

Groundwater- Surface Water Interaction at the Regional Scale **in the context of IWRM**

– a review

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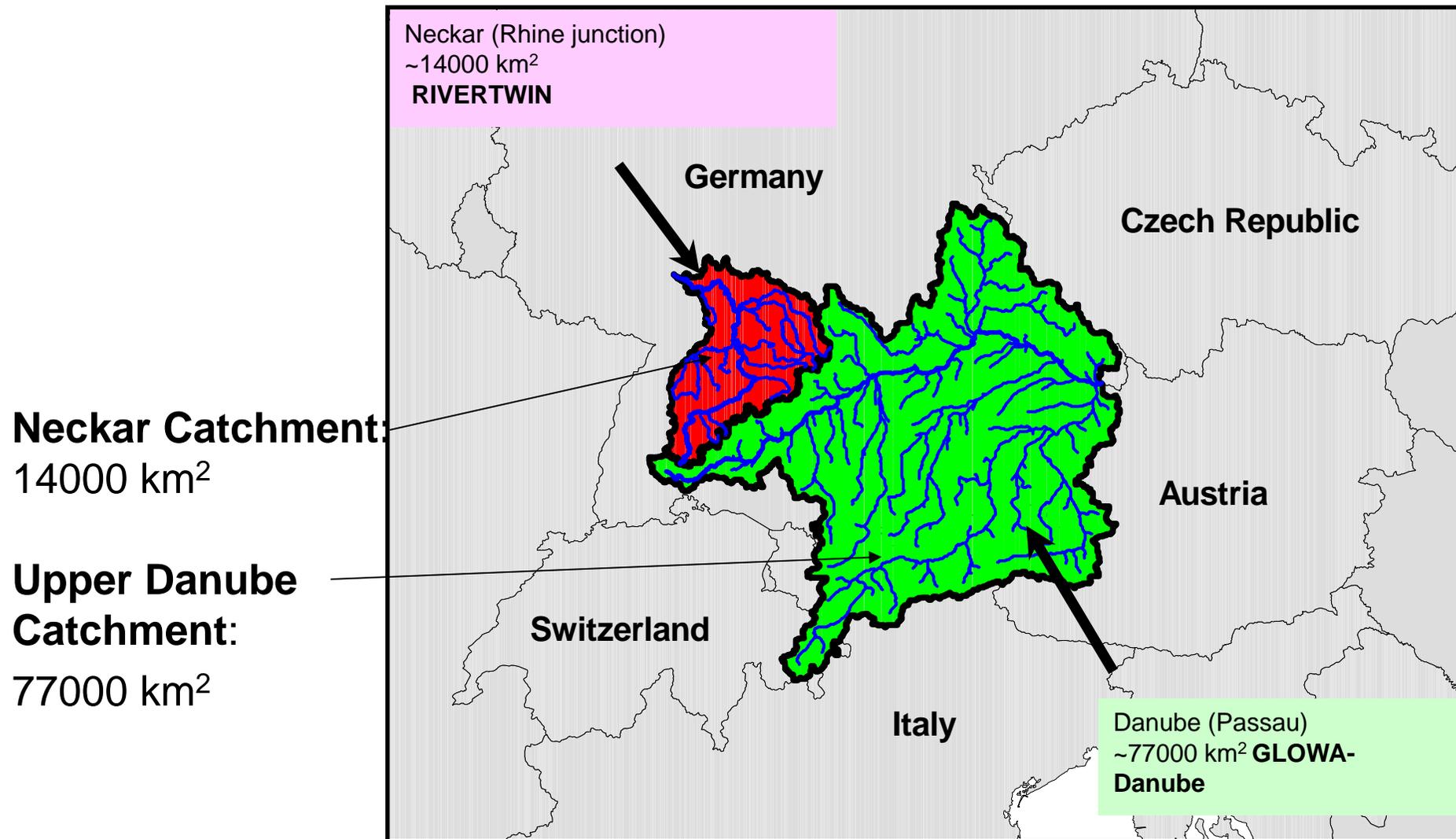


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Starting point and motivation (1)



