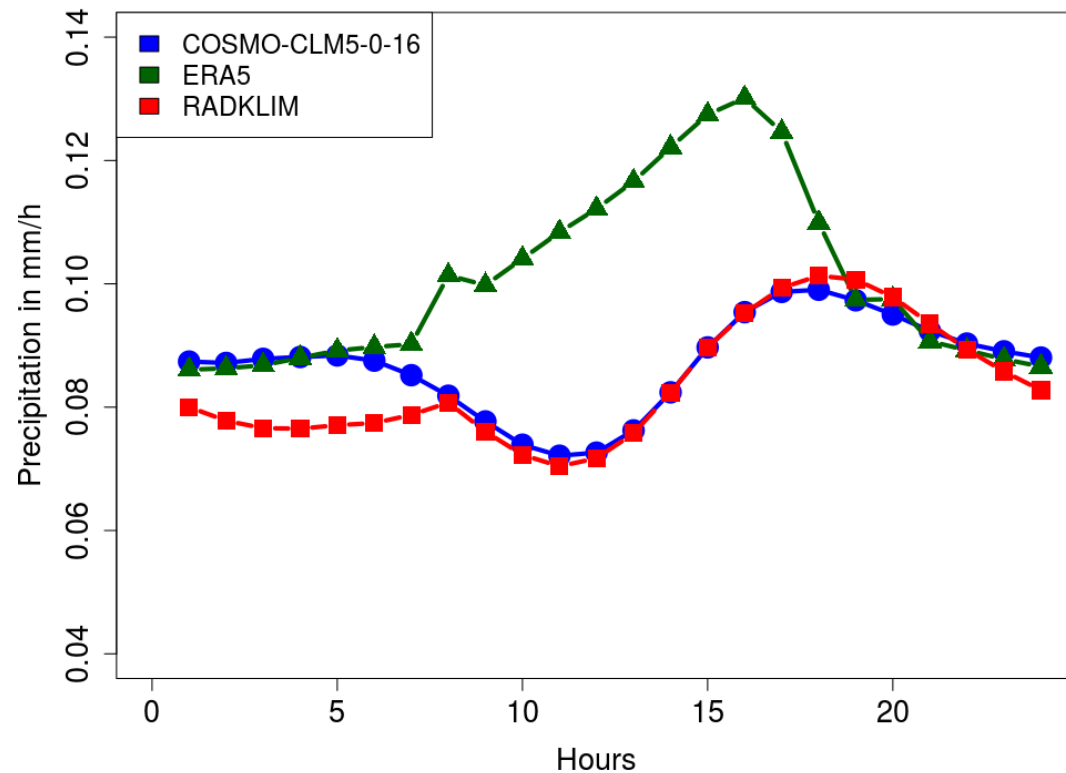
    ➜ for different seasons and different regions

