

Climate Change and Alpine Water



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$$Q = P - E \pm \Delta S$$

Runoff = Precipitation – Evaporation $\pm$ Δ Storage

Drivers: Precipitation + Temperature

time scales of interest:

< hourly peaks * seasonal variations * annual sums

Precipitation change RCP4.5 in 2046-2065: April-September

Apr-Sep

75%

Precipitation change RCP4.5 in 2046-2065: October-March

Oct-Mar

75%

RCP4.5 precipitation changes 2046-2065 rel. 1986-2005

Precipitation change RCP4.5 in 2081-2100: April-September

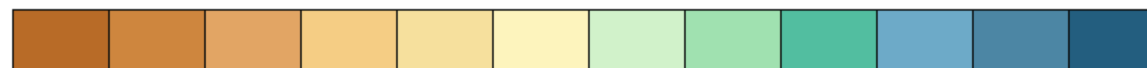
75%

Precipitation change RCP4.5 in 2081-2100: October-March

75%

2081-2100

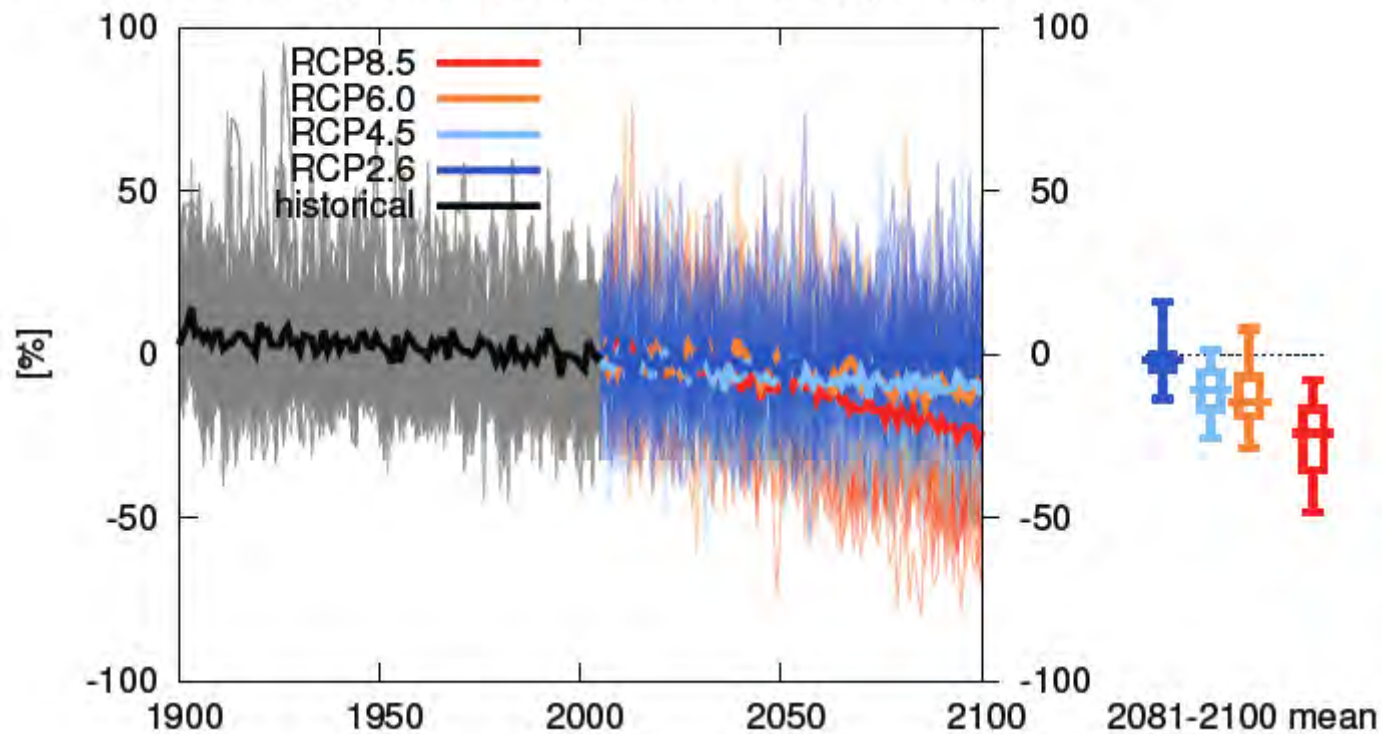
IPCC AR5 WG1 Atlas (2013)



-50 -40 -30 -20 -10 0 10 20 30 40 50

[%]

