Convection-resolving regional climate simulations for Rhineland-Palatine

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FORSCHUNGSZENTRUM
in der HELMHOLTZ-GEMEINSCHAFT

# Motivation

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Climate change = more weather extremes, more intense thunderstorms (wind gusts, heavy precipitation)

Motivation

Number of flashes as a function of mean monthly temperature, Germany, 1992-1998

$y = 95.219\ e^{0,3749x}$

$R^2 = 0,8158$
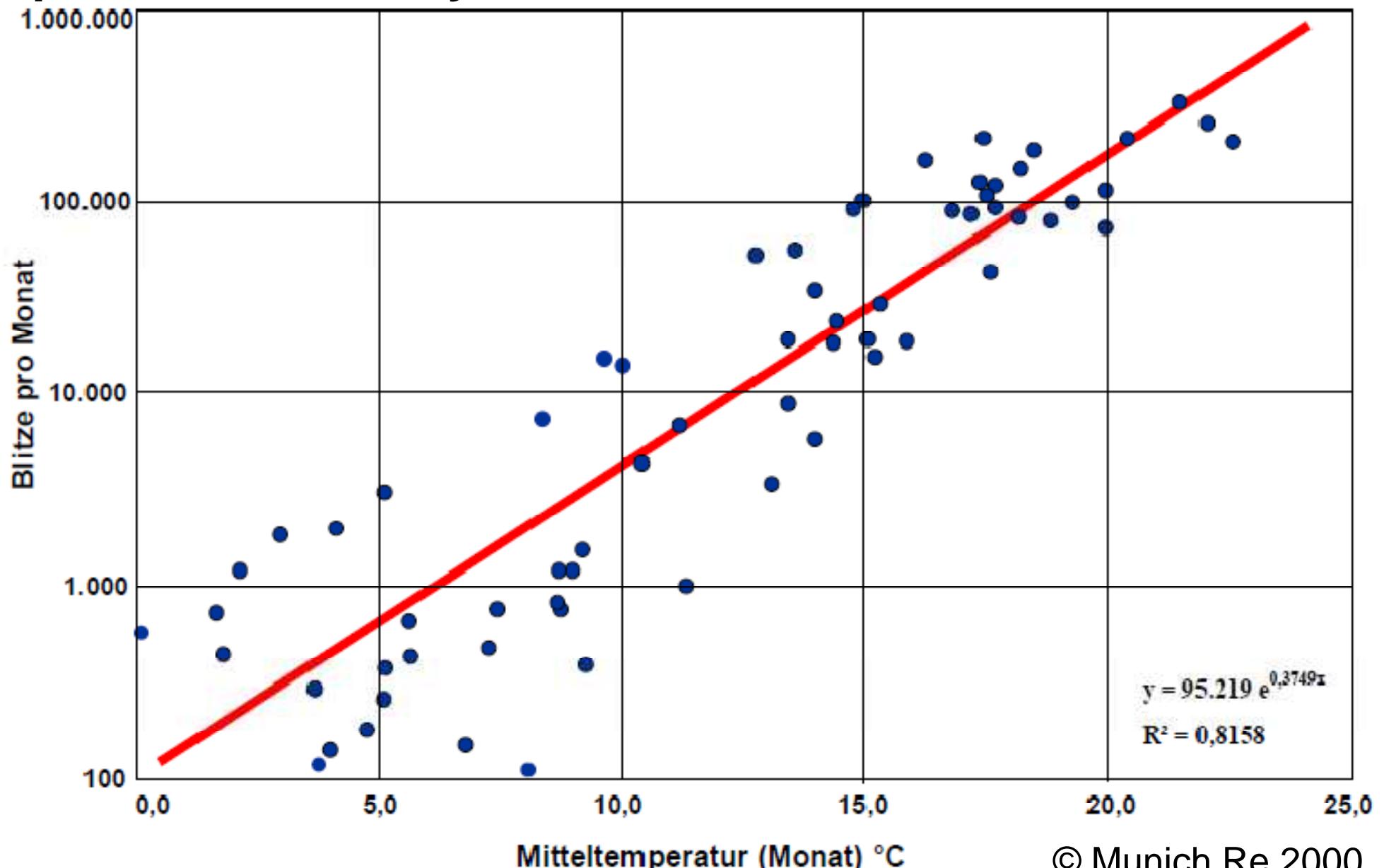
Motivation

Why high resolution climate modelling?

Influence of small-scale
features on atmospheric flow
(orography, land use)

convection resolving

CLM (18km)

COSMO CLM (2.4.11)
0.04125°
approx. 5 km resolution

hourly
forced

LandCaRe 2020
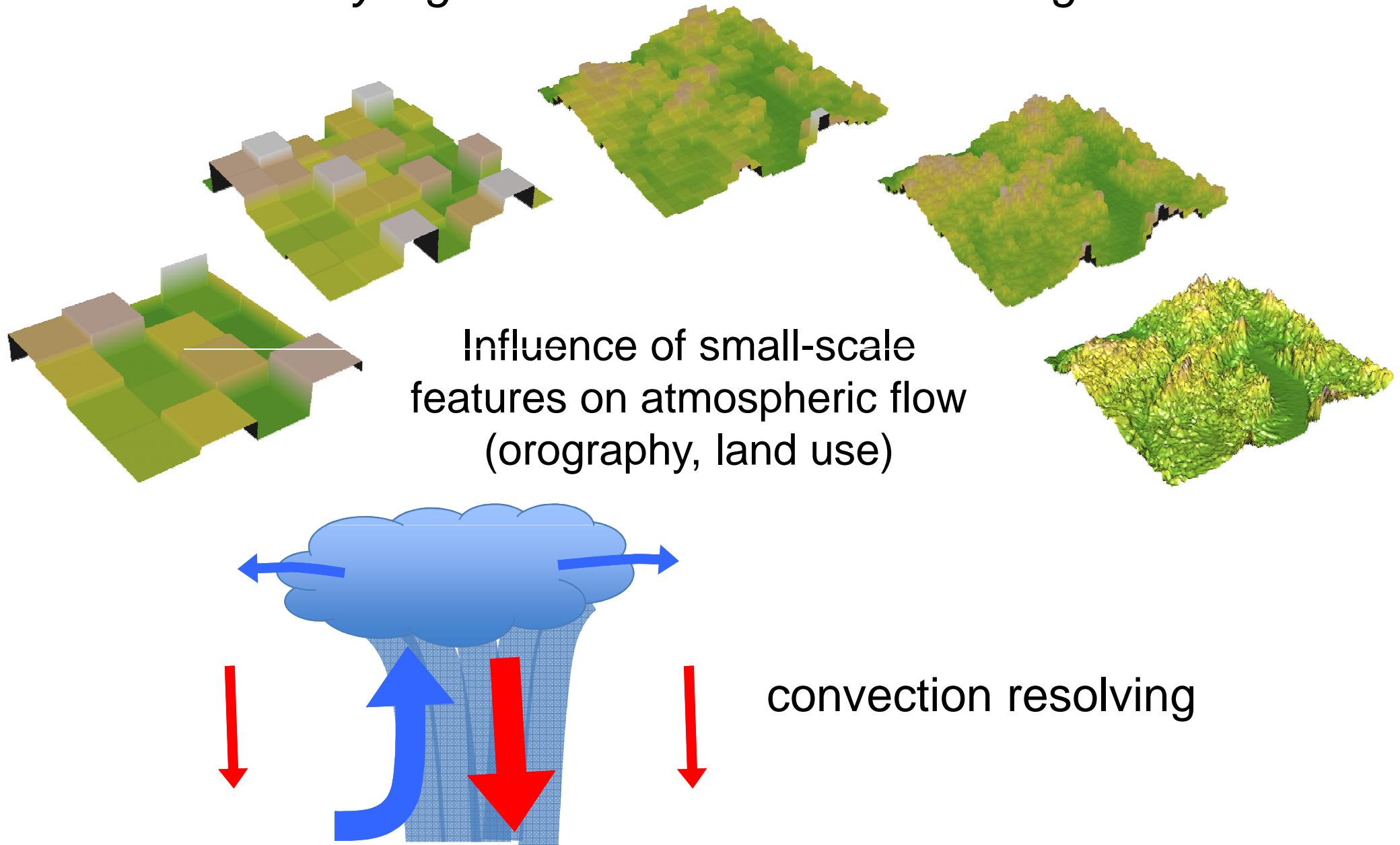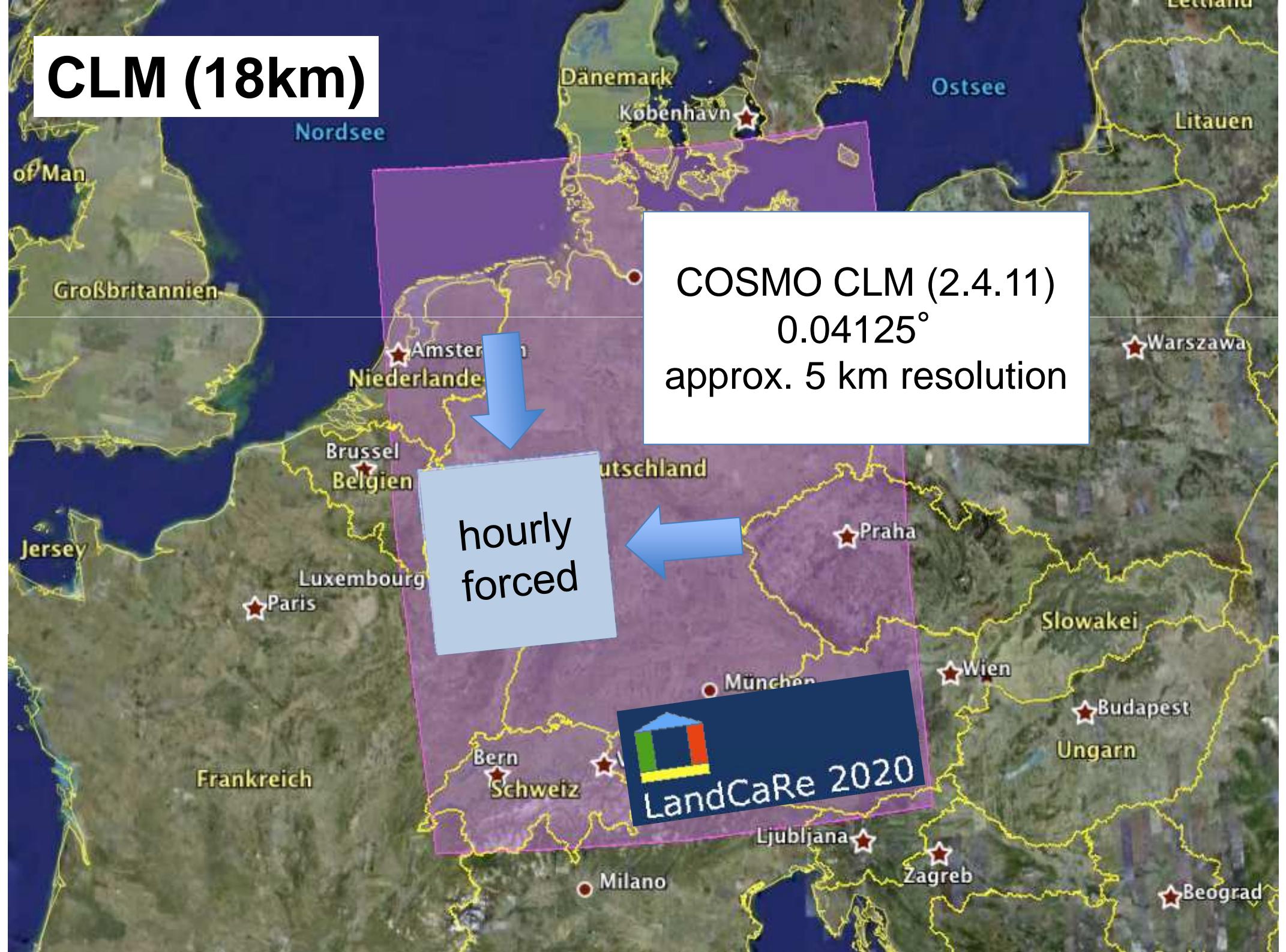
200 x 200 gridpoints
40 levels

