The hydrological research basin Schäfertal in the Harz Mountains / Central Germany – current state of the observation programme and results of the recent runoff analysis

F. Reinstorf[1], J. Tiedge[1], J. Bauspieß[1], H. John[1], G. Ollesch[2]

[1] University of Applied Sciences Magdeburg-Stendal, Dept. of Water and Waste Management, Breitscheidstr. 2, 39114 Magdeburg, Germany

[2] Helmholtz Centre for Environmental Research - UFZ, Dept. of Soil Physics, Brückstr. 3a, 39114 Magdeburg, Germany

Aim and Motivation

- Aim:
  - Contribution to the understanding of the impact of global change on water and substance balance and runoff formation, especially storage and movement
- Motivation:
  - The hydrological research basin Schäfertal is one of the oldest and best equipped investigation areas in the Harz Mountains
  - Long-term measurements since 1968 as well as naturally and anthropogenic effects on the water and substance balance provide a „test site“ for prediction tools

Impressions of the research basin Schäfertal/Harz

V-weir of the Schäfertal with meteorological station.

Typical view in to the catchment of the Schäfertal
in direction of the upper Harz with the Brocken

Late summer

Winter,
snow cover

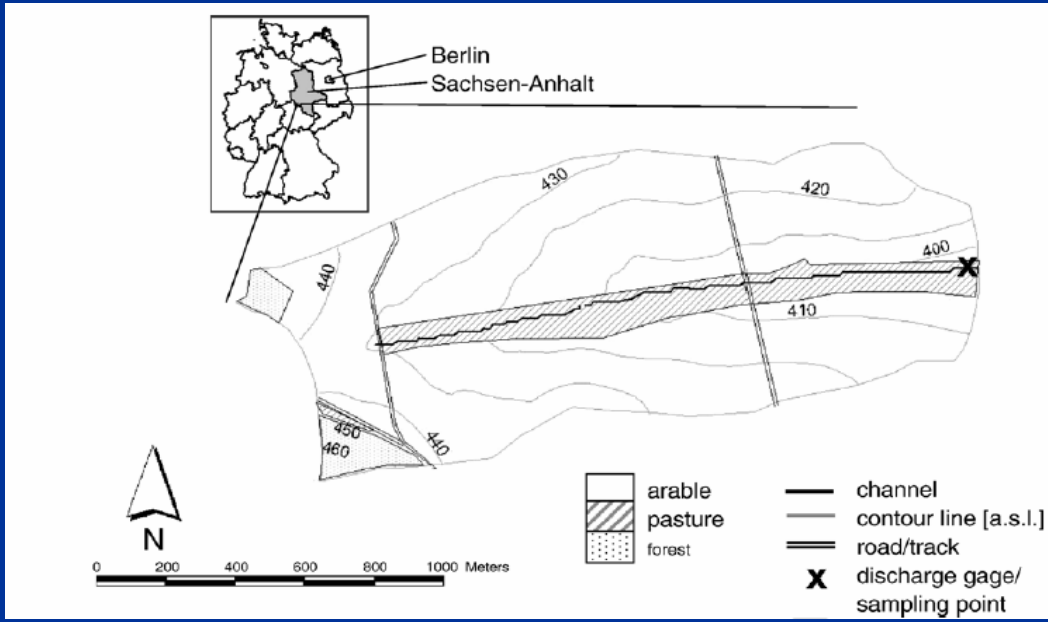
Late winter,
surface runoff

Instrumentation, data, models

Meteorology	Hydrology	Others
air temperature air humidity and air pressure wind speed (2, 5, 10 m) wind direction short and long wave radiation PAR heat-flux several temperature sensors at different above-ground heights and soil depths	five automatic rainfall gages "watermark" soil moisture sensors, TDR and tensiometers continuous measurements of discharge, ground water table at numerous points snow cover height and water equivalent tile drain flows	temperature in discharge electric conductivity of discharge biweekly manual and automatic event water sampling for sediment yield, phosphorus nitrogen DOC / LC-DOC soil water sampling with suction plates and chemical characterisation