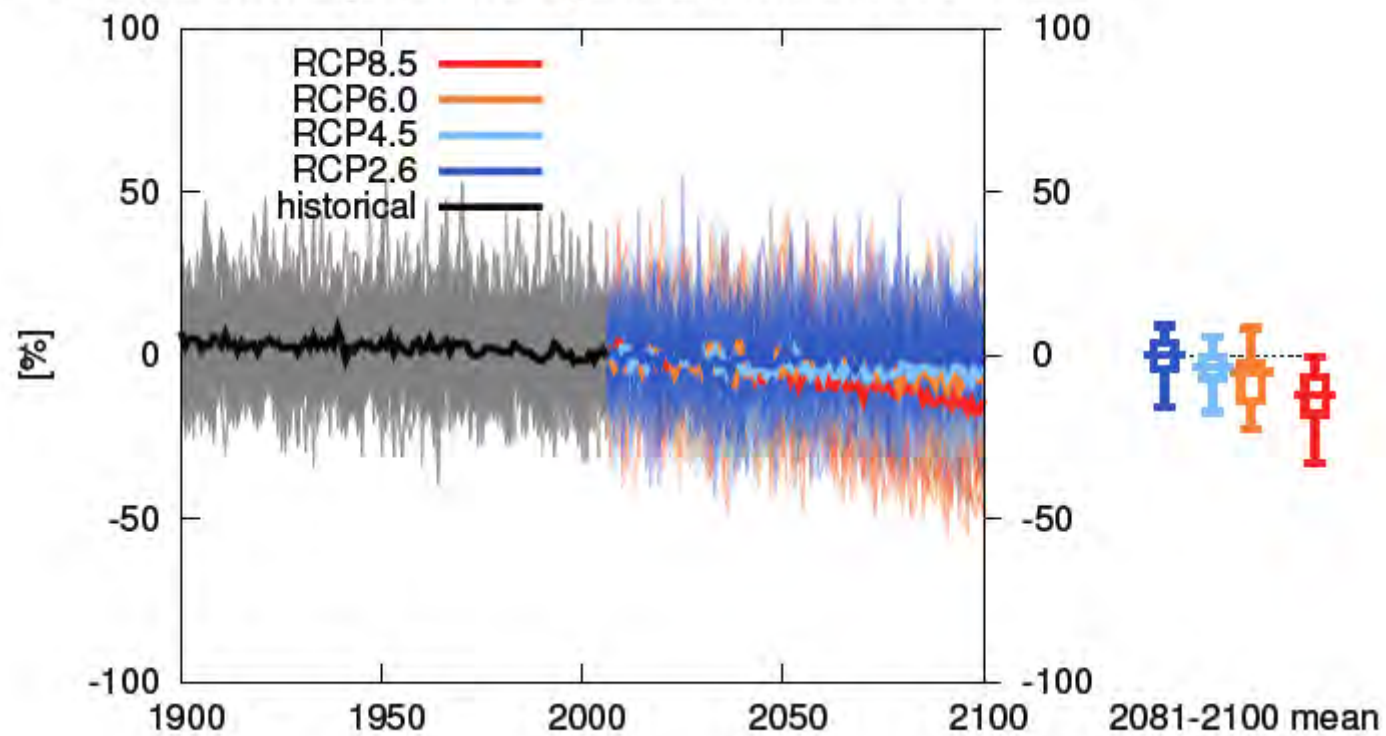
Precipitation changes Apr-Sep



IPCC AR5 WG1 Atlas (2013)

www.climatechange2013.org

Precipitation changes Oct-Mar



IPCC AR5 WG1 Atlas (2013)

Temperature change RCP4.5 in 2046-2065: December-February

Dec-Feb

75%

Temperature change RCP4.5 in 2046-2065: June-August

June-Aug

75%

RCP4.5 temperature changes 2046-2065 rel. 1986-2005

Temperature change RCP4.5 in 2081-2100: December-February

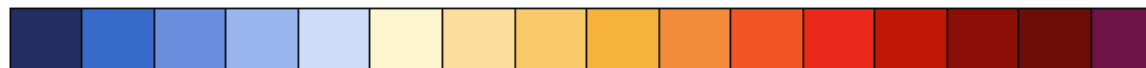
75%

Temperature change RCP4.5 in 2081-2100: June-August

75%

2081-2100

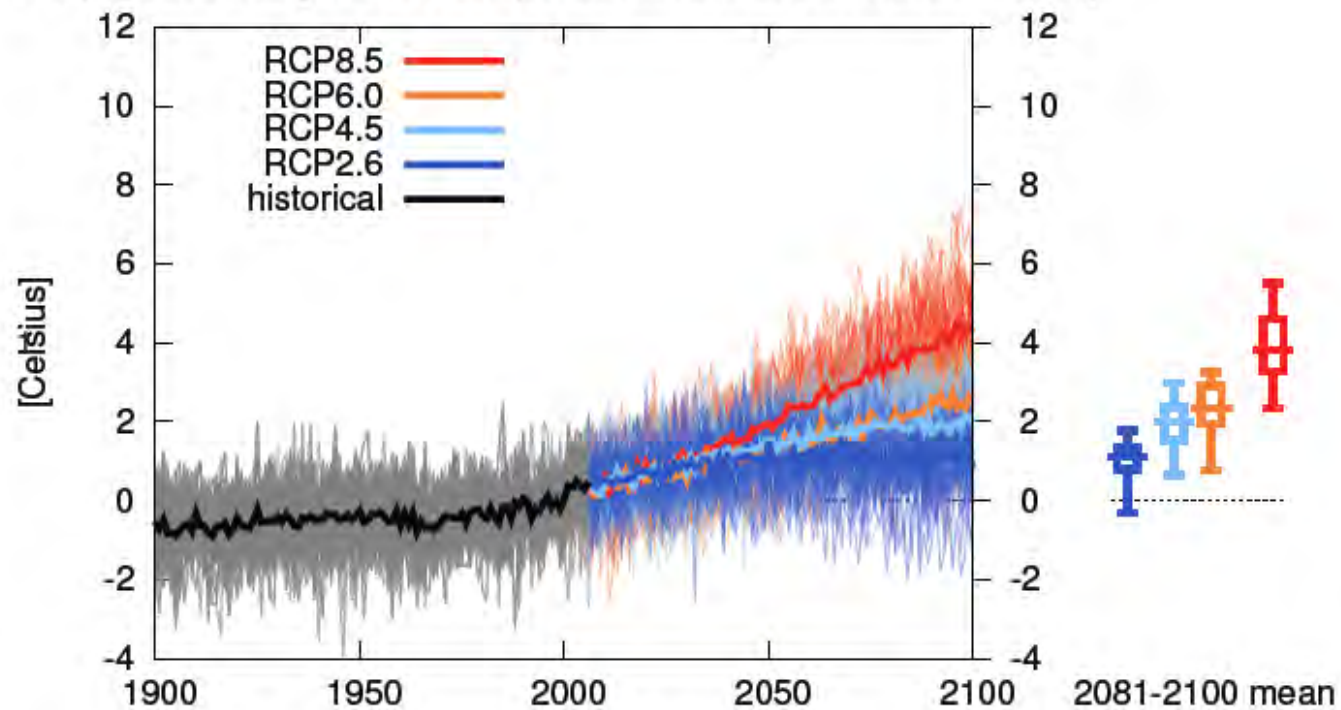
IPCC AR5 WG1 Atlas (2013)