$\Delta x = \Delta y = 0.012°$
(approx. 1.3 km)

COSMO-DE
Configuration
+ *bigger relaxation zone*

200

200
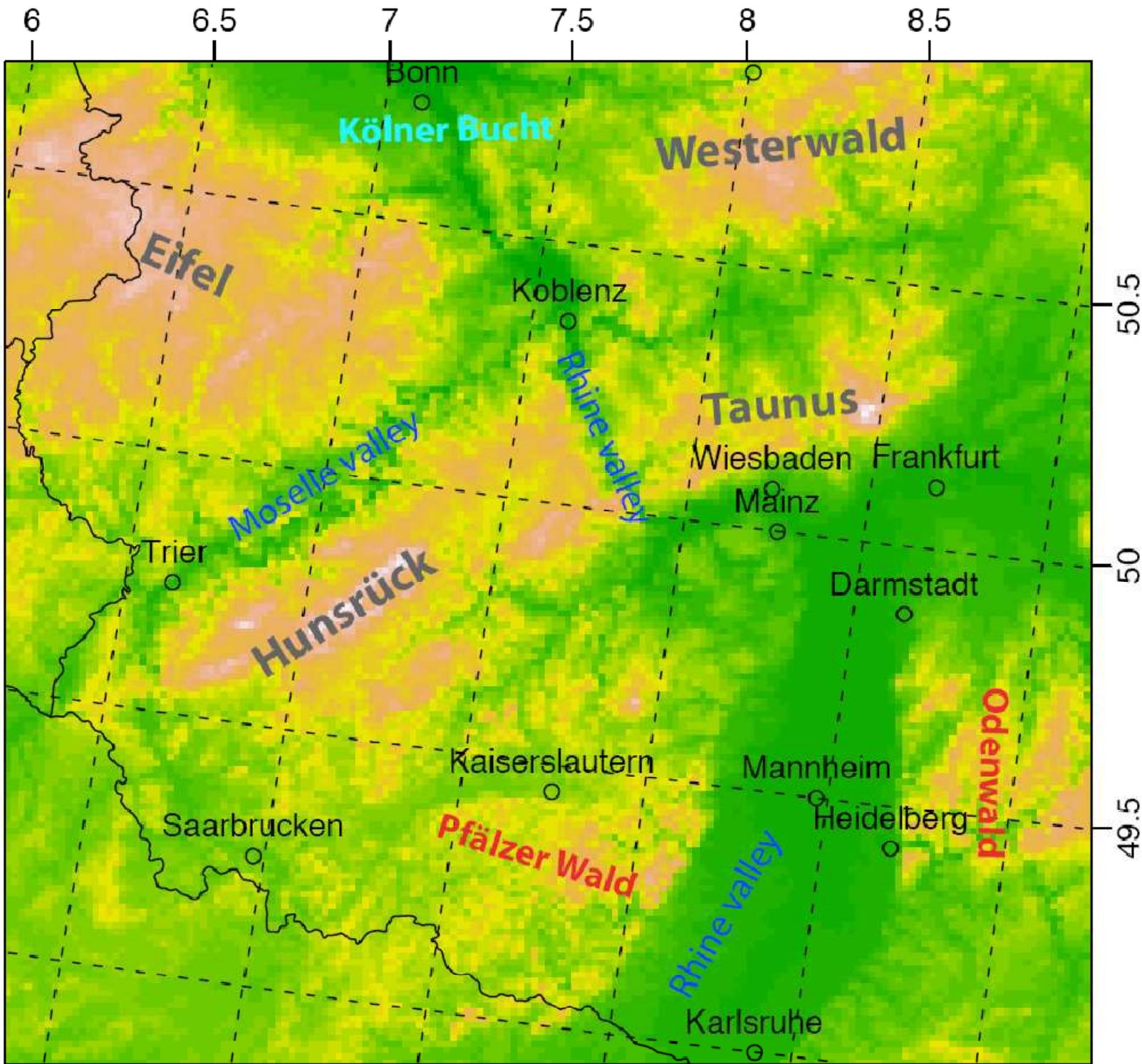
Knote et al. (2009)

Setup

Time slice experiment:
10 years of summer months in 2 scenarios

Check against forcing data:
Resolution increase from 5 to 1.3 km

18 km   Mean 2m-temperature July   1.3 km
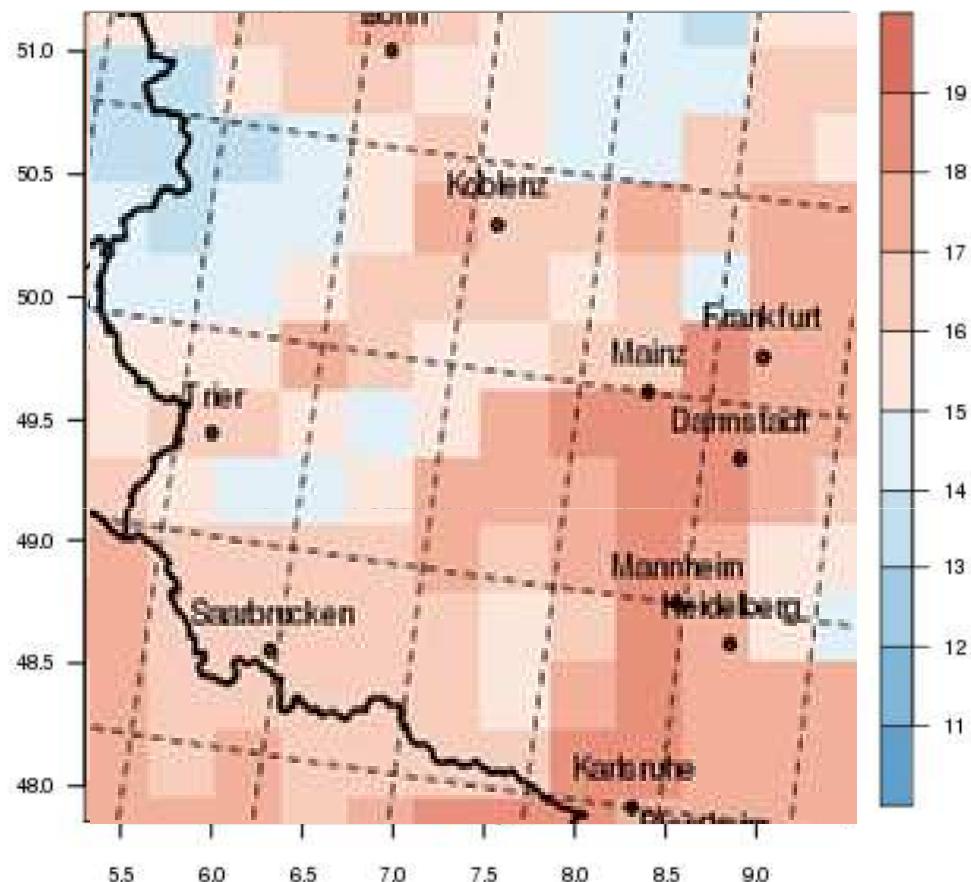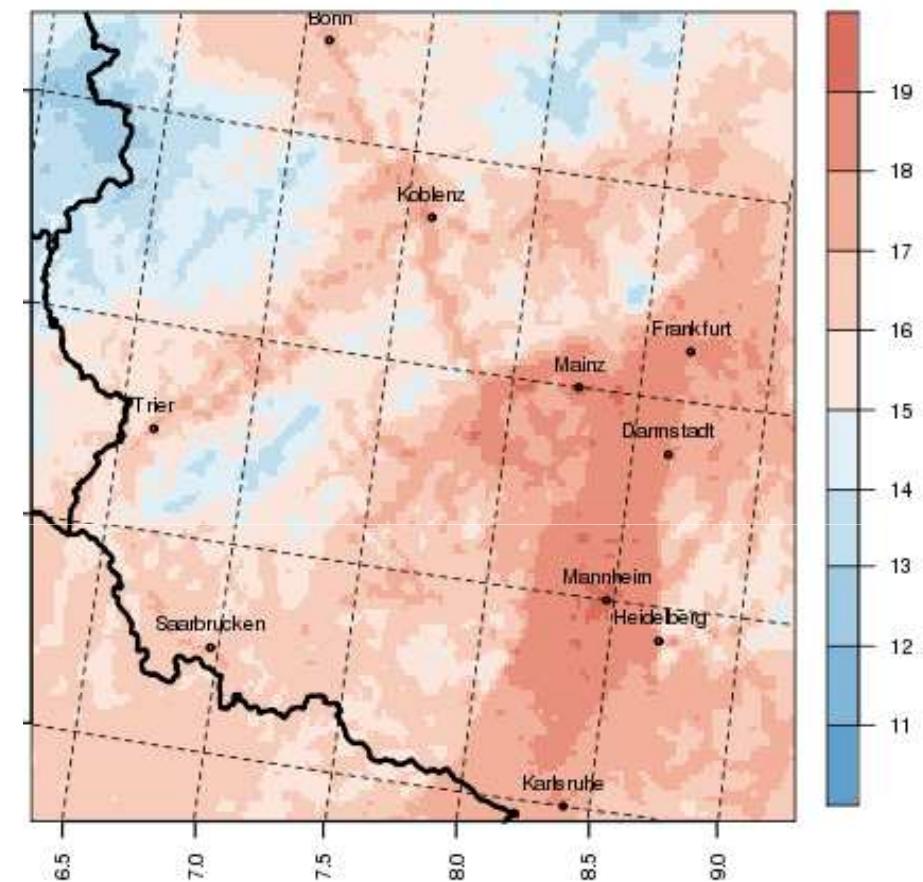
C_1960

