Tracking climate impact chains across sectors in Germany

The case of low flow situations of the River Rhine

Dr. Enno Nilson
(Bundesanstalt für Gewässerkunde)

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Adaptation strategies

Water resources Transport sector

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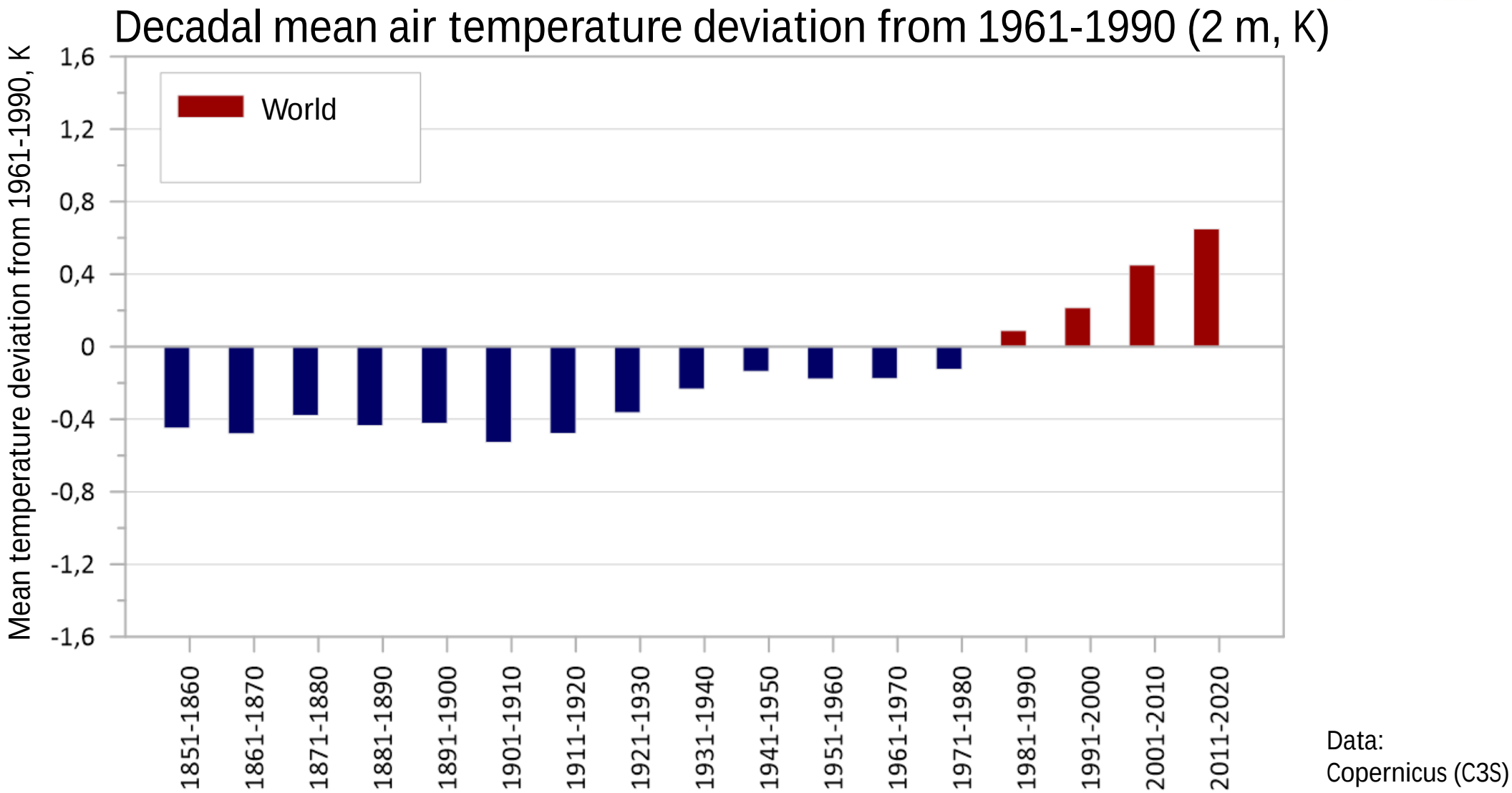
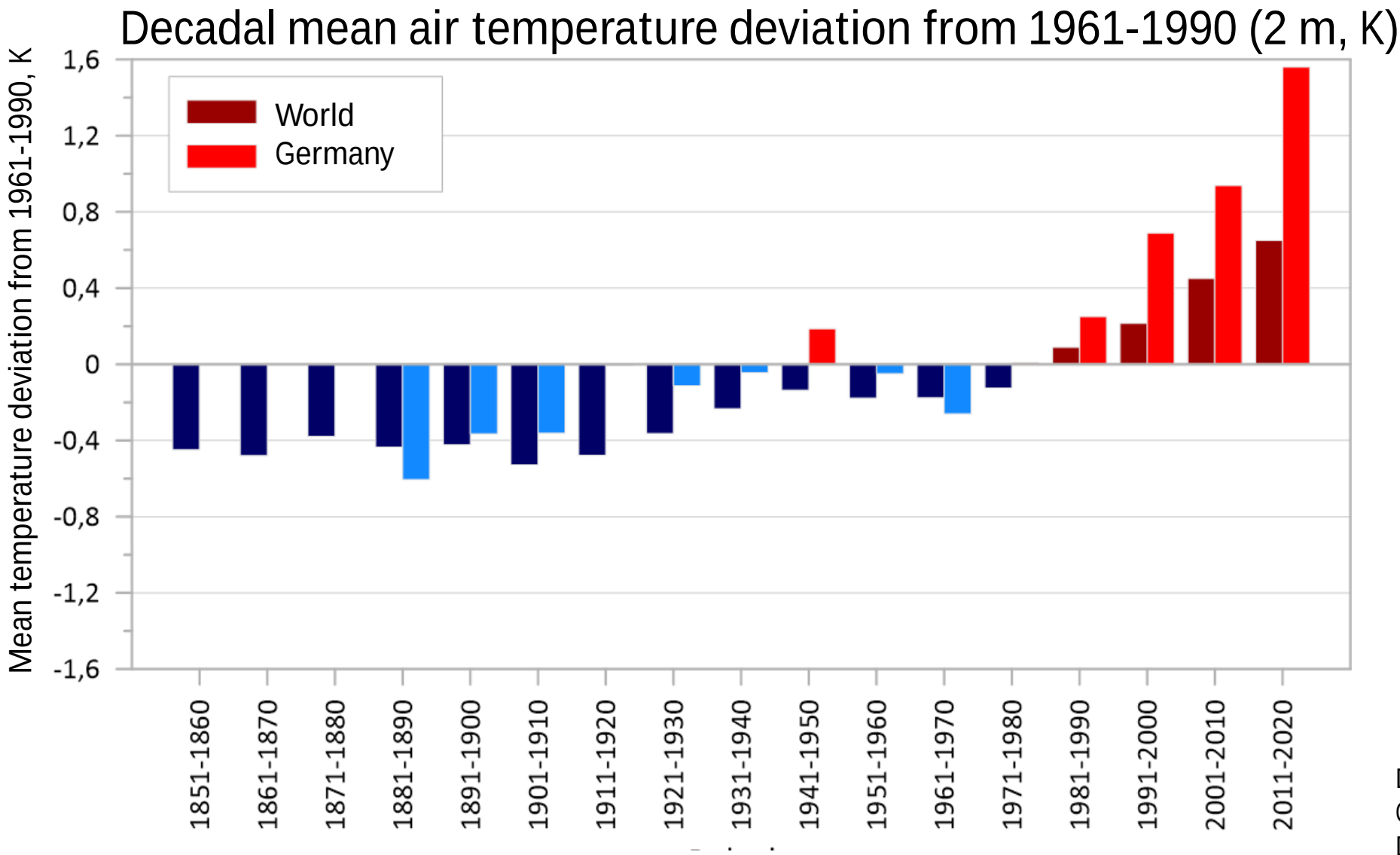
Climate change worldwide...



