UNIVERSITÄT BERN
OESCHGER CENTRE CLIMATE CHANGE RESEARCH

# Climate Change – will we have still enough water for (hydropower) use?

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**Workshop Montana, 24 September 2009**



## Introduction

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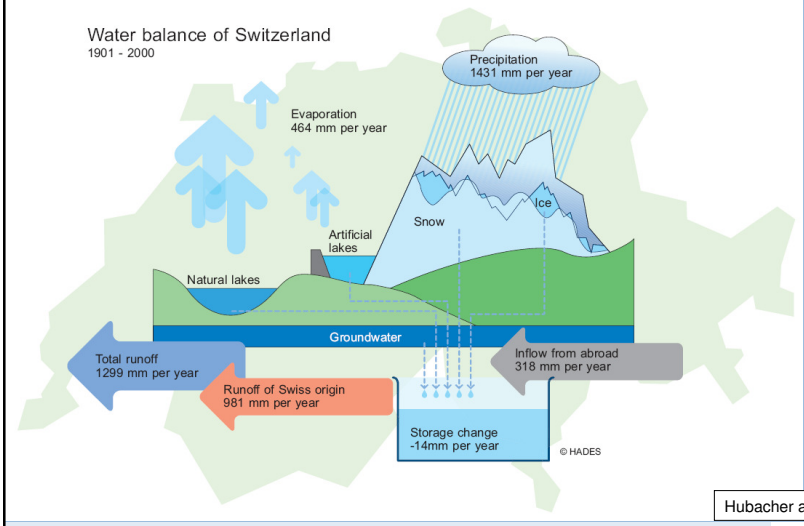
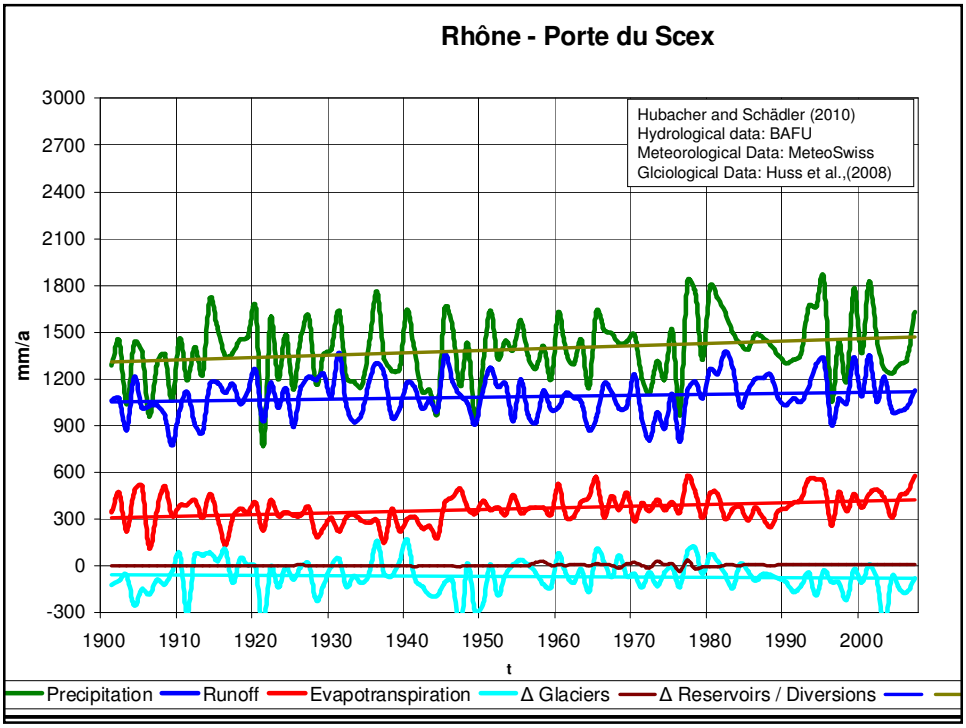
- What are our water resources ?
- How much, when and where ?
- How was development until now ?
- How is water demand ?
- Is water demand changing ?
- How changes climate ?
- And consequently water resources ?
- What is the importance of glaciers ?
- What is important in water cycle ?
- Do we still have enough water in future ?