-2 -1.5 -1 -0.5 0 0.5 1 1.5 2 3 4 5 7 9 11

[°C]

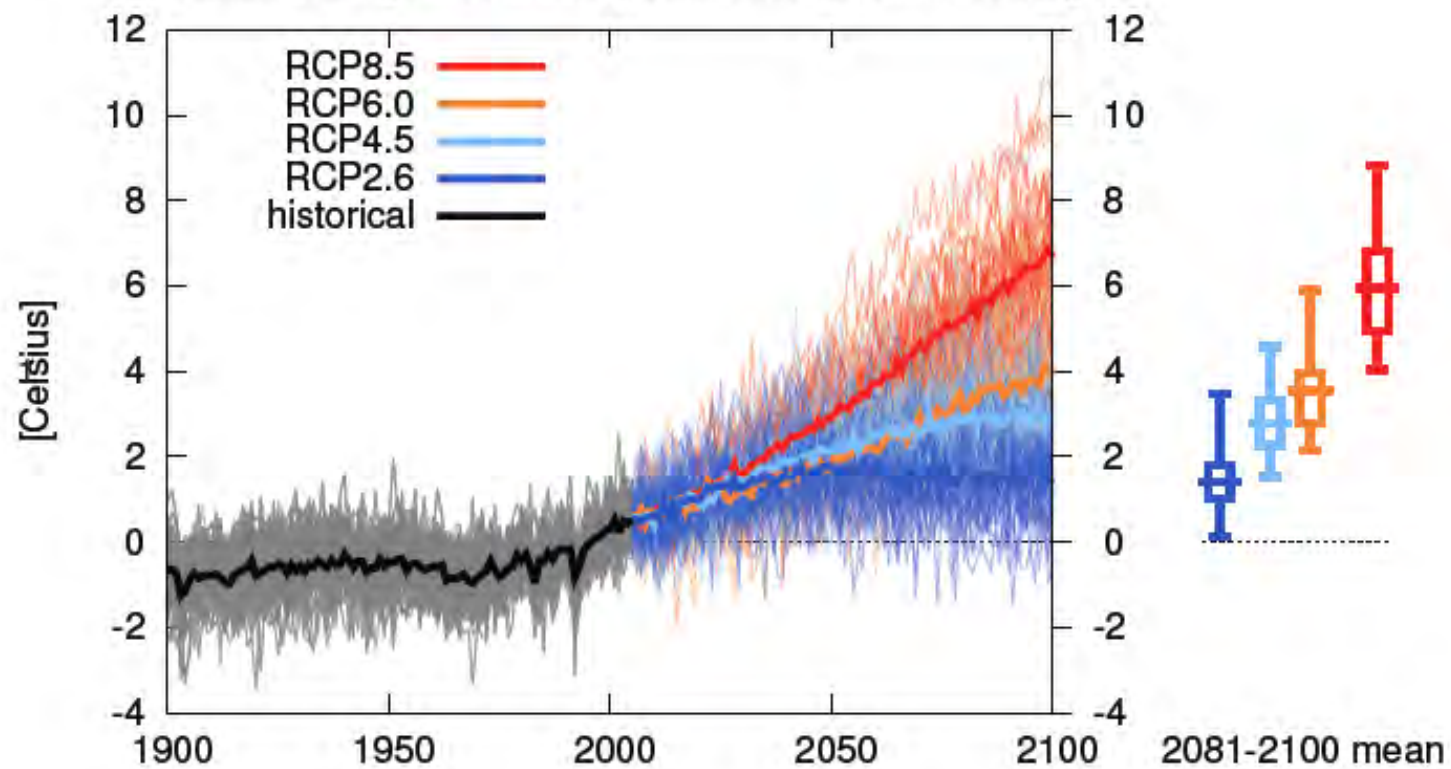
Temperataure changes Dec-Feb



IPCC AR5 WG1 Atlas (2013)

+1°C » +170 m freezing level

Temperataure changes Jun-Aug

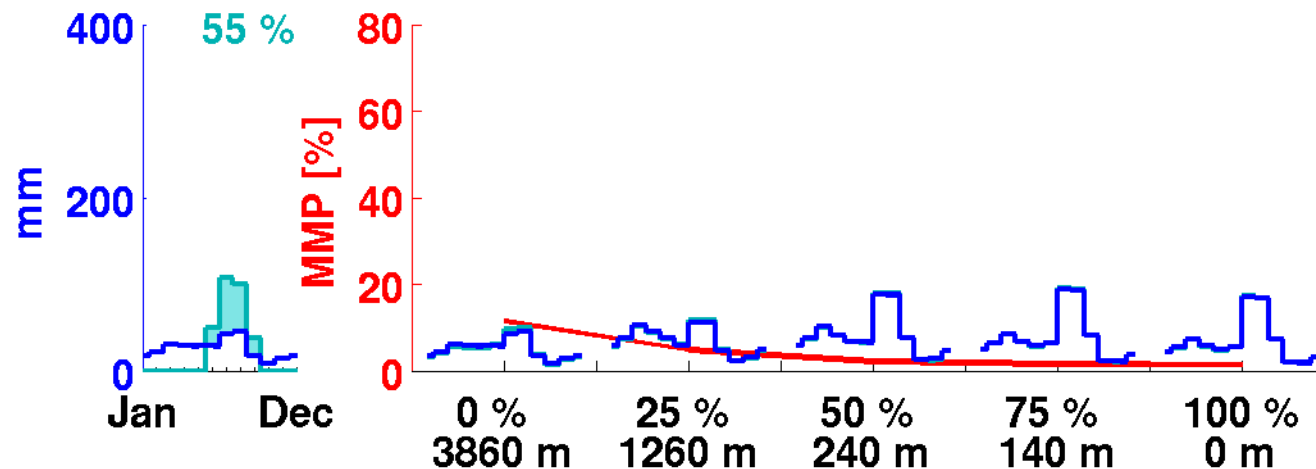


IPCC AR5 WG1 Atlas (2013)

