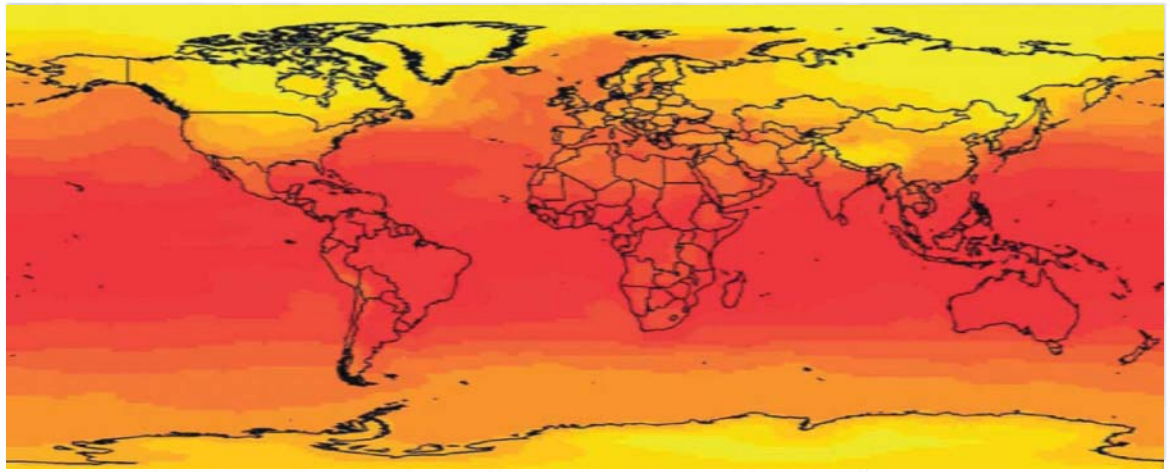


Knowledge about direct climate change effects on the water regime and water temperature of the Rhine

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

Adrian Schmid-Breton ICPR

Knowledge basis about climate change effects

Studies about the effects of climate change:

- **Summary synthesis of available literature (ICPR–Publication 2009 – No. 174)**

- **Developing hydrological scenarios with the help of water discharge models: “Study of Scenarios for the Discharge Regime of the Rhine” (ICPR-Publication 2011 - No. 188)**

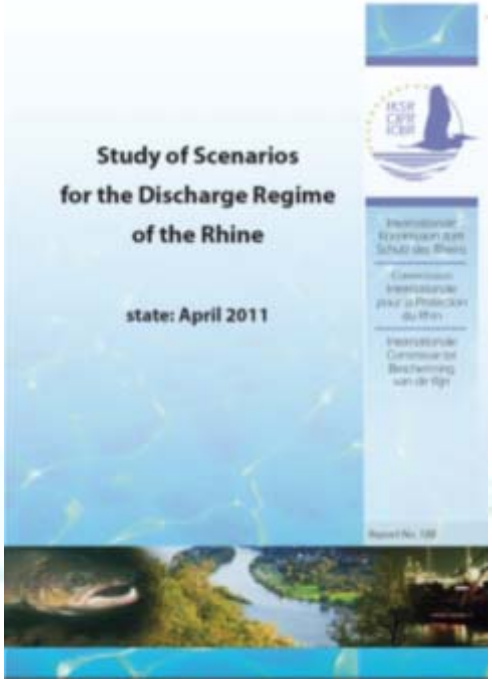
"Study of Scenarios for the Discharge Regime of the Rhine"

Based mostly on the KHR report „RheinBlick2050 (Görgen et al. (2010)"

