

# Anpassung an den Klimawandel: was kommt auf uns zu und wie müssen wir reagieren?

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Climate Service Center Germany – GERICS

**82. Jahrestagung der DPG und DPG-Frühjahrstagung  
6.3.2018 in Erlangen**

# ■ GERICS: science for solutions



Dimensions	Policies/tools
Global	Global goal on adaptation
Regional / Continental	Regional Strategies
National	National Adaptation Plans - Strategies National Communications
Subnational	Cities / Sectoral Adaptation Plans
Local	Adaptation implementation / undertaking / efforts

## GERICS R&D strategy:

- **Networking**
- **Modeling**
- **Prototype development**
- **Capacity building**

→ **service needs science**

- WMO: 2017 bislang wärmste Jahr ohne El Niño, mit bislang noch nie gemessenen Extremen



<https://public.wmo.int/en/media/press-release/2017-set-be-top-three-hottest-years-record-breaking-extreme-weather>

# ■ Beispielhafte Schäden nach Extremereignissen

## Schiene

Dammrutsch und Unterspülung im Raum Wasserburg (Mai 2013)



- Kalkulierte Sanierungskosten für den Dammrutsch von bis zu 700.000 Euro

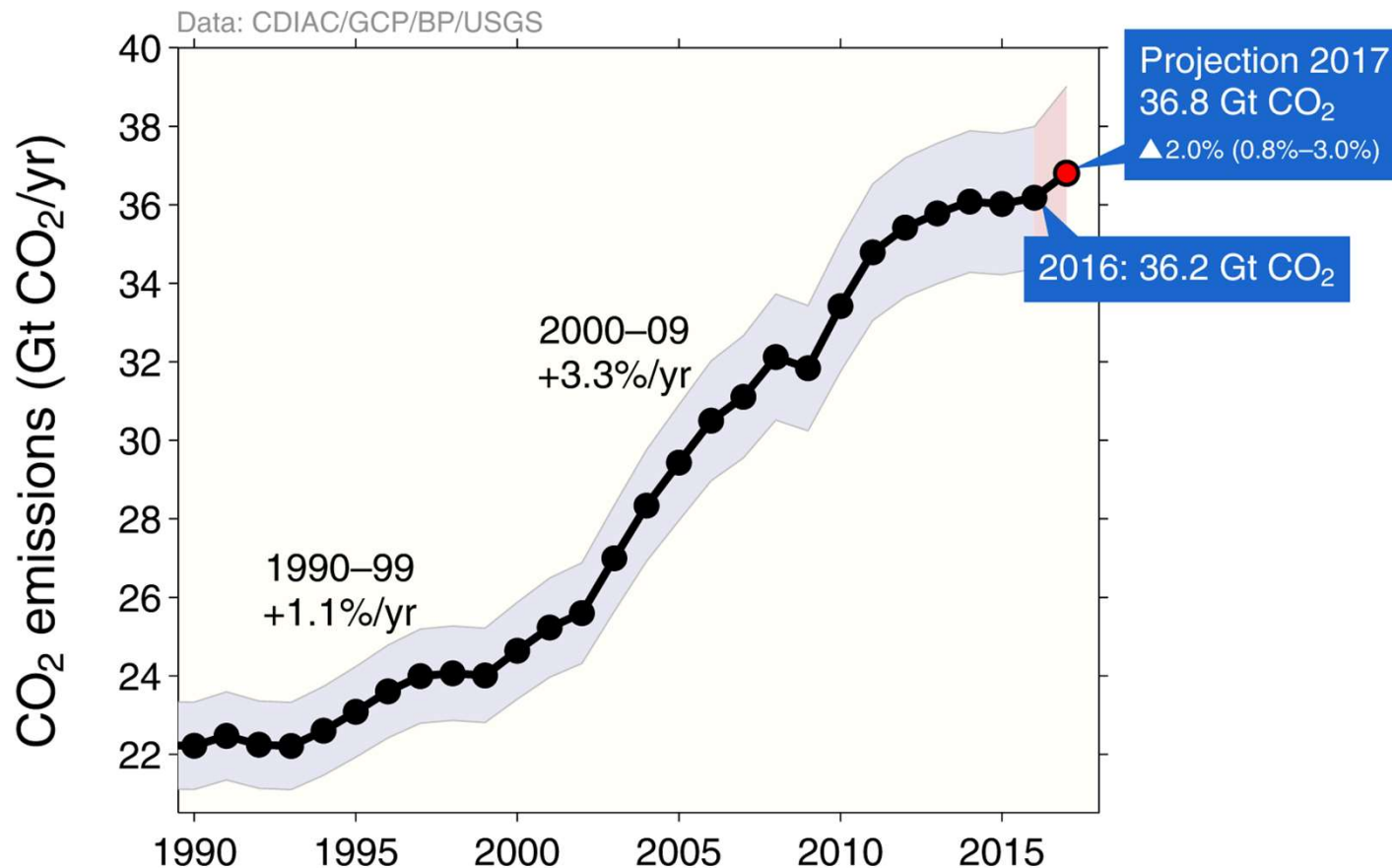
## Straße

Hitzeschäden Fahrbahndecke A93 in Bayern (Juni 2013)

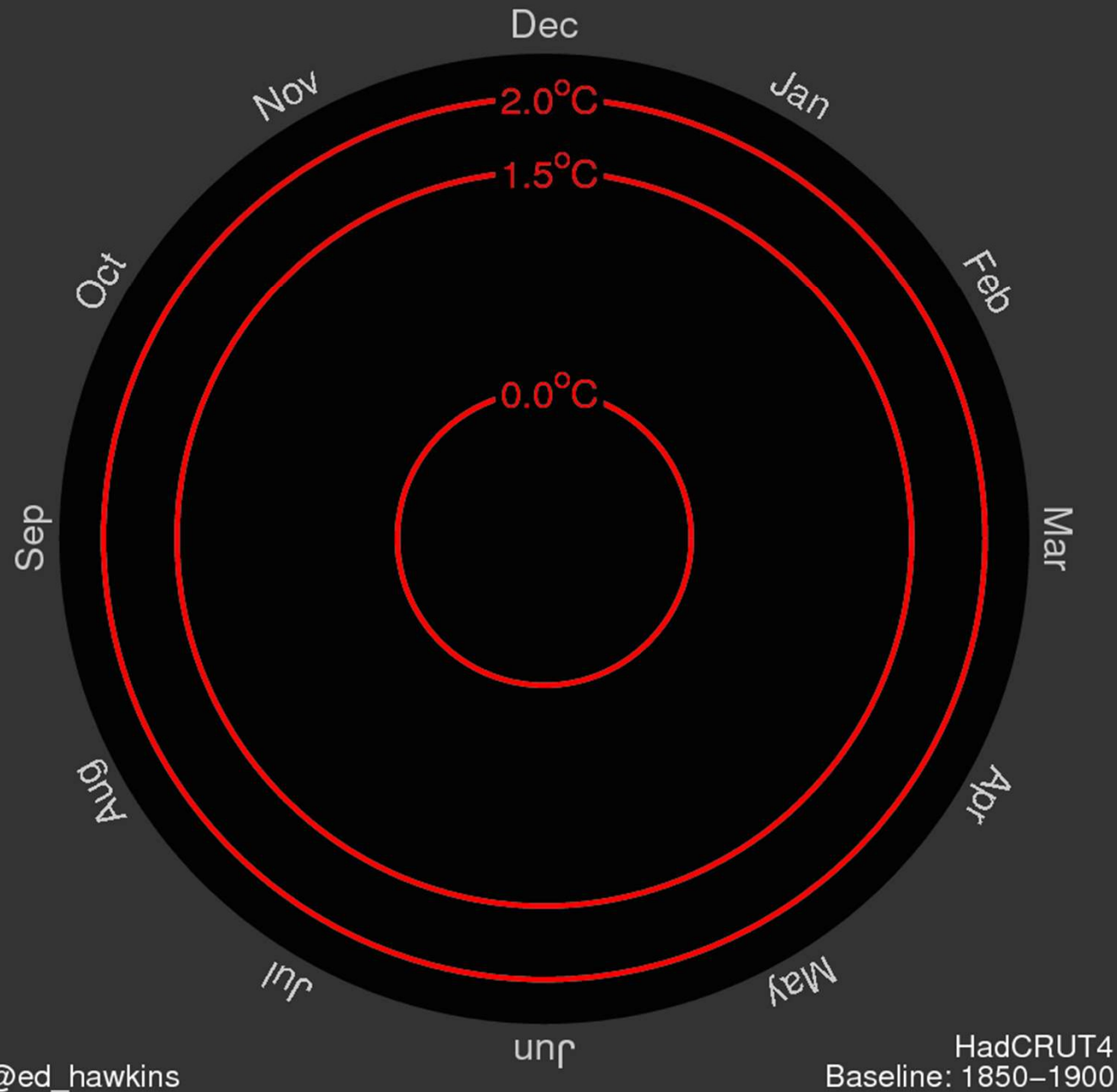


- Motorradunfall mit einem Toten
- Bei ähnlicher Situation im Jahr 2015 wurde das Tempolimit auf 80 km/h reduziert

Wo stehen wir heute?



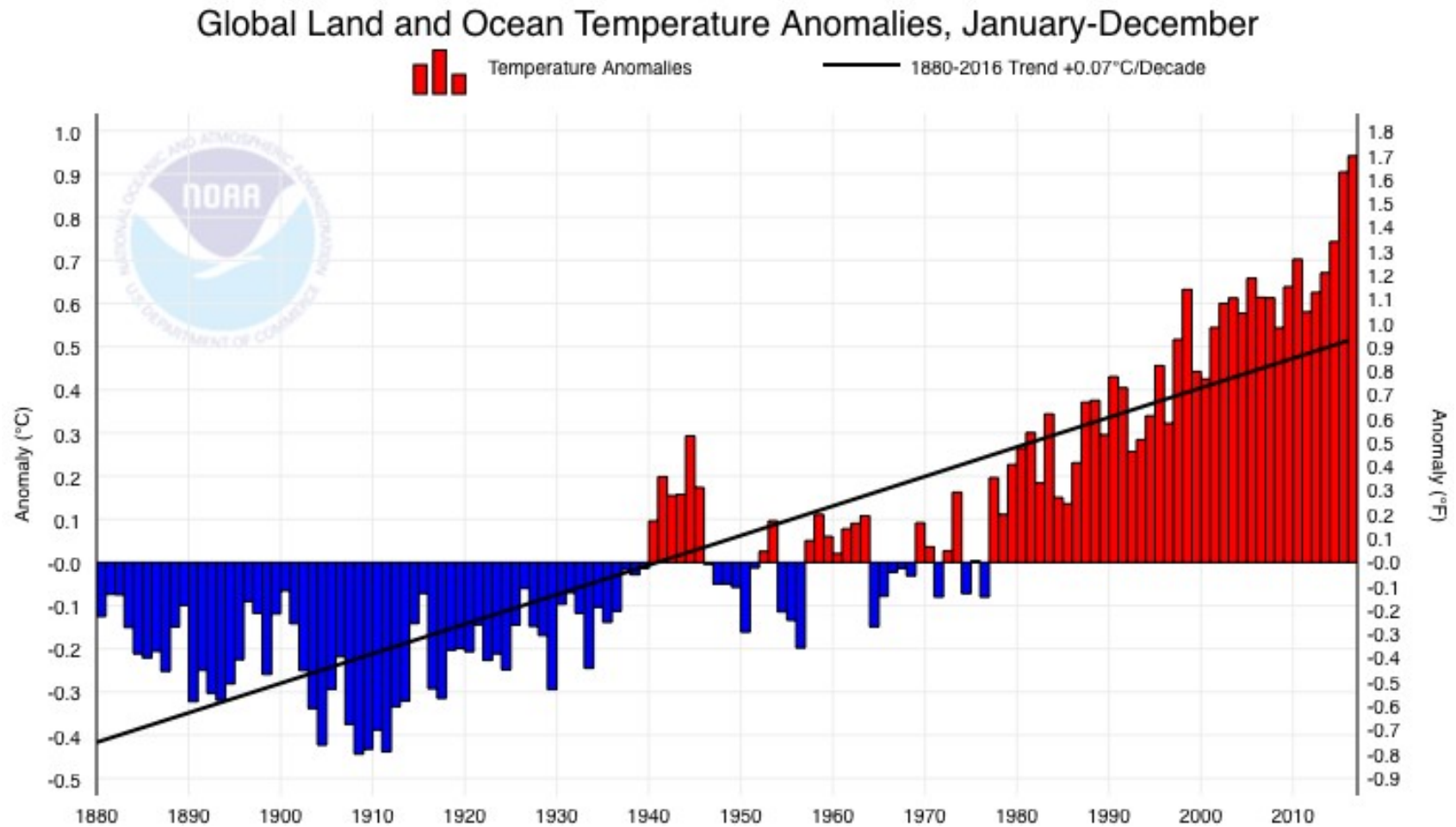
# Global temperature change (1850–2016)



