



POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH



Modelling and intercomparison of climate impacts simulated by regional-scale hydrological models in 12 large river basins

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& the Regional Water Sector team of ISI-MIP

Outline

- **Regional-scale water modelling in ISI-MIP**
- **Modelling status**
- **Model evaluation: some examples**
- **Scenario runs: an example (3 models x 3 basins)**
- **Regional-global comparison: an example**
- **Papers planning**

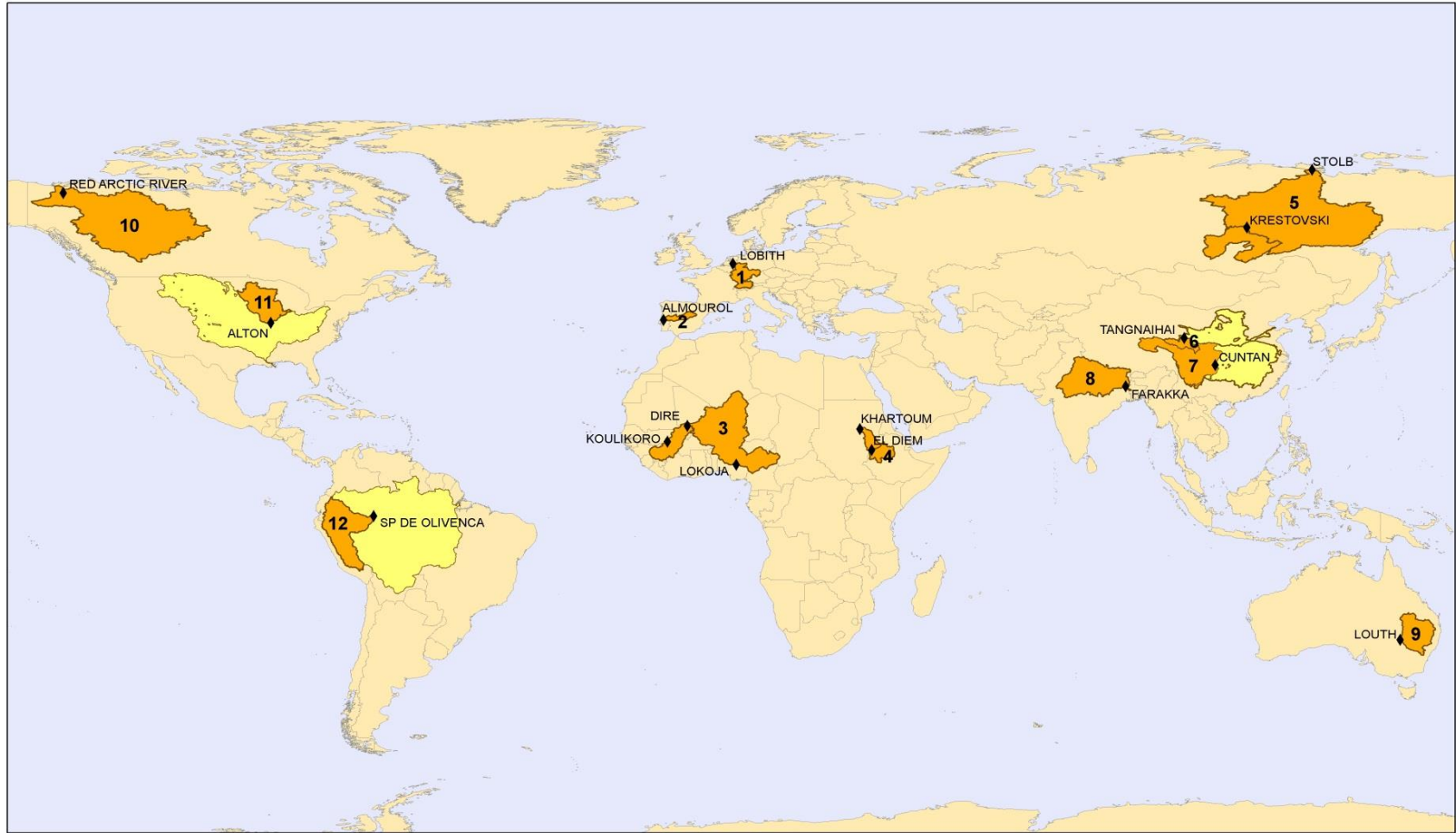
ISI-MIP project

- The Inter-Sectoral Impact Model Intercomparison Project (**ISI-MIP**) is a community-driven modelling effort bringing together **impact modellers across sectors and scales** to create more consistent and comprehensive projections of climate change impacts.
- ISI-MIP is **coordinated by PIK**, with support from IIASA.
- Based on these common scenarios, the impacts are derived for different sectors from **multiple impact models** using policy-relevant metrics, and **uncertainties** are evaluated.
- First results of ISI-MIP from the global-scale models are already published (**PNAS, 111, 2013**).

An overview of current state of the **regional-scale hydrological modelling** in ISI-MIP will be given.



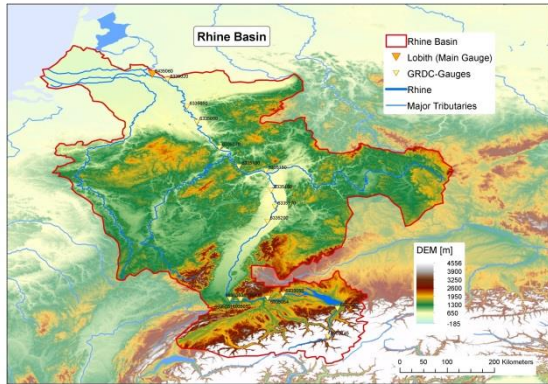
Regional scale: 12 river basins for the modelling



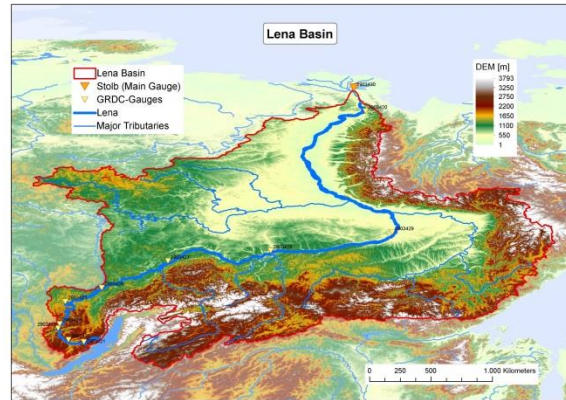
Europe	Africa	Asia	Australia	North America	South America
1. Rhine	3. Niger	5. Lena	9. Darling	10. Mackenzie	12. Upper Amazon
2. Tagus	4. Blue Nile	6. Upper Yellow	7. Upper Yangtze	11. Upper Mississippi	
		8. Ganges			

