HydroPredict' 2010

Discriminating Among Direct Human Interventions and Climate Change Impacts on the Water Cycle

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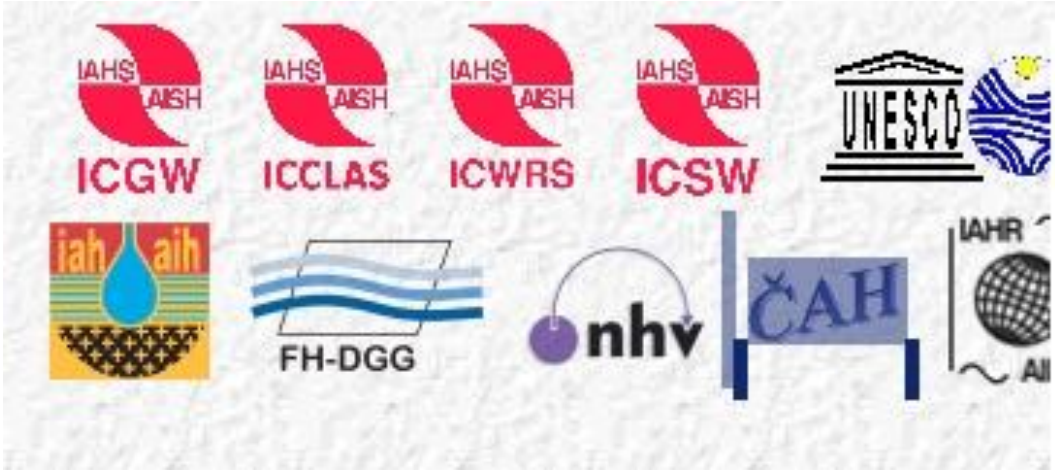
Organisers and sponsors

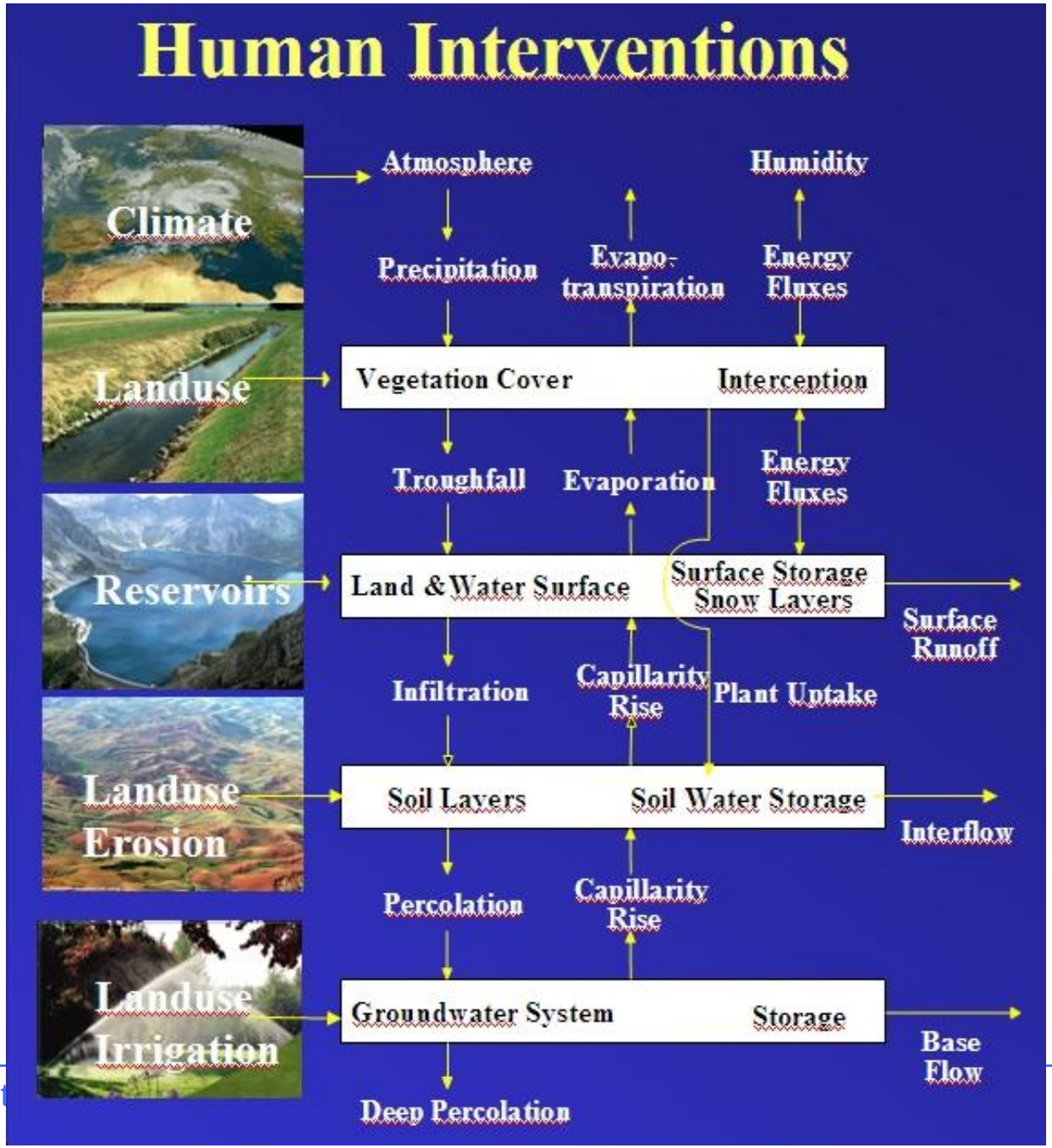


Organisation of the presentation

- Objectives and introduction
- Methodology for assessing human impacts
- Methodology for climate change impact studies
- Identified changes and discrimination among CC and HI
- Summary and conclusions

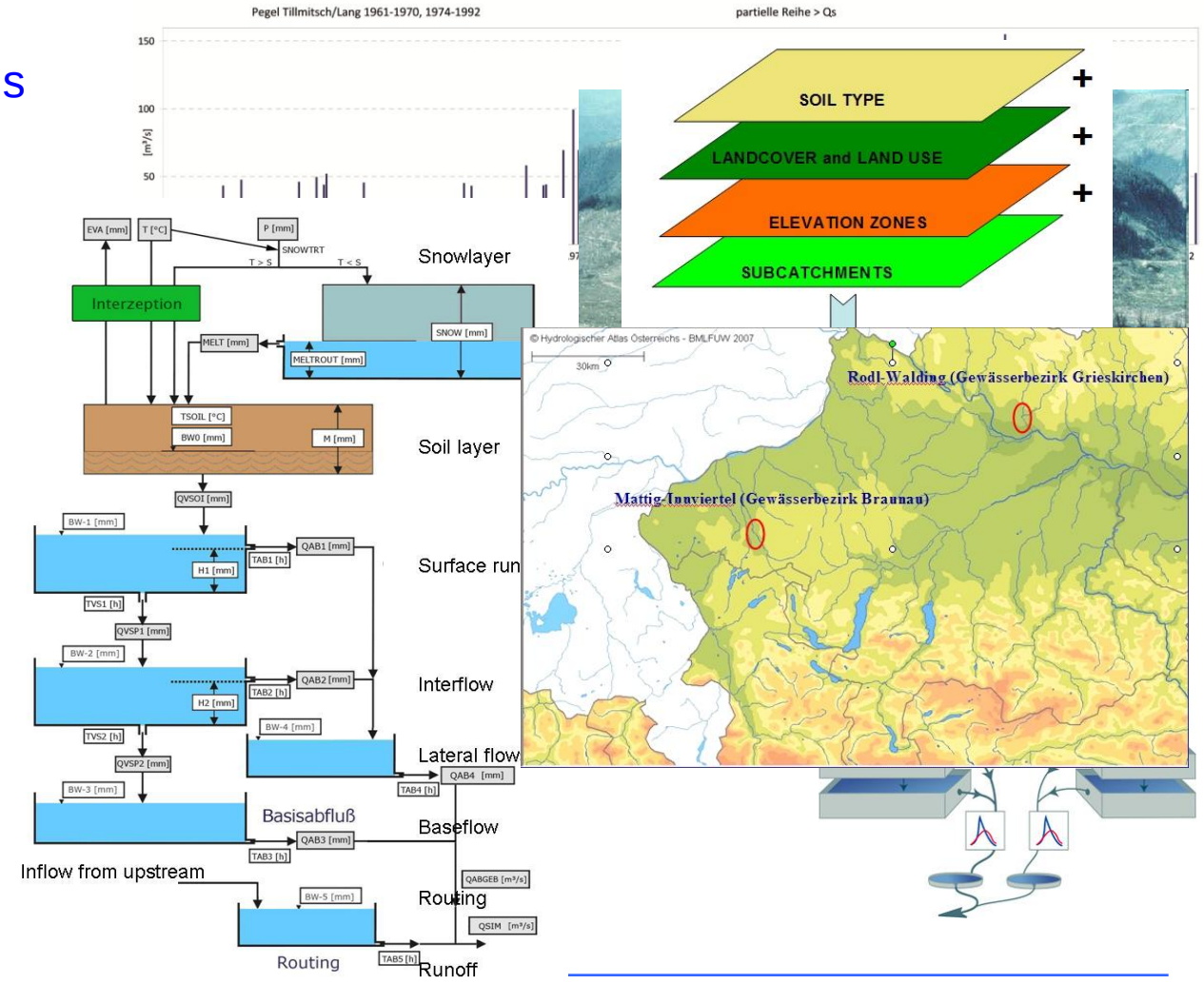
Objectives

- Analysis of changes in the hydrological cycle
- Evaluation of methodological approaches to discriminate among impacts originating from climate change, direct human intervention and natural variability of processes
- Elaboration of techniques for regional impacts studies

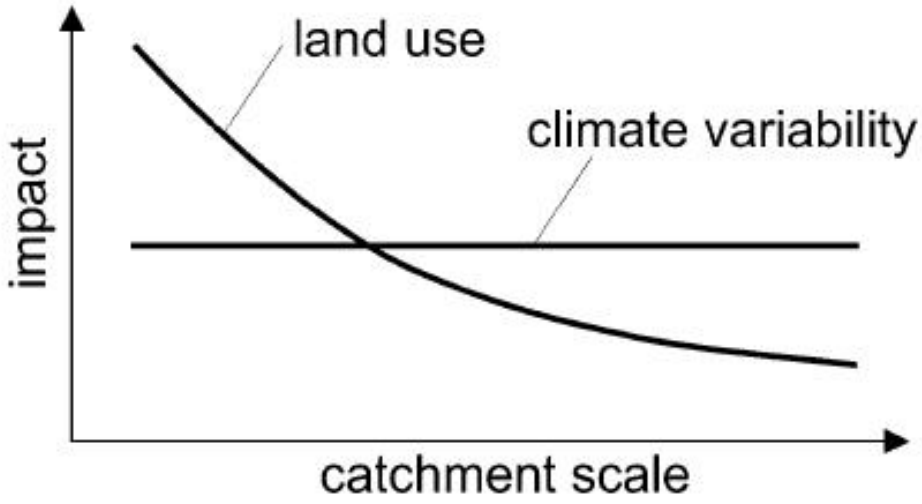

Human Interventions
Climate
Landuse
Reservoirs
Landuse
Erosion
Landuse
Irrigation
Atmosphere
Humidity
Precipitation
Evapo-
transpiration
Energy
Fluxes
Vegetation Cover
Interception
Throughfall
Evaporation
Energy
Fluxes
Land & Water Surface
Surface Storage
Snow Layers
Surface
Runoff
Infiltration
Capillarity
Rise
Plant Uptake
Soil Layers
Soil Water Storage
Interflow
Percolation
Capillarity
Rise
Groundwater System
Storage
Base
Flow
Deep Percolation

