zalf. Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) e.V.

Mitglied der Leibniz Leibniz-Gemeinschaft

Leibniz Centre for Agricultural Landscape Research

# Modelling the hydrological signatures of a complex landscape: The Quillow Catchment (TERENO North-East)

Gunnar Lischeid*, Ralf Dannowski, Steffen Gliege, Christian Lehr, Christoph Merz, Jörg Steidl, Martin Wegehenkel

*: Lischeid@zalf.de

# Why Modelling?

Models as tools for

- Visualization of complex systems;

- Testing our understanding;

- Scenario analysis;

- Optimising monitoring schemes;

- Planing of measurement campaigns and experiments.

# Quillow Catchment

- Part of TERENO Northeast Germany

- Pleistocenic lowlands of Northeast Germany

- Tributary to the U(e)cker

- Area 168 km$^2$ (188 km$^2$)

- Elevation 14 – 157 m a.s.l.

- Annual mean temperature (1961-1990): 7,8°C

- Annual mean precipitation (1961-1990): 508 mm

- Agricultural landuse: 73.5%

- Soils: 86,2% loam, 8,8% sand, 5% wetlands
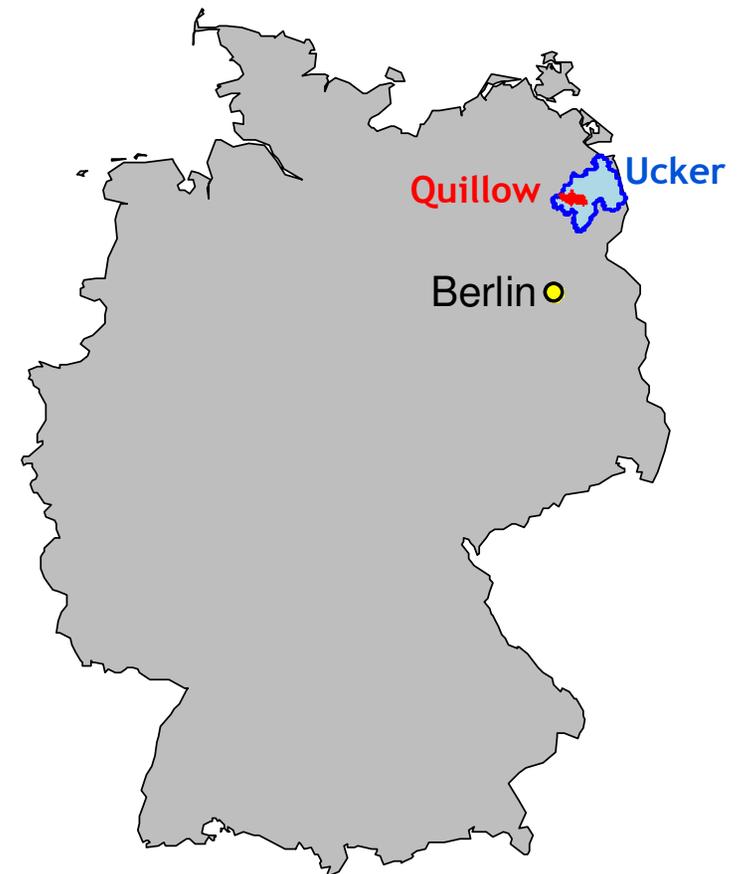
# Modelling the Ucker Basin

Dannowski and Steidl (2000)

ABIMO Model



See

Fluss

**Recharge [mm/yr]**

- < -50
- -50 - 0
- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- > 350

5   0   5   10   15   Kilometers
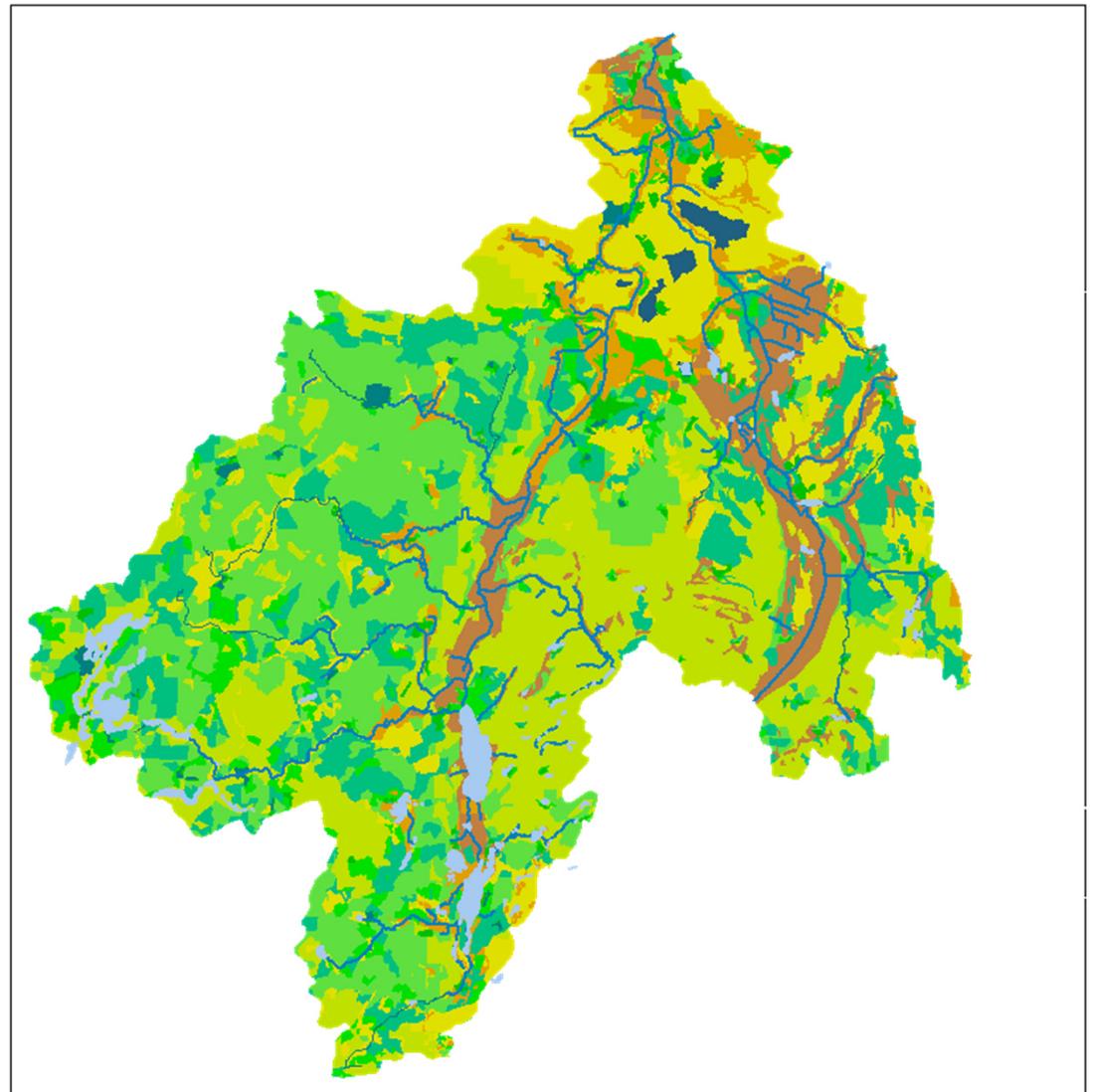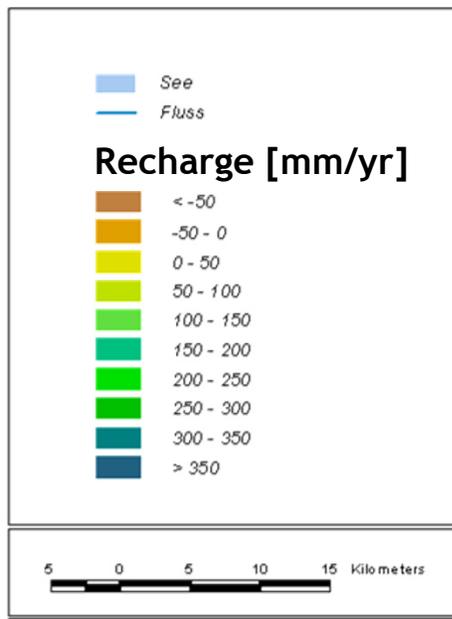
# Modelling the Ucker Basin

Dannowski and Steidl (2000)

MODEST Model



**Residence time [yr]**

- <= 5 a
- > 5 a <= 10 a
- > 10 a <= 20 a
- > 20 a <= 50 a
- > 50 a <= 100 a
- > 100 a

