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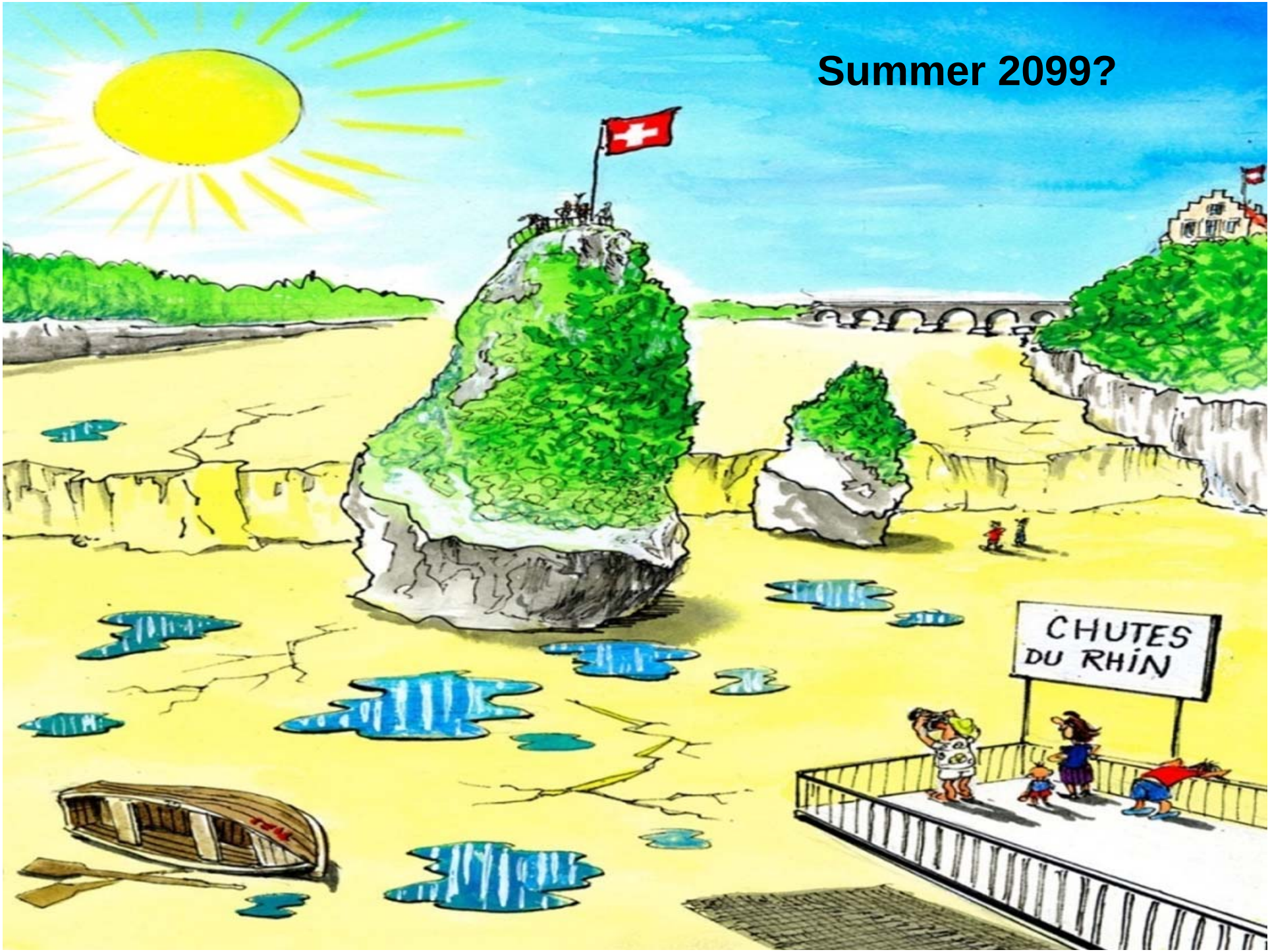
CLIMATE CHANGE RESEARCH

The Alpine water tower – past, present, future

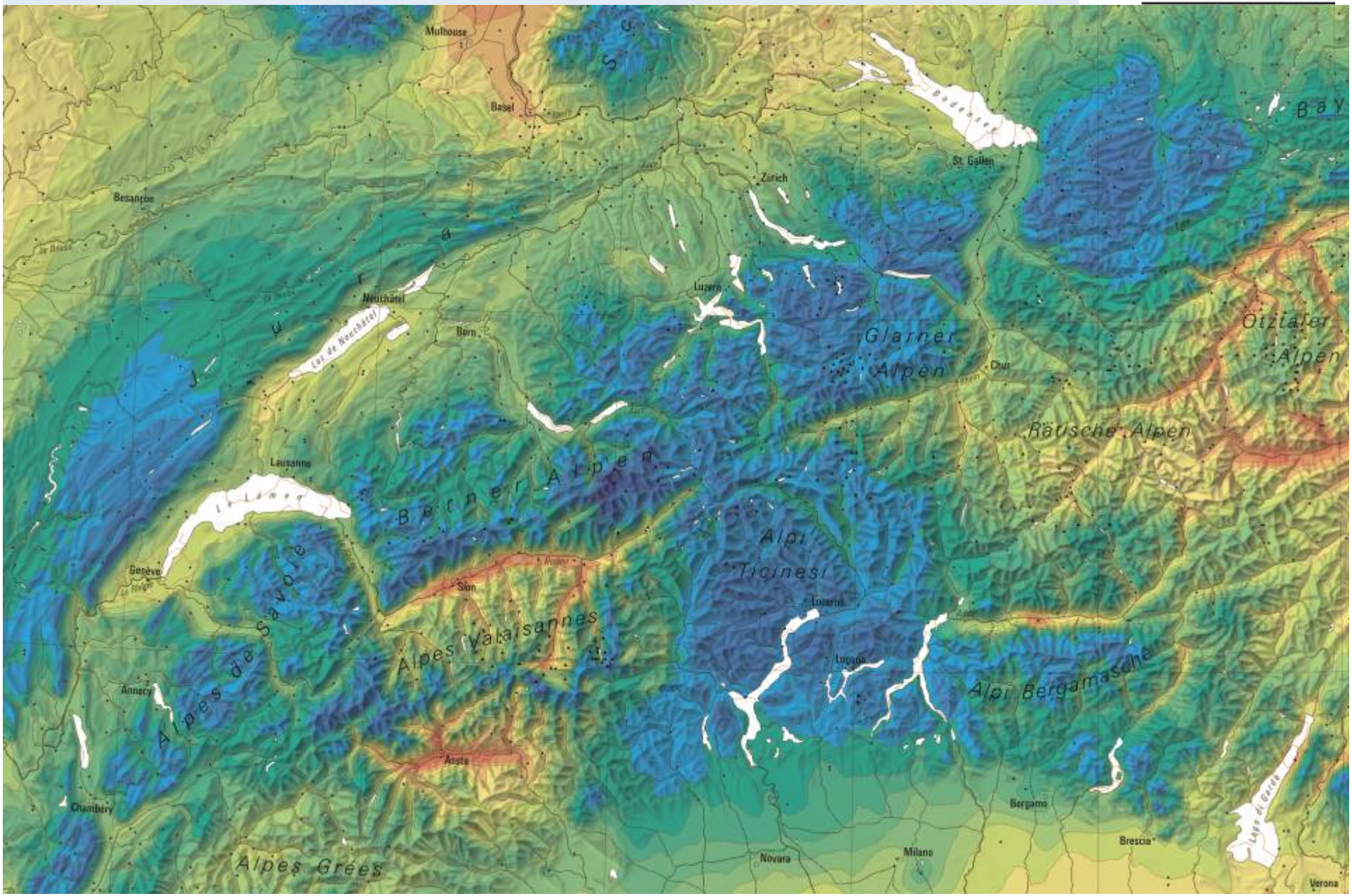
Bruno Schädler
Swiss Hydrological Commission c/o
Group for Hydrology, Institute of Geography
University of Bern

CHR – Spring seminar «Socio-economic influences on the discharge of the River Rhine»

26-27 March 2014, Bregenz


Summer 2099?
CHUTES
DU RHIN

Precipitations in the Alps (HADES 2.6)



From where the water comes

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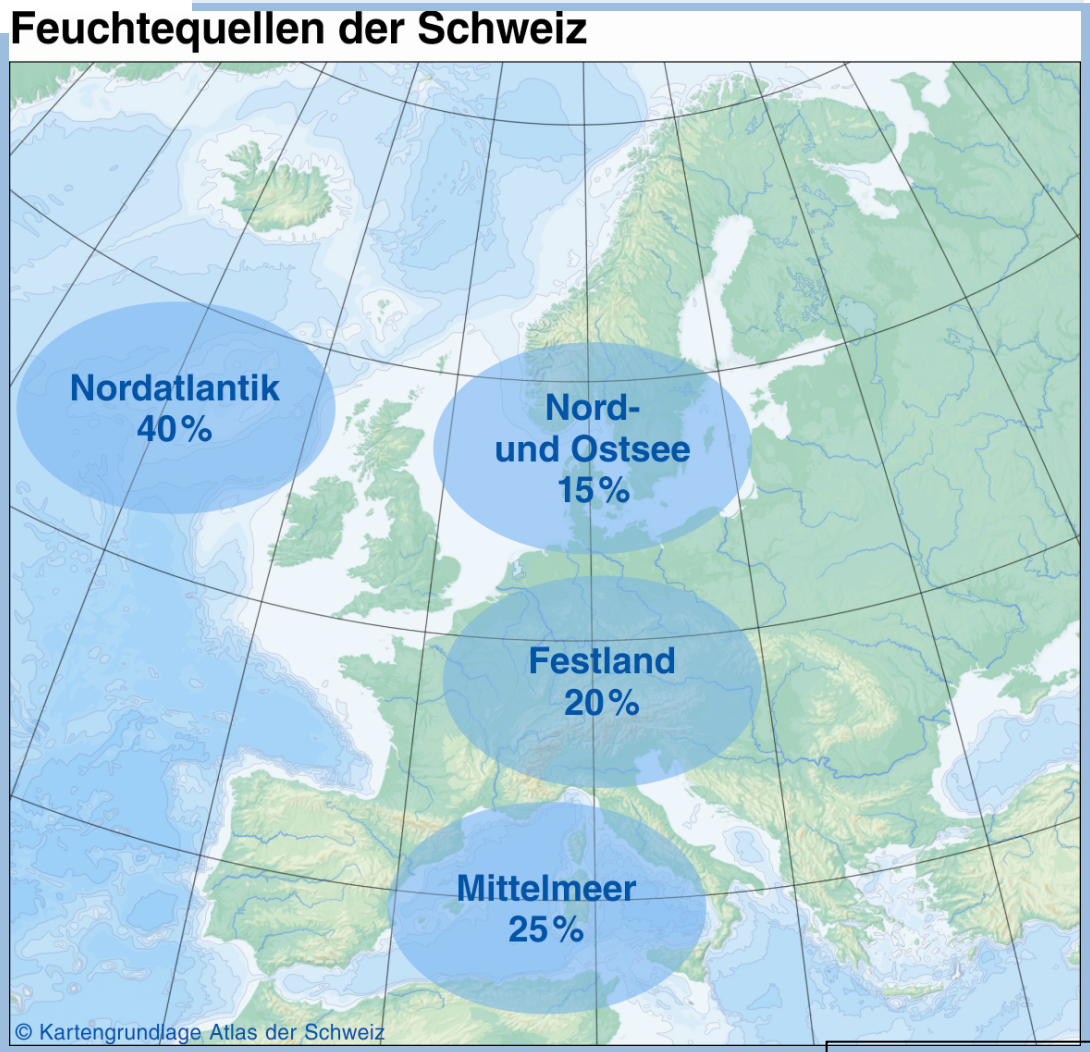