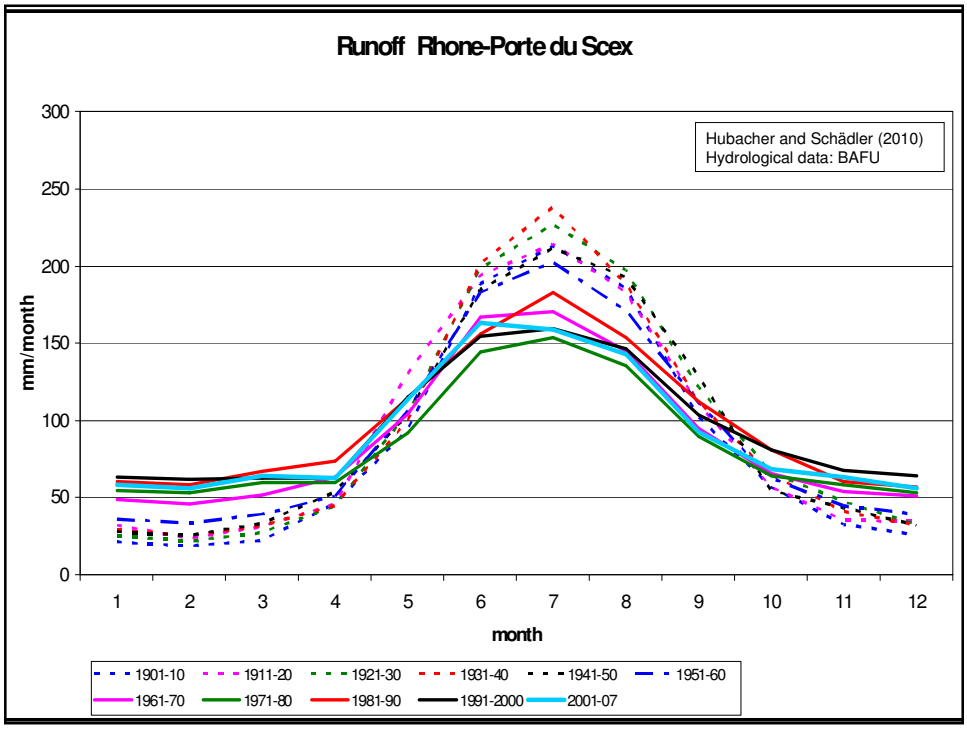
# Water Budget in Switzerland

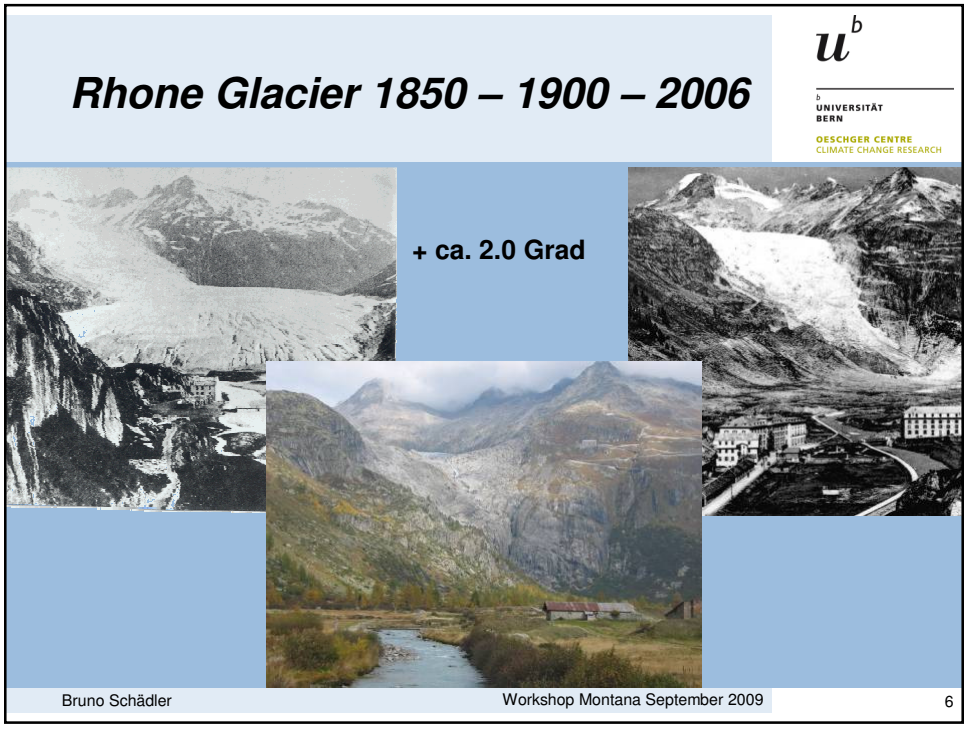



Hubacher and Schädler (2010)






Runoff Rhone-Porte du Scex
Hubacher and Schädler (2010)
Hydrological data: BAFU
mm/month
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12
month
1901-10
1911-20
1921-30
1931-40
1941-50
1951-60
1961-70
1971-80
1981-90
1991-2000
2001-07