5  0  5  10  15  Kilometers
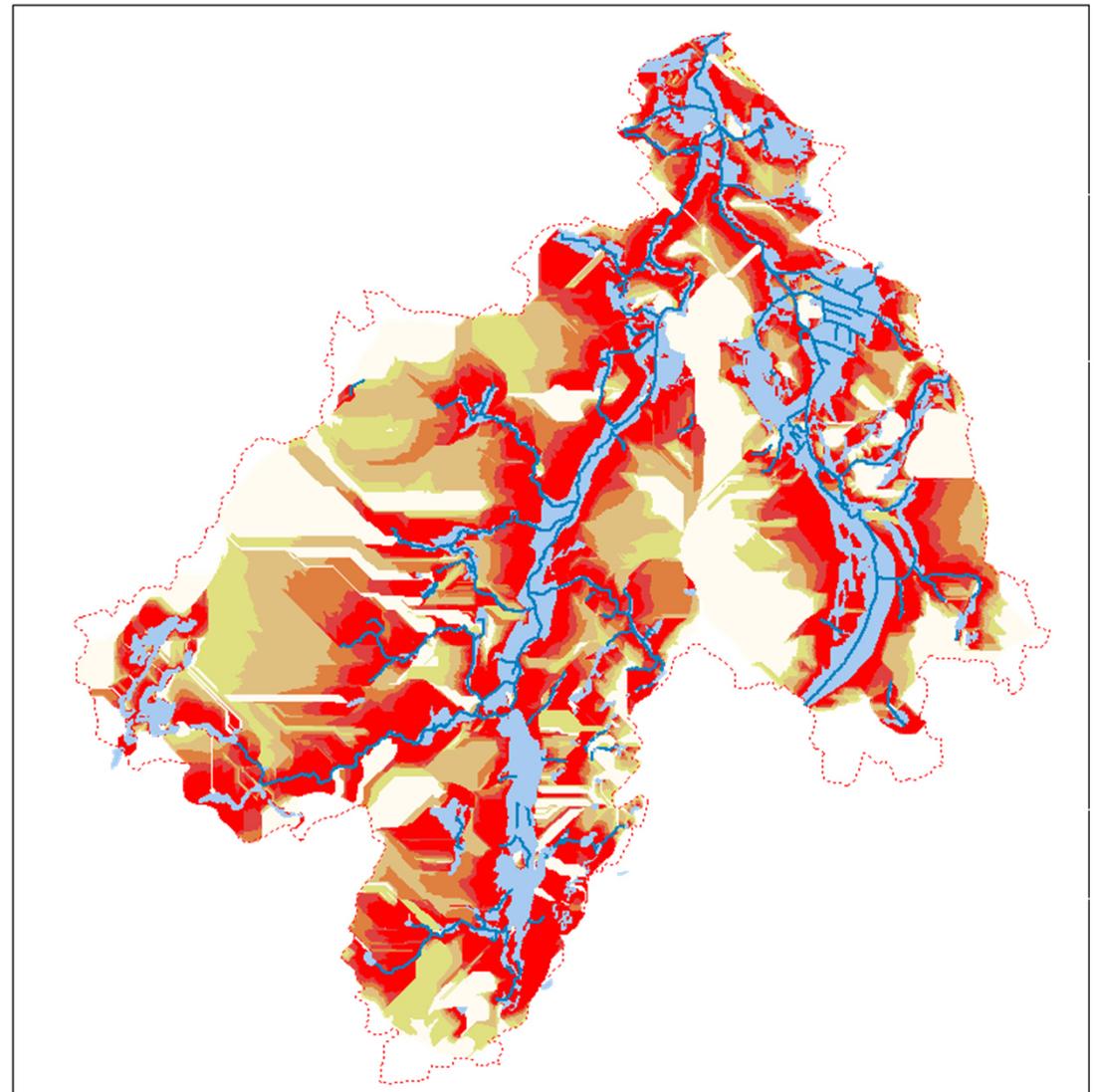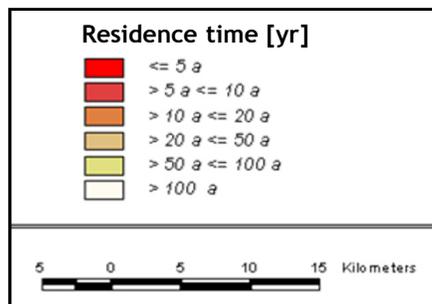
# Modelling the Ucker Basin

Wegehenkel and Kersebaum (2009)

- Climate change scenario: A1B (Gerstengarbe et al. 2003); 2001-2050 vs. 1951-2000

- THESEUS model (Wegehenkel 2002)

# Quillow Catchment

Dedelow Research Station

GWM3    GWM4    GWM5

GW_527      GWM1      GW_532

GW_529

GW_534

Prenzlau

10 km

(Google Earth)

# „Stream" Network



Legend

- **Lake**
- Stream, Ditch
- Culvert
- Piping

Total stream length:  151.1 km
-  thereof piped:        36.2 km (24%)

# Landuse Mosaic



(Google Earth)

# Geology (simplified)



(Foto: R. Dannowski)