DEMs: some of our basins

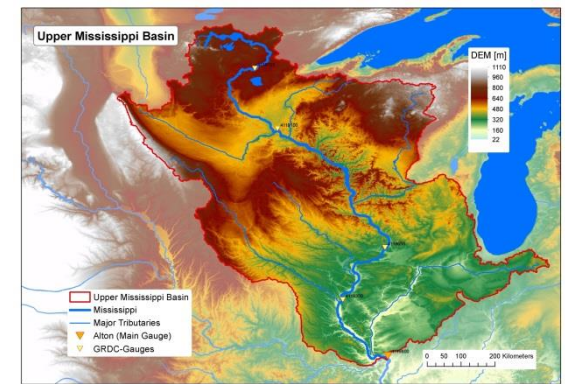
Rhine



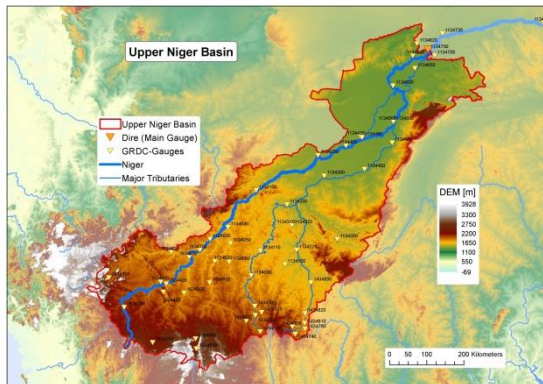
Lena



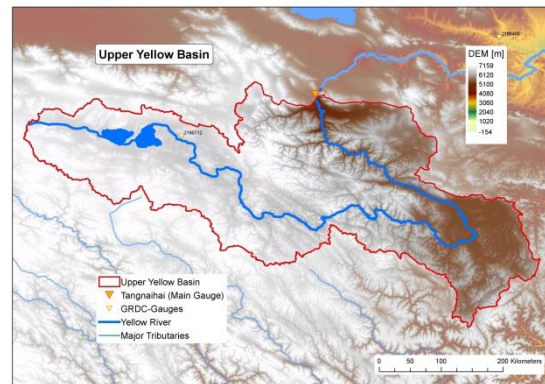
Upper Mississippi



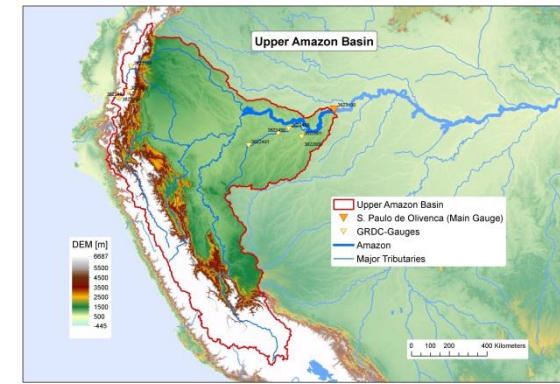
Upper Niger



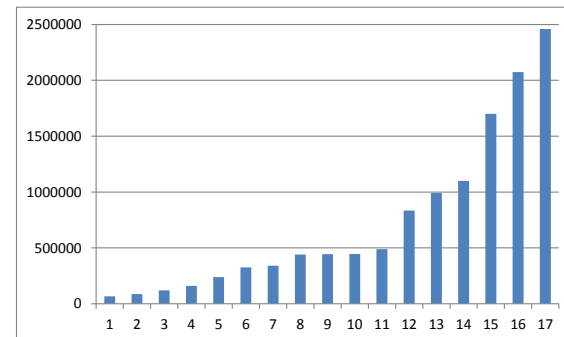
Upper Yellow



Upper Amazon



Our twelve river basins: gauges and areas



<i>River</i>	<i>Gauge station</i>	<i>GRDC ID</i>	<i>lat</i>	<i>long</i>	<i>Area (km2)</i>
RHINE	LOBITH	6435060	51,84	6,11	160.800
TAGUS	ALMOUROL	6113050	39,47	-8,37	67.490
NIGER	KOULIKORO	1134100	12,86	-7,55	87.952
NIGER	DIRE	1134700	16,26	-3,38	340.000
NIGER	LOKOJA	1834101	7,8	6,76	2.074.171
BLUE NILE	KHARTOUM	1663100	15,62	32,55	325.000
BLUE NILE	EL DIEM	1563100	11	35	238.977
GANGES	FARAKKA	2846800	25	87,92	835.000
LENA	STOLB	2903430	72,37	126,8	2.460.000
LENA	KRESTOVSKI	2903427	59,73	113,17	440.000
YELLOW	TANGNAIHAI		35,5	100,15	121.000
YANGTZE	CUNTAN		29,61	106,6	1.099.264
MISSISSIPPI	ALTON, ILL.	4119800	38,88	-90,18	444.185
AMAZONAS	S. PAULO DE OLIVENCA	3623100	-3,45	-68,75	990.781
DARLING	LOUTH	5204250	-30,53	145,11	489.300
MACKENZIE	ARCTIC RED RIVER	4208025	67,46	-133,74	1.805.200

Our team

Institution	Country	Coordinator(s)	Modeller(s)	Models
PIK	Germany	Valentina Krysanova, Fred Hattermann	Shaochun Huang, Tobias Vetter, Valentin Aich, Stefan Liersch, Michel Wortmann, Hagen Koch, Anastasia Lobanova, Julia Tecklenburg	SWIM, VIC, HBV
CESR	Germany	Martina Flörke	Stephanie Eisner	WaterGAP3
UFZ	Germany	Luis Samaniego	Rohini Kumar	mHM
International	International: Belgium, Germany, USA, Poland, Australia, Canada, Switzerland	Ann van Griensven	Michael Strauch, Tadesse Alemayehu, Prasad Daggupati, Mikołaj Piniewski, Willem Vervoort, Floris van Ogtrop, Dipangkar Kundu, Elham Rouholahnejad, Ousmane Seidou	SWAT
SMHI	Sweden	Berit Arheimer	Pechlivanidis Ilias, Chantal Donnelly, Yeshewa Hundecha	HYPE
HUni	China	Tao Yang	Xiaoyan Wang, Xudong Zhou, Tongfei Feng, Siyuan Wang	VIC
JLU	Germany , UK	Lutz Breuer	Alejandro Chamorro, Jeff Exbrayat, Philipp Kraft	LASCAM, HBV-I, HBV-dis, Hymod
CNCC	China	Su Buda	Huang Jinlong, Gao Chao, Zeng Xiaofan	SWAT, SWIM, VIC, HBV
WPI	Russia	Alexander Gelfan	Yuri Motovilov, Inna Krylenko	ECOMAG
IWW	Germany	Uwe Haberlandt	Stefan Plötner, Markus Wallner	HBV
IIT	India	Vimal Mishra		VIC
JRC	Italy	Ad de Roo	Luc Feyen, Hylke Beck, Bernard Bisselink, Peter Burek	LISFLOOD
IGSNRR	China	Xingguo Mo	Suxia Liu	VIP

Total: 55

Climate scenarios

Climate scenarios from five **Earth System Models**:

- **HadGEM2-ES**, Hadley Centre, UK;
- **IPSL-CM5A-LR**, The Institute Pierre Simon Laplace, France;
- **MIROC-ESM-CHEM**, University of Tokyo, Japan;
- **GFDL-ESM2M**, NOAA GFDL, USA;
- **NorESM1-M**, Norwegian Climate Centre, Norway

for 4 RCPs are applied after bias-correction.



Uploaded model validation and scenario runs

	Europe		Africa				Asia				America			Australia
	<i>Rhine</i>	<i>Tagus</i>	<i>Niger</i>		<i>Blue Nile</i>		<i>Ganges</i>	<i>Yellow</i>	<i>Yangtze</i>	<i>Lena</i>	<i>Mississippi</i>	<i>Amazon</i>	<i>MacKenzie</i>	<i>Darling</i>
	<i>Lobith</i>	<i>Almourol</i>	<i>Lokoja</i>	<i>Koulikoro</i>	<i>Khartoum</i>	<i>El Deim</i>	<i>Farakka</i>	<i>Tangnaiha</i>	<i>Cuntan</i>	<i>Stolb</i>	<i>Alton</i>	<i>Olivenca</i>	<i>A.RedRiver</i>	<i>Louth</i>
VIC	nc4	nc4	nc4	nc4	nc4 *	nc4	nc4	nc4	nc4	nc4	nc4	nc4	later	nc4
SWIM	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4		
WaterGAP3	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4		nc4	nc4	nc4		
mHM	nc4			nc4	nc4		nc4	nc4			nc4	nc4		nc4
HYMOD	nc4 + nc4			nc4	nc4		nc4 + nc4	nc4			nc4 + nc4	nc4		nc4
HBV	nc4 + nc4			nc4				nc4	nc4					
SWAT	coming			nc4		nc4			nc4		nc4	nc4		nc4
HYPE	nc4	nc4	nc4				nc4			nc4			nc4	
ECOMAG										nc4			nc4	
VIP								coming						
LISFLOOD	later	later	later	later	later	later	later	later	later	later	later	later	later	later
uploaded	9	5	4	7	5	4	8	6	4	5	8	6	2	4
coming	1								1					1

