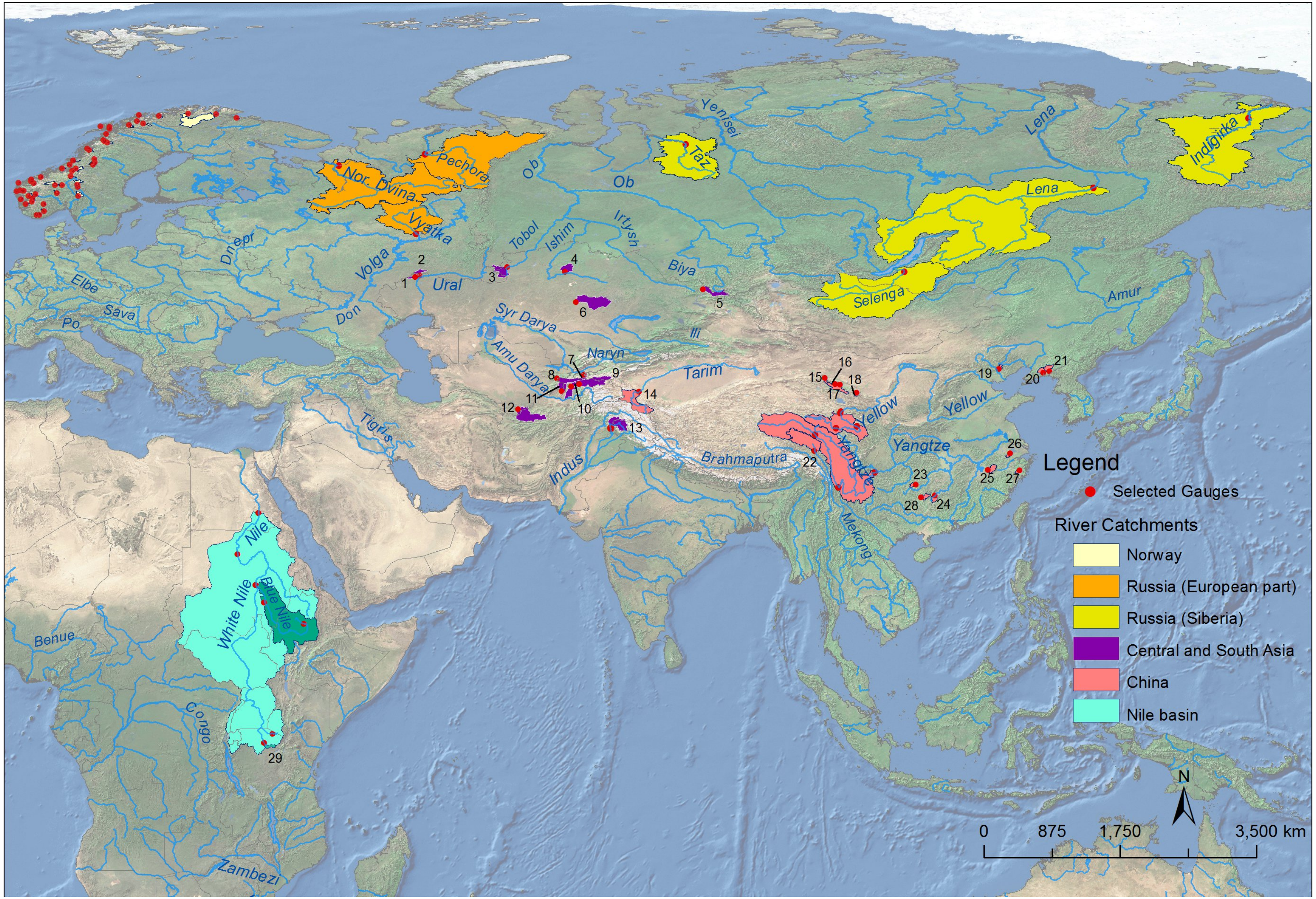
Summary of results on climate impact attribution for river discharge at the regional scale

(based on Topical Collection of papers in Climatic Change)

