Vrije Universiteit Brussel

Developing an integrated groundwater-surface water modeling tool for the Upper Biebrza Basin

O. Batelaan and J. Chormanski
Department of Hydrology and Hydraulic Engineering
Vrije Universiteit Brussel

Vrije Universiteit Brussel

~~3~~…2 Points

1. What kind of science, we need for W3M?

4. What kind of hydrological modeling would give functional insight?

Vrije Universiteit Brussel

Overview

1. Remark on modeling — **Point 1**
2. Upper Biebrza and hydrological character — **Point 2**
3. Model concepts and application — **Point 2**
4. Model integration and possible feedback — **Point 2**

Vrije Universiteit Brussel

Remark on modeling

from the 1948 book *Sand County Almanac*, by the ecologist and conservationist Aldo Leopold:

In terms of conventional physics, the grouse

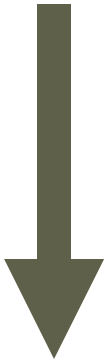
Central role for ideal systems (ideal gas, harmonic oscillator)

Disdain for caricatures of nature

Vrije Universiteit Brussel

1st Point

1. What kind of science, we need for W3M?



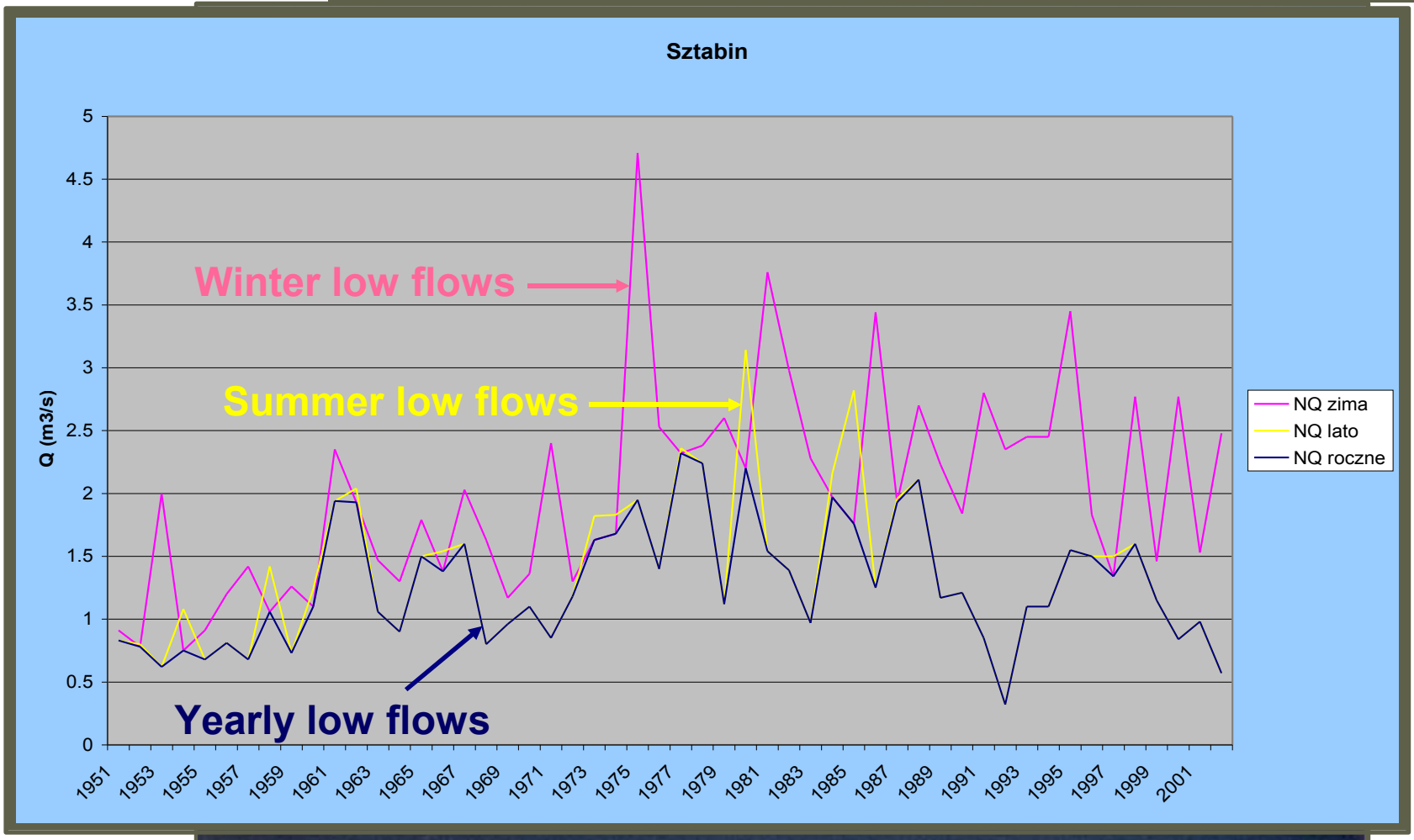
Embrace science of place: try to understand very specific environments, then it is possible to go from pattern to process to generalizations

Vrije Universiteit Brussel

Study area

Vrije Universiteit Brussel

Low flows at Sztabin



Vrije Universiteit Brussel

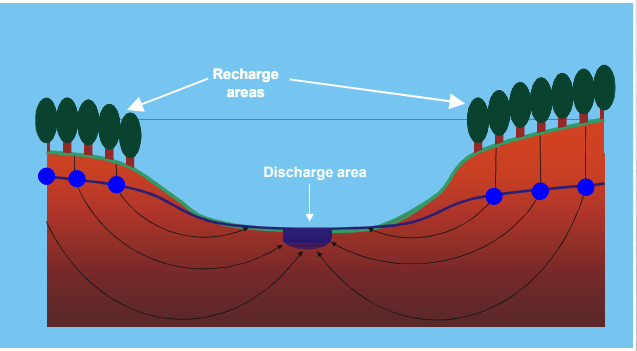
Time series at Sztabin

- Significant increasing trend of yearly low flows
- Significant jump in the discharge 1972-1973
- Interpretation: drainage engineering works in Biebrza catchment in beginning of 1970ties increased drainage of water from river (valley), resulting in an increase in low flows
- No significant observed change in average discharge. Maximum discharge has a small significant decreasing trend.