Rhone Glacier 1850 – 1900 – 2006
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+ ca. 2.0 Grad
Bruno Schädler
Workshop Montana September 2009
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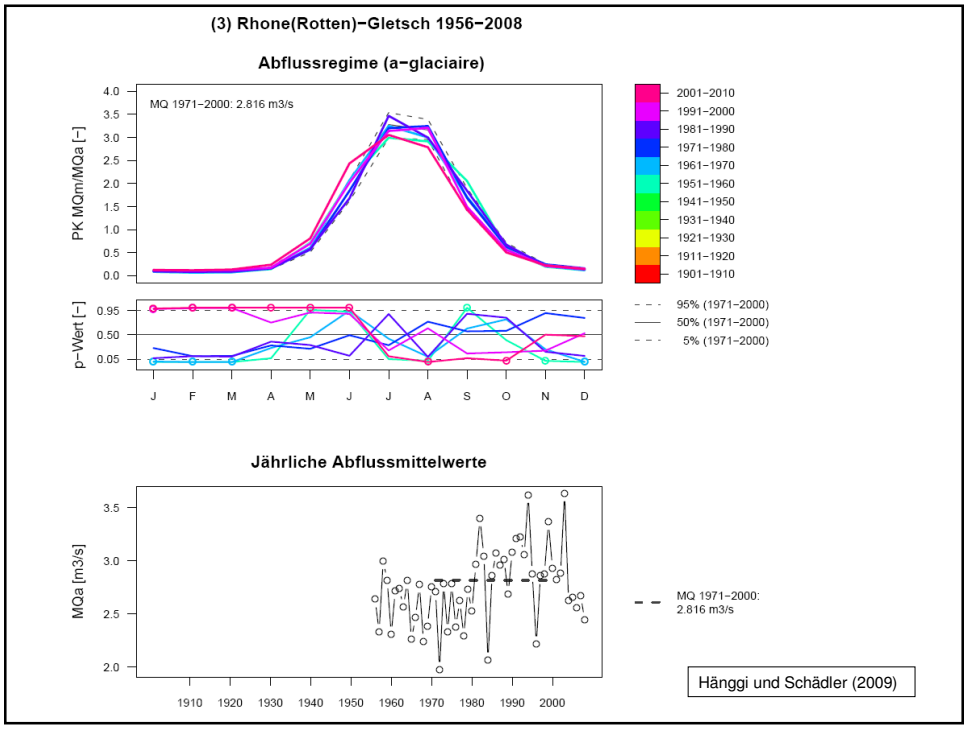