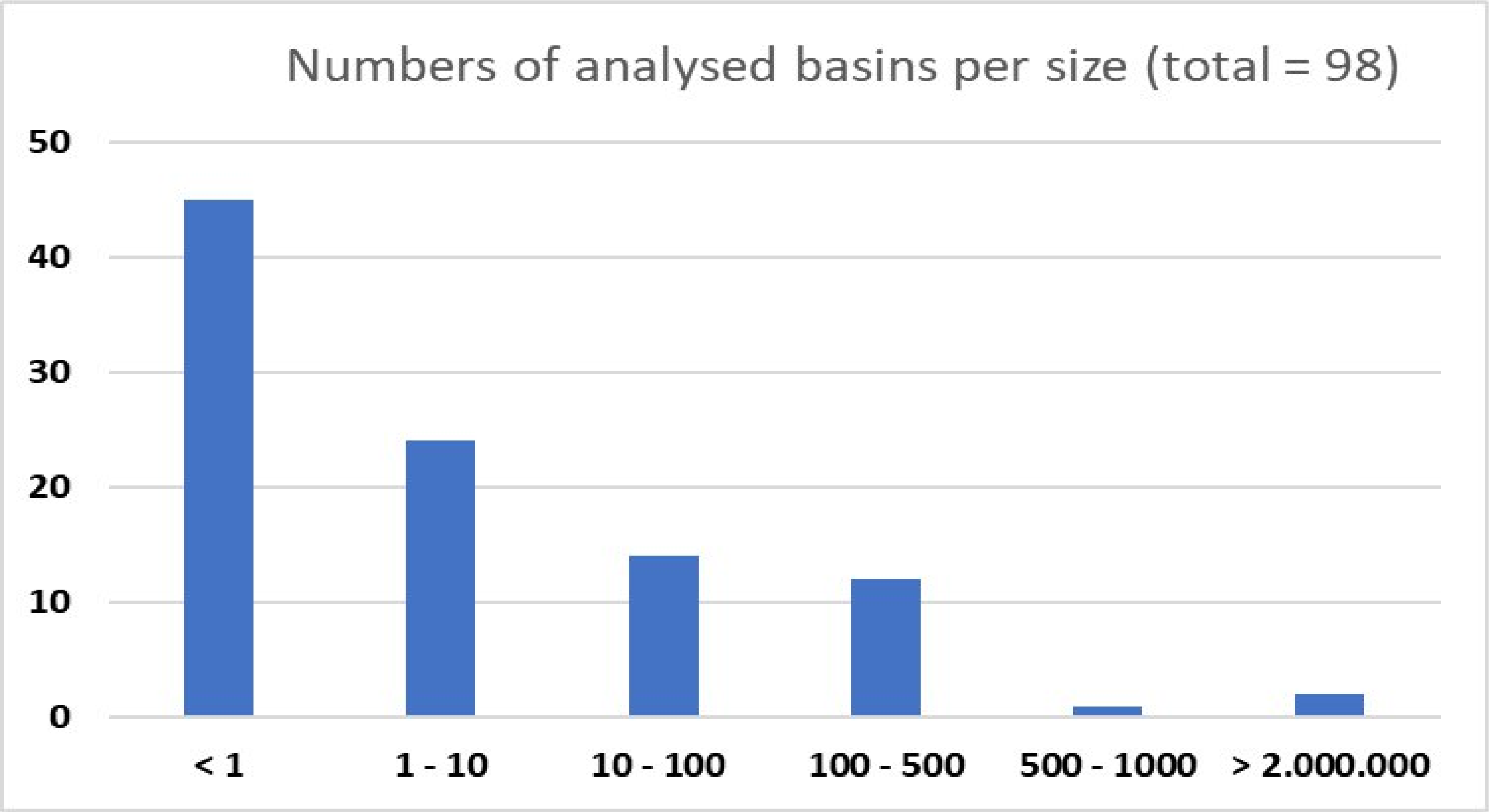
https://link.springer.com/collections/bibbfajfea

