Climate Change effects on hydropower plants in the Upper Danube watershed

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Hydrology and Remote Sensing WG of the BMBF-project GLOWA-Danube

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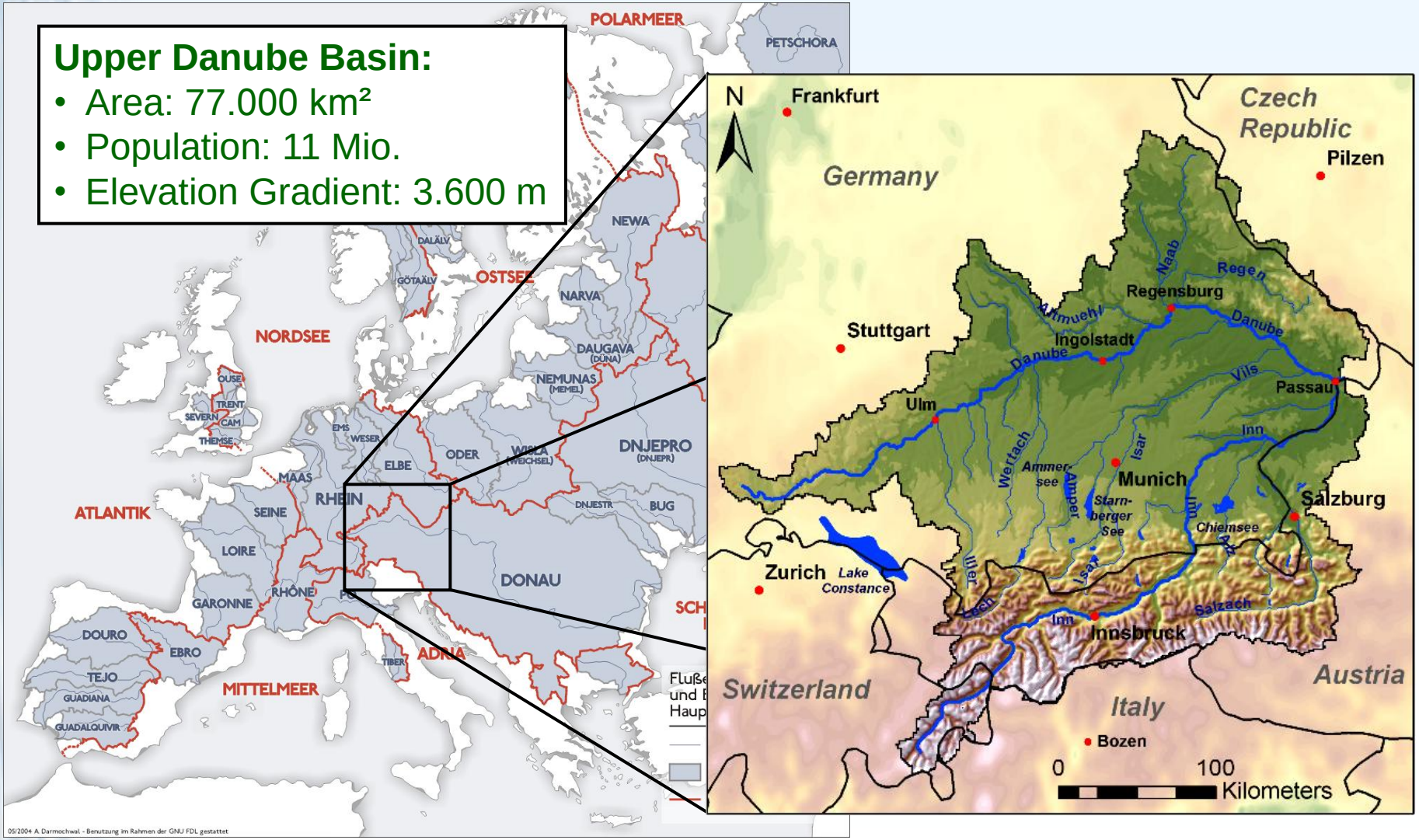
A Regional Scale River Basin

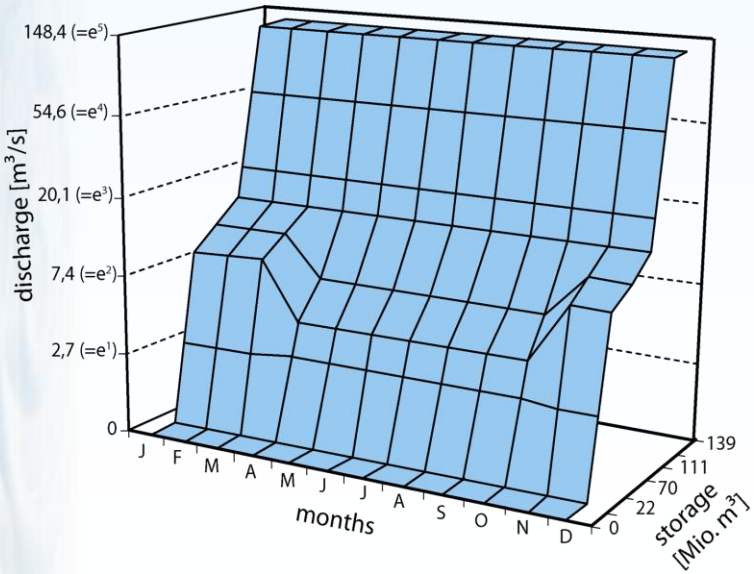
Upper Danube Basin:

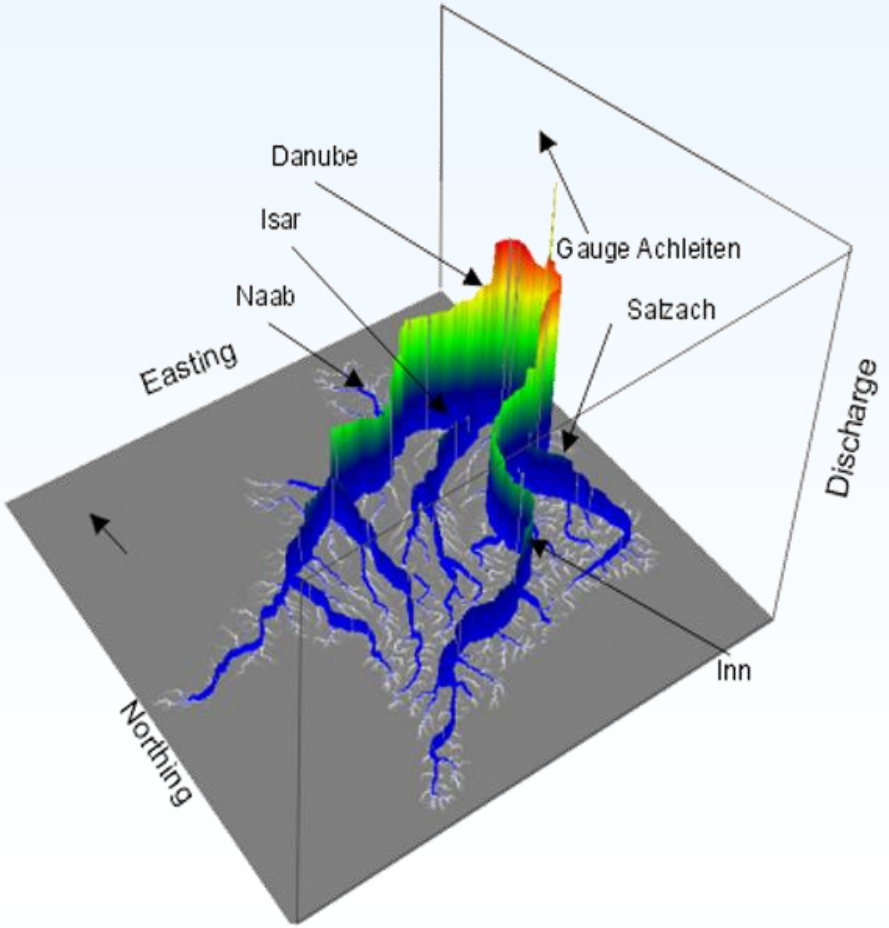
- Area: 77.000 km²
- Population: 11 Mio.
- Elevation Gradient: 3.600 m