Applied models: AKWA-M, WASIM-ETH, DIFGA, EROSION-3D, Nutrient load model

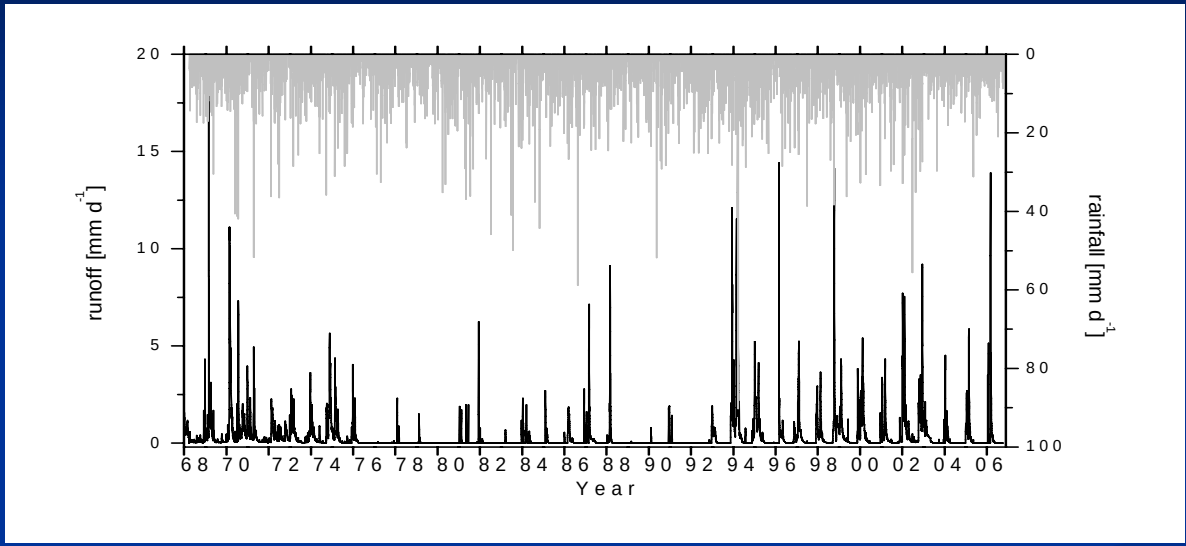
Basin characteristics



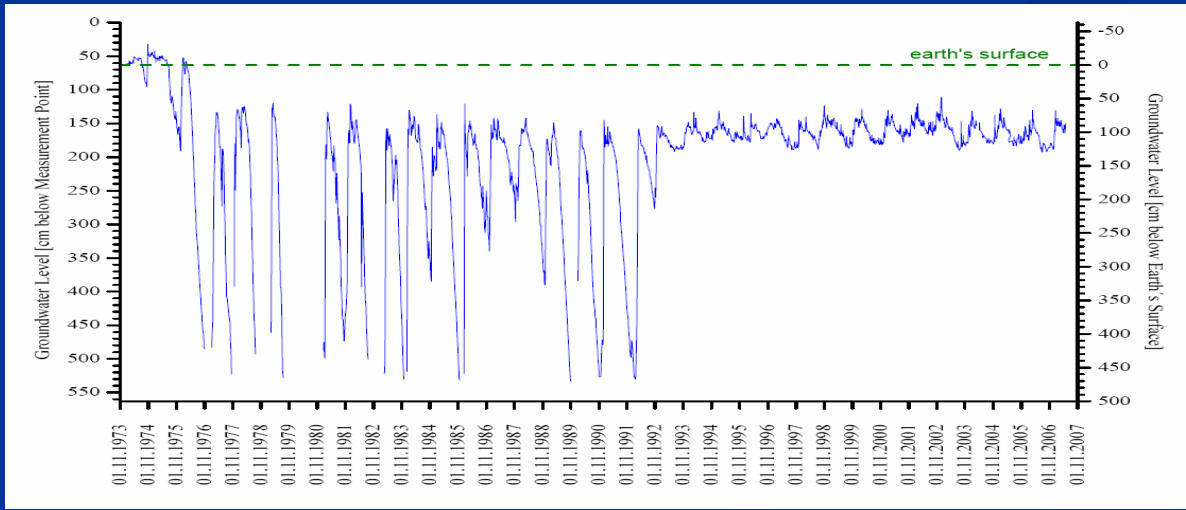
Location of the basin „Schäfertal/Harz“

River Basin (according EU-WFD)	Selke, Bode, Saale (Elbe)
Operation (from... to...)	1968 – ongoing
Gauge coordinates / Gauge datum:	11° 3’ 10’’ E, 51° 39’ 16’’ N
Catchment area:	1.44 km2
Elevation range:	392 – 474 m asl
Basin type:	Low mountain
