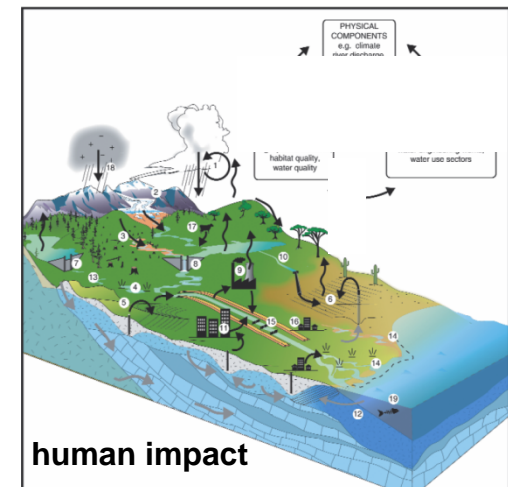
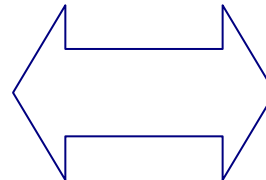
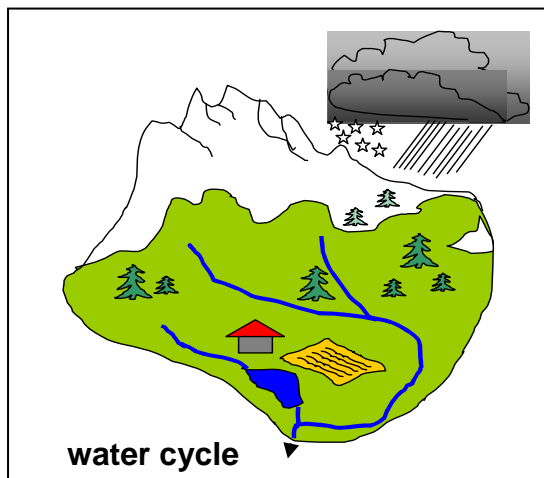


# Projects on the influence of anthropogenic activity or climate change on water quantity

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# **Contents:**

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- 1. Integrated water resources management in a catchment under changing framework and boundary conditions**
  - 2. Project „GLOWA-Elbe“**
  - 3. Project „BEWASYS Rhine - Oder“**
  - 4. Project „WBalMo HavelSpree“**
-

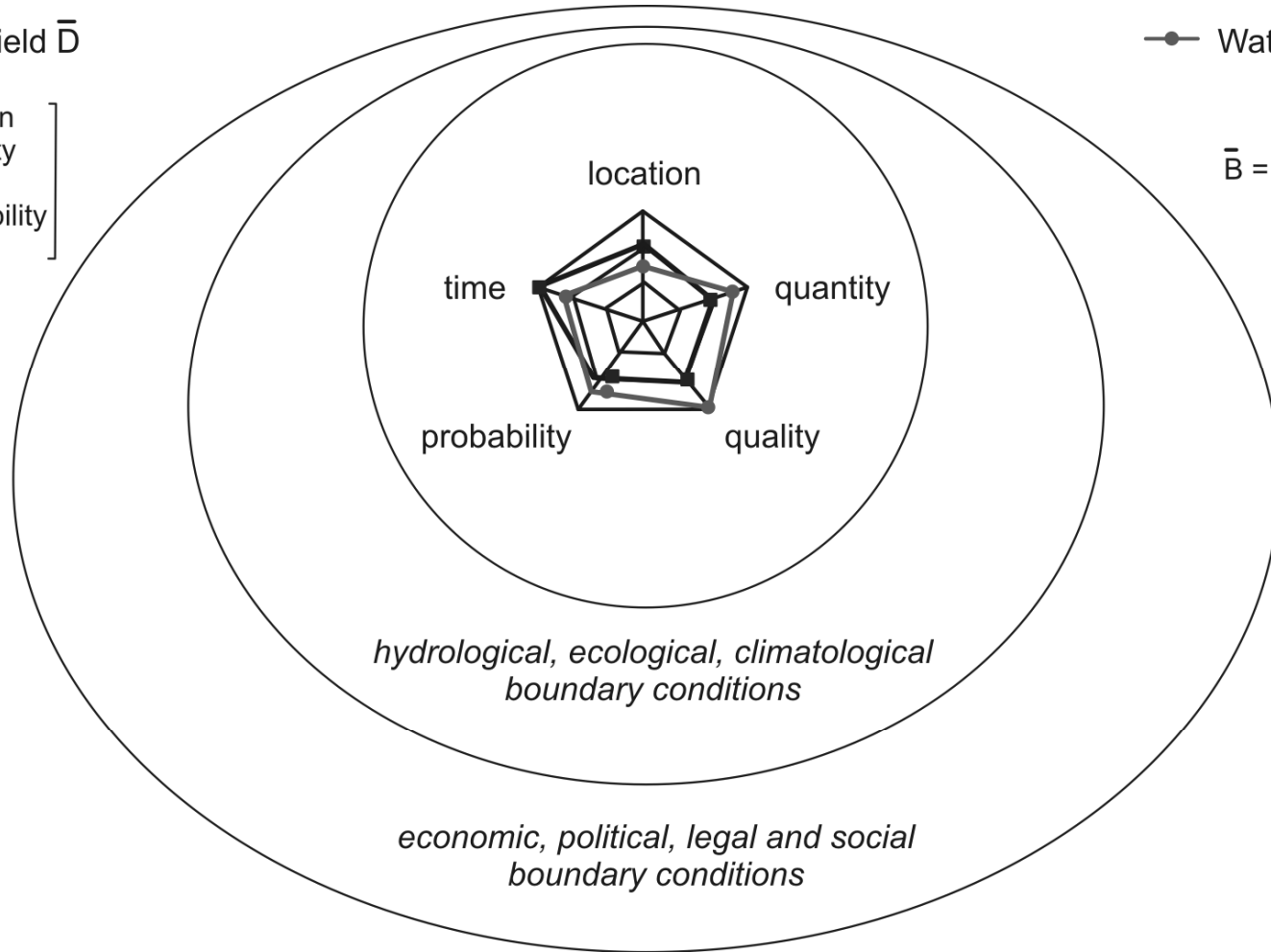
# „Central issues of integrated water resources management in a catchment under changing framework and boundary conditions”

—■— Water yield  $\bar{D}$

$$\bar{D} = \begin{bmatrix} \text{location} \\ \text{quantity} \\ \text{quality} \\ \text{probability} \\ \text{time} \end{bmatrix}$$

—●— Water demand  $\bar{B}$

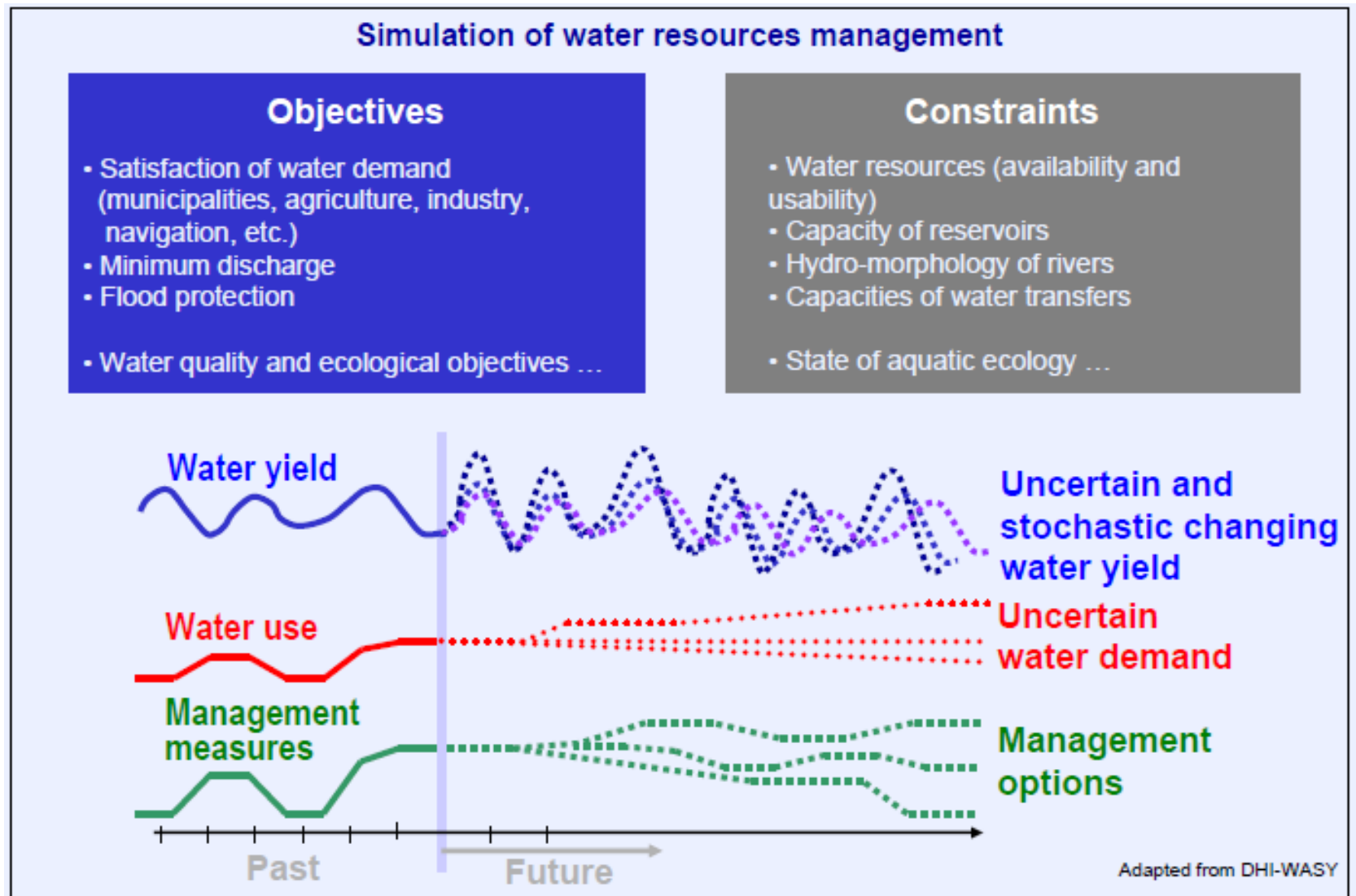
$$\bar{B} = \begin{bmatrix} \text{location}^* \\ \text{quantity}^* \\ \text{quality}^* \\ \text{probability}^* \\ \text{time}^* \end{bmatrix}$$



