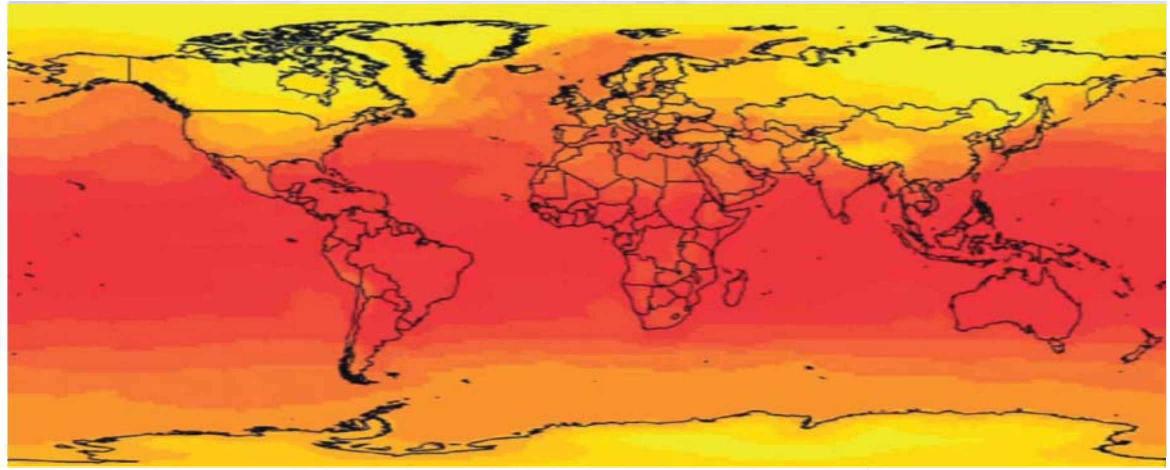


KLIWAS: organisational aspects and current work of BfG on climate change

1st Rhine-Mekong Symposium
"Climate change and its influence on water and related sectors"
8-9 May 2014, Koblenz, Germany

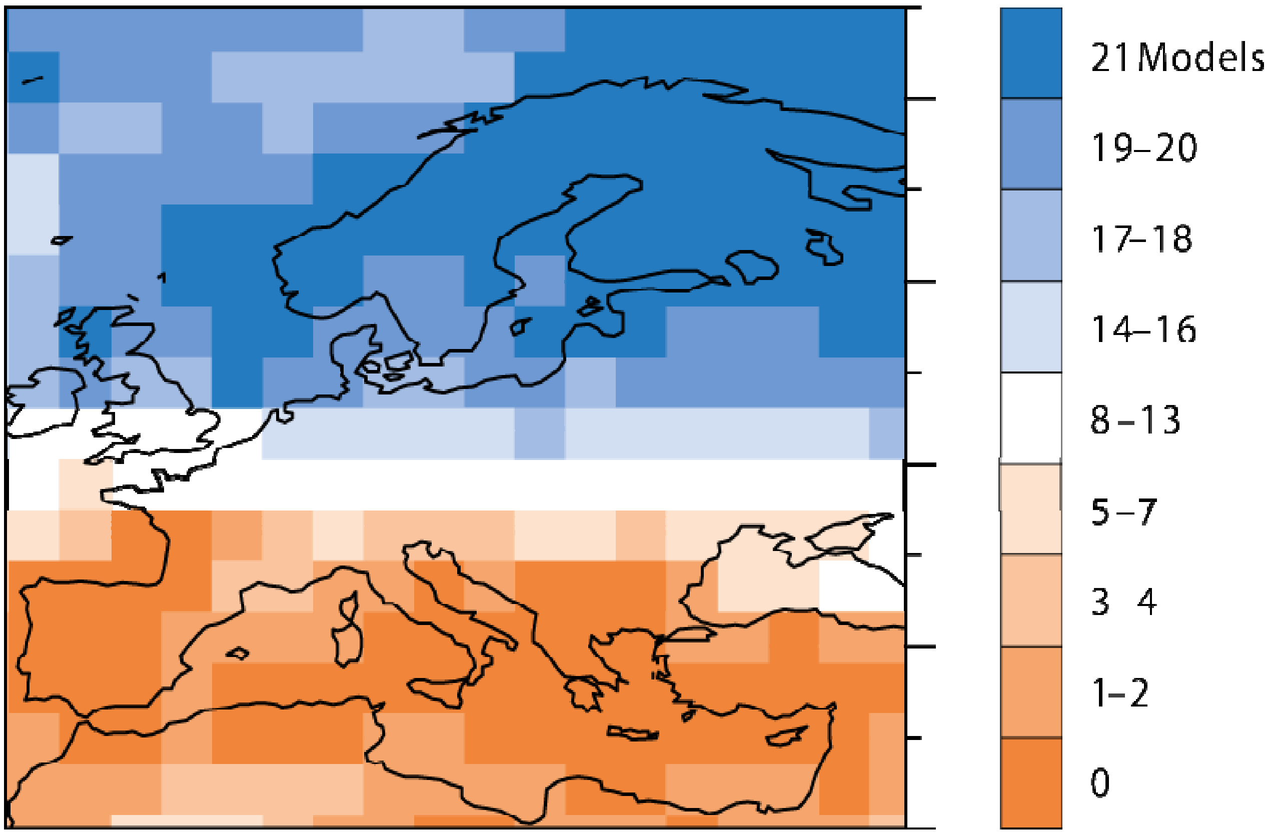
Sebastian Kofalk & Stefanie Wienhaus, BfG

Drought

Low flow Rhine river 2003

Courtesy: BfG

Uncertainty, global Scale: Range of GCM: 21 Projections (A1B)



Number of models projecting an increased annual mean precipitation

comparison of the periods 1980–1999 and 2080–2099, Multi-Model Data (MMD)

Figure 1: Number of models projecting an increased annual mean precipitation (comparison of the periods 1980–1999 and 2080–2099, Multi-Model Data (MMD), A1B Scenario)

IPCC, CHRISTENSEN et al. 2007

Reliable supply?

Policy Questions

- How will climate change influence inland and coastal waterways in Germany?
- When will changes occur?
- What is the range of regional potential changes?
- What adaptation measures can help?

KLIWAS

DWD BSH bfg BAW

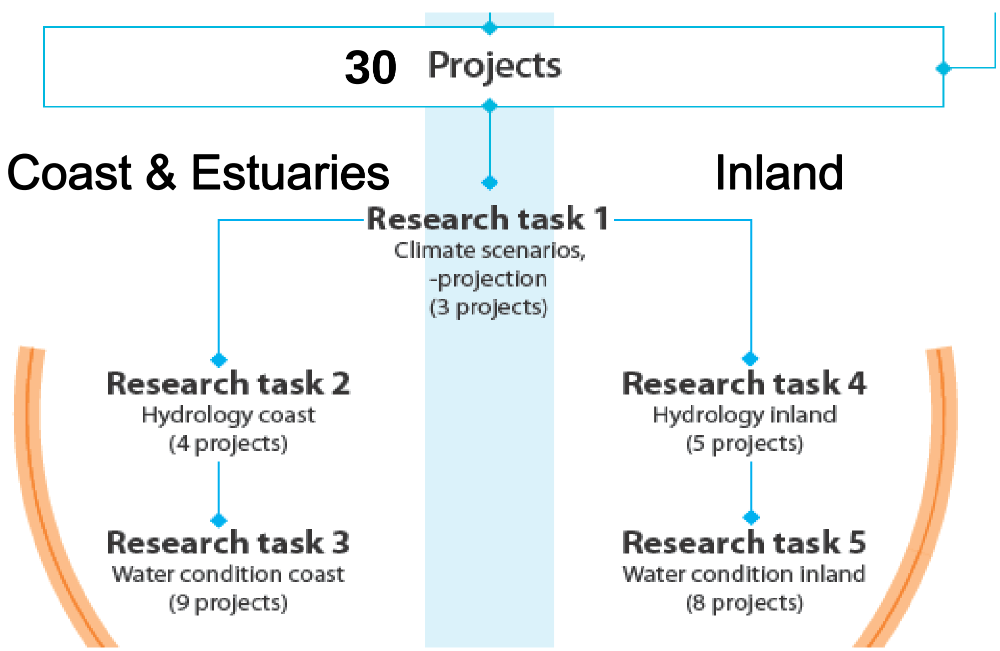
+

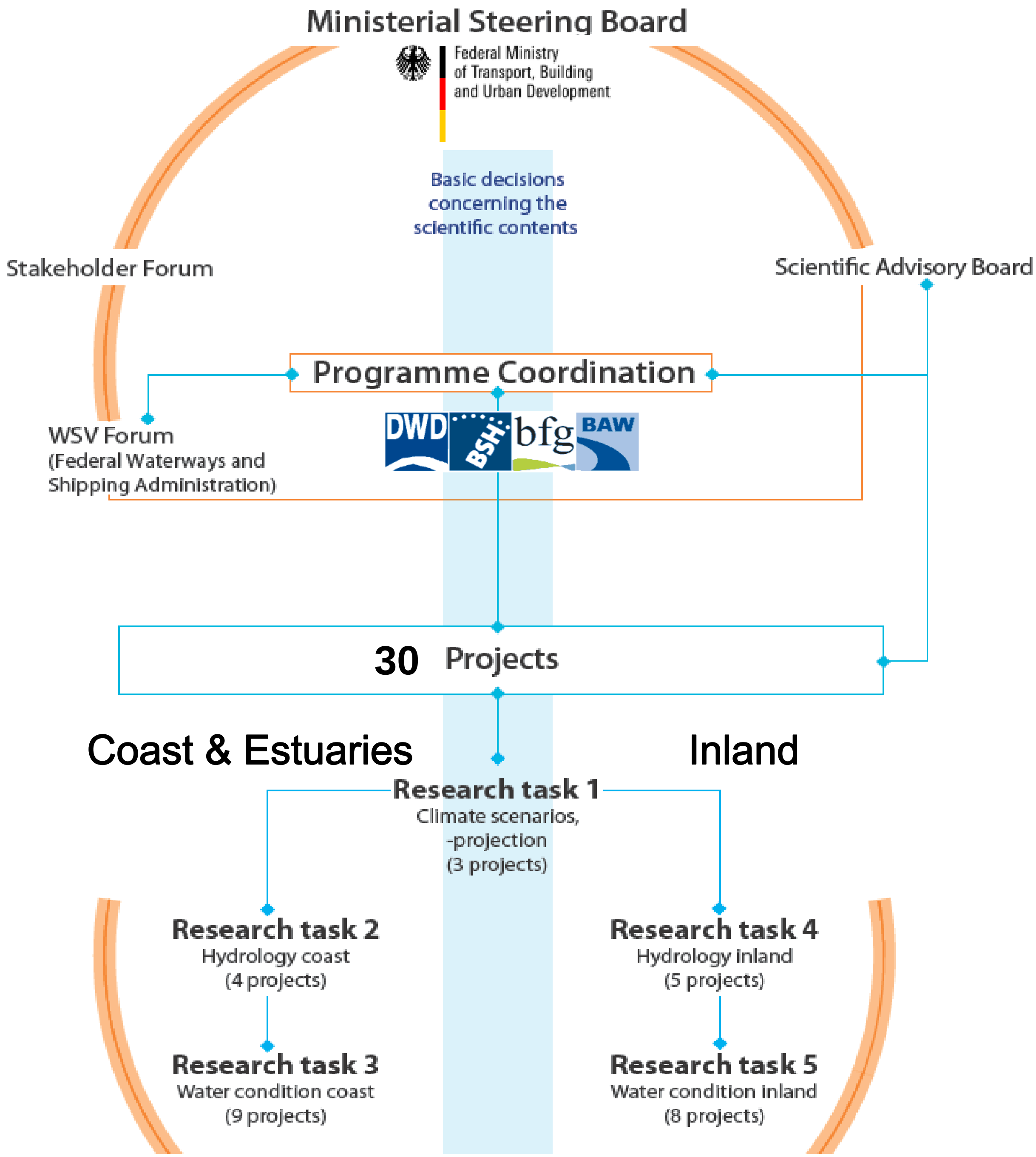
national and international cooperation

30 Projects

+

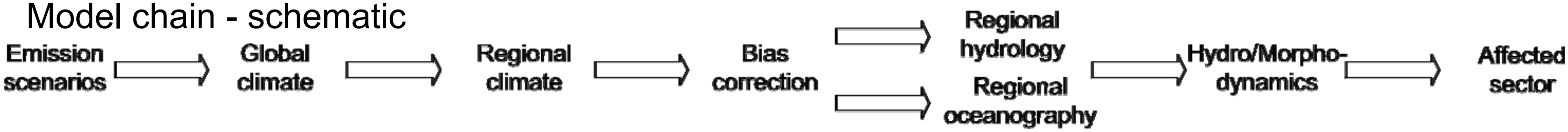
national and international cooperation



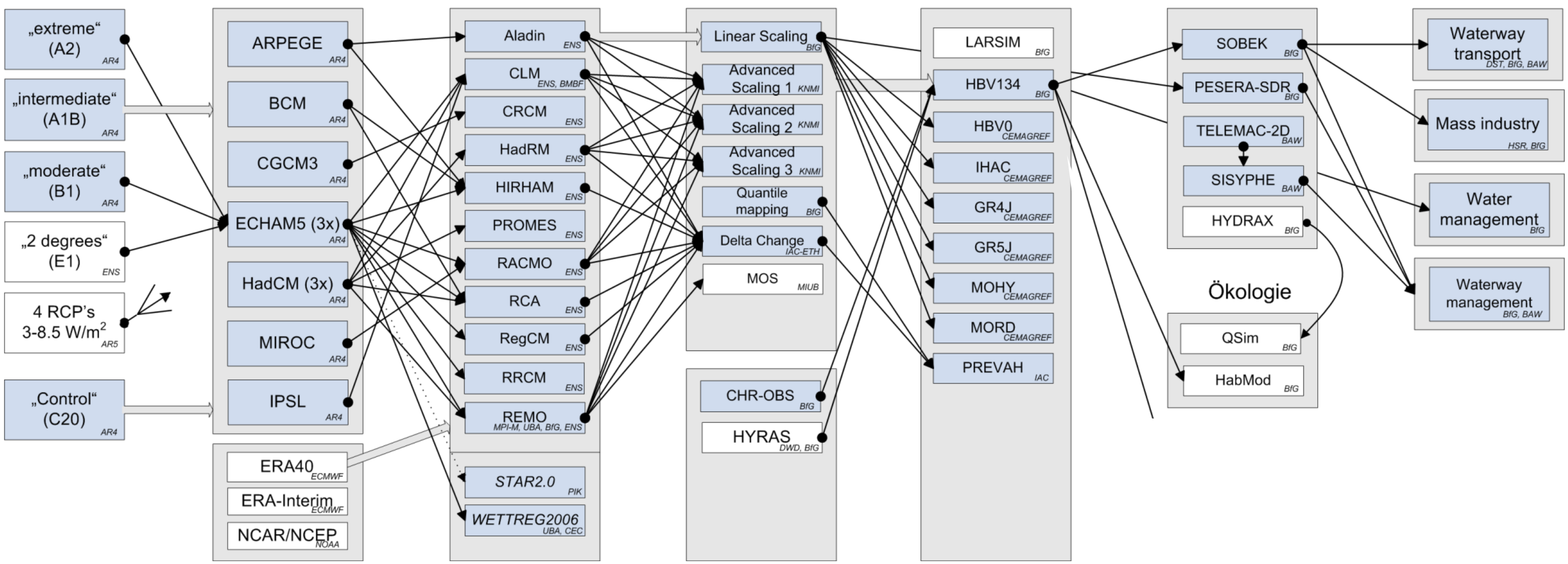

Ministerial Steering Board
Federal Ministry of Transport, Building and Urban Development
Basic decisions concerning the scientific contents
Stakeholder Forum
Scientific Advisory Board
Programme Coordination
WSV Forum
(Federal Waterways and Shipping Administration)
DWD
BSH
bfg
BAW
30 Projects
Coast & Estuaries
Inland
Research task 1
Climate scenarios, -projection
(3 projects)
Research task 2
Hydrology coast
(4 projects)
Research task 3
Water condition coast
(9 projects)
Research task 4
Hydrology inland
(5 projects)
Research task 5
Water condition inland
(8 projects)