Climatic parameters:	653 mm a-1, 6.9 °C (station Schäfertal)
Land use:	>80% arable, pasture/set aside, forest
Soils:	Cambisol, luvisol, gleyic livisol
Geology:	Palaeozoic greywacke, argillaceous shale
Hydrogeology:	Fractured rock aquifer
Characteristic water discharges:	0 (Qmin) / 36 (Qmax) / 0.33 (Qmean) [mm d-1]

Special basin characteristics

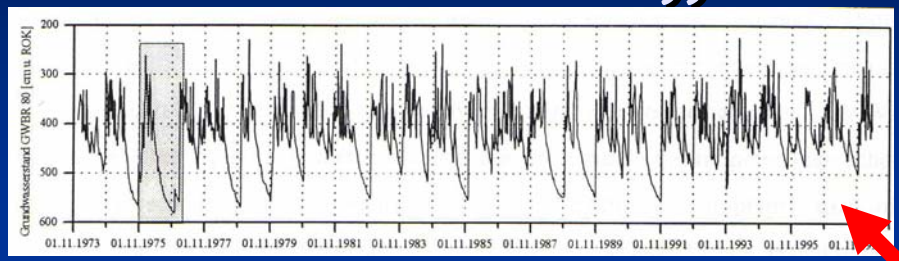


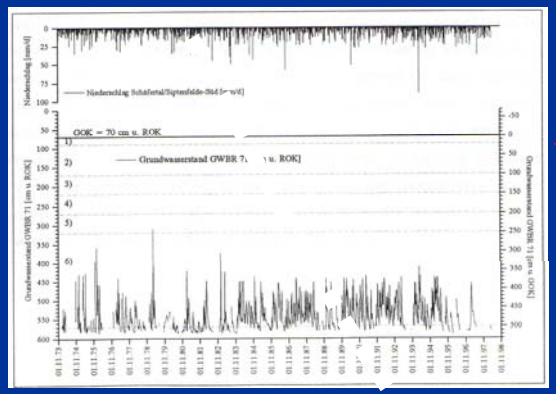
Rainfall and discharge variation of the Schäfertal from 1968 until 2006