$\bar{B} \Leftrightarrow OP(\bar{D})$  - yield oriented measures and / or  $\bar{D} \Leftrightarrow OP(\bar{B})$  - demand oriented measures  
with costs at a minimum and sustainability reaching maximum

Source: Gruenewald, 2001; Schoenheinz, Gruenewald, Koch, 2011

# „Action frame in water resources management“



## General Objective:

Adjustment of water management strategies to global change

## Topics:

- Surface water quality
- Surface water quantity



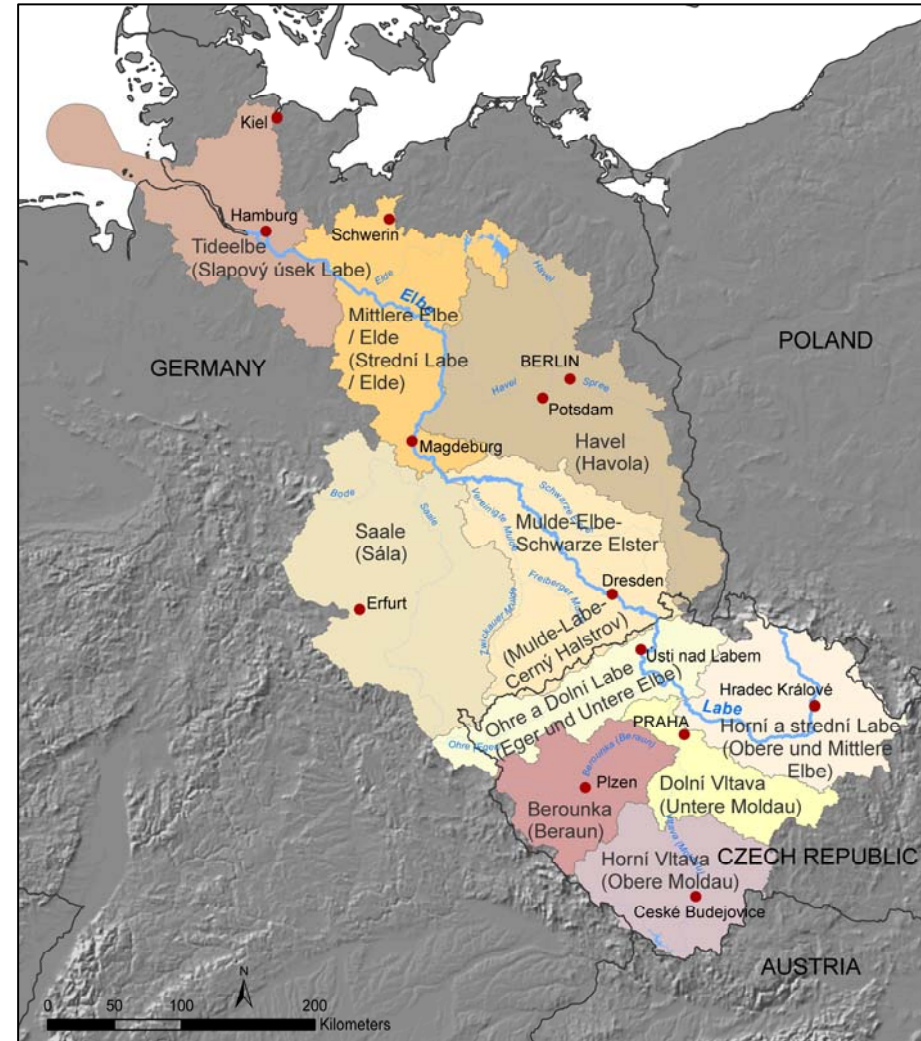
## Phases:

1. 2000-2003 Exploration of the basin
2. 2004-2007 Solutions for the basin
3. 2007-2010 Transfer of Tools (confirmed by BMBF) involving Czech partners and institutions

Source: Wechsung, 2007

## „Research area“

- GLOWA-ELBE: investigation of changes in the water availability in the whole Elbe River Basin under global change scenarios
- Czech Republic covers one third of the Elbe River Basin roughly
- Inflow to Germany at different locations:
  - Main stream of river Labe
    - => Decin / Labe
  - Sub-basin of the river Mulde
    - => downstream reservoir Přisečnice / Přisečnice
    - => downstream reservoir Flaje / Flajský potok
- Effects of climate change and reservoir management in the Czech Republic will in all probability have an influence on inflow to Germany



Source: Koch, Kaltofen, Kaden, Grünewald, 2010

Two frames of development analysed:

- i) “**Globalisation**”: fast global integration, higher economic growth rates and regional convergence
- ii) “**Differentiation**”: slow global integration, lower economic growth rates and regional differentiation

Both frames of development are combined with two **environmental policies**:

- a) continuation of the **present policy**
- b) **higher** standards for **environmental regulation**, e.g. higher reduction targets for CO<sub>2</sub>

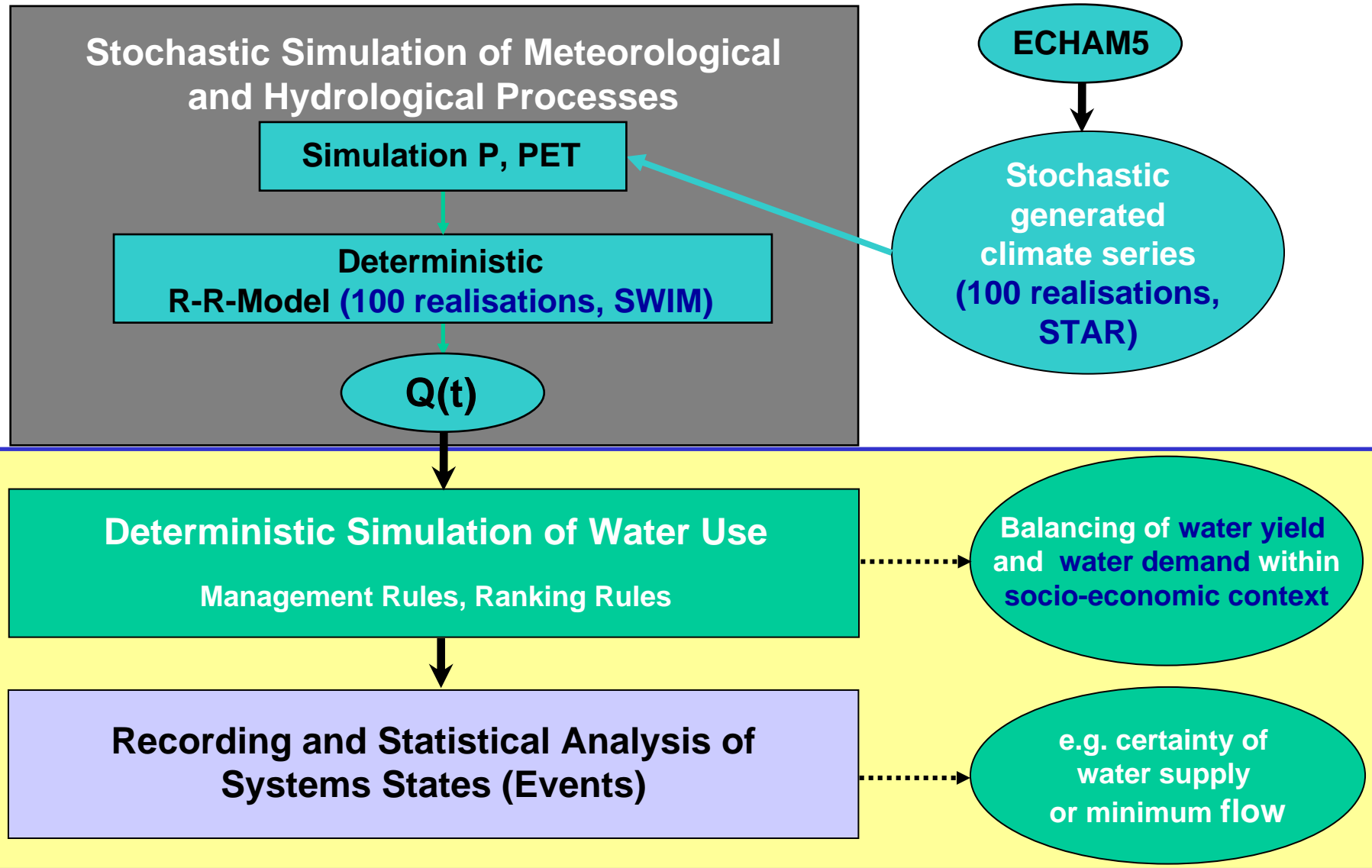
➔ **2 scenarios**:

- ia) “Globalisation without stronger environmental protection” (**Globalisation w/o env. reg.**),
- iib) “Differentiation with stronger environmental protection” (**Differentiation w env. reg.**).

A climate warming of approximately 2°C (GCM: ECHAM5) by 2050 is assumed.