Sodemann et al., 2010

Water balance of Switzerland

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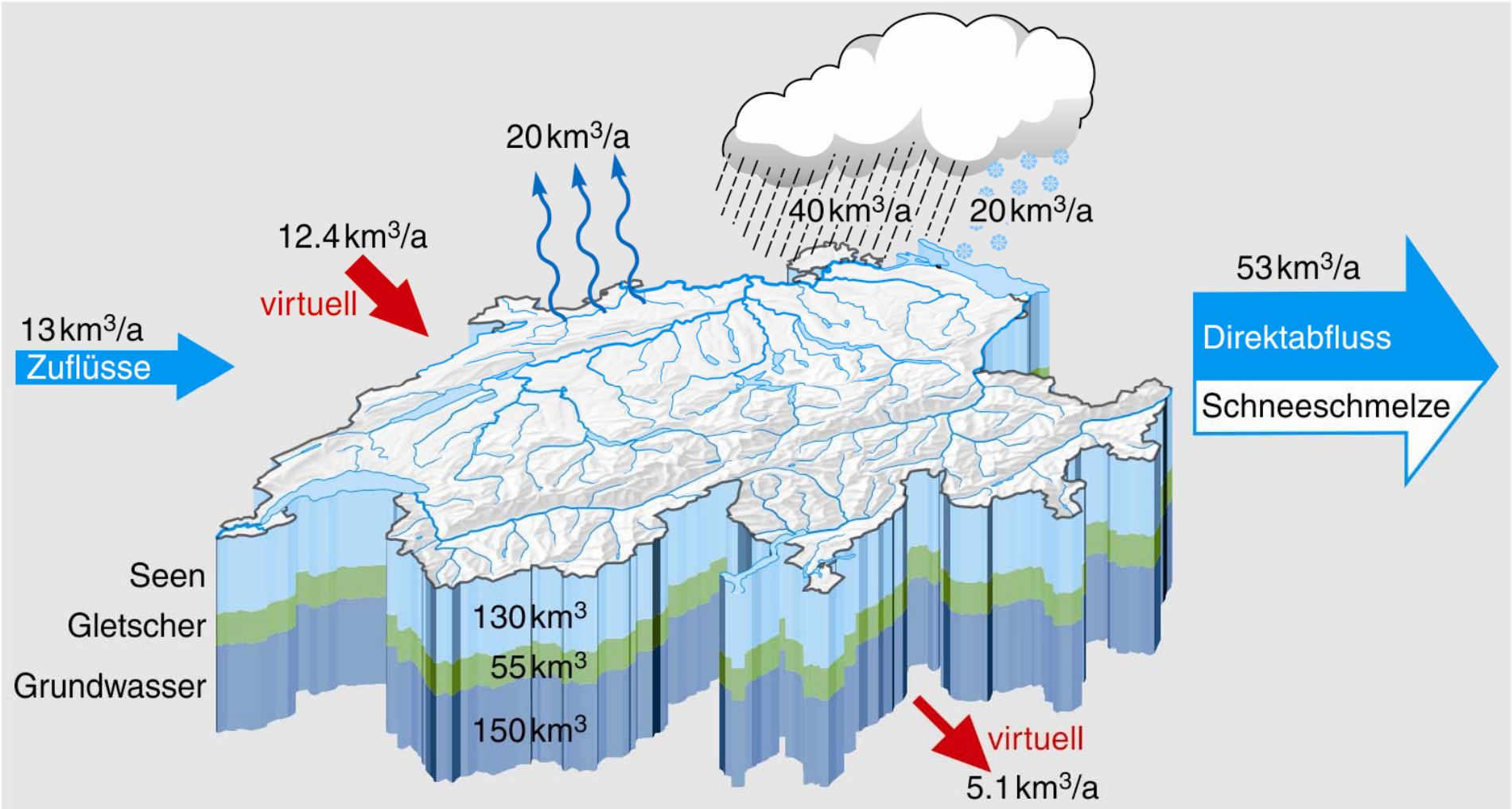
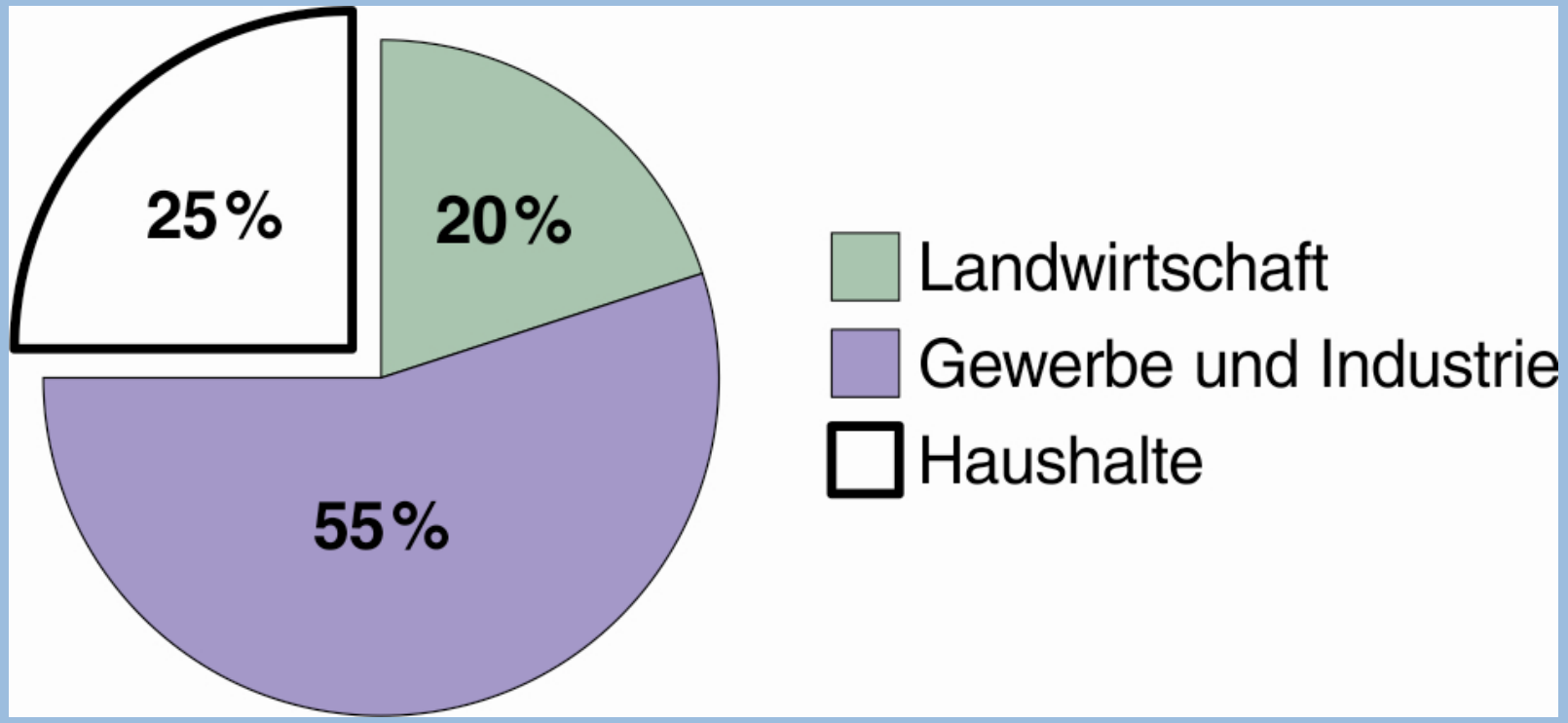


Water use: 2.2 km³



+ 1.64 km³ for cooling nuclear power plants

Water balance in Switzerland since 1901

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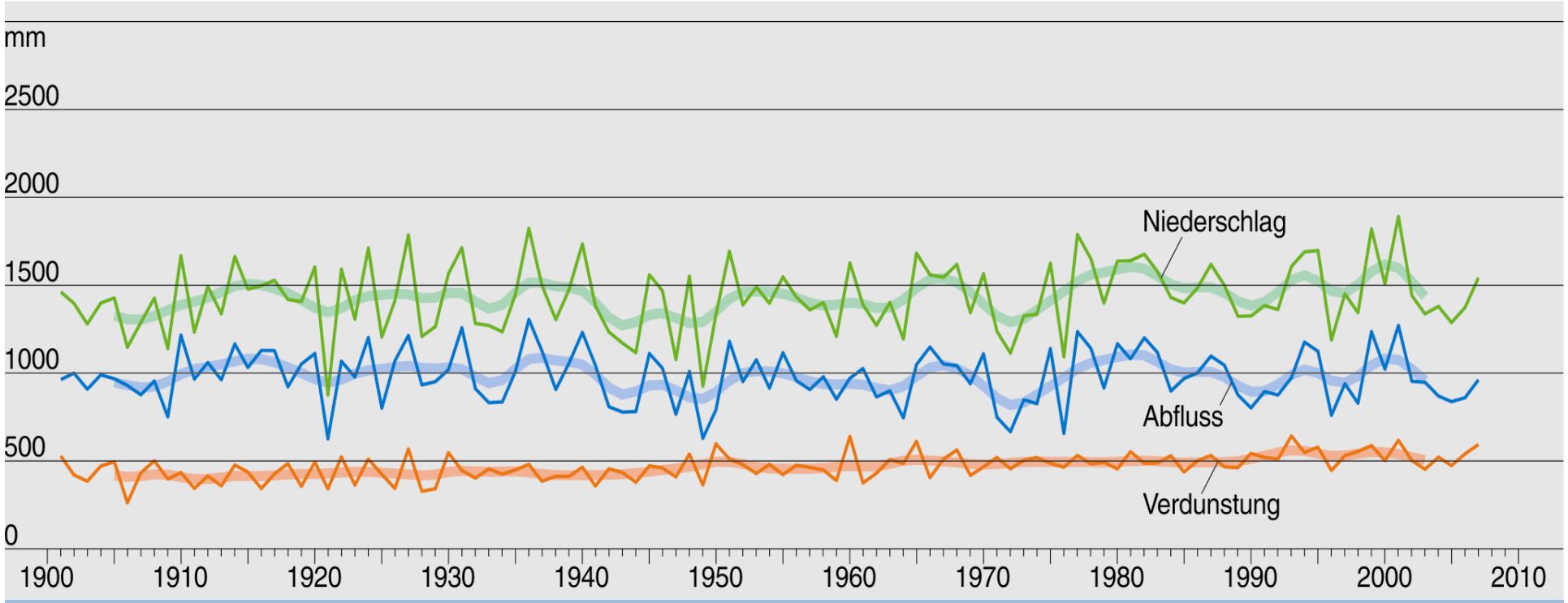
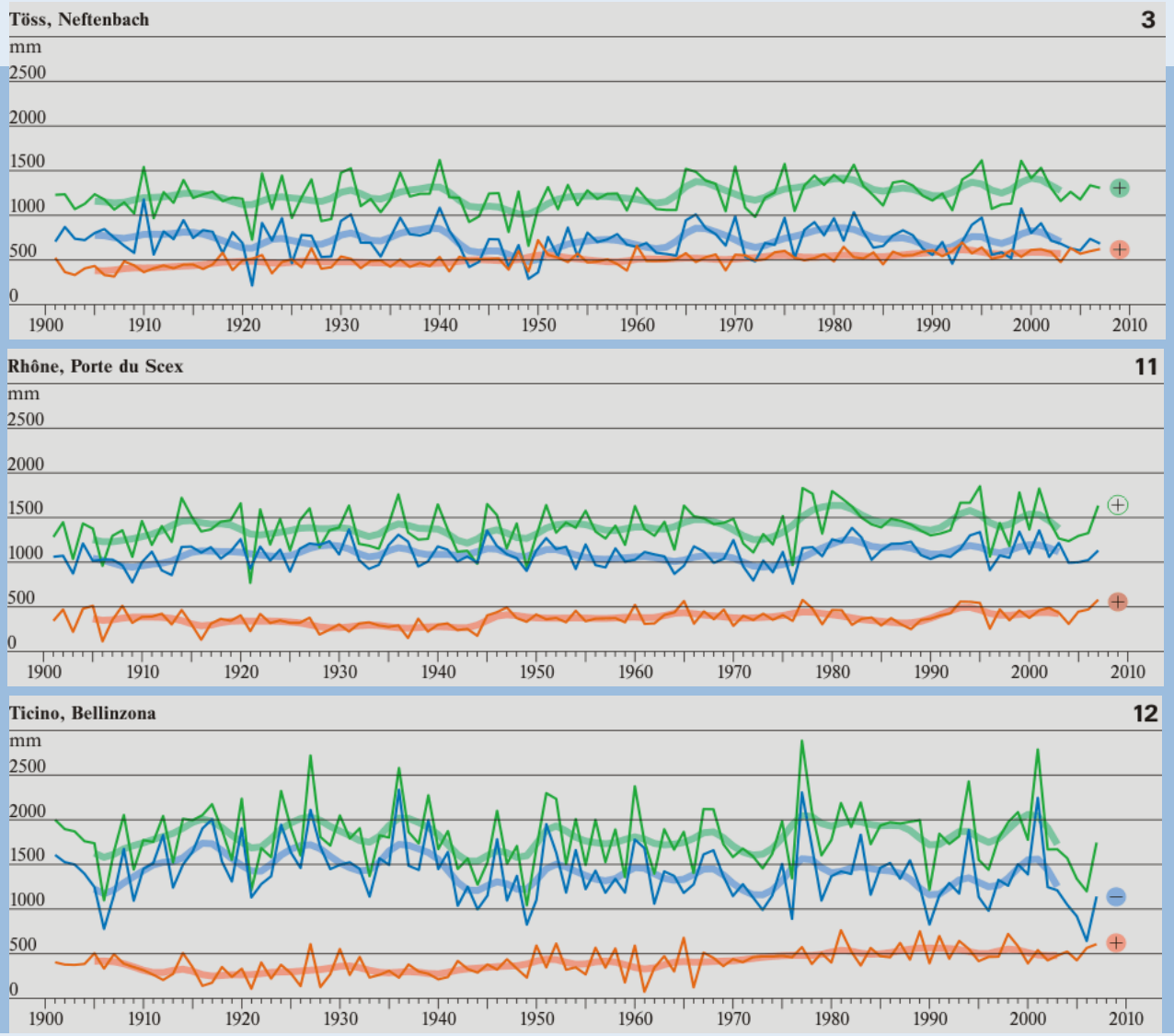
Zeitreihen von Niederschlag, Abfluss und Verdunstung



HADES; Hubacher & Schädler, 2010

Wasserhaushalt Töss, Rhone, Ticino ab 1901

(HADES; Hubacher & Schädler, 2010)



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Runoff regimes in Switzerland

Pardé-coefficients $P = MQ_{Month} / MQ_{Year}$

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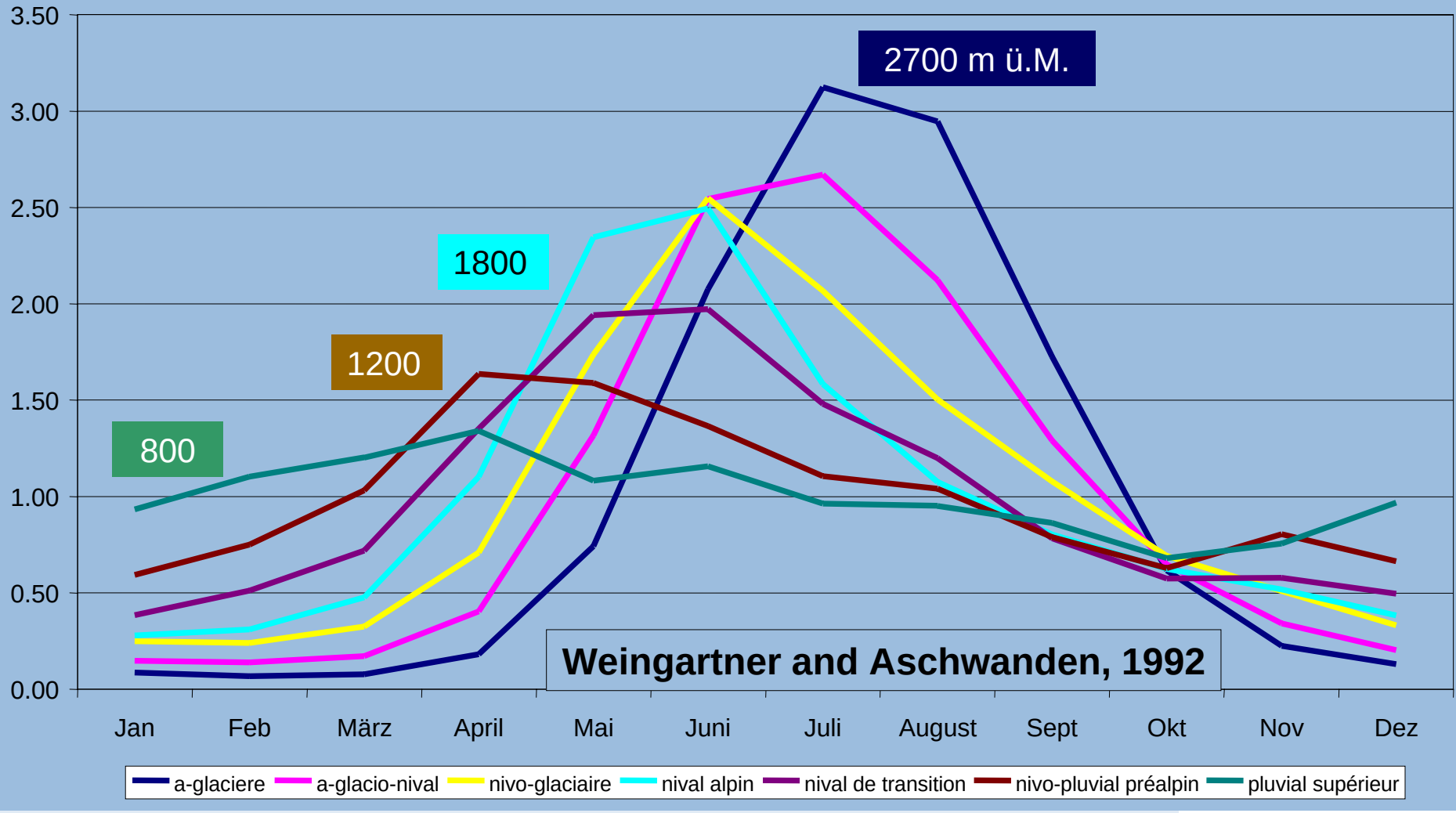
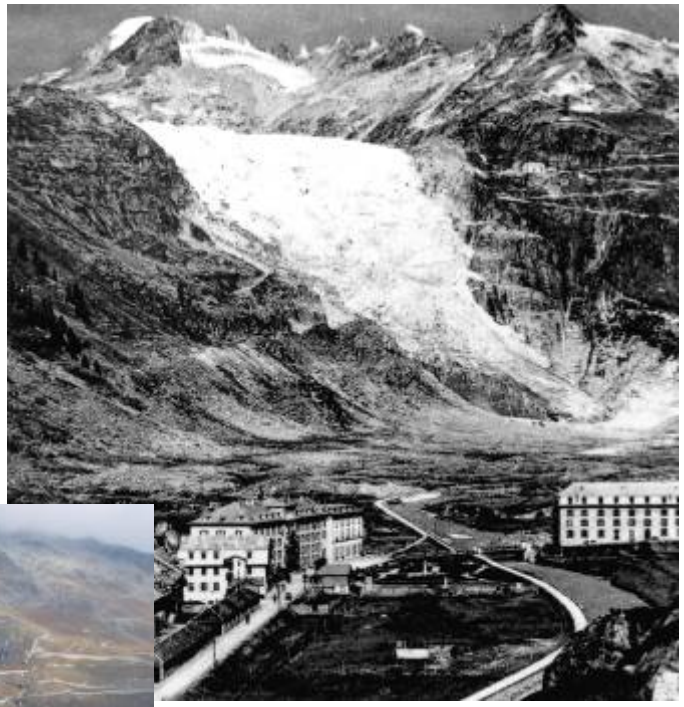