Present glaciers' contribution to water availability (steady state)

Indus

Total basin area: 1139814 km²
 Total glacier area: 20325 km² (1.78 %)
 Mean precipitation: 405 mm/year
 Total population: 211.28 Mio. people
 Total PIX: 4.82 Mio. people



Present glaciers' contribution to water availability (steady state)

population impact index (PIX)

=

population x MMP

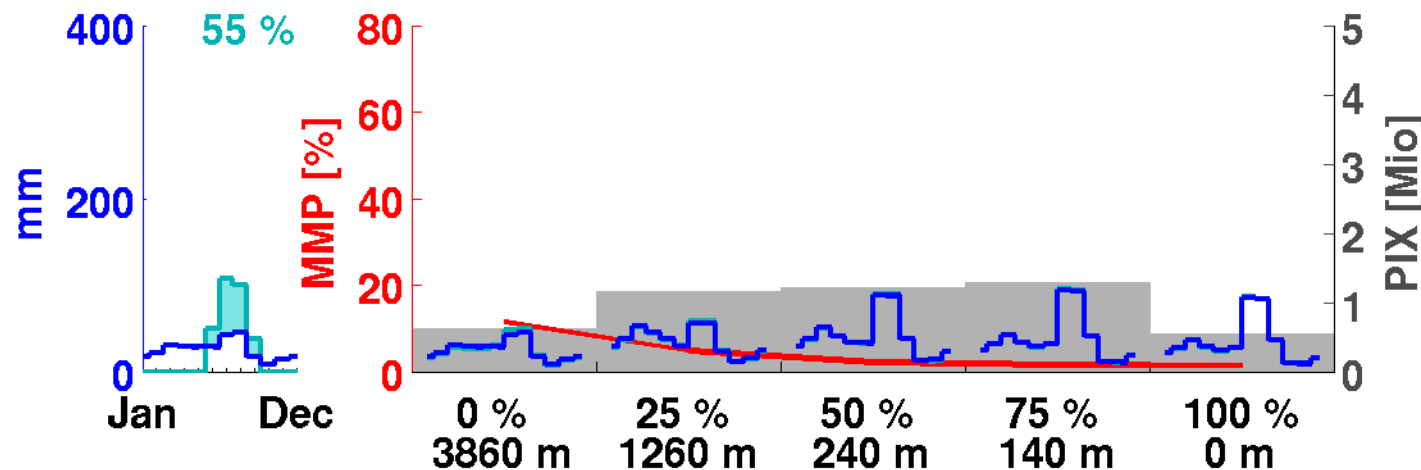
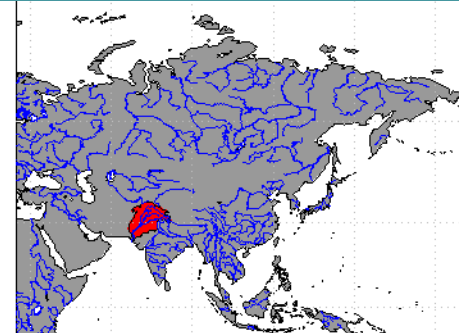
a measure of seasonally delayed glacier melt
as a resource for human water consumption

Kaser, Marzeion, Großhauser **PNAS** (2010)

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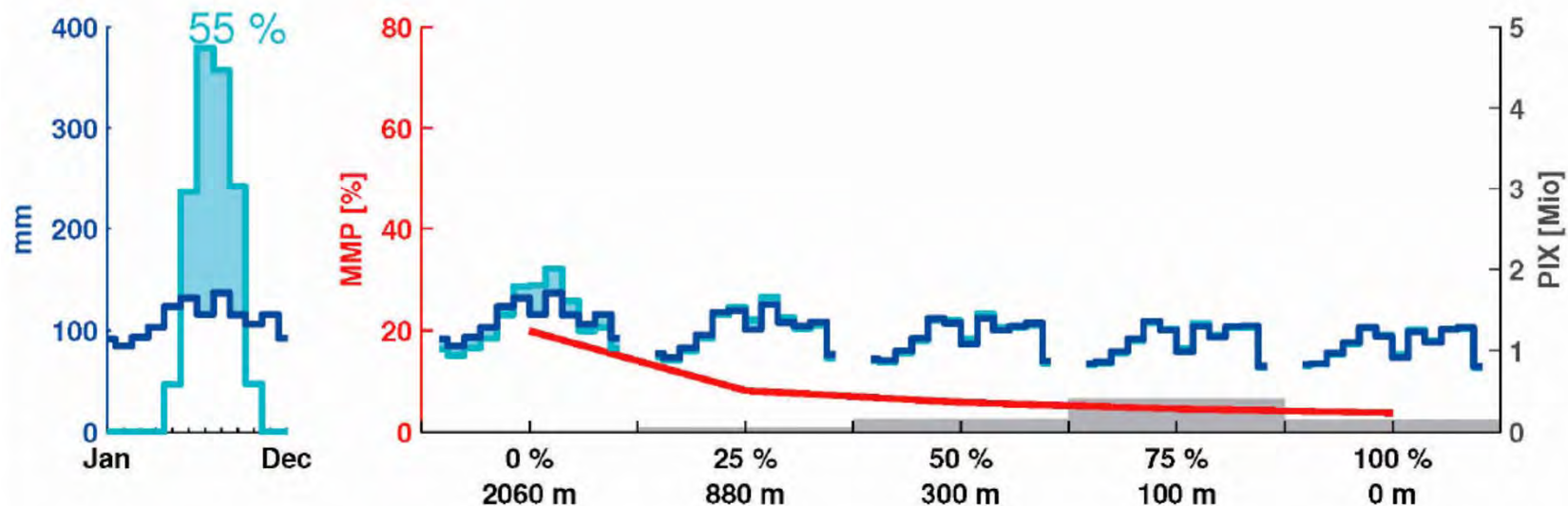


Kaser, Marzeion, Großhauser PNAS (2010)

