

# Available climate simulations and GERICS products for adaptation

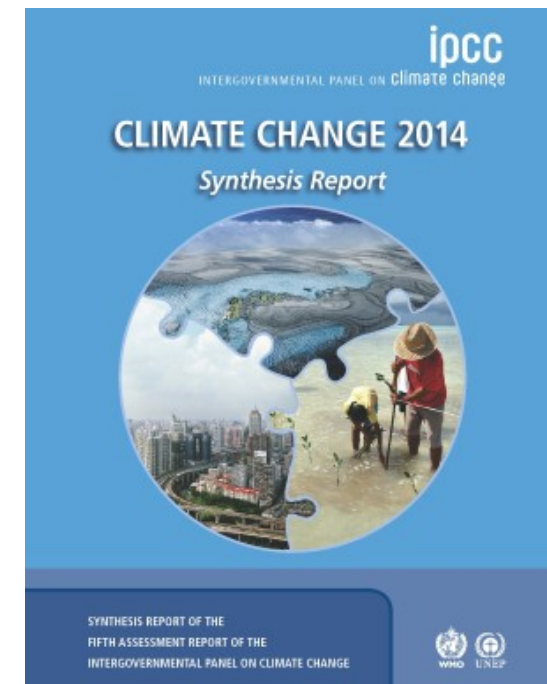
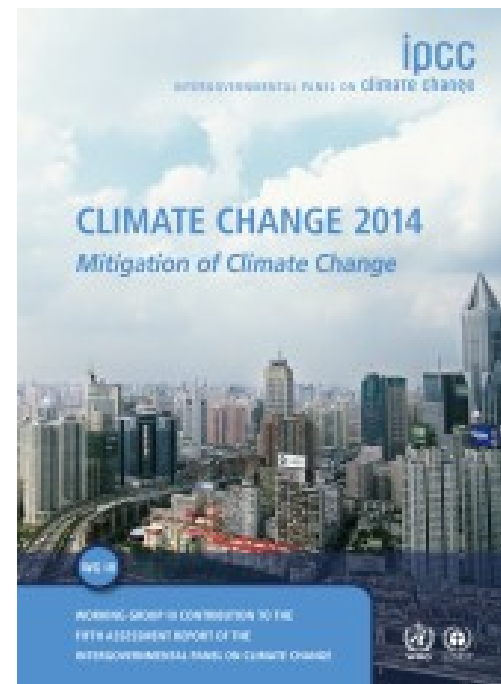
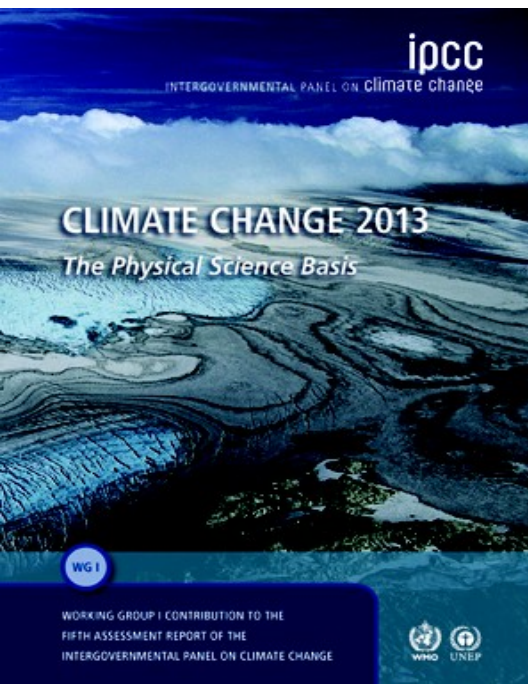
Claas Teichmann and María Máñez  
and the GERICS team

Expert meeting to assess progress made in the process to  
formulate and implement  
National Adaptation Plans (NAPs)

7–9 February 2018, Sao Tome, Sao Tome and Principe

# IPCC Assessment Report 5

**Current state of scientific knowledge relevant to climate change:**  
<http://www.ipcc.ch/report/ar5/>



**5th Assessment Report of the Intergovernmental Panel on Climate Change:**  
WGI 2013, WGII, WGIII,SYR 2014

# ■ Emission scenarios SRES / RCPs

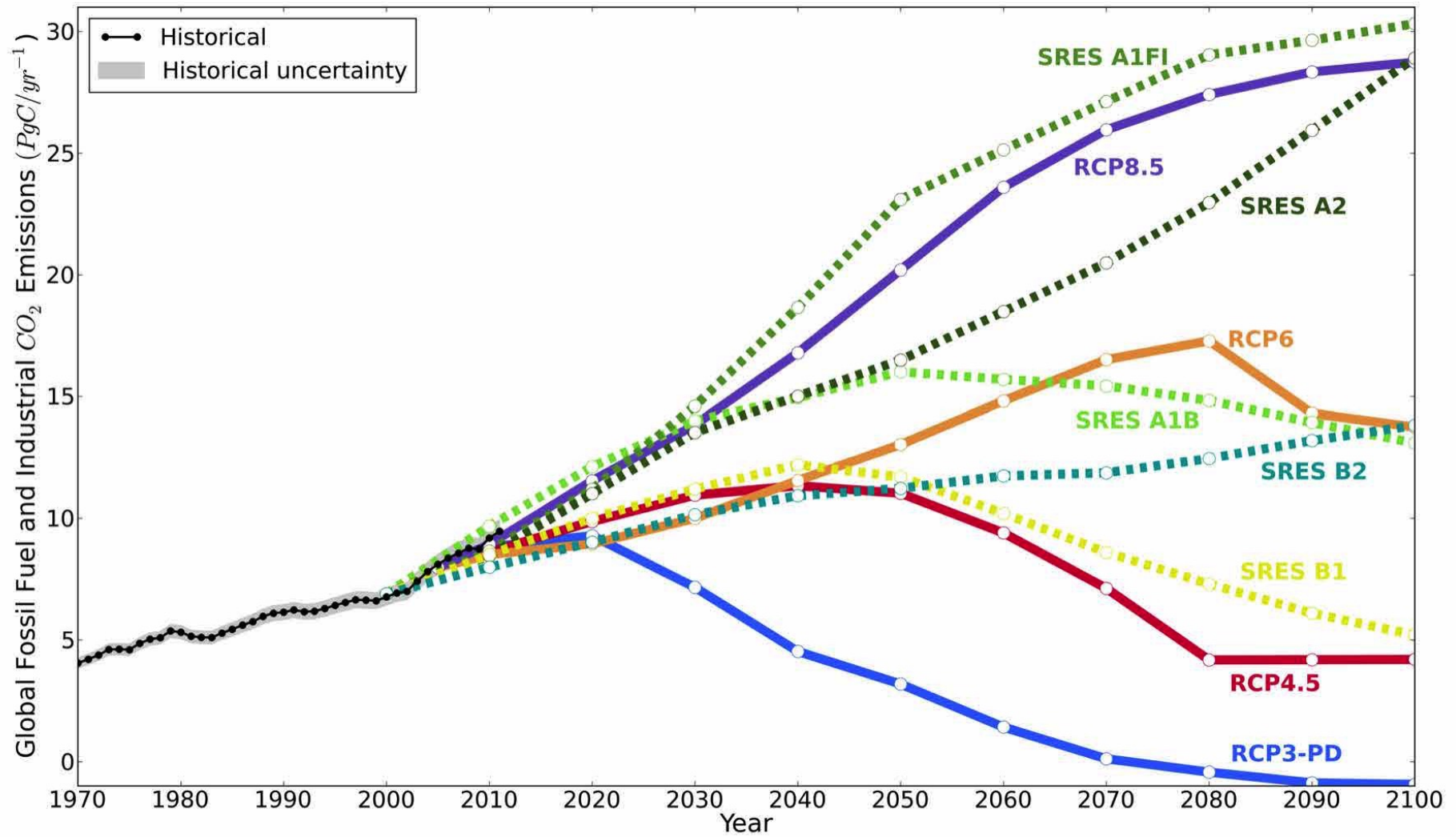
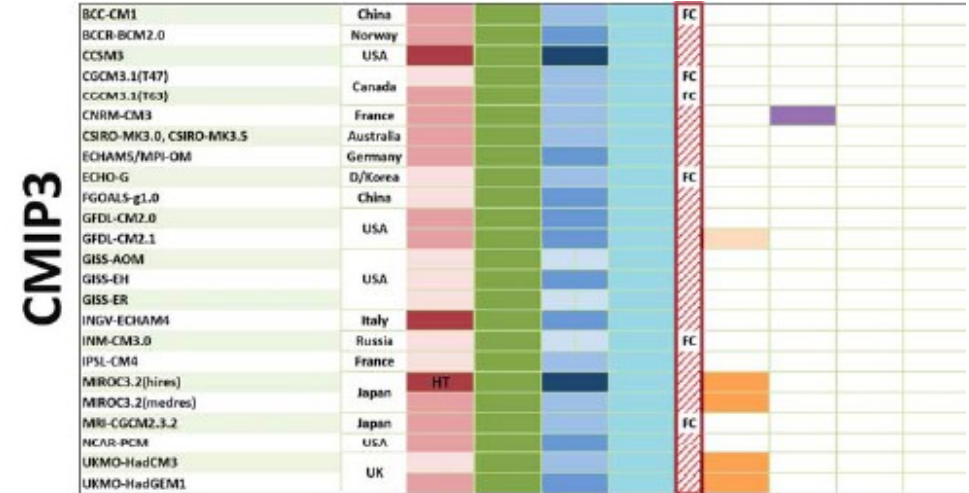
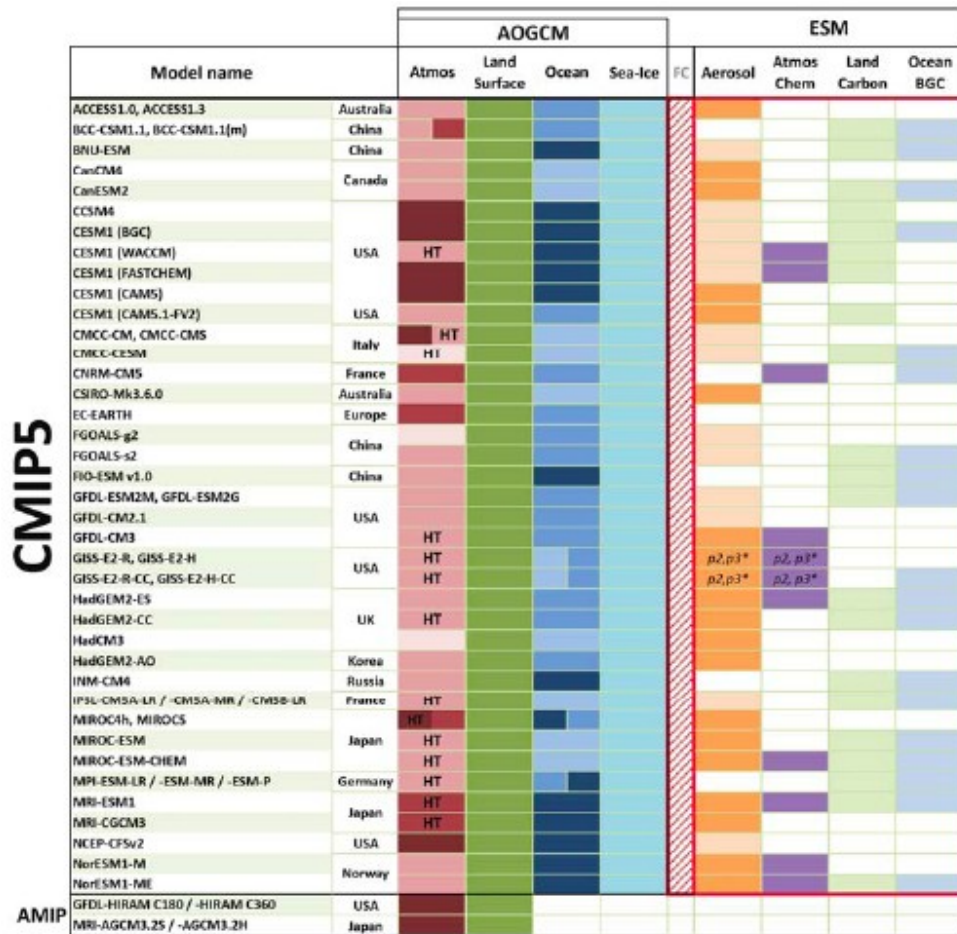


Figure: P. Bowyer; Data based on SRES, IIASA and Global Carbon Project

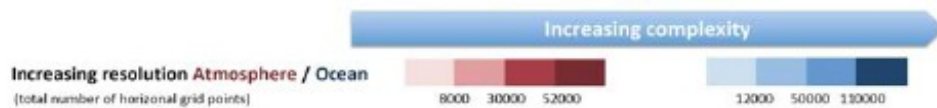
# Multi-model ensemble CMIP5 and CMIP3



**MIPs** Model Intercomparison Projects (since 1990): standard experiment protocol and an world wide community-based infrastructure in support of model simulations, validation, intercomparison, documentation and data access.

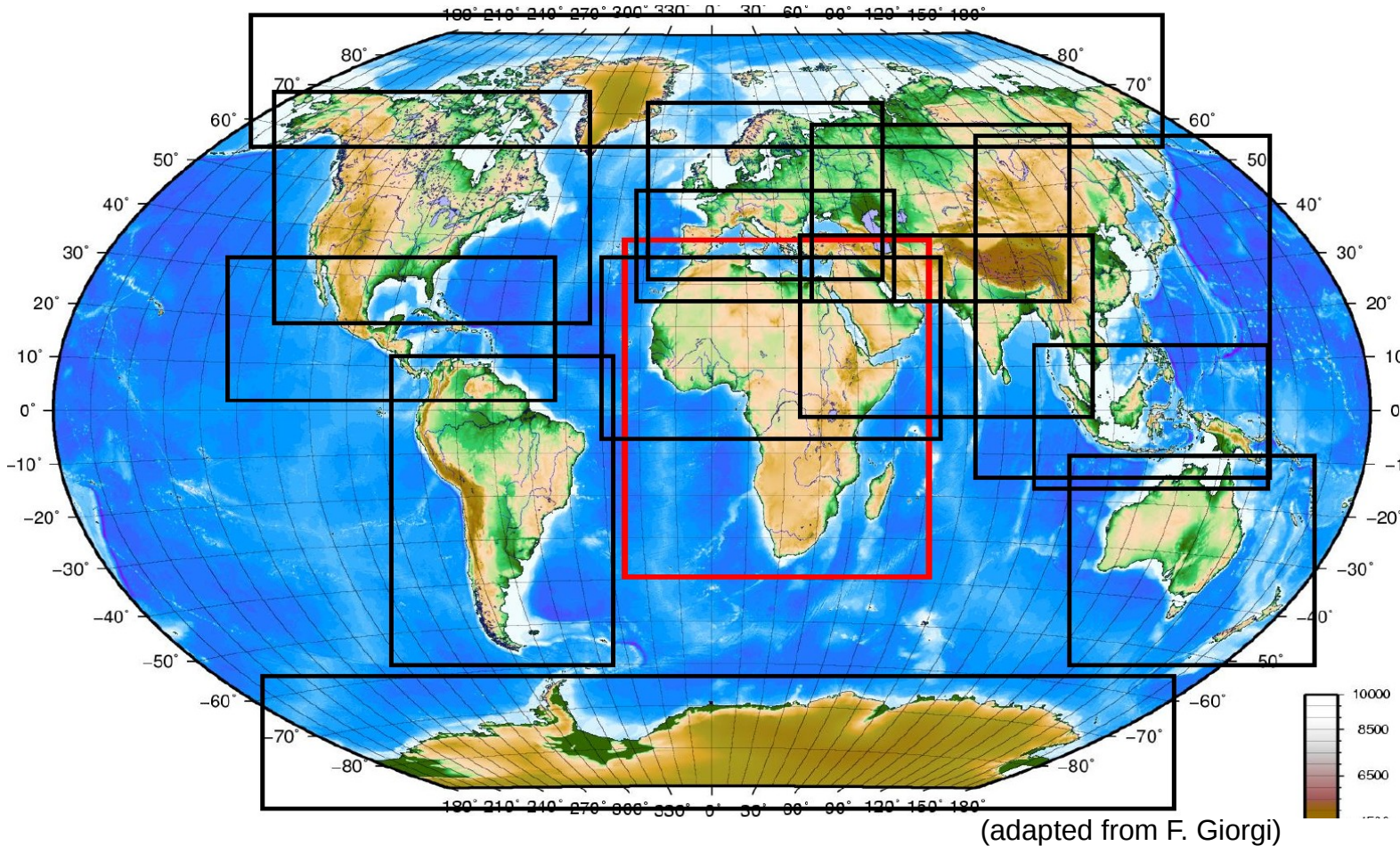
**CMIP3:** coordinated climate projections, based on emission scenarios from SRES, global model basis for IPCC AR4

**CMIP5:** a new set of coordinated, based on the new RCPs, global model basis for IPCC AR5



Source: IPCC 2013 AR5 Chapter 9

# Regional climate simulations: WCRP CORDEX



14 domains with a resolution of  $0.44^\circ \times 0.44^\circ$  (approx.  $50 \times 50 \text{ km}^2$ )

High resolution simulations with  $0.11^\circ \times 0.11^\circ$  (approx.  $12 \times 12 \text{ km}^2$ ) for Europe

CORDEX data available via *Earth System Grid Federation*: <https://esgf-data.dkrz.de/search/cordex-dkrz/>

- CORDEX focus on Africa
- GERICS participates in many CORDEX-regions

# ■ CORDEX vision and goals

**The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships.**

- To better understand relevant regional/local climate phenomena, their variability and changes, through downscaling.
- To evaluate and improve regional climate downscaling models and techniques
- To produce coordinated sets of regional downscaled projections worldwide
- To foster communication and knowledge exchange with users of regional climate information