Data:
Copernicus (C3S)

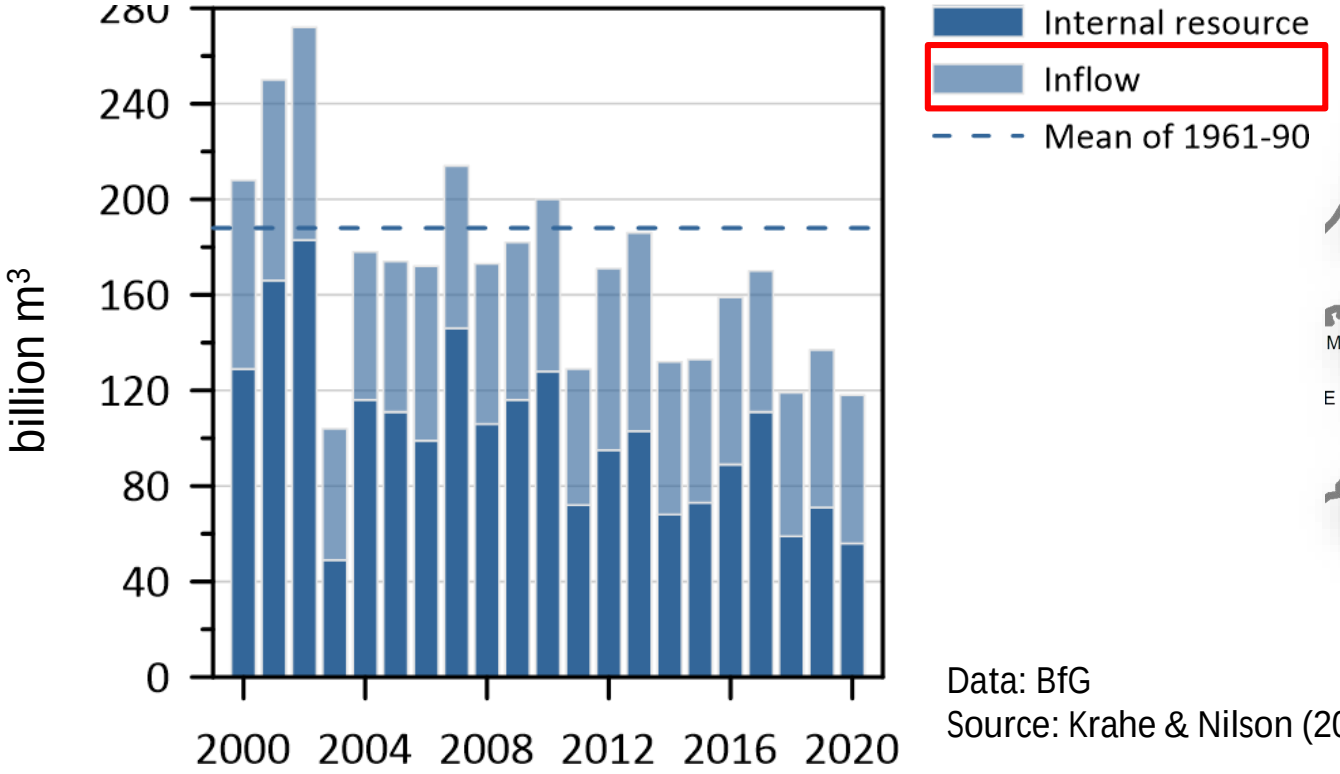
Climate change in Germany...



Data:
Copernicus (C3S)
DWD (CDC)

Fresh water ressources of Germany

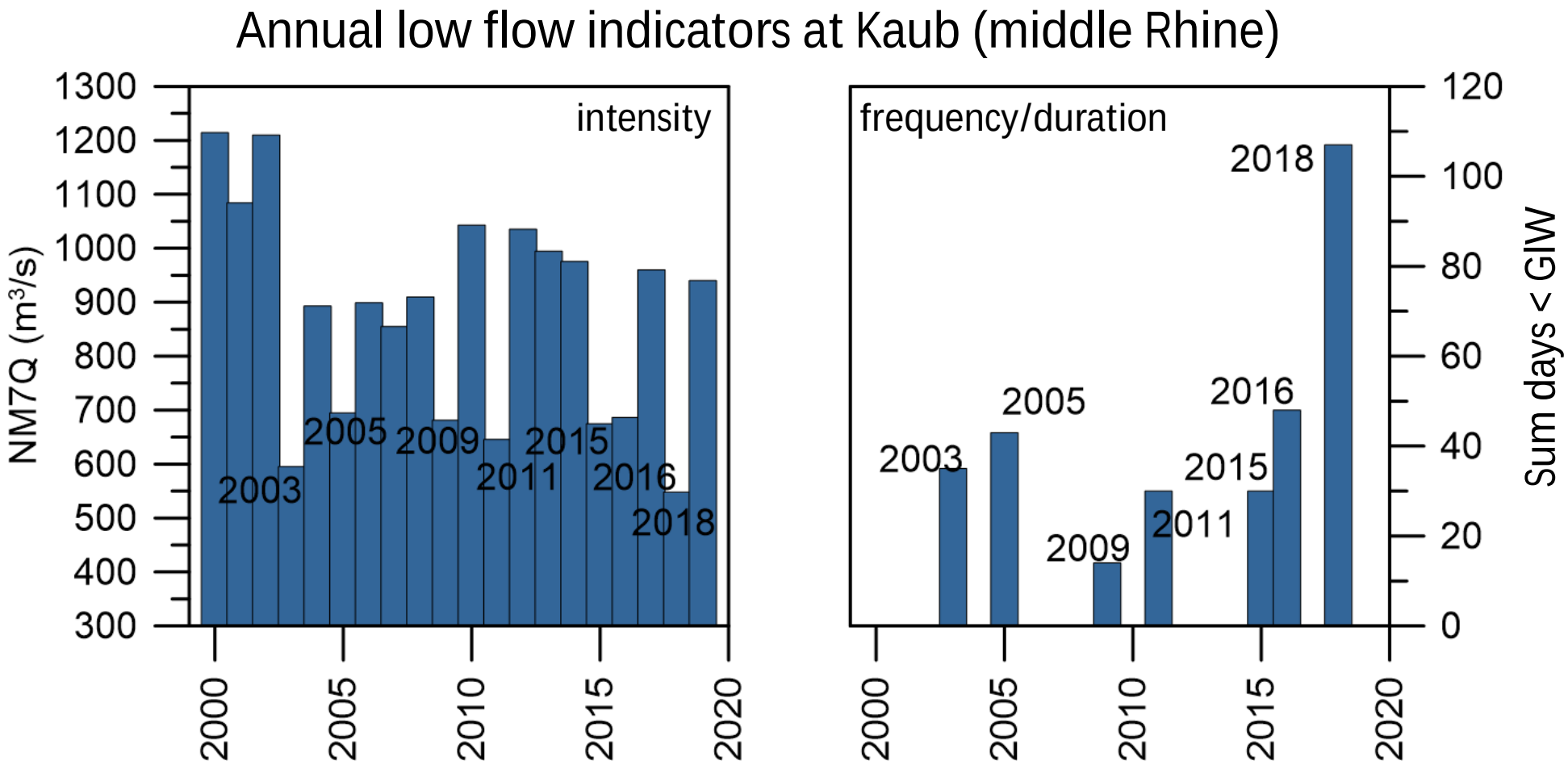
Annual renewable fresh water resources of Germany



Data: BfG
Source: Krahe & Nilson (2021)

- Variability: Interplay of precipitation, evaporation, …, and storage change
- Inflow mainly via Rhine, Elbe, Danube, particularly relevant in dry years
- Motivation for a national water strategy

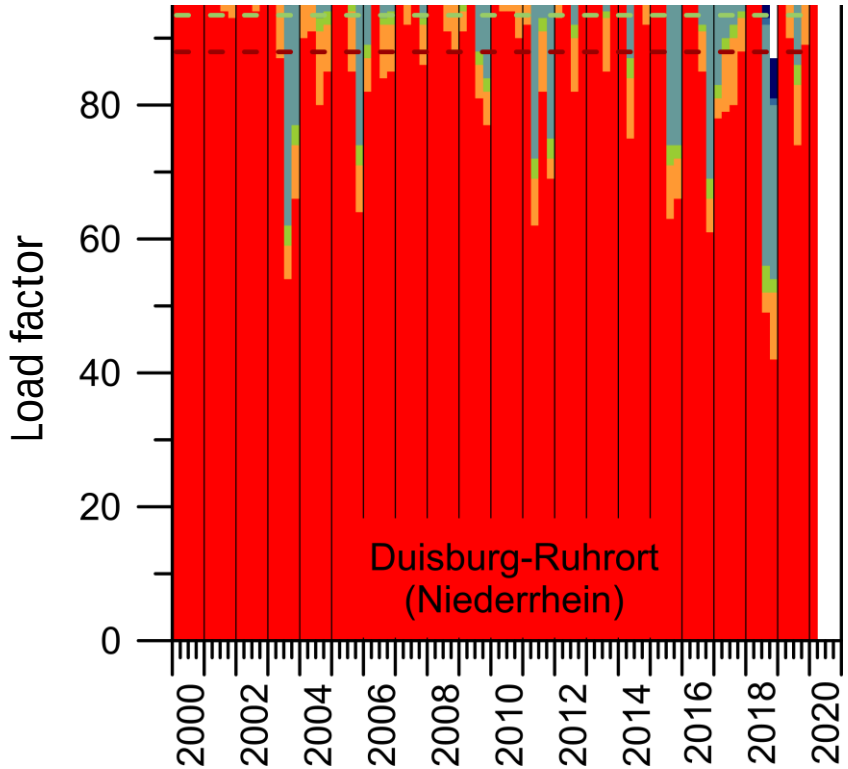
Low flow on the Rhine river…

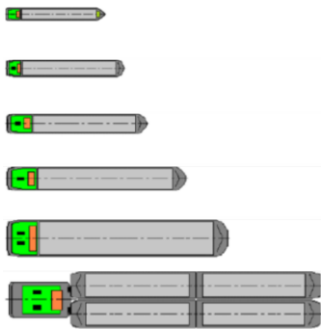


- Several low flow years in the recent past
- But generally no all-time-extremes in the Rhine region (time series since 18XX)
- Relevant (among others) for the transport sector