(Sonntag 2005)
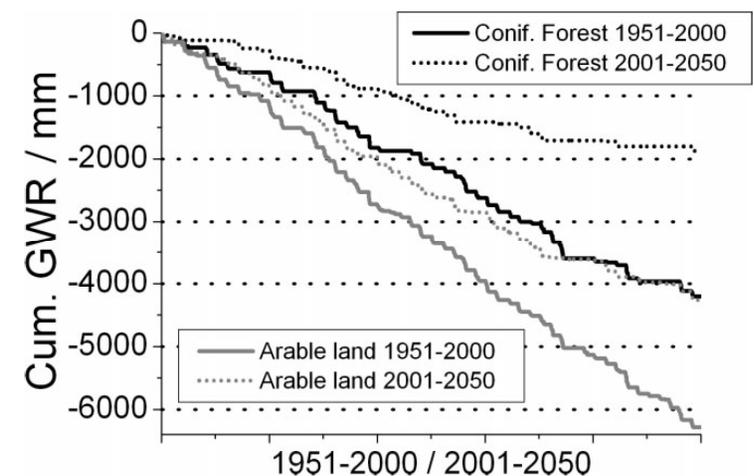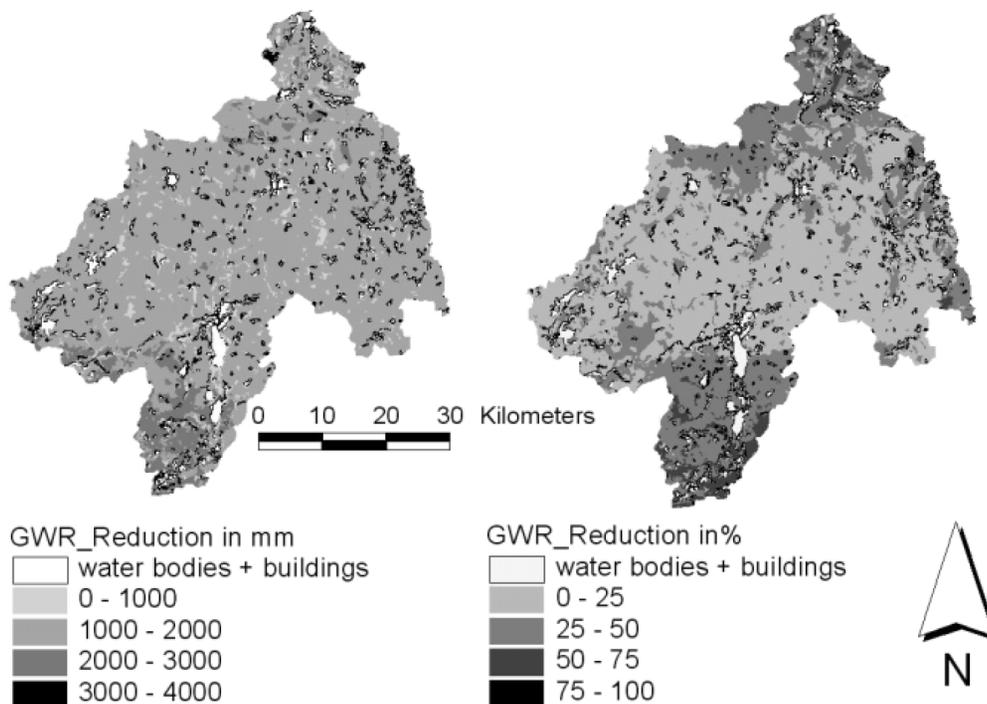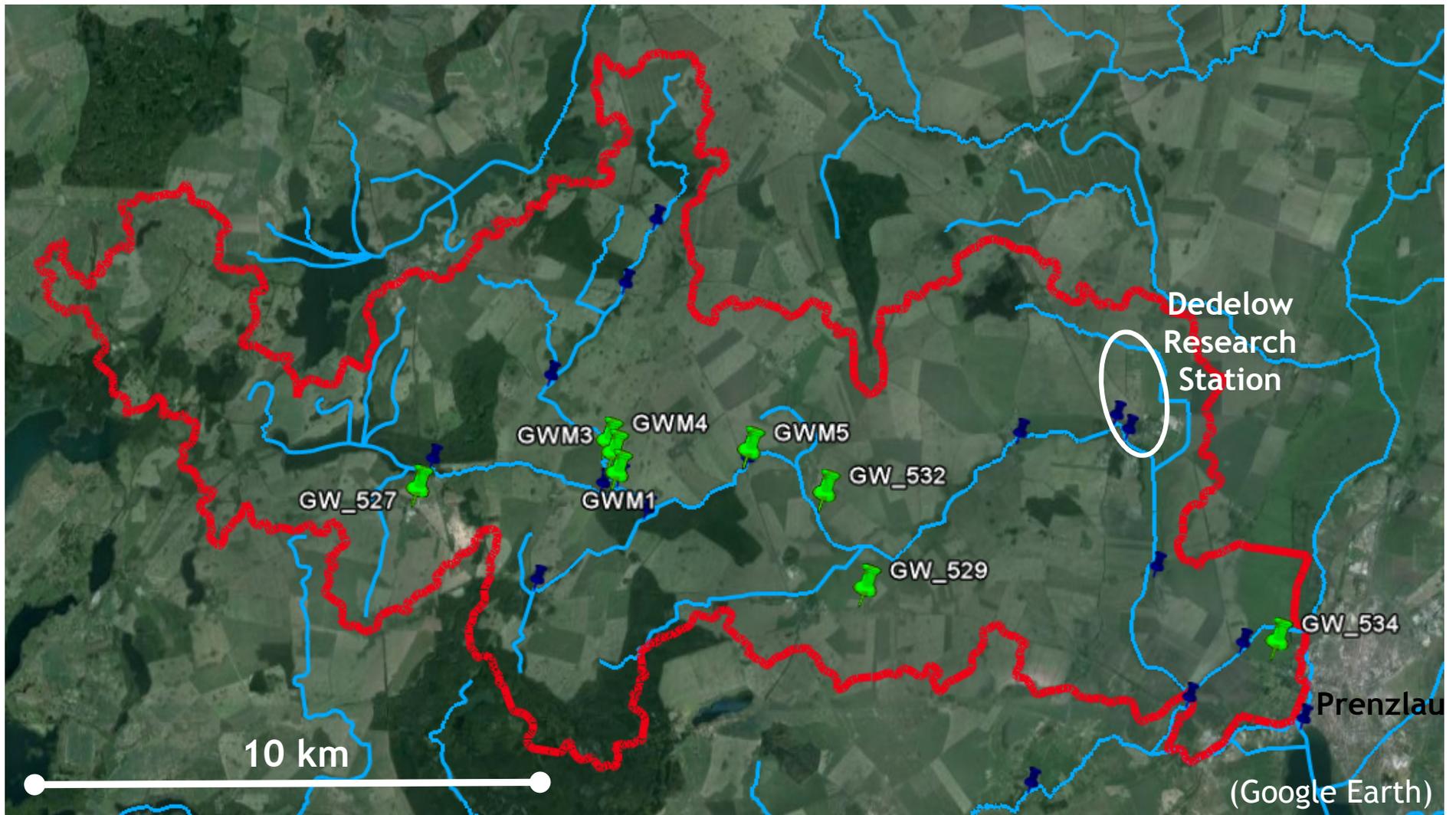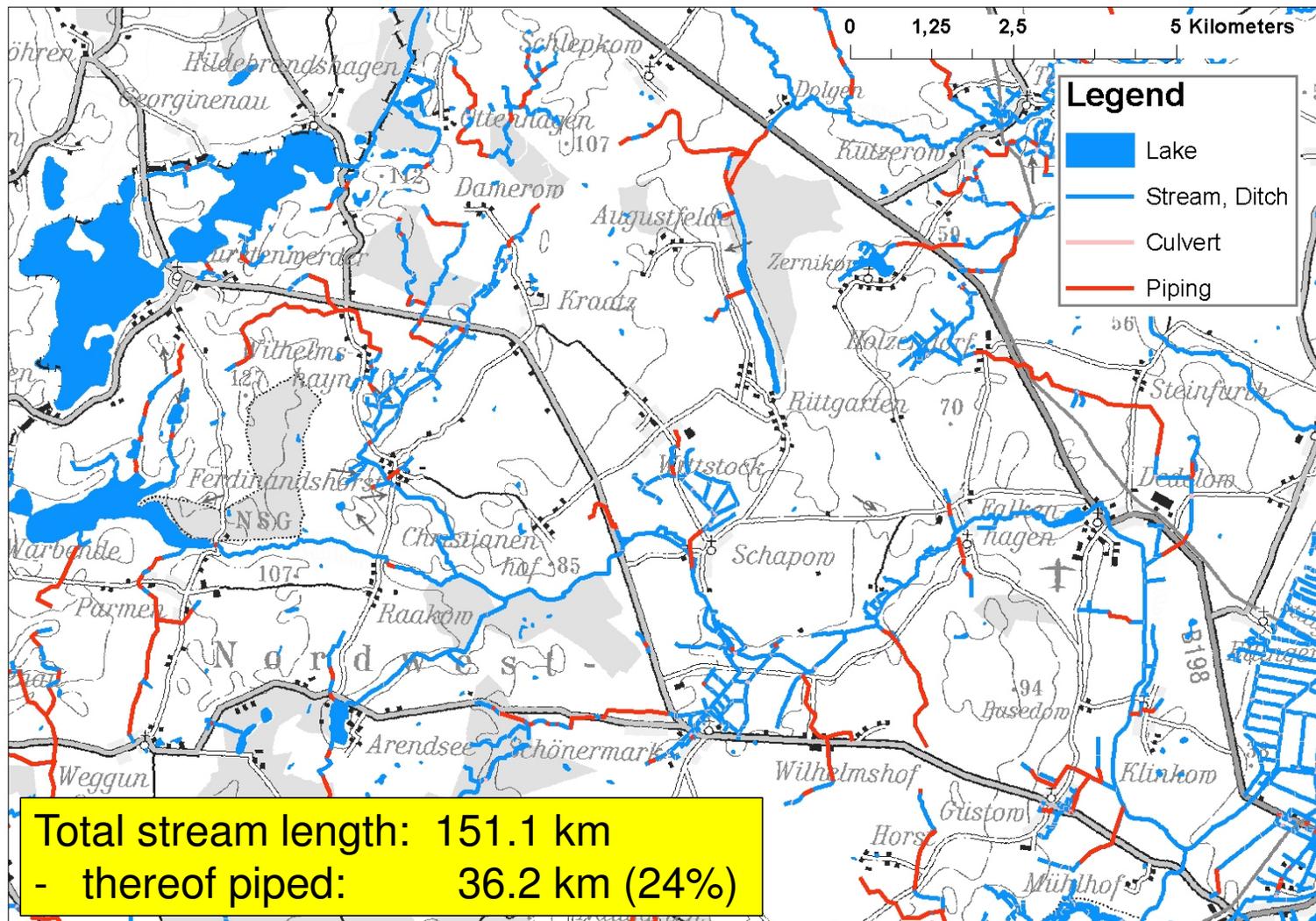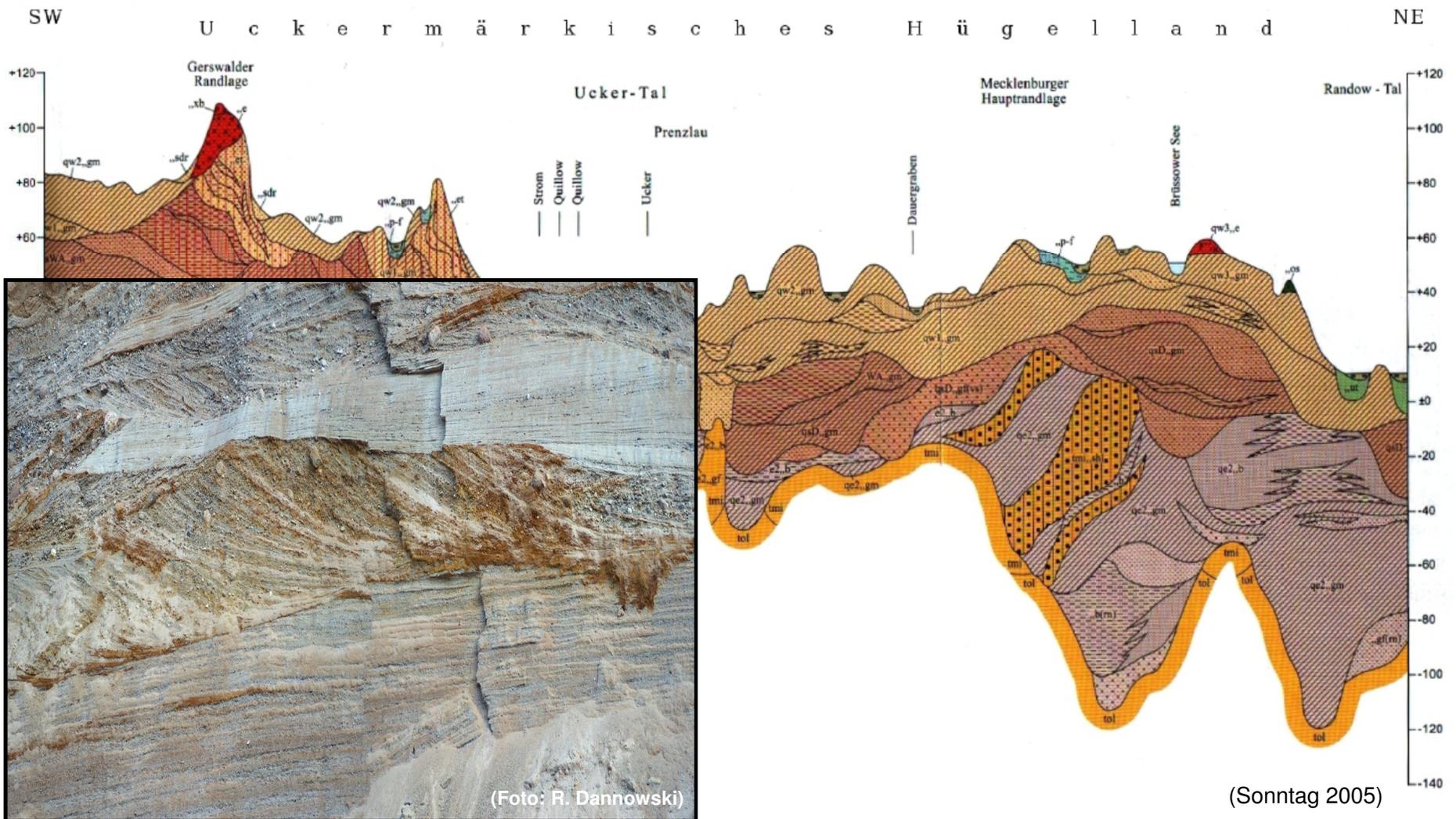
# Structure and Function



