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70 Jahre Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Analyses of added value for heavy rain fall and strong wind in convection-permitting climate simulations over Germany

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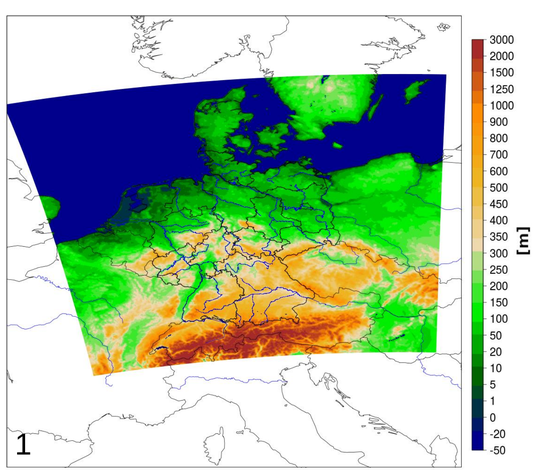
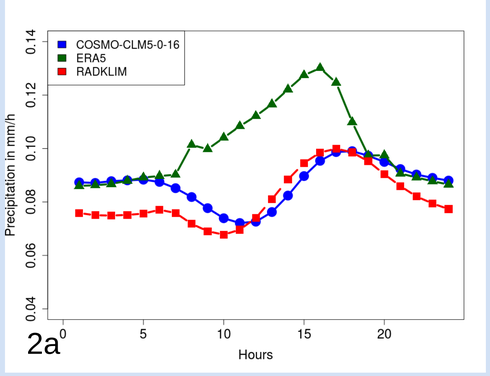


Fig. 1: Model domain and orography in m of COSMO-CLM simulations with 3 km grid.

Fig. 3: Annual cycle of maximum 1-day (a) and 5-day (b) precipitation per month (Rx1day/Rx5day) from COSMO-CLM, ERA5 and HYRAS for 1971-2000.



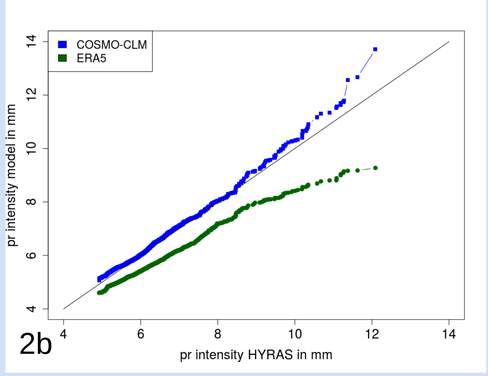
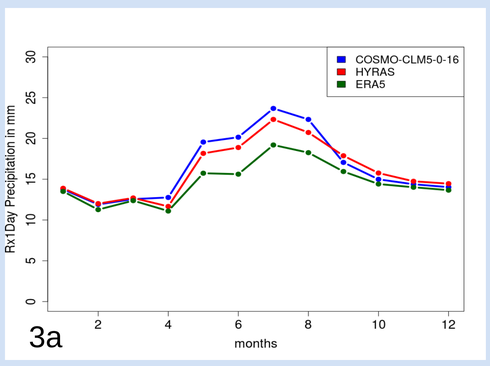
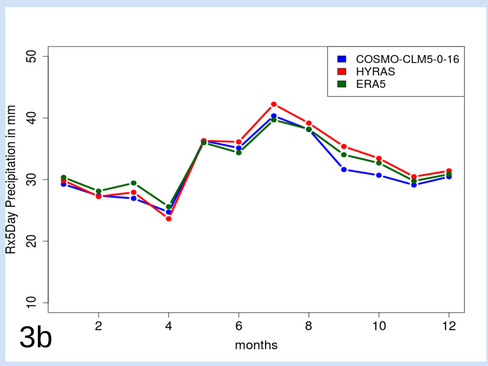
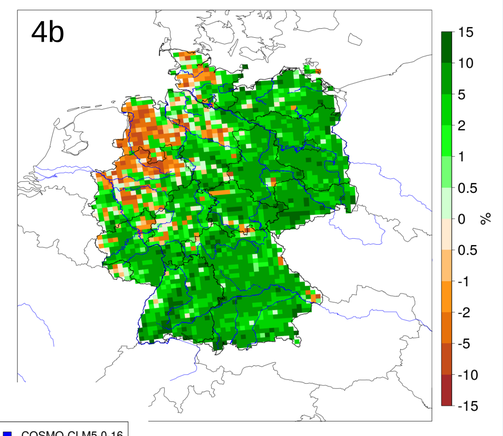


Fig. 2 a: Mean daily cycle of precipitation of models (COSMO-CLM5-0-16 and ERA5) and observation (RADKLIM) for 1971-2000. b: Q-Q-plot of precipitation intensity for the daily data of HYRAS (x-axis) and different models results (y-axis) for 1971-2000.