Multi model approach

Model chain - schematic



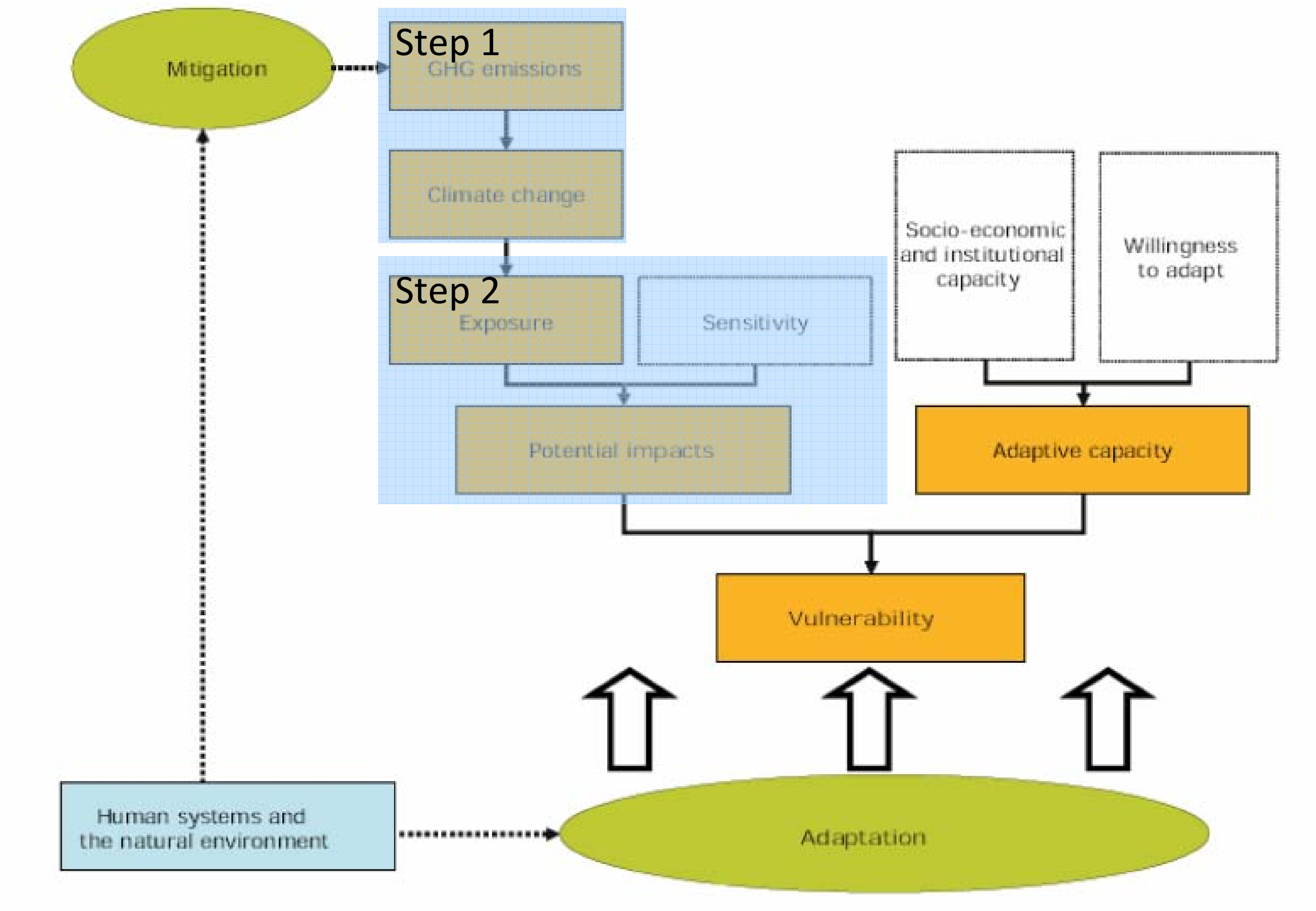
Model chain - data



Selection of relevant indicators

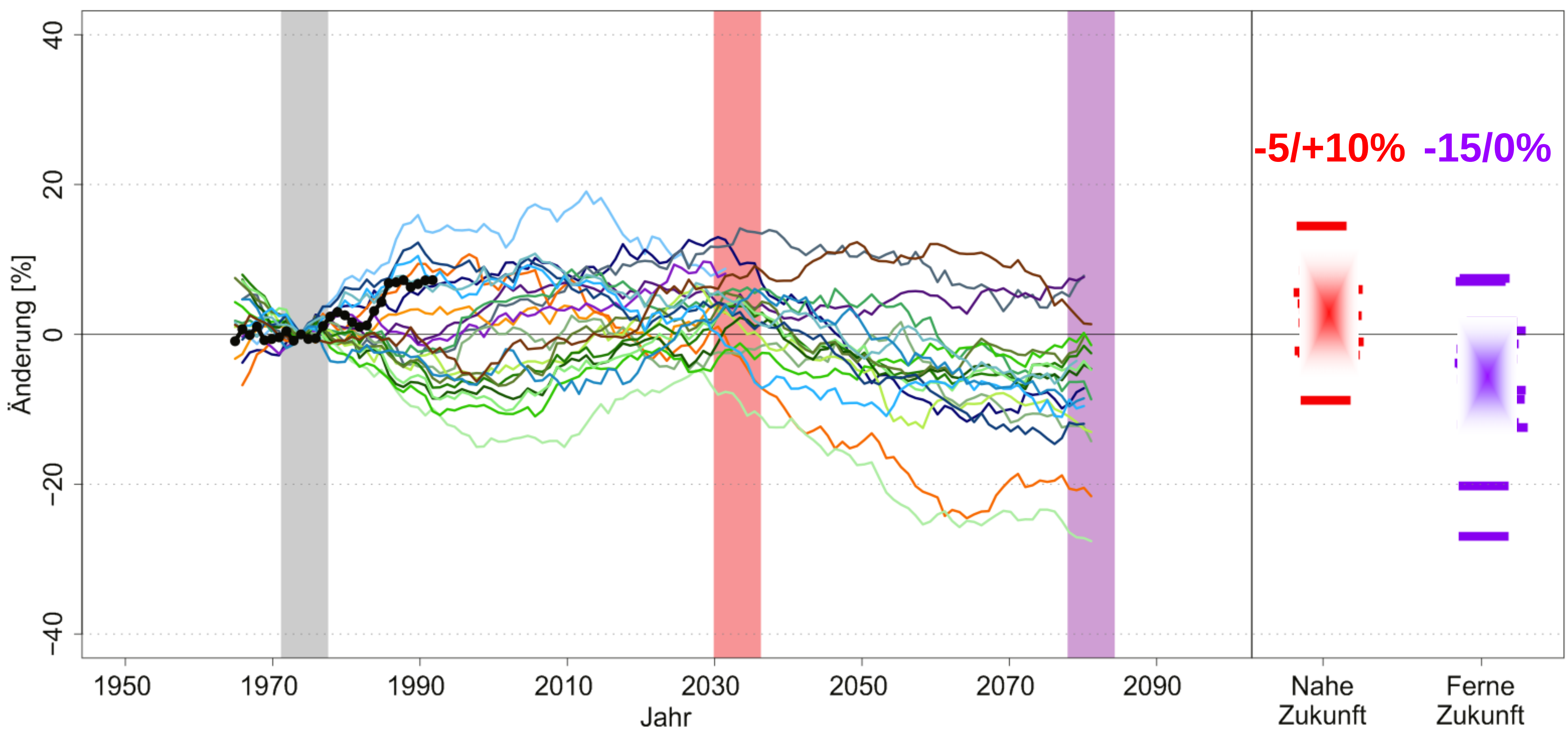
Diagnostics	Notation	Unit	Description and definitions
Average discharge	MQ	m³/s	**Mean discharge; arithmetic mean of daily mean discharge per time-span** (annual and seasonal, with reference to the hydrological year or hydrological season); averaged to 30- year long-term annual seasonal means; hydrological yearbook primary statistic
Low flow	NM7Q	m³/s	**Lowest arithmetic mean of discharge during 7 consecutive days**; calculated per hydrological season; averaged to 30- long long-term annual or seasonal means
	FDC_Q90	m³/s	**Discharge undershot on 10% of all days of a 30- year period** (i.e. the 90th percentile of the flow duration curve representing 10950 days, no leapyears taken into account)
High flow	MHQ	m³/s	**Mean maximum discharge**; arihtmetic mean of all annual maximum discharges (per hydrological year) per timespan (here: 30- year, 3000- year); hydrological yearbook primary statistic
	HQ10	m³/s	**Discharge corresponding to a 10- year return period**, i.e. discharge which occurs once every 10 years; calculated from a fitted distribution to the annual (hydrological year) maximum discharge values per timespan in a return level plot; for HQ10 a 30-year time-span is used
	HQ100	m³/s	**Discharge corresponding to a 100- year return period**; a 3000-year time-span from the rainfall generator is used

vulnerability



[5] European Environment Agency. 2008. Impacts of Europe's changing climate: 2008 indicator based assessment (Ch.6. Adaptation to climate change; figure from Isoard, Grothmann and Zebisch (2008)).

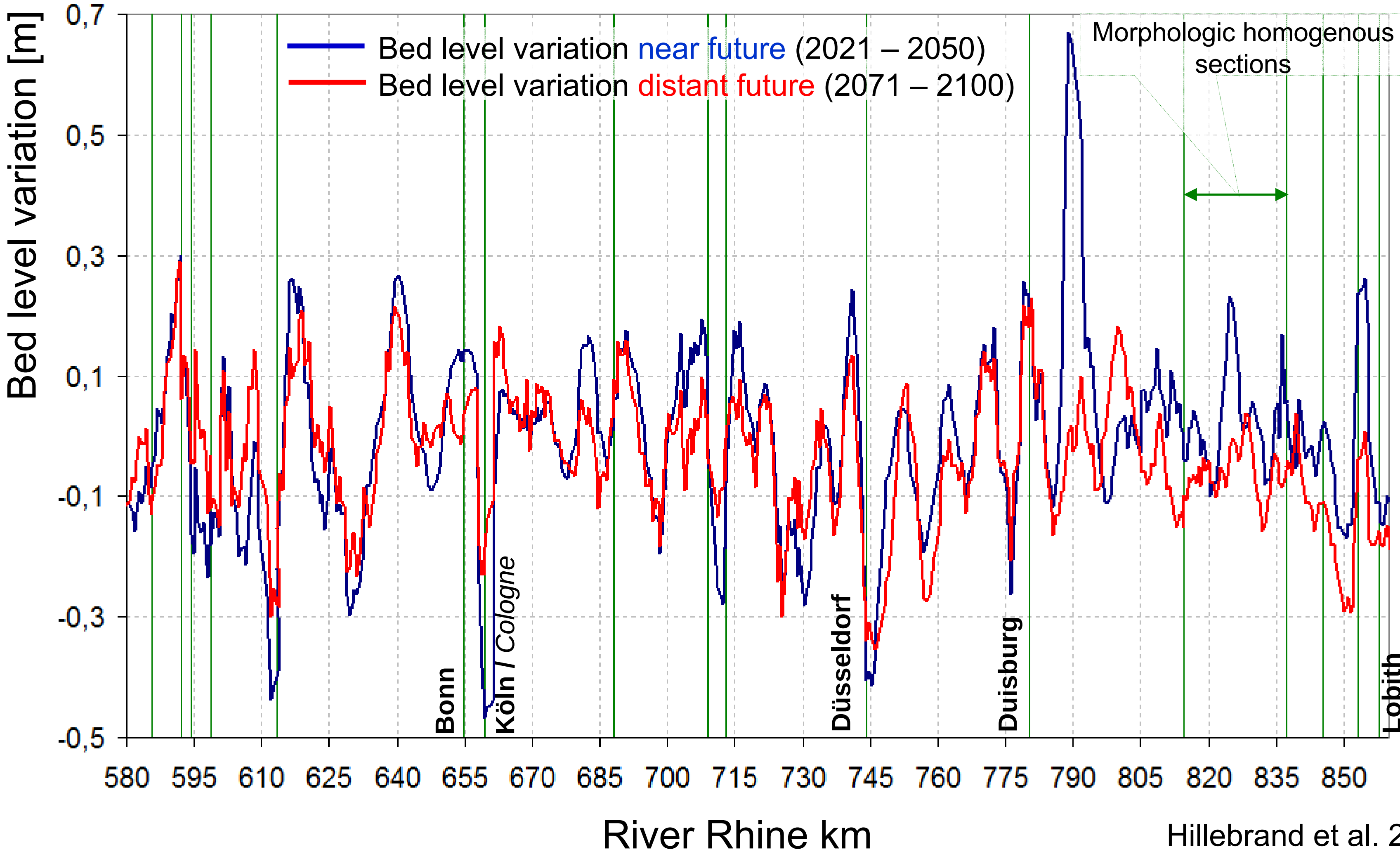
gauge Kaub, Rhine
Change in low flow*



* NM7Q, water year (Apr-Mar), 31 years, moving average

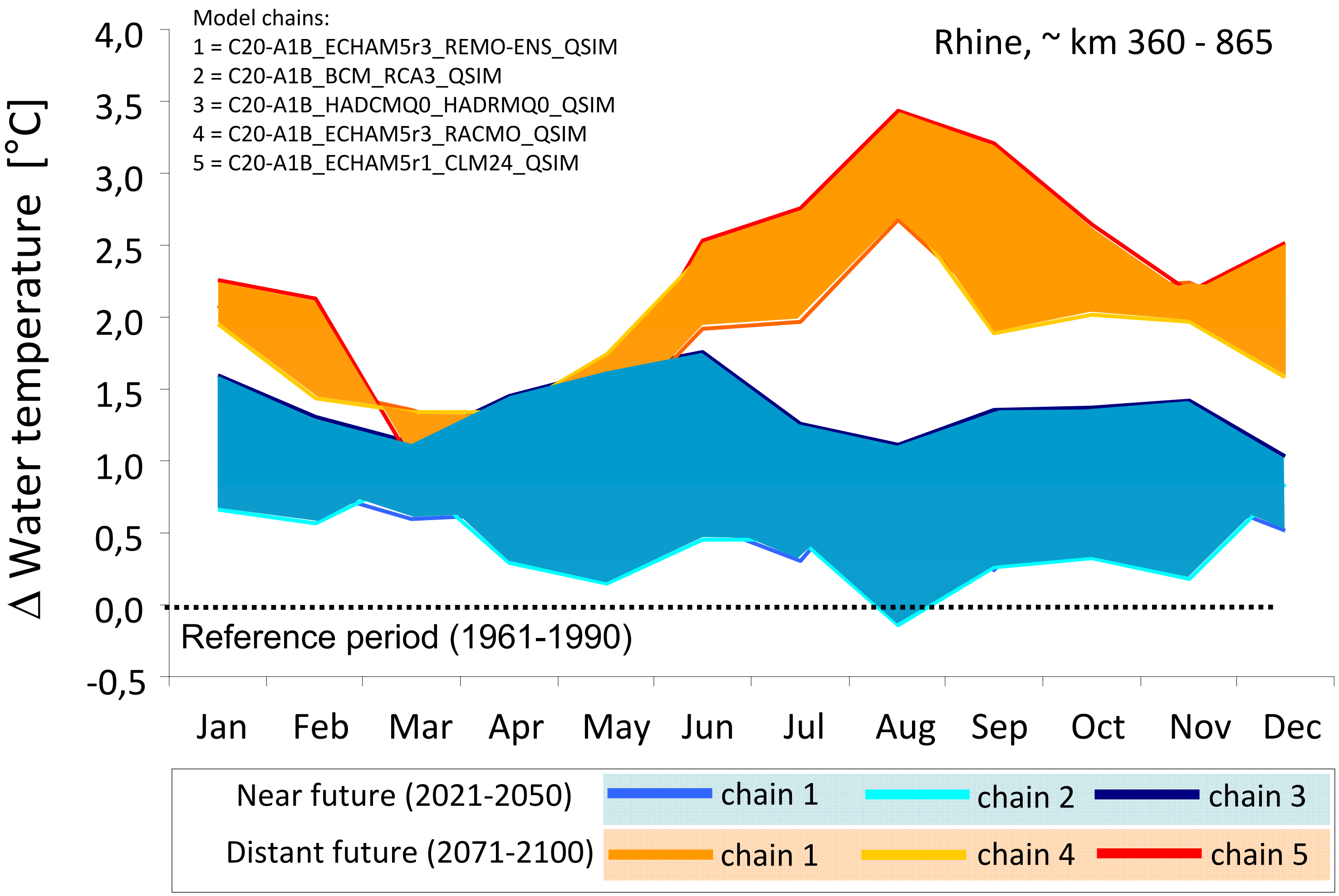
Morphodynamics

River Rhine



Hillebrand et al. 2013

Water temperature

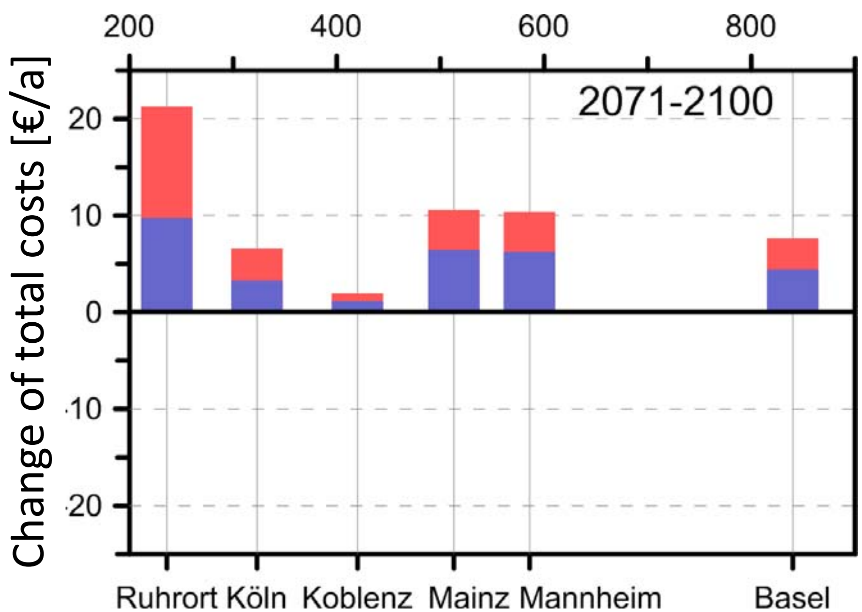


Hardenbicker et al. 2013

Impacts of climate change on annual total transport costs [€ /a]

→ Optimistic and pessimistic discharge scenario

Distant future

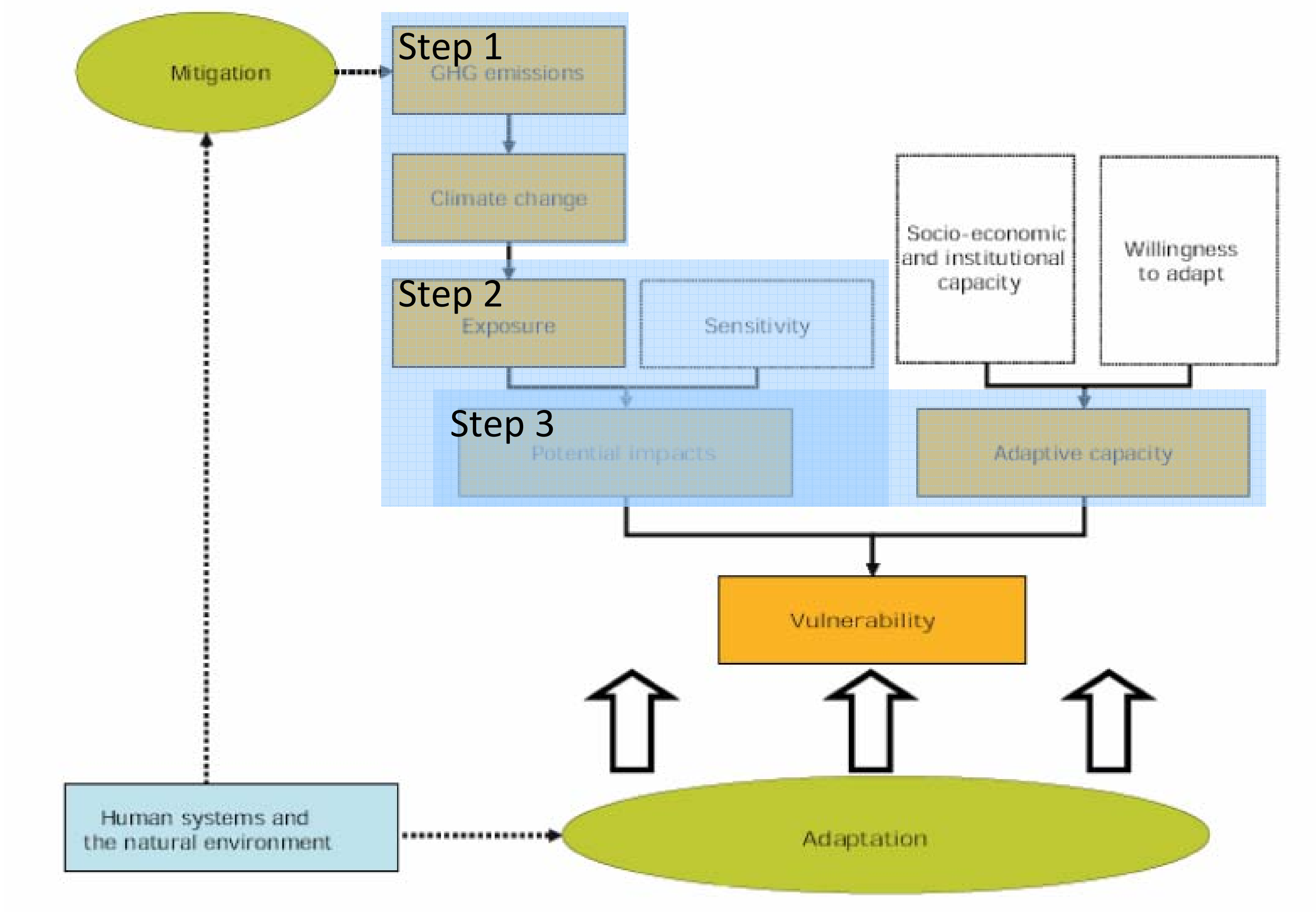


Cost rise
~30 Mio. EUR/a ~ 5%

Cost rise
~60 Mio. EUR/a ~ 9%

Quelle: Nilson et al. (2013)

vulnerability



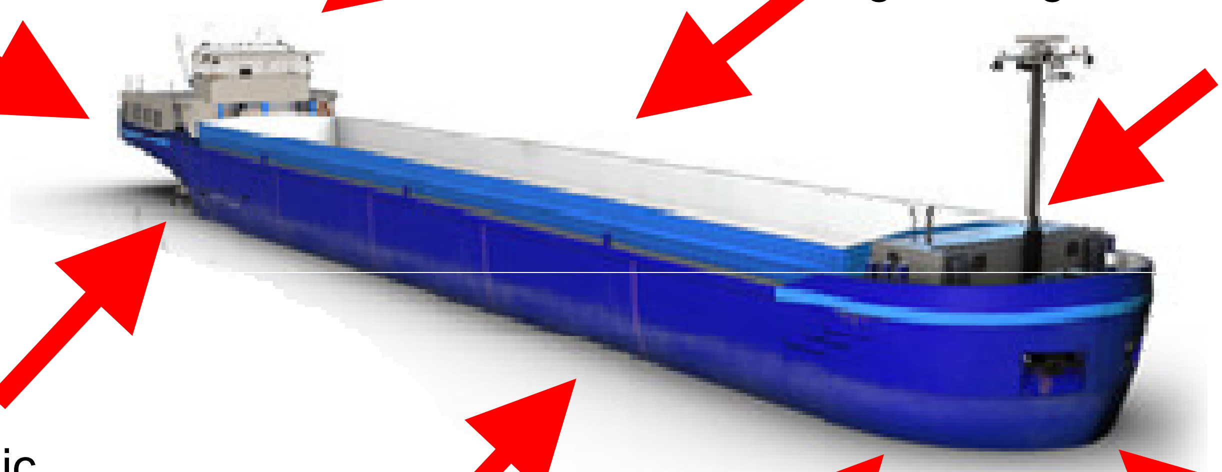
[5] European Environment Agency. 2008. Impacts of Europe's changing climate: 2008 indicator based assessment (Ch.6. Adaptation to climate change; figure from Isoard, Grothmann and Zebisch (2008)).

Science + responsibility

KLIWAS

Uses/functions depending on	Parameters	Need for action with view to		Assessment of information	
		River basin/ waterway	Period	Signal intensity	Confid-ence
Water supply (e.g. water abstractions)	**MQ** (mean river discharge), hydrological year (Nov.-Oct.)	Rhine	-	**0**	**+**
		Elbe	Since 2050	**++**	**+**
		Danube	Since 2050	**++**	**+**
Summer flow (e.g. water resources management)	**MQ** (mean river discharge), hydrological summer (May-Oct.)	Rhine°	Since 2050	**++**	**++**
		Elbe	At once	**+**	**++**
		Danube°	At once	**+**	**++**
Minimum water volume (e.g. fish migration, navigability)	**NM7Q** (lowest mean discharge in a period of 7 days) or **NMoMQ** (lowest mean monthly discharge), water year (Apr.-March)	Rhine°	Since 2050	**+**	**++**
		Elbe	Since 2050	**++**	**+**
		Danube°	At once	**+**	**++**

Technical and operational adaptation options



Operation mode

Multiple propellers

High strength steal

Reduction of max. draught

Dynamic tunnel apron

Diesel-electric engine

Reduction of safety depth

Small vessels as tug-barge systems

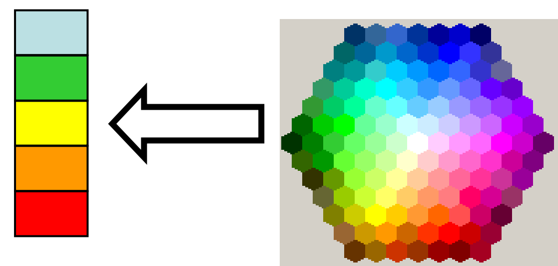
Fleet composition

Hydraulic engineering

Currently ….