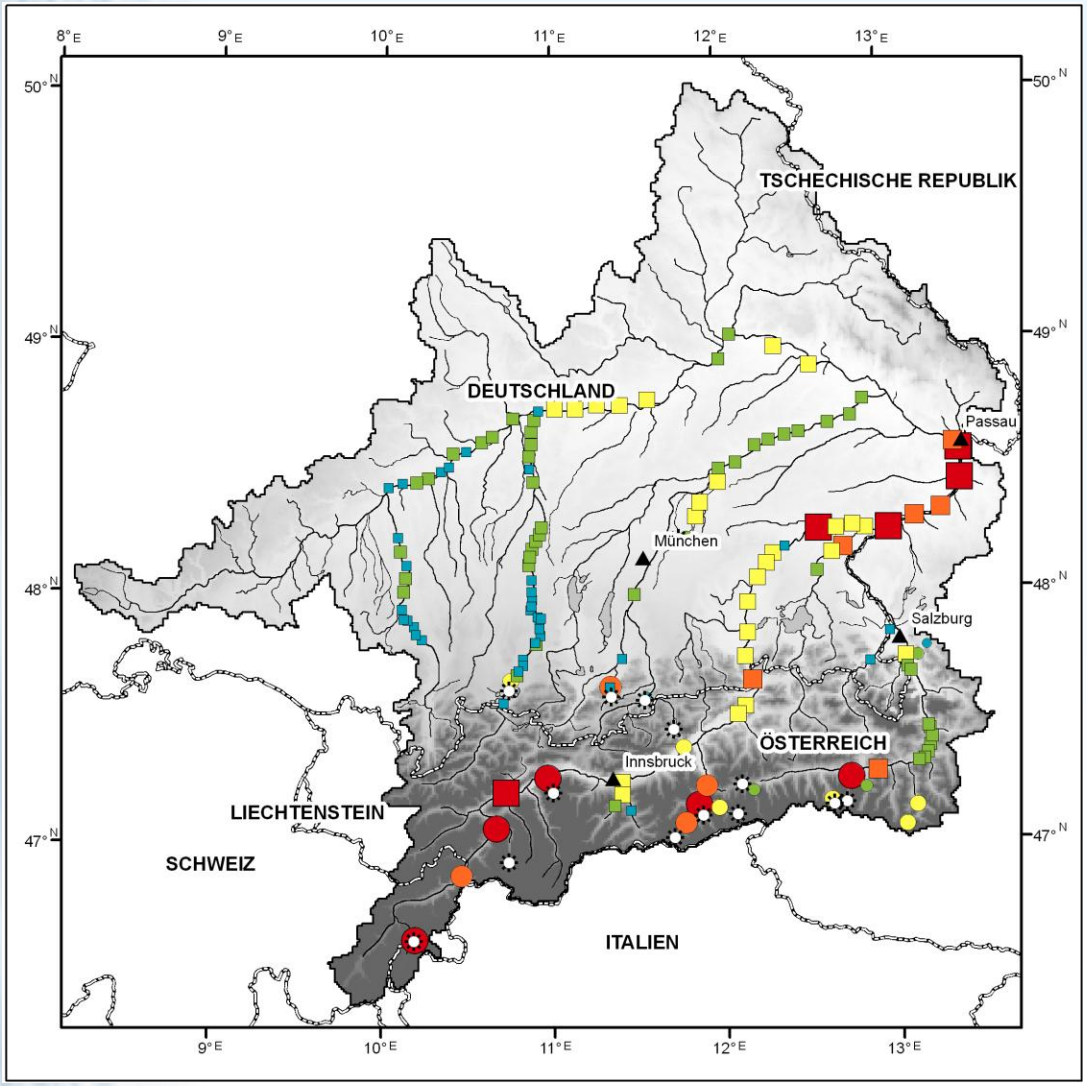
Routing

- runoff concentration
- ground water flow
- lake retention
- reservoir management
- water transfers





Hydropower Plants



maximum capacity > 5 MW

~ 120 runoff-river power plants

~ 20 reservoir hydropower plants

runoff-river power plant
hydropower generation [GWh]

- 20 - 50
- > 50 - 100
- > 100 - 250
- > 250 - 500
- > 500

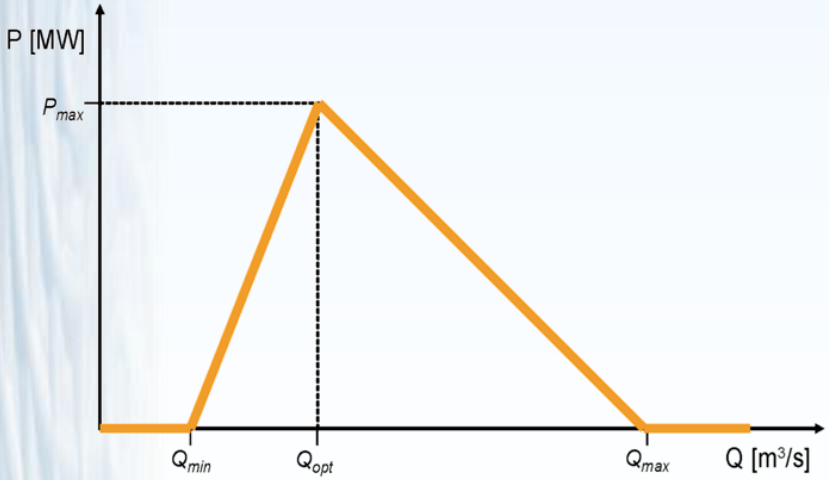
reservoir hydropower plant
hydropower generation [GWh]

