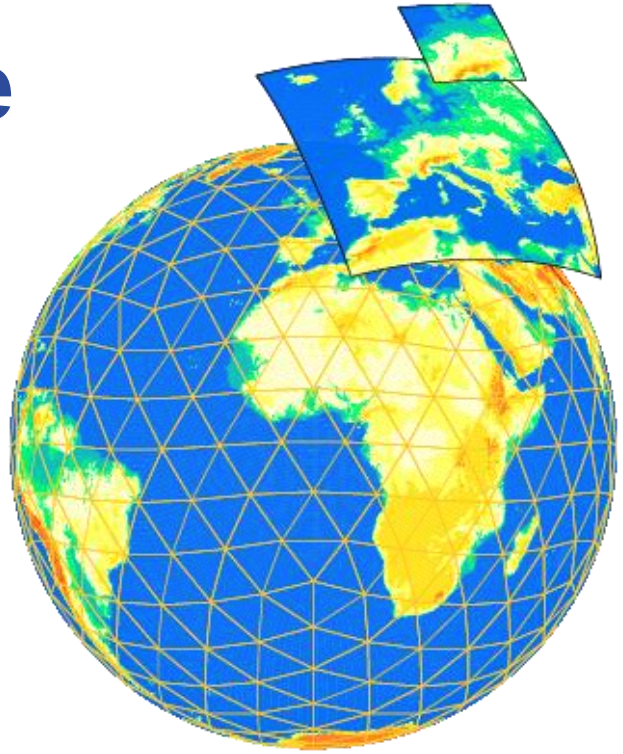
Assessing climate change and extreme events in Germany simulated by COSMO-CLM on convection-permitting scale



Michael Haller, Susanne Brienen, Jennifer Brauch, Barbara Früh
Deutscher Wetterdienst (DWD)

Outline

- Convection-permitting simulations in Project „Network of Experts“ (NoE)
  - Dynamical downscaling from 12 km to 3 km for Germany
  - Two sets of simulations for NoE
- Comparisons of simulations NoE Phase 1 and Phase 2
- First results of
  - Model evaluation
  - Climate change and analyses of extremes

Project „Network of Experts“ (NoE)

- Network of several agencies in the frame of the German Federal Ministry of Transport and Digital Infrastructure (BMVI)
  - Integrates the knowledge and abilities available within the departmental research institutes
  - Datasets and analysis methods for observations and climate projections for Germany for the assessment of specific climate impacts on the transport infrastructure network
- Local information of extreme events are essential for adaption strategies for traffic infrastructure
  - Convection-permitting simulations (CPS) in high resolution are performed

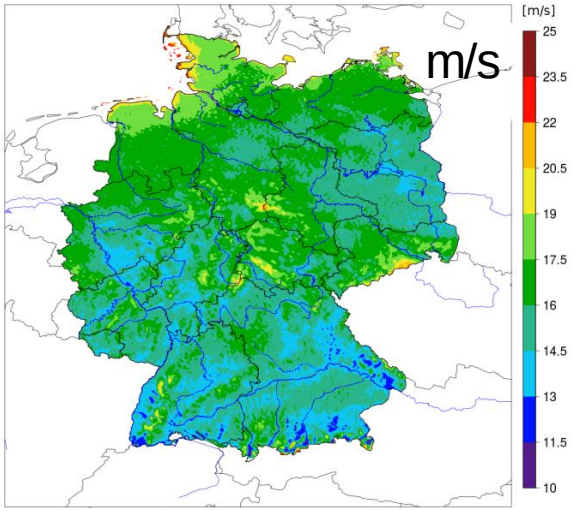
BMVI Network of Experts
Knowledge Ability Action