Rhonegletscher 1850 – 1900 – 2006

+ ca. 2.0 deg



Switzerland

- 30 % Surface
- 55 % Volume

Climate scenario A1B for Bern/Zollikofen

***compared to 1980-2009** (Bosshard et al., 2011; CH2011, 2011; BAFU, 2012)*

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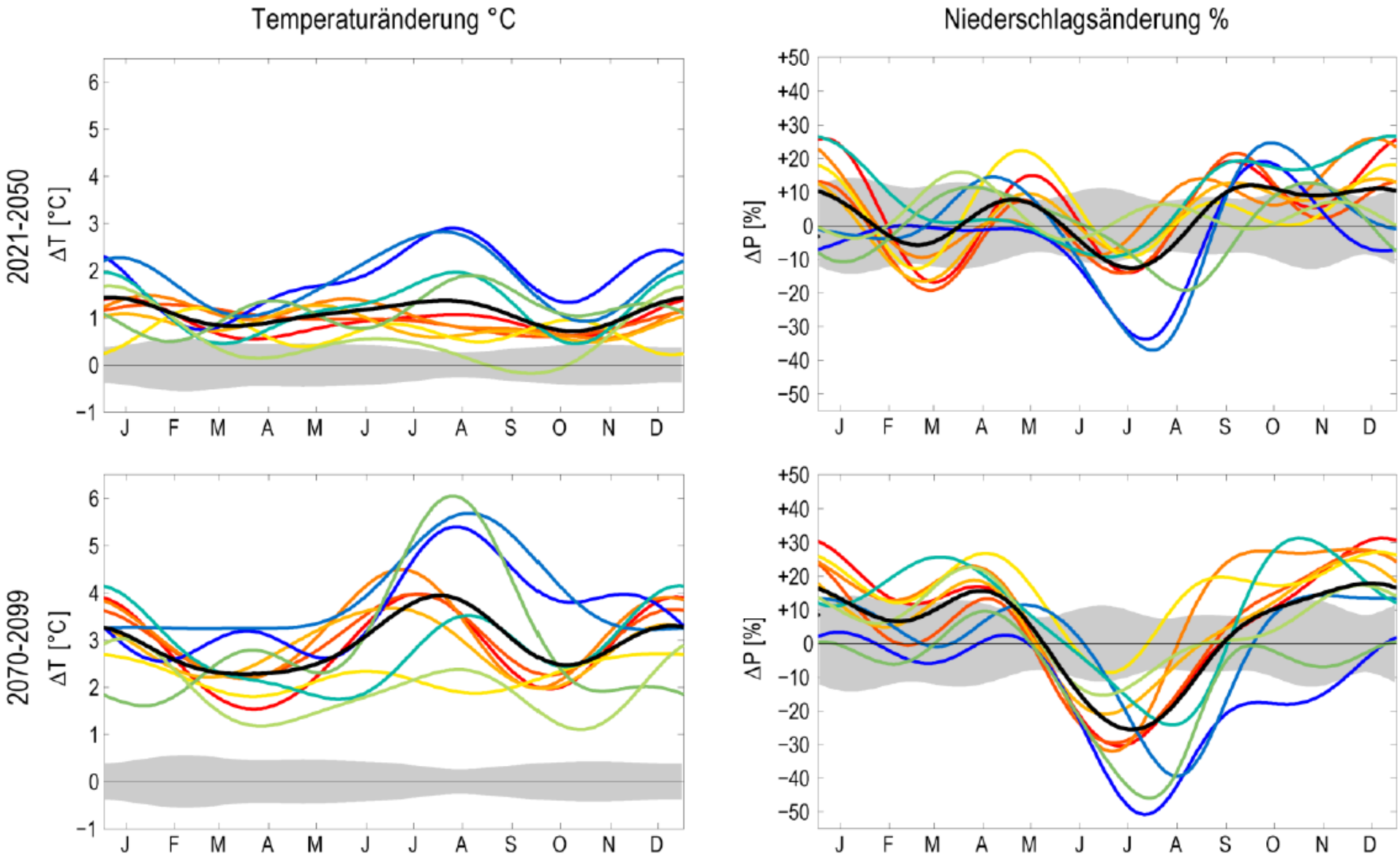

Annual precipitation: changes until 2021 – 2050 and 2070 –2099 compared to 1980 – 2009

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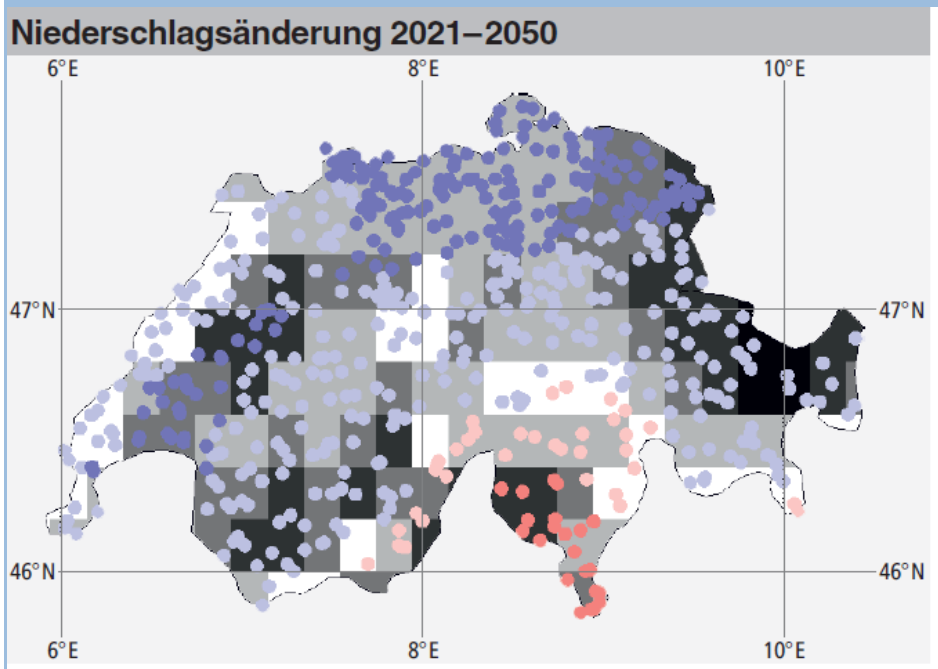

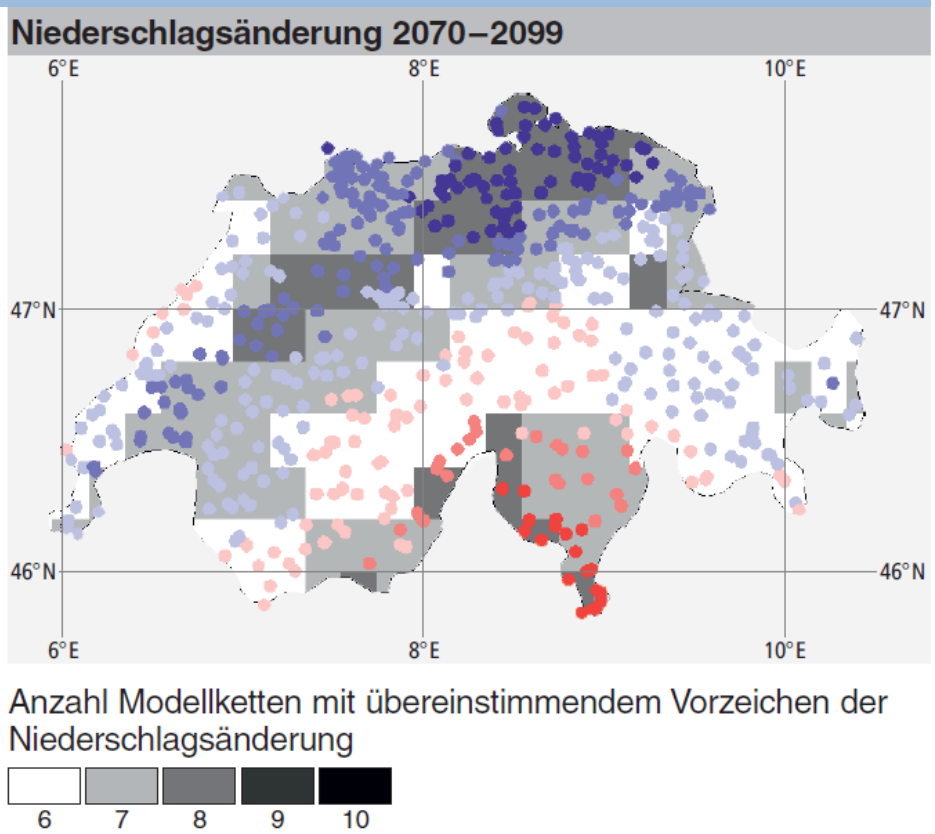

Thomas Bosshard et al.; CH2011, 2011

Triftgletscher
Juni 2004 und Juni 2005

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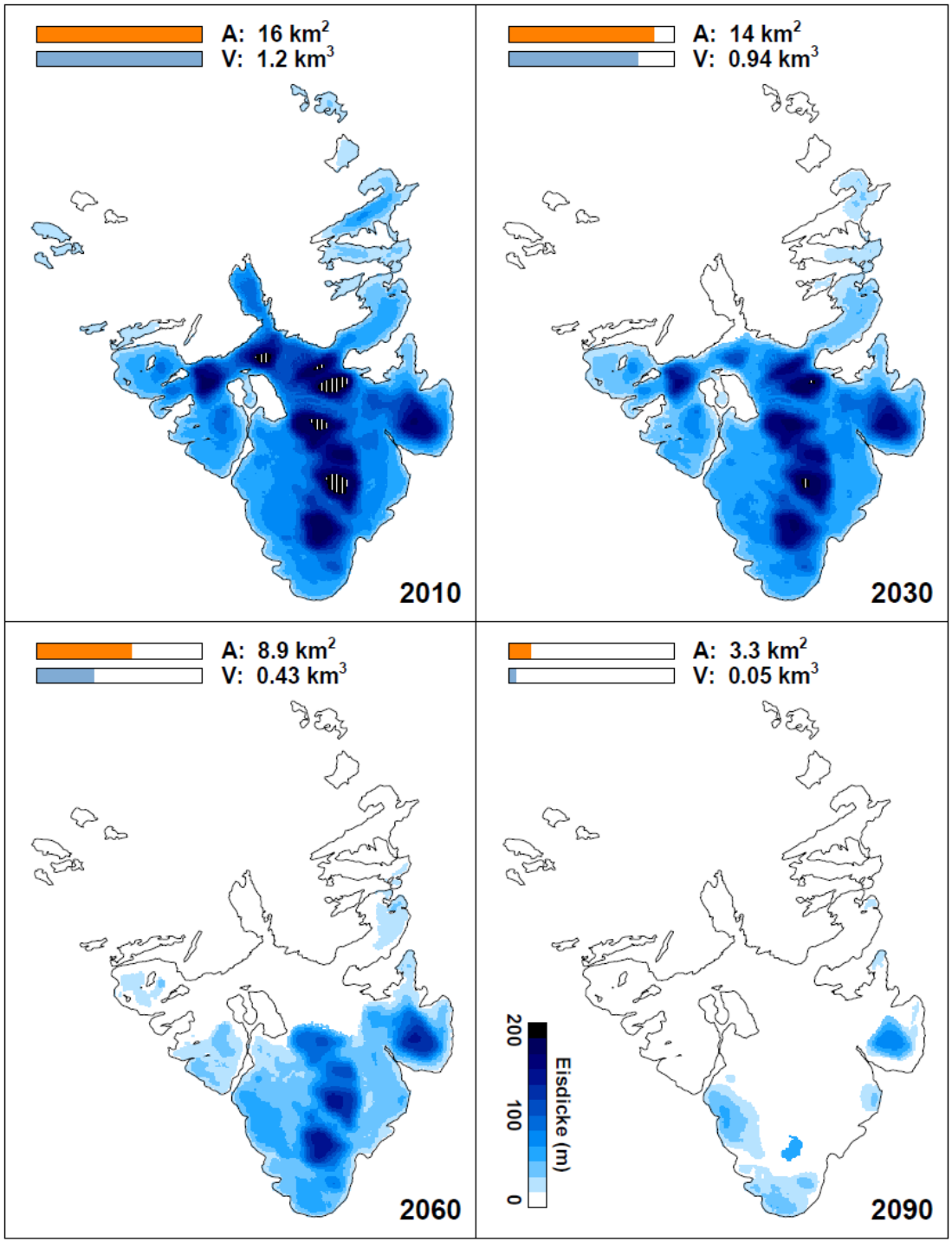
Foto: VAW