Methodology for the assessment of human interventions

- Time series analysis
- Experiments
- Comparative studi
- Detailed (physical



Role of scale



Hypothesized impact of land use and climate variability on hydrological response as a function of scale

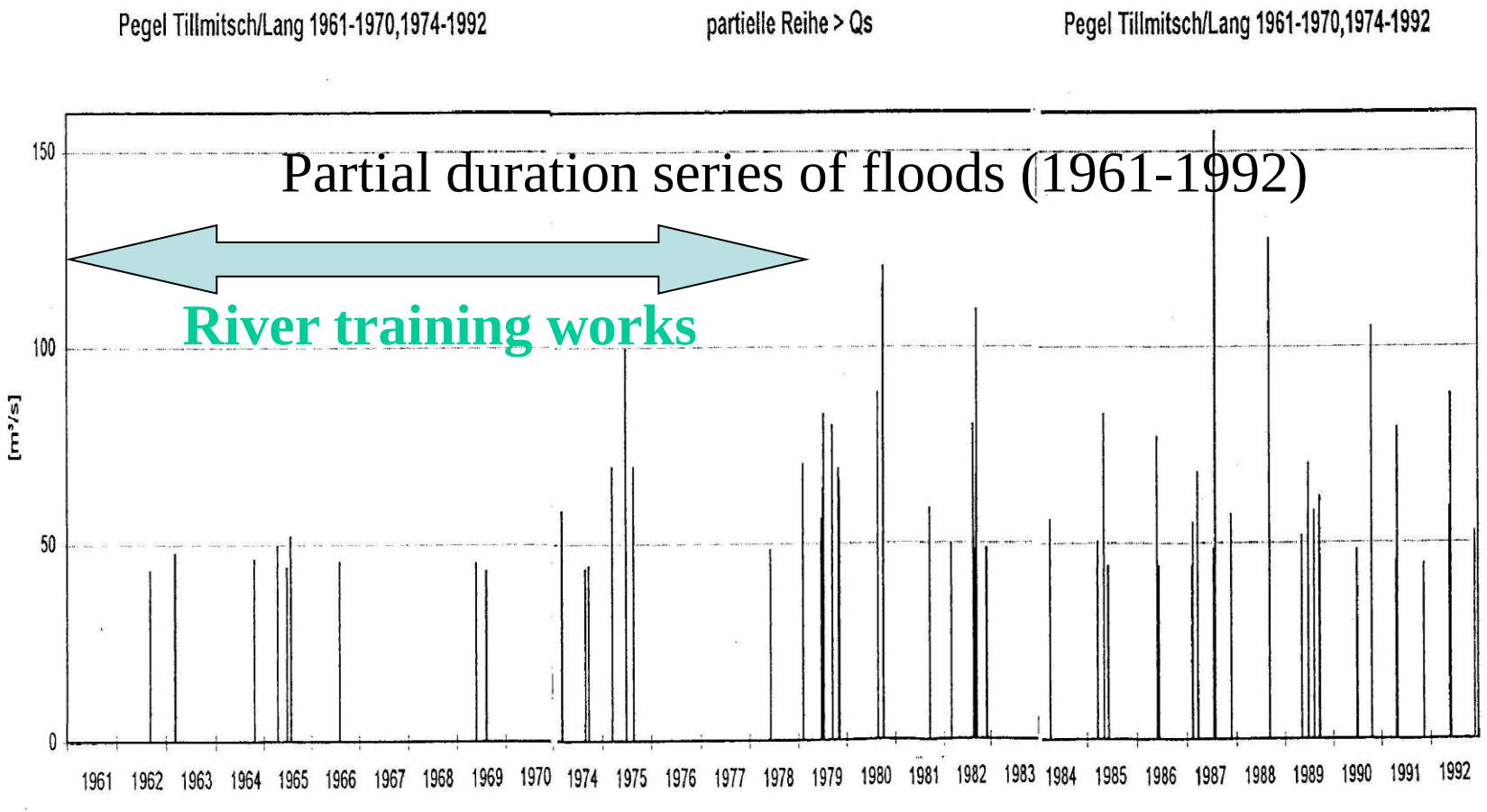
From Blöschl et al; 2007

Human Impacts at different scales

- Linear, local measures (river channelisation)
- Regional spatial measures (land use changes)
- Large scale impacts (land use changes)

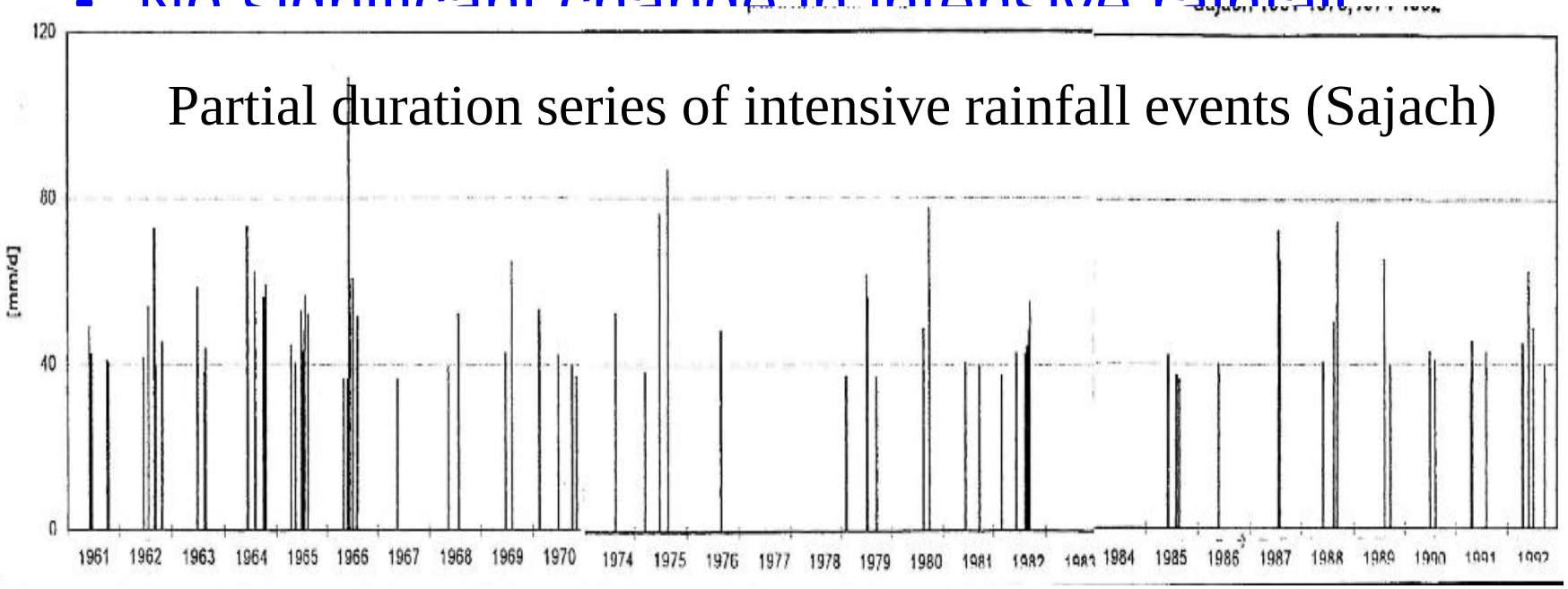
Channelisation of rivers

Impacts on floods

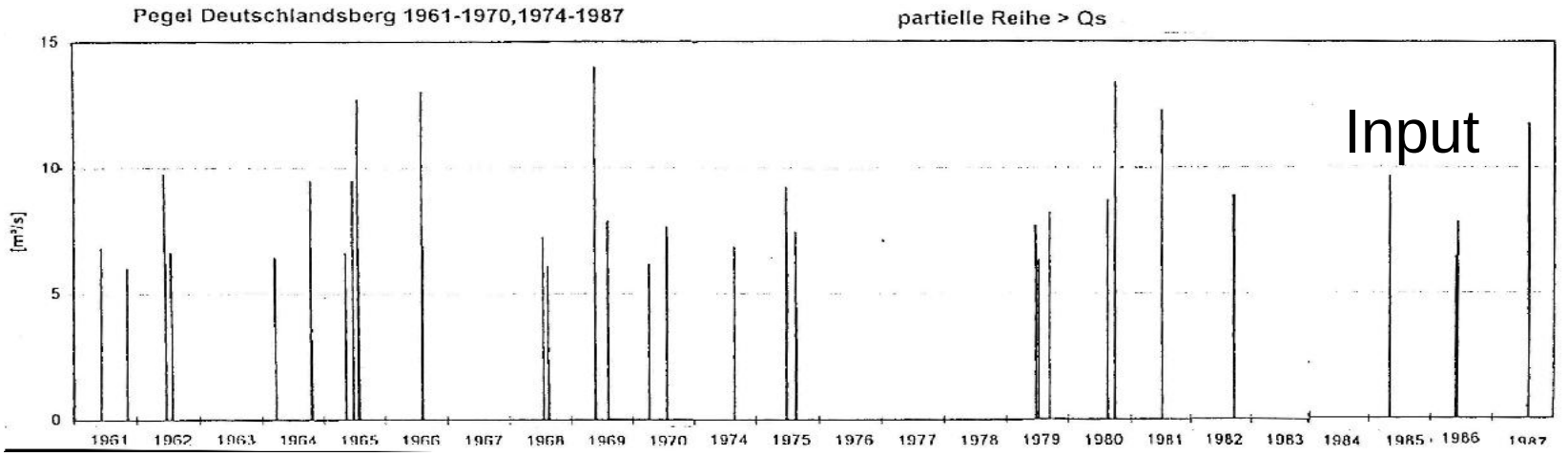


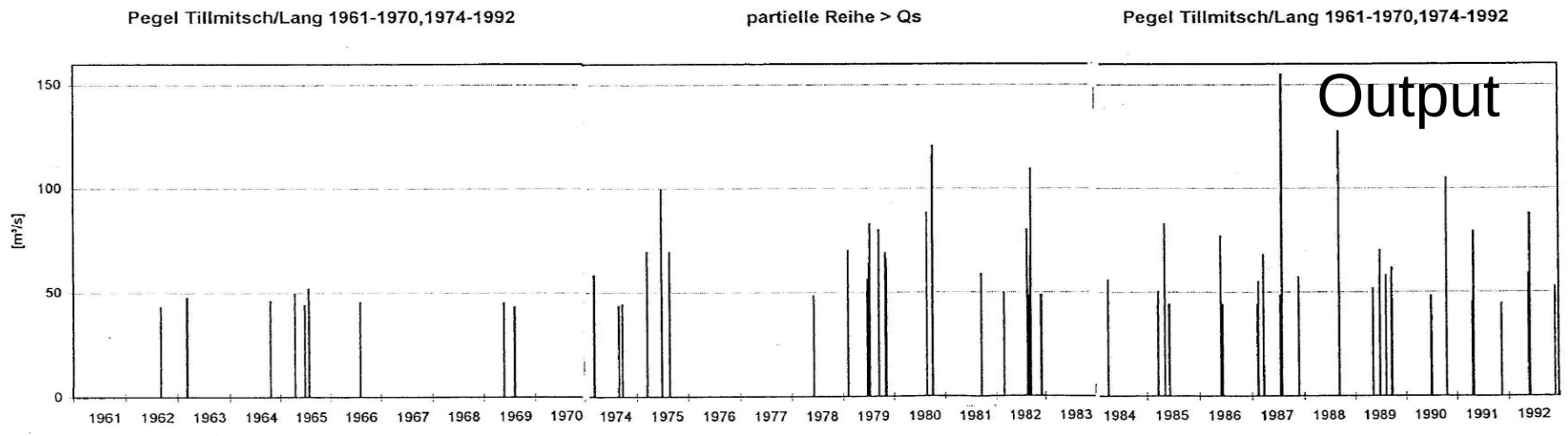
Climate change ?

- No significant changes in the annual precipitation (rather a decrease)
- No significant change in intensive rainfall



Comparison of input and output



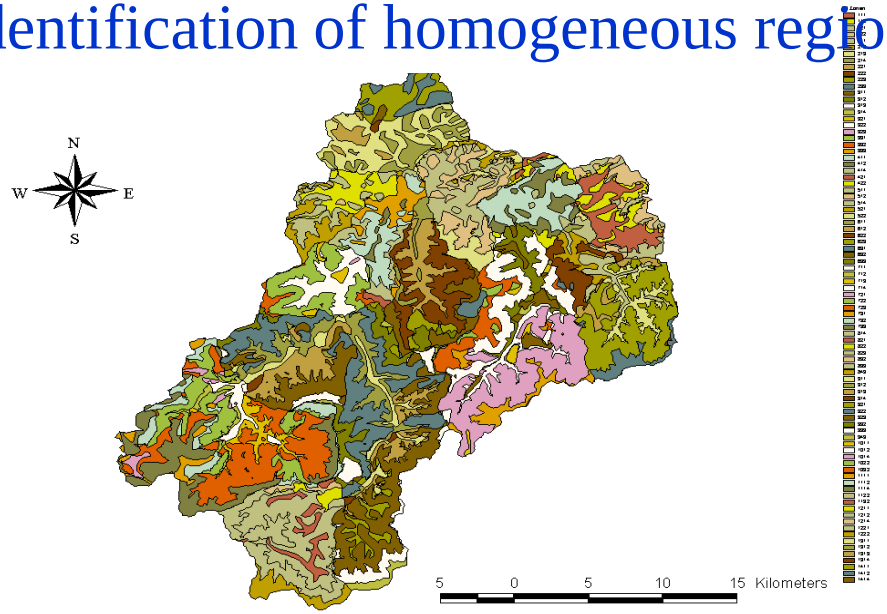


Land use changes in a smaller catchment

- Catchment area about 700 km^2
- Increase in forested area in the last 100 years
- Channelisation of rivers (up to 30 years flood)
- Small increase in residential area

Assessment of Land Use Changes

Identification of homogeneous regions



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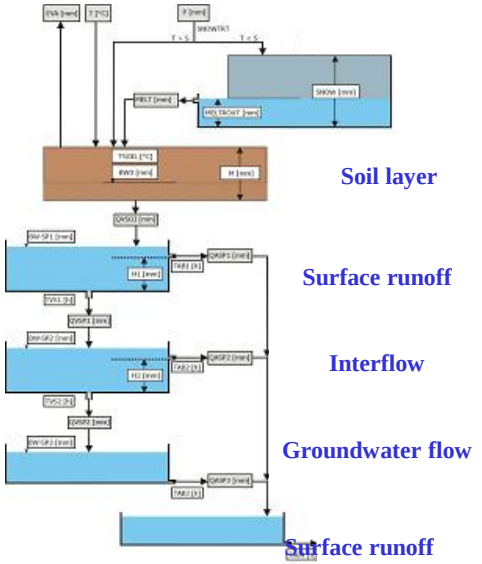
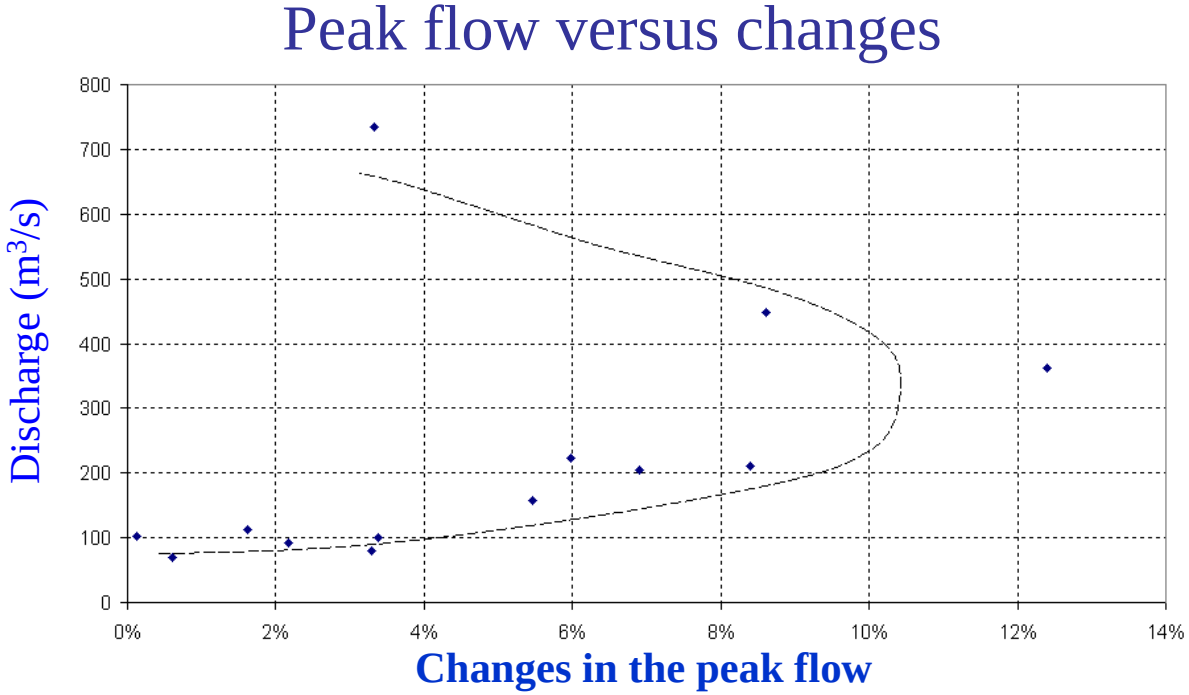


HBV-type

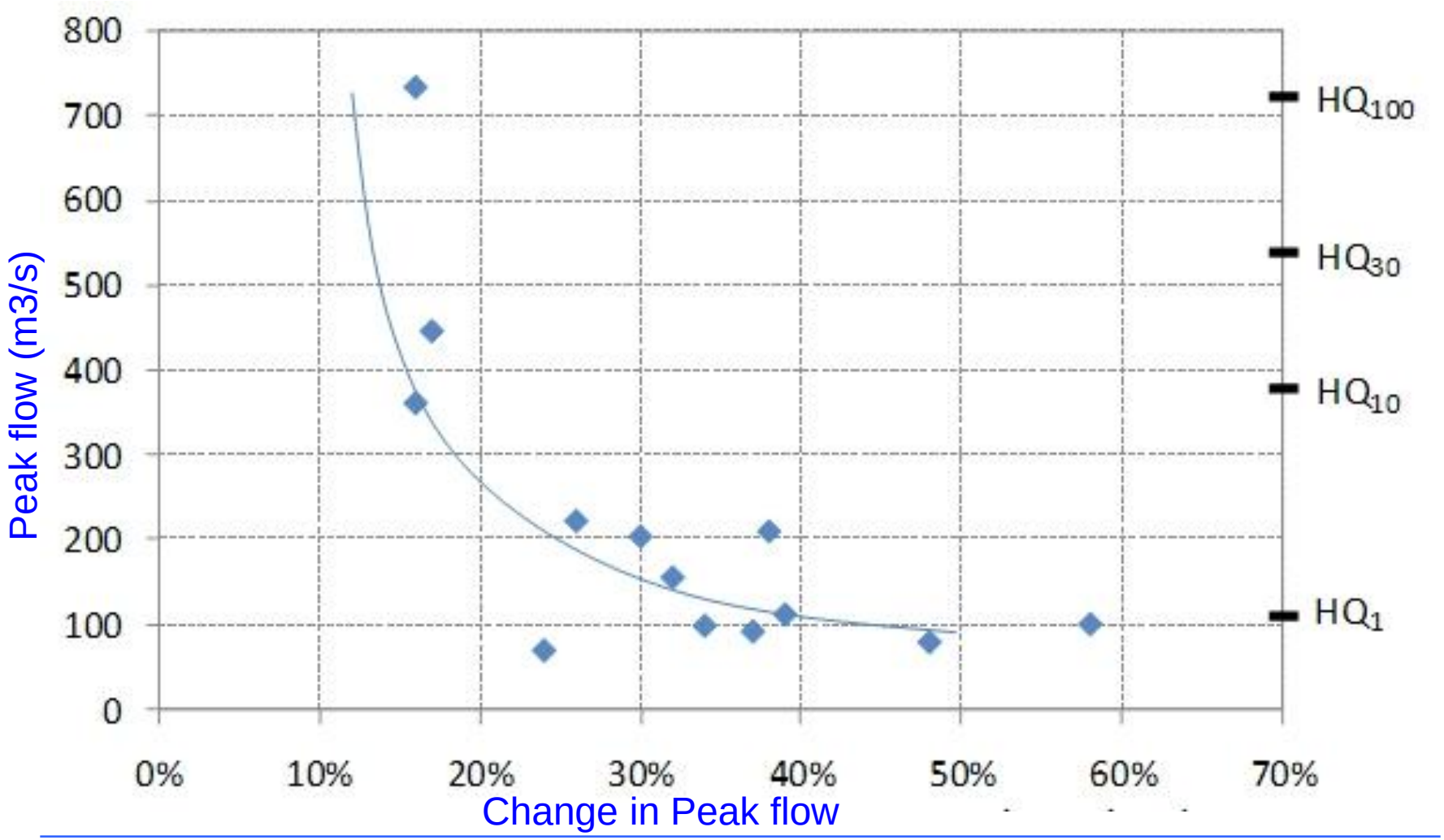
A distributed model is applied (Debene and Nachtnebel, 2004)

Assessment of River Training Works in the Traisen catchment

Debene (2004)

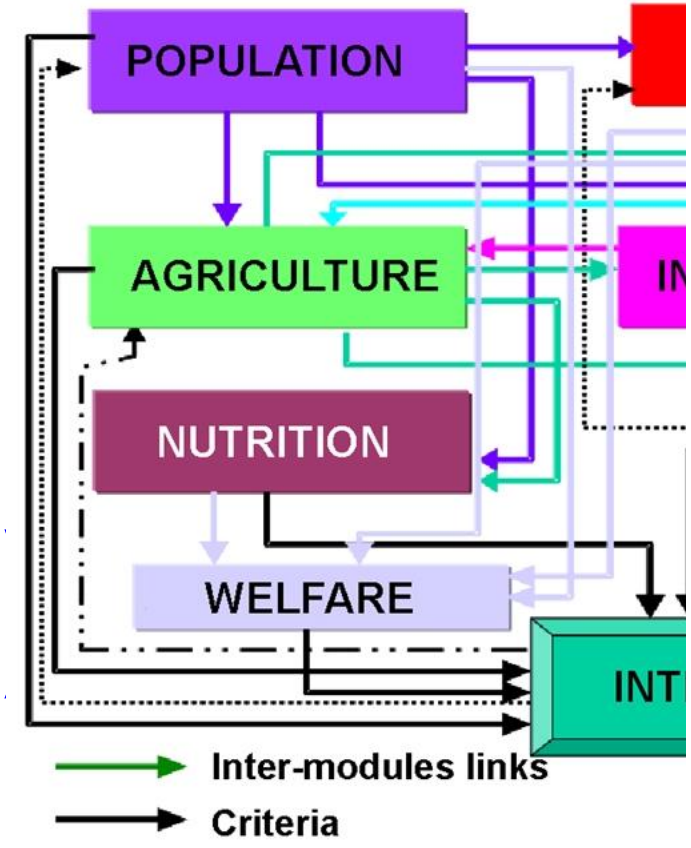


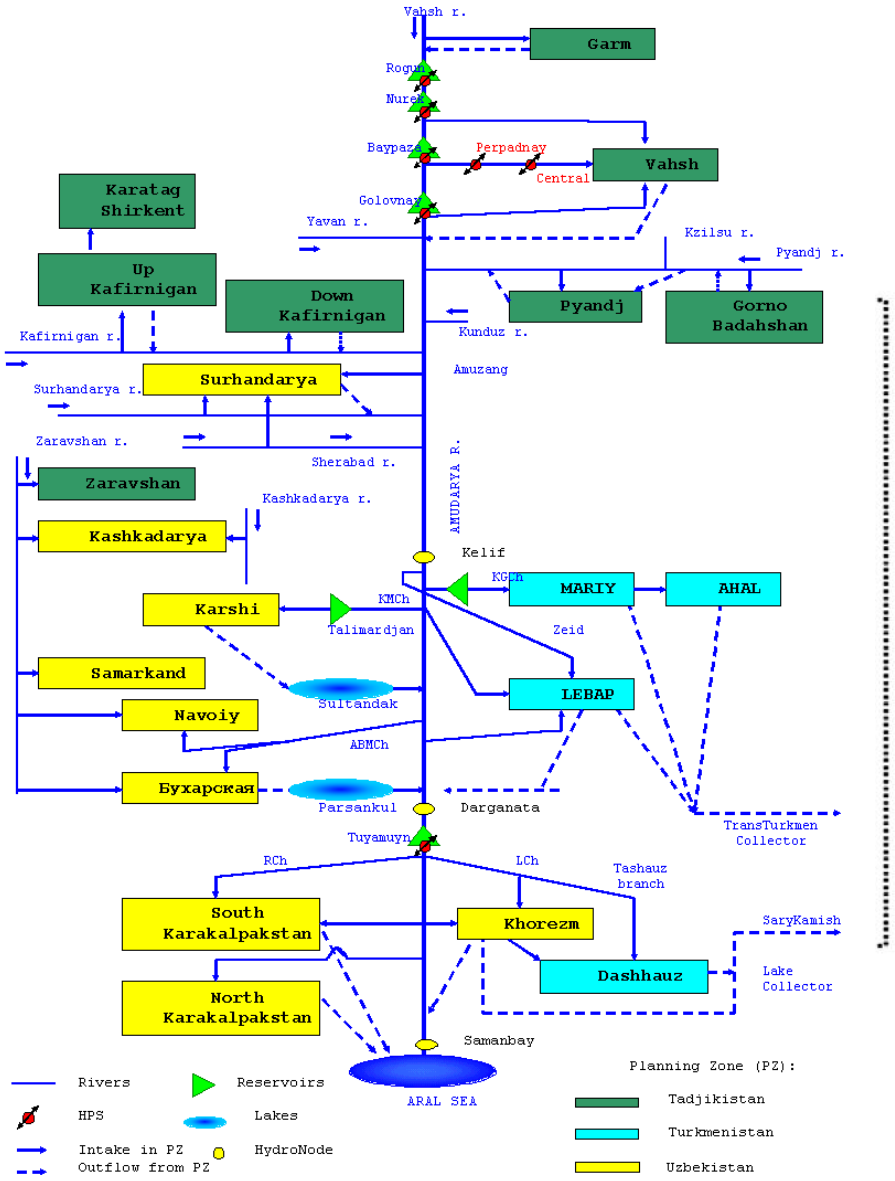
Assessment of Land Use Changes



Impacts on Aral Sea

Modelling th





The Aral Sea catchment

- Growth of population
- Enlargement of irrigation from 1950-1980
- Increase of industrial water demand
- Inefficient water use
- Lack of international cooperation
- The inflow to Aral Sea has been drastically reduced
- The seasonal cycle has been changed
- …..

Conclusions

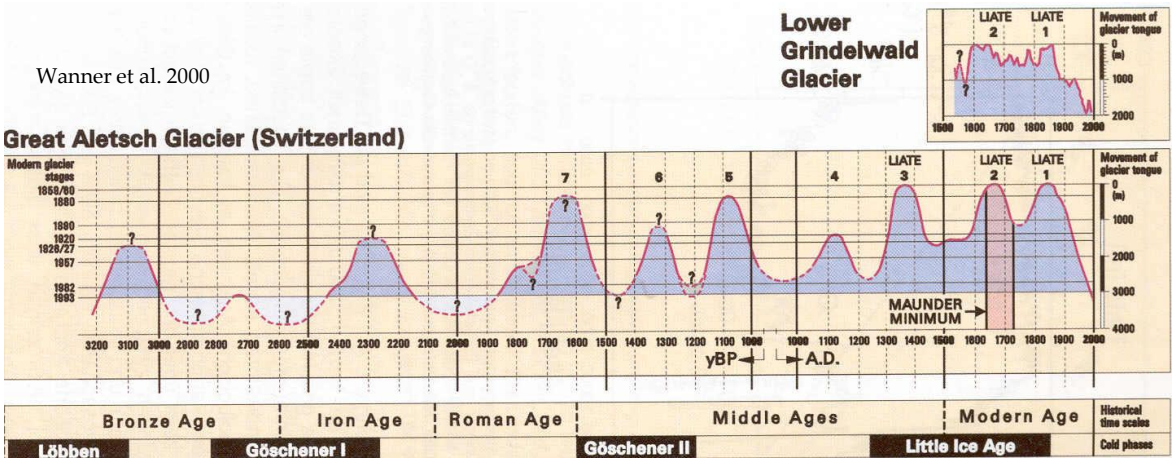
- The direct human impacts are measurable
- The human impacts may change the water regime drastically
- Human impacts may chane also the seasonal cycle
- What‘s about climate impacts ?

Methodology for the assessment of climate change impacts

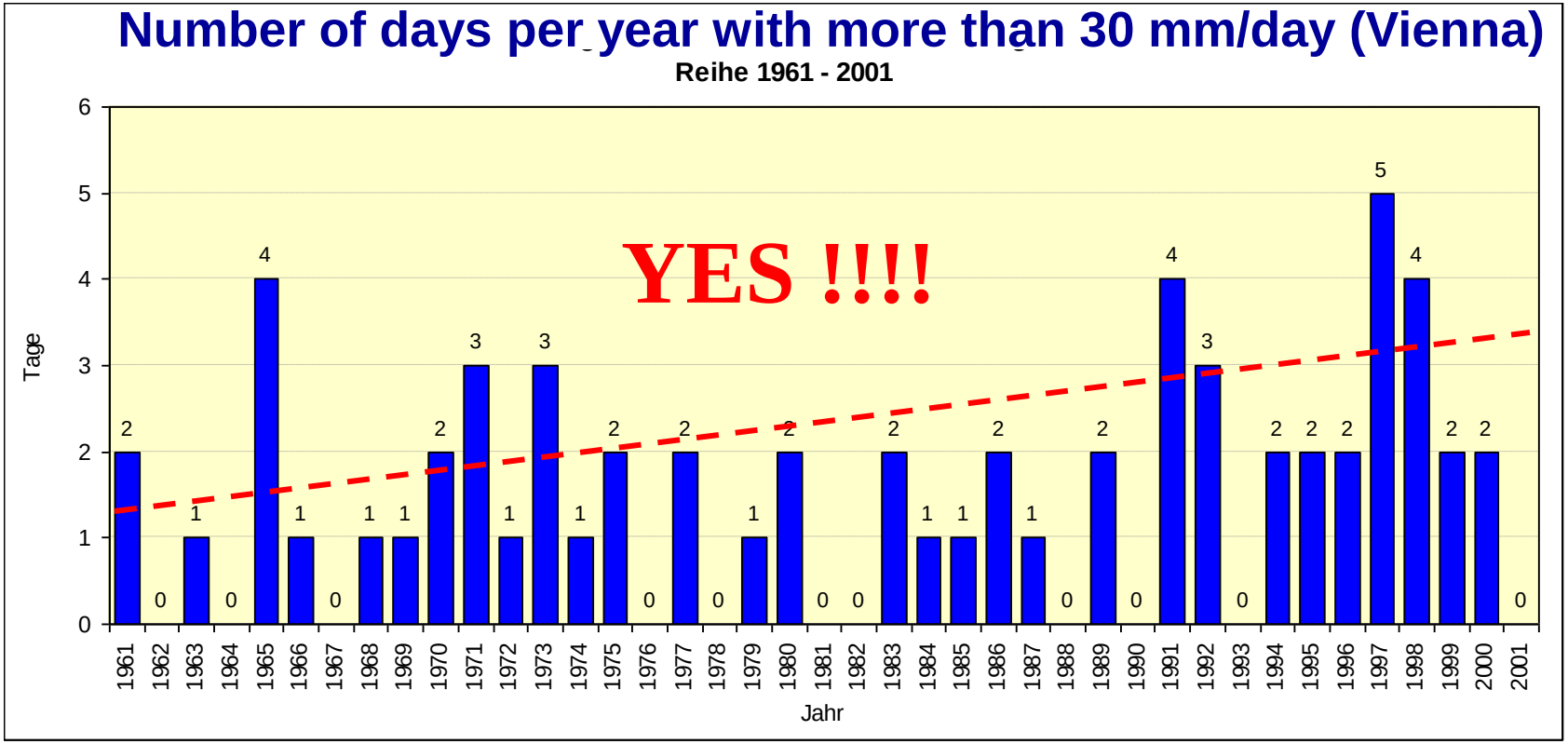
- **Trend analysis of time series**
- **Comparative catchment studies**
- **GCMs and RCMs**
- **Downscaling approaches**

1912 → 1969

Vernagt glacier

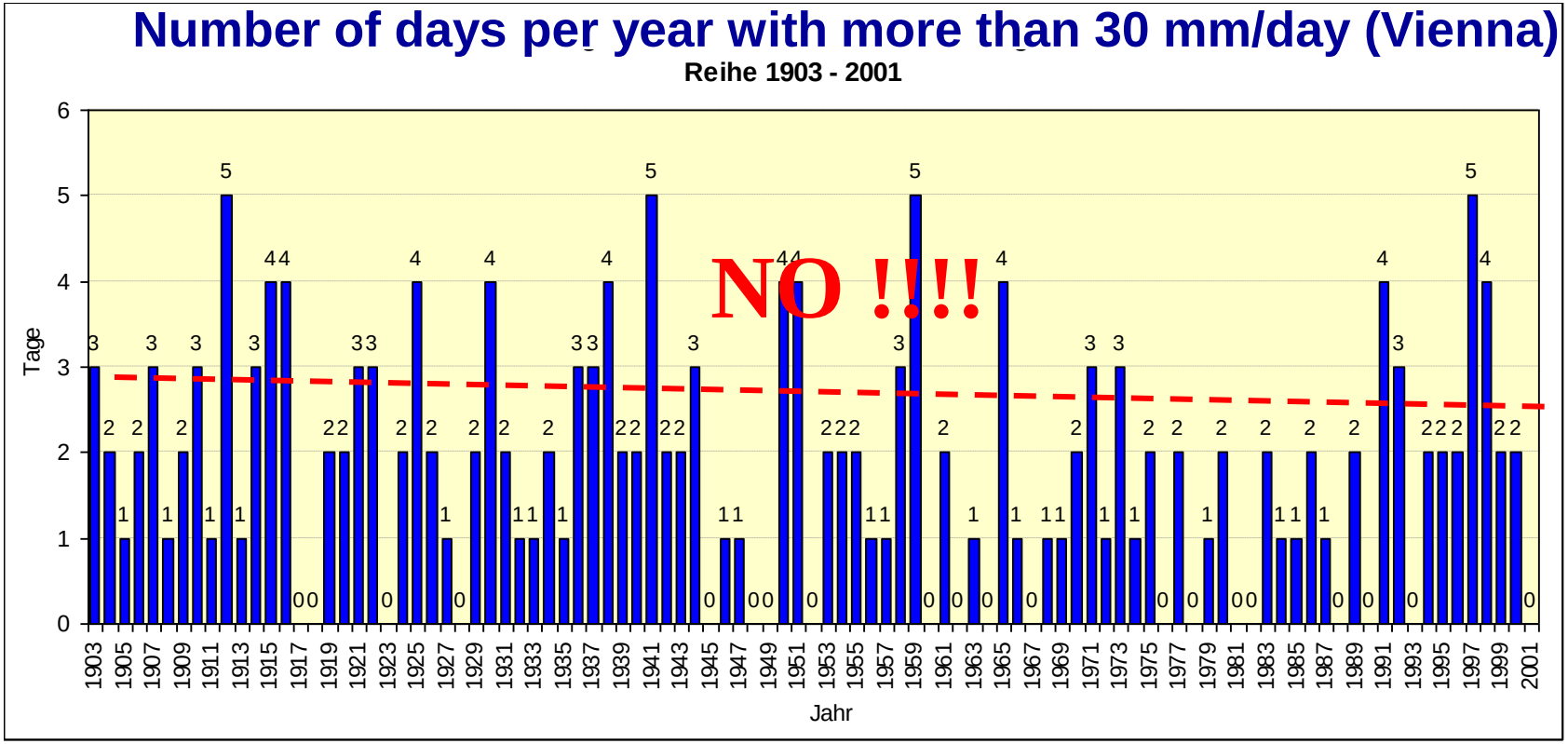


Do Heavy Rainfall Events Become more Frequent ?



(after Rudel, ZAMG 2002)

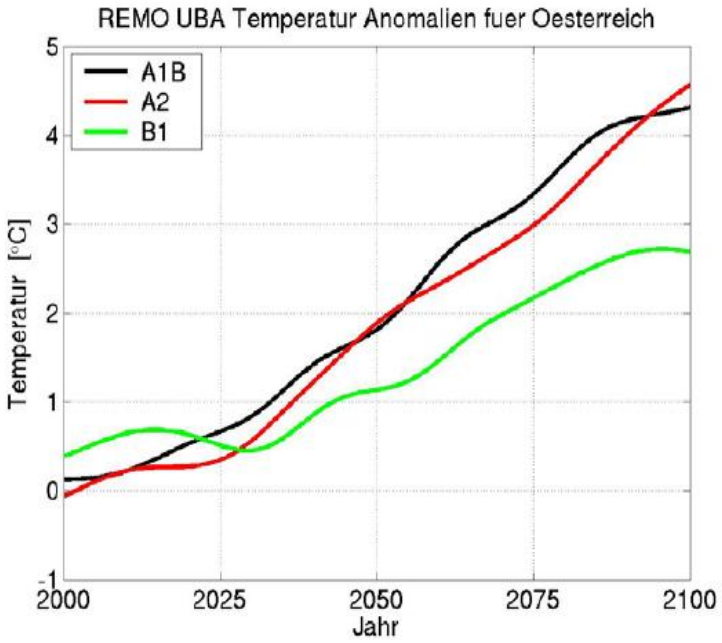
Do Heavy Rainfall Events Become more Frequent ?



(after Rudel, ZAMG 2002)

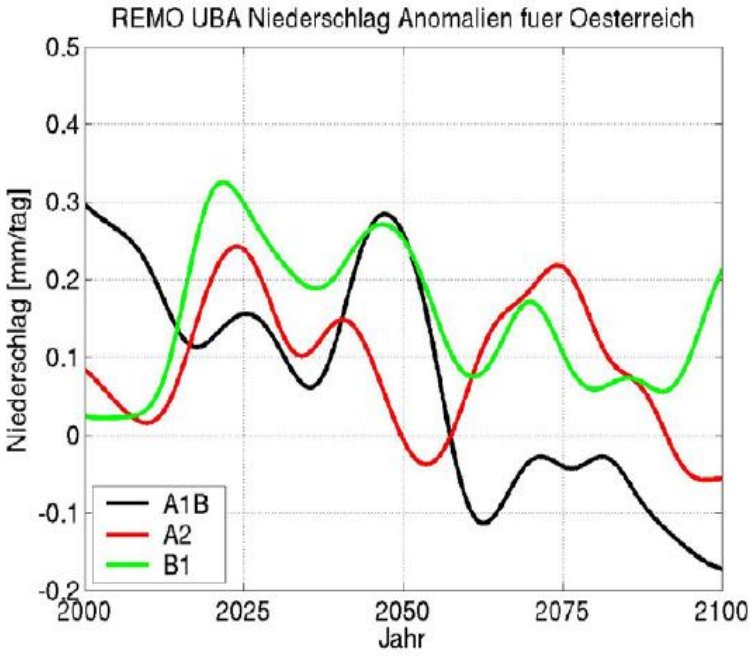
Possible impacts of climate change on the water balance of Austria

Anomalies in temperature



Quelle: Formayer

Anomalies in rainfall

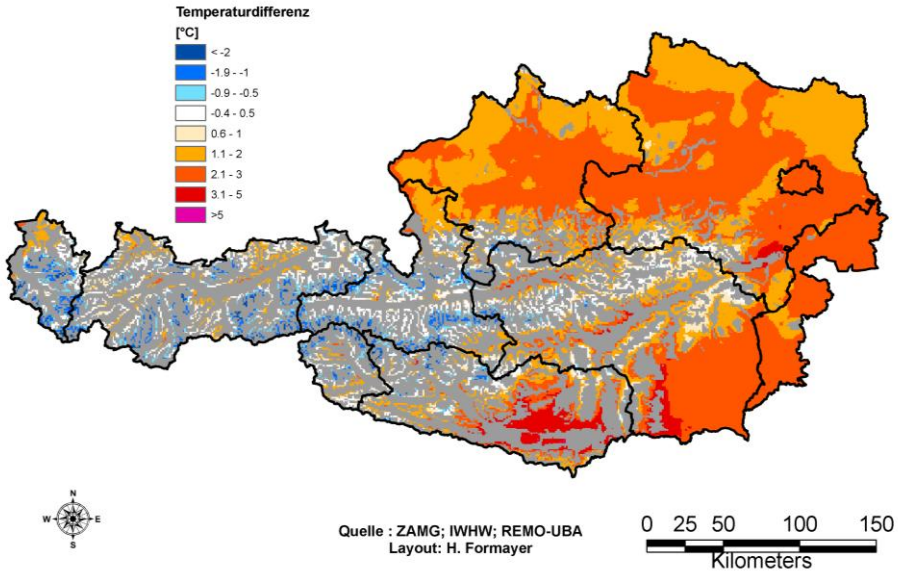


Analysis of RCMs

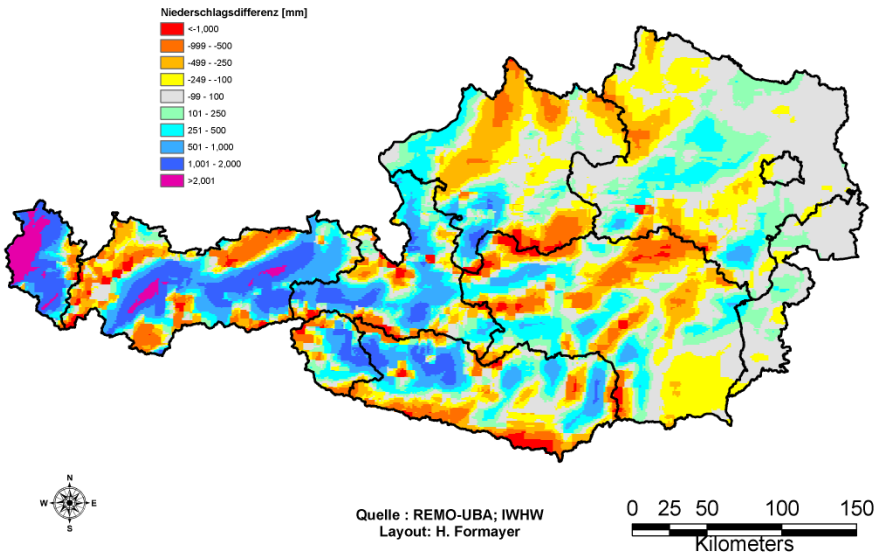
- The simulated T and P time series show large deviations from observations
- The spatial pattern is shifted
- Data need adjustment (bias correction, transfomation, quantile mapping, etc.)
- The scenario outputs show large differences in P
- Large uncertainty in the simulated data

Comparison between simulation and observation for the control period

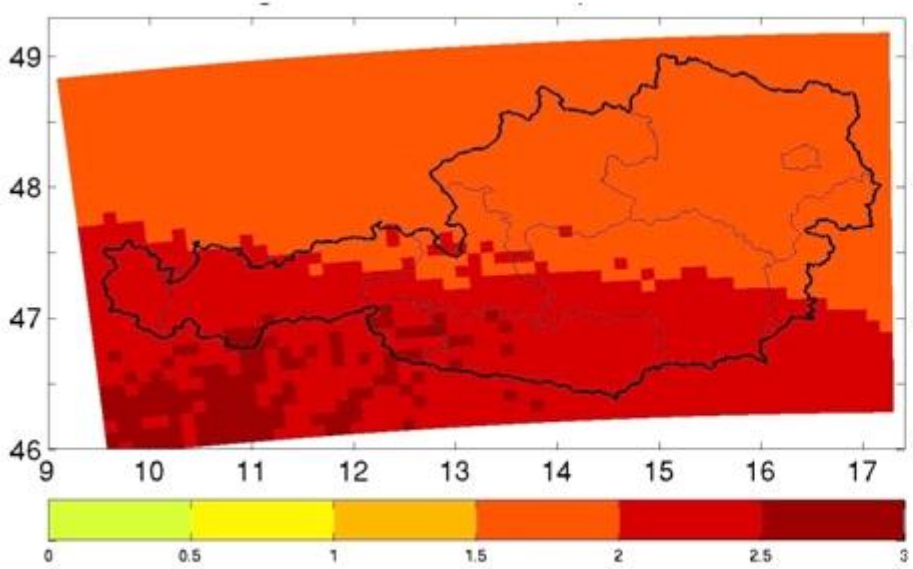
Differenz der Jahresmiteltemperatur 1961-1990
(REMO_UBA - Beobachtung)
Grau = Bereiche mit mehr als 150 m Höhenunterschied

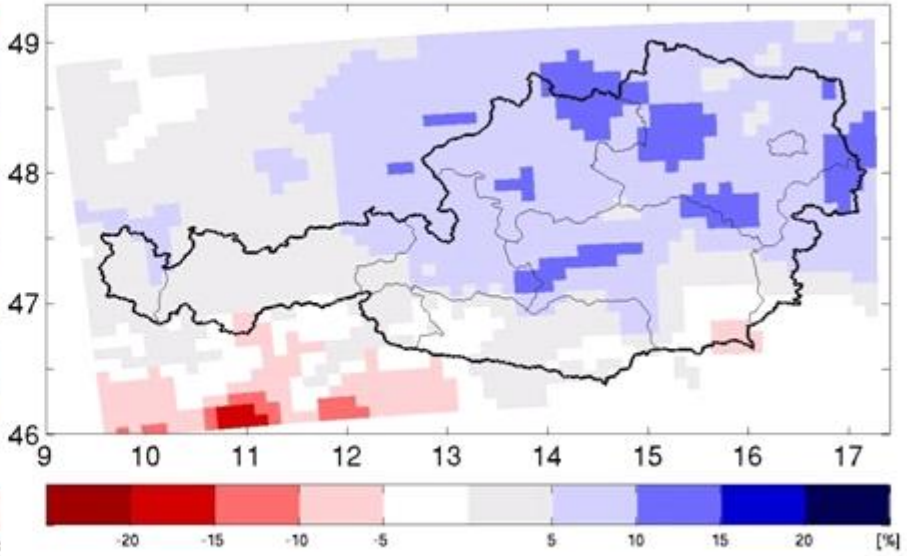


Differenz der mittlere Jahresniederschlagssumme1961-1990
(REMO_UBA - Beobachtung)



Climate signal in T and P

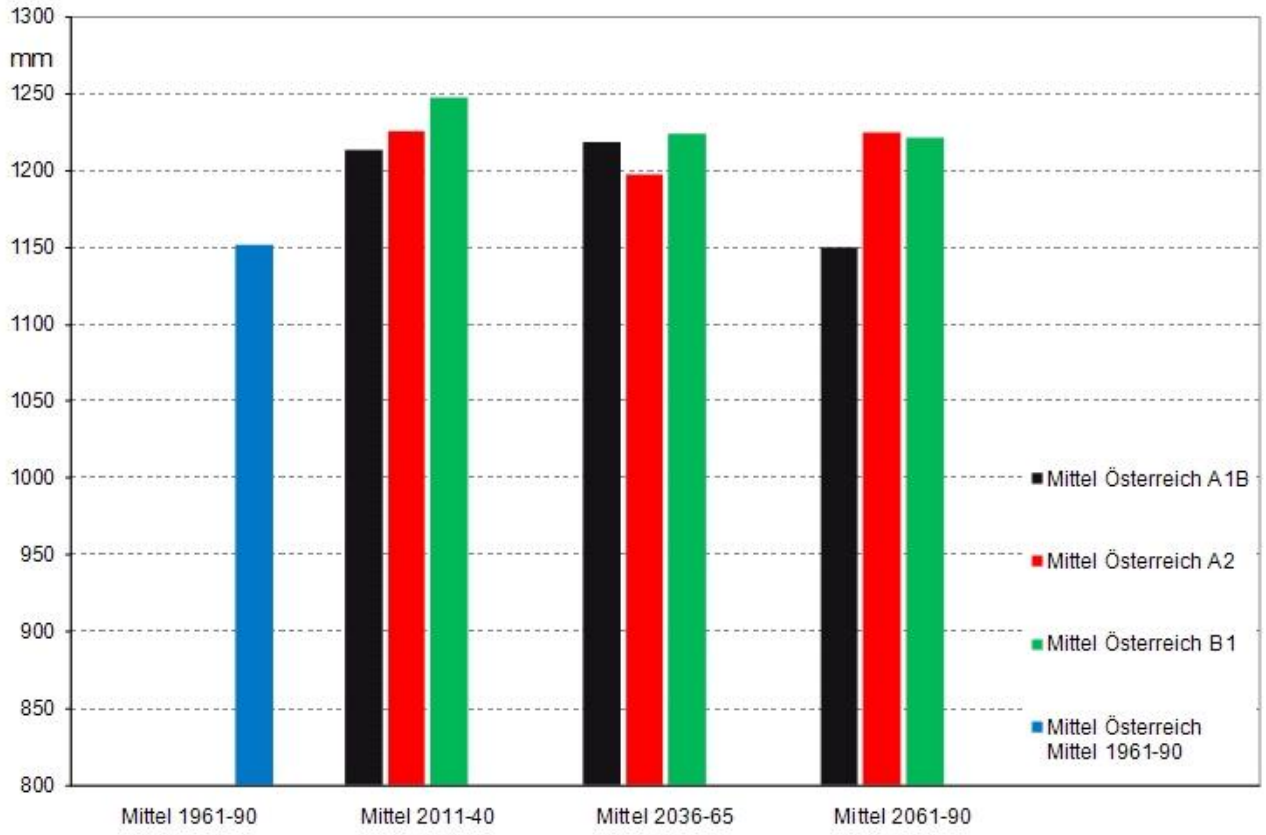




Temperature **Precipitation**

Difference of long term mean values (1961-1990 und 2036-2065)
A1B scenario

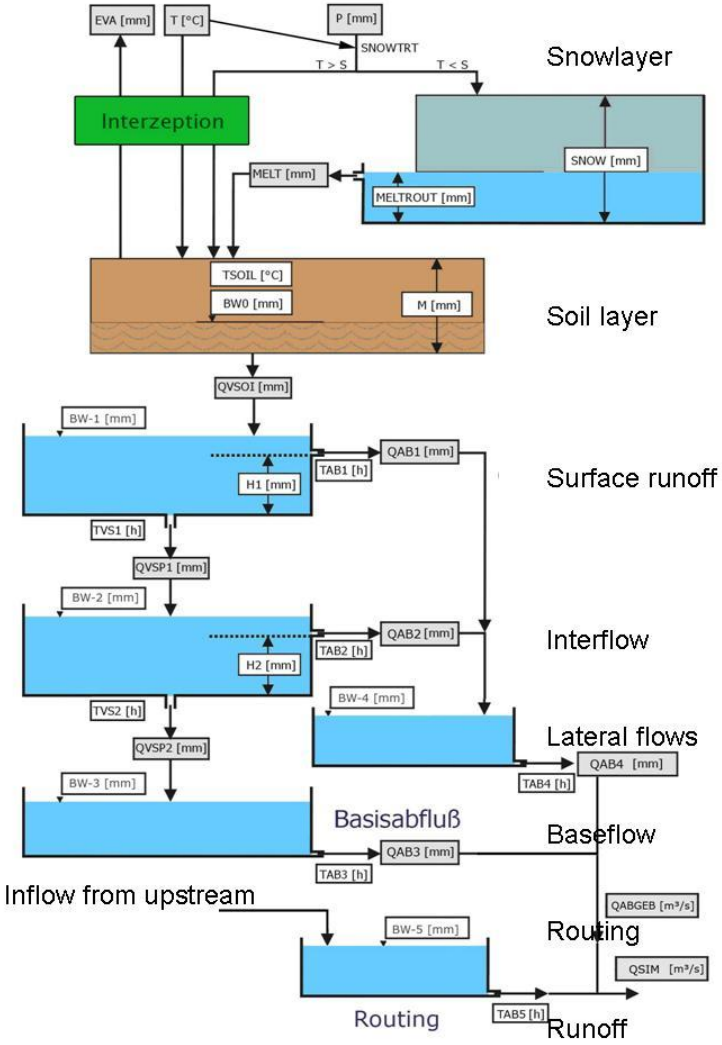
Changes of long term mean values of precipitation



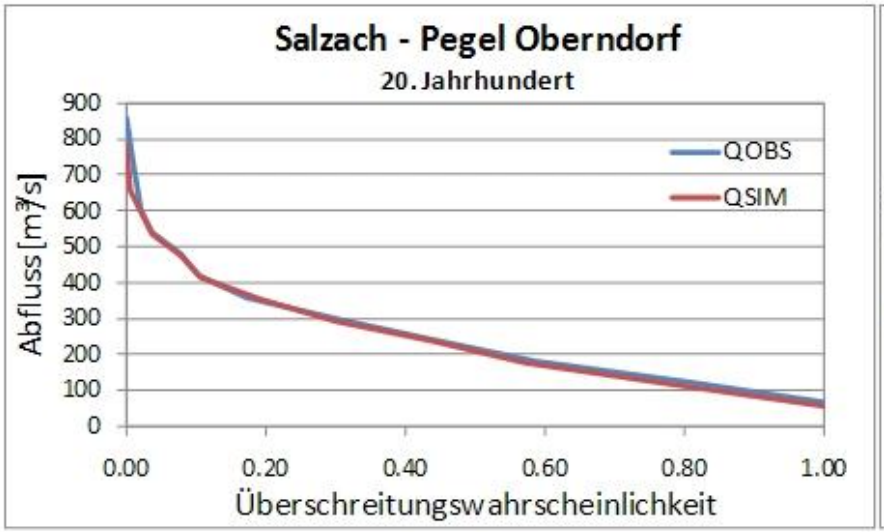
Long term mean annual precipitation

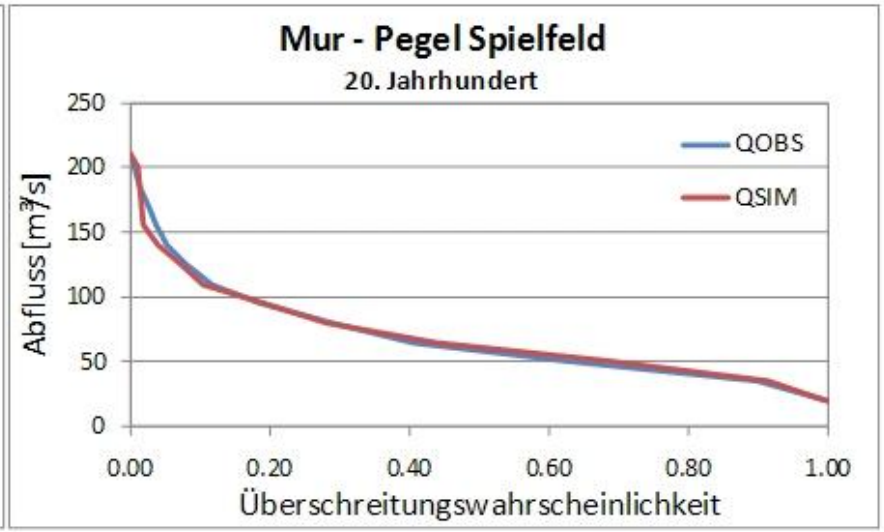
Hydrological simulation

- RCM- data were correcte
- A 1*1 km grid was used f
- Simualtion at monthly tim
- The hydrological model w past by fitting to 188 gauç
- Glaciers were also simula



Some simulation results (1961-1990) flow duration curves



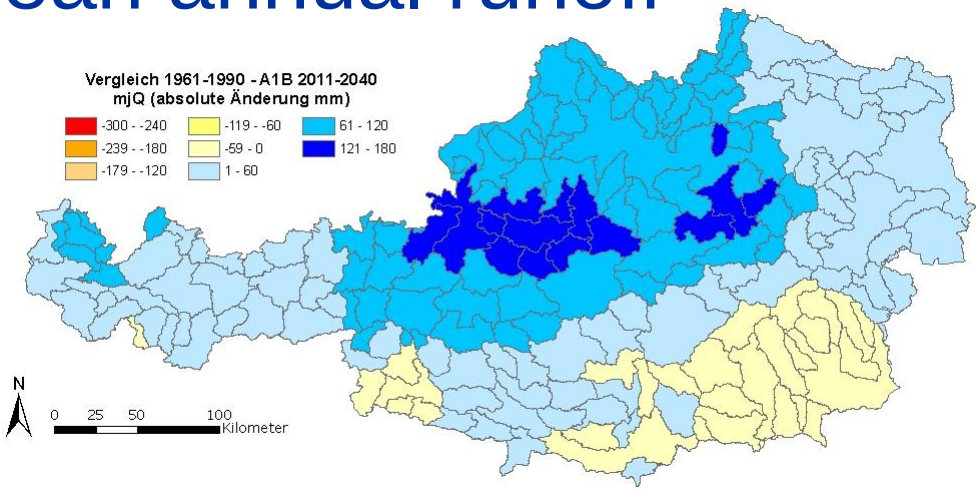


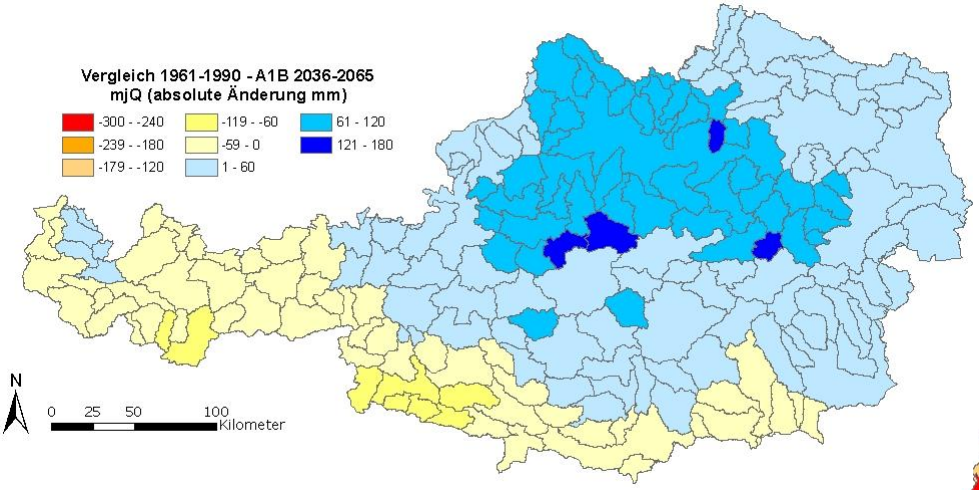
Changes in mean annual runoff

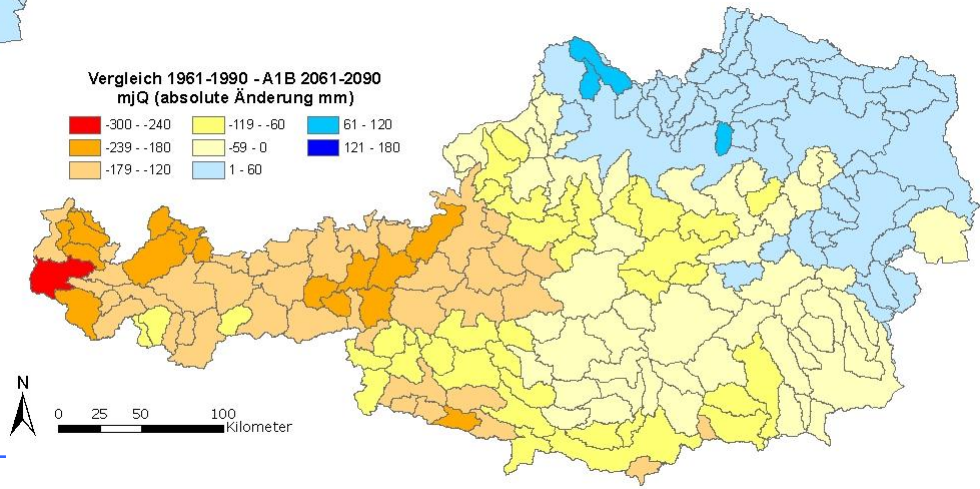
A1B scenario

Difference between 1961-1990 in mm

- 2011-2040
- 2036-2065
- 2061-2090



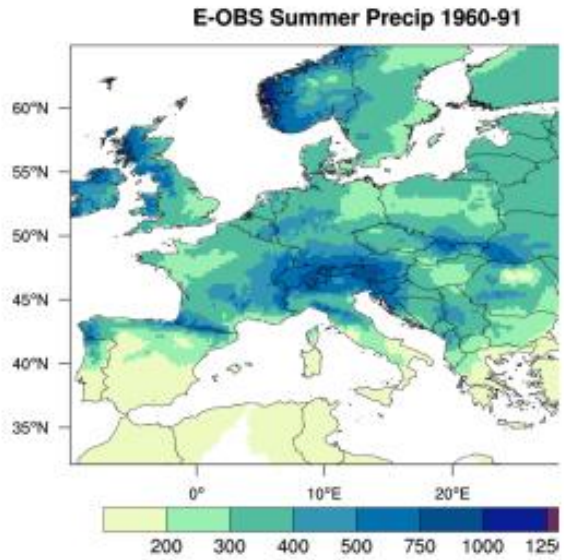


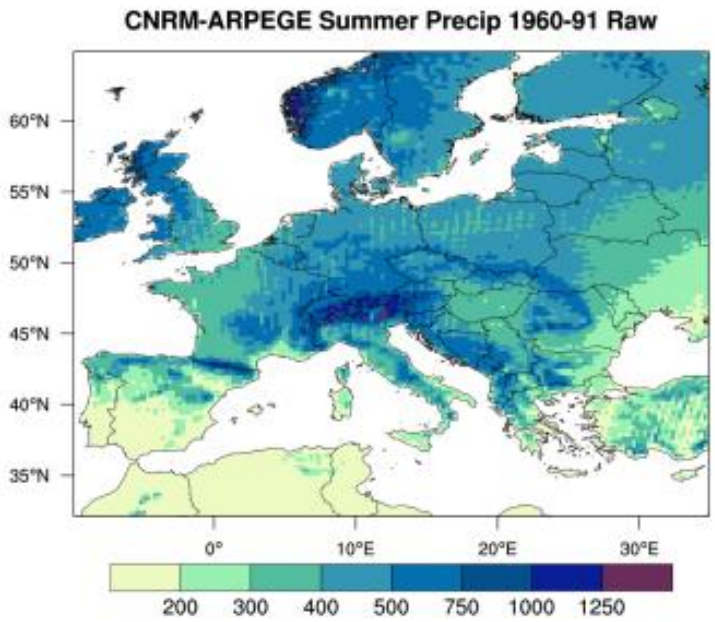


Water balance of Austria

- The observed trend in the last fifty years is also found in the hydrological simulations
- A different development N and S of the mountains (in the South decrease in the North a small increase in P)
- Runoff decreases between 5-25 % due to increased evaporation

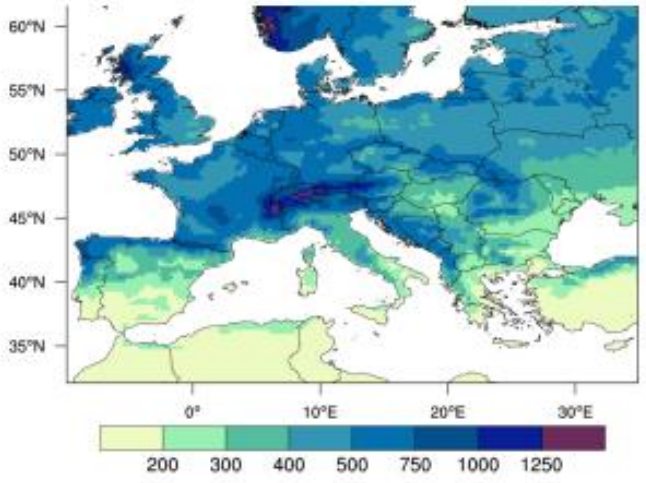
Large scale simulations: precipitation



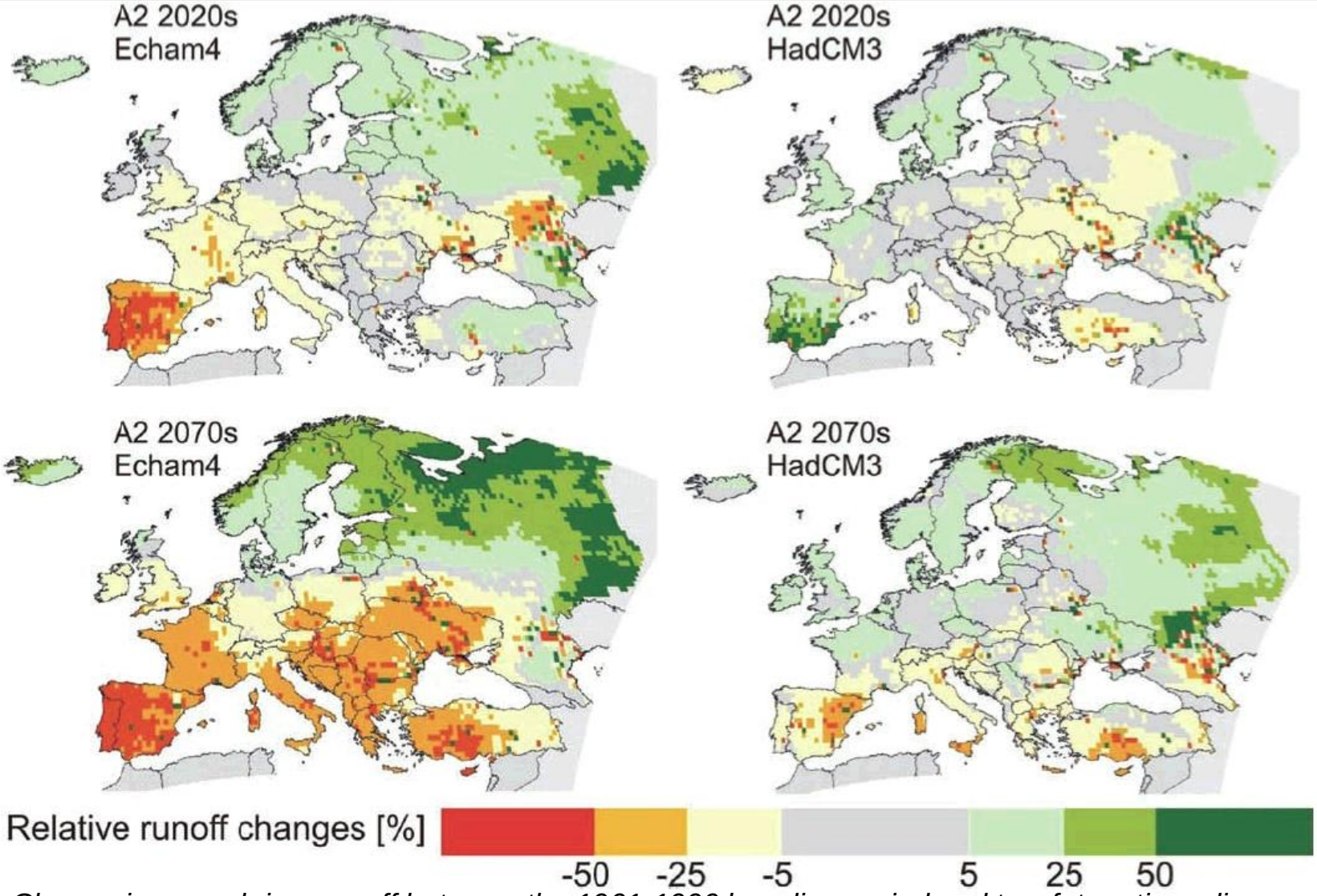


Summer (Apr-Sep) Precipitation

Observations versus raw RCM results (up ALADIN, down RegCM3)



Large scale simulations: runoff



Change in annual river runoff between the 1961-1990 baseline period and two future time slices (2020s and 2070s) for the A2 scenarios (Alcamo et al., 2007).

Considering both:

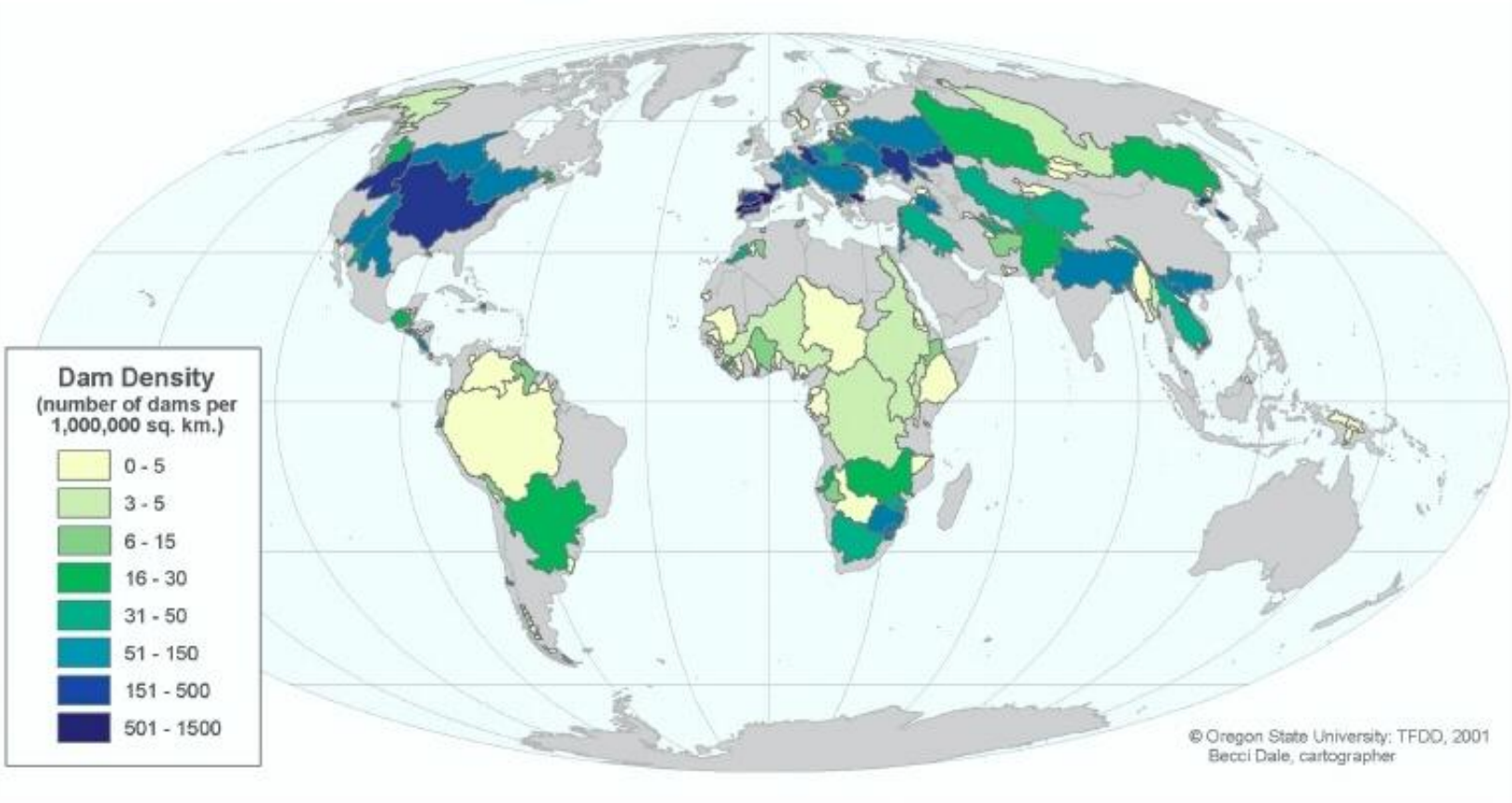
- Human impacts: dams, irrigation,…
- Climate change

- At the global scale

Irrigated Areas, circa 1995

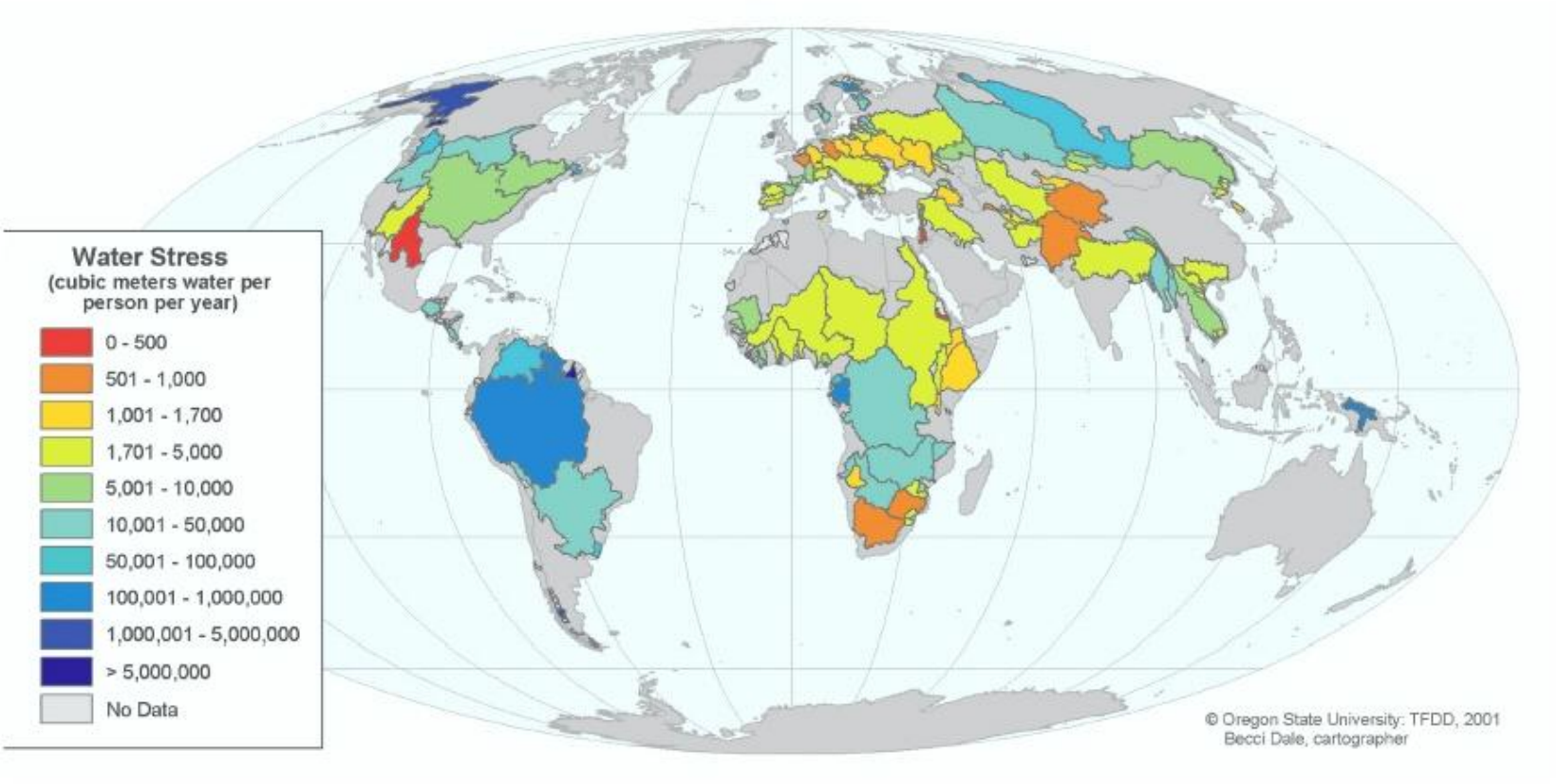
Data source: Irrigated agriculture- Döll and Siebert (2000), Siebert and Döll (2001).

Dam Density per International River Basin



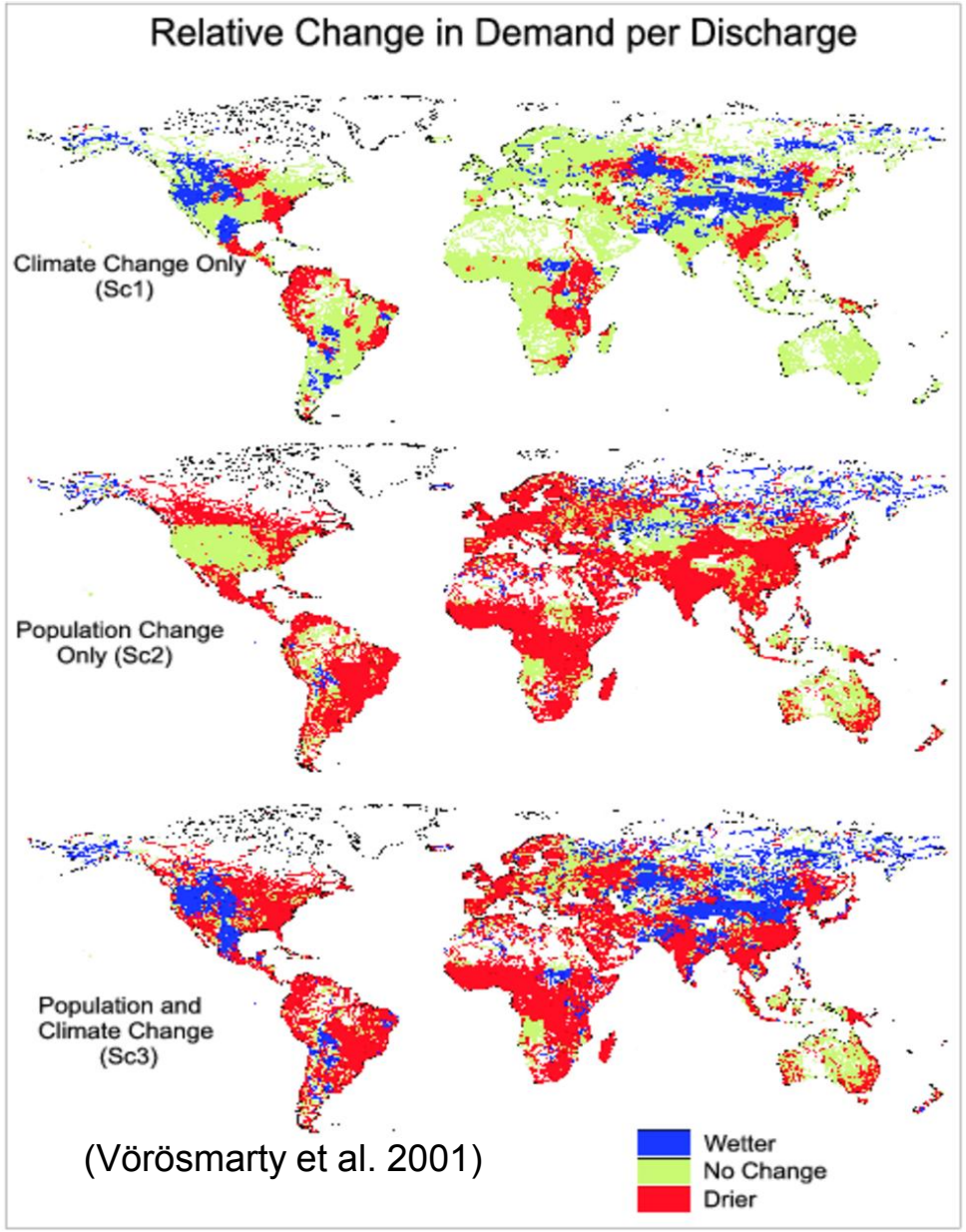
Data sources: Dams- Ph.D. Associates Inc. (1998); Density by basin- Fiske and Yoffe (2001).

Water Stress per International River Basin



Data sources: Runoff- Fekete et al. (2000); Population- Dobson et al. (2000); Water stress by basin- Fiske and Yoffe (2001).

Water Stress Changes until 2025



(Vörösmarty et al. 2001)

80% of future stress from population & development

not climate change!

e.g. 85% US global change research funding goes to climate and carbon

Role of scale

- Land use impact may increase with catchment area (Aral Sea catchment, Nile,…)
- Climate change impact may decraese with catchment area (when areas with different climate signals are within the catchment)

Summary and conclusions

- In all our data we find both: human impacts and climate change
- In many regions the direct human impacts on water resources are much larger than expected changes
- For climate change impacts studies a careful adjustment of RCM data is needed, otherwise…
- Large uncertainty in RCMs
- Select different model outputs and different emission scenarios

Thank you for your attention