

A 3D globe of the Earth with a grid overlay. A semi-transparent weather map with a color scale from blue to yellow is draped over the top of the globe.

Dynamical and statistical downscaling of climate projections for transport infrastructure in Germany

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Outline

- Introduction
 - Project „Network of Experts“
 - Contribution of high resolution modeling to „Network of Experts“
- Dynamical downscaling
 - Overview and first results
- Statistical downscaling
 - Method and first results

Project „Network of Experts“

- ➔ **Network of Experts (NoE):**
Knowledge – Ability – Action
- ➔ Innovations for future transport in climate adoption, environment protection and digitization
- ➔ Project start 01/01/2016, duration 4 years
- ➔ 5 fields of interest
 - ➔ TF1: Adapt Transport and Infrastructure to climate change and extreme weather situations



Network of Experts

Knowledge Ability Action





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Relevant climate/weather situations in NoE

Heavy precipitation	Storms	Heat waves	Cold/ Frost damage
			

Roads



Waterways

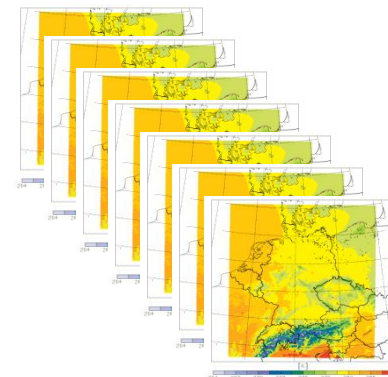
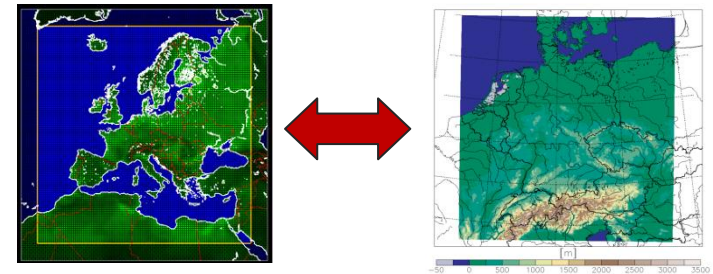
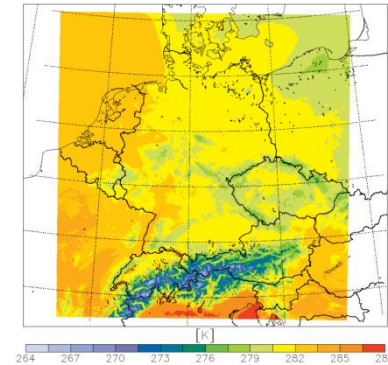


Railways



Contribution to NoE

- High-resolution climate projections with dynamical downscaling for Germany / Central Europe, based on EURO-CORDEX
- Test and apply statistical downscaling method to EURO-CORDEX member for historical time period
- Apply statistical downscaling to EURO-CORDEX ensemble members to span a high-resolution data set of climate projections

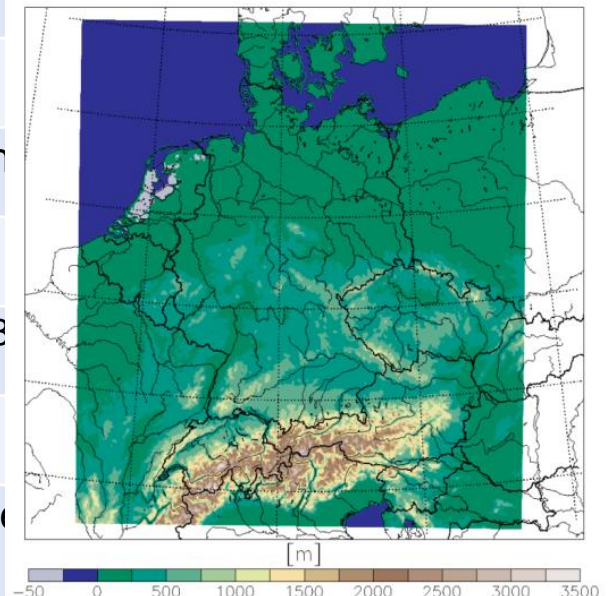


Dynamical downscaling: Overview

CCLM Version	COSMO 4.8 CLM 18 (INT2LM Version 1.19)		
Resolution	horizontal: 2.8 km	vertical: 50 layers	
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
	2006–2100	Scenario run	MIROC5 - CCLM
	Focus time periods	Near future (2031-2060)	MIROC5 - CCLM
		Far future (2071-2100)	MIROC5 - CCLM
Relevant variables	Temperature, dew point temperature, precipitation, wind, pressure, radiation		

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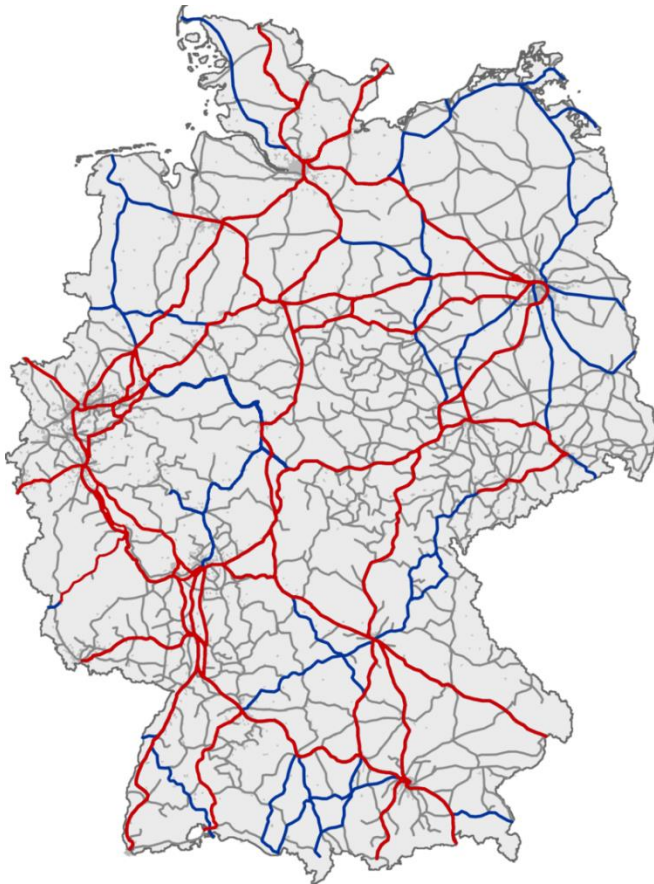