  ➜ **Mean intensity and wet hours**

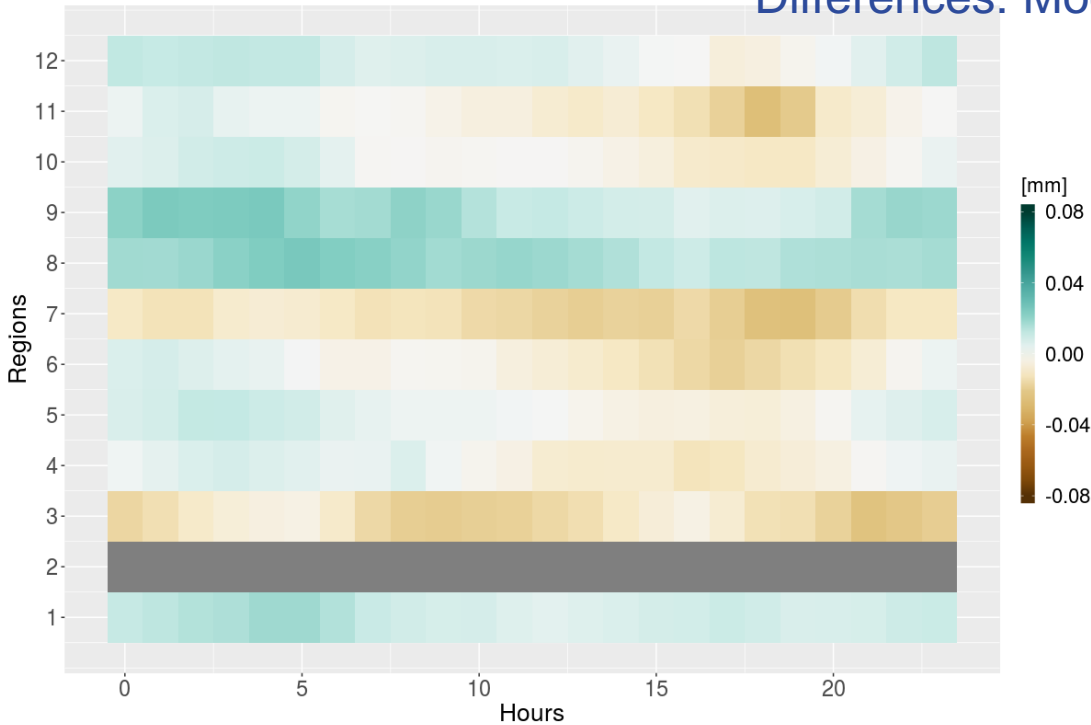 ➜ **Peak-over-threshold method**

  ➜ Reference data: RADKLIM

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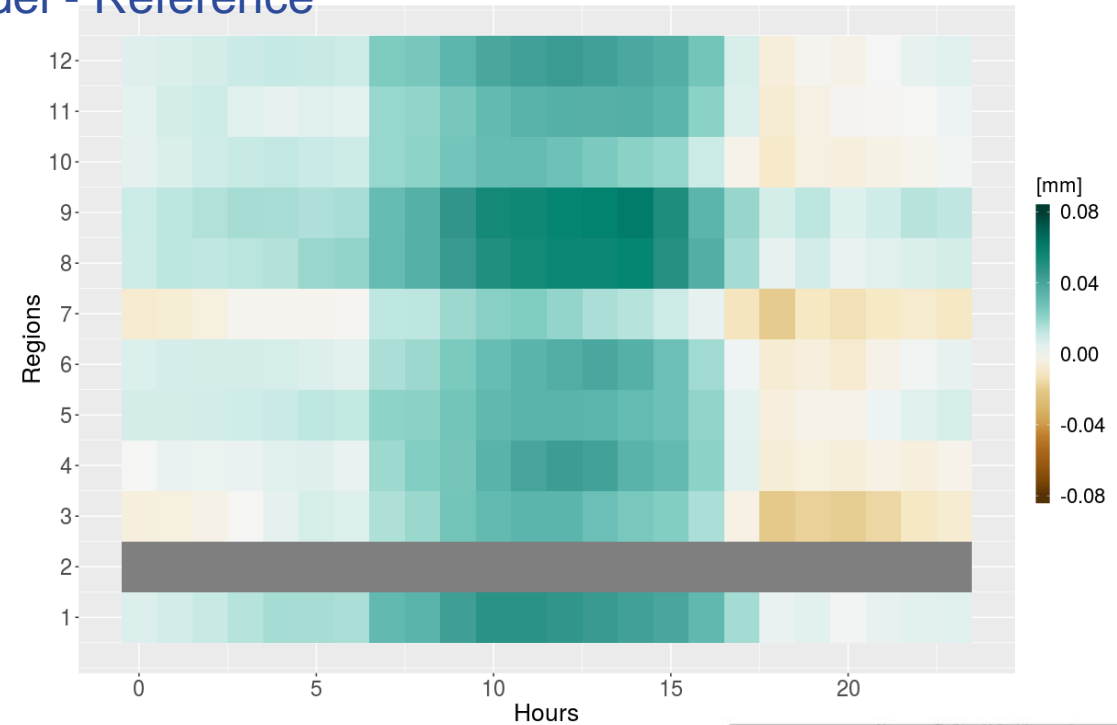
Diurnal cycle for **year** (Jan-Dec)

- Good correspondence between COSMO-CLM and RADKLIM, except night-time precipitation
- Strong overestimation of ERA5 precipitation over the day