Water Regional, Valentina Krysanova and Fred Hattermann

98 case study river basins/catchments in Europe, Asia and Africa



Numbers of the analysed river basins by size



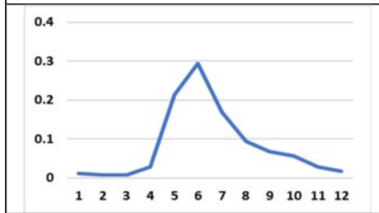
thous.
km2

Main hydroclimatic characteristics for the selected 24 river basins

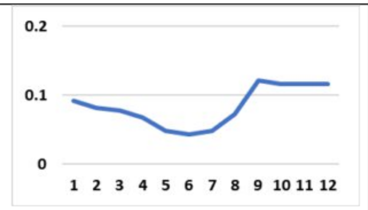
Country/Region	Mean annual T, °C	Mean annual P, mm	Mean annual runoff, mm/day	Runoff coefficient
Norway	-2.4..... 5.4	499..... 2470	1.0...... 5.8	0.77......0.88
Russia, Eur. part	-2.5...... 2.9	589..... 718	0.67..... 1.25	0.36.......0.64
Russia, Siberia	-12.7.....-2.9	245..... 485	0.17...... 0.9	0.19......0.71
Central Asia & U. Indus	2.3...... 10.8	296.....1050	0.08......2.46	0.09.....0.89
China	-3.5......15.9	161.....1928	0.4.......3.5	0.33.......0.9
Nile RB	21.9.....26.3	675.....1010	0.06.....0.37	0.08......0.17