Storms



- Strong winds cause damage on
 - Trees, buildings, bridges, ...
- Affecting traffic infrastructure
 - Railways ++
 - Coastal areas/waterways ++
 - Streets +
 - Waterways (inland) ○
- Mean wind, wind gusts
- In combination with wet soil: enhanced vulnerability of trees (less stability)

Storm winds affecting railway infrastructure



Deutsche Bahn tracks (2010)
(from Wikimedia Commons)

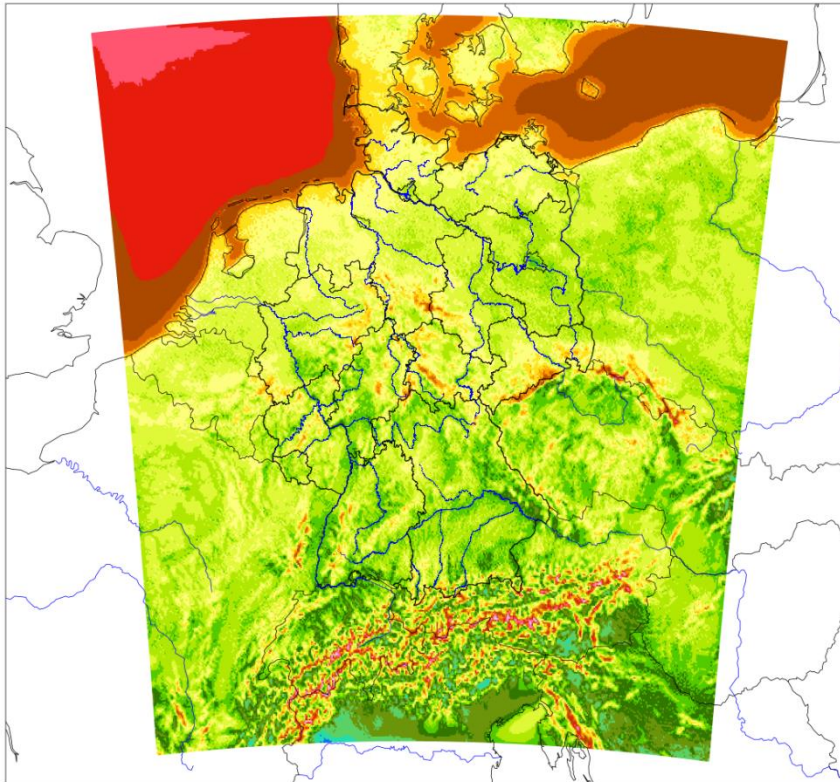


After storm
Christian (2013),
© dpa

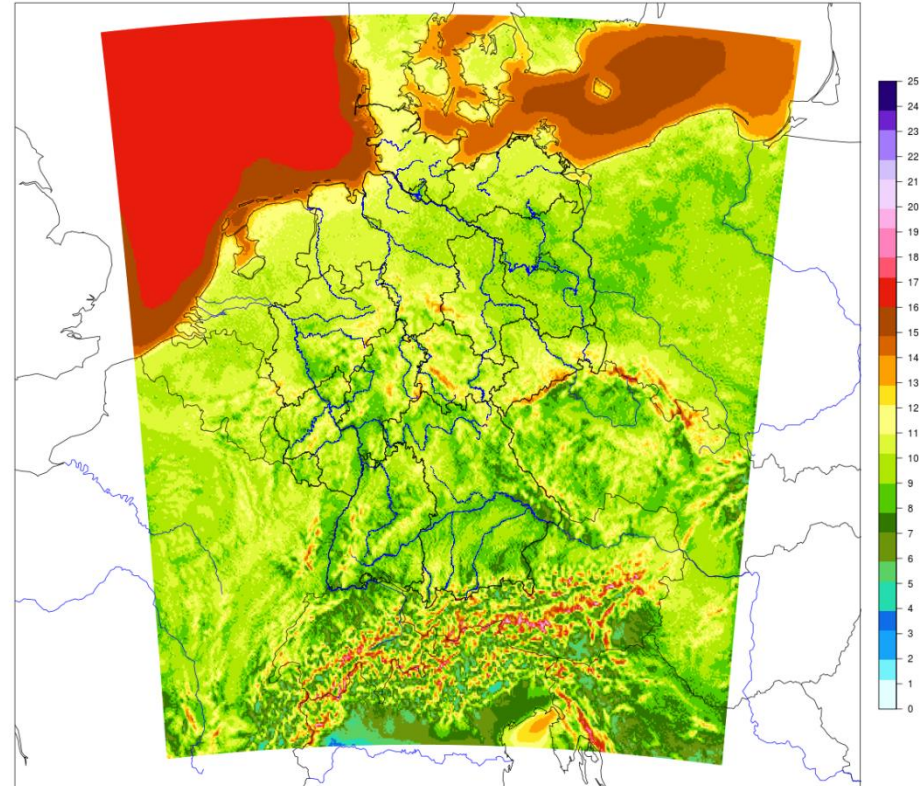
- Bring together results of high wind potential (present/future) and vulnerable traffic infrastructure
 - Risk analyses → GIS-maps for risk of hazard

CCLM 2.8 km Wind speed maxima

Mean wind gust DJF (m/s)