- Integrated models of the entire hydrological cycle, including GW-SW interaction: MODFLOW, coupled to HBV, LARSIM, Promet, DAFLOW)

Starting point and motivation (2)

1. Groundwater – surface water interaction is essential for integrated water resources management (IWRM)
 2. The regional scale is the scale at which all relevant processes of human-environment systems can be captured → **IWRM**
- ⇒ **It is important to consider groundwater surface water interaction at the regional scale**

Questions

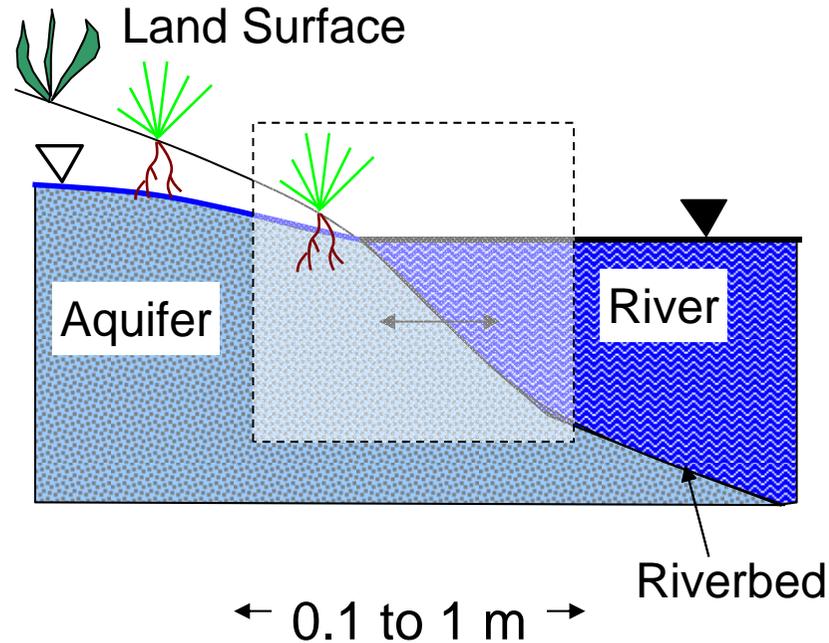
1. Do we have **the knowledge and the tools** to analyse, describe and model GW-SW interaction at the regional scale?

⇒ ~150 related papers evaluated

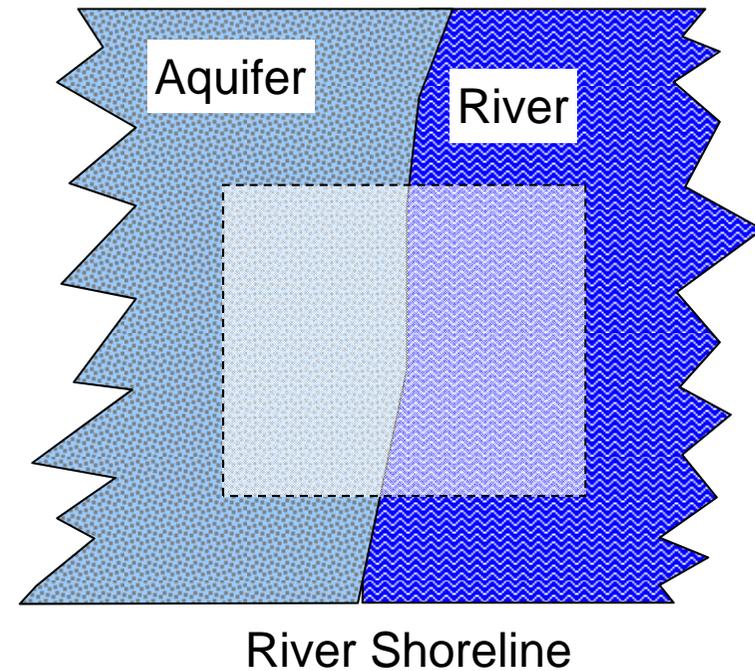
2. Is GW-SW interaction at the regional scale different from GW-SW interaction smaller scales?

The “point” scale

Cross Section