Work load by model

<i>Models</i>	<i>Number of Basins</i>	<i>Number of gauges</i>	<i>Comment</i>
VIC	11	13	
SWIM	10	12	
WaterGAP3	9	11	
mHM	8	8	
HYMOD	8	8	3 - twice
HBV	7	7	1- twice
SWAT	7	7	
HYPE	6	6	
ECOMAG	2	2	
VIP	1	1	
LISFLOOD	exp.	exp.	
Total	69	75	

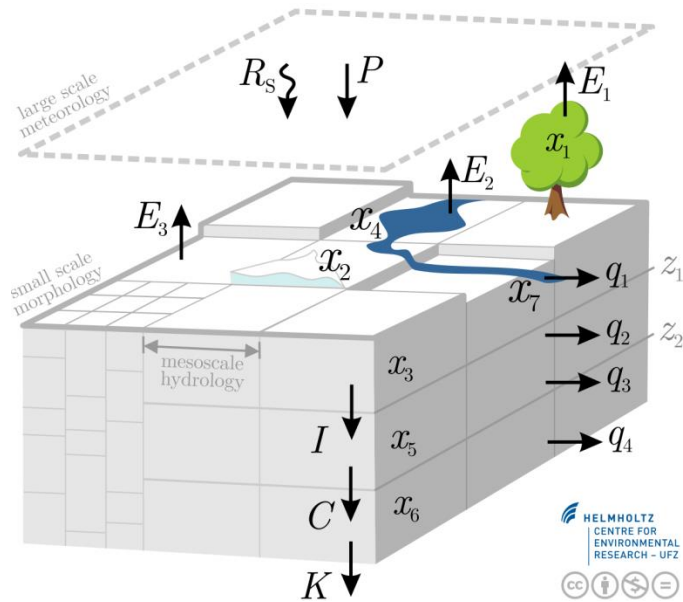
SWAT and SWIM modelling in ISI-MIP

	Europe		Africa				Asia				America			Australia	
	Rhine	Tagus	Niger		Blue Nile		Ganges	Yellow	Yangtze	Lena	Mississippi	Amazon	MacKenzie	Darling	
	Lobith	Almourol	Lokoja	Koulikoro	Khartoum	El Deim	Farakka	Tangnaiha	Cuntan	Stolb	Alton	Olivenca	A.RedRiver	Louth	
SWIM	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4	nc4			10
SWAT	coming			nc4		nc4			nc4		nc4	nc4		nc4	7

	Modeller	Basins		
SWIM	Shaochun Huang	Rhine	Yellow	Mississippi
	Tobias Vetter	Ganges	Amazon	
	Stefan Liersch	Blue Nile		
	Julia Techlenburg	Blue Nile		
	Valentin Aich	Niger		
	Michel Wortmann	Lena		
	Anastasia Lobanova	Tagus		
SWAT	Michael Strauch	Amazon		
	Prasad Daggupati	Mississippi		
	Tadesse Alemayehu	Blue Nile		
	Ann van Griensven	Blue Nile		
	Mikolaj Piniewski	Darling		
	Willem Vervoort	Darling		
	Floris van Ogtrop	Darling		
	Dipankur Kundu	Darling		
	Ousmane Seidou	Niger		
Elham Rouholahnejad	Rhine			

Basins not covered by	
SWIM	Darling
	MacKenzie
SWAT	Tagus
	Ganges
	Yellow
	Lena
	MacKenzie

Calibration and validation: mHM in the Upper Yellow



Model set-up

Gauging station: Tangnaihai

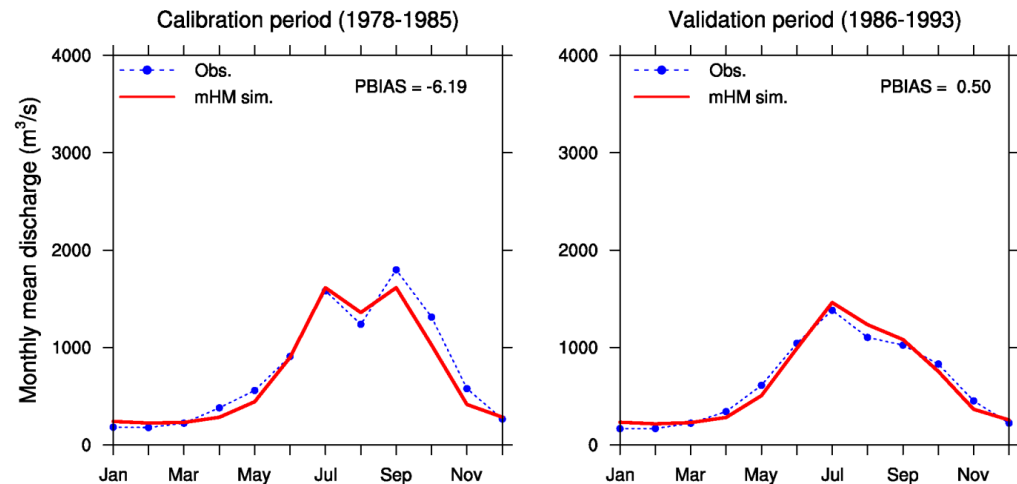
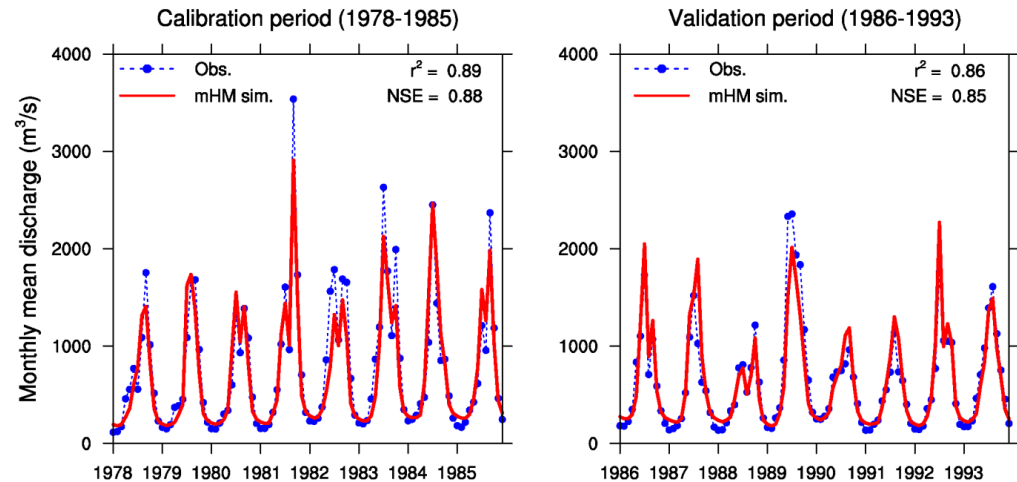
Drainage area: 122,340 km²