Credits: Ed Hawkins

<https://www.climate-lab-book.ac.uk/spirals/>

# Trend der globalen Mitteltemperatur 1880-2016



*NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published October 2017, <http://www.ncdc.noaa.gov/cag/>*



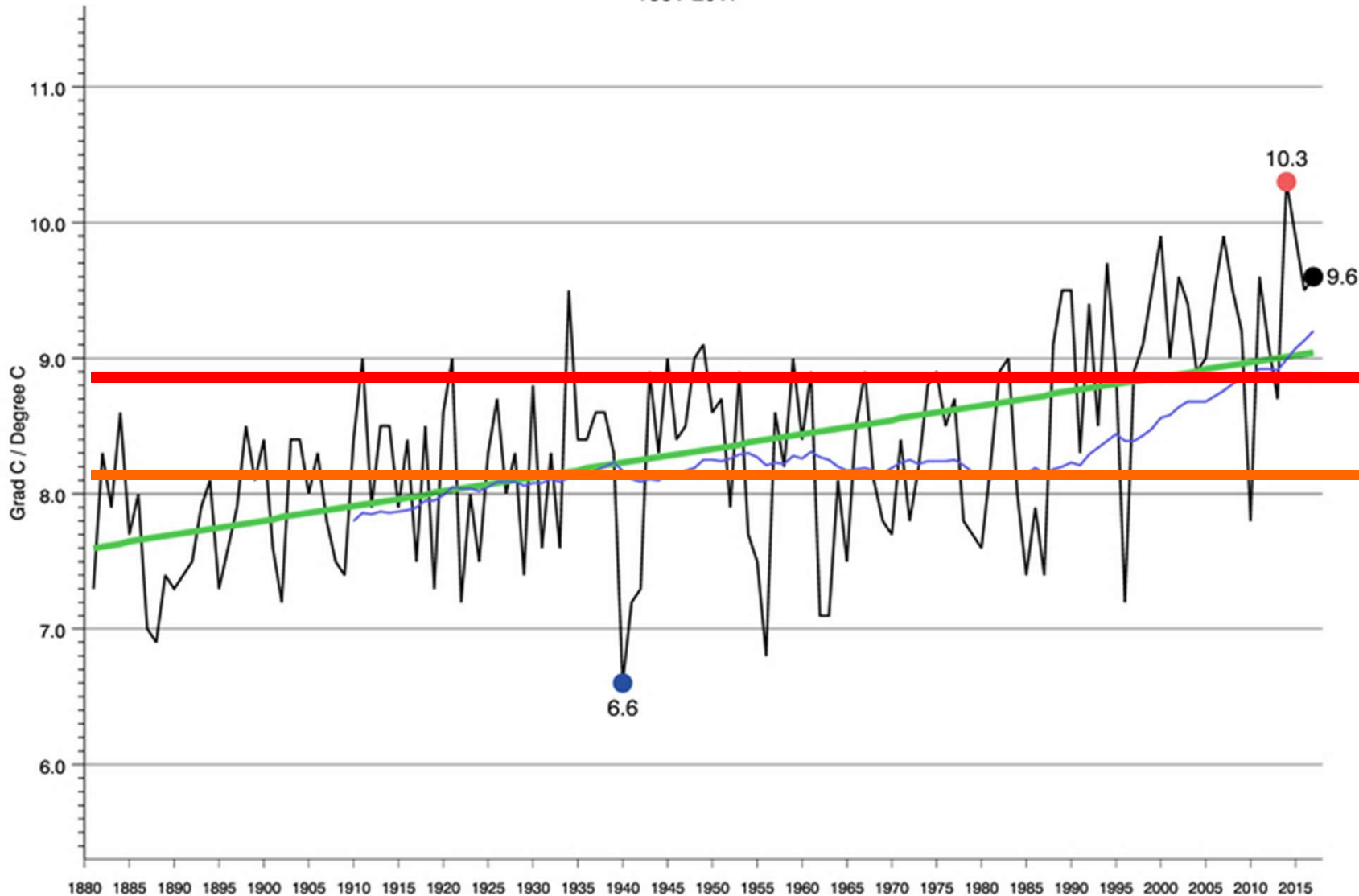
## Die zwölf wärmsten Jahre 1880-2016

YEAR	ANOMALY	RANK
2016	0.94°C	137
2015	0.90°C	136
2014	0.74°C	135
2010	0.70°C	134
2013	0.67°C	133
2005	0.66°C	132
2009	0.64°C	131
1998	0.63°C	130
2012	0.63°C	129
2003	0.61°C	126
2006	0.61°C	128
2007	0.61°C	127

*NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published October 2017, <http://www.ncdc.noaa.gov/cag/>*

# Jahresmitteltemperatur für Deutschland 1881-2017

Mitteltemperaturen Deutschland Jahr  
Mean Temperature Germany Year  
1881-2017



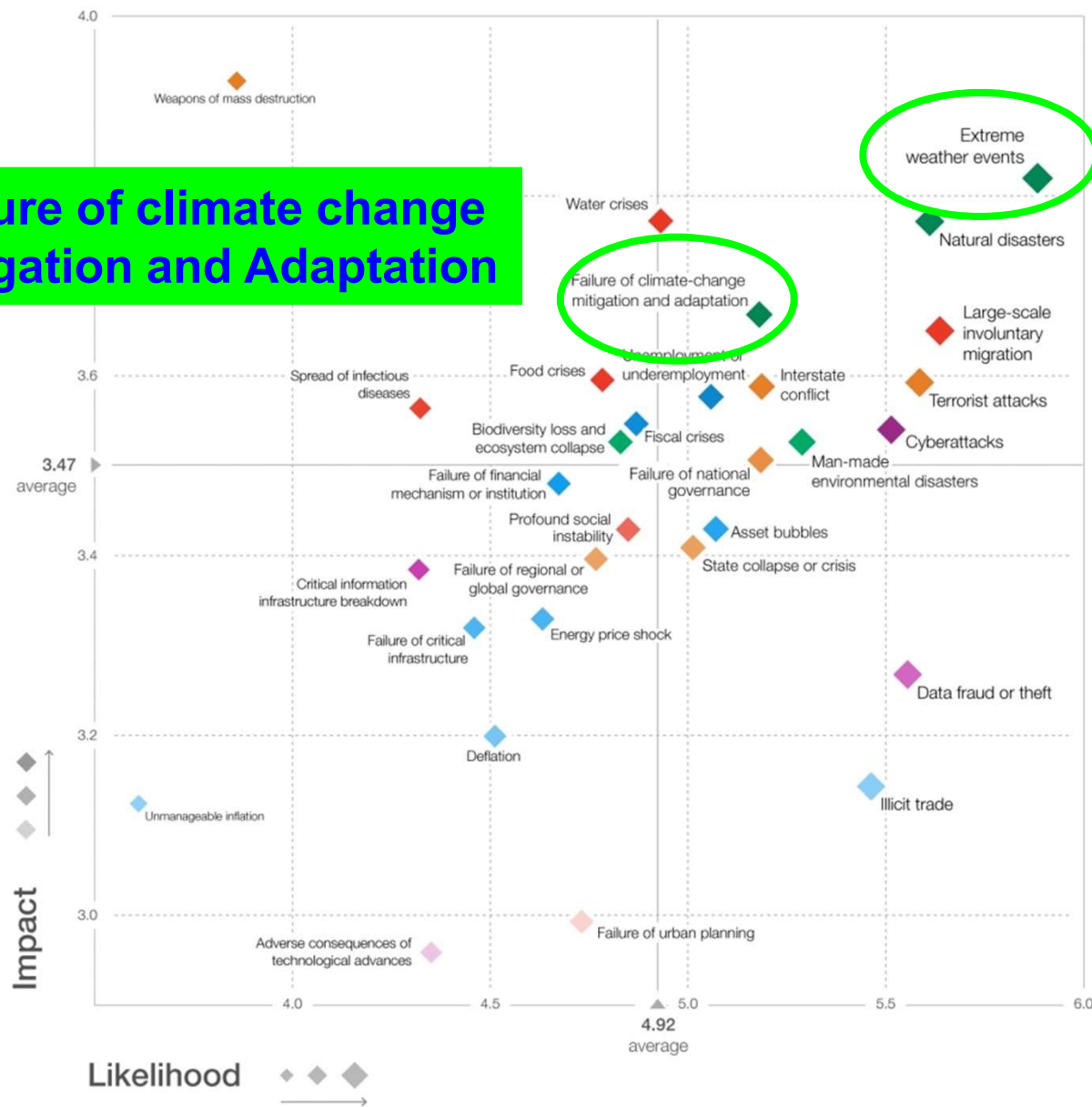
1981-2010  
8,8 ° C

1961-1990  
8,2 ° C

— Einzelwerte / individual values  
— Mittelwert / mean value (1981-2010)

— linearer Trend / linear trend  
— gleitendes 30-jähriges Mittel / sliding 30 year mean

# The Global Risks Report 2017



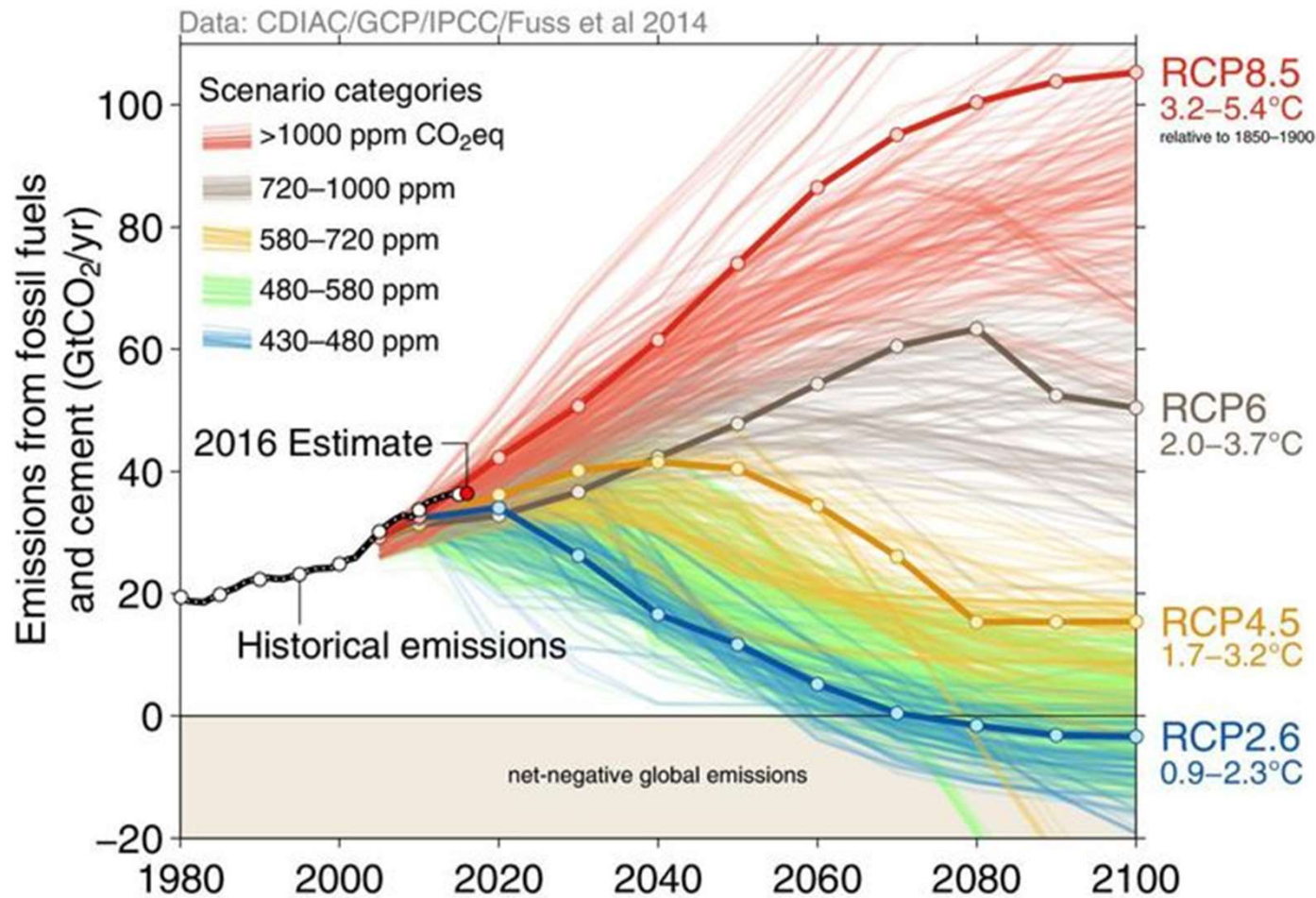
**Extreme Weather Events**

**Failure of climate change Mitigation and Adaptation**

*The Global Risks Report 2017, 12th Edition by the World Economic Forum:  
[http://www3.weforum.org/docs/GRR17\\_Report\\_web.pdf](http://www3.weforum.org/docs/GRR17_Report_web.pdf)*

Was bringt die Zukunft?

