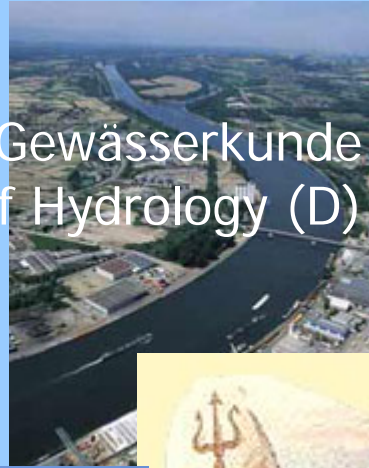


Manifestation of Socio-Economic Influences in Discharge Patterns

Jörg Uwe Belz

Bundesanstalt für Gewässerkunde
Federal Institute of Hydrology (D)

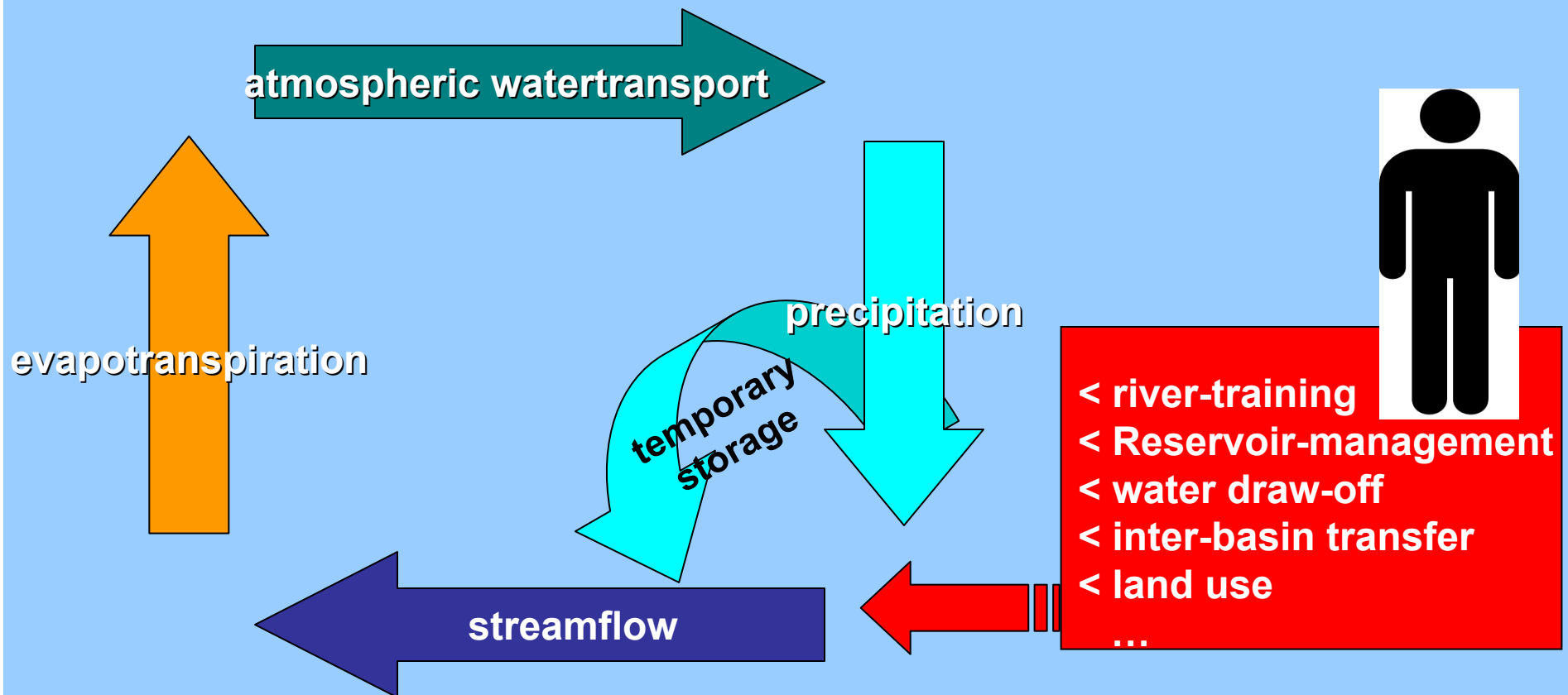


Socio-economics...

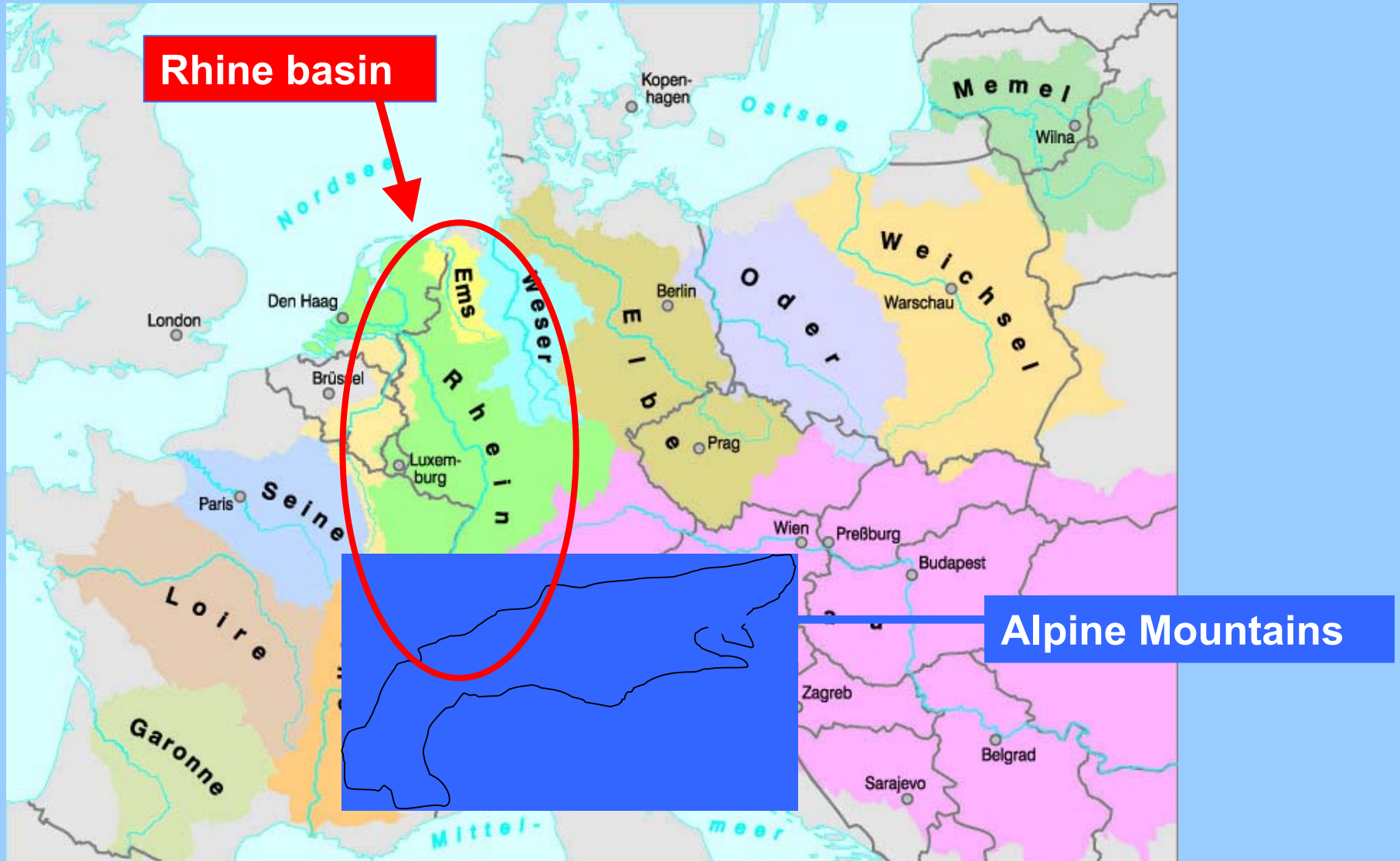
...focus on the interactions and interdependencies of politics, society and economics...

...thus „**socio-economic influence**“ is a complex of developments, like an indirect force triggering various anthropogenic processes, which may lead to substantial modification of elements of the natural water-cycle.

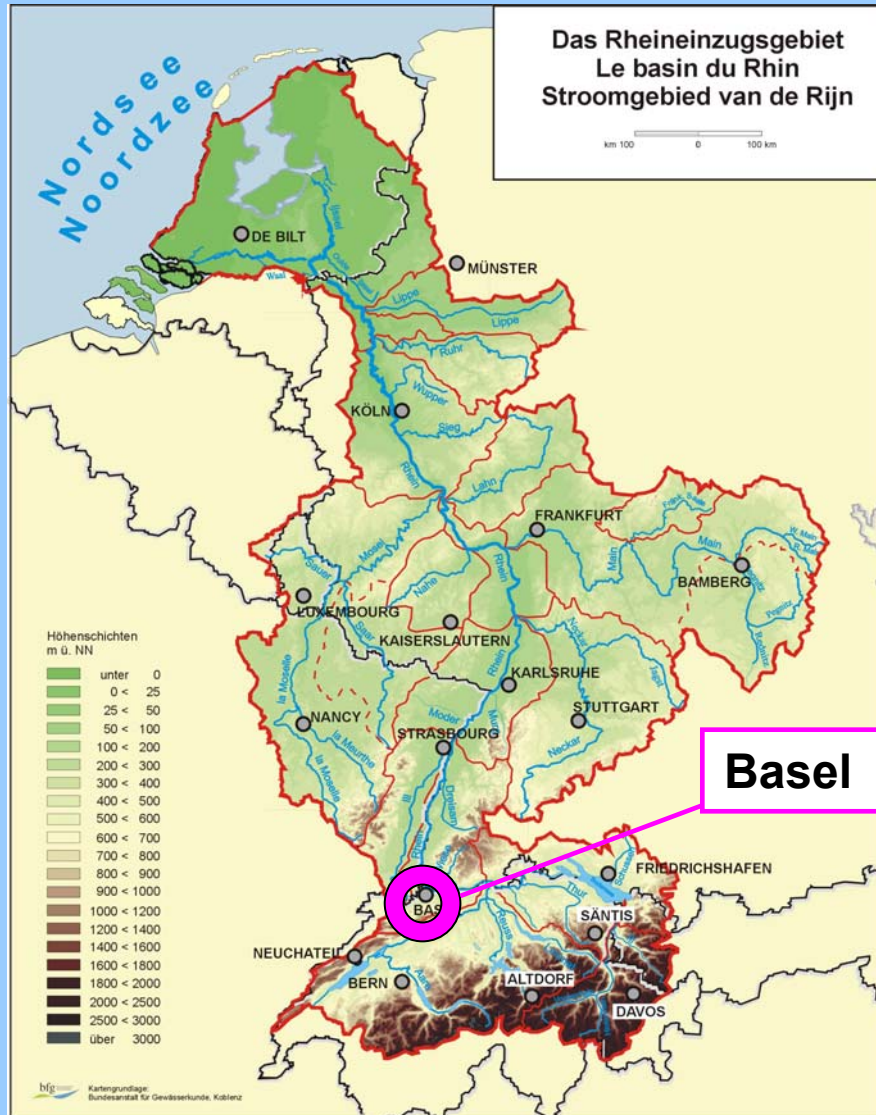
Hydrologic cycle and the anthropogenic impact on streamflow characteristics



Major river basins in Europe



River Rhine: Basin characteristics



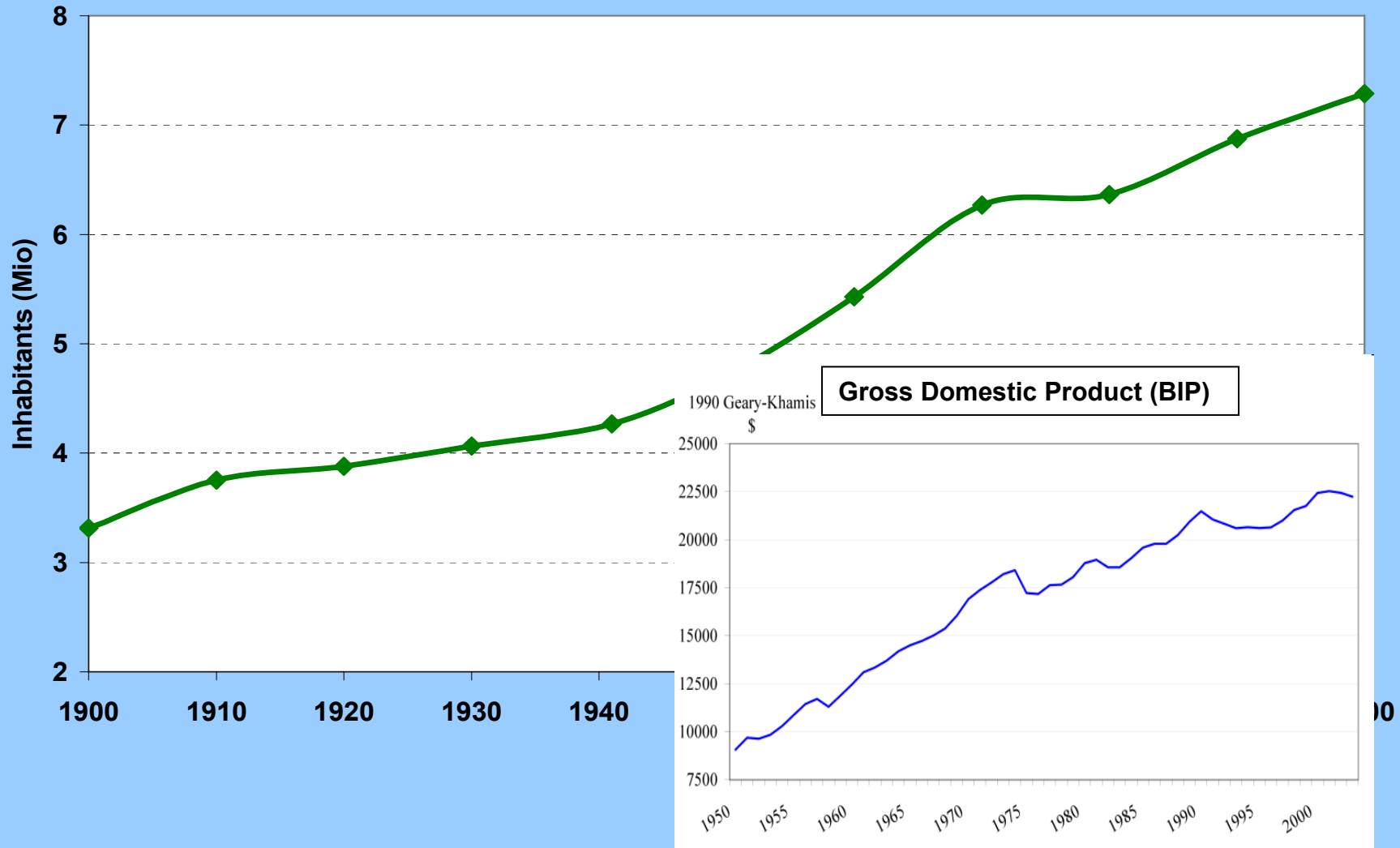
- $A_{E0} \sim 197.000 \text{ km}^2$
- $\sim 58 \text{ Mio. inhabitants}$
- $9 \text{ riparian countries}$
- $\text{river length: } \sim 1238 \text{ km}$
- $\text{primary flow-parameters near the mouth:}$
 - $\text{NNQ} \sim 600 \text{ m}^3/\text{s}$
 - $\text{MQ} \sim 2.500 \text{ m}^3/\text{s}$
 - $\text{HHQ} \sim 12.000 \text{ m}^3/\text{s}$