Domain: **Germany**
Time range: **2001-2015**

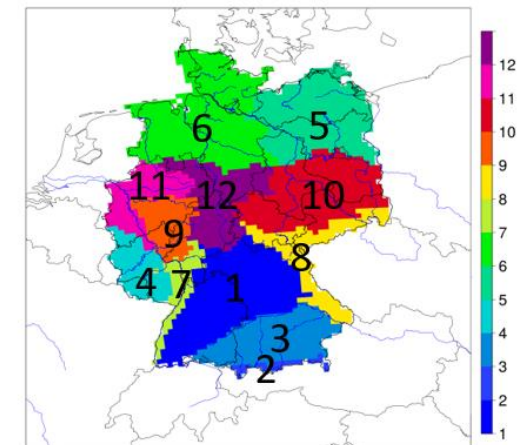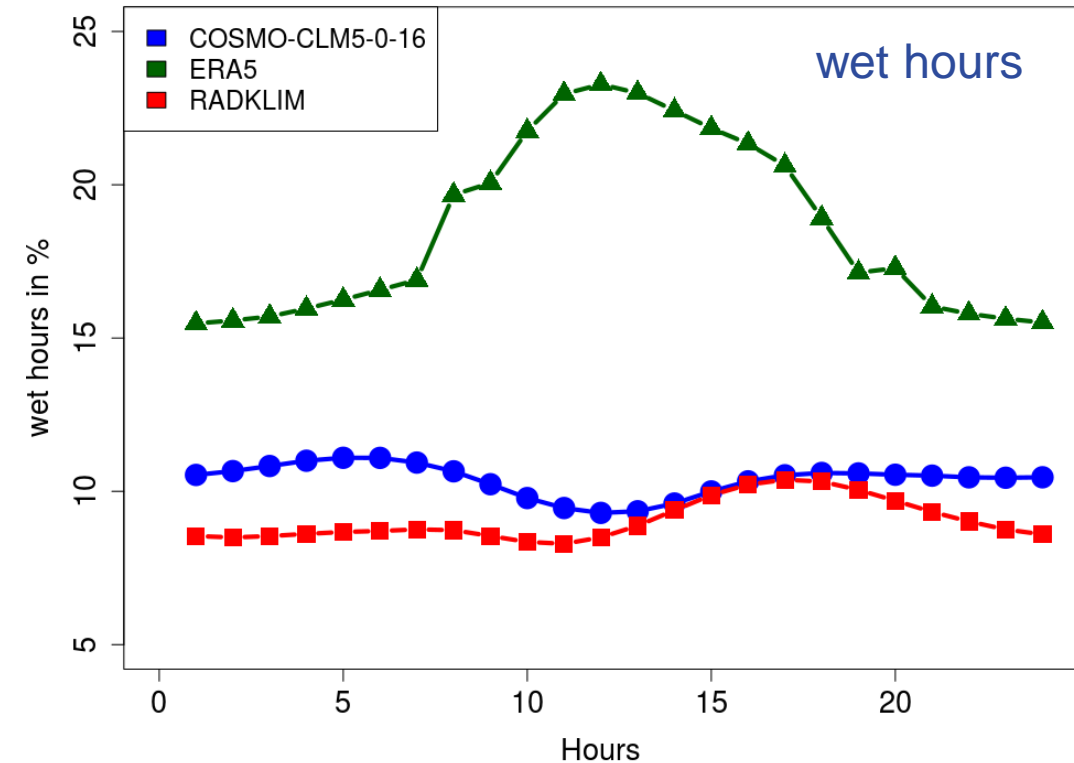# Diurnal cycle of precipitation
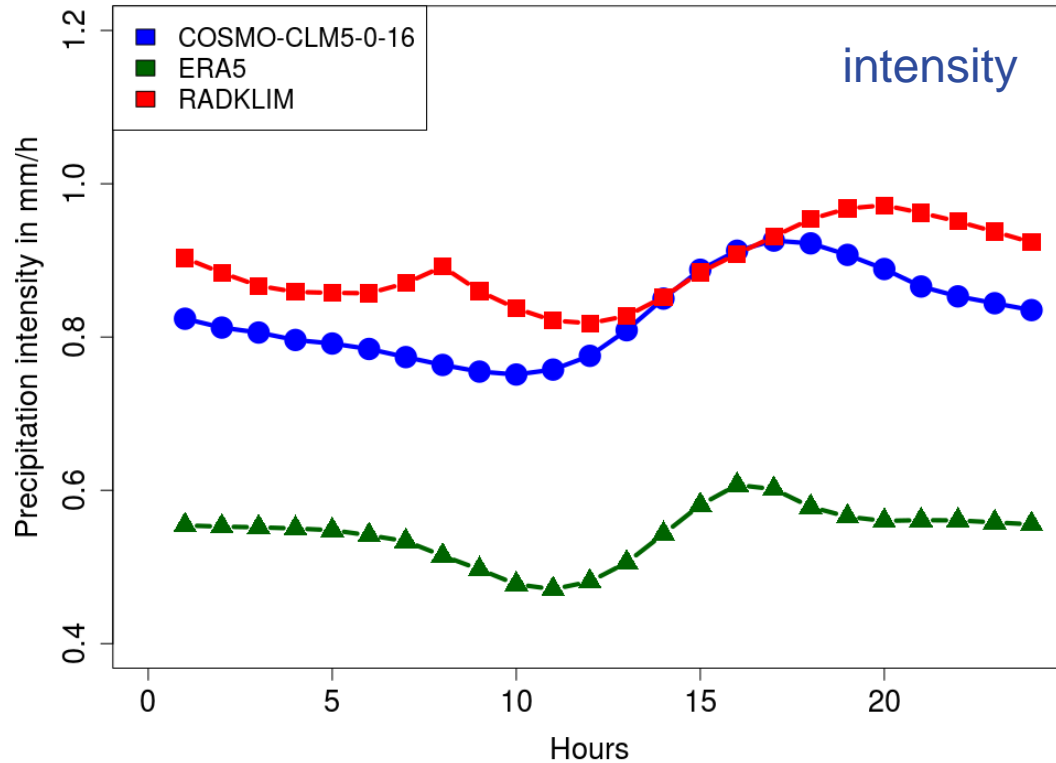
Differences: Model - Reference
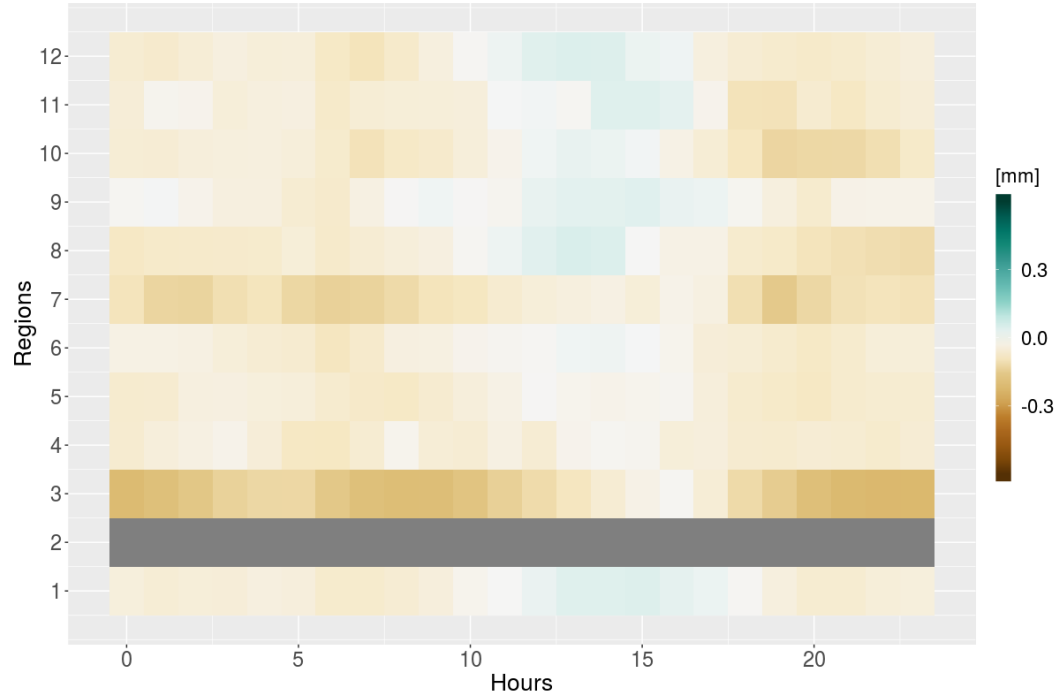