Seasonal dynamics of runoff in 24 selected river catchments

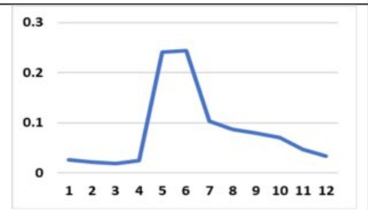
2.614, Norway, eastern
5-8



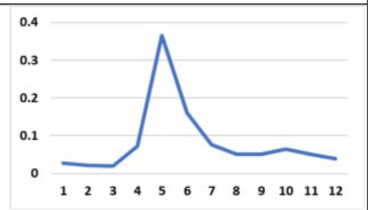
91.2, Norway, coast
9-1



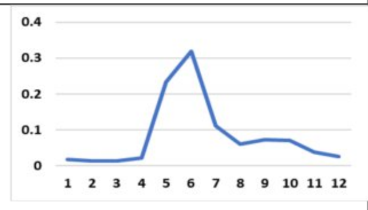
234.18, Norway, northern
5-8



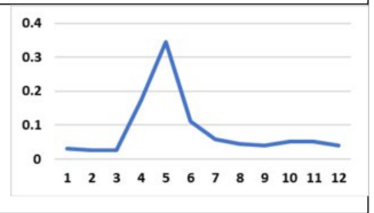
Northern Dvina, Russia
5-6



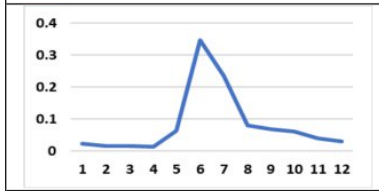
Pechora, Russia
5-7



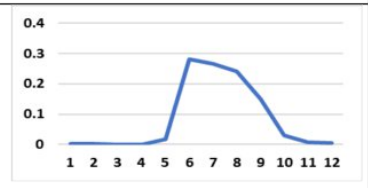
Vyatka, Russia
4-6



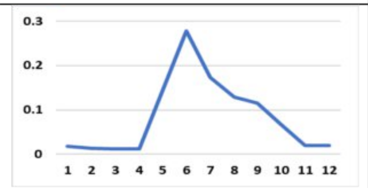
Taz, Russia
6-7



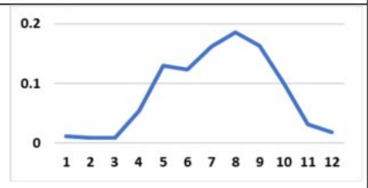
Indigirka, Russia
6-9



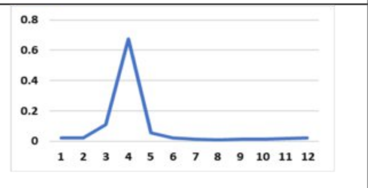
Lena, Russia
5-9



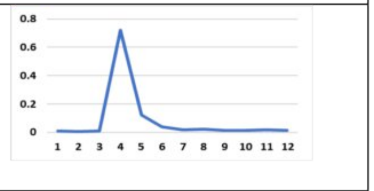
Selenga, Mongolia & Russia
5-10



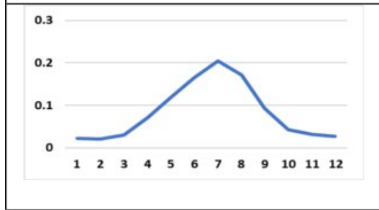
Shagan, Kazakhstan
3-4



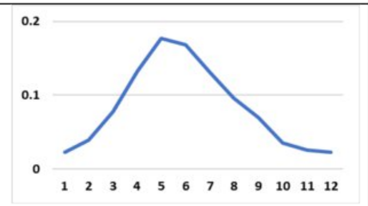
Zhabay, Kazakhstan
4-5



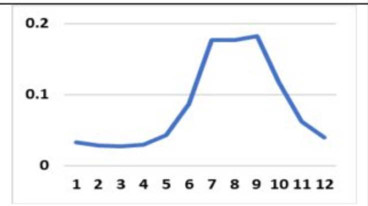
Vakhsh, Tajikistan
5-9



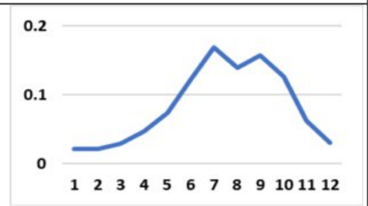
Jhelum, Pakistan & India
4-8



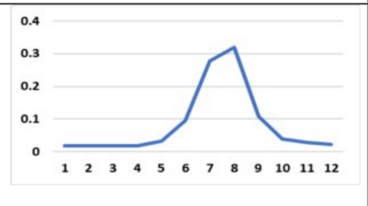
Upper Yangtze, China
6-10



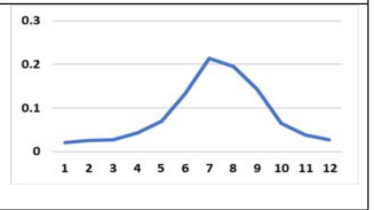
Upper Yellow, China
6-10



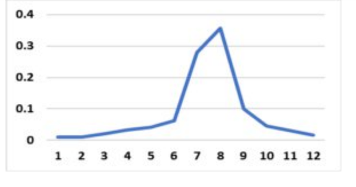
Tarim- Yeerqiang, China
6-9



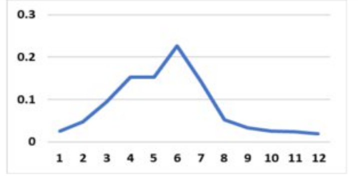
Heihe, China
6-9



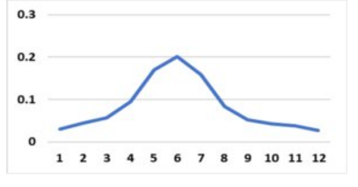
Yalujiang-Aihe, China
7-9



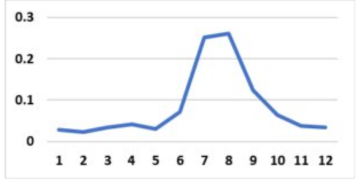
Raohe, China
4-8



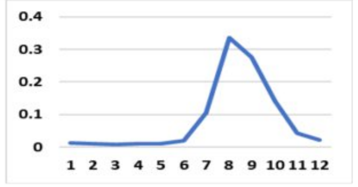
Liujiang-Xunjiang, China
3-7



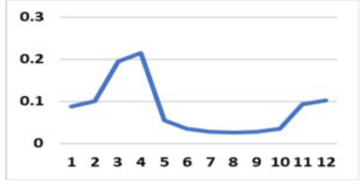
Main Nile, 12 countries
7-9



Blue Nile; Ephiopia & Sudan
7-10



Simiyu, Tanzania
1-4, 11-12



Flow > Q50 during 2 months

Flow > Q50 during 5-6 months

Climate data used as the observational climate

GSWP3-W5E5 (suggested as the first priority data for attribution studies in ISIMIP):

Gelfan et al.; Nkwasa et al., Nasonova et al.; Wen et al.; Sun et al.; Fallah

GSWP3-W5E5; 20CRv3; 20CRv3-W5E5:

Javed et al.

GSWP3-W5E5; GCMs with anthropogenic and natural forcings:

Didovets et al.

Observed climate data for Norway:

X. Yang & Sh. Huang

Problems encountered in model setup and climate input data

1. **Water management** (e.g. dams & reservoirs) could be included only if it is implemented in the model.