Source: Koch, Kaltofen, Kaden, Grünewald, 2010

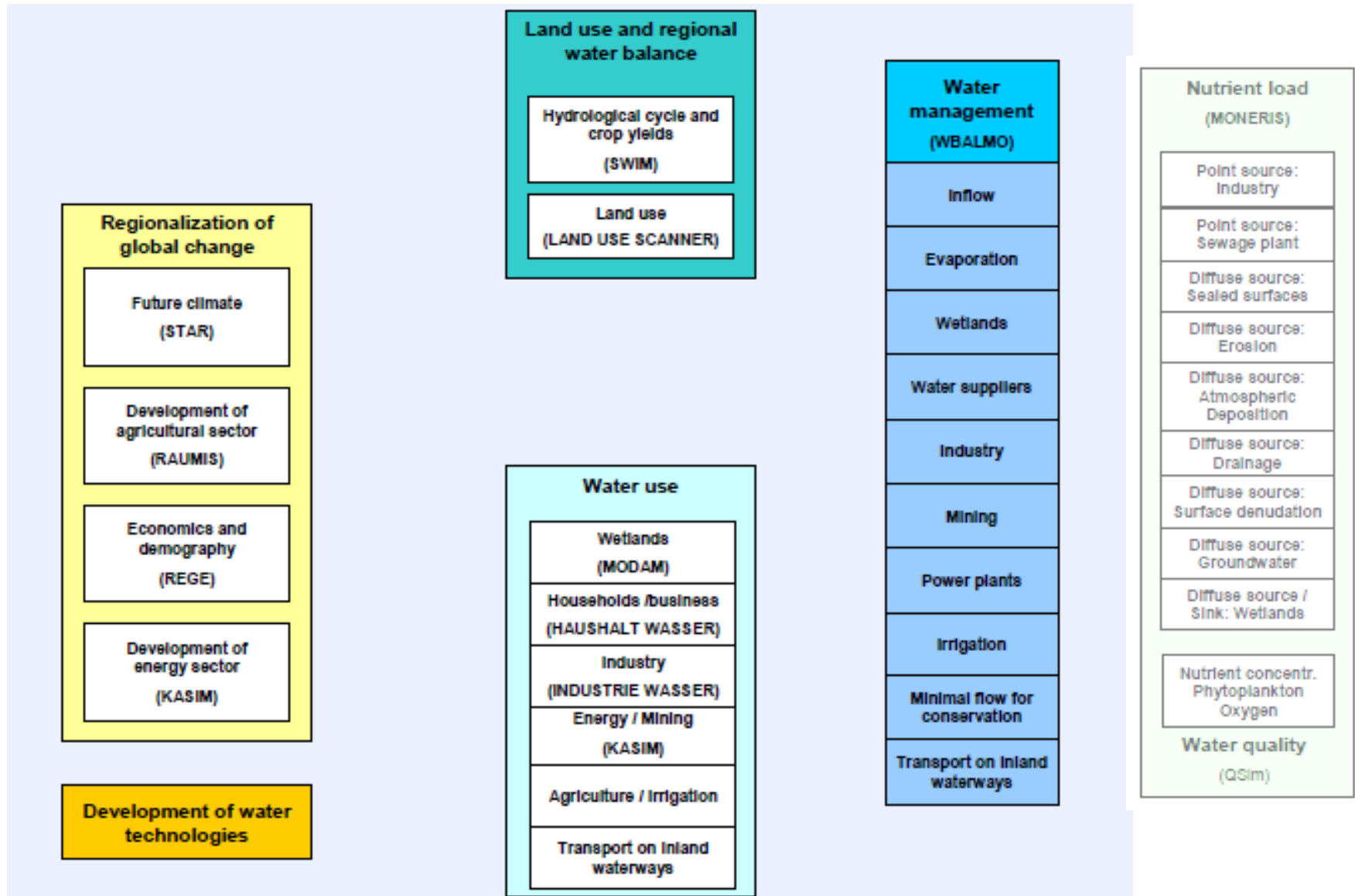
## „Simulation and modelling system“



Source: Koch, Kaltofen, Kaden, Grünewald, 2010

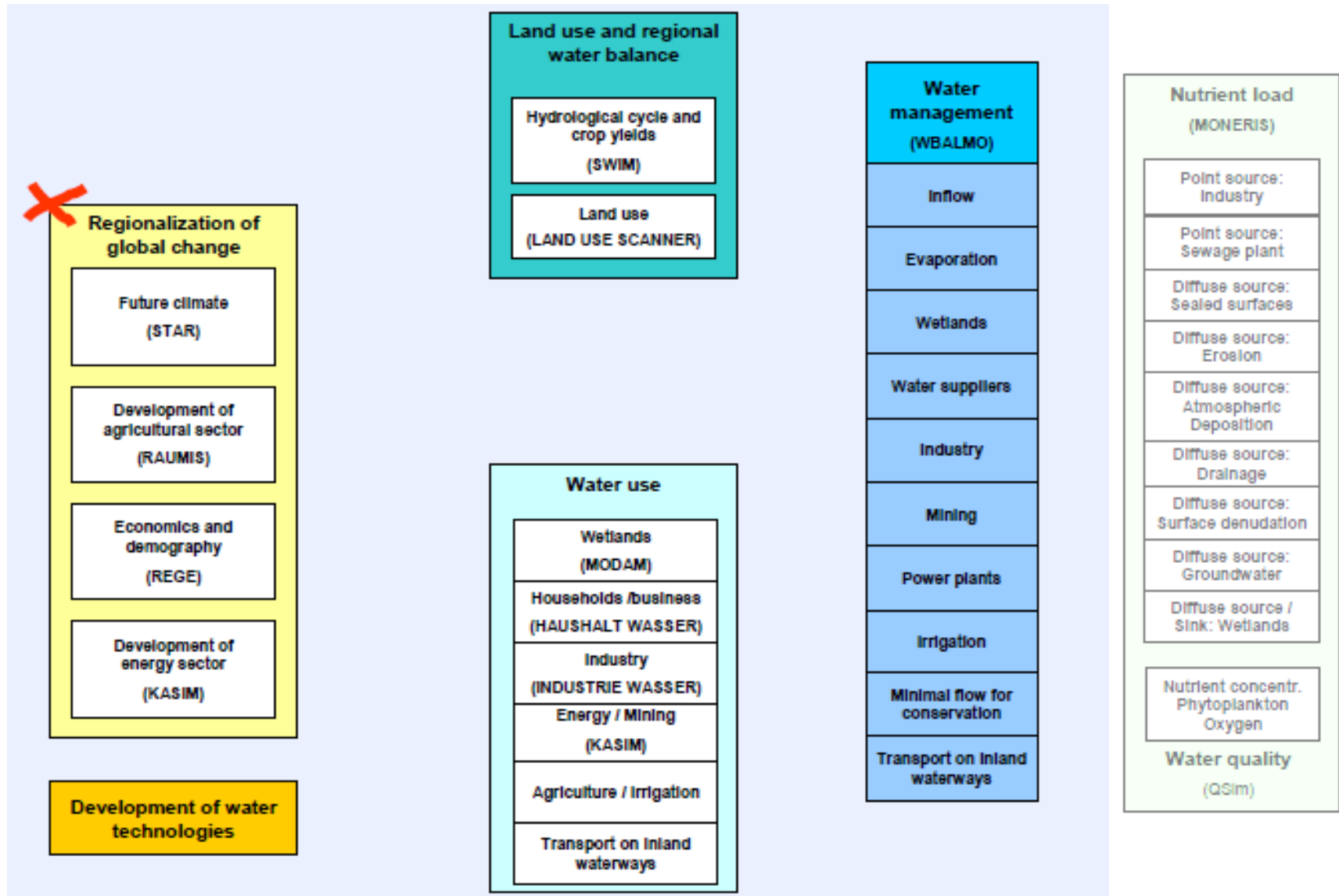


# „Product line - Boxes of the modelling system“



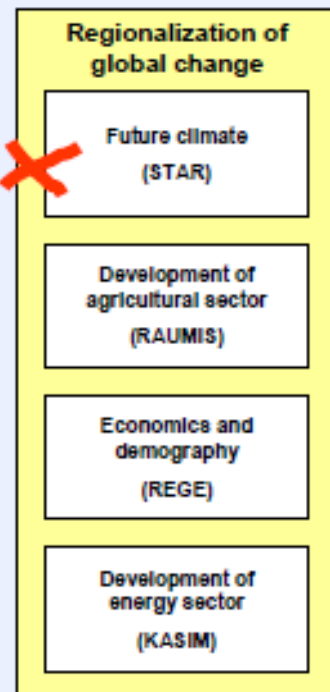
Source: Wechsung 2007

# „Product line - Regionalisation of global change“

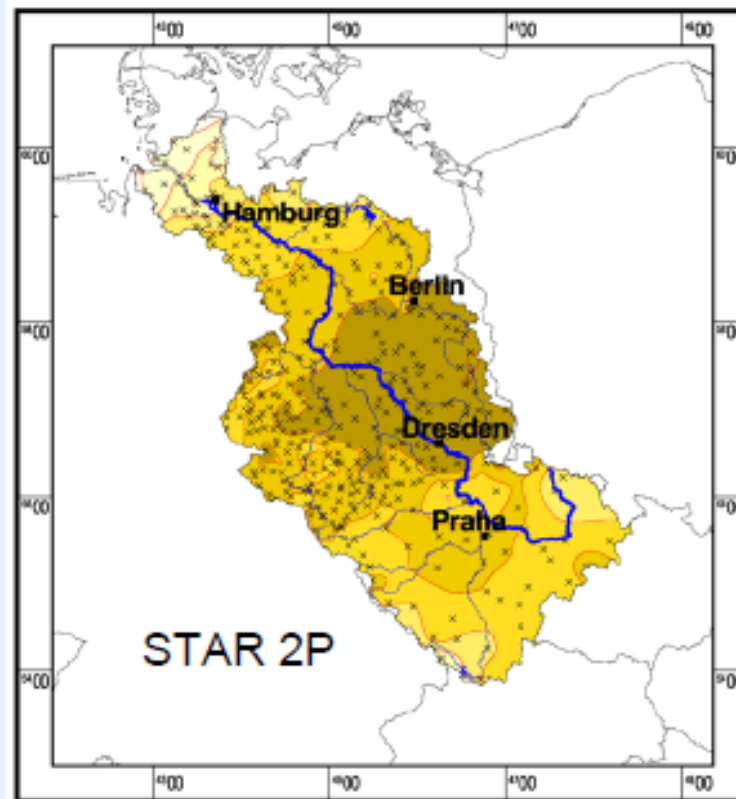


Source: Wechsung 2007

## „Product line - Climate - Elbe STAR2P“

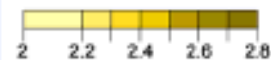


Development of water technologies



Orlowski et al. 2006, PIK

Change in mean yearly temperature [K°]  
2046/55-1951/2003



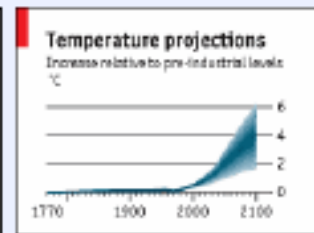
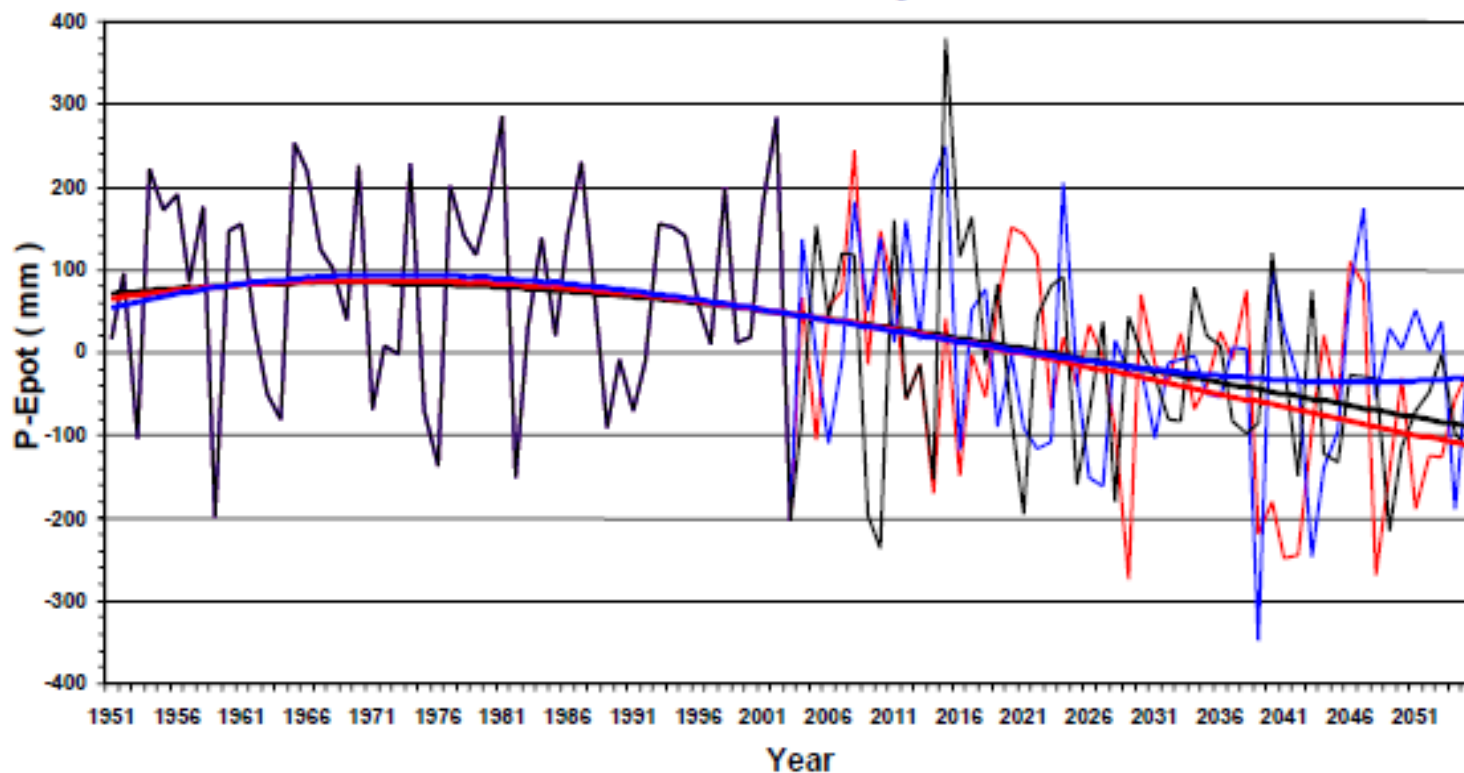
( 831 German and  
Czech stations )

Meteorologische Sta

Source: Wechsung 2007

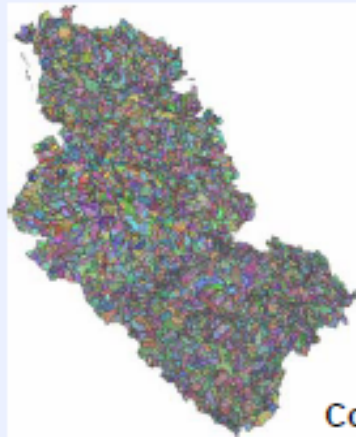
