New insights in the perspectives of glaciers to supply water for hydropower production

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SCCER-SoE, Annual Conference, Sion, 12.9.2016

ETH
Eidgenössische Technische Hochschule Zürich
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VAW
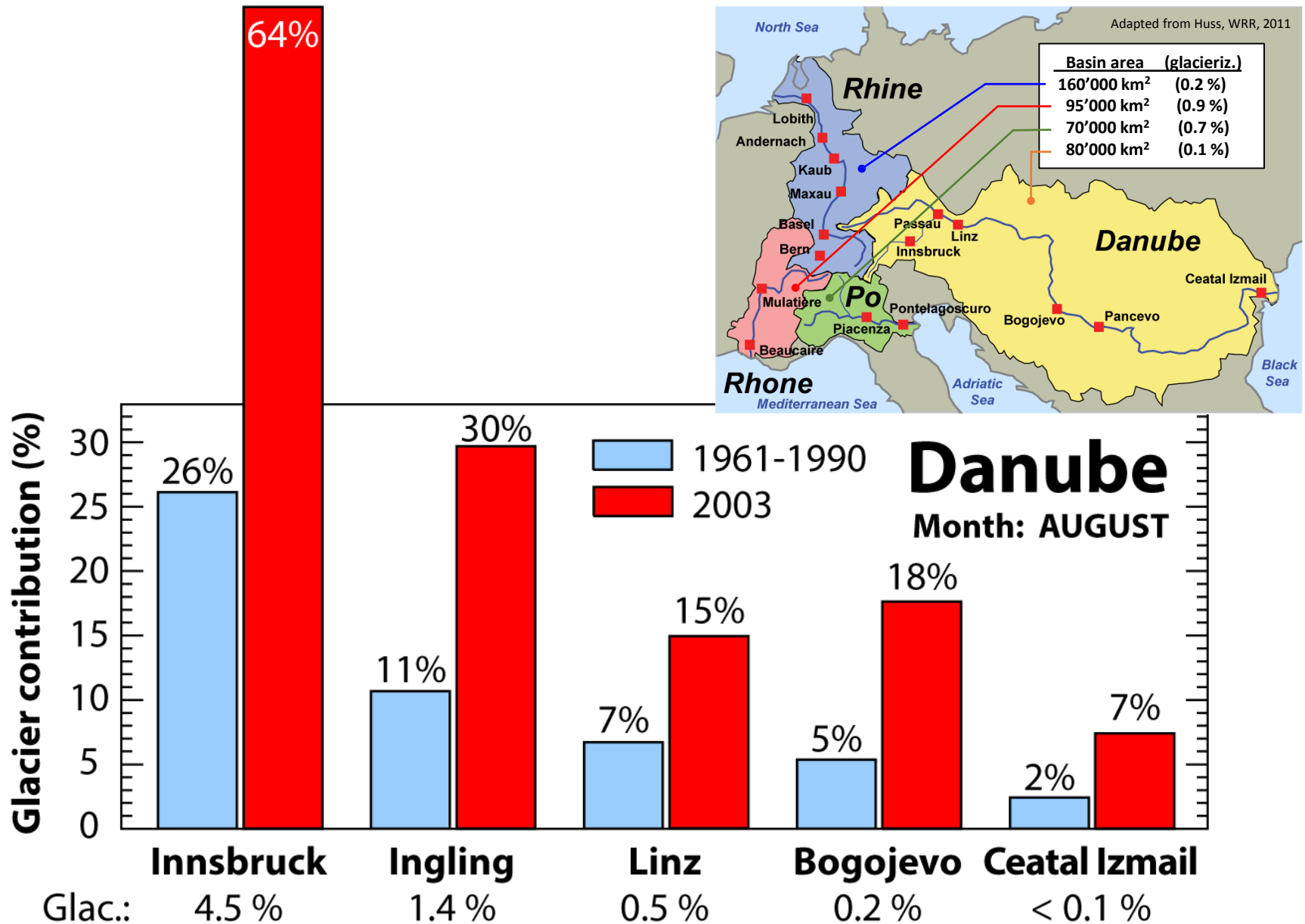Versuchsanstalt für Wasserbau,
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Glacier meltwater contribution to runoff

Adapted from Huss, WRR, 2011

Basin area	(glacieriz.)
160'000 km^2	(0.2 %)
95'000 km^2	(0.9 %)
70'000 km^2	(0.7 %)
80'000 km^2	(0.1 %)

Danube
Month: AUGUST

1961-1990
2003

Glacier contribution (%)

64%

26%
30%
18%
15%
11%
7%
5%
7%
2%

	Innsbruck	Ingling	Linz	Bogojevo	Ceatal Izmail
Glac.:	4.5 %	1.4 %	0.5 %	0.2 %	< 0.1 %