à The Nile case study was done with SWAT, where major reservoirs with water management rules were implemented (Nkwasa et al.).

à For China only catchments without water management or with a minor influence of reservoirs (checked) could be analysed: 21 catchments were chosen for two studies (Wen et al., Sun et al.).

2. **Counterfactual climate data for Norway**: the GSWP3-W5E5 with 0.5 deg. resolution could not be applied for small catchments < 1000 km2.

☾ Therefore, observed climate data were used as factual, and counterfactual data for Norway was produced by authors (Yang and Huang) using the ATTRICI approach based on the observed data.

3. **Counterfactual climate data for China**: a problem was found in precipitation (P) data in GSWP3-W5E5 (as well as in other reanalysis datasets: 20CRv3; 20CRv3-W5E5) for the first half of 20th century in the Tibet plateau and surrounding areas: very high P fluctuations in 1901-1930/1940 dropping down after 1930/1940. Due to that, the counterfactual data based on GSWP3-W5E5 from 1901-2019 are not reliable.

☾ Therefore, the counterfactual data for China were recalculated by Simon Treu based on GSWP3-W5E5 in 1961-2019, and used for two Chinese studies (Wen et al., Sun et al.).

Models applied

Paper by authors	Country/Region, catchments	Models applied
Yang & Huang	**Norway, 50 catchments**	**GR4J, WASMOD, HBV, XAJ**
Gelfan et al.	**Russia, 4 basins**	**ECOMAG**
Nasonova et al.	**Russia, 3 basins**	**SWAP**
Didovets et al.	**Central Asia, 12 catchments**	**SWIM**
Javed et al.	**U. Indus, 1 catchment**	**SWIM**
Wen et al.	**China, 6 catchments**	**HBV, SWAT**
Sun et al.	**China, 20 catchments**	**VIC**
Nkwasa et al.	**Nile River basin, 7 subbasins**	**SWAT+**
Fallah B.	**Central Asian Region**	**Analysis of T, P extremes**

Hydrological variables analysed

Authors	Country	Annual runoff at 5, 25, 50, 75 & 95 percentiles	Seasonal runoff in 4 seasons at 5, 25, 50, 75 & 95 percentiles	Annual max flood peak: magn. & timing	Spring and autumn max flood peaks: magn. & timing	Annual max drought duration	Annual max deficit volume
Yang & Huang	Norway	+	+	+	+	+	+

Authors	Country/ Region	Mean annual runoff	High Flow Volume, HFV_{20}	High Flow (Q5) (Q10)	Low Flow (Q95) (Q90)	Annual max daily discharge	Annual min daily discharge	Mean and max Snow Water Equivalent	Snow cover: start, end, duration	Annual river sediment load
Gelfan et al.	Russia	+	+							
Nasonova et al.	Russia	+						+	+	
Didovets et al.	Central Asia	+		+	+					
Javed et al.	U. Indus	+		+	+	+	+			
Wen et al.	China	+		+	+					
Sun et al.	China	+				+				
Nkwasa et al.	Nile RB	+								+

Attribution of climate change impacts on trends in annual runoff

Paper(s) by authors	Country/Region	Attribution of trends in mean annual discharge	No attribution of trends in mean annual discharge
Yang & Huang	Norway	58% of catchments: 29 catchments of 50 ↑↑↑↑↑↑	42% of catchments: 21 catchments of 50
Gelfan et al.; Nasonova et al.	Russia	Vyatka ↑, N. Dvina ↑, Taz ↑, Indigirka ↑, Lena ↑, Selenga ↓	1: Pechora
Didovets et al.	Central Asia	Derkul ↑, Shagan ↑, Tobol ↑, Sarysu ↓, Kafirnigan ↓, Murghab ↑ (neg. trend)	6: Zhabay, Bukhtarma, Isfara, Zeravshan, Vakhsh, Tupalan
Javed et al.	U. Indus	Jhelum ↓	-
Wen et al.; Sun et al.	China	U. Yangtze (Zhimenda, Shigu, Pingshan) ↑↑↑, U. Yellow (Jimai, Maqu, Tangnaihai) ↑↑↑, Lancangjiang ↑,Tarim-Yeerqiang ↑, Heihe ↑	12: Liyuanhe, Hongshui, Shiyanghe-Xiyinghe, Puhe, Dayanghe, Aihe, Wuyanghe, Xiangjiang, Raohe, Tiaoxi, Yonganxi, Xunjiang,
Nkwasa et al.	Nile River basin	Simiyu ↑, Mara mines ↑, Sennar ↓, Khartoum ↓, Dongola ↓, Aswan ↓	-
		Total = 57 catchments	Total = 40 catchments