## Yearly mean of the climatic water balance (P-Epot) for the Elbe basin, 1951 - 2055

Three of hundred realisations: **Dry**, Median, **Wet**

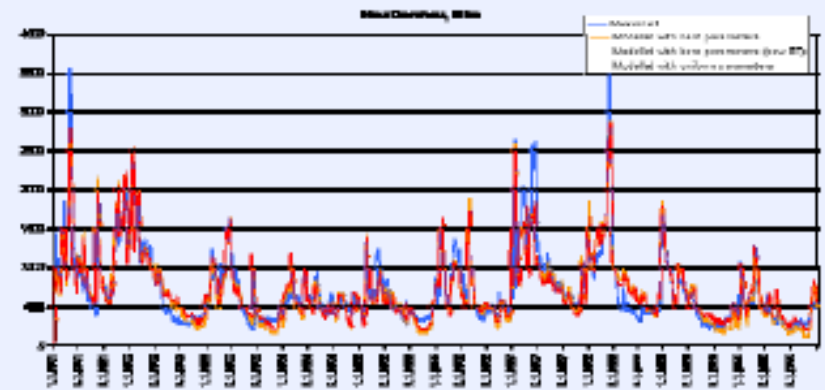
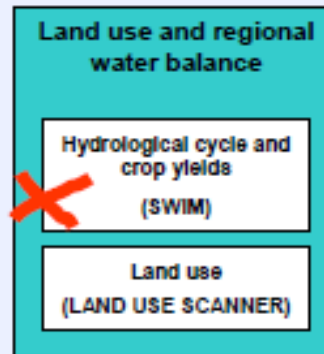


Werner et al. 2006, PIK

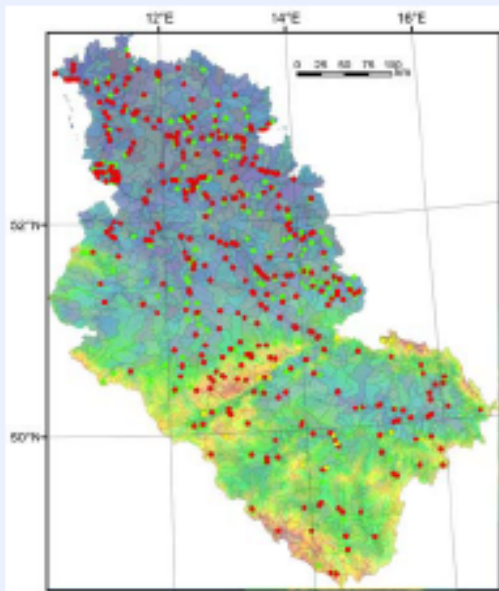
# „Product line - Elbe SWAT = SWIM“



Conradt et al. 2006, PIK



Hattermann et al. 2006, PIK



## Land use classes

(CORINE)

15

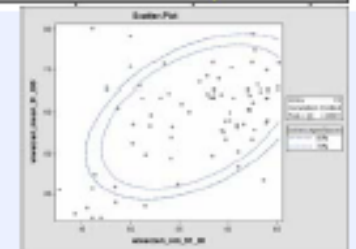
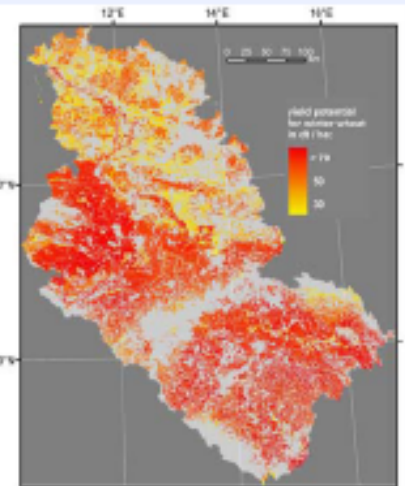
## Soil types

70

50 German + 20 Czech (map based on BÜK 1000 and Němeček et al. 2005 homogenized by Conradt and Hesse 2006)

## Hydrotopes

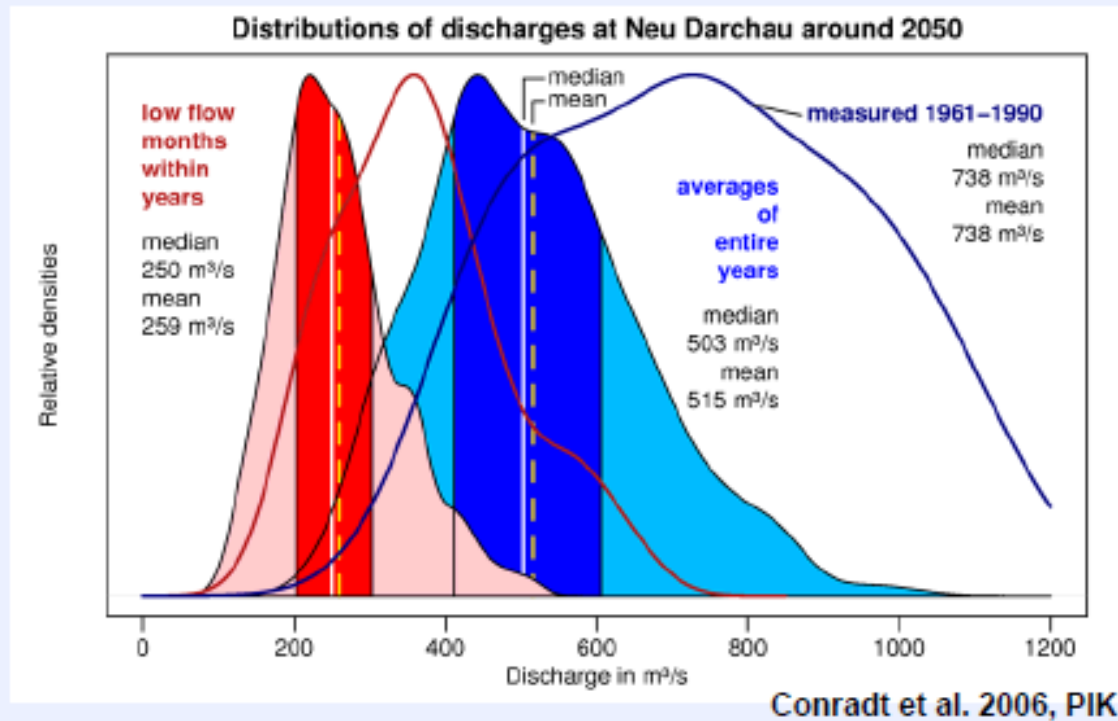
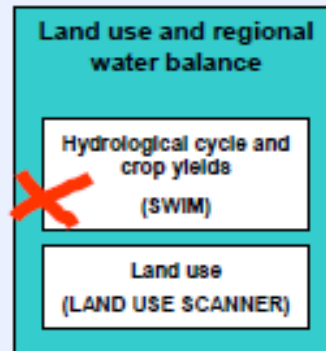
42708



The simulation area with 2255 subbasins and data transfer points for the coupling with WBalMo.