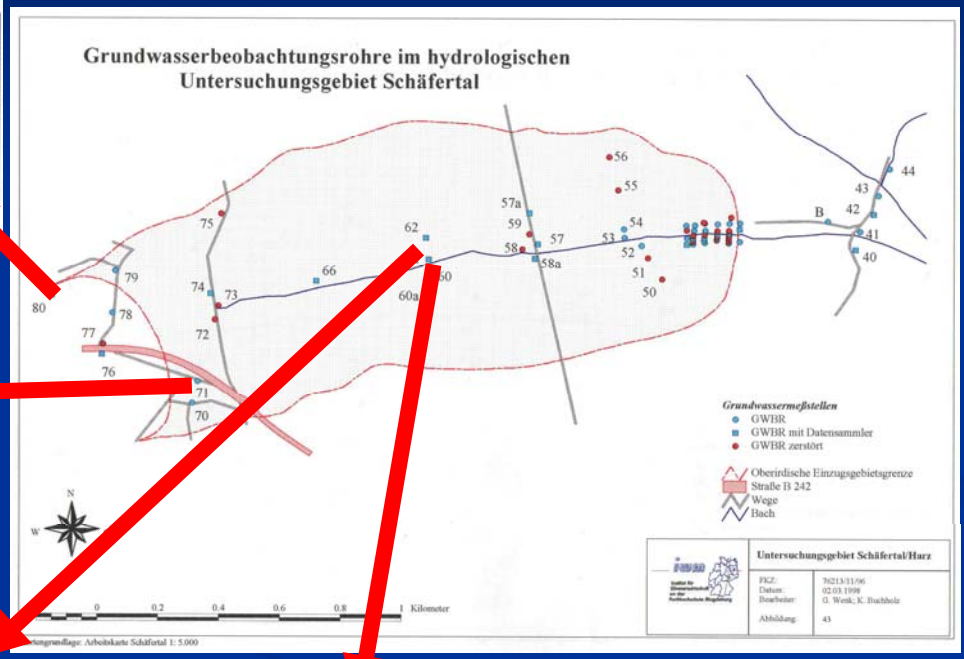


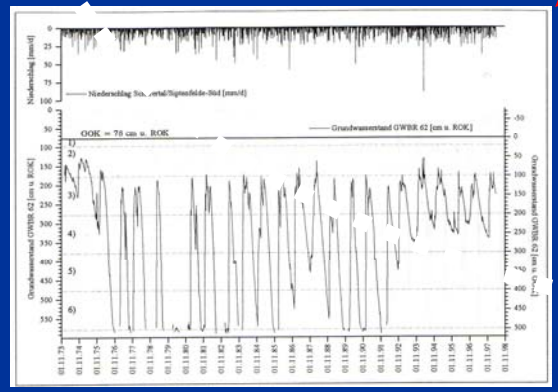
Variation of the groundwater level at GWBR 61, 1973 - 2006