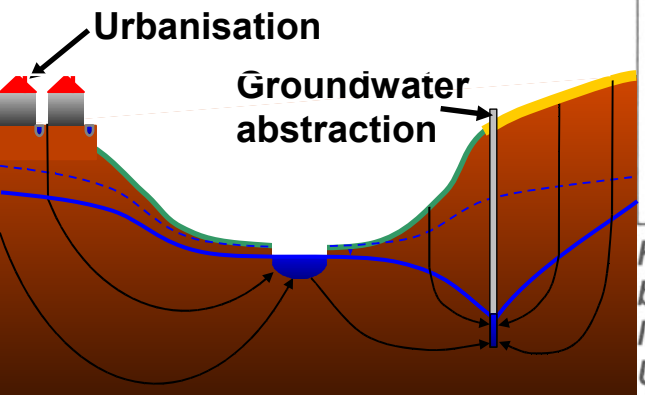
Vrije Universiteit Brussel

Interaction spatially complex

Natural system



Effects of landuse



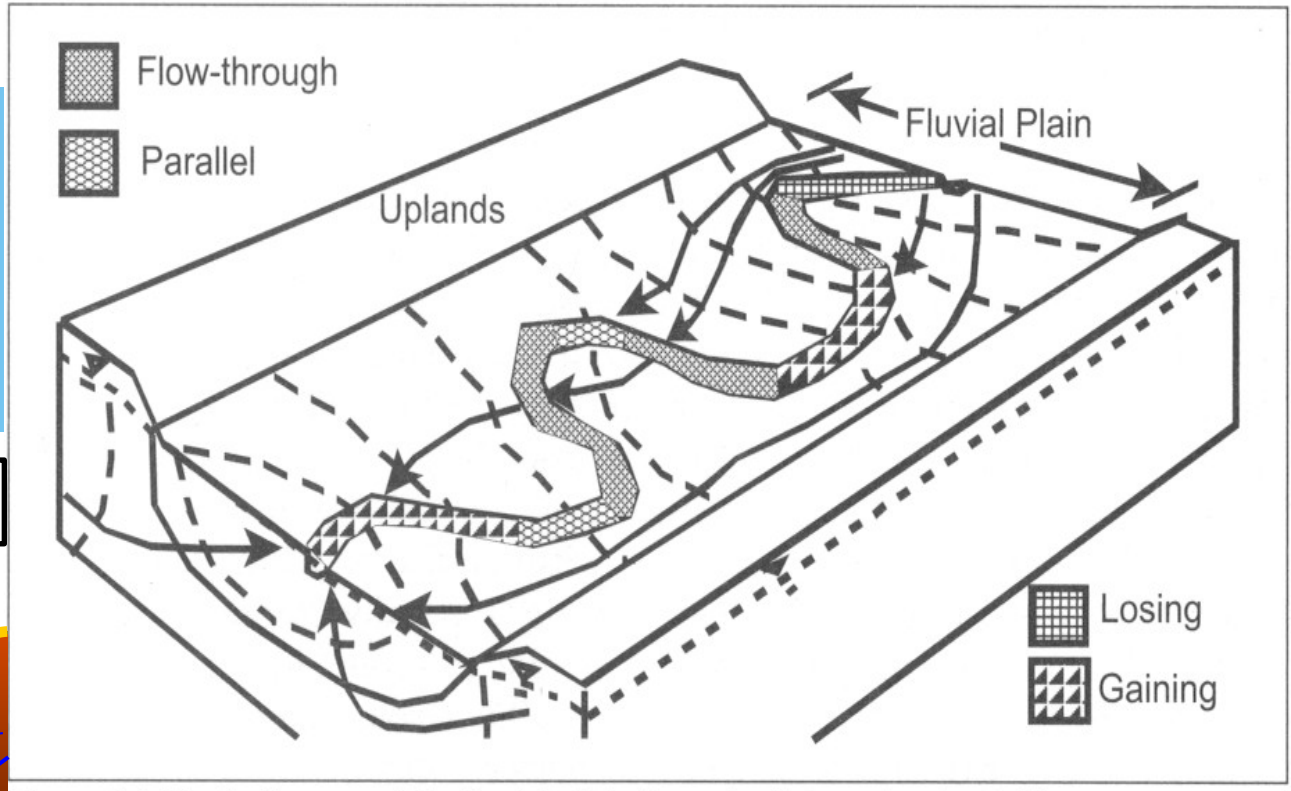
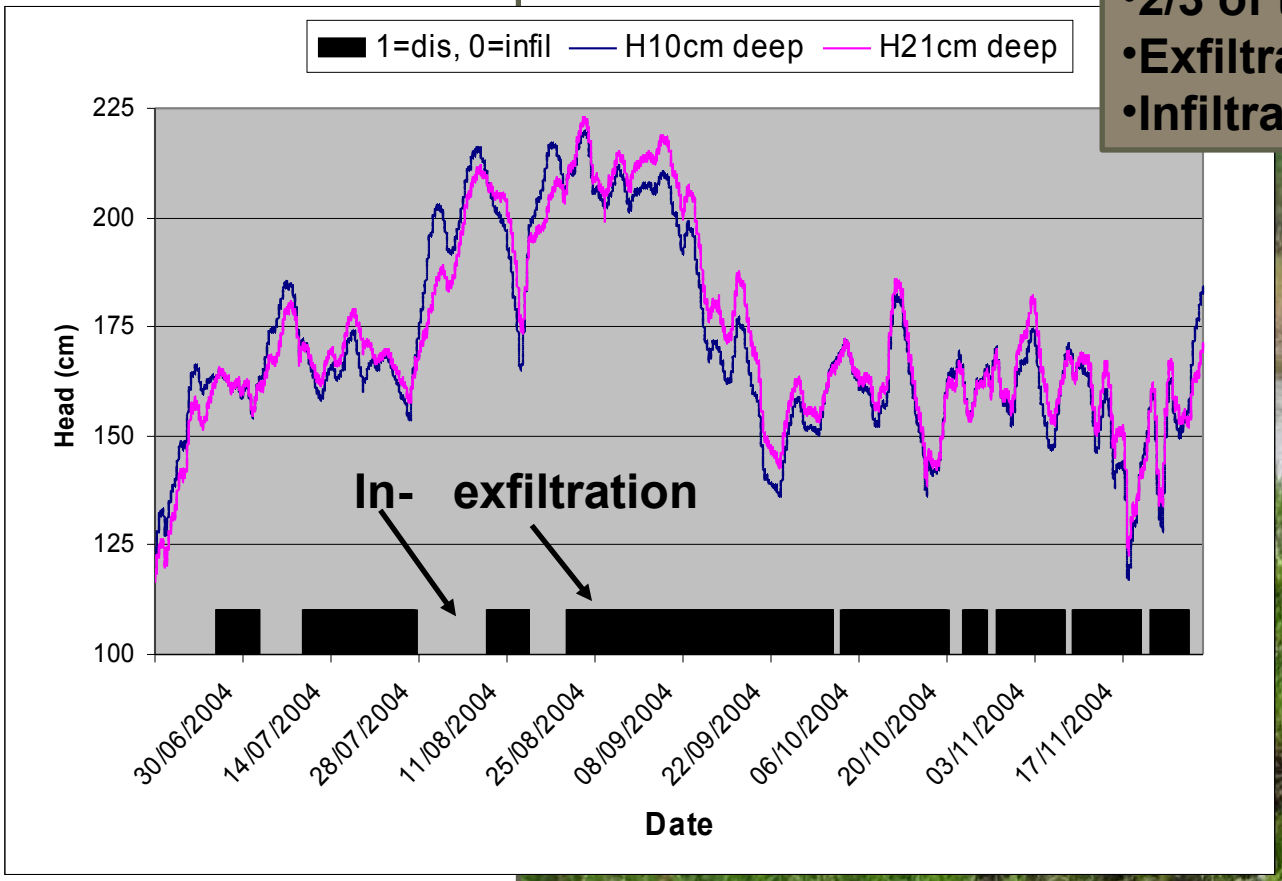