Attribution of climate change impacts on trends in high flow

Paper(s) by authors	Country/Region	Attribution of trends in high flow	No attribution of trends in high flow
Yang & Huang	Norway	65% of catchments: 33 catchments of 50 ↑↑↑↑↑↑	35% of catchments: 17 catchments of 50
Gelfan et al.; Nasonova et al.	Russia	Lena ↑, Selenga ↓	5: Pechora, Vyatka, N. Dvina, Taz, Indigirka
Didovets et al.	Central Asia	Derkul ↑, Shagan ↑, Tobol ↑, Kafirnigan ↓, Murghab ↑ (neg. trend)	6: Zhabay, Bukhtarma, Isfara, Zeravshan, Vakhsh, Tupalan
Javed et al.	U. Indus	Jhelum ↓	-
Wen et al.; Sun et al.	China	U. Yangtze (Zhimenda, Shigu, Pingshan) ↑↑↑, U. Yellow (Jimai, Maqu, Tangnaihai) ↑↑↑, Lancangjiang ↑,Tarim-Yeerqiang ↑, Heihe ↑, Liyuanhe ↑, Hongshui ↑, Shiyanghe-Xiyinghe ↑	9: Puhe, Dayanghe, Aihe, Wuyanghe, Xiangjiang, Raohe, Tiaoxi, Yonganxi, Xunjiang,
		Total = 53 catchments	Total = 37 catchments

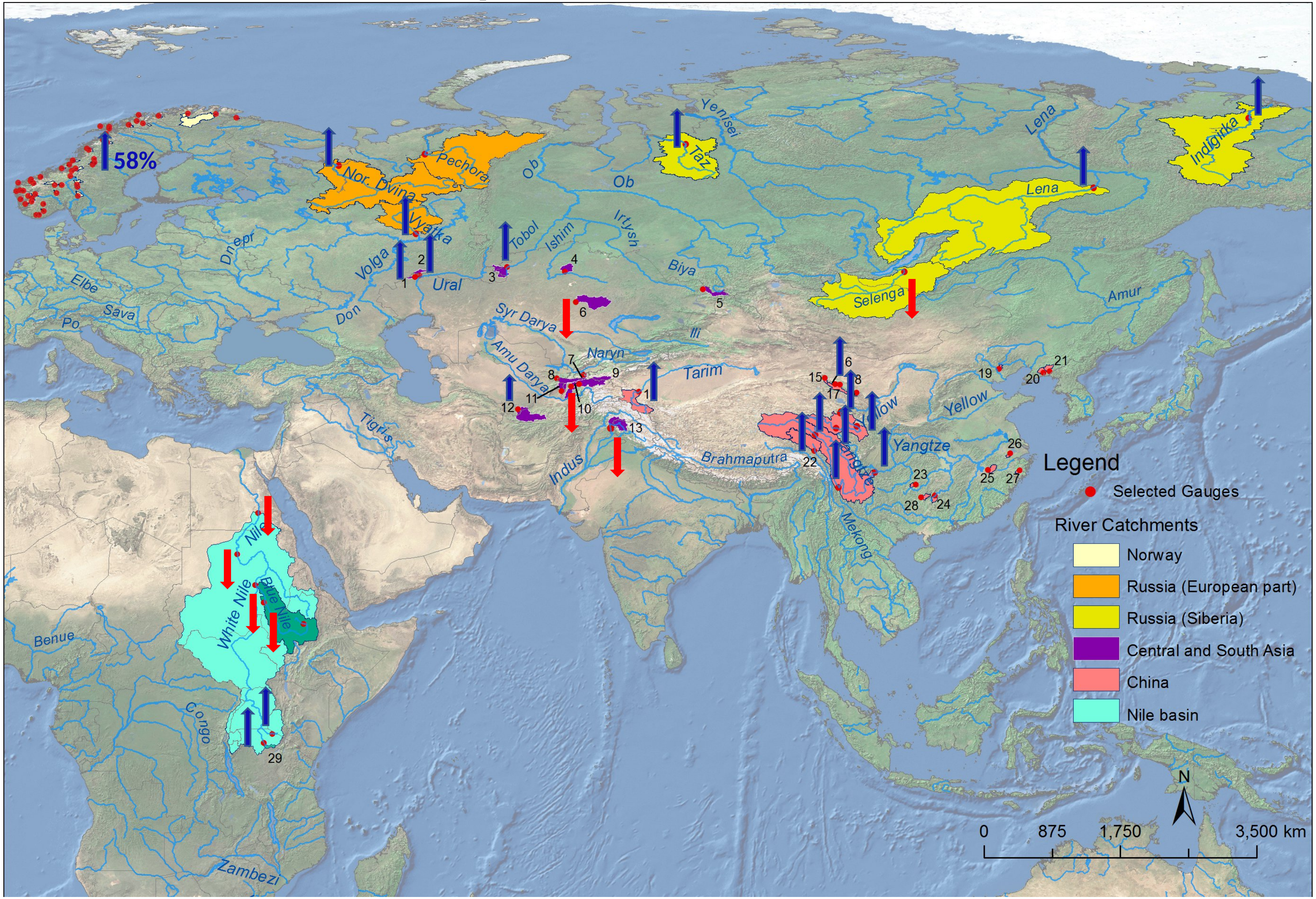
Climate Change Impacts on extreme weather events in Central Asia