Present glaciers' contribution to water availability (steady state)

Po

Total river basin area:	73297 km ²
Total glacier area:	818 km ² (1.12 % of total river basin area)
Mean annual precipitation:	1028 mm
Total population	16.55 Mio. people
Total PIX	0.81 Mio. people

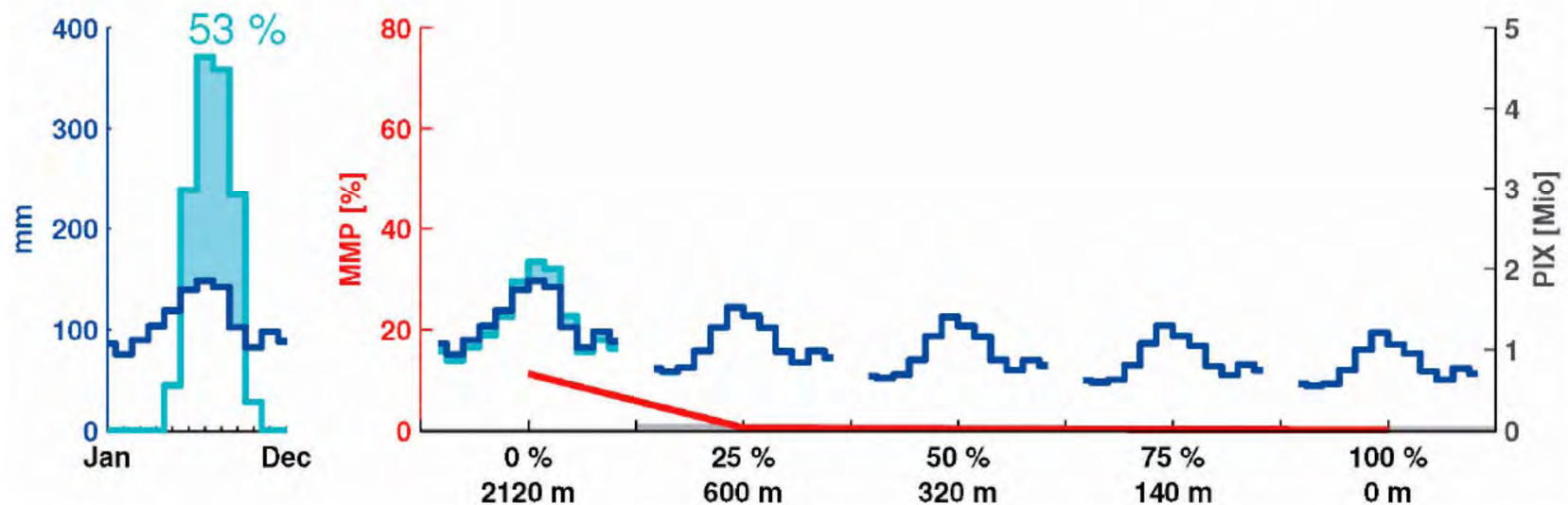
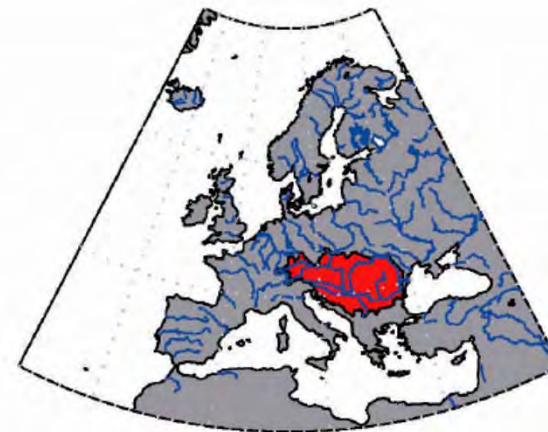


Kaser, Marzeion, Großhauser **PNAS** (2010)

Present glaciers' contribution to water availability (steady state)