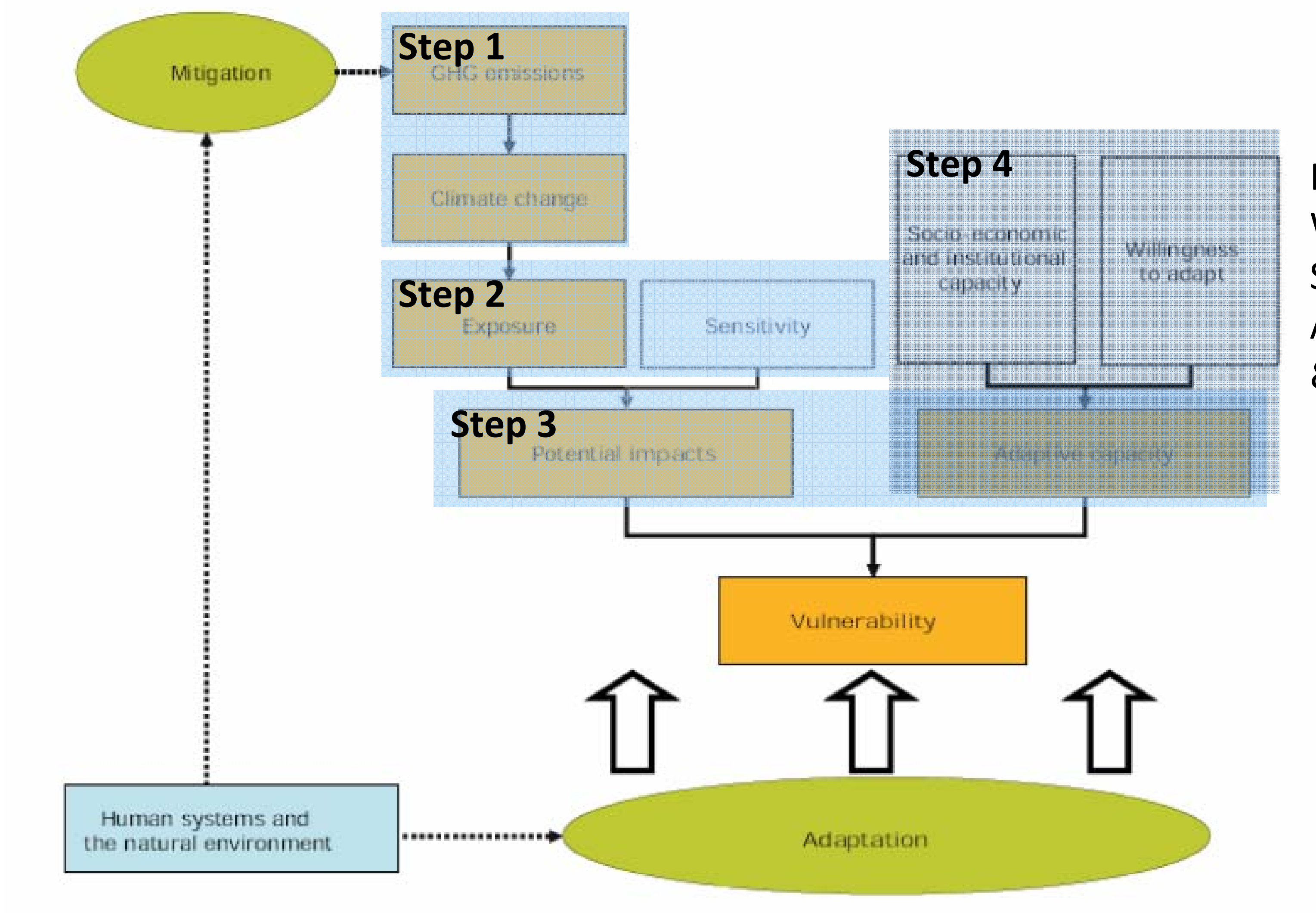
- Project reports & publications
  dimension of climate signals & when,
  dimension and relevance of impacts for
  running the waterways, adaptation options

- Synthesis for decision makers



- Synthesis on methodology
- → contributions for the GFCS

Currently + outlook



Ministry & Water and Shipping Authorities & research

[5] European Environment Agency. 2008. Impacts of Europe's changing climate: 2008 indicator based assessment (Ch.6. Adaptation to climate change; figure from Isoard, Grothmann and Zebisch (2008)).

Currently …

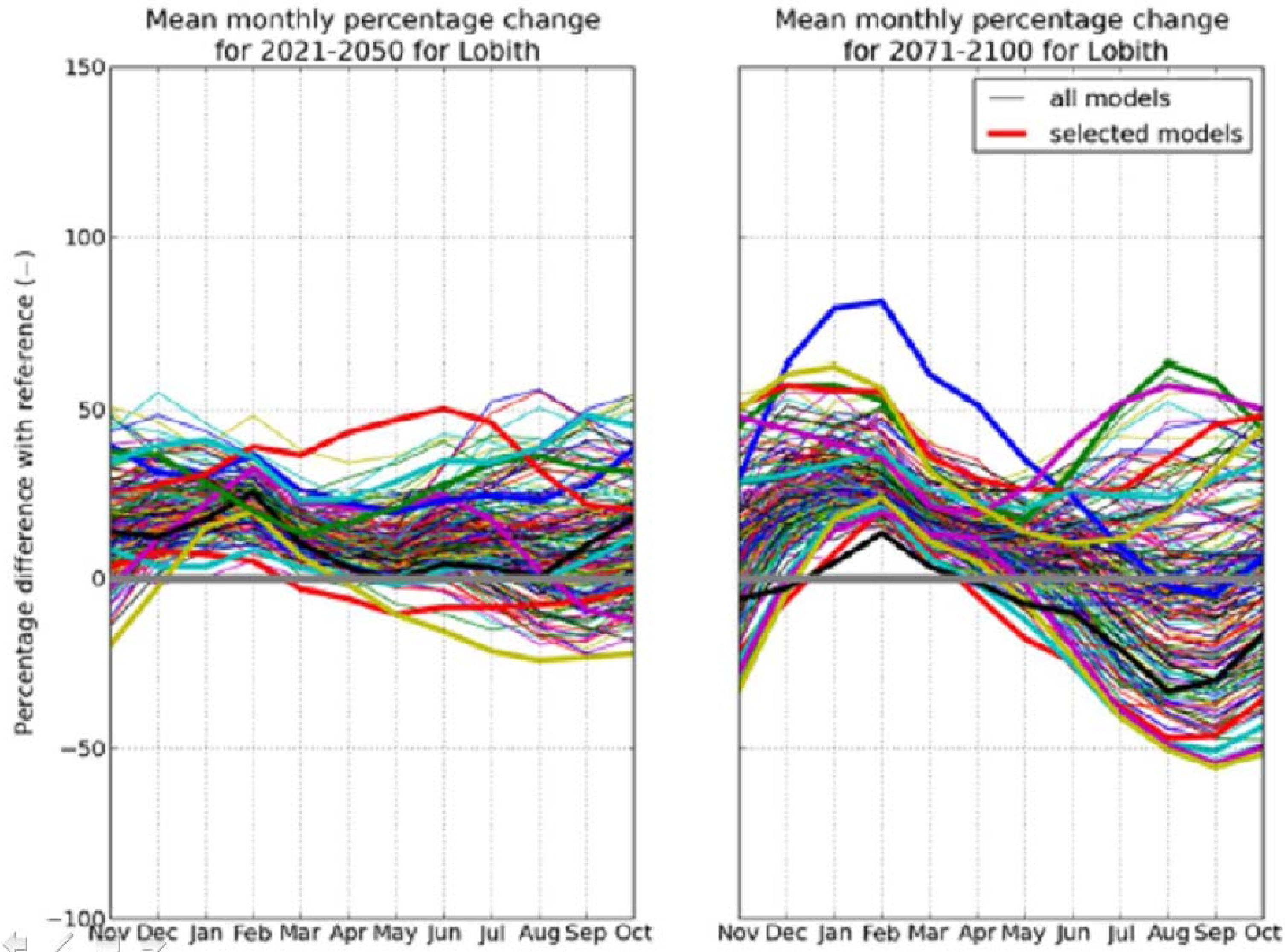
Seasonal prognosis/ decadal projections

2021-2050 2071-2100

Short-term long-term

planning horizon investments in infrastructure

outlook: new projections



Source: Sperna Weiland & Bouaziz (2014)

Deltares

outlook: consistent scenarios for all transport modes

KLIWAS

Source: dpa (2013)

Thanks

To the KLIWASians

Thank you!

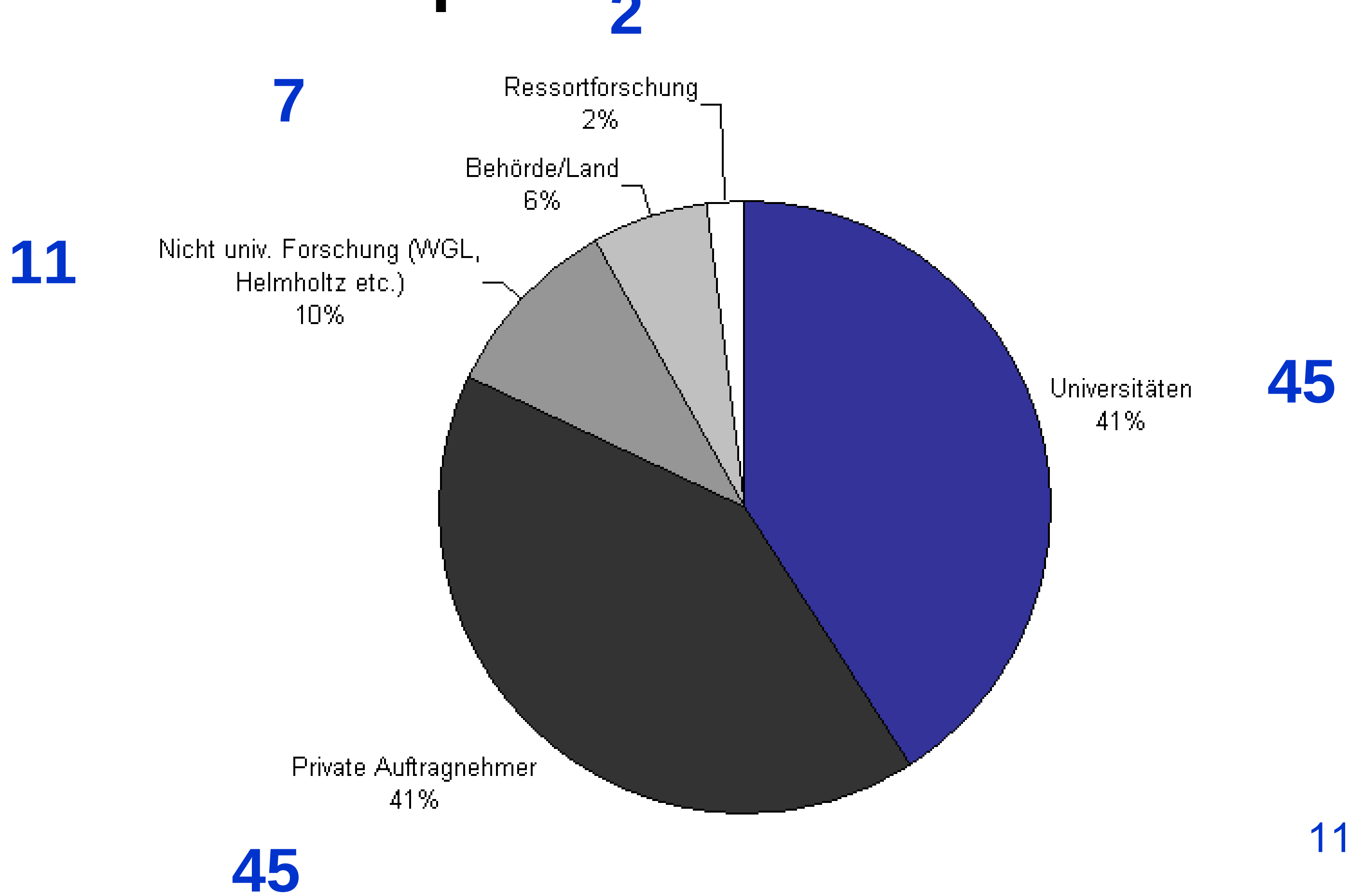
www.kliwas.de

Sebastian Kofalk
Stefanie Wienhaus

Coordination office
Kliwas@bafg.de

KLIWAS

within the network of science and departmental research



110 cooperations
100 partners

Projections, near & distant future

2021-2050 2071-2100

Short-term

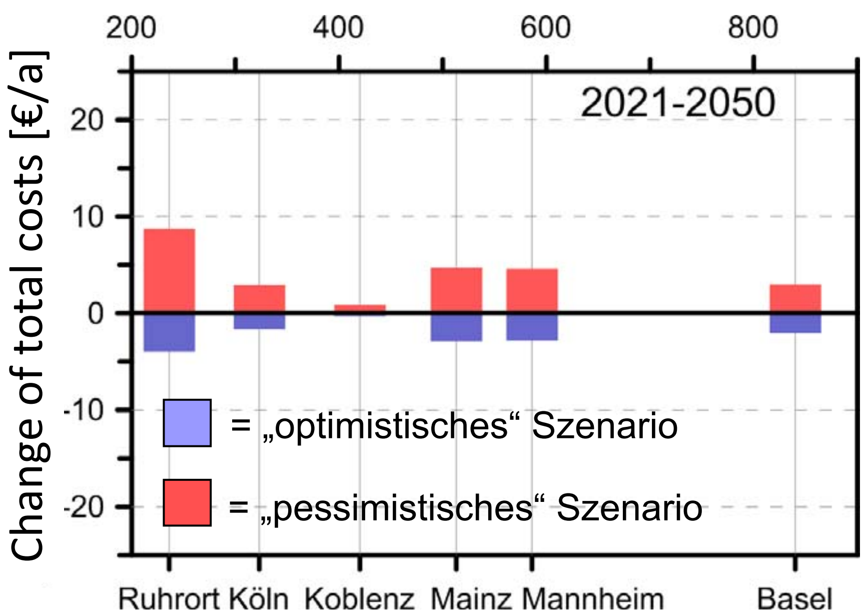
long-term

planning horizon investments in infrastructure

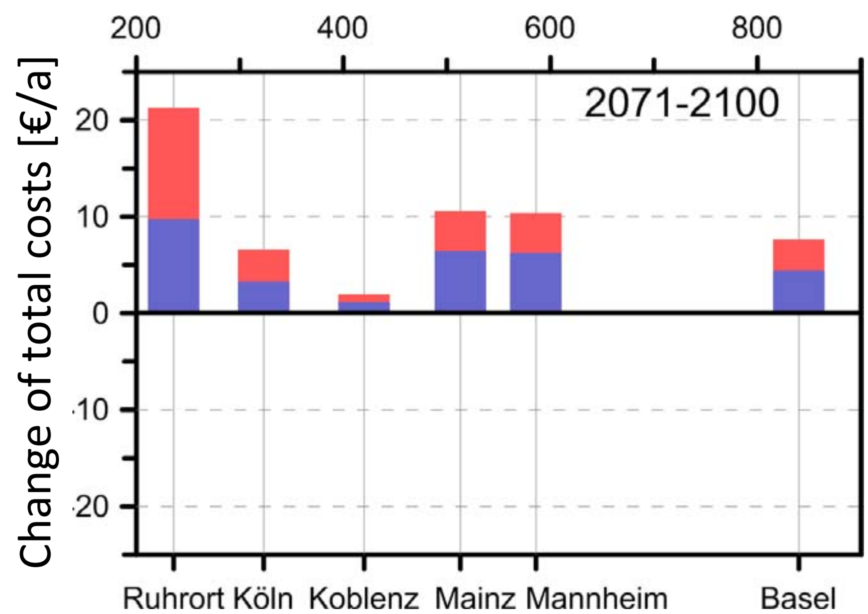
Impacts of climate change on annual total transport costs

→ Optimistic and pessimistic discharge scenario

Near future



Distant future



Cost reduction
~15 Mio. EUR/a (~ 2%)

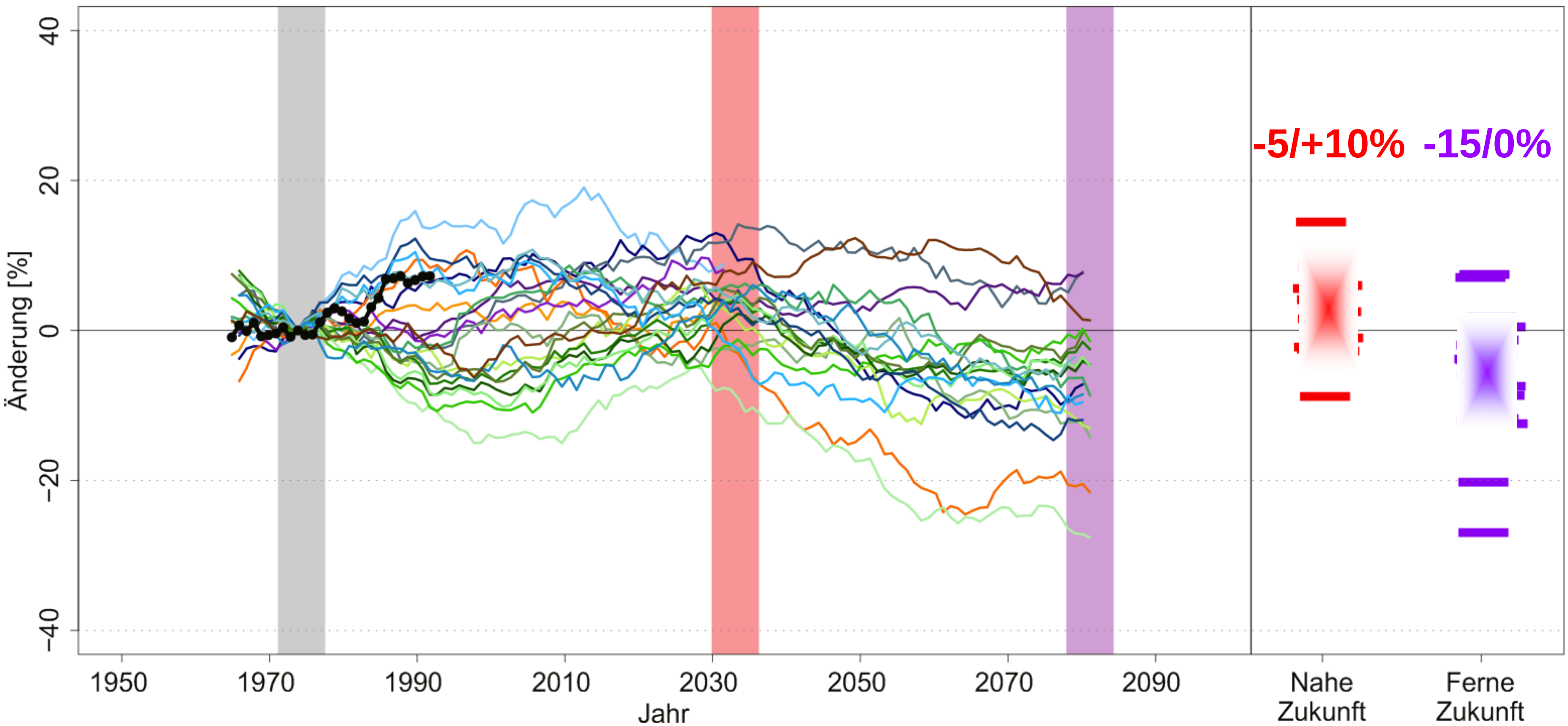
Cost rise
~25 Mio. EUR/a ~ 4%

Cost rise
~30 Mio. EUR/a ~ 5%

Cost rise
~60 Mio. EUR/a ~ 9%

Quelle: Nilson et al. (2013)

gauge Kaub, Rhine
Change in low flow*

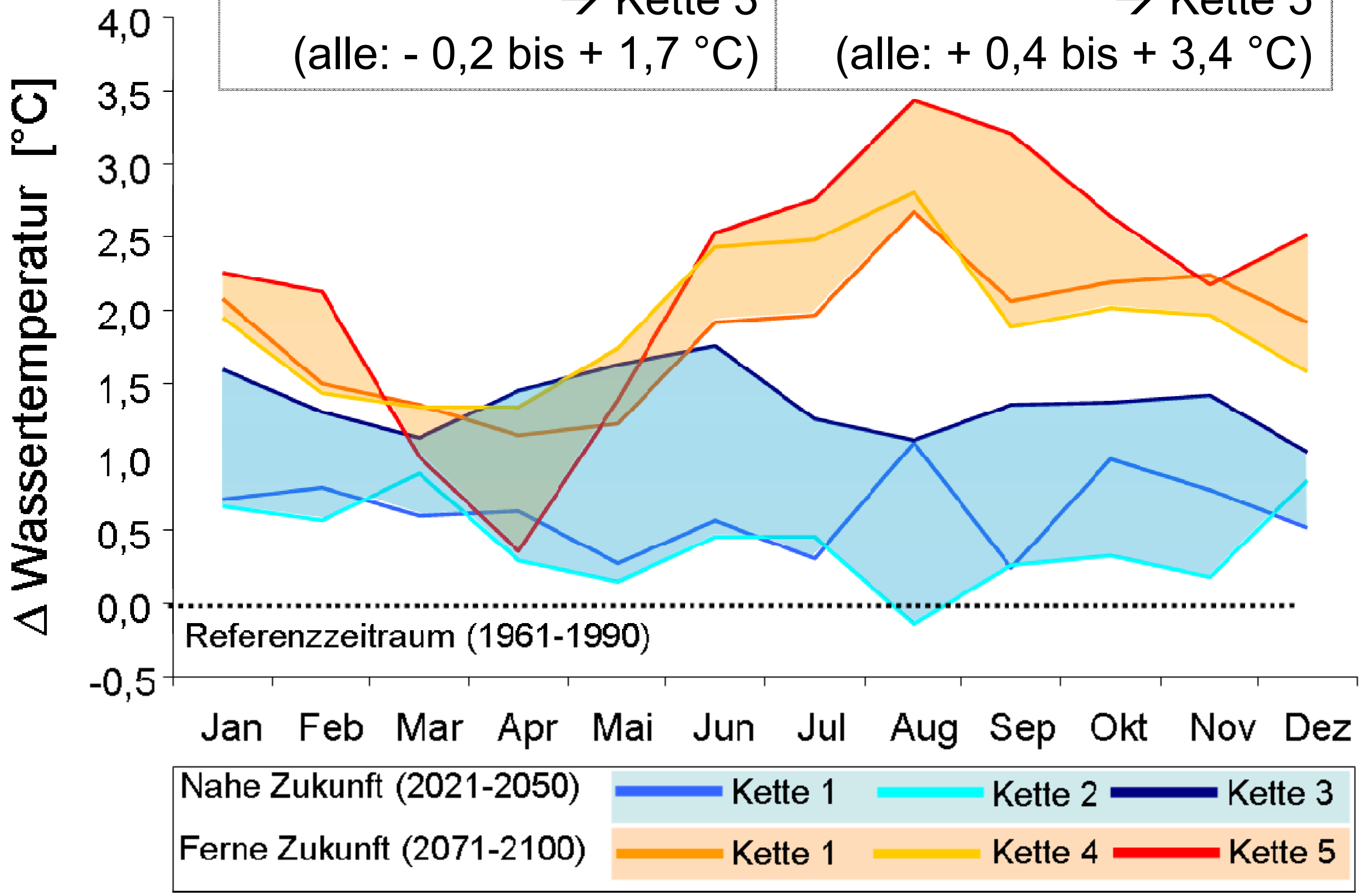


* NM7Q, water year (Apr-Mar), 31 years, moving average

Water temperature

- ferne Zukunft alle Ketten: + 2 °C (Mittelwert über 9 Stationen)
- Monatsmittelwerte: Δ **nahe Zukunft: + 1,7 °C** → Kette 3 (alle: - 0,2 bis + 1,7 °C) | Δ **ferne Zukunft: + 3,4 °C** → Kette 5 (alle: + 0,4 bis + 3,4 °C)