Source: Wechsung 2007

## „Product line - Elbe SWAT = SWIM“



2047-2053

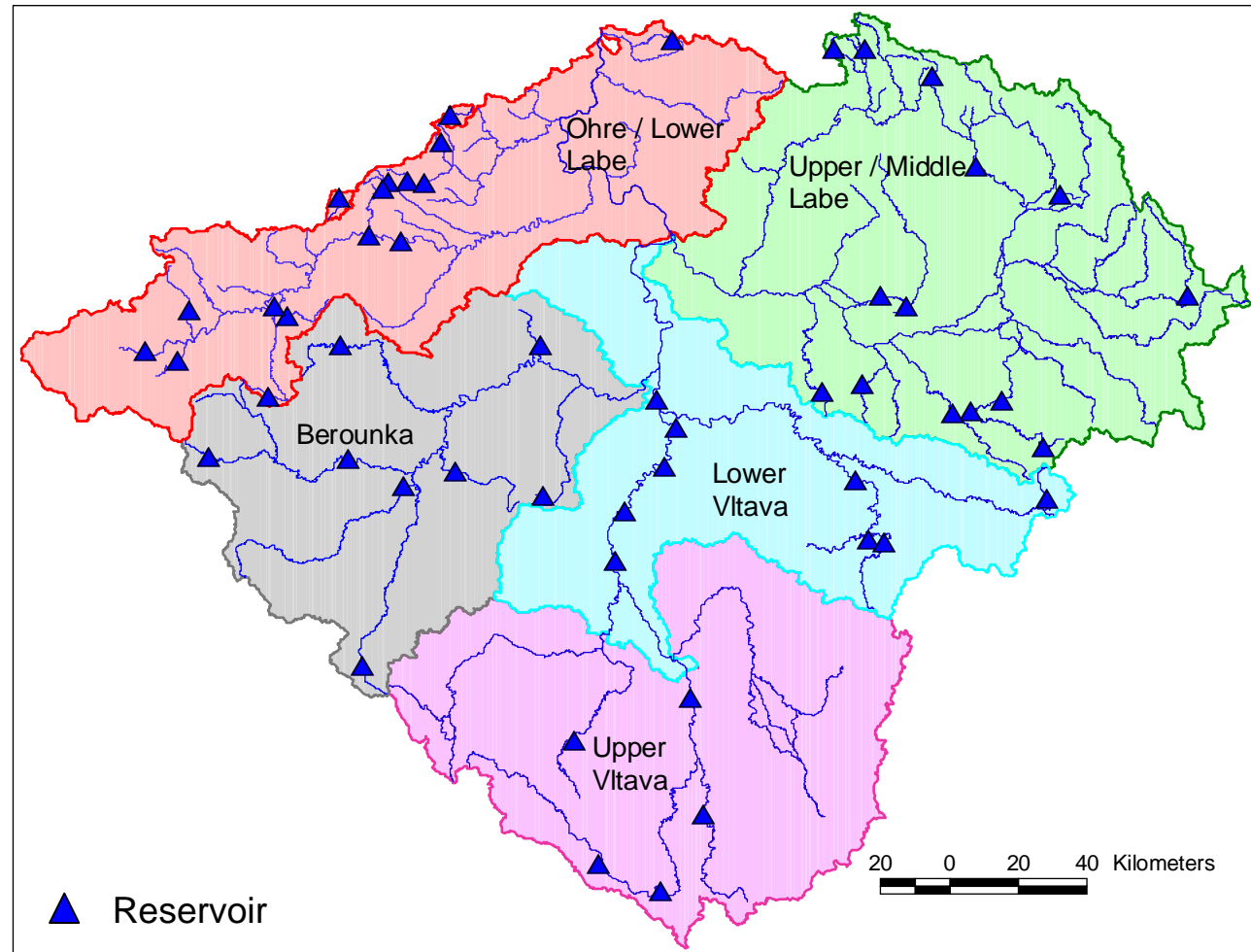
7 x 100

Realisierungen

# „Structure of the modules in the Czech Republic”

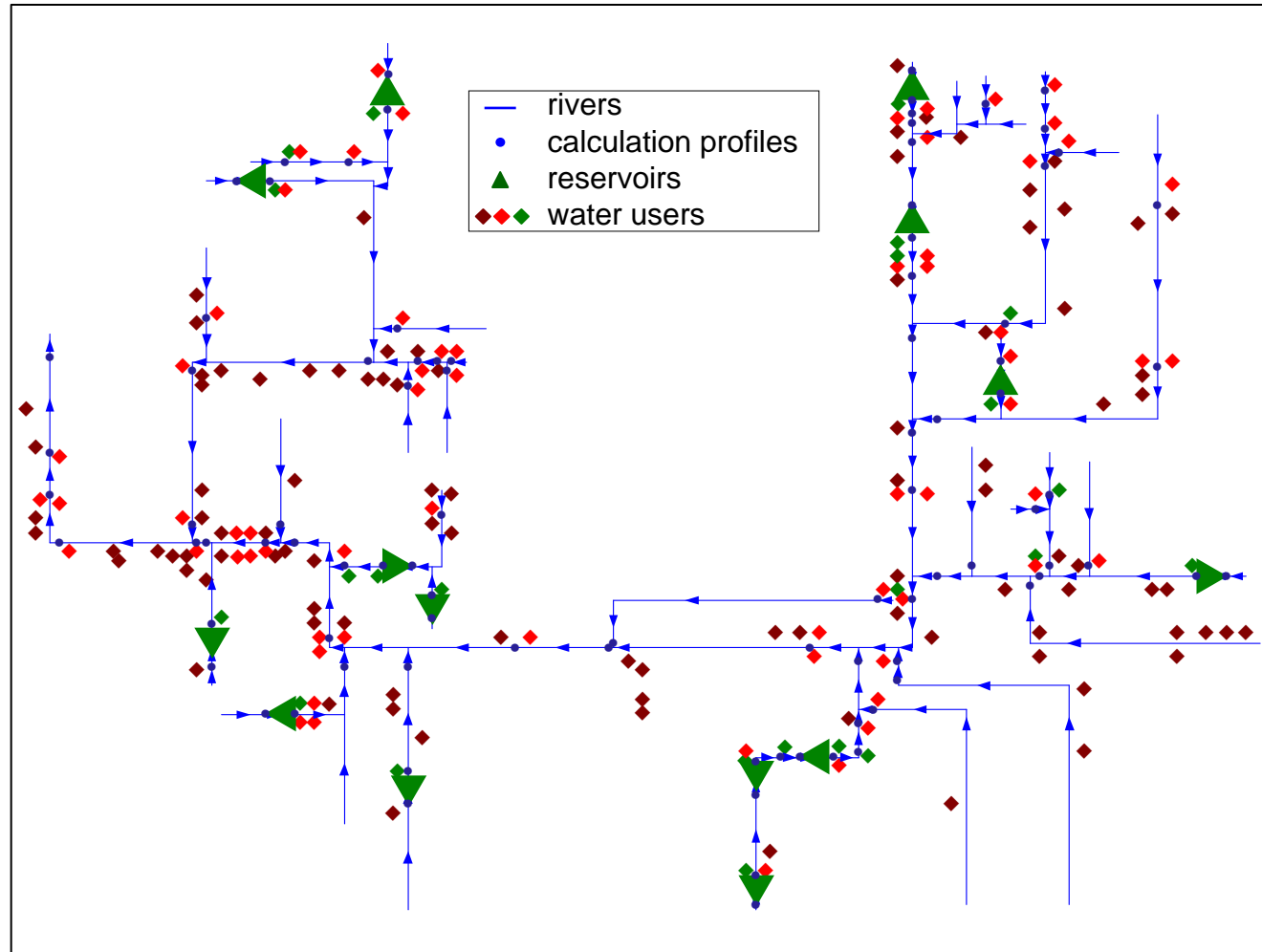
... is according to the river basin districts (Povodis) in the Czech Republic

- Upper Vltava,
- Lower Vltava,
- Berounka,
- Upper and Middle Labe,
- Ohre and Lower Labe.



Source: Koch, Kaltofen, Kaden, Grünewald, 2010

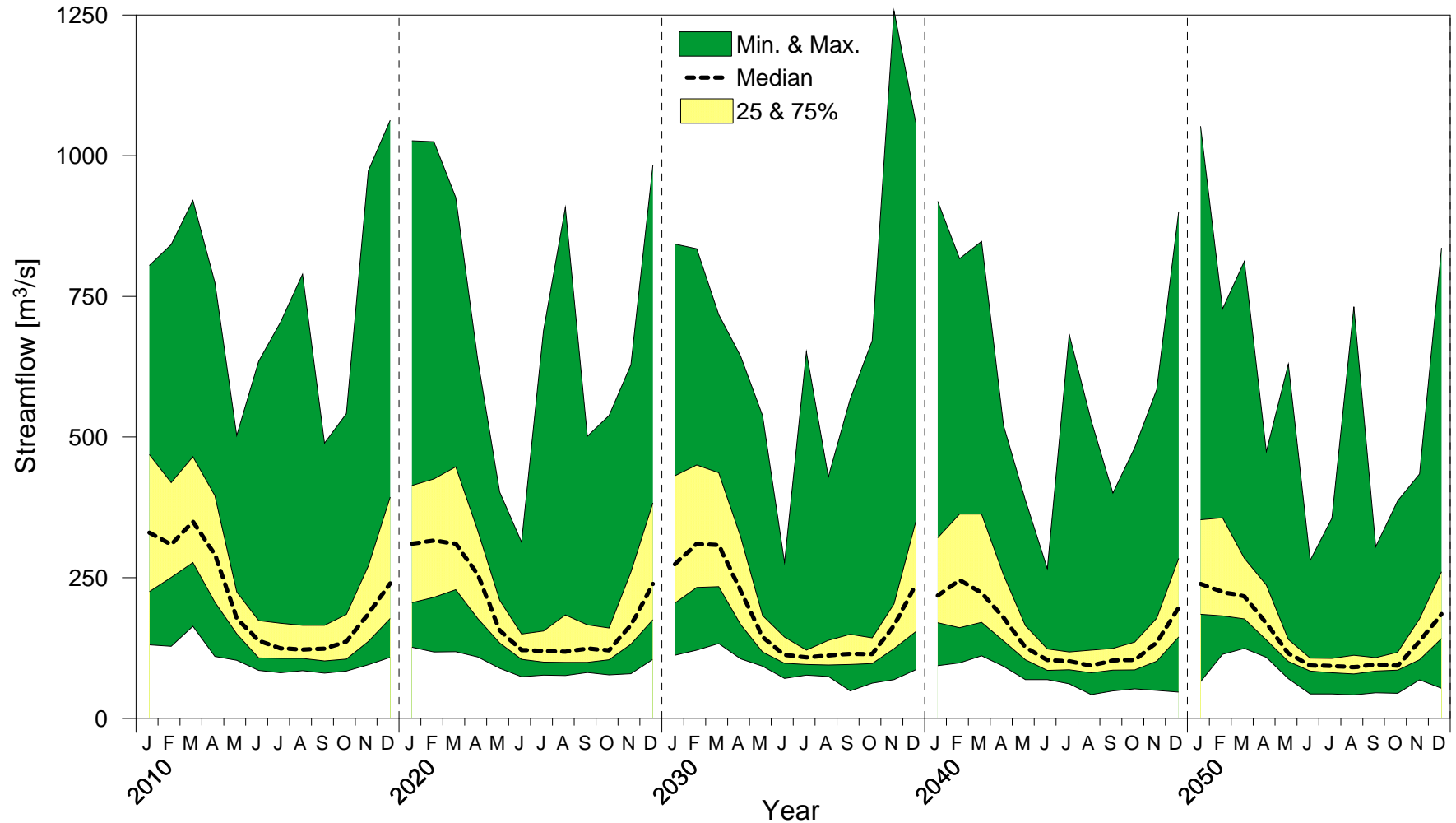
- Upper Vltava,
- Lower Vltava,
- Berounka,
- Upper and Middle Labe,
- Ohre and Lower Labe.