- 20 - 50
- > 50 - 100
- > 100 - 250
- > 250 - 500
- > 500
- reservoir

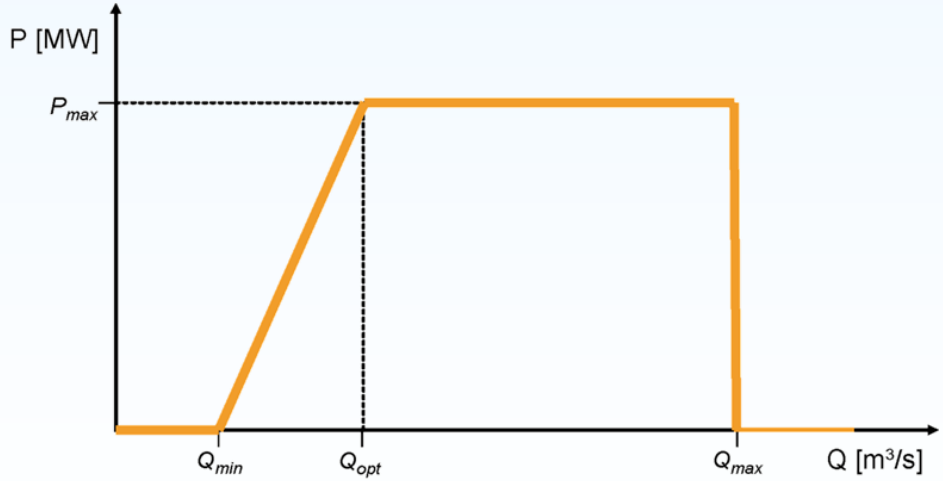
Hydropower Module

Capacity: $P = \eta * \rho * Q * g * H$ [kW]

runoff-river power plant



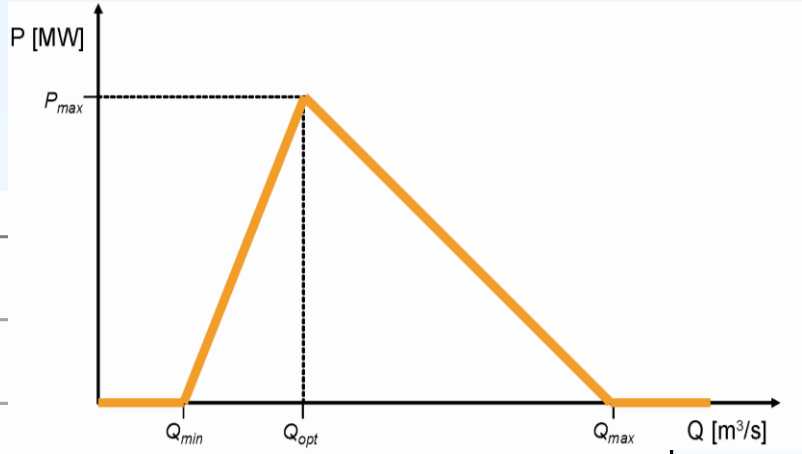
reservoir hydropower plant

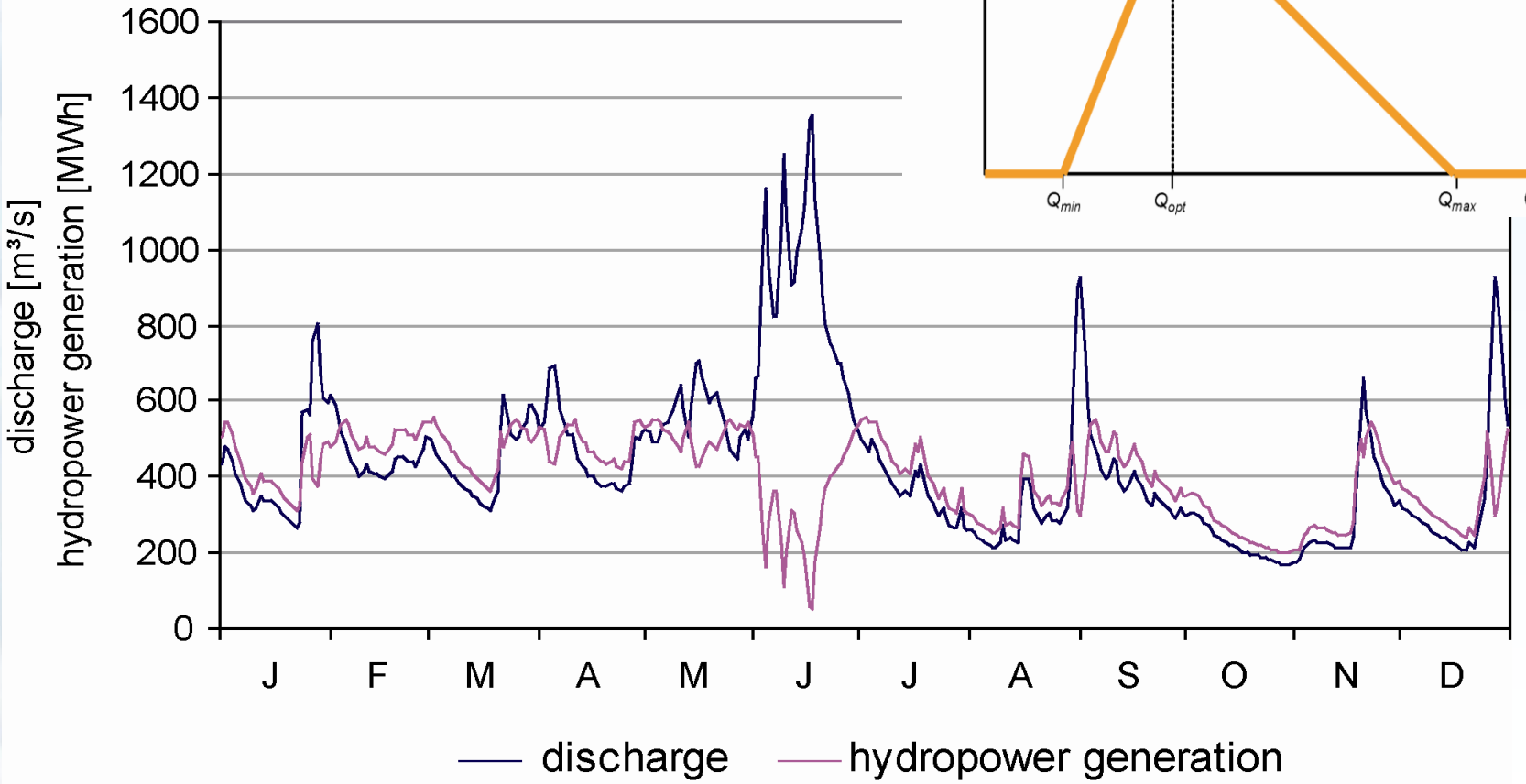


Parameters: hydraulic height, maximum capacity, maximum turbine discharge, efficiency