Rhein



Hardenbicker et al. 2013

Departmental Research

+

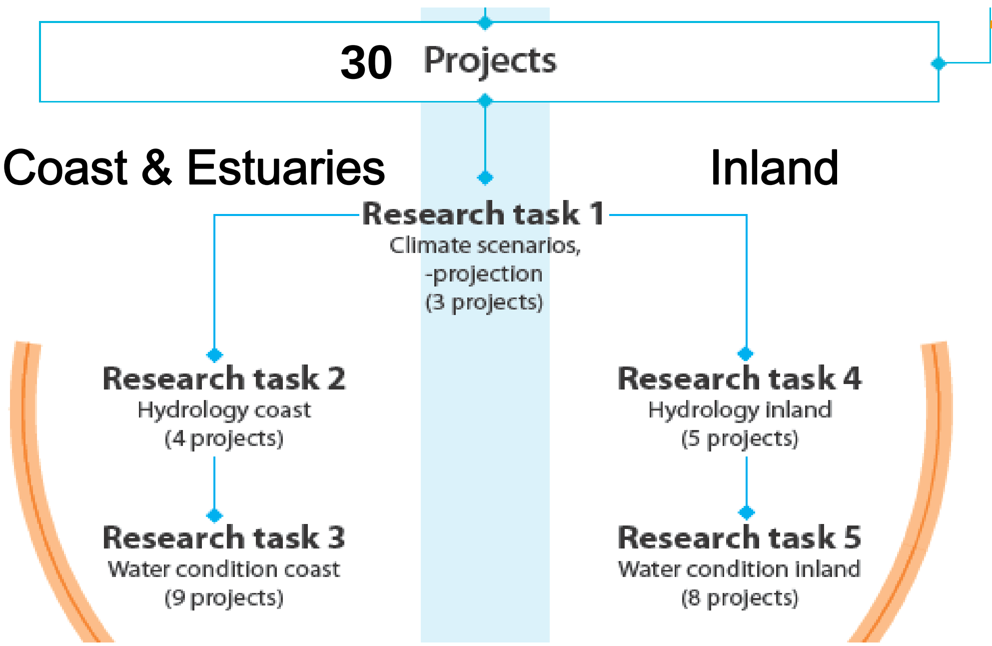
national and international cooperation

KLIWAS

DWD BSH bfg BAW

+

national and international cooperation



- meteorological climate scenarios, regionalisation, reference data
- changes in the oceanografic & hydrological system
- morphological, qualitative, ecological impacts on waters
- options to adapt


Low flows Rhine 2011
groins
Courtesy: TM

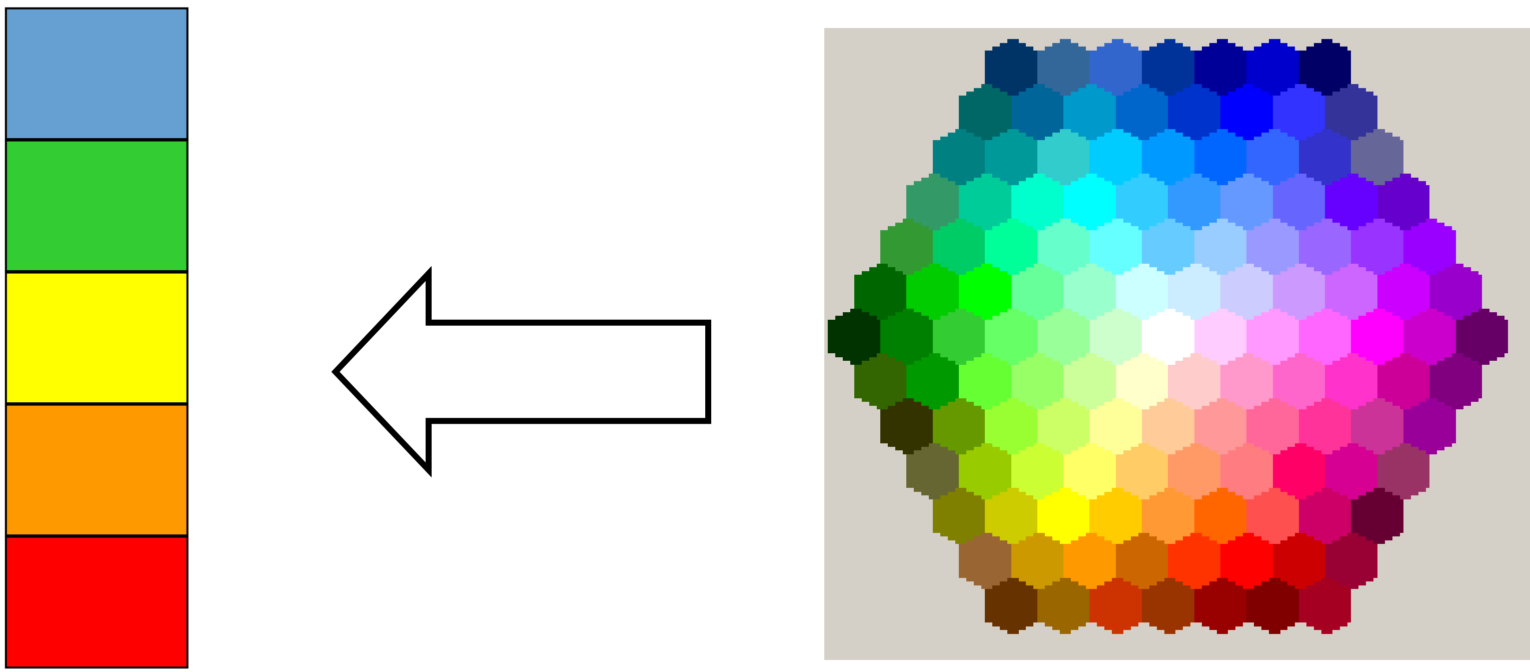

Courtesy: BAW
Courtesy: BAW


www.zdf.de


Low flows Rhine 2003
Courtesy: BfG

bfg Bundesanstalt für Gewässerkunde

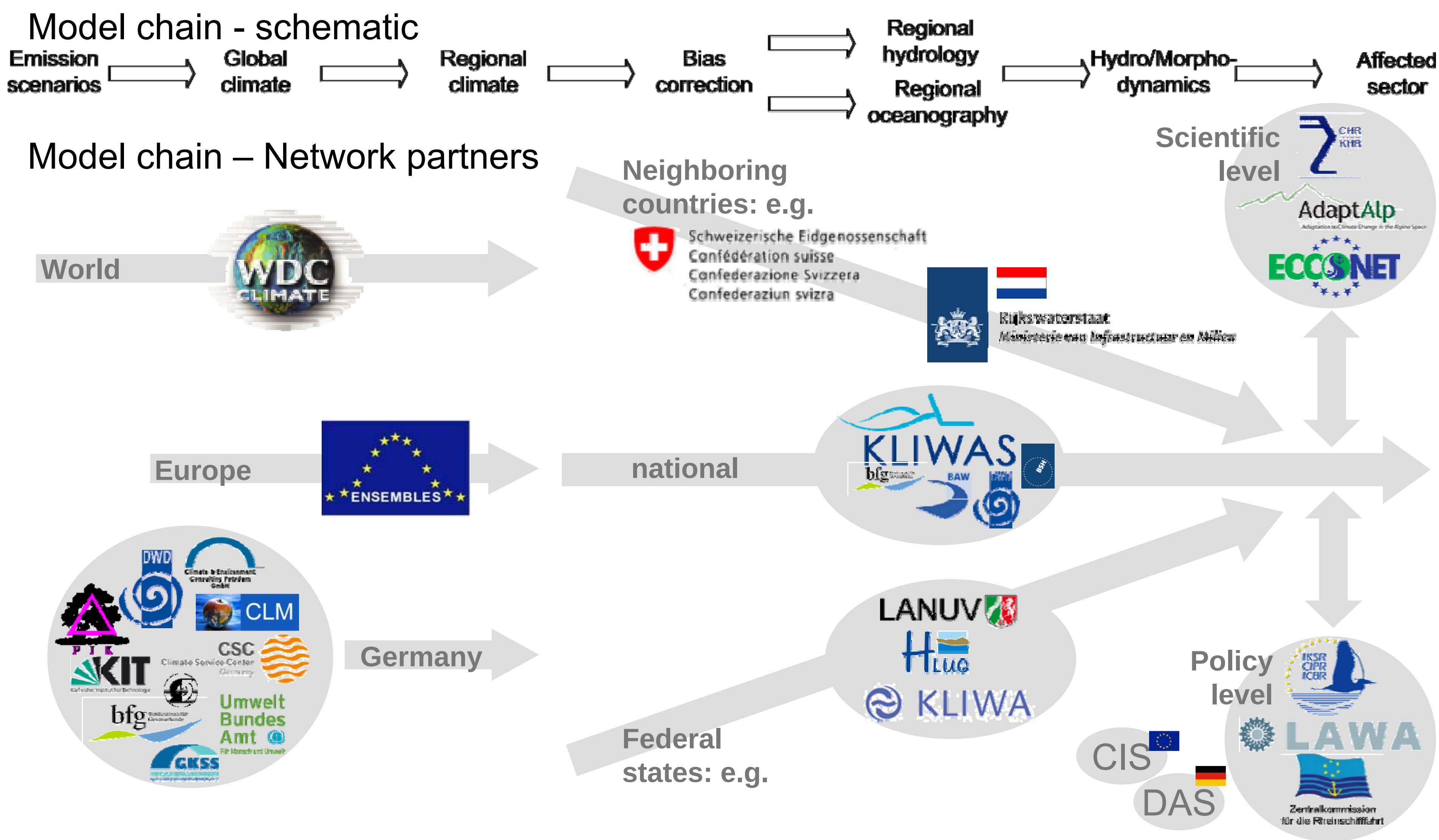
Challenge to simplify …



Thank you for your attention!

www.kliwas.de

KLIWAS research framework: Network partners



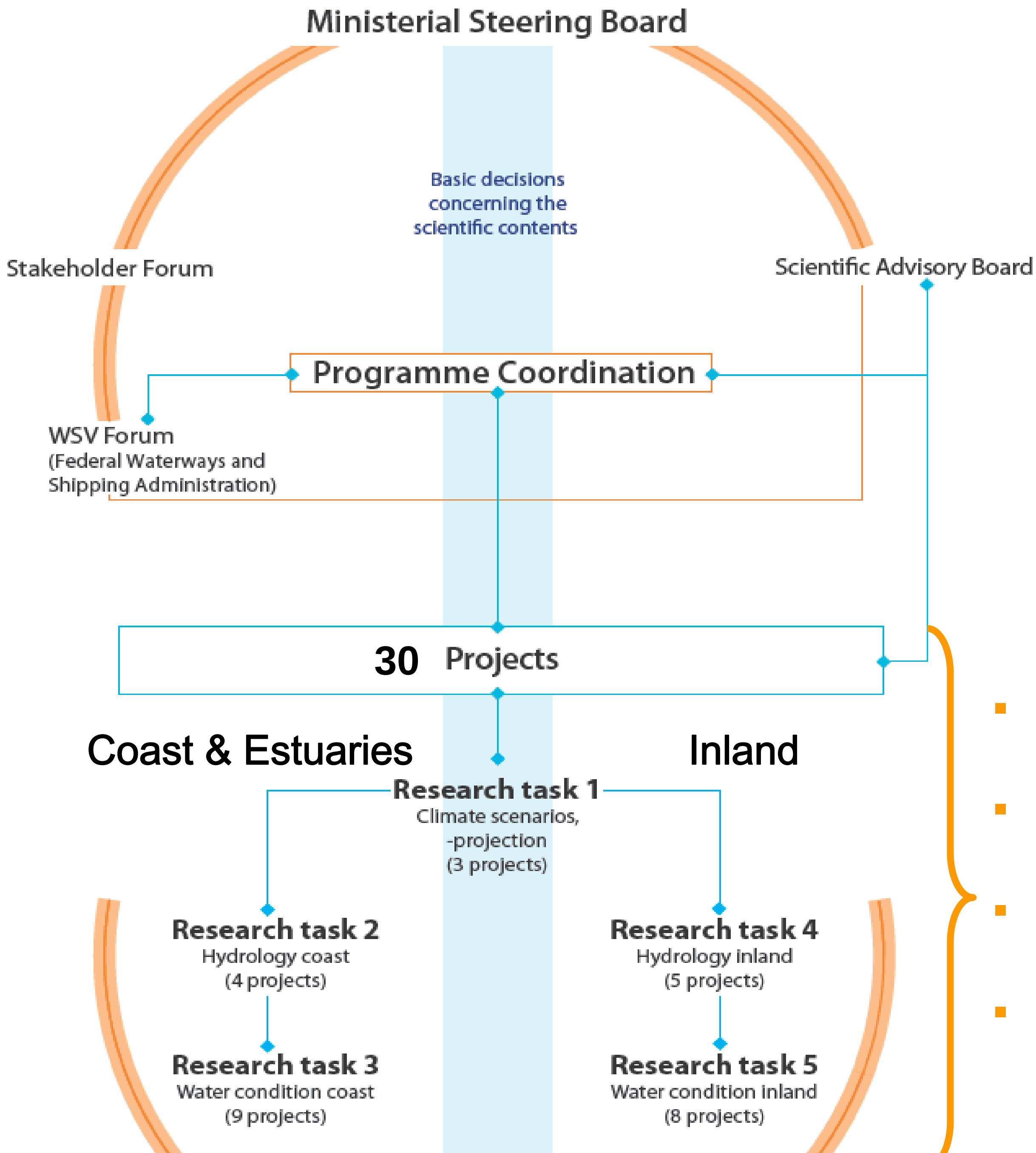
Model Chain

KLIWAS
Climate · Water · Navigation

1. Global emission scenarios / future development
2. Projections by global climate models
3. Projections by regional climate models
4. Oceanografic / water balance models
5. Sediment and morpho-hydraulic and navigation models
6. Water quality models
7. Ecosystem models

economic valuation inland navigation

Source: BMVBS (2008)



- meteorological climate scenarios, regionalisation, reference data
- changes in the oceanografic & hydrological system
- morphological, qualitative, ecological impacts on waters
- options to adapt