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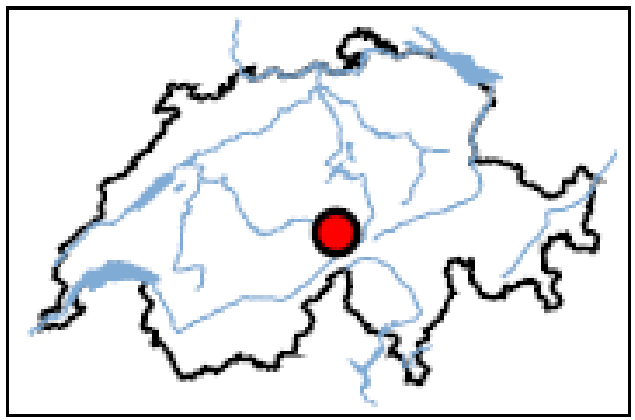
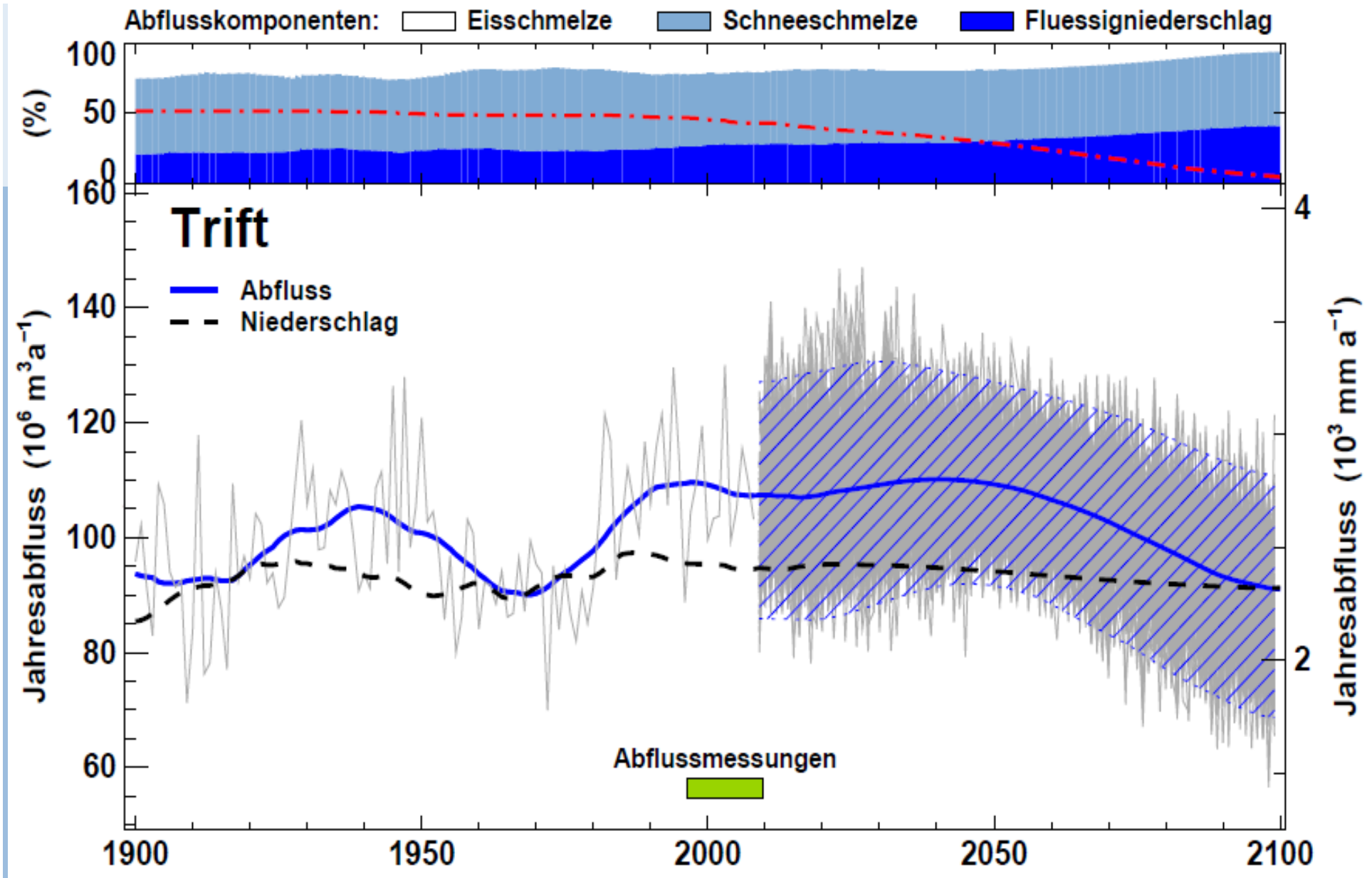
Triftgletscher



Farinotti & Bauder, 2012



Farinotti & Bauder, 2012

Triftgletscher
Rnoff 1940 - 2099

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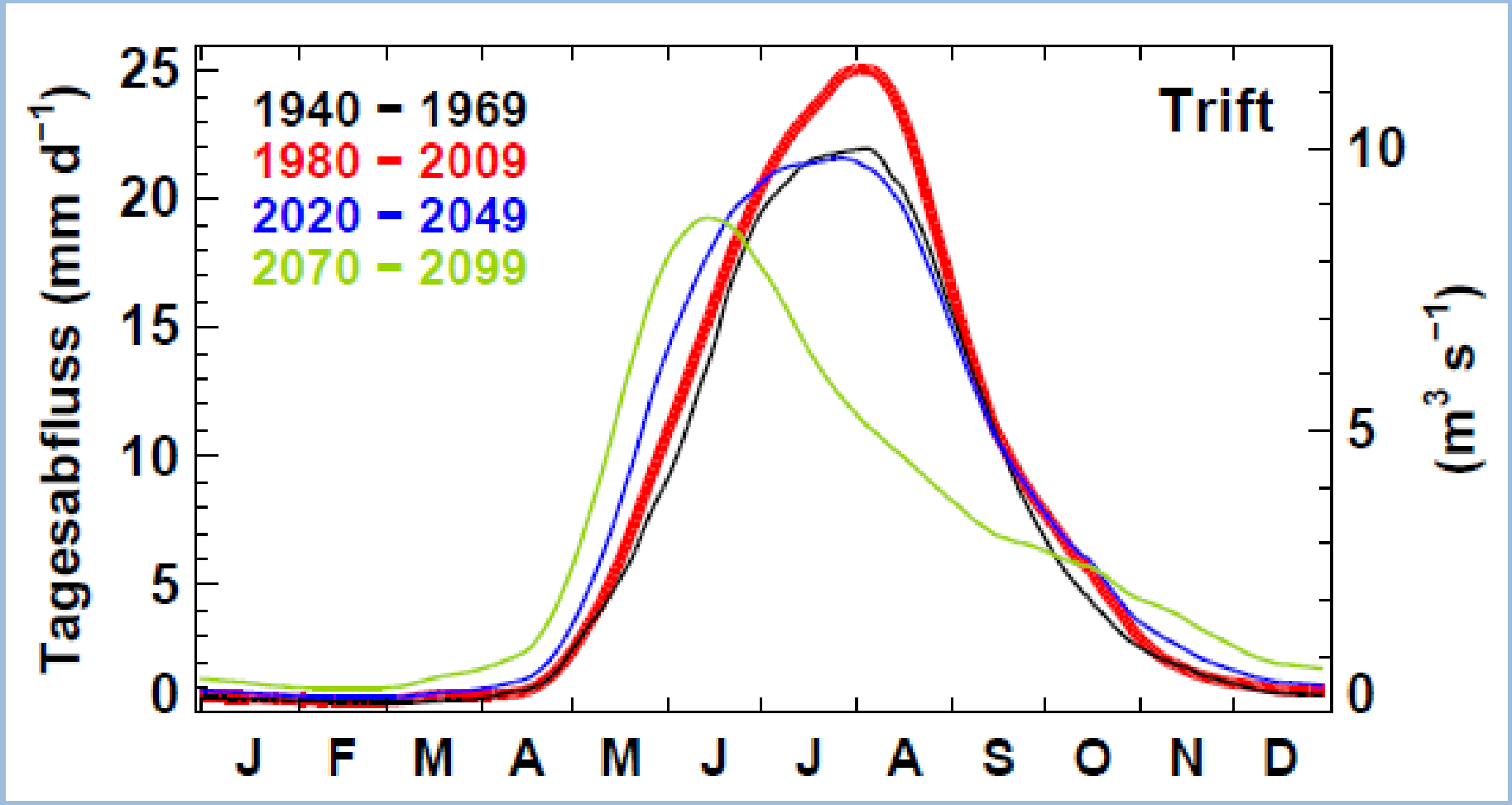

Farinotti & Bauder, 2012

Water volums in form of ice in Switzerland 1850 - 2100

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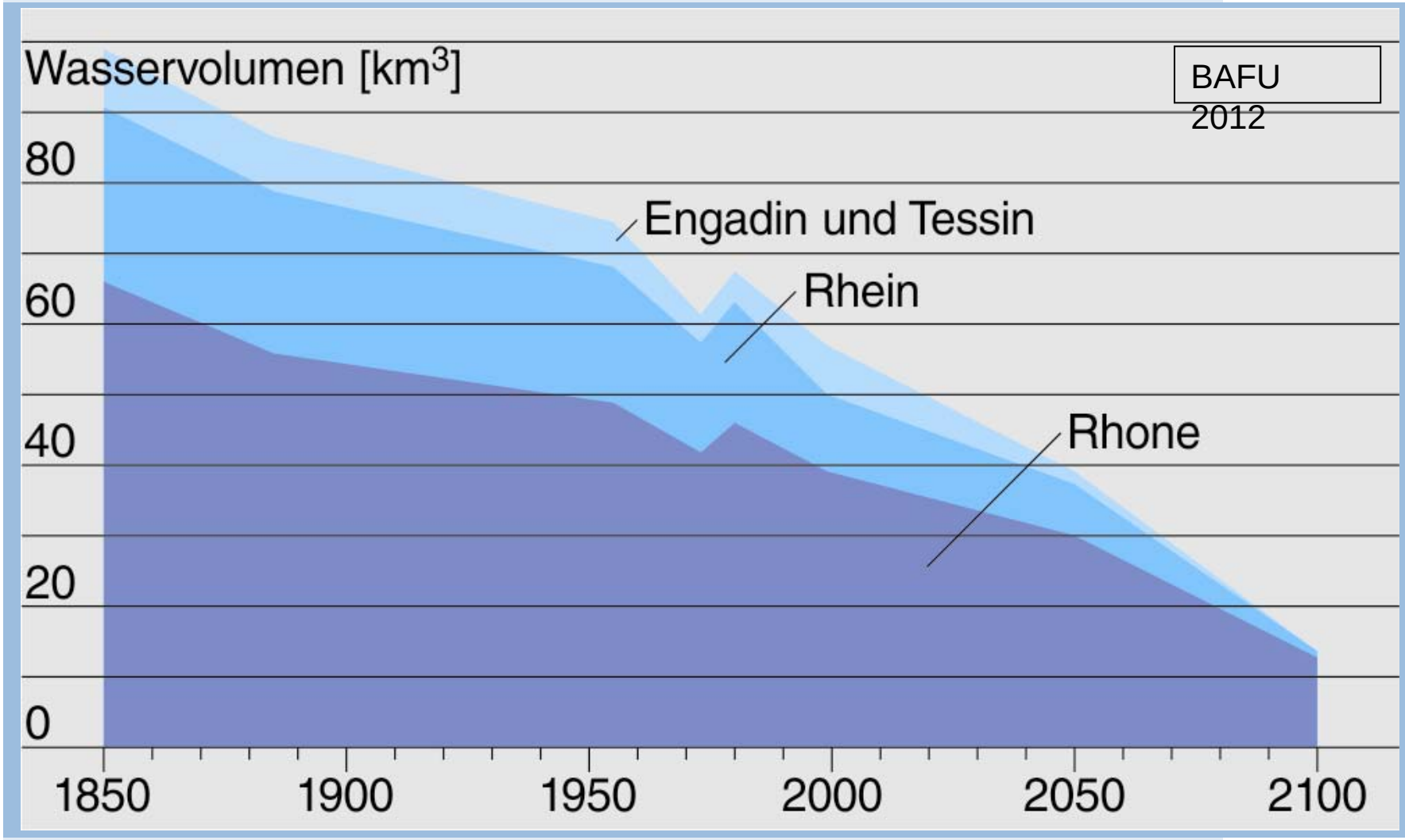
OESCHGER CENTRE CLIMATE CHANGE RESEARCH



Water storage in form of seasonal snow in Switzerland

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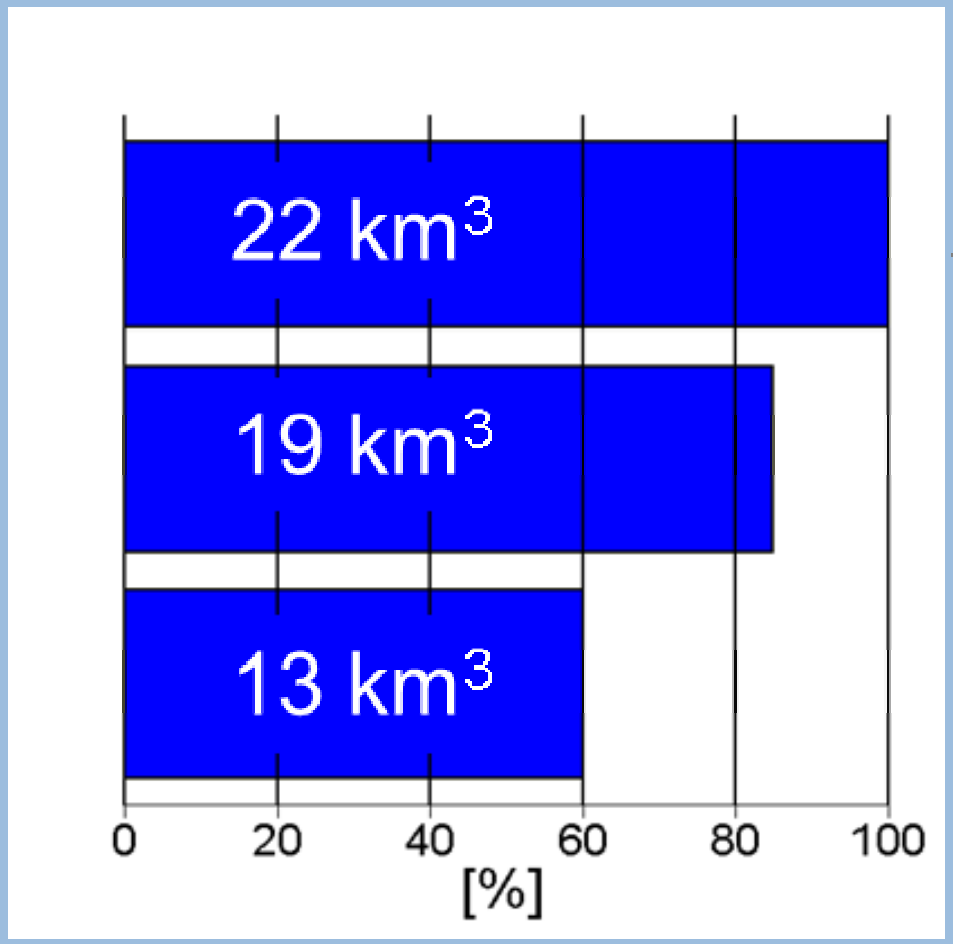