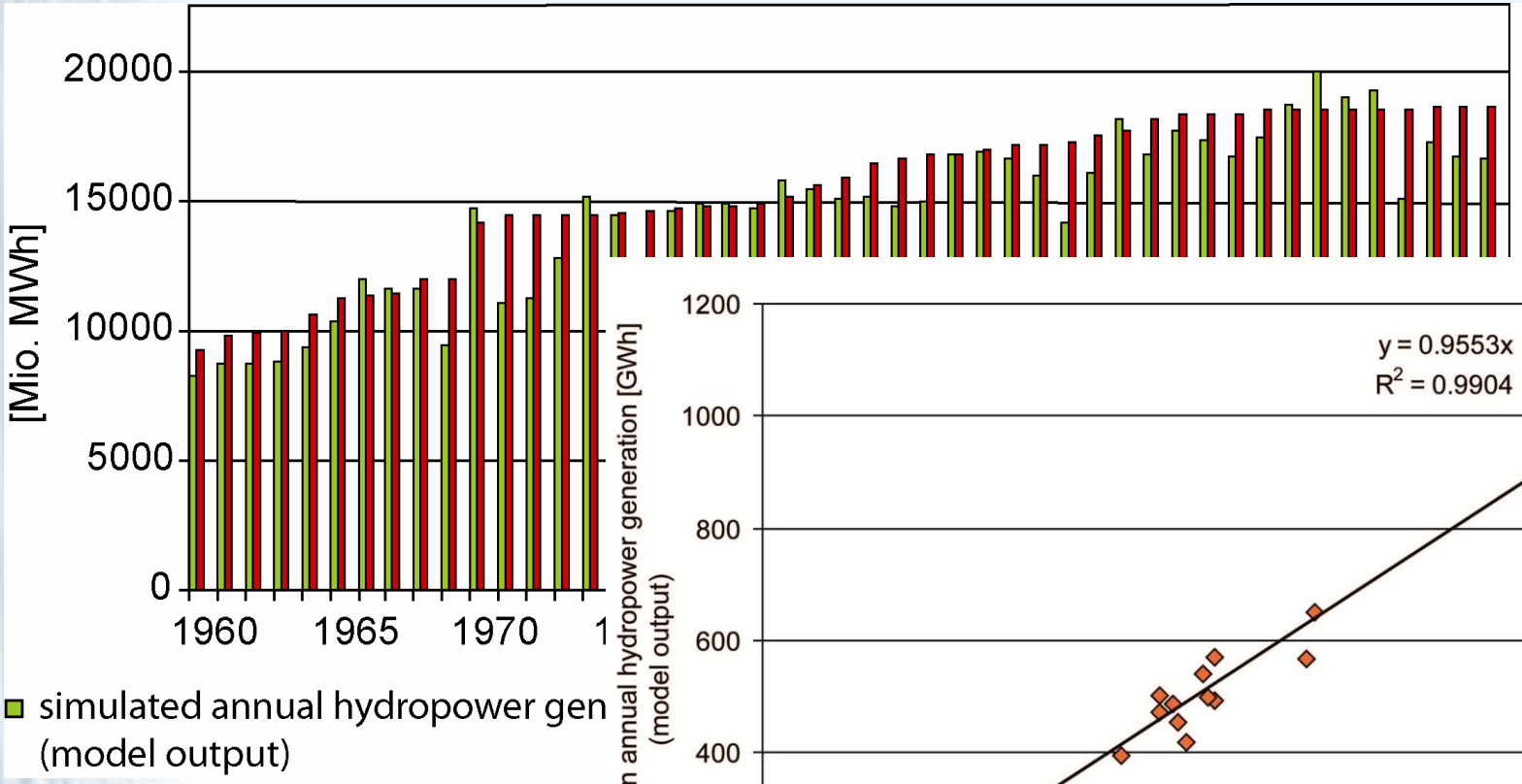
Hydropower generation vs. discharge

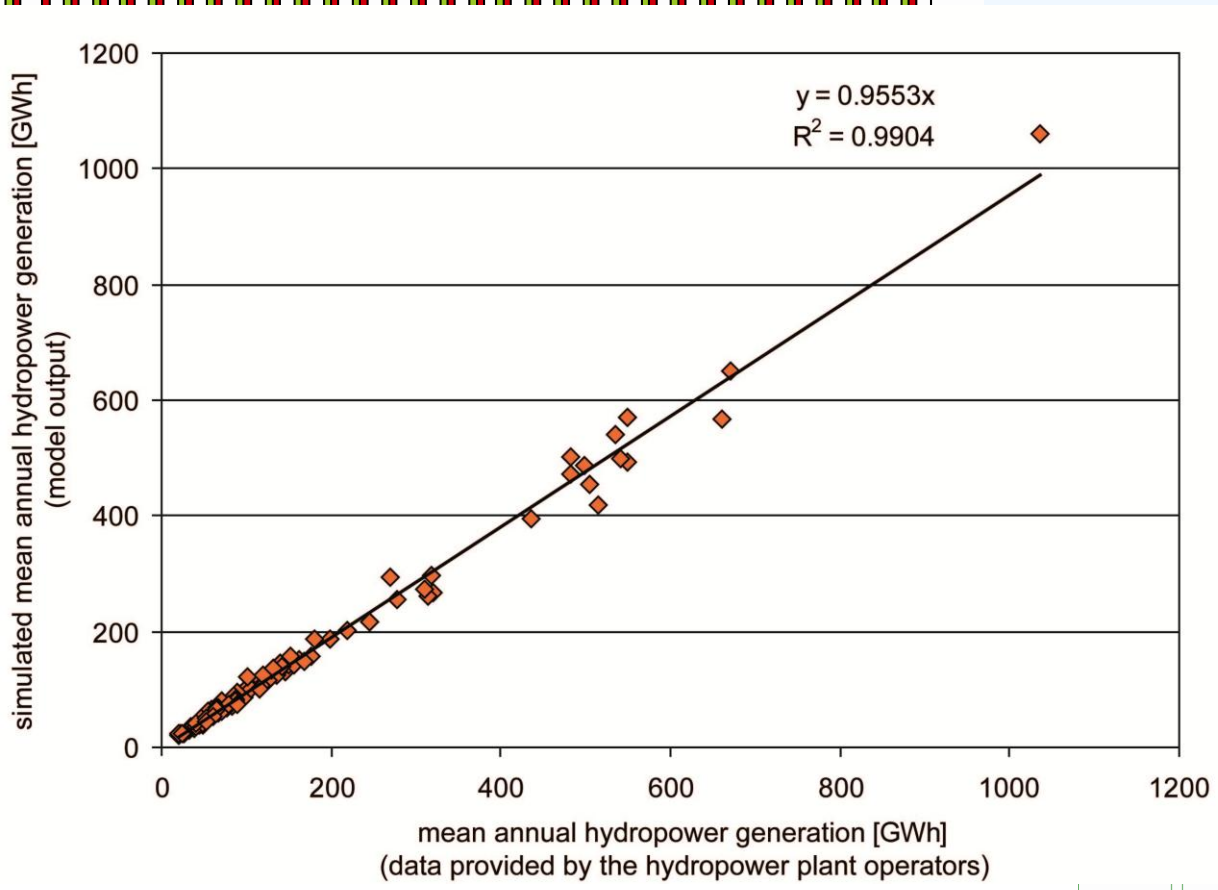
Example: runoff-river power plant Vohburg, Danube (1995)