Impact of CC: Research → Adaptation

Inventory and Fundaments

- Data processing
- Climate projections

- Model generation
- Discharge and other projections
- …

Sensitivity analysis of sectors and sub-systems

- quantity
- quality
- ecology

inland + coast

Adaptation options and vulnerability

KLIWAS + WSV

Decision

Planning and implementation of adaption measures

BMVBS +
BfG, BSH, BAW + WSV

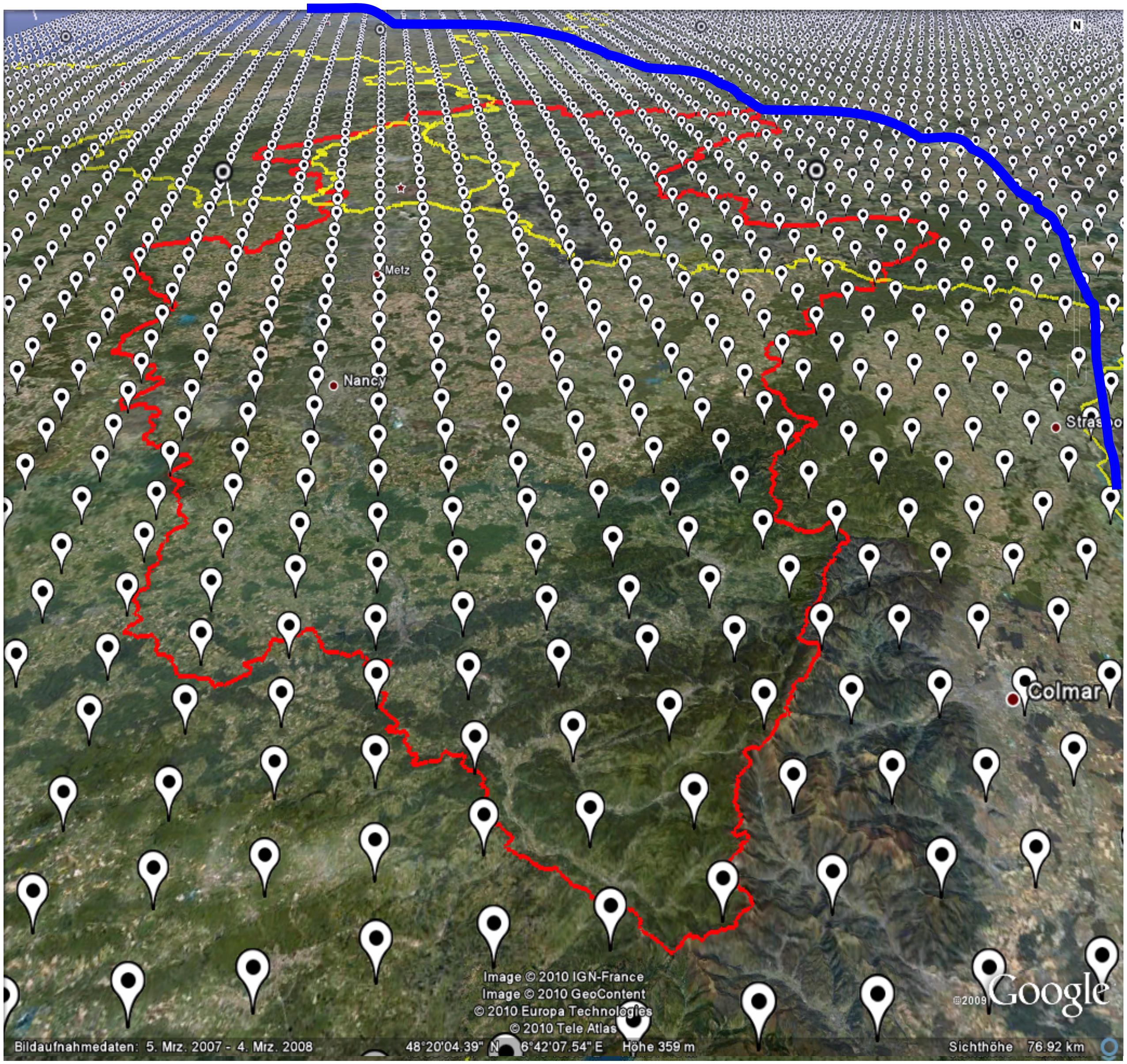
KLIWAS-Research 2009-2013

Adaptation strategy BMVBS

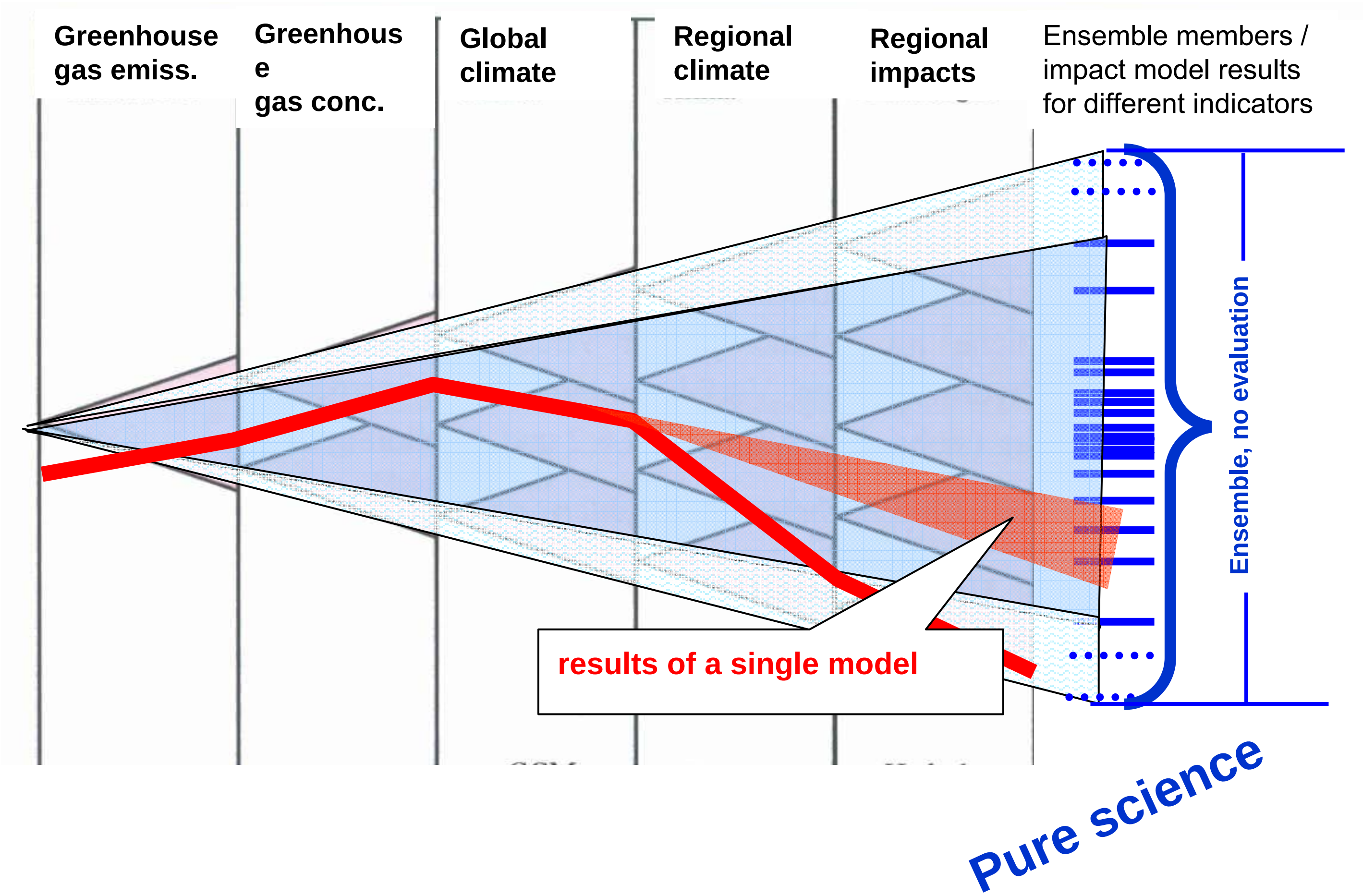
embedded in the German Adaptation Strategy (DAS)

GCM

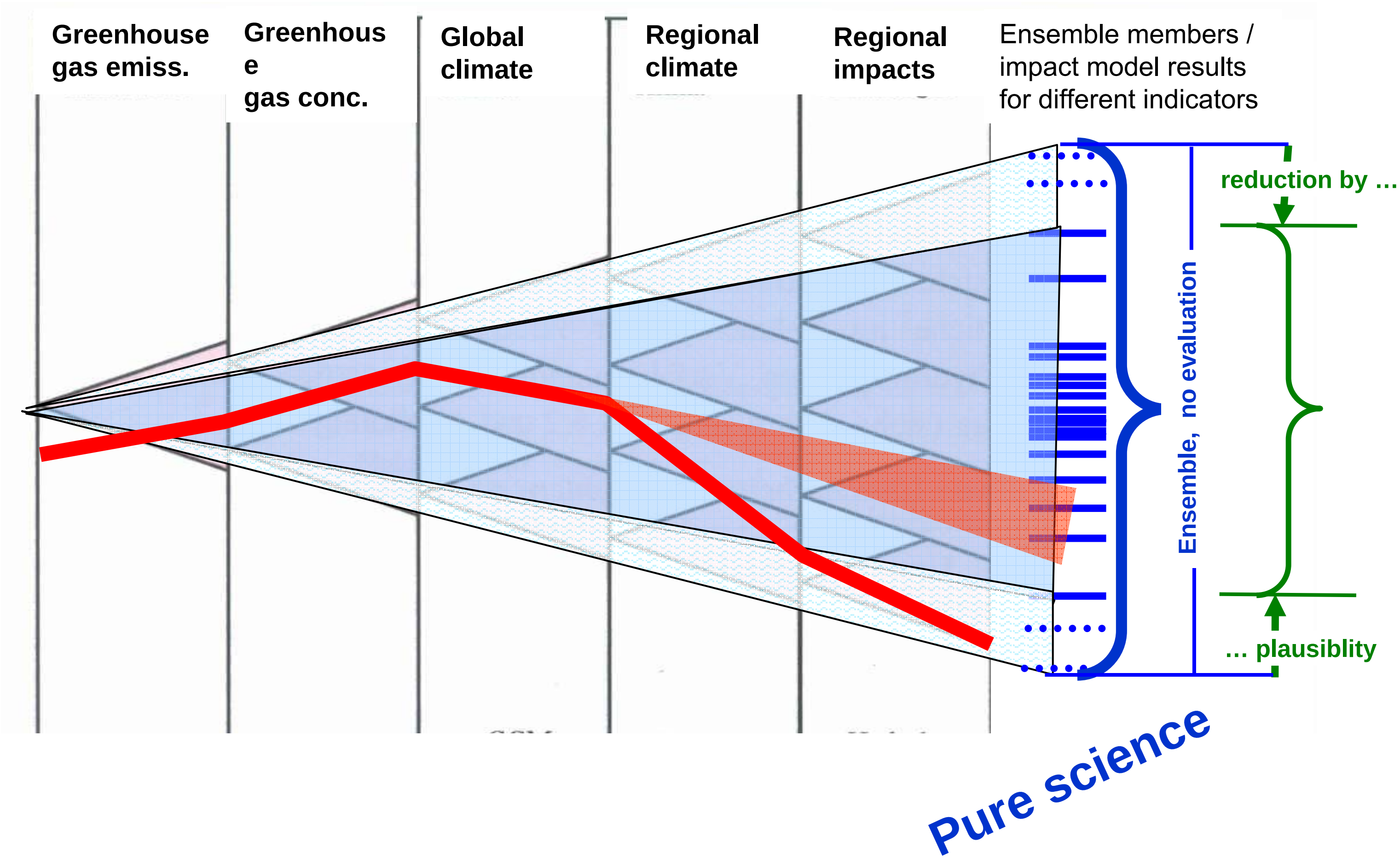
RCM


Metz
Nancy
Strasbo
Colmar
Image © 2010 IGN-France
Image © 2010 GeoContent
© 2010 Europa Technologies
© 2010 Tele Atlas
©2009
Google
Bildaufnahmedaten: 5. Mrz. 2007 - 4. Mrz. 2008
48°20'04.39" N 6°42'07.54" E Höhe 359 m
Sichthöhe 76.92 km

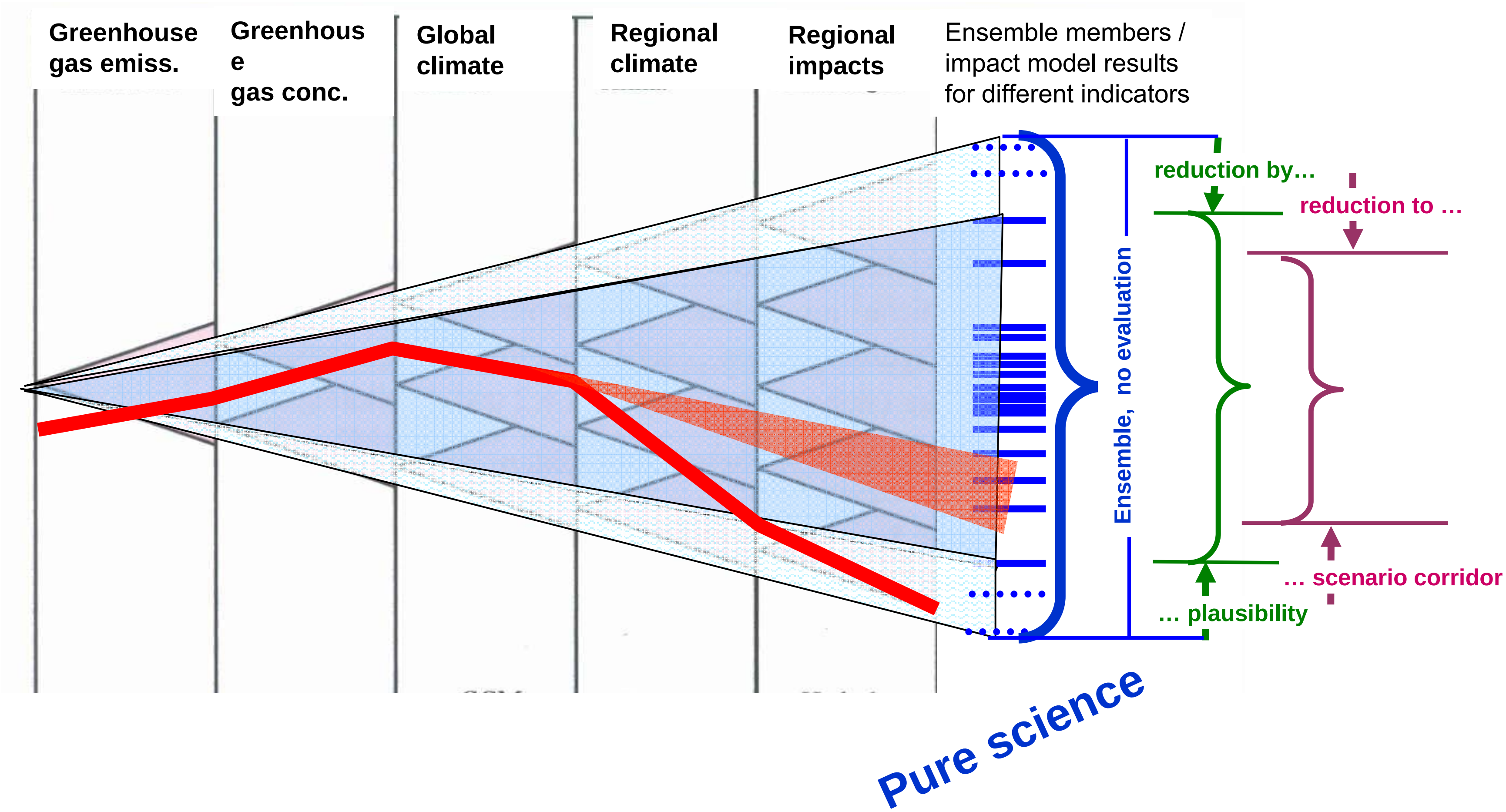
Adaptation Decisions reflecting Uncertainty



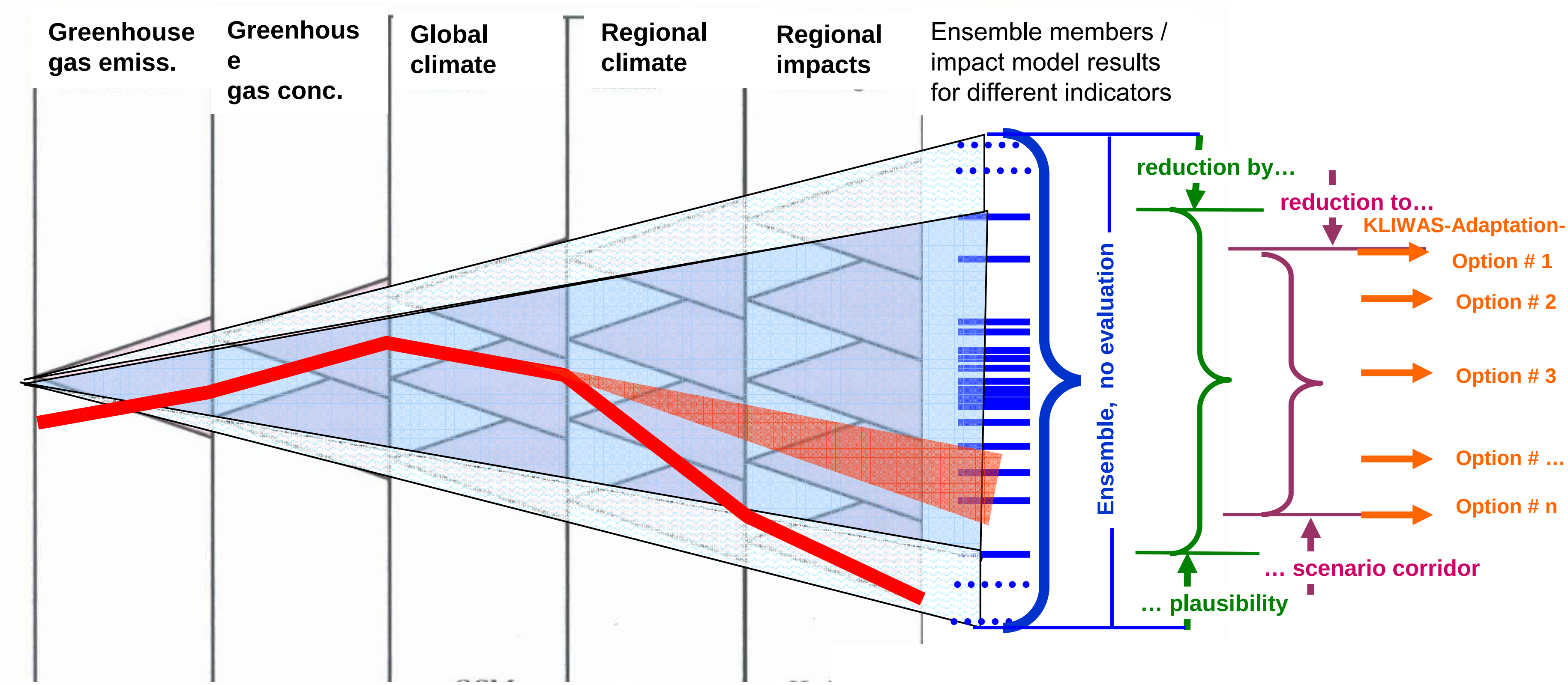
Adaptation Decisions reflecting Uncertainty