heute

2021-2050

2070-2099

Zappa et al., 2012

Simme

mH: 1598 m ü.M., Vgl. 2 %

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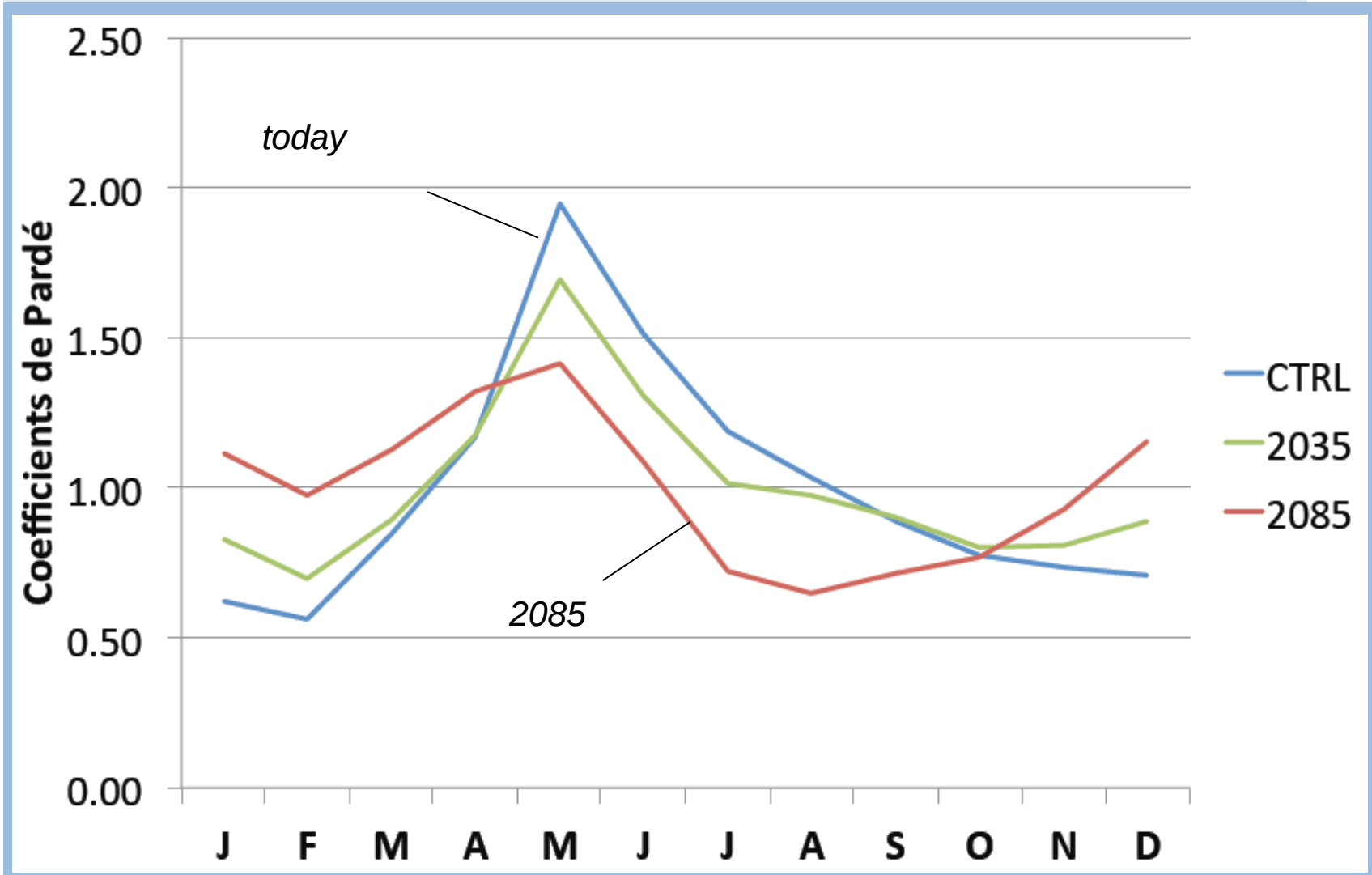


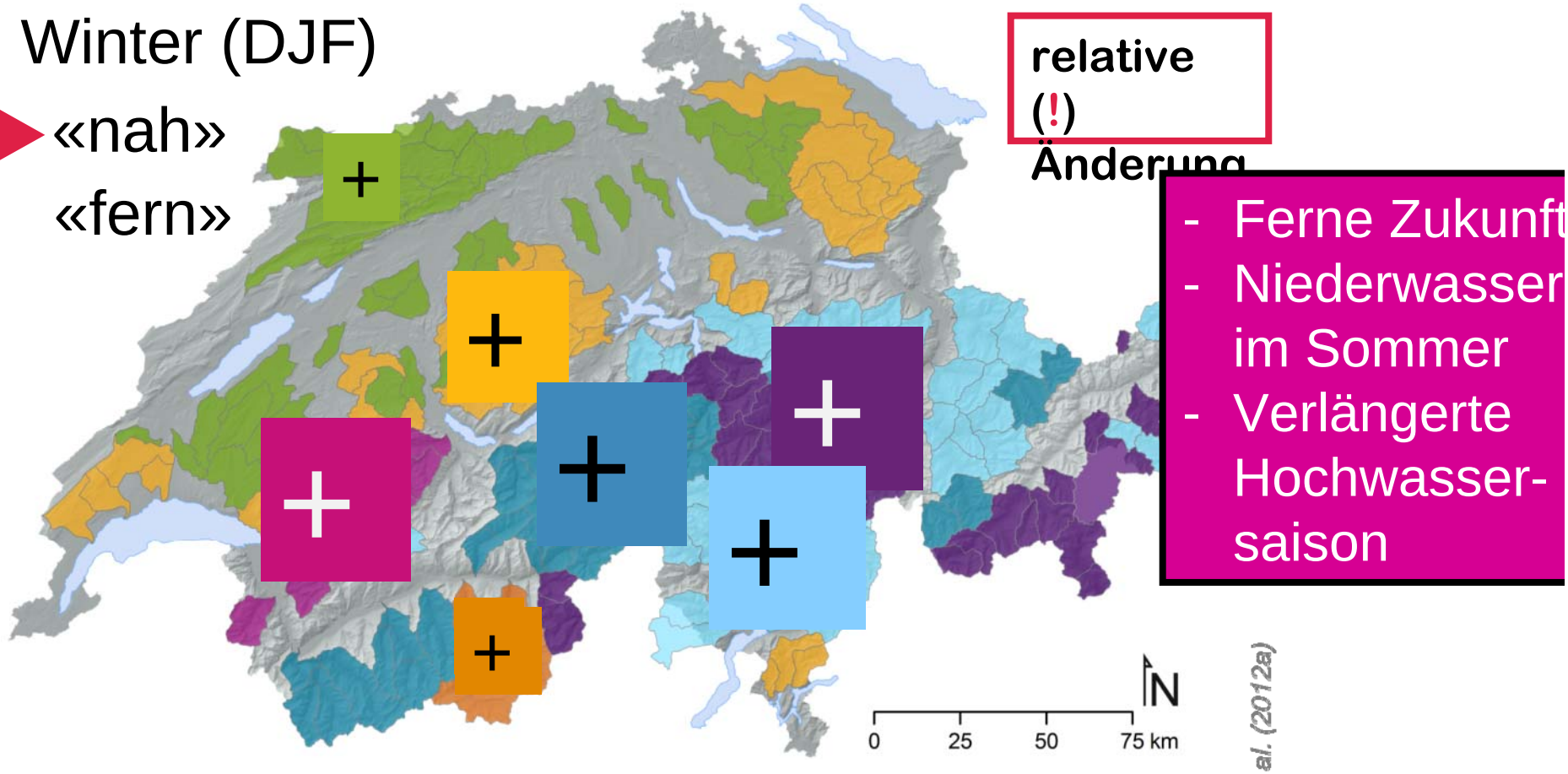
Nina Köplin et al., 2012

Veränderungen im saisonalen Abflussverhalten (langjähriges Mittel)

Winter (DJF)

«nah»

«fern»



Regime changes

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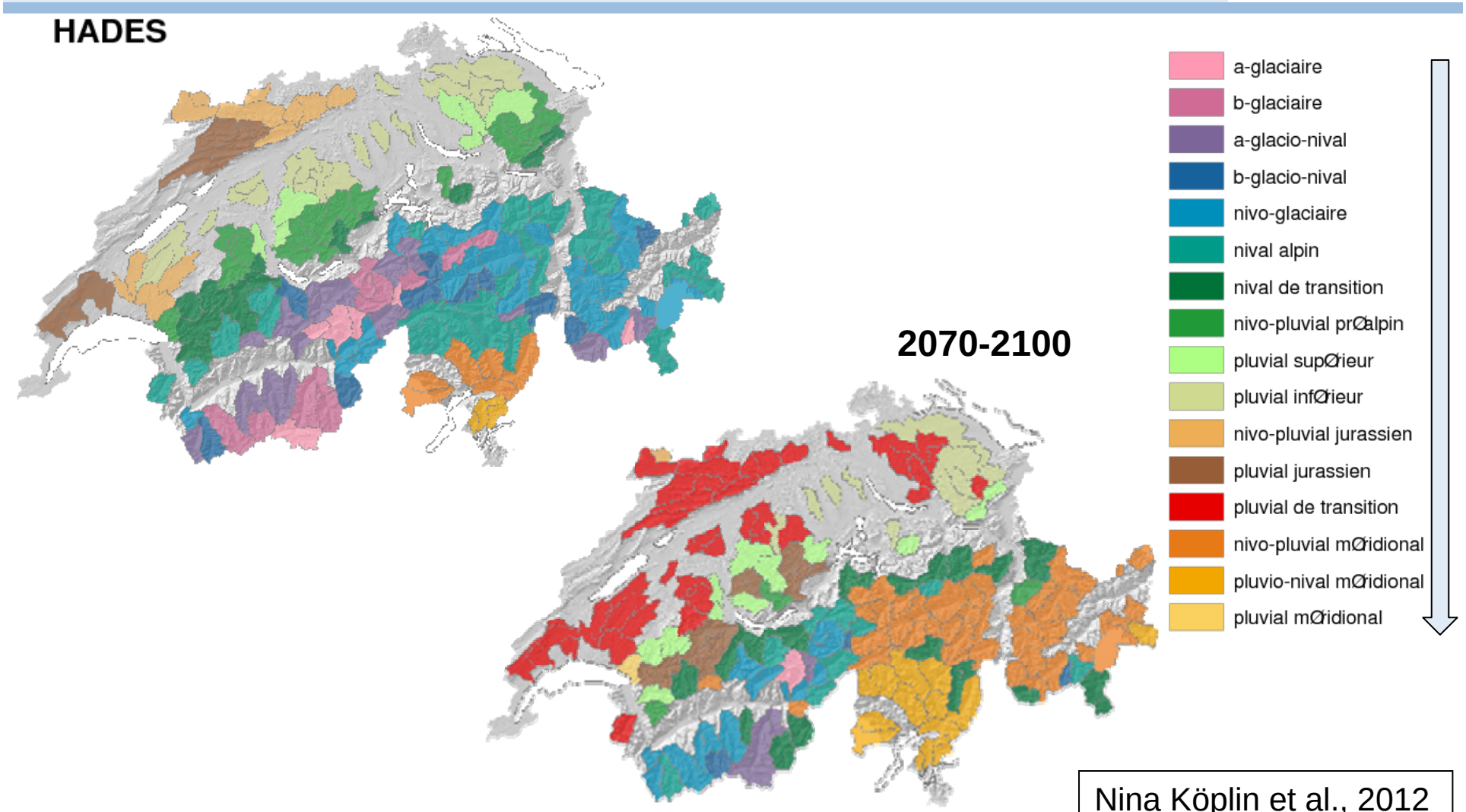

Nina Köplin et al., 2012

Broye: low waters in summer 2085

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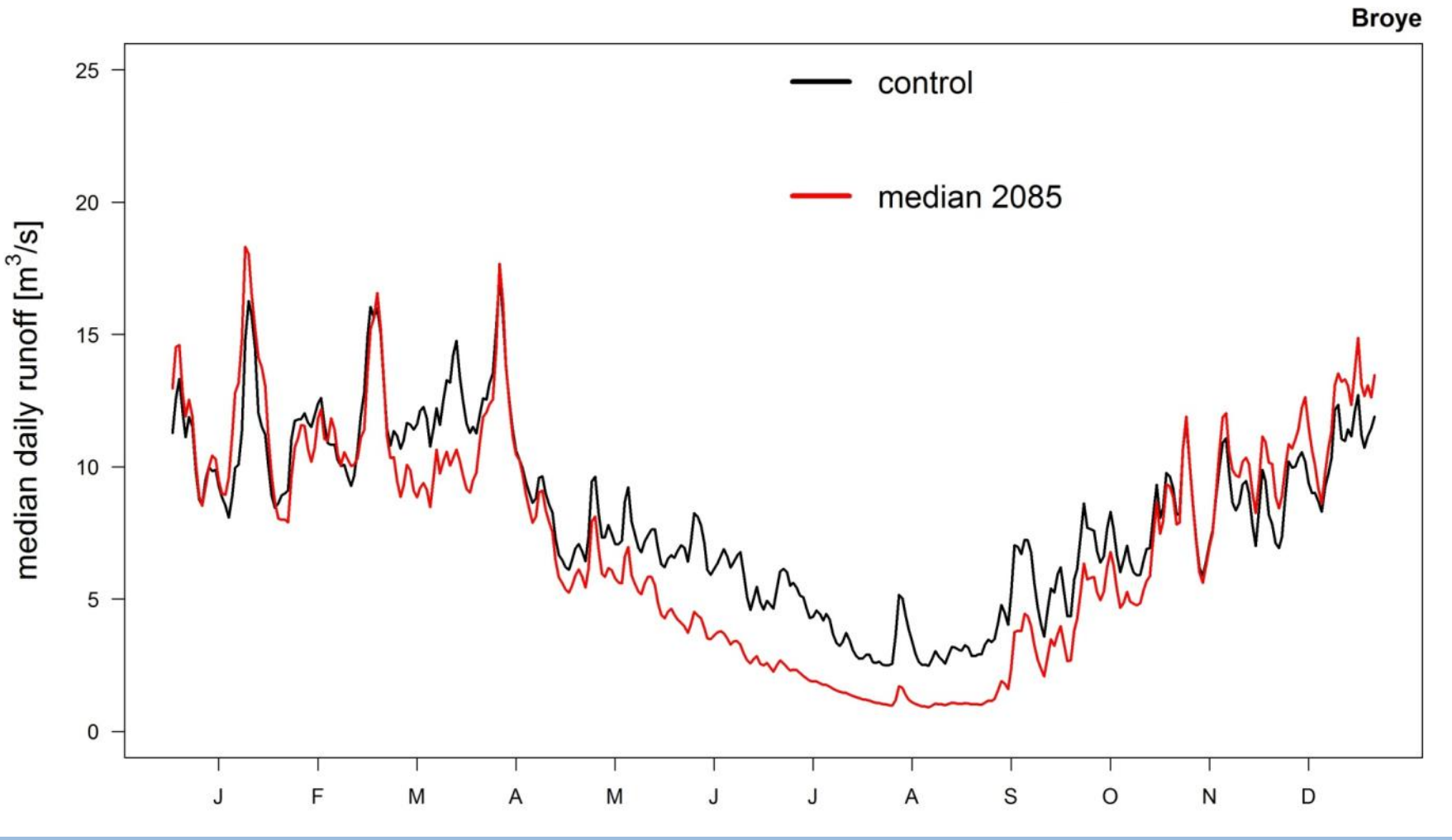

Rhine- Basel: Monthly frequency of the occurence of AM7 1870 – 2006

(Weingartner & Pfister, 2007)

