Regionalisation of statistical model outputs creating gridded data sets for Germany

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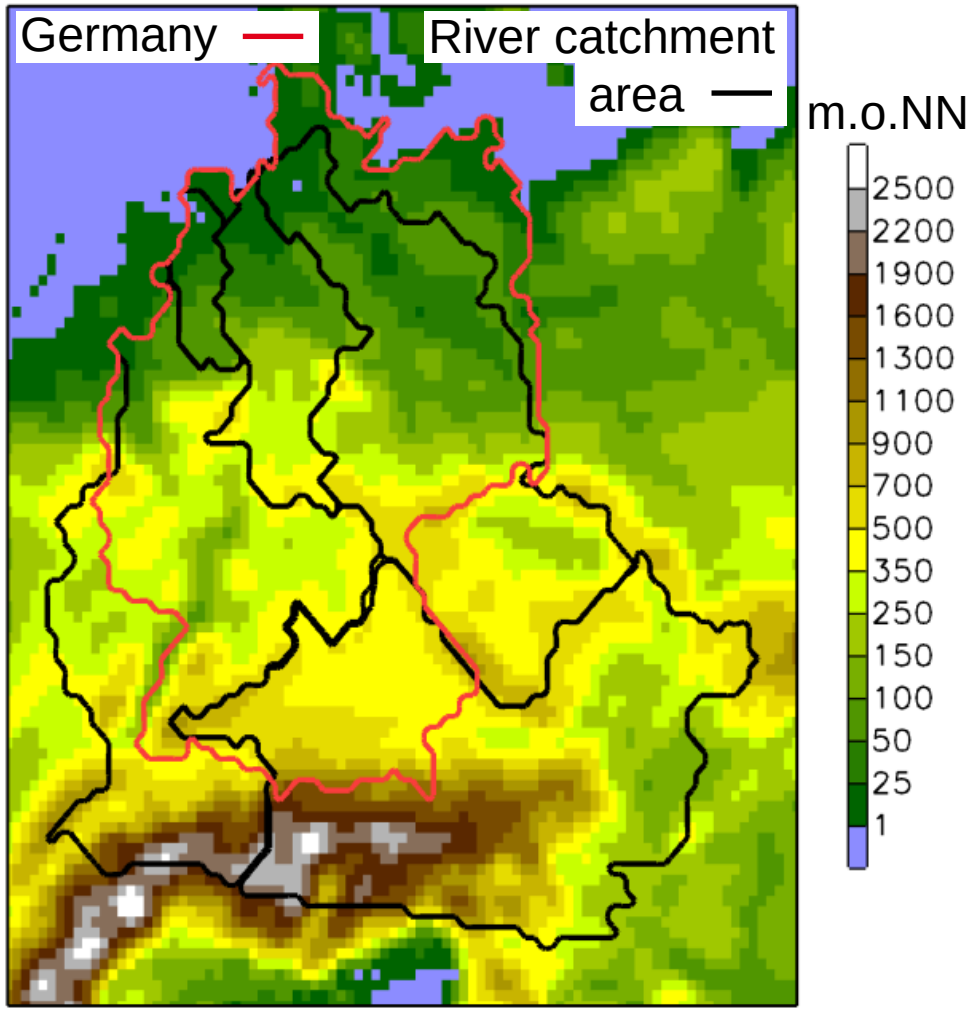
ReKliEs-De
Regionale Klimaprojektionen Ensemble für Deutschland

ReKliEs-De (Regionale Climate projections ensemble for Germany)

Objectives:

- Providing **robust information** about the **range** and the **extremes** of future climate change in Germany and its river catchment areas in a high spatial resolution (12.5 x 12.5 km^2)



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- Enlarging the **CORDEX-EUR11 ensemble** with more dynamical and statistical climate simulations
- Analysing possible **systematical differences** between the results of statistical and dynamical climate models

http://reklies.hlnug.de/

GCM + RCP	**CCLM**	**REMO**	**WRF**	**WR'10**	**STARS**
MPI-ESM-LR RCP 2.6					
MPI-ESM-LR RCP 8.5		**CORDEX**			
CNRM-CM5 RCP 8.5	**EURO -**				**Klimafolgen-Online**
HadGEM2-ES RCP 8.5		**ReKliEs-De simulations**			
EC-EARTH RCP 8.5					
CanESM2 RCP 8.5					
MIROC5 RCP 8.5					

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EURO - CORDEX

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HYRAS reference data set

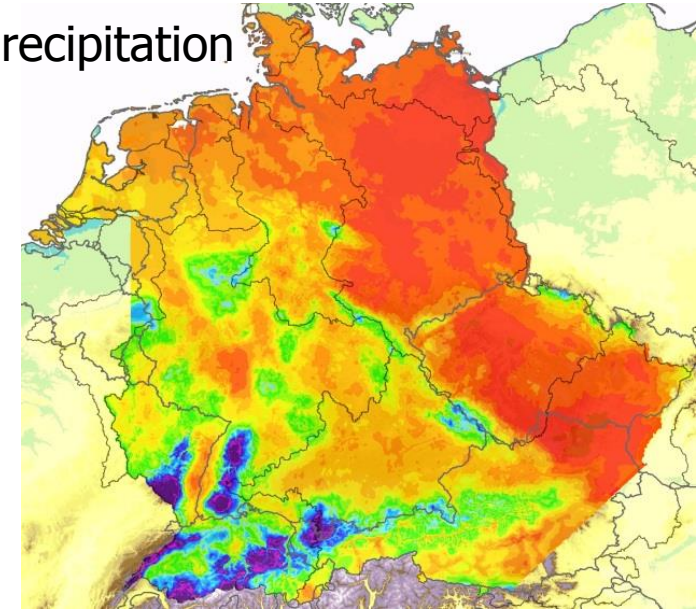
HYRAS („**HY**drologische **RAS**terdaten“; hydrological gridded data set):