© dpa, 2016

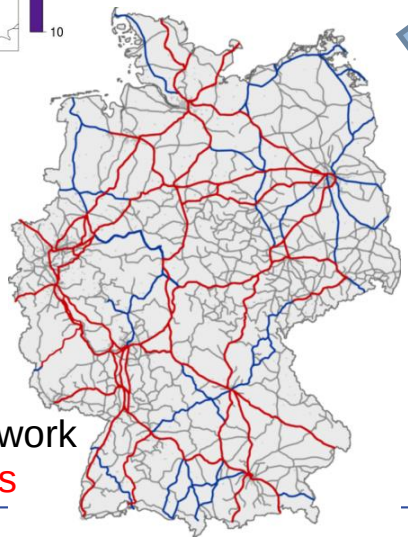
© DLR, 2013

Climate model data for adaptation

- Sensitivity of railroad tracks to storm events

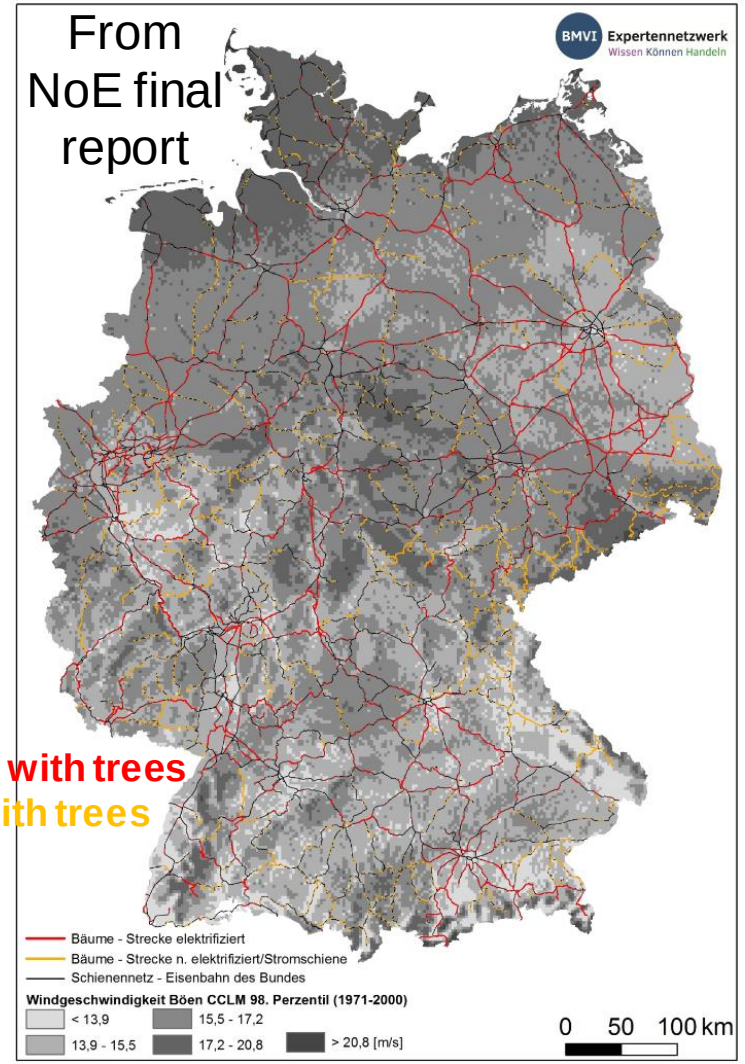


COSMO-CLM
p98 of wind gusts



Railway network
Express rails

From NoE final report



E-Tracks with trees
Tracks with trees

DAS-Basisdienst "climate and water"

Bundesministerium für Verkehr und digitale Infrastruktur

Support of the German adaption strategy to climate change „Deutsche Anpassungsstrategie an den Klimawandel (DAS)"

- 1. Expansion stage starting 2020 with focus on climate and water:

  DAS-Basisdienst addresses many decision-making and process chains associated with weather extremes, hydrological extremes and potential sea-level changes.

- Goal:

  ongoing provision of quality checked climate data, evaluation and advisory service on the topics climate and water in Germany.

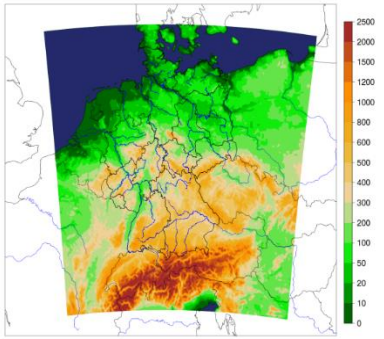
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

bfg Bundesanstalt für Gewässerkunde

BSH Bundesamt für Seeschifffahrt und Hydrographie

BAW Bundesanstalt für Wasserbau

Dynamical downscaling simulations in NoE



Model domain	**COSMO-DE plus eastern river catchments** **461x481 grid points**		
Climate scenario	RCP 8.5		
Time periods	1971–2005	Historical run	MIROC5 - CCLM
	1971–2000	Evaluation run	ERA-40/ERA-Interim/ERA5
	Focus time periods	„Near Future“ (2031-2060)	MIROC5 - CCLM
		„Far Future“ (2071-2100)	MIROC5 - CCLM

NoE Phase 1	NoE Phase 2
2016-2019	2020-2025

Main differences

	NoE Phase 1	NoE Phase 2
Model version	COSMO4.8_clm18 INT2LM 1.19	COSMO5_clm16 INT2LM 2.0
Eval forcing data	ERA-40/ERA-Interim	ERA-40/ERA5
Graupel scheme	off	on
Grid size	0.025° (≈ 2,8 km)	0.0275° (≈ 3 km)
Time period	1971-2100	1971-2005, 2031-2060, 2071-2100
Highest temporal resolution	1 hour	5 minutes (only for precipitation)
Wind gust parametrization (itype_diag_gusts)	1 (default)	4
FLake parameterization	off	on

Model Simulation analyses

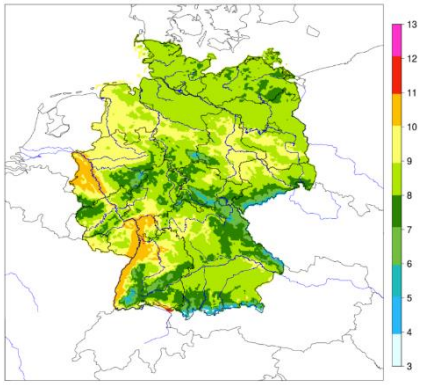
- ➔ Comparison of COSMO-CLM historical simulation for NoE Phase 1 and Phase 2
  - ➔ Same forcing, but different model version and different setup
- ➔ Model evaluation of Phase 2 simulations with HYRAS and RADKLIM observations
- ➔ Climate change and extremes in Phase 2 simulations

HYRAS (version 2015a, *Rauthe et al. 2013; Razafimaharo et al. 2020 in rev.*):
- Gridded station observations for Germany and surrounding river catchments
- 5 x 5 km horizontal resolution, daily data
- tas, tasmin, tasmax, pr, hurs, rsds
- Time period 1951-2015