5 km Mean 2m-temperature July 1.3 km
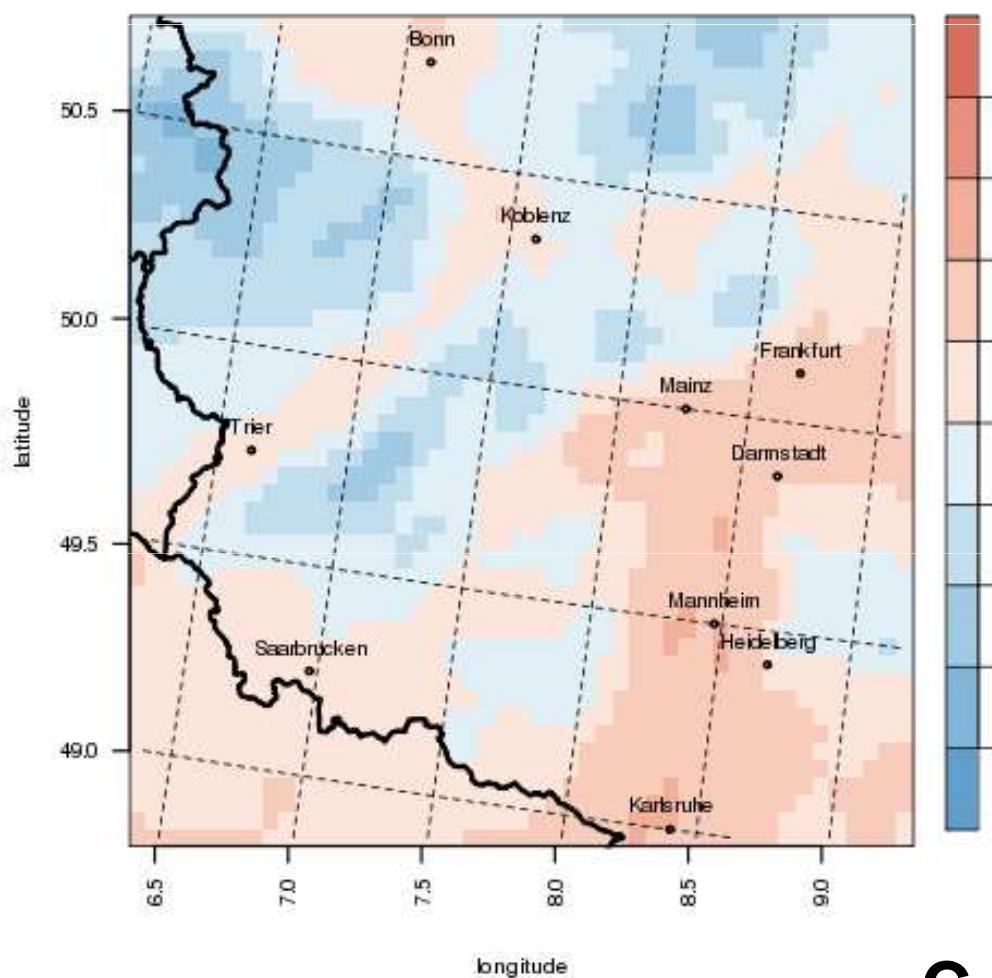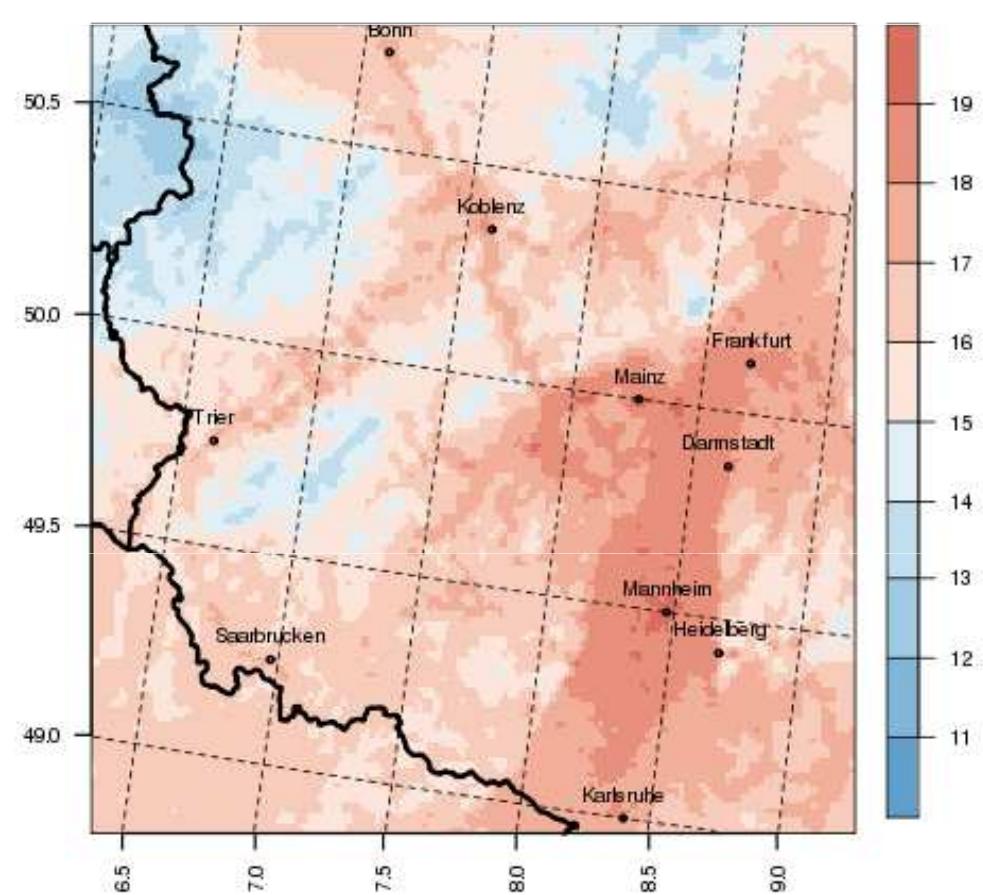
C_1960

Mean maximum 2m-temperature JJA
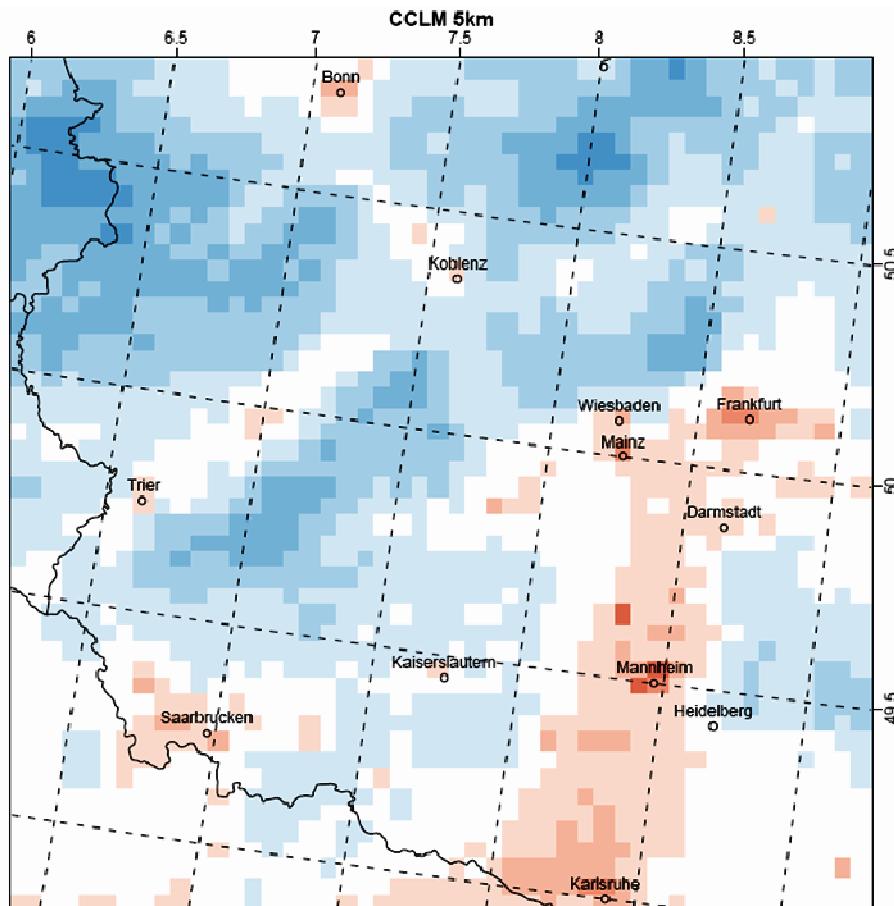
5 km   1.3 km
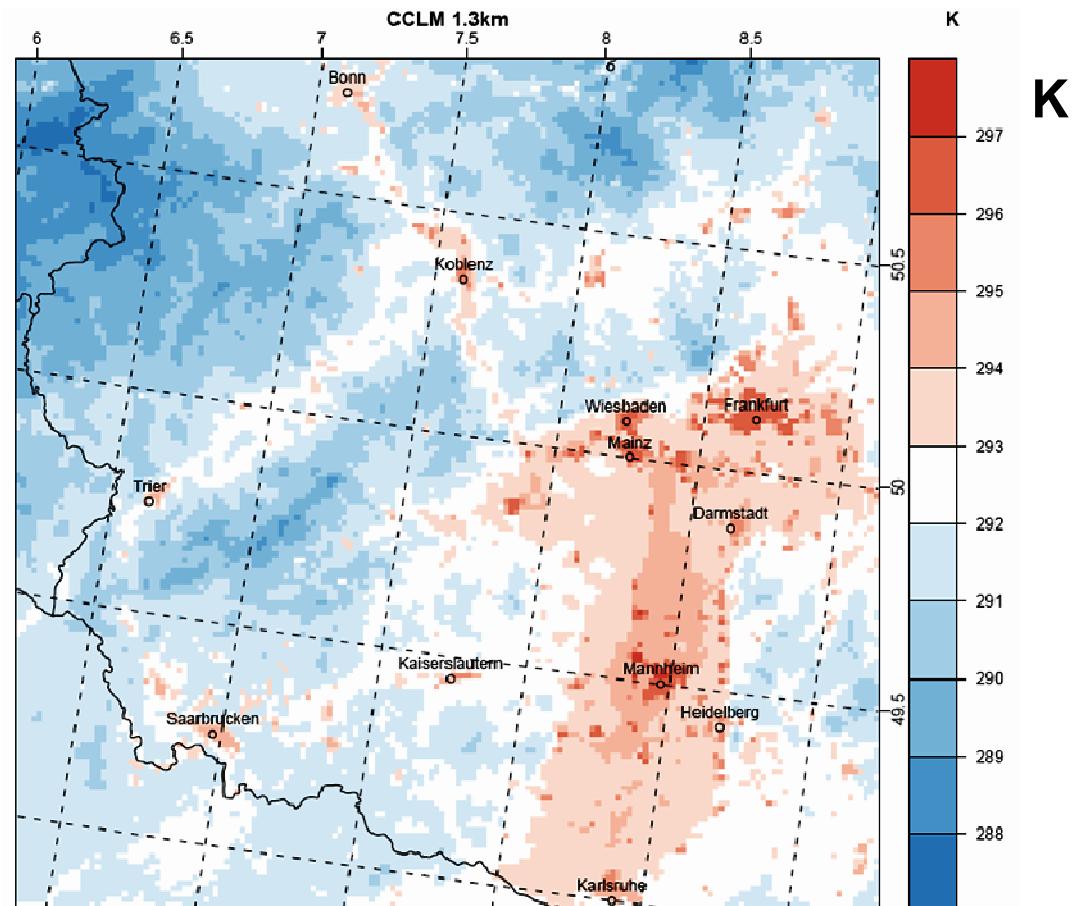
C_1960

Check against forcing 5km:
Differences in mean max. 2m-temp. histograms

Differences (average 0.08 K)