Validation hydropower generation





GLOWA-Danube climate scenarios

Selection 1: climate trends

- *IPCC regional*
- *REMO regional*
- *MM5 regional*
- *Extrapolation*

X

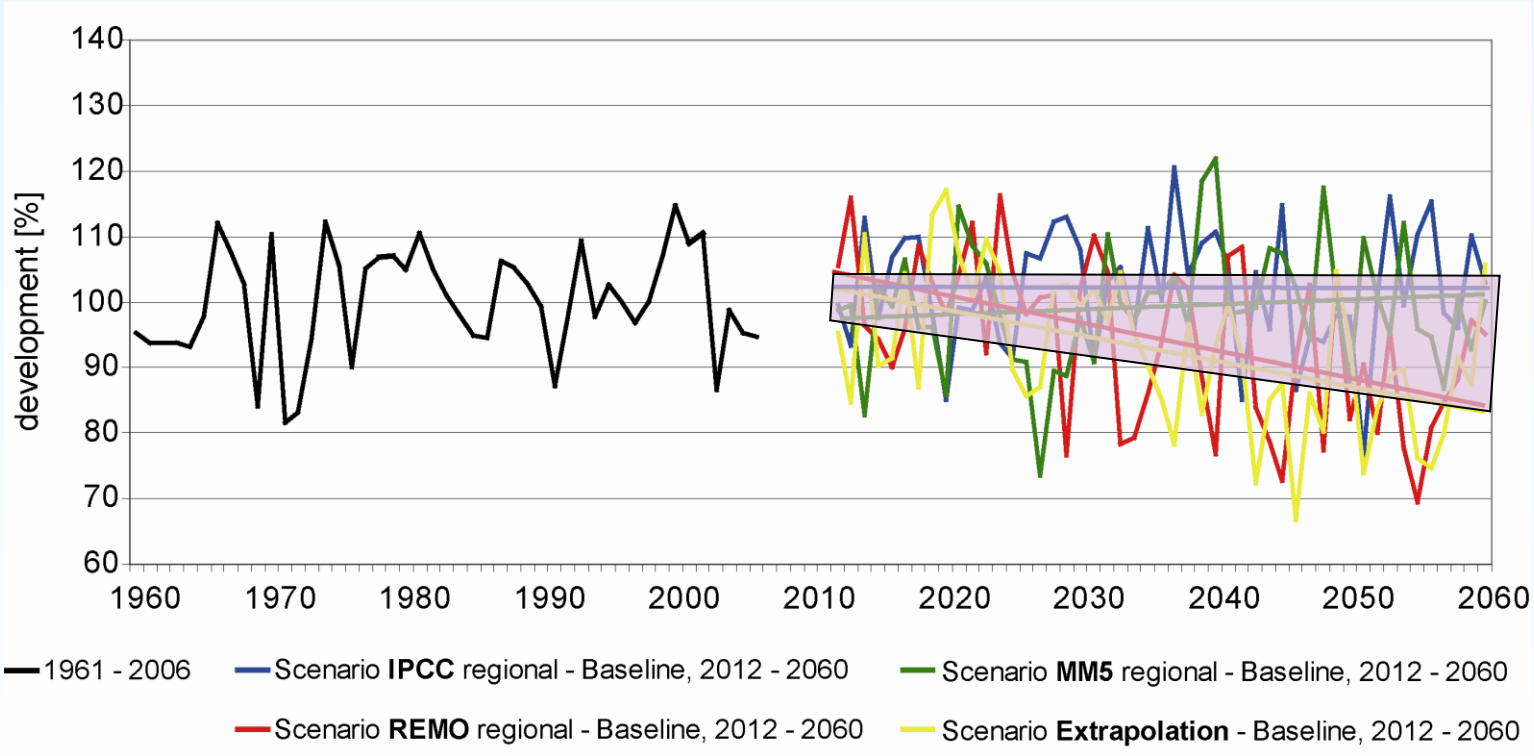
Selection 2: climate variants

- *Baseline*
- *5 warm winters*
- *5 hot summers*
- *5 dry years*

=

16 different climate scenarios

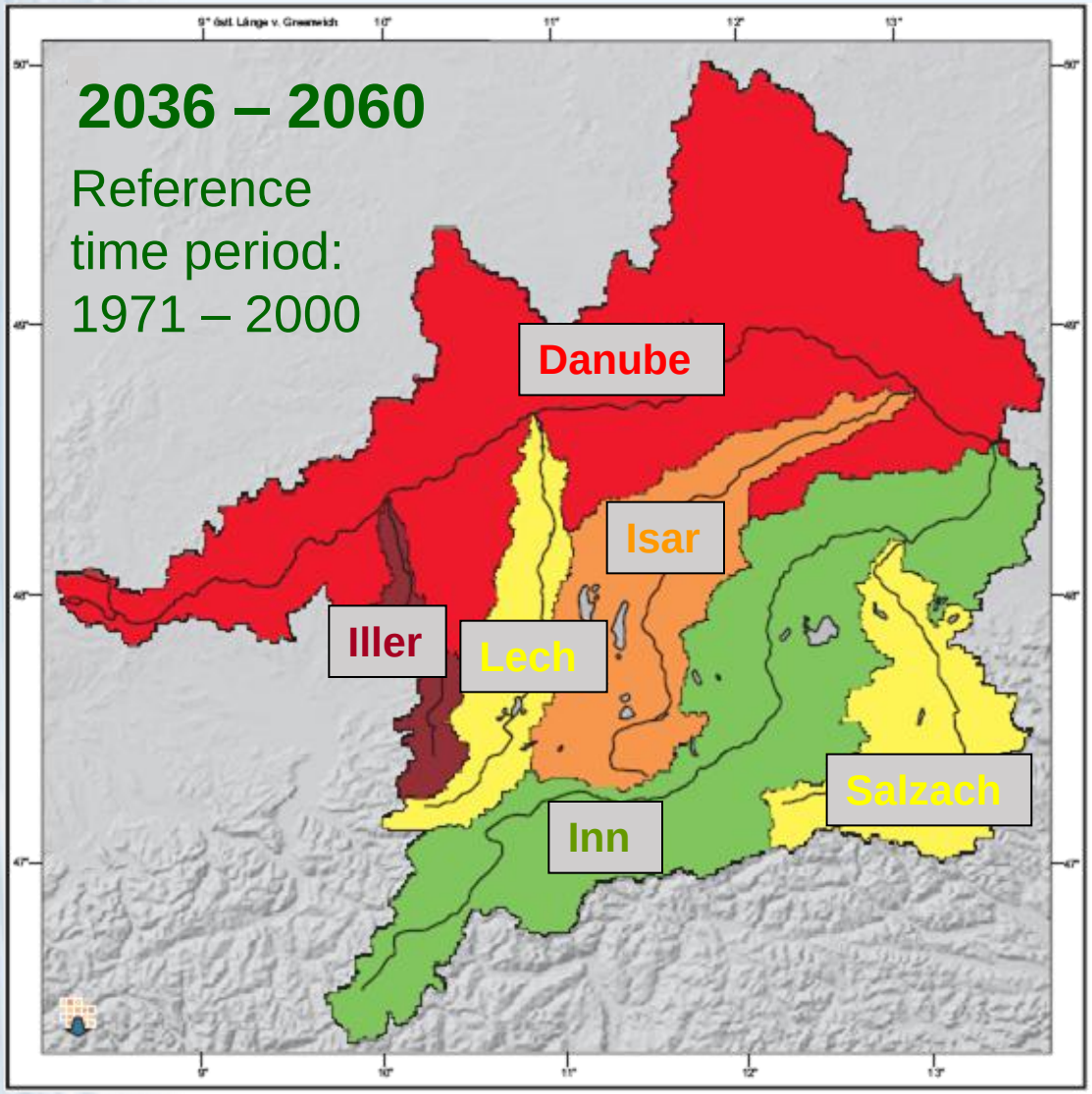
Development of hydropower generation in the Upper Danube watershed