$$y_{out} = f(x_{in}, \; structure)$$
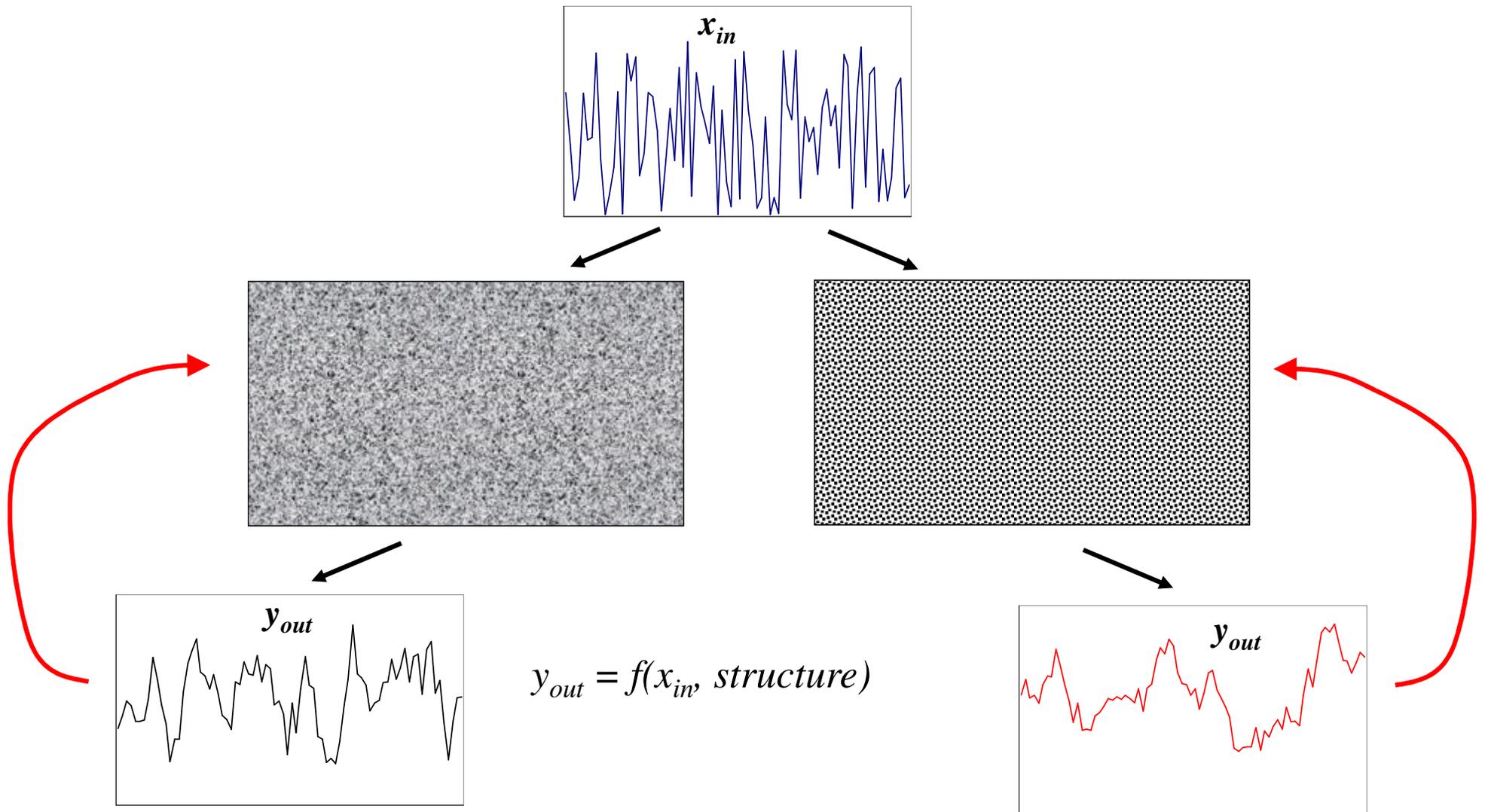
# Longitudinal Discharge Measurements

During base flow (May 2014)
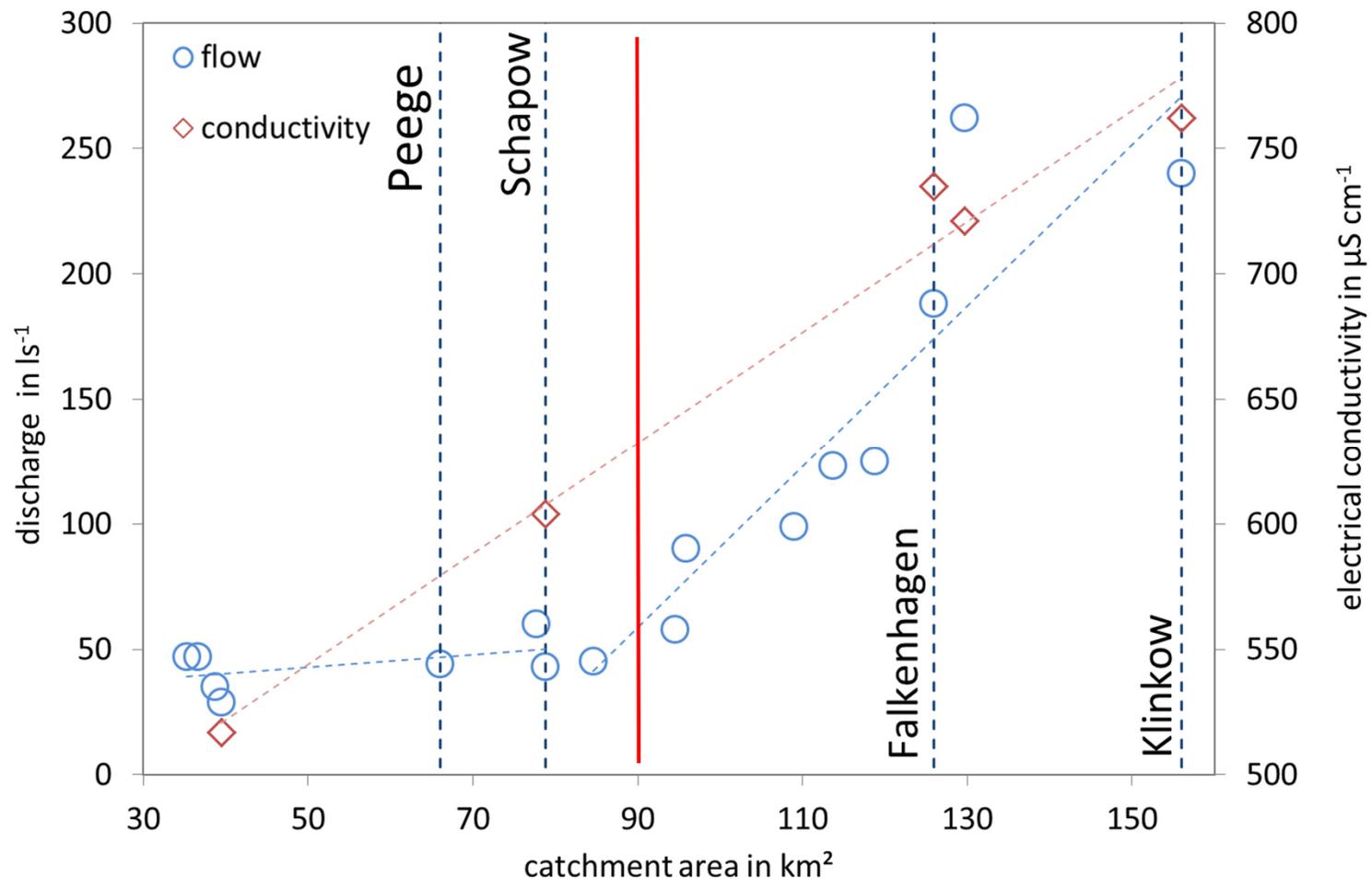
# Groundwater Head