Frequency

K

Mean unchanged (+-)
Variability increased
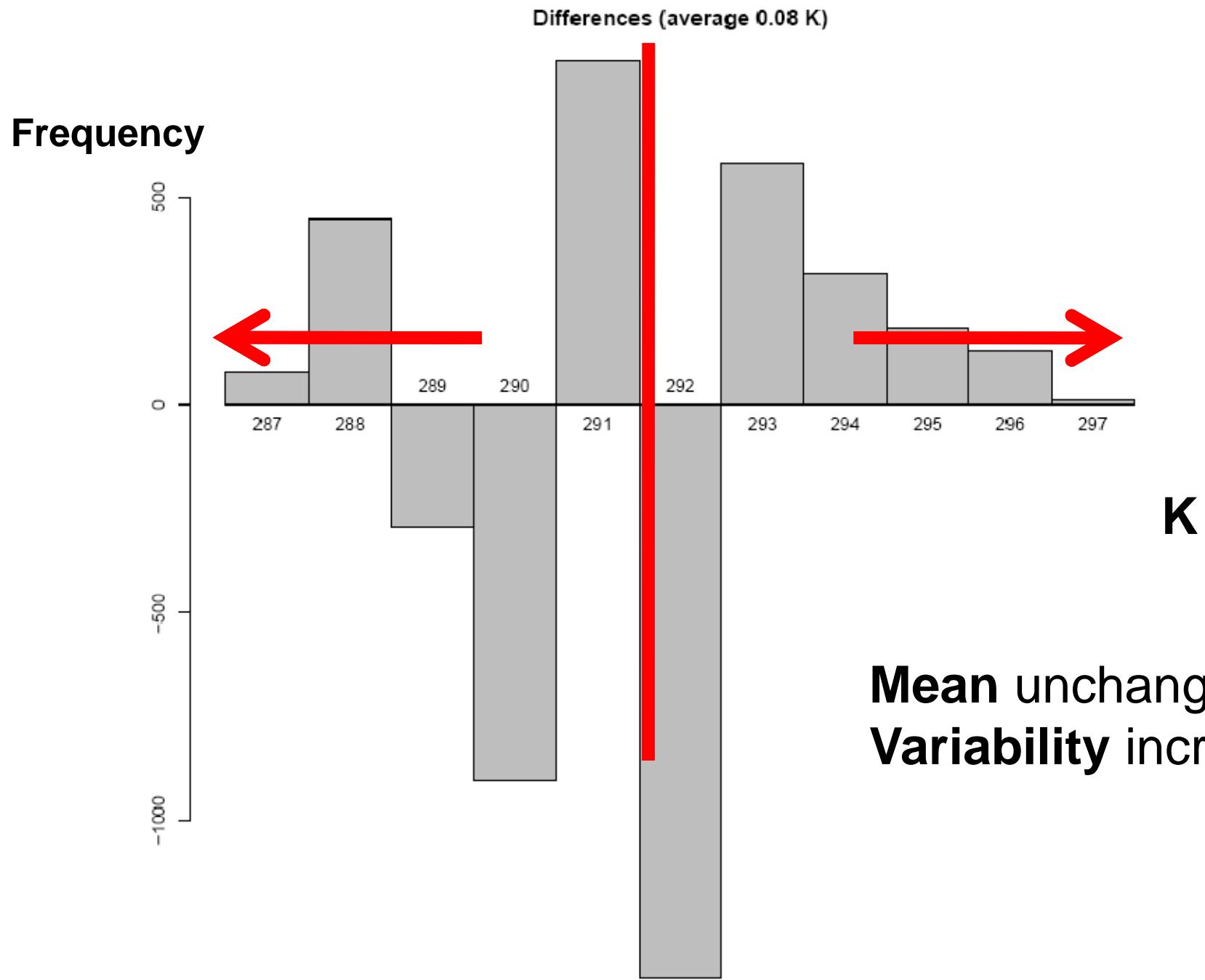
Check against forcing:
Differences in 10 m-windspeed histograms

Mean unchanged (+-)
Variability increased

Mean changes between scenarios
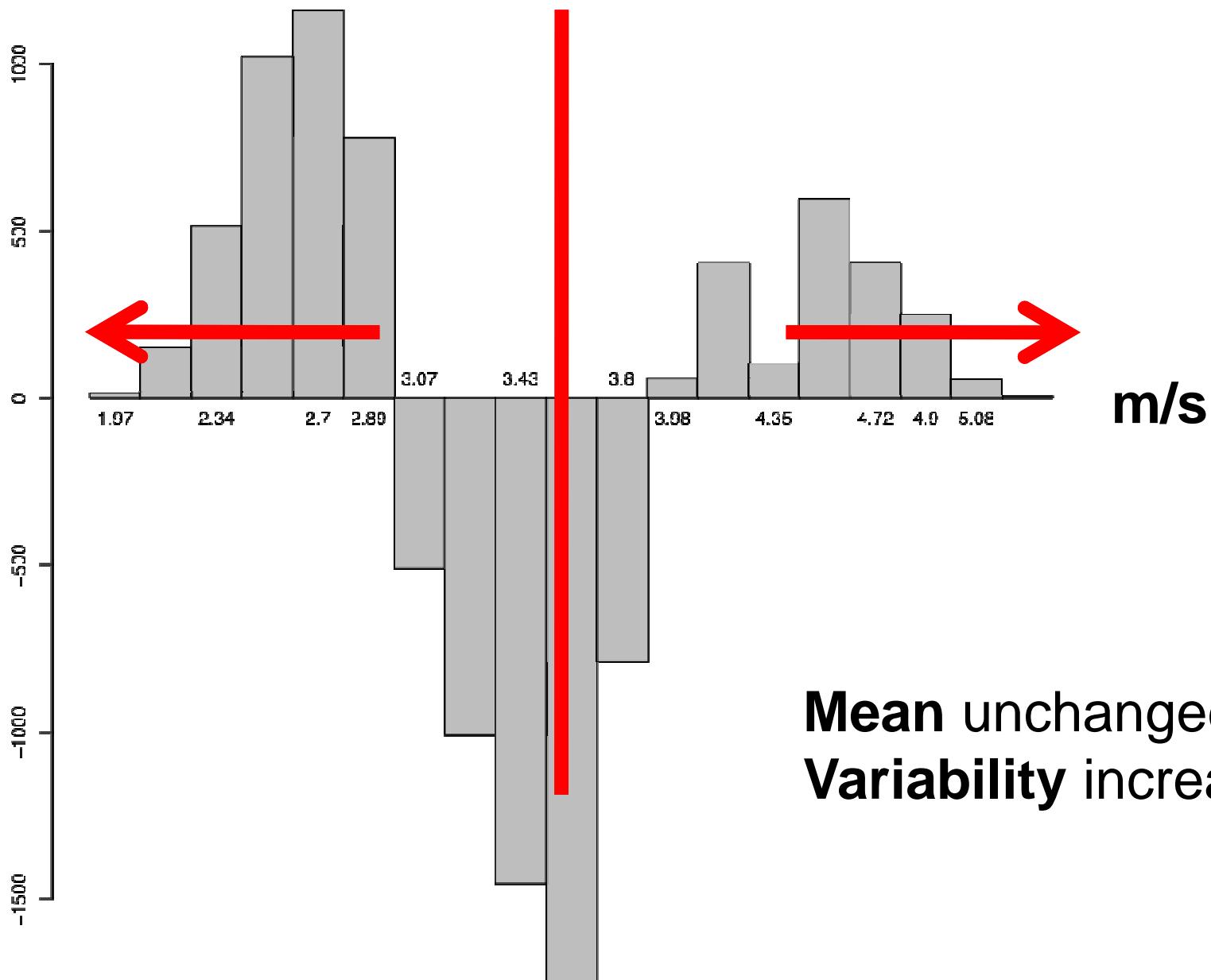
Δ (A1B – C1960)

|	mean
Temperature at 2m — daily maximum	+2.1 K
Temperature at 2m — daily mean	+1.8 K
Temperature at 2m — daily minimum	+2.0 K
Precipitation	very uncertain
Wind at 10m — gusts	-0.05 m/s
Wind at 10m — mean speed	-0.03 m/s

# Extreme value analysis: Peaks over threshold
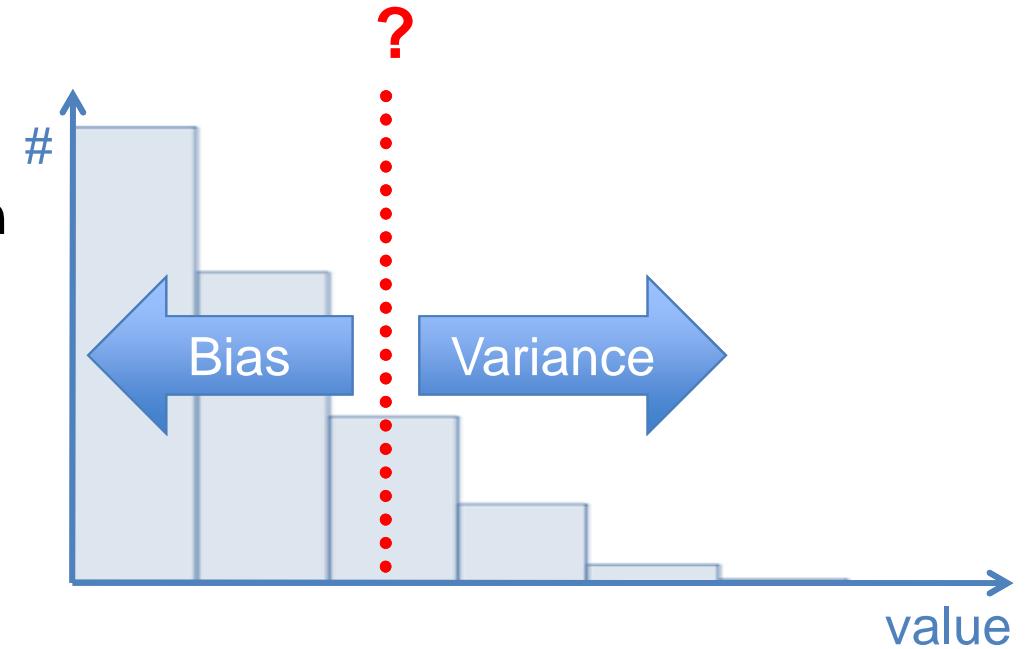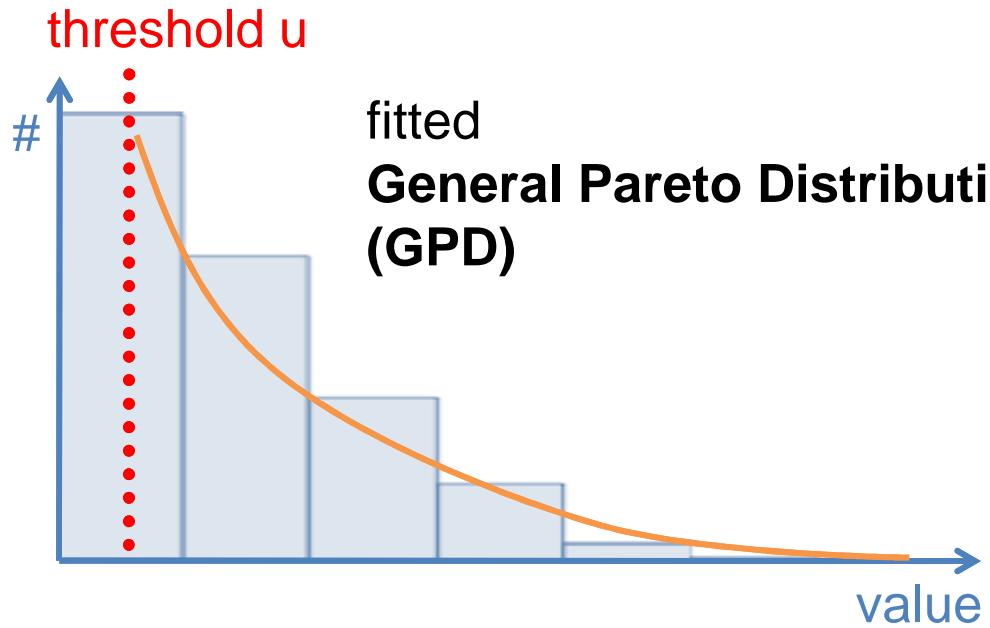
Search of independent events: Decorrelation time scales
Temperature: ca. 10d
Wind: ca. 36h
Precip.: ca. 24h