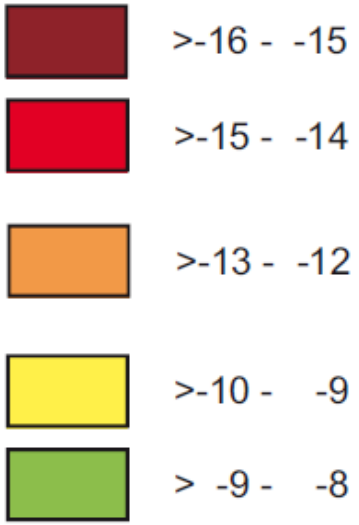
REMO regional x

Baseline:	2011 – 2035:	**- 1,8%**
	2036 – 2060:	**- 11,3%**
5 dry years:	2021 – 2025:	**- 17,1%**

Regional differences



Reduction of hydro-power generation [%]



climate scenario:
REMO regional – Baseline

Conclusions

- Hydropower generation is expected to decrease in the next decades
- Strong influence of dry years
- Regional differences based on future low-flow conditions and the snow & ice storage
- Changes of the runoff regime will also influence the inter-annual hydropower generation

- Development, analysis and evaluation of scenarios and adaption strategies in cooperation with **Stakeholders,** e.g. hydropower plant operators


Thank you very much
for your attention!
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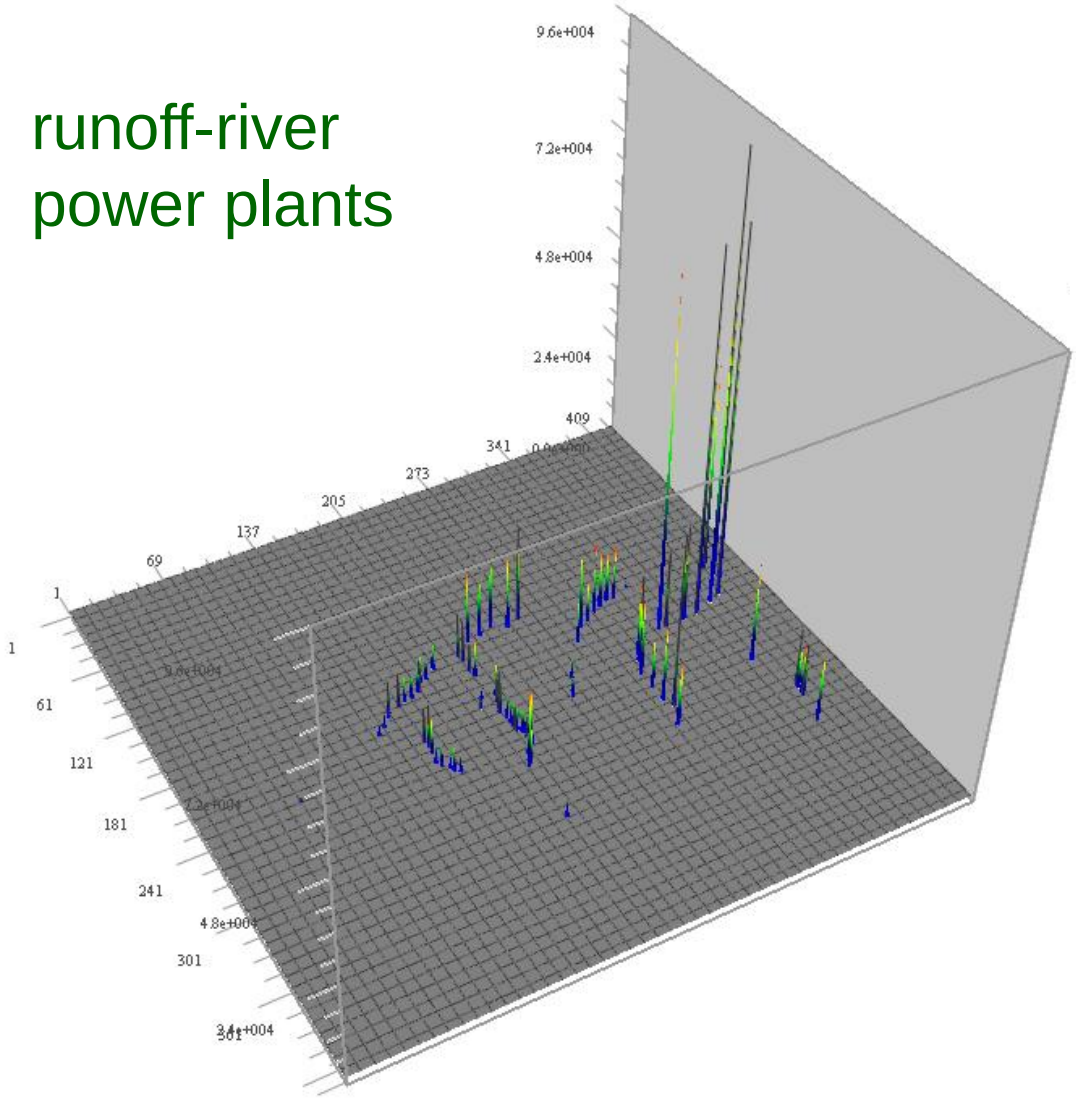
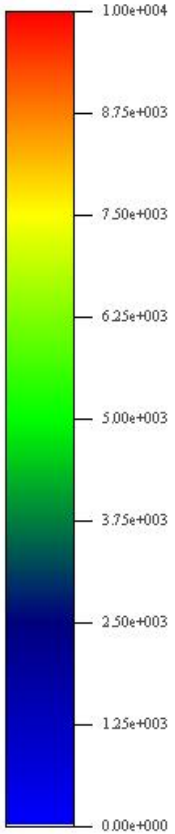
Vista
Schlegeisspeicher, 1782m
Zillertaler Alpen, 24.6.2006
http://www.christianengl.de/Schlegeisspeicher.jpg

