The ASG-Project in Relation to Low Flows

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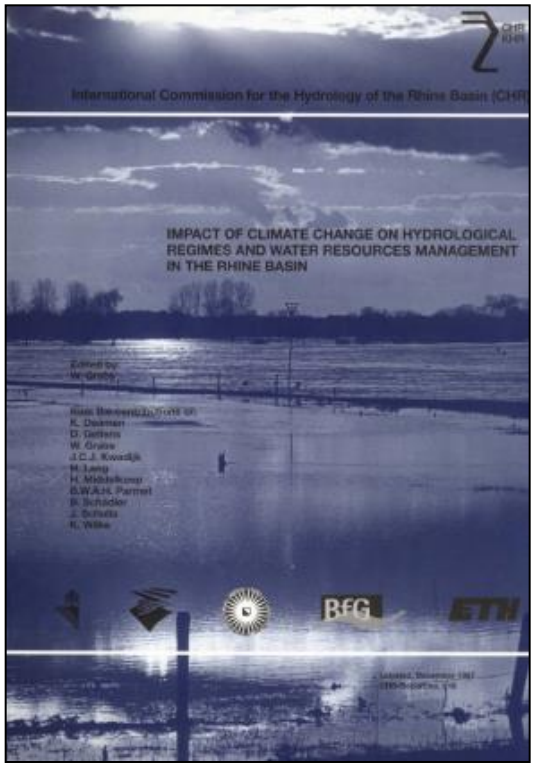
CHR/KHR: : Researching about Flow Regime and Climate Change within the River Rhine Catchment

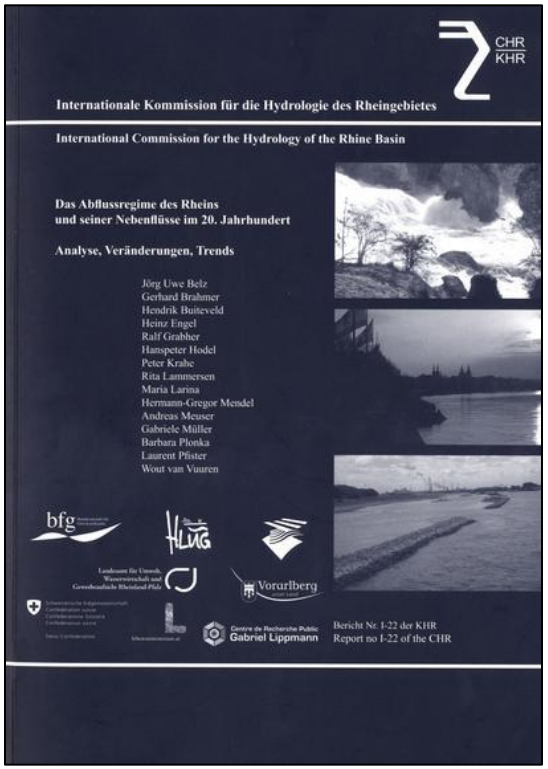
Impact of climate change on the flow regime (model-simulations)



CHR report I-16
Grabs et al. **(1996)**

Impact of climate change on hydrological regimes and water resources management in the Rhine basin

Analysis of changes of flow regime in the 20th century



CHR report I-22
Belz et al. **(2007)**

Das Abflussregime des Rheins und seiner Nebenflüsse im 20. Jahrhundert - Analyse, Veränderungen, Trends

Perspectives of the future development of the discharge

CHR report I-23
Görgen et al. **(2010)**

Assessment of Climate Change Impacts on Discharge in the Rhine River Basin: Results of the RheinBlick2050 project

ASG-Rhein: Getting Started

…and in the beginning there were headlines…

CLIMATIC CHANGE: River Rhine is falling dry! (2003)

ASG-Rhein: Getting Started

…and some more serious voices

Climate change… Germany …another result will be, that

…Rivers like the Rhine „will fall dry from time to time…“

as **Hans Joachim Schellnhuber**,
Director of PIK (Potsdam Institut
for Climate Impact Research),

stated, beeing interviewed by the
well-respected newspaper „Die Zeit“

(n-tv Wednesday, 21. November 2012)

ASG-Rhein I: Conceptual Items and Tasks

Snow and glacier melt components of streamflow of the river Rhine and its tributaries considering the influence of climate change

Step I (3 years) / covering period 1901)1951-2006)

1. **Gaining knowledge: Identification of the relevant processes, quantification of the amounts and determination of developments of snow and glacier melt runoff** within the whole basin, structured in gauge-controlled subcatchments.

2. **Setting-up a routing system for discharge, considering the relevant factors and processes (steering of reservoirs, swiss lake regulation etc.) to allow proportional tracking of the discharge fractions**

3. **Quantification (in daily resolution) of the fractions of snow and glacier melt runoff for the gauges of the subcatchments and especially for the gauges Basel, Maxau, Worms, Mainz, Kaub, Andernach, Köln und Lobith.**

ASG-Rhein: Architecture of the Project

Customer: KHR/CHR

Project lead: BELZ

Scientific personnel:

Freiburg University, chair Prof. Weiler
(WEILER, STAHL, FREUDIGER, FRIELINGSDORF, HOHMANN, KOHN, STEINBRICH)

Hydron GmbH
(GERLINGER, BÖHM)