Adaptation Decisions reflecting Uncertainty

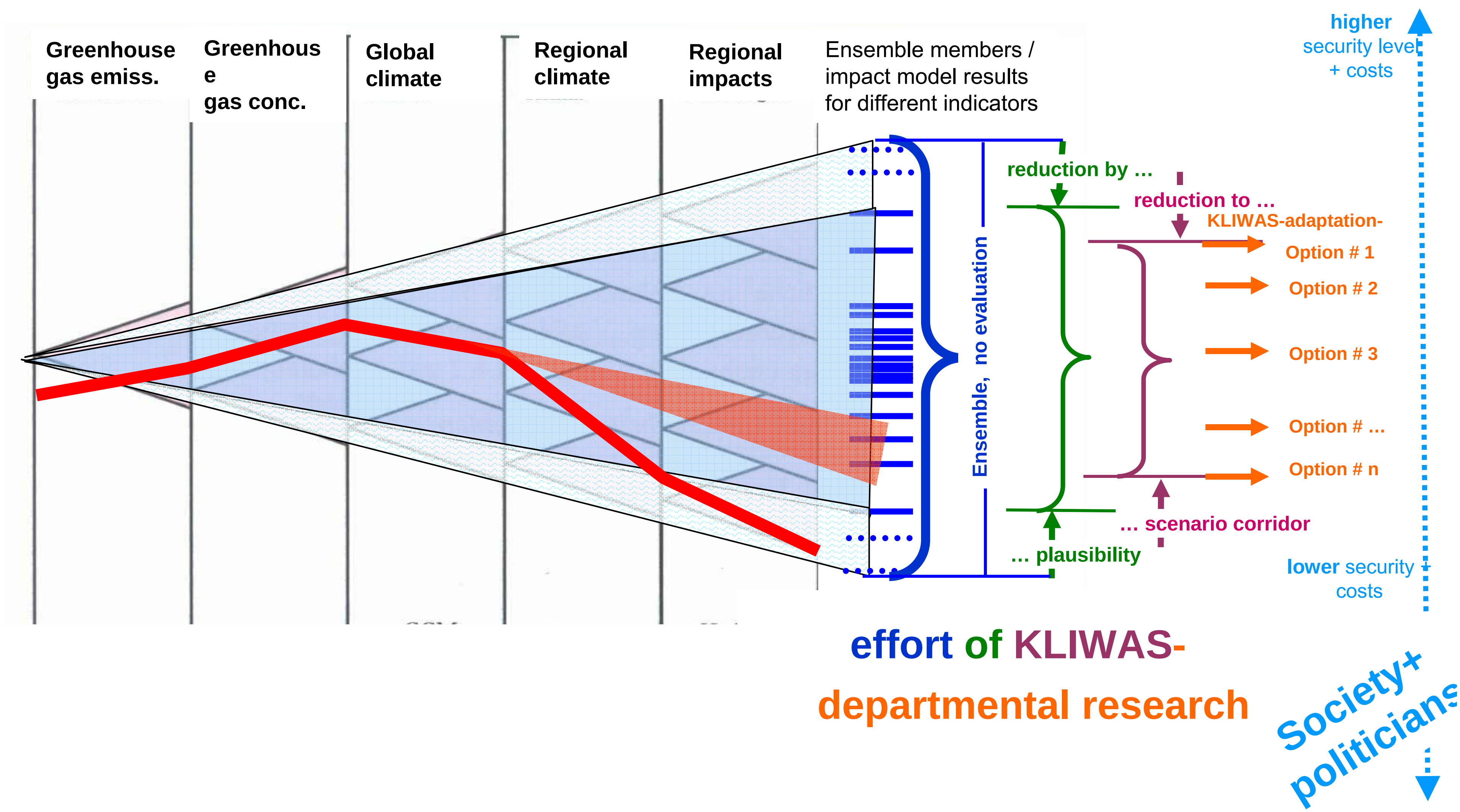


Adaptation Decisions reflecting Uncertainty

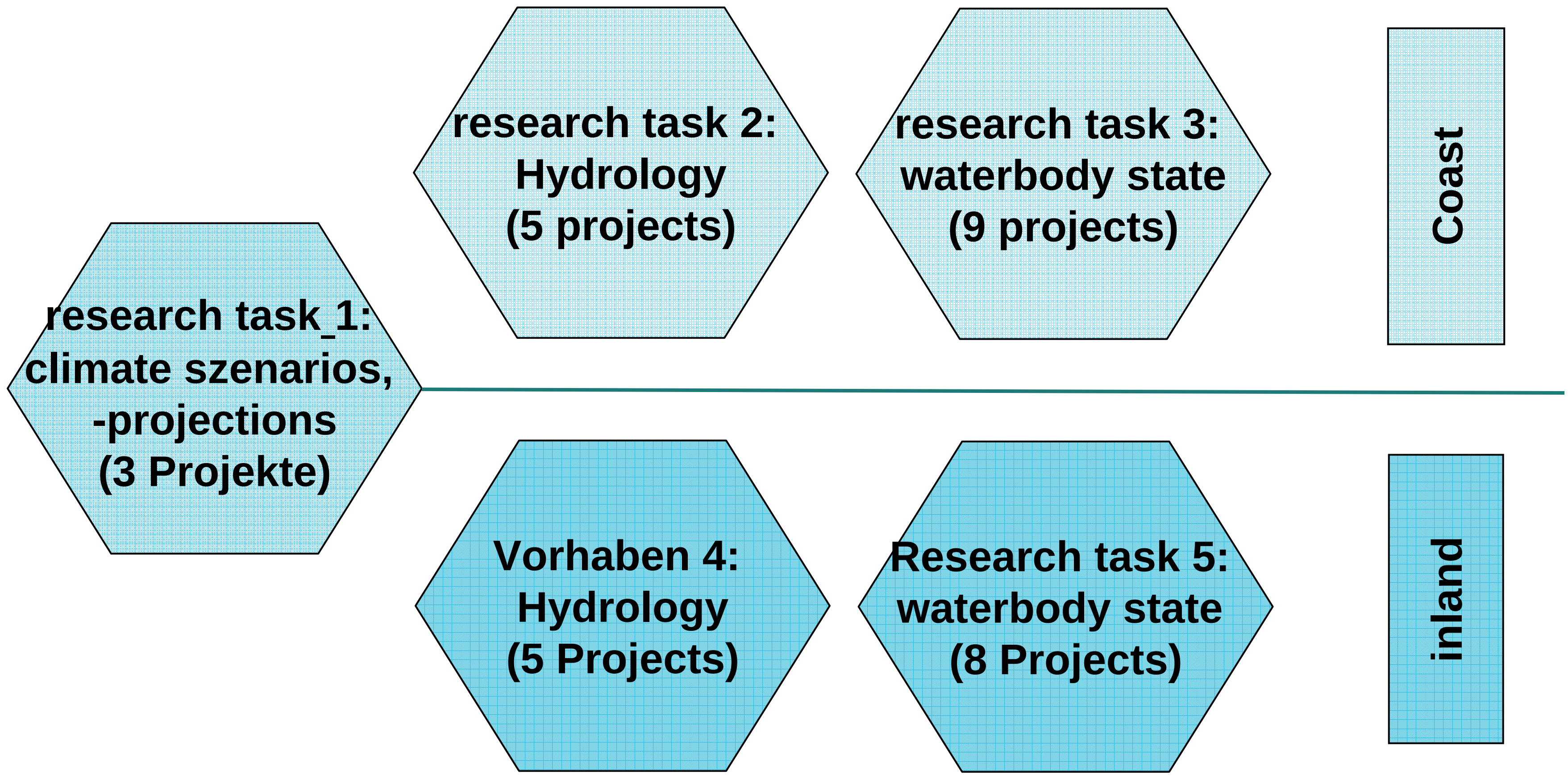


effort of KLIWAS-departmental research

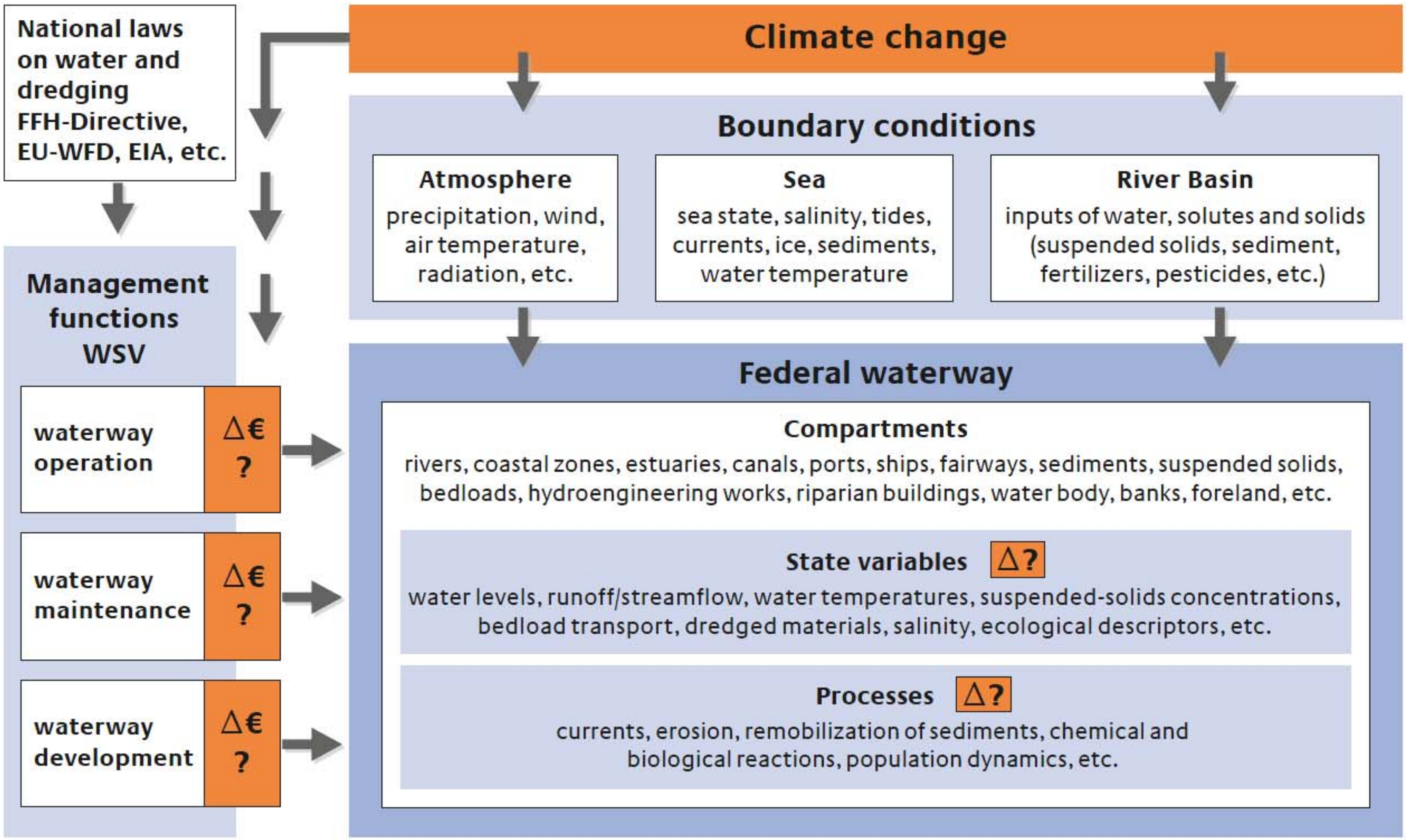
Adaptation Decisions reflecting Uncertainty



Research programme



System of the Waterways



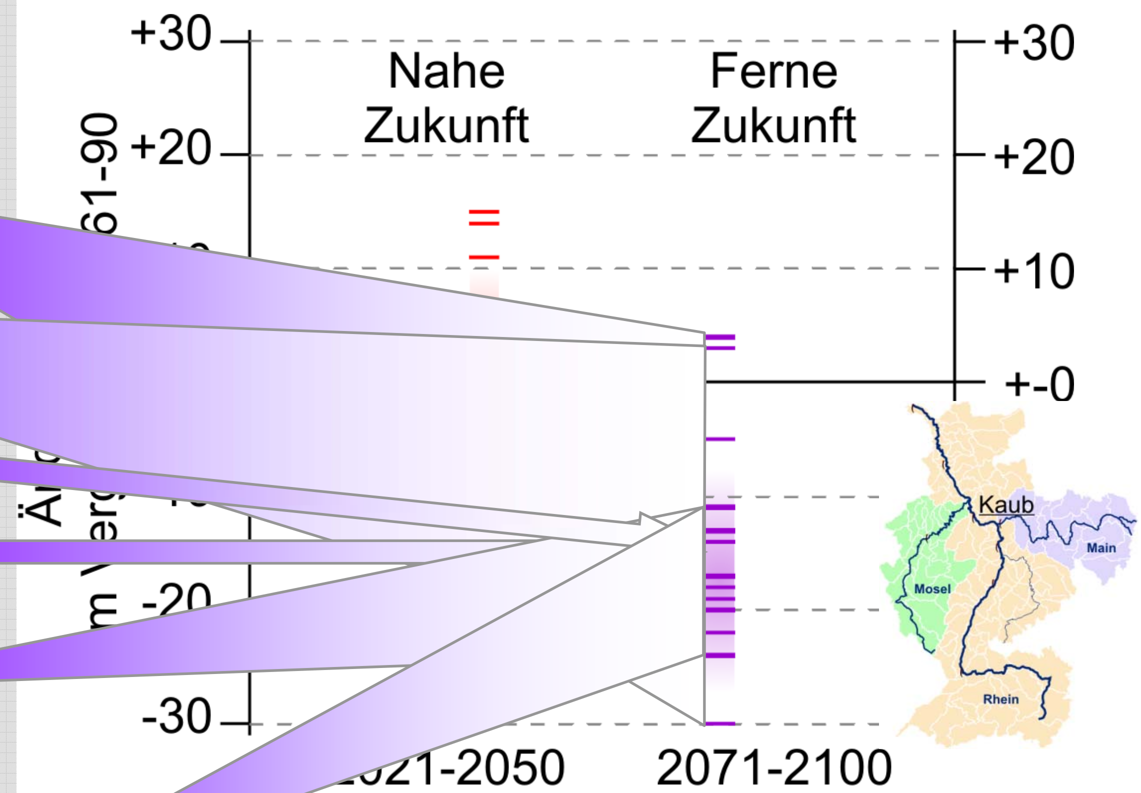
Ausblick

- KLIWAS-Berichte
  - z.B. Vorhaben 4 (Hydrologie Binnen)
- Neue Projektionen
  - CMIP5 (5. IPCC Sachstandsbericht)
  - EURO-CORDEX
- Bewirtschaftungsszenarien
  - Natürliche Wasserdargebotsänderungen + anthropogene Einwirkungen
  - BfG-Projekt, KHR-Aktivität
- Verkehrsträgerübergreifende Szenarien
  - Expertennetzwerk des BMVI (DWD, BfG, BAW, EBA, BASt, BBSR)

handling the uncertainty

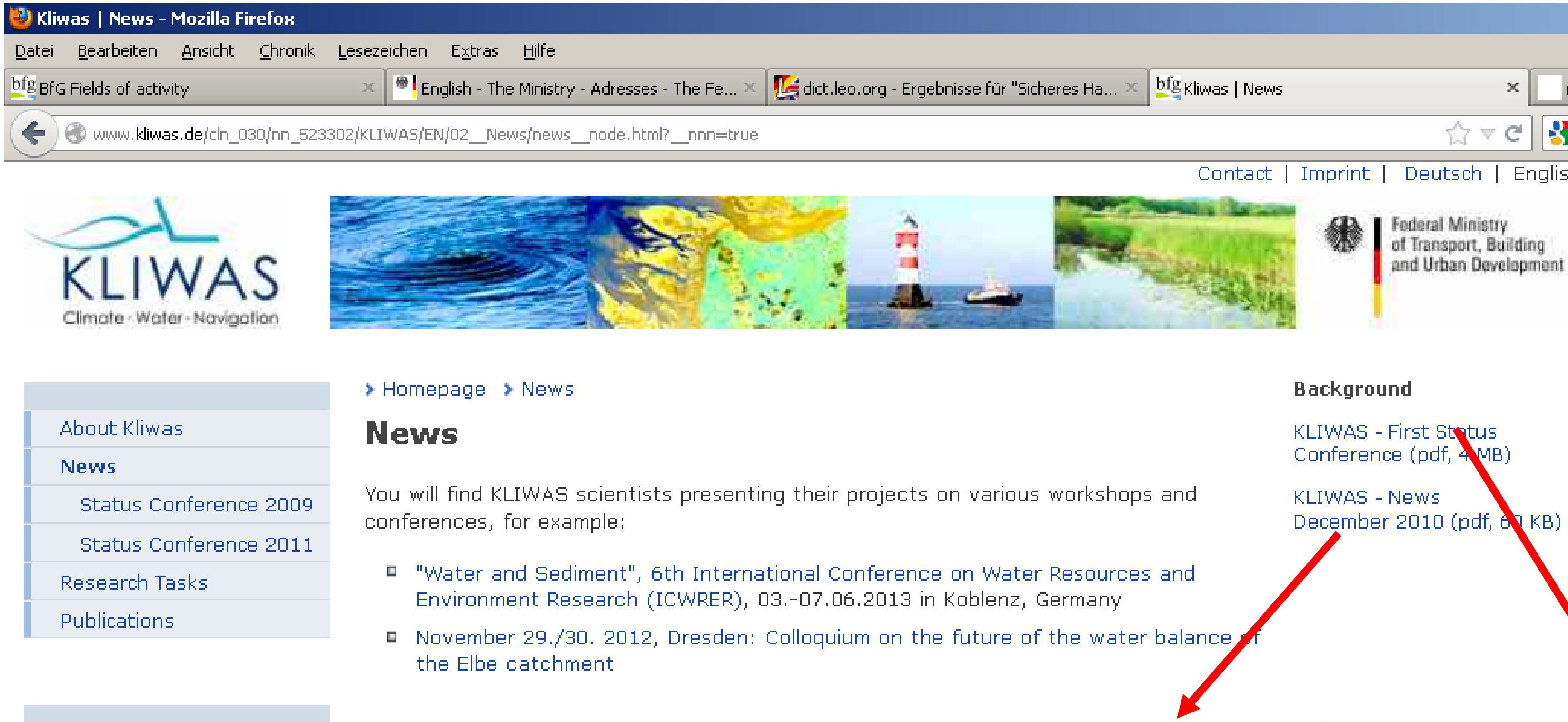
Niedrigstes 7-Tagesmittel (NM7Q) am Pegel Kaub, hyd. Sommer

1. minimum/maximum
2. percentiles
3. median
4. arithmetic mean
5. „scenario corridors"



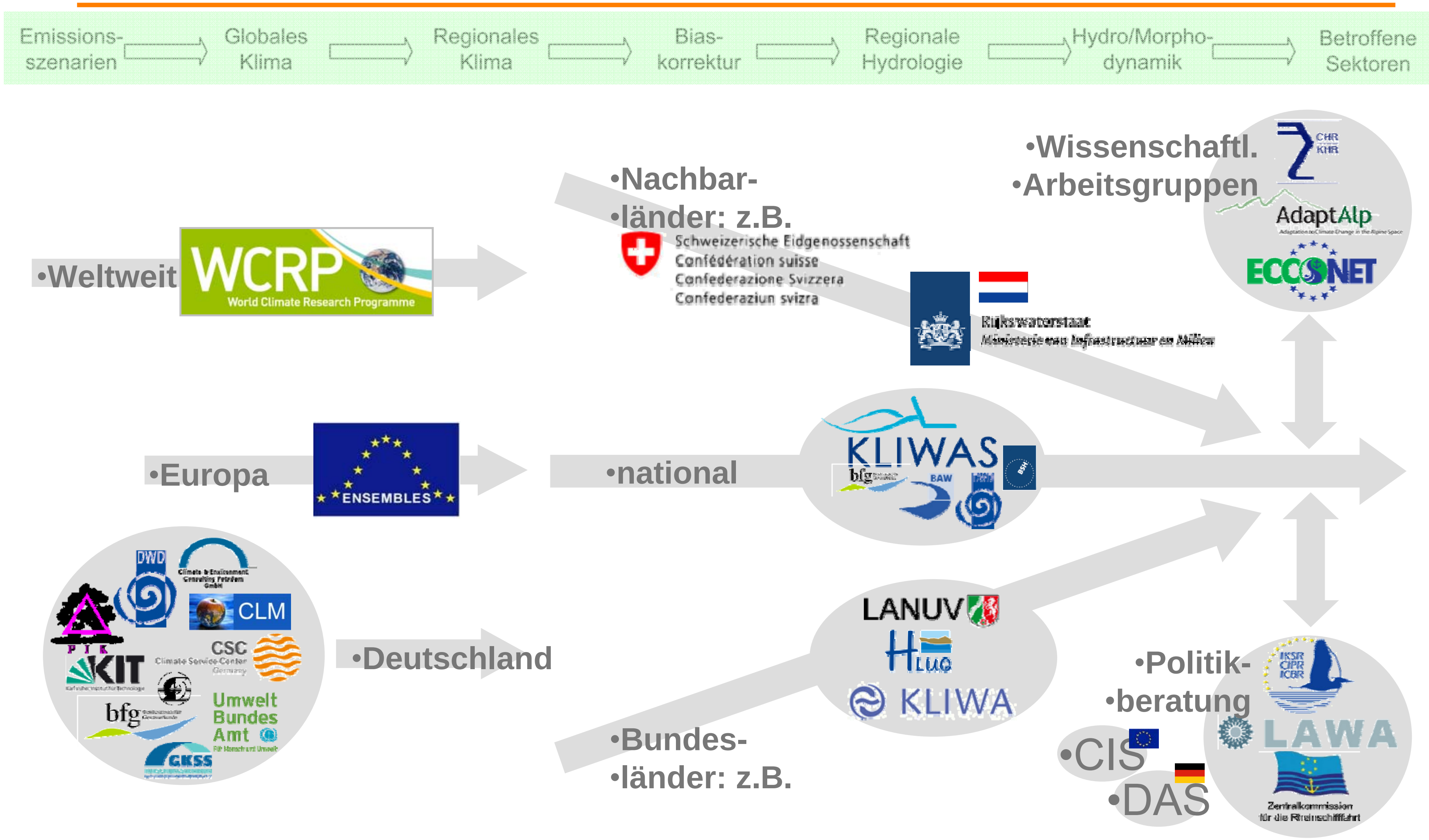
Gauging station	2021 to 2050	2071 to 2100
Basel	+/- 10%	-20 to -10%
Maxau	+/- 10%	-20 to -10%
Worms	+/- 10%	-25 to -10%
Kaub	+/- 10%	-25 to -10%
Köln	+/- 10%	-30 to -10%
Lobith	+/- 10%	-30 to -10%
Raunheim	0 to +20%	-20 to 0%
Trier	+/-20%	-50 to -20%

Source: Nilson, E. (2011) http://dx.doi.org/10.5675/KLIWAS_Statuskonferenz_2011_4



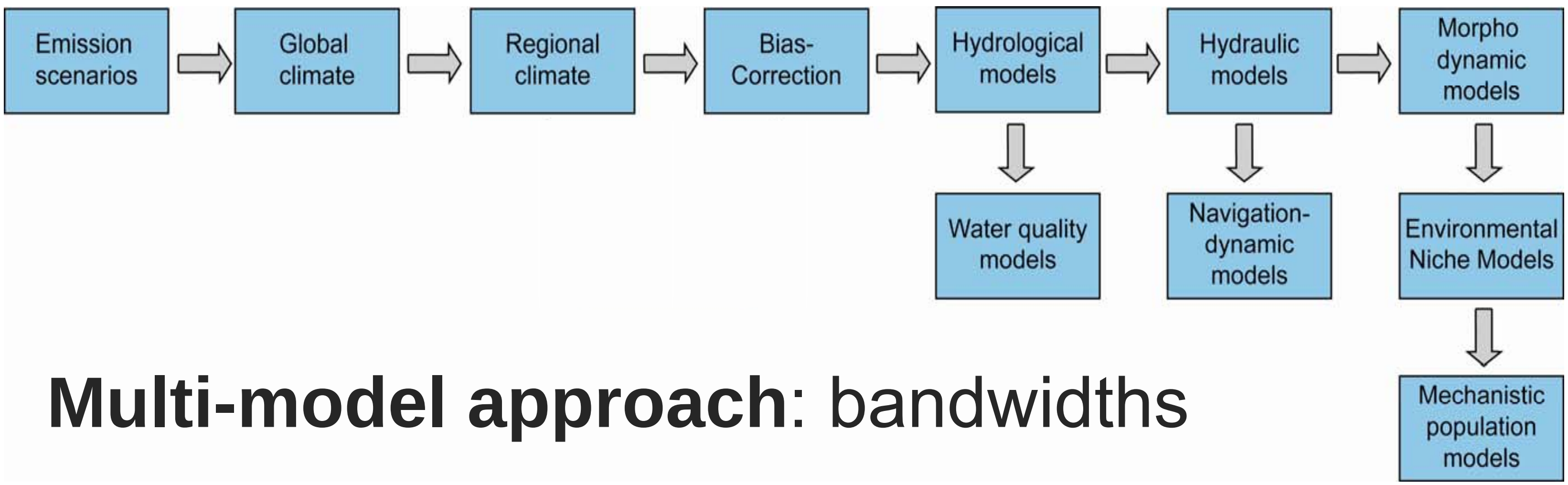
http://www.kliwas.de

Ergebniskette -
in der Kooperation und Kommunikation



KLIWAS approaches

- **System approach**: model chain



- **Multi-model approach**: bandwidths

→ Different SRES scenarios (IPCC AR4)