# Representative Concentration Pathways RCPs



**RCP8.5**  
**> 1000 ppm CO<sub>2</sub>-eq**

**RCP6.0**  
**720-1000 ppm CO<sub>2</sub>-eq**

**RCP4.5**  
**580-720 ppm CO<sub>2</sub>-eq**

**RCP2.6**  
**430-480 ppm CO<sub>2</sub>-eq**  
Large and sustained mitigation is required

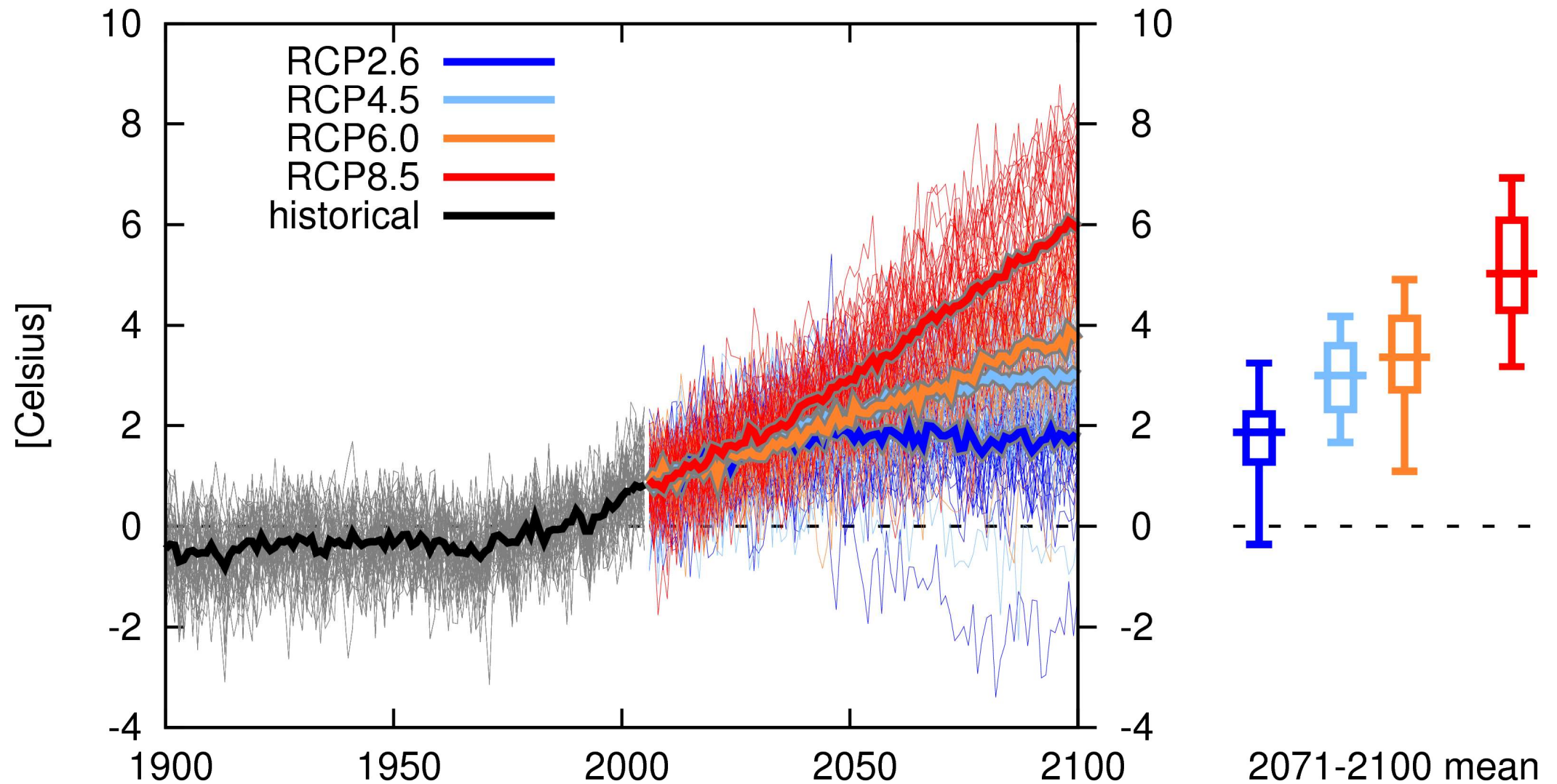
Over 1000 scenarios from the IPCC Fifth Assessment Report are shown

Source: *Global Carbon Budget 2016*, Data: Fuss et al 2014; CDIAC / GCP / IPCC

<http://www.globalcarbonproject.org/carbonbudget/15/presentation.htm>

# ■ CMIP5: Jährliche Temperaturwerte vs. 1971-2000 Europa

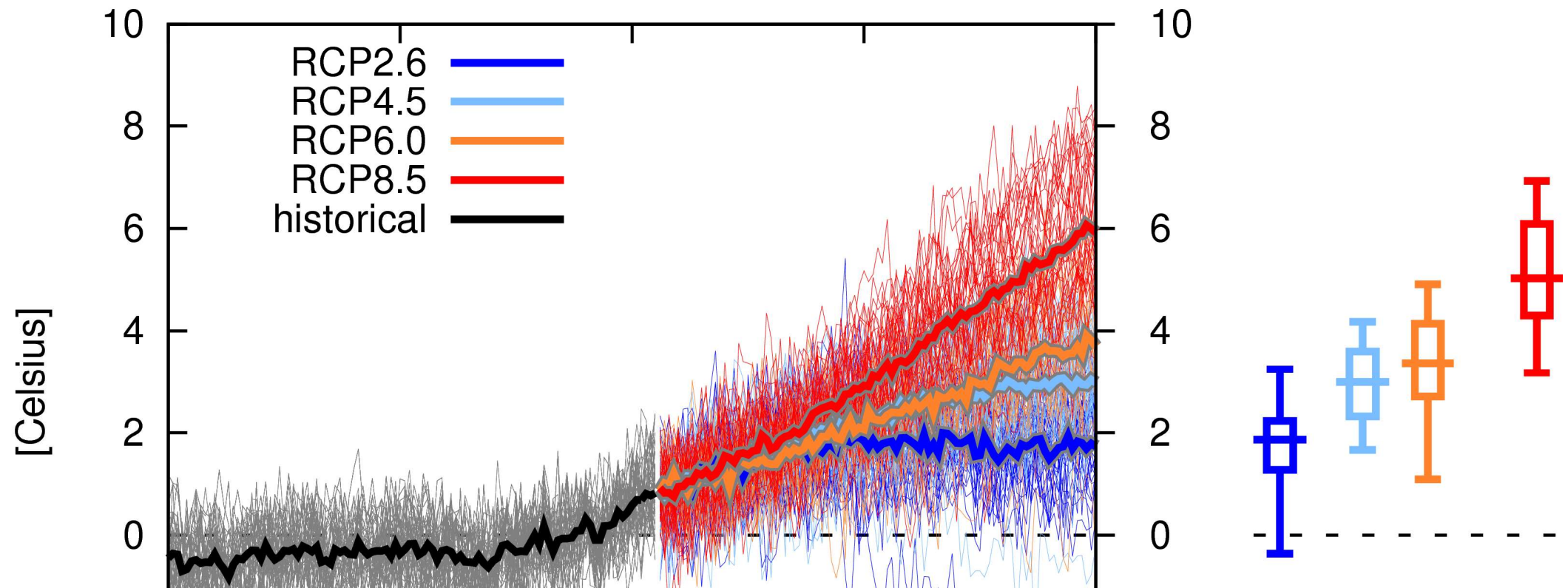
Temperature change Europa Jan-Dec wrt 1971-2000 AR5 CMIP5 subset



Source: KNMI Climate Explorer

# CMIP5: Jährliche Temperaturwerte vs. 1971-2000 Europa

Temperature change Europa Jan-Dec wrt 1971-2000 AR5 CMIP5 subset



CMIP5 data available via **Earth System Grid Federation ESGF**:

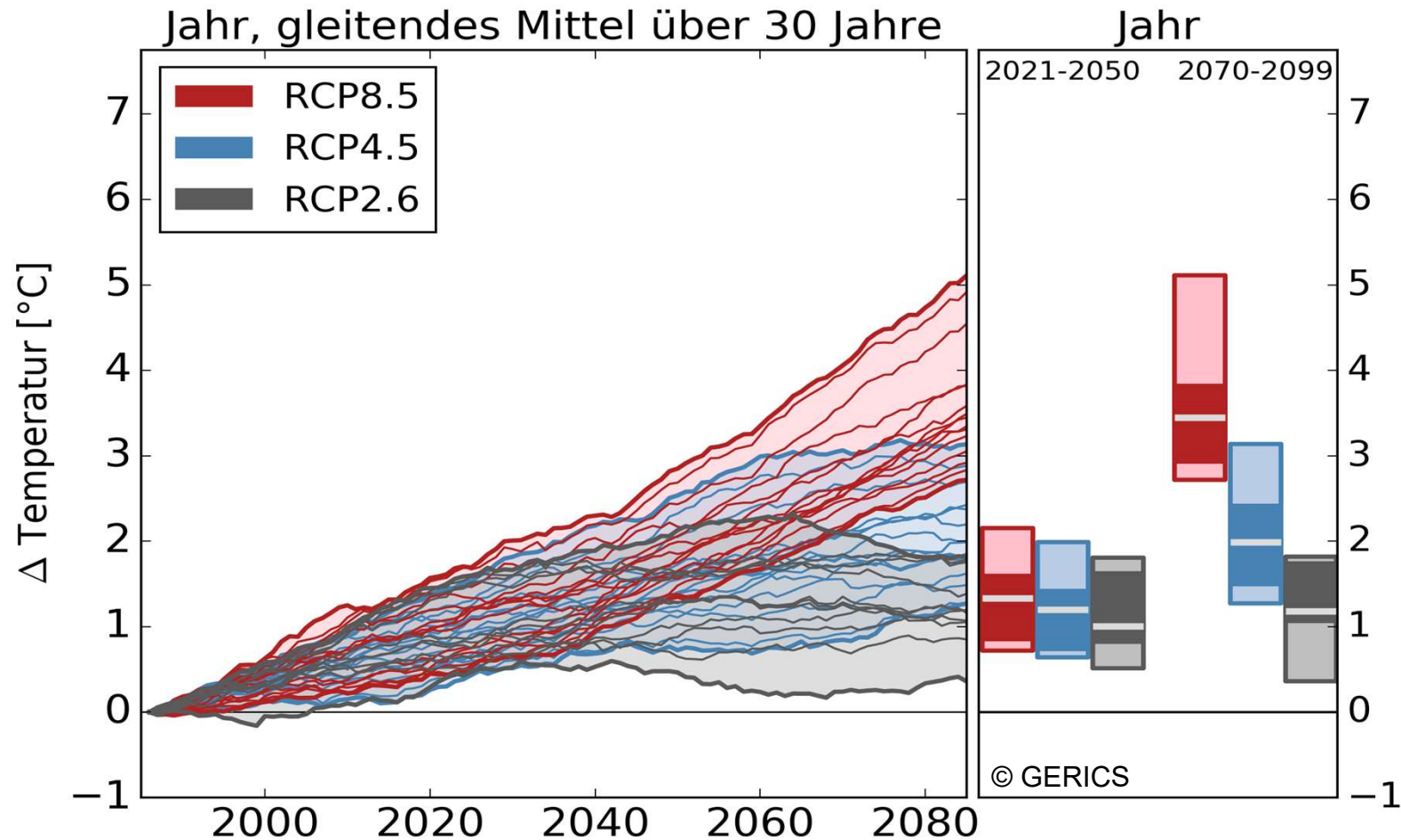
<http://esgf-data.dkrz.de/esgf-web-fe/>

Monthly values can easily be accessed by **KNMI climate change atlas**:

[http://climexp.knmi.nl/plot\\_atlas\\_form.py](http://climexp.knmi.nl/plot_atlas_form.py)