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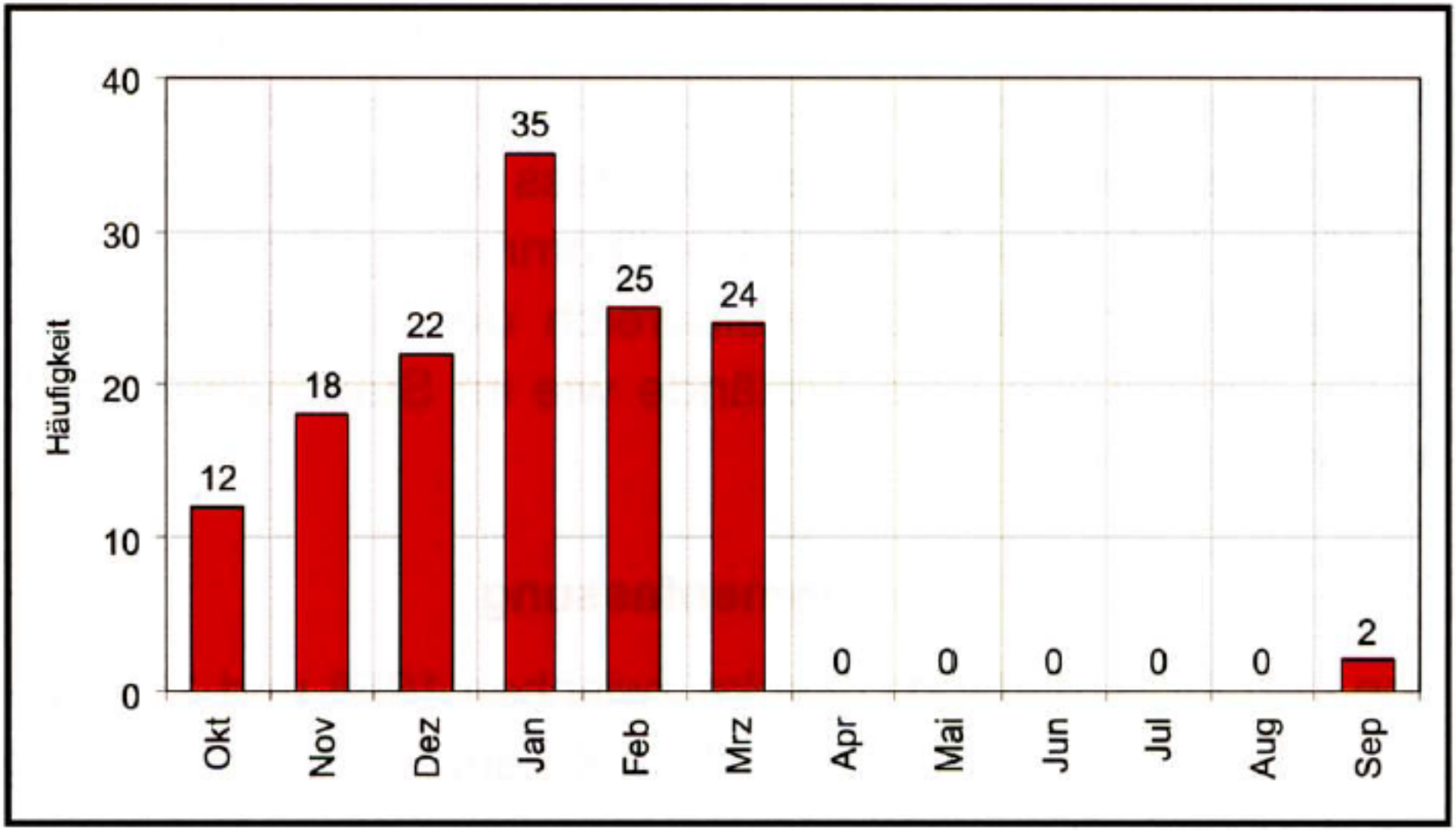

Rhine- Basel: series of AM7 1870 – 2006 and extremely low discharges from 1808

(Pfister et al., 2006)

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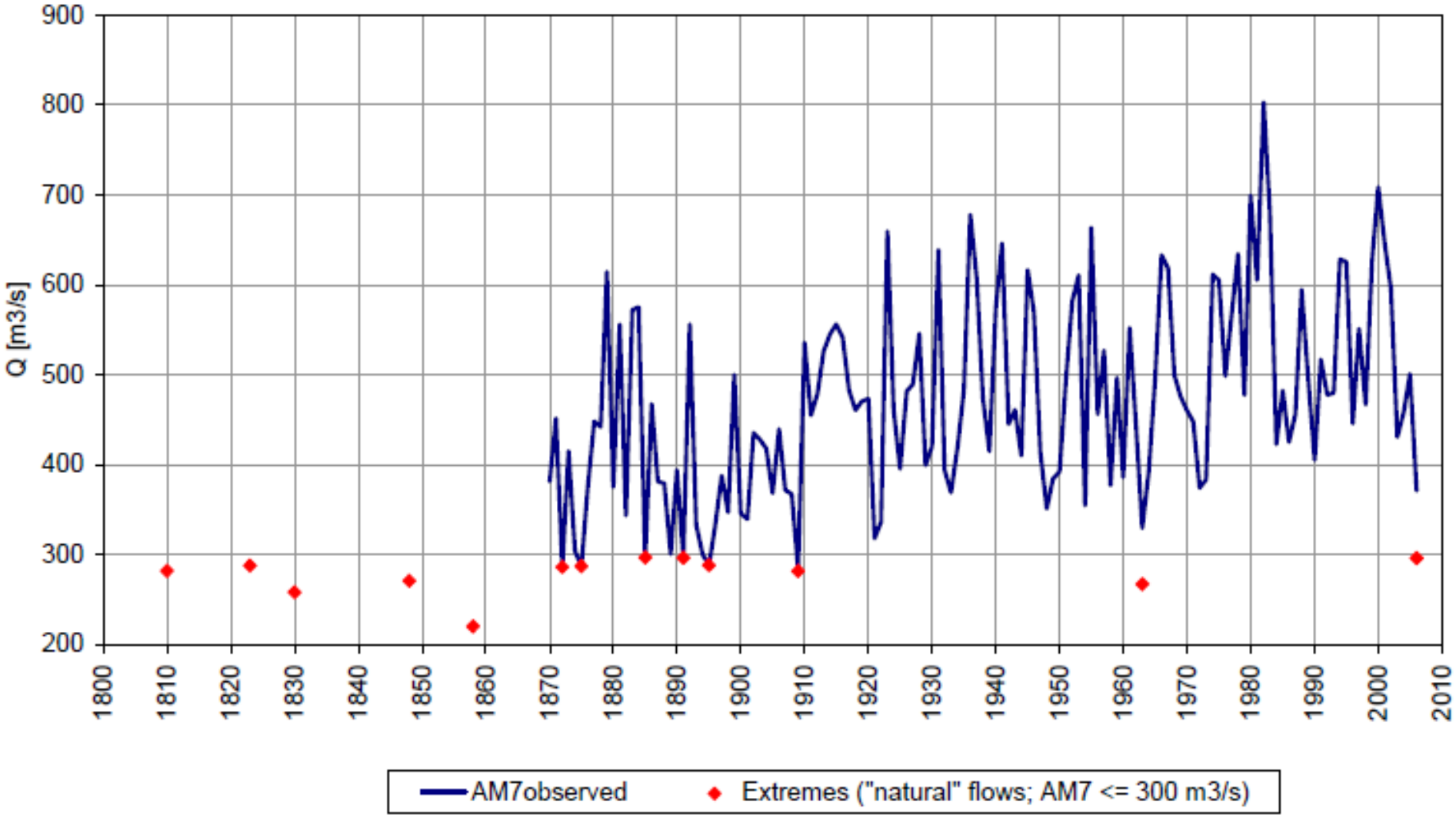

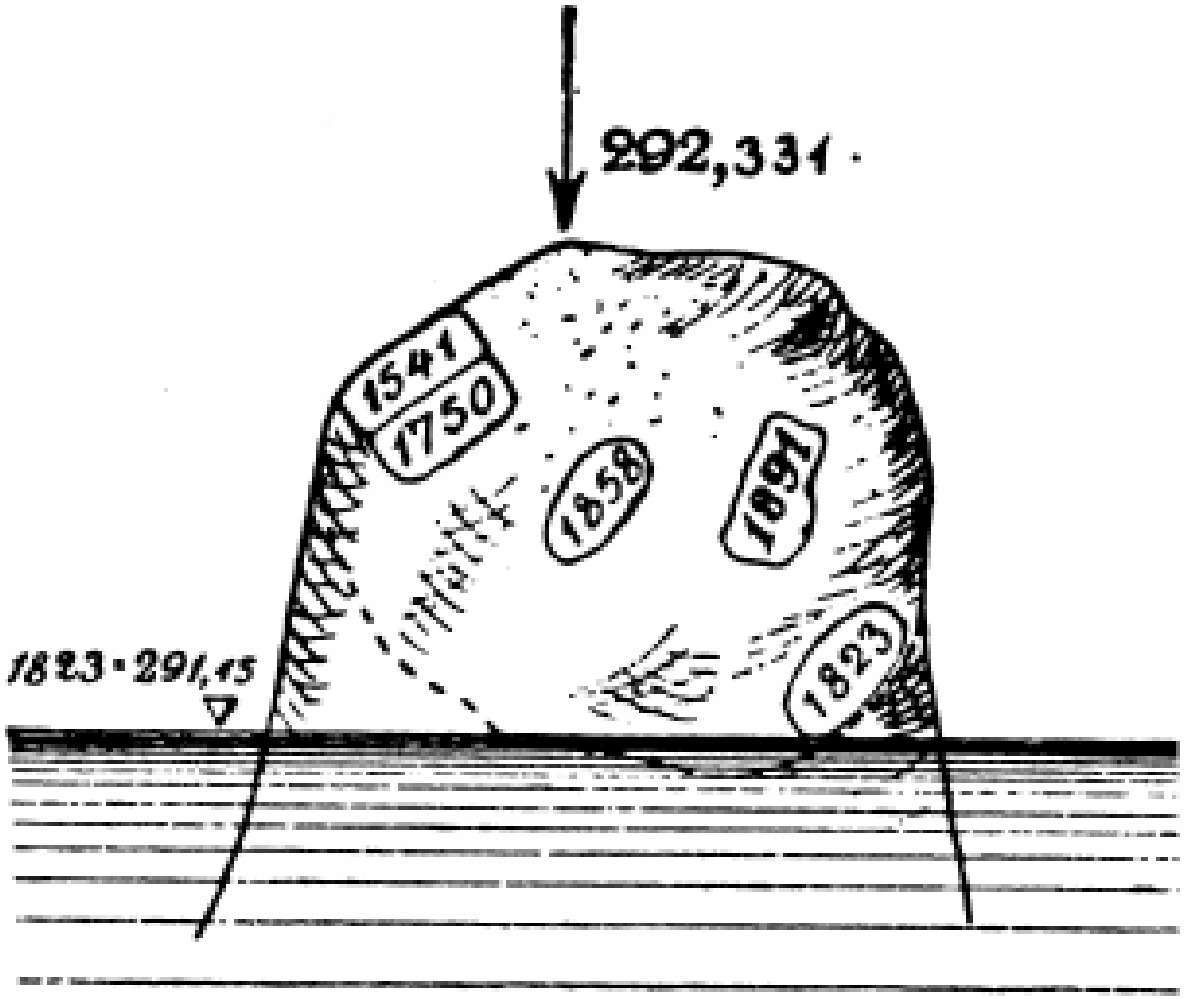

Coten der Marken ü. M.:

1541	= 292,25;	1858	= 292,03
1750	= 292,25;	1891	= 291,87
1823	= 291,15;	1899	= 292,30.

Low water marks at the Laufenstein in River Rhine at Laufenburg (above Basel)

(Walter 1901)

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Snow storage Rhine - Basel 2070

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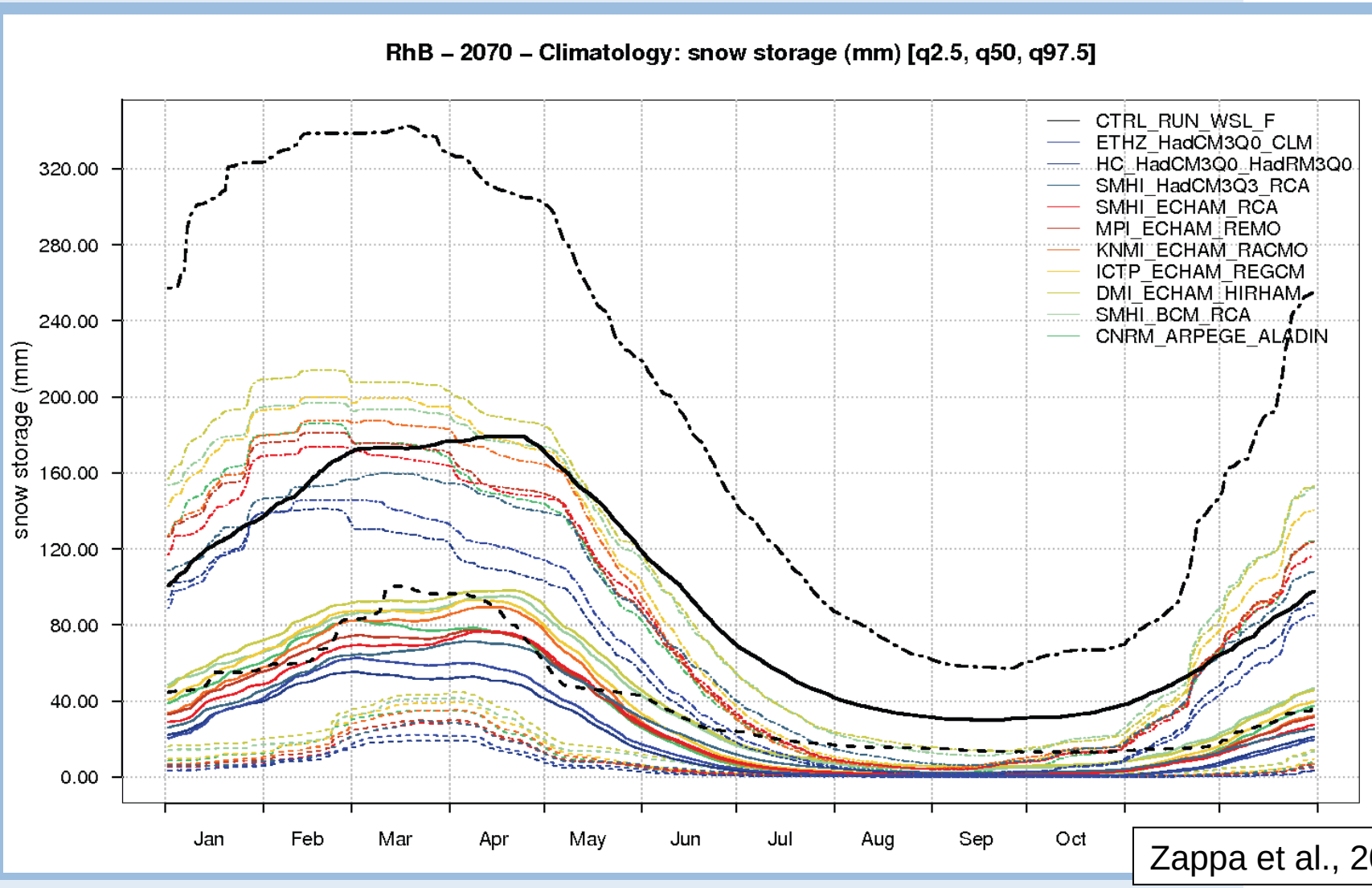