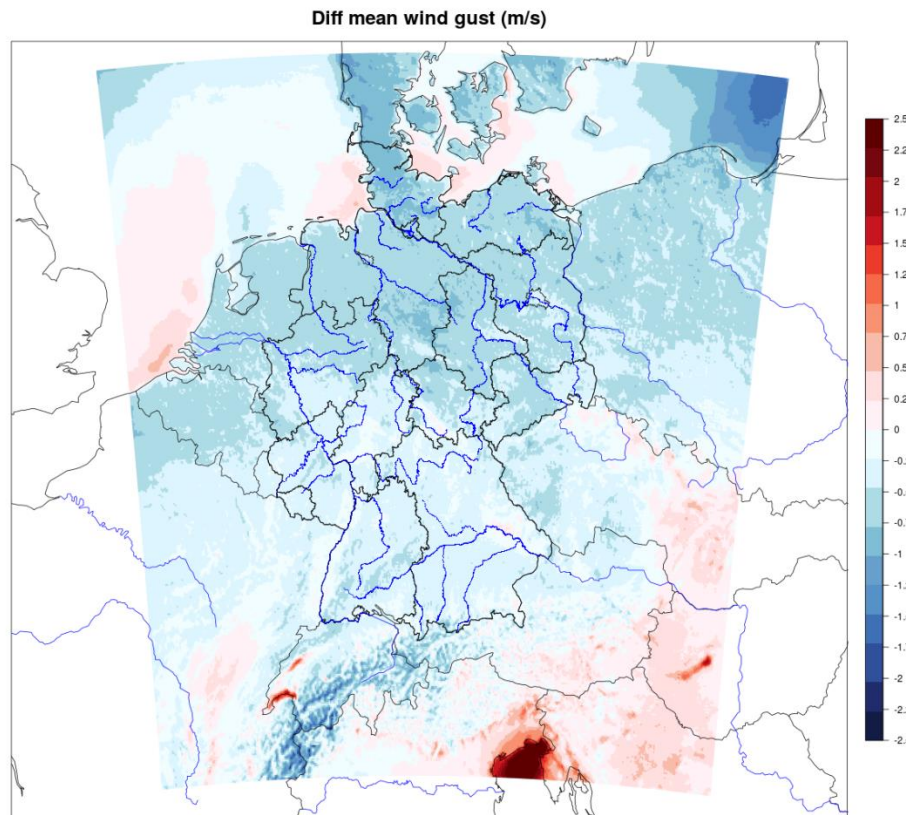
Mean wind gust DJF (m/s)