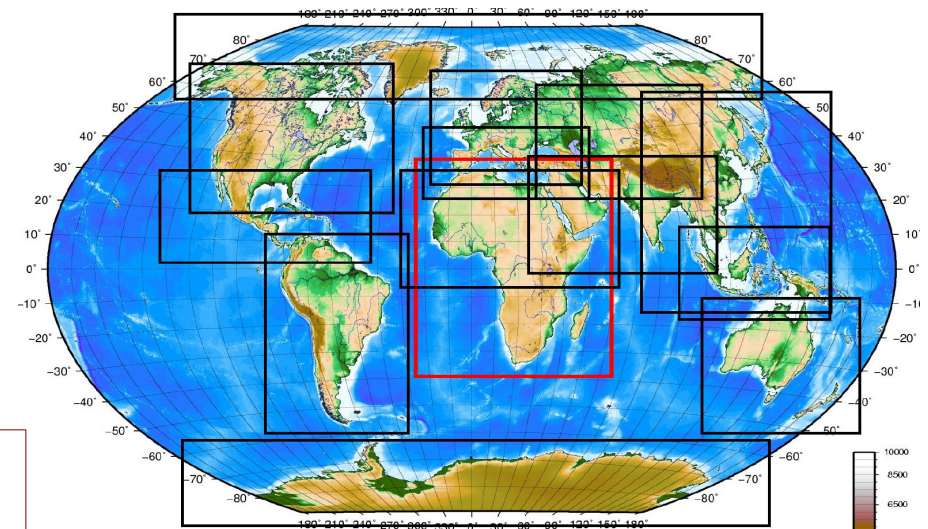
## Emerging scientific challenges

- Added value
- Human element
- Coordination of regional coupled modelling
- Precipitation
- Local wind systems



Great parts of the information of climate change is based on CORDEX activities

## CORDEX domains



(adapted from F. Giorgi)

# EURO-CORDEX

European branch of the WCRP CORDEX initiative



## Model domain

- $\sim 27^{\circ}\text{N}$ – $72^{\circ}\text{N}$ ,  $\sim 22^{\circ}\text{W}$ – $45^{\circ}\text{E}$
- Horizontal resolutions: 12.5 km and 50 km

## Scenarios:

- RCP2.6, RCP 4.5, RCP 8.5, CMIP5 forcing

## Time periods:

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

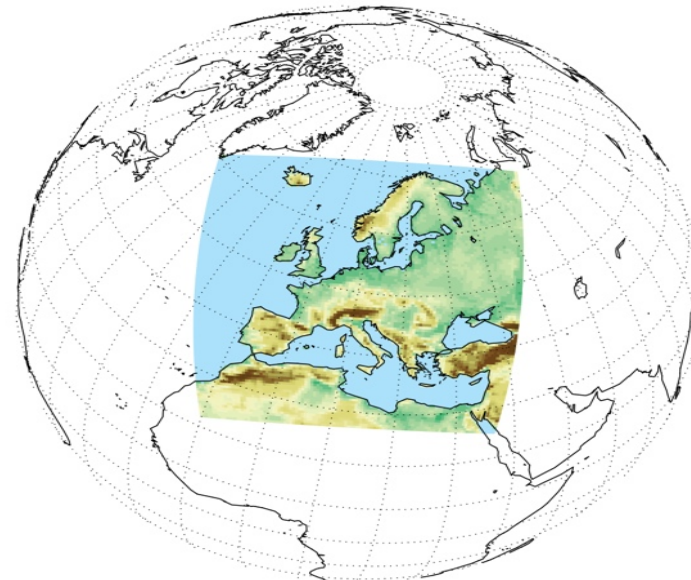
## Models:

- 10 RCMs in combination with 12 different GCMs
- 49 scenario simulations are available for users at standard resolution (EUR-44, 50 km)
- 59 scenario simulations are available for users at high resolution (EUR-11, 12.5 km)

Additional simulations are in preparation and are continuously filling the EURO-CORDEX simulation matrix and are made available via the ESGF (e.g., <https://esgf-data.dkrz.de>)

## Community

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



Model Domain

# CORDEX-CORE



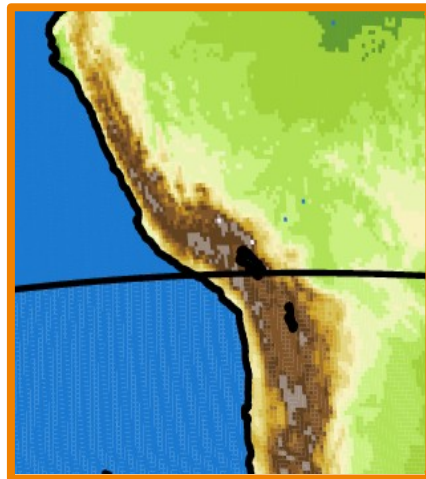
Towards a homogeneous high-resolution simulation dataset for the world

**Horizontal resolution:** 0.22° (~25km) resolution

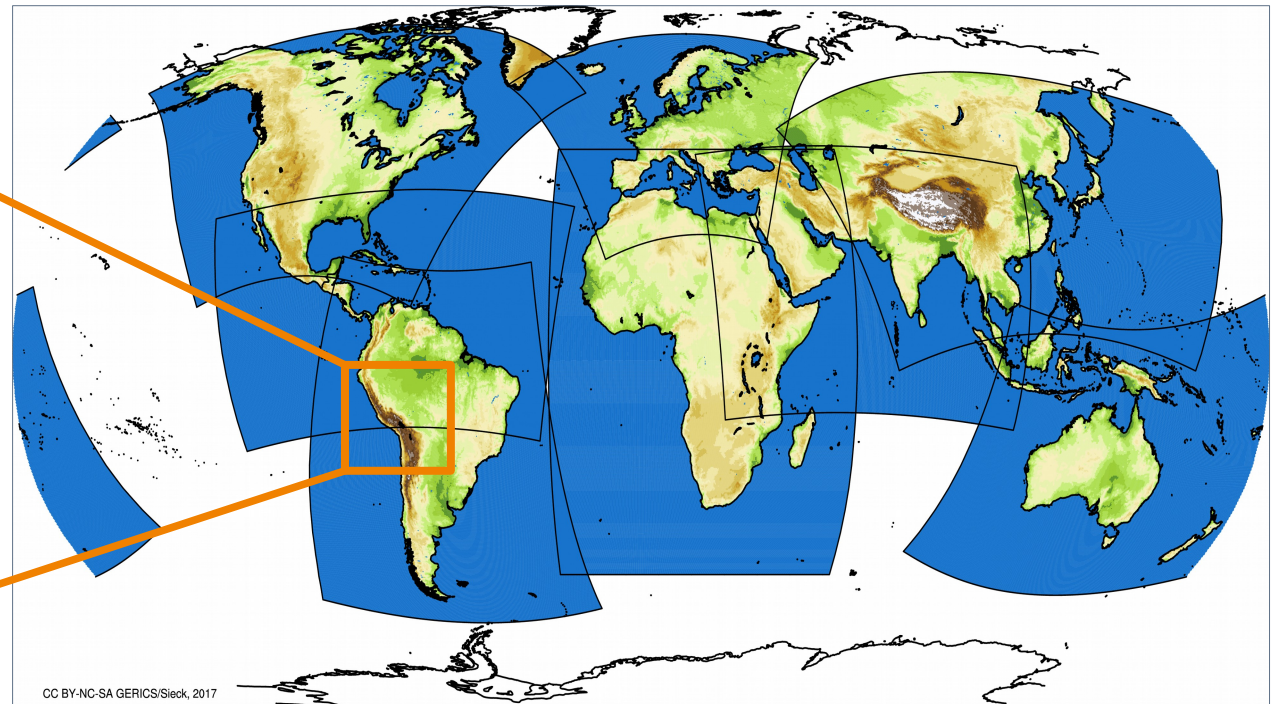
**Forcing:** re-analysis (ERA-Interim), RPC2.6 and RCP8.5 driven global simulations

**GCMs:** HadGEM (backup: MIROC5), MPI-ESM (backup: EC-Earth), NorESM (backup: GFDL-ESM)

**RCMs:** REMO, RegCM, CLM



Orographically structured area.



CORDEX-CORE model domains as setup for simulations by the regional climate model REMO.

Domains from top-left to bottom right: North America, Central America, South America, EURO-CORDEX, Africa, South Asia, East Asia, Australasia.



# ■ CORDEX-CORE

Towards a homogeneous high-resolution simulation dataset for the world



**Horizontal resolution:** 0.22° (~25km) resolution

**Forcing:** re-analysis (ERA-Interim), RPC2.6 and RCP8.5 driven global

sim  
GO The main ideas of the CORDEX CORE framework are

- No  
RC
- to use a core set of RCMs
  - to downscale a core set of GCMs
  - to cover the major inhabited areas of the world
  - to use different representative concentration pathways (RCPs)
  - to incrementally extend the CORDEX-CORE ensemble with further contributions by additional models/experiments

CORDEX-CORE model domains as setup for simulations by the regional climate model REMO.

Domains from top-left to bottom right: North America, Central America, South America, EURO-CORDEX, Africa, South Asia, East Asia, Australasia.

# ■ Accessing observation data

## Climate at a Glance

- Climate Monitoring
- State of the Climate
- BAMS State of the Climate
- Temp, Precip, and Drought
- Climate at a Glance
- Extremes
- Societal Impacts
- Snow and Ice
- Teleconnections
- GHCN Monthly
- Monitoring References

[Time Series](#) | [Mapping](#) | [Data Information](#) | [Background](#)

### Time Series

[U.S.](#) | [Globe](#)

Choose from the options below and click "Plot" to create a time series graph.

*Please note, Global and hemispheric anomalies are with respect to the 20<sup>th</sup> century average. Continental anomalies are with respect to the 1910 to 2000 average.*

Timescale:

Month:

Start Year:

End Year:

Region/  
Continent:

Surface:

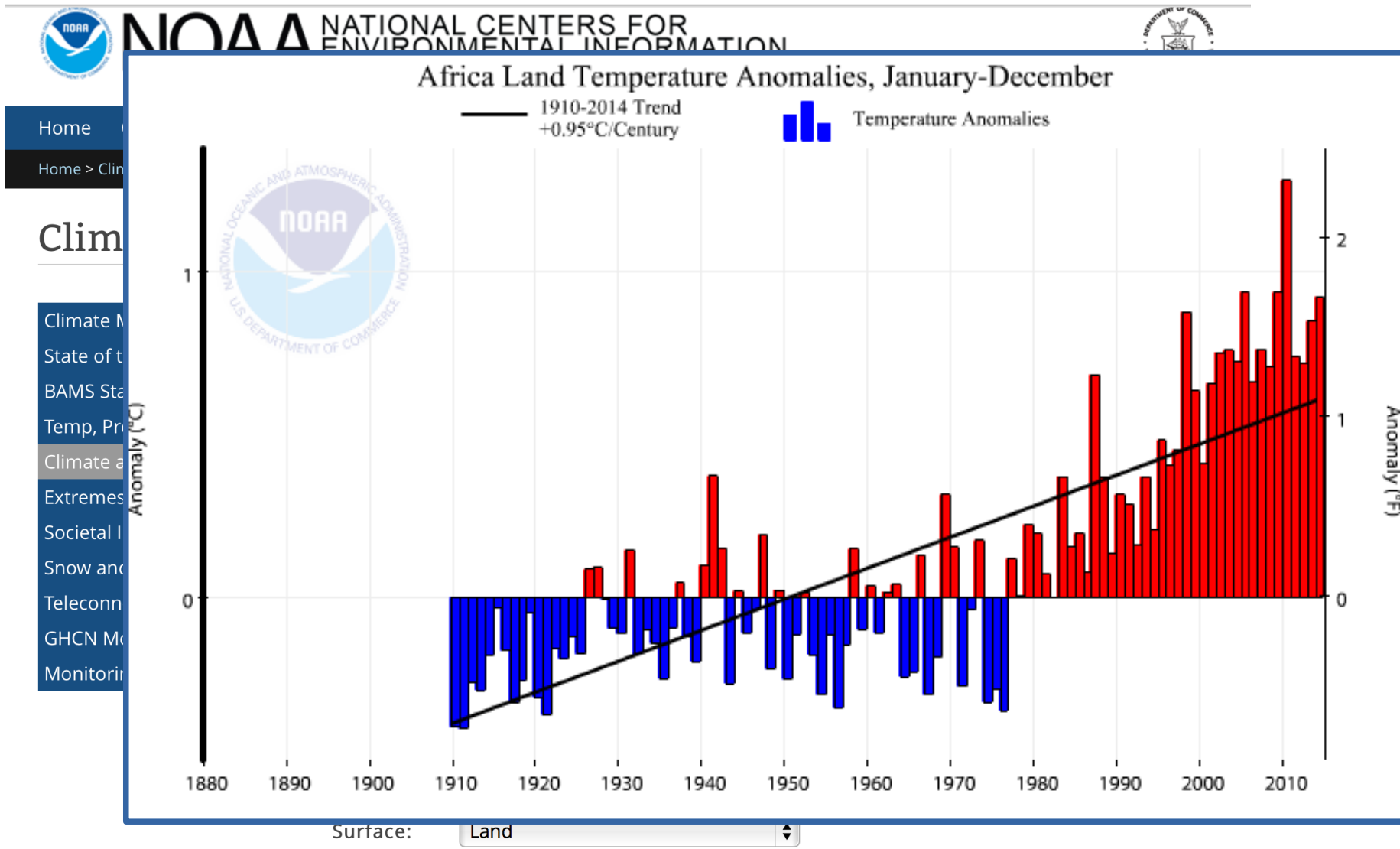
#### Options

Display Trend

per Decade  per Century

Start:  End:

# ■ Accessing observation data



[www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)

# ■ Accessing simulation data

## ESGF Node at DKRZ

You are at the [ESGF-DATA.DKRZ.DE](#) node

[Home](#) [About Us](#) [Contact Us](#)


### Welcome to the DKRZ ESGF-CoG Node

**Search & Download Data** ?

  [More search options](#)

As a national HPC center, the [German Climate Computing Centre \(DKRZ\)](#) is part of the European IS-ENES Infrastructure. It provides high performance computers, high capacity data storage and data management for German climate research. In addition DKRZ's specialists offer a range of services and support covering modeling and programming as well as data dissemination and long-term archival.

The [Earth System Grid Federation \(ESGF\)](#) maintains a global system of federated data centers that allow access to the largest archive of climate data world-wide.



#### Search Data

The following projects require a [ESGF Account \(create account\)](#) and some also require a [Group Registration \(see links below\)](#) to access their data.

- [Search all Projects](#)
- **CMIP5:** Coupled Model Intercomparison Project Phase 5
  - [Group Registration: CMIP5 Research](#) [CMIP5 Commercial](#)
  - [CMIP5 Data Search](#)
- **CORDEX:** Coordinated Regional Climate Downscaling Experiment
  - [Group Registration: CORDEX Research](#) [CORDEX Commercial](#)
  - [CORDEX Data Search](#)
- **Obs4MIPs:** Observations for Climate Model Intercomparisons
  - [Group Registration: CMIP5 Research](#)
  - [Obs4MIPs Data Search](#)
- **ISI-MIP:** Inter-Sectoral Impact Model Intercomparison Project
  - [Group Registration: ISI-MIP Research](#) [ISI-MIP Unrestricted](#)
  - [ISI-MIP Data Search](#)

#### User help and related links

For technical support please have a look at the [User Tutorials](#) and [ESGF FAQ](#).