# Projizierte Änderungen der Jahresmitteltemperatur Fortlaufendes 30-Jahresmittel 1971-2099 vs. 1971-2000

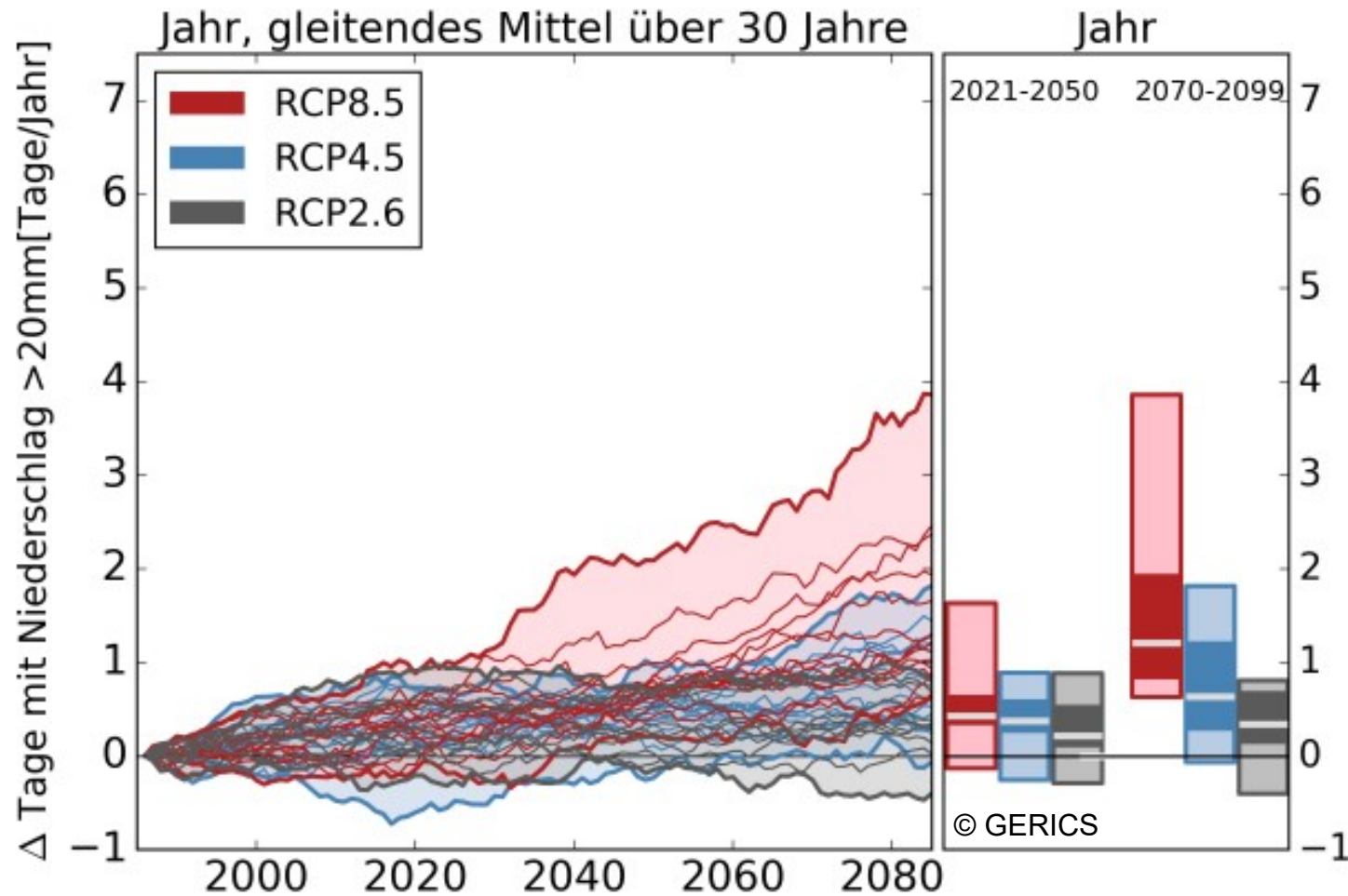
## Deutschland





# Projizierte Änderungen der Tage mit Niederschlag > 20 mm Fortlaufendes 30-Jahresmittel 1971-2099 vs. 1971-2000

## Deutschland



# ■ EURO-CORDEX

## Creating a multi-scenario & multi GCM/RCM ensemble

### Region:

- ▶  $\sim 27^\circ \text{ N} - 72^\circ \text{ N}, \sim 22^\circ \text{ W} - 45^\circ \text{ E}$

### Horizontal resolutions:

- ▶ EUR-44:  $0.44^\circ$  (50km)
- ▶ **EUR-11:  $0.11^\circ$  (12.5 km)**

### Time periods:

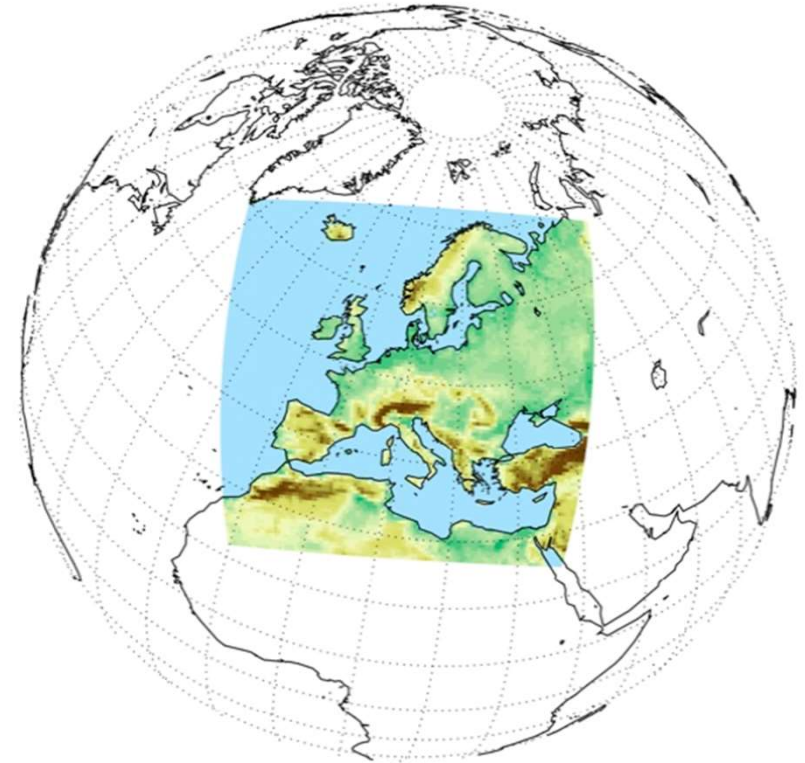
- ▶ Historical runs: 1951 – 2005
- ▶ Projections: 2006 – 2100

### Boundary forcing:

- ▶ CMIP5

### External forcing:

- ▶ RCP 4.5, RCP 8.5 (focus)
- ▶ RCP 2.6



- Leading institutions in the field of regional climate modeling in Europe
- Voluntary effort, contributions are funded by the contributors

*30 modelling groups in Europe*  
**10 RCMs in combination with 12 GCMs**

# Regionale Klimaprojektionen Ensembles - De

Funded by:



## Extending the EURO-CORDEX ensemble



UNIVERSITÄT HOHENHEIM



POTSDAM-INSTITUT FÜR KLIMAFOLGENFORSCHUNG



Provides **consistent and user-tailored information** on climate change.

Generated the **largest database of high resolution regional climate model data** for Germany, using dynamical and statistical downscaling.

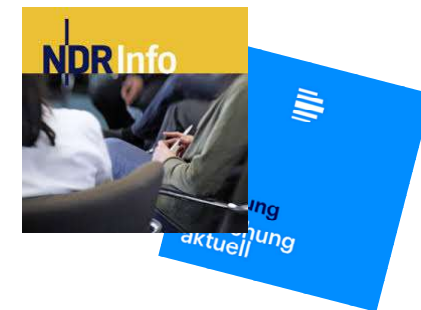
**Public access** to data, climate change indices, manuals, graphics, and more.

Forms the **scientific basis** for the **new German adaptation strategies**.

Presented in the media in December 2017.



<http://reklies.hlnug.de>



DER TAGESSPIEGEL



# EURO-CORDEX simulations (May 2017)



GCM / RCM RCP	CCLM	REMO	WRF	WR'13	STARS	RCA4	RACMO	HIRHAM5
EC-EARTH RCP2.6	EURO CORDEX					EURO CORDEX	EURO CORDEX	EURO CORDEX
HADGEM2-ES RCP2.6						EURO CORDEX	EURO CORDEX	
MPI-ESM-LR RCP2.6		EURO CORDEX				EURO CORDEX		
MPI-ESM-LR RCP8.5	EURO CORDEX	EURO CORDEX	EURO CORDEX			EURO CORDEX		
CNRM-CM5 RCP8.5	EURO CORDEX					EURO CORDEX		
HADGEM2-ES RCP8.5	EURO CORDEX					EURO CORDEX	EURO CORDEX	
EC-EARTH RCP8.5	EURO CORDEX					EURO CORDEX	EURO CORDEX	EURO CORDEX
Can-ESM RCP8.5								
MIROC5 RCP8.5								
IPSL-INERIS RCP8.5			EURO CORDEX			EURO CORDEX		

**Simulations**  
RCP2.6 = 9  
RCP8.5 = 16

# EURO-CORDEX simulations (May 2017) + ReKliEs-De



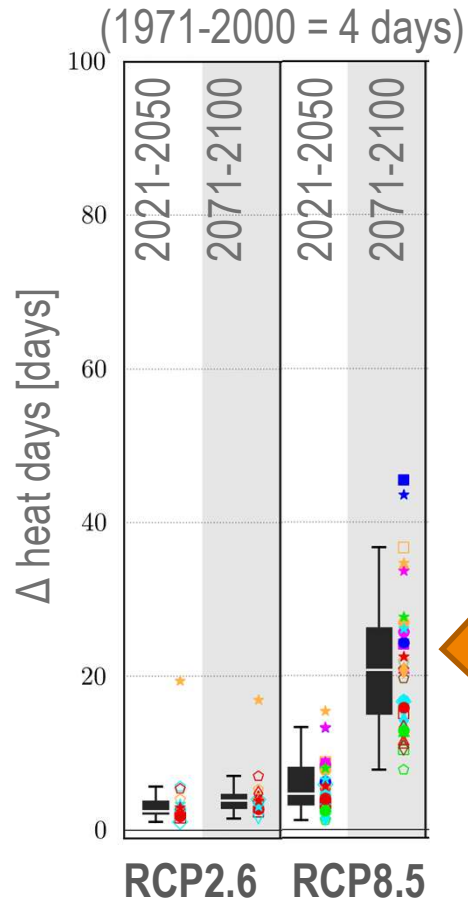
GCM / RCM RCP	CCLM	REMO	WRF	WR'13	STARS	RCA4	RACMO	HIRHAM5
EC-EARTH RCP2.6	EURO CORDEX					EURO CORDEX	EURO CORDEX	EURO CORDEX
HADGEM2-ES RCP2.6						EURO CORDEX	EURO CORDEX	
MPI-ESM-LR RCP2.6		EURO CORDEX				EURO CORDEX		
MPI-ESM-LR RCP8.5	EURO CORDEX	EURO CORDEX	EURO CORDEX			EURO CORDEX		
CNRM-CM5 RCP8.5	EURO CORDEX					EURO CORDEX		
HADGEM2-ES RCP8.5	EURO CORDEX					EURO CORDEX	EURO CORDEX	
EC-EARTH RCP8.5	EURO CORDEX					EURO CORDEX	EURO CORDEX	EURO CORDEX
Can-ESM RCP8.5								
MIROC5 RCP8.5								
IPSL-INERIS RCP8.5			EURO CORDEX			EURO CORDEX		



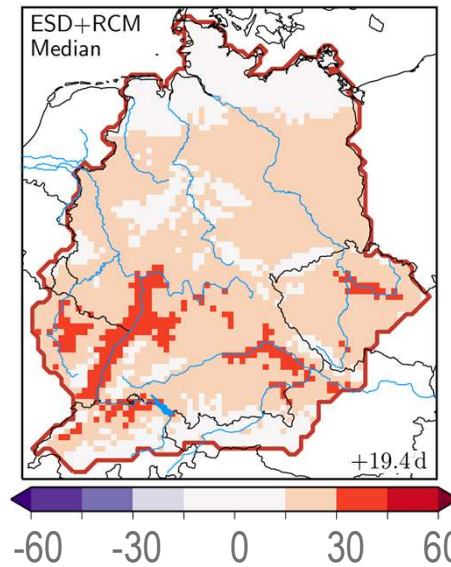
**Simulations**  
**RCP2.6 = 9 + 6**  
**RCP8.5 = 16 + 21**