Evaluation run, seasonal mean DJF 1980-1989

Historical run, seasonal mean DJF 1980-1989

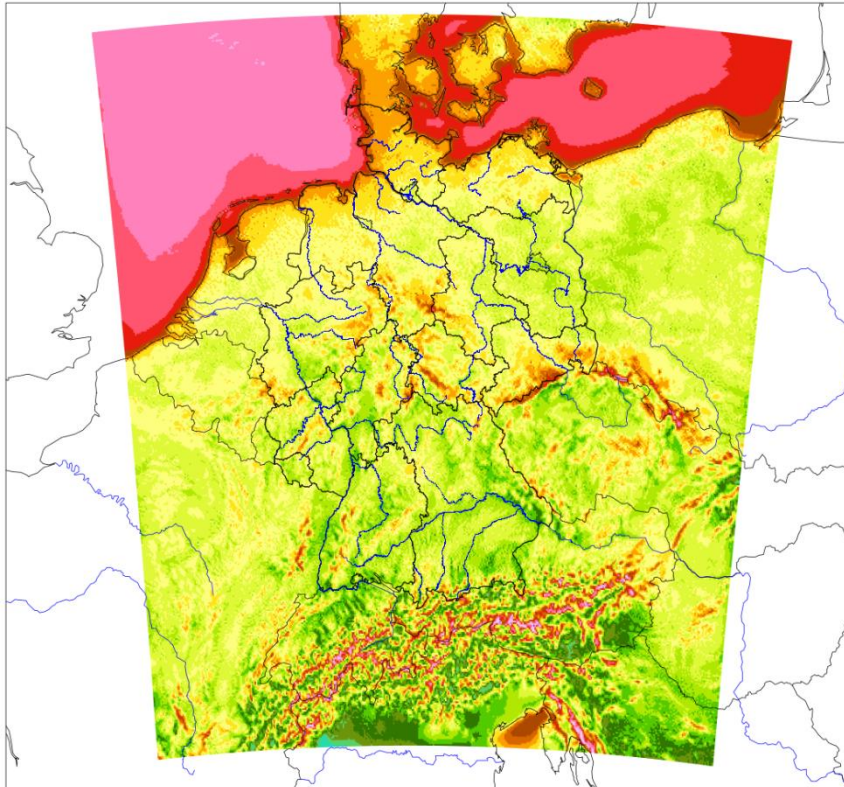
CCLM 2.8 km Wind speed maxima



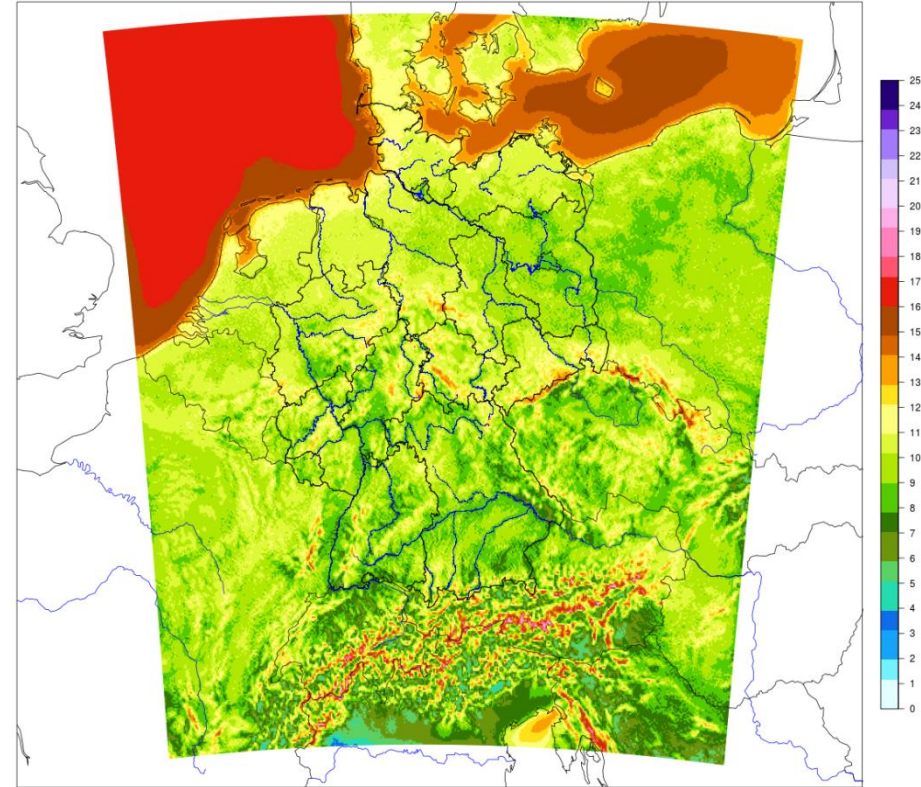
Differences hist-eval DJF 1980-1989

CCLM 2.8 km Wind speed maxima

Mean wind gust DJF (m/s)



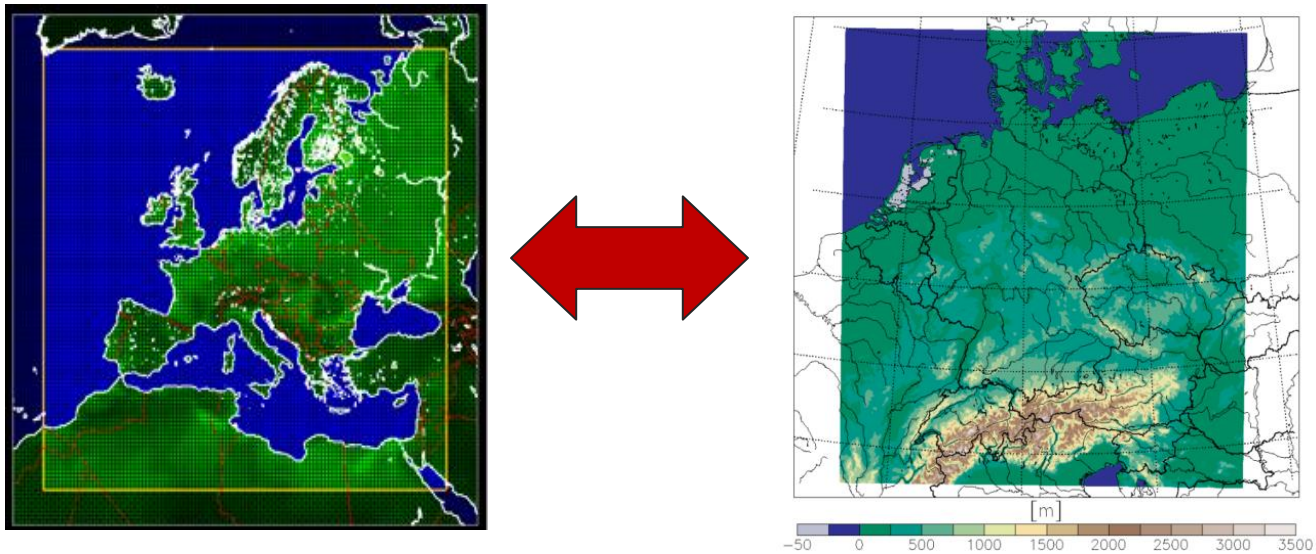
Mean wind gust DJF (m/s)



Scenario run, seasonal mean DJF 2020-2029

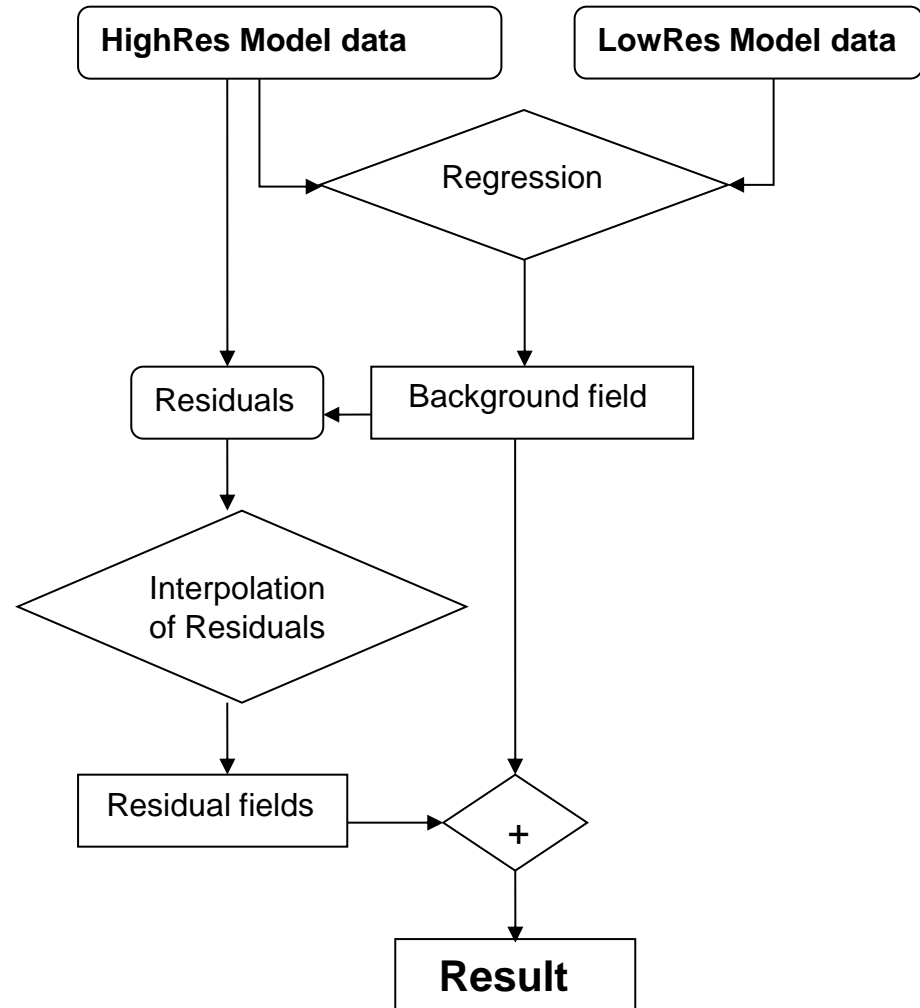
Historical run, seasonal mean DJF 1980-1989