The following impacts on extreme weather events were found under the observational climate compared to counterfactual climate):

- increase in frequency and magnitude of extreme T and P events;
- significant increase in heatwave occurrence (frequency and duration);
- enhancement of areas under dry and wet conditions

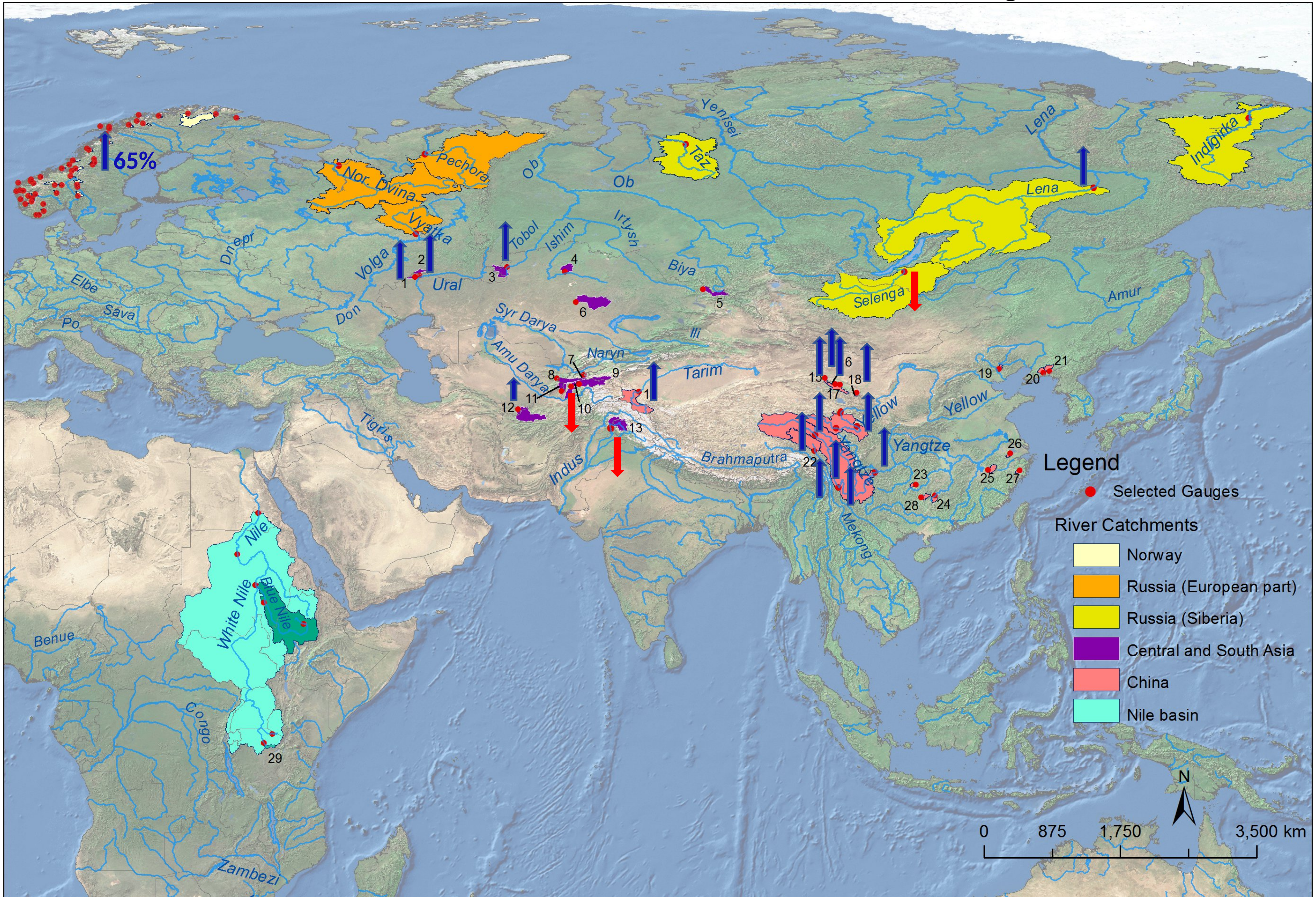
(Bijan Fallah)