Extreme value analysis: Return periods

A1B
C_1960

dashed lines: the 95 %
condence interval of the
the fitted GPD function

Maxima of
daily minimum 2m temperature
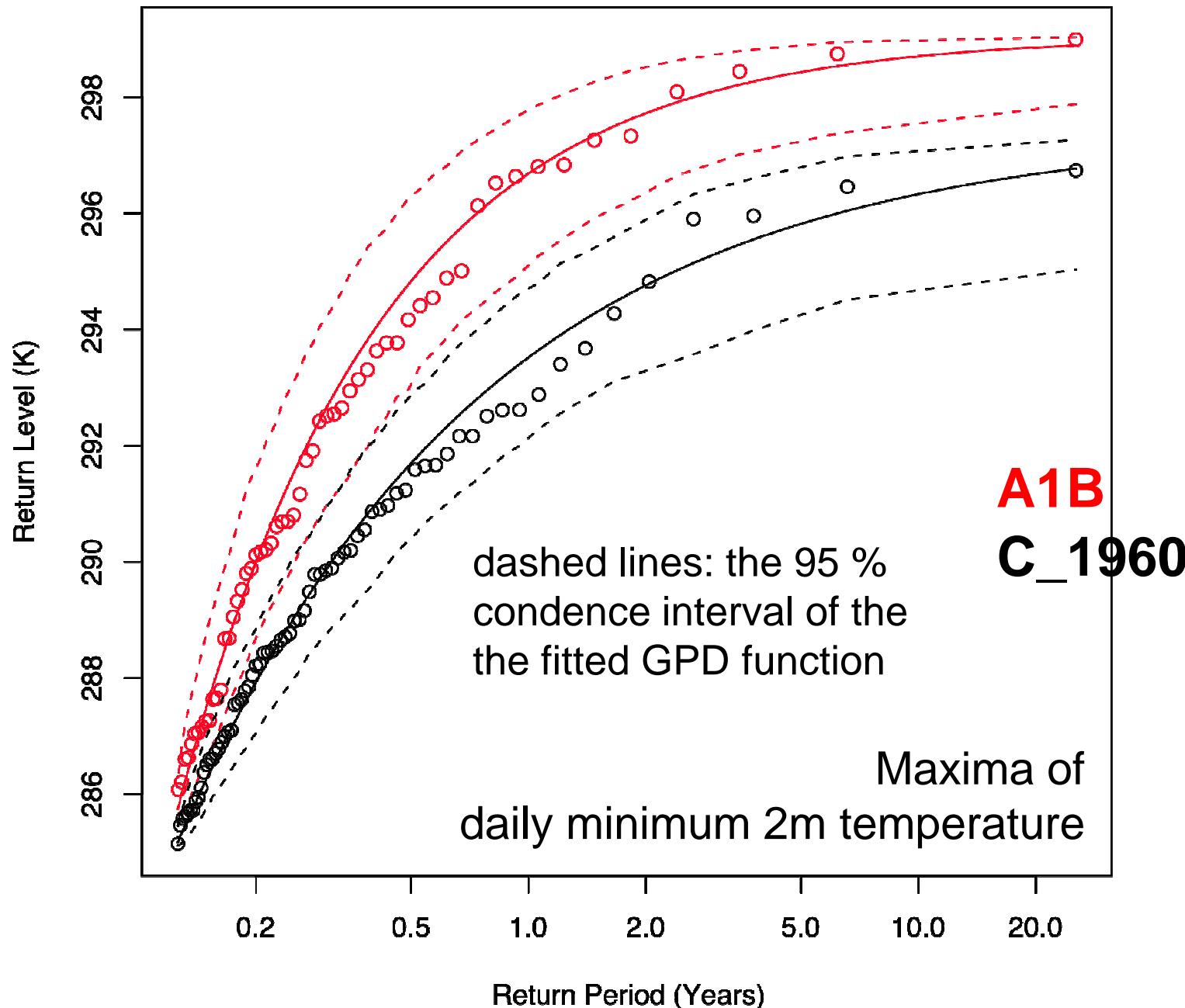
Difference mean 2m-temperature: 2015-24 (A1B) / 1960-69
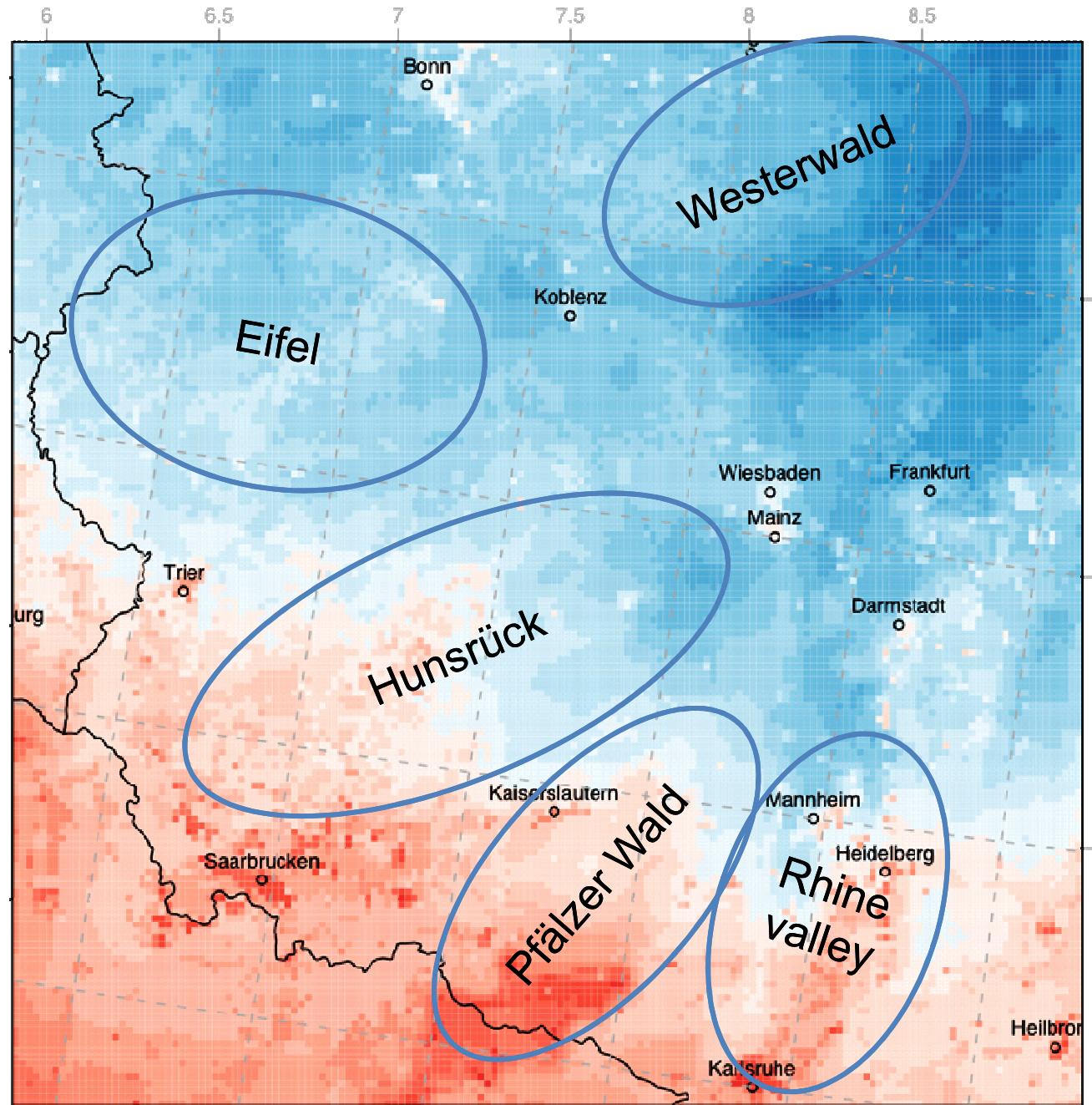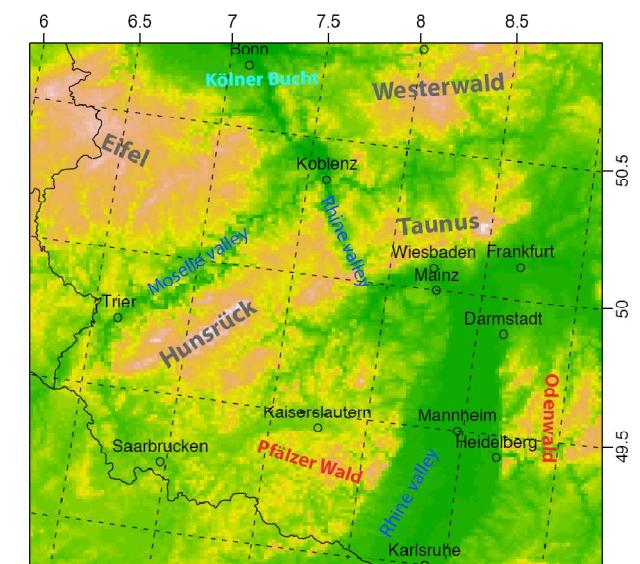
Knote et al. (2009)