Zappa et al., 2012

Runoff in Rhein- Basel 2021

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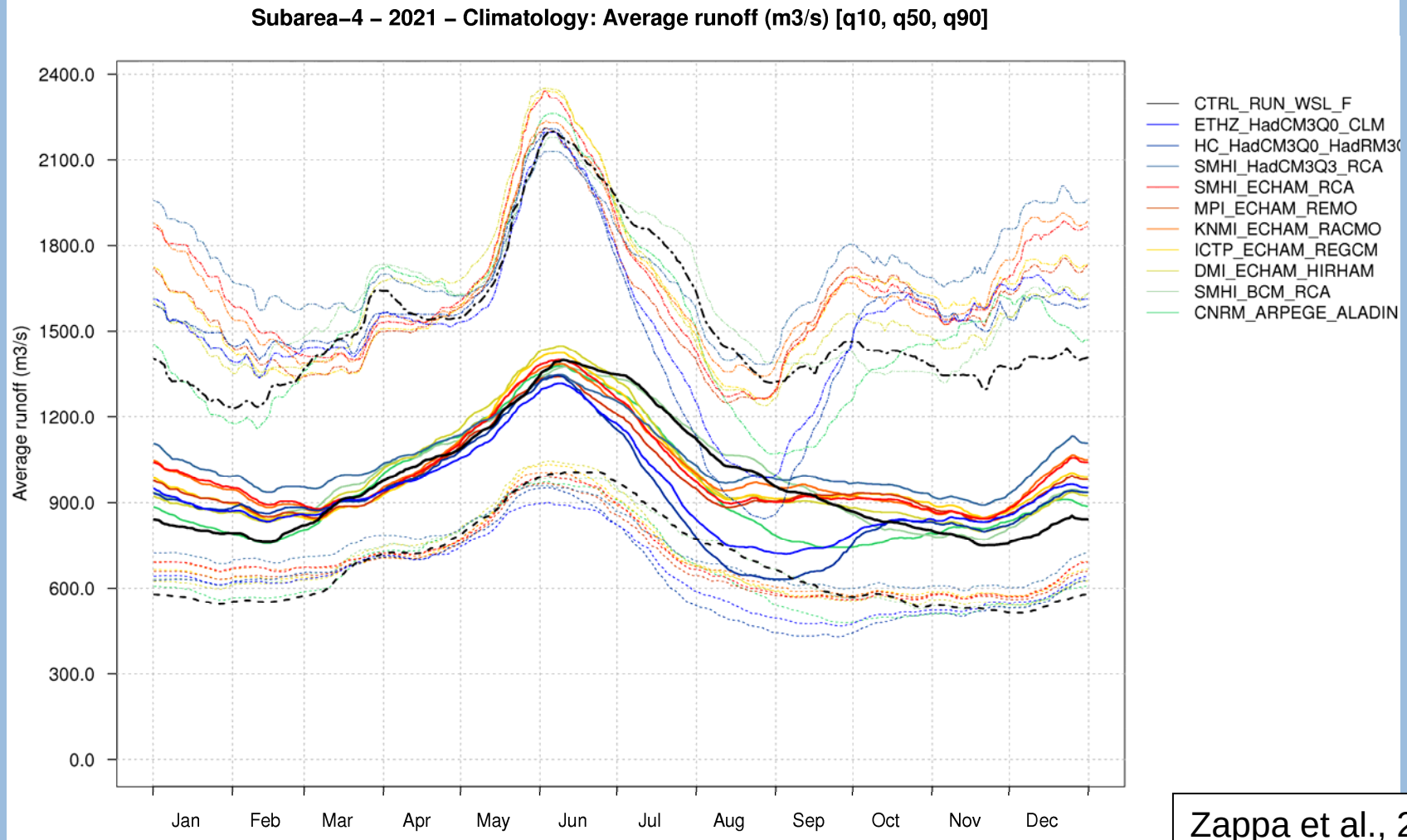

Zappa et al., 2012

Runoff in Rhein- Basel 2070

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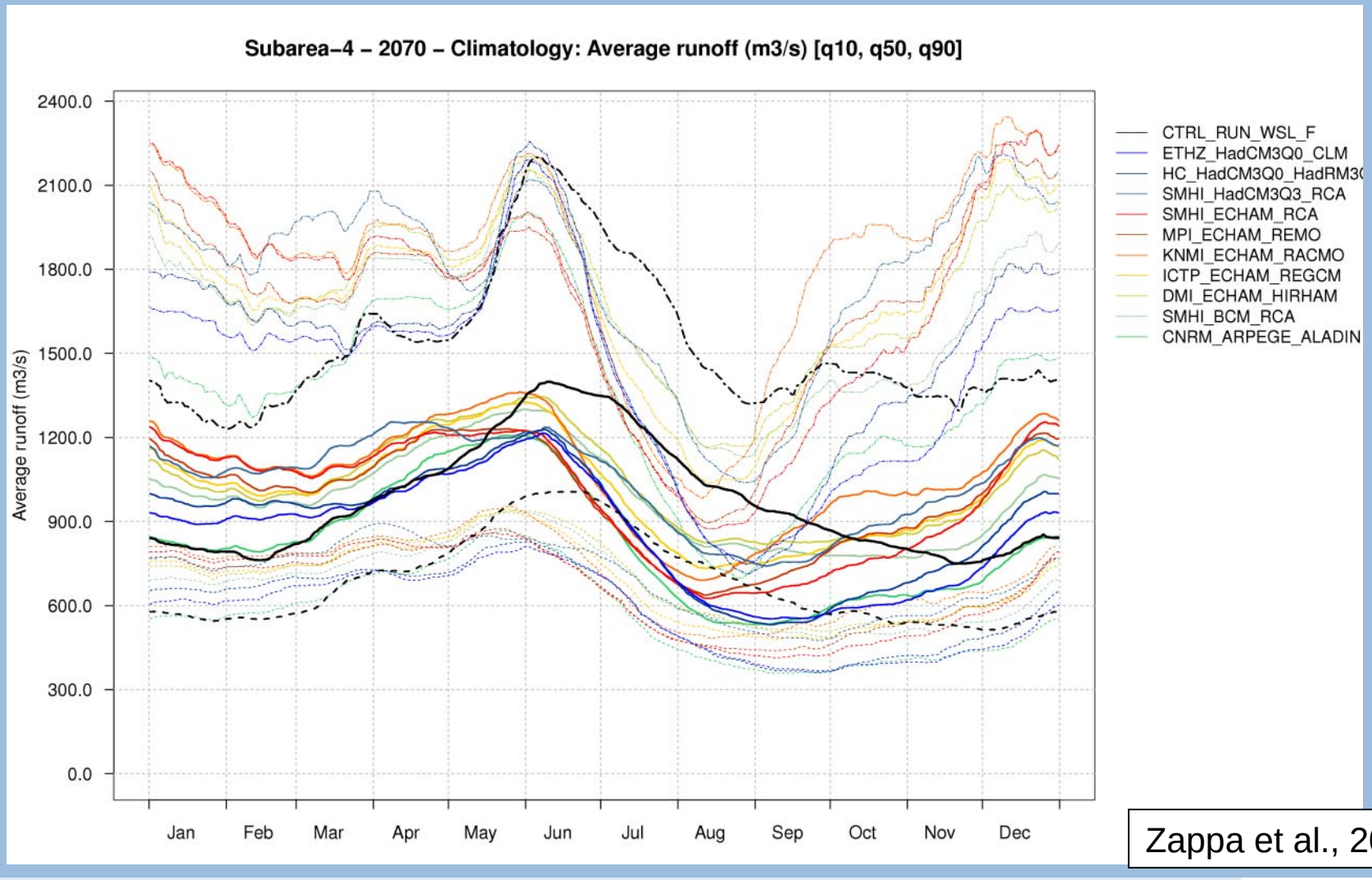

Zappa et al., 2012

Extreme runoff in Rhein – Basel 2070

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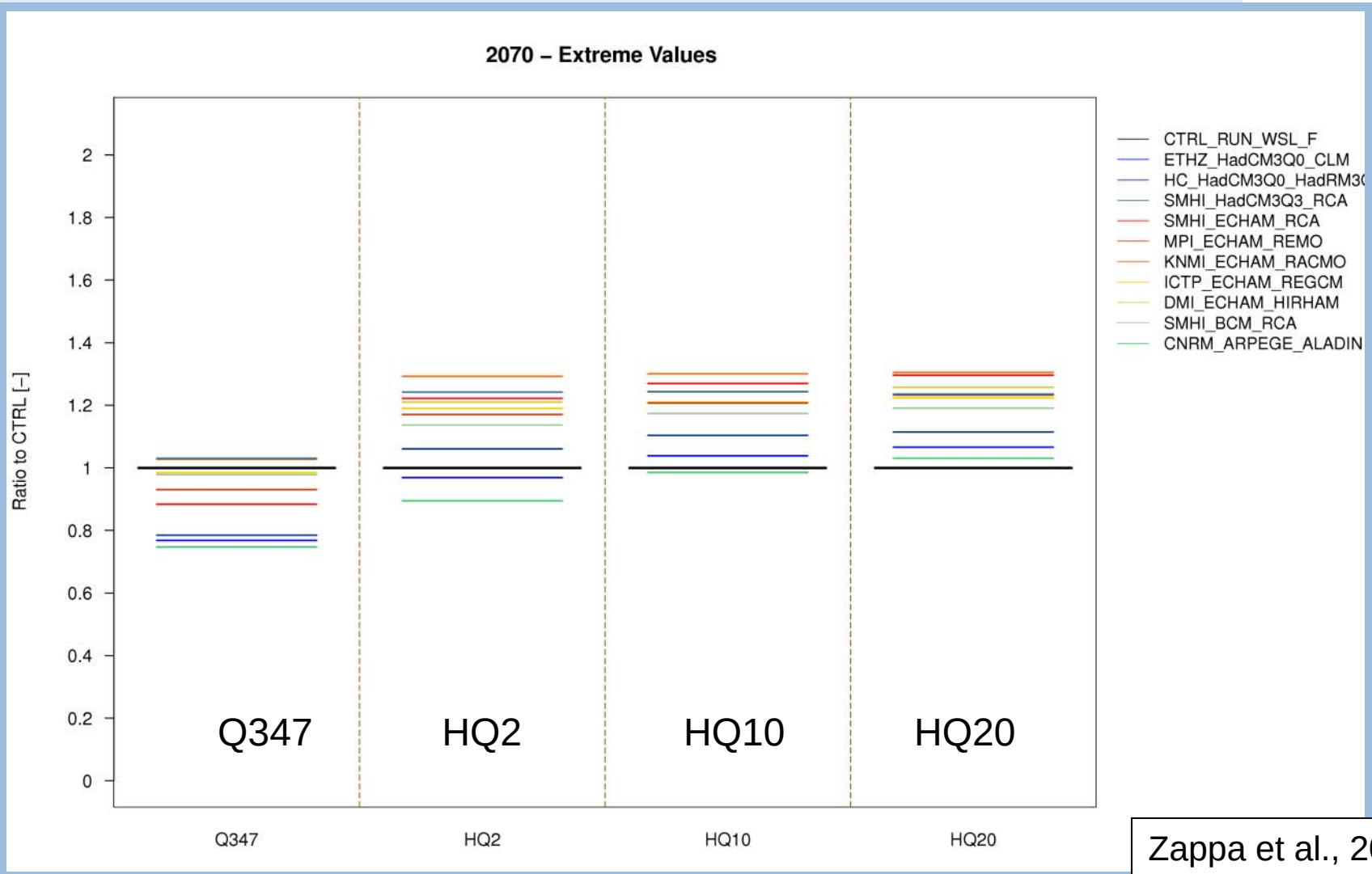

Zappa et al., 2012

conclusions

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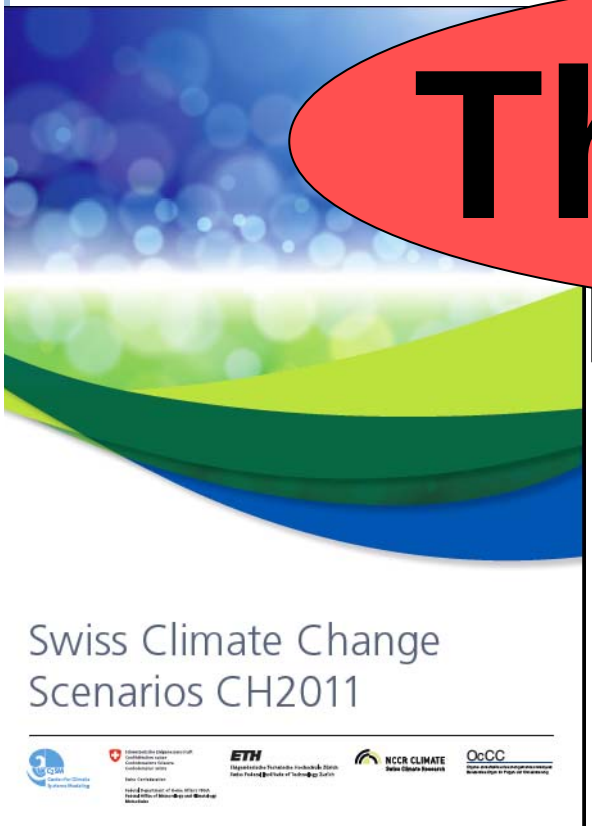
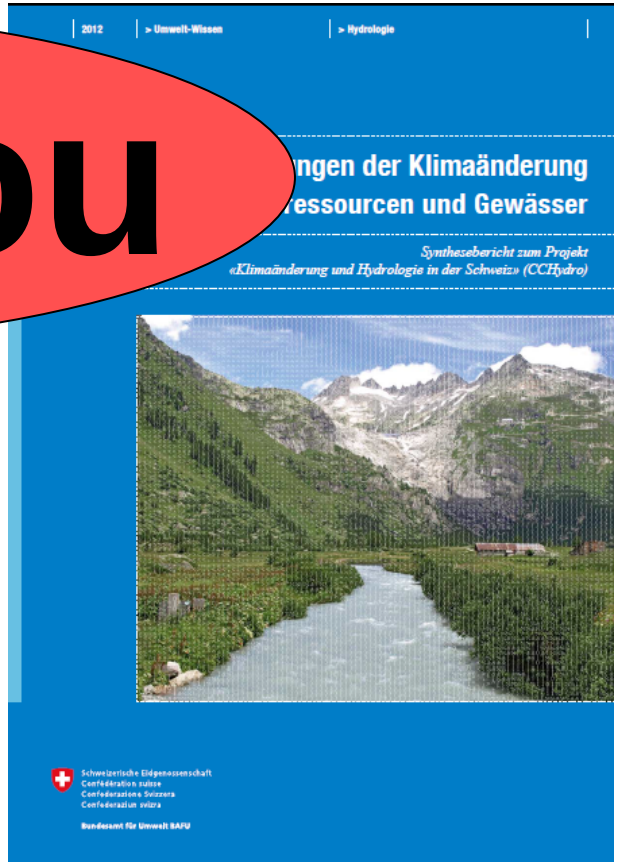
- Temperature increases
- Precipitations with little changes
- Glaciers disappear almost completely
- Snow storage getting smaller
- Runoff: larger in winter, smaller in summer
- Low water events emerging in late summer
- Flood season prolonged
- Temporarily more melt water from Glaciers
- In general still favourable situation concerning water resources


Curia Confoederationis Helveticae
Das Wasser in der Schweiz –
ein Überblick
Schweizerische Hydrologische Kommission (CH)


Swiss Climate Change
Scenarios CH2011
ETH
NCCR CLIMATE
OcCC


2012
> Umwelt-Wissen
> Hydrologie
ngen der Klimaänderung
ressourcen und Gewässer
Synthesebericht zum Projekt
«Klimaänderung und Hydrologie in der Schweiz» (CCHydro)
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Bundesamt für Umwelt BAFU

Thank you

Entwicklung Wasserhaushalt Schweiz

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Natürlicher Wasserhaushalt der Schweiz für die Kontrollperiode und beide Szenarioperioden.
P-kor: Korrigierter Niederschlag; EREA: Verdunstung; RGES: Gesamt-Abfluss;
GLAC: Gletscherschmelze; P-SME: Schneeschmelze; DS: Speicheränderungen.