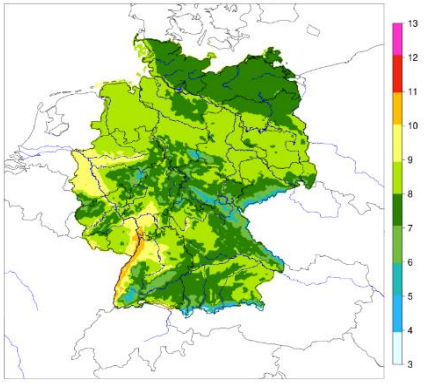
RADKLIM (version 2017.002, *Winterrath et al. 2018*)**:**
- Gridded radar observations for Germany, calibrated with station gauges
- 1 x 1 km horizontal resolution, hourly to 5 minutes data
- Precipitation and derivated data products (e.g. exceedance frequencies)
- Time period 2001-2017

Results: temperature at 2m

Mean difference: 0.5 K

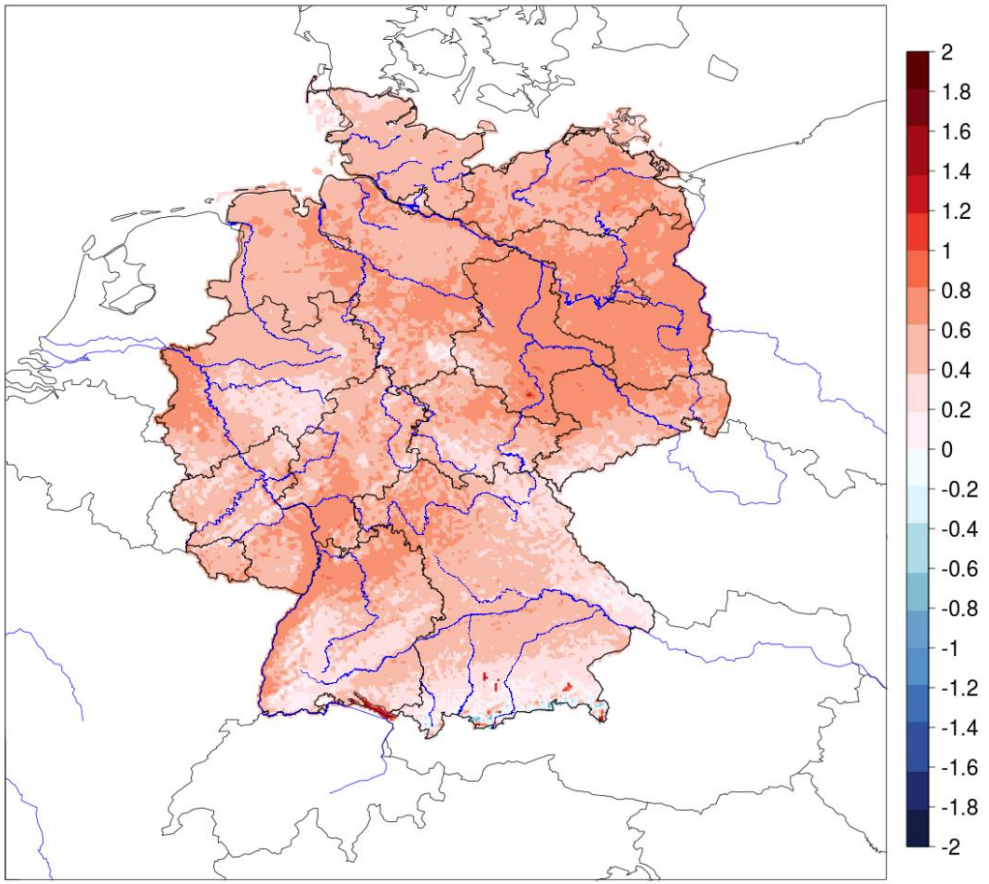


Historical simulation Phase 1



Historical simulation Phase 2

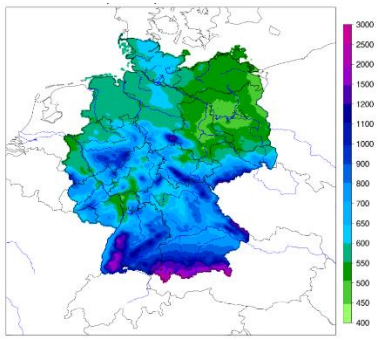
30 year mean 1971-2000



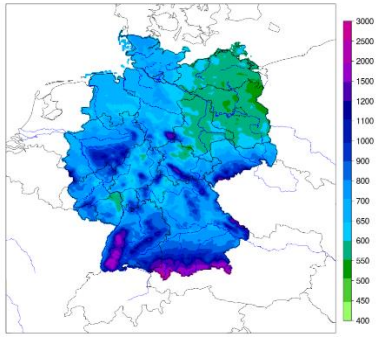
Historical simulations Phase 1 – Phase 2