If you can not find what you are looking for please contact the ESGF user support: [esgf-user@lists.llnl.gov](mailto:esgf-user@lists.llnl.gov)

Expert users may also want to use the [ESGF Search RESTful API](#): <http://esgf-data.dkrz.de/esg-search/search?>

#### Technical Support

##### Federated ESGF-CoG Nodes

- CoG-CU
- ESGF@CEDA
- ESGF@DOE/LLNL
- ESGF@IPSL
- ESGF@NASA/JPL
- ESGF@NCI
- ESGF@NOAA/ESRL
- ESGF@NOAA/GFDL
- ESGF@NSC/ILL

##### Browse Projects

[This](#) [All](#) [My](#) [Tags](#)

Parent projects (0)

Peer projects (6)

- ESGF-CEDA
- ESGF-GFDL
- ESGF-IPSL
- ESGF-JPL
- ESGF-LIU
- ESGF-NCI

Child projects (5)

- CMIP5-DKRZ
- CORDEX-DKRZ
- ISI-MIP-DKRZ
- obs4MIPs-DKRZ
- ReKIEs-De

Enter Tag

*Start typing, or use the 'Delete' key to show all available tags.*

**ESGF-DKRZ Tags:** None

<https://esgf-data.dkrz.de/projects/esgf-dkrz/>

# Quick visualization of simulation data

KNMI Climate Explorer

Climate Explorer European Climate Assessment & Data KNMI

Help News About Contact World weather Effects of El Niño Seasonal forecasts

### KNMI Climate Change Atlas

**Select a region**

Type:  IPCC WG1  IPBES  countries  place  box [i]

Country:

**Select a season**

Season: First month [i]

**Select a dataset and variable**

Dataset:  [i]

Variable:  [i]

absolute  relative changes are shown [i]

Output:  map  time series [i]

**Map options**

Scenario:  [i]

Measure:  [i]

Reference period:  -

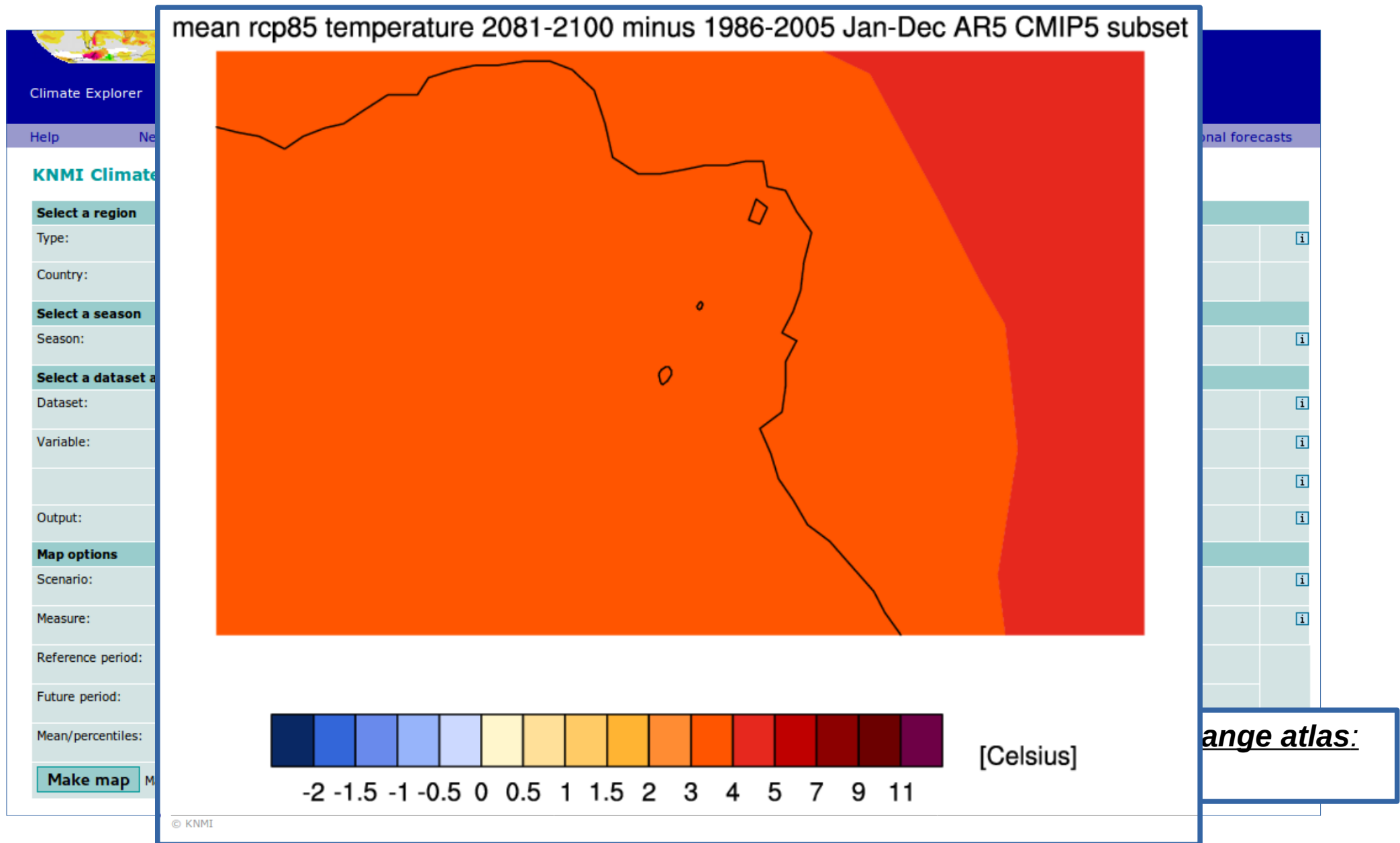
Future period:  -

Mean/percentiles:  [i]

**Make map** May take up to 15 minutes the first time

*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)*

# Quick visualization of simulation data



# ■ Summary and further information

- Accessing observation data:
  - [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)
  - <https://www.esrl.noaa.gov/psd/data/gridded/data.gpcp.html>
- Accessing reanalysis data
  - <https://www.ecmwf.int/en/forecasts/datasets/browse-reanalysis-data-sets>
- Accessing simulation data:
  - <https://esgf-data.dkrz.de/projects/esgf-dkrz/>
  - <https://climate4impact.eu/impactportal/general/index.jsp>

# ■ Summary and further information

- Quick visualization of simulation data
  - KNMI: Climate Explorer
    - [http://climexp.knmi.nl/plot\\_atlas\\_form.py](http://climexp.knmi.nl/plot_atlas_form.py)
  - SMHI: Regional climate change in a 1.5 degrees warmer world
    - <https://www.smhi.se/en/climate/global-warming-levels#sc=15C>
  - SMHI: Climate Scenarios
    - <https://www.smhi.se/en/climate/climate-scenarios>



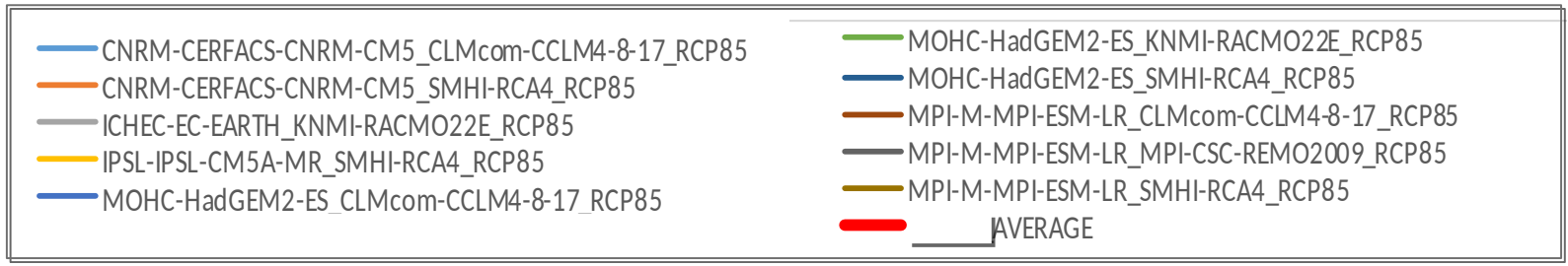
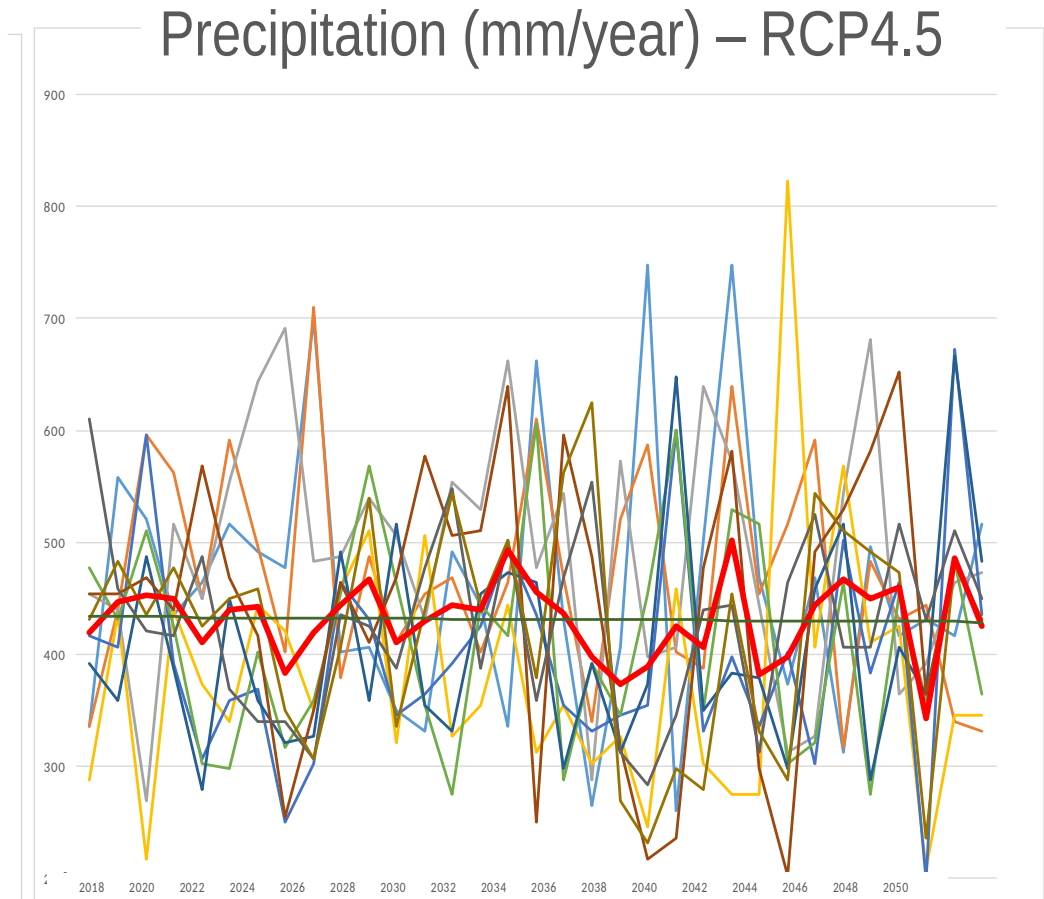
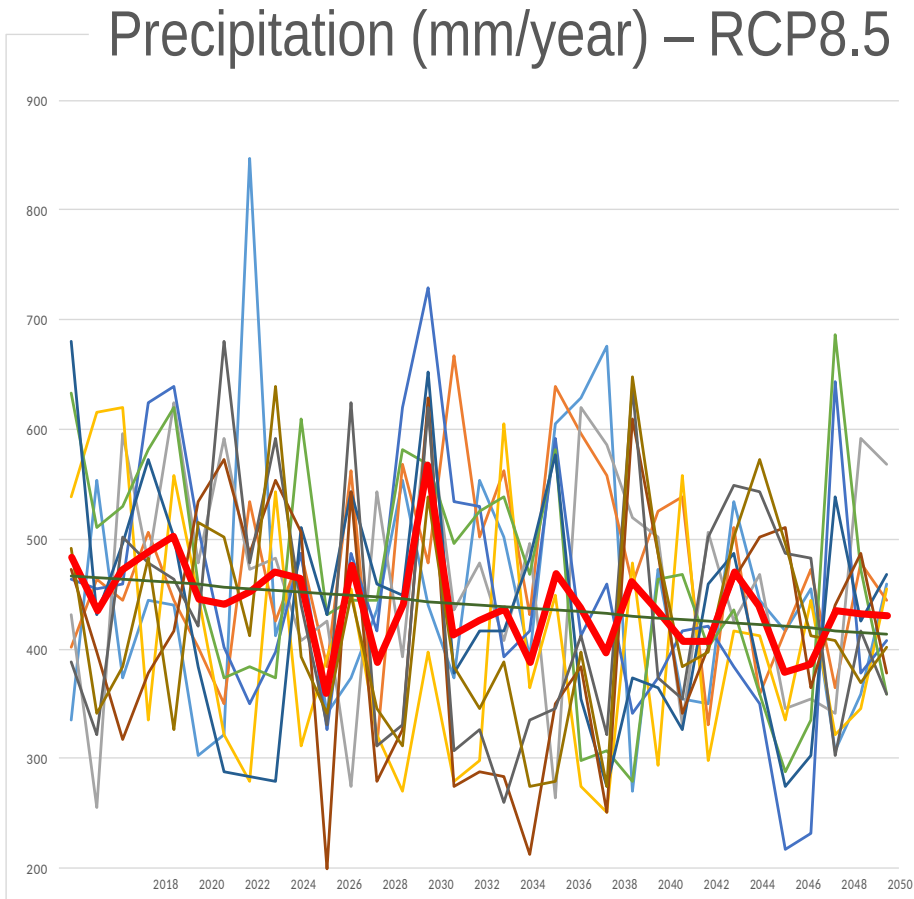
# ■ Summary and further information

- Accessing climate change information
  - Climate Change Knowledge Portal of the World Bank
    - <http://sdwebx.worldbank.org/climateportal/>
  - UNDP Climate Change Country Profiles
    - <http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/>
  - Copernicus Climate Change Services (focus on Europe)
    - <https://climate.copernicus.eu/>

# GERICS products for adaptation

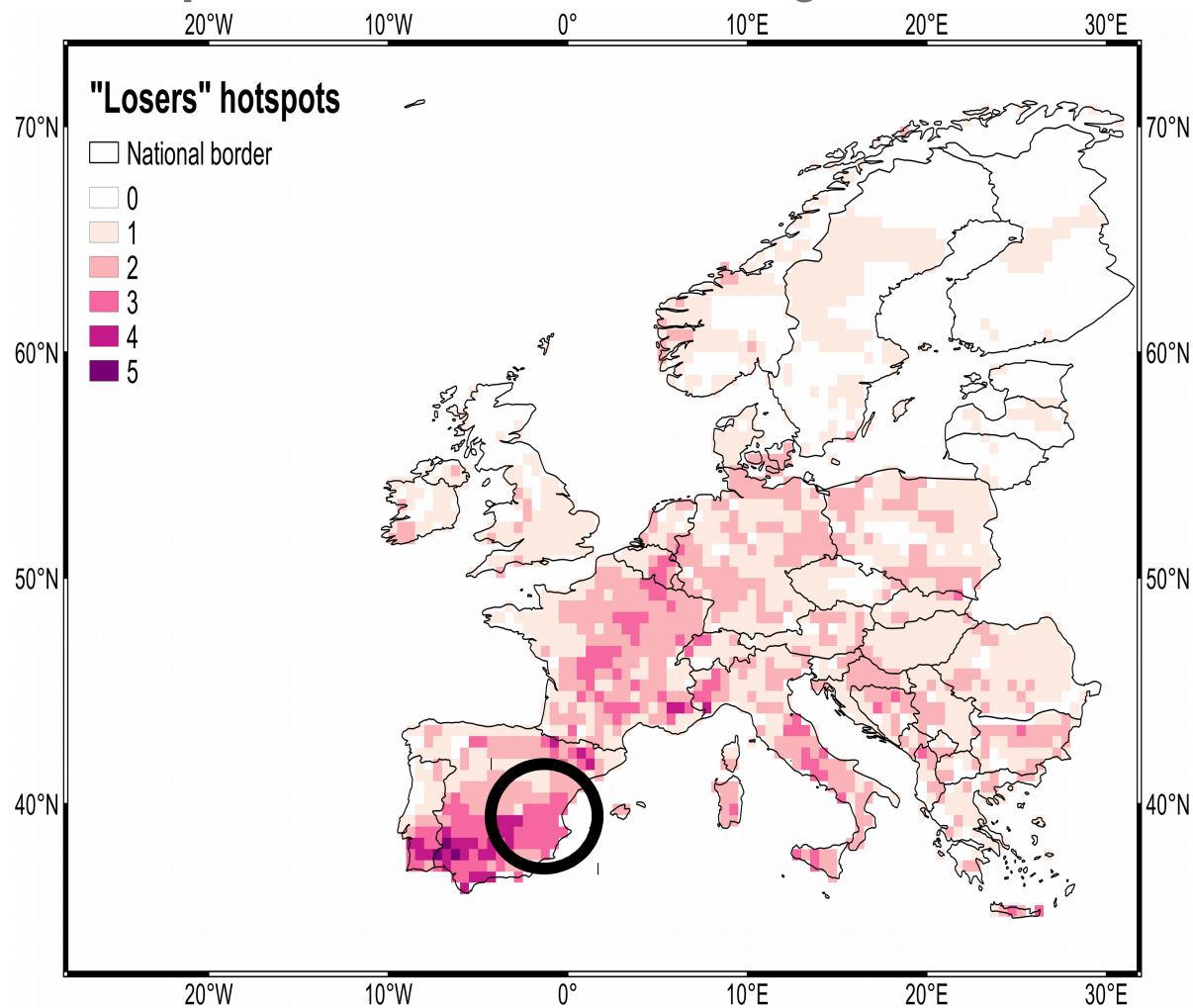
Claas Teichmann and María Máñez  
January 25, 2018