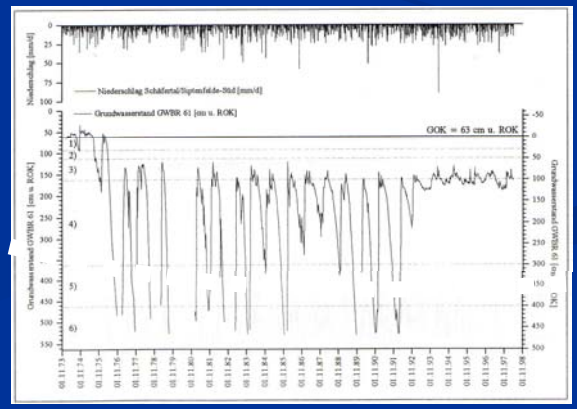
Groundwater Monitoring „Schäfertal“





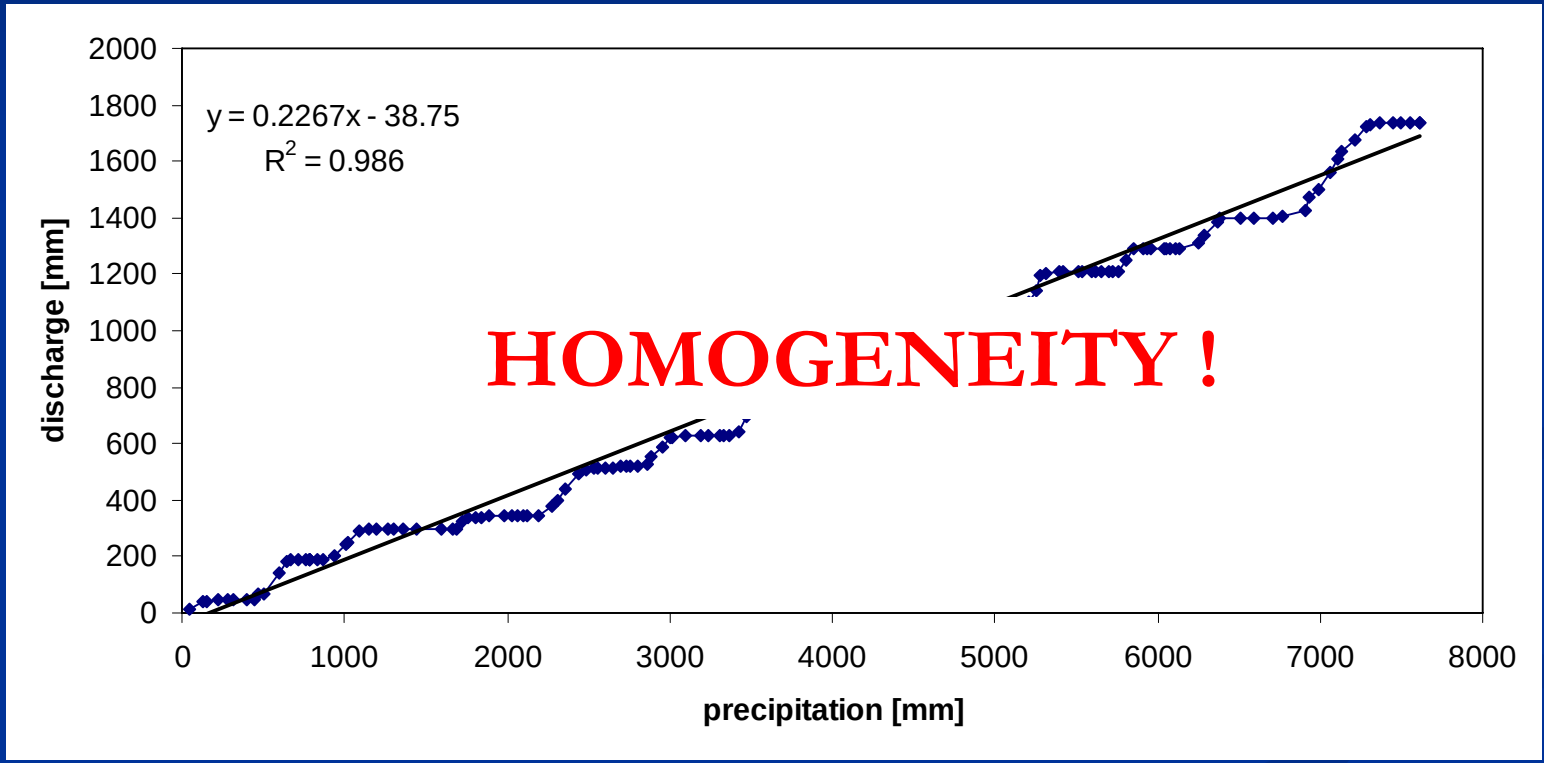






Analysis of the precipitation – discharge – time series

04/1996 – 11/2008



Double sum analysis curve between precipitation and discharge of the Schäfertal (04.1996 – 11.2008).