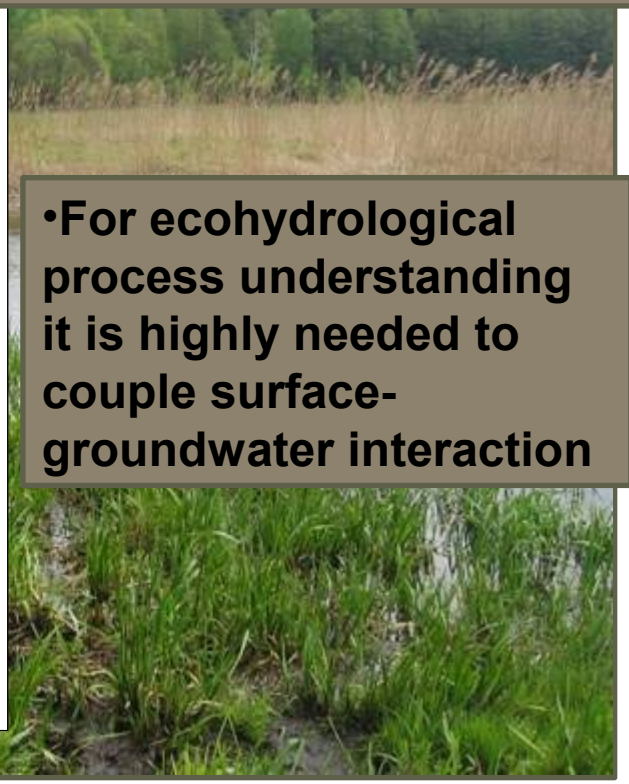
Figure 6.1 Block diagram of the fluvial plain. Isopotentials and water table are represented by dashed lines and groundwater movement by flow arrows; reaches are broken into losing, gaining, flow-through, and parallel stretches. [Adapted from Woessner (2000). Used with permission of Groundwater (2000).]

Vrije Universiteit Brussel

Rogozynek gw-sw interaction

- 1/3 of time infiltration conditions
- 2/3 of time exfiltrating conditions
- Exfiltration is -4.3 cm/d
- Infiltration 4.6 cm/d





- For ecohydrological process understanding it is highly needed to couple surface-groundwater interaction