# Annual Precipitation projections



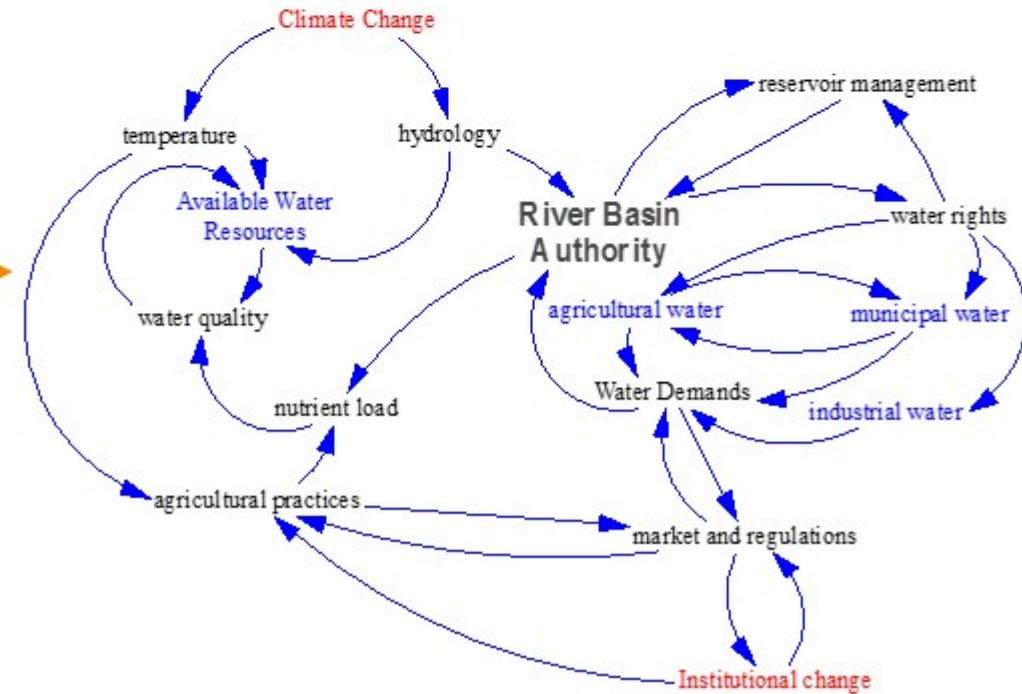
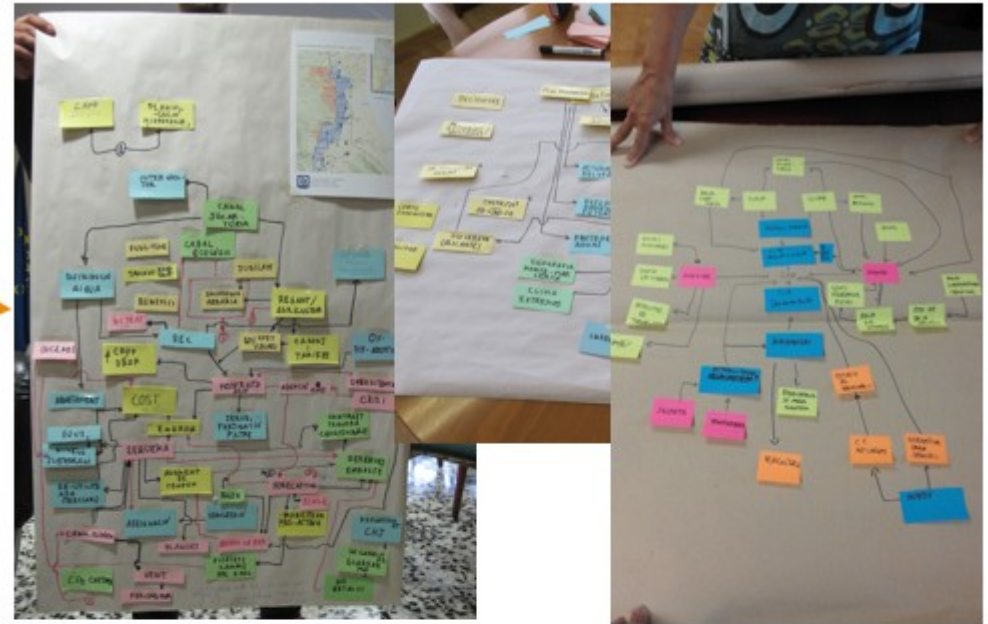
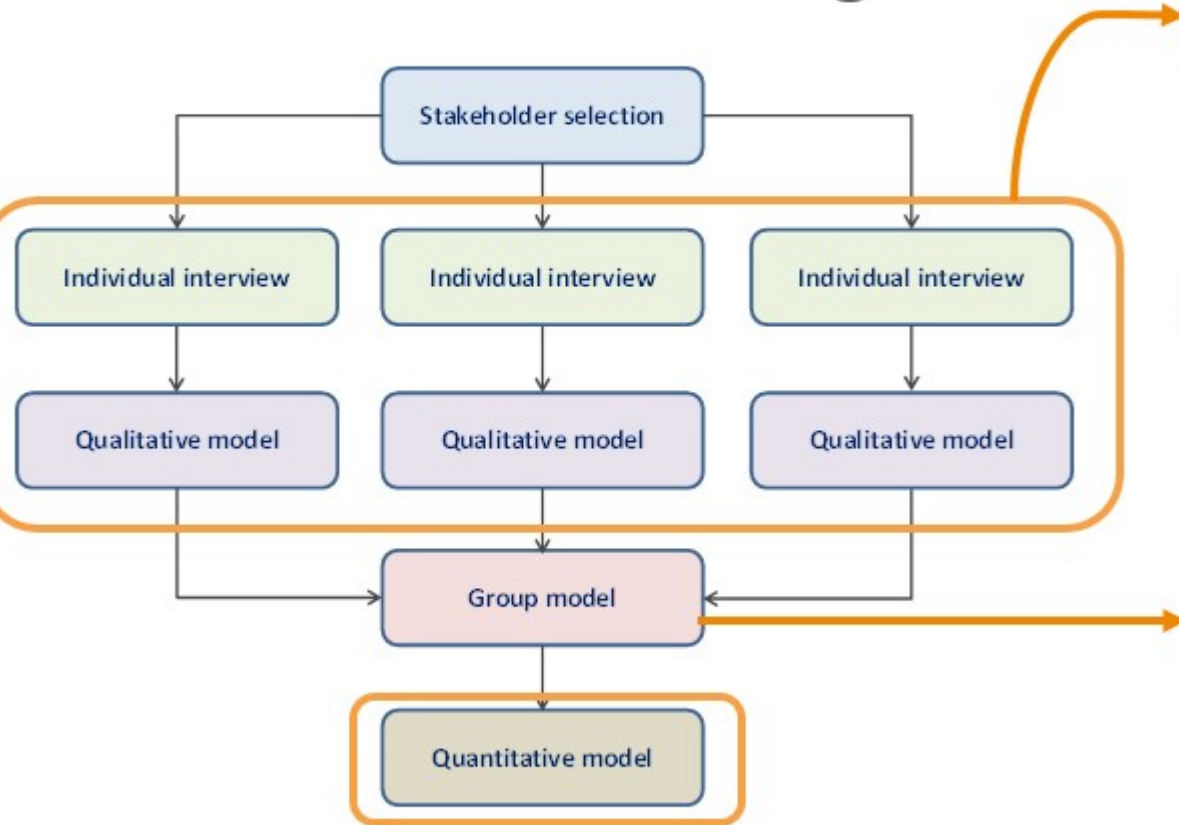
# Identification of hot-spot regions

## Climate impact “losers” in a two degree world

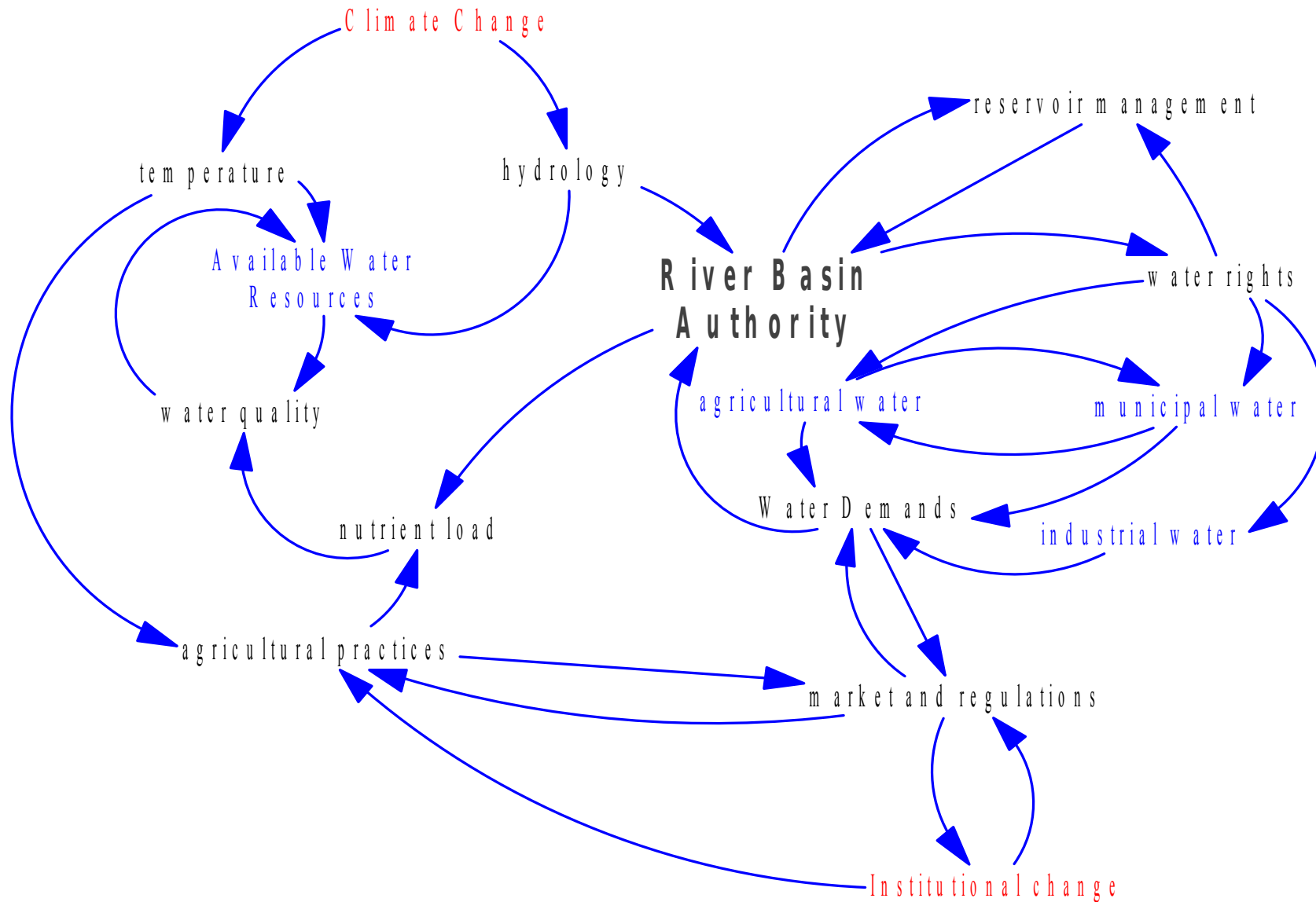


(refer to the presentation of Paul Bowyer, yesterday)