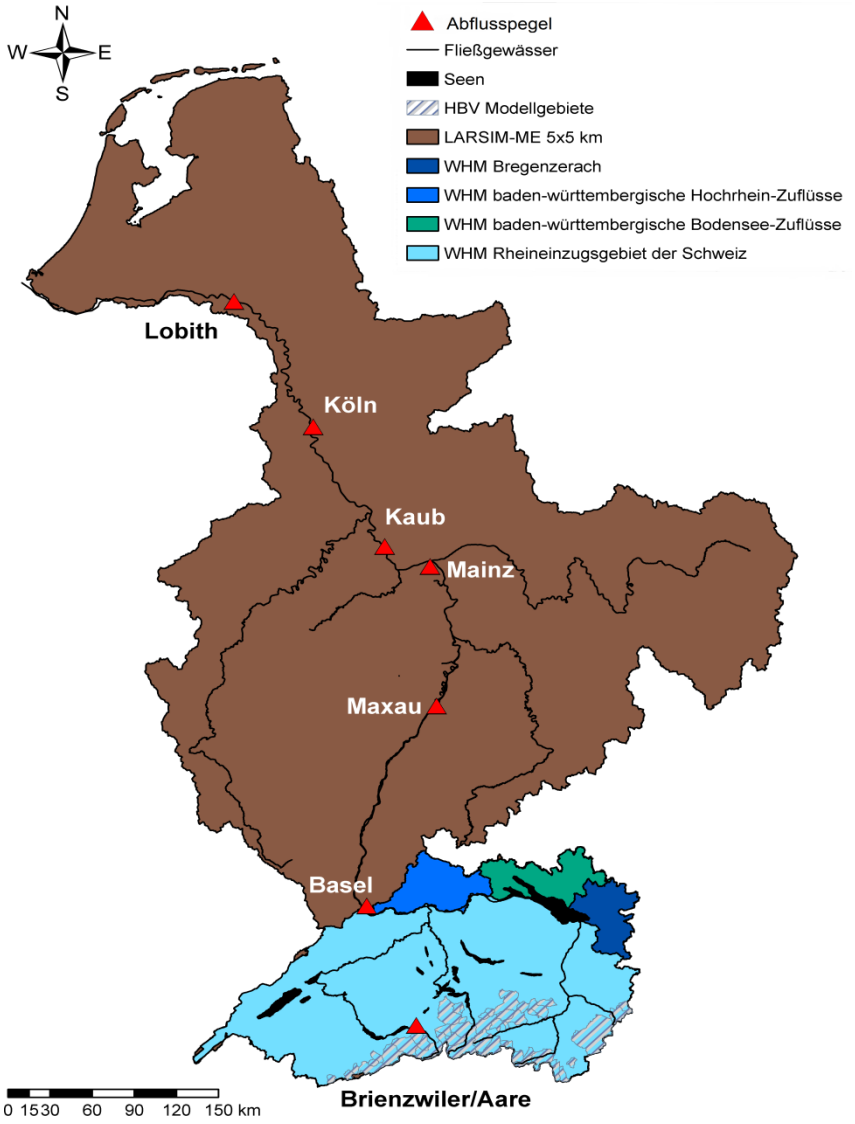
Zürich university, chair Prof. Seibert
(SEIBERT, FINGER, VIS)

ASG-Steering group:

KHR/CHR
(BELZ, KRAHE, MÜLLER, SCHMOCKER-FACKEL, SPROKKEREEF)

External experts
(BREMICKER/LfU-BW, NACHTNEBEL/BOKU Univ. Wien, NÄF/ETH Zürich, SCHÖNER/ Graz Univ., SPERNA-WEILAND/ Deltares, [JONAS/SLF])

ASG-Rhein I / Operation (2012-2016): Model chain



- Close analysis of observed data ->climate sensitivity of runoff

- Model-chain:

downstream of Basel:
LARSIM 5x5km

⇧

upstream of Basel:
LARSIM 1x1km

⇧

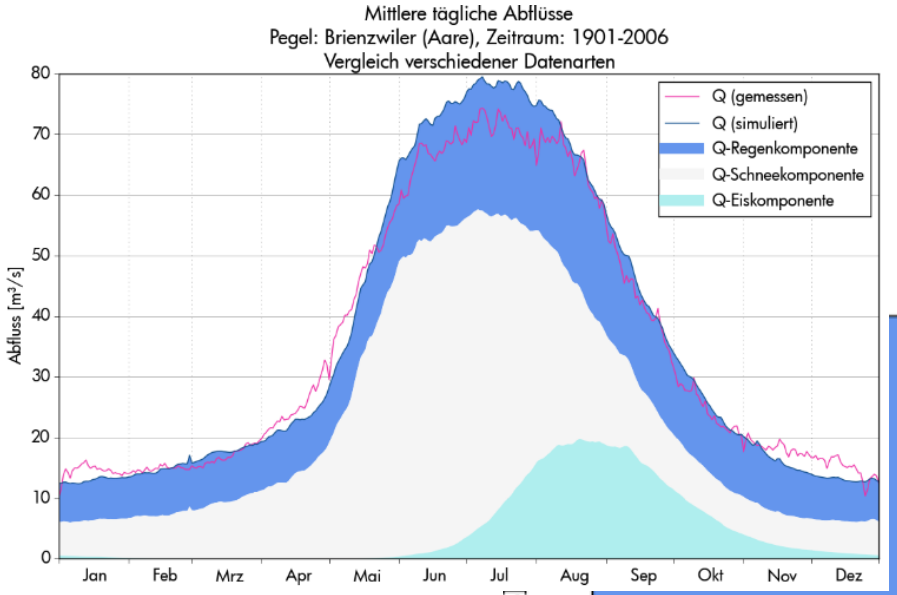
head catchments:
HBV*light*

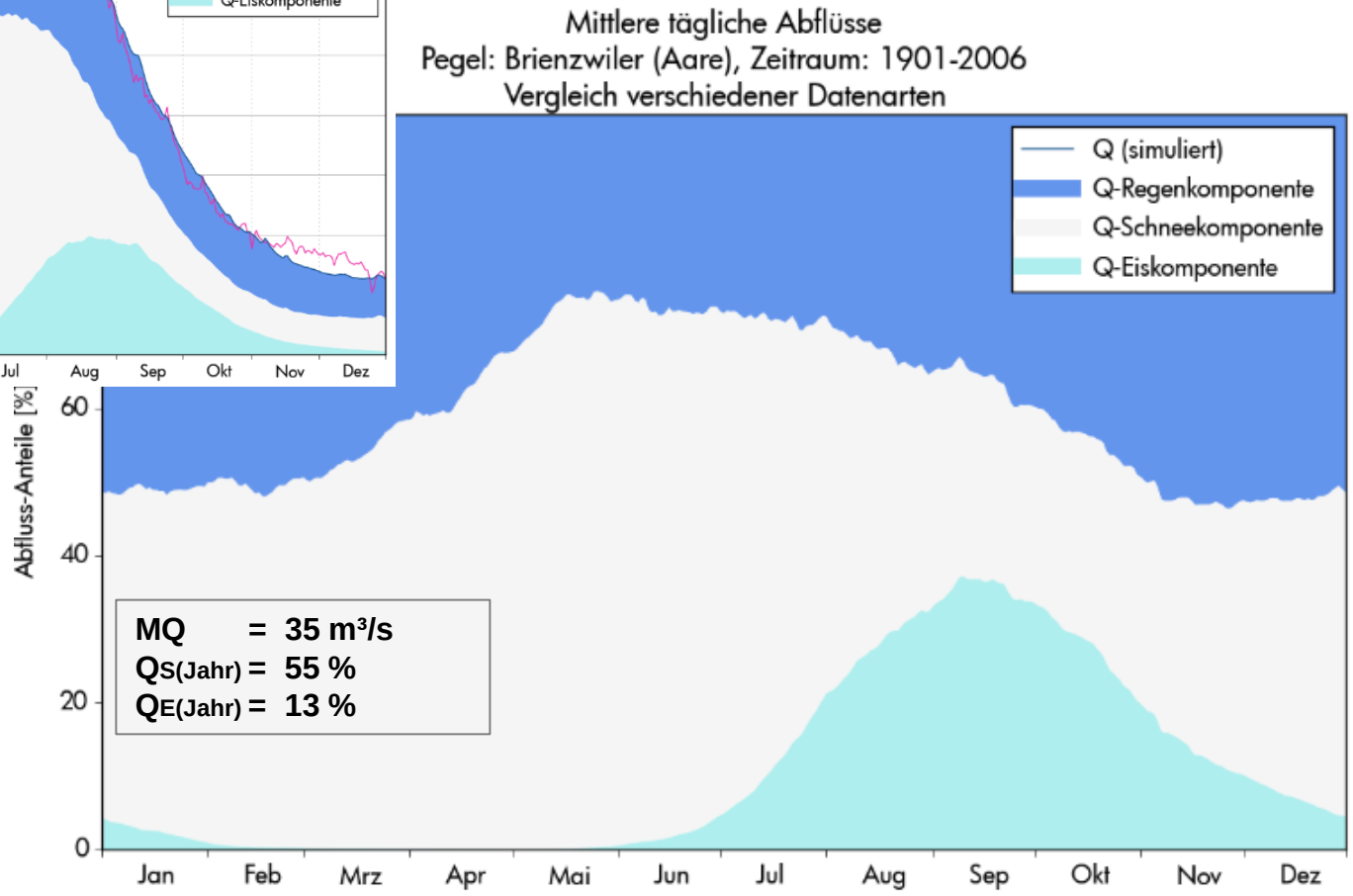
ASG-Rhein I: Milestones

- Gridded meteorological dataset 1901-1950 (daily values temperature & precipitation), reconstructed by using a station-related resampling method (analogue conditions of HYRAS-database are transfered to similar days in the earlier period)
- Digital register of glacier areas for early 20th century (based upon „Siegfriedkarten“ 1 : 50 000)
- detailed empirical data analysis about climate-sensitivity of runoff generation in non-regulated alpine catchments
- Combined model chain, covering the whole Rhine-catchment (HBV*light* + LARSIM 1x1km + LARSIM 5x5km), all improved and multi criteria-calibrated
- New development of a model system for proportional discharge routing of different runoff fractions (Q*Eis* , Q*Schnee*, Q*regen* / = Q*ice,* Q*snow,* Q*rain*) („virtual mixing tanks“)
- **Daily values of discharge, period 1901-2006 for the important gauges along river rhine, distinguished for the runoff-fractions (Q*ice,* Q*snow,* Q*rain*)**

ASG-Rhein I: Results for the Headcatchment Brienzwiler

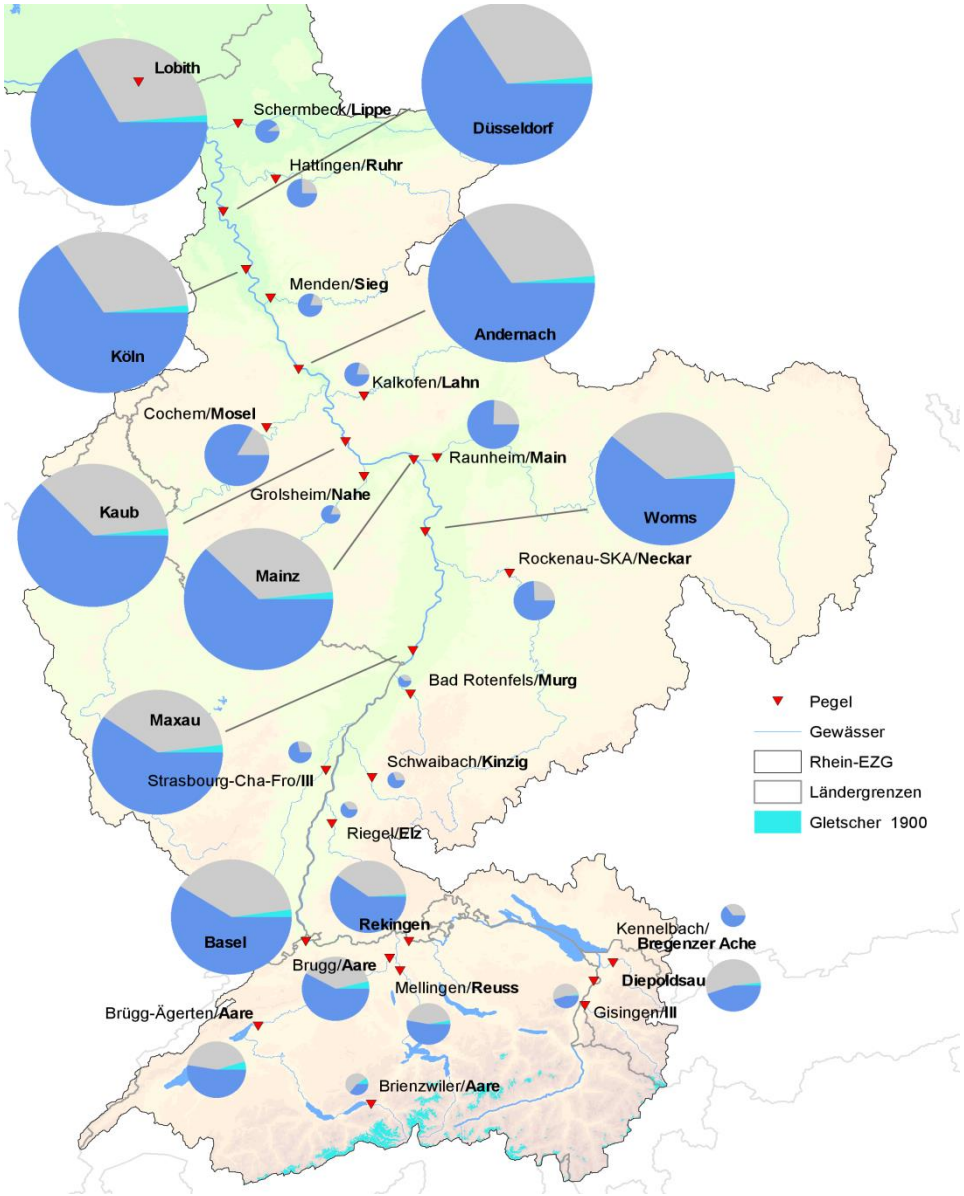
Daily means of discharge (average values 1901-2006) in absolute and relative numbers