Vrije Universiteit Brussel

Model concepts

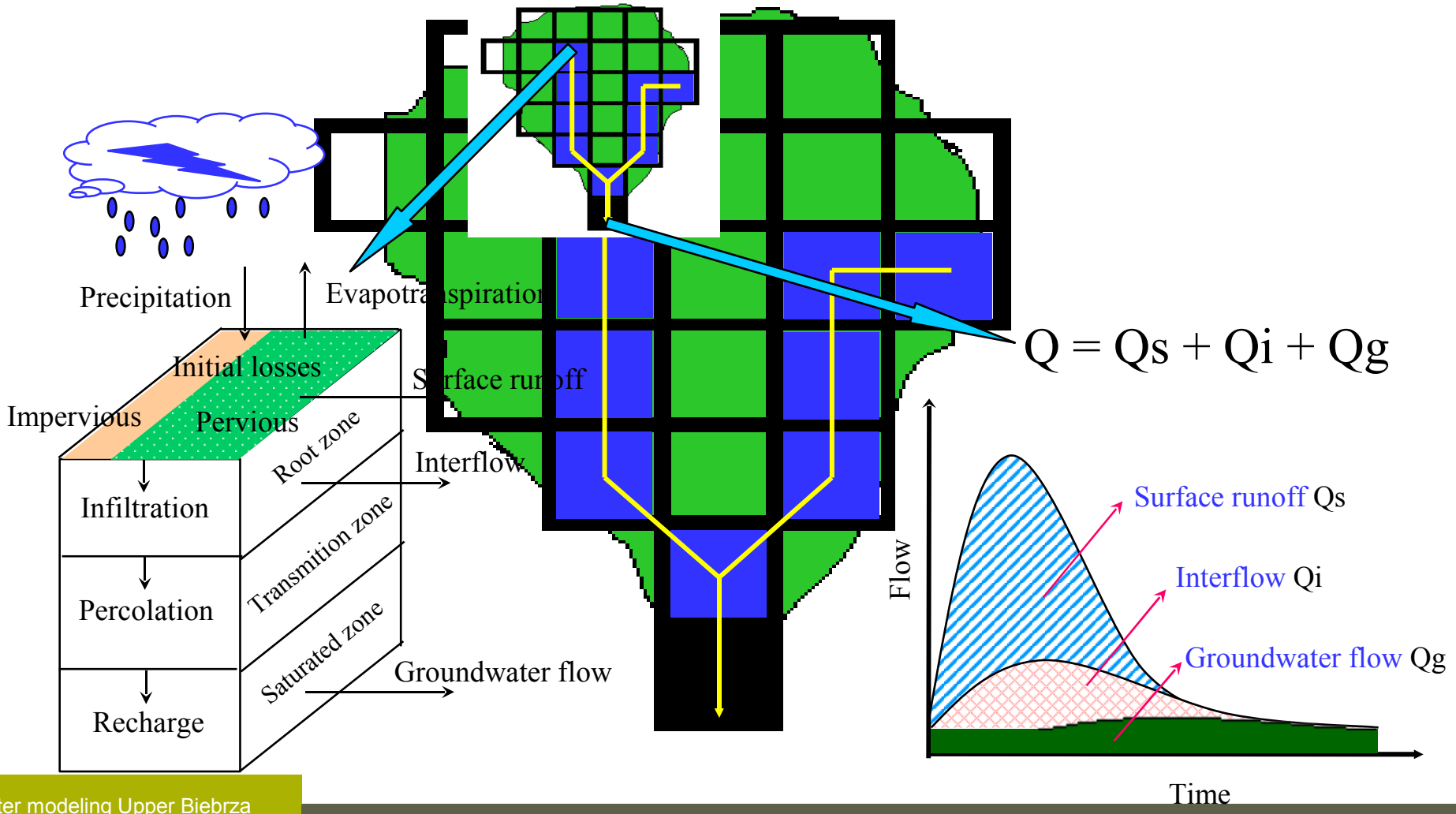
Hydraulic models (Verhoeven, Miroslaw-Swiatek)