Socio-economic Dynamics in Switzerland



Switzerland: Demographic Development

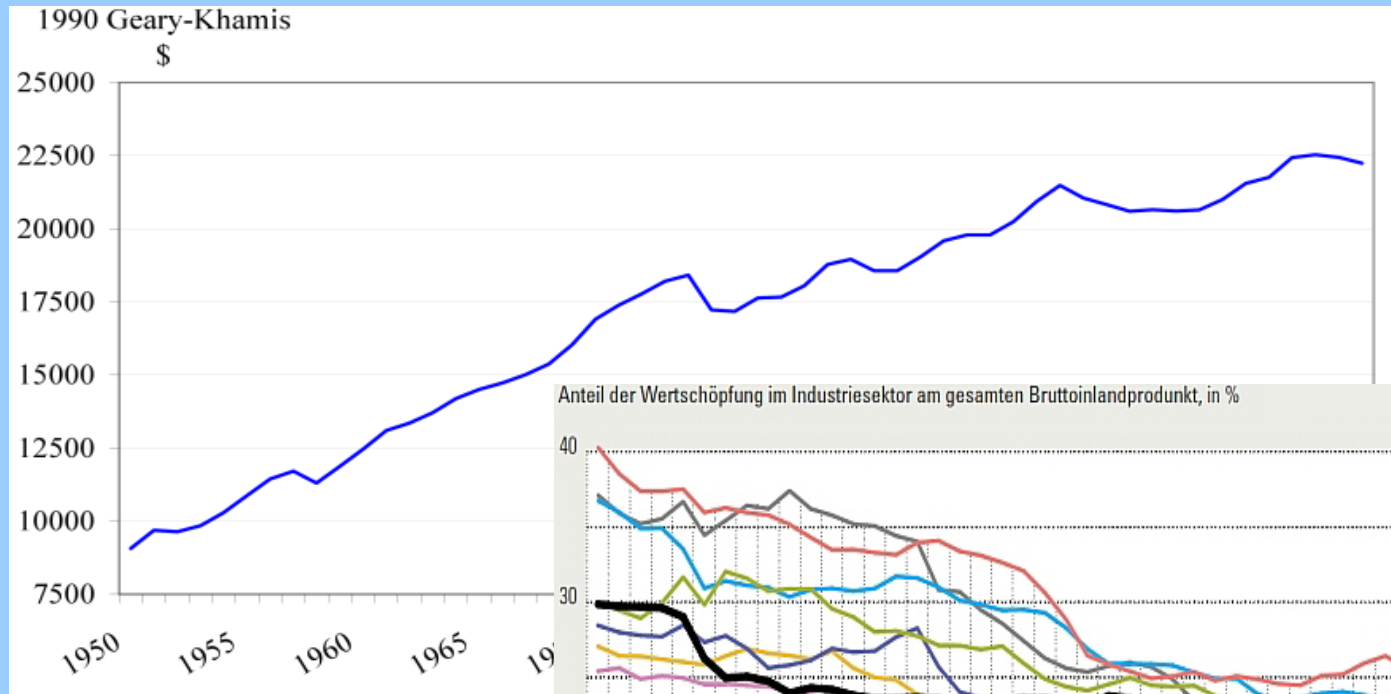
(data: BFS CH)



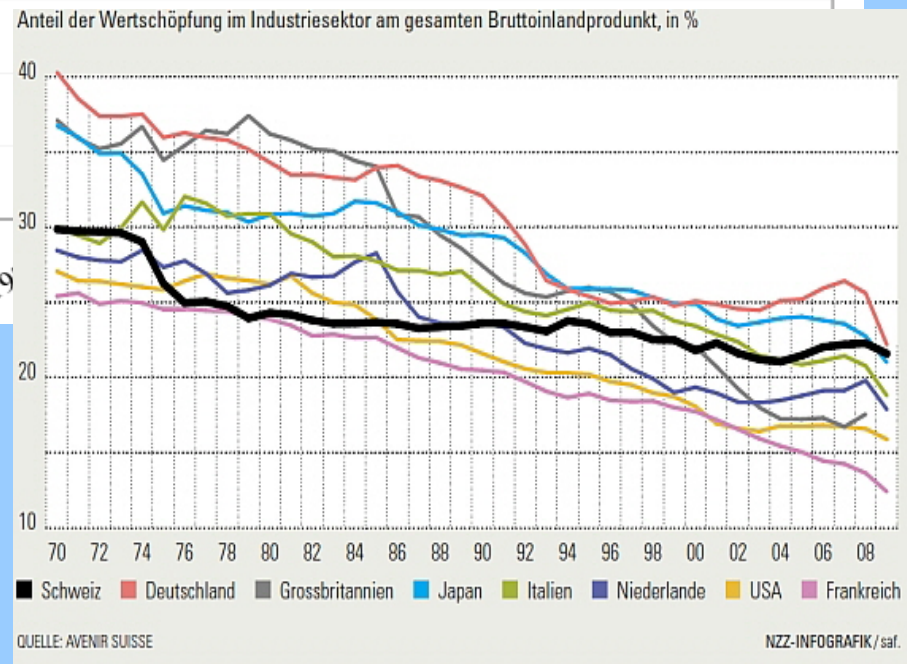
Socio-economic Dynamics in Switzerland



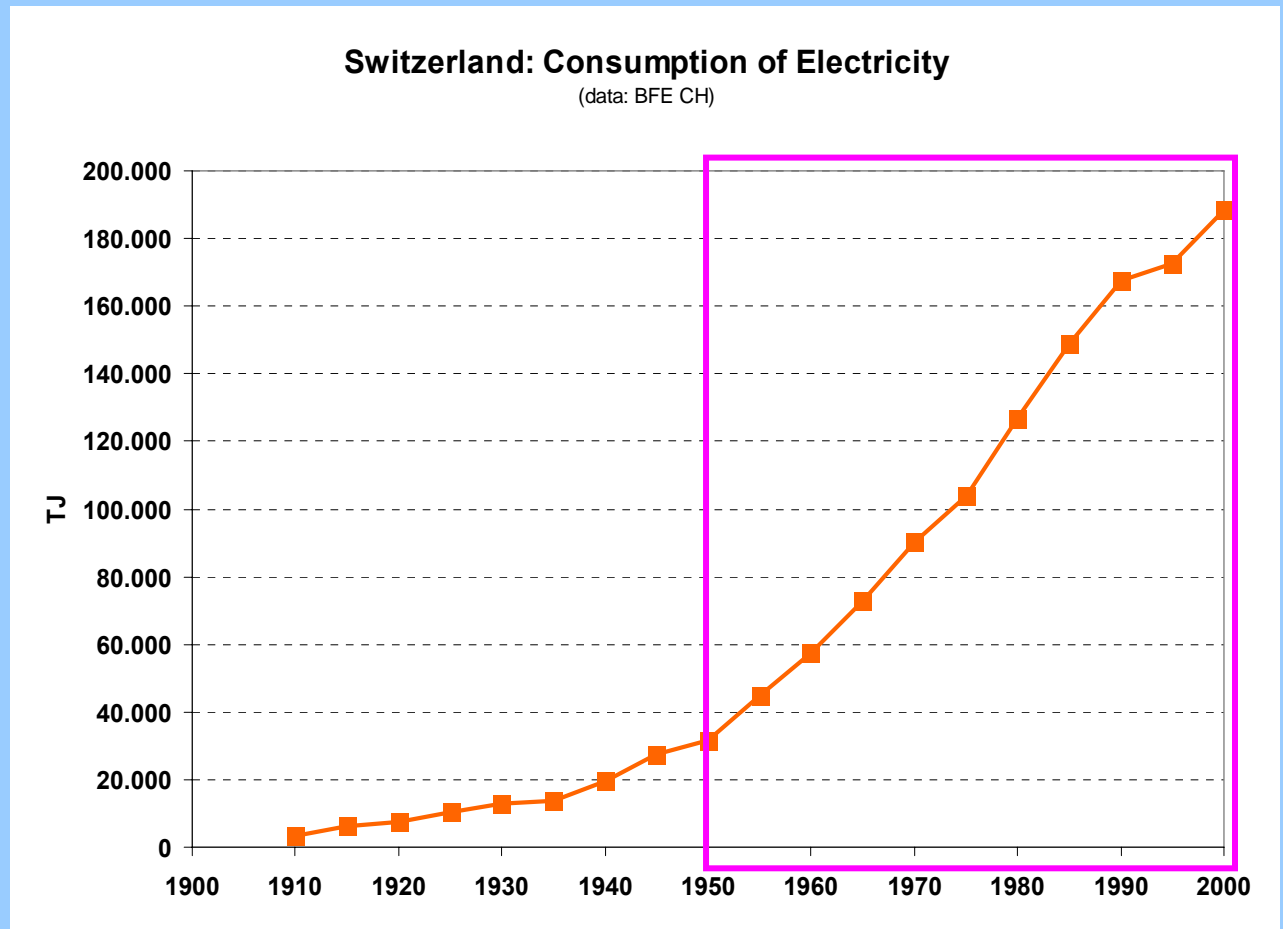
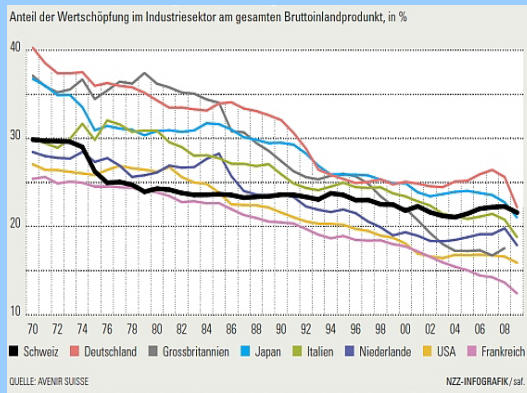
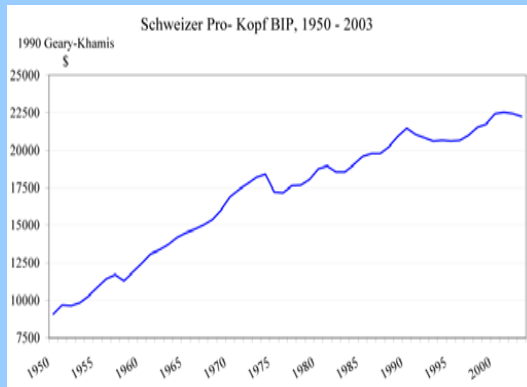
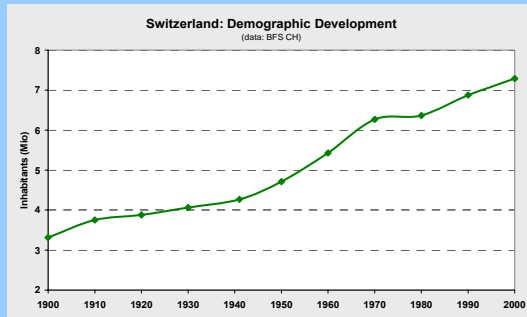
**Increasing
Gross
Domestic
Product**