Hydropower Plants

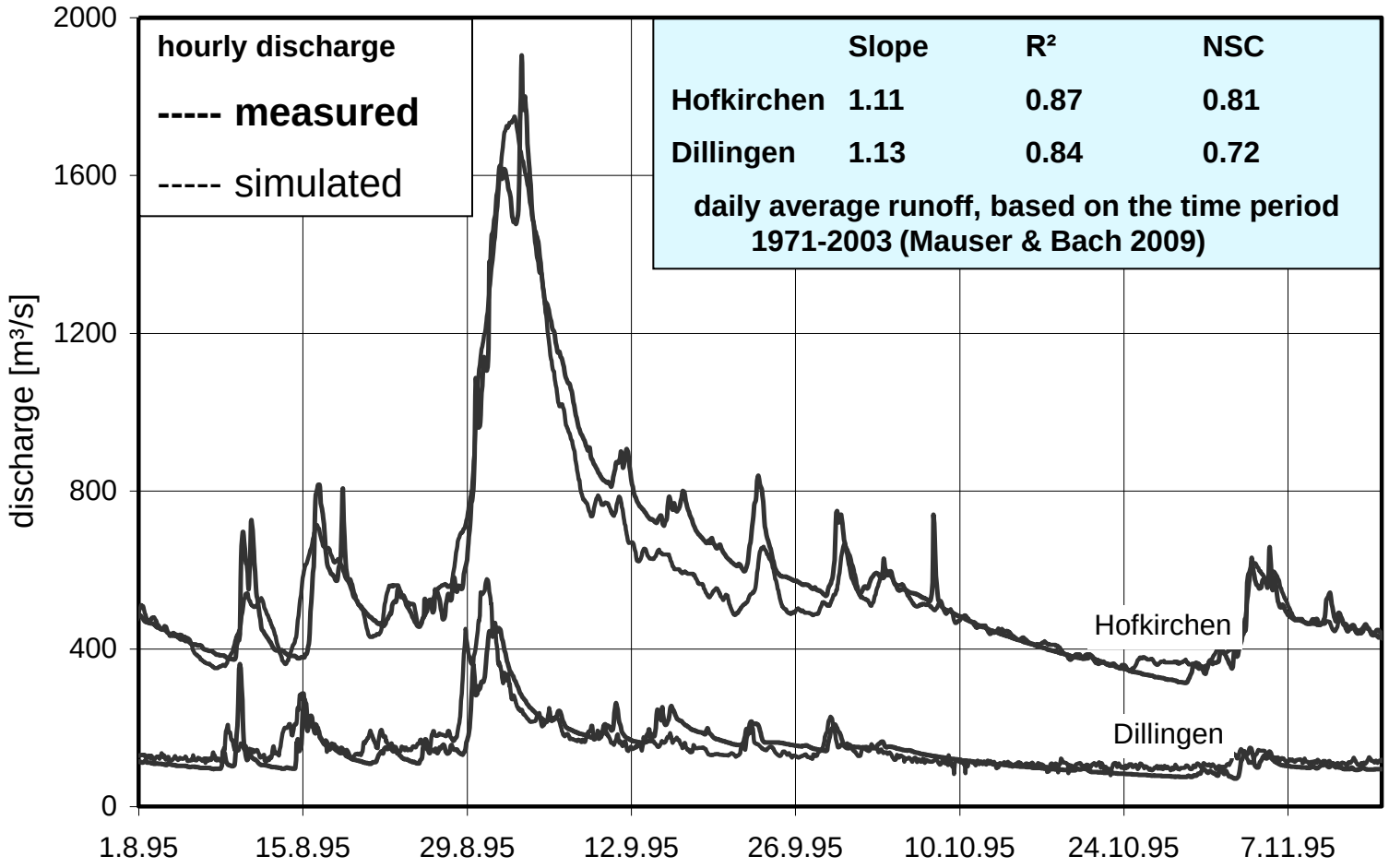
runoff-river
power plants



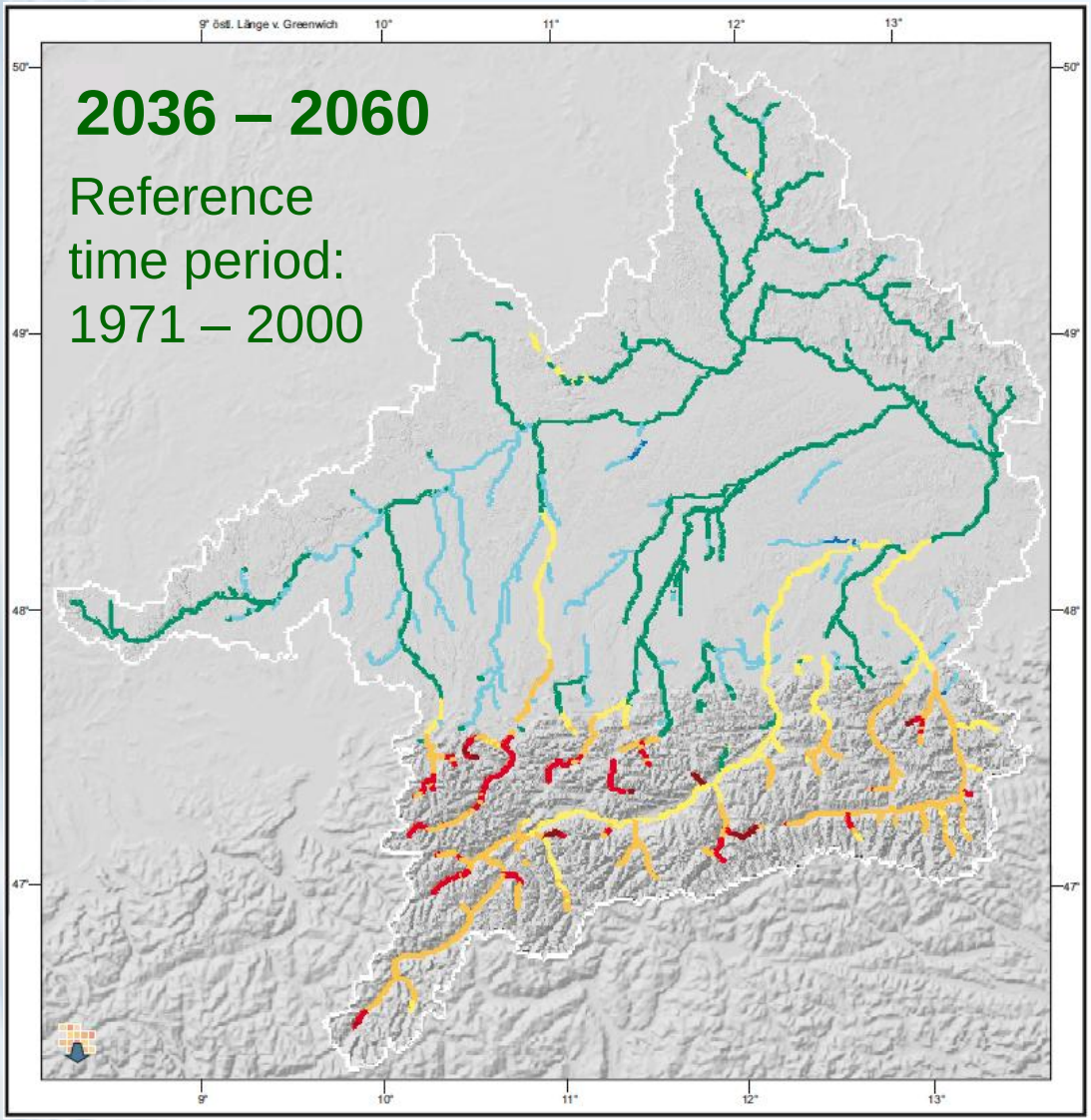
hydropower generation



Validation runoff



Low-flow conditions



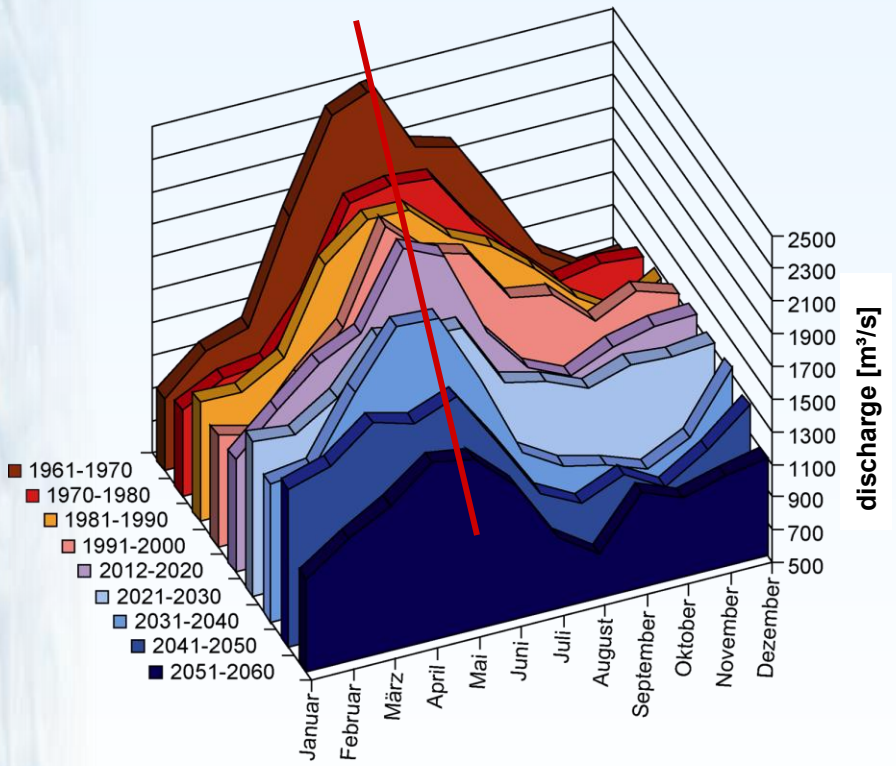
Development of the low-flow situation [%]

0 - 0,25	
>0,25 - 0,50	→ more drastic
>0,50 - 1,00	
>1,00 - 1,50	
>1,50 - 2,00	→ less drastic