Difference 30 year return period of the 2m maximum temperature: 2015-24 (A1B) / 1960-69
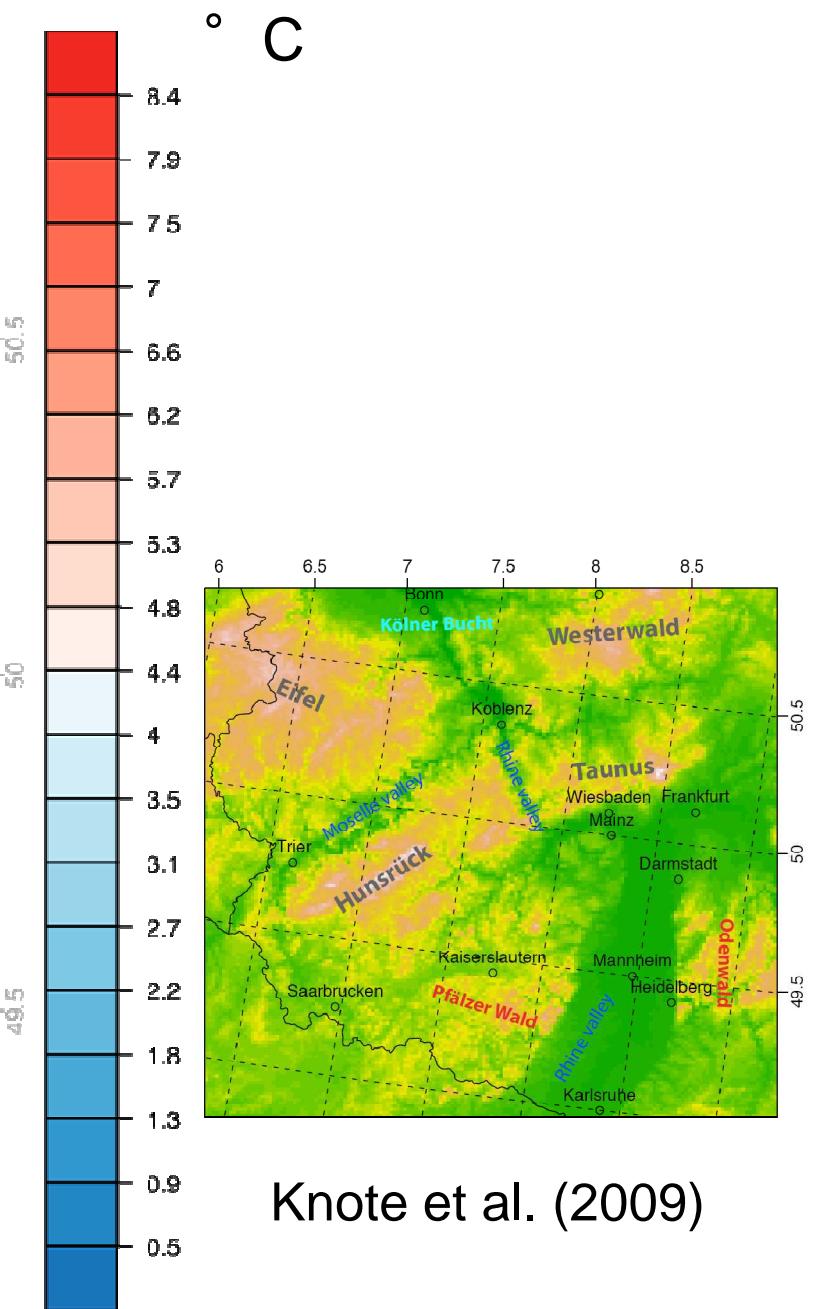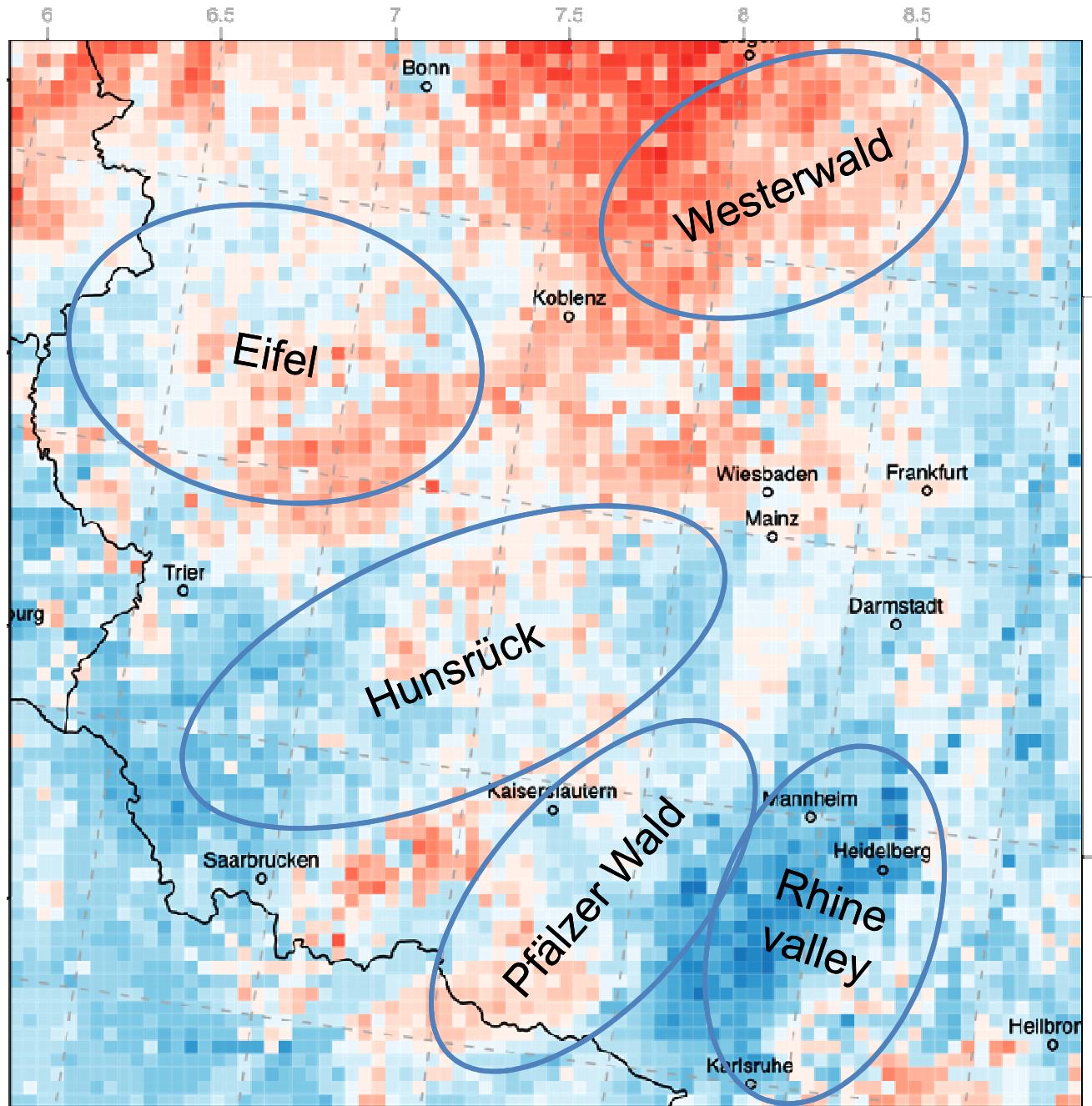
Knote et al. (2009)

Stability of 30 yrs return value for daily 2m temperature mean
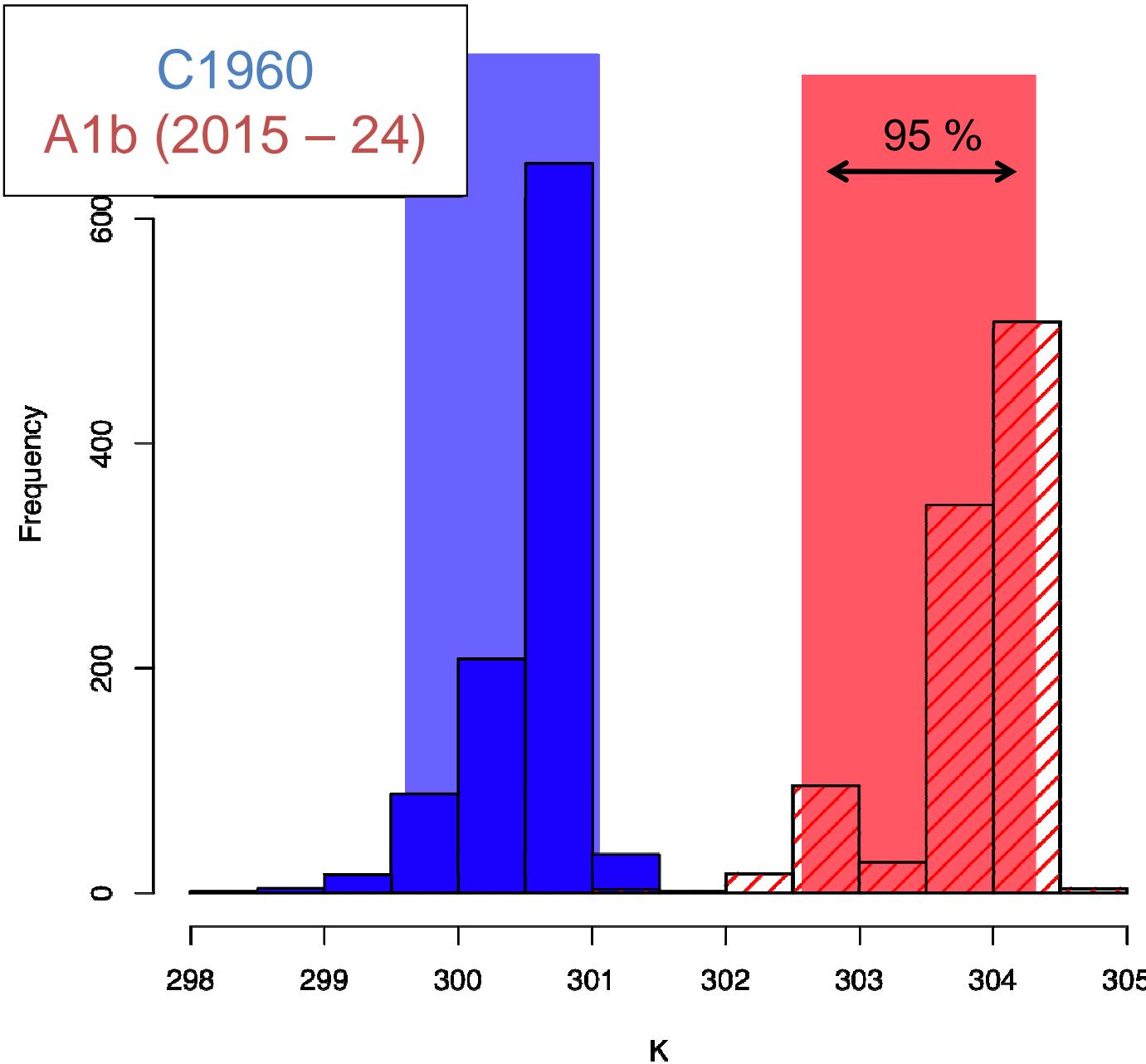
# Stability of 20 yrs return value for wind gusts

20 year return levels distribution comparison for VGUST_10M
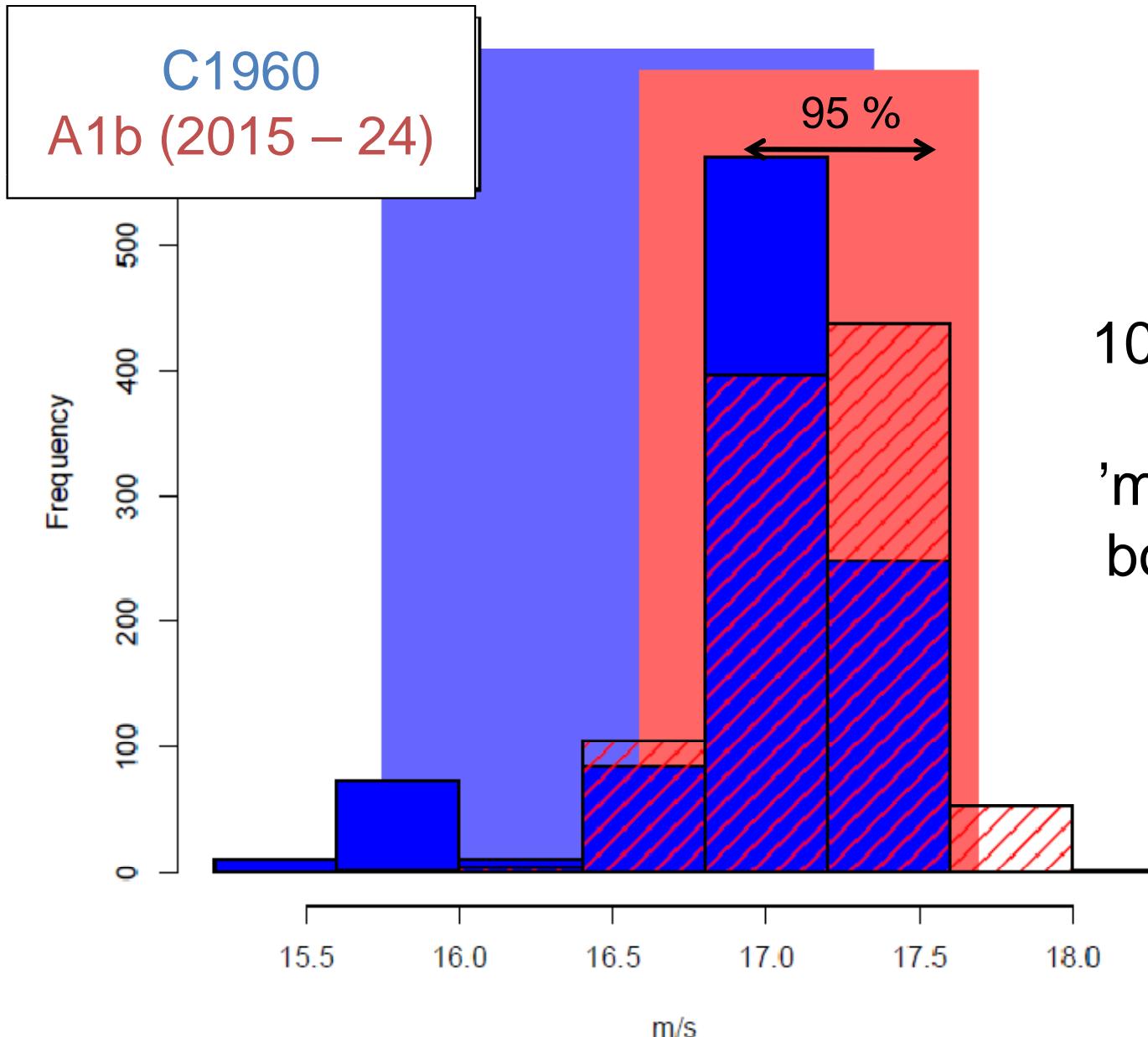
# Extreme value analysis: Changes in 30 yrs return levels