**Decrease of
industrial
added value**

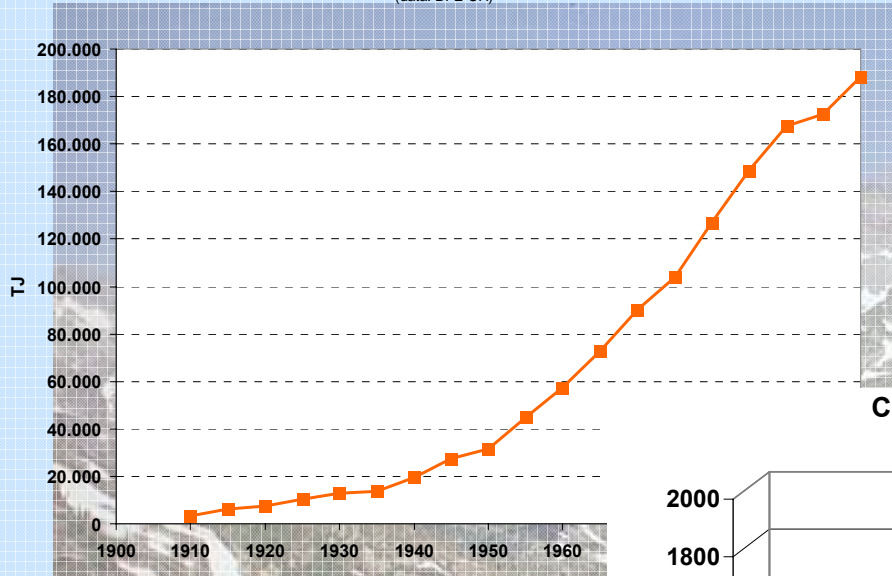


Electricity: A Vital Need in Modern Societies

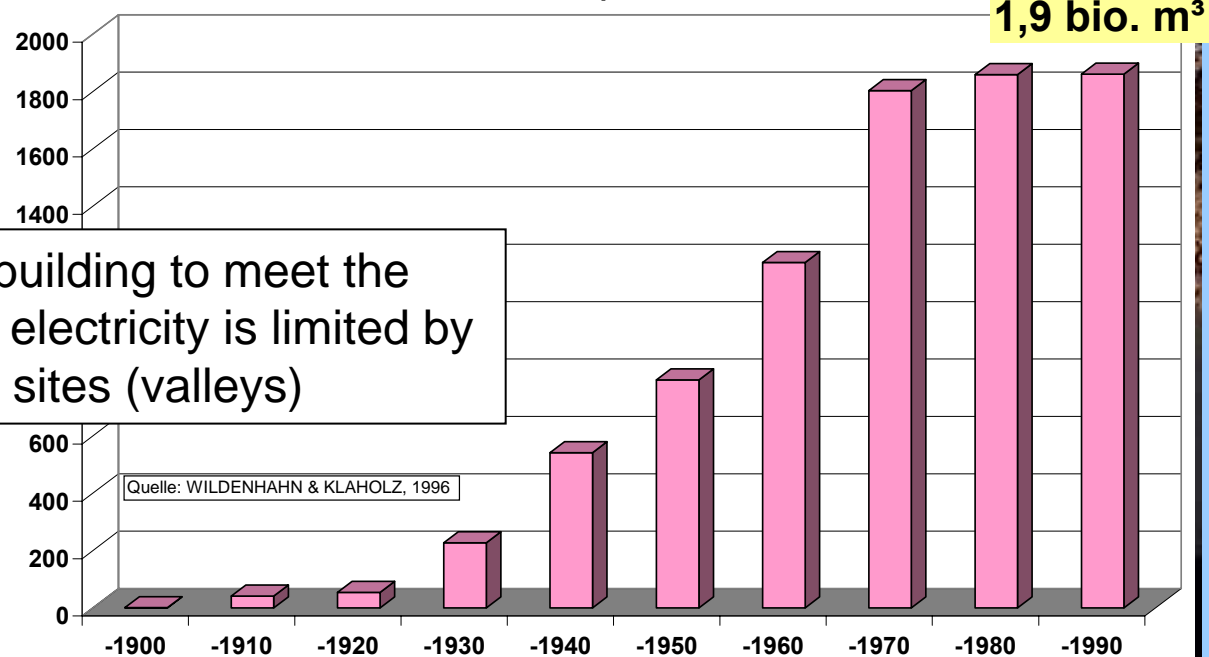


Reservoir-Building as result of socio-economic needs

Switzerland: Consumption of Electricity
(data: BFE CH)



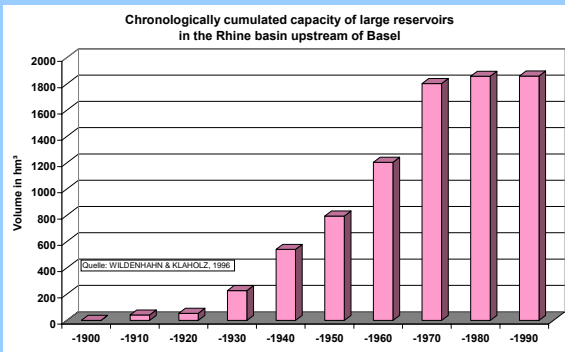
Chronologically cumulated capacity of large reservoirs in the Rhine basin upstream of Basel



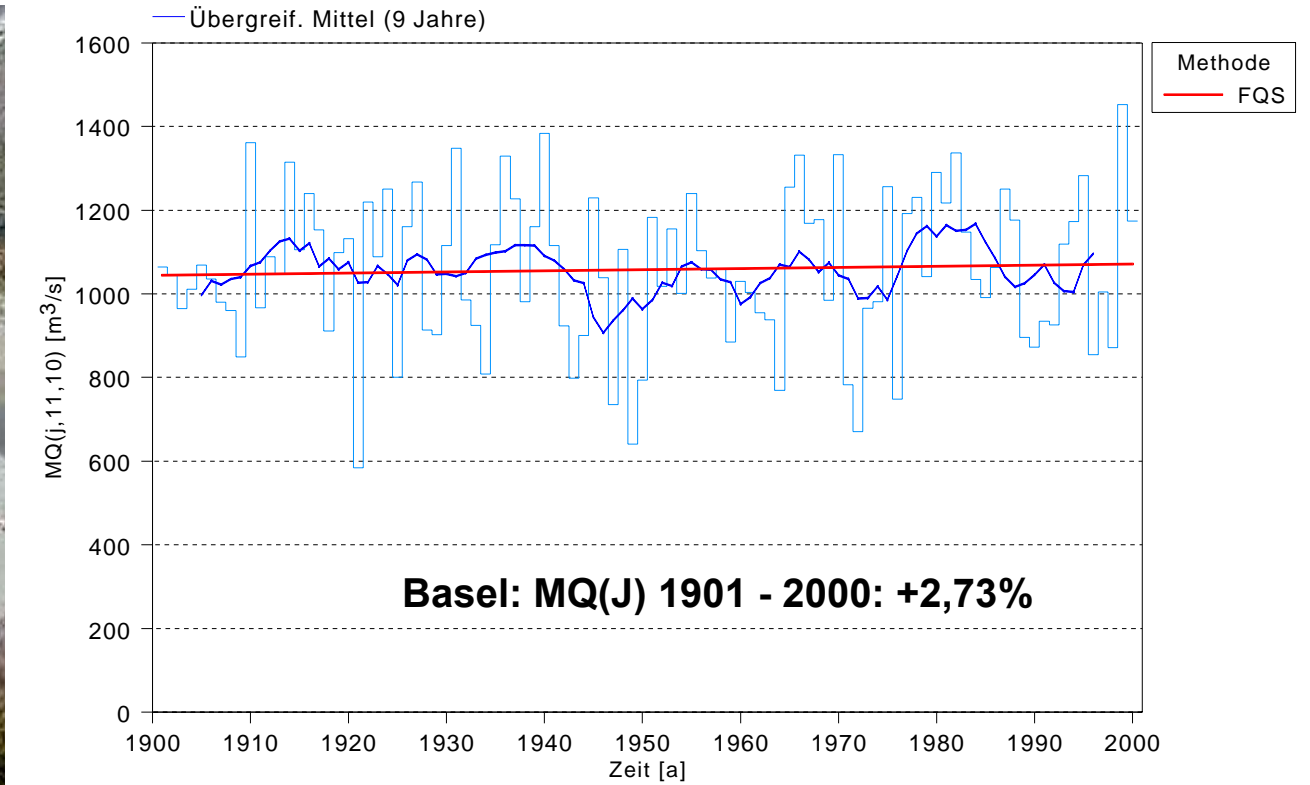
Reservoir-building to meet the demand of electricity is limited by disposable sites (valleys)



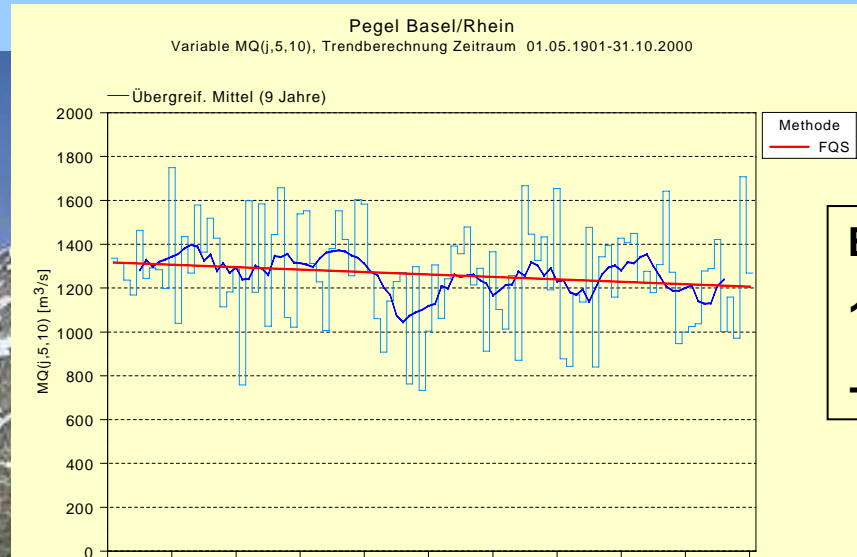
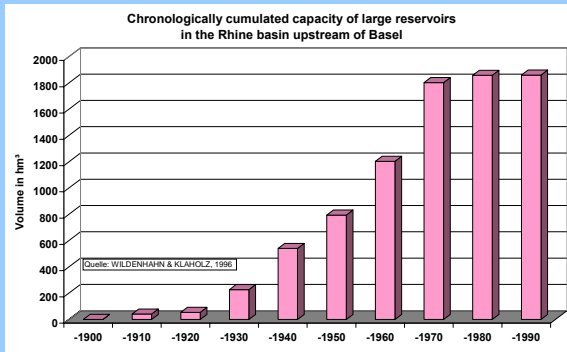
Changes of flow-regime: Seasonal Redistribution



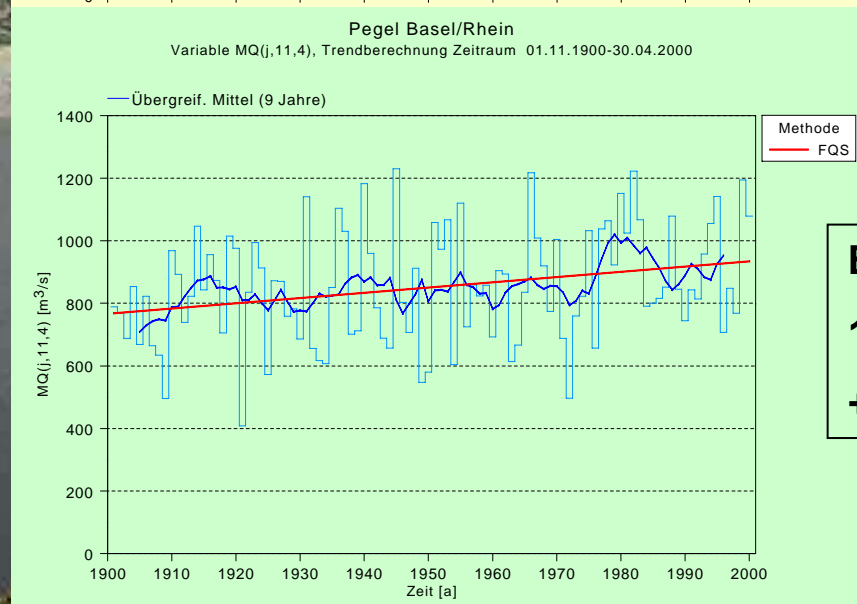
Pegel Basel/Rhein
Variable $MQ(j,11,10)$, Trendberechnung Zeitraum 01.11.1900-31.10.2000



Changes of flow-regime: Seasonal Redistribution

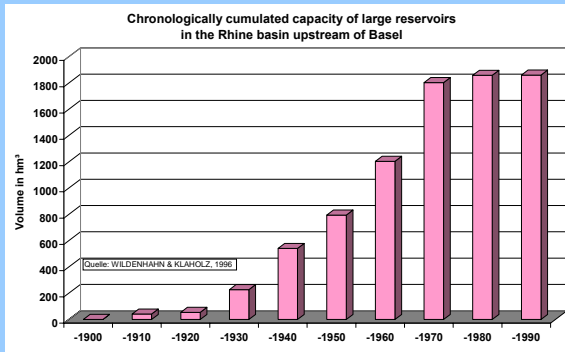


Basel: MQ(s)
1901 - 2000:
-8,72%



Basel: MQ(w)
1901 - 2000:
+21,95%

Changes of flow-regime: Seasonal Redistribution



**Power-storage: Reservoir-
management with seasonal
redistribution-effects**

summer → winter

Reservoirs in the Alpine region (mainly run for energy-production purposes) have seasonal redistributing effects:

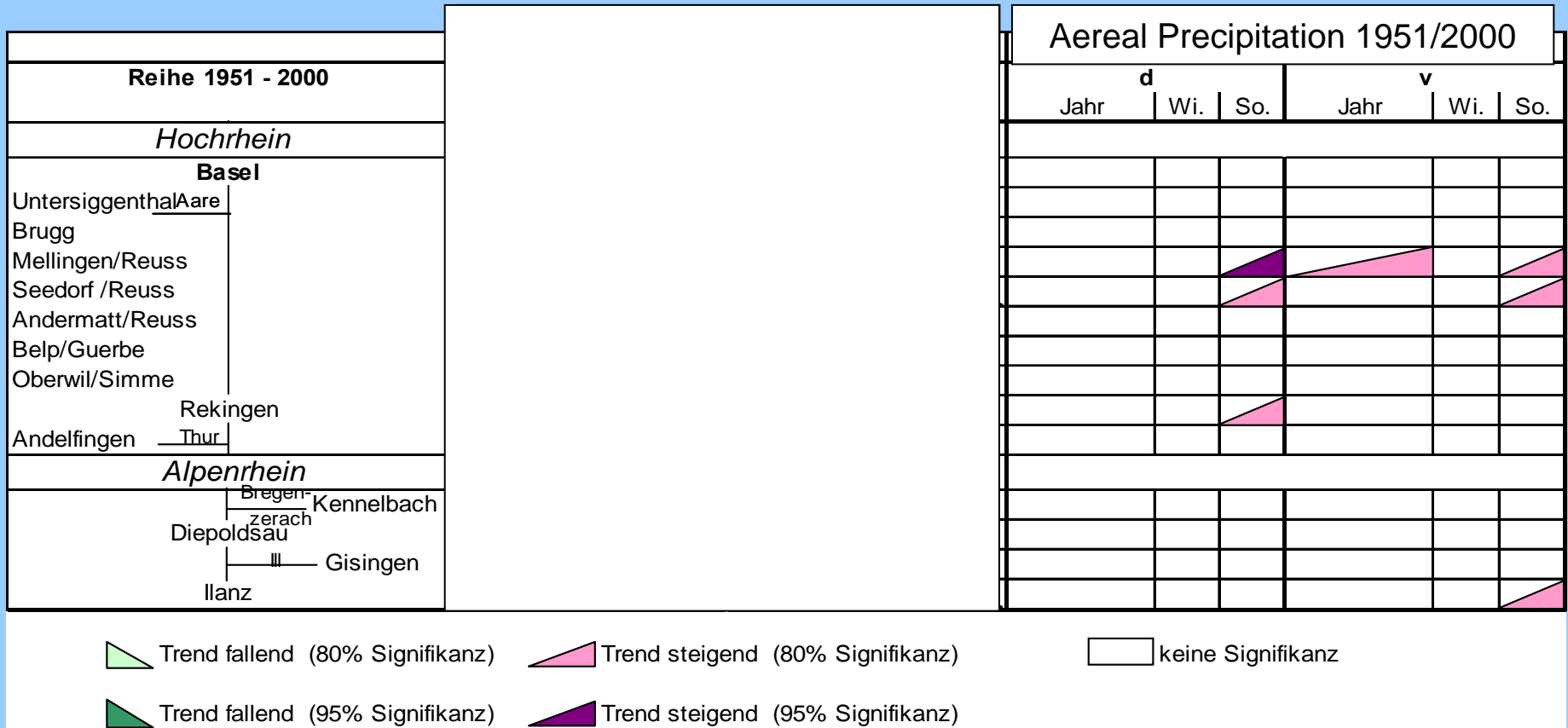
- **collecting water during surface-water affluence in summer**
- **releasing water during frost-induced low-flow-season in winter**

Upstream Basel: total reservoir-capacity 1,9 bio. m³ p.a.