- High-resolution gridded station data DWD/BFG-HYRAS

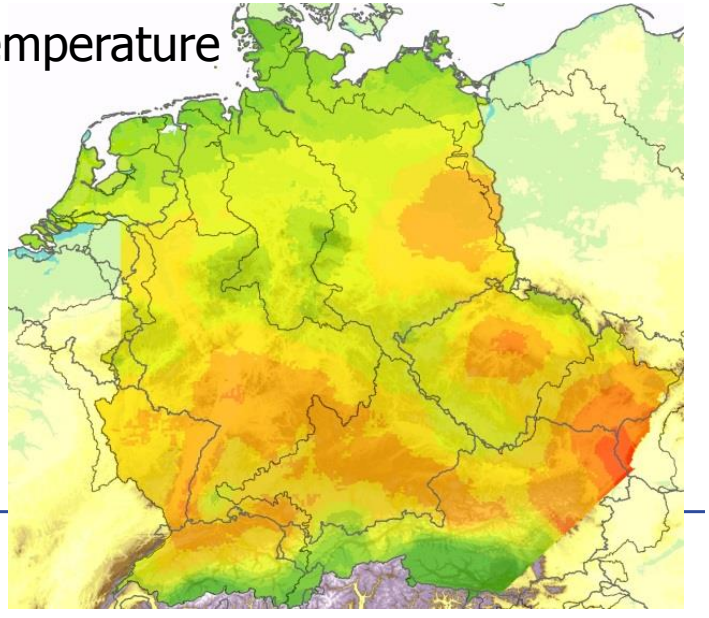
- 3 variables on daily basis between 1951 and 2006 (5 x 5 km^2)
  - precipitation (max. 6200 stations)
  - mean temperature (max. 1000)
  - relative humidity (max. 800)

- In progress:
  - more variables
  - temporal extension

precipitation



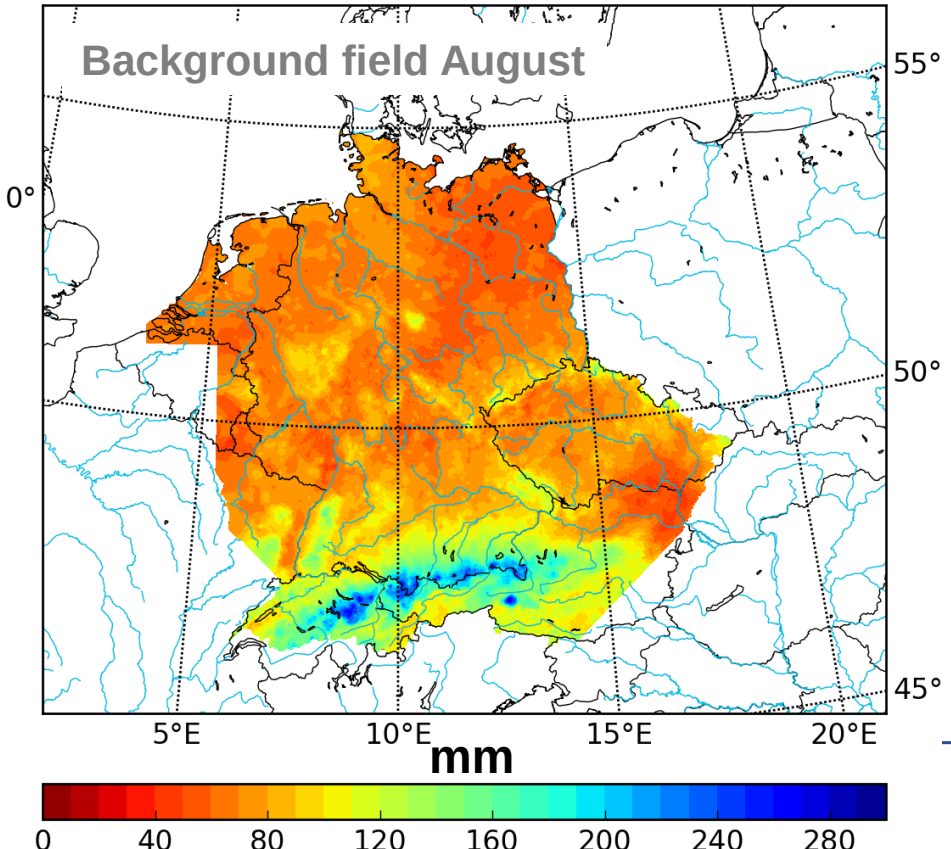
temperature

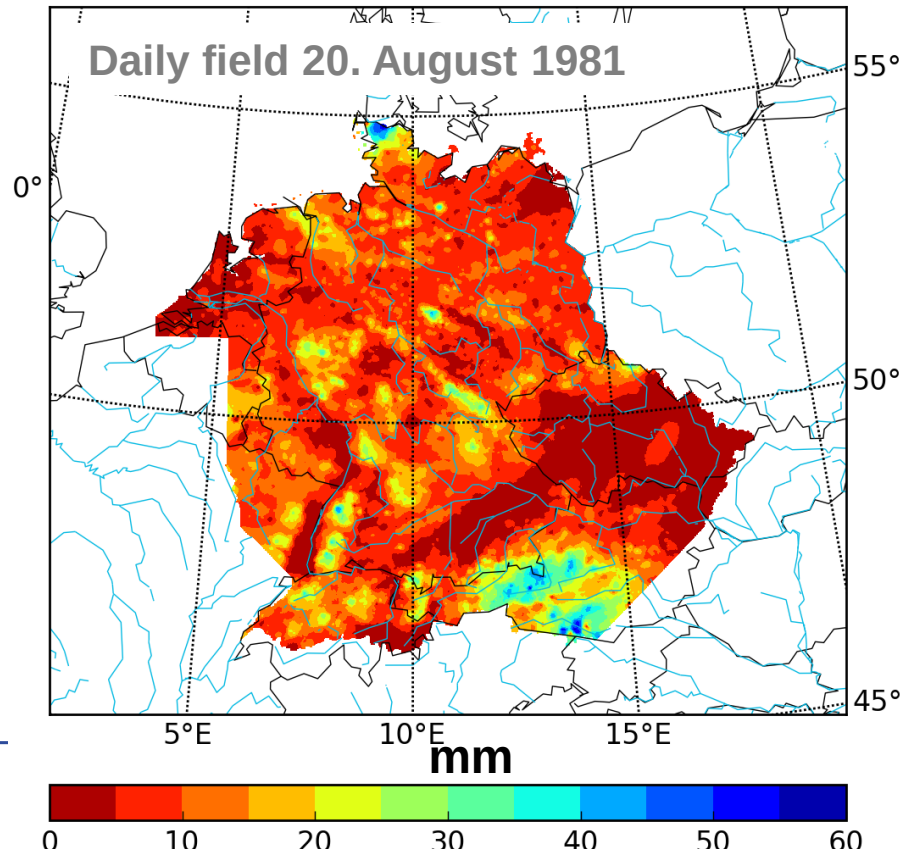


Regionalisation method for precipitation

REGNIE method („**REG**ionalisierung der **NIE**derschlagshöhen“; regionalisation of precipitation heights):