# Tschiervagletscher - Rosegbach

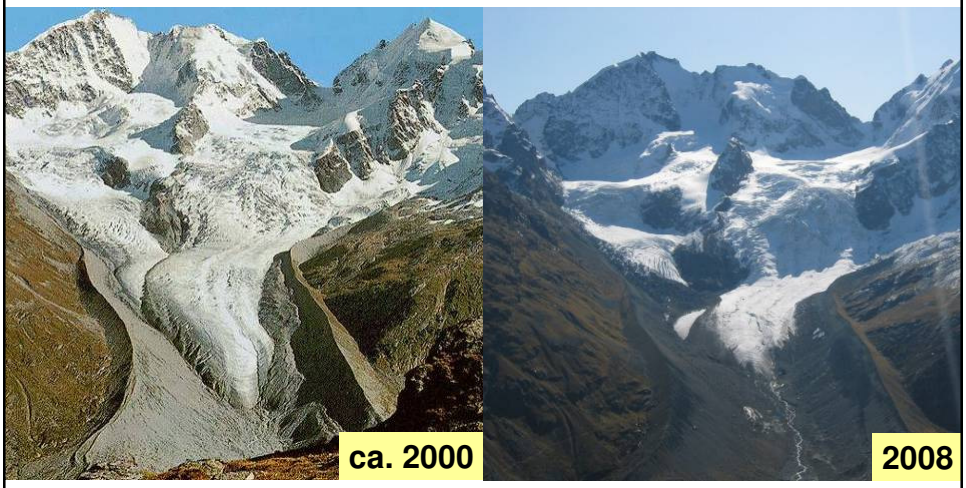
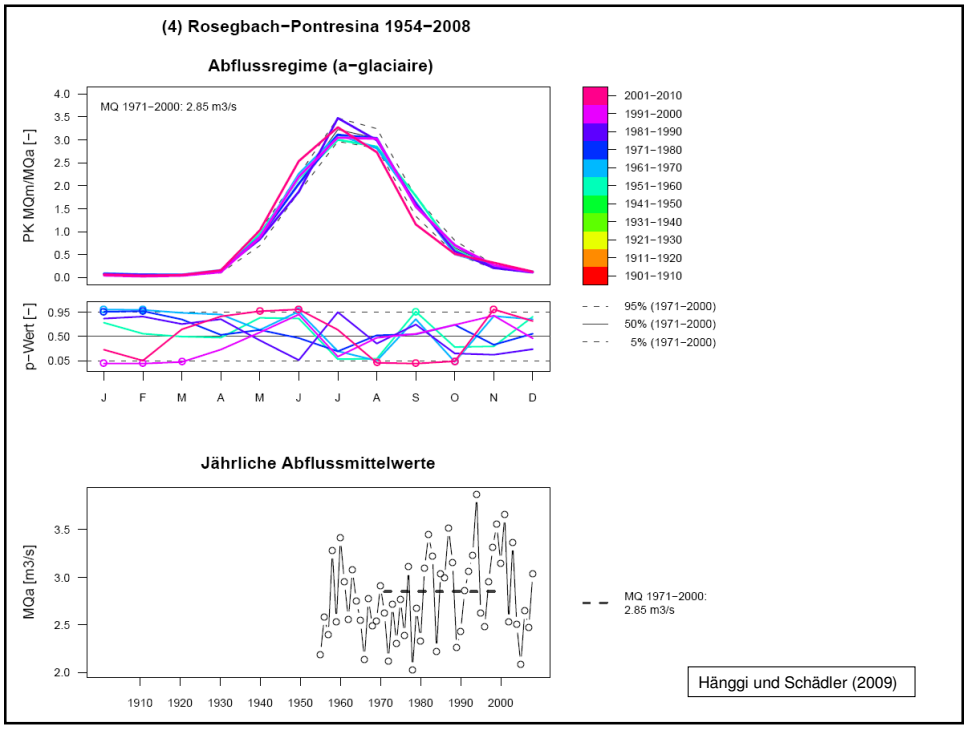
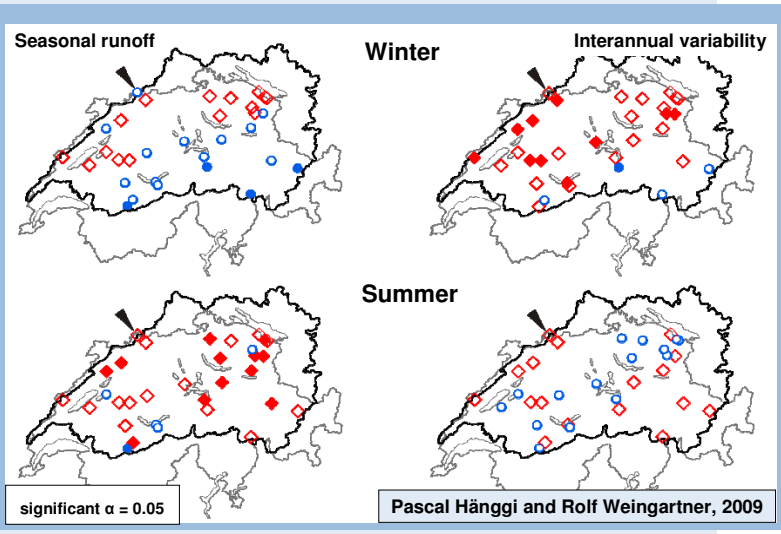