Results: Precipitation

Mean difference: -54 mm

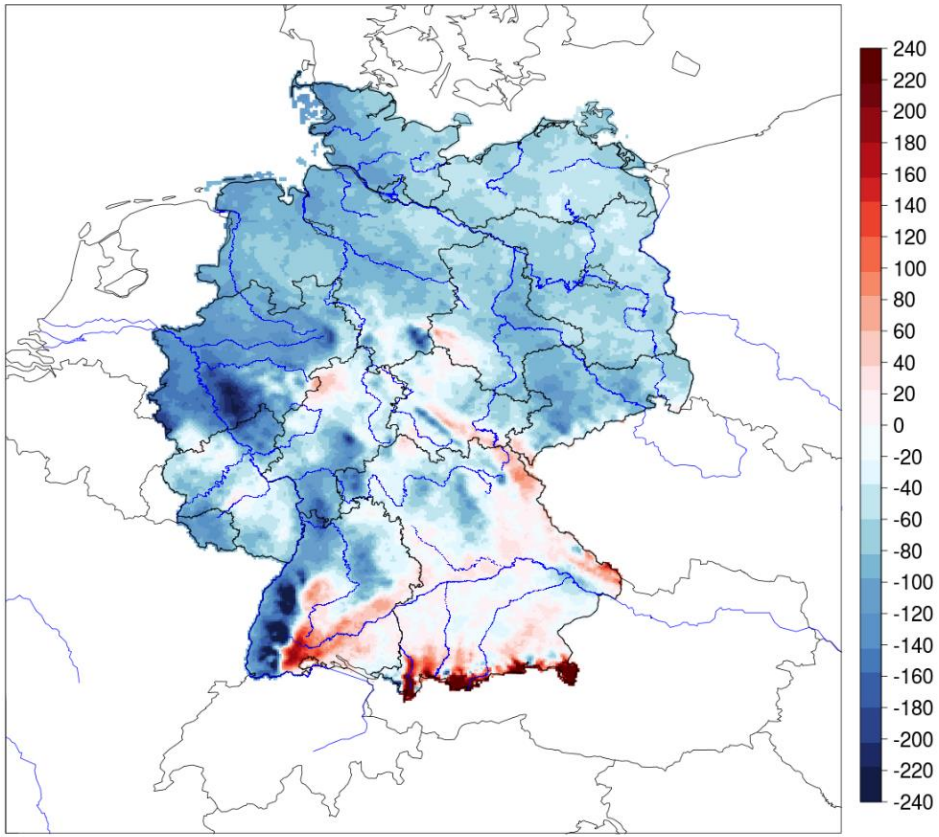


Historical simulation Phase 1



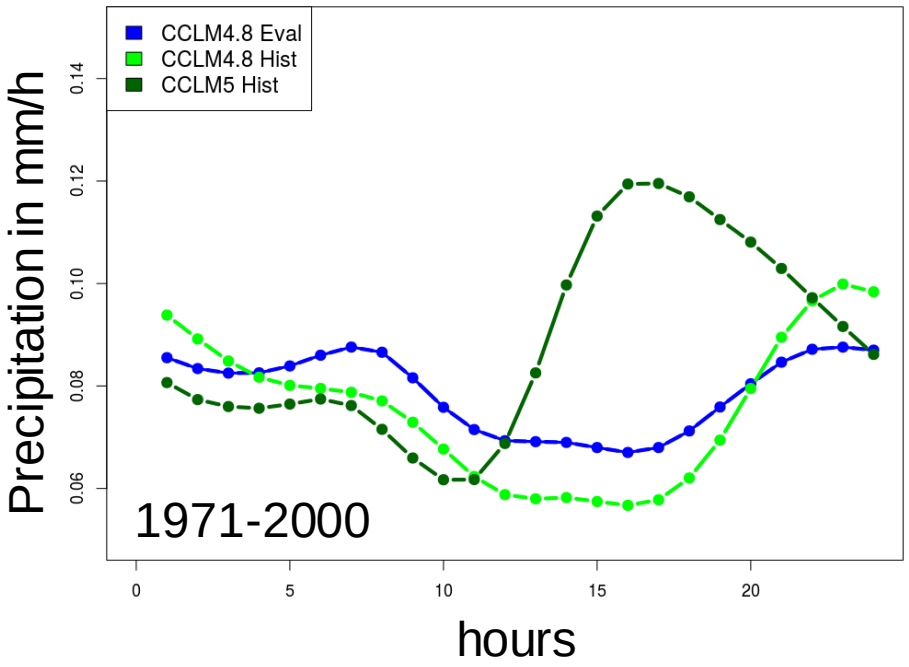
Historical simulation Phase 2

Mean annual sum 1971-2000

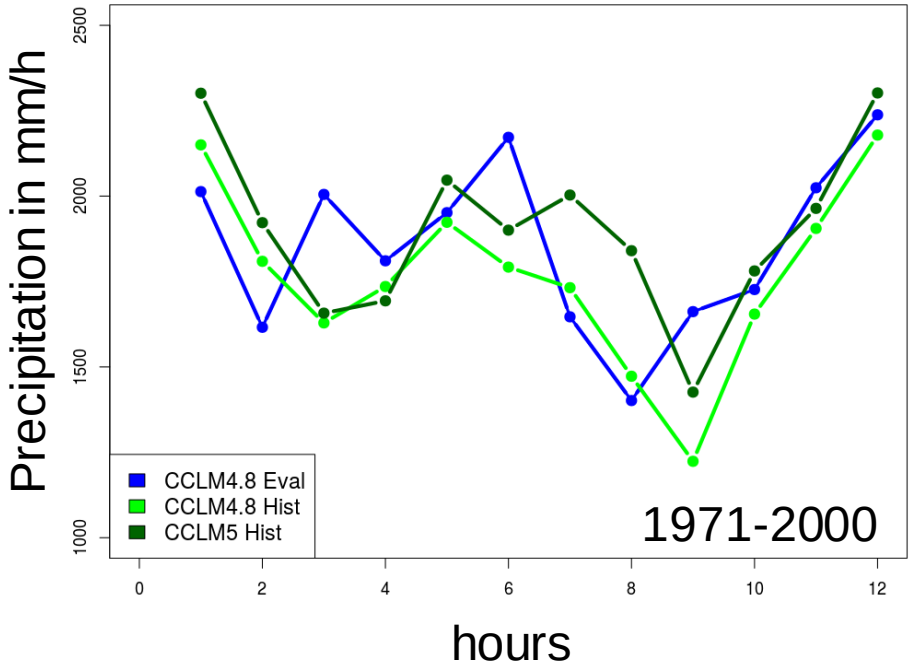


Historical simulations Phase 1 – Phase 2