Statistical downscaling



Statistical downscaling method

- Principal component analysis (PCA) on HR fields for each month of time period
- PC-loadings adapted to LR fields
- Stepwise regression of PC-loadings on LR fields for each day
 - Regression coefficients
- Calculation of background field (coefficients applied on HR PC-loadings)
- Calculation of Residuals (difference of background fields to LR fields)
 - IDW-Interpolation on HR field
- Combination of Background plus Residuals gives the Result



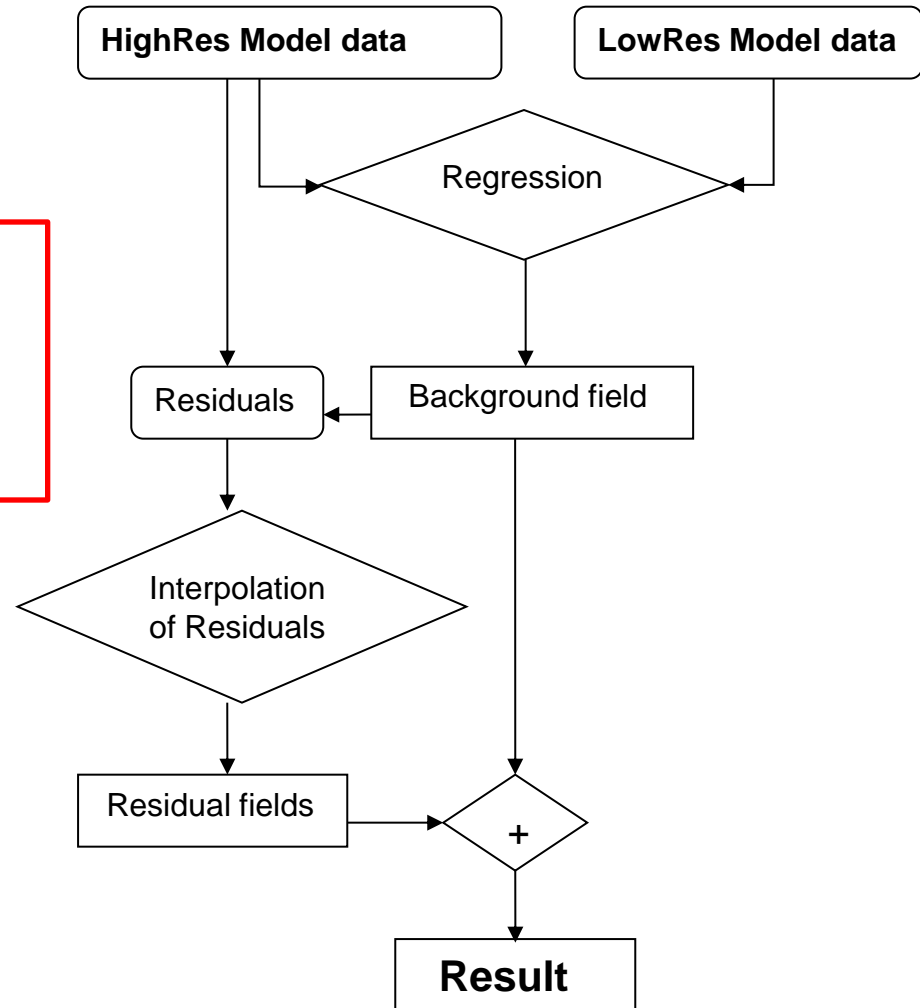
S. Krähenmann



Statistical downscaling method

Results:

- Horizontal resolution of 2.8x2.8 km
- Daily temporal resolution
- tas, pr, ...