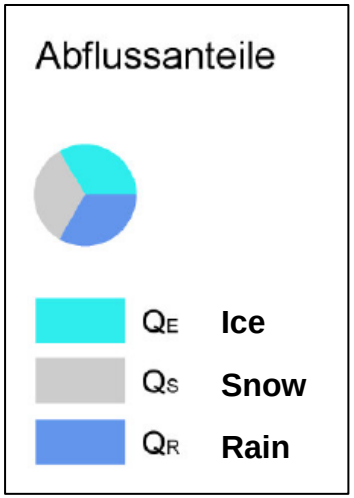




ASG-Rhein I: Results for the Subcatchments

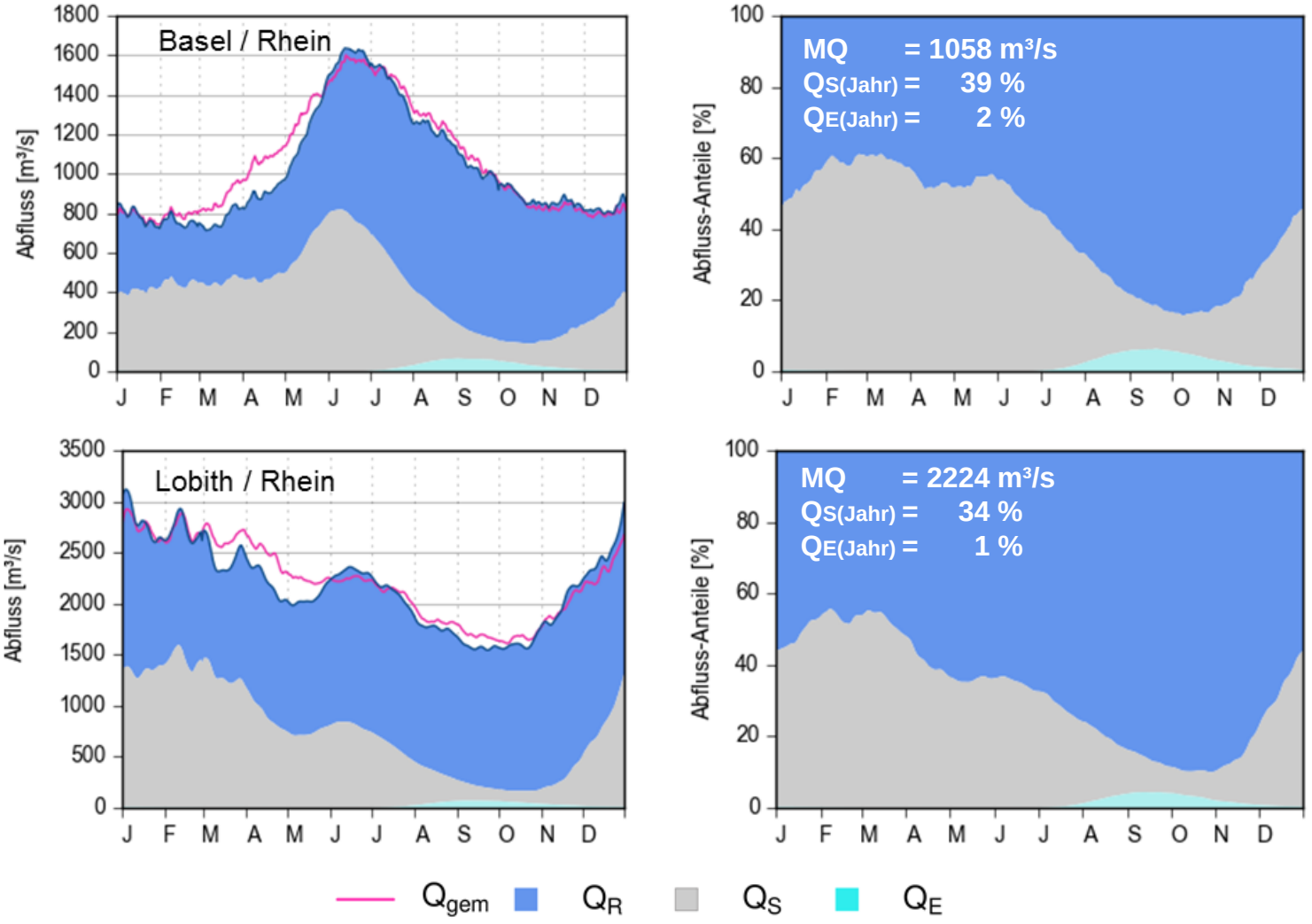
Runoff fractions, annual means / period 1901-2006