Low flow … means less cargo per ship, …

Quarterly load factors of typical Rhine vessels at Duisburg-Ruhrort (lower Rhine)





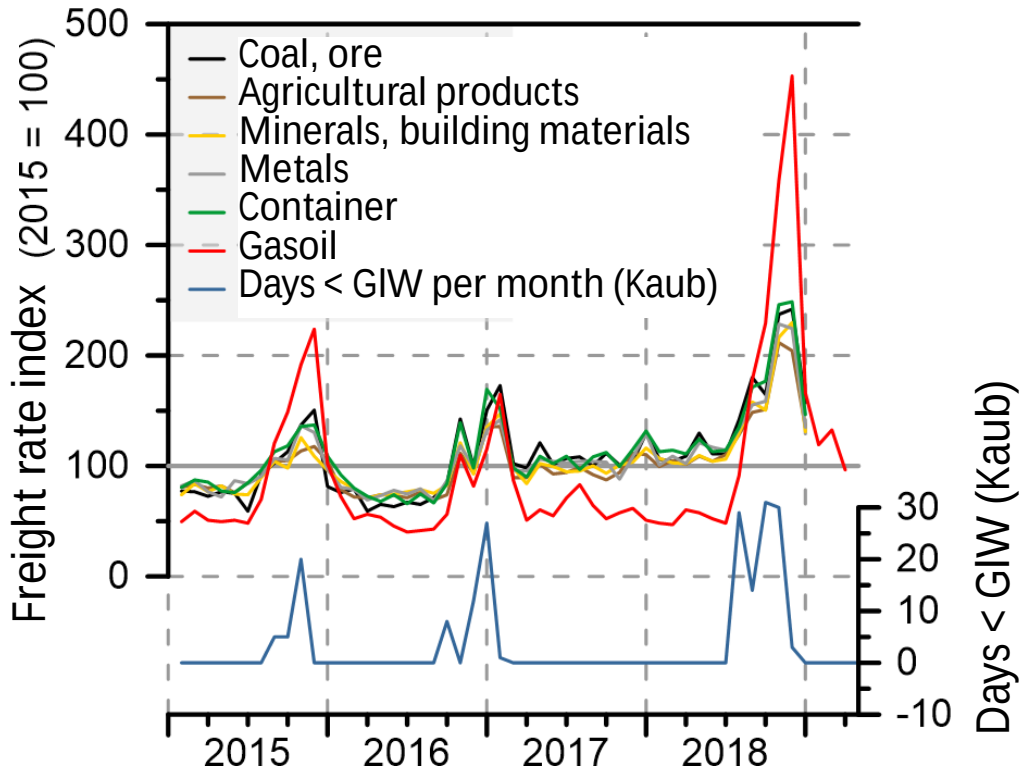
Vessel types (max. draught)

- Karl Vortisch (2.30 m)
- Gustav Königs (2.50 m)
- Johann-Welker (2.50 m)
- GMS-110 (3.50 m)
- JOWI (3.50 m)
- Pushed convoy 2x2 EII (4.00 m)
- Mean values of the total period

- Decrease of the load factor by up to 60 percentage points in extreme years
- Calculation based of ship parameters and observed waterway conditions

Data: DST, BfG
Source: Nilson & Krahe (2019)

Low flow … means higher prices of transport …



Monthly Freight rates for typical goods in the Rhine region related to a low flow indicator

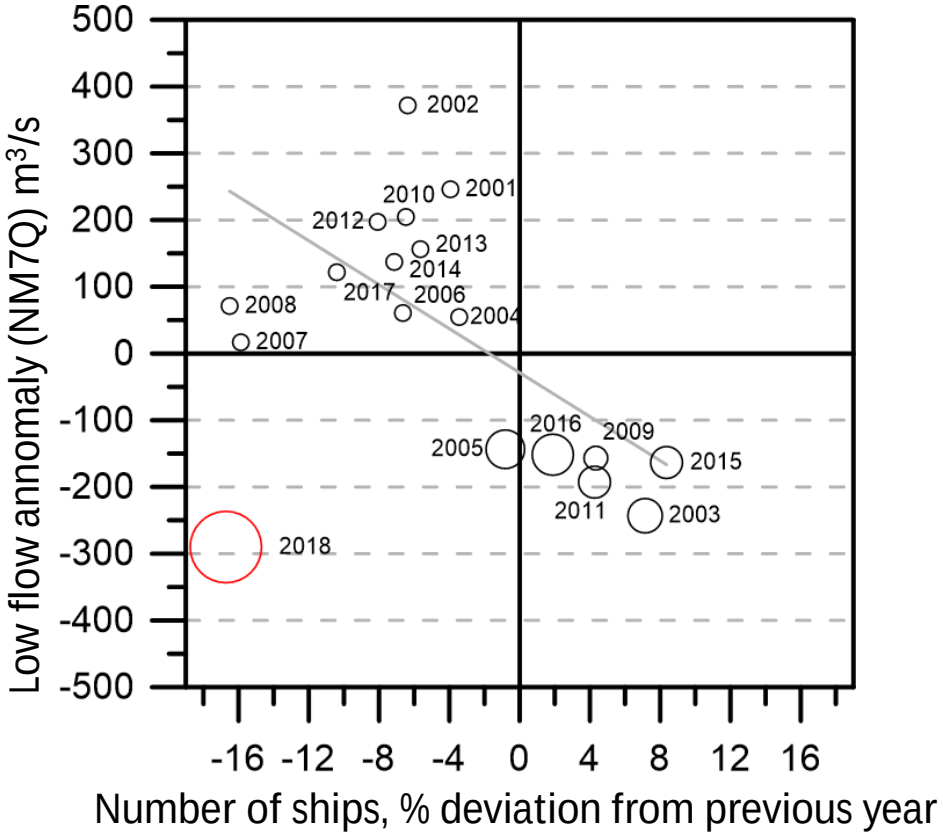
Data: PANTEIA, PJK International, WSV
Source: CCNR

- Redrawn/combined from CCNR market observations.
- PANTEIA-Index for all goods except Gasoil*.