Spatial resolution: 50 km

Temporal resolution: 1 h

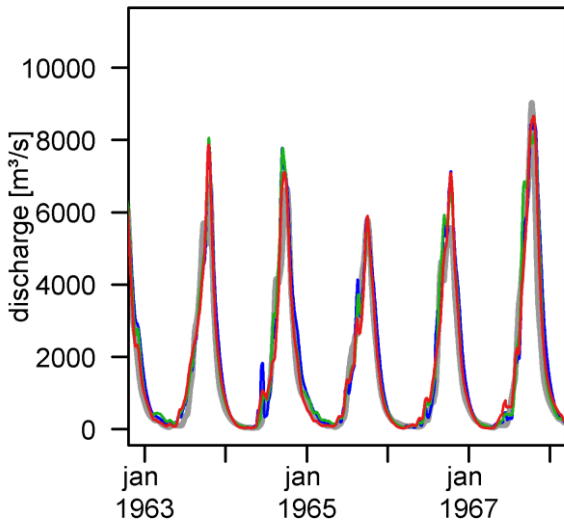
Model details: <http://www.ufz.de/mhm>

Yellow River (Tangnaihai gauge)

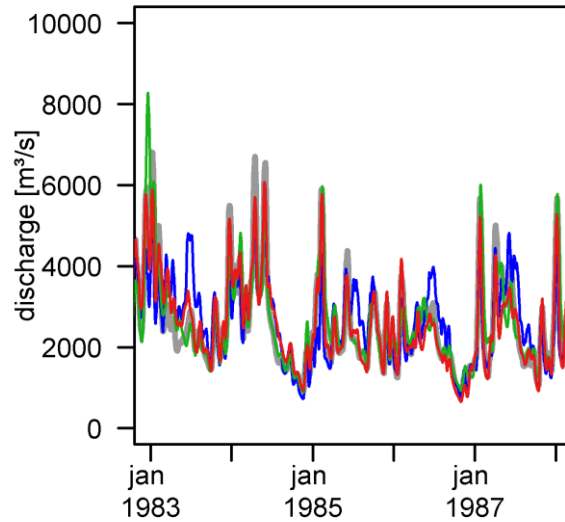


Validation: HBV, SWIM and VIC for three basins

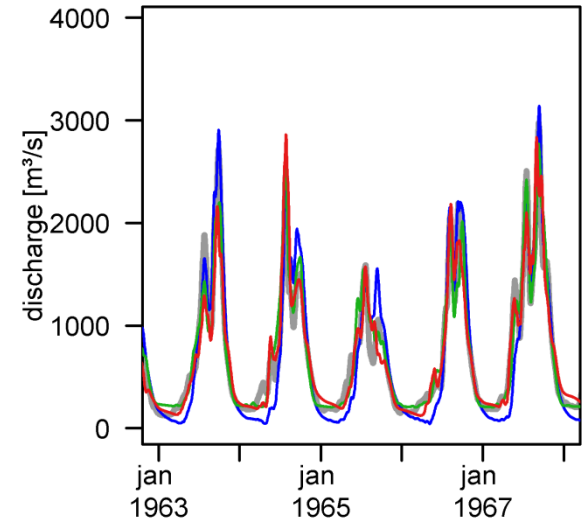
Upper Niger



Rhine



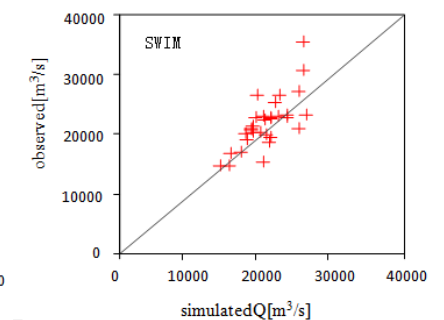
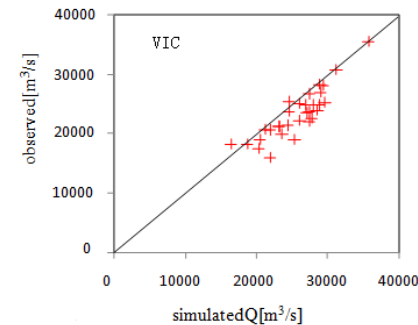
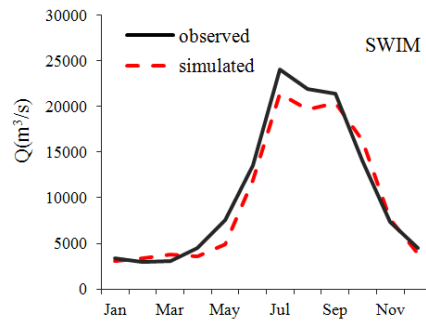
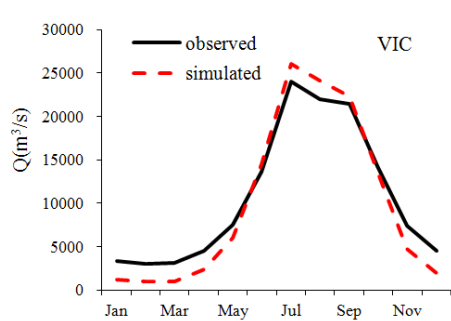
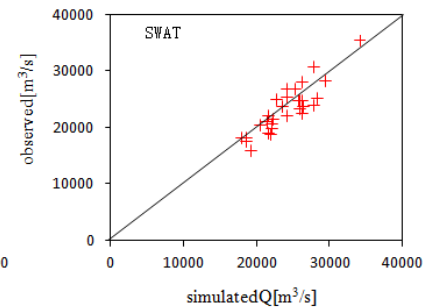
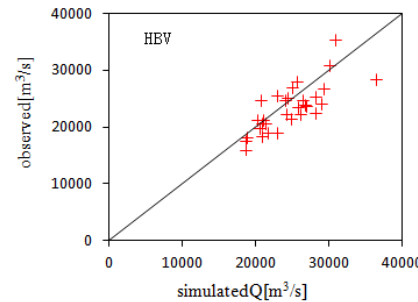
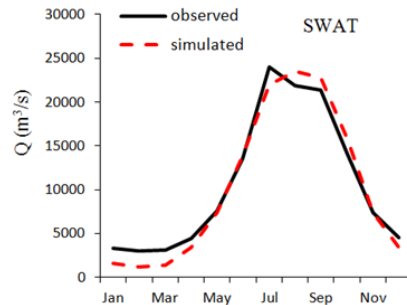
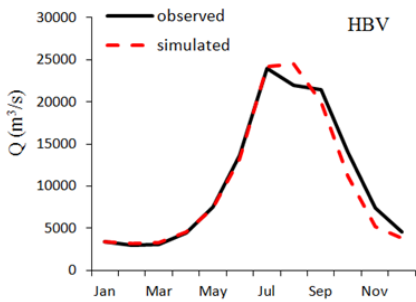
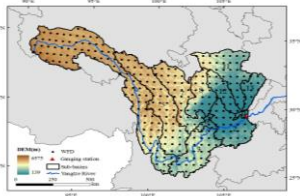
Upper Yellow