Annual contribution of glaciers

Annual runoff share from glacierized surfaces (average 1980-2009)
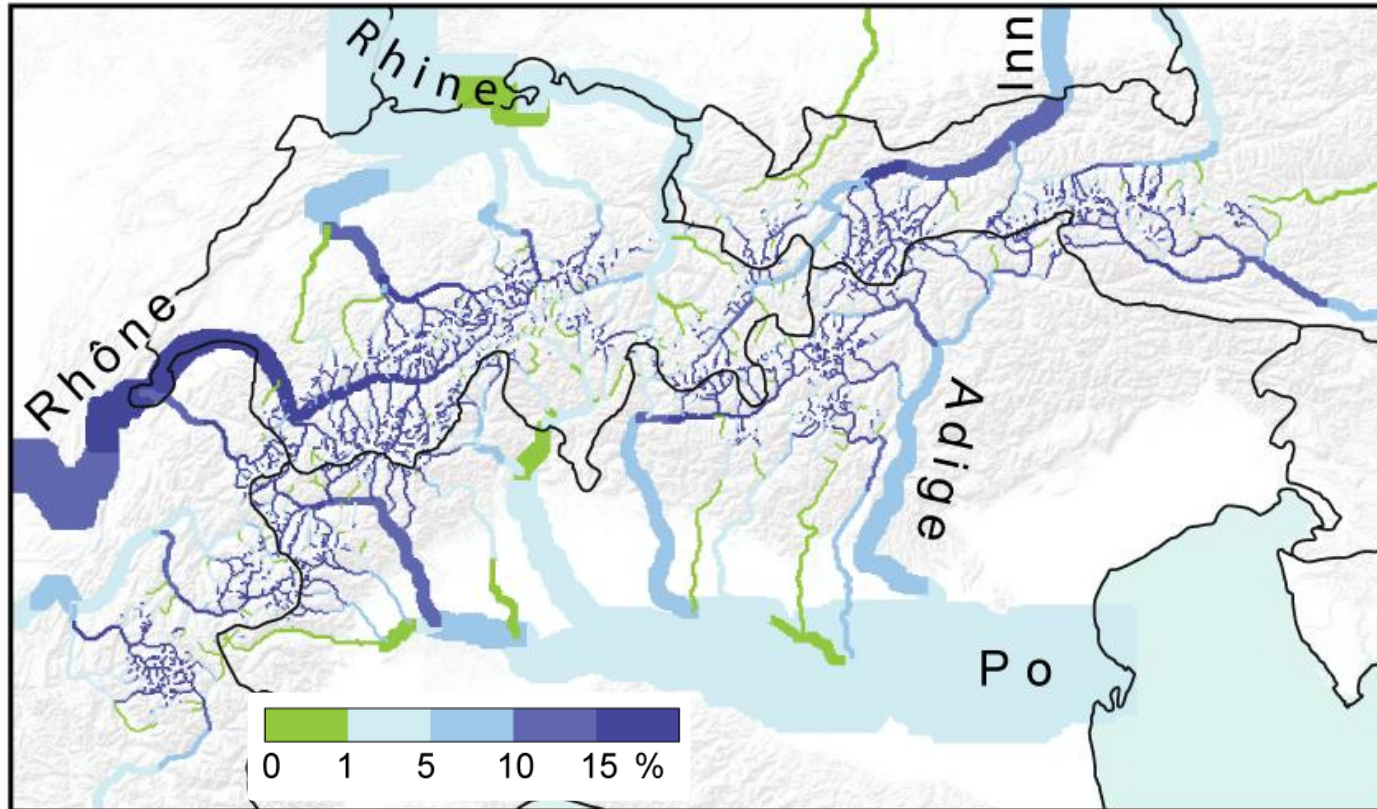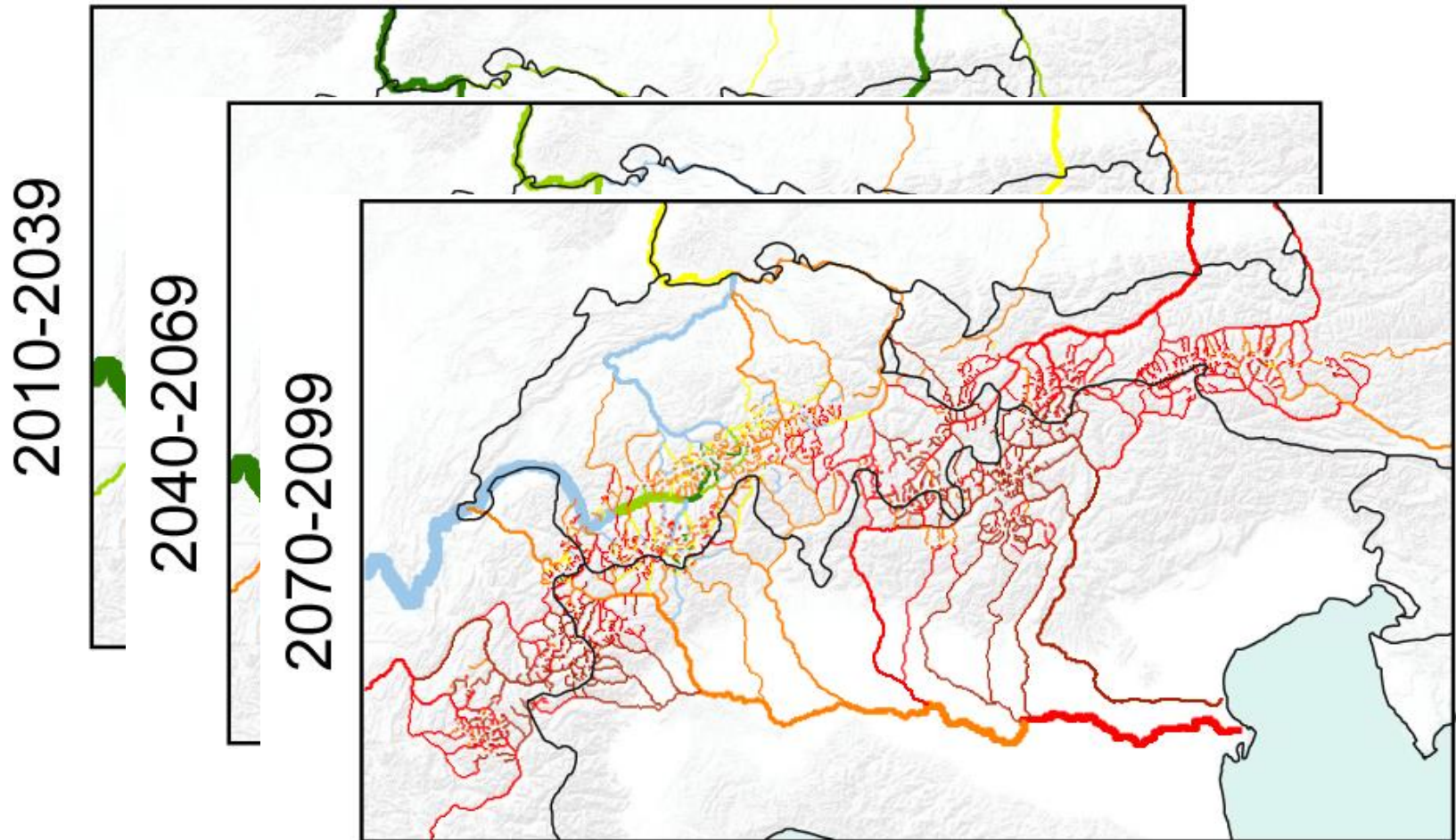