* Gasoil: PJK-Index, more sensitive to low flow on the Rhine

Low flow … means more ships on the river (?), …

Annual ship counts at Iffezheim related to two low flows indicators

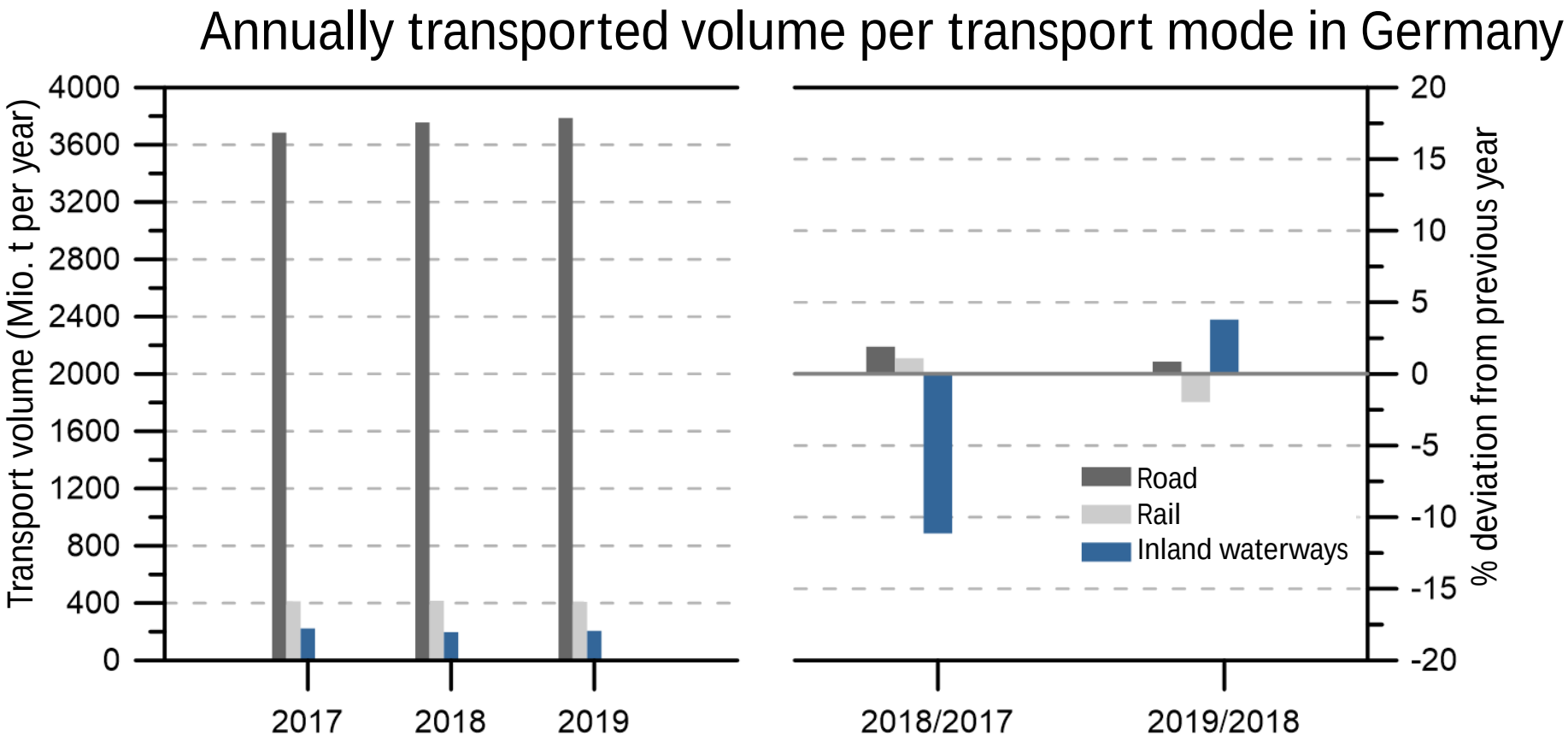


- River flow anomaly (NM7Q) vs. 1971-2000
- Number of days below GlQ (low flow threshold),
  - ○ 10 days
  - ◯ 100 days
- Number of ships, deviation from previous year

- General agreement of high ship counts and low flow years, except 2018
- Variability of ship numbers has various drivers (e.g. global economy, fairway conditions).

Data: WSV, DESTATIS
Source: BfG

Low flow … means less goods on the river, …

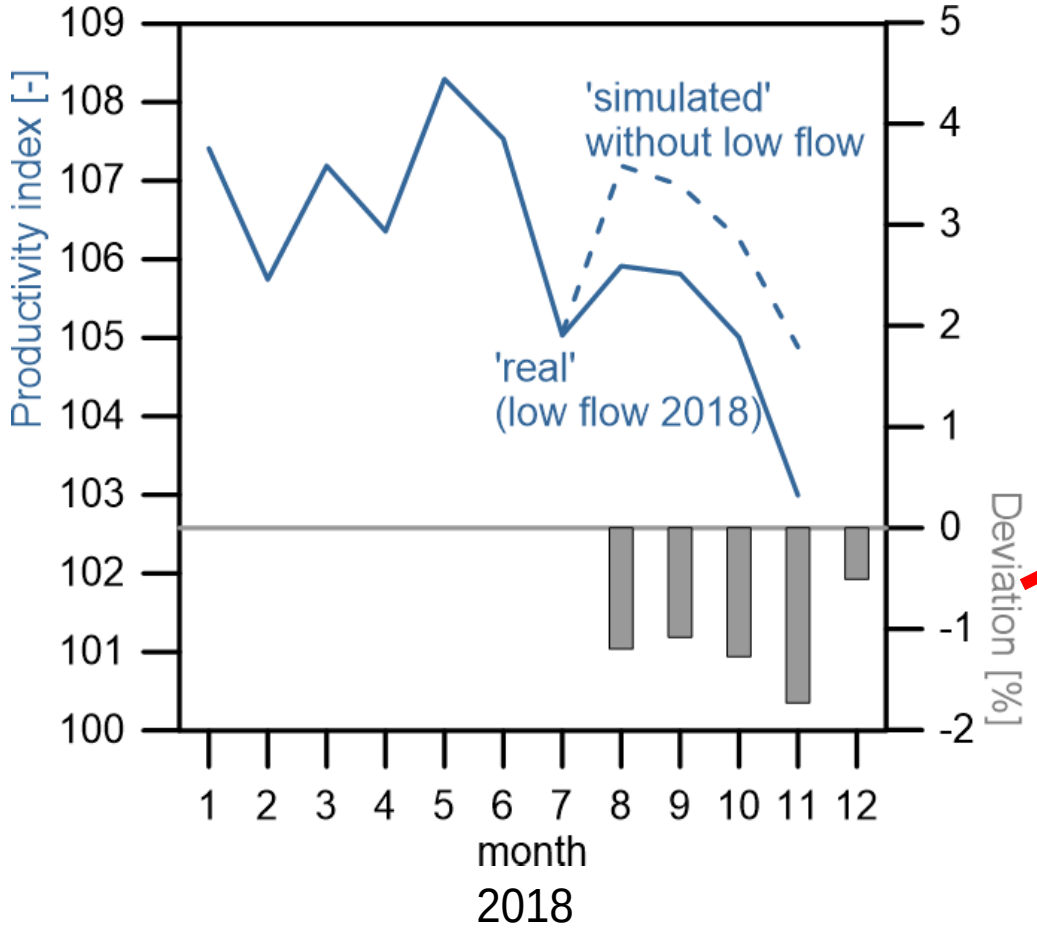


- Partial shift from inland waterway transport to other transport modes
- Limited capacity and much higher costs.

Data: DESTATIS, BAG

Low flow ... can cause significant damage in economy, ...

Reduced growth rate of production in the manufacturing sector in Germany



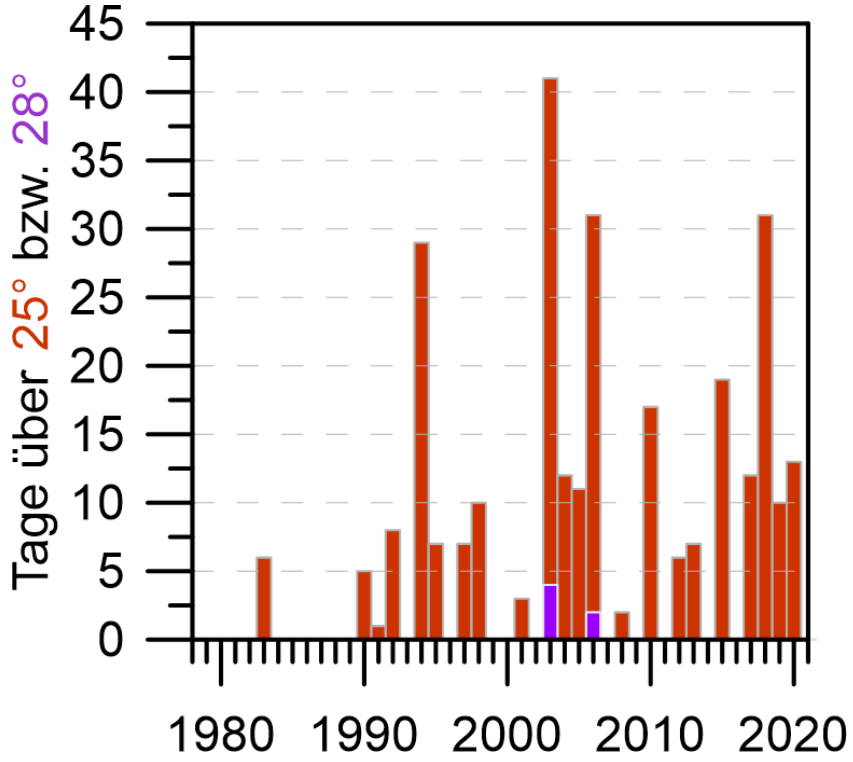
Estimates of total effect

- 2,5 billion € (Ademmer et al. 2018)
- 1,8 billion € (CCNR, 2019)
- 2,4 billion (Streng et al., 2020)

Data: WSV, DESTATIS
Source: Ademmer et al., 2018

Low flow … can cause stress for river ecosystems.