— HBV — SWIM — VIC — observed

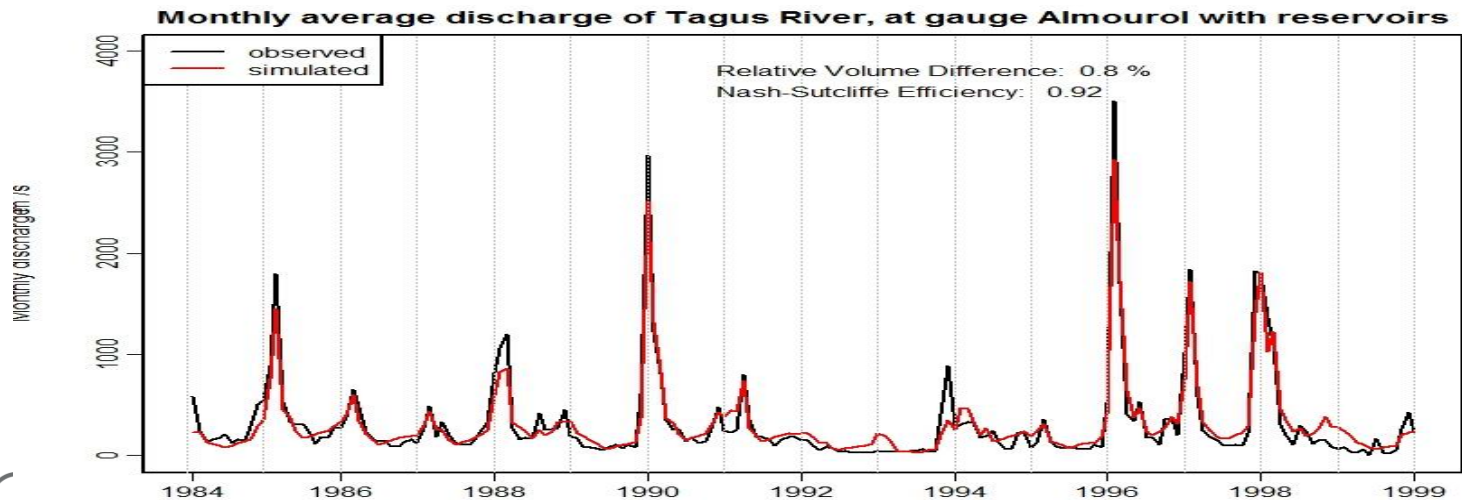
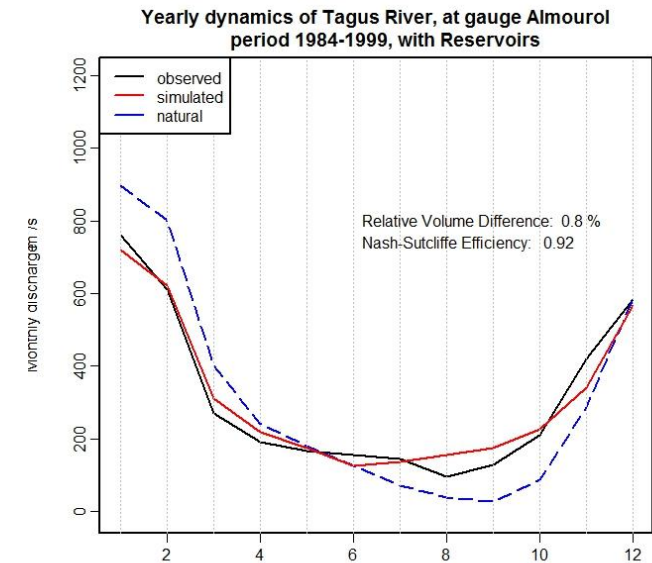
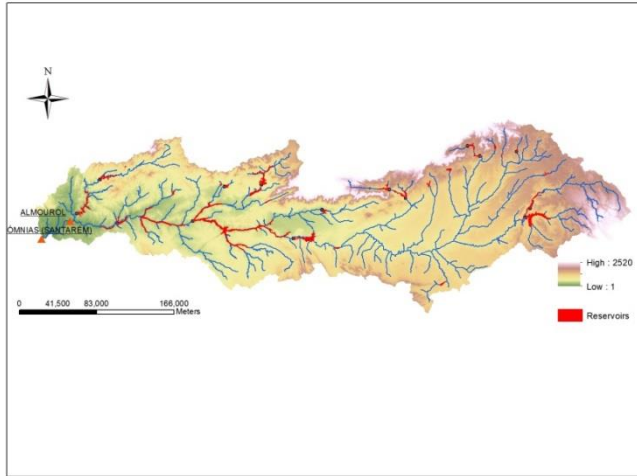


Validation: HBV, SWAT, VIC and SWIM for the Yangtze



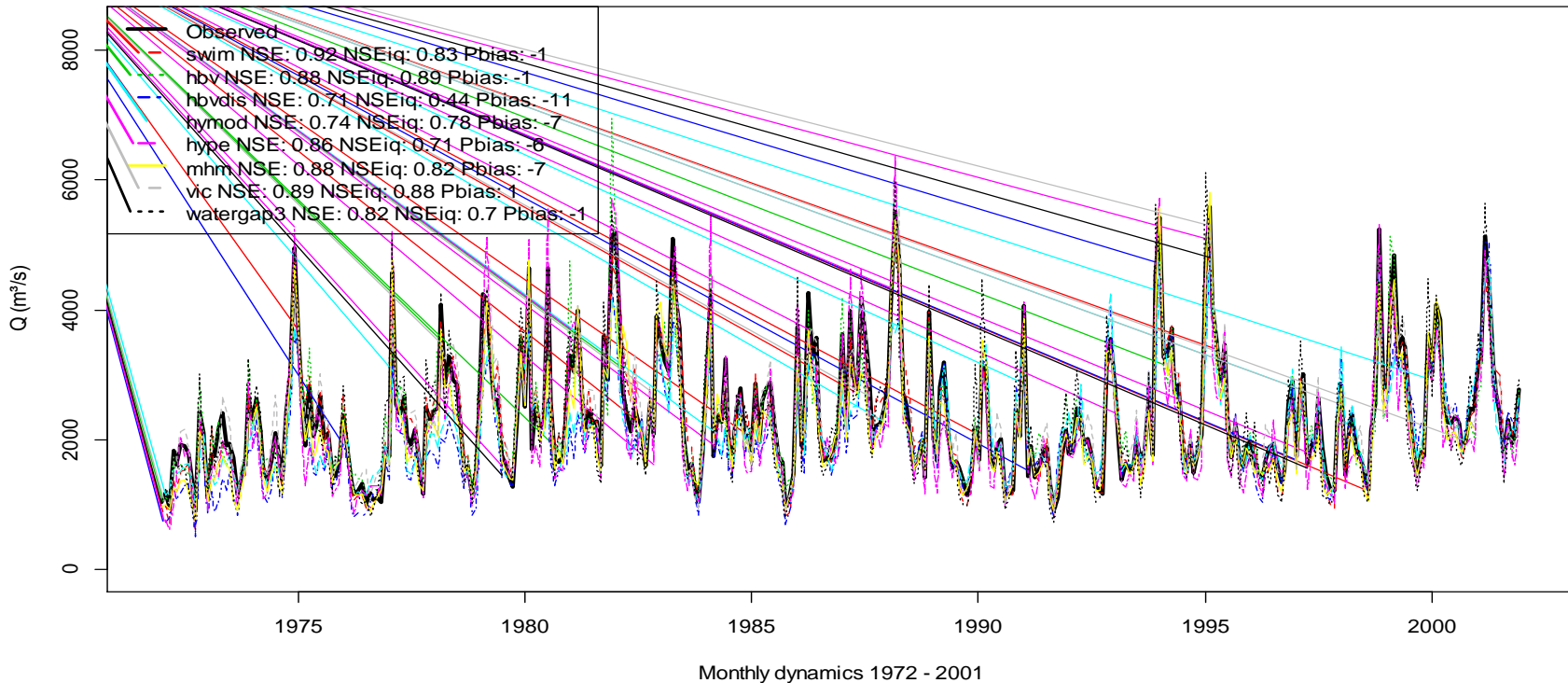
Modellers: Huang Jinlong, Zeng Xiaofan, Gao Chao and Su Buda (CNCC)