Statistical model

generally

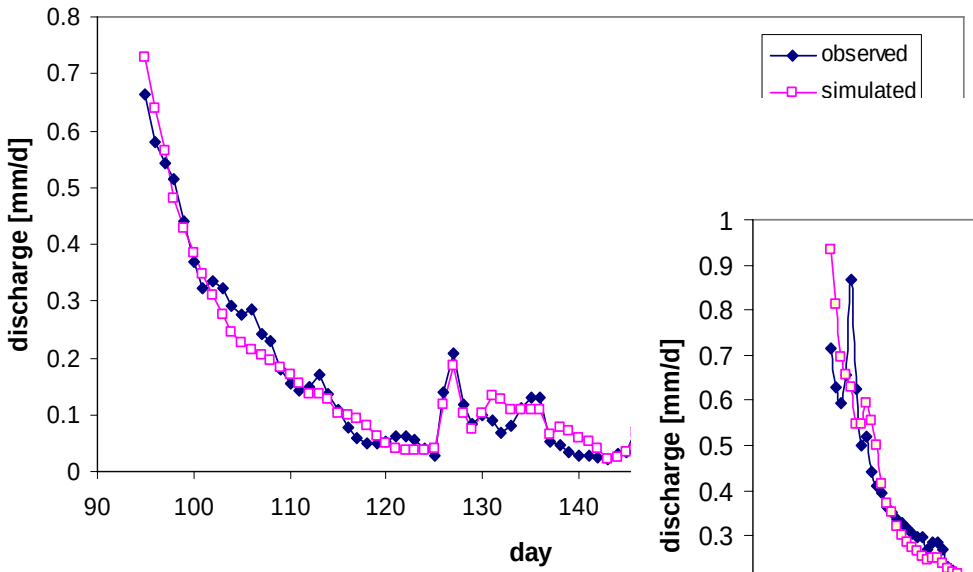
$$QA = \sum_{t-m}^{t} QA_t + \sum_{t-m}^{t} GN_t + \sum_{t-m}^{t} GT_t + \sum_{t-m}^{t} QS_t + \sum_{t-m}^{t} QB_t$$

The reduced model is a coupling between “moving averages” for Q with a part to consider P. For the case of m=2 the following formulation can be found:

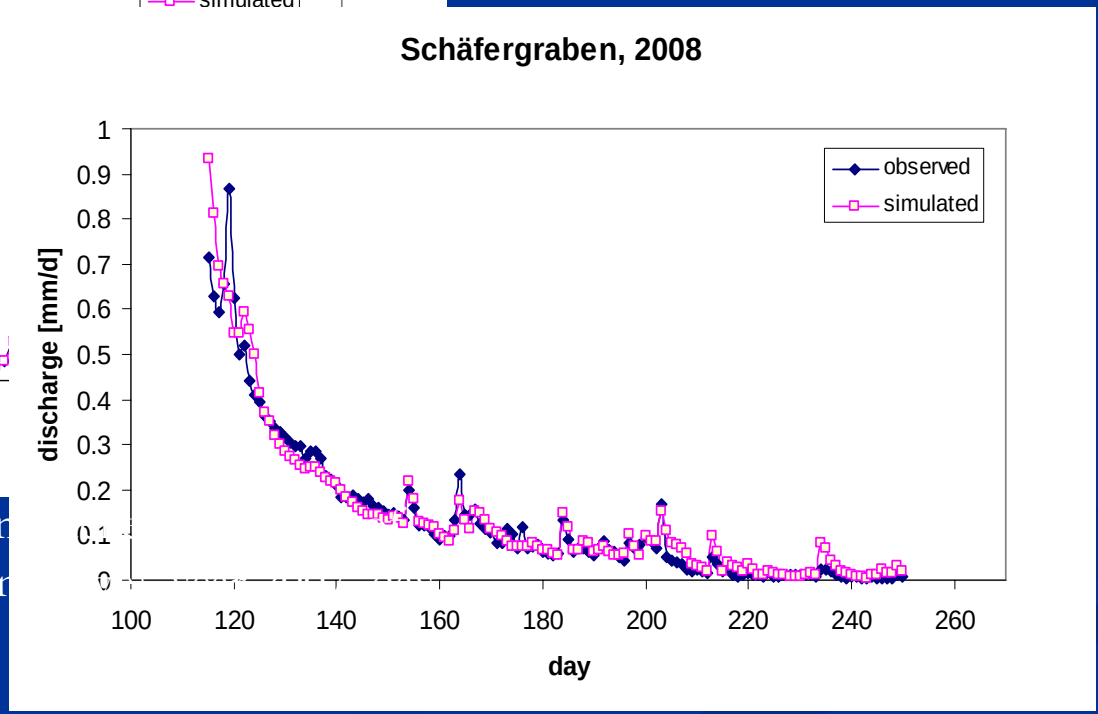
$$Q(t) = \gamma_o P(t) + \gamma_1 P(t-1) + \beta_1 ((Q(t-2) + Q(t-3) + Q(t-4) + Q(t-5))/4) + \varepsilon_n$$

with Q(t) … discharge at day t, γ, β_1… weighting factors, P(t) … precipitation at day t and ε_n ... random term.