Foto: M. Maisch

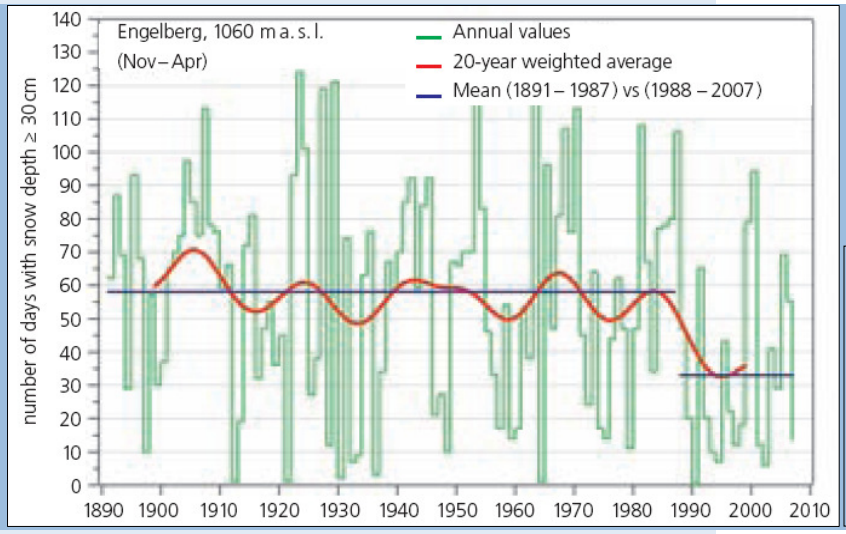
Foto: B. Schädler




# *Trends Runoff 1966 - 2005*



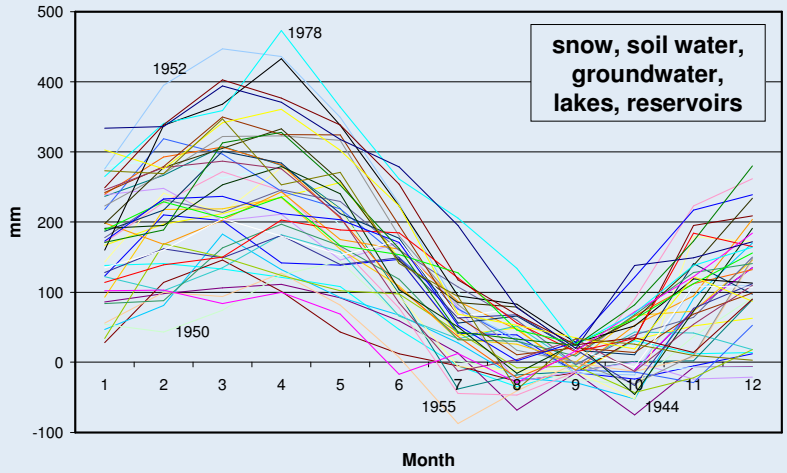
# Engelberg: Number of Days with Snowdepth > 30 cm, 1891 - 2007



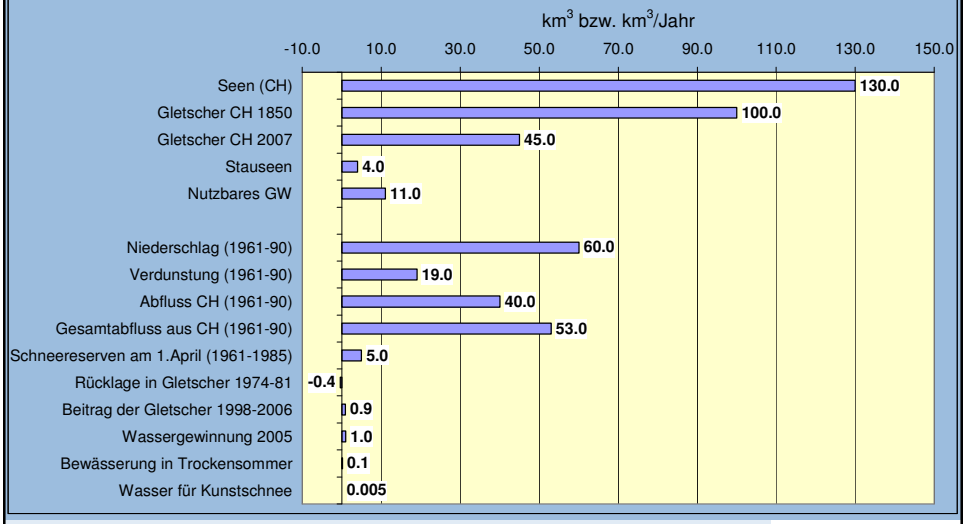

Seiz and Foppa, 2007



# Seasonal Water Storage Switzerland 1941 - 1981



## Schweiz: Wasserreserven und Umsätze



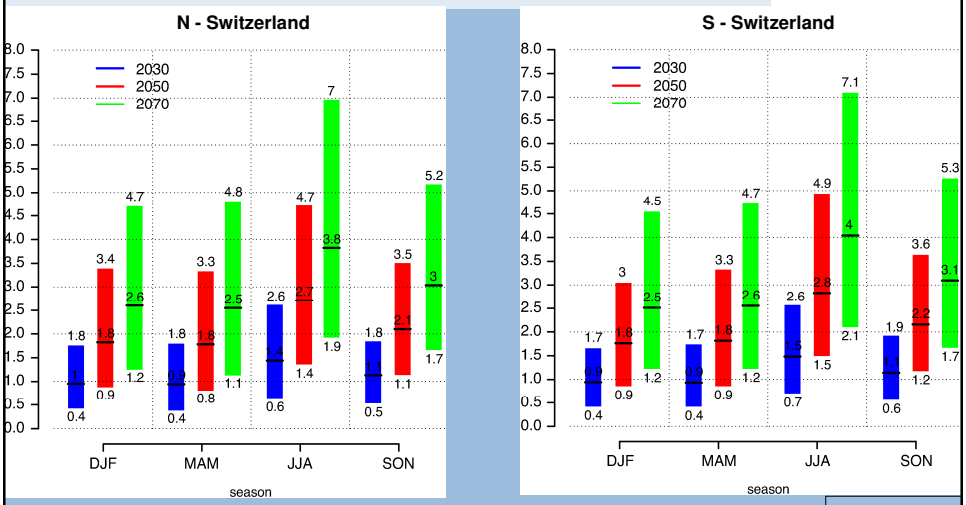



## Water demand

- Drinking water: tourism +
- irrigation meadows + -
- irrigation grapes, cultures +
- snow making ++
- industry (cooling) + -
- hydraulic power plants + -

- Change from demand oriented to resources oriented water management:
  - water use gauging and pricing
  - more efficient irrigation systems
  - management of swimming pools (e.g. water pice)
  - .....