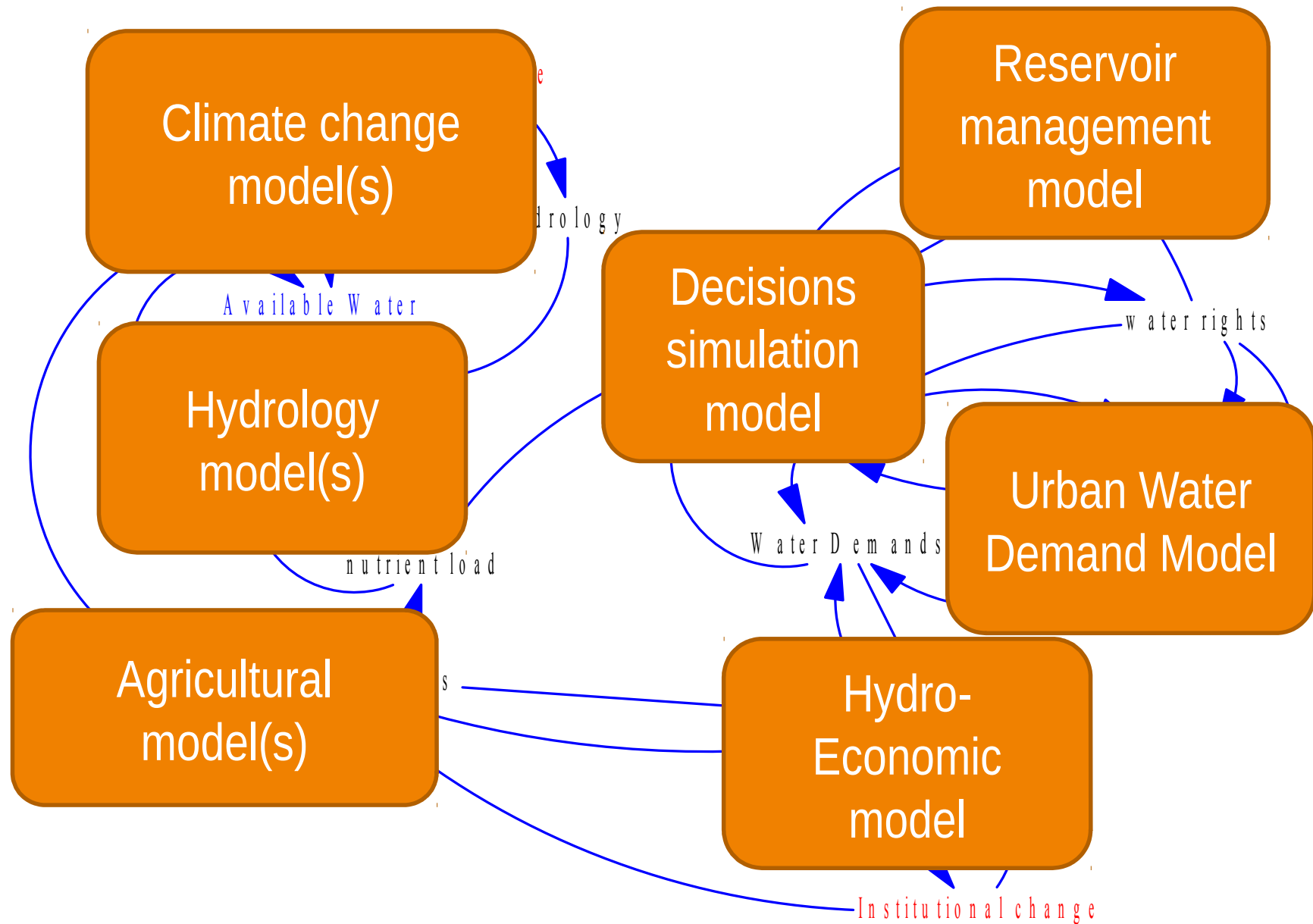
# System Dynamics Modelling



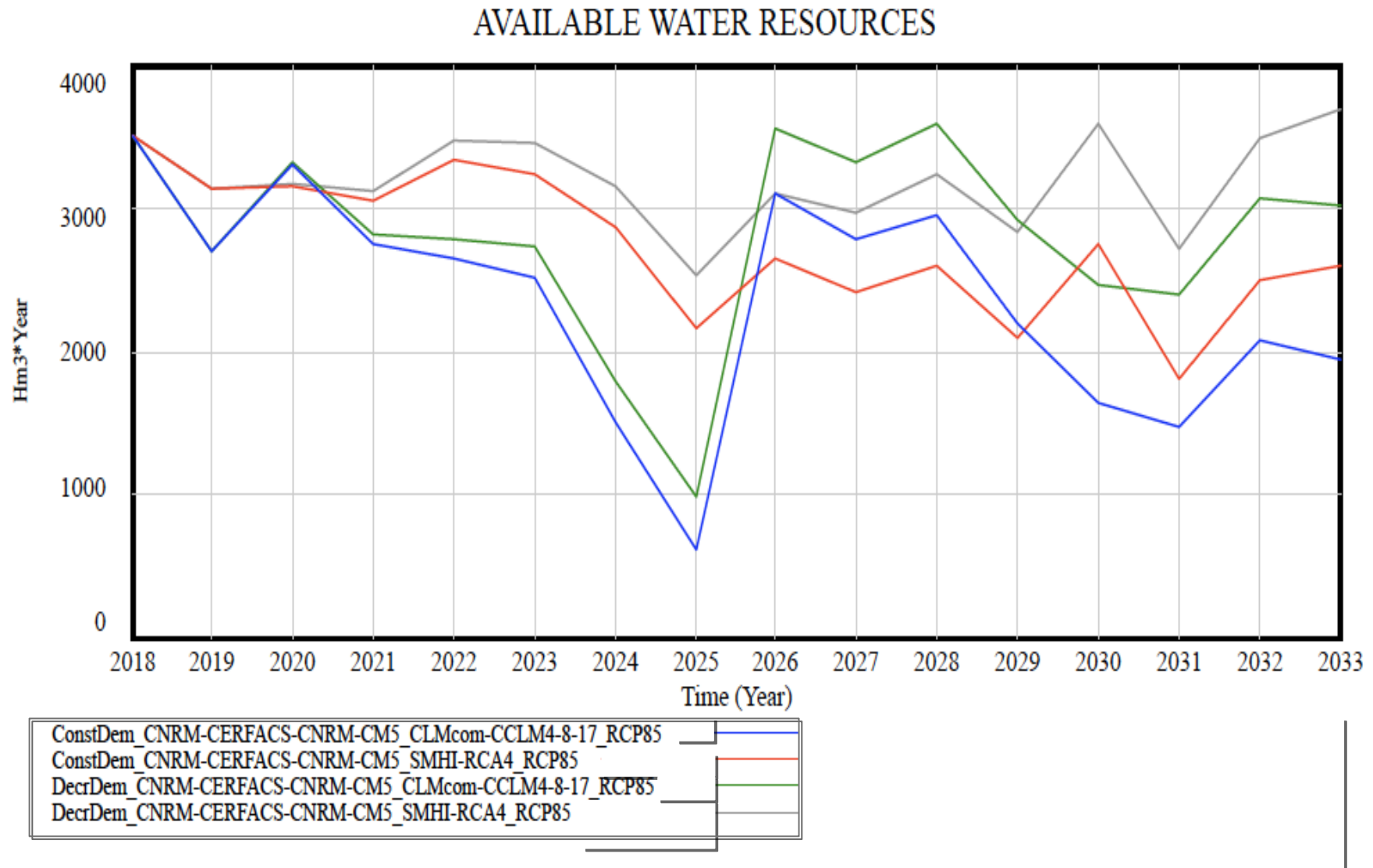
# Qualitative group model



# Qualitative group model



# Social policy experiment – Permanent drought commission





# Social policy experiment – Permanent drought commission

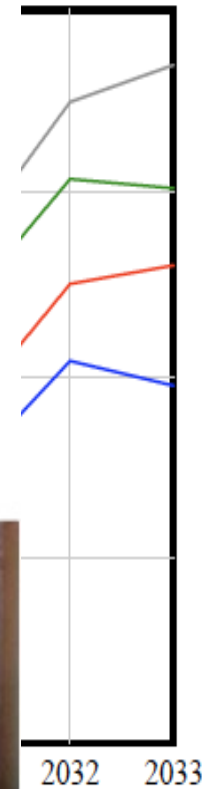
Hm3\*Year

40

30

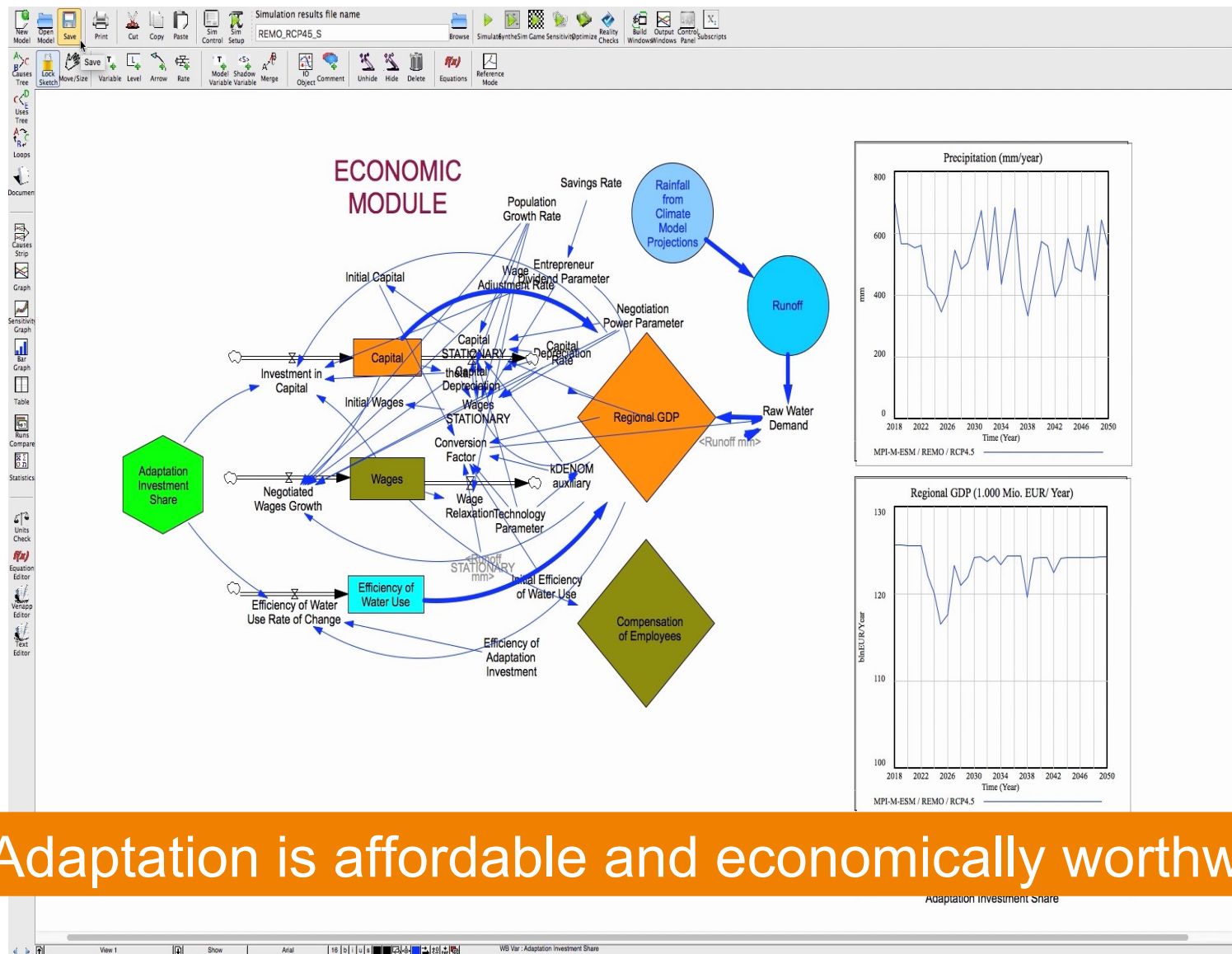
20

10

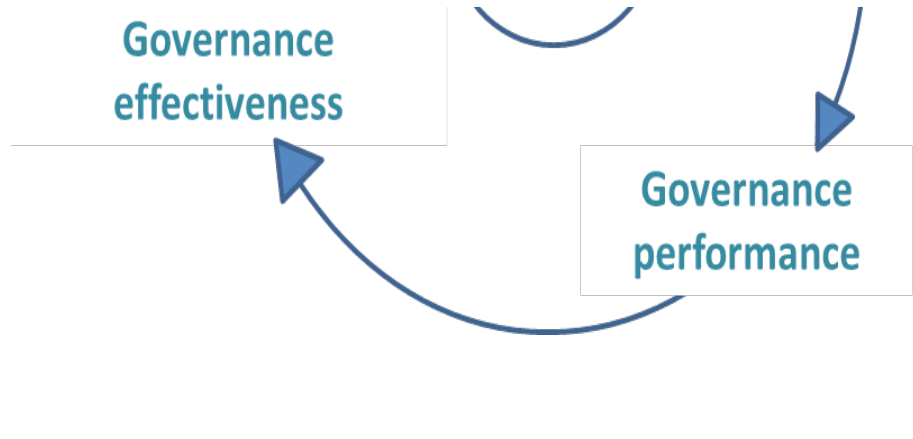


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# Trade-offs – Adaptation Investment Share for Irrigation Efficiency



# Governance performance - Capital Approach Framework Implementation



Factor	No.	Indicator related to the factor	Units of measure	Assess-ment	Notes
		disasters.			
	17	Mobilization of volunteers in the face of risk.			
	<b>Human capital</b>				
Skills and competences	18	Level of education (average academic degree of Commission members)			
	19	Innovation capacity of the Commission members. Enterprising spirit.			
	20	Valuation of the social skills of the members (e.g. assertiveness, active participation and listening, decision making, conflict resolution, etc.)			
	21	Percentage of membership with training on drought management.			
	22	Level of member's experience in drought management.			
	<b>Political capital</b>				
Transparency and trust in political actors	23	Information updating regarding the submission of new laws or decrees related to droughts.			
	24	Equal vote of all Commission members in processes of formal voting.			
	25	Equal participation (the right to have voice) of all Commission members in decision making.			
	26	Percentage of members taking part in internal elections of the Commission (voting participation).			
	27	Existence of statistical surveys published reflecting the opinions of the actors (Commission members and external representatives of drought management partnerships) in regards to the governance of the Commission.			
	28	Existence of comprehensive anti-corruption policy.			
	29	Existence of laws/decrees, etc. in order to provide legal basis that promote the freedom of media.			
Regulatory framework: formal rules and norms	30	Periodic revision and updates of laws and regulations concerning the protection against droughts and the management of drought disasters.			
	31	Existence of emergency plans.			
	32	Existence of obligation to obtain insurance for protection in the face of disasters.			
	33	Existence and open access (whole public) to risk			

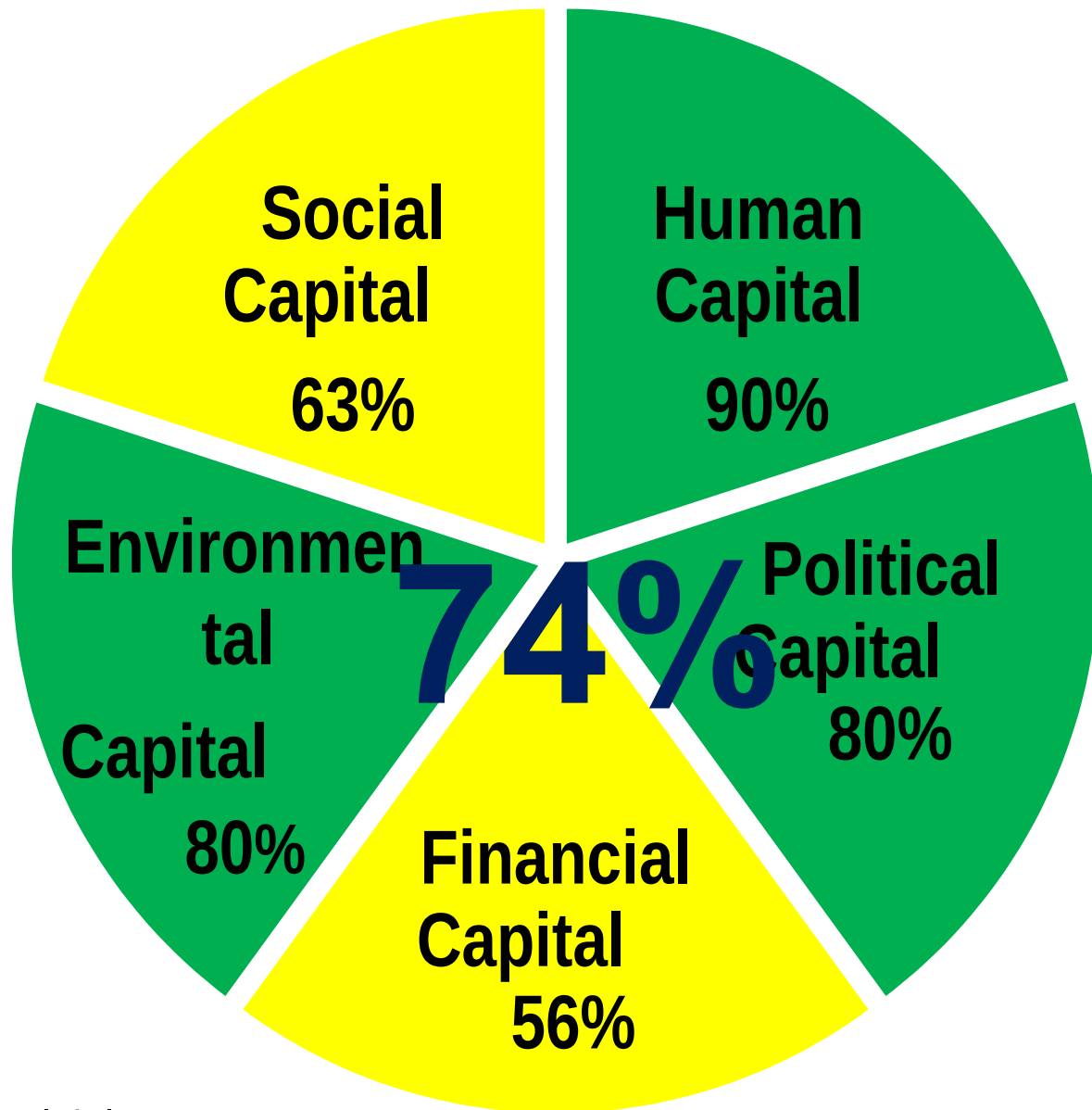
Factor	No.	Indicator related to the factor	Units of measure	Assess-ment	Notes
		(promoted or not by the Commission).			
	<b>Financial capital</b>				
Disaster funds	34	Percentage of the drought expenses covered by the government			
	35	Proportion of public and private investments on drought funding.			
Risk of impoverishment	36	Existence of rights of compensation (offered by the government) to affected population.			
	37	Percentage of losses covered by these compensations if they exist.			
	38	Percentage of households/institutions that have insurance related to the specific threat in basin (e.g. droughts, floods, etc.).			
	39	Percentage of damages that were covered by insurances during the last drought event.			
	<b>Environmental capital</b>				
Regeneration of environment	40	Percentage of ecologic compensation per total area.			
	41	Percentage of actions taken by the Commission for environmental regeneration after a disaster.			
	42	Existence of climate change studies for preparedness for potential increment of drought events.			
Management strategies and planning processes	43	Binding deadlines/committees for implementation of drought management processes.			
	44	Existence of big infrastructures that affect the environment (e.g. diversion of water)			
	45	Percentage of different (and use types within the basin in order to implement targeted strategies/actions to minimize droughts).			
	46	Percentage of protected area within the total basin area			



Factor	No.	Indicator related to the factor	Units of measure	Assess-ment	Notes
	<b>Social Capital</b>				
Available treatment of all parties	1	All members are equal in decision-making processes.			
	2	Existence of a transparent and well established communication process (e.g. periodic reports, meetings, etc.) that guarantees the flow of information.			
Communication and information	3	Existence of platforms, committees and networks where all representatives can join the process of information exchange.			
	4	Cooperation of partners from different sectors such as public, private and civil, as well as agricultural, energy, tourism, etc.			
Participation	5	Amount of periodic formal meetings held between members of the Commission.			
	6	Implementation of monitoring processes (e.g. internal or external audits)			
Knowledge	7	Percentage of individual members of the Commission or institutions represented in the Commission trained in droughts and prevention management.			
	8	Existence of registration of past drought events in the basin. Access to these registrations for all members.			
Trust (of other members)	9	Evidence whether knowledge gained from historical events in the basin has influence over the increase in trust to lead new drought events.			
	10	Existence of longstanding cooperation between the same members which encourages trust (teamwork during years).			
Communication and relation to the society	11	Experiences of conflict and problem resolution.			
	12	Existence of informal boards/groups resulting from cultural-historic development.			
	13	Existence of educational programmes in relation to the droughts promoted by the Commission and/or awareness campaigns addressed to civil society.			
	14	Access by civil society to the last drought events registered in the basin.			
	15	Information material on drought management. Presented through different information channels and available in different languages where appropriate.			
	16	Launching of donation initiatives promoted by the Commission to aid in covering losses caused by natural			



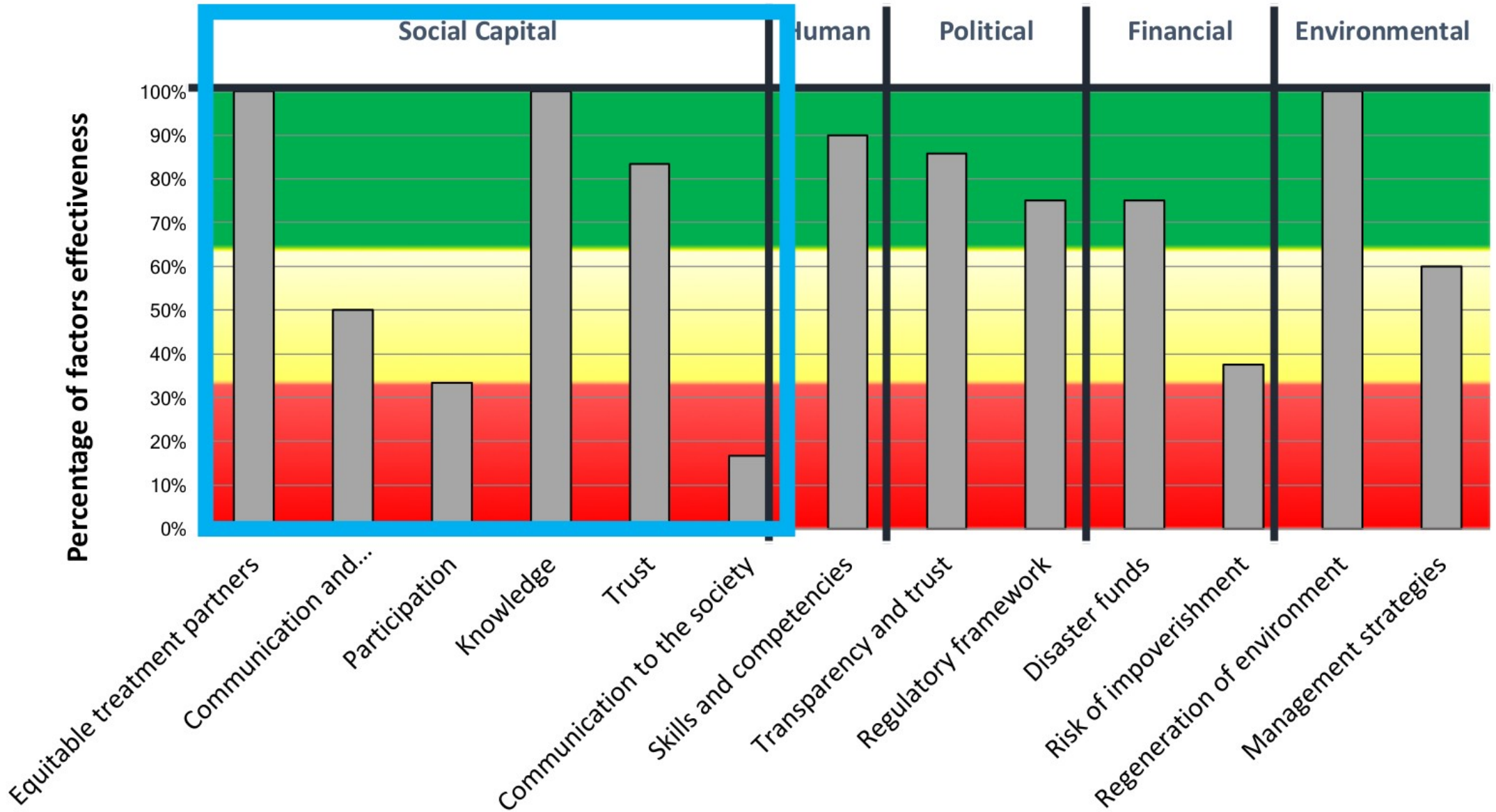
■ Governance performance in the Jucar River Basin – Empirical findings



	Percentage of effective governance related to the capital
Ineffective governance	0% to 32%
Moderately effective governance	33% to 67%
Effective governance	68% to 100%

**Effective**

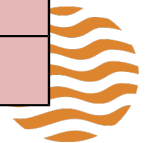
# Governance performance



# Governance performance

## Social Capital

Valuation		Green	Yellow	Red
Indicators		All members are equal in decision-making processes.		Existence of platforms, committees and networks where all representatives can join the process of information exchange.
		All members are equal in decision-making processes. established communication process (e.g. periodic reports, meetings, etc.) that guarantees the flow of information		Amount of periodic formal meetings held between members of the Commission.
		Cooperation of partners from different sectors such as public, private and civil, as well as agricultural, energy, tourism, etc.	Existence of longstanding cooperation between the same members which encourage trust (teamwork during years)	Amount of periodic formal meetings held between members of the Commission. (e.g. internal or external audits).
		Percentage of individual members of the Commission or institutions represented in the Commission trained in droughts and prevention management.		Existence of informal boards/groups resulting from cultural-historic development.
		Existence of registration of past drought events in the basin. Access to these registrations for all members. ?		Existence of educational programmes in relation to the droughts promoted by the Commission and/or awareness campaigns addressed to civil society.
		Evidence whether knowledge gained from historical events in the basin has influence over the increase in trust to lead new drought events.		Information material on drought management. Presented through different information channels and available in different languages where appropriate
		Experiences of conflict and problem resolution.		Launching of donation initiatives promoted by the Commission to aid in covering losses caused by natural disasters.
		Access of the civil society to the last drought events registered in the basin.		Mobilization of volunteers in the face of risk.
	<b>Total indicators</b>	<b>8</b>		<b>1</b>