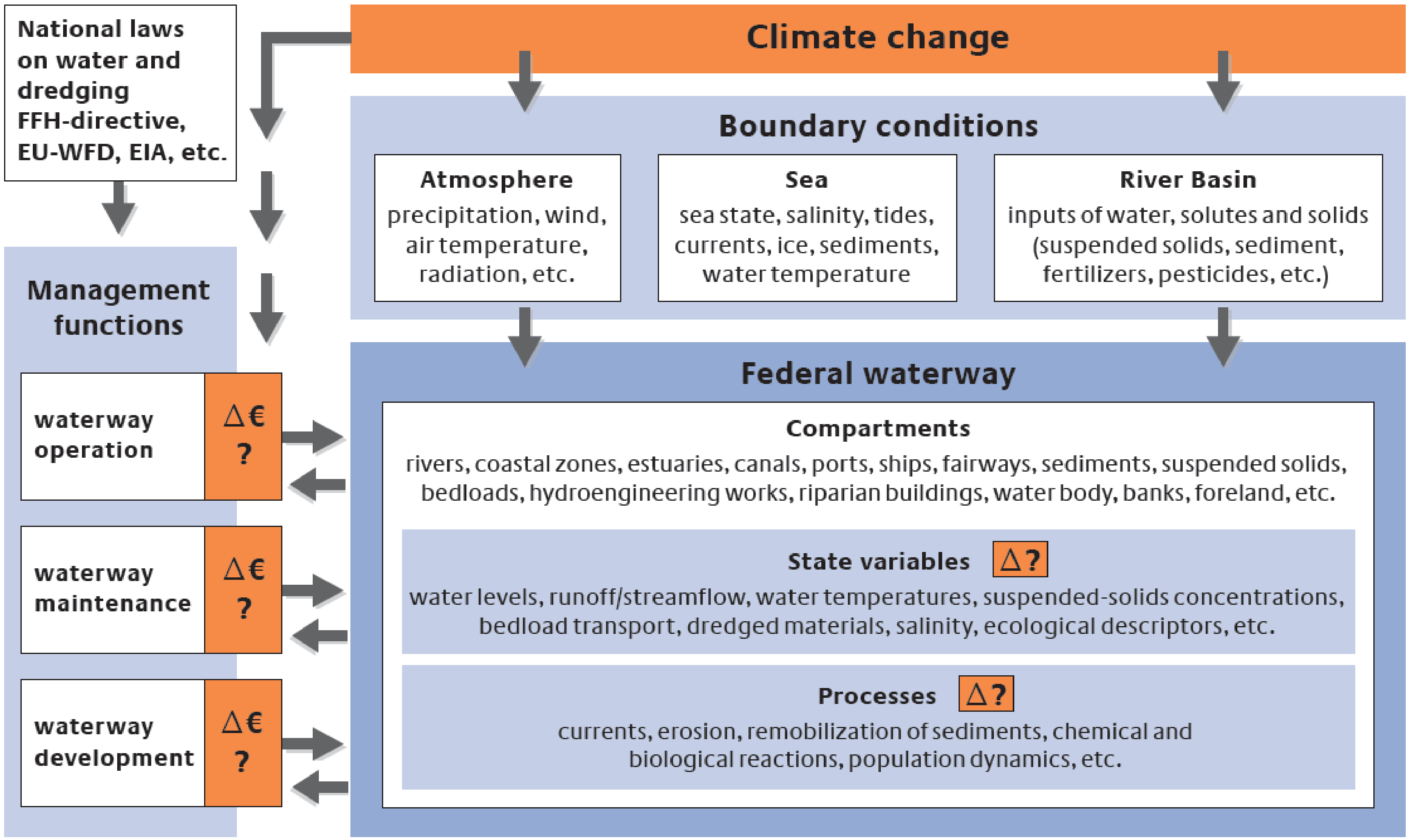
→ 17 plausible GCM-RCM-combinations

→ two different bias-corrections

→ Attempted are at least two different hydrological models for each river basin

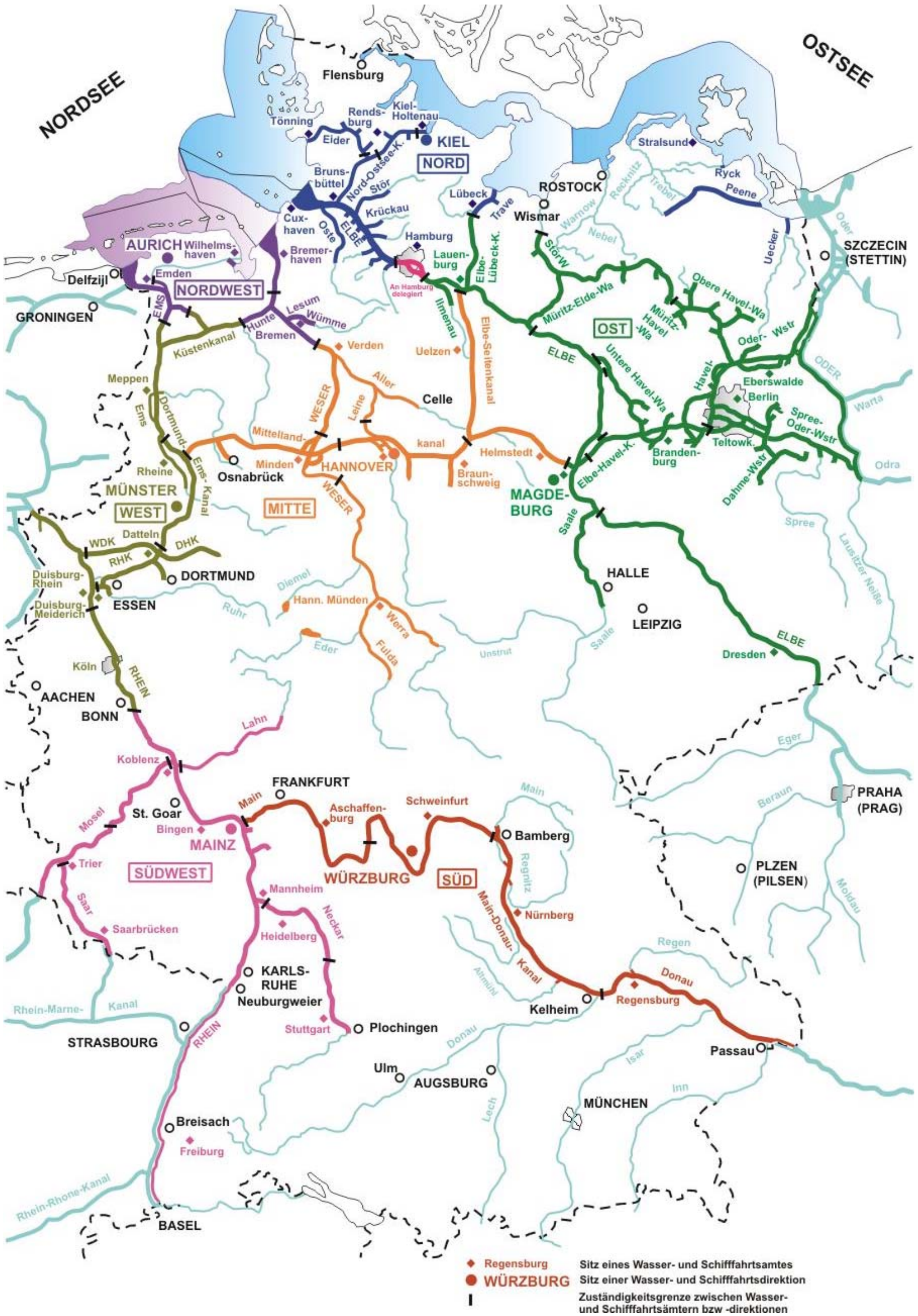
See KLIWAS contributions in ICWRER programme for more information

System analysis



after BMVBS (2007): Proceedings of First KLIWAS Status Conference, Berlin bfg Bundesanstalt für Gewässerkunde

Federal Ministry of Transport, Building and Urban Development



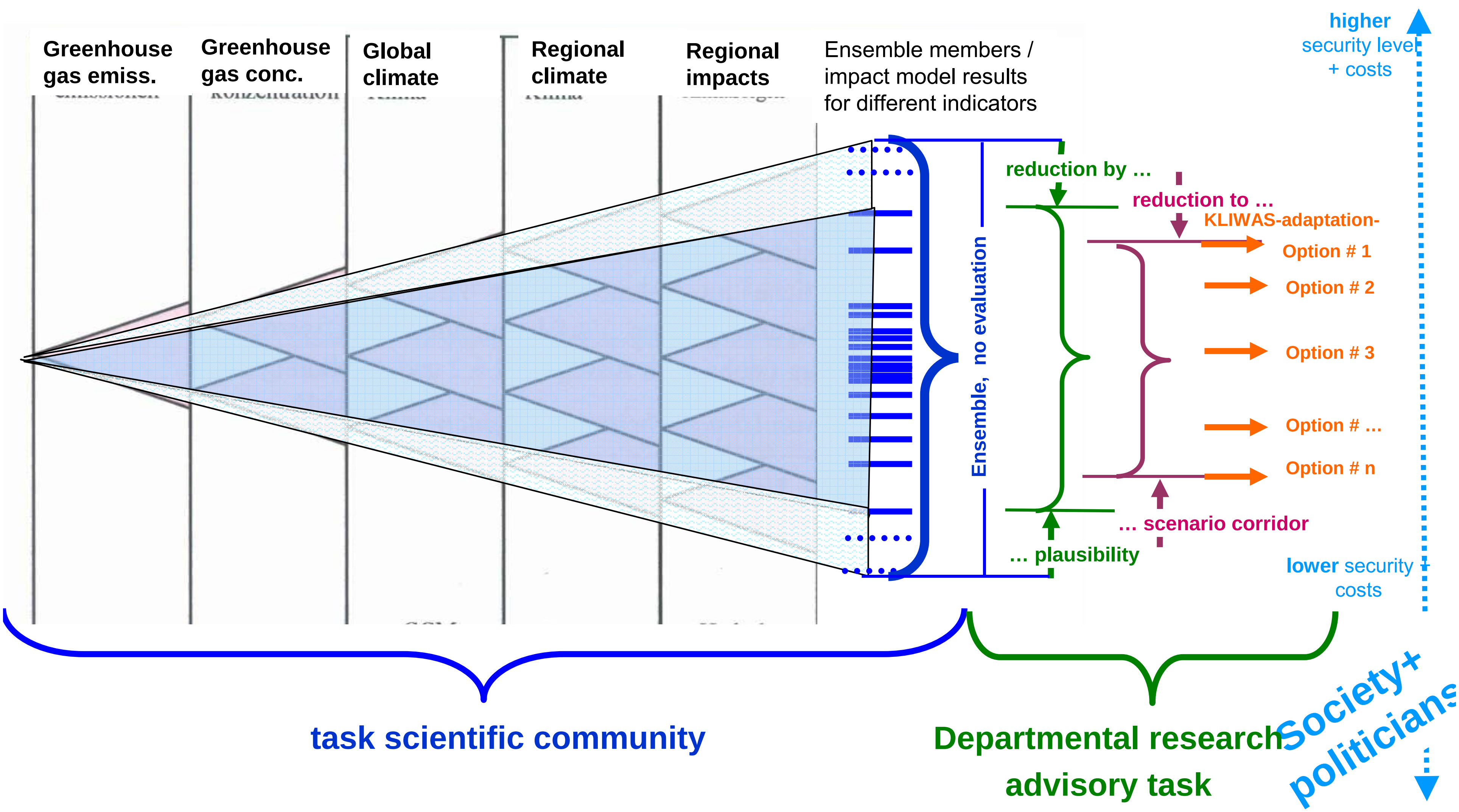
Navigable waterways in Germany

Rivers and canals	7.300 km
Coastal waterways	23.000 km²

managed by the

Federal Waterways and Shipping Administration (WSV)

Adaptation decisions reflecting uncertainty



Assessing the Impacts of Climate Change on Navigation and Waterways

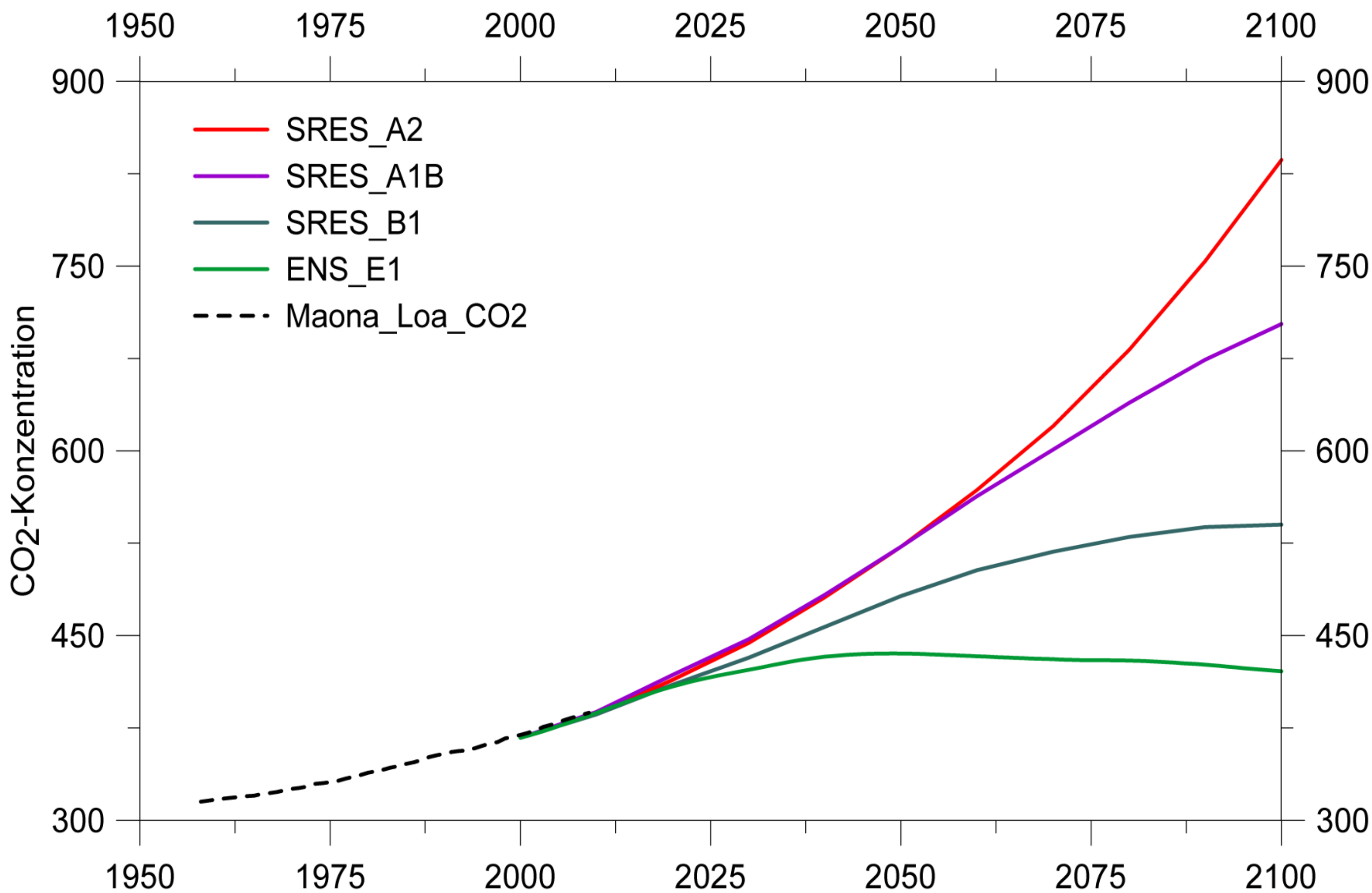
The German Departmental Research Programme KLIWAS

- Approach and recent results -

Prof. Dr. H. Moser
Federal Institute of Hydrology (BfG)
Dr. B. Rudolf
National Meteorological Service of Germany (DWD)
Dr. H. Heinrich
Federal Maritime and Hydrographic Agency (BSH)
Dr. A. Schmidt
Federal Waterways Engineering and Research Institute (BAW)
Dr. S. Kofalk
Coordination & Operational Office, BfG

Federal Ministry
of Transport, Building
and Urban Development

Span CO_2-Concentrations



Daten: IPCC-SRES, EU-ENSEMBLES

System oriented Approach: Model Chain

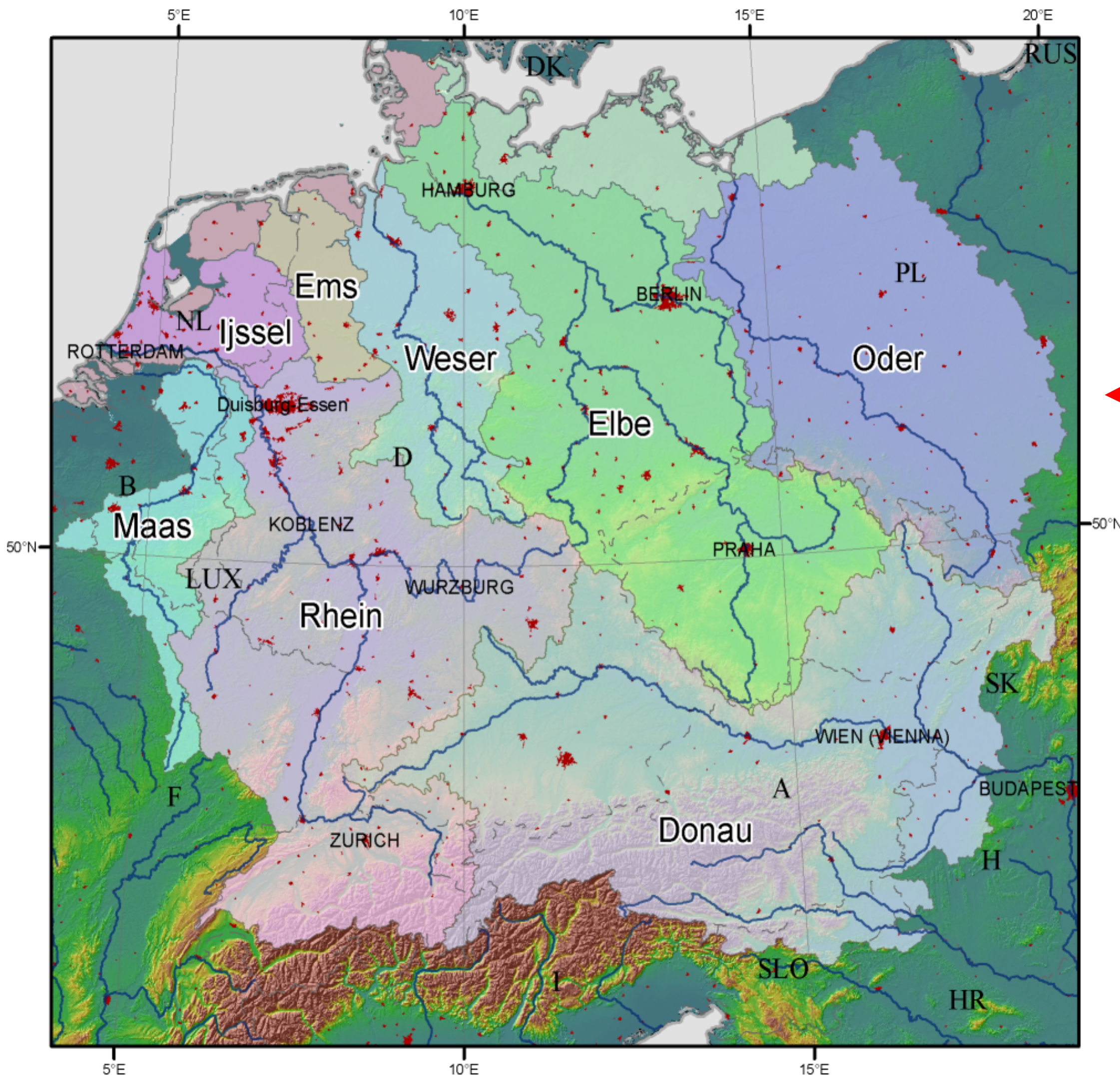
KLIWAS

1. Global emission scenarios / future development
2. Projections by global climate models
3. Projections by regional climate models
4. Oceanografic / water balance models
5. Sediment and morpho-hydraulic and navigation models
6. Water quality models
7. Ecosystem models

economic valuation inland navigation

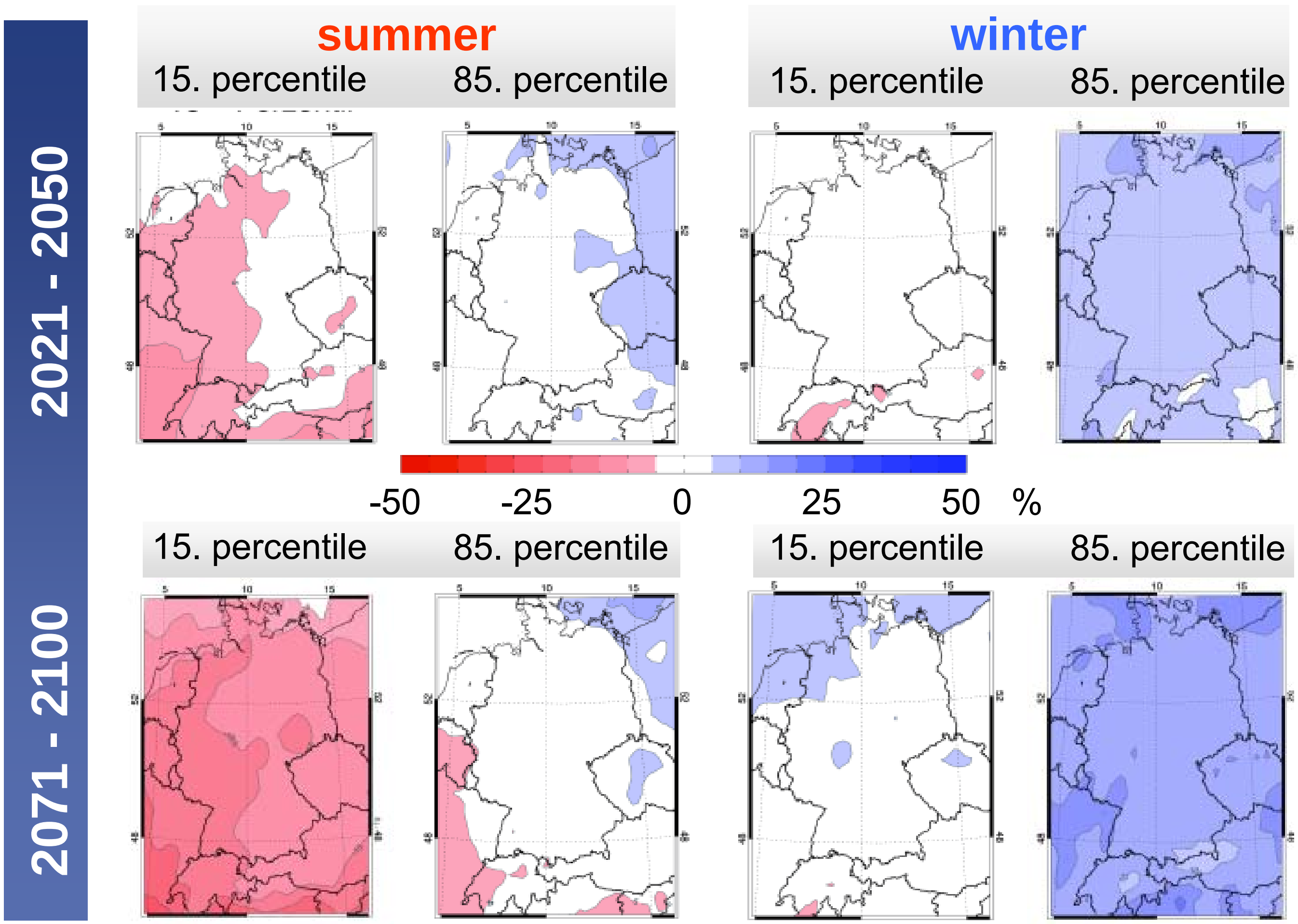
Source: BMVBS (2008)