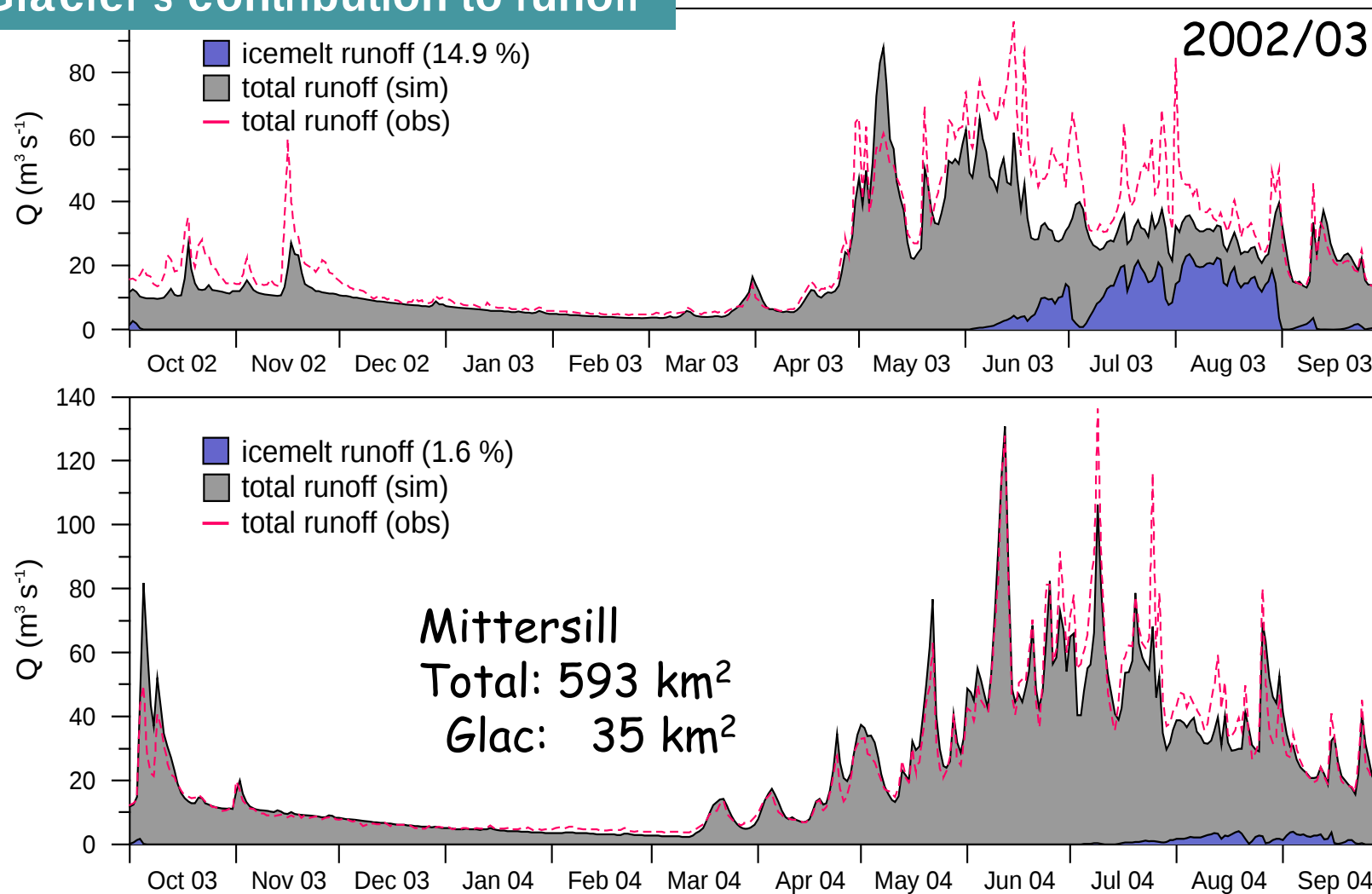
Danube

Total river basin area:	794133 km ²
Total glacier area:	617 km ² (0.08 % of total river basin area)
Mean annual precipitation:	765 mm
Total population	81.38 Mio. people
Total PIX	0.31 Mio. people



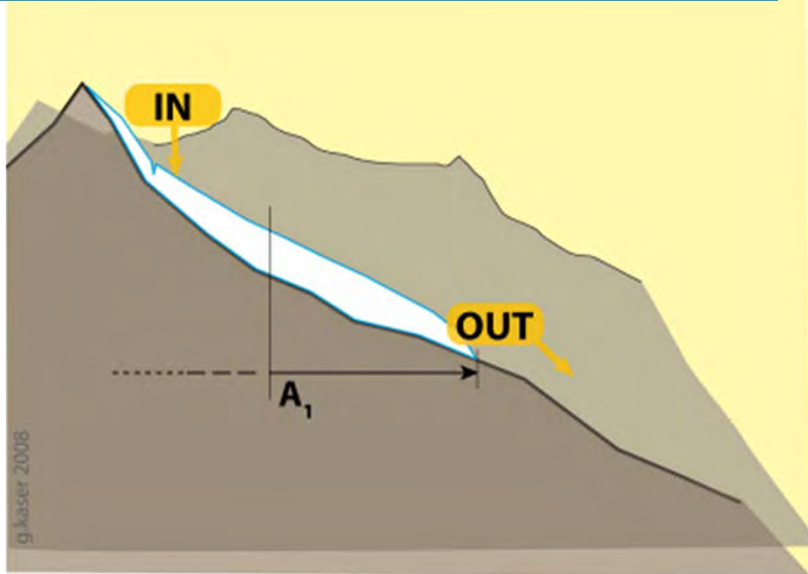
Kaser, Marzeion, Großhauser **PNAS (2010)**