# ■ Interlinking Science and Society

## We develop innovative, cutting-edge solutions



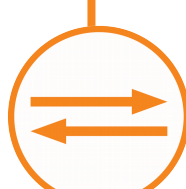
- regional climate modelling
- regional system modelling
- climate change impacts
- economics and politics
- transdisciplinary processes



- prototype product development
- inter- and transdisciplinary approaches
- application of climate service infrastructure
- evaluation of climate services

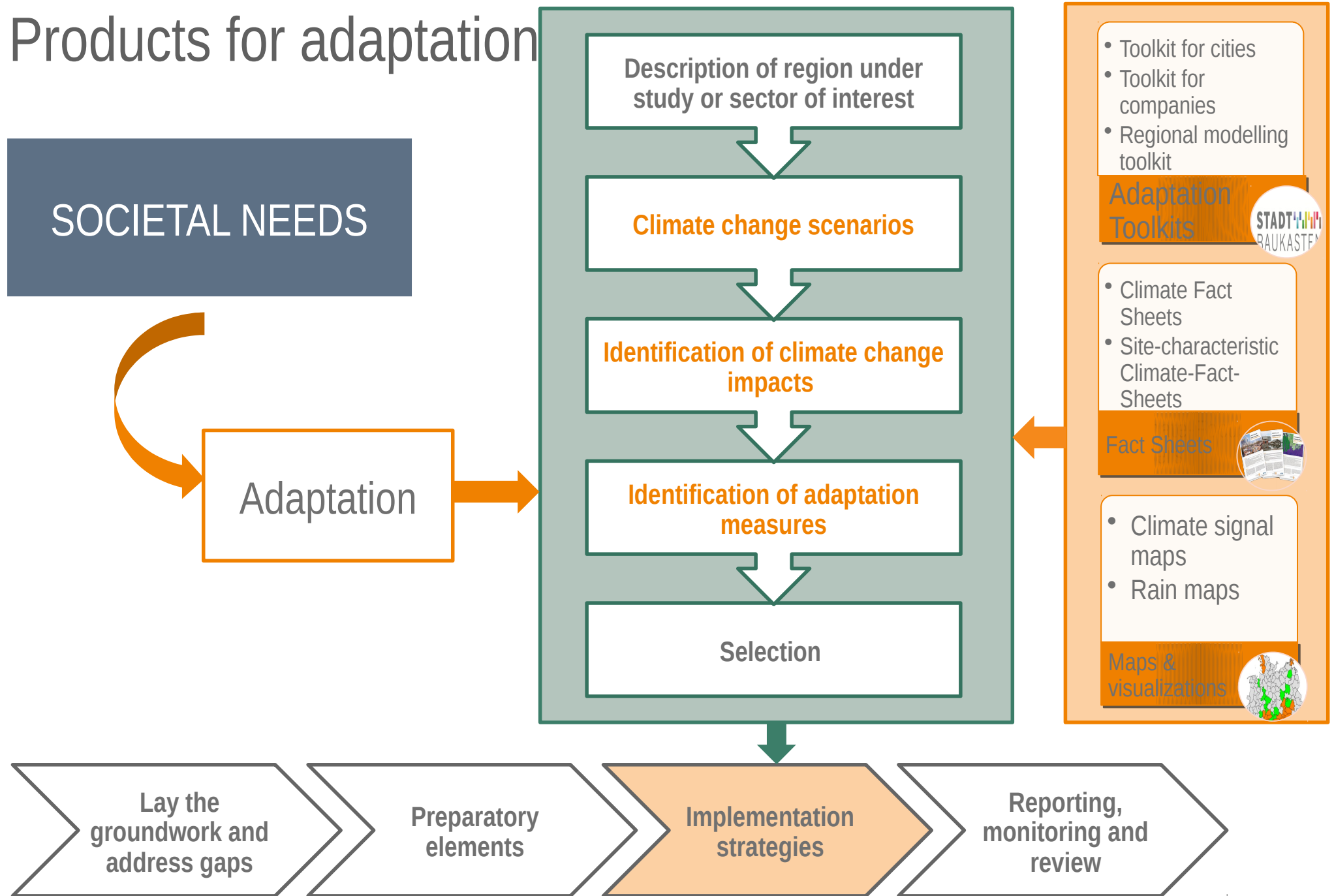


- climate-fact-sheets and focus papers
- maps and visualisations
- modular toolkits
- training concepts
- books, reports and studies



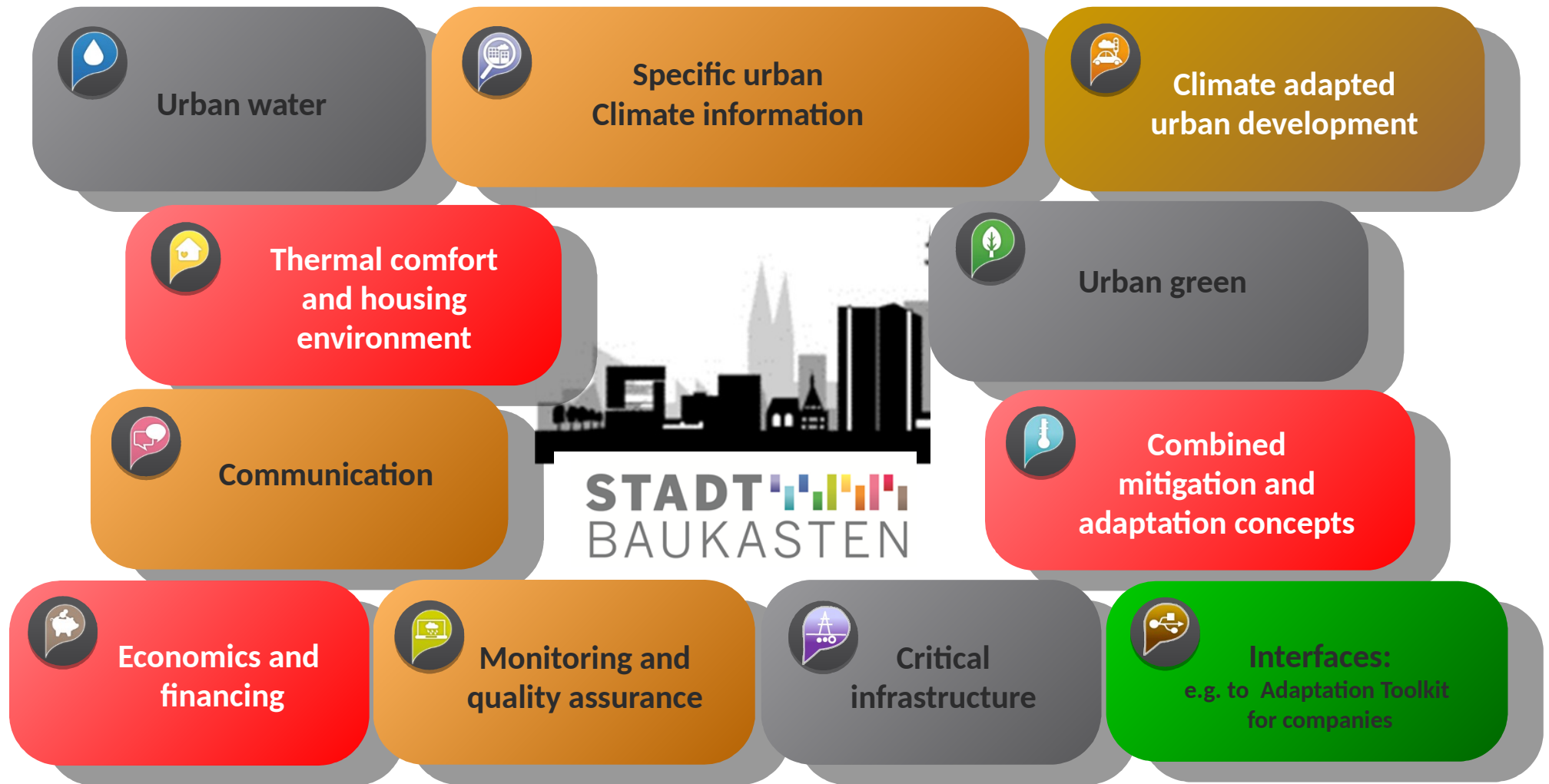
- strategic partnerships and associates
- creating and facilitating networks
- hosting secretariats
- operationalising climate services
- continuous user interaction

# Products for adaptation





# GERICS Adaptation Toolkit for Cities



# GERICS Climate-Fact-Sheets

## Concise climate characteristics of individual countries or regions



## Example-pages from CFS: Burkina Faso – Togo – Ghana

**GERICS**  
Climate Service Center  
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**Current climate**  
Observed mean values are taken from literature and available global data sets (averaged over the whole region):

- Major climate zones (see also climate diagrams - CD1-3):  
Tropical wet and dry (Aw)
- Annual mean temperature: 27°C
- Annual total precipitation: 1100 mm/yr
- Annual mean actual evaporation: 882 mm/yr
- Annual mean climatic water balance\*: 122 mm/yr
- Intensity of heavy rain events\*: 122 mm/day
- Mean duration of dry spells\*: 12 days
- Mean duration of heat waves\*: 7 days
- Mean duration of cold spells\*: 7 days
- Annual mean solar irradiance (surface): 1460 kWh/m<sup>2</sup> / yr
- Annual mean wind speed (10 m above surface): 2.1 m/s

**Reported recent extreme events:**

- In Benin, flood-events in 2010 affected 831,000 people

The climate parameters marked with \* are defined in the manual „How to read a Climate-Fact-Sheet“. Whenever mentioned in the fact-sheet, statistical significance is indicated at the 95% confidence level. The description of the climate zones is based on the Köppen-Geiger climate classification.  
\*\*The climatic water balance is derived from a different data set than precipitation and evaporation, therefore it is possible that the values do not sum up.

**Historical climate trends (based on the global CRU data set and literature sources)**

**Observations from globally available data (CRU) show:**

- A significant temperature increase of 0.04°C per decade was observed between 1901 and 2013, whereas over the last thirty years the observed increase was slightly stronger, but not significantly.
- Over the same period of 113 years almost no change has been observed in annual total precipitation amounts.

**Additional information from literature sources:**

- Over Benin, the annual maximum 30-day total rainfall was 1160 mm between 1960 and 2000.
- No clear trend has been observed in extreme rainfall events.

**Summary of projected future climate (for a 30-year period centred around 2085)**

**Temperature** The likely range of projected change in annual mean temperature is from +1.4 to +5.1°C. Confidence in these figures is medium. The change in temperature is strong. The likely range of projected change in maximum temperature is from +1.5 to +4.8°C.

**Heat waves** The likely range of projected change in the duration of long-lasting heat waves is from +6 to +14 days. Confidence in these figures is medium. The change in duration of long-lasting heat waves can be considered to be strong.

**Cold spells** The likely range of projected change in the duration of long-lasting cold spells is from -11 to +1 days, with only a few projections showing an increase. Confidence in the duration of long-lasting cold spells can be considered to be strong.

**Precipitation** The likely range of projected change in annual total precipitation is from -3 to +7% by 2085. The very likely range is from -8 to +12%, with some projections showing an increase and some a decrease. The projected change in precipitation shows a large relative change for the dry season (November to February). During the rainy season a tendency for a drying in the first half of the rainy season from March to June, whereas in the second half from July to October a slight increase is projected (likely range from -25 to +25%). Confidence in these figures is medium. The change in annual total precipitation can be considered to be weak.

**Dry spells** The likely range of projected change in the duration of long-lasting dry spells is from -10 to 0 days by 2085 and the very likely range is from -24 to +4 days, with only a few projections showing an increase. Confidence in these figures is low. The change in the duration of long-lasting dry spells can be considered to be weak.

Climate-Fact-Sheet  
Benin - Ghana - Togo 2

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**Projections of possible development of precipitation and water availability**

**Annual total precipitation**

- Likely range of projected change in annual total precipitation is from -1 to +5% by 2030, from -2 to +6% by 2050 and from -3 to +7% by 2085.
- Very likely range: -4 to +10% by 2030; -6 to +12% by 2050; -8 to +12% by 2085.

**Separate scenario examination (by 2085):**

- Low-Scenario: Median +1%
- High-Scenario: Median +4%

**Comparison to projections of IPCC AR4:**

- Latest ARS projections show the same outcome of no clear trend but with a smaller bandwidth.

**Range of projected changes for all simulations with global mean warming below 2°C or above 4°C (by 2085):**

- below 2°C-target: -3 to +8%
- above 4°C-threshold: -8 to +16%

**Precipitation seasonality (by 2085)**

- A large relative change is projected for the dry season (November to February). During the rainy season, there is a tendency for a drying in the first half of the rainy season from March to June, whereas in the second half from July to October a slight increase is projected.
- Likely range (rainy season): -25 to +25%.
- Very likely range (rainy season): -30 to +30%.

During the rainy season, there is almost no difference between the changes in precipitation projected under the low and high scenario.

**Signal strength**

**Confidence**

Left part of figures: Bandwidth of change of all model simulations from IPCC ARS for the low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emission scenarios combined. - likely range (central 95%) - very likely range (central 90%)

Right part of figures: Very likely range: Median, High, Low

Other information: Range of projected changes by end of century (IPCC-AR4, ARS) - for above 4°C globally - for below 2°C globally

Left figure: relative change in the seasonal precipitation cycle by 2085. The coloured lines represent the median for the different scenarios, respectively, the grey shadings the different ranges.

Bottom figure: observed seasonal cycle of precipitation (in mm/month) derived from globally available monthly observation data (CRU). It is depicted to support the interpretation of the projected changes.

Left figure: relative change in the duration of long-lasting dry spells is from -7 to +1 days by 2030, from -8 to 0 days by 2050 and from -10 to -14 to +3 days by 2085.

Left figure: relative change in the duration of long-lasting cold spells is from -11 to +1 days, with only a few projections showing an increase. Confidence in the duration of long-lasting cold spells can be considered to be strong.

Left figure: relative change in the duration of long-lasting heat waves is from +6 to +14 days. Confidence in these figures is medium. The change in duration of long-lasting heat waves can be considered to be strong.

Left figure: relative change in the frequency of a heavy rainfall event of today's intensity is from +5 to +31% by 2030, from +7 to +36% by 2050 and +5 to +42% by 2085.

Climate-Fact-Sheet  
Benin - Ghana - Togo 6

Available on request:

[www.climate-service-center.de/climate-fact-sheets](http://www.climate-service-center.de/climate-fact-sheets)

Jointly developed with



# The Climate-Fact-Sheet – a successful prototype product

## Key data of the Climate-Fact-Sheets

- 58 Climate-Fact-Sheets available as of December 2017
- ~ 300 different single customers
- 14 new Climate-Fact-Sheets will be produced for IFAD



Climate Service Center  
**Climate-Fact-Sheet**  
 Benin - Ghana - Togo  
 Updated Version 2015

**Abstract**  
 The region comprising Benin, Ghana and Togo is characterised by hot and humid tropical conditions (Aw) and distinctive wet and dry seasons with a strong influence of the West African Monsoon. In general, the region shows a moderate climate response to the increasing greenhouse gas concentrations. The region will experience a significant increase in annual precipitation, a decrease in the number of dry days, and a decrease in the number of hot days. The annual mean temperature will increase by 0.8 to 1.4 °C by 2050, with a very likely range of 0.8 to 1.4 °C. The annual mean precipitation will increase by 10 to 15 % by 2050, with a very likely range of 10 to 15 %.

**Zusammenfassung**  
 Das Klima der Region, welche die Länder Benin, Ghana und Togo umfasst, ist typischerweise tropisch und Regenwetter (Aw). Während es ein starkes Einfluss der Westafrikanischen Monsun-Systeme. In der Regel zeigt die Region eine moderate Klimareaktion auf die zunehmende Konzentration der Treibhausgasen. Die Region wird einen signifikanten Anstieg der Jahresniederschlag, eine Abnahme der Anzahl der trockenen Tage und eine Abnahme der Anzahl der heißen Tage erleben. Die mittlere Jahresmitteltemperatur wird um 0,8 bis 1,4 °C bis 2050 ansteigen, mit einem sehr wahrscheinlichen Bereich von 0,8 bis 1,4 °C. Der mittlere Jahresniederschlag wird um 10 bis 15 % bis 2050 ansteigen, mit einem sehr wahrscheinlichen Bereich von 10 bis 15 %.

On behalf of  
 KfW BMZ Federal Foreign Office German Development Cooperation GERICS Climate Service Center Germany

The abstract page about the development of the future

GERICS Climate Service Center Germany

**Current climate**  
 Observed mean values are taken from literature and available good data sets (based on the whole region):  
 • Major climate zones (see also climate diagrams - CDI3): Tropical wet/dry (Aw)  
 • Annual mean temperature: 27°C  
 • Annual precipitation: 1500 mm/y  
 • Annual mean cloud response: 80% monthly  
 • Annual mean relative humidity: 72% monthly  
 • Mean duration of dry spells: 12 days  
 • Mean duration of hot spells: 7 days  
 • Annual mean wind speed (10 m above surface): 2.1 m/s  
 • Annual mean wind speed (10 m above surface): 2.1 m/s

**Historical climate trends (based on the global CDI data set and literature sources)**  
 Observations from globally available data (CDI) show:  
 • A significant temperature increase of 0.8°C per decade was observed between 1951 and 2013, whereas over the last five years the observed increase was slightly stronger, but not significant.  
 • Over the same period of 15 years almost no change has been observed in annual total precipitation amounts.