Periode		P-kor	EREA	RGES	GLAC	P-SME	DS
1980-2009	Jahresmittel [mm]	1415	454	977	14	408	-15
2021-2050	Jahresmittel [mm]	1434	458	988	11	345	-12
	Veränderung [%]	↗ 1.4%	↗ 1.0%	↗ 1.1%	↓ -22.4%	↓ -15.6%	↓ -24.0%
	"+/-"	3.3%	1.0%	4.0%	34.0%	6.0%	-18.5%
2070-2099	Jahresmittel [mm]	1409	457	967	14	251	-14
	Veränderung [%]	→ -0.4%	↗ 0.7%	↘ -1.1%	→ -0.3%	↓ -38.6%	↓ -7.8%
	"+/-"	6.1%	1.7%	7.9%	27.2%	6.4%	-10.8%

Zappa et al., 2012

Klimaänderung im Überblick

	2021–2050		2070–2099	
	Temperatur	Niederschlag	Temperatur	Niederschlag
Jahr	+1.2°C ± 0.5°C	N → S →	+3°C ± 1°C	N → S →
Frühling	+1°C ± 0.5°C		+2.5°C ± 1°C	N ↗ S →
Sommer	+1.5°C ± 0.5°C	N →	+4°C ± 1°C	N/S ↘
Herbst	+1°C ± 0.5°C	N ↗	+2°C ± 1°C	N →
Winter	+1°C ± 0.5°C	N →	+3°C ± 1°C	N/S ↗

leicht (< 10%) ⇉ stark (10 - 20%) ⇉ sehr stark (> 20%) ⇉

BAFU, 2012

Hochwasser-saisonalität

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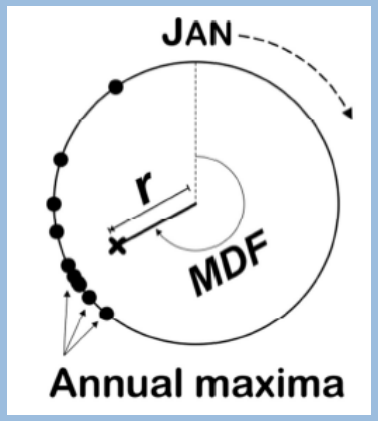
CTRL

SCE_{far}

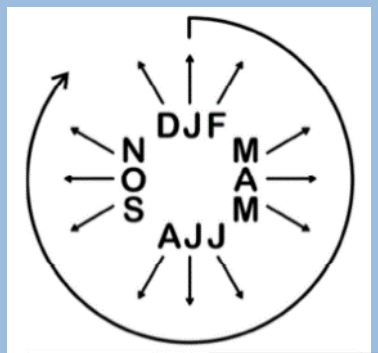
r = 1

r = 0.5

r = 0.25



Annual maxima



Köplin et al., 2013

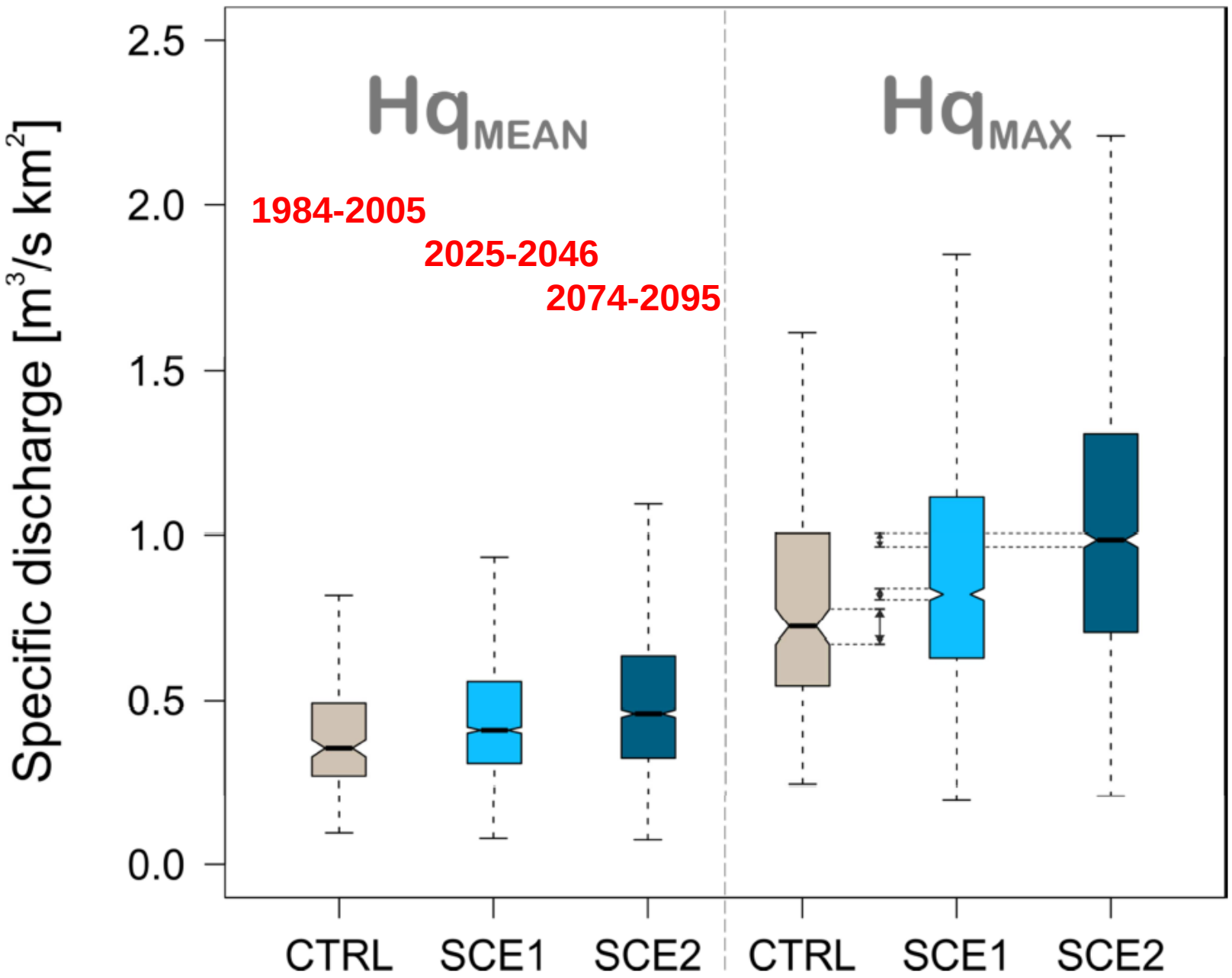


Fig. 3. Boxplots of specific discharges (left: Hq_{MEAN}, right: Hq_{MAX}) of all 189 catchments for the control period (CTRL), the near future (SCE1) and far future period (SCE2).

Köplin et al., 2013

Veränderung Niedrigwasserintensität im Vergleich zu Q_{347} (control)

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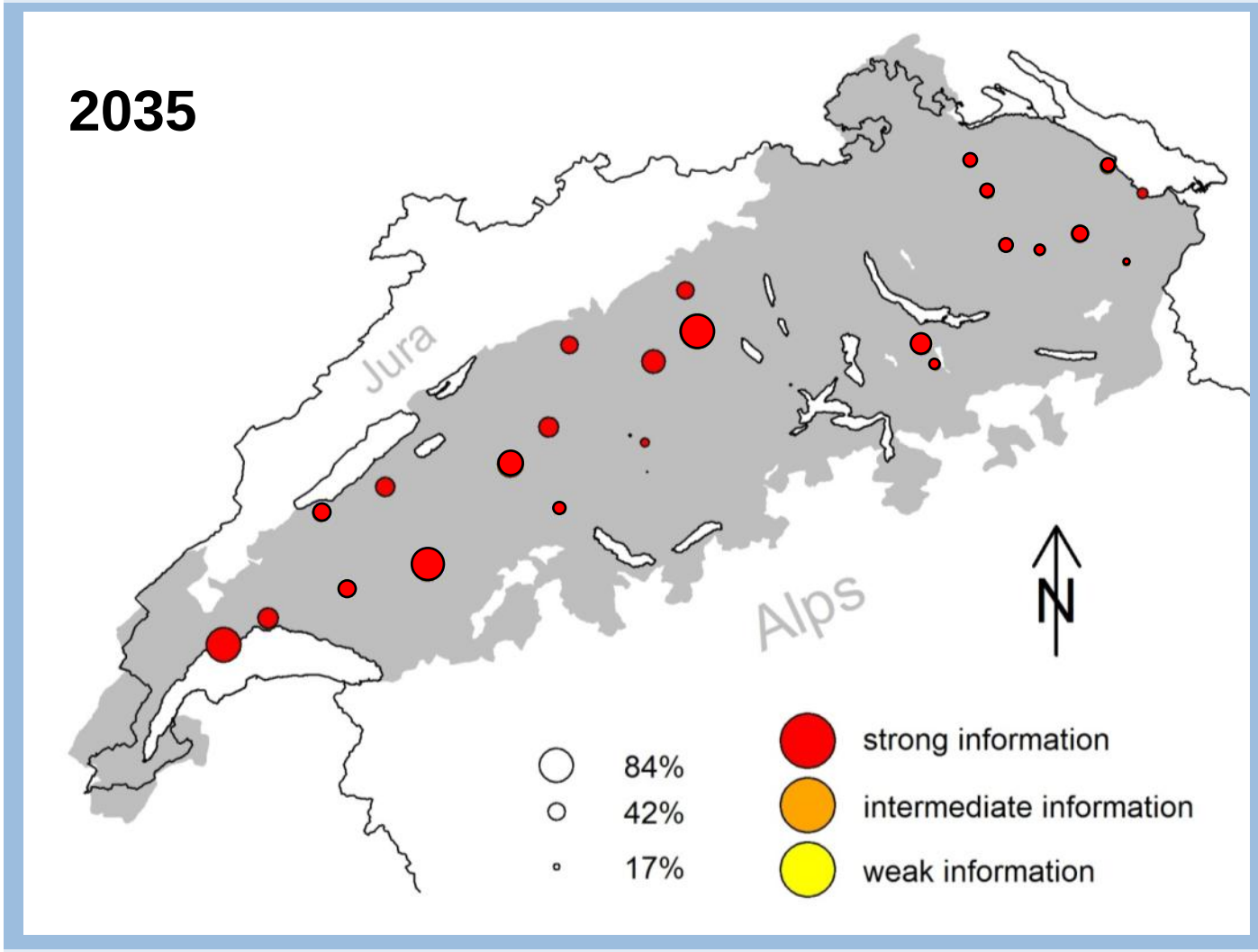

(Meyer *et al*., submitted)

Veränderung Niedrigwasserintensität im Vergleich zu Q_{347} (control)

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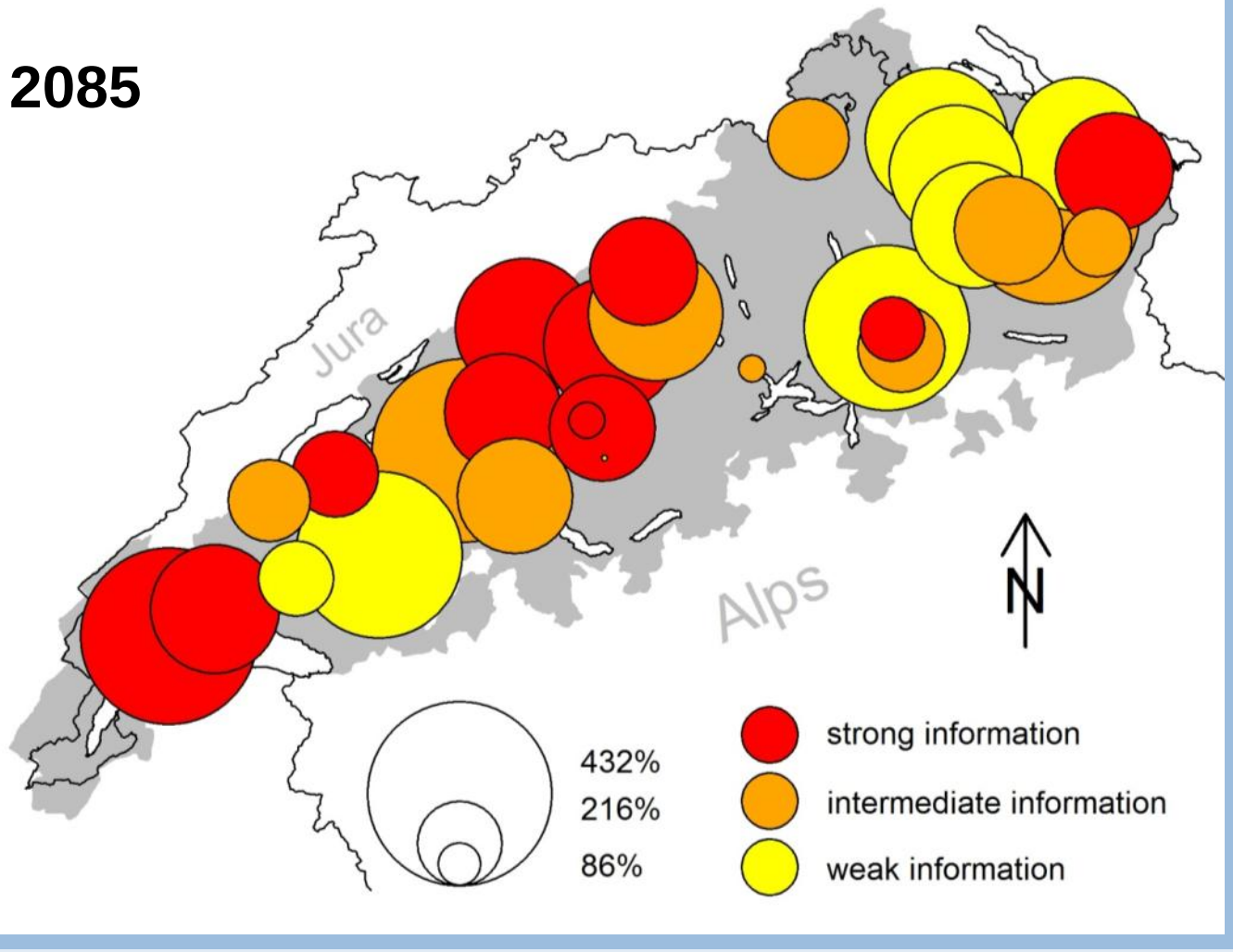
2085



(Meyer *et al*., submitted)