Assumption: Seasonal transfer-volume 50% → ~60 m³/s per season

(Basel: MQ(w) 1901 – 2000: +167 m³/s)

Changes of flow-regime: Variability of Discharge



Mean error

„fluctuation around the average“

$$d = \frac{1}{n} \sum |x_i - \bar{x}|$$

n = sample size
 x_i = (monthly-)solitary value of the sample
 \bar{x} = arith. mean of the sample

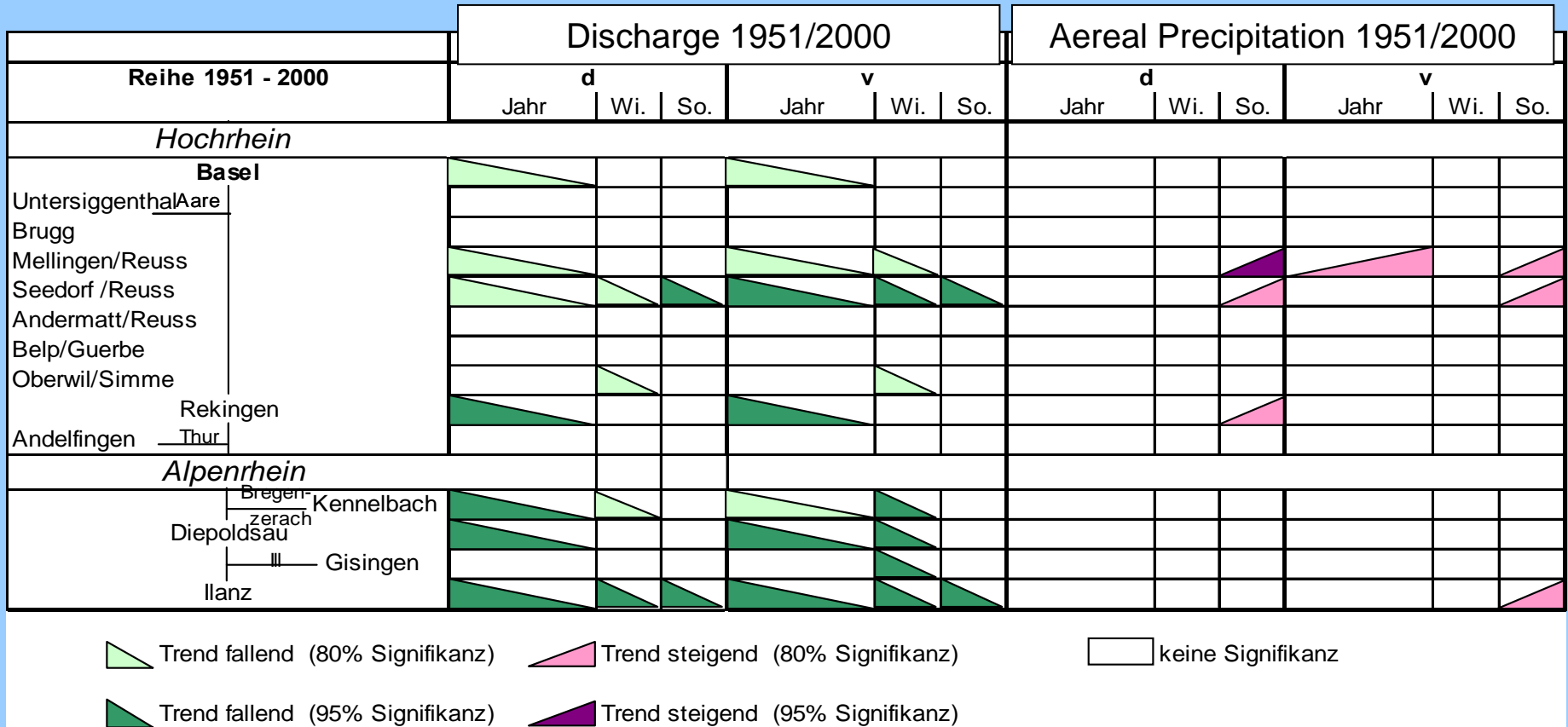
Robust variation-coefficient

„span of the more frequent extreme-values vs. median“

$$v = (Q_{95} - Q_5) : Me$$

Q_{95} = 95%-quantile of annual/seasonal series
 Q_5 = 5%-quantile of annual/seasonal series
 Me = median of annual/seasonal series

Changes of flow-regime: Variability of Discharge



„fluctuation around the average“

$$d = \frac{1}{n} \sum |x_i - \bar{x}|$$

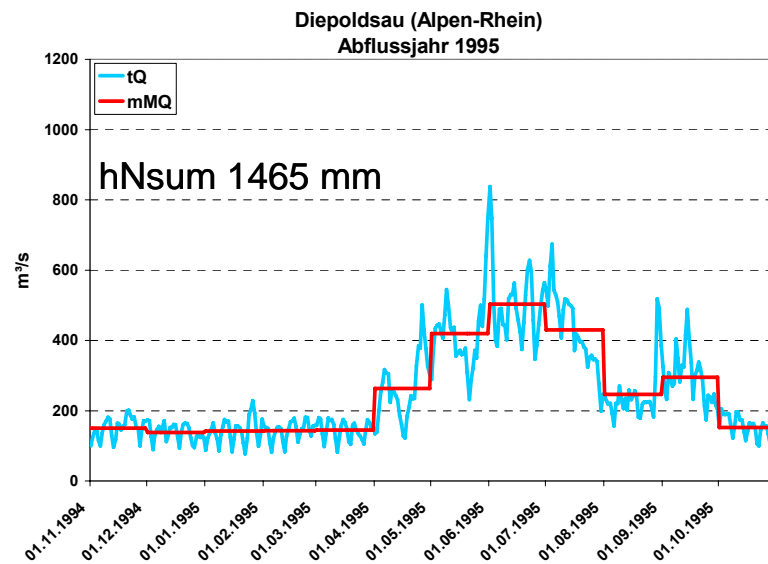
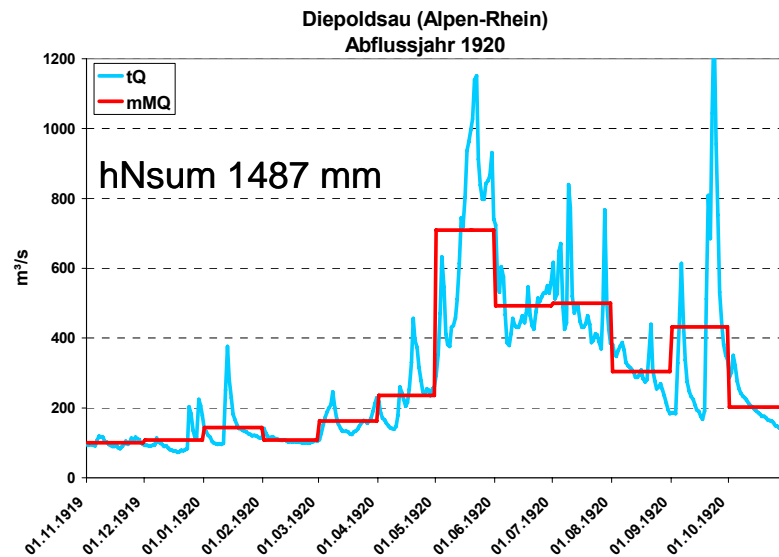
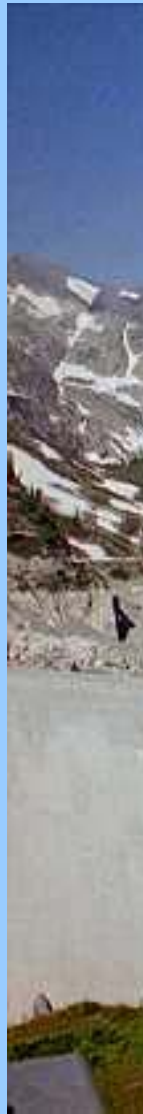
n = sample size
 x_i = (monthly-)solitary value of the sample
 \bar{x} = arith. mean of the sample

„span of the more frequent extreme-values vs. median“

$$v = (Q_{95} - Q_5) : Me$$

Q_{95} = 95%-quantile of annual/seasonal series
 Q_5 = 5%-quantile of annual/seasonal series
 Me = median of annual/seasonal series

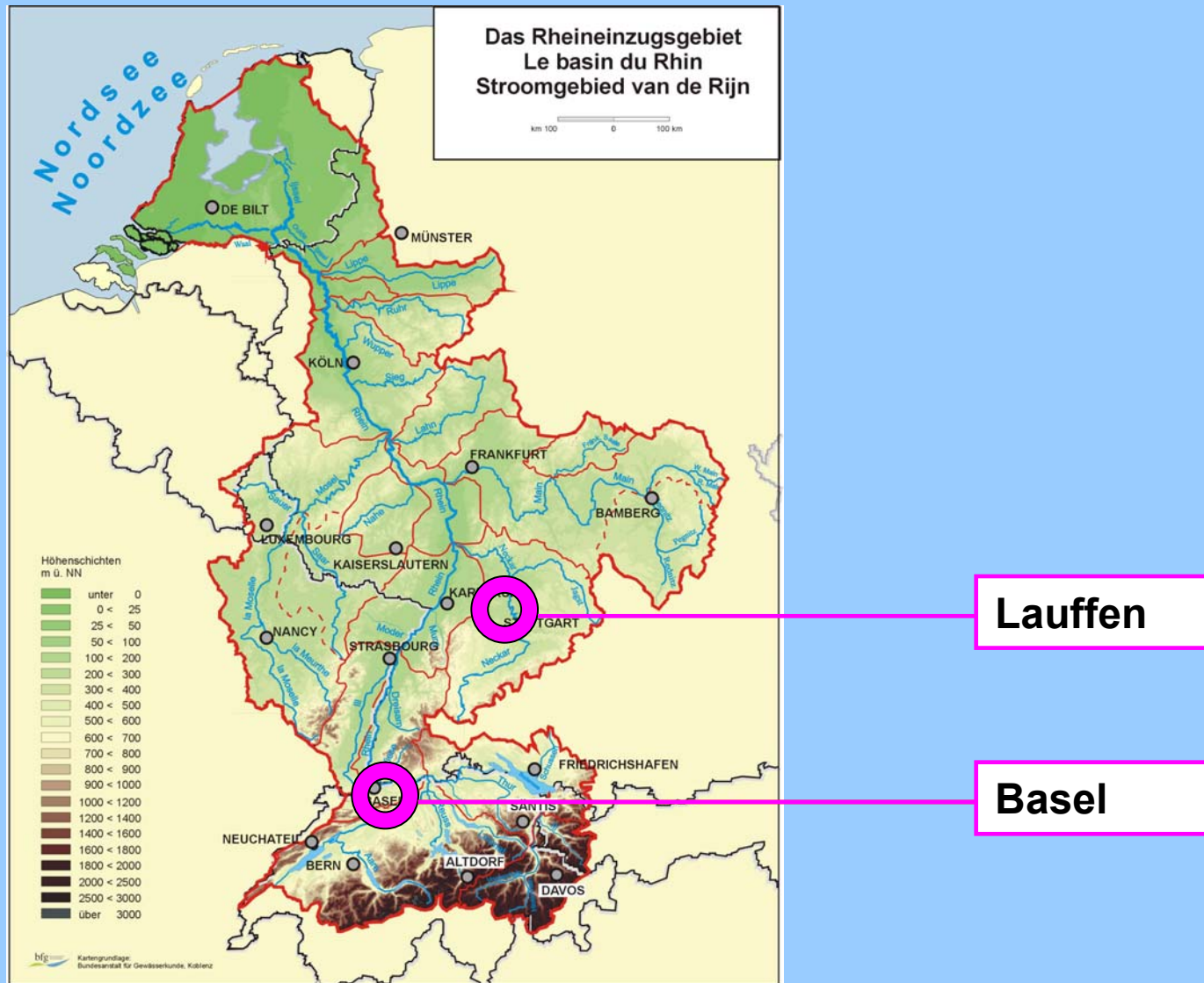
Changes of flow-regime: Variability of Discharge