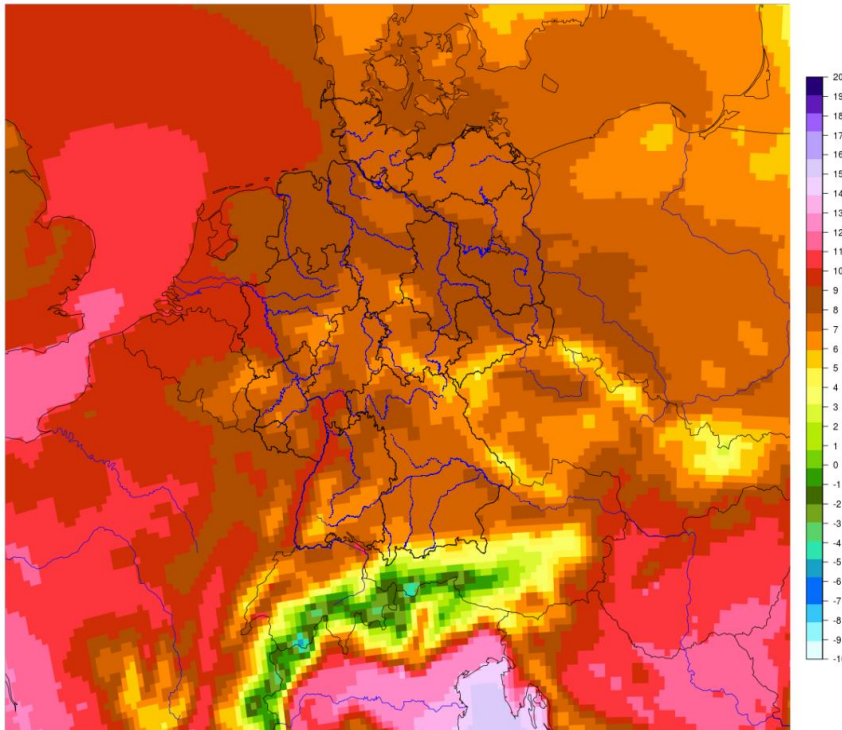
S. Krähenmann

Test phase statistical downscaling

- Input data: daily means of
 - LR model data: MIROC5-CCLM 12 km
 - HR model data: CCLM 2.8km evaluation run (ERA-Interim-CCLM)
- Time period: 10 years (1980-1989)
- Variables: tas, pr
- Tuning parameters:
 - 30 PC-loadings + x,y,z
 - Step-wise regression: exclusion of unimportant PC-loadings
 - Dependent on each day
 - IDW-interpolation: 6 nearest neighbours

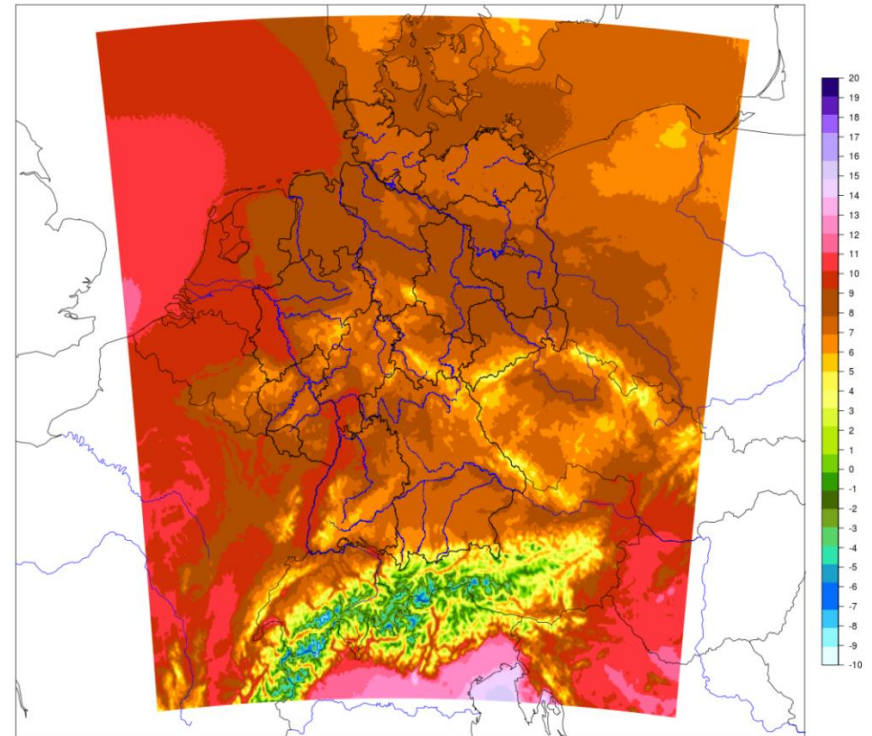
Test phase results: temperature at surface

Mean tas 1980-1989 (deg C)



MIROC5-CCLM 12 km

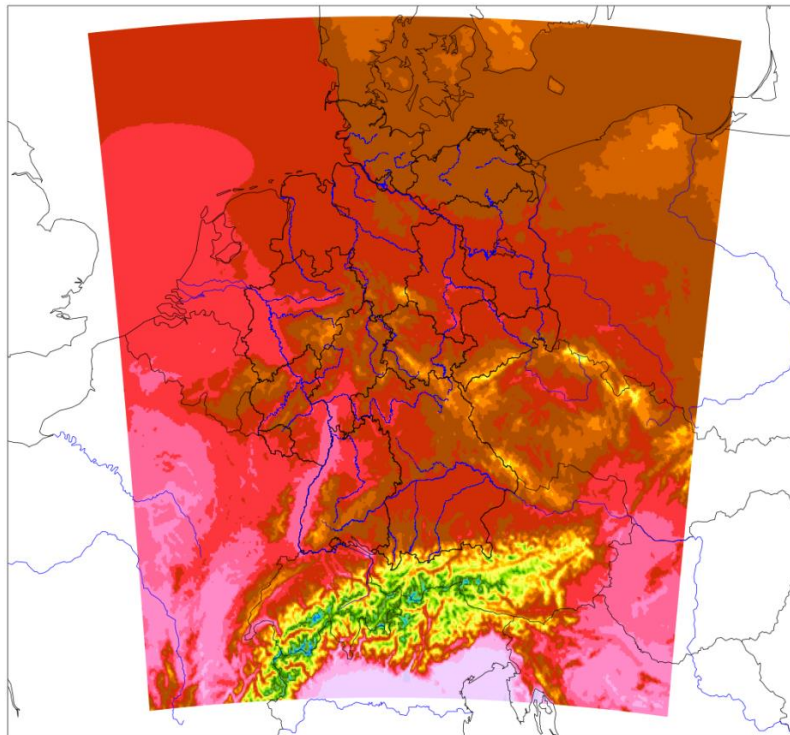
Mean tas 1980-1989 (deg C)