Validation: SWIM for the Tagus: with & without reservoirs

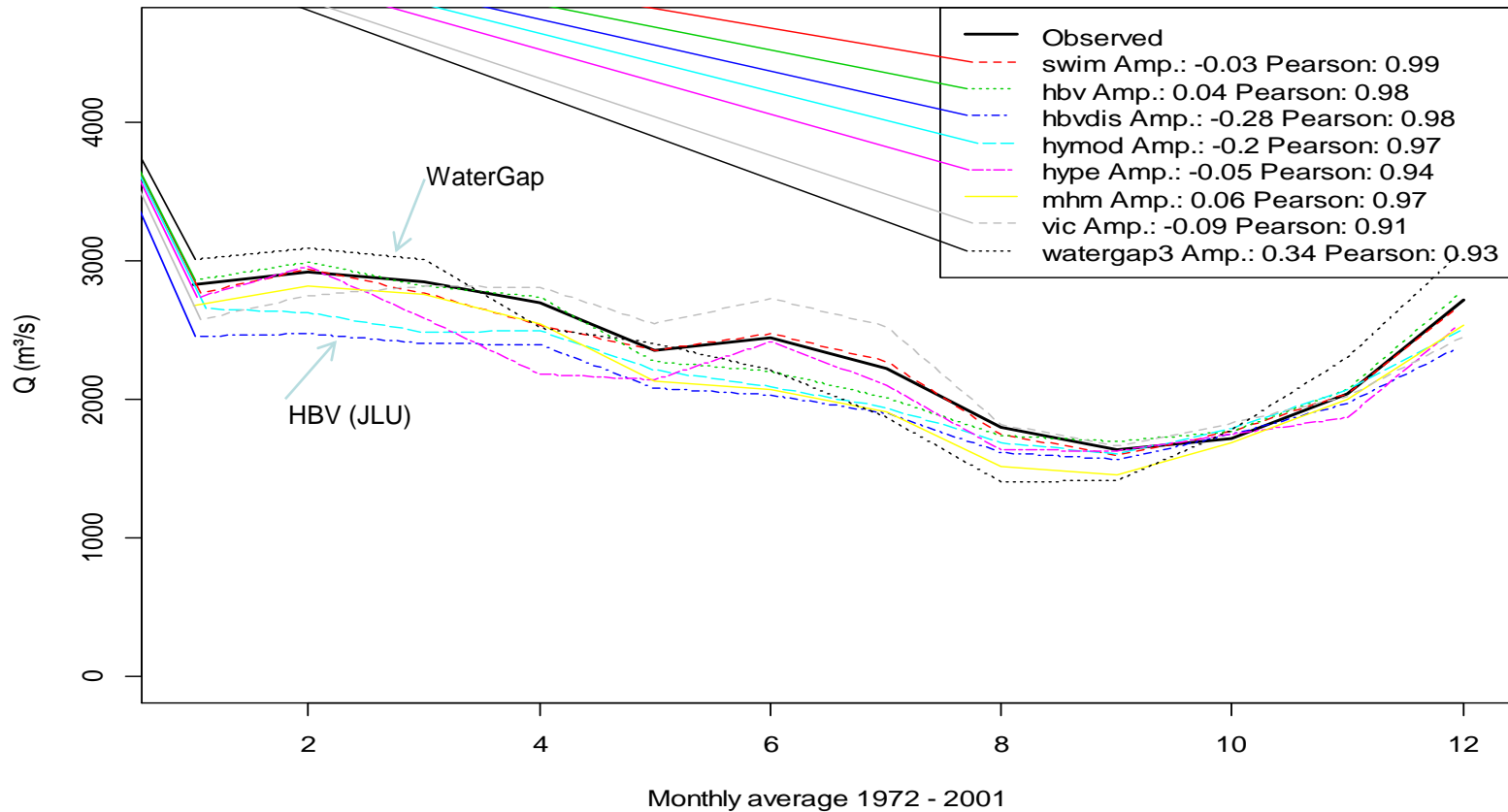


Validation of eight models: SWIM, HYPE, mHM, VIC, WaterGAP3, HBV & HYMOD for the Rhine

Validation lobith watch(wfd)

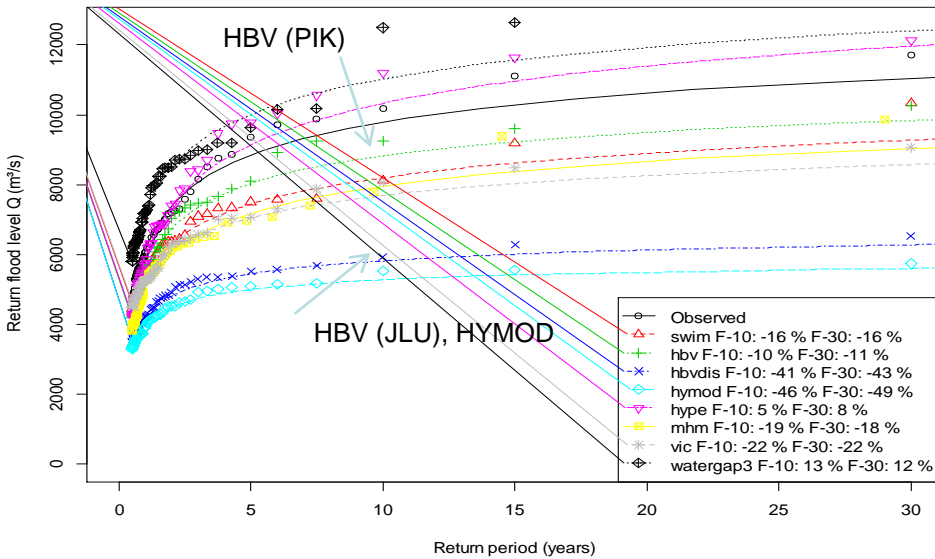


Validation of eight models for the Rhine: seasonal dynamics

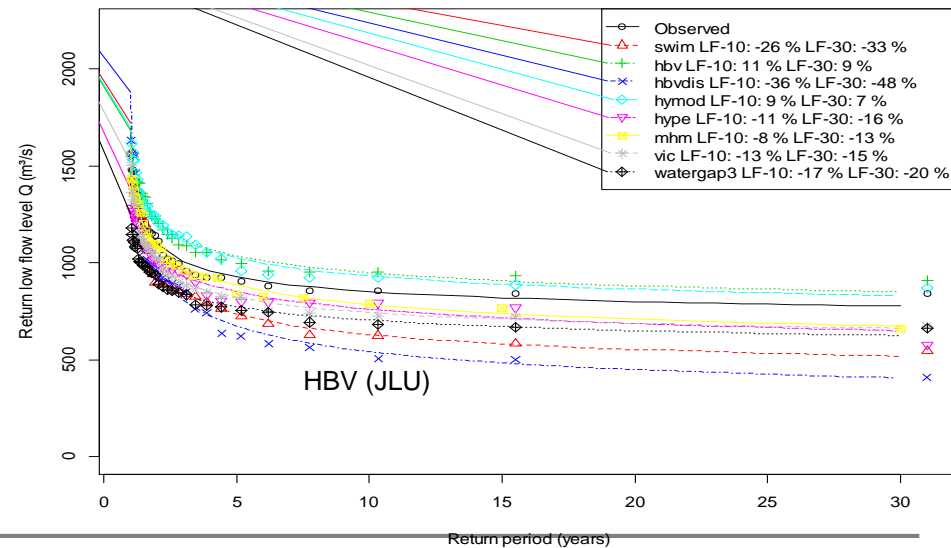


Validation of eight models for the Rhine, extremes

floods



Low flow



Trends in Q for 3 basins by the end of the century, RCP 8.5



Rhine	Q10	Q50	Q90	Niger	Q10	Q50	Q90	Yellow	Q10	Q50	Q90
GFDL	↓↓↓	↓↓↓	↓↓↓	GFDL	↓↑↑	↑↑↑	↑↑↑	GFDL	↓↓↑	↓↓↓	↓↓↑
Had	↓↓↓	↓↓↓	↓↓↓	Had	↓↓↓	↓↓↓	↓↓↓	Had	↑↑↑	↓↓↑	↑↑↑
IPSL	↓↓↓	↓↓↓	↓↓↓	IPSL	↓↓↓	↓↓↓	↓↓↓	IPSL	↓↓↑	↓↓↑	↑↑↑
Miroc	↓↓↓	↓↓↓	↓↓↓	Miroc	↑↑↑	↑↑↑	↑↑↑	Miroc	↑↑↑	↑↑↑	↑↑↑
Nor	↓↓↓	↓↓↓	↓↓↑	Nor	↓↓↑	↓↓↓	↑↓↑	Nor	↓↓↑	↓↓↓	↓↓↑
	HBV	SWIM	VIC								

Rhine: decreasing trends in Q10, Q50 and Q90, good agreement.