Farinotti et al., ERL, 2016

Glacier contribution to runoff is significant for a number of rivers across Europe – even at the annual time scale.
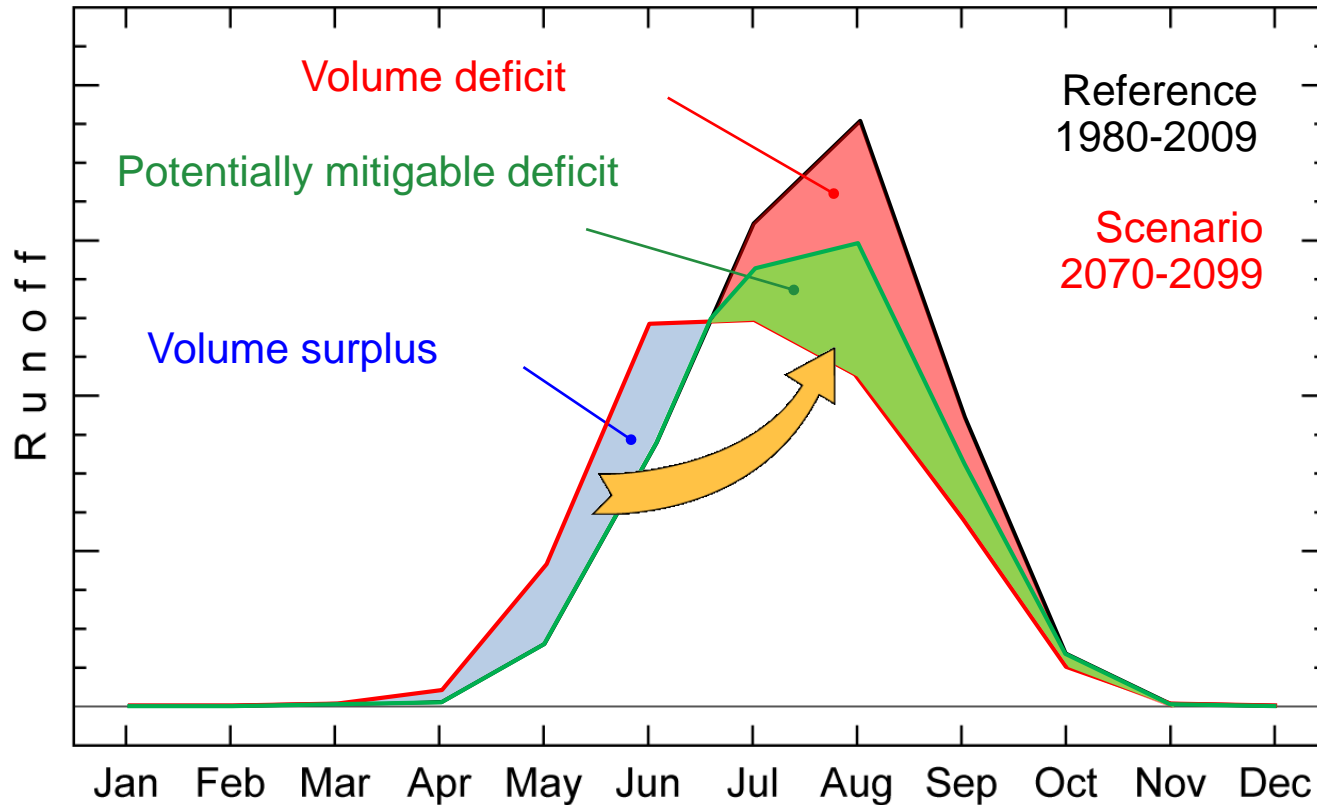
Expected future changes

Annual changes in runoff from presently glacierized surfaces
(changes relative to 1980-2009; RCP 4.5)