MIROC5-CCLM stat. downscaled to 2.8 km

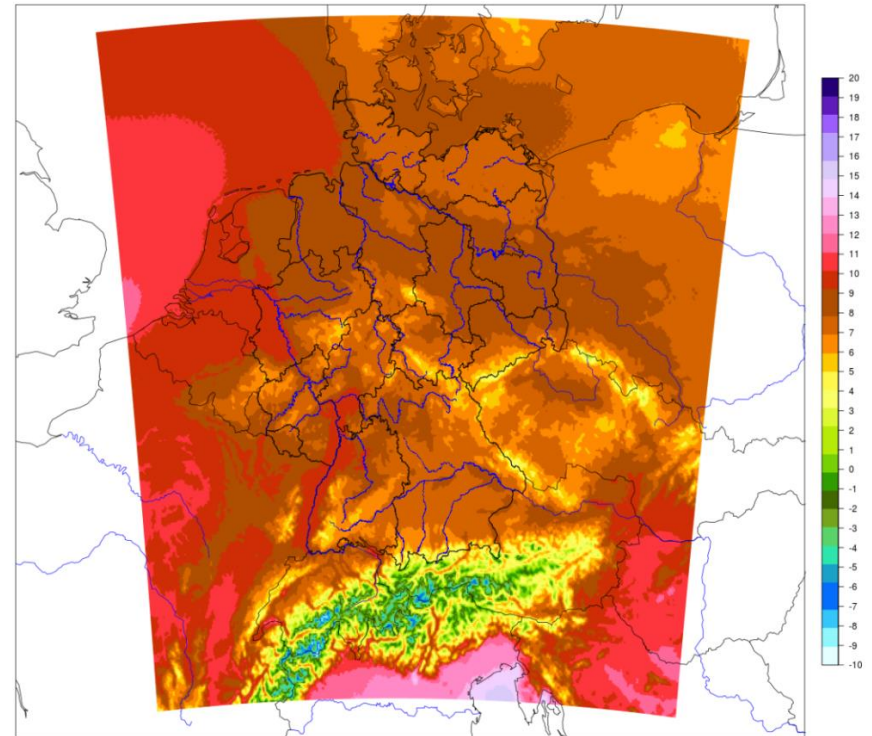
Test phase results: tas

Mean tas 1980-1989 (deg C)



Evaluation run CCLM 2.8 km

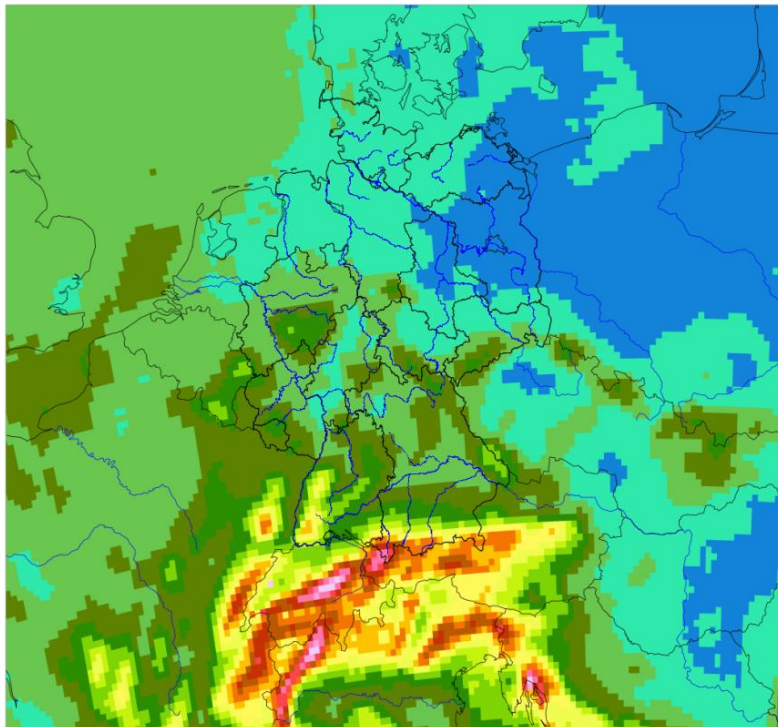
Mean tas 1980-1989 (deg C)



MIROC5-CCLM stat. downscaled to 2.8 km

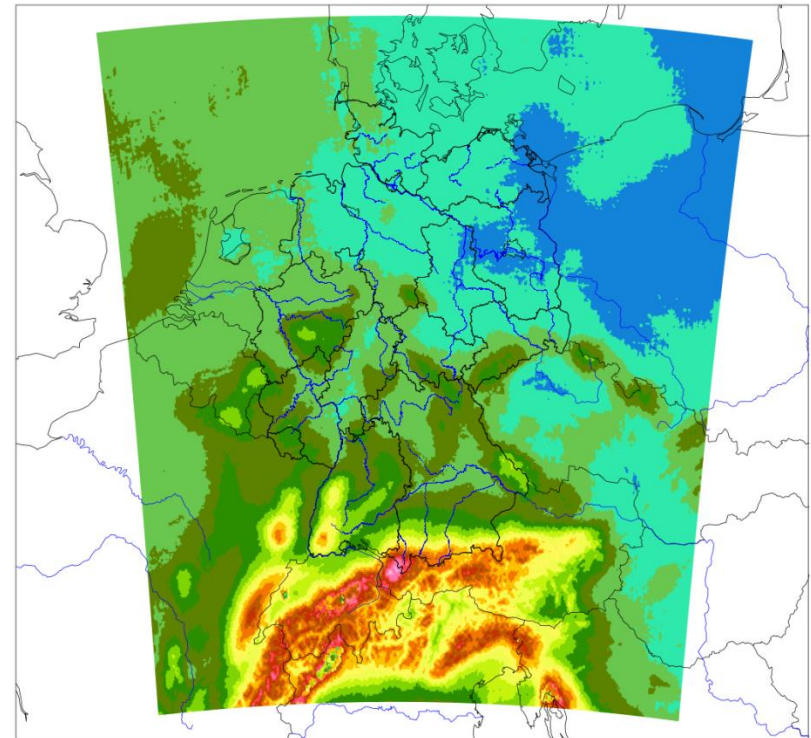
Test phase results: precipitation

Mean ysum pr 1980-1989 (mm)



