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Sub-daily precipitation characteristics in convection-permitting COSMO-CLM simulations for Germany

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The focus of the German research project "Network of Experts - Adapting transport and infrastructure to climate change and extreme weather events“ is the provision of high-resolution climate information in order to make the national transport infrastructure resilient to extreme weather and climate change. Temperature, precipitation and wind are key parameters.
A large ensemble of RCM simulations at 0.11° grid spacing is available from EURO-CORDEX. The transport sector, however, is interested in higher resolution information in space and also in time (hourly data).
In this context, we investigate the characteristics of hourly precipitation in some convection-permitting simulations with the COSMO-CLM model (Rockel et al., 2008) and analyze the impact of using the Graupel scheme.

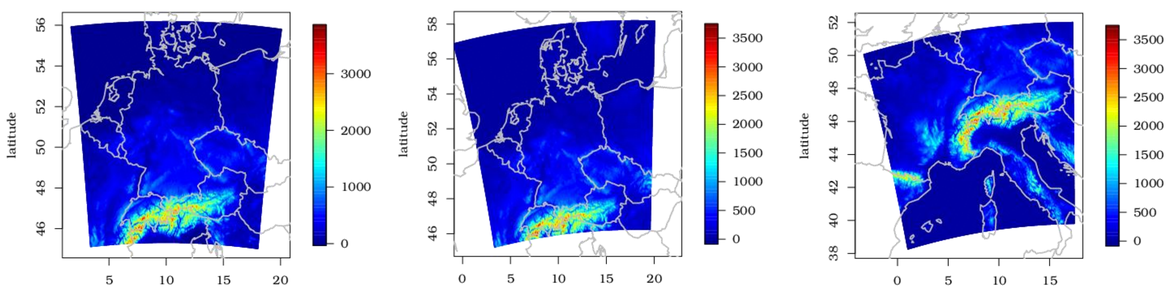


Fig. 1: Model orography (HSURF, m) in the ExpN (left), new evaluation run (middle) and FPS-C (right) domain.

Model simulations with COSMO-CLM

3 sets of simulations (with acronyms of Table 1, model domains in Fig. 1)

EVAL / EVAL12 / HIST: from project Network of Experts („ExpN“), evaluation run (12km driven by ERA40 and ERA-Interim, then nesting to 2.8km) and historical run (2.8km, driven by MIROC-5 and CCLM-0.11°), Germany

FPS-C: CORDEX Flagship Pilot Study on Convection, historical run (driven by HadGEM2 + CCLM-0.11°); configuration agreed on in WG CRCS; Alpine mandatory domain

EVAL_new: new simulation with similar settings as in FPS-C, driven by ERA40+CCLM-0.11° (1970-1978) and ERA5 (direct nesting since 1979); will be prolongated continuously; can serve as reference for different kind of projects

Physics: all high-resolution simulations use only the shallow convection scheme, microphysics in the ExpN simulations without graupel, new evaluation run and FPS-C simulations with graupel parameterization

Additional Sensitivity run (EVAL_gr): 2001 with ExpN settings, switching on the graupel parameterization

Table 1: Overview of some characteristics of the investigated simulations. First 3 rows with „old“ ExpN settings, followed by the sensitivity run, the FPS-C simulation and the new evaluation run.

Acronym	Domain	Time Period	Graupel	Grid spacing	Driving Data	CCLM version
EVAL	Germany (Fig. 1a)	1971 – 2000	no	0.025°	ERA	4.8_clm18
EVAL12	Germany (Fig. 1a)	1971 – 2000	no	0.11°	ERA	4.8_clm18
HIST	Germany (Fig. 1a)	1971 – 2000	no	0.025°	MIROC5	4.8_clm18
EVAL_gr	Germany (Fig. 1a)	2001	yes	0.025°	ERA	4.8_clm18
FPS-C	Alps (Fig. 1c)	1996 – 2005	yes	0.0275°	HadGEM2	5.0_clm15
EVAL_new	Germany (Fig. 1b)	1971 – 2019	yes	0.0275°	ERA	5.0_clm16

RADKLIM data

- **Variables:** precipitation
- **Version**: v2017.002
- **Grid**: 1x1 km
- **Domain**: Germany
- **Time**: 2001 – 2017, 1 hour (+ 5 min)
- **Source**: radar measurements corrected with station observations
- **Reference**: Winterrath et al. 2018

Summary / Outlook

- Bad diurnal cycle with CCLM 4.8_18 without graupel scheme; → better with CCLM 5.0_15/16 and graupel
- Effect of graupel large in summer
- Diurnal cycles different in different regions, seasons, years, and between 12 and 2.8 km grid spacing
- **New evaluation simulation: data available on request, common analysis with similar simulations in the community would be great!**

Results

Diurnal cycle of precipitation, old and new evaluation simulations compared to RADKLIM:
with old model version without graupel precipitation maximum too late in the evening and cycle completely different in 2.8 and 12 km grid spacing (Fig. 2a). Better comparison to RADKLIM for new simulation, although still too much rain in the night, and cycle very similar in different time periods (Fig. 2b).