Δ (A1B − C1960)

|		mean	30 yr return value
Temperature at 2m	maximum	+2.1 K	+4.3 K
	mean	+1.77 K	+3.3 K
	minimum	+1.95 K	+2.1 K
Precipitation	accumulation	uncertain	-0.9 mm/h
Wind at 10m	gusts	-0.05 m/s	0.16 m/s
	mean speed	-0.03 m/s	-0.21 m/s
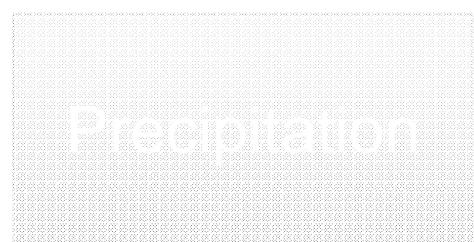
daily

Comparison with measurements

Klimabericht Rheinland-Pfalz (2007)

Mittlere jährliche Niederschlags-höhen 1961-1990 in mm
(Datenquelle: REGNIE-DWD)

400 - 500	901 - 1000
501 - 600	1001 - 1100
601 - 700	1101 - 1200
701 - 800	1201 - 1300
801 - 900	

Niederschlagsmessnetz

● Ombrometerstationen der WWV

Höhe [mNN]

< 100	450 - 500
100 - 150	500 - 550
150 - 200	550 - 600
200 - 250	600 - 650
250 - 300	650 - 700
300 - 350	700 - 750
350 - 400	> 750
400 - 450	
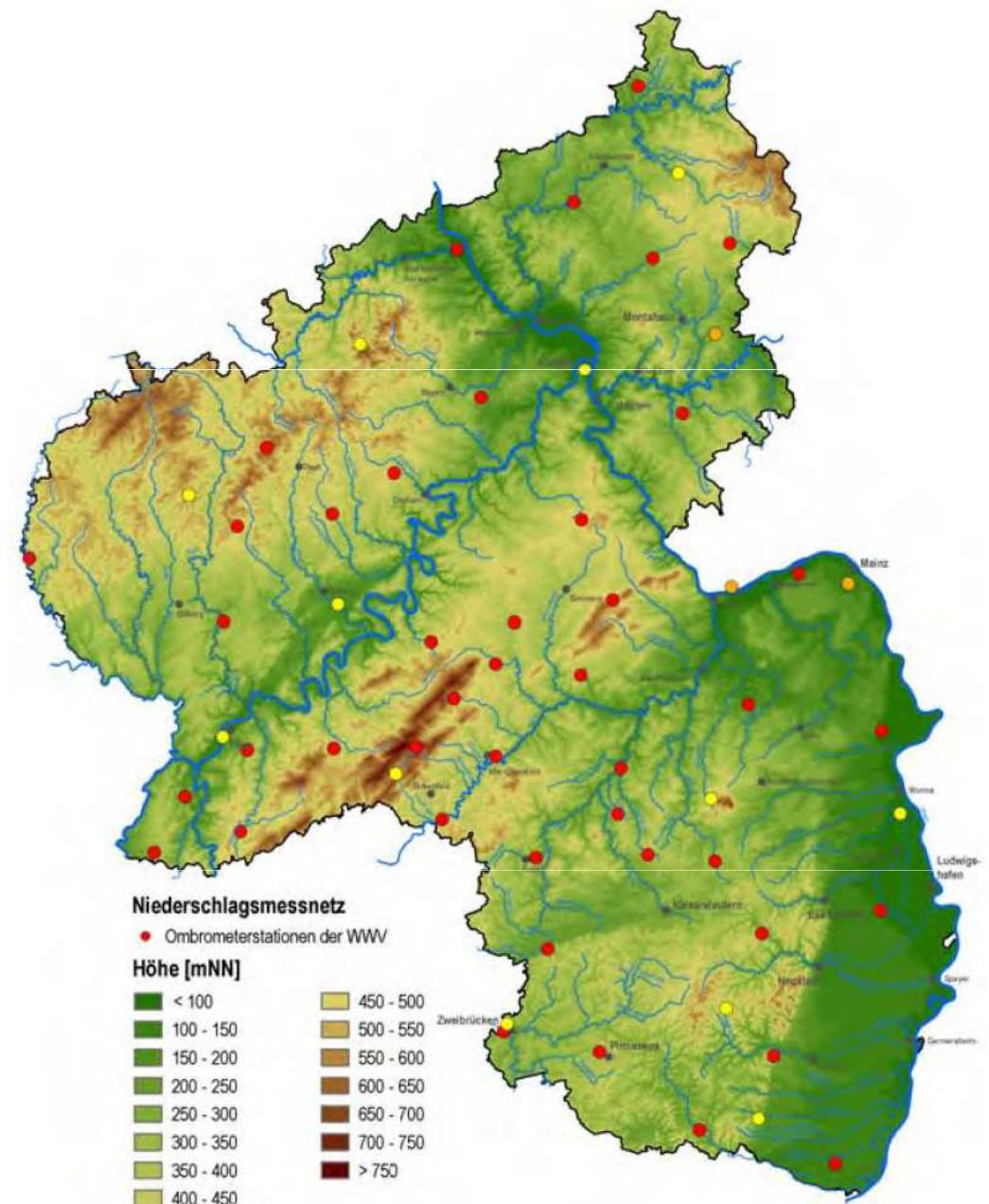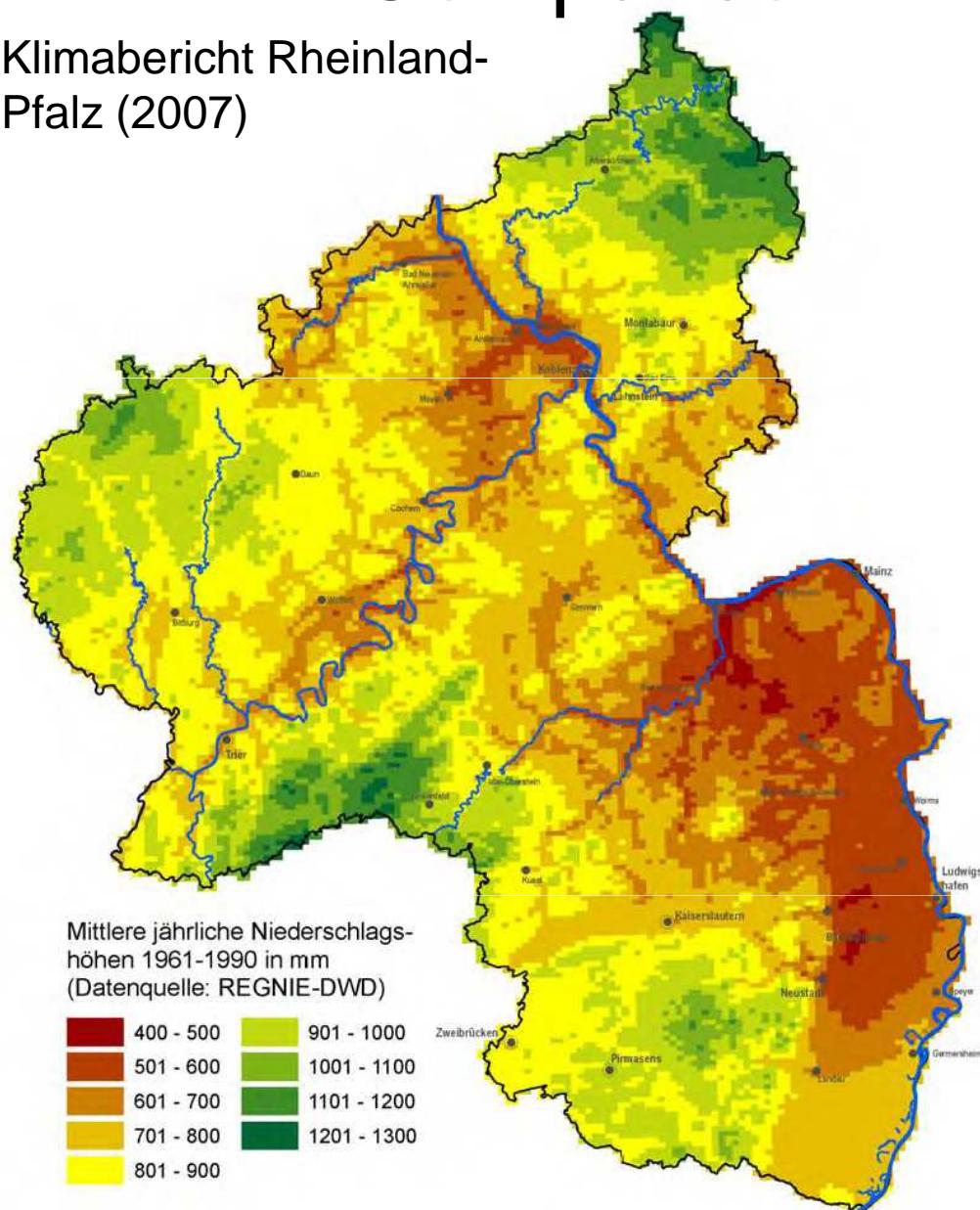
Precipitation and climate stations in Rheinland-Pfalz (Wasserwirtschaftsverwaltung)