By the end of the century, 0.73 km^3/a of melt water could be missing.
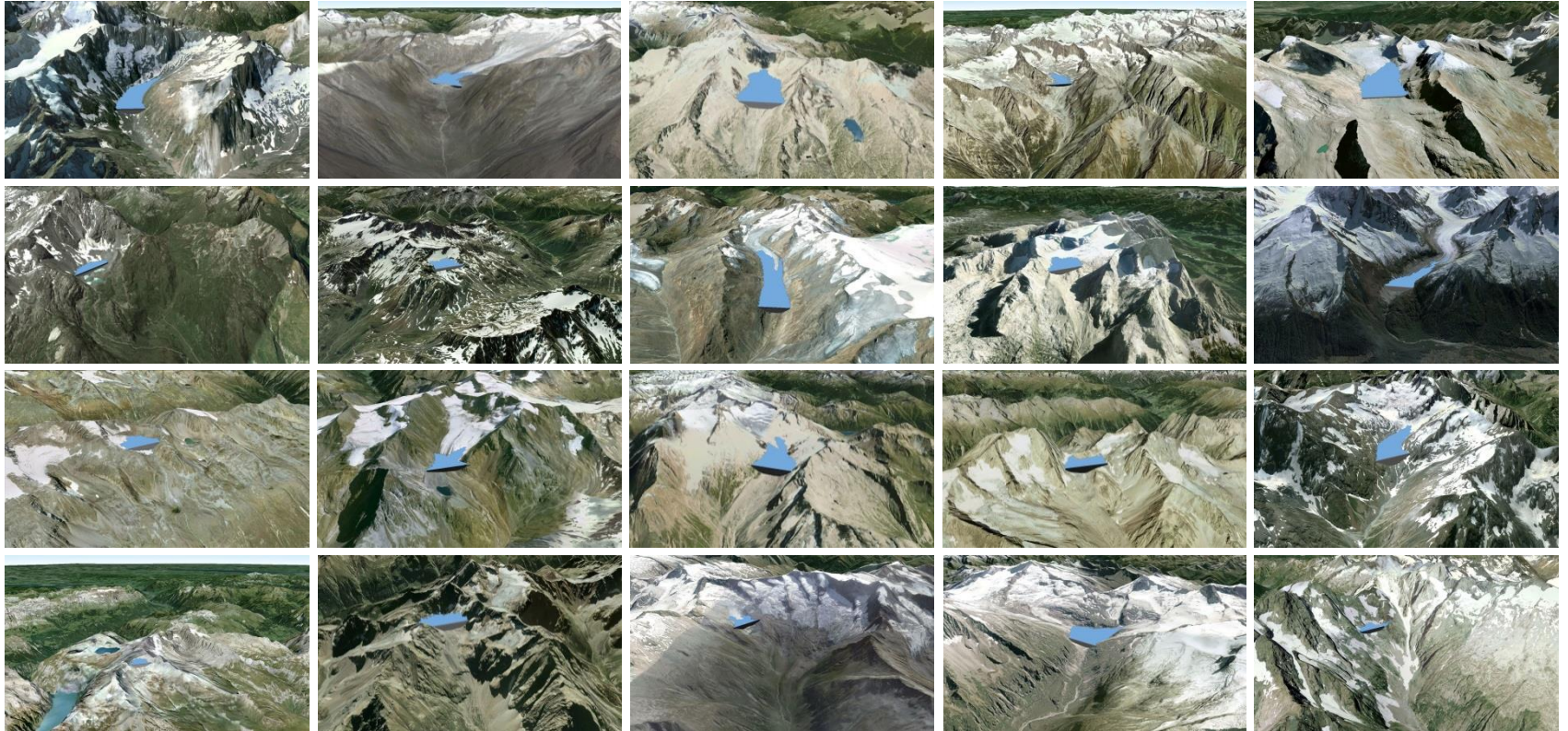(80% of the annual freshwater consumption in Switzerland)

Expected seasonal changes

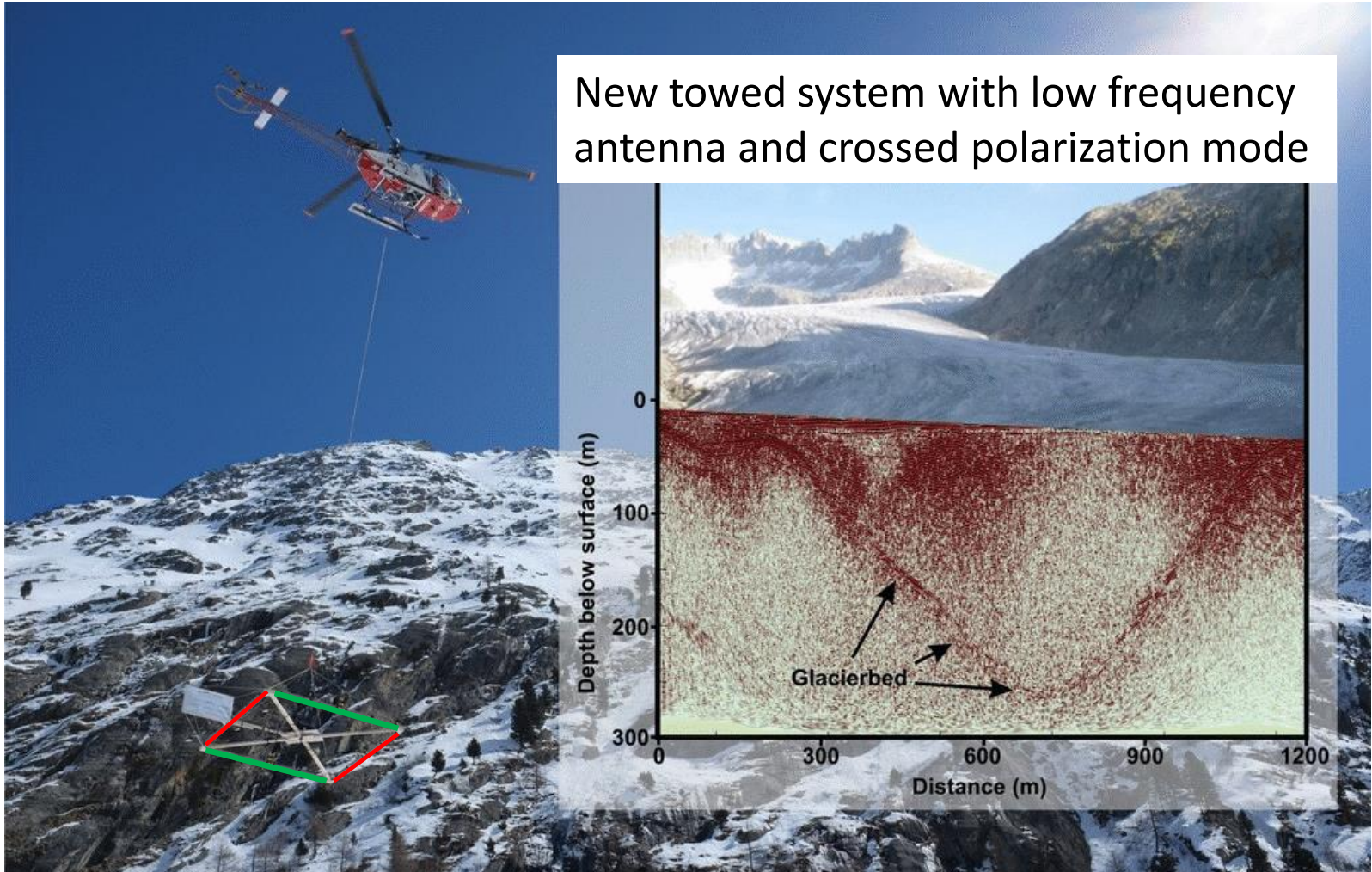**Idea:** Use the volume surplus to mitigate (part of) the deficit