Data: C. Merz (ZALF) and Landesumweltamt Brandenburg
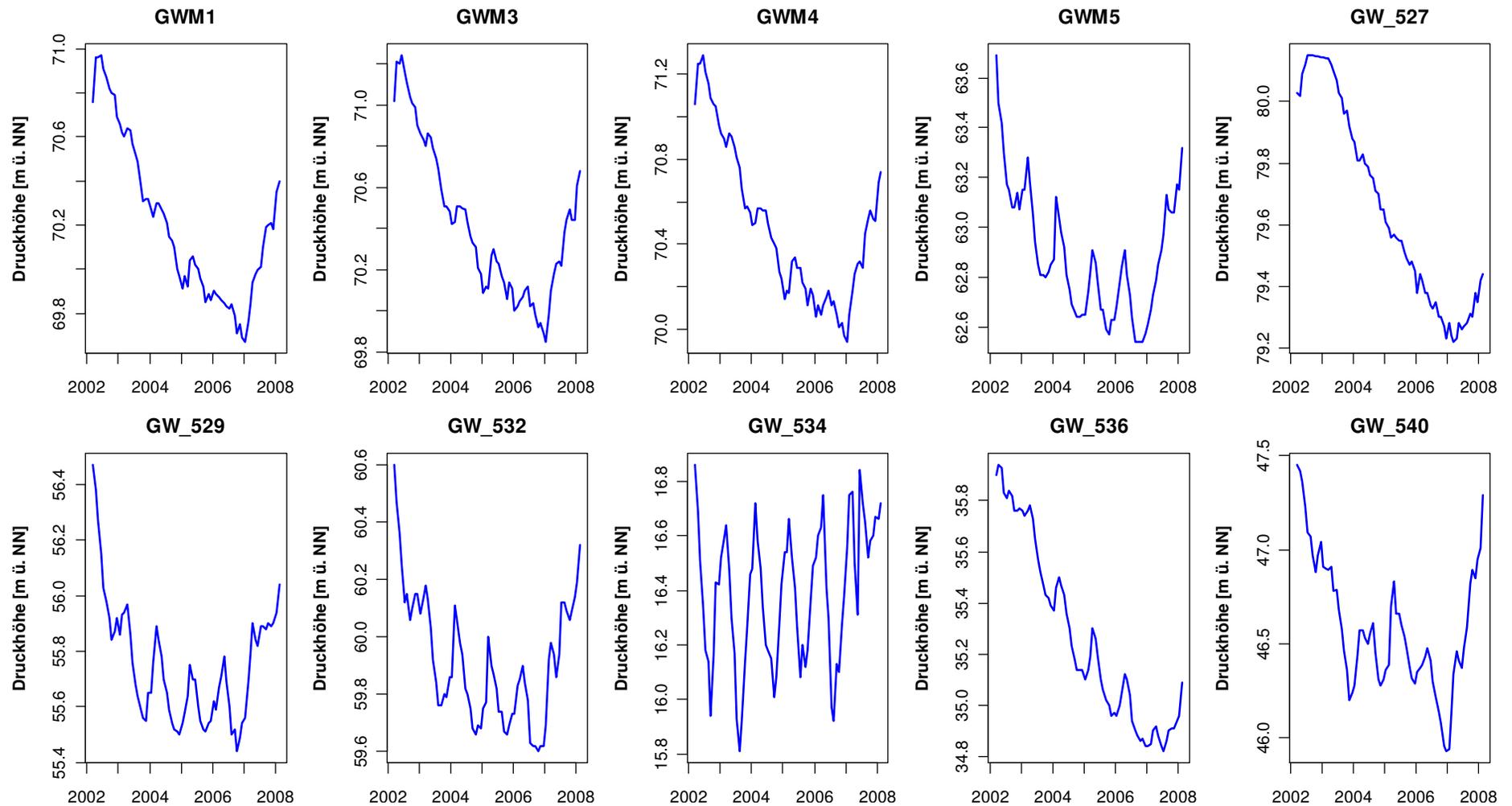
# Damping Coefficient

Σ of the first two components:

93% of the variance
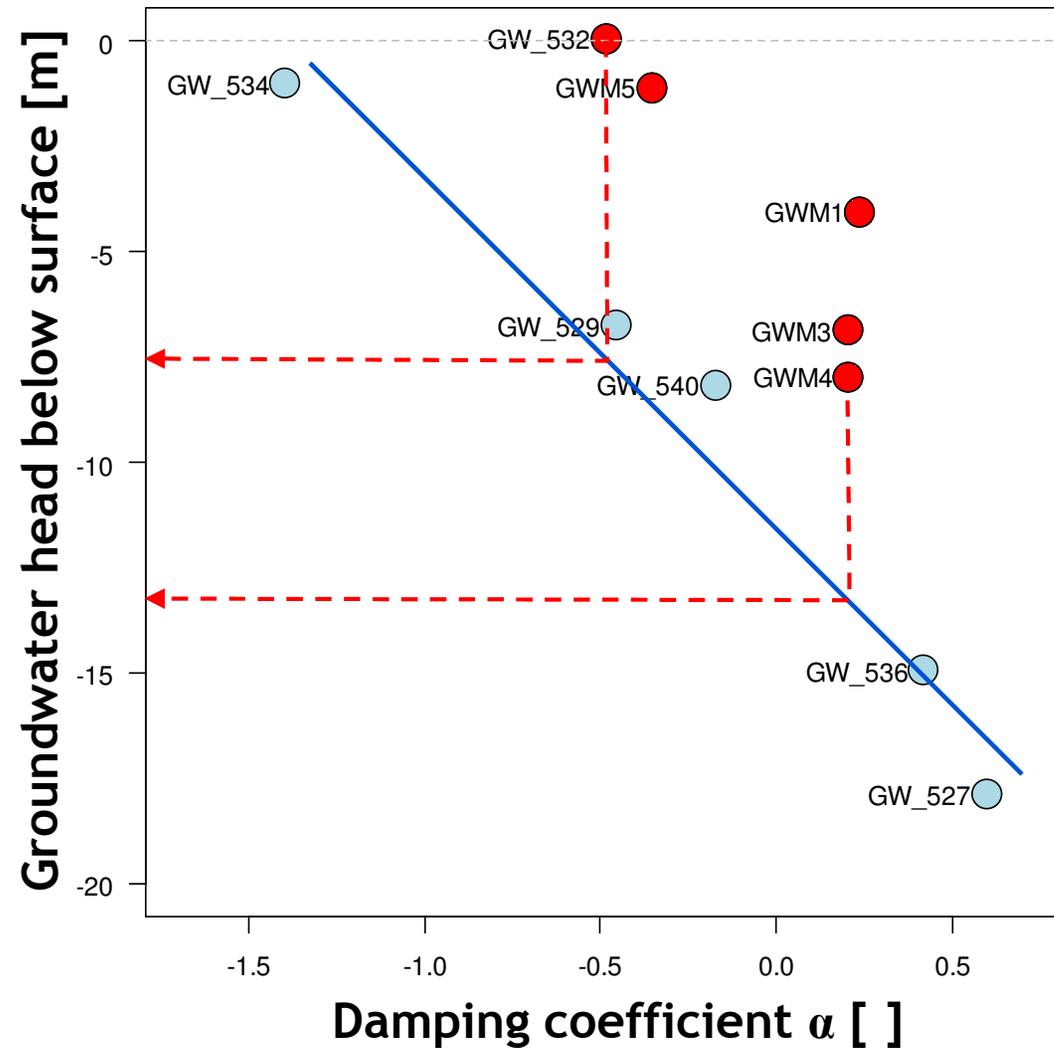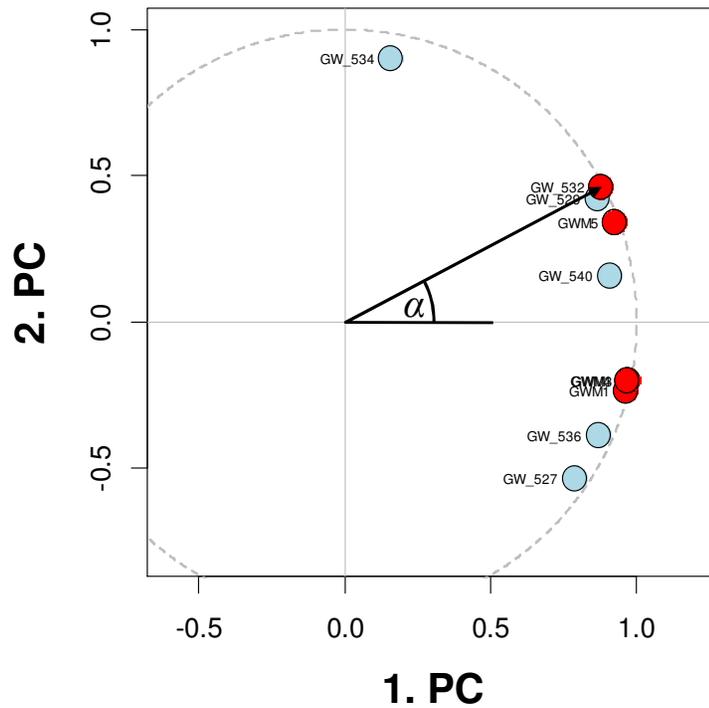
# The PCA Approach