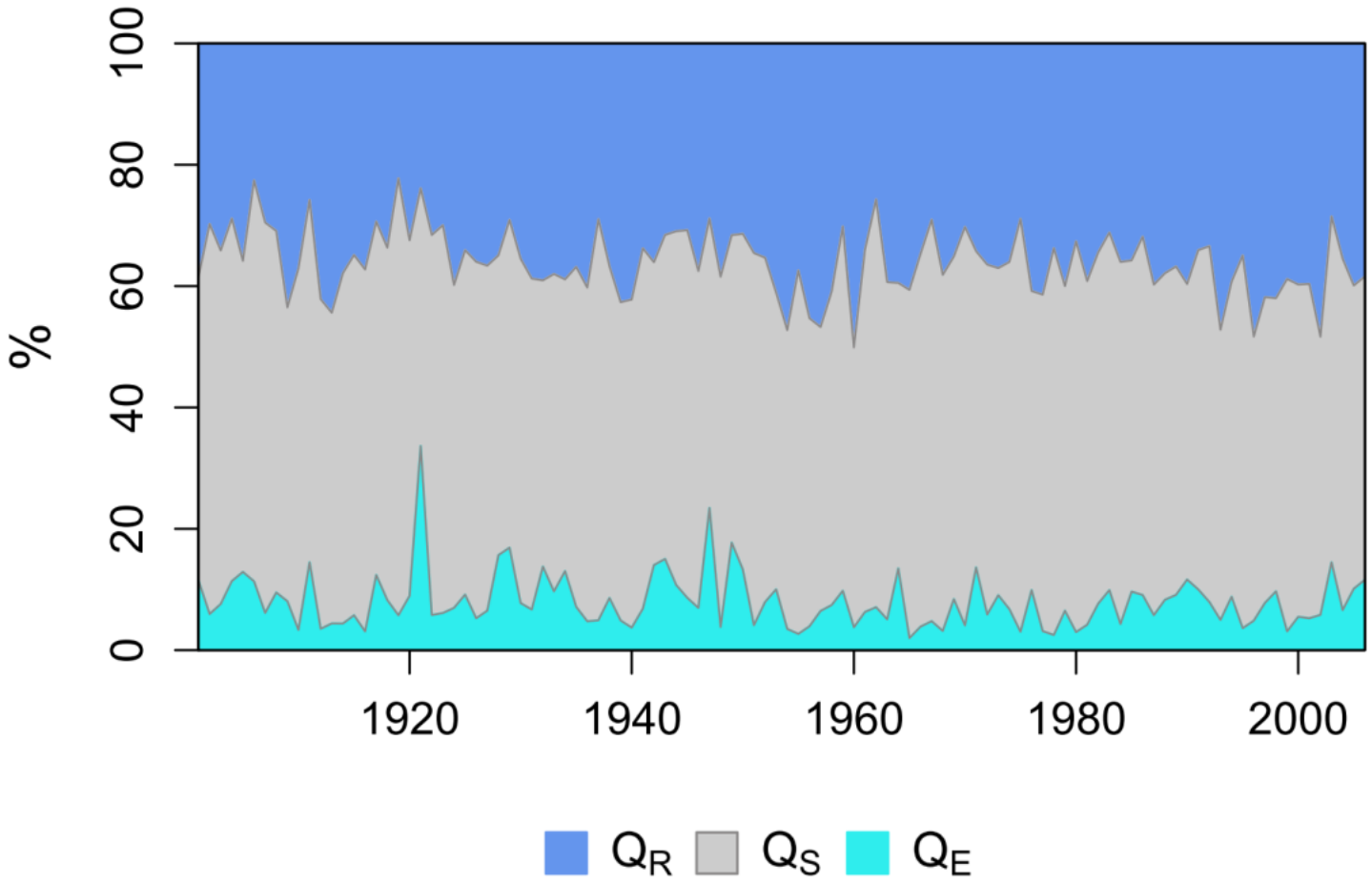
ASG-Rhein I: Results for the Gauges Basel (CH) und Lobith (NL)

Monathly means (1901-2006) in absolute and relative values



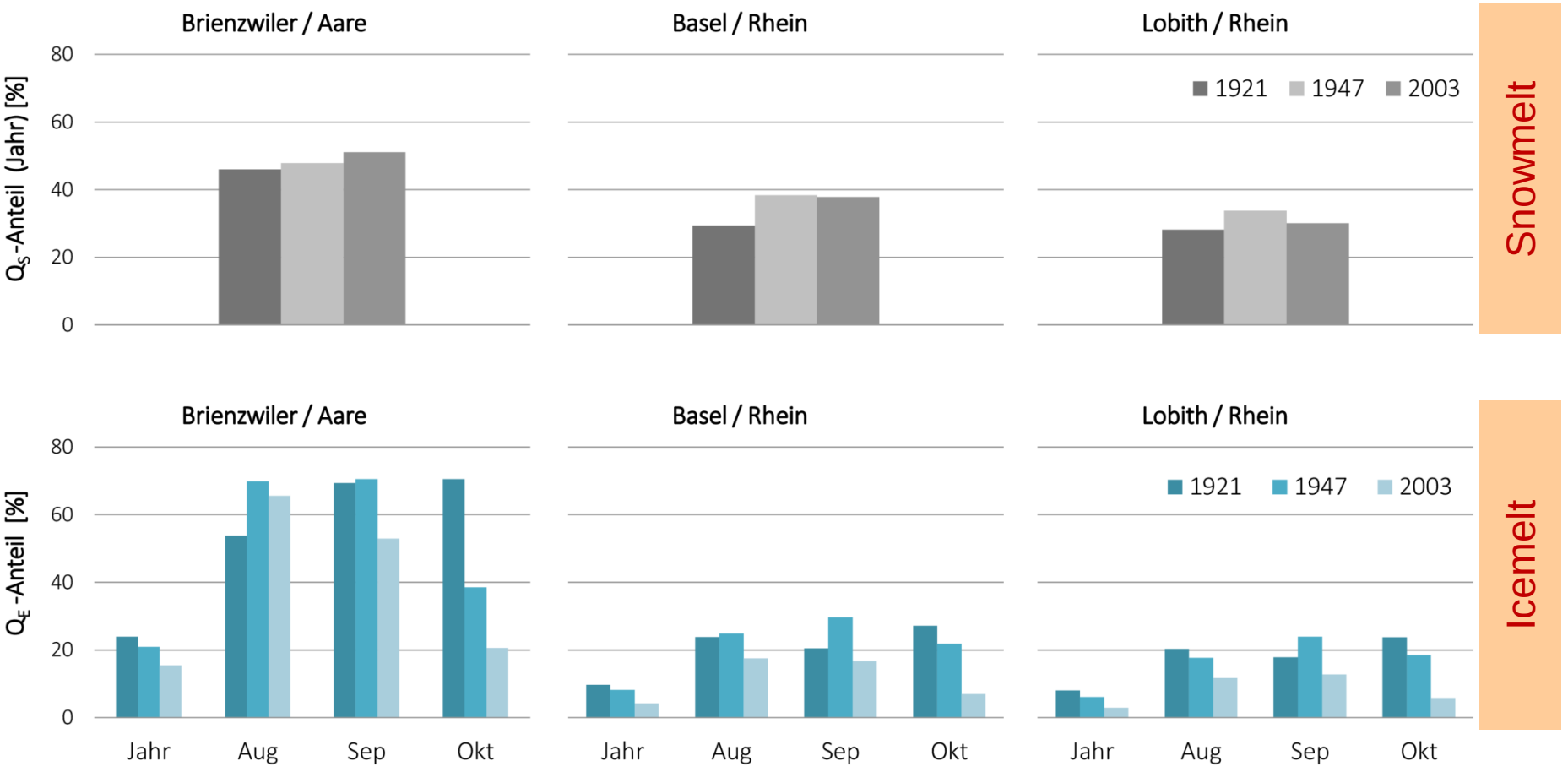
ASG-Rhein I: Results for the Glacierized Headwater Catchments (MQ(a); Period 1901-2006)