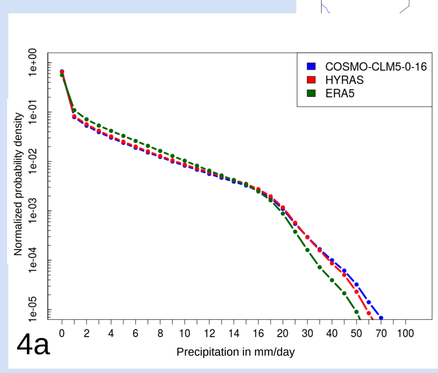


Fig. 4 a: Probability density of precipitation for daily model and observation data. b: Distribution added value (DAV) for Germany. Positive value (green colors) indicate an added value of the high resolution.

In the project "BMDV - Network of experts: Adapting transport infrastructure to climate change and extreme weather events", we address the needs of our project partners for highly resolved climate model data by performing convection-permitting simulations (CPS) with the regional climate model COSMO-CLM 5.0.
A focus of our analyses is the quantification of the added value from the high resolution in comparison to the forcing model data concerning extreme events like heavy rain fall and strong winds. For the analyses of our model data, we use observation data with daily and hourly resolution. Further analyses of return levels for extreme precipitation using the peak-over-threshold method have also been performed.

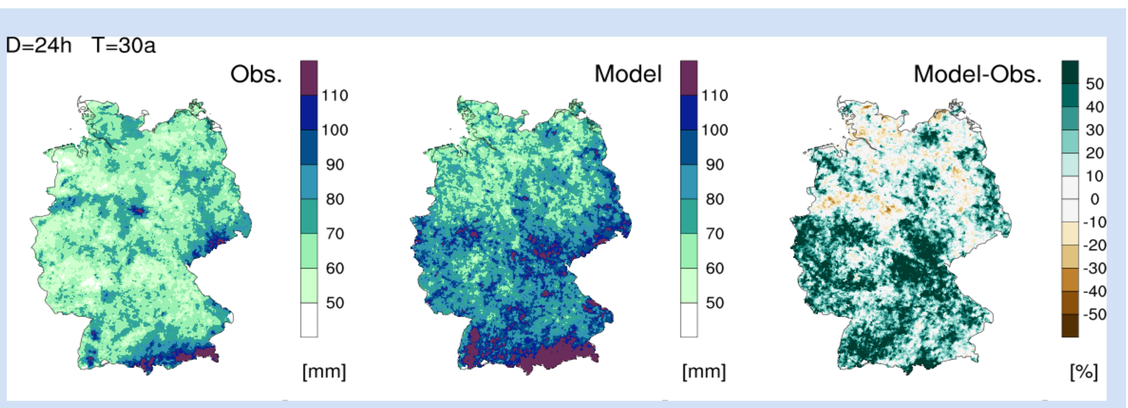
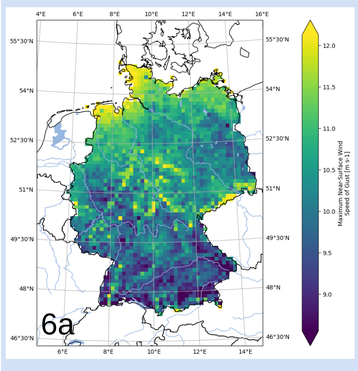
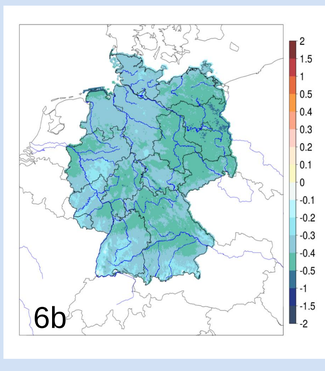


Fig. 5: Comparison of 24 hours rain fall duration with return level of 30 years for RADKLIM (Obs) and COSMO-CLM historical simulation (Model). COSMO-CLM overestimates the 24 hours rain fall, especially for southern Germany. For shorter durations (e.g. 3 hours), the precipitation overestimation of the model increases.