Water temperatures at Koblenz



- 2031-2060
  +11 days (10 to 17)
  + 1 day (0 to 2)
- 2070-2100
  + 36 days (30 to 38)
  + 3 days (2 to 6)
- 30-yr mean

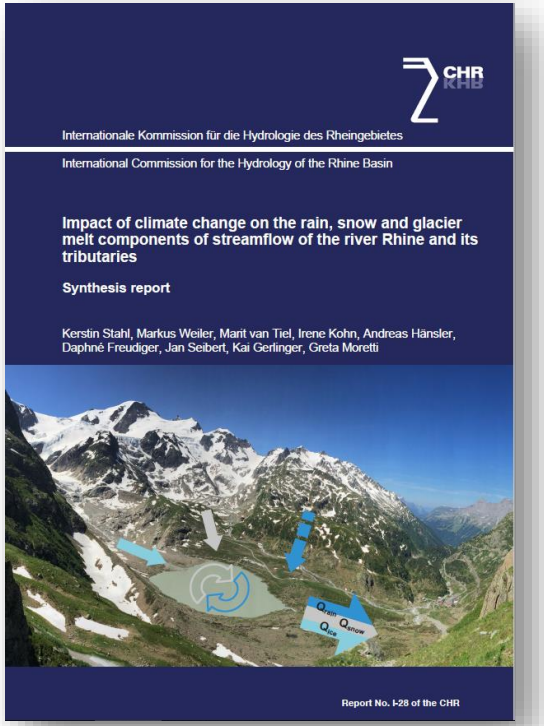
Data: WSV, BfG
Source: BfG

- Threshold values 25°C and 28°C: Ecological reference values according to the EU Water Framework Directive
- Observations (01/1978-08/2021) and 5 water quality projections for the high scenario RCP8.5

Interim summary

Why is ASG-I/II relevant for BfG and its clients?

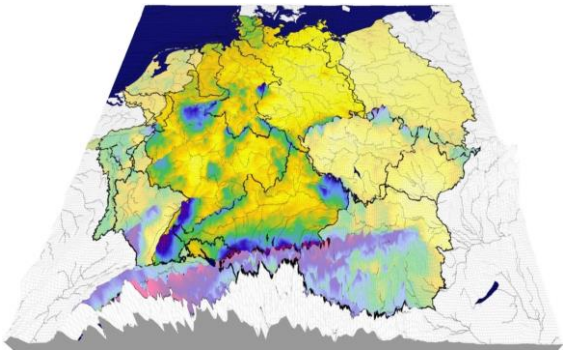
1. Renewable freshwater resources of Germany are in part related to upstream inflow.
2. Extreme low flow situations cause significant damage to economy and ecology.
3. ASG…
   - *… confirms the need to think about adapting to 'new' hydrological extremes.*
   - *… casts light on so far underexposed hydrological processes (river flow from glaciers).*
   - *… provides data that should be compared to and integrated with national and international climate impact assessments.*

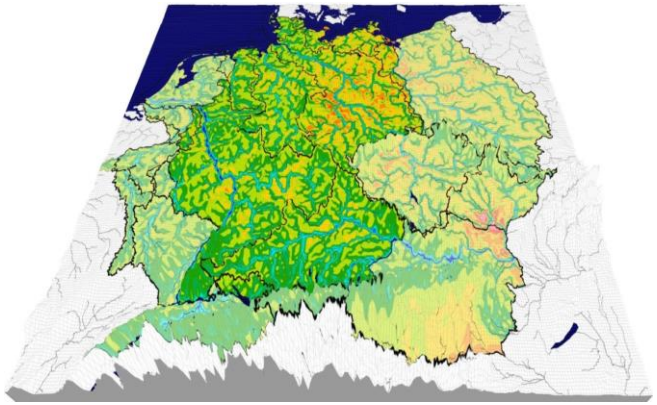


DAS-Basisdienst "Klima und Wasser"

"DAS core service Climate and Water"

- Permanent climate service
  - supporting the German strategy for adaption to Climate Change "DAS"
  - supported by research activities (e.g. "BMDV Network of Experts")
- Data and consultancy on climate change and water-related impacts in Germany
- Clients: BMDV, WSV, UBA, federal states, industry, universitites, citizens…
- Partners
  - Direct partners: DWD, BfG, BAW, BSH
  - Network Partners: Other agencies on national and federal state level





Abbreviations: Federal Ministry for Digital and Transport (BMDV), Federal Waterways and shipping administration (WSV), German Federal Environmental Agency (UBA), Deutscher Wetterdienst DWD, Federal Institute of Hydrology (BfG), Federal Waterways Engineering and Research Institute (BAW), Federal Maritime and Hydrographic Agency (BSH), German strategy for adaption to Climate Change "DAS"

WS-Klimaportal

ws-klimaportal.bafg.de/_w_3d0faa28/#Stationen

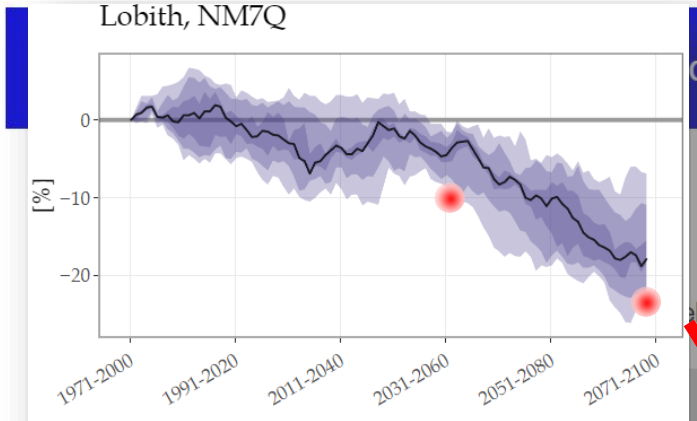
ws-klimaportal.bafg.de*

daten Hintergrund Situationsberichte FAQ Kontakt

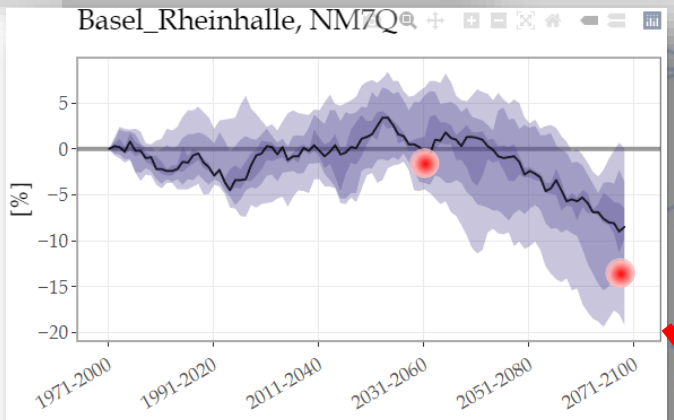
DAS Basisdienst Klima und Wasser

Low flow projections of DAS Basisdienst

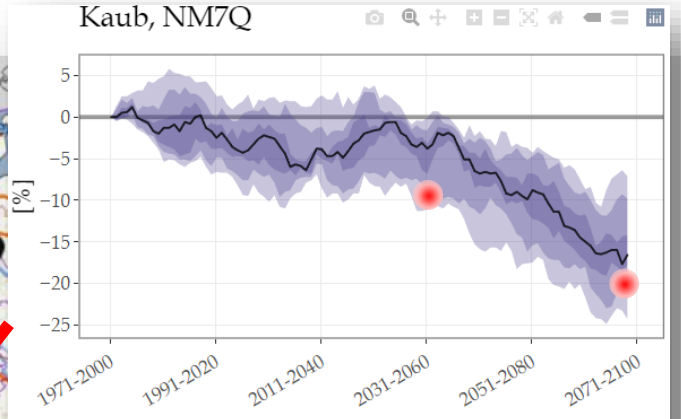
- ASG-II (Median)



Kennwert	Bezugszeitraum [m³/s]	Gegenwart [%]	Nahe Zukunft [%]	Ferne Zukunft [%]
NM7Q	1073.94	1.5	-9 bis -1 (-4)	-24 bis -7 (-18)



Kennwert	Bezugszeitraum [m³/s]	Gegenwart [%]	Nahe Zukunft [%]	Ferne Zukunft [%]
NM7Q	544.18	-1.7	-4 bis +7 (-0)	-19 bis -0 (-9)



Kennwert	Bezugszeitraum [m³/s]	Gegenwart [%]	Nahe Zukunft [%]	Ferne Zukunft [%]
NM7Q	856.46	0.4	-11 bis -0 (-4)	-24 bis -7 (-17)