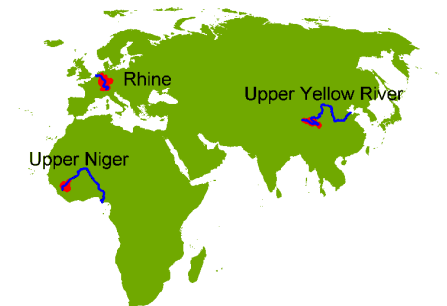
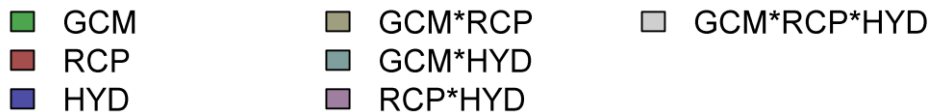
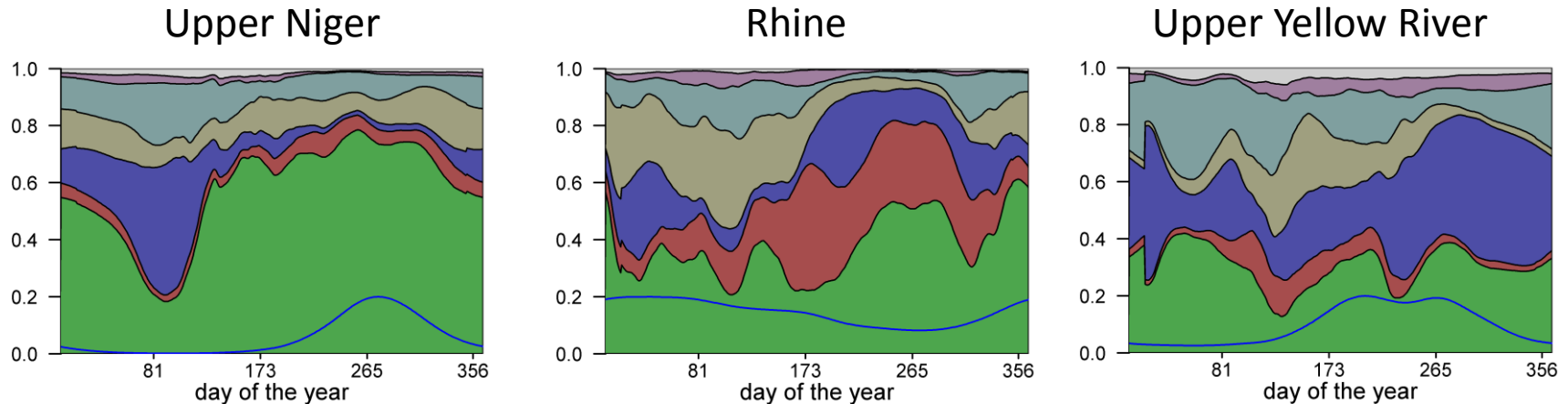
Niger: high uncertainty from climate models but good agreement between hydrological models

Yellow River: high uncertainty from both climate and hydrological models

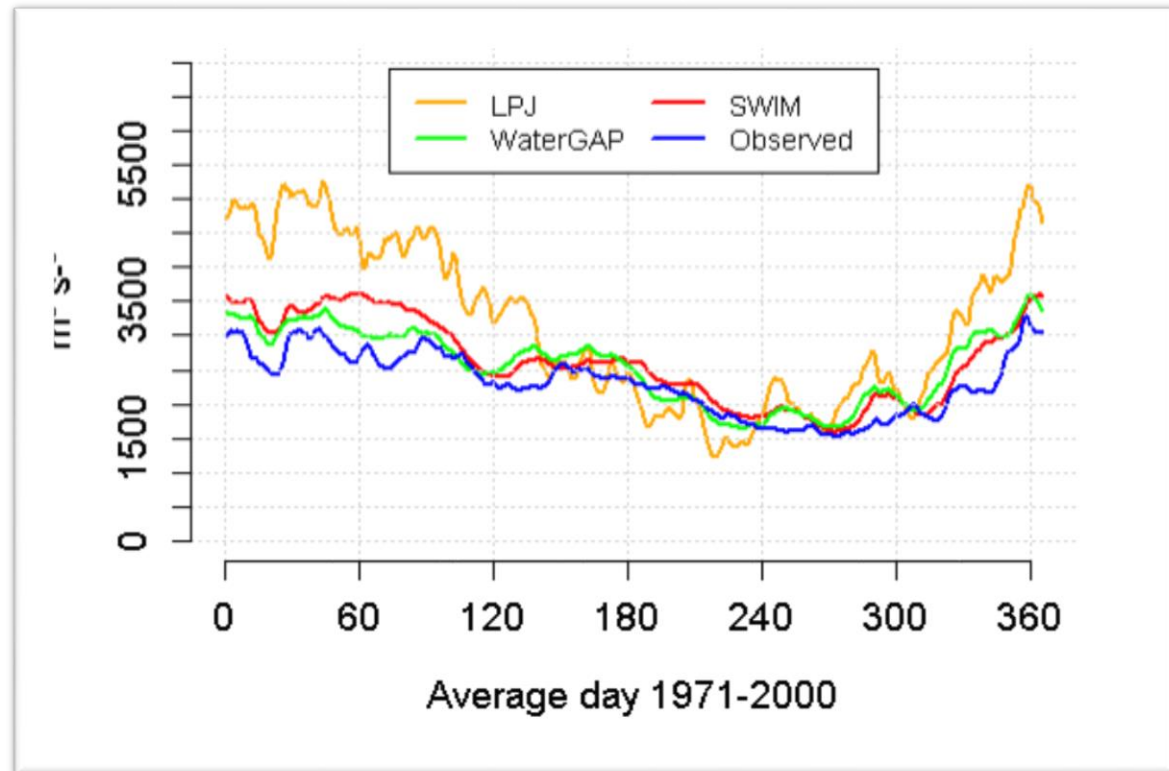


Comparison of Uncertainty Sources

Contribution of different sources of uncertainty (elements of the impact chain): GCMs, RCPs, Hydrological Models (HYD) and their combinations to the total uncertainty in projected future water availability for three river basins on three continents:



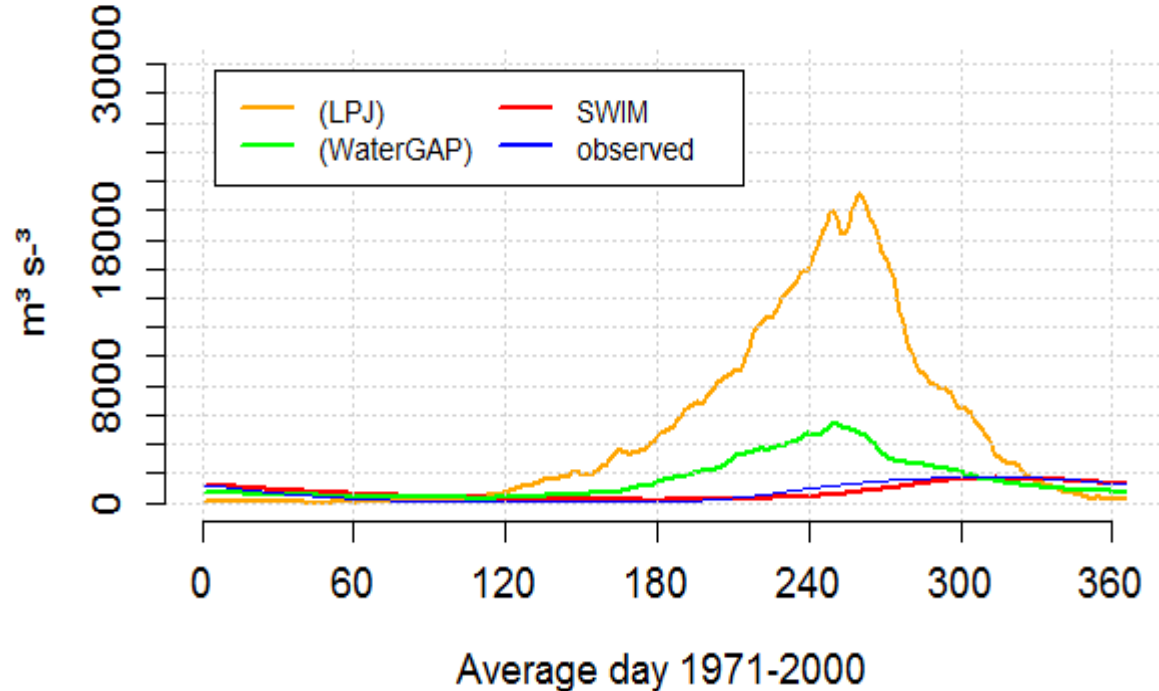
Comparison of validation runs: global and regional models: Rhine



Comparison of validation runs: global and regional models: Niger

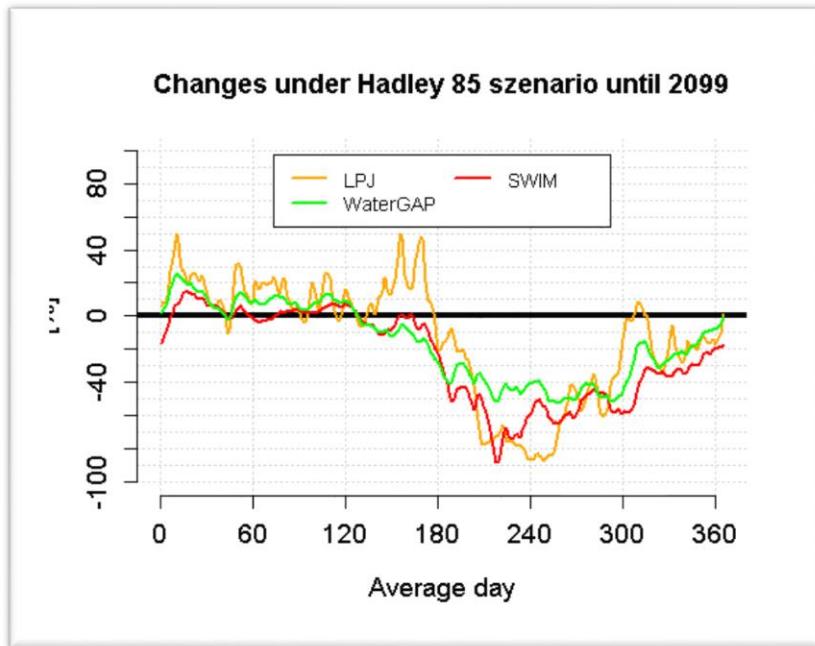


Niger at Dire, SWIM and LPJ under Hadley 85 szenario

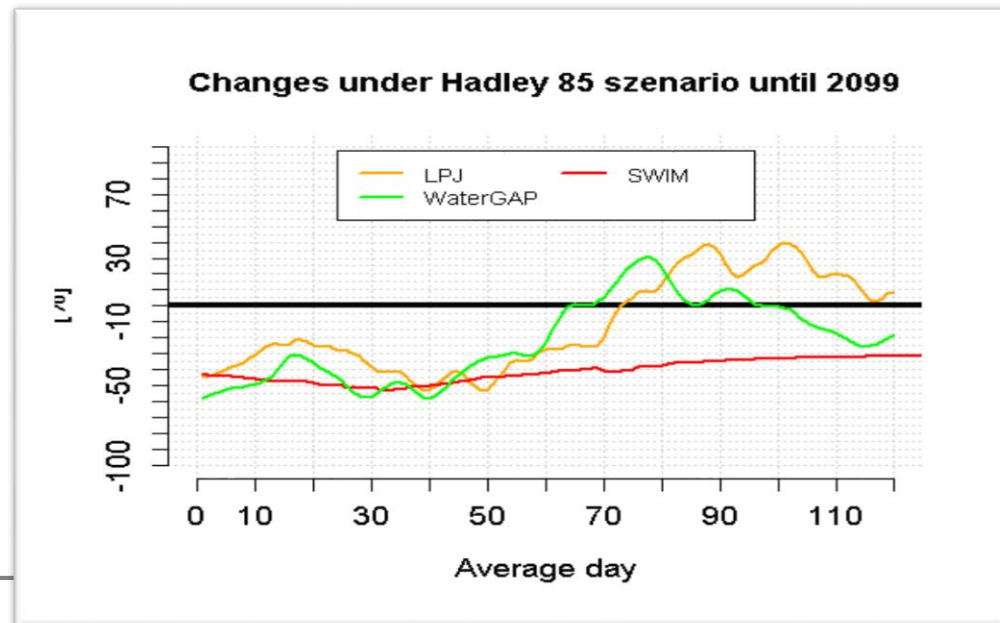


Global & Regional: comparison of impacts by the end of the century

Rhine



Niger



Intercomparison of regional-scale hydrological models: papers planning

Evaluation of models ● Multi stat. indices, return periods

- MacKenzie, Lena
- Blue Nile
- Amazon
- Yangtze

1-2 basins, multi-models

Comparison of impacts

5-12 basins, multi-models

- seas. dyn.
- extremes (%)
- droughts
- IHA
- water balance

● HMs & parametrization

Sources of uncertainty

● trends: RCPs, GCMs, HMs

● extremes: impacts

Global – Regional comparisons

● validation & seasonal dynamics



Planned Special Issue papers

Calibration & validation:

1. **Evaluation of models**, including extremes, *Huang et al*

Impacts:

1. Comparison of impacts for eleven basins: **seasonal dynamics**, S. Eisner, *Flörke et al.*
2. **Comparison of hydrological extremes** along a hydro-climatic gradient, *Pechlivanidis et al.*
3. Comparison of impacts for eleven basins: **low flow and drought indices**, *Samaniego et al.*
4. Evaluation of climate impacts using **Indicators of hydrological alteration** (IHA), *Yang et al.*
5. Sensitivity of **water budget components**: a multi-scenario study V. *Mishra, H. Shah, et al.*

Uncertainty:

1. Evaluation of trends and **sources of uncertainties** (ANOVA method), *Vetter et al.*
2. Evaluation of **uncertainties due to model structure** & parameters, *Chamorro-Chavez et al.*

Individual basins:

1. Comparison of impacts for the **Lena and MacKenzie**, *Gelfan, Pechlivanidis et al.*
2. Comparison of impacts and evaluation of uncertainties for the **Blue Nile**, *Griensven et al.*
3. Comparison of impacts and evaluation of uncertainties for the **Yangtze**, *Su Buda et al.*
4. Comparison of impacts and evaluation of uncertainties for the **Amazon**, *Strauch et al.*

Global & Regional:

1. Comparison of impacts simulated by **regional and global** scale models, *Hattermann, S. Gosling et al.*

Thanks for your attention!