Source: Koch, Kaltofen, Kaden, Grünewald, 2010



## „Results - Streamflow gauge Hrensko / Labe (Border Czech Republic / Germany)”

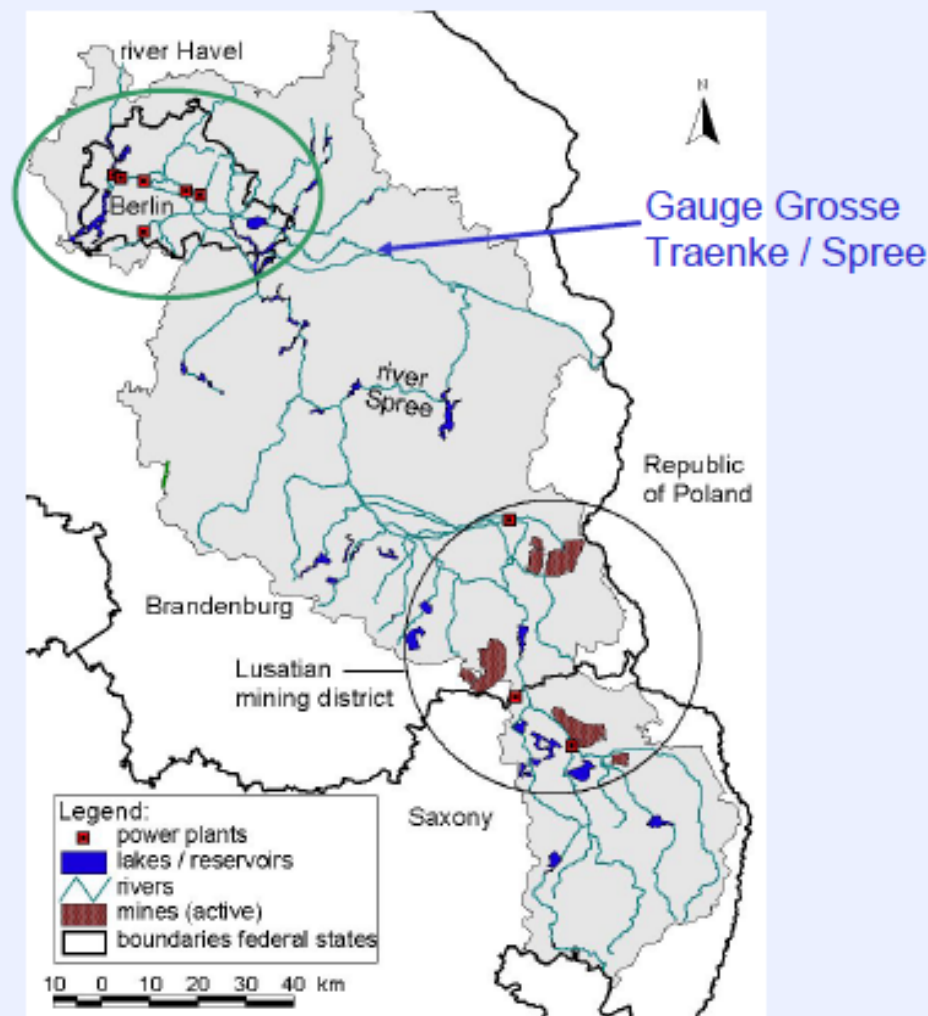


Source: Koch, Kaltofen, Kaden, Grünewald, 2010

## „Structure of the modules in the Spree sub-basin”

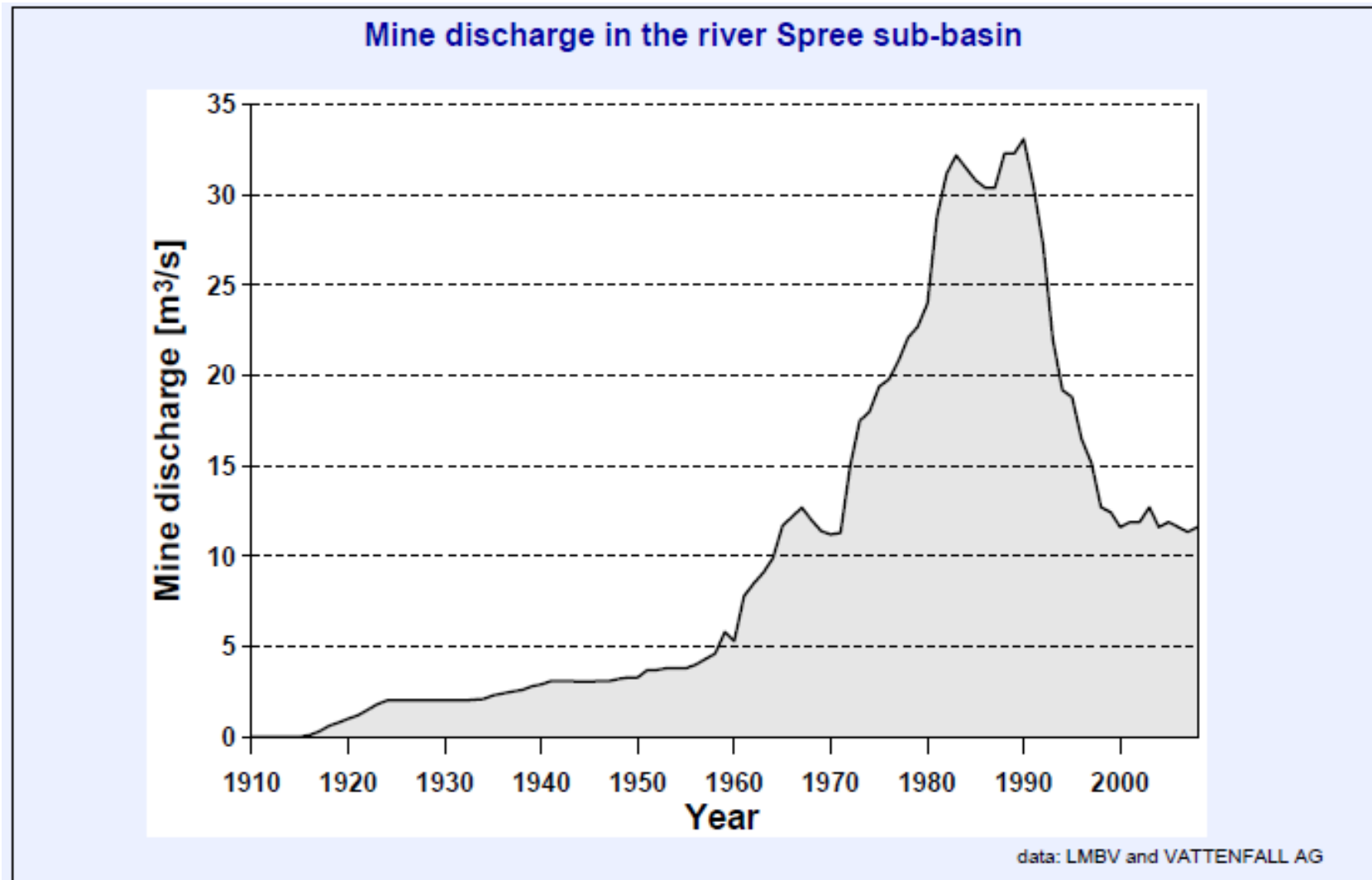
### Overview Spree sub-basin:

- Low natural water availability (continental climate)
- Strongly affected by lignite mining
- Water resources overstrained (power plants, wetlands, pond fishery,...)



Source: Vögele, Koch, Grünewald, 2010

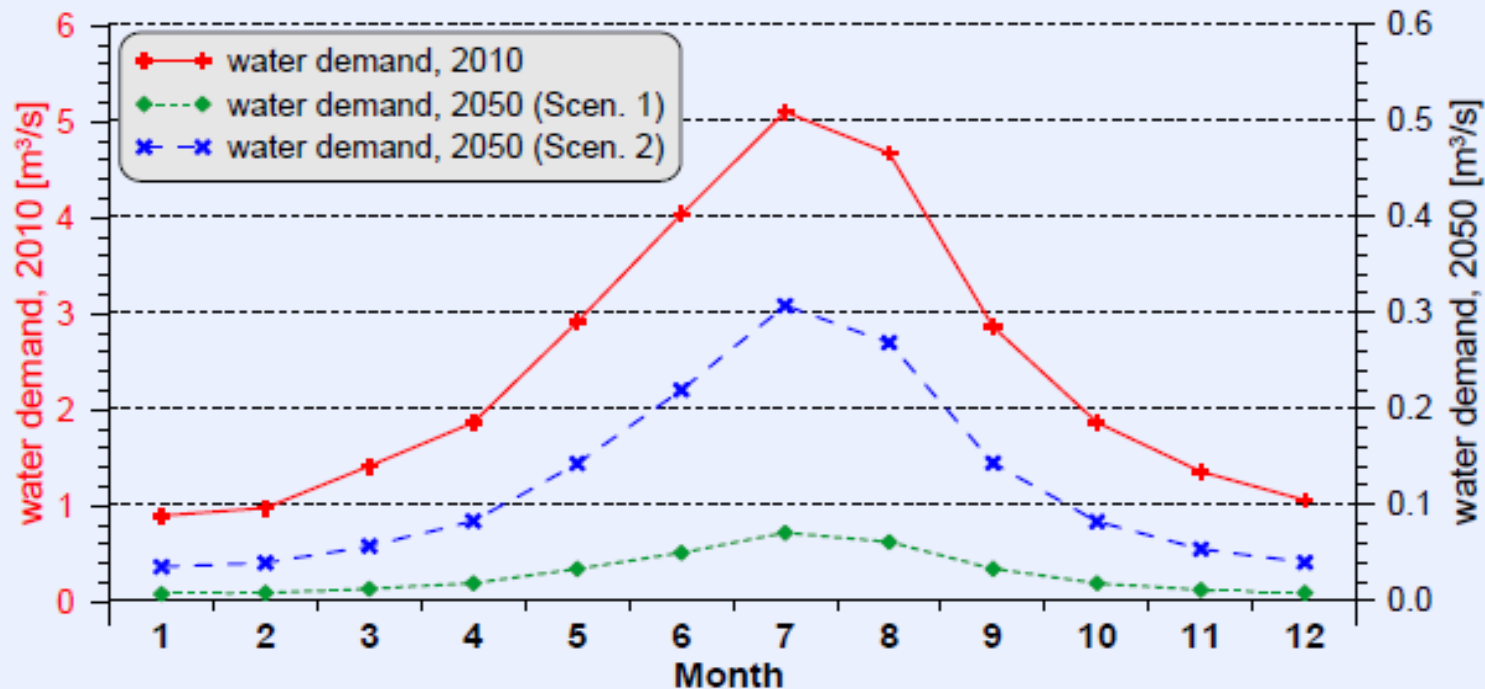
## „Influence of global change on mine discharges”