Results: Precipitation daily and annual cycle



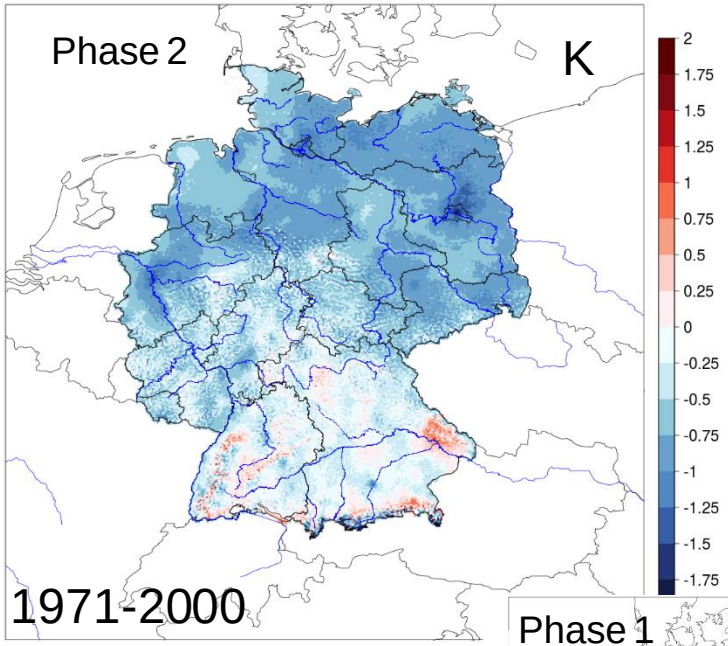
Daily cycle



Annual cycle

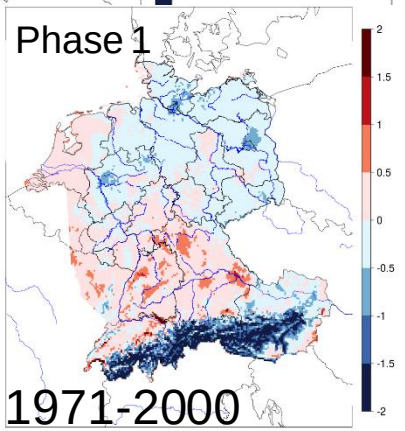
CCLM4.8 = Phase 1
CCLM5 = Phase 2

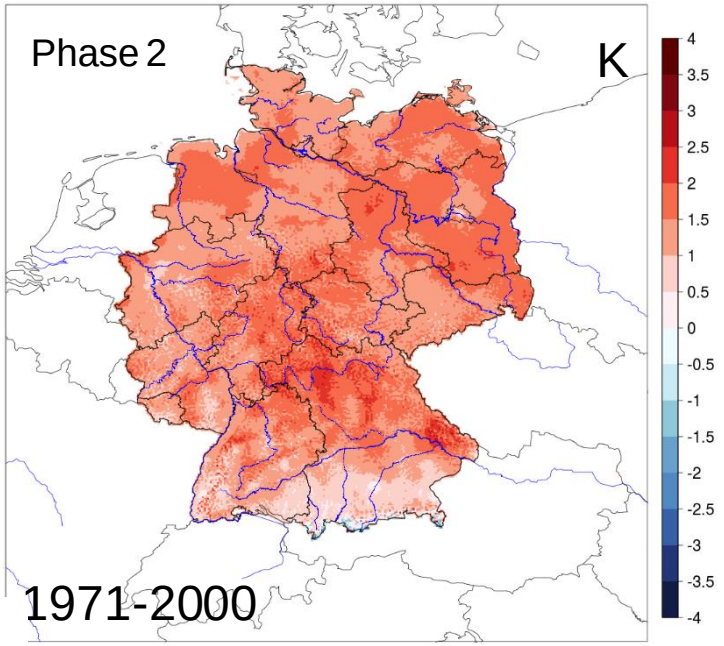
Model evaluation with HYRAS: 2m temperature