Papers:

1. Lewandowski et al. (2009, *Hydrol Proc.*)

2. Lischeid et al. (2010, *Adv. Water Res.*)

3. Lischeid et al. (2012, *Grundwasser*)

4. Page et al. (2012, *J. Hydrol.*)

5. Thomas et al. (2012, *J. Hydrol.*)

6. Böttcher et al. (*2014, J. Hydrol.*)

7. Hohenbrink et al. (*submitted, J. Hydrol.*)

8. Lehr et al. (*submitted, J. Hydrol.*)

# Water Quality Sampling
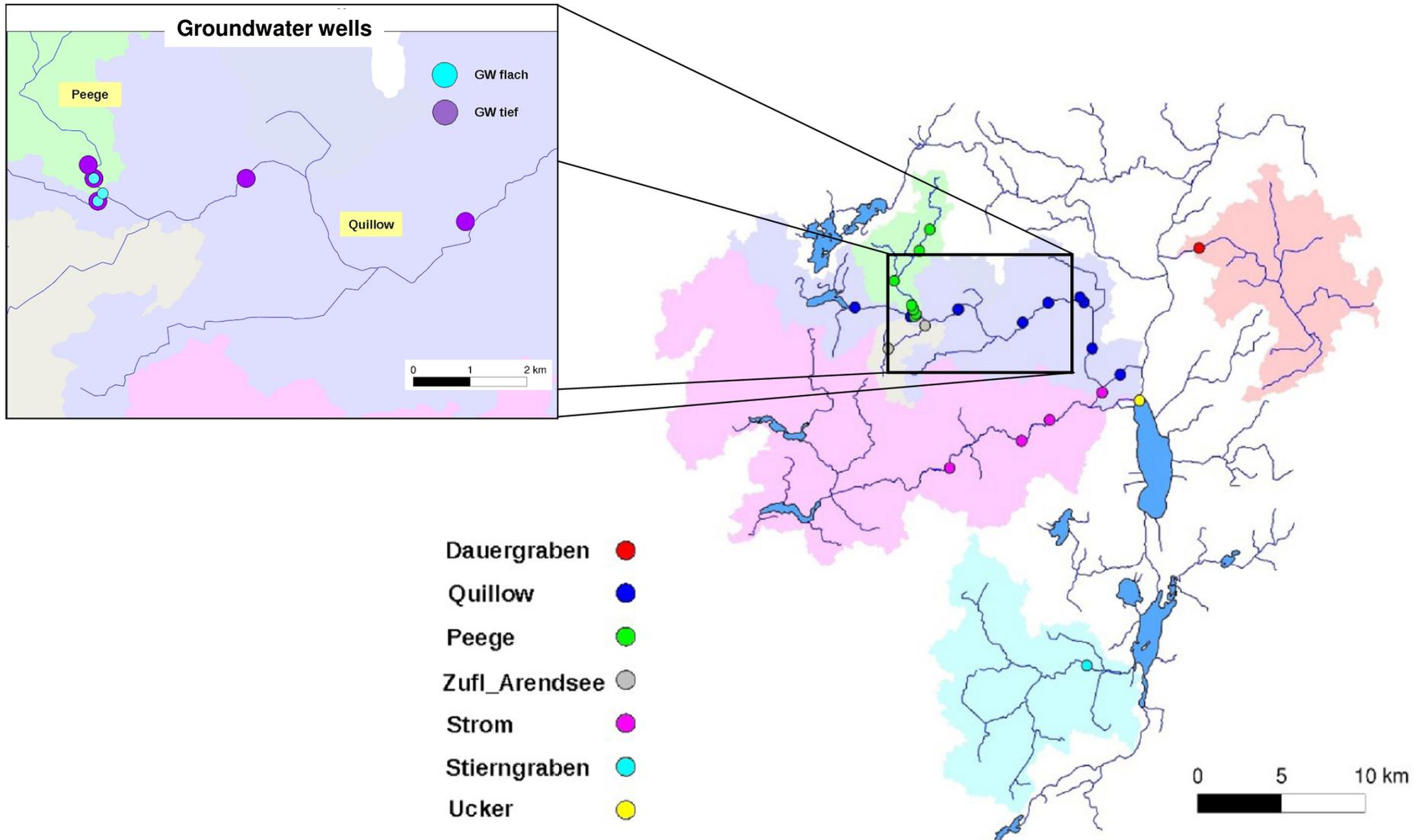
# Effect of Agriculture (Lehr 2010)
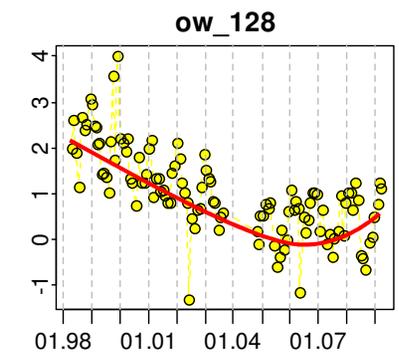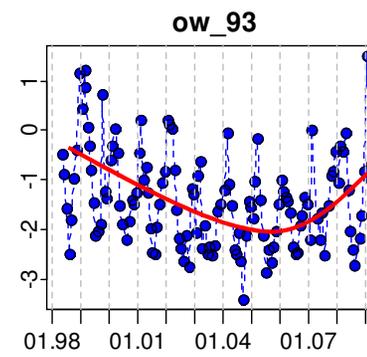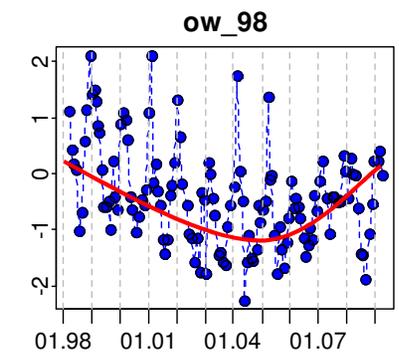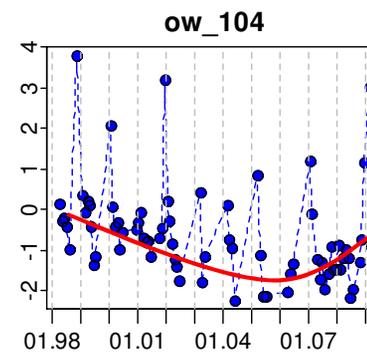