**Summary of projected future climate (based on a 30-year period centered around 2030 and continued for all scenarios)**  
**Temperature**  
 The likely range of projected change in annual mean temperature is from +1.4 to +4.2°C by 2050, and the very likely range is from +1.4 to +4.1°C. Confidence in these figures is medium. The change in temperature is considered the medium strong. The likely range of projected change in maximum temperature is from +1.3 to +4.1°C by 2050 and in the minimum temperature from +1.5 to +4.4°C.

**Heat waves**  
 The likely range of projected change in the duration of long-lasting heat waves is from +10 to +50 days by 2050, and the very likely range is from +10 to +45 days. Confidence in these figures is medium. The change in the duration of long-lasting heat waves can be considered to be strong.

**Cold spells**  
 The likely range of projected change in the duration of long-lasting cold spells is from -0.2 to 2 days by 2050, and the very likely range is from -0.1 to 1.1 days. Confidence in these figures is low. The change in the duration of long-lasting cold spells can be considered to be strong.

**Precipitation**  
 The likely range of projected change in annual total precipitation is from 3 to +7% by 2050. The very likely range is from 3 to +7%, with some projections showing an increase and some showing a decrease. The projected change in precipitation shows a large relative change. Due to the very high inter-model spread, the projected change in precipitation is considered to be medium strong. The likely range of projected change in precipitation is from +5 to +15% by 2050, and the very likely range is from +5 to +15%.

**Dry spells**  
 The likely range of projected change in the duration of long-lasting dry spells is from -1 to +1 days by 2050 and the very likely range is from -1 to +1 days, with only a few projections showing an increase. Confidence in these figures is low. The change in the duration of long-lasting dry spells can be considered to be weak.

Climate-Fact-Sheet Benin - Ghana - Togo 2

In this part data are:

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**Projections of possible development of temperature, heat waves and cold spells**  
**Annual mean temperature**  
 The likely range of projected change in annual mean temperature is from +0.8 to +1.4°C by 2050, and the very likely range is from +0.8 to +1.4°C. Confidence in these figures is medium. The change in temperature is considered the medium strong. The likely range of projected change in maximum temperature is from +1.3 to +4.1°C by 2050 and in the minimum temperature from +1.5 to +4.4°C.

**Maximum and minimum temperature**  
 The trends of maximum and minimum temperature are consistent with the trend of annual mean temperature depicted above.  
 • Likely range of projected change in maximum temperature is from +1.3 to +4.1°C by 2050, and the very likely range is from +1.3 to +4.1°C.  
 • Likely range of projected change in minimum temperature is from +1.5 to +4.4°C by 2050, and the very likely range is from +1.5 to +4.4°C.

**Heat waves**  
 The likely range of projected change in the duration of long-lasting heat waves is from +10 to +50 days by 2050, and the very likely range is from +10 to +45 days. Confidence in these figures is medium. The change in the duration of long-lasting heat waves can be considered to be strong.

**Cold spells**  
 The likely range of projected change in the duration of long-lasting cold spells is from -0.2 to 2 days by 2050, and the very likely range is from -0.1 to 1.1 days. Confidence in these figures is low. The change in the duration of long-lasting cold spells can be considered to be strong.

Climate-Fact-Sheet Benin - Ghana - Togo 6

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**Projections of possible development of wind speed**  
 The likely range of projected change in annual mean wind speed is from 0 to +11% by 2050, and the very likely range is from 0 to +11% by 2050. Confidence in these figures is low. The change in wind speed is considered to be weak.

**Projections of possible changes in regional sea level**  
 The likely range of projected change in regional sea level is from -0.1 to +0.5 m by 2050, and the very likely range is from -0.1 to +0.5 m. Confidence in these figures is low. The change in sea level is considered to be weak.

**What is presented in the sea level change figure?**  
 For the likely range of projected change in regional sea level, the projections are based on different coupled atmosphere-ocean general circulation model simulations, which are the basis of the IPCC AR5 chapter 13 on sea level rise. Due to data availability, projected changes in sea level are presented for the 20-year period from 2030 to 2050 and 2080 to 2100 to be consistent with the reference period from 1986 to 2005. Projected changes are also presented for each of the three emission scenarios (RCP2.6, RCP4.5, and RCP8.5) and for the full range, but a measure of uncertainty. The blue lines indicate the likely range, and the red lines indicate the very likely range.

**Vulnerability to sea level change:**  
 Coastal areas of Benin, Ghana and Togo are vulnerable to future changes in sea level. They experience frequent coastal erosion and flooding. In the world there is a forecast impact in the magnitude of about 0.5 m of sea level rise by 2050. The sea level rise in this scenario is the world when estimating potential impacts of sea level rise and increased storm surges on the agriculture in coastal areas.

Climate-Fact-Sheet Benin - Ghana - Togo 8

Possible shown as plus change year peric

Possible

# Climate-Fact-Sheets in a nutshell

- Climate-Fact-Sheets usually have some 4 to 6 pages with short text passages, tables and different diagrams
- Focus of the Climate-Fact-Sheets is on the projected future changes. Short information on current climate and past extremes is also included.
- Information is based on primary data (e.g. projections from global and regional climate models or continental wide observational datasets) and literature review

## Climate parameters included in the Climate-Fact-Sheets

Temperature (Annual mean, min, max)

Heat waves and cold spells

Precipitation (Annual total, Seasonal cycle), Evaporation, climatological water balance

Dry spells and heavy rainfall events

solar Irradiance, Wind speed, Sea level rise

The image displays six pages of a Climate-Fact-Sheet for Pakistan, organized into a grid. Each page contains a mix of text, tables, and charts. The pages cover the following topics:

- Page 1 (Top Left):** Introduction and overview of the sheet, including a table of contents and a summary of key findings.
- Page 2 (Top Middle):** Current climate conditions, including annual mean temperature, precipitation, and other key parameters.
- Page 3 (Top Right):** Projections of possible development of temperature, heatwaves, and cold spells, including annual mean temperature and maximum/minimum temperature.
- Page 4 (Middle Left):** Projections of possible development of precipitation and water availability, including annual total precipitation and precipitation seasonality.
- Page 5 (Middle Right):** Projections of possible development of wind speed and climatological water balance, including annual mean wind speed and evaporation.
- Page 6 (Bottom):** Projections of possible development of solar irradiance, wind speed, and sea level rise, including annual mean solar irradiance and sea level rise.

Each page includes a header with the title 'Climate-Fact-Sheet Pakistan' and the logo of the Climate Service Center (CSC) and the German Research Aerospace Establishment (DLR). The pages also feature various charts, including line graphs, bar charts, and tables, illustrating the projected changes and uncertainties.

# ■ Main elements of a Climate-Fact-Sheets

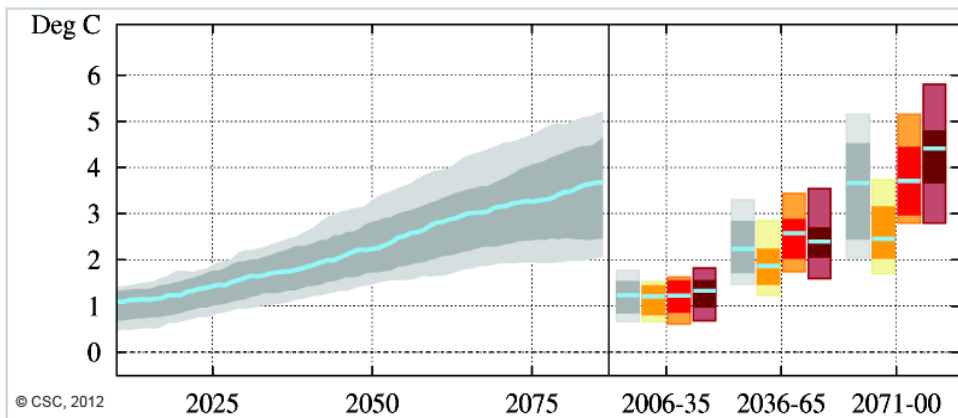
Detailed description of temporal development projected changes

## Annual mean temperature

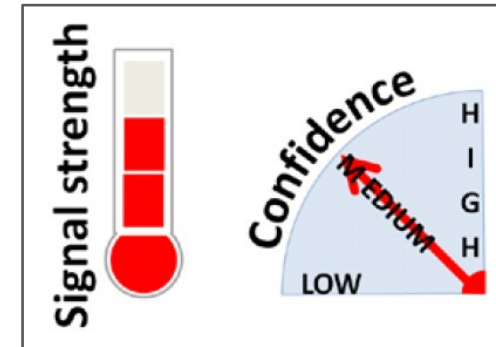
- Median projection of change in annual mean temperature is for an increase of 3.7 °C by 2100.
- Likely range: 2.5 to 4.5 °C; very likely range: 2.0 to 5.2 °C

Separate scenario examination:

- **Low-Scenario B1:** Median +2.5 °C
- **High-Scenario A2:** Median +4.4 °C



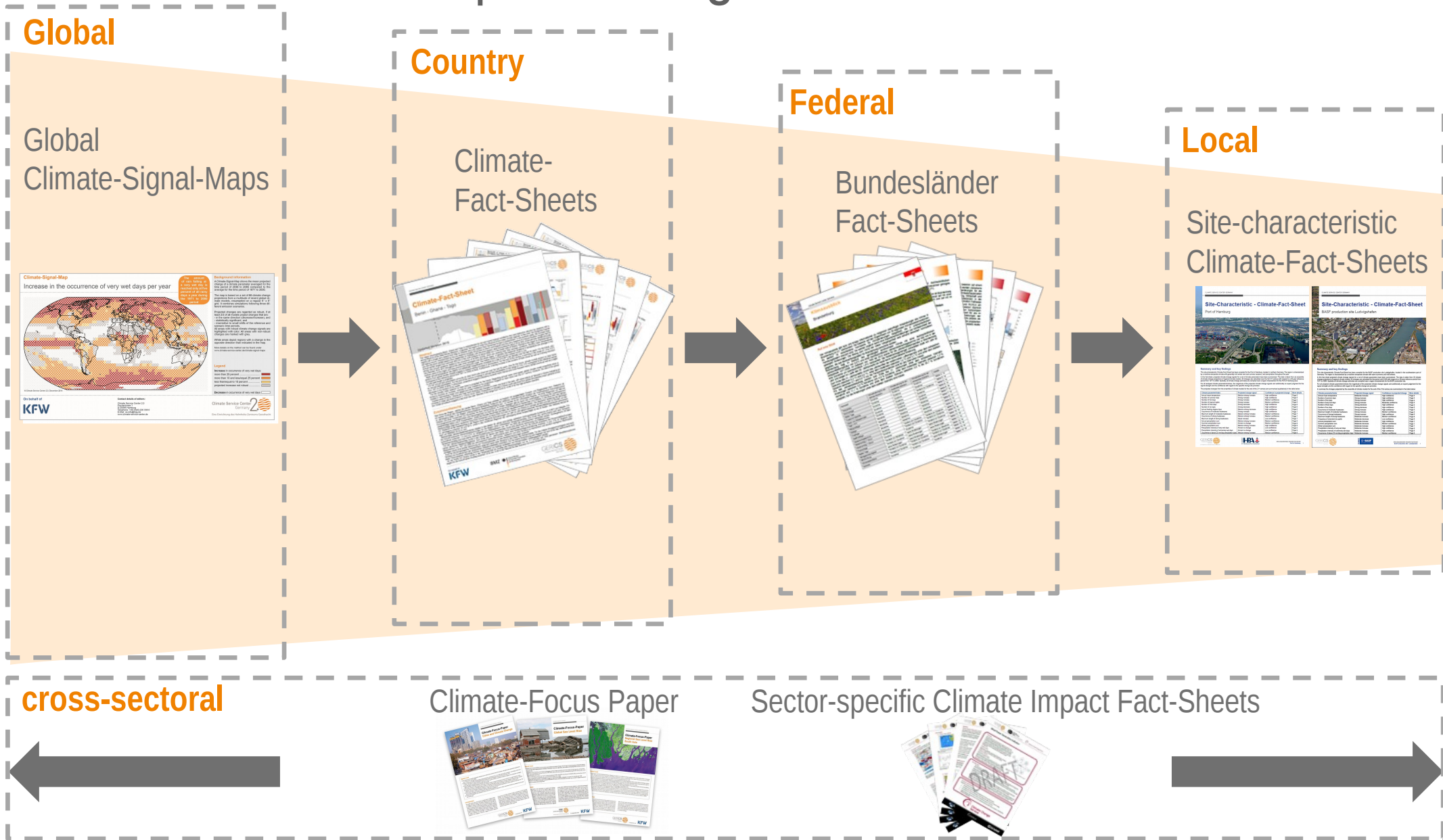
Expert Judgement on signal strength and confidence



based on

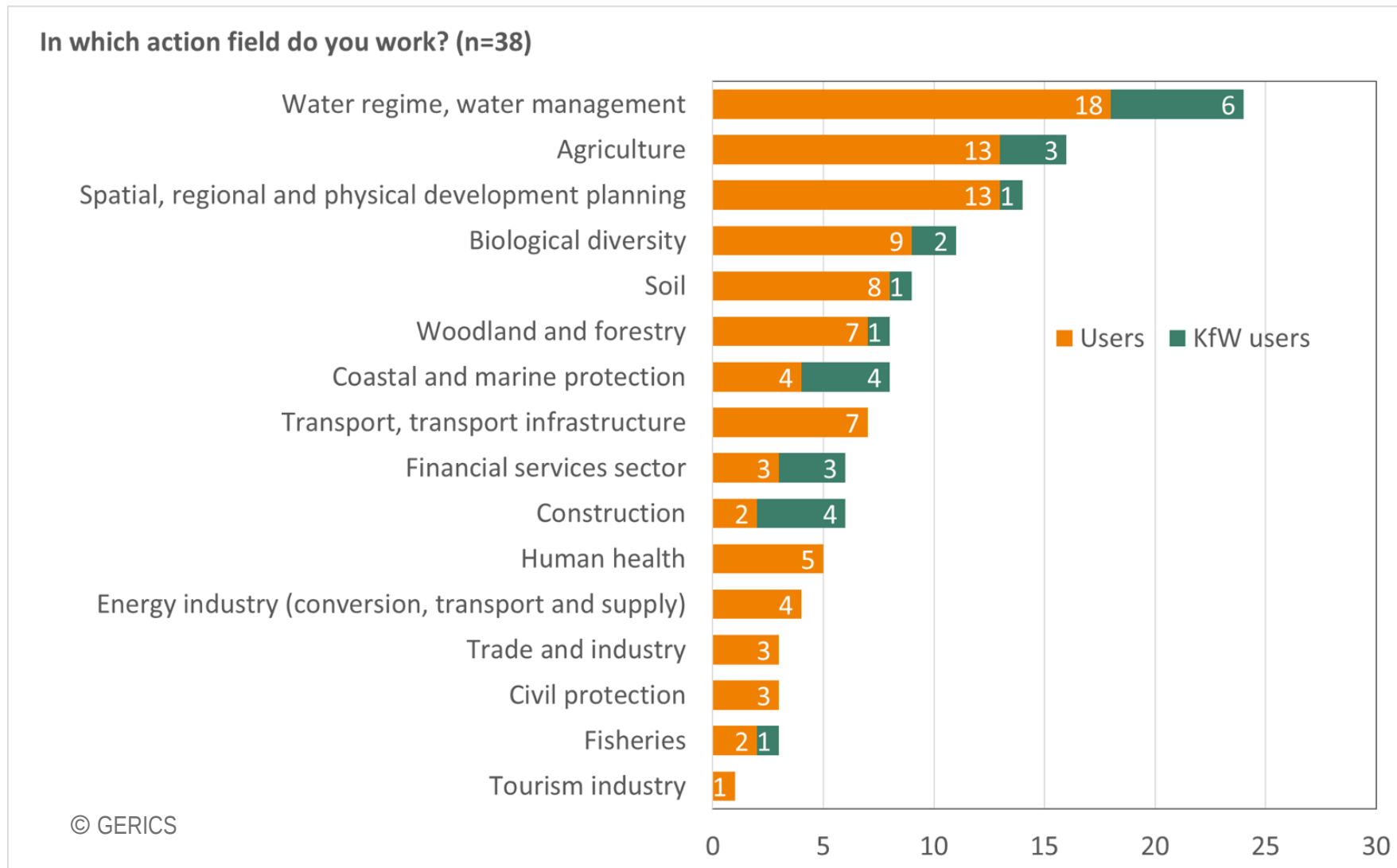
- statistical significance & magnitude of absolute change
- quality of simulations in comparison to observations
- signal-to-noise ratio of projected changes
- agreement of model simulations

# Fact-Sheet concept covers global scales and issues



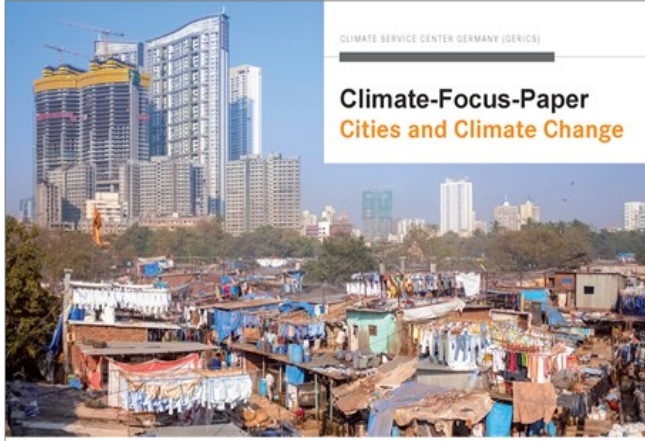


# ■ Use of GERICS Climate-Fact-Sheets (CFS)





# GERICS Climate-Focus-Papers



CLIMATE SERVICE CENTER GERMANY (GERICS)



## Climate-Focus-Paper Cities and Climate Change

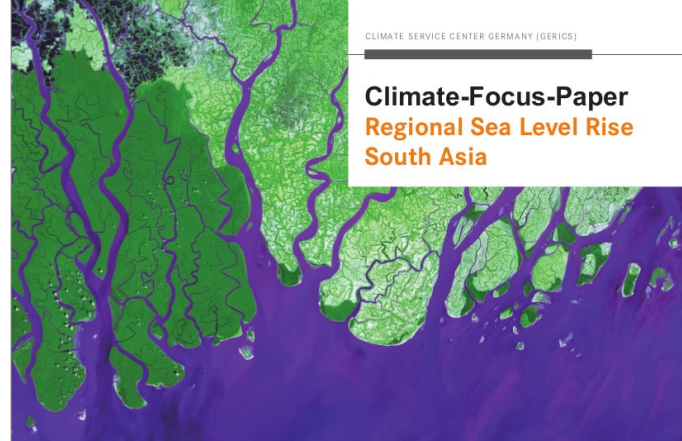
**Speed read**

- The majority of the world's population already lives in urban areas, and this trend will increase, with global urban population projected to have increased to 66% by 2050.
- Cities consume up to 80% of total global energy production, and account for 71 to 76% of global CO<sub>2</sub> emissions. Accordingly, cities have a major role to play in achieving the global climate policy goal of limiting global warming to no more than 2°C.
- Cities are highly vulnerable to climate change, and as such, require coherent, carefully considered mitigation and adaptation strategies, where potential co-benefits between the two, are included.
- With carbon emissions still rising, and the threat posed by climate impacts becoming ever clearer, there is an urgent need for action.
- Existing infrastructure in developing cities is often of substandard quality, and thus fails to provide adequate protection from extreme weather events and changing climatic conditions. The urban poor are particularly vulnerable towards extreme weather events.
- Many of the world's cities are situated along the coast, and as such are exposed to flooding from storm surges and sea level rise. The risk of coastal flooding is further increased in cities affected by subsidence.
- Financing for mitigation and adaptation actions exist, but are difficult to access for cities. Innovative solutions are needed now to close the finance gap.