Annual Variablility of the streamflow components due to weather conditions



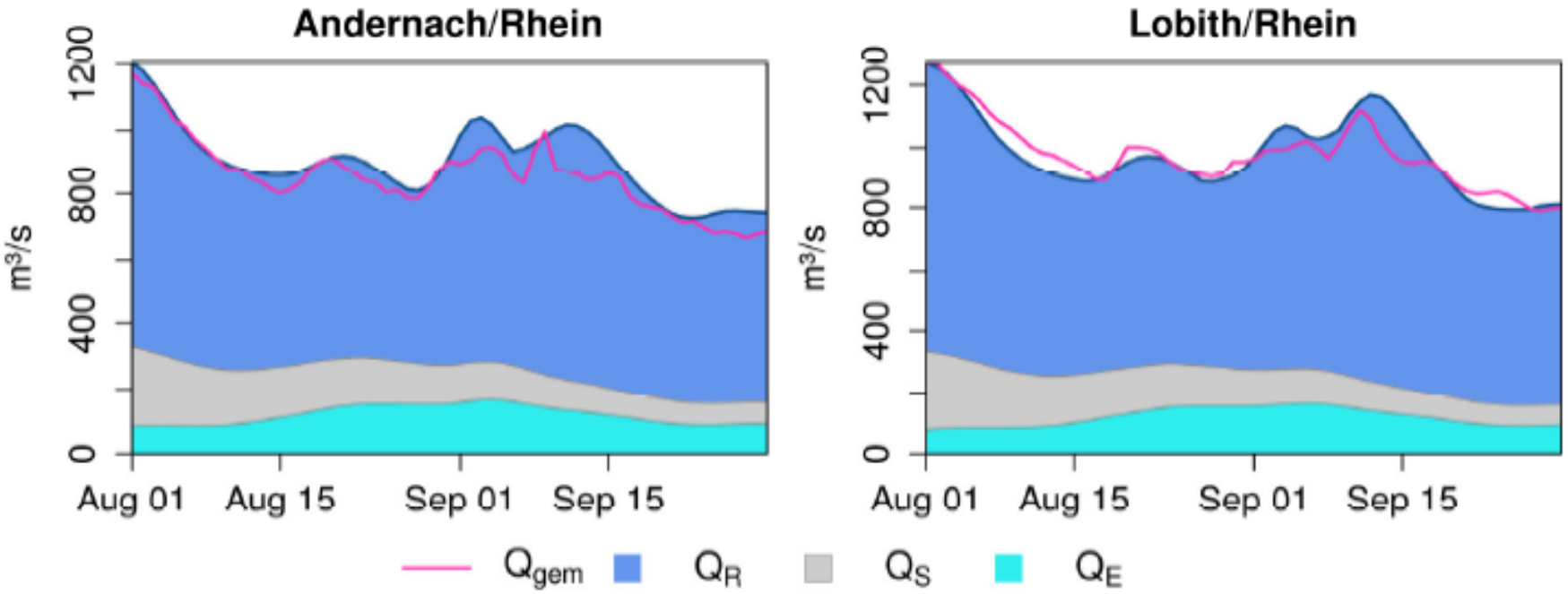
ASG-Rhein I: Results

Modified amounts of the runoff fractions in hot low flow years [%/a]



ASG-Rhein I: Results for the Low flow Extreme 2003

Hydrographs of the runoff fractions at gauges along river rhine downstream mouth of river



ASG-Rhein I: Results for the Low-Flow Extreme 2003

Lowest simulated (total) discharge, highest amount of Q_{Ice} (absolute values) and highest amount of Q_{Ice} of total discharge (relative values)

Pegel	Minimum Q_{sim} (NQ 2003)				Max. absoluter Q_E-Anteil				Max. relativer Q_E-Anteil			
	Tag	Q_{sim} (m^3/s)	Q_{gem} (m^3/s)	Q_E (%)	Tag	Q_E (m^3/s)	Q_E (%)	Q_E/Q_{gem} (%)	Tag	Q_E (%)	Q_E (m^3/s)	Q_E/Q_{gem} (%)
Brienzwiler	31. Dez	14	7	1	13. Aug	53	74	74	13. Aug	74	53	74
Basel	12. Dez	555	507	1	31. Aug	171	20	24	27. Aug	23	147	27
Maxau	22. Sep	586	421	14	02. Sep	167	20	23	27. Aug	22	148	26
Worms	22. Sep	610	511	14	02. Sep	166	18	20	27. Aug	21	149	24
Mainz	22. Sep	660	619	13	03. Sep	165	18	19	27. Aug	20	150	22
Kaub	23. Sep	668	621	13	03. Sep	164	17	18	27. Aug	20	151	21
Andernach	23. Sep	726	716	12	04. Sep	164	16	17	27. Aug	19	151	19
Köln	23. Sep	742	738	12	04. Sep	163	16	17	28. Aug	18	151	19
Düsseldorf	24. Sep	751	730	11	05. Sep	163	16	17	28. Aug	18	152	19
Lobith	26. Sep	794	820	11	06. Sep	162	16	16	28. Aug	17	153	17

28.08.2003, gauge Lobith (NL): ~17% of the whole daily discharge of River Rhine was glacier-melt fraction

ASG-Rhein I: Results for the Low-Flow Extreme 2003

Lowest simulated (total) discharge, highest amount of Q_{Ice} (absolute values) and highest amount of Q_{Ice} of total discharge (relative values)

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Main message:

- **In average neglectable importance of icemelt for most of the rivers in the Rhine basin**
- **In hot low flow years, glaciermelt enriches the total discharge of river Rhine in an essential amount**

28.08.2003, gauge Lobith (NL): ~17% of the whole daily discharge of River Rhine was glacier-melt fraction

ASG-Rhein I: Conclusions for navigation

GlW(Rhine) without icemelt

GlW *(= equivalent waterlevel):* For every gauge along River Rhine, the GlW marks the waterlevel, which is not exceeded for 20 d/a in average during the period 1911-2010.

GlW is important for purposes of navigation and river maintenace (reference value for the depth of the fairway).