# Temperature Scenarios

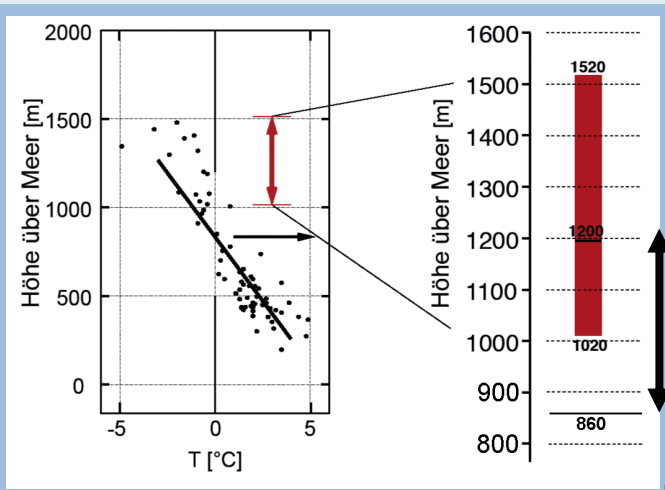



**Changes since 1990, median und 95% confidence**

**Frei, 2004**



# Snow line increase

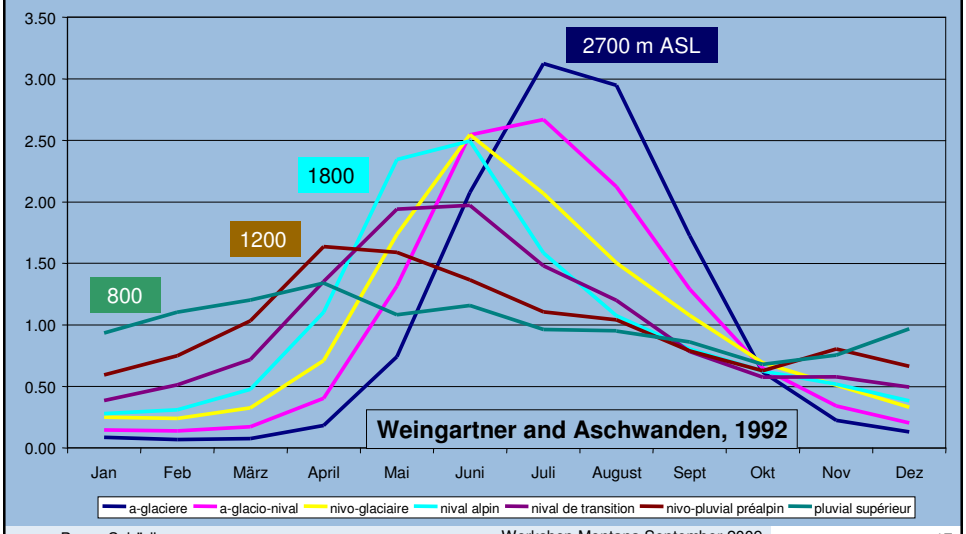



**200 m increase per deg warming**

**1.8 deg 360 m**

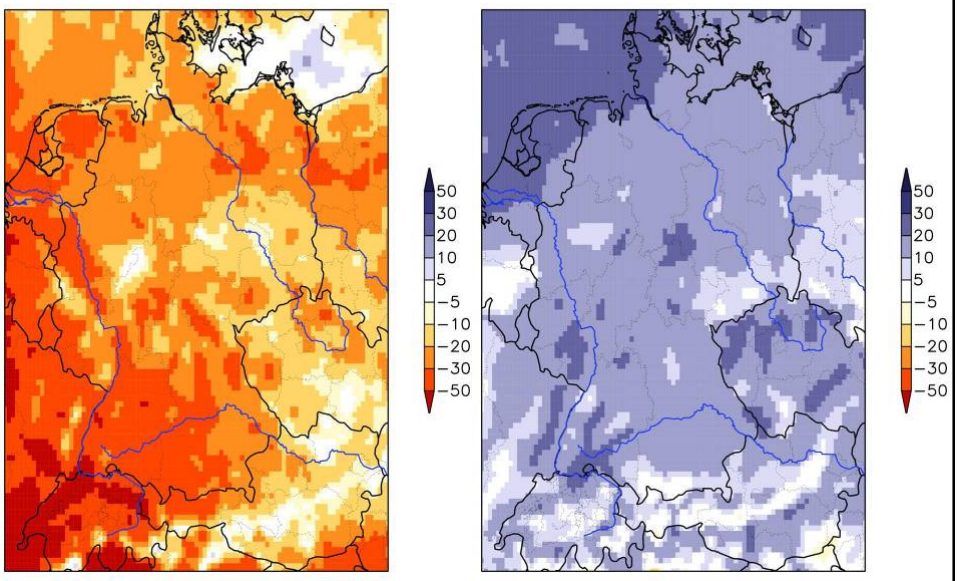
**Scherrer et al. 2006**

# Runoff Regimes in Switzerland
## Pardé-coefficients $P = MQ_{Month} / MQ_{Year}$



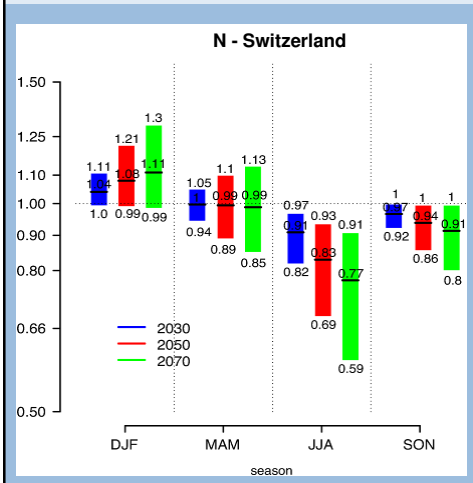


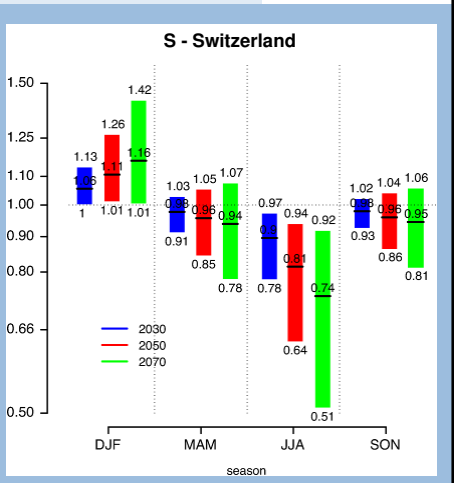

**P summer** **rel. change (2071/2100) – (1961/90)** **P winter**




http://www.mpimet.mpg.de/wissenschaft/ueberblick/atmosphaere-im-erdsystem/regionale-klimamodellierung/remo-uba/aktualisierte-abbildungen.html