Simulation of the precipitation – runoff - transformation



Comparison of the observed and r
the gauge Schäfergraben (recessior
95-170.



Comparison of the observed and modelled discharge of the gauge Schäfergraben, year 2008, day 110-250.

Simulation parameters and quality

Tab. 1: Parameters and quality criteria of the linear statistical model for the summer runoff of the years 1996 – 2008.

Year	β_1 (p-value*)	γ_0 (p-value*)	γ_1 (p-value*)	RMSE	NS-coef	Number
2008	0.794 (0.00)	0.005 (0.00)	0.003 (0.00)	0.034	0.97	134
2007	0.668 (0.00)	0.003 (0.00)	0.004 (0.00)	0.027	0.98	75
2006	0.626 (0.00)	0.008 (0.00)	0.010 (0.00)	0.03	0.98	34
2005	0.731 (0.00)	0.007 (0.00)	0.004 (0.01)	0.035	0.98	54
2004	0.642 (0.00)	0.005 (0.00)	0.005 (0.00)	0.027	0.92	66
2003	0.842 (0.00)	0.006 (0.00)	0.004 (0.00)	0.036	0.99	66
2002	0.935 (0.00)	-0.006 (0.73)	0.024 (0.06)	0.232	0.88	29
2001	0.798 (0.00)	0.003 (0.00)	0.002 (0.09)	0.021	0.99	76
2000	0.776 (0.00)	0.003 (0.03)	0.006 (0.00)	0.047	0.97	85
1999	0.661 (0.00)	0.005 (0.10)	0.005 (0.09)	0.053	0.69	30
1998	0.762 (0.00)	0.003 (0.06)	0.008 (0.00)	0.029	0.94	39
1997	0.881 (0.00)	0.005 (0.21)	-0.001 (0.80)	0.07	0.97	77
1996	0.604 (0.00)	0.004 (0.00)	0.002 (0.11)	0.043	0.93	49

*The p-value is the probability, calculated under the null hypothesis H_0, of obtaining a test result as extreme as that observed in the sample ... If this probability is regarded as small, H_0 should be rejected; otherwise it should not be rejected.

NS-coef … Nash-Sutcilffe model efficiency coefficient

RSME … root mean squared error

Summary

Summarized parameters and quality criteria of the linear statistical model of the summer runoff for 2008 and mean values for the years 1996 – 2008.

Year	β_1 (p-value*)	γ_0 (p-value*)	γ_1 (p-value*)	RMSE	NS-coef
Average 1996 - 2008	0.73	0.004	0.006	0.053	0.938
Standard deviation 1996 - 2008	0.103	0.003	0.006	0.055	0.081

Further interpretations

1.) The parameters of the linear statistical model permit a further access to a quantification of the relationship between precipitation P and runoff Q for a prediction of runoff. In a balanced regime the following relationship for P and Q can be assumed in mean:

$$\frac{Q}{P} = \frac{0.003 + 0.005}{1 - 0.794} \approx 0.04$$

2.) From the double sum curve the long-term relationship between precipitation and runoff can be estimated. In the whole investigated period an average of about **22%** of the precipitation can be observed in runoff.

Conclusions

- Differentiated impact of the mining activities on the groundwater in the basin
- Homogeneity of the period 04/1996 – 11/2008 with regard to the relationship of precipitation and runoff
- The reduced statistical model permits already a well description of the recession curves and hints to hydrological relationships

Thank you for your attention !