# Number of heat days

**Tmax ≥ 30 °C**



Median Δ (2071-2100) RCP8.5

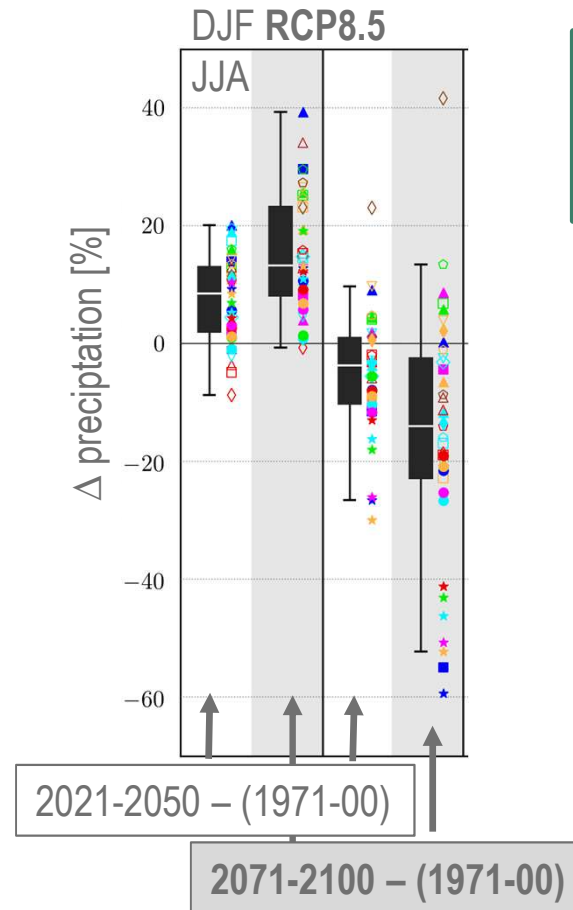
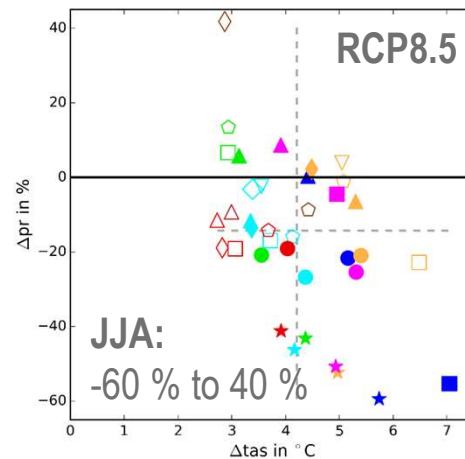
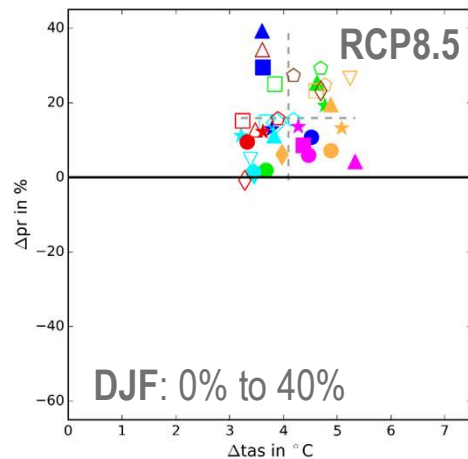
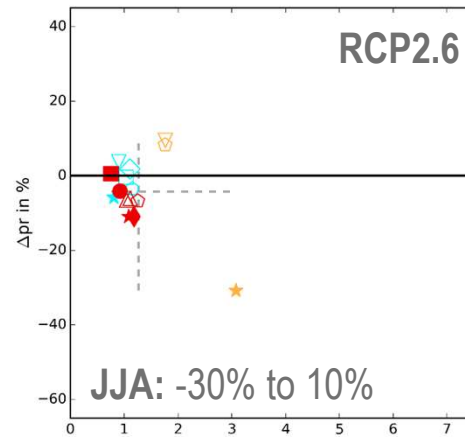
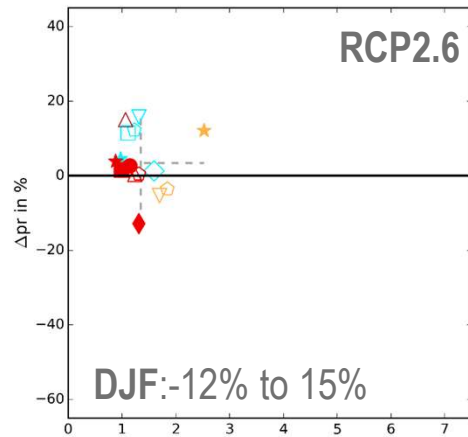


- CA2
- CN5
- ECE
- HG2
- IP5
- MI5
- MPI
- CLM
- CLM
- CLM
- CLM
- ◇ HIR
- ▽ RAC
- ▽ RAC
- ◇ RCA
- ◇ RCA
- △ REM
- △ REM
- △ REM
- △ REM
- △ REM
- ★ ST3
- ★ ST3
- ★ ST3
- ★ ST3
- ★ ST3
- ★ ST3
- ★ ST3
- W13
- W13
- W13
- W13
- W13
- W13
- W13
- ◇ WRF
- ◇ WRF
- ◇ WRF
- ◇ WRF
- ◇ WRF

Change 2071-2100	Climate Variable	RCP 2.6	RCP 8.5
↑	Annual mean temperature (°C)	1.2	4
↑	Number of heat days (Tmax ≥ 30°C)	4	19



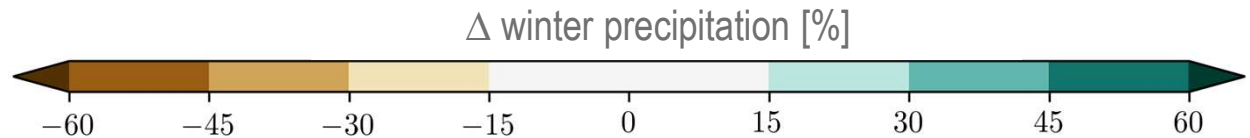
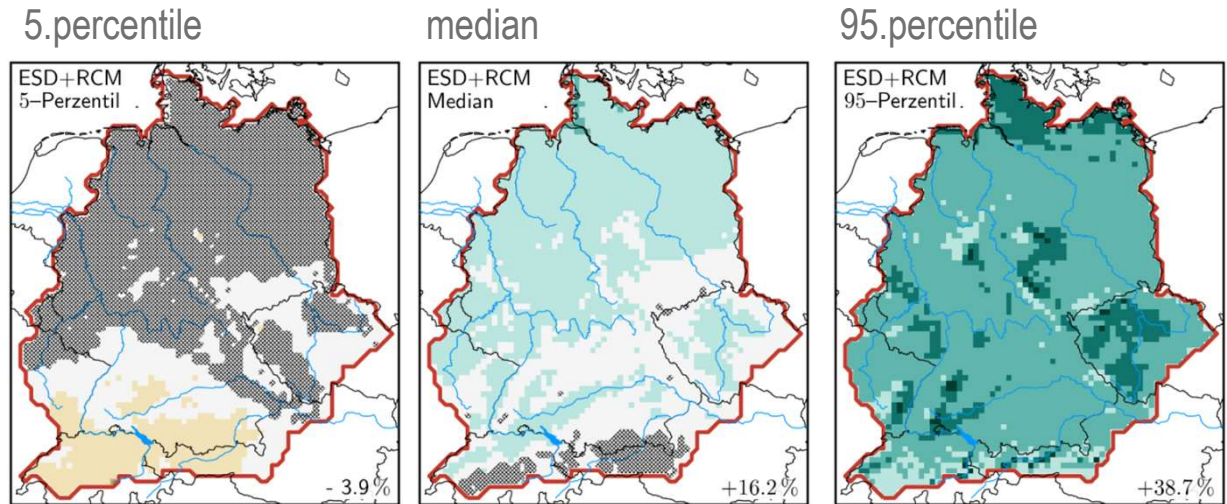
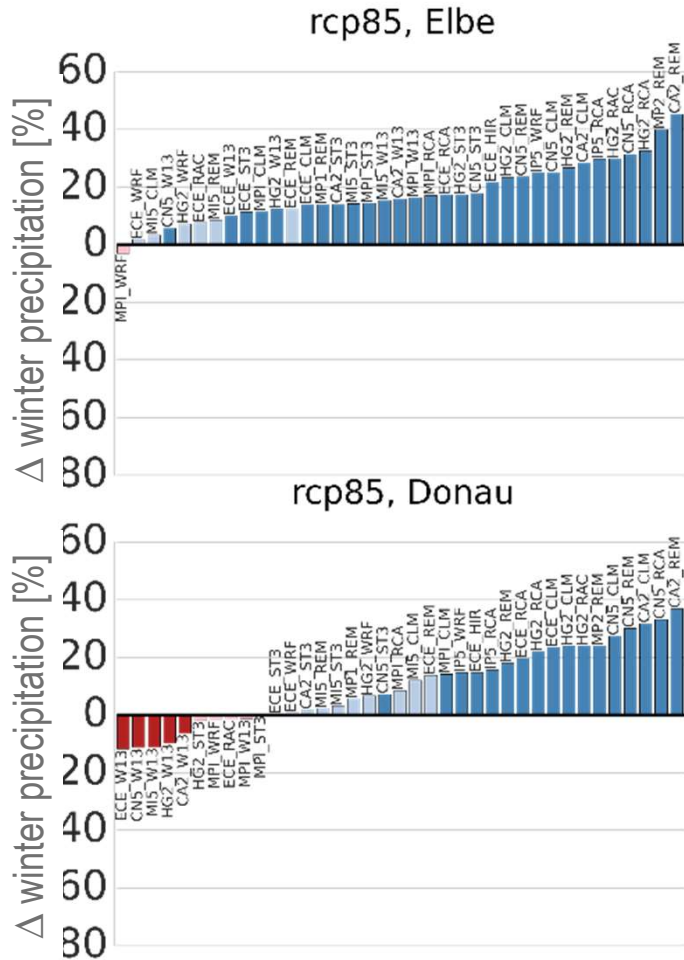
# Seasonal precipitation change [%] (2071 - 2100) - (1971 - 2000)



mean 1971-2000:  
pr DJF= 225 mm  
pr JJA = 258 mm

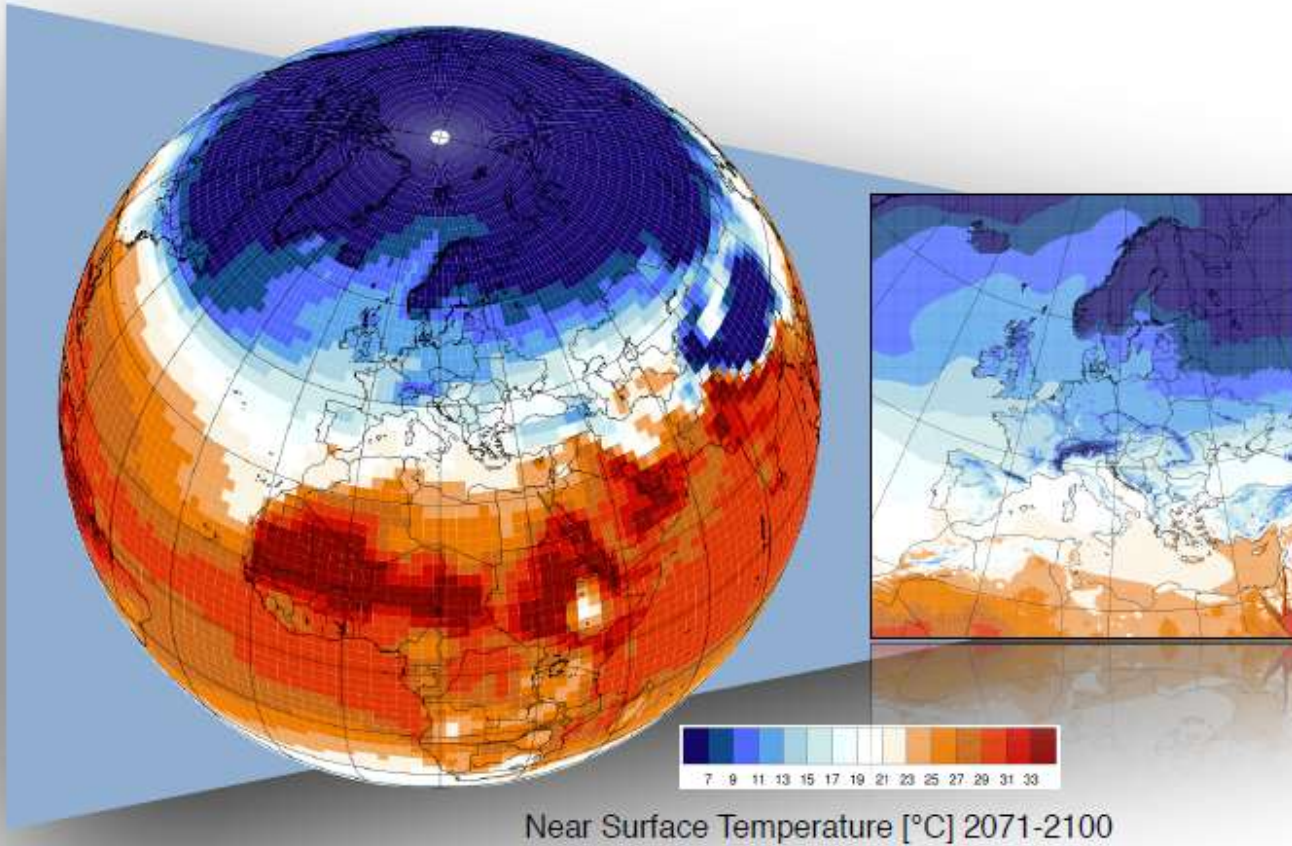
# Winter precipitation change [%] (2071 - 2100) - (1971 - 2000)