**How large is the** theoretical **potential** for the Alps?

Potential storage volume

Detailed knowledge of glacier bed topography required for accurate forecast of runoff and storage potential
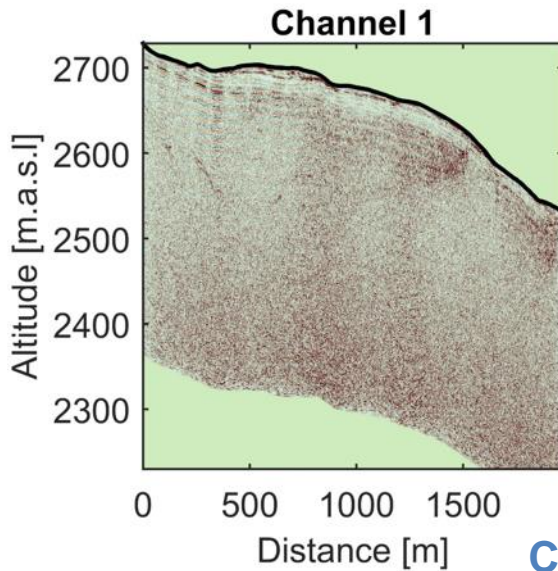
Ice thickness measurements

New towed system with low frequency antenna and crossed polarization mode

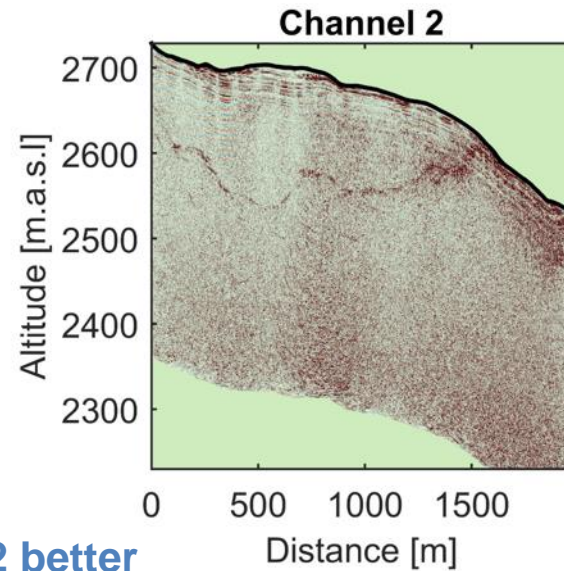Improved ice radar system with good performance in complex Alpine glacier topography