# Precipitation Scenarios



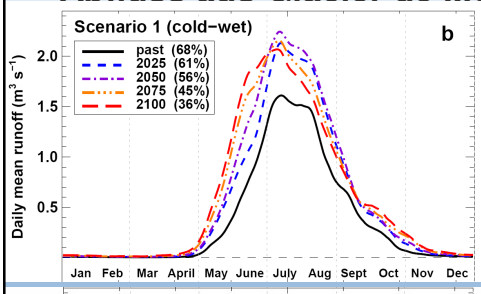



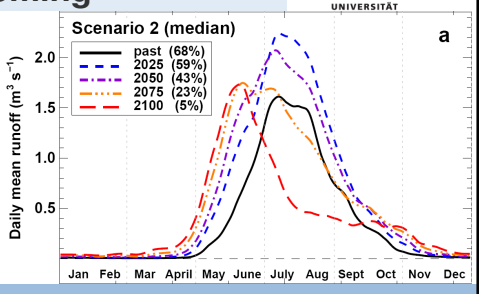

**Changes since 1990, median und 95% confidence**

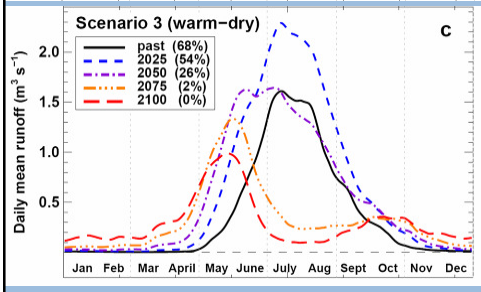
**Frei, 2004**



# Abfluss aus Glacier de Moming



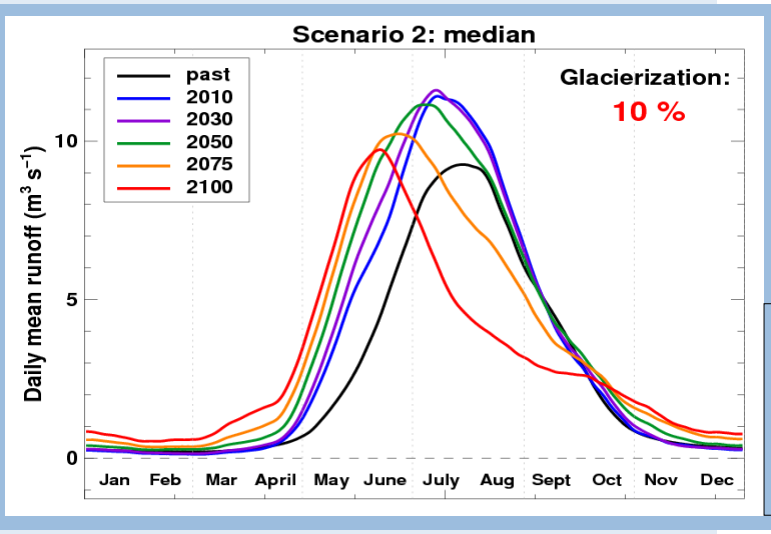




**Abfluss des Glacier de Moming**
(2525 – 4070 m; 6.0 km²; 0.35 km³; 63 %)
im Vergleich mit der Vergangenheit (1961-90)

**Grafik aus**:
Matthias Huss, Daniel Farinotti, Andreas Bauder and Martin Funk (2008):
Modelling runoff from highly glacierized alpine drainage basins in a changing climate.
Hydrological Processes; DOI: 10.1002/hyp.7055

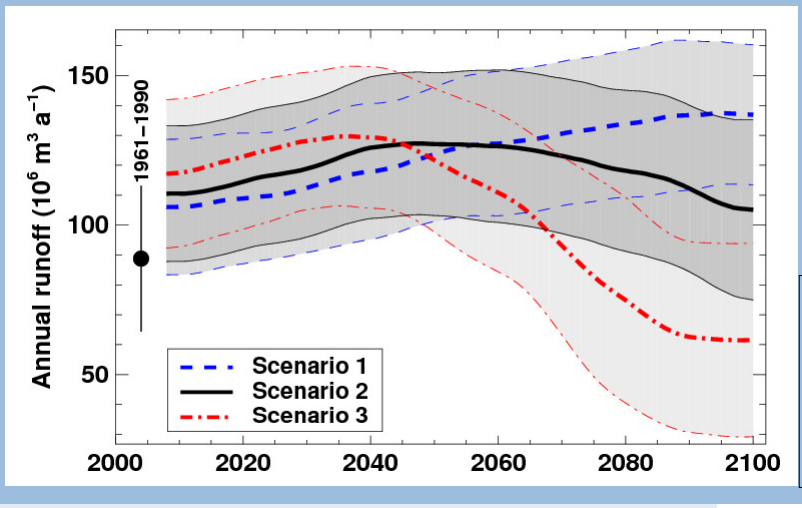
# Runoff Regimes Rhone Glacier




Huss et al. 2008