WetSpa, Rainfall-runoff distributed model

Groundwater model

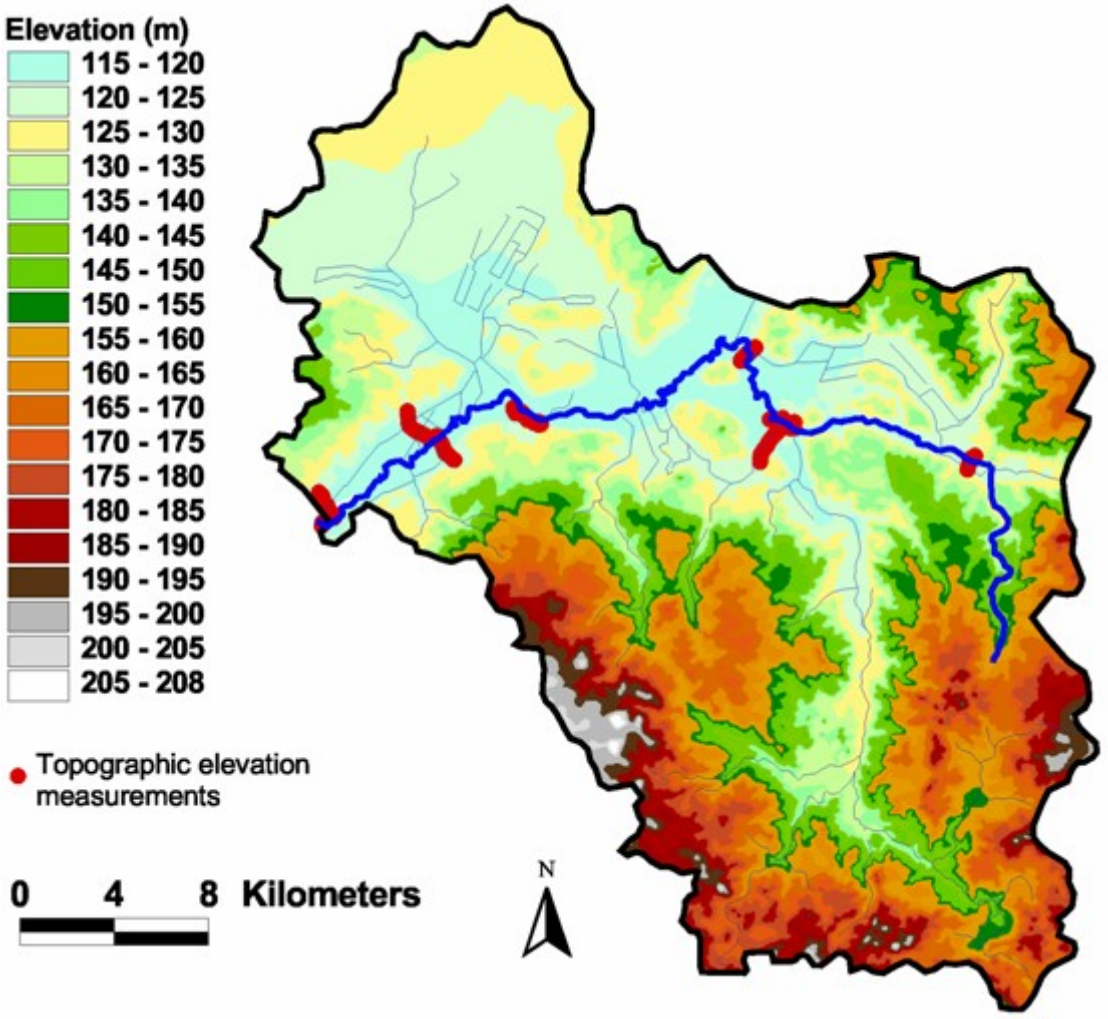
Vrije Universiteit Brussel

WetSpa – Model Concept



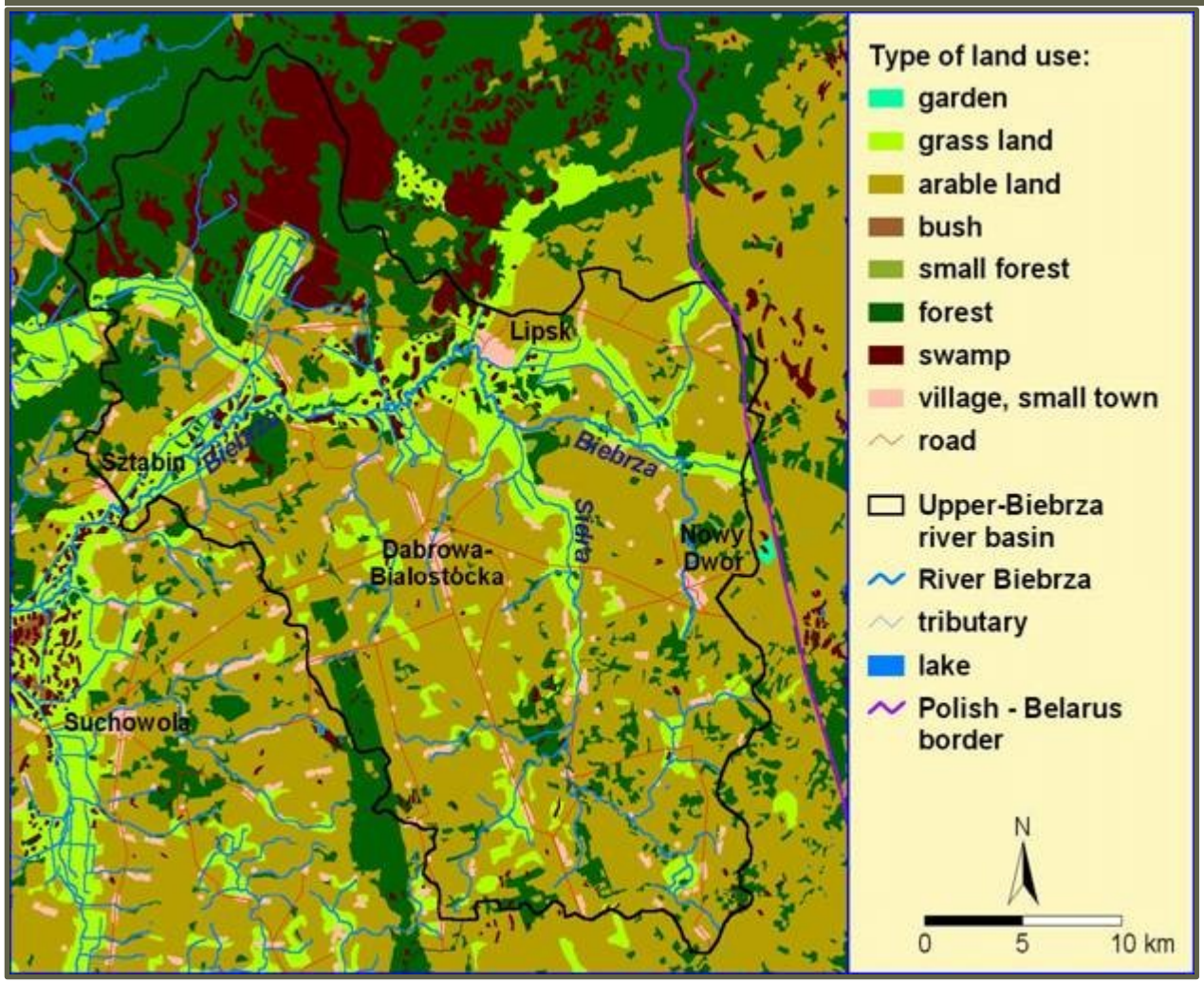
Vrije Universiteit Brussel

Digital Elevation Model



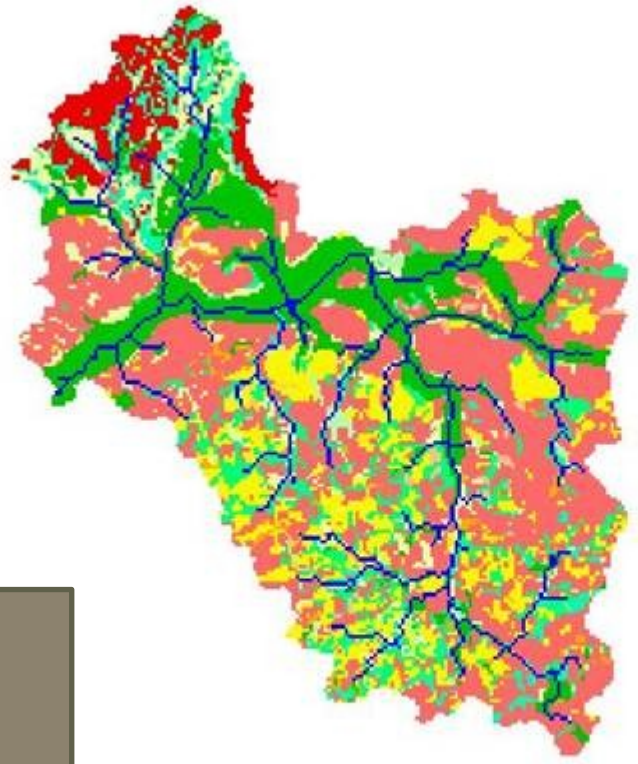
Vrije Universiteit Brussel

Land use map



Vrije Universiteit Brussel

Soil type map



Stream Network

Soil

- clay
- clay loam
- loam
- loamy sand
- sandy clay
- sandy clay loam
- sandy loam
- silt
- silt clay
- silt loam
- No Data