First consistent study for the whole Rhine catchment

Different hydrometeo. parameters

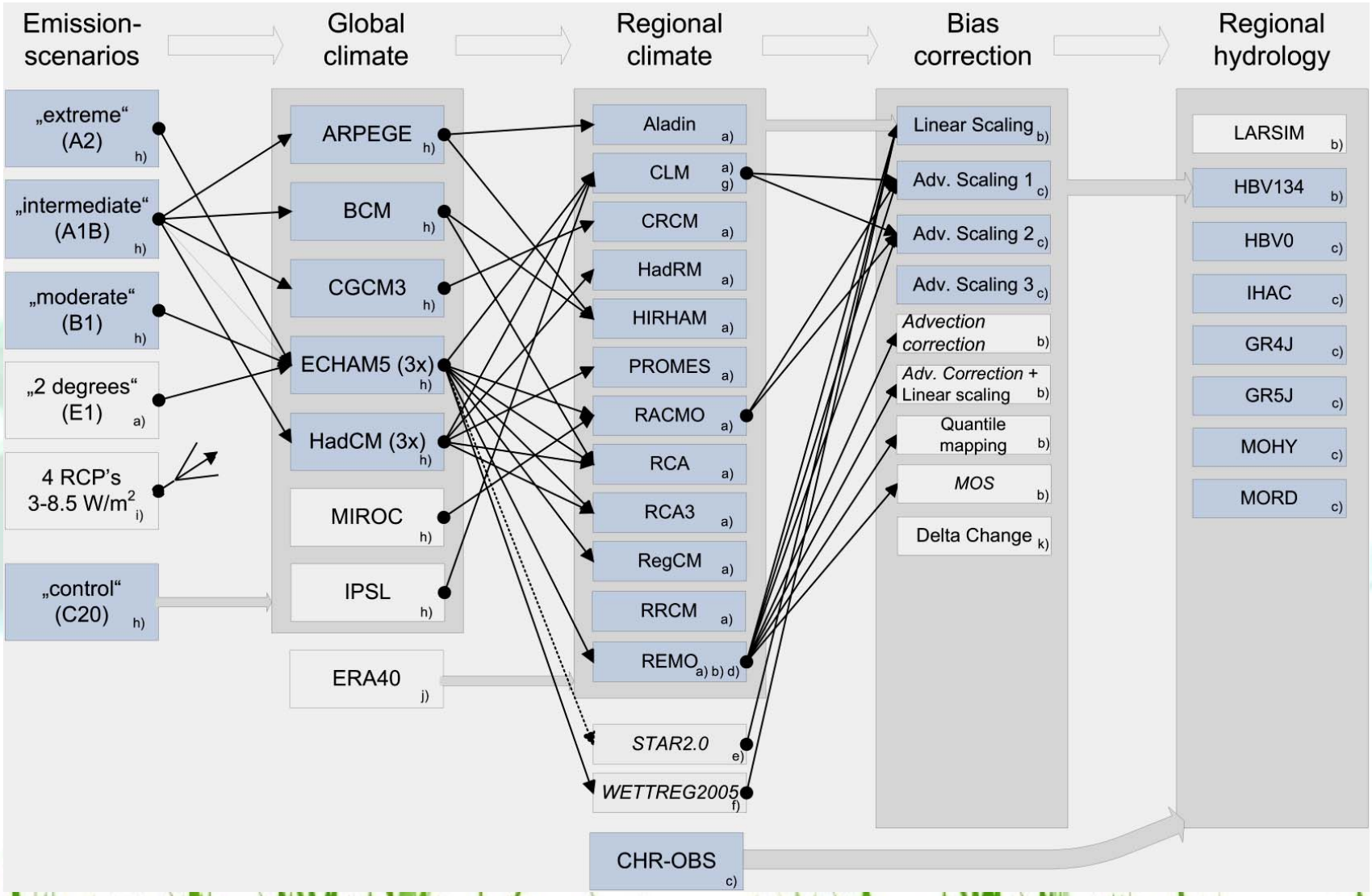
20th cent.: 1961-1990 (so-called control run)
21st century:
projection of the "near future": 2021-2050,
projection of the "remote future": 2071-2100



Focus on ranges of change

BUT: almost no data/knowledge on the evolution of water temperatures in the future

“Study of Scenarios for the Discharge Regime of the Rhine”: methodology



"Study of Scenarios for the Discharge Regime of the Rhine": methodology

EG KLIMA – First indications
Signals of climate change during the 21st century for the near (- 2050) and remote future (- 2100)
Qualitative evaluation: Bandwidth of change in % for different sub-basins

colour	Meaning	Explanation
Orange	decreasing tendency	A great majority (~ 80 %) of projections indicates a decreasing tendency
Grey	No tendency	Approx. the same number of tendencies shows an increase resp. decrease
Light blue	Increasing tendency	A great majority (~ 80 %) of projections indicates an increasing tendency
White	No statement possible	Spread of values ≥50 % or methodical deficits

Projections for the 21st century:
Example for the mean discharge (MQ)

Parameter	Gauge	Corridors of scenarios	
		Change in % Near future	***Change in % Remote future***
MQ Hydrological summer- half year (May-Oct)	Basel	-10% to +5%	*-25% to -10%*
	Maxau	-10% to +5%	*-25% to -10%*
	Worms	-10% to +5%	*-25% to -10%*
	Kaub	-10% to +10%	*-25% to -10%*
			-25% to -10%
			-25% to -10%
			-20% to +10%
			-25% to -5%
MQ Hydrological winter- half year (Nov-Apr)			*+5% to +25%*
			+5% to +25%
	Worms	0% to +20%	*+5% to +25%*
	Kaub	0% to +20%	*+5% to +25%*
	Cologne	0% to +15%	*+5% to +25%*
	Lobith	0% to +15%	*+5% to +25%*
	Raunheim (Main)	0% to +25%	*+15% to +40%*
	Trier (Moselle)	0% to +20%	*+10% to +30%*