1. Calculation of climatological background fields on a monthly basis
2. Calculation of the daily values





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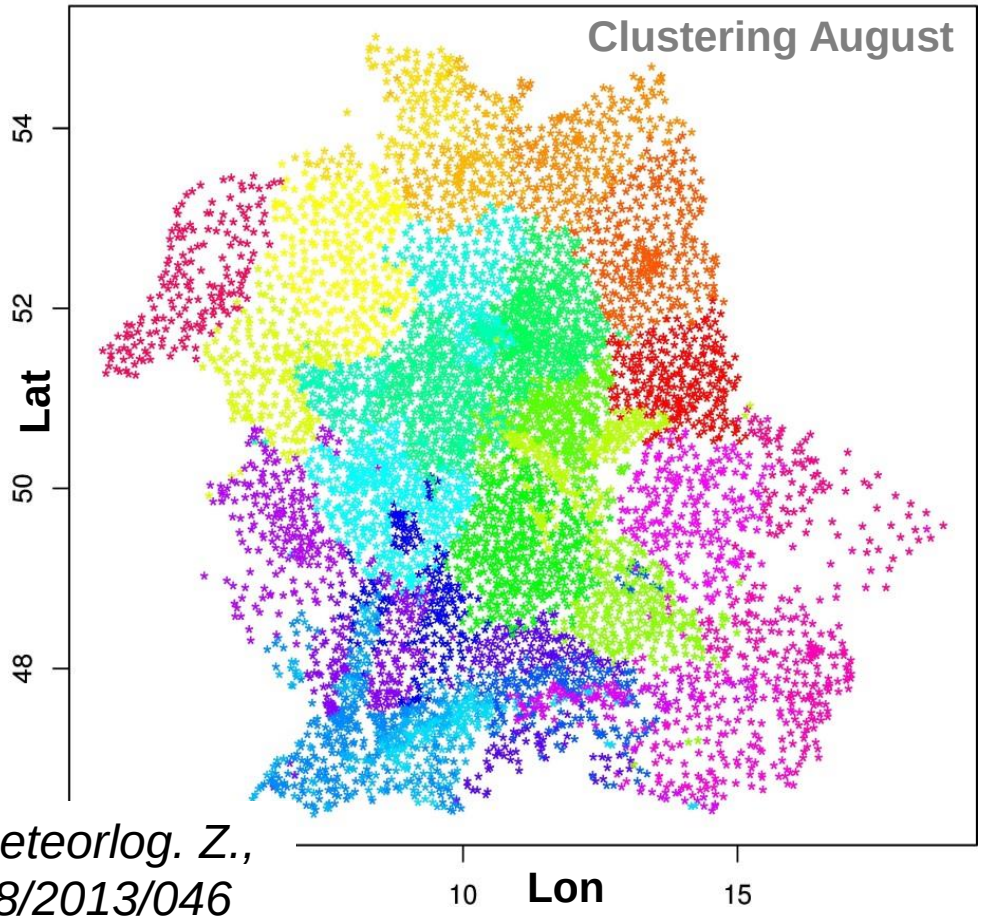
- Cluster analysis
- Multiple linear regression
- Inverse distance weighting (IDW)

2. Calculation of the daily values

- Allocation of station values to nearest grid cell
- IDW of ratio of station values and background values on grid cell
- Daily values: ratio x background