**Introduction**

This paper outlines the role of cities as being drivers of global climate change and at the same time being affected by climate change. In addition to climate change, cities are confronted by challenges in relation to urbanization, natural hazards, and their interaction. The paper highlights the need to reduce greenhouse gas (GHG) emissions through climate mitigation policies, as well as the need for adaptation action to combat existing and potential climate impacts. Moreover, the paper underlines the challenges in finding synergies between adaptation and mitigation measures, suggests possible adaptation responses to inevitable climate change, and points out the financial barriers. The main focus lies on rapidly growing cities in developing countries and emerging economies. Given the complexity and unique characteristics of individual cities, it is not possible to provide an in-depth analysis of existing and projected climate risks, and possible mitigation and adaptation policies, for one particular city. Rather, this Focus-Paper provides a brief overview of various aspects, topics, and sectors of relevance to cities in general.

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## Climate-Focus-Paper Regional Sea Level Rise South Asia

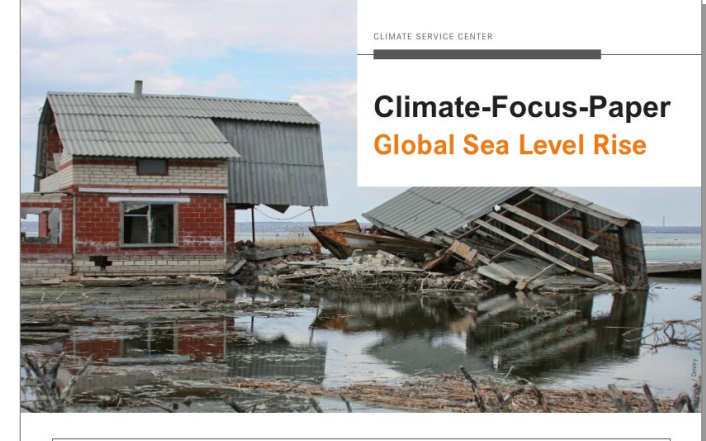
**Speed read**

- South Asian countries bordering the Bay of Bengal are subject to a number of climate related hazards, chief among which is rising sea levels. Rising sea levels lead to impacts in many different economic sectors, including agriculture, water resources, and human health. As such, many economic sectors will need to adapt to the threat posed by rising sea levels.
- Successful adaptation to rising sea levels requires an understanding of the relative importance of the various drivers of change, whether these be climatic, or non-climatic factors. Understanding changes in sea level in the highly populated and low-lying south Asian region is of major importance, but is challenging because of inadequate tide-gauge, and subsidence time-series, data.
- Tide gauge observations of changes in sea level in the region show a large range of variation in linear rates of relative sea level rise (RSLR), ranging from 0.7 mm yr<sup>-1</sup> at Chennai, to 8.2 mm yr<sup>-1</sup> at Charchanga, in the Ganges delta.
- Projections of future changes in RSLR across the region, in 2080-2099, are fairly similar, with mean increases in the range 0.32 m to 0.38 m under a stringent mitigation scenario (RCP2.6), and 0.53 m to 0.58 m under a business-as-usual scenario (RCP8.5). These projections do not take account of local subsidence, however, which in some areas is a more important driver of changes in RSLR than climatic factors.
- Coastal flooding is one of the most important impacts associated with rising sea levels, and a major study shows the avoided damage costs by investing in infrastructure adaptation, i.e. dikes and sea walls, to maintain present day standards, may be as high as 1800%.

**Introduction**

Changes in mean sea level are the result of the complex interplay of a number of climatic and non-climatic factors. Regional and local mean sea level may differ significantly from global mean sea level because of variation in the relative importance of the different factors across the world'. A Focus Paper on Global Sea Level Rise is also available which discusses these issues'. Particularly at the regional and local level, the importance of non-climatic factors, e.g. subsidence or uplift, may be more important drivers of sea level change, than climatic ones. As such, when developing projects and considering investment decisions that may be sensitive to changes in sea level, it is important that adequate consideration of all relevant factors has been taken, and the implications this may have for projects well understood. This Focus Paper highlights the challenge of understanding changes in sea level, and the associated impacts, for a region in south Asia, focused on the Bay of Bengal.

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## Climate-Focus-Paper Global Sea Level Rise

**Speed read**

- Global mean sea level (GMSL) rise is one of the main indicators of climate change, and is of major concern for policy and decision makers, as it can have wide ranging impacts including on freshwater resources, agriculture, the incidence of flooding events, and loss of land in coastal areas.
- Adapting to these impacts is essential but challenging, as there is large uncertainty around how high sea levels may rise, and how fast.
- GMSL has increased by 0.19 m over the period 1901-2010, and the rate of increase has accelerated during the 20<sup>th</sup> century, with current rates estimated at 3.2 mm yr<sup>-1</sup>.
- GMSL is projected to increase over the 21<sup>st</sup> century by between 0.28 m and 0.98 m by the year 2100 (IPCC AR5), and the future rate of increase is very likely to exceed the rate observed over the period 1971-2000.
- Using the IPCC AR5 estimates, it is possible to suggest an upper limit for GMSL of between 1.4 m and 1.6 m by the year 2100.
- This Climate-Focus-Paper is intended to provide information on various issues associated with GMSL rise, in order to support investment decisions in coastal and low-lying areas.

**Background**

When planning projects and investments in coastal and low-lying areas the potential impact of sea level rise (SLR) is highly relevant, particularly in the context of feasibility studies. Planners and decision makers may wish to know what a plausible upper limit for sea level rise may be. Establishing an upper limit for sea level rise is extremely challenging, as changes in sea level are the result of a range of different physical processes. At the global scale the chief processes are through thermal expansion as the oceans warm, and through the addition of water from land ice i.e. from melting glaciers and ice sheets. It is estimated that since the early 1970s these two processes account for around 75% of the observed global mean sea level rise'. Adapting to the impacts of SLR however, will take place at the local to regional scale, where additional processes related to vertical land movement e.g. subsidence or uplift, sedimentation rates, ocean currents, gravity, and regional variation in temperature and salinity, will also need to be considered in deriving local estimates of sea level change'. These factors will be discussed in more detail in a supplementary regional sea level focus paper. Here, the focus is on understanding past and future changes in global mean sea level, and the impacts that SLR has in a range of different economic sectors, illustrated with a detailed analysis of the impacts associated with flooding events. The work presented in this paper draws heavily on the results reported in the recent IPCC Fifth Assessment Report (AR5).

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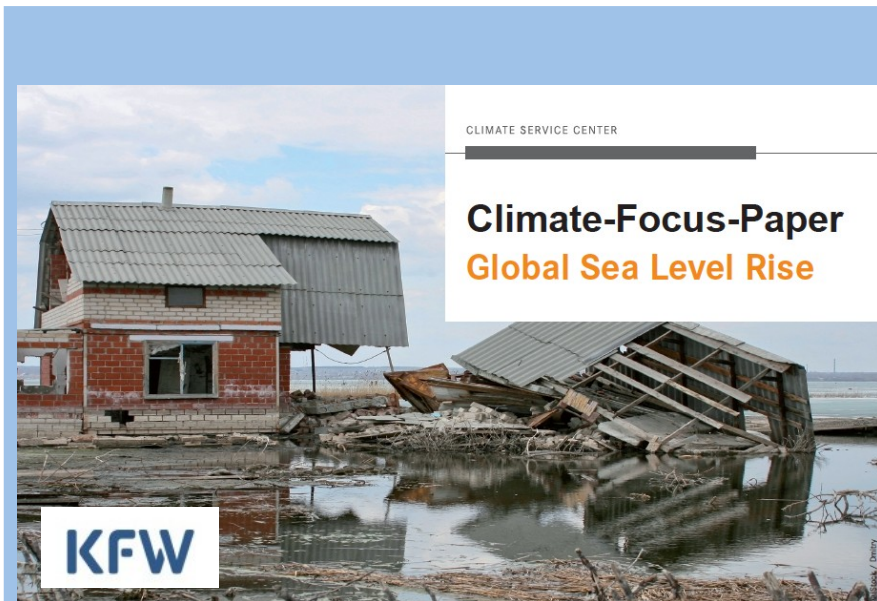
# ■ Climate-Focus-Paper

## Value

Climate-Focus-Paper provide an **accessible but wide-ranging introduction** to a topic of major relevance to the work of development cooperation. The paper helps project managers and technical experts **to better incorporate and consider** the importance of the specific topic, when carrying out climate feasibility studies

## Topics included in the Climate-Focus-Paper on Global Sea Level Rise

- "Speed Read" und Background
- Past and present sea level rise
- Differences between global and regional sea level change
- Future sea level change; potential limits of global mean sea level rise
- Impacts and Costing global mean sea level rise
- References and Weblinks

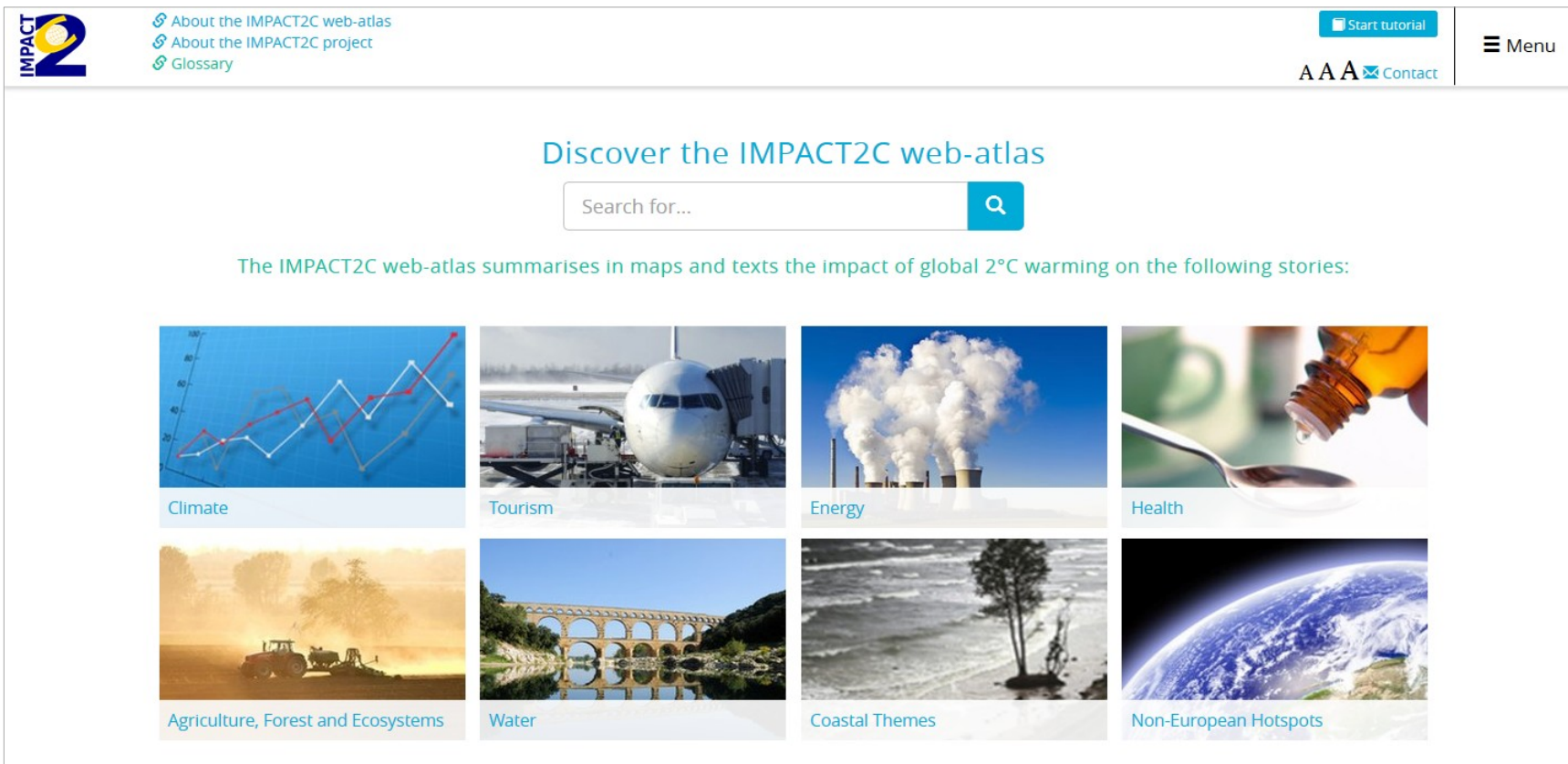




# IMPACT2C web-atlas

GERICS coordinated the EU Project IMPACT2C: Estimating the key impacts of a +2°C climate change signal for different regions and sectors of the world. The IMPACT2C web-atlas provides climate change information for the development of possible adaptation strategies.

[www.atlas.impact2c.eu](http://www.atlas.impact2c.eu)



IMPACT2C

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About the IMPACT2C project  
Glossary

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The IMPACT2C web-atlas summarises in maps and texts the impact of global 2°C warming on the following stories:

Climate

Tourism

Energy

Health

Agriculture, Forest and Ecosystems

Water

Coastal Themes

Non-European Hotspots



# GERICS products in a nutshell

## Fact Sheets

- Climate Fact Sheets
- Site-characteristic Climate-Fact-Sheets
- GERICS Climate-Focus-Paper



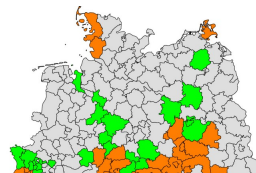
## Toolkits

- Adaptation toolkit for Cities (*Stadtbaukasten*)
- Adaptation toolkit for Companies (*Unternehmensbaukasten*)
- Regional modeling toolkit (*Regionaler Modellierbaukasten*)



## Maps and Visualizations

- GERICS Climate Signal Maps
- GERICS Climate Signal Maps (global)
- GERICS Rain Map



## Trainings

- Customer specific training
- Sector specific training
- Capacity building programmes for countries in Africa, Asia and Latin-America
- Publications and tools supporting our capacity building measures



## Publications

- National Assessment on Climate Change
- GERICS Reports
- Studies, Brochures and Documentations
- Klima konkret
- Newsletter
- Books
- GERICS articles at Earth System Knowledge Platform (ESKP) of Helmholtz-Association
- Publications in scientific journals



## Webportals

- IMPACT2C Web-Atlas
- Klimanavigator
- Document Server Climate Change (Dokumentenserver Klimawandel)



# For further information: Visit GERICS online

[www.gerics.de](http://www.gerics.de)

Key interfaces to users and practitioners are the GERICS web-services. The main gateway is the homepage, which is available in German, English, and in Arabic (only main pages).

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## Prototypical product development

**Developing Climate Service Prototypes for Products and Services**  
Both the commercial and the public sectors have recognised the growing importance of climate-relevant questions, particularly in regards to reducing greenhouse gas emissions (mitigation). The need, however, for adapting to climate change is often neither sufficiently understood nor taken into consideration in long-term planning. One reason is because strategic planning in business, for example, might normally only cover a time period of a few years. It can also be attributed to the fact that decision makers often lack the necessary knowledge on this topic. GERICS is dedicated to this issue by developing application-oriented knowledge in close cooperation with partners and customers so that the climate perspective can be adequately integrated into the respective decision process. This concerns Climate Service product and service prototypes that precisely correspond to the particular user's needs. The practicability of the prototypes is then tested after development. The emphasis, however, lies in the development of prototypes. Operational creation of products is handed over to third parties where appropriate.

# ■ Contact

## Contact:

Claas Teichmann  
María Máñez  
Climate Service Center Germany  
Fischertwiete 1  
20095 Hamburg

[claas.teichmann@hzg.de](mailto:claas.teichmann@hzg.de)  
[maria.manez@hzg.de](mailto:maria.manez@hzg.de)  
[www.climate-service-center.de](http://www.climate-service-center.de)