COSMO-CLM

ERA5

- Differences show better performance of COSMO-CLM for all regions
- Strong overestimation of precipitation at noon by ERA5
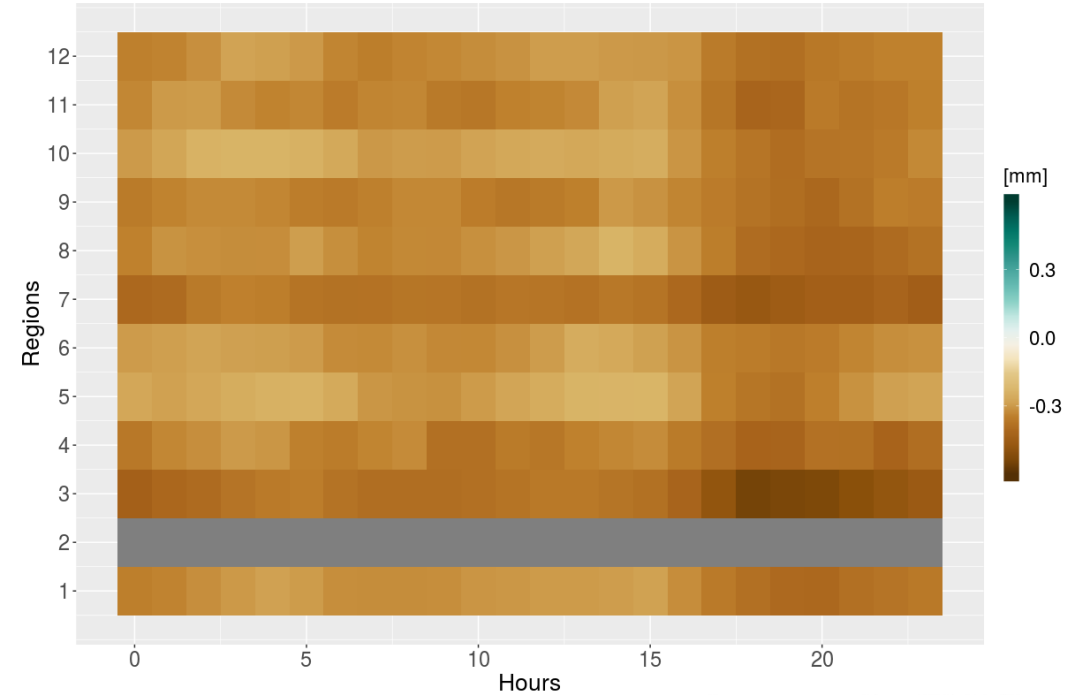- Differences of COSMO-CLM vary for different regions