30-year mean difference

Mean = -0.52 K

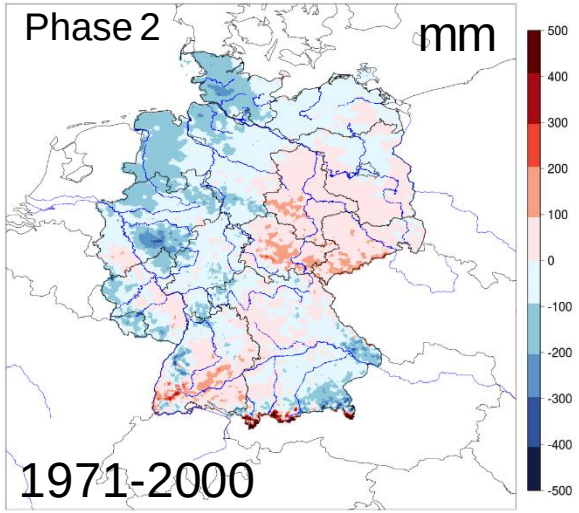


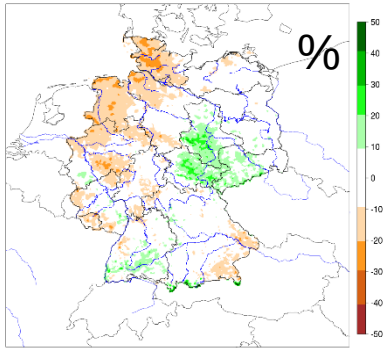


Mean difference of 85. percentile

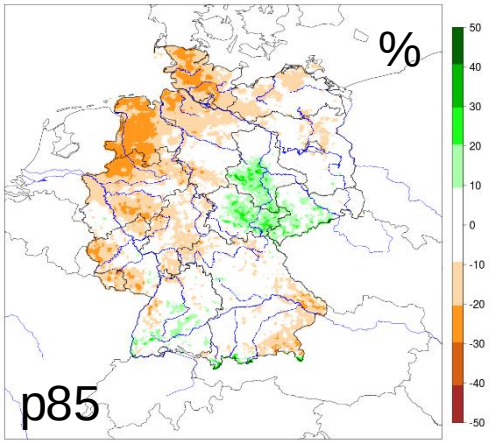
Mean = 1.4 K

Model evaluation with HYRAS: precipitation



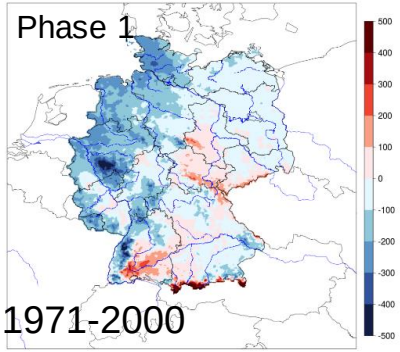


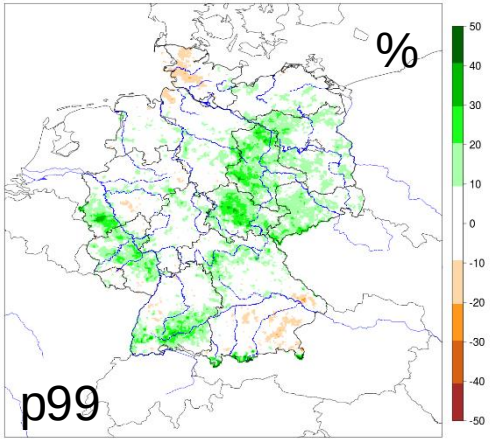
$$D = \frac{N_{mod} - N_{Hy}}{N_{Hy}}$$



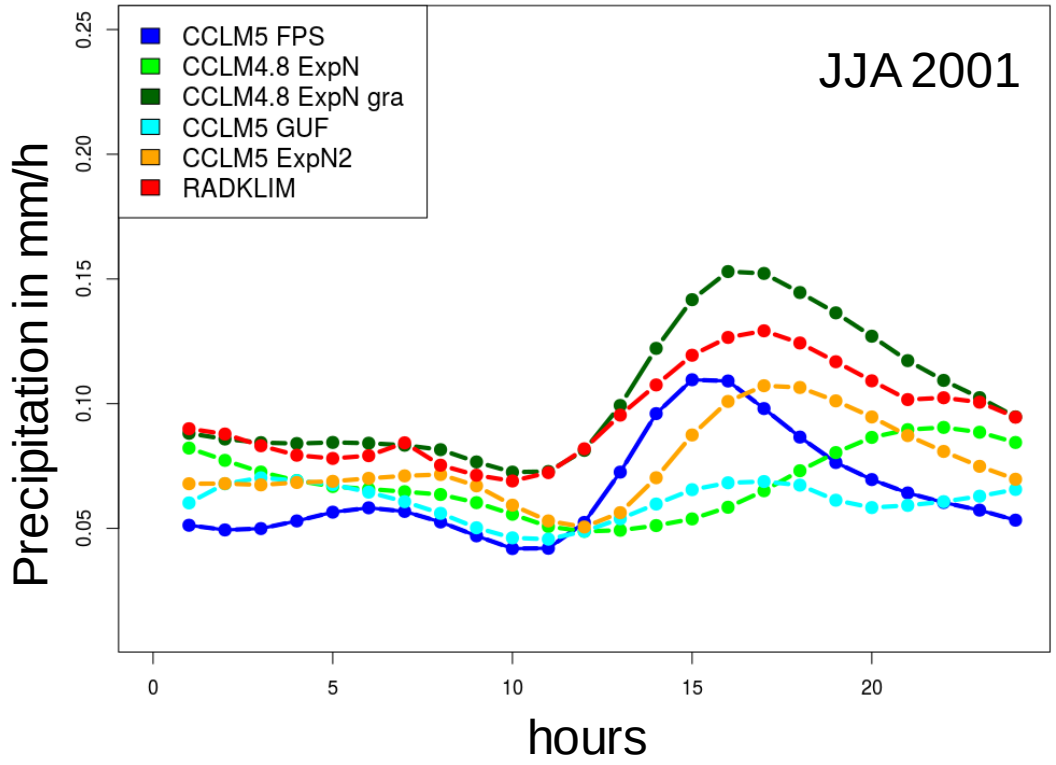