Mean discharge
"Near" future:

Summer +/- 10%
Winter 0 to +20%

"Study of Scenarios for the Discharge Regime of the Rhine": main results

Climate projections (until 2050 and 2100) show:

- Rise of winter/summer air temperatures
- Precipitation: wetter winters, drier summers

Possible consequences:

- Winter: increase of runoff (floods)
- Summer: decrease of runoff (low water)

"Study of Scenarios for the Discharge Regime of the Rhine": main results

Air temperature

Summer +1 to+1,5°C

Winter +1,5 to+2°C

MQ (average run-off)

Summer +/- 10%

Winter 0 to +20%

Flood run-off

MHQ -5 to 25%

HQfrequent -5 to +15%

Low water run-off:

Summer +/- 10%

Winter 0 to +15%

Knowledge basis about climate change effects: water temperature – observed changes

Report no 209 (2013):
Development of Rhine water temperatures based on validated temperature measurements between 1978 and 2011

→ describes the developments of Rhine water temperature during the past 30 years.

Knowledge basis about climate change effects: water temperature – observed changes: results

- Clear correlation between water temperature and air temperatures evolution.
- **On average, between 1978 and 2011, water temperatures rise by about 1°C to 1.5°C.**
- Not continuous, rise in 1987-1989 (North Atlantic Oscillation)
- Regional scale: thermal discharges from power plants further contribute to an increase beyond the natural water temperature.
- Past decade: number of days with water temperatures in over 22°C or 25°C considerably increased compared to the two preceding decades.

Water temperature:
Long-term development/prognoses

- July 2012: expert group STEMP “temperature model prognoses” commissioned to draft an assessment of the future development of Rhine water temperatures (from Basel to Rhine delta)
- Assessment based on climate scenarios from RheinBlick2050/ICPR Climate report.

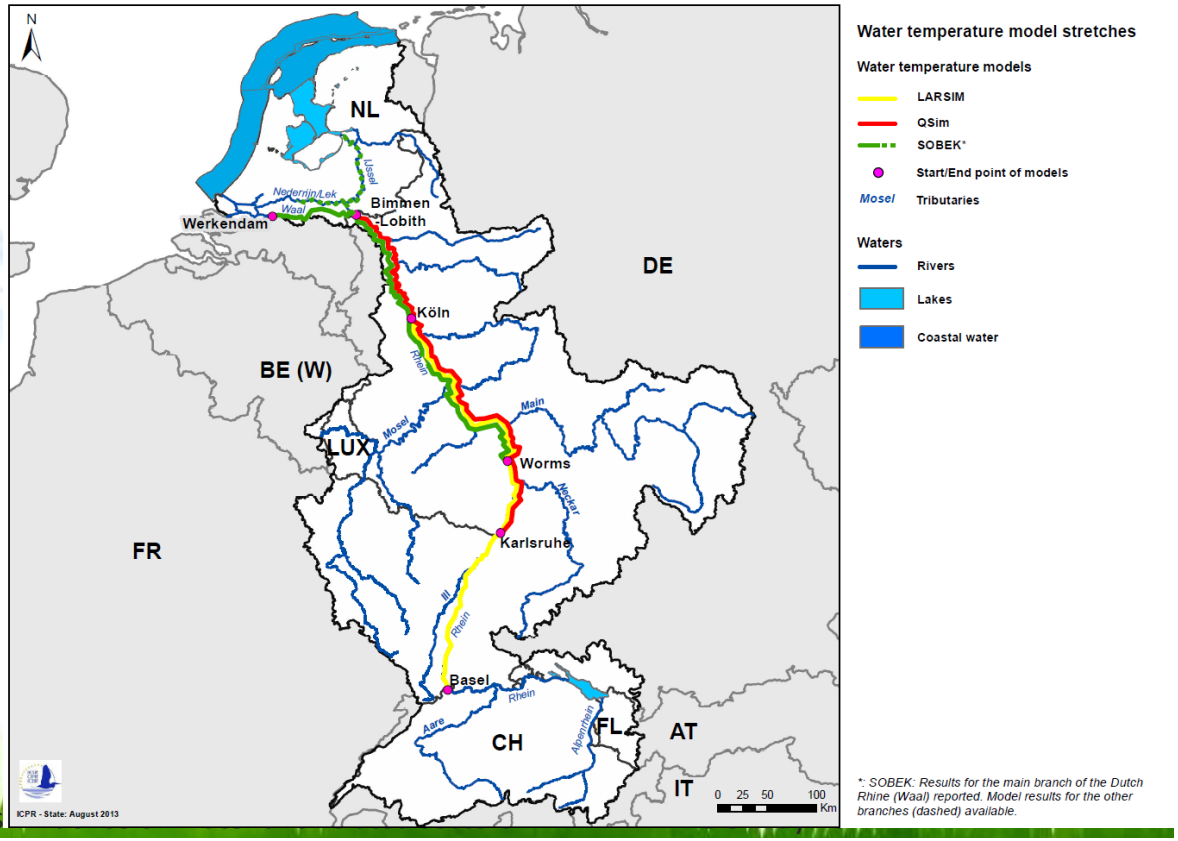
→Reports no. 213./214:

Estimation of the effects of climate change scenarios on future Rhine water temperature development

Water temperature:
Long-term development/prognoses (methodology)

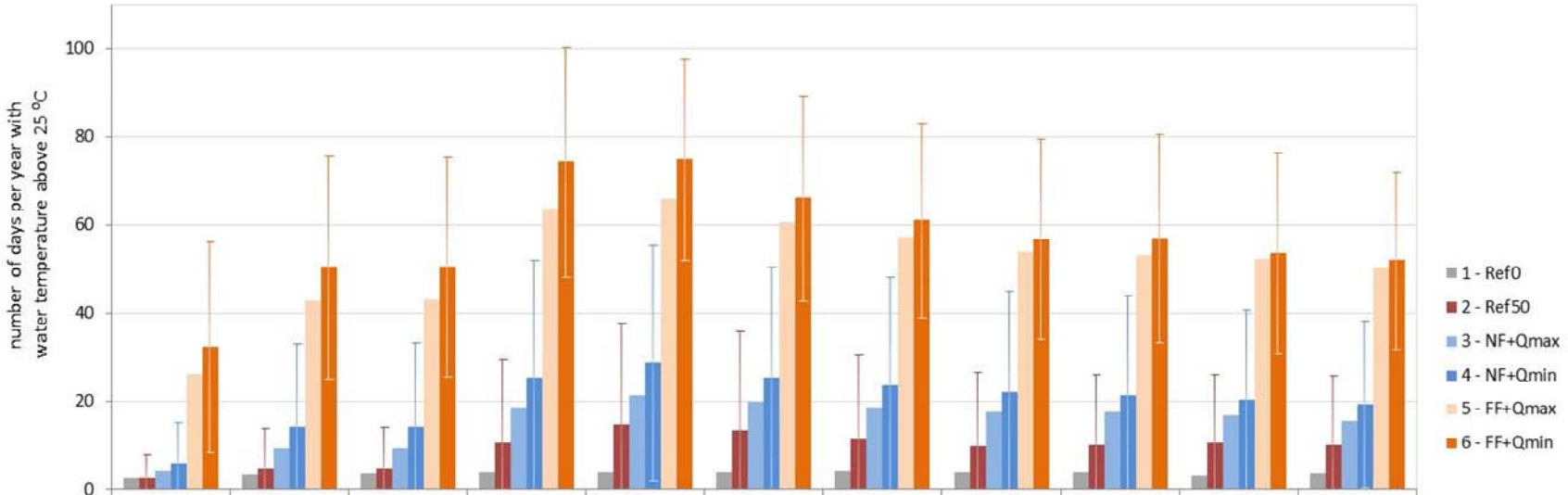
- Uses reliable deterministic simulation models to predict the combined effect of expected changes in meteorology and discharge on the future water tempera-ture.

- Three models used (after validation/ calibration)



Water temperature - Long-term development: Main results

Average number of days per year with a water temperature of more than 25°C



	Basel	Plittersdorf	Karlsruhe	Worms	Mainz	Koblenz	BadHonnef	Koeln	Duesseldorf	Lobith	Werkendam
	171	340	359	443	498	592	640	688	732	863	949
1 - Ref0	2	3	4	4	4	4	4	4	4	3	4
2 - Ref50	2	5	5	11	15	13	11	10	10	10	10
3 - NF+Qmax	4	9	9	19	21	20	19	17	18	17	15
4 - NF+Qmin	6	14	14	25	29	25	24	22	21	20	19
5 - FF+Qmax	26	43	43	64	66	61	57	54	53	52	50
6 - FF+Qmin	32	50	51	74	75	66	61	57	57	54	52

Water temperature - Long-term development: Main results

Water temperature (summer/August)

- Near future + 1,5 °C
- Remote future + 3,5 °C

(higher increase during low water)

In the far future the days exceeding 25°C will increase strongly.

Effects of heat input have been assessed, can lead (regionally) to an additional + 1°C