- Good performance of COSMO-CLM, small shift in diurnal cycle
- Strong underestimation of ERA5, but diurnal cycle of intensity is present in both model data. Wet hours are too high in ERA5, especially around noon

70 Jahre
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

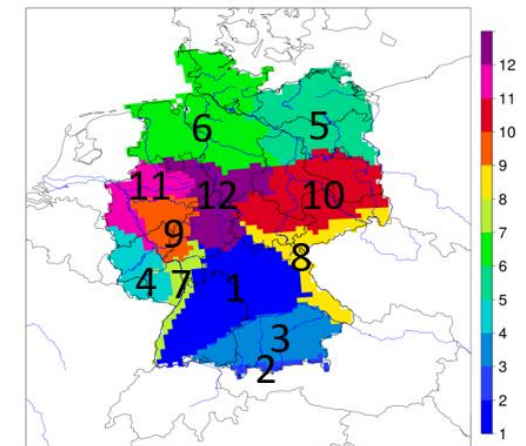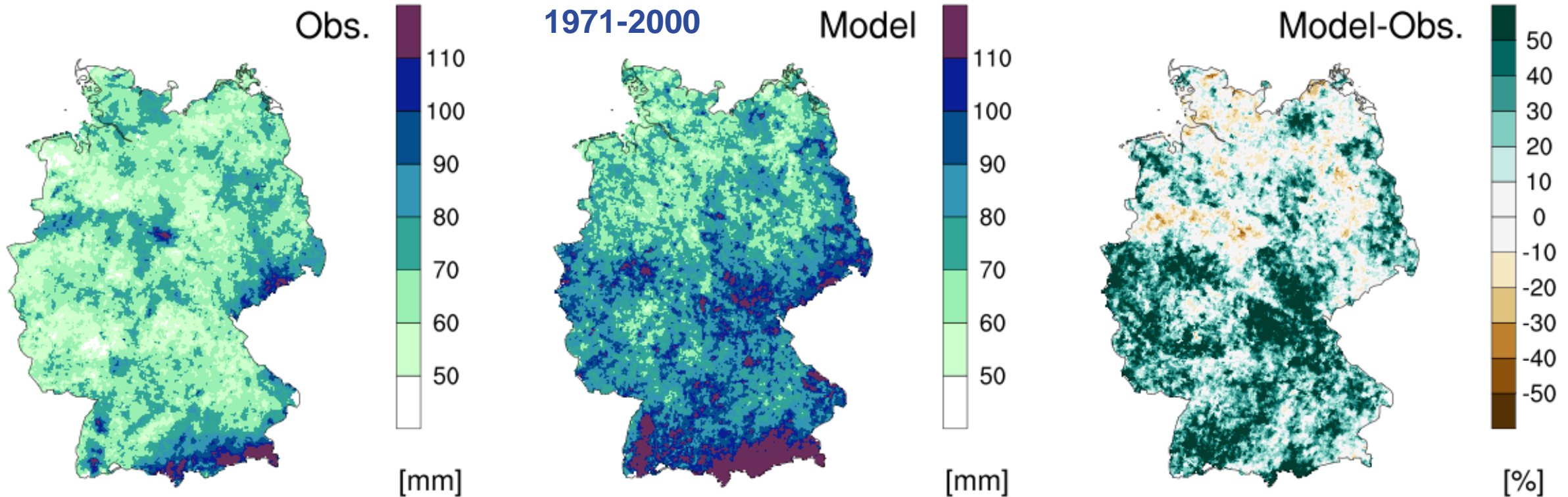Differences: Model - Reference