➔ **Station data are conserved on final grid**

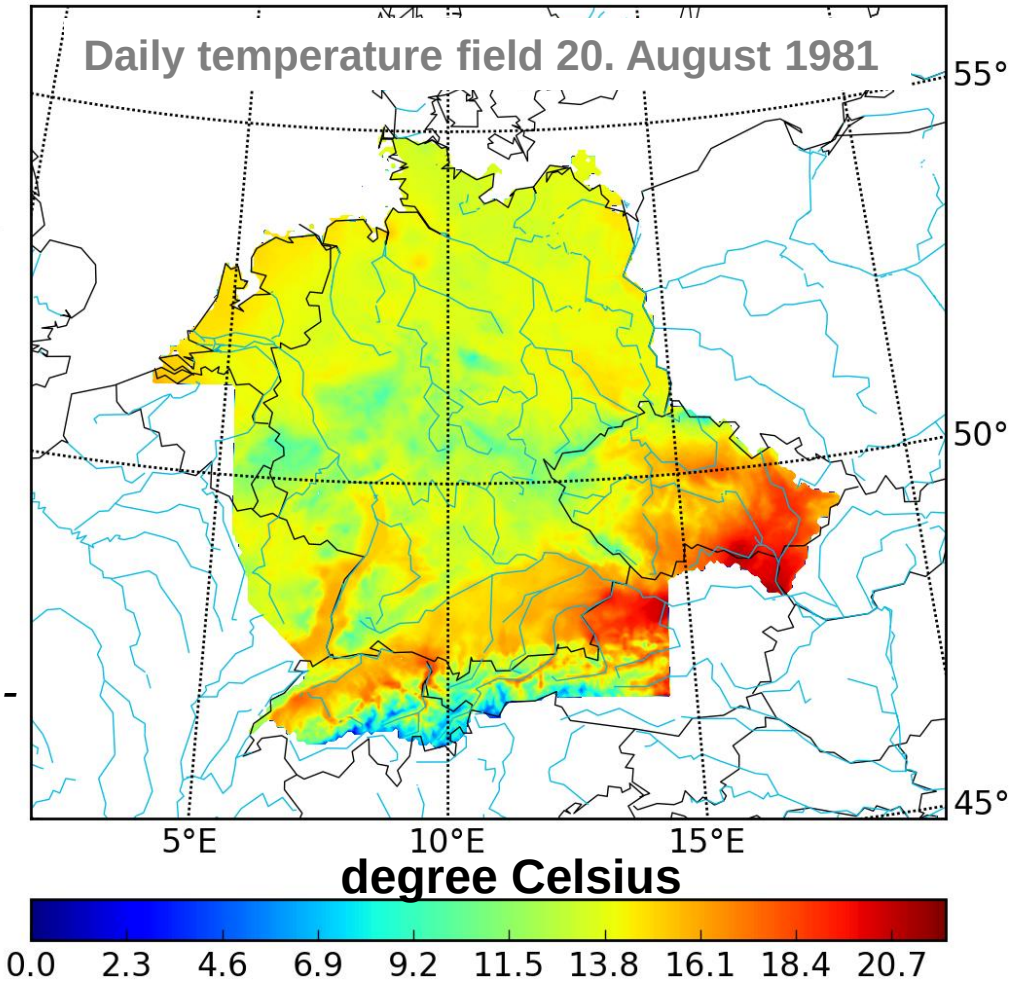


Rauthe et al. (2013), *Meteorlog. Z.,*
DOI: 10.1127/0941-2948/2013/046

Regionalisation method for mean temperature and relative humidity

Optimal Interpolation method:

- Operational use of the Optimal Interpolation method in the **SNOW-Modell Version 4** of DWD (forecast of snow cover)
- More about the method in ***Frick et al. (2014)***, *Meteorolog. Zeitschr., Central European high-resolution gridded daily data sets (HYRAS): Mean temperature and relative humidity, DOI: 10.1127/0941-2948/2014/0560*

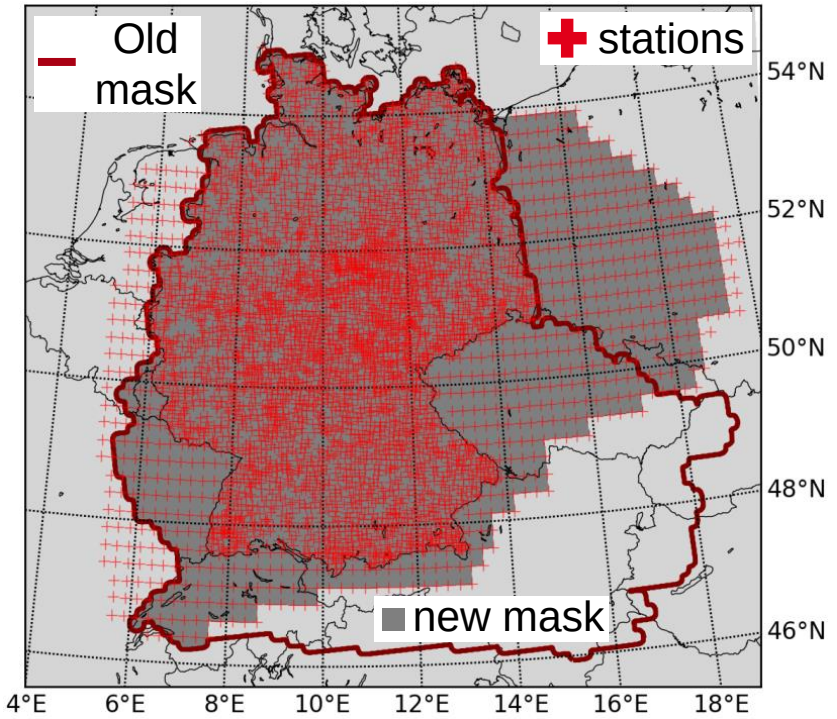


Application of the HYRAS methods to the statistical WETTREG model

WETTREG („**WETT**erlagenbasierte **REG**ionalisierung“; regionalisation based on circulation patterns):

- Output station based (1951 – 2100)
- 7 model runs with 10 realisations
- Within Germany: climate stations (403) and precipitation stations (3248)
- Outside of Germany: EOBs data (gridded data set of about 28 x 28 km^2)

- Adjustment of the ReKliEs-De mask
- Regionalisation of the WETTREG output with adjusted HYRAS methods