Ice radar performance
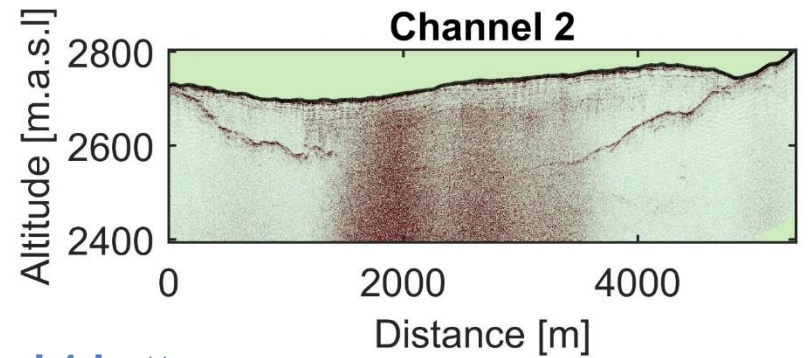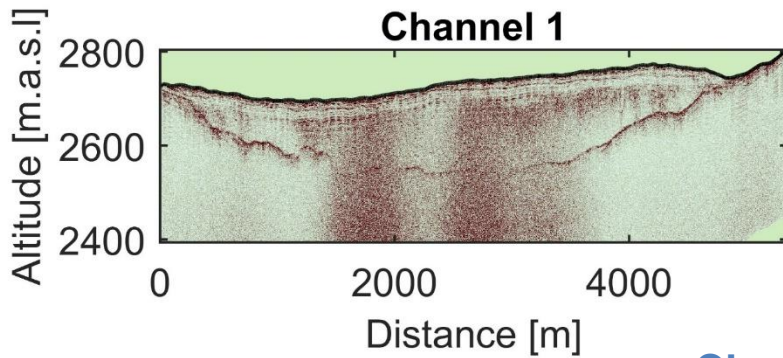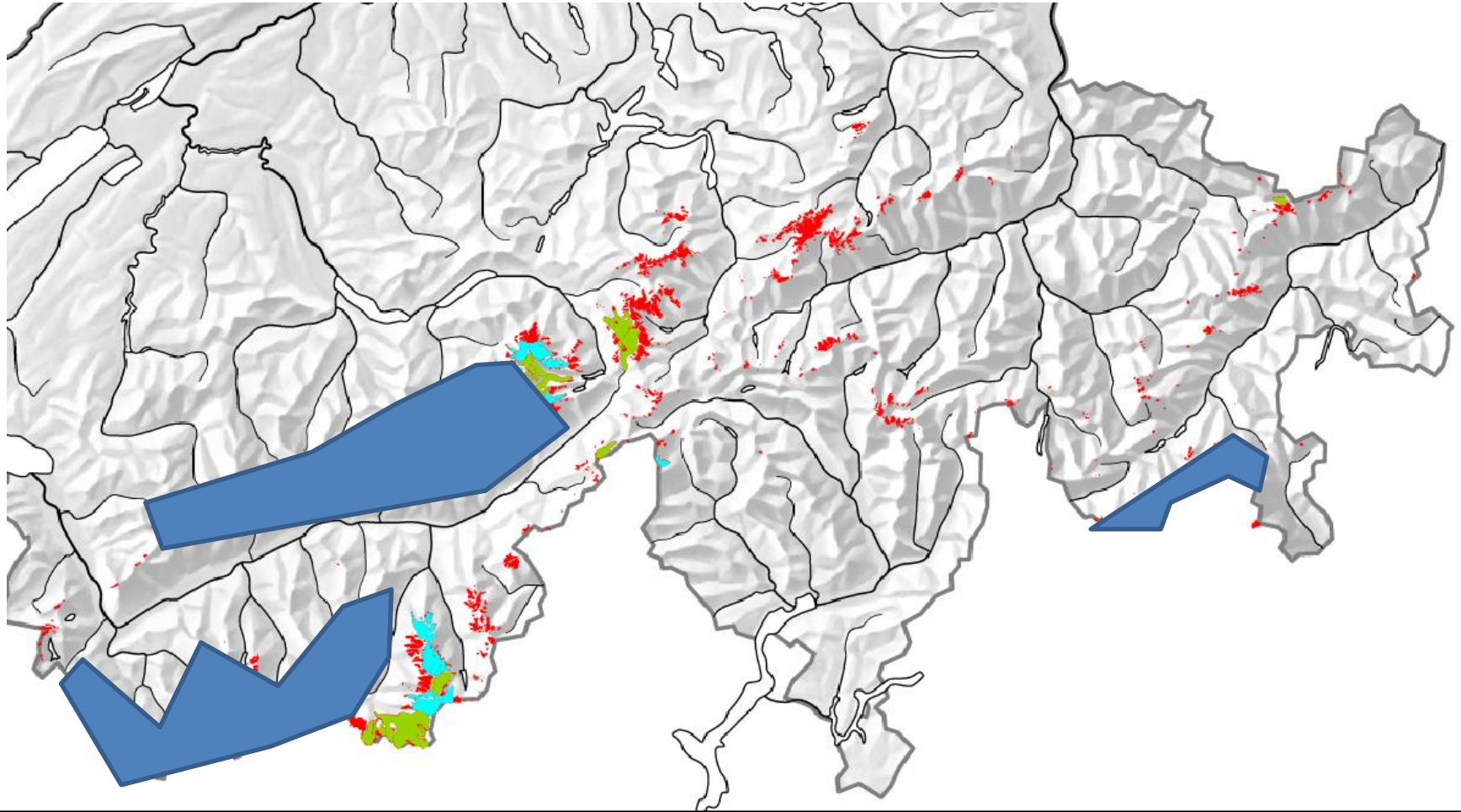

Channel 1 better

Channel 2 better

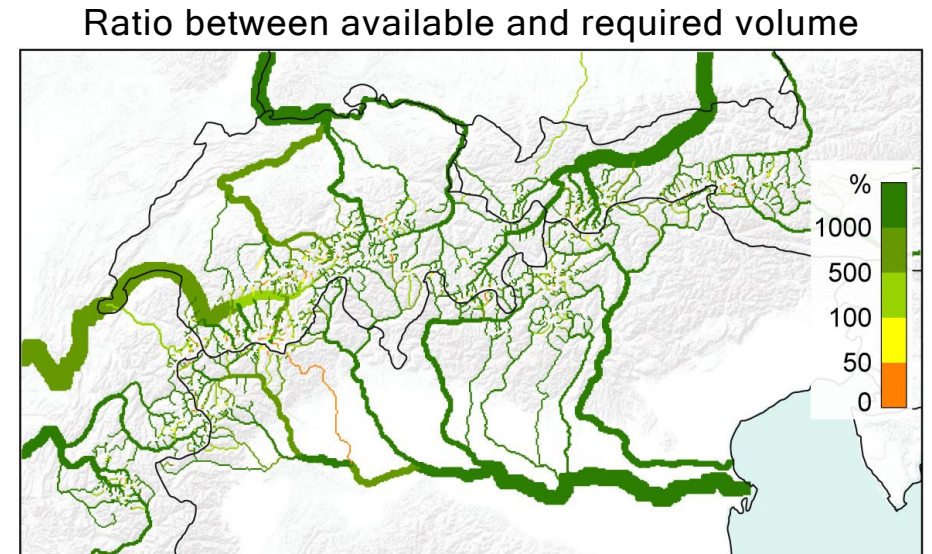Dense and efficient survey, improved data quality