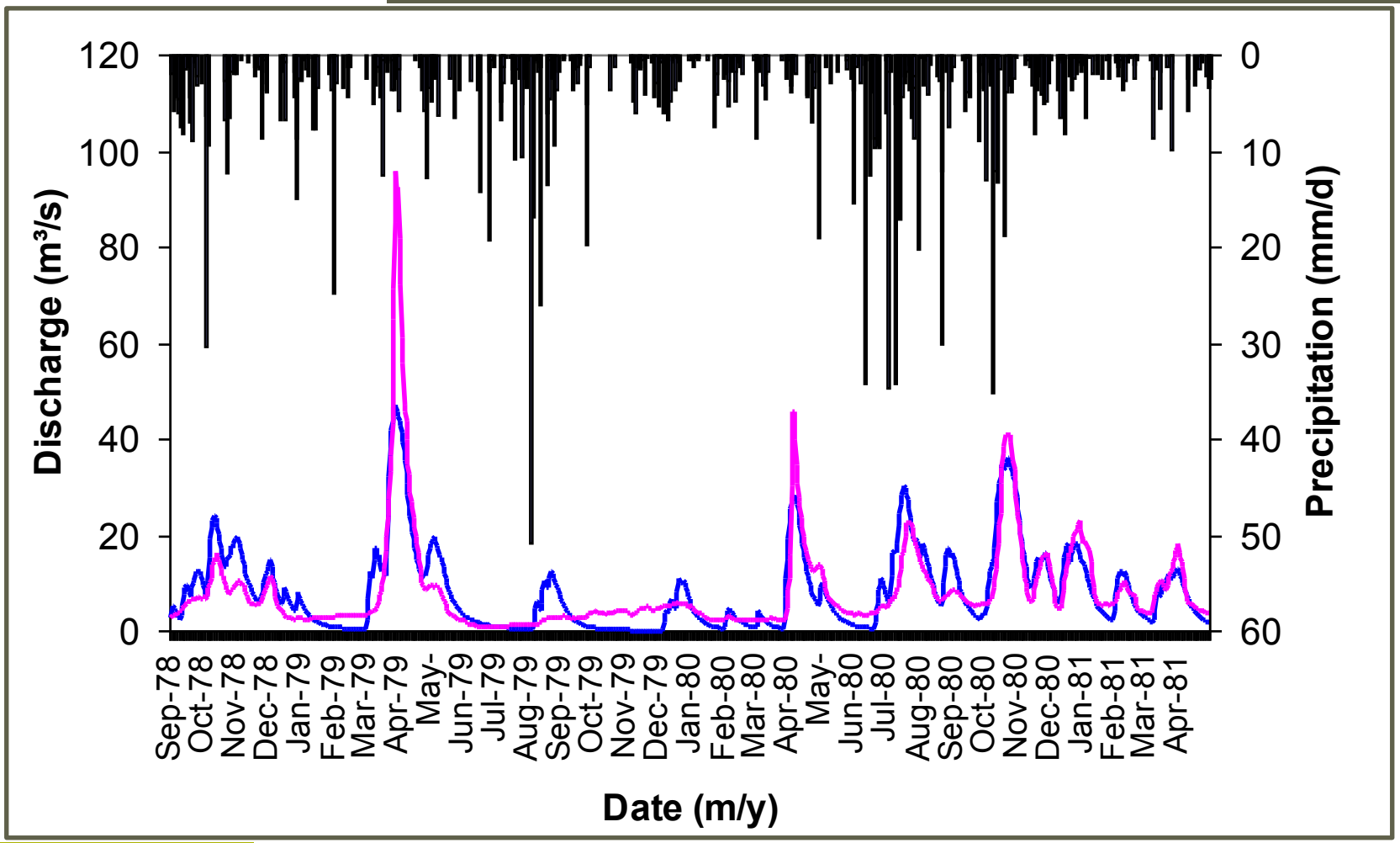
N
W
E
S

0 10 20 Kilometers

- **39 %** sandy clay loam
- **19 %** clay loam
- **13 %** sandy loam

Vrije Universiteit Brussel

WetSpa simulated hydrograph



Vrije Universiteit Brussel

Model evaluation

C1	C2	C3	C4	C5
0.015	0.717	0.732	-0.107	0.768

C1: Model bias (0-1, optimum 0)
C2: Model confidence (0-1, optimum 1)
C3: Nash-Sutcliffe efficiency (optimum 1)
C4: Nash-Sutcliffe efficiency for low flow (optimum 1)
C5: Nash-Sutcliffe efficiency for high flow (optimum 1)

Too little non-linearity and spatial subsurface heterogeneity taken into account in baseflow generation

Performance is satisfactory for water balance simulation and spring flood prediction,
however not for low flow situation.