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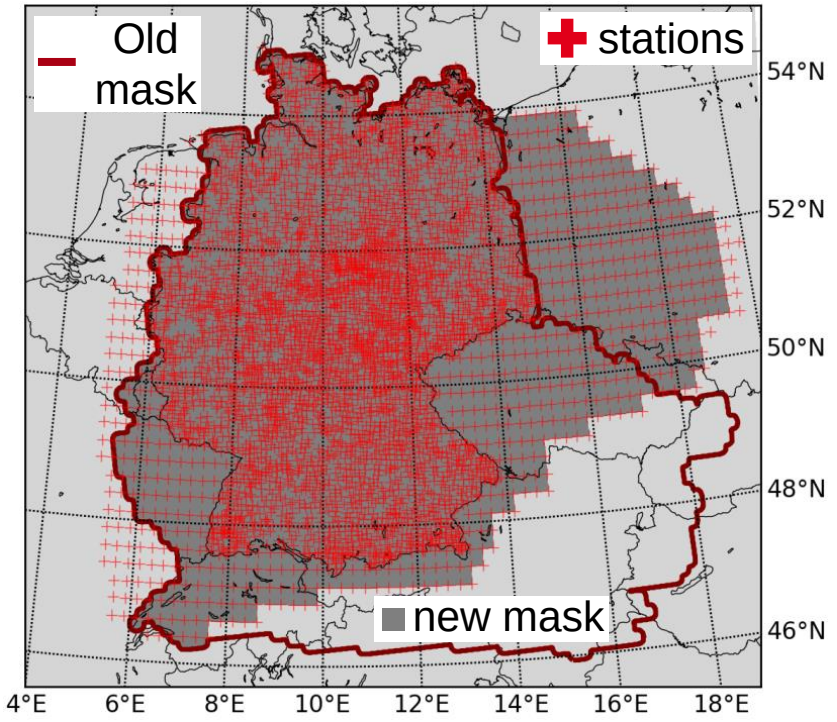
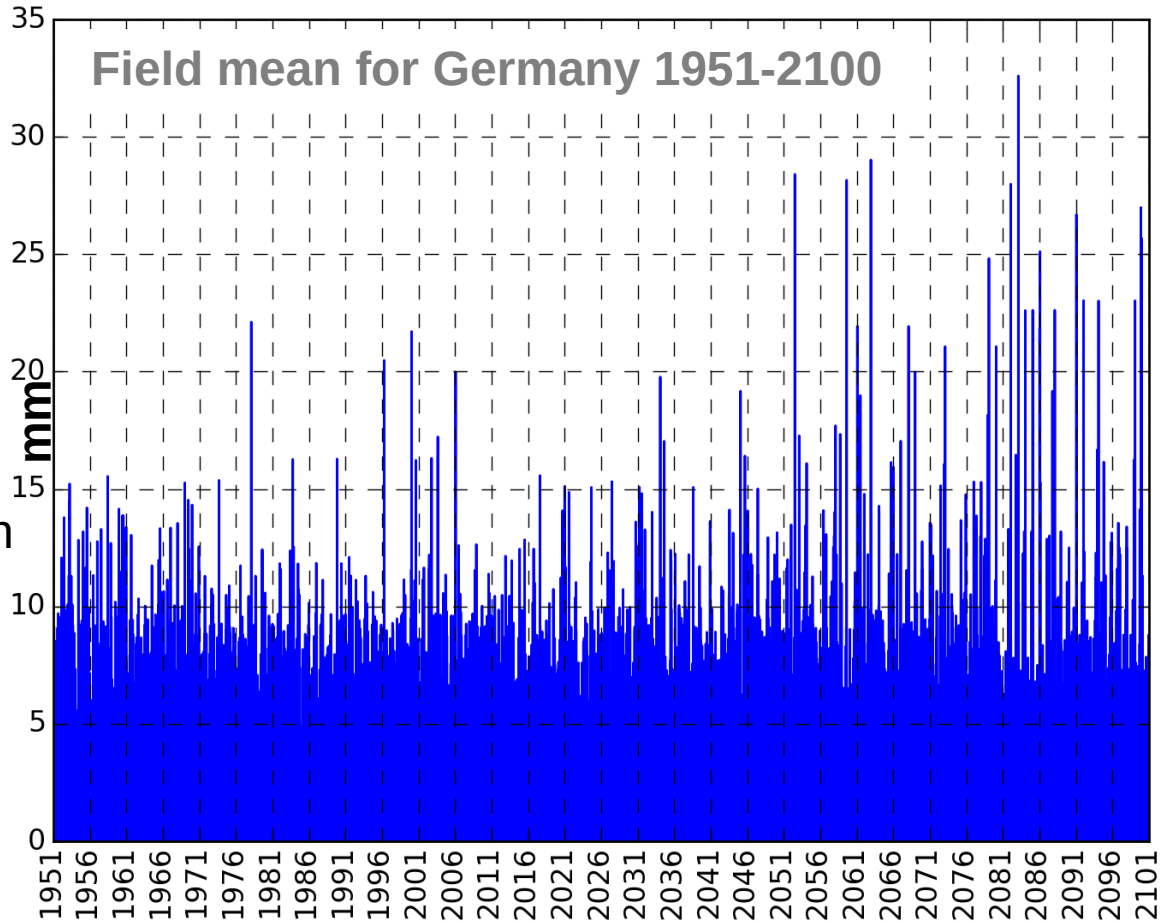


Comparability of dynamical und statistical models
Enlarging the ReKliEs-De ensemble

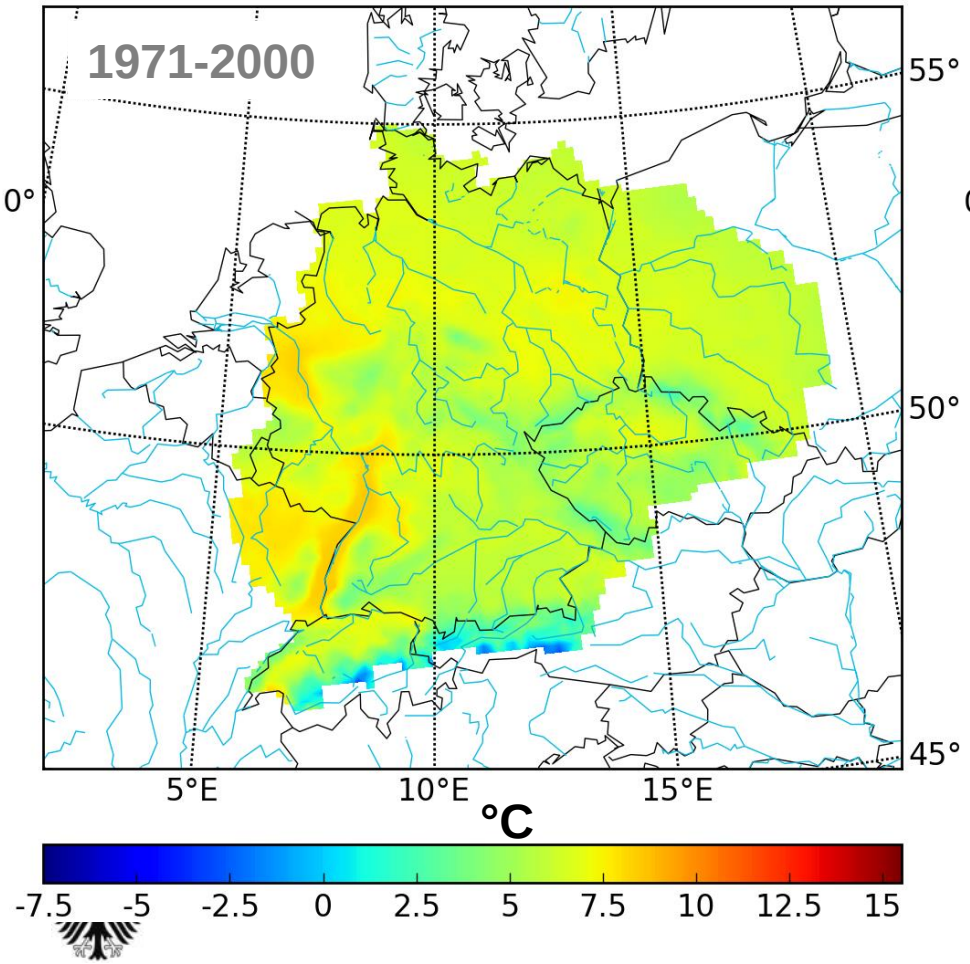
First results: precipitation WETTREG (CNRM-CM5, RCP 8.5)