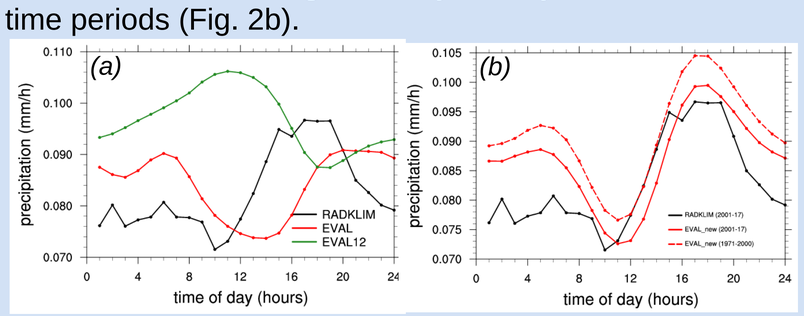


Fig. 2: Mean diurnal cycle over Germany. a) in old simulations with 2.8 km (EVAL) and 12 km (EVAL12) for 1971-2000 (simulations) b) in new simulation (EVAL_new) for 2 time periods (2001-2017 and 1971-2000);RADKLIM in both plots for 2001-2017.

Influence of graupel: (Fig. 3)
Annual cycle: more precipitation with graupel scheme, especially in summer.
Diurnal cycle: change in structure; more similar to RADKLIM with graupel.

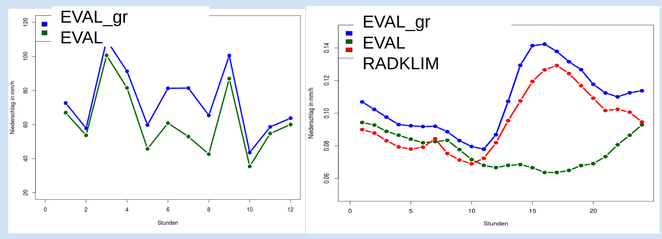


Fig. 3: Mean annual (left) and mean diurnal (right) cycle for JJA 2001, average over model domain (left) and Germany (right). Simulations with and without graupel and RADKLIM (right).

From FPS-C runs for south part of Germany:
cycle comparable to RADKLIM, but even more too much rain in the night and morning (Fig 4a); large interannual variability in the simulations (Fig. 4b).

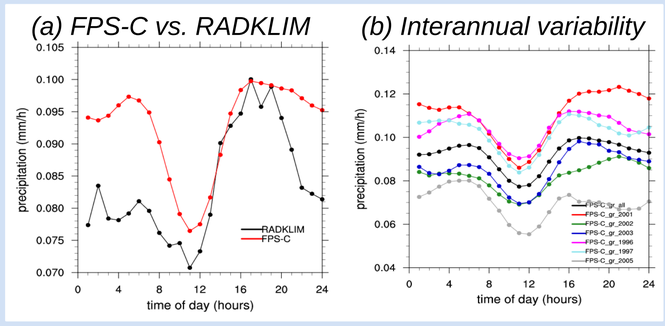


Fig. 4: mean diurnal cycle averaged over south half of Germany (cf. Fig. 1); a) simulation vs. RADKLIM, average for years 2001-2005, b) simulation, average for 1996-2005 (black line) and individual years (colours).

Regional differences:
structure of the cycle and differences in resolution varies in different parts of Germany (Fig. 5); 12 km much less diurnal amplitude than 2.8km.

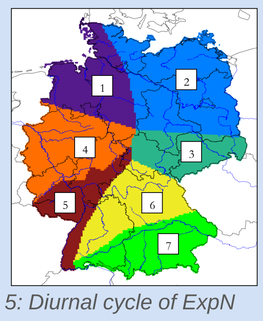
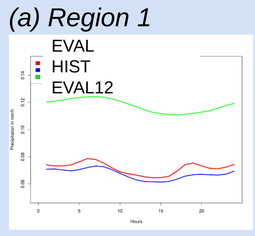
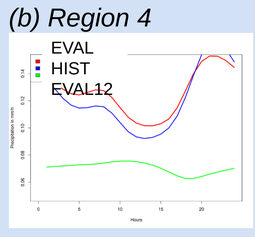


Fig. 5: Diurnal cycle of ExpN simulations (EVAL: red, HIST: blue and EVAL12: green) for different regions in Germany. Average over the years 1971-2000.

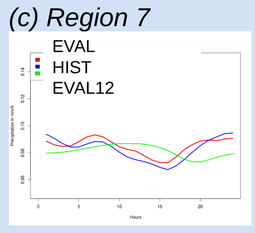
(a) Region 1



(b) Region 4



(c) Region 7



References

Rockel, B., A. Will and A. Hense (eds.), 2008: *Regional climate modeling with COSMO-CLM (CCLM)*, Meteorologische Zeitschrift, 17(4), 347
Winterrath, T., C. Brendel, M. Haferio, T. Junghänel, A. Klameth, K. Lengfeld, E. Walawender, E. Weigl and A. Becker (2018): *RADKLIM Version 2017.002: Reprocessed gauge-adjusted radar data, one-hour precipitation sums (RW)* DOI: 10.5676/DWD/RADKLIM_RW_V2017.002 (data access: https://opendata.dwd.de/climate_environment/CDC/help/landing_pages/doi_landingpage_RADKLIM_RW_V2017.002-en.html)

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