Mean = -26 mm
Stddev = 83 mm

Difference of mean annual sum





Model evaluation with RADKLIM



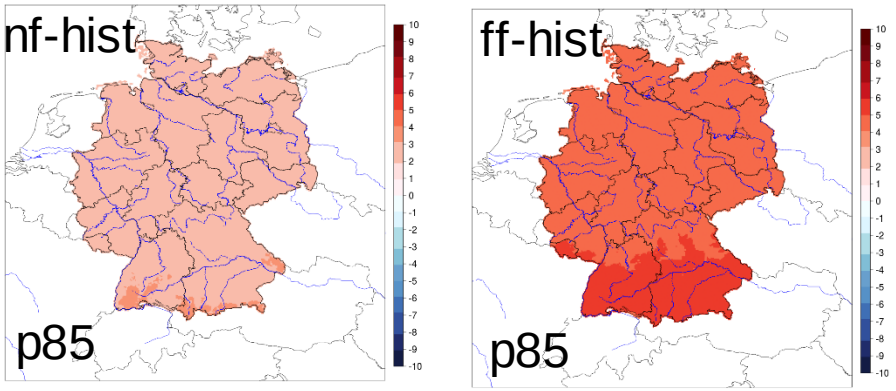
- CCLM4.8: Too low precipitation due to missing graupel
- Far better representation by all CCLM5 simulations

GUF and FPS runs: model domain is different to ExpN domain!

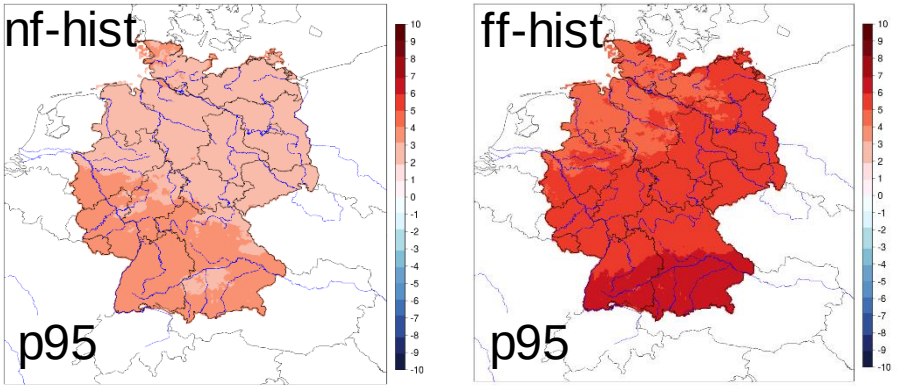
Poster presentation: Susanne Brienen et al. !