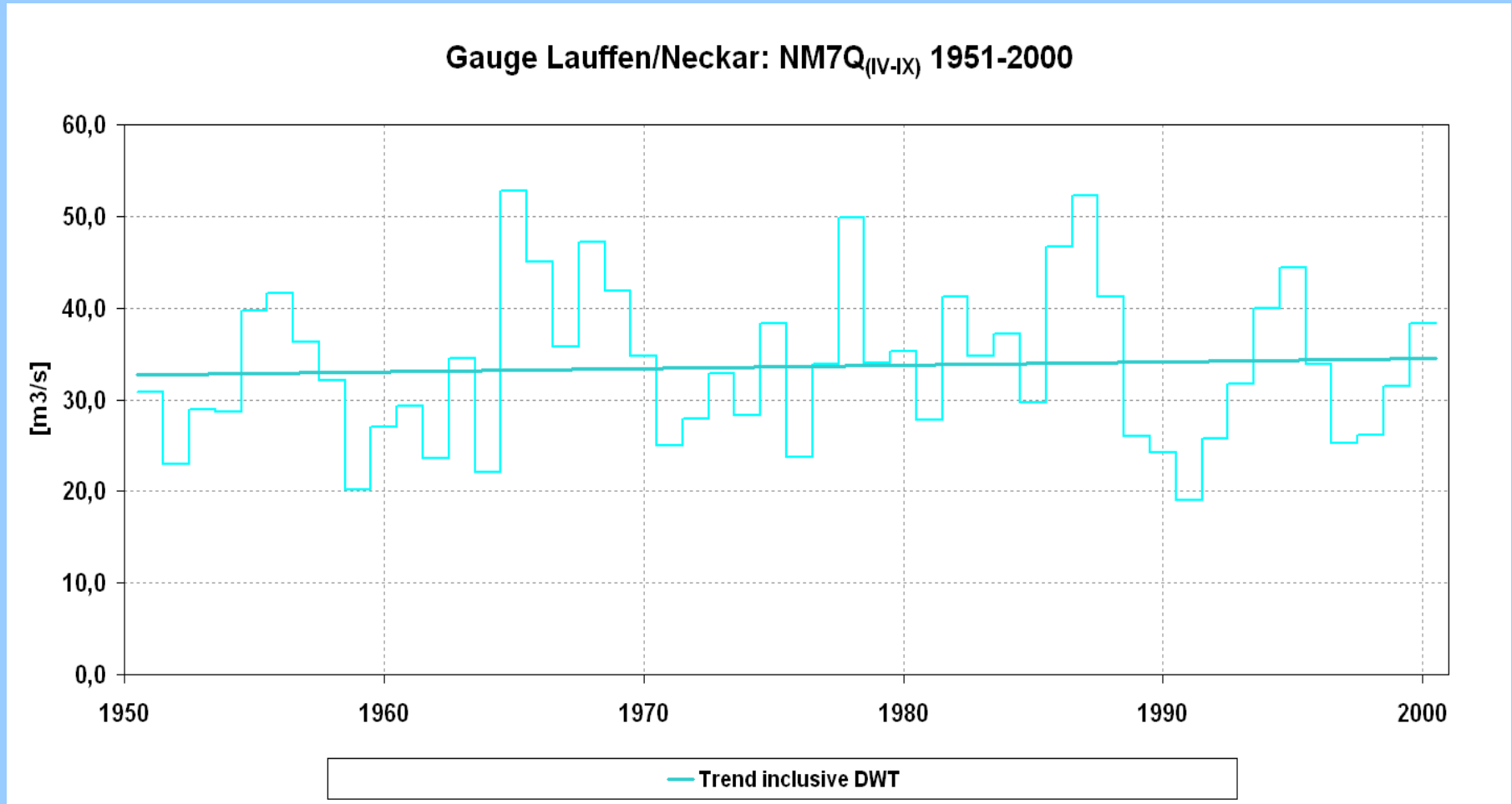
**Reservoir-management
with reducing effects
on annual and intra-annual
flow variability**

**...one important,
but not the only responsible
process to enforce
equalizing runoff**

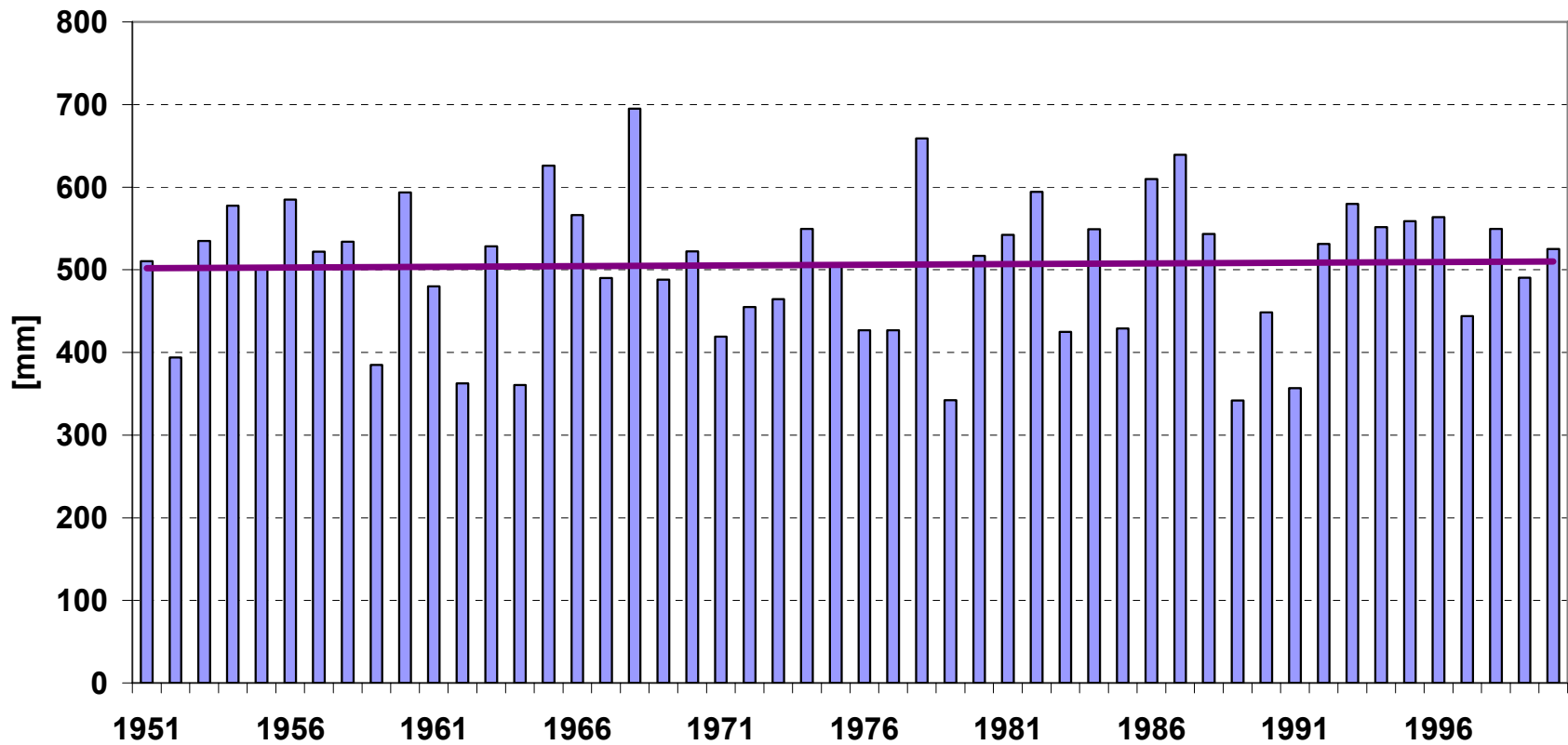
Socio-Economic Influence on Runoff-Characteristics: River Neckar



Socio-Economic Influence on Runoff-Characteristics: River Neckar

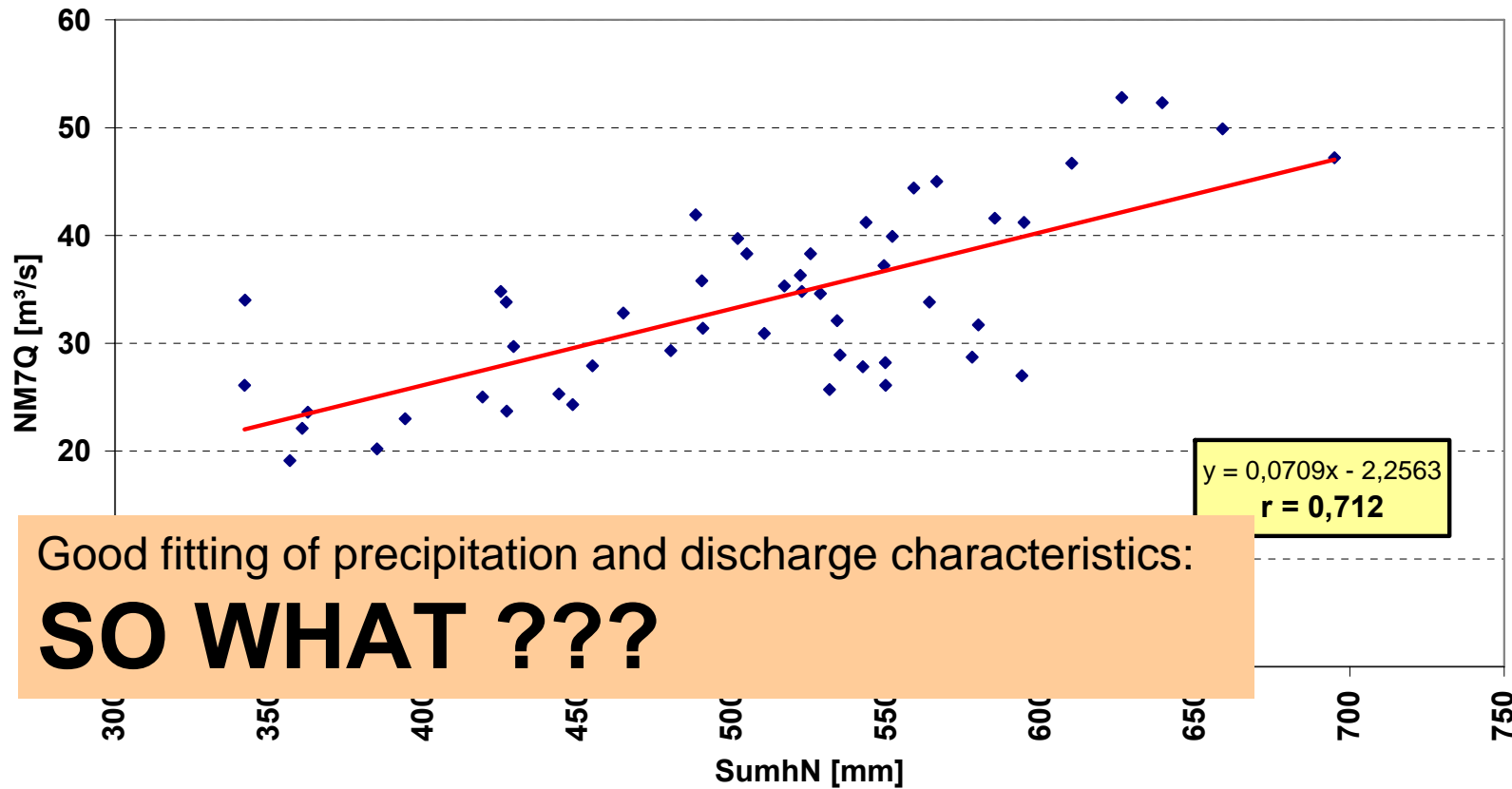


Laufen / Neckar: Seasonal Areal Precipitation Depth (Summer, 1951-2000)



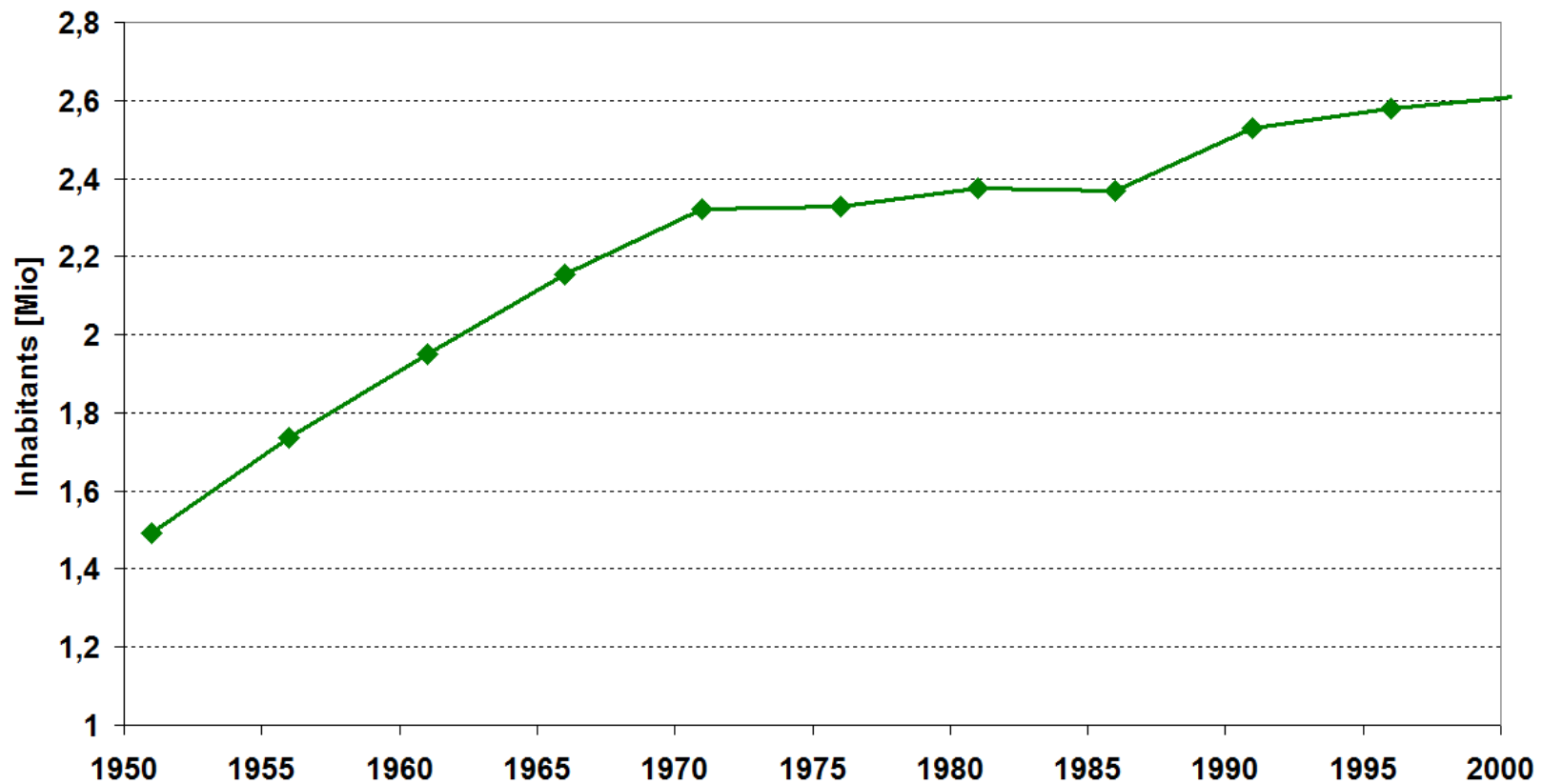
Socio-Economic Influence on Runoff-Characteristics: River Neckar