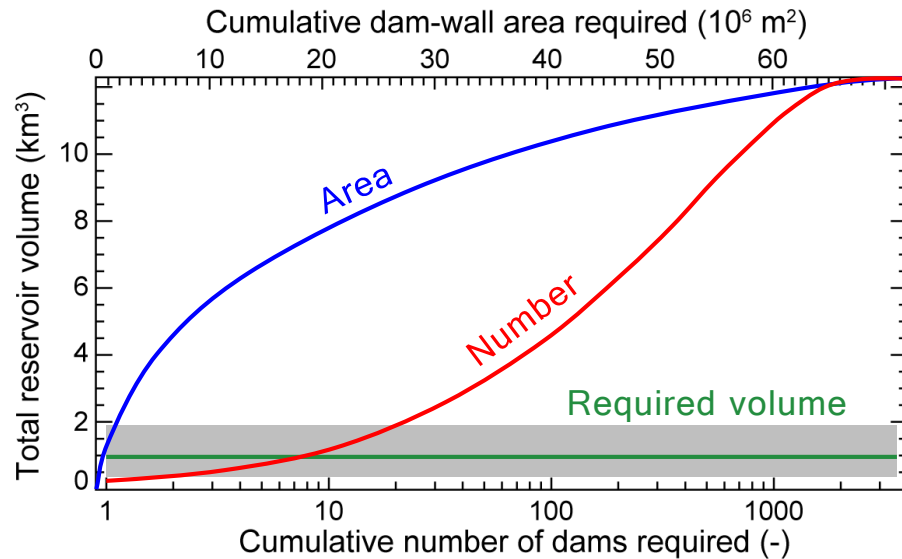# Glacier bed mapping

Planed activity in next acquisition period in winter 2016/17

Required storage volume

Storage potentially to be installed in currently glacierized areas:

Farinotti et al., ERL, 2016

The **theoretically** installable storage volume is largely (at least one order of magnitude) in excess of the required one. Less than a dozen dams would provide the entire volume required.

Past CH runoff from net ice melt, 1981-2000

Ratio glacier runoff / total annual runoff

Legend:
- 0.75 to 1
- 0.5 to 0.75
- 0.25 to 0.5
- 0.1 to 0.25
- 0.075 to 0.1
- 0.05 to 0.075
- 0.025 to 0.05
- 0 to 0.025
- No glacier

0   50   100
kilometers
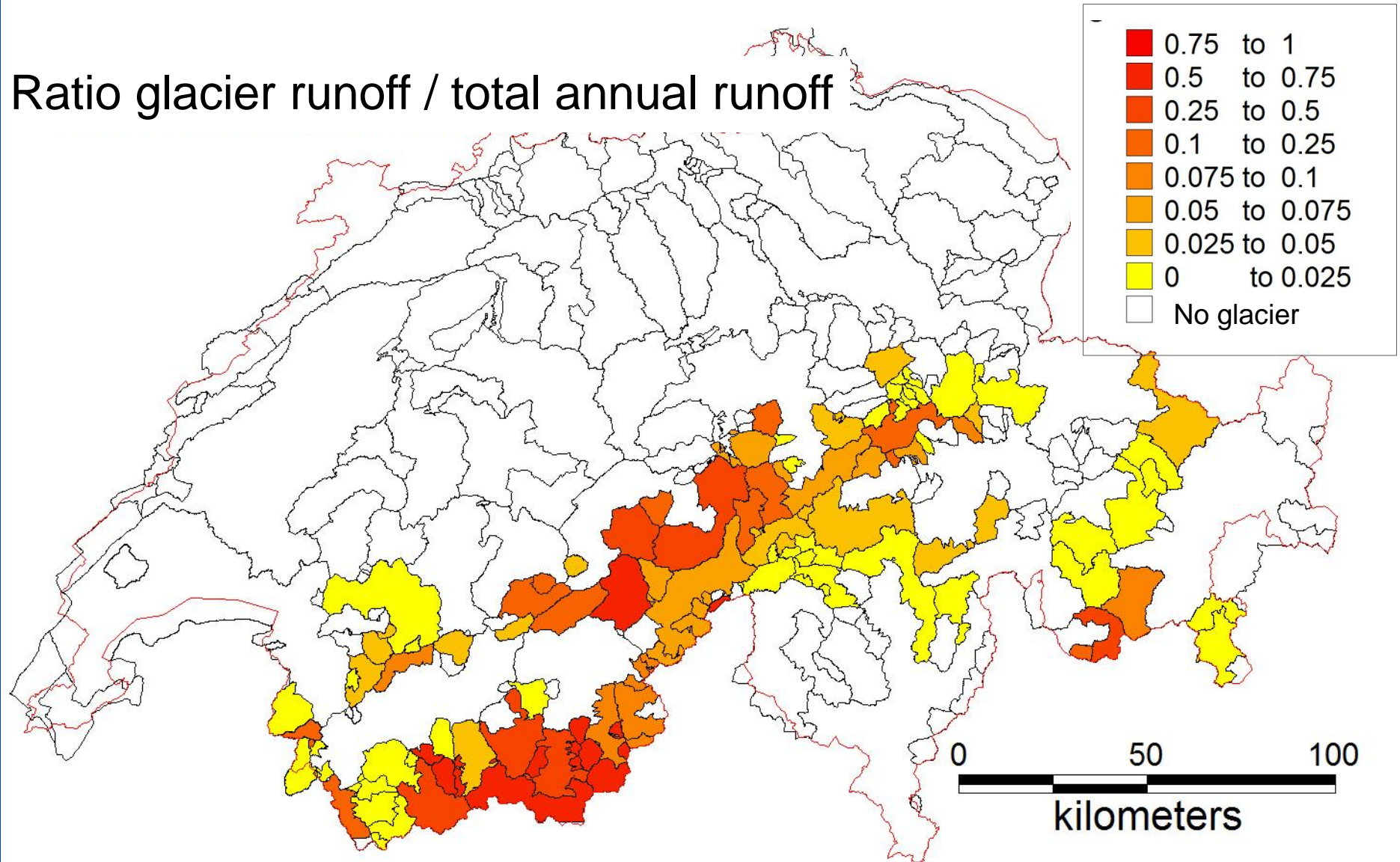
Source HPP catchments: HydroGIS, Balmer 2011