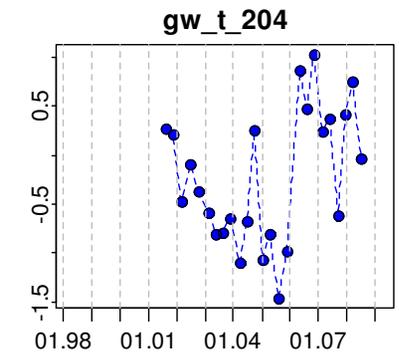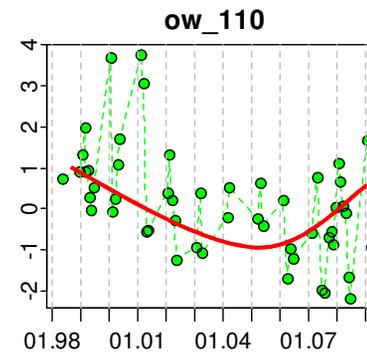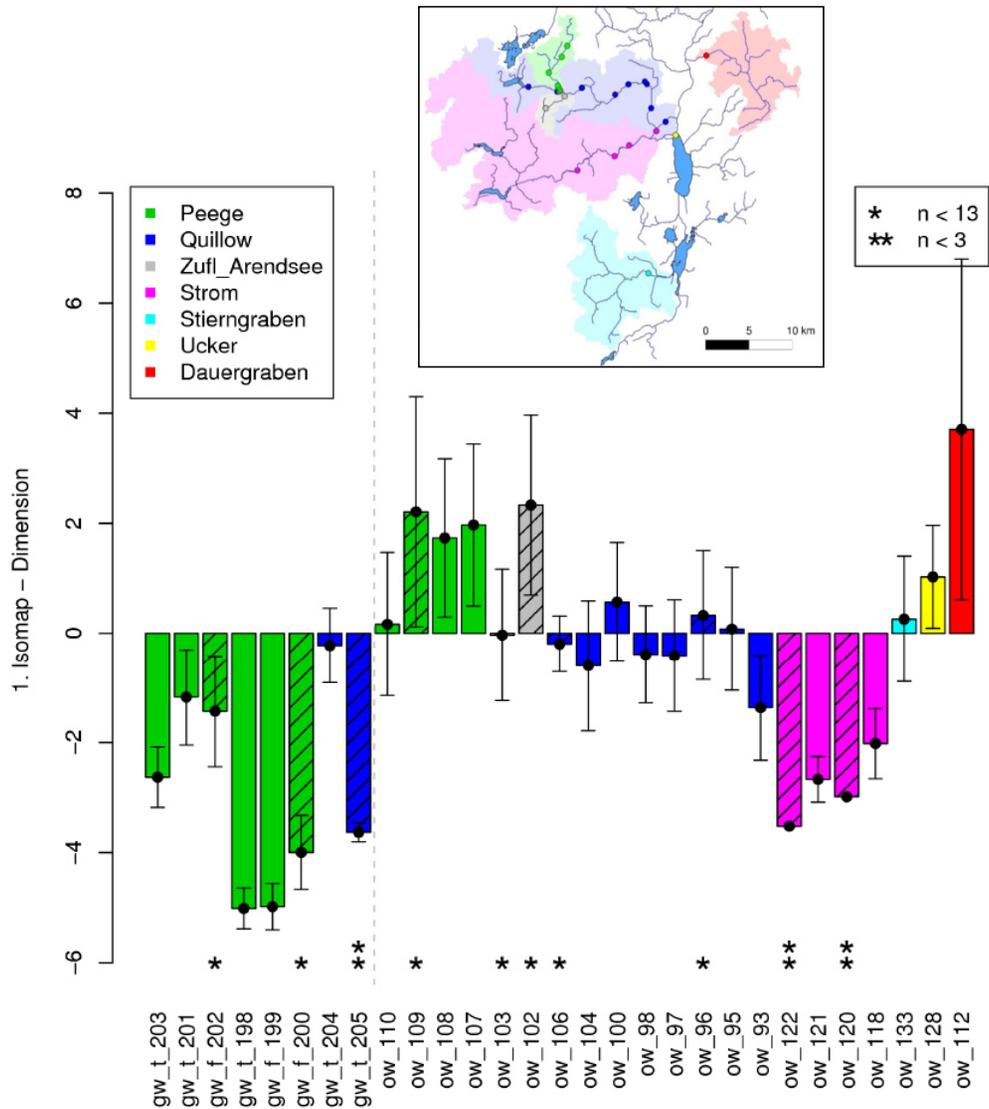
# Effect of Agriculture (Lehr 2010)
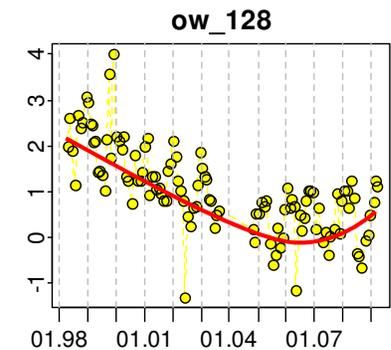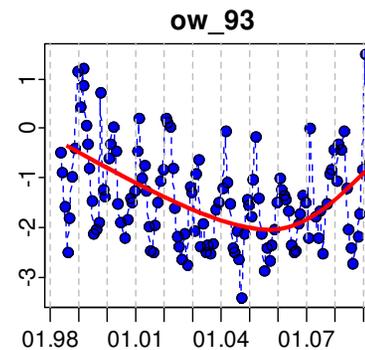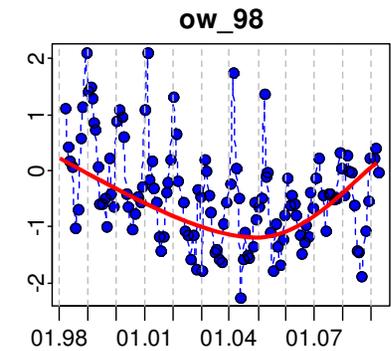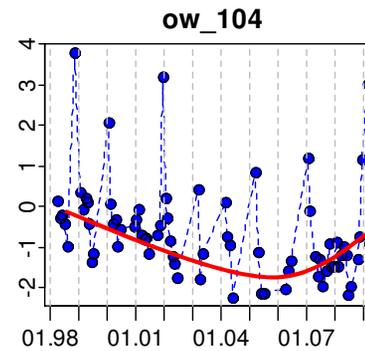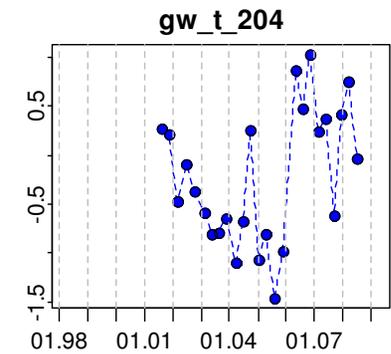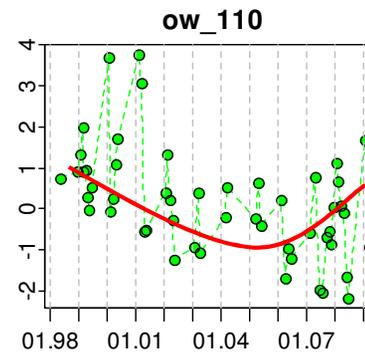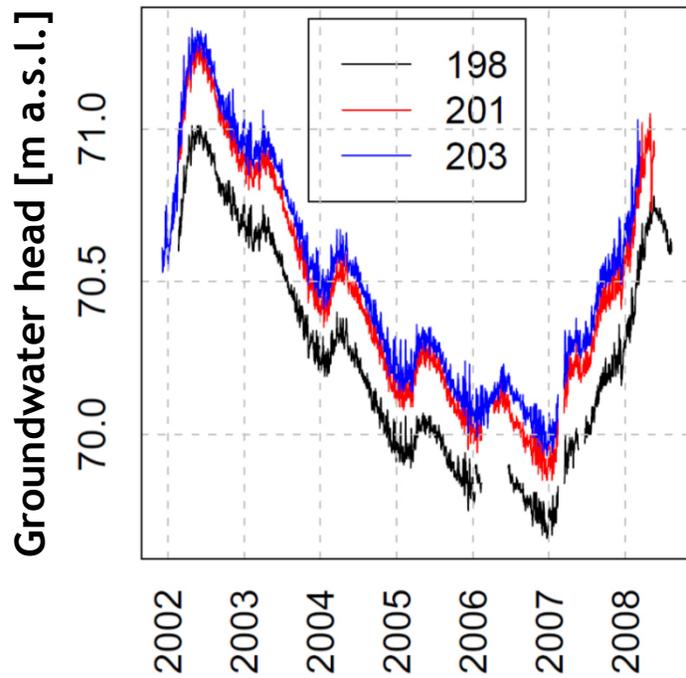
# Streams and Groundwater
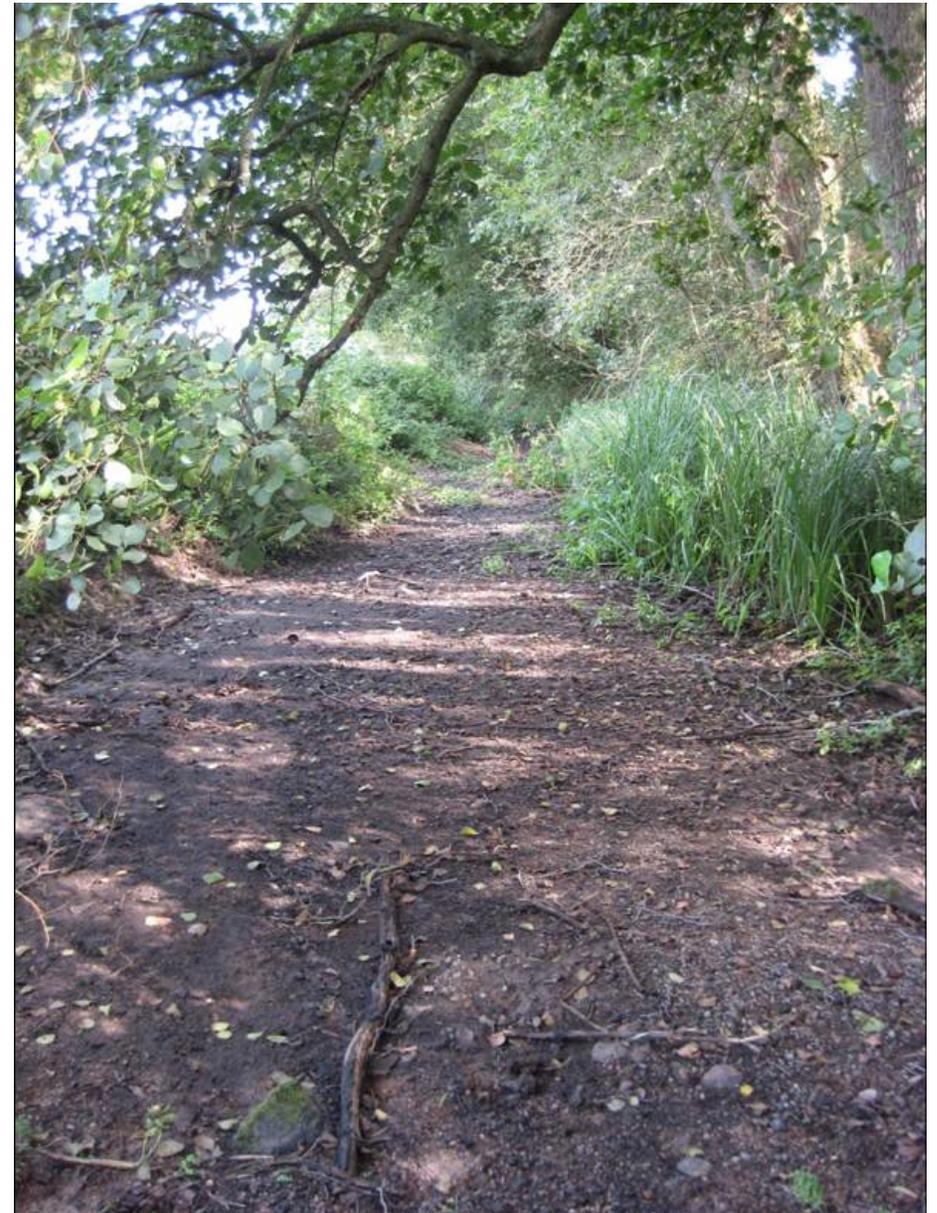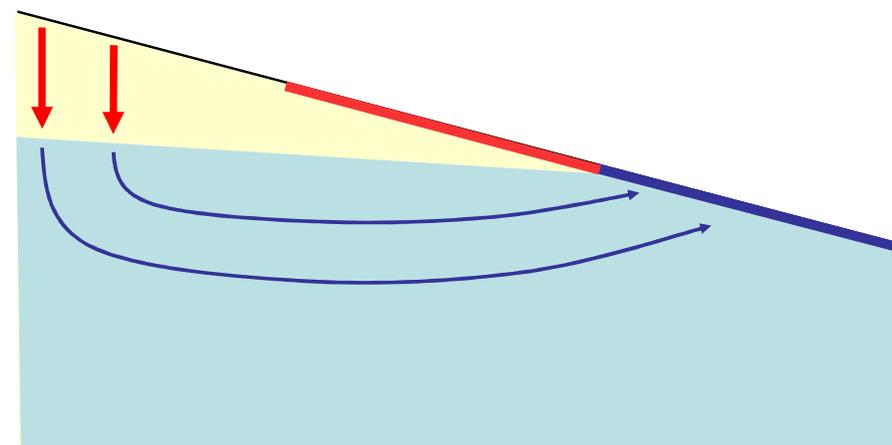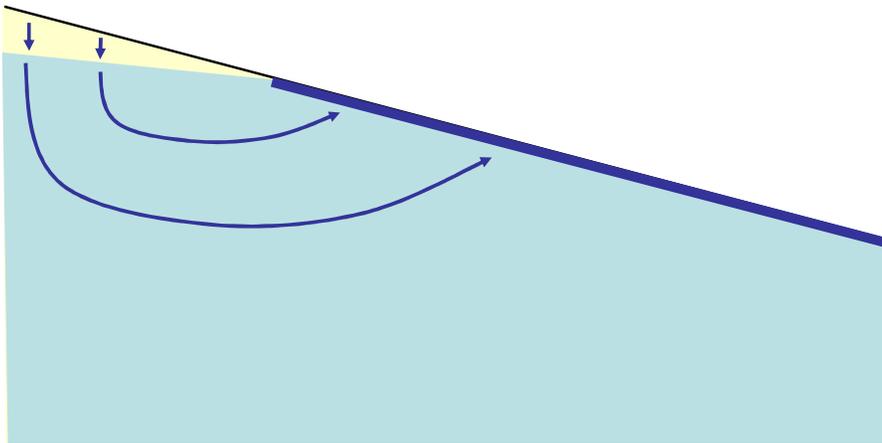
# The HydroGeoSphere Model