COSMO-CLM

ERA5

- Differences in intensity most pronounced for region 3 & 7 for COSMO-CLM
- For ERA5 differences are negative in all regions and all months
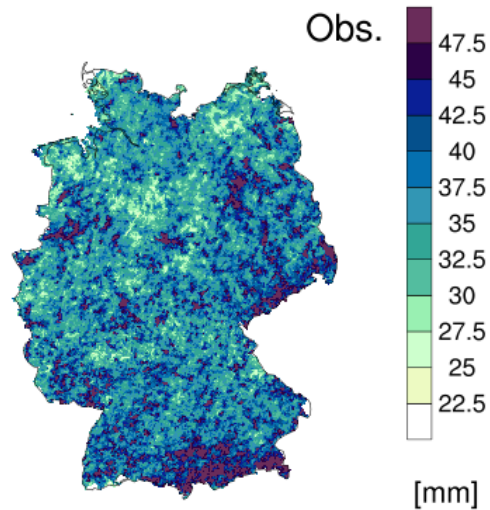
PoT-method application to extreme precipitation

- Good correspondence in Northern Germany
- Strong overestimation (30-50%) in mountainous areas / Southern Germany

Rybka et al. 2022, submitted

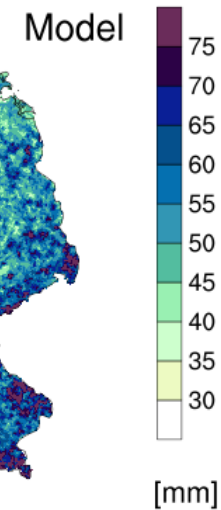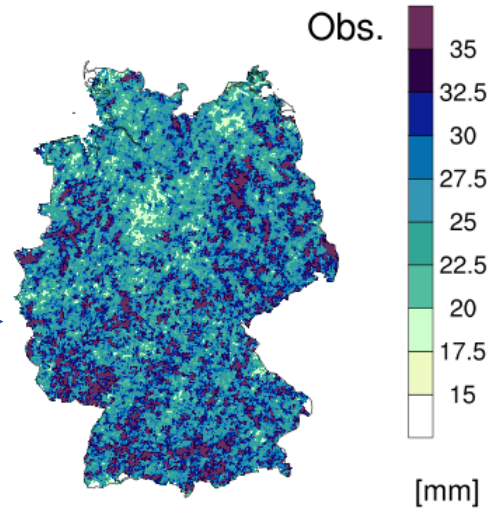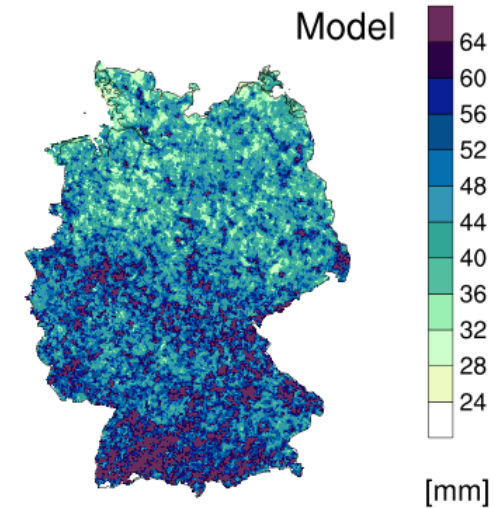# Short durations (D=3h / 1h; T=30a)

D=3h T=30a

Obs.

D=1h T=30a

Obs.