mean 1971-2000: pr DJF= 225 mm



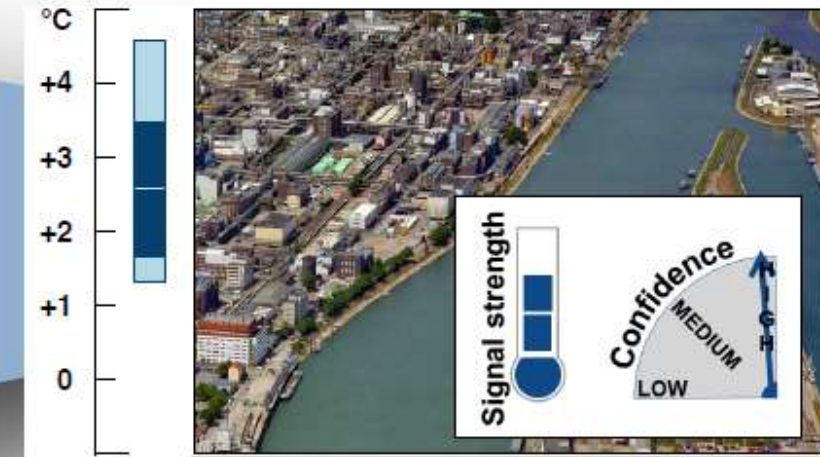


# Klimainformation von global bis lokal



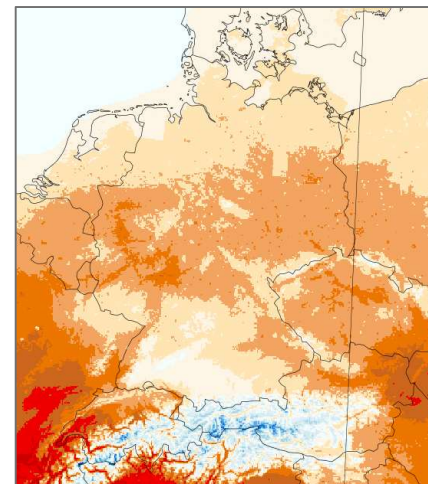
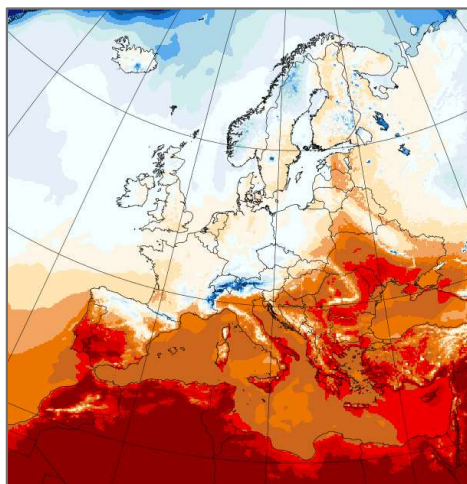
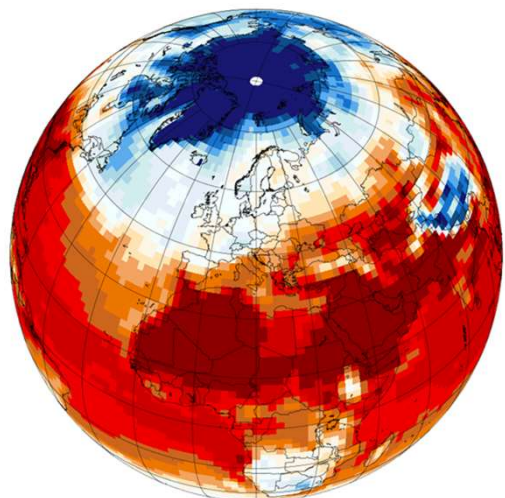
**Global Simulations**  
~ 200 km resolution

**Regional Simulations**  
~12 km resolution

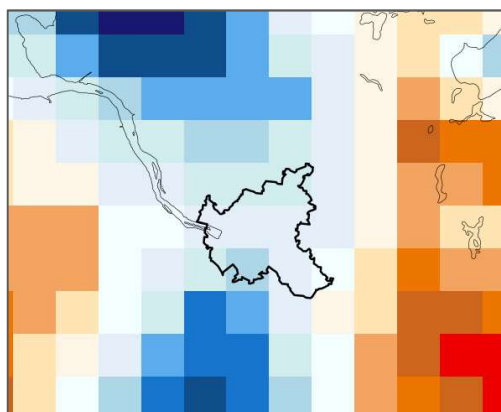


**BASF production site Ludwigshafen**  
Site-specific climate analysis

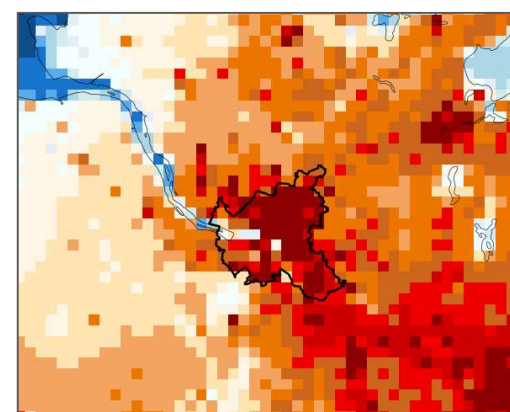
# Grid Representation of Local Temperature (July 2, 1995)



~150 km



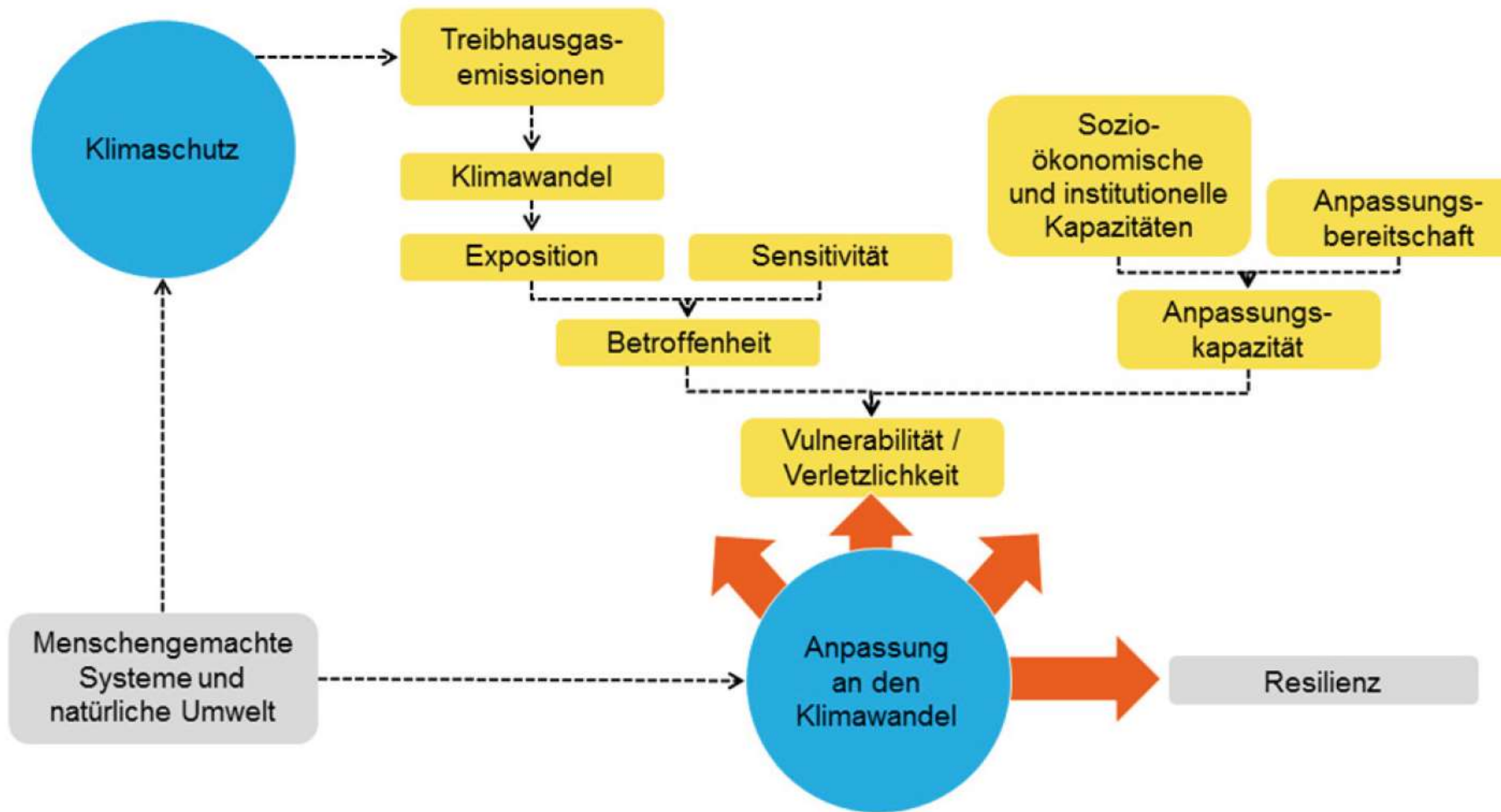
~12.5 km



~3 km

Wie kommen Klimainformationen in die Praxis?

# Konzept Klimawandel, Vulnerabilität und Anpassung



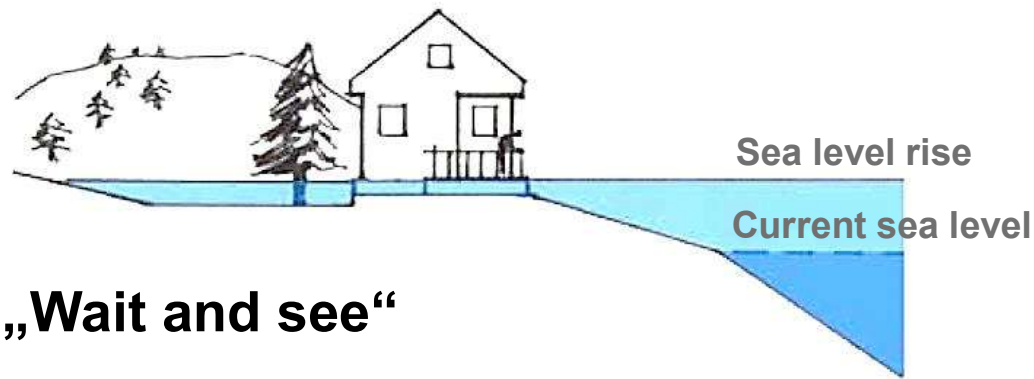
**Quelle:** EEA Report, N 4/2008, Ch.6. Adaptation to climate change; Figure from Isoard, Grothmann and Zebisch (2008).  
Übersetzt und angepasst in: Groth, M. und Nuzum, A.-K. (2016): Informations- und Unterstützungsbedarf von Kommunen zur Anpassung an die Folgen des Klimawandels. GERICS-Report 25. Hamburg.