Electricity coefficients [kWh/m³] 1981 - 2000

■ (yellow)	6 to 9.9
■	3 to 6
■	1.5 to 3
■	0.75 to 1.5
■ (gray)	0.25 to 0.75
■	0.1 to 0.25
■	0.02 to 0.1
■	0.01 to 0.02
■ (blue)	0 to 0.01
□	Not shown

0   50   100
kilometers

Balmer, 2011; Schaefli et al, in preparation
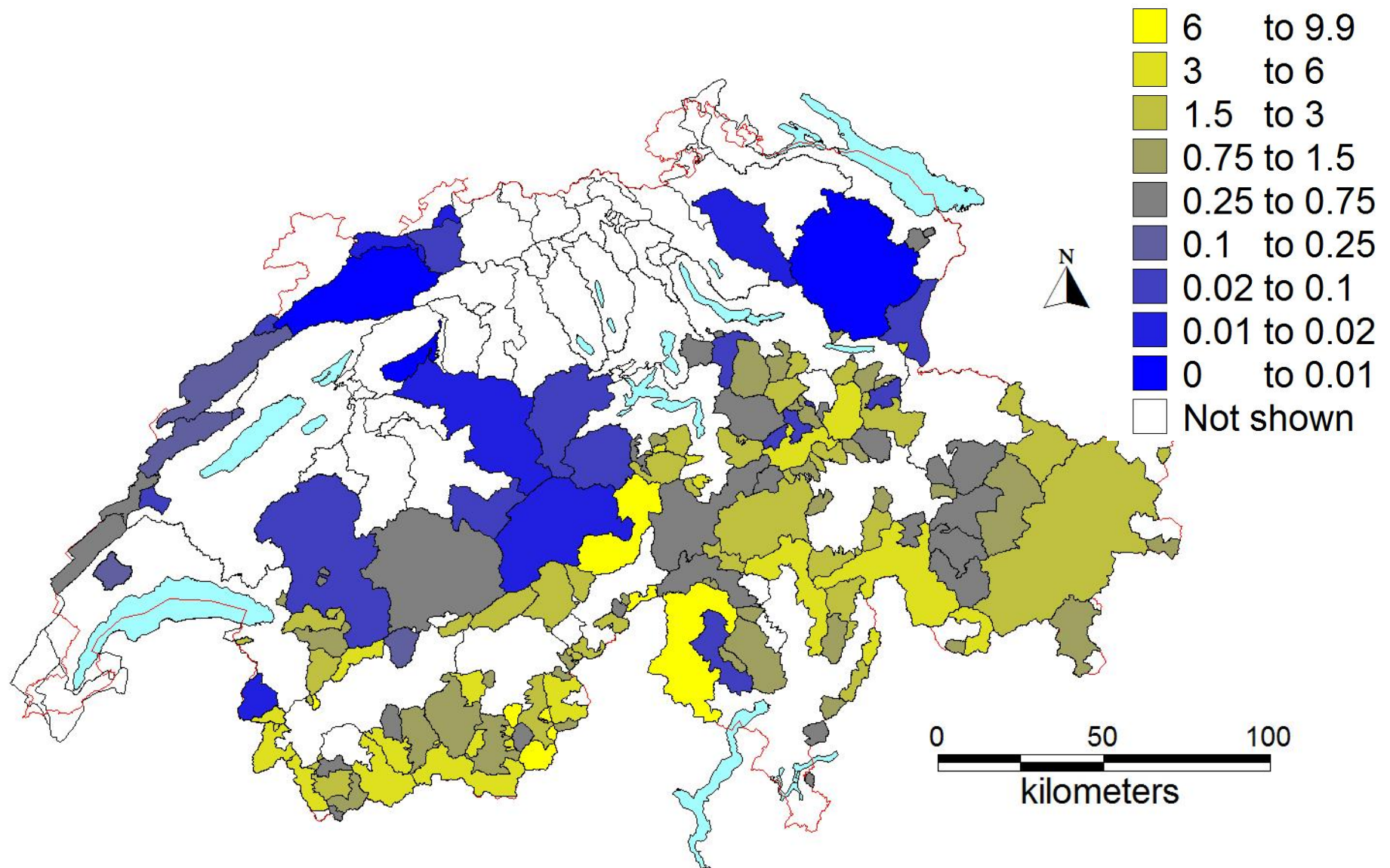
Past hydropower from net ice melt

Non-renewable HPP ?
2% − 5%

glacier runoff / total di

0.75 to 1
0.5 to 0.75
0.25 to 0.5
0.1 to 0.25
0.075 to 0.1
0.05 to 0.075
0.025 to 0.05
0 to 0.025
all others

0   50   100
kilometers

Source HPP catchments: HydroGIS, Balmer 2011