Temperature at climate stations 1961-69


climate stations temperature
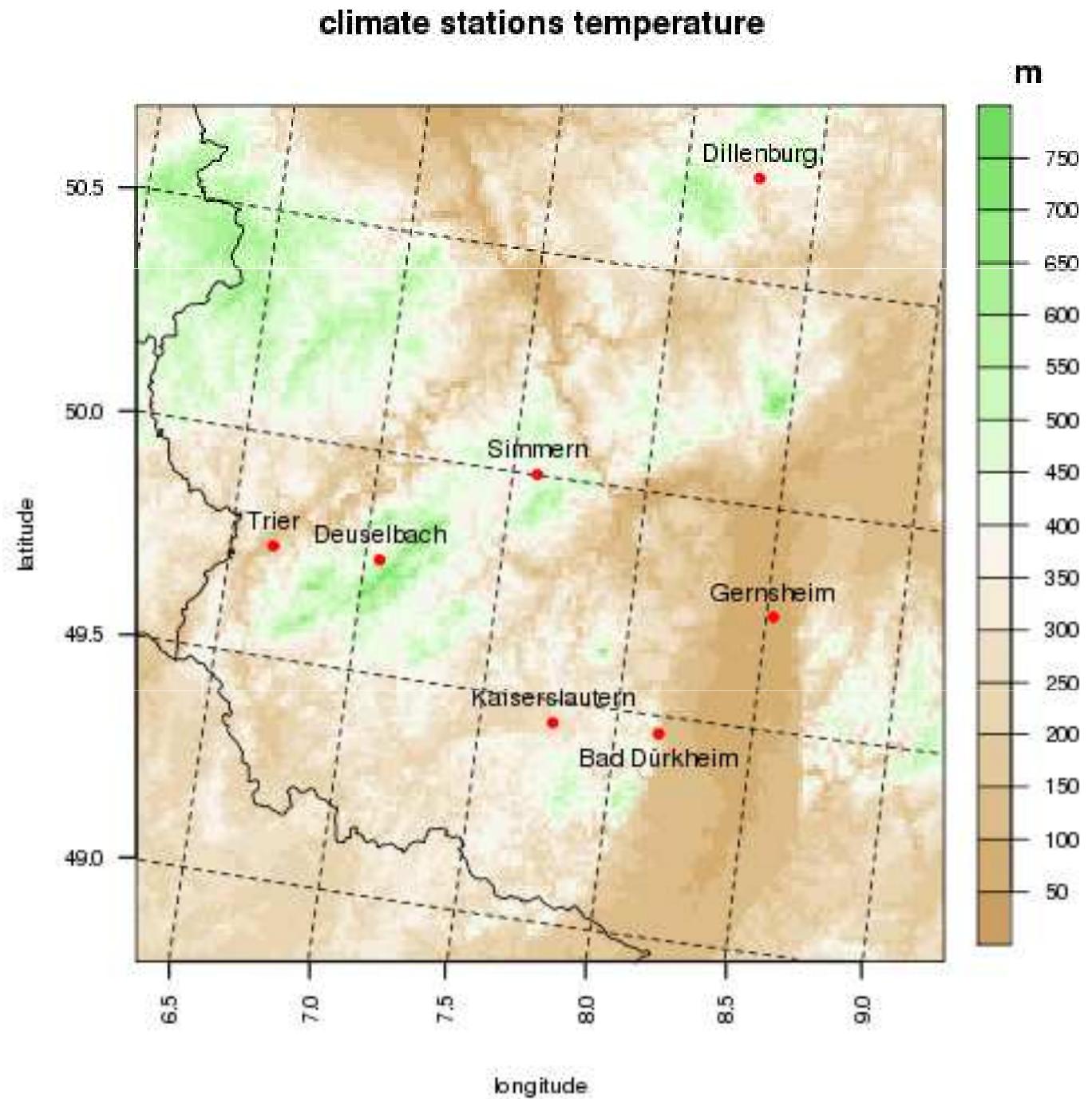
Temperature 1961-69

Mean 2m-temperature June-August 1961 - 1969
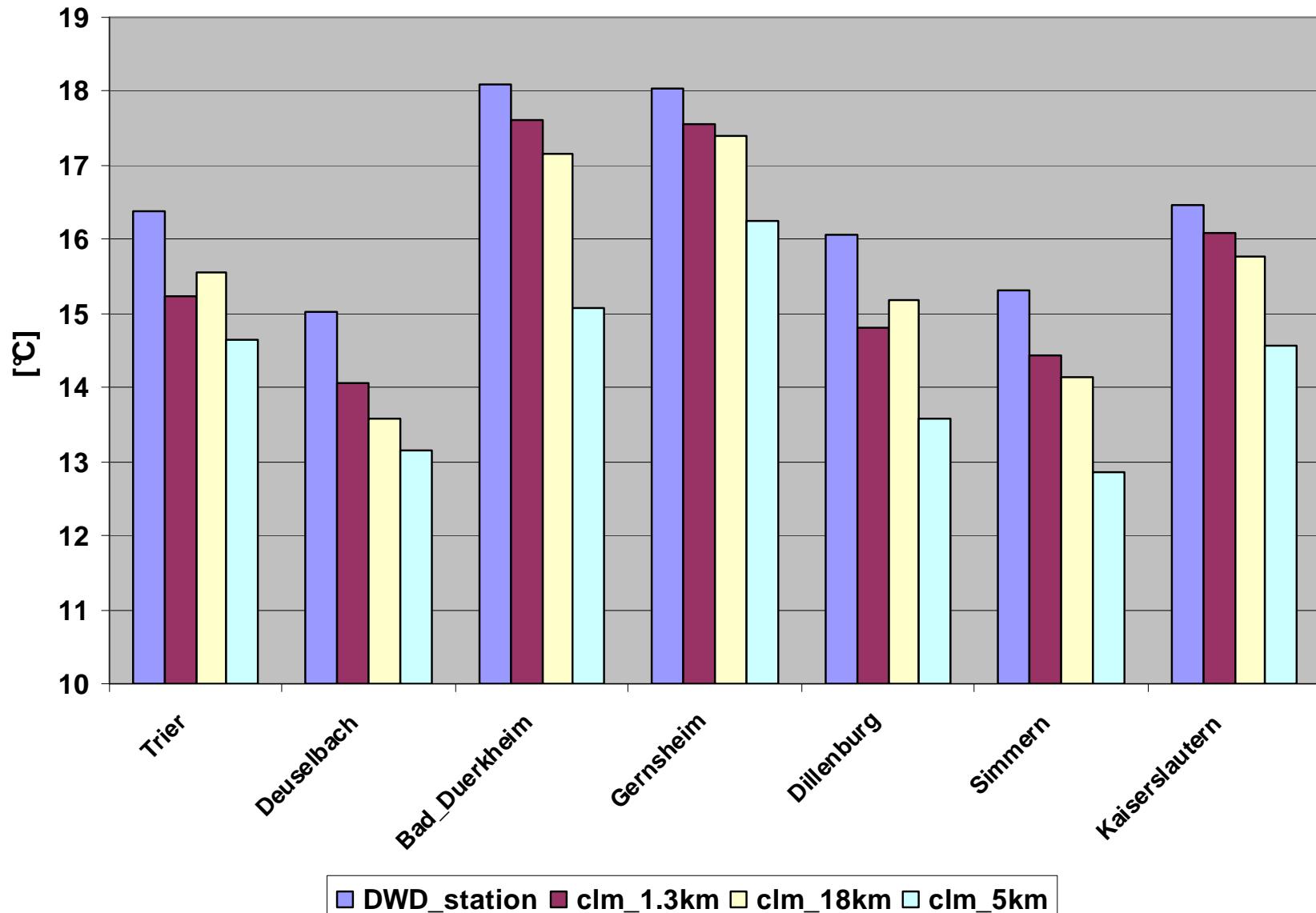
Precipitation 1961-69

Mean sum precipitation June-August 1961 - 1969
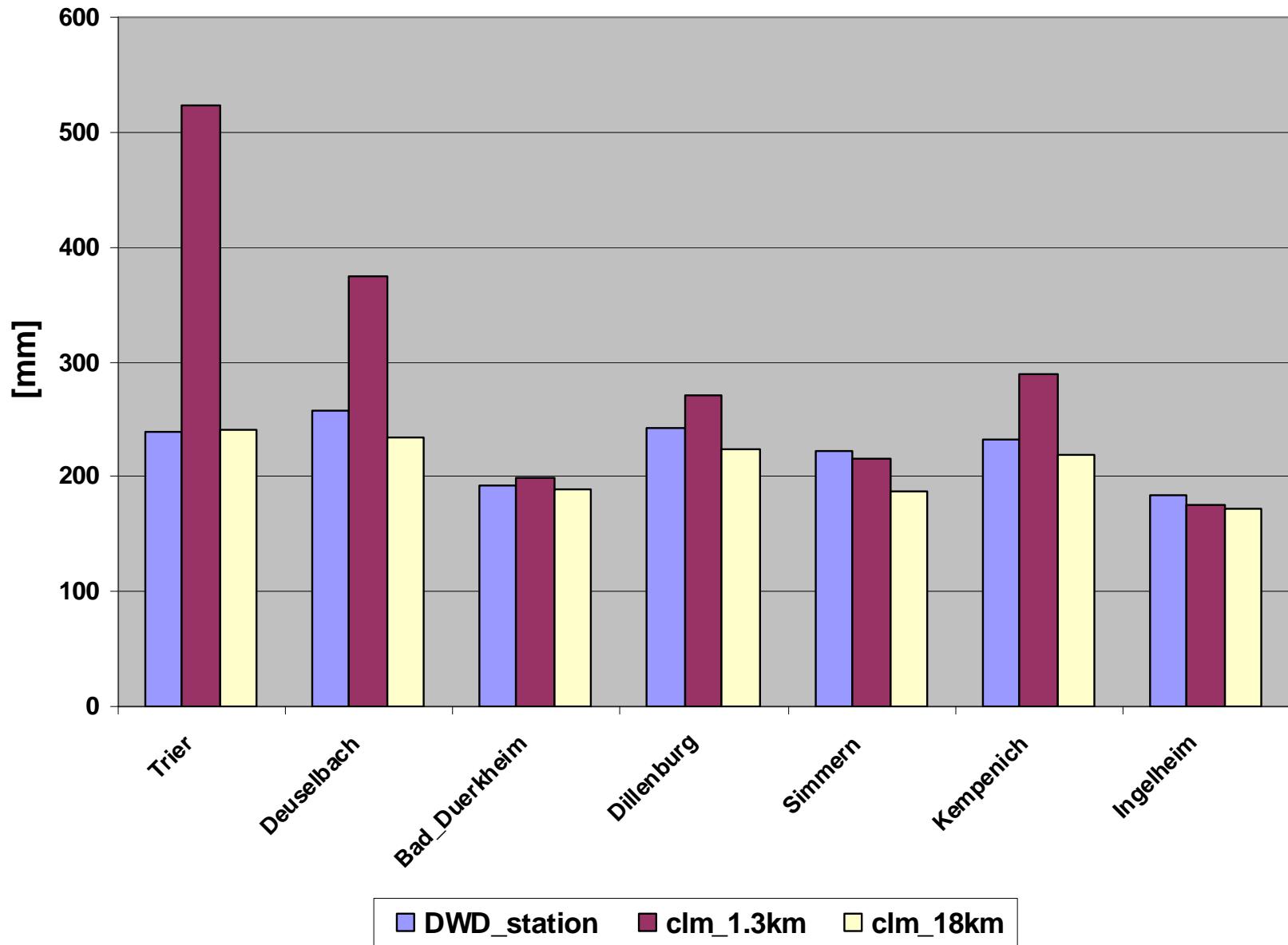
Conclusions

- **Resolution increase** added variability

- **Mean changes** between scenarios **1960 to 2025** in expected range (temperature, wind)

- Increases in **temperature extremes** exceed mean changes, different spatial distribution

- **No change in wind extremes**

- **Change in precipitation extremes uncertain**