Attribution of CC impacts on trends in mean annual runoff



No attribution for 40 catch.:
21 in Norway,
Pechora,
6 in CA,
12 in China

Attribution of CC impacts on trends in high flows



Papers: Topical Collection in Climatic Change, guest editors F. Hattermann & V. Krysanova

Detection, attribution, and specifying mechanisms of hydrological changes in geographically different river basins
Alexander Gelfan, Andrey Kalugin & Inna Krylenko

Attribution assessment of hydrological trends and extremes to climate change in Northern high latitude catchments
Xue Yang & Shaochun Huang

Detection and attribution of changes in streamflow and snowpack in Arctic river basins
Olga Nasonova, Yeugeniy Gusev & Evgeny Kovalev

Attributing historical streamflow changes in the Jhelum River basin to climate change
Mustafa Javed, Iulii Didovets … Shabeh ul Hasson

Attribution of current trends in streamflow to climate change for 12 Central Asian catchments
Iulii Didovets, Valentina Krysanova … Fred Hattermann

Historical climate impact attribution of changes in river flow and sediment loads at selected stations in the Nile basin
Albert Nkwasa, Celray James Chawanda … Ann van Griensven

Attribution of streamflow changes during 1961–2019 in the Upper Yangtze and the Upper Yellow River basins
Shanshan Wen, Buda Su … Han Jiang

and coming soon:

Exploring the impact of the recent global warming on extreme weather events in Central Asia
Bijan Fallah

The recent trends of runoff in China attributable to climate change
Hemin Sun, Valentina Krysanova … Jiang Tong

Editorial introductory paper
Fred Hattermann & Valentina Krysanova (guest editors)

https://link.springer.com/collections/bibbfajfea

DISCUSSION

Possible topics for future studies in Regional-Water, ISIMIP

Firstly, the following 3 topics were suggested:

1. Adaptation to climate change in the water sector;
2. Cross-sectoral studies with agriculture and/or energy as additional sectors;
3. Water scarcity, droughts (and maybe also floods);

After that, some of these topics were reformulated and new ones suggested by you:

1b. Adaptation in the water – agriculture (or forestry) nexus to new hydro-climatic extremes;
2b. Cross-sectoral studies with agriculture and forestry as additional sectors;
3b. Climate change-induced threats (floods, droughts, water scarcity) to water security;
3c. Water scarcity, droughts and floods;
3d. Flood inundation mapping under Climate change;
2-3b. Droughts, floods and agriculture yield under climate change:
4. Dam break risk under climate change

Possible topics for future studies (& next SI?) in Regional-Water

After merging and adjusting, we come to the following three topics:

1. Adaptation to climate change in the water (and agriculture) sector(s);

2. Cross-sectoral studies with agriculture (or forestry) as additional sector;

3. Climate change-induced threats (floods, droughts, water scarcity) to water security;

Let us discuss these options and choose one of them.