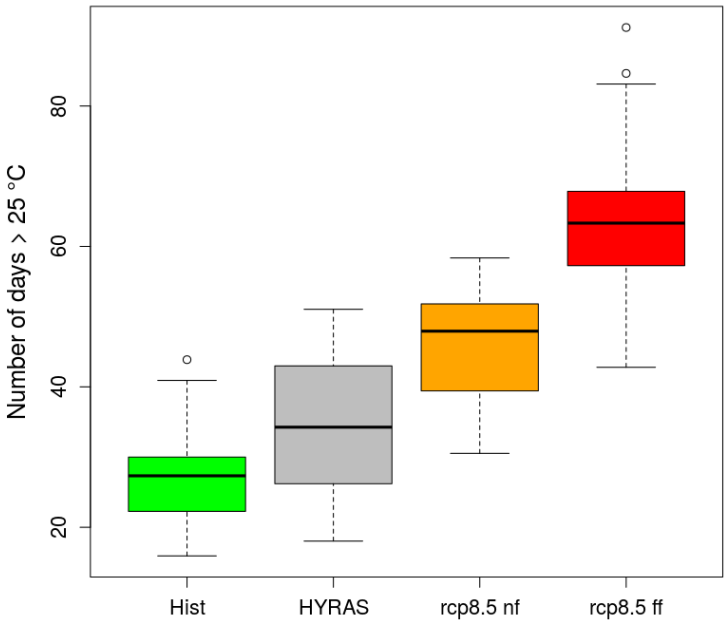
Climate change: 2m Temperature

- COSMO-CLM CPS 2.8 km historical and scenario time periods



Climate change signal for extreme temperatures



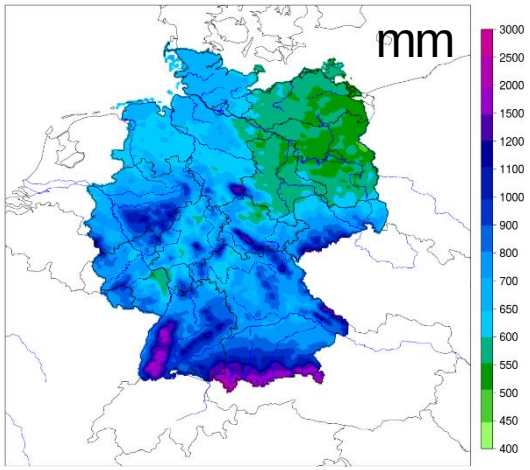


Summer days: tmax ≥ 25 °C

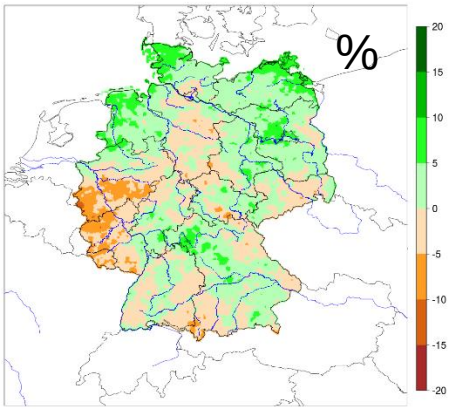
nf: near future (2031-2060)
Ff: far futuer (2071-2100)

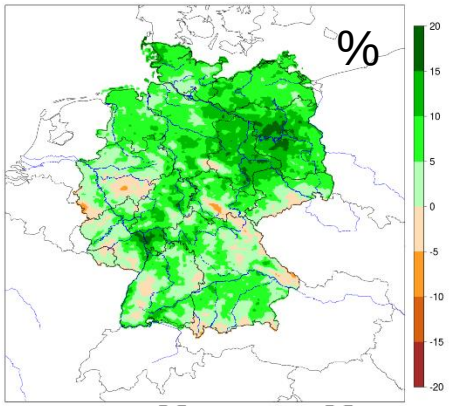
Climate change: precipitation

- COSMO-CLM CPS 2.8 km historical and scenario time periods

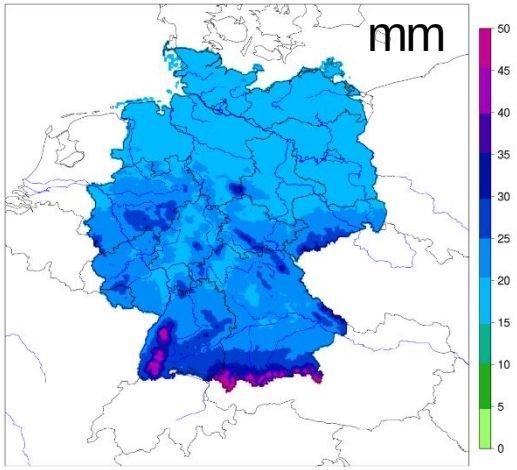


30-year mean of annual sum

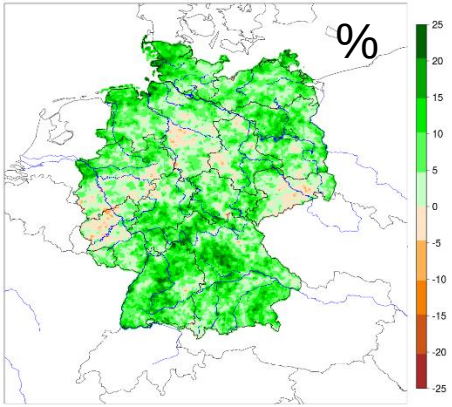


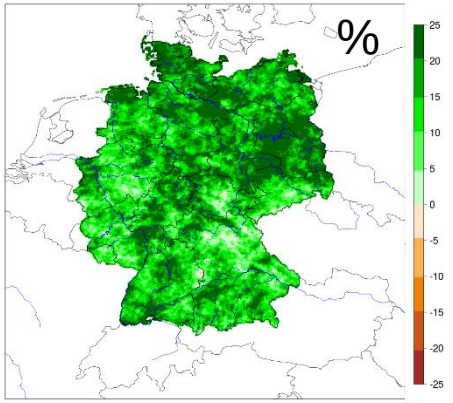


Climate change signal $D = \frac{N_{scen} - N_{hist}}{N_{hist}}$



p99 of daily sum over 30 years





2031-2060

2071-2100

Conclusion

- ➔ New simulations with COSMO-CLM 5 for 30-year periods
- ➔ Analyses of simulations for NoE cover Germany
- ➔ Model evaluation show improvement from Phase 1 to Phase 2 for precipitation
- ➔ Comparions with HYRAS and RADKLIM show good performance
- ➔ Different wind gust parameterization shows significant differences (not shown)
- ➔ First analyses of climate change and extreme events show strong increase of temperatures for RCP8.5 (which seems to be in line with recent observations)
- ➔ Future precipitation seems to increase on average, but extremes show strong increase
  - ➔ More analyses in NoE will follow, important for traffic infrastructure

Outlook

- New projections with very high time resolution for precipitation (5min)
  - Analyses on high temporal resolution and focus on extremes
    - Focus on precipitation and wind (gusts)
- Switch to ICON-CLM (first on 10 km, later on convection-permitting scale)
- COSMO-CLM CPS data set of new projections available on ESGF-node soon
  - https://esgf.dwd.de/