Gauge		GlW 2012 *(obs.)* Reference period 100 years (IV/1911-III/2011)	Example: GlW *(Qsim-oe)* Reference period 95 years (IV/1911 - III/2006)	
Name	Position [Rhein-km]	[cm]	[cm]	Δ
Maxau	362,3	**369**	**354**	**-15**
Kaub	546,2	**78**	**67**	**-11**
Düsseldorf	744,2	**97**	**79**	**-18**

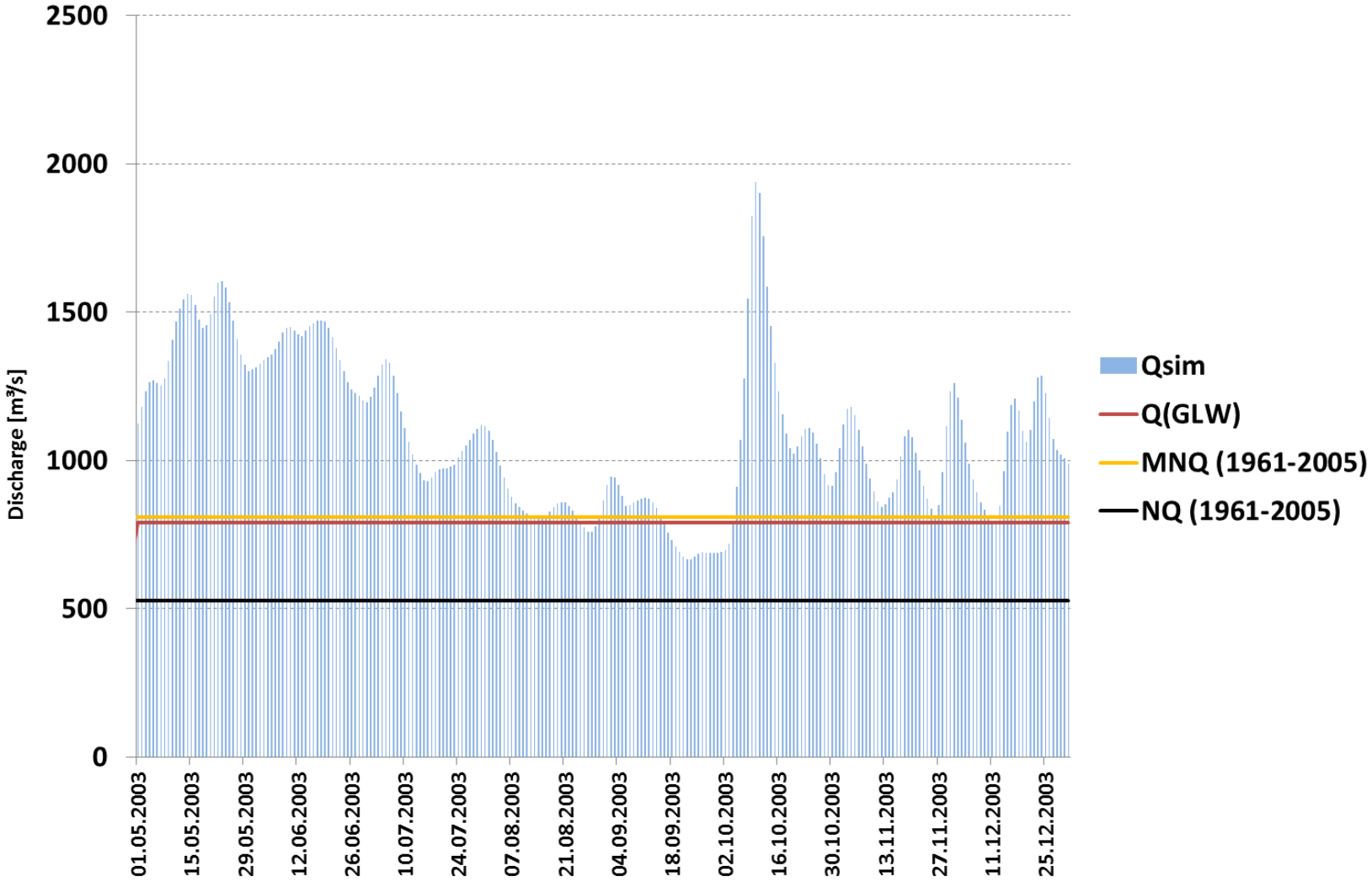
ASG-Rhein I: Conclusions for navigation

GlW(Rhine): Undercutting the treshold with and without icemelt

Gauge	Number of days falling below Q(GlW) / 15-year periods					
	Qsim [d]			Qsim-oe [d]		
	1961-1975	1976-1990	1991-2005	1961-1975	1976-1990	1991-2005
Maxau	184	34	45	232	68	74
Kaub	342	110	124	395	169	210
Düsseldorf	405	189	176	507	239	237