River Basins, Central Europe



~ 1.000 km
Scale

Uncertainty, regional Scale:
Range of RCM: 19 Projections (A1B)

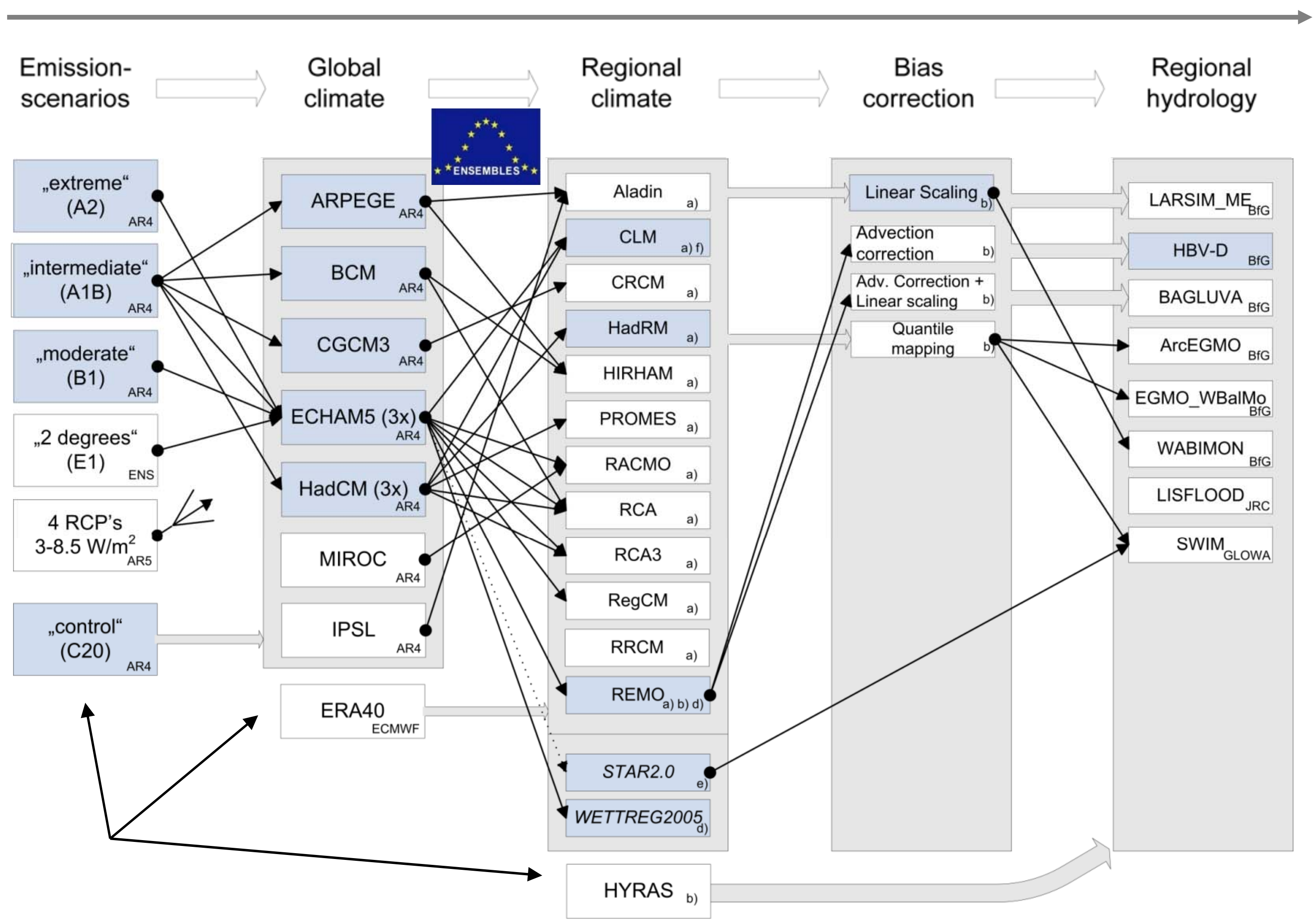


likely changes in annual mean precipitation

relative to 1971-2000; climate model ensemble at DWD

Operational Uncertainty Assessment

Model chain + Multi-Model approach



Nilson, 2010

“Climate Variables” - Indicators

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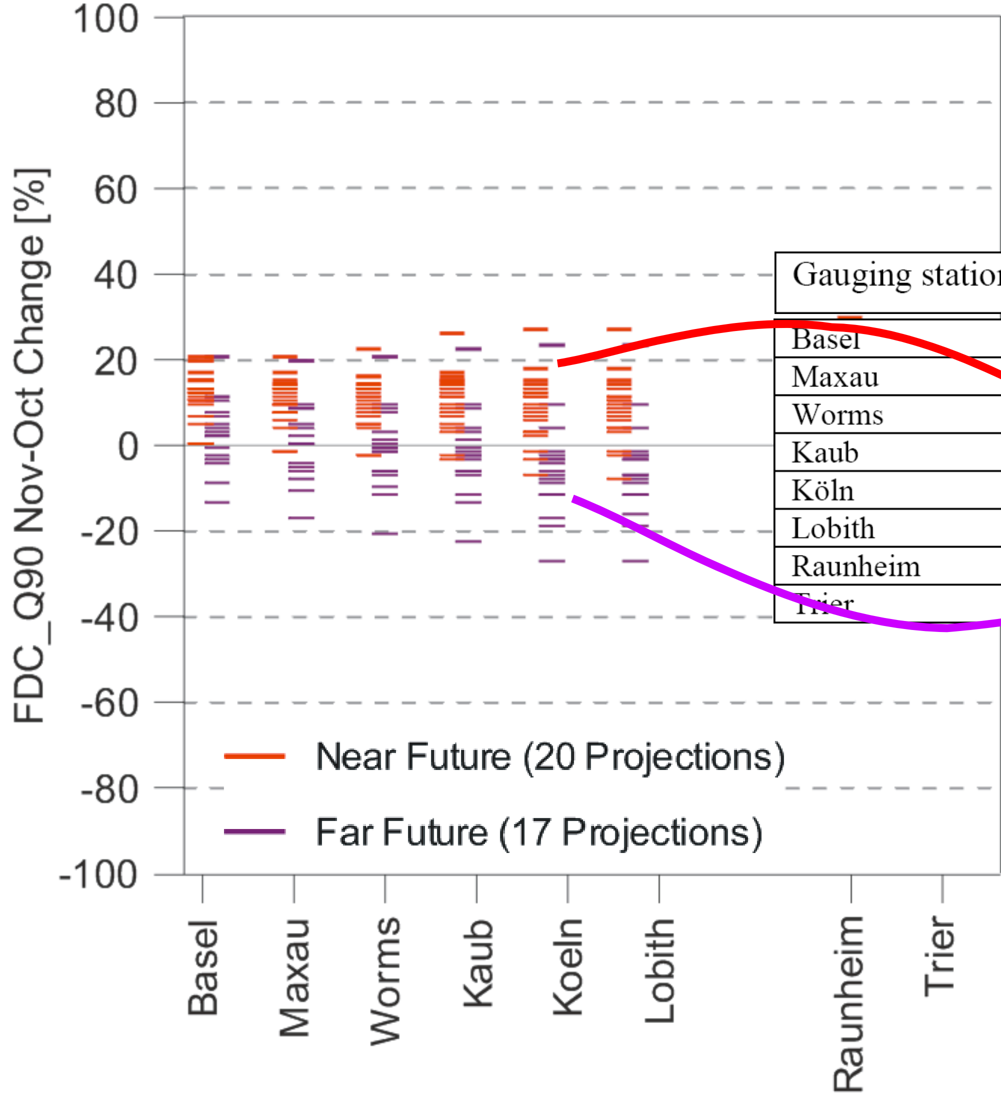
- Inland navigation
- low/high water periods,
- water depth, navigability
- water temperatures (warming, ice)
- water quality,
- water ecology
- …

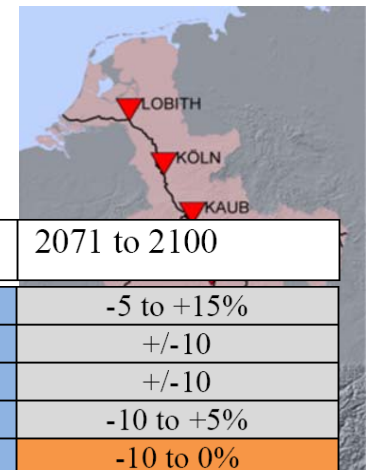
- Maritime navigation
- sea level changes
- tidal dynamics
- waves, wind
- water temperatures (warming, ice)
- water quality,
- water ecology
- ….

Operational Uncertainty Assessment

Impacts by Projection Ensembles

low flow, discharge undershot on 10% of all days of a 30- year period)





Gauging station	2021 to 2050	2071 to 2100
Basel	+5 to +15%	-5 to +15%
Maxau	+5 to +15%	+/-10
Worms	+5 to +15%	+/-10
Kaub	+5 to +15%	-10 to +5%
Köln	+5 to +15%	-10 to 0%
Lobith	+5 to +15%	-20 to 0%
Raunheim	+5 to +25%	+/-10
Trier	-5 to +15%	-40 to -25%

Scientific Findings

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1. Air temperature: Increase of annual average at least 1.5°C (far future, regional differences)

2. Precipitation tendency: Decrease in summer and increase in winter

3. Sea level rise: Further research need (unknown effects concerning melting of ice caps and connecting ocean-atmosphere models), no acceleration of sea level rise (1mm-3mm/a) at present but possible in future (first observations)

4. Discharge: Magnitude of changes in main rivers 10 up to 30% (2100, far future)

Conclusions, adaptation messages

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1. research and operational task:
   dealing with uncertainty

2. ensembles and multi model results
   = „state of the art“ for policy advise

3. Communication of projection uncertainties is
   essential for decision making

4. Adaptation challenge: Options → selection → taking
   measures at the right time & on an appropriate level


Thank you for your attention!
www.kliwas.de

PIANC www.pianc.org

- global organisation
- guidance for sustainable waterborne transport and infrastructure sector.
- Permanent Task Group on Climate Change (PTGCC)
- Review CC drivers, impacts, responses + mitigation

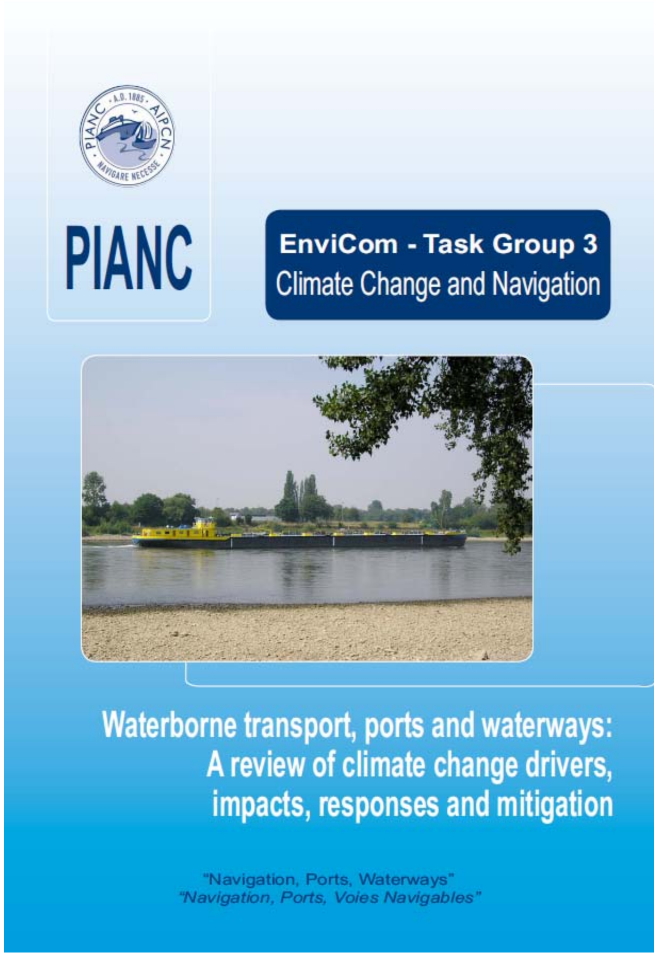


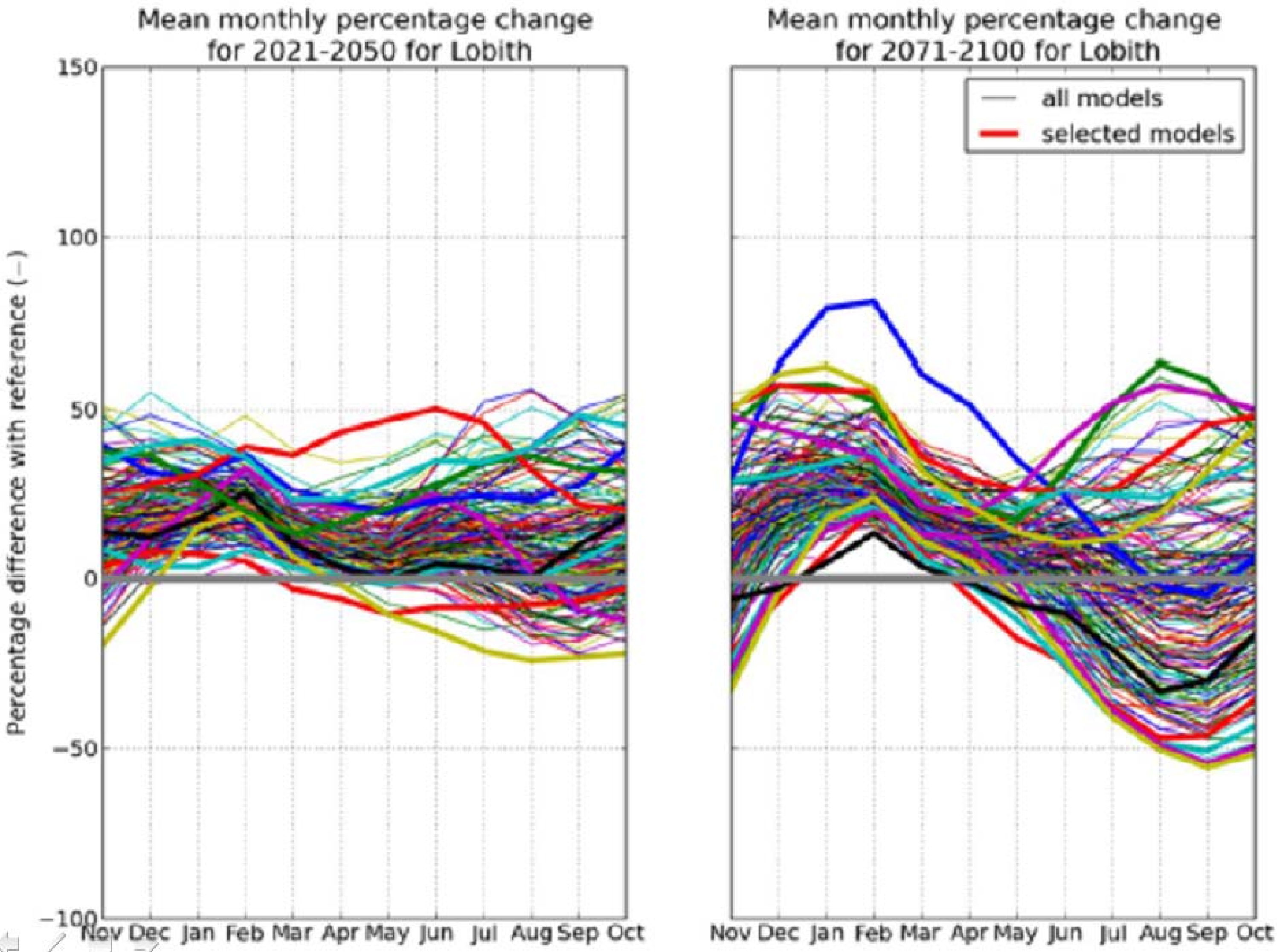
Table 3.2: Range of responses of navigation to possible future climate change

Area of intervention	Response (measures)
Maritime infrastructure design	Redevelopment of wharf fendering (to barrier ships at dock)
	Increase of quay levels, sea wall structures and connected area behind to overcome increased frequency of overtopping and low land flooding
	Lowest point in buildings placed at a higher level
	Revision of ship tunnel dimensions
	Relocation or strengthening of less protected marinas for pleasure boats
	Stronger and higher salt water erosion resistant bridges needed
	Overtopping and stability of breakwaters: crest height and armour unit block size increased; possible reorientation
	Restrictions on existing port developments, and limitations on location of new ports
	In the absence of site-specific guidance, a sensible allowance for sea level rise is 5 mm/yr
	A sensible response to possible future wave condition change is to check that design and operability are not seriously affected by a blanket 10 % increase in offshore wave heights (plus 5% increase in wave periods to maintain the same wave steepness): Defra (2006)
	For nearshore wave conditions affected by wave breaking, change in sea level (and hence water depth) is another consideration: apply the 10% precautionary increase in deep water wave height, and then break the waves to the limit determined by the water depth at any particular location
	A reasonable test of sensitivity to possible future wind condition change is to check that design and operability are not seriously affected by a blanket 10 % increase in wind speeds: Defra (2006)
	Communities and industrial facilities in coastal zones may already be threatened or forced to relocate, while others face increasing risks and costs
	Rebuilding or new design elements of land-based Arctic infrastructure may be required by melting permafrost: ACIA (2004)
Maritime infrastructure operation and maintenance	Increased maintenance and replacement costs of port, coastal and sea platform infrastructure
	Increased maintenance due to increased storm surge damage to coastal protection infrastructure, seawalls, dunes, breakwaters etc.
	More sedimentation at river outlets, increasing dredging need
Maritime navigation practice	Adapting to fish migration, changes in fishing fleet design and harbour location
	Fishing fleet needs bigger boats to maintain activity if wave height increases, or else the work time is changed
	Change in beach erosion may require new or changed beach nourishment
	More frequent moist and cold air requires more compact and airtight equipment to avoid condensation problems
	Pilot meeting places may need to be altered
	Terminals for smaller passenger boats may need to be relocated; use of "quieter" parts of the coastline

Table 4.3: Possible responses of inland navigation to climate change impacts

Area of intervention	Response (measures)	Additional information
Waterway design and maintenance	Creation of water storage facilities	(Upstream) reservoirs needed for flood mitigation could also be used to improve navigation
	Deepening of channels instead of widening	
Waterway operation	Managing water flow	Store water in times of high water flow, release water in times of low flow
	Improving forecast of water level	Better information, further ahead, could optimise the use of vessel capacity for given conditions, and reduce uncertainty margins
	Improved queuing procedures	Decision support systems and automation of queuing could help to overcome capacity restrictions of waterway infrastructure
	Implementation of River Information Services (RIS)	RIS in general support safe and efficient navigation
	Providing up-to-date electronic charts of fairway with water depth information	Better information to optimise use of vessels in given conditions, and reduce uncertainty margins
Transport management	Chartering of additional vessels	
	Increasing daily operation times of vessels	
	Cooperation with other modes of transport	Contractual arrangements with road and rail transport can be made for times of reduced navigability
	Increased storage of goods	
Vessel operation	Employing sophisticated Inland ECDIS (Electronic chart display and information system)	Provision of all necessary and always up-to-date information, better to utilize given navigation possibilities
Vessel design	Reduction of weight	Using alternative design or materials, installing lighter equipment
	Increasing width	Wider vessels need less draught

Ausblick: Neue Projektionen



Source: Sperna Weiland & Bouaziz (2014)

Deltares

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