Vrije Universiteit Brussel

8 Glaciations in 1Ma…

Ice-pushed moraines

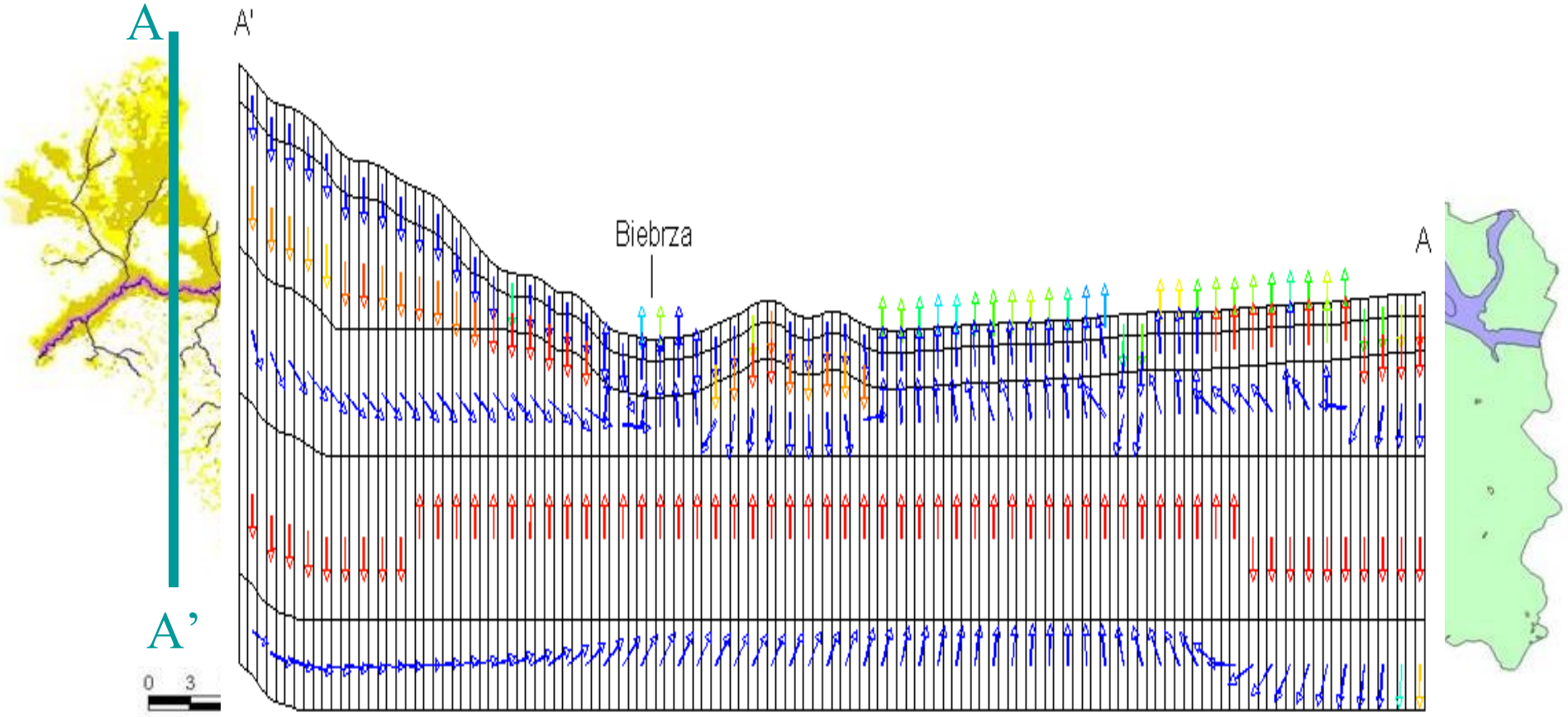
Coarse sand with boulders

Ice-pushed and glacial structures

Ber (2005)