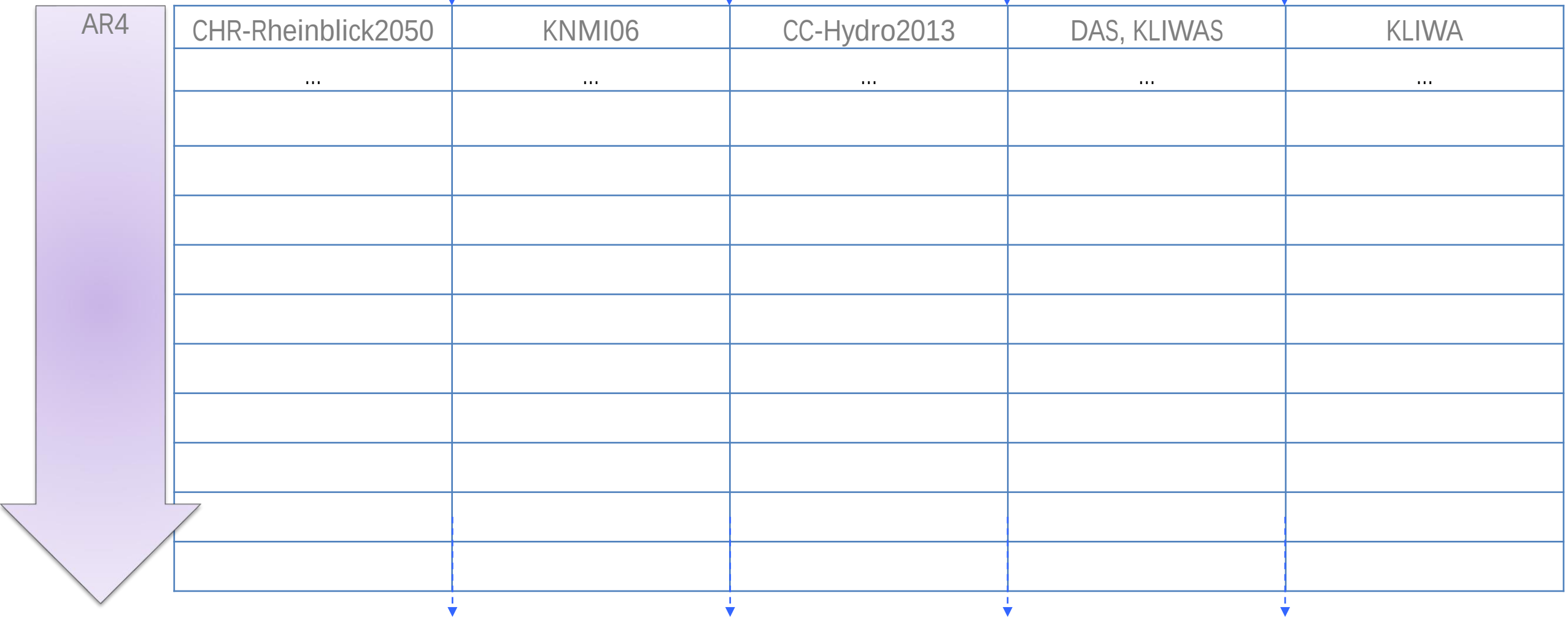
* WS = Watermanagement & Shipping

Integration of different Rhine assessments

Matches and mismatches

Integration of different Rhine assessments

Matches and mismatches



Integration of different Rhine assessments

Matches and mismatches

AR4	CHR-Rheinblick2050	KNMI06	CC-Hydro2013	DAS, KLIWAS	KLIWA
	...	...	...	...	...
AR5	CHR-ASG II	KNMI14	CC-Hydro2018	DAS, XPN	KLIWA

Integration of different Rhine assessments

Matches and mismatches

AR4	CHR-Rheinblick2050	KNMI06	CC-Hydro2013	DAS, KLIWAS	KLIWA
	...	...	...	...	...
AR5	CHR-ASG II	KNMI14	CC-Hydro2018	DAS, XPN	KLIWA
Scenario					
Climate					
Members					
Hydrology					
Reference					
Future 1					
Future 2					

Integration of different Rhine assessments

Matches and mismatches

AR4	CHR-Rheinblick2050	KNMI06	CC-Hydro2013	DAS, KLIWAS	KLIWA
	...	...	...	...	...
AR5	**CHR-ASG II**	**KNMI14**	**CC-Hydro2018**	**DAS, XPN**	**KLIWA**
Scenario	RCP8.5	RCP8.5	RCP8.5, ...	RCP8.5, ...	RCP8.5
Climate	CORDEX	CMIP5	CORDEX	CORDEX	CORDEX
Members	7	AdvDC, RACMO	20	16	10
Hydrology	HBV-light/LARSIM	HBV	HBV-light/PREVAH	LARSIM	LARSIM
Reference	1981-2010	1951-2006	1981-2010	1971-2000	1971-2000
Future 1	2031-2060	2021-2050	2045-2074	2031-2060	2021-2050
Future 2	2071-2100	2071-2100	2071-2100	2071-2100	2071-2100

Integration of different Rhine assessments

Matches and mismatches

	CHR-Rheinblick2050	KNMI06	CC-Hydro2013	DAS, KLIWAS	KLIWA
AR4	...	...	...	...	...
AR5	CHR-ASG II	KNMI14	CC-Hydro2018	DAS, XPN	KLIWA
Scenario	RCP8.5	RCP8.5	RCP8.5, ...	RCP8.5, ...	RCP8.5
Climate	CORDEX	CMIP5	CORDEX	CORDEX	CORDEX
Members	7	AdvDC, RACMO	20	16	10
Hydrology	HBV-light/LARSIM	HBV	HBV-light/PREVAH	LARSIM	LARSIM
Reference	1981-2010	1951-2006	1981-2010	1971-2000	1971-2000
Future 1	2031-2060	2021-2050	2045-2074	2031-2060	2021-2050
Future 2	2071-2100	2071-2100	2071-2100	2071-2100	2071-2100

Integration of different Rhine assessments

Matches and mismatches

	CHR				
AR4	CHR-Rheinblick2050	KNMI06	CC-Hydro2013	DAS, KLIWAS	KLIWA
	...	...	...	...	...
AR5	CHR-ASG II	KNMI14	CC-Hydro2018	DAS, XPN	KLIWA
Scenario	RCP8.5	RCP8.5	RCP8.5, ...	RCP8.5, ...	RCP8.5
Climate	CORDEX	CMIP5	CORDEX	CORDEX	CORDEX
Members	7	AdvDC, RACMO	20	16	10
Hydrology	HBV-light/LARSIM	HBV	HBV-light/PREVAH	LARSIM	LARSIM
Reference	1981-2010	1951-2006	1981-2010	1971-2000	1971-2000
Future 1	2031-2060	2021-2050	2045-2074	2031-2060	2021-2050
Future 2	2071-2100	2071-2100	2071-2100	2071-2100	2071-2100
	...	...	...	...	...
AR6	CHR-...	KNMI/Deltares	CC-Hydro	DAS	KLIWA

Summary

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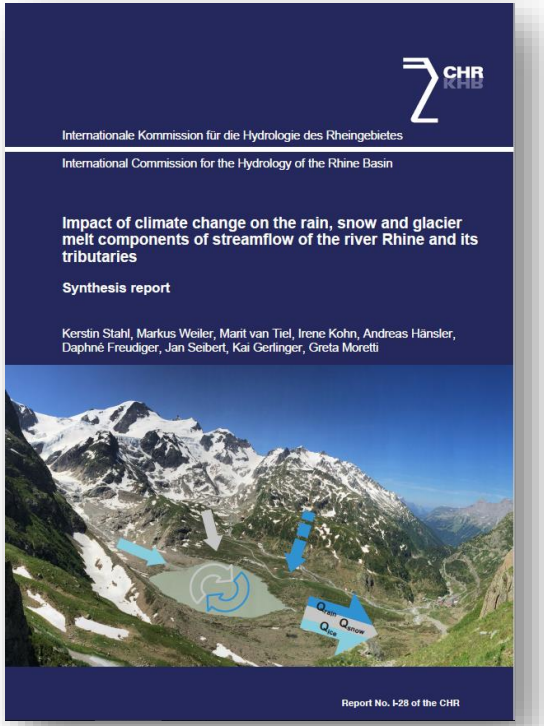

What should follow after ASG-II?

4. Coordination of the riparian countries of the Rhine basin and their climate services/consultants …
5. … targeting on the conversion of individual assessments to international scenarios …
6. … that can serve as basis for coherent decisions on adaptation strategies and measures.

Questions/Comments?

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ws-klimaportal.bafg.de*, das-basisdienst.de

* soon online again

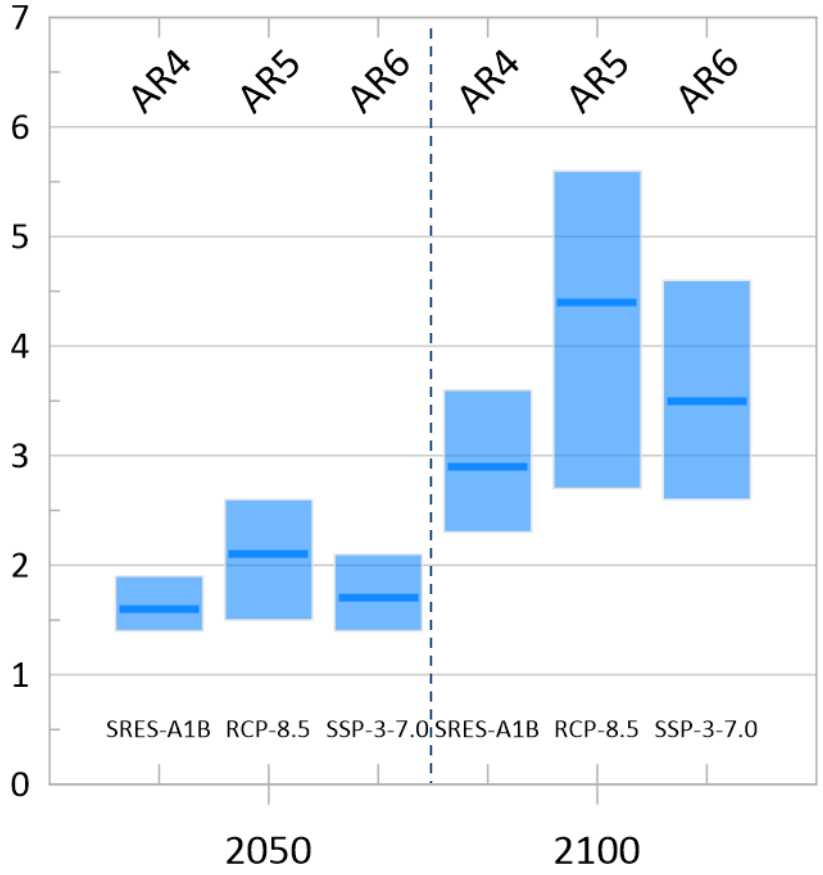
Foto: Nilson 05/2019 Upper Rhine at Basel