3D finite element model, describing fully integrated sub-surface and surface flow (Therrien et al. 2006; Brunner and Simmons 2012)

Towards a parsimonious, but powerful model:

- Starting with the simplest model (homogeneous subsurface and landuse);

- Stepwise including more geological features and landuse classes:

  - Check improvement of the model with respect to matching observed behaviour;

  - Delete non-successful modifications.

# The HydroGeoSphere Model

- 149,870 nodes

- 260,247 elements

- in 14 layers (sheets)
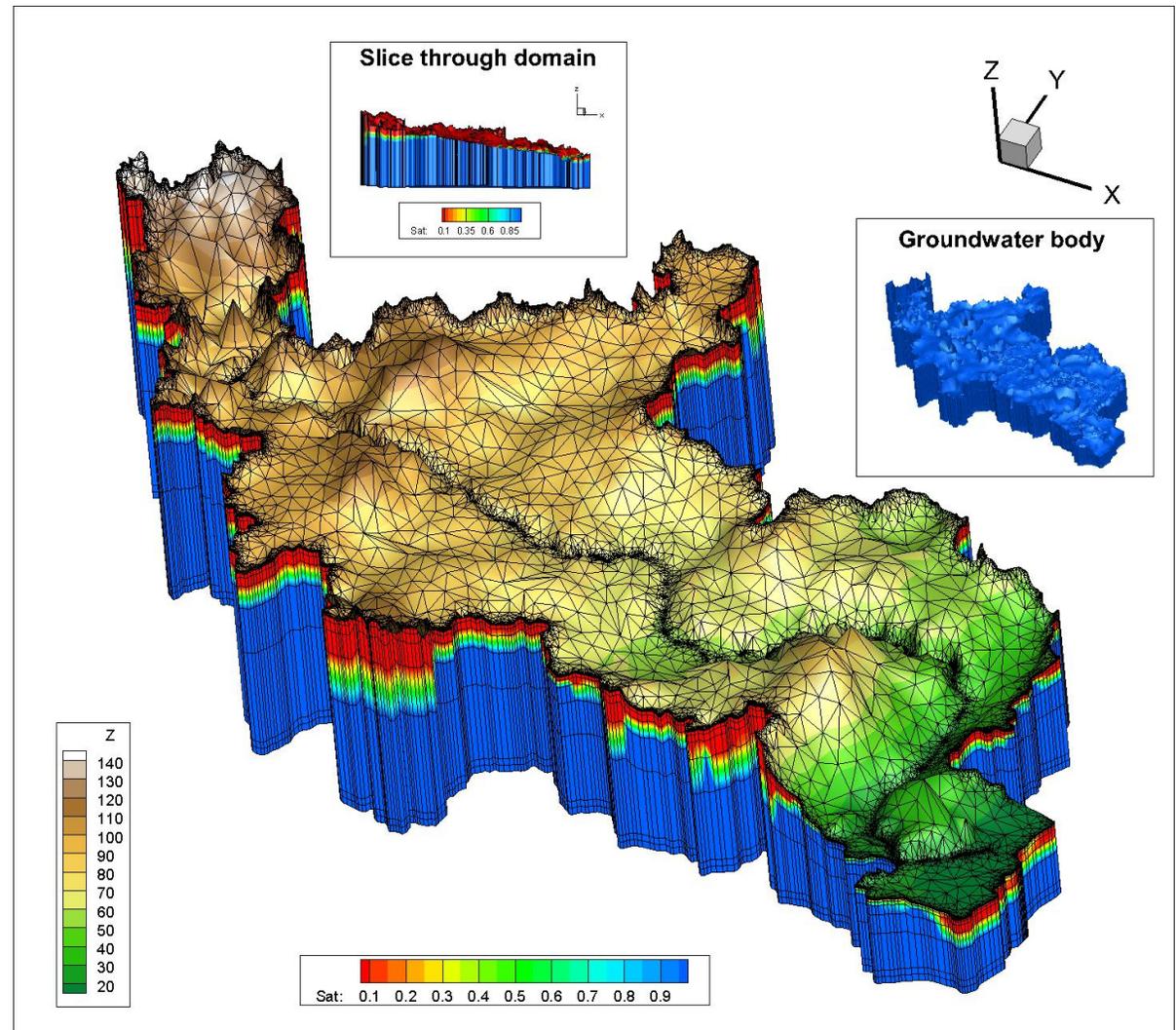
# Conclusions

1. Highly flexible models are necessary requisites for studying hydrology, biogeochemistry, biology, agriculture, … of complex landscapes.

2. In complex landscapes, observed behaviour (*hydrological, hydrochemical, micro-meteorological, …* = ***signatures***) reveals a lot about ***relevant*** structures and processes

    => Optimise models with respect to mimicking observed behaviour;

    => Make more efficient use of available data to constrain models.

*Comments, critizism?* → *lischeid@zalf.de*