Model
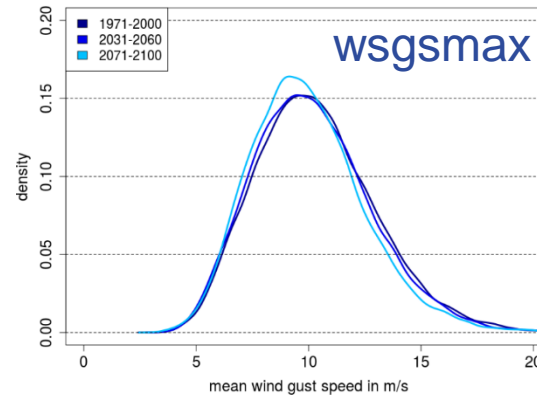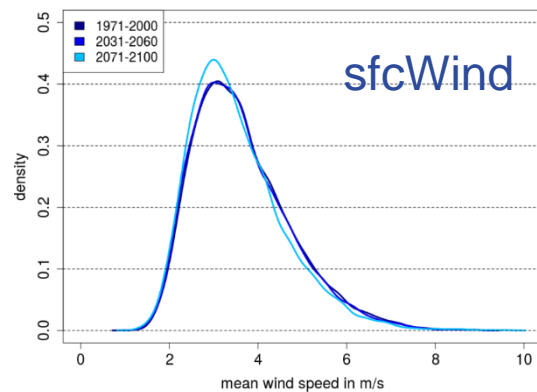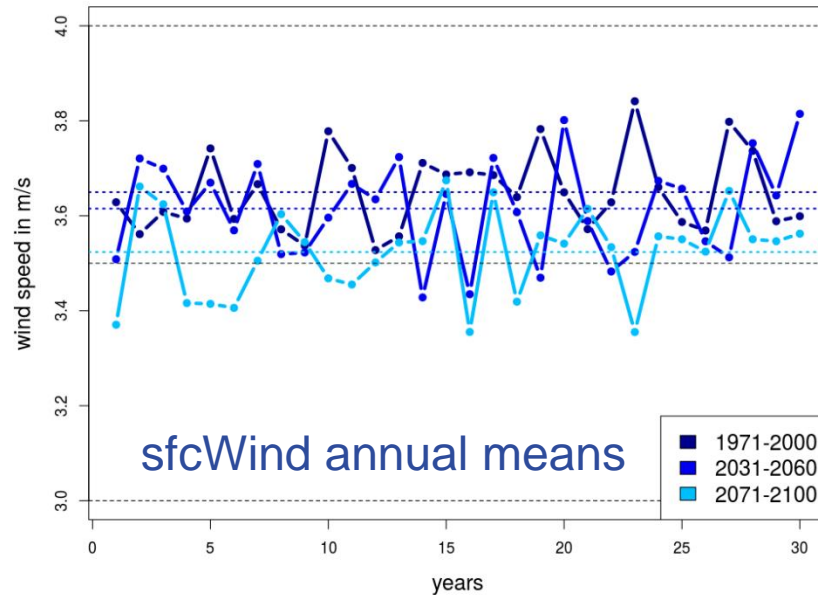
Model

Disappearing orographic patterns

**Orographic patterns weakening**

Rybka et al. 2022, submitted

- Model overestimation of short durations (mind the scale!)
- Overestimation of orographic dependance of extreme precipitation

sfcWind annual means

sfcWind

wsgsmax

- ➔ Do the time series differ and is the difference significant?