Lauffen: Cross-Correlation NM7Q (y) vs. hNsum (x)
(summer period, 1951-2000)

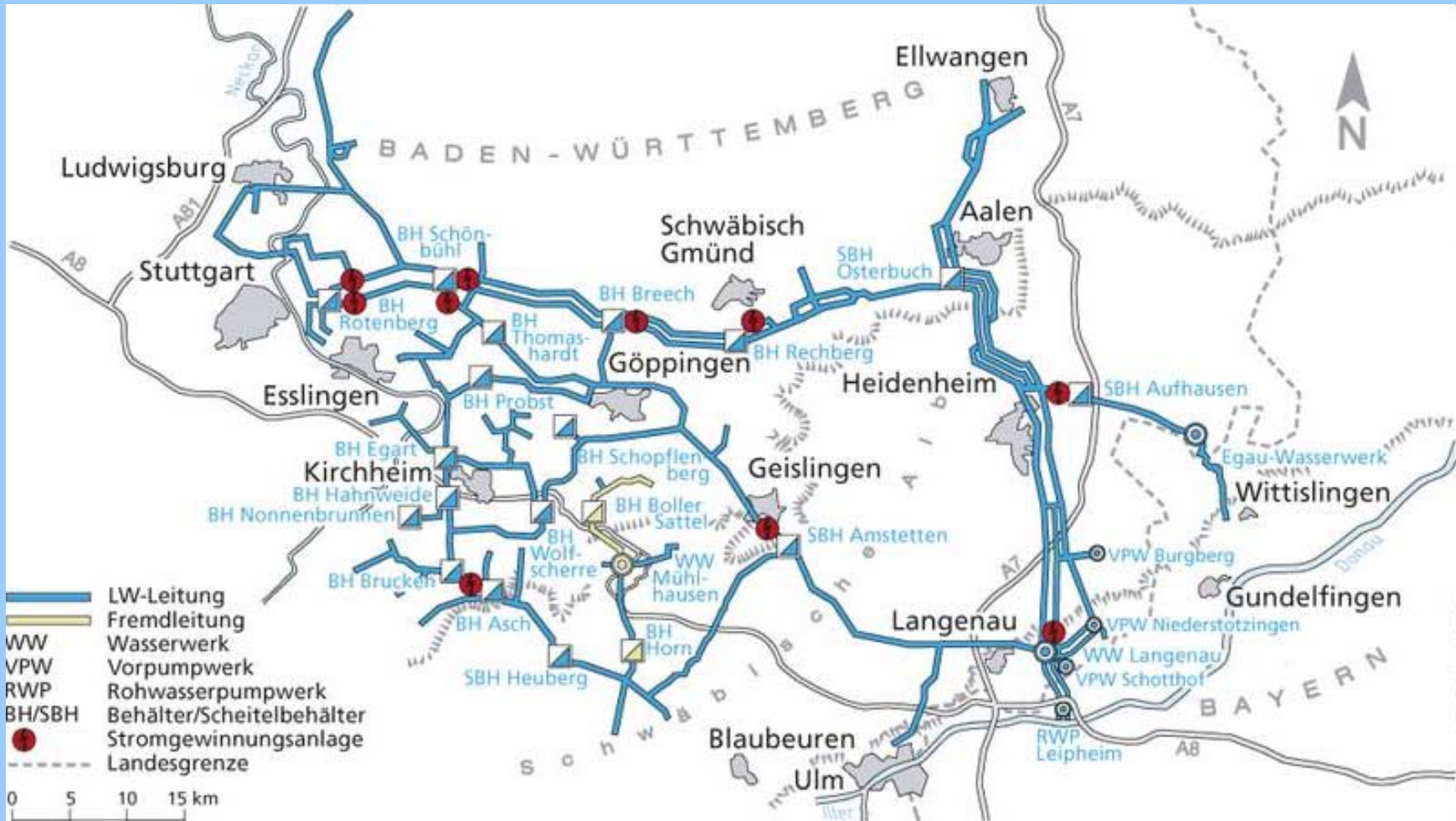


Stuttgart Region: Demographic Development

(data: DeStatis)



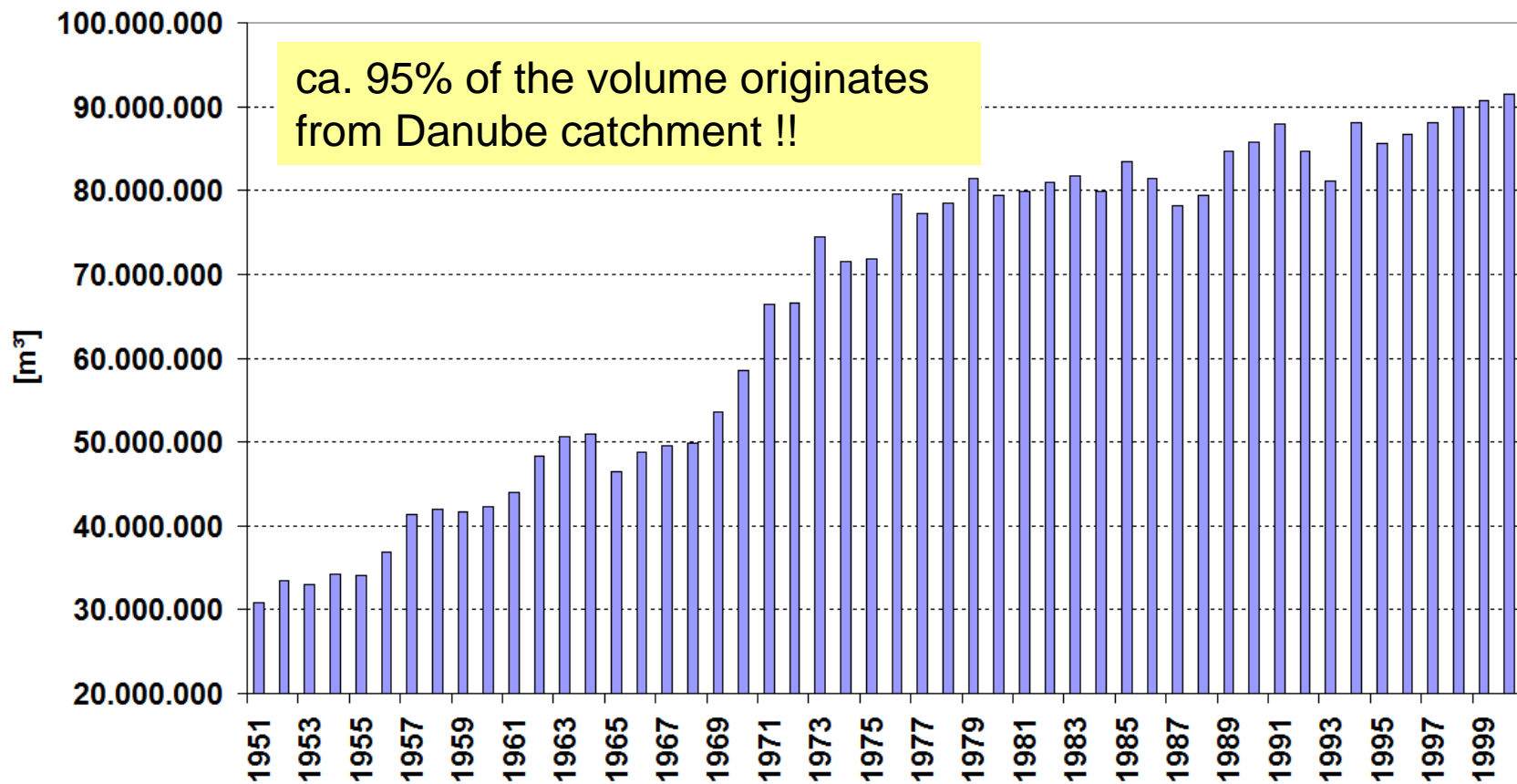
Drinking Water Supply: Another Vital Need...



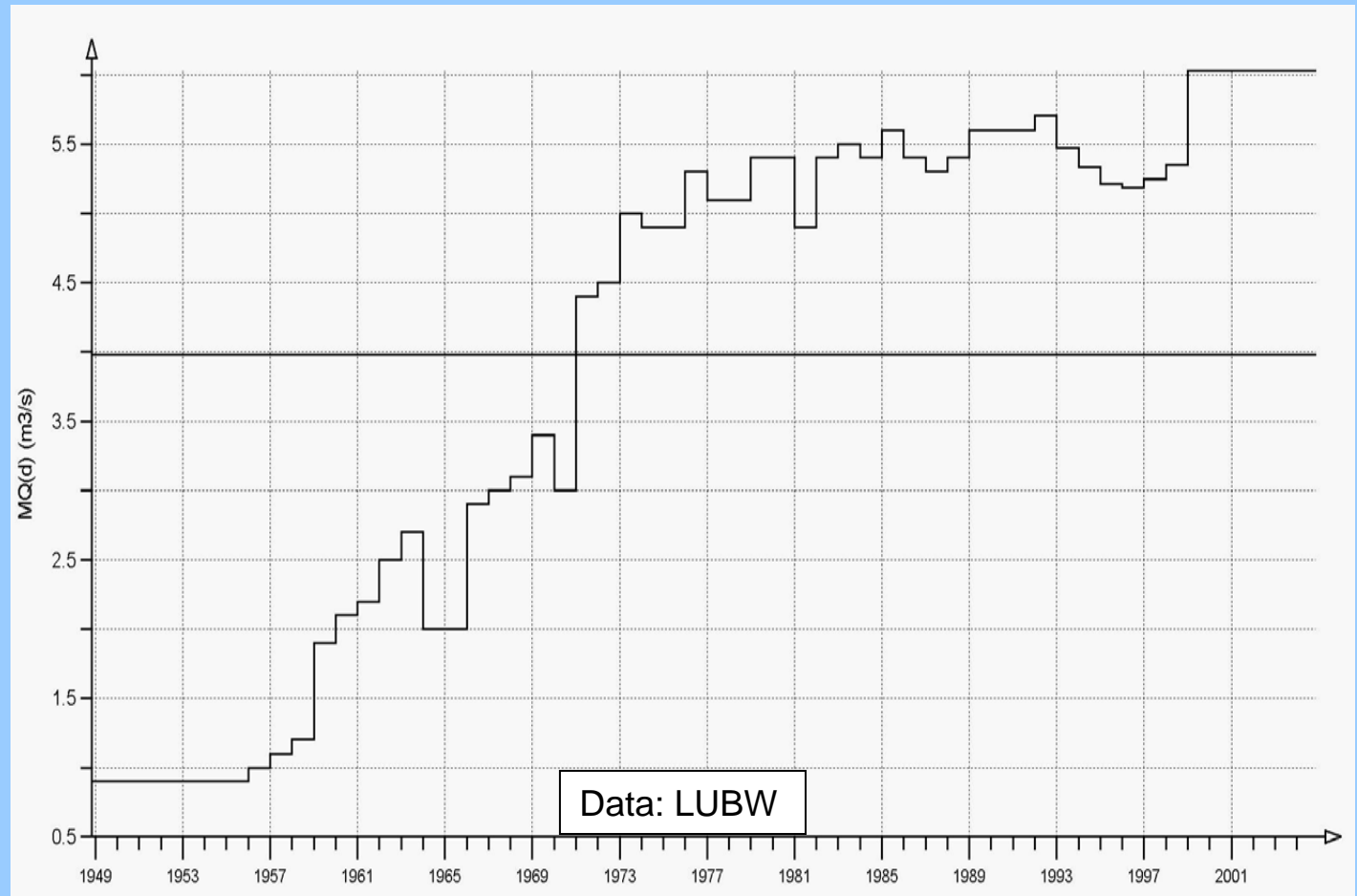
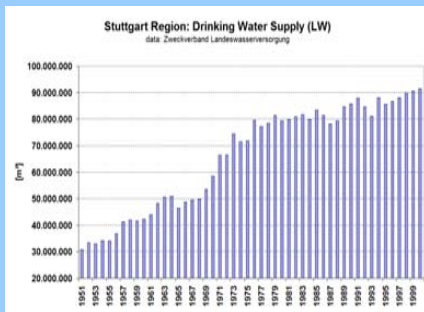
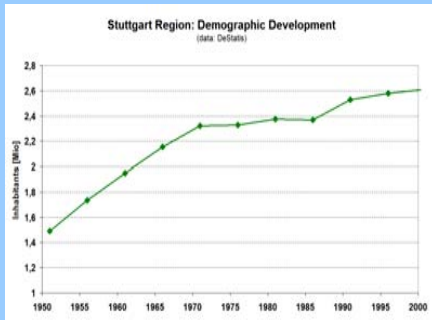
Drinking Water Supply: Another Vital Need...