Foto: Nilson 04/2022 Middle Rhine near Kaub

Foto: Nilson 09/2021 Lower Rhine at Cologne

Climate change and scenario change

Changes in global surface temperature
in the mid- and end of 21st century according to different IPCC Reports.



BfG working figure

- Changes relative to 1990 as given in the SPMs of different IPCC assessments
- The scenarios shown are those that played, play or could play a main role in the DAS-Process (SRES A1B, RCP 8.5, SSP3-7.0).

Climate assessment cycles since IPCC AR4 (Germany)

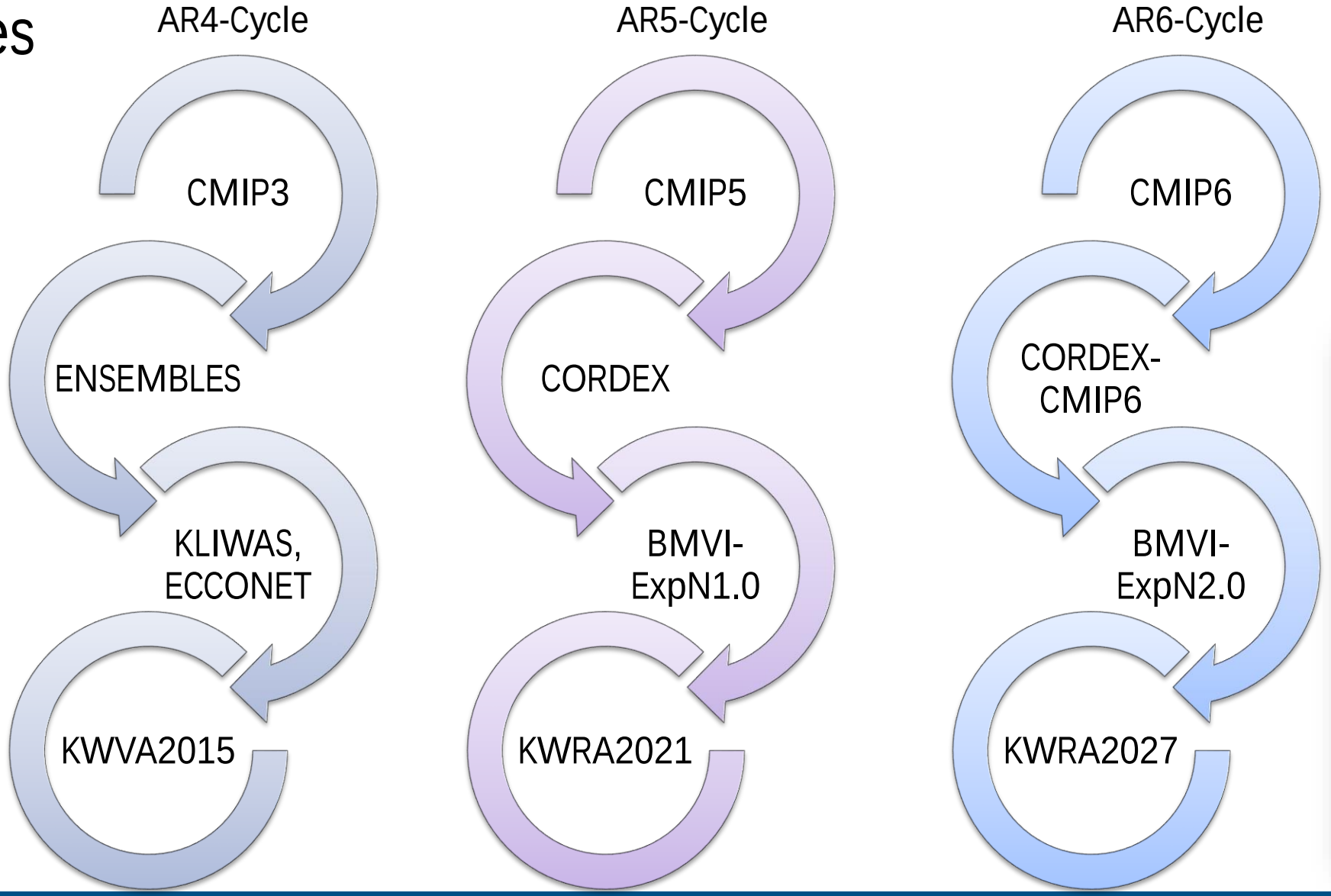
Activities

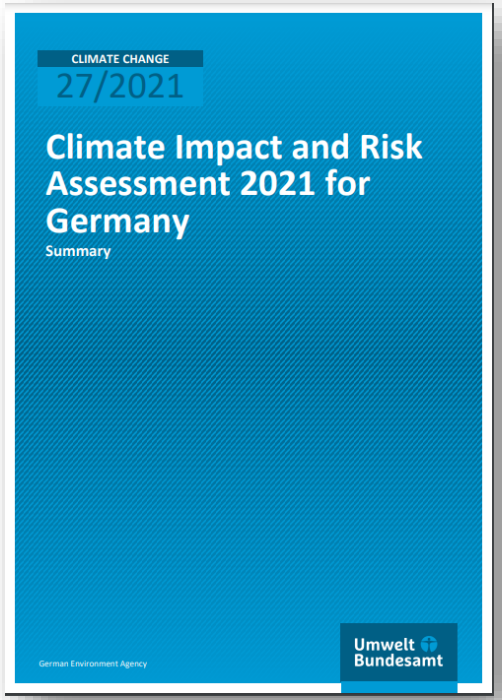
Global Climate Change Assessments

Regional Climate Change Assessments

Regional Climate Impacts Assessments

Coordinated Scenarios for Adaptation





Climate assessment cycles since IPCC AR4 (Germany)