- ➔ Mann-Whitney-u-Test:
    - ➔ Significance at p-Value < 0.05
    - ➔ historical / near future: p=0.68
    - ➔ historical / far future: p=4.867e-06
- ➔ Similar results also for wind gusts: significant changes in the far future for wind and wind gusts
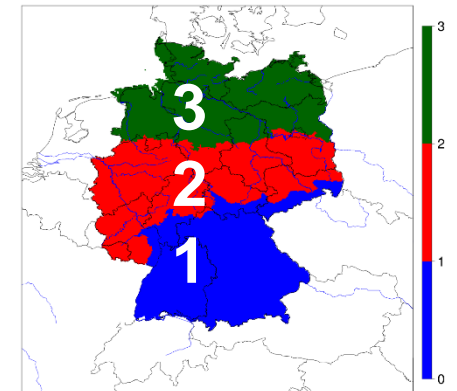
sfcWind annual cycle of 30 years
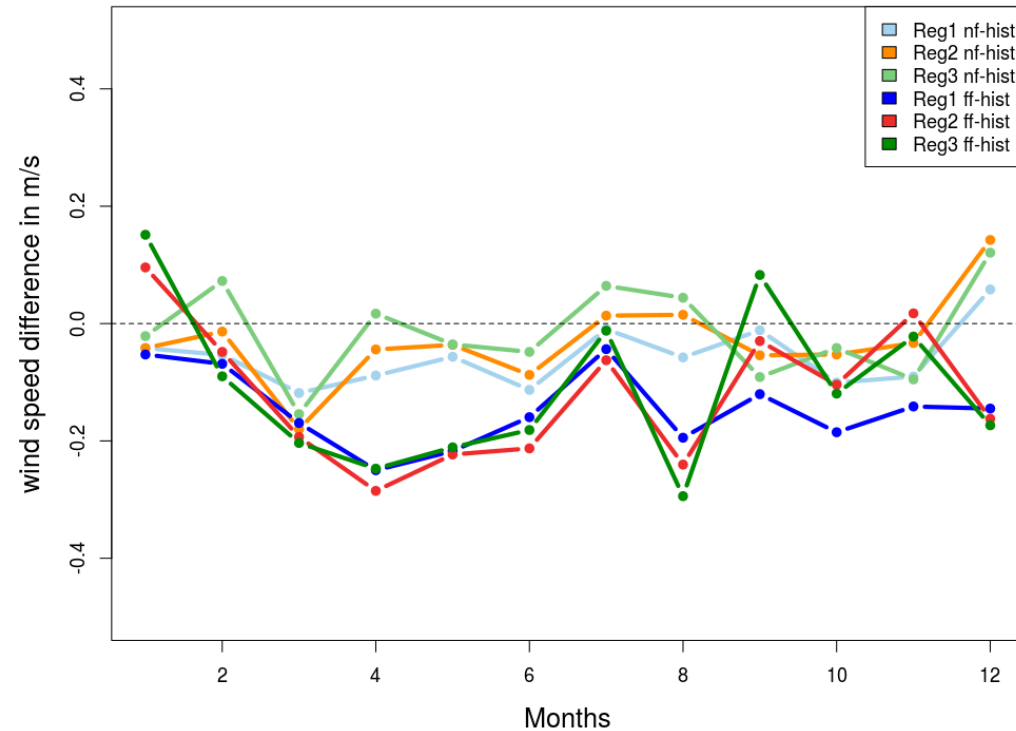
wsgsmax annual cycle of 30 years
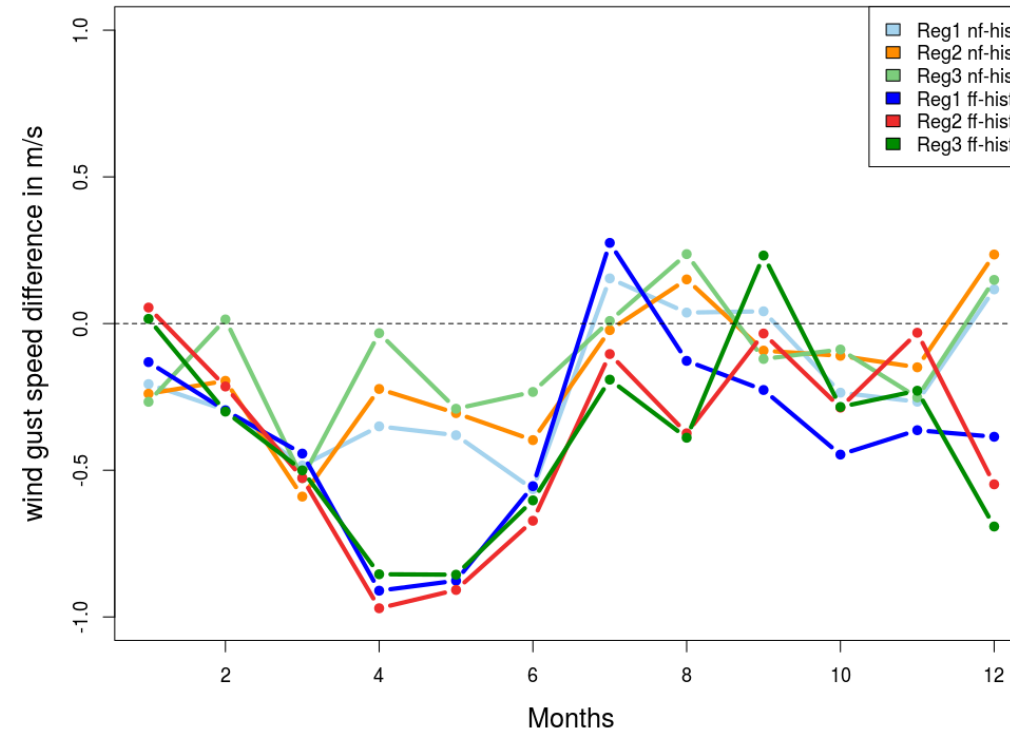
- Aggregating the analyses from 12 to 3 regions:
  - Decreasing wind and wind gusts in nearly all months, especially in spring
    - Visible in all three regions

- COSMO-CLM Simulations with 3km grid resolution for 30-year periods
  - CMORized and published on ESGF:
    https://esgf.dwd.de/projects/dwd-cps/
  - Data evaluation for core variables temperature, precipitation and wind
- Precipitation: Good correspondence to reference data
  - Positive added value in comparison to coarse reanalysis data
  - …but
  - Overestimation of very extreme precipitation and its orographic patterns on short time intervals (1-3h)
- Wind/ wind gusts: good correspondence to reference data (reanalyses)
  - Comparisons to station data are planned
  - Slight but significant decrease of mean winds for far future (2071-2100), more work needed!