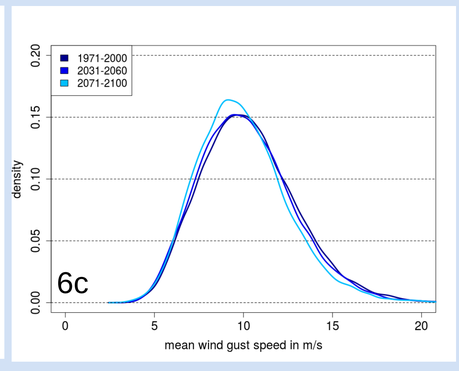


Fig. 6 a: Mean wind gusts (m/s) of COSMO-CLM simulation (1971-2000). b: Climate change signal of mean wind gusts (m/s) for RCP8.5 (2071-2100) and historical (1971-2000) simulation. c: Density plot of mean daily wind gusts for Germany for the projection simulations.

Data sets

- **Convection-permitting simulation (CPS):** We used **COSMO-CLM5-0-16** on a **3 km grid**, which is centred over Central Europe (Fig. 1). Besides the **projection runs** forced with MIROC-MIROC5 (Haller et al. 2022a,b), we performed also an **evaluation run**, driven by **ERA5/ERA40 reanalysis**, for the time period of **1971-2019** (Brienen et al. 2022). Some variables of the full data set are accessible on ESGF (https://esgf.dwd.de/projects/dwd-cps/).
- **ERA5 reanalyses:** Hourly fields of precipitation with grid width of ≈ 30 km (Hersbach et al. 2020).
- **HYRAS precipitation data (v3.0)**: Gridded station observations for Germany and surrounding river catchments on 5 km grid and daily resolution (1951-2015) (Rauthe et al. 2013).
- **RADKLIM (v2017.002)**: Gridded radar observations for Germany, calibrated with station gauges. Data are available on 1 km grid and hourly resolution for 2001-2018 (Winterrath et al. 2018).

Methods

The precipitation data sets have been interpolated to the EUR-0.11° grid. The analyses are focused on Germany (Fig. 1). For the quantification of added value of CPS, several indices have been applied, averaged for Germany and are shown in the figures:

- Mean daily cycle of precipitation (Fig. 2a).
- SDII: The simple precipitation intensity index is the sum on wet days (RR>1mm) divided by the number of wet days (Fig. 2b).
- Rx1day/Rx5day: The mean monthly maximum precipitation of 1 day / 5 days (Fig. 3a/b).
- Distribution added value (DAV): Comparison of the PDFs of both model datasets (see Fig. 4a) with the reference (Soares & Cardoso 2018) (Fig. 4b).
- Analyses of return levels and different duration of extreme precipitation has been performed, using the peak-over-threshold method (Fig. 5) (Rybka et al. 2022).

Conclusions:

- Added value of the high resolution for precipitation demonstrated e.g. by DAV index and daily cycle.
- COSMO-CLM overestimation of extreme precipitation.
- First results from wind analyses indicate a small decrease of winds and wind gusts for Germany in the far future (2071-2100).

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Literature:
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Haller, M. & Co-Authors (2022a): Historical simulation with COSMO-CLM5-0-16 version V2022.01. DOI: 10.5676/DWD/CPS_HIST_V2022.01
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Hersbach, (2020): The ERA5 global reanalysis. Q. J. R. Meteorol. Soc Vol. 146 Issue 730, DOI: 10.1002/qj.3803
Rauthe, M. & Co-Authors (2013): A Central European precipitation climatology - Part I: Generation and validation of a high-resolution gridded daily data set (HYRAS). Meteorologische Zeitschrift Vol. 22 Issue 3, DOI: 10.1127/0941-2948/2013/0436
Rybka, H. & Co-Authors (2022): Convection-permitting climate simulations with COSMO-CLM for Germany: Analysis of present and future sub-daily extreme precipitation. Meteorologische Zeitschrift , submitted
Soares P. & Cardoso, R. (2018): A simple method to assess the added value using high-resolution climate distributions: application to the EURO-CORDEX daily precipitation. Int. J. Climatol. Vol. 38 Issue 3, DOI:10.1002/joc.5261
Winterrath T. & Co-Authors (2018): RADKLIM Version 2017.002: Reprocessed gauge-adjusted radar-data, one-hour precipitation sums (RW). DOI: 10.5676/DWD/RADKLIM_RW_V2017.002

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