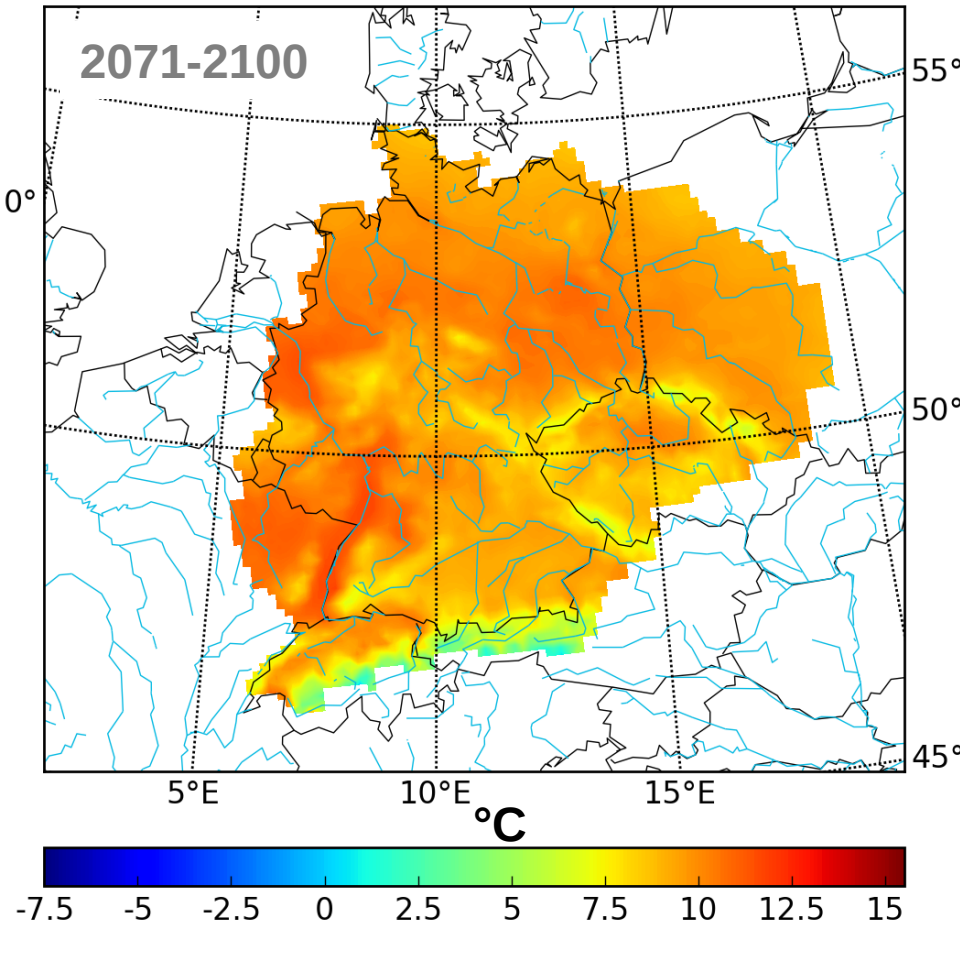
- Calculation of the field mean for Germany (daily values) over the whole simulation period
- High variability of daily precipitation
- Increasing frequency of extreme precipitation events in this WETTREG simulation (as of 2nd half of 21st century)
- Increase of precipitation amount per extreme precipitation event



First results: Mean temperature WETTREG (CNRM-CM5, RCP 8.5)

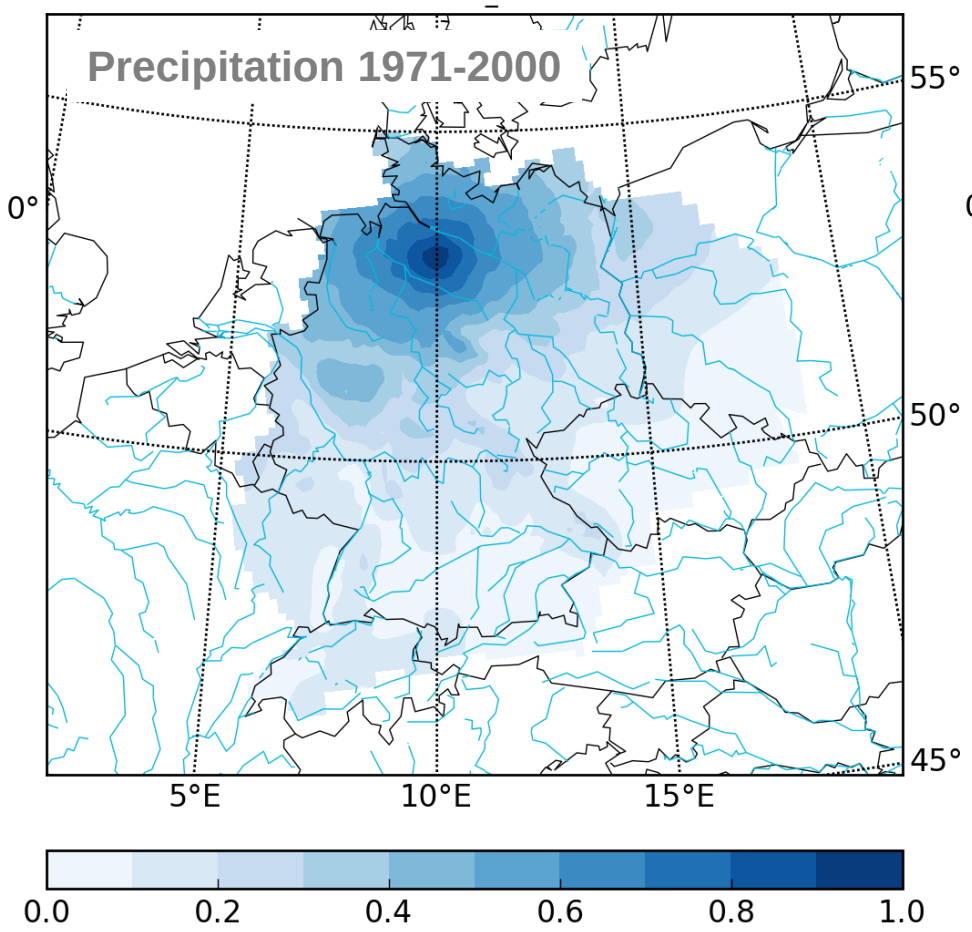
- Long-term **temperature** mean for present and future conditions (WETTREG)
- Future temperature increase