# Anpassungsstrategien



**KLIMZUG-NORD**

Strategische Anpassungsansätze  
zum Klimawandel in der Metropolregion Hamburg



**„Wait and see“**



**„Absicherung“**



**„Anpassung“**



**„Zurückweichen“**

Quelle: KLIMZUG-Nord

# Extremereignisse: eine der Herausforderungen für Städte

**CO<sub>2</sub> Emissionen**  
(global 25% der  
direkten THG-Emissionen)



**Folgen des  
Klimawandels  
(Extremereignisse)**

**Energiebedarf**



**Abfall/  
Abwasser**



**Demographischer  
Wandel**



**Grundwasser-  
einzugsgebiete**



**Wachsende/  
Schrumpfende Städte**



**Kritische Infrastruktur**

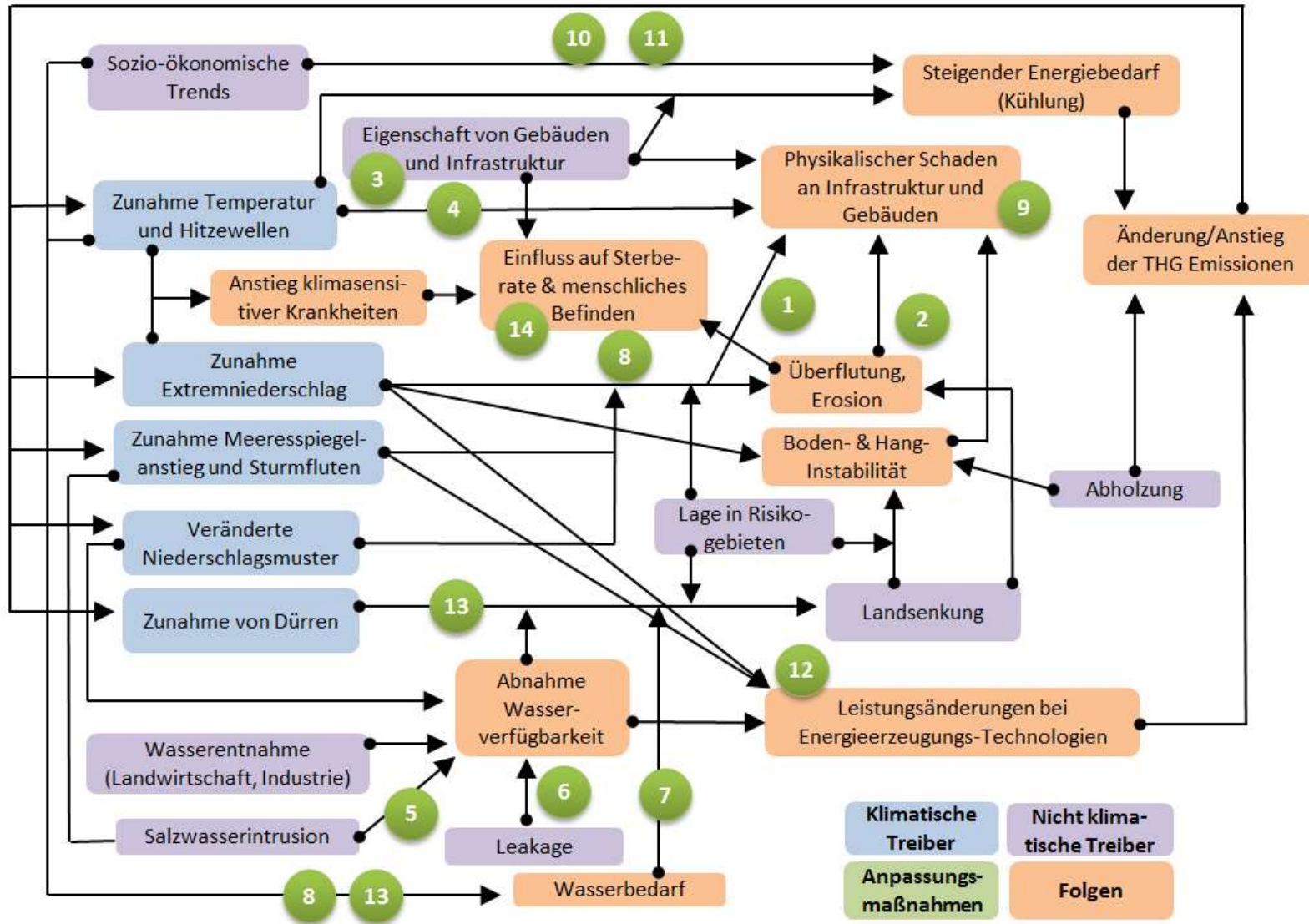


**Frischluftschneisen**

**Flusseinzugsgebiete**

(Quellen: fotolia)

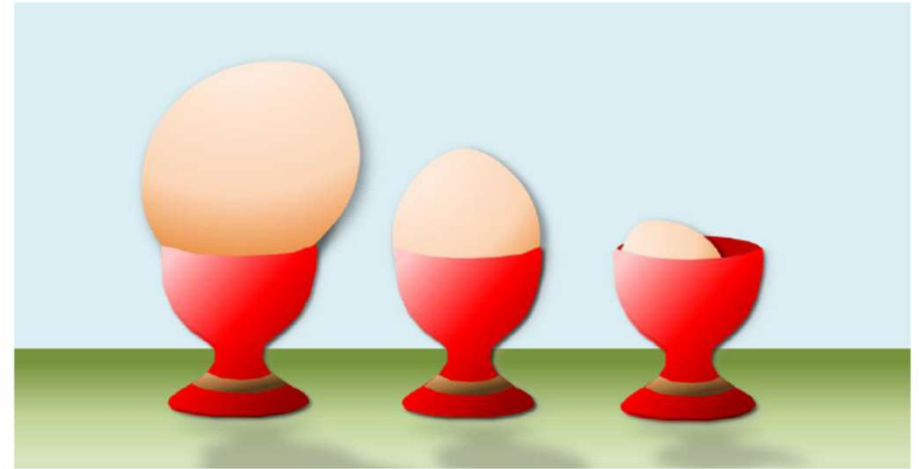
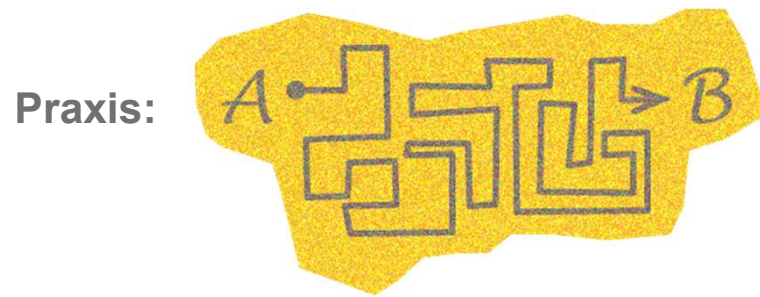
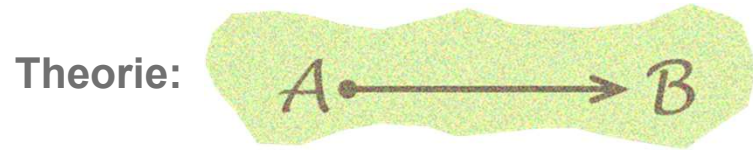
# Systemkarte wichtiger Treiber in Städten mit Ansatzpunkten für Anpassungsmaßnahmen



- 1 Erhöhen von Straßen, Wechsel von Routen
- 2 Verbesserter Hochwasserschutz
- 3 Risikoversicherung
- 4 Hitzeresistentes Baumaterial
- 5 Verbesserte Regenwasserkanalisation
- 6 Erhaltung oder Verbesserung der Infrastruktur
- 7 Bedarfsmanagement (Wasserpreise, Bewusstsein fürs Wassersparen erhöhen; ...)
- 8 Landnutzungsplanung
- 9 Verbesserte Bauvorschriften
- 10 Verbesserte Energieeffizienz / Isolierung
- 11 Nutzung natürlicher „Klimaanlagen“-Effekte (Schatten, Werkstoffe)
- 12 Verbesserter Hochwasserschutz, Standortwechsel
- 13 Verbessertes Wassermanagement
- 14 Verbesserte Gesundheitseinrichtung bzw. -kampagnen

(Quelle: Climate Service Center Germany (GERICS) and KfW Development Bank (2015) Climate Focus Paper: Cities and Climate Change, verändert)

# Adaptation in theory and practice



**But: one size does not fit all.**

**“In theory, there is no difference between theory and practice.  
But, in practice, there is.” (Manfred Eigen, Yogi Berra, ...)**



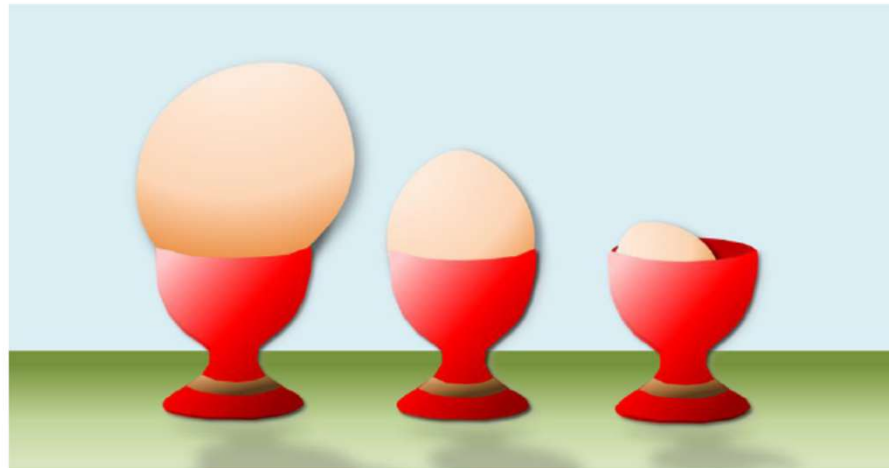
# Barrieren und Hemmnisse



Barriers to  
Climate Change Adaptation  
in Urban Areas in Germany



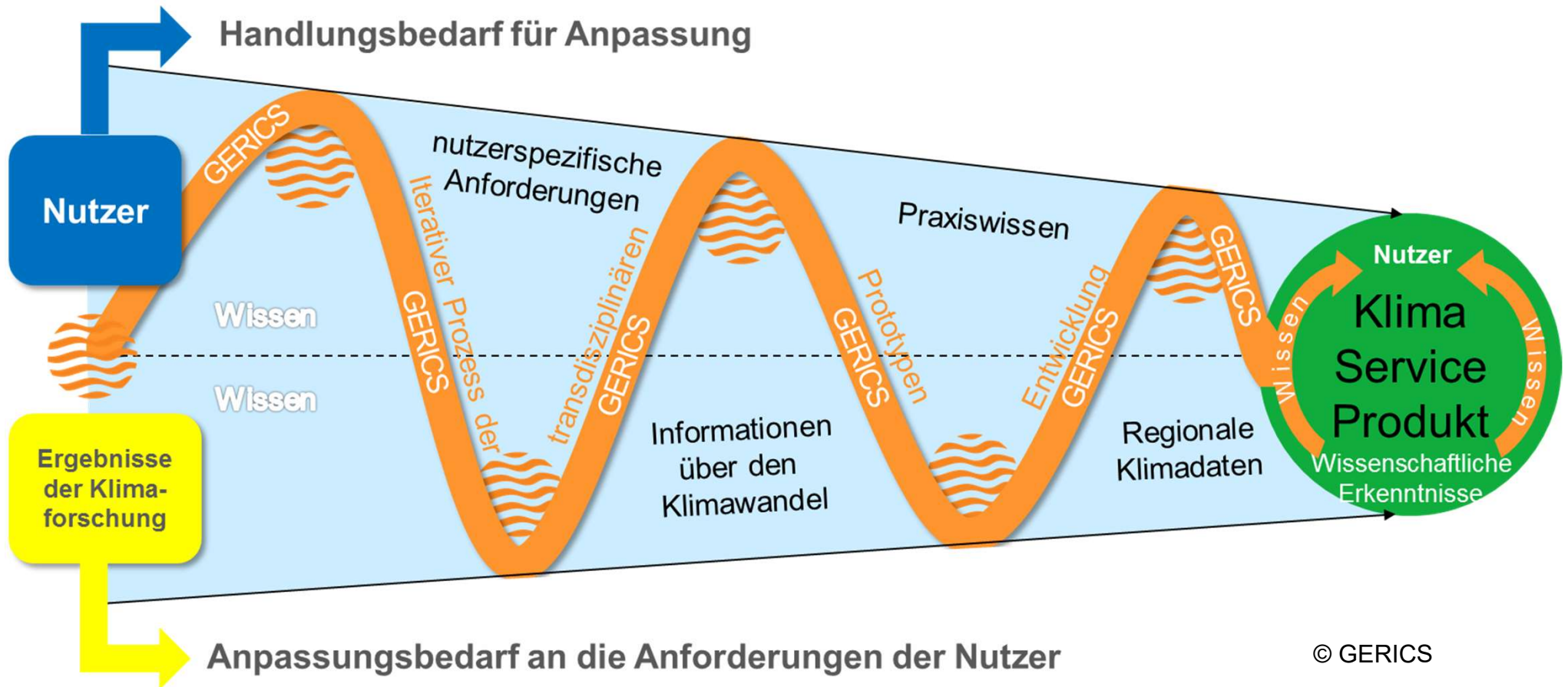
- **Strukturelle Hemmnisse** (Verantwortlichkeiten unklar, andere Themen wichtiger, ...)
- **Ressourcen-bezogene Hemmnisse** (finanzieller Anreiz fehlt, personelle Ressourcen,...)
- **Sensibilisierung** (Fehlendes Bewusstsein oder Weitsicht, keine akute Betroffenheit, ...)