A Glacier's contribution to runoff

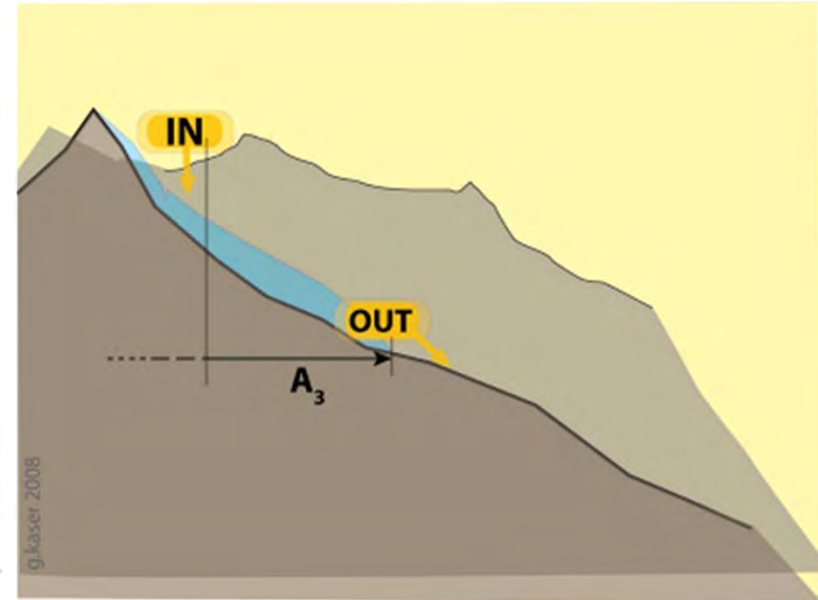


Koboltschnig (2007) – PhD Thesis, BOKU, Vienna

A Glacier's contribution to runoff



1. Melt water runoff (A_1)



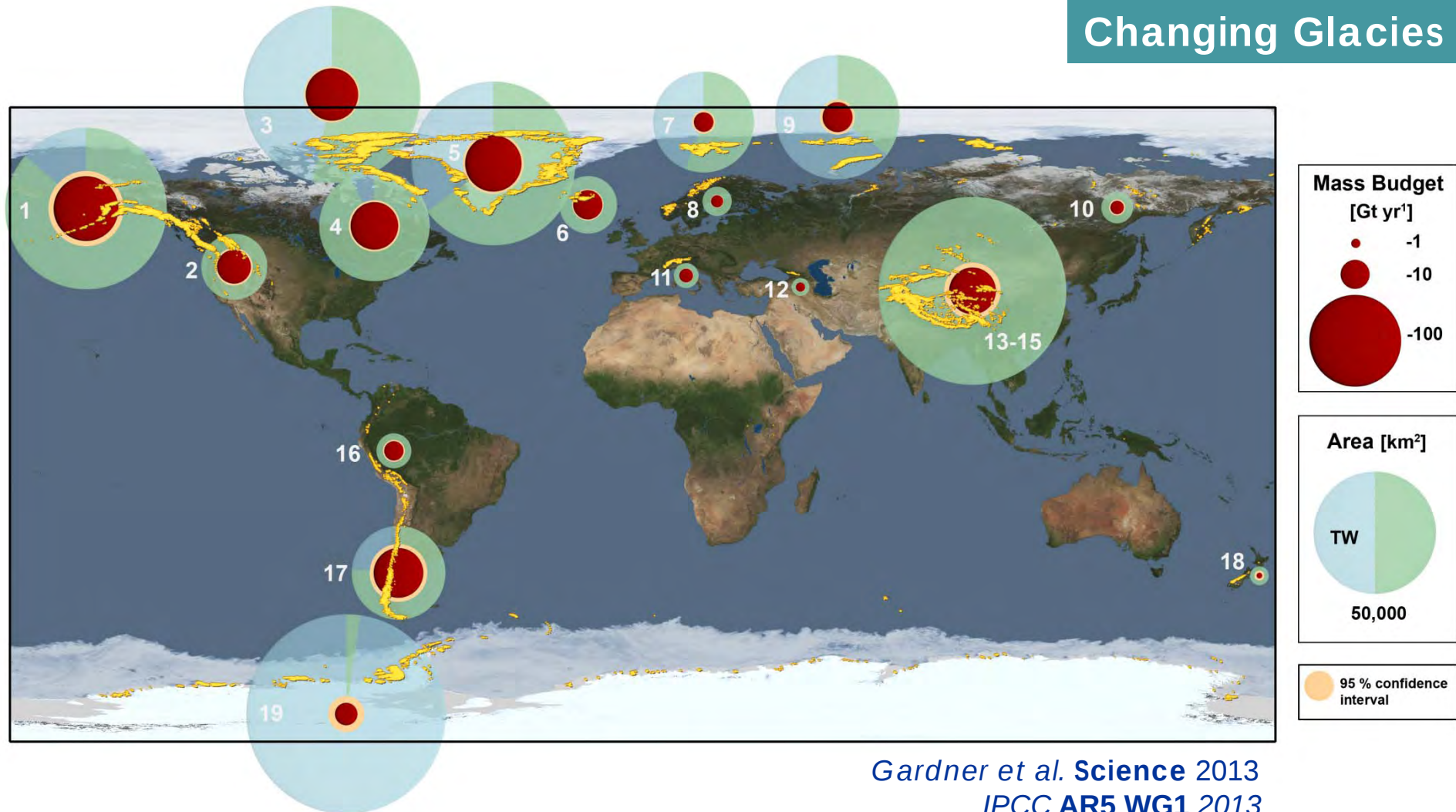
2. $A_2 > A_1$

3. Increasing runoff

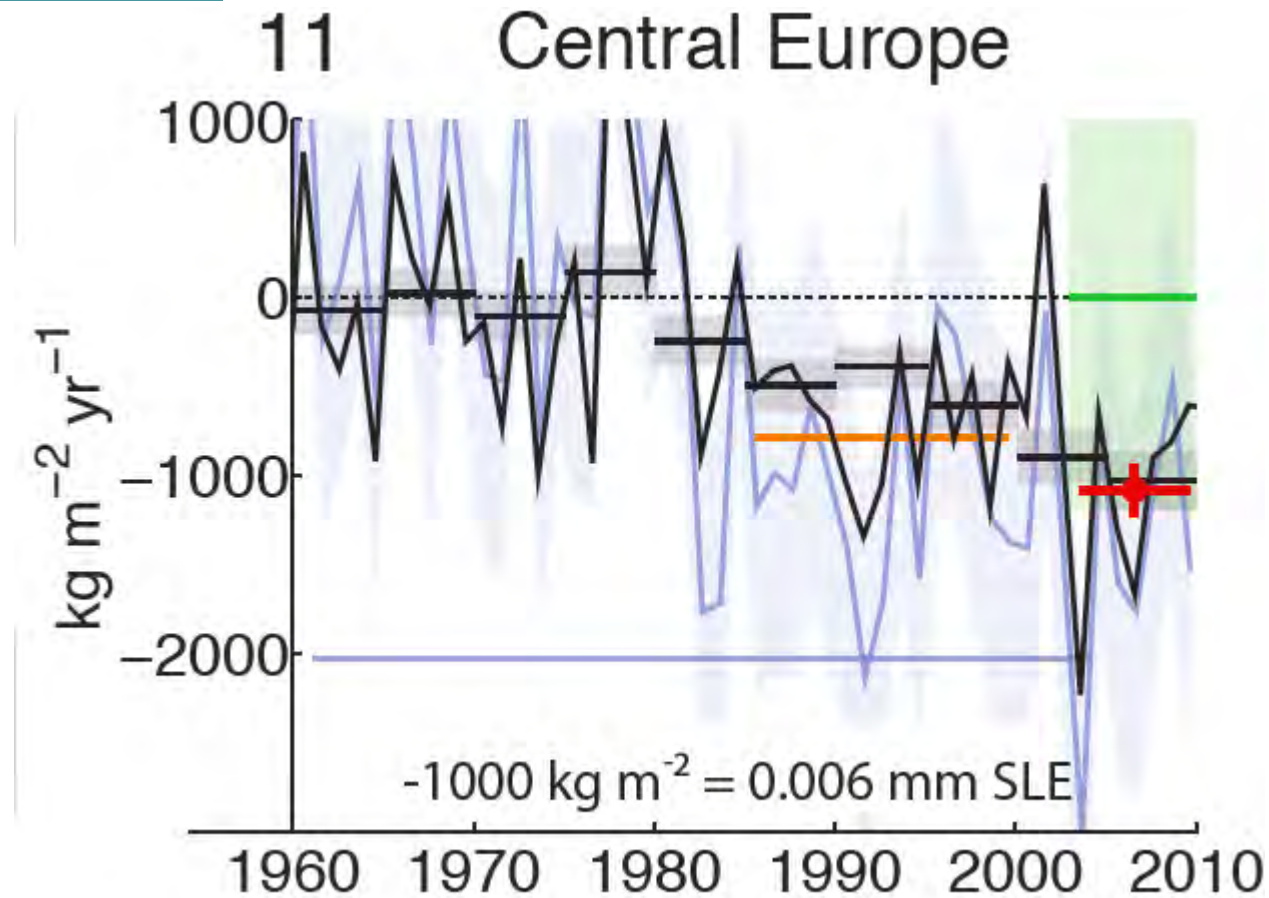
4. $A_3 < A_2 < A_1$

5. Decreasing runoff

Changing Glaciers



Changing Glaciers



IPCC AR5 WG1 2013

$$Q = P - E \pm \Delta S$$

SUMMARY:

Precipitation: moderate changes

Seasonal snow cover: rise of freezing level

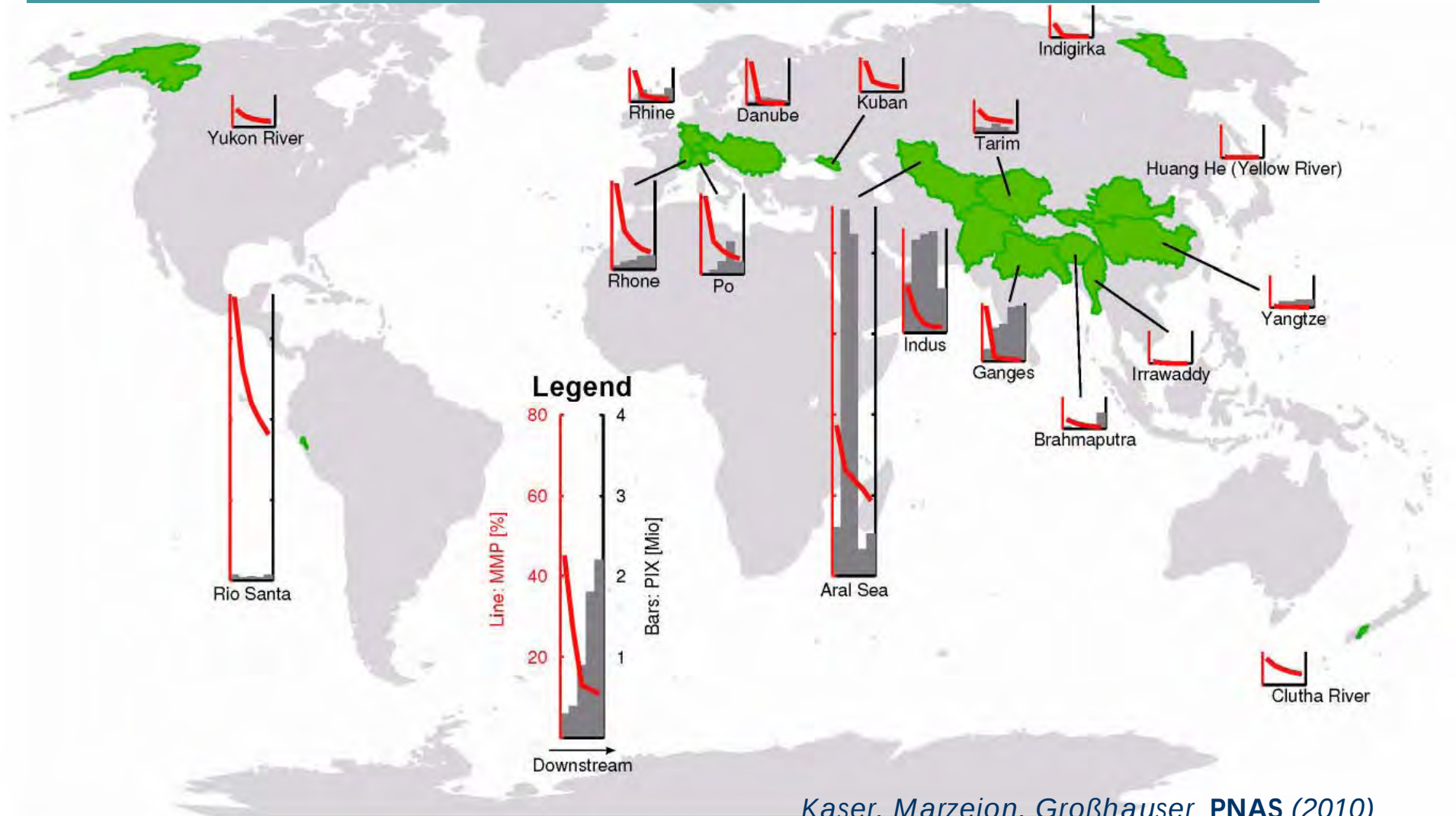
Evaporation: increase

Glaciers: will widely loose their contribution

TOTAL:

less water, particularly during vegetation period

Present glaciers' contribution to water availability (steady state)



Kaser, Marzeion, Großhauser **PNAS** (2010)

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An aerial photograph of a vast, rugged glacier. The ice surface is heavily textured with numerous cracks, crevasses, and ridges. In the lower right corner, a small group of people is visible, providing a sense of scale to the immense size of the glacier. A semi-transparent white rectangular box is positioned in the lower-left quadrant, containing the text "Thank you very much" in a bold, teal-colored font.

Thank you very much

Foto: B. Marzeion