Source: Vögele, Koch, Grünewald, 2010

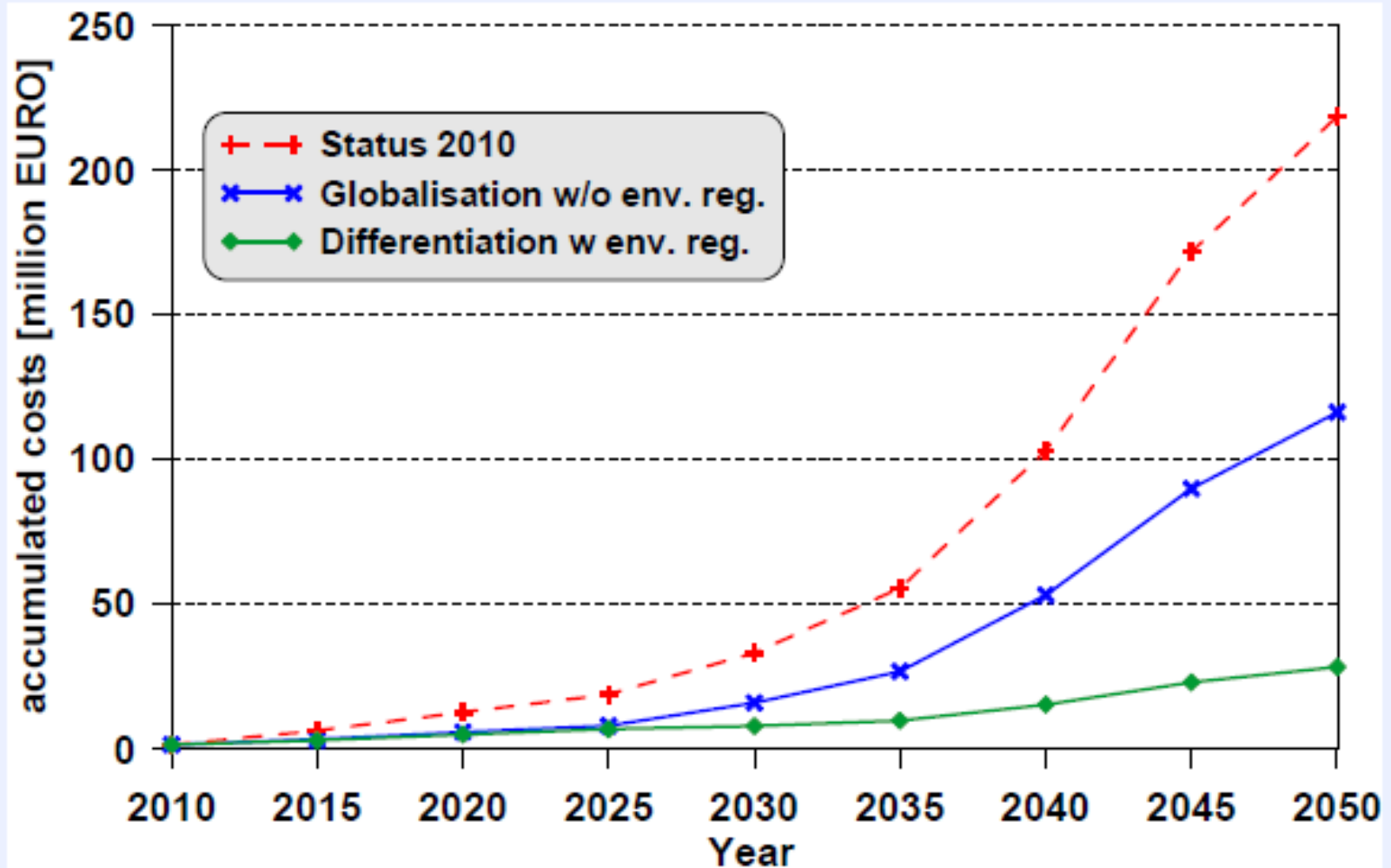
## „Changing water demand for power plants in the river Spree sub-basin“

Changing water demand for power plant with once-through system due to global change (one selected user, new built generating units equipped with closed circuit system)



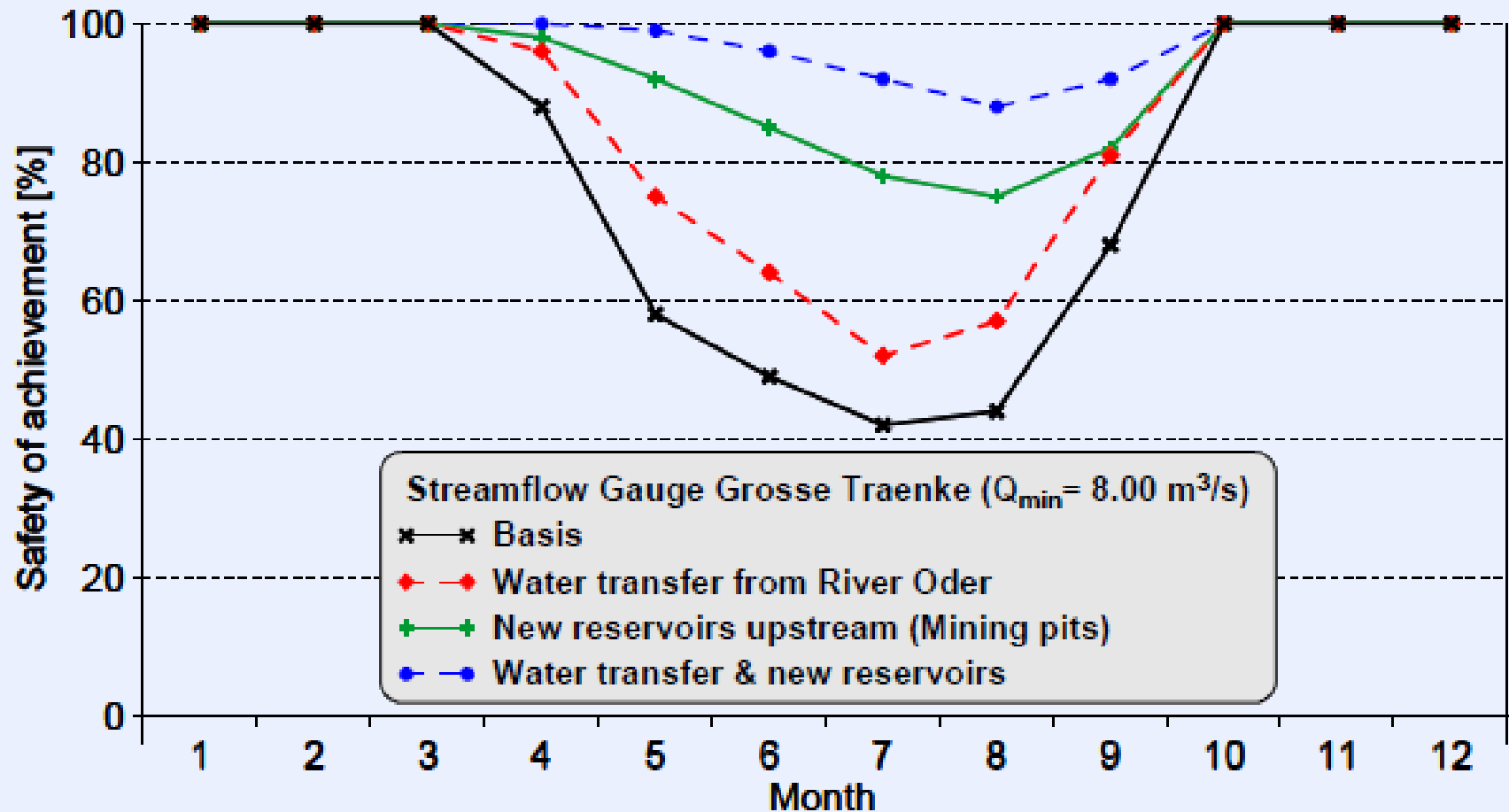
Source: Vögele, Koch, Grünwald, 2010

## „Economic costs of water shortages for power plants in the city of Berlin (mean values)”



Source: Vögele, Koch, Grünwald, 2010

# „Low safety for minimum discharges at Gauge Grosse Traenke / Spree due to socio-economic change and possible management options”



Source: Vögele, Koch, Grünwald, 2010

- tool for modelling the management of the channel system between Rhine and Oder at a daily time step
  - safety and facility of river navigation
  - sustainable, transregional and energetically optimised quantitative management of the German waterways in federal ownership

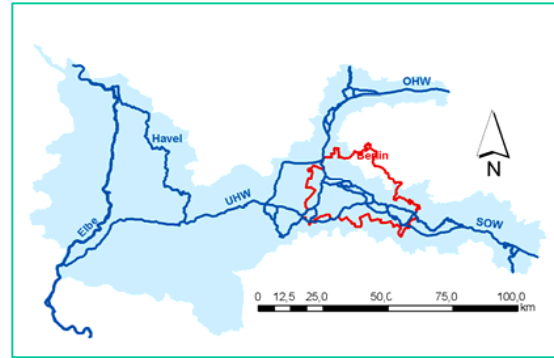
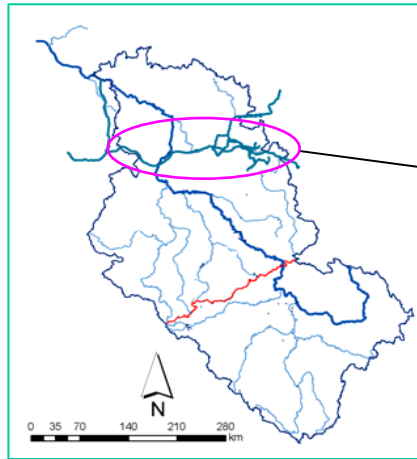
### Objectives

By means of model simulations **potential water reserves** at the different system elements **can be identified**. On this basis it is possible to analyse whether large scale diversions of water are possible and economically acceptable.