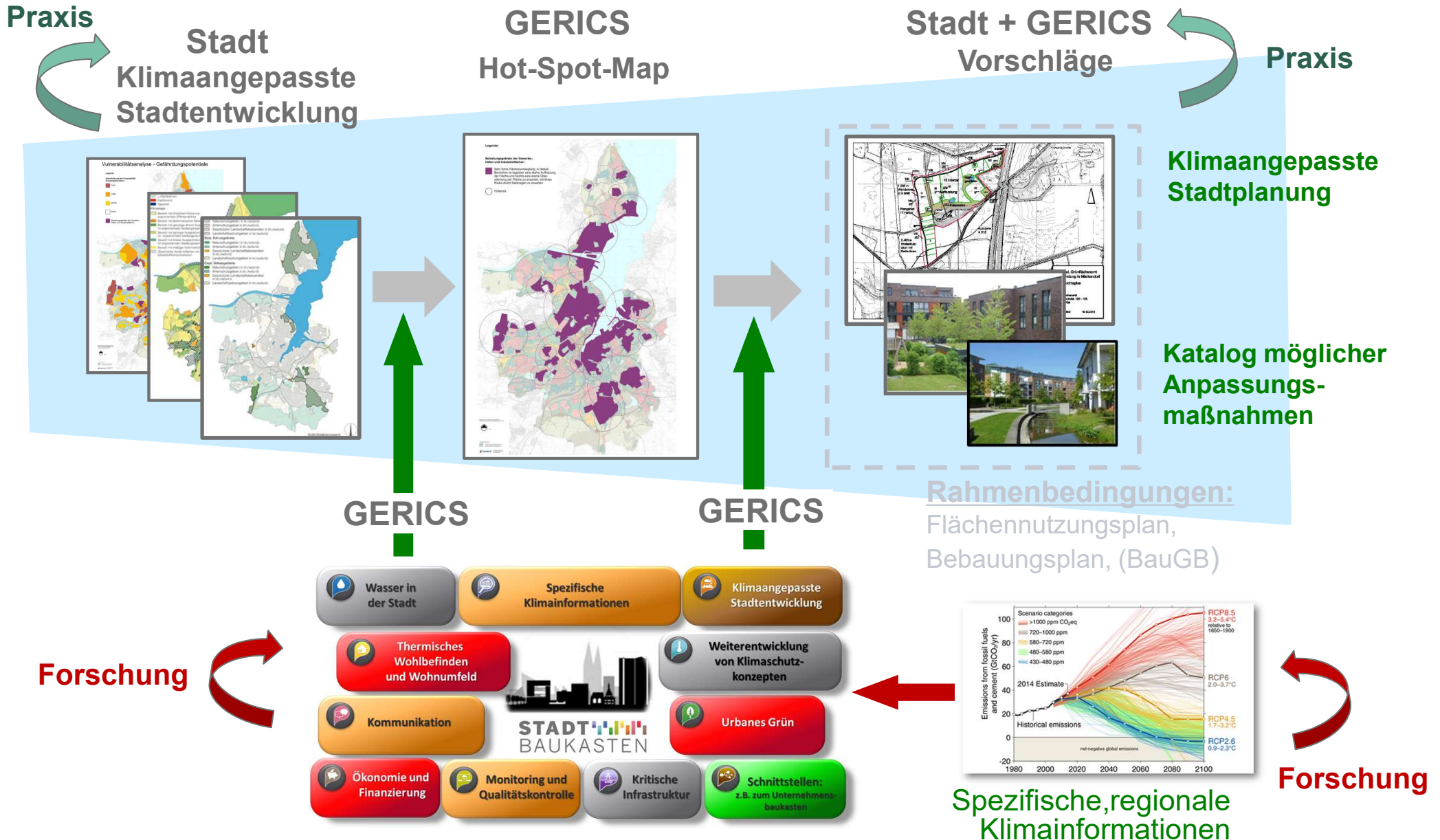
**Nicht zu vergessen:**  
Gesetze, Richtlinien,  
Verordnungen, Prozessketten



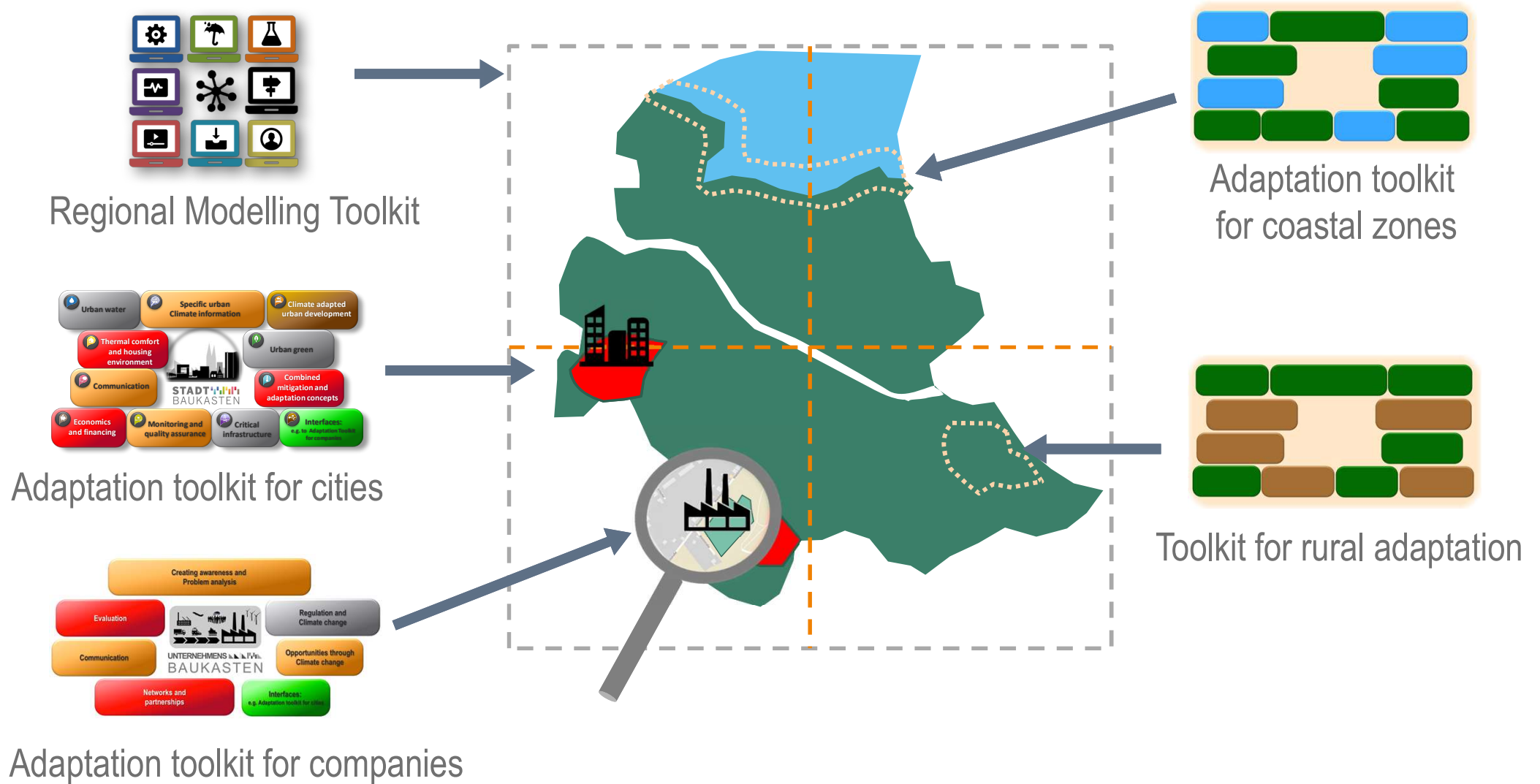
# GERICS: Nutzerspezifischer Wissenstransfer



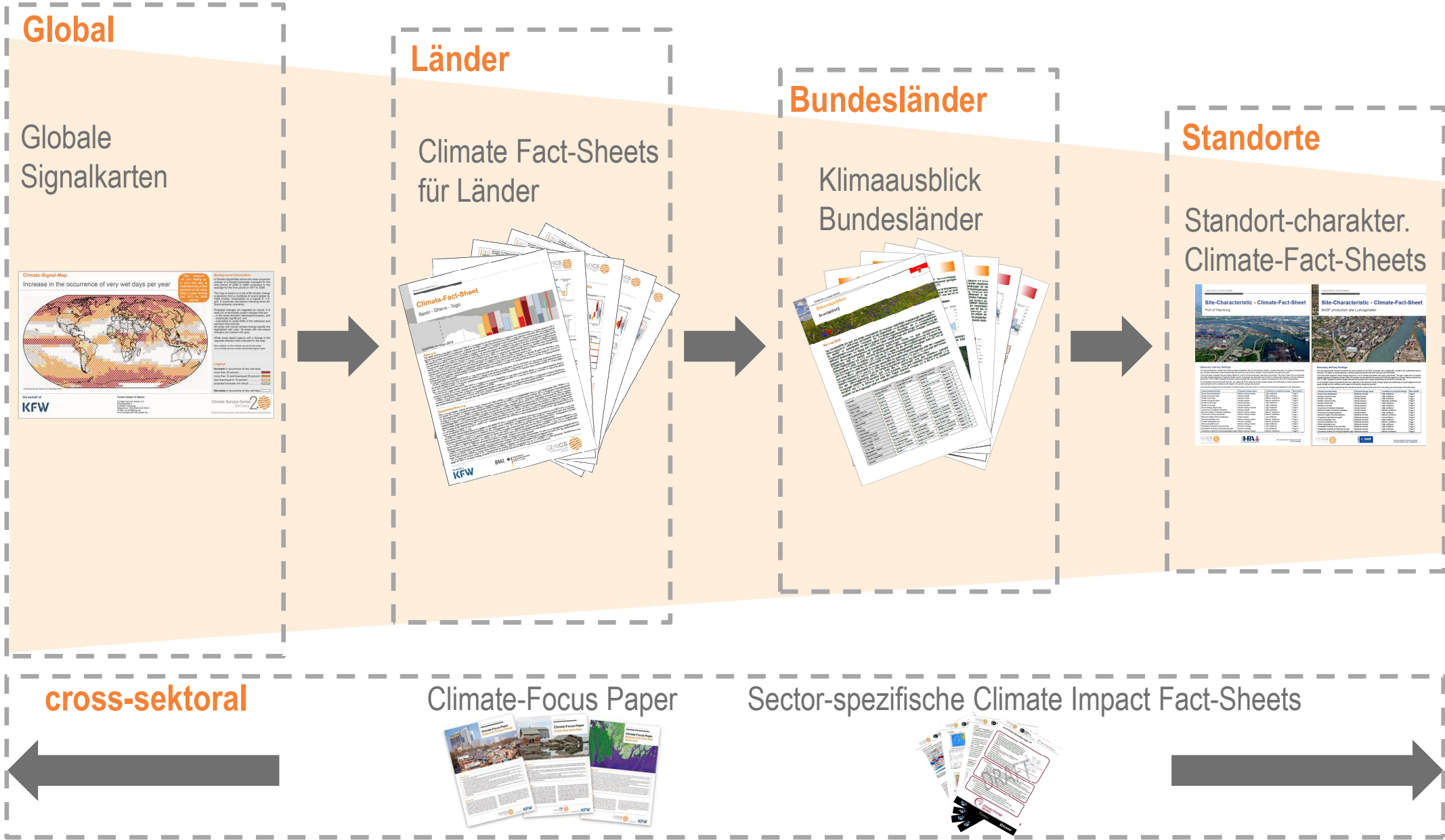
# Stadtbaukasten: Klimaangepasste Stadtentwicklung



# How to succeed in regional adaptation



# Klimainformation von global bis lokal: GERICS Produkte

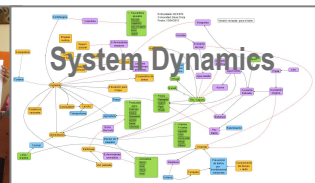
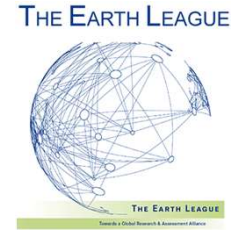


# GERICS: science for solutions

## Adaptation strategies across local to global scales



Dimensions	Policies/tools
Global	Global goal on adaptation
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Subnational	Cities / Sectoral Adaptation Plans
Local	Adaptation implementation / undertaking / efforts



## ■ Conclusions

What are the challenges when adapting to climate change?

- Bringing together all relevant sectors affected by climate impacts in a region
- Identify where climate impacts are important
- Getting the best information – consistent climate information to investigate climate impacts is often too coarse
- Climate services need and make use of a **solid scientific basis**: statistical methods and ensembles of climate simulations up to high-resolution spatial and temporal scales

# ■ Thank you for your attention!

What are the challenges when adapting to climate change?

- Bringing together all relevant sectors affected by climate impacts in a region
- Identify where climate impacts are important
- Getting the best information – consistent climate information to investigate climate impacts is often too coarse
- Climate services need and make use of a **solid scientific basis**: statistical methods and ensembles of climate simulations up to high-resolution spatial and temporal scales

<http://www.climate-service-center.de>

Contact: [claas.teichmann@hzg.de](mailto:claas.teichmann@hzg.de)