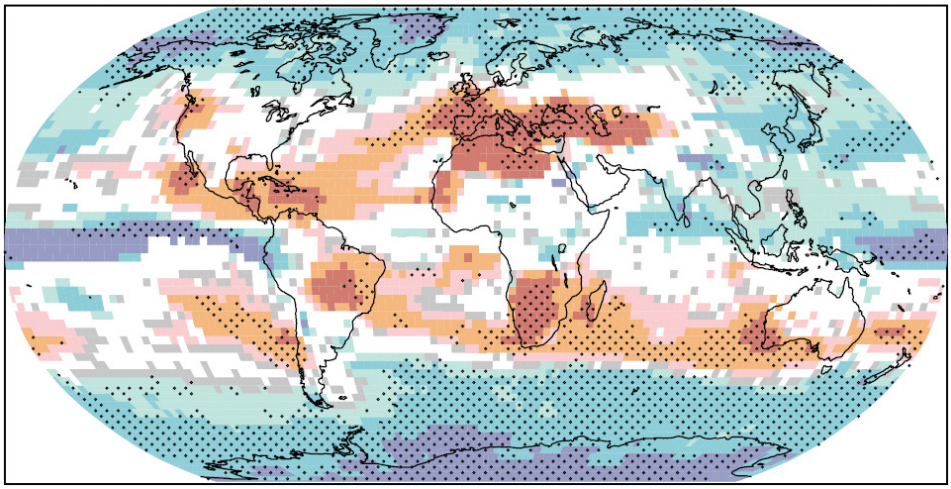
# Annual Runoff 2008-2100




Huss et al. 2008

## Projected Patterns of Precipitation Changes

multi-model A1B JJA



IPCC-AR4 2007 Fig SPM-7

1980-1999 → 2090-2099

% -20 -10 -5 5 10 20

## *Summary Water Resources in the Alps*

- Changes in runoff regimes (1 – 2 classes)
- Mean runoff decreasing
- low water: risk for more severe and longer low water periods in summer, mainly in small streams close to glaciers
- Importance of Water Tower function for lowlands increases
- Seasons, altitude layers and climatic regions have to be considered
- New role of large dam reservoirs towards multi purpose reservoirs: flood protection, irrigation and snow making, drinking water emergency reserve → new roles and rules


Thank you