bfg Bundesanstalt für Gewässerkunde

Activities

Global Climate Change Assessments

Regional Climate Change Assessments

Regional Climate Impacts Assessments

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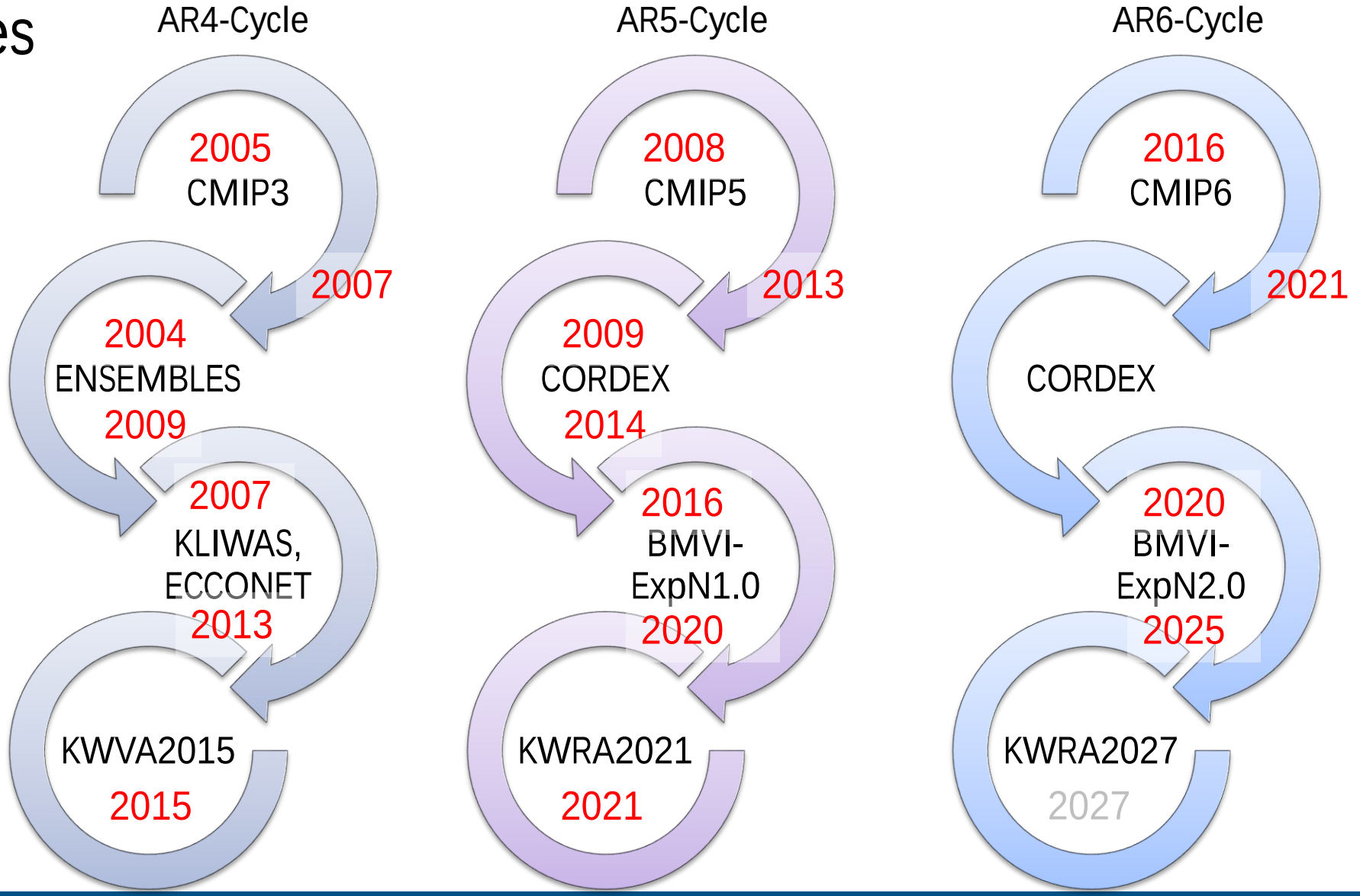


Milestones

Global Simulation Protocol released

IPCC WG-I Physical Science Basis Report published

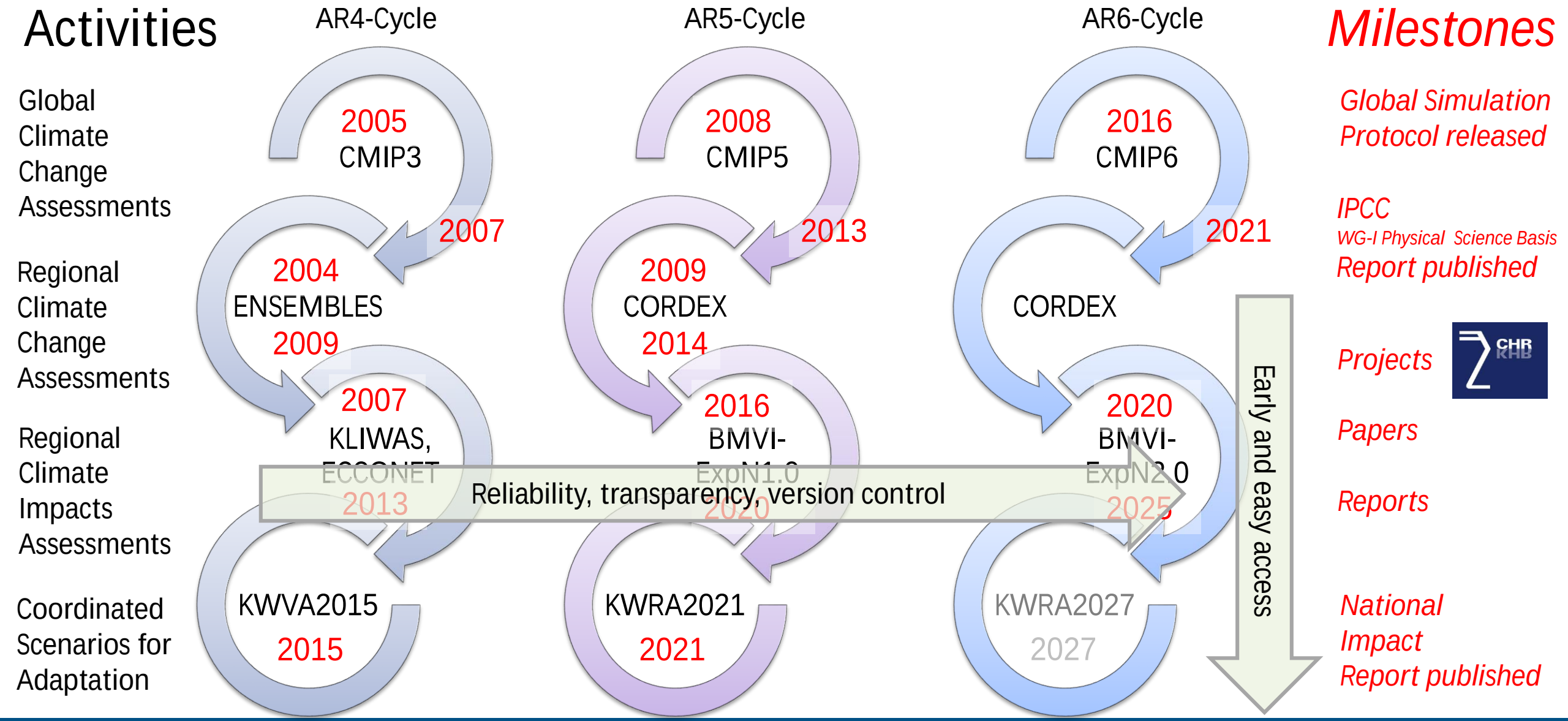
Projects

Papers

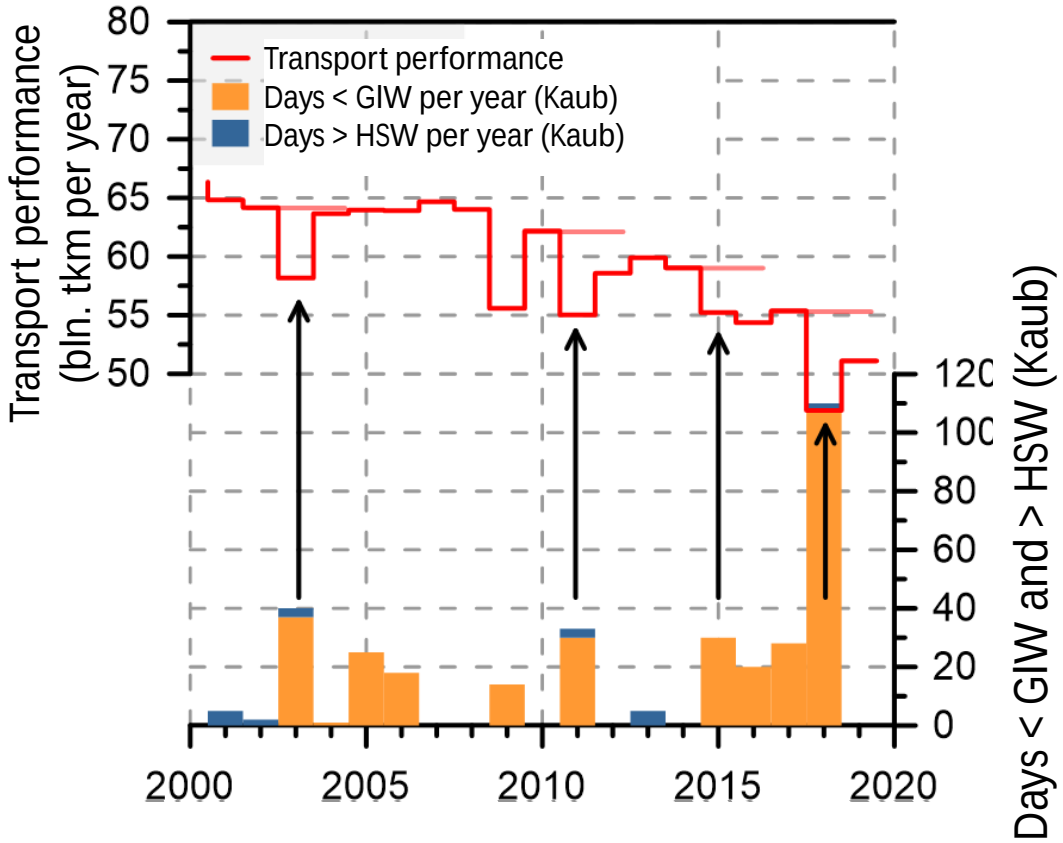
Reports

National Impact Report published

Climate assessment cycles since IPCC AR4



Low flow ... means reduced performance for IWT (sustained?) ...



Annual Transport performance
of inland navigation
related to high and low flow indicators

Data: WSV, DESTATIS
Source: BAG, modified, supplemented