Stuttgart Region: Drinking Water Supply (LW)

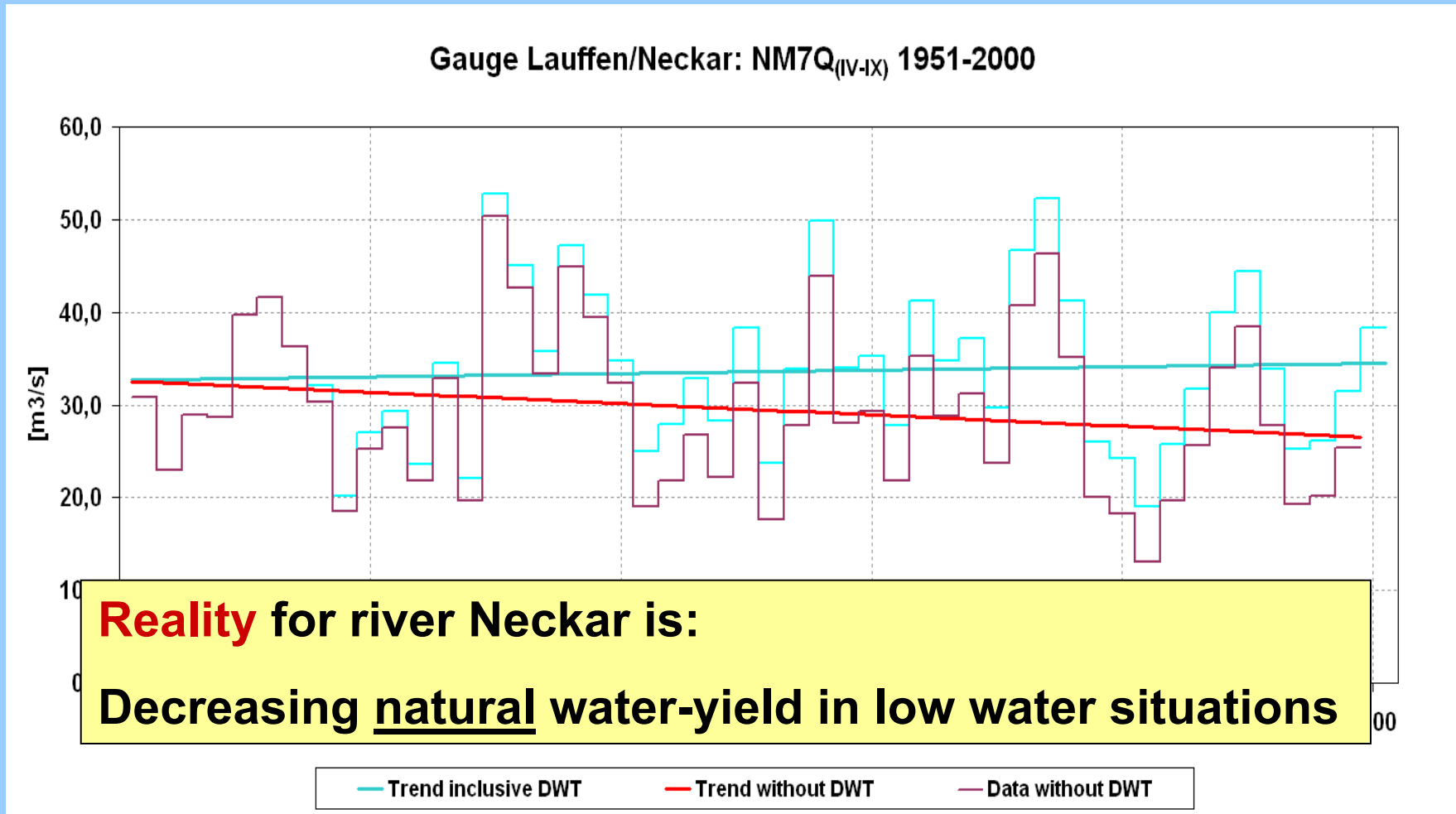
data: Zweckverband Landeswasserversorgung



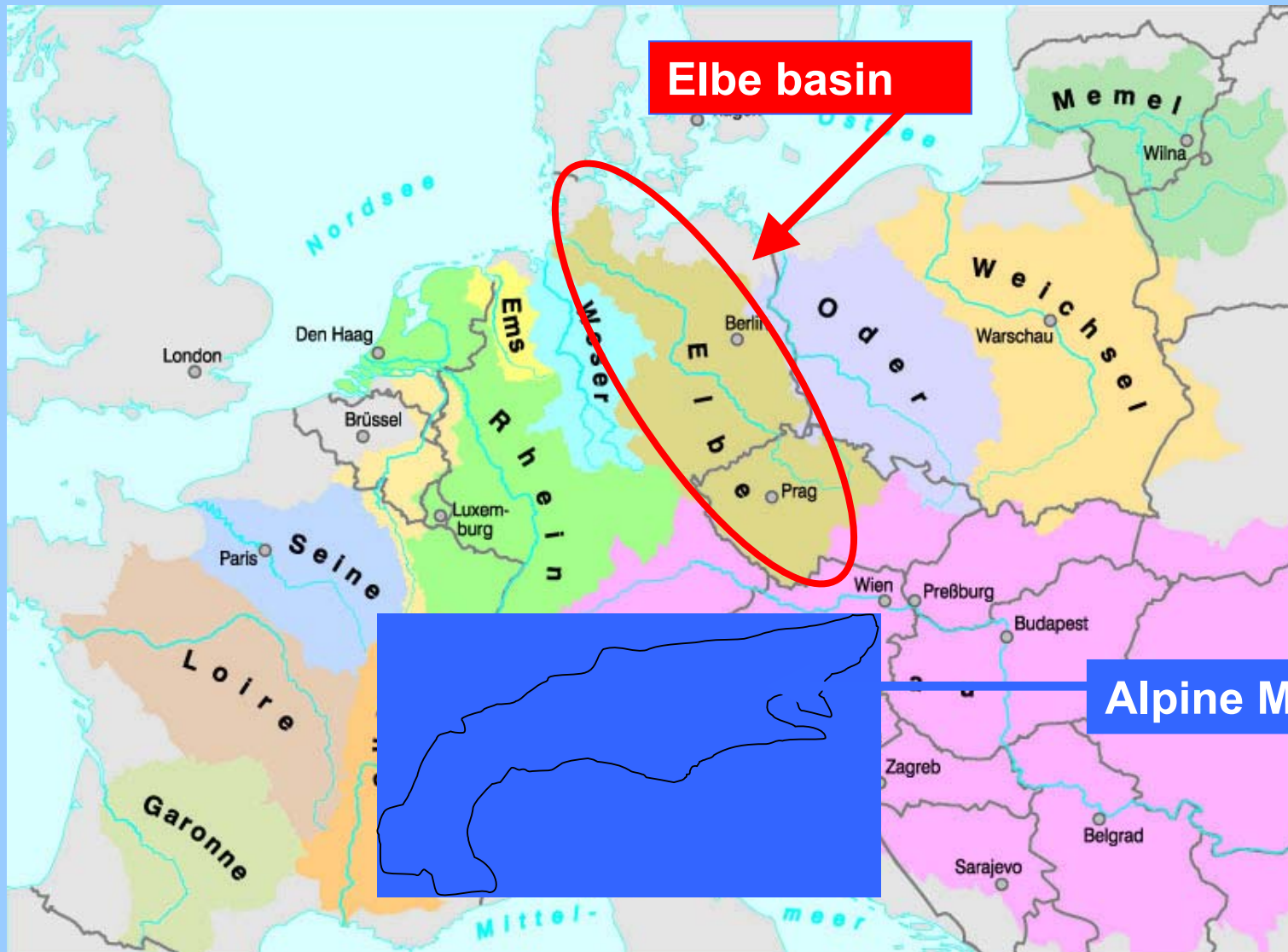
Lauffen/River Neckar (period 1949/2004): Quantity of Discharge, resulting from interbasin DWT (drinking- water transfer) [m³/s]



Socio-Economic Influence on Runoff-Characteristics: Trend and reversed trend against the background of DWT




















Socio-Economic Influence on Runoff-Characteristics: Elbe Basin



Trends and Tendencies in Time Series 1961-2005

Areal precipitation: Annual, Seasonal and Monthly Sums

Analýza trendů dle Mann-Kendallova testu
Trendanalyse, Methode FQS mit Mann-Kendall-Signifikanztest


Profil	Období	SumhNr	SumhNzimn	SumhNletn	SumhNm	SumhNm(I)	SumhNm(II)	SumhNm(III)	SumhNm(IV)	SumhNm(V)	SumhNm(VI)	SumhNm(VII)	SumhNm(VIII)	SumhNm(IX)	SumhNm(X)	SumhNm(XI)	SumhNm(XII)
Profil	Jahresreihe	SumhN(J)	SumhN(Wi)	SumhN(So)	SumhN(m)	SumhN(m,I)	SumhN(m,II)	SumhN(m,III)	SumhN(m,IV)	SumhN(m,V)	SumhN(m,VI)	SumhN(m,VII)	SumhN(m,VIII)	SumhN(m,IX)	SumhN(m,X)	SumhN(m,XI)	SumhN(m,XII)
Dresden	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Torgau	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Löben	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(+)	(-)	(-)	(+)	(-)
Wittenberg	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Bad Dübén	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(-)	(-)		(-)	(+)	(+)	(+)	(+)
Aken	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(+)	(+)	(+)	(+)	(+)
Calbe-Grizehne	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(-)	(-)		(-)	(+)	(+)	(+)	(+)
Barby	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(-)	(-)		(-)	(+)	(+)	(+)	(+)
Magdeburg-Str.	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)		(-)	(-)		(-)	(+)	(+)	(+)	(+)
Tangermünde	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Rathenow	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(-)	(+)
Havelberg	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)
Wittenberge	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Malliß	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)
Lüchow	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)		(+)	(+)	(+)	(-)
Neu Darchau	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)		(-)	(+)	(+)	(+)	(+)
Garlitz	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(+)	(-)	(+)	(+)	(-)	(+)
Bienenbüttel	1961-2005	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)

Vysvětlivky / Erläuterungen:


hladina významnosti / Signifikanzniveau

() bez tendence / ohne Tendenz

(-) klesající tendence/fallende Tendenz

 významně klesající trend/ fallender Trend / sig. 95%

(+) rostoucí tendence/ steigende Tendenz

 významně rostoucí trend/ steigender Trend / sig. 95%

Elbe Basin: Trends and Tendencies in Time Series 1961-2005

Mean discharges and low-flow extremes

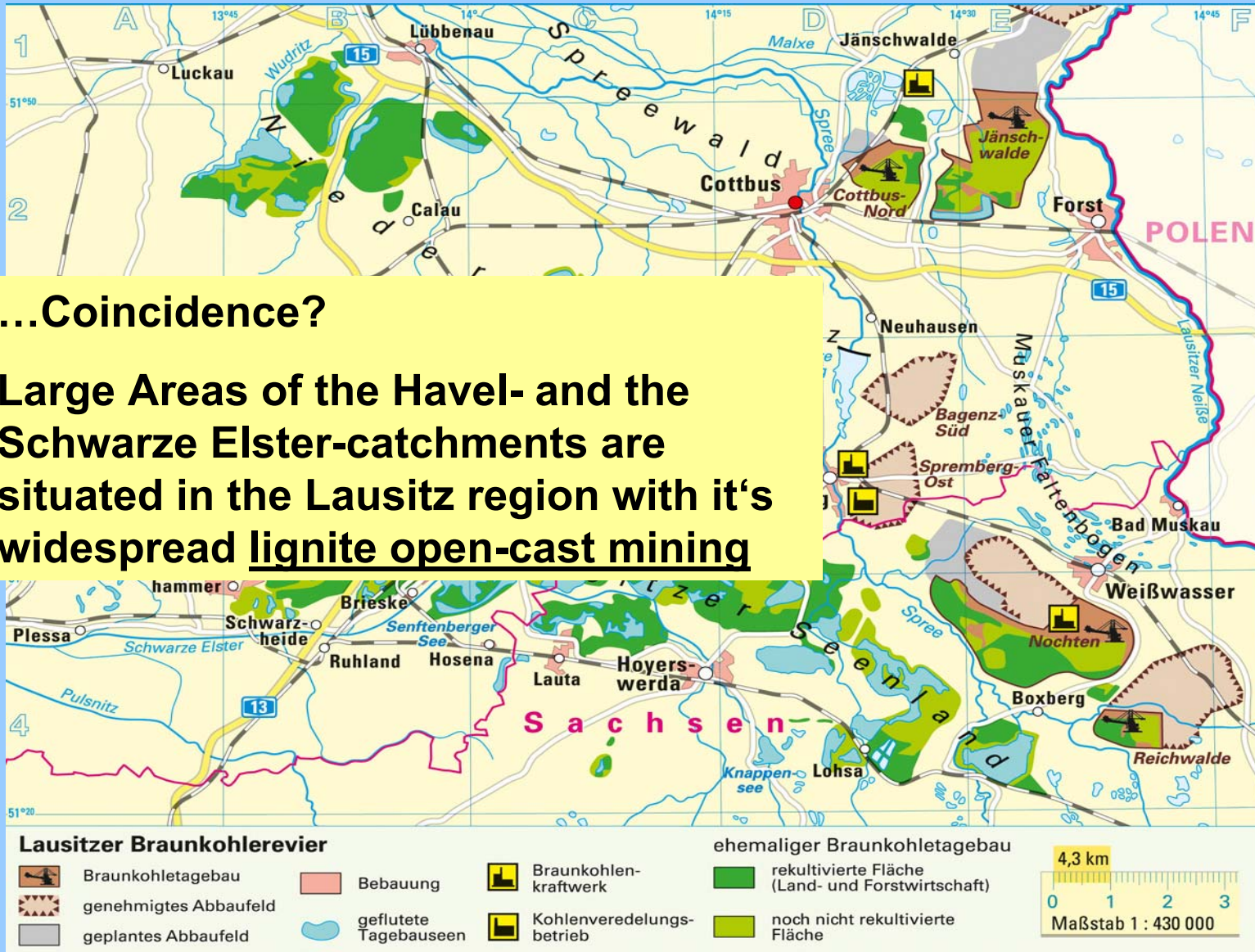
Analýza trendů die Mann-Kendalova testu -
Trendanalyse, Methode FQS mit Mann-Kendall-Signifikanztest (mit Ausnahme der Einzelmonatsanalysen ggf. autokorrelationsbereinigt)