>2,00 - 2,50	
> 2,50	

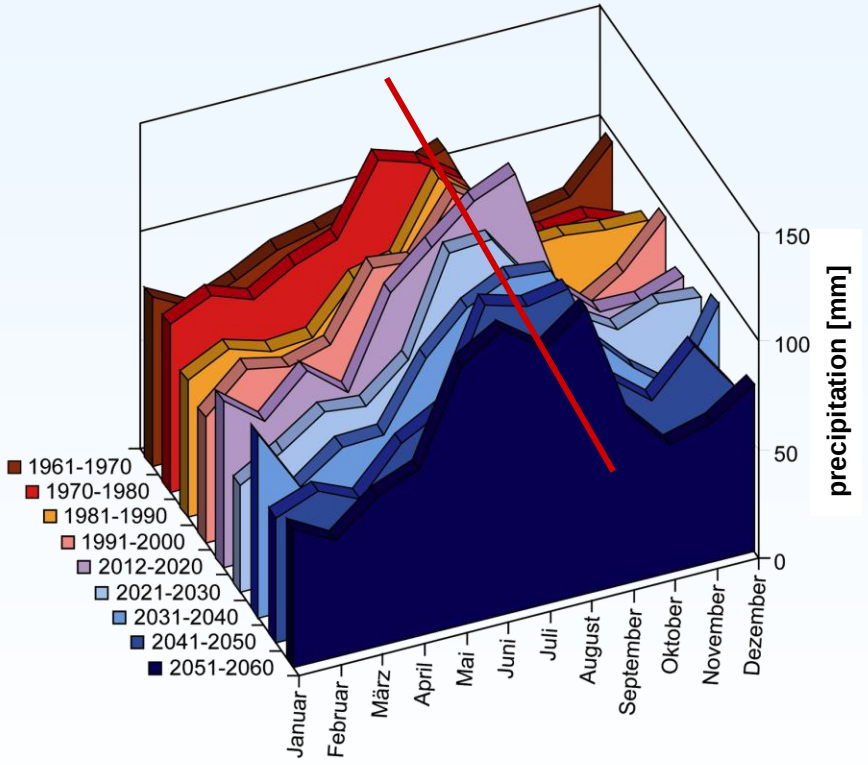
climate scenario:
REMO regional – Baseline

Seasonal development

Discharge (outlet Achleiten)



precipitation



⇨ discharge maximum is shifted from summer to spring

⇨ smoother annual hydrograph

⇨ Influence on inter-annual hydropower generation

climate scenario:
REMO regional – Baseline