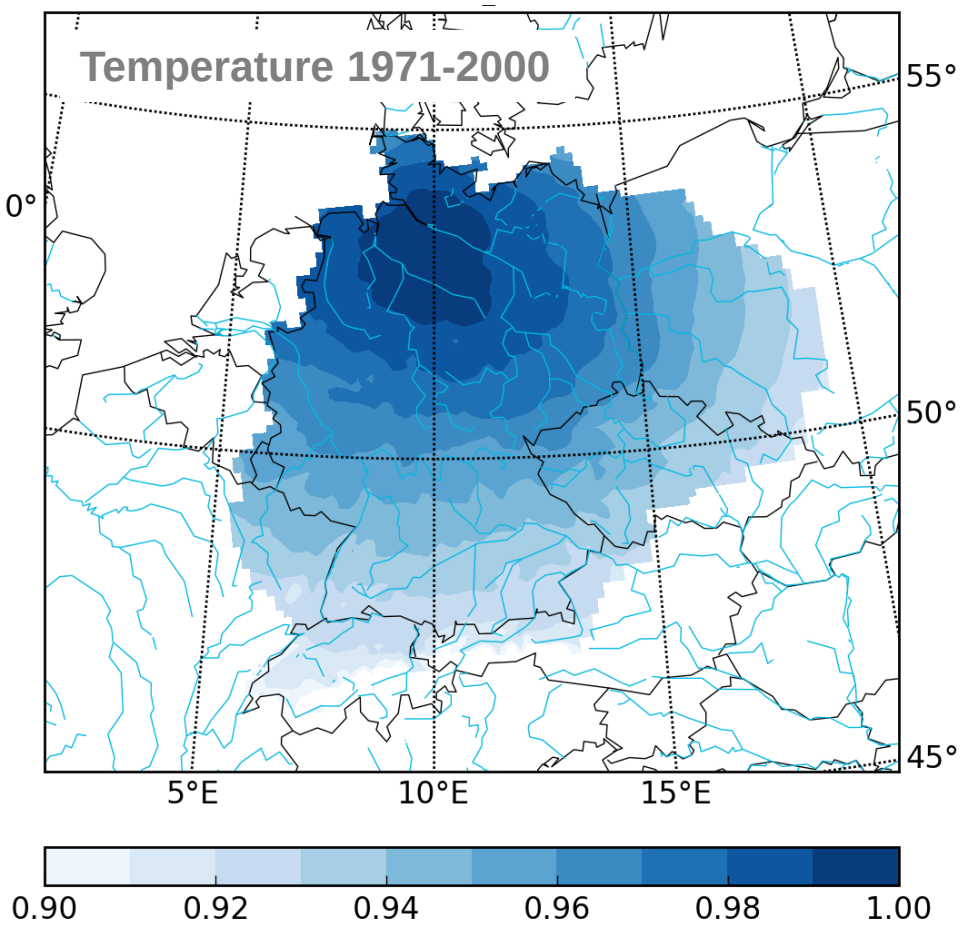




Plausibility of gridded model output

- Correlation matrix for precipitation and temperature





Summary

Transfer of HYRAS regionalisation methods to the output of the statistical climate model WETTREG:

- Gridded model results are plausible
- Comparability of statistical and dynamical model simulations
- Joint analysis of statistical and dynamical model outputs

Outlook:

- Analysis of the ReKliEs-De ensemble for future climate
- Analysis of robustness of the ensemble

ReKliEs-De user workshop
June 14th/15th 2016 in Potsdam
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Thank you for your attention!

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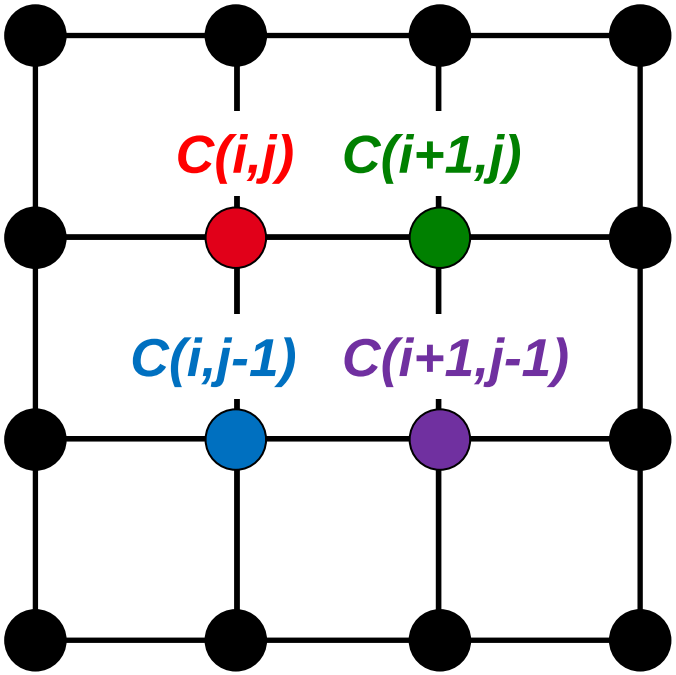
Plausibility of gridded model output

Calculation of correlation matrix C for all ReKliEs-De grid points:

- Selection of a single grid point $P(i,j)$
- Selection of a specific period (e. g. 1971-2000)
- Calculation of the correlation of grid point $P(i,j)$ to any other grid point



$$C(i,j) = corr(\, P(i,j), P(i,j) \,)$$

$$C(i+1,j) = corr(\, P(i,j), P(i+1,j) \,)$$

$$C(i,j-1) = corr(\, P(i,j), P(i,j-1) \,)$$

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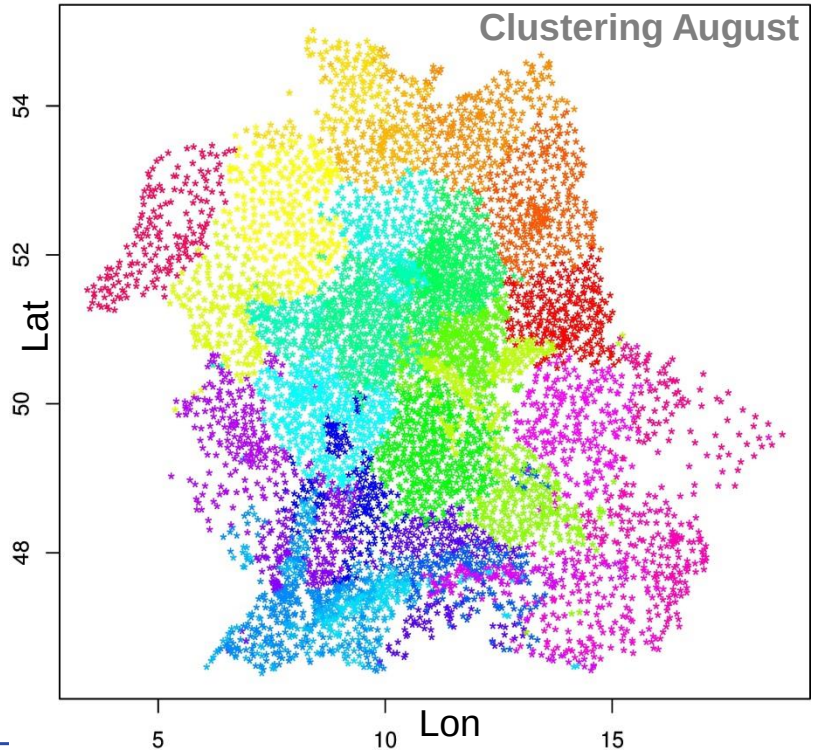
Regionalisation method for precipitation

REGNIE method („**REG**ionalisierung der **NIE**derschlagshöhen“; regionalisation of precipitation heights):

1. Calculating the climatological background fields on monthly basis

- ***Cluster analysis***: Dividing the whole area into homogeneous, climatological areas (30 clusters)
- ***Multiple lineare regression*** of monthly mean of each station for long time period (z. B. 1961-1990)
- ***Inverse distance weighting (IDW)*** of residuals and regression coefficients to final grid
- ***Calculation the background values*** of each grid cell by substituting the resiuals and regression values into the regression equation



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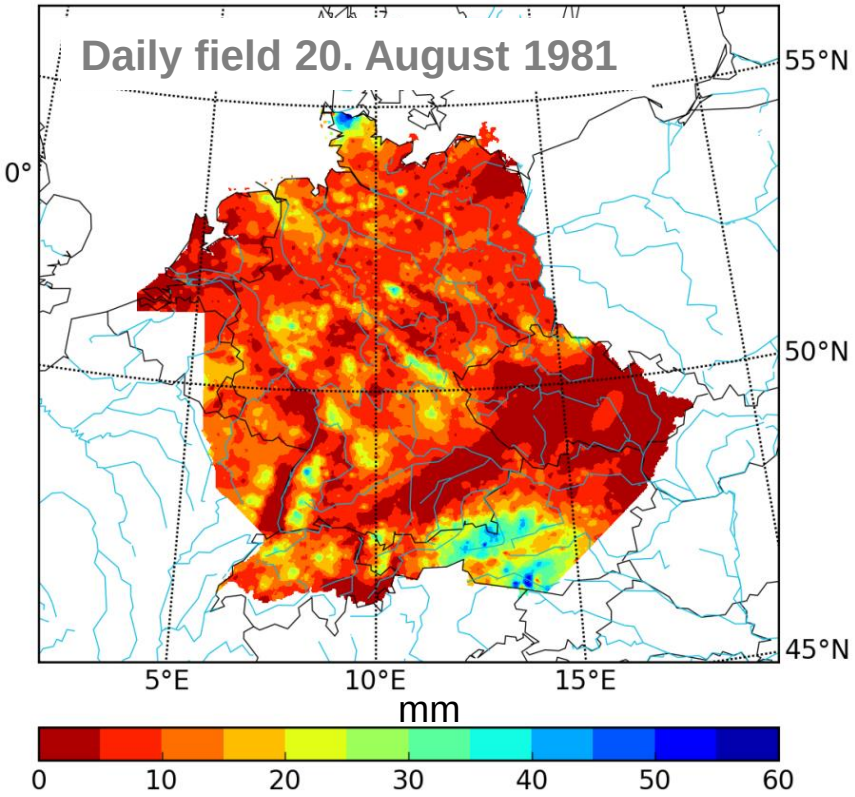
2. Calculation of the daily data set

- Allocation of the station values to the **nearest grid cell**
- **Calculation of the ratio** of station values and background values
- **IDW of the ratios** to the grid cells without station values
- **Calculation of the daily data set** by multiplication of the ratios with the background values

➔ **Station data are conserved on final grid**



***Rauthe et al. (2013)**, Meteorlog. Z., DOI: 10.1127/0941-2948/2013/046*

Regionalisation method for temperature and relative humidity

Optimal Interpolation (interpolation for each time step separately):

- Find 15-30 stations influencing the grid point
- Splitting the station values z into background value z_b and anomaly value z_a: $\boldsymbol{z = z_b(x, y, h) + z_a}$
  1. Calculation of the **background values** for stations and grid points by means of a Trend Surface Analysis employing a multiple linear regression using all station values and successive calculation of station anomalies
  2. Statistical interpolation of all station anomalies to the grid by the **spatial correlation function**
  3. Calculation of **interpolation weights** by solving the linear equation system consisting of the station correlation matrix and the correlation vector between stations and grid points

  → Calculation of **anomalies** by multiplication of normalized interpolation weights and background values
- Grid point values: background values + anomalies