Profil	Období	Qmin7d(R)	Qmin7d(Z)	Qmin7d(L)	Q355	Qr	Qzimní	Qletní	Qm	Qm(I)	Qm(II)	Qm(III)	Qm(IV)	Qm(V)	Qm(VI)	Qm(VII)	Qm(VIII)	Qm(IX)	Qm(X)	Qm(XI)	Qm(XII)
Profil	Jahresreihe	NM7Q(J)	NM7Q(Wi)	NM7Q(So)	Q10	MQ(J)	MQ(Wi)	MQ(So)	MQ(m)	MQ(m,I)	MQ(m,II)	MQ(m,III)	MQ(m,IV)	MQ(m,V)	MQ(m,VI)	MQ(m,VII)	MQ(m,VIII)	MQ(m,IX)	MQ(m,X)	MQ(m,XI)	MQ(m,XII)
Dresden	1961-2005	(+)	(+)	(-)	(-)	(+)	(+)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(-)
Dresden	1931-2005	(+)	(+)	(-)	(+)	(+)	(+)	(-)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(+)
Targu	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Löben	1974-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Wittenberg	1961-2005	(+)	(+)	(-)	(-)	(+)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(-)
Bad Dübén	1961-2005	(+)	(+)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(+)
Aken	1961-2005	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)
Calbe-Grizehne	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)
Barby	1961-2005	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)
Barby	1931-2005	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(-)	(+)
Magdeburg-Str.	1961-2005	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(-)
Tangermünde	1931-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Rathenow	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Havelberg	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Wittenberge	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)
Malliß	1970-2005	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(-)	(-)
Lüchow	1967-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(-)
Neu Darchau	1961-2005	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)
Neu Darchau	1931-2005	(+)	(+)	(-)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(+)
Garlitz	1961-2005	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(-)
Bienenbüttel	1961-2005	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Contradictions / disagreements of the flow- and the precipitation-dynamics in the last 50 years in large regions of the catchment:
in wide areas slight increase of precipitation
versus moderate decrease of runoff

analýza Qmin7d
řního roku

Socio-Economic Influence on Runoff: Lignite and Politics



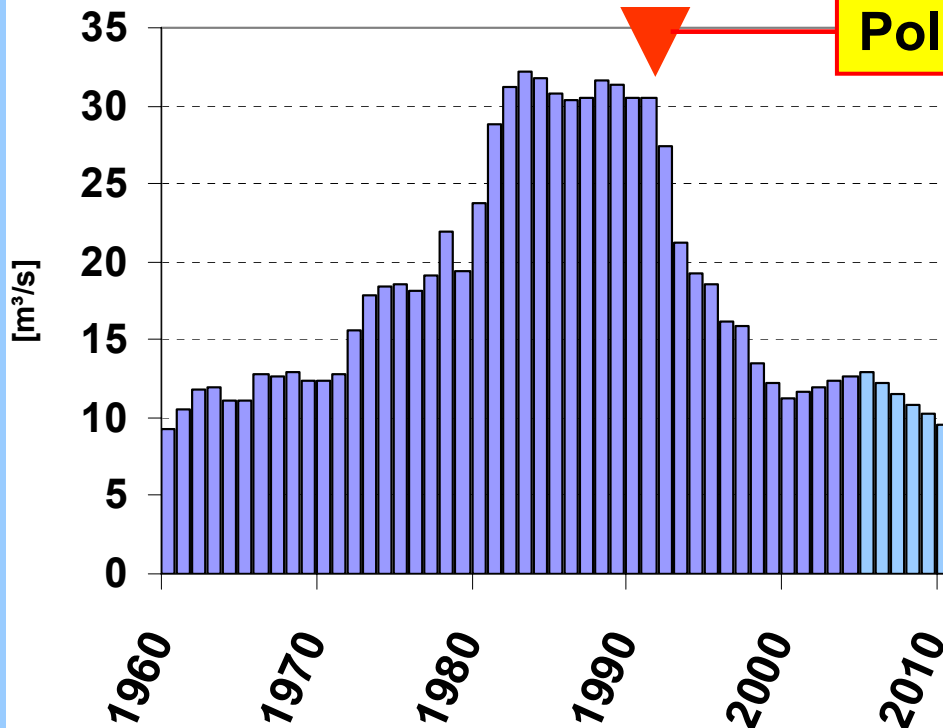
...Coincidence?

Large Areas of the Havel- and the Schwarze Elster-catchments are situated in the Lausitz region with it's widespread lignite open-cast mining

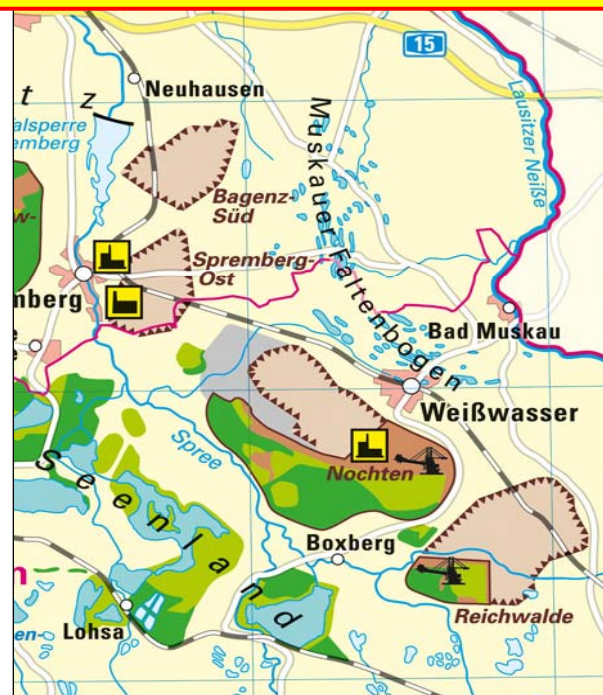
Socio-Economic Influence on Runoff: Lignite and Politics



Spree-region: groundwater-haulage in total



Political Change: „Wende“ 1989



Lausitzer Braunkohlerevier

Braunkohletagebau	Bebauung	Braunkohlenkraftwerk	rektivierte Fläche (Land- und Forstwirtschaft)
genehmigtes Abbaufeld	geflutete Tagebauseen	Kohlenveredelungsbetrieb	noch nicht rektivierte Fläche
geplantes Abbaufeld			

ehemaliger Braunkohletagebau

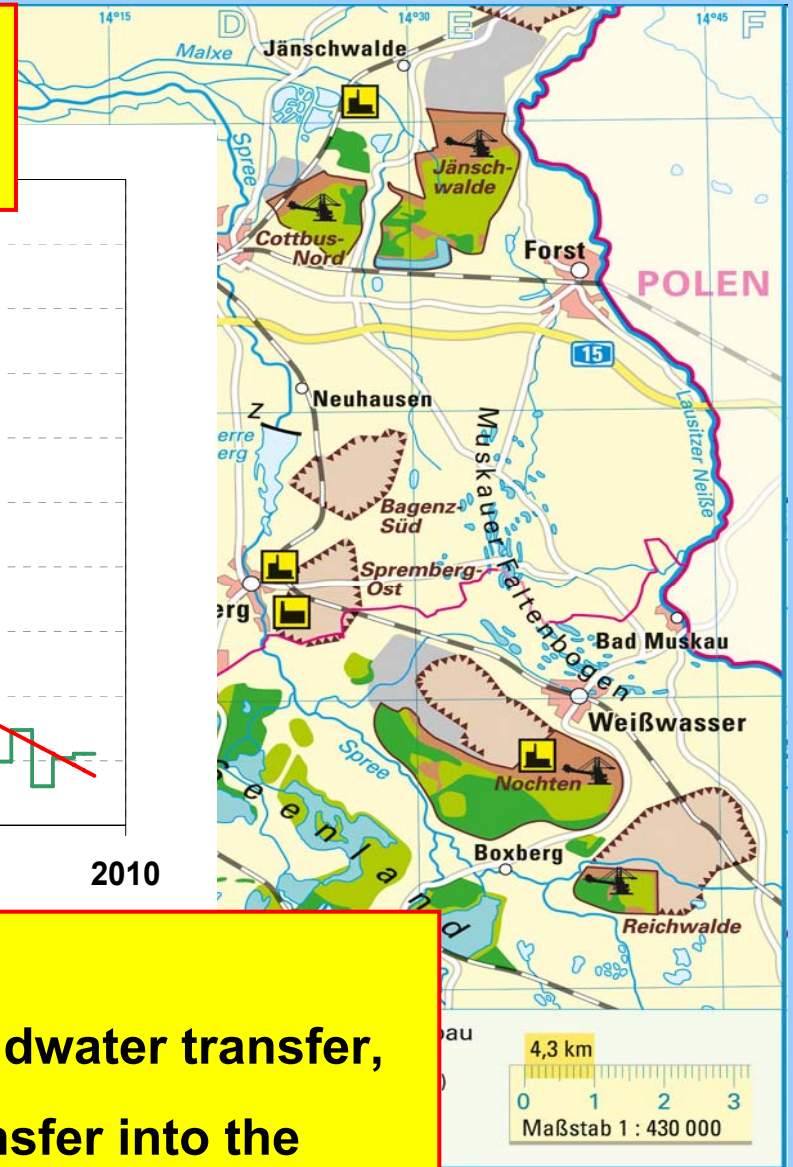
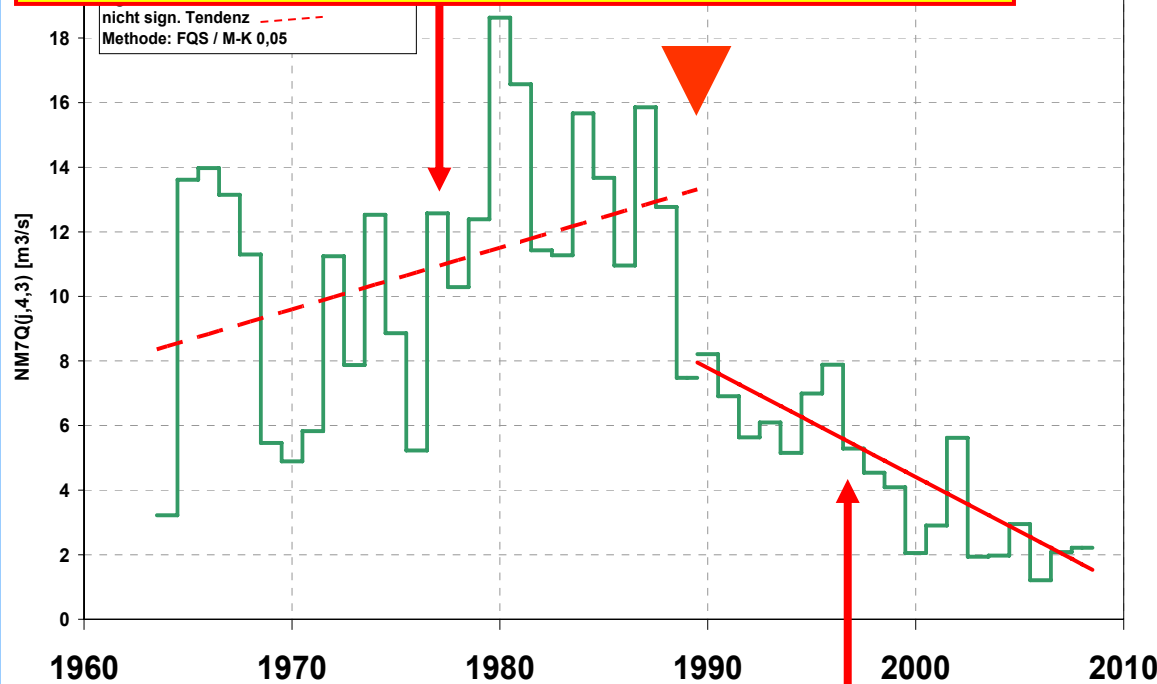
4,3 km

0 1 2 3

Maßstab 1 : 430 000

Socio-Economic Influence on Runoff: Lignite and Politics

...before 1989: Groundwater-transfer into surface-waters (pumping-water from open-cast lignite-mining aquifers)



...after 1989:

- reducing of groundwater transfer,
- surface water-transfer into the open pits (recultivation)

After all (1): **Trivial theses on modelling in general**

Modelling close to reality requires understanding of the system.

Understanding of the system in hydrology arises from closest-possible knowledge of the existing structures in both past and present.

Thus, understanding of the system implies data-analysis, which means identification of the responsible factors and processes to avoid results of accidental nature (and not to rely on parametrics to optimize the model fitting).

After all, modelling without consideration of comprehensive data-analysis means to accept a higher probability of uncertainties and mistakes.

Data-analysis as the initial part of the modelling-work has to be as profound as possible. With it, pure statistical analysis without solid hydrological or (preferably: and) regional background-knowledge is not reliable.

After all (2): **Trivial theses on socio-economics within hydrological modelling**

Socio-economic influence subsums various anthropogenic effects on the water-cycle. Therefore, it is an important, but in the whole hardly quantifiable protagonist within the water-cycle. Socio-economic development (via its dependant process-elements) is able to mark its footprint on the discharge-regime even of larger watercourses.

The consideration of socio-economic items in context of hydrological modelling helps to improve the realism and practicability of the model-results

Therefore, it is recommendable to implement socio-economic effects into the hydrological modelling (which, of course, is to be understood as a close compound together with the initial data-analysis): for interpretation and evaluation purposes and to get insights about possible future developments.

Thank you for your kind attention !