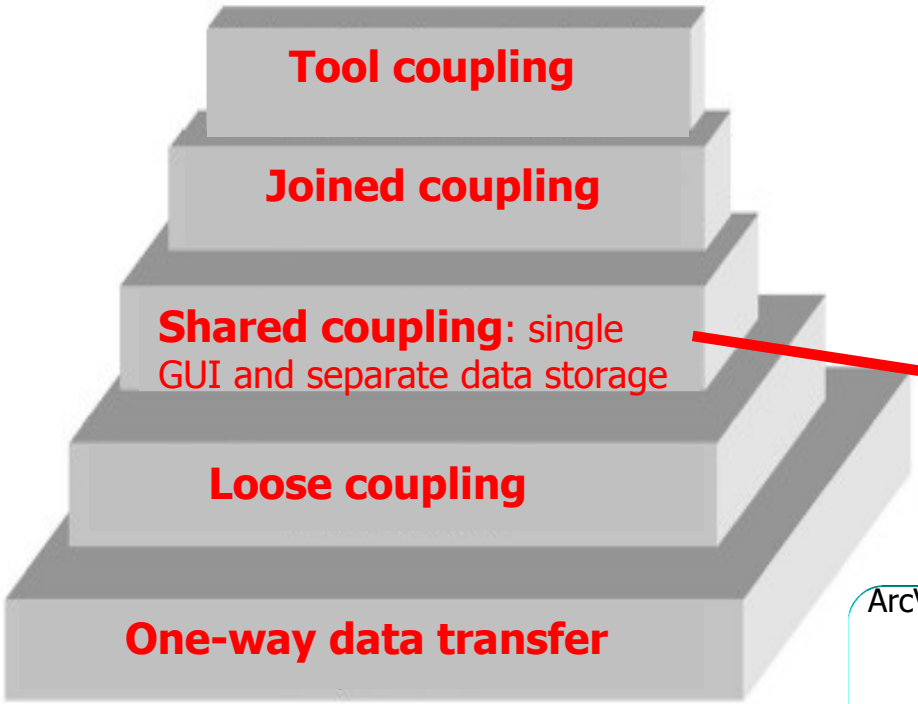
Vrije Universiteit Brussel

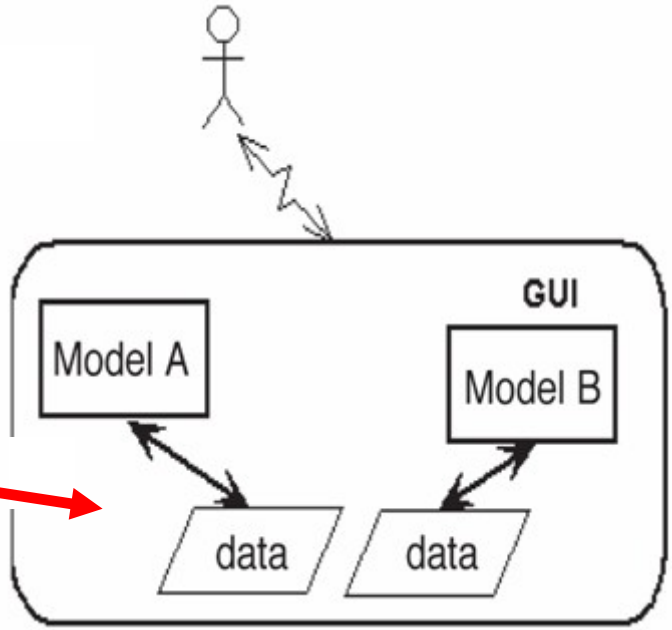
Results: Groundwater Discharge Modeling



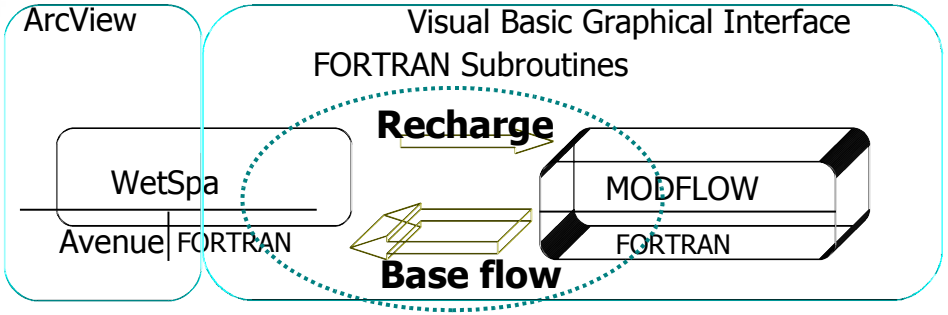
Vrije Universiteit Brussel

Model integration



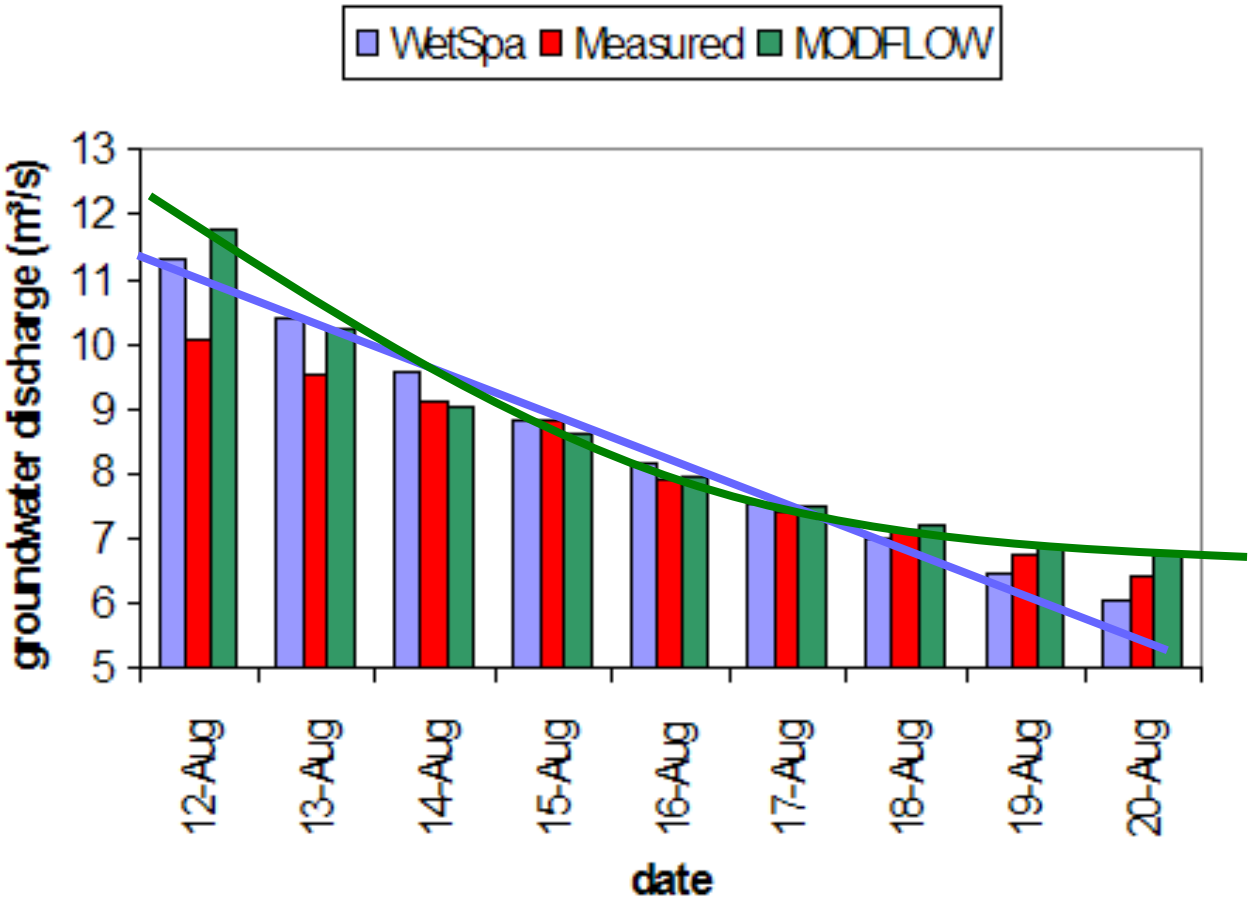


Brandmeyer and Karimi (2000)



Vrije Universiteit Brussel

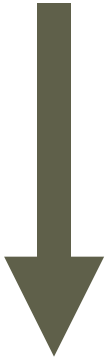
Coupled baseflow



Vrije Universiteit Brussel

Conclusion: 2nd Point

1. What kind of hydrological modeling would give functional insight?



Relatively simple, mechanistic but integrated surface-hydraulic-groundwater model, which should enable us to ***learn*** e.g. about feedback.