MIROC5-CCLM 12 km

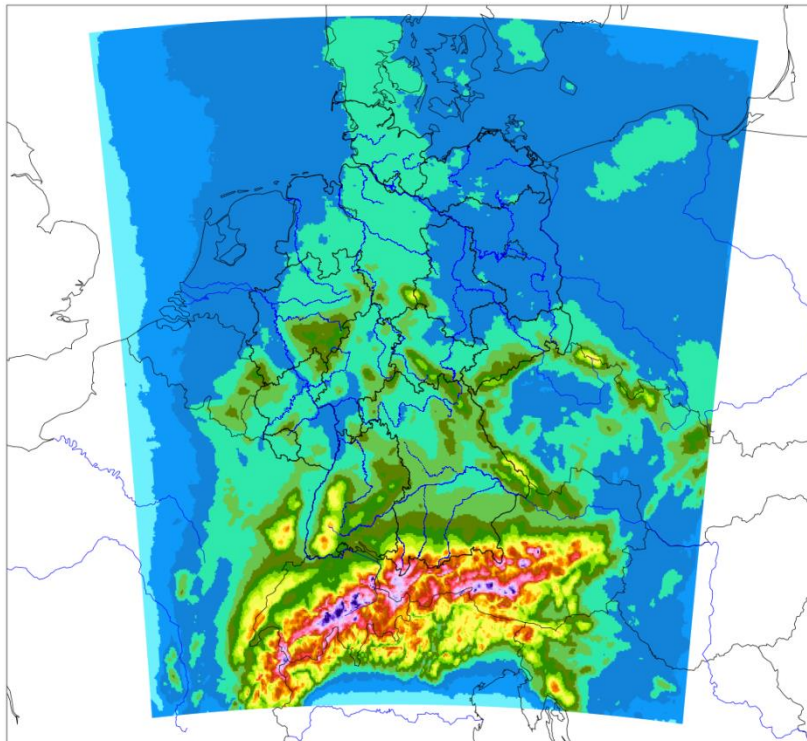
Mean ysum pr 1980-1989 (mm)



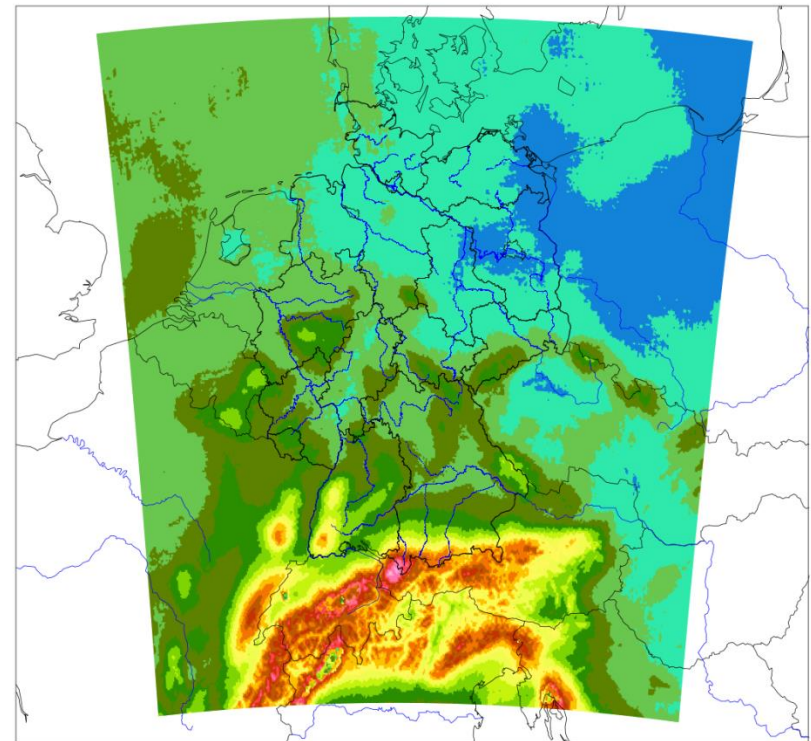
MIROC5-CCLM stat. downscaled to 2.8 km

Test phase results: pr

Mean ysum pr 1980-1989 (mm)



Mean ysum pr 1980-1989 (mm)

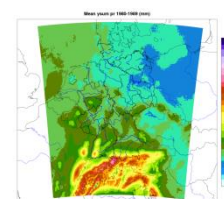
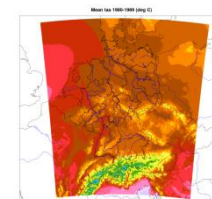
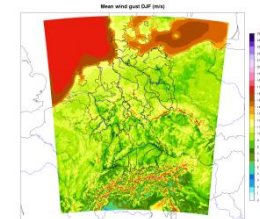
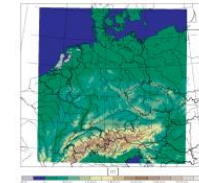


Evaluation run CCLM 2.8 km

MIROC5-CCLM stat. downscaled to 2.8 km

Conclusion

- „Network of Experts“: adaptation strategies to climate change for public transport systems
- High-resolution COSMO-CLM climate projections for COSMO-DE-plus domain
 - Simulations still ongoing
 - First results, focus on wind speeds
 - Further analyses, with other relevant variables in project
 - combination with data sets from other agencies
- Test of statistical downscaling method successful
 - extend to climatological time period (historical/scenarios)
 - Transition from test phase to „operational“ mode
 - Apply method to climate ensemble in Network of Experts



Thank you for your attention!