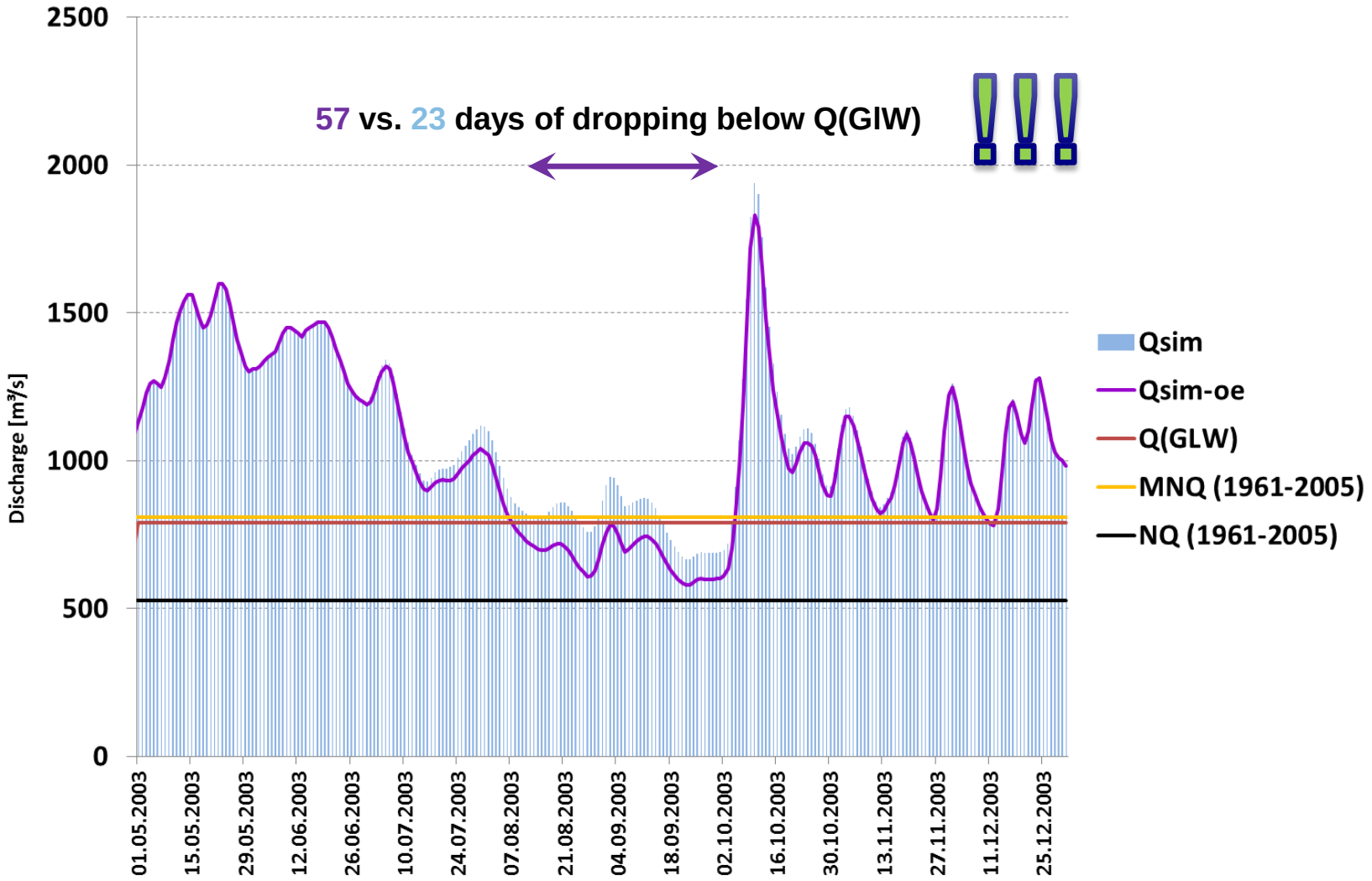
ASG-Rhein I: Conclusions for navigation

GlW(Rhine) / observed data: gauge Kaub 2003



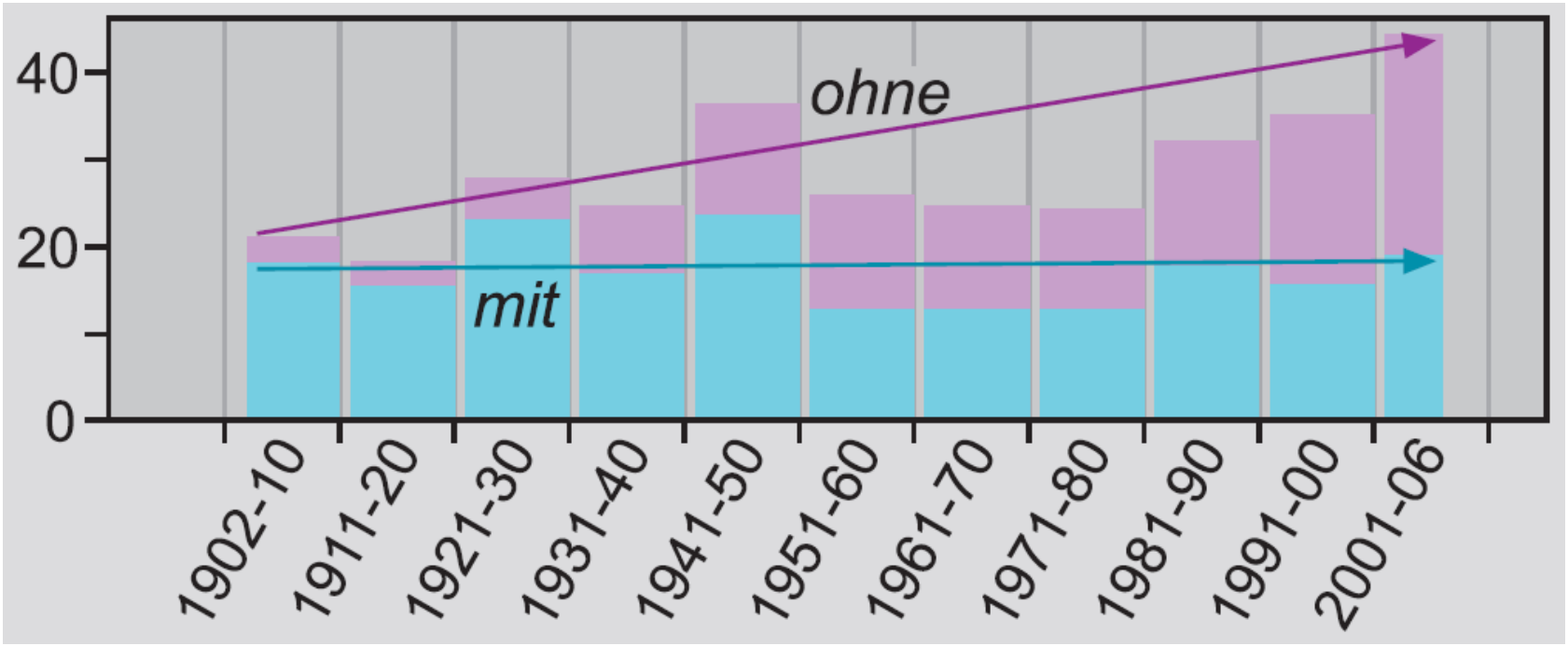
ASG-Rhein I: Conclusions for navigation

GlW(Rhine) / Discharge without icemelt: gauge Kaub 2003



ASG-Rhein I: Results / Perspectives

Icemelt Q_E [m^3/s] with and without shrinkage of glaciers



Compensation of decreasing volume of glaciers by intensifying icemelt-dynamics throughout 20th century because of rising of temperatures induced by climate change (?)

THANKS TO THE LARGE TEAM OF SCIENTISTS FOR THEIR QUALIFIED WORK AND THANKS TO YOU FOR YOUR ATTENTION !

Jörg Uwe BELZ
Bundesanstalt für Gewässerkunde (BfG)

Report available via http://www.chr-khr.org

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- **Synthesis (bilingual German + English)**