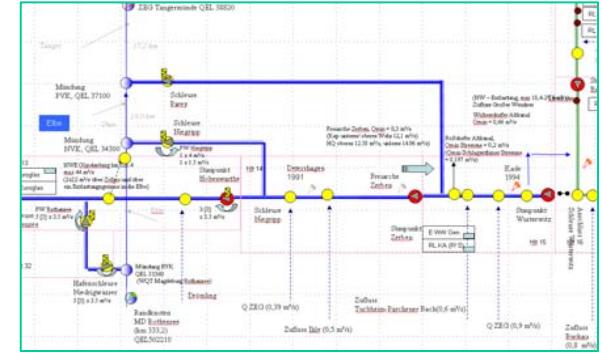
### Methodology

The modularly built water management model quantitatively balances natural and artificial waterbodies at a daily time step. For the managing of artificial waterways, like channels, pumping plants and spillways are essential. The controlling of the pumping plants within the model is realised by FORTRAN-algorithms in which element specific strategies for water supply in case of a deficit are implemented. The model results are daily time series of simulated water levels in channels, runoff in waterbodies as well as pumping and spillway water for the different model elements. By means of a post-processing procedure also pumping costs can be computed.

# "BEWASYS - study area & data"



part of the study area



## • study area

The German waterways in federal ownership between the rivers Rhine and Oder form a system of trans-basin waterbodies with different authoritative responsibilities.

At a total length of 1300 km three boat lifts and 45 locks enable boats to overcome altitude differences. The channels are supplied with water by 30 pumping plants.

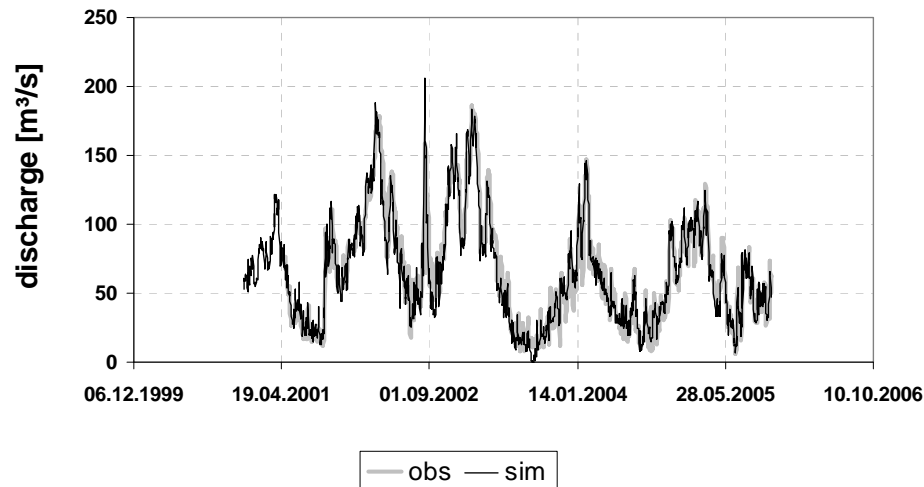
## • data

The balancing of the waterways is performed using **meteorological variables** (precipitation and evaporation), **inflow from tributaries** and information about interactions between the channel system and **groundwater**. In addition, **parameters of channel geometry**, information on withdrawal or input of water, locking of ships and capacities of pumping plants and spillways are used.

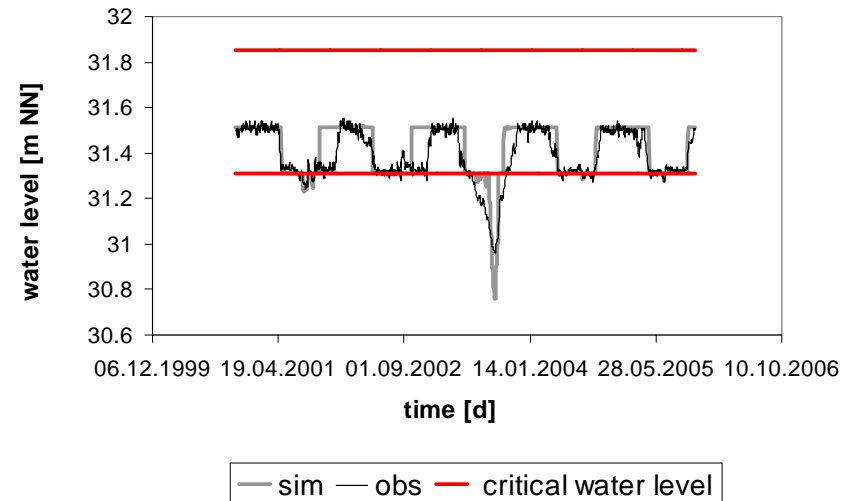


## "BEWASYS - results - "

discharge gauge Tieckow / Havel



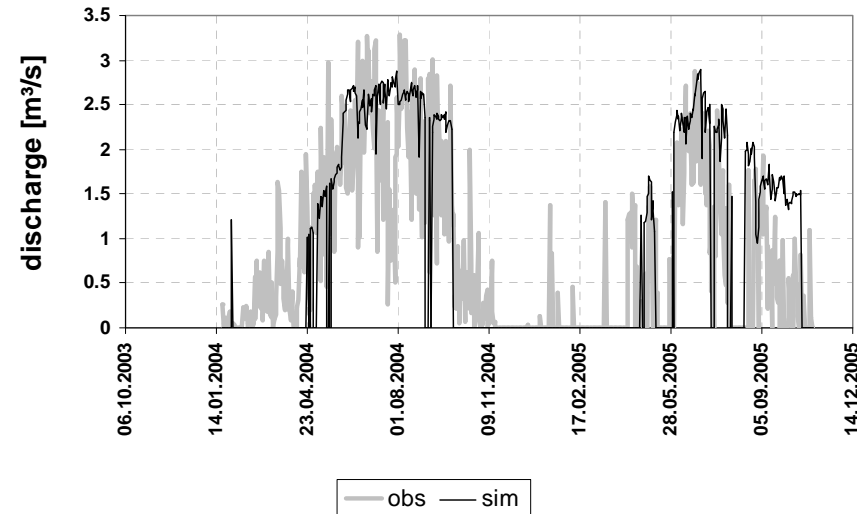
lock Spandau - gauge upstream



### • results

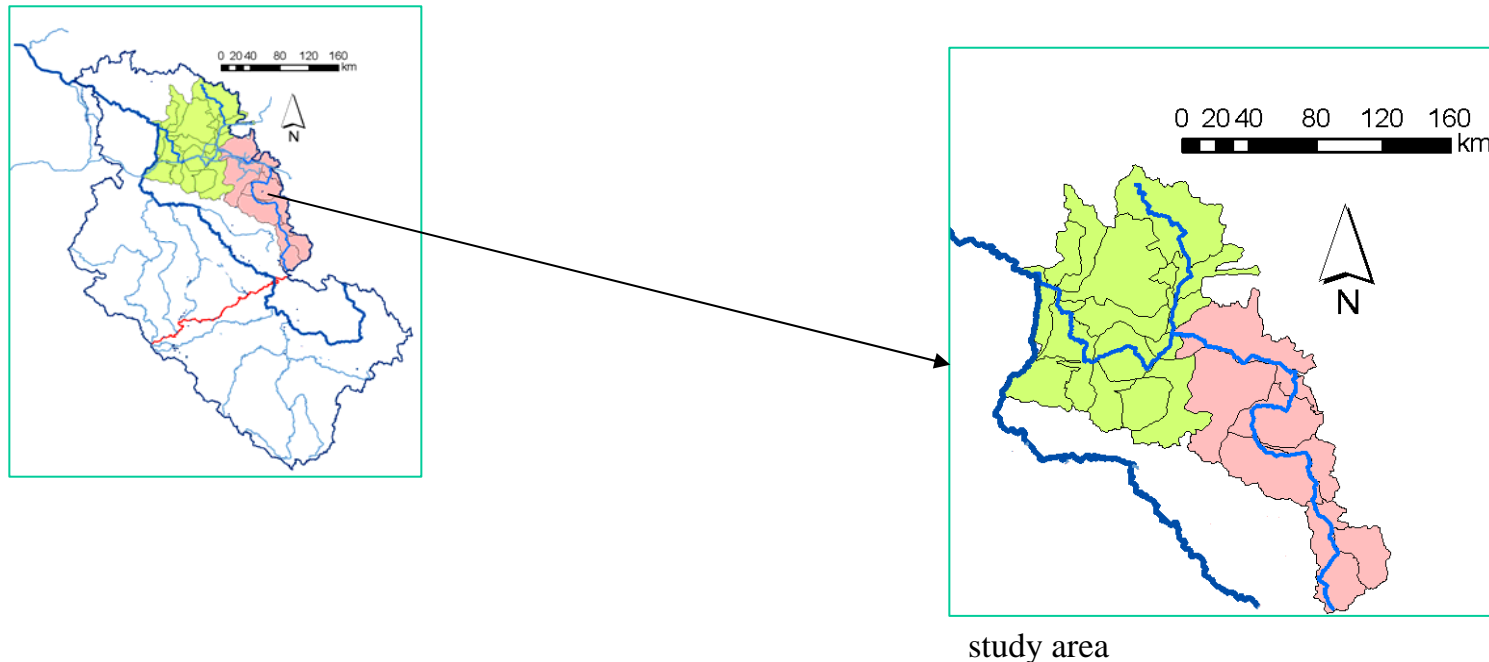
The daily management model BEWASYS was developed and parameterised for the German waterways in federal ownership between the rivers Rhine and Oder. The model simulations (*sim*) were validated against observed (*obs*) data. Furthermore, different variants of alternative management strategies with varying boundary conditions were simulated.

pumping water Eisenhüttenstadt



## “WBalMo HavelSpree”

- tool for modelling the management in the Havel-Spree catchment at a monthly time step



- Duration: Jan 2011 - May 2012
- Project: Impacts of water management of water supply in the Havel-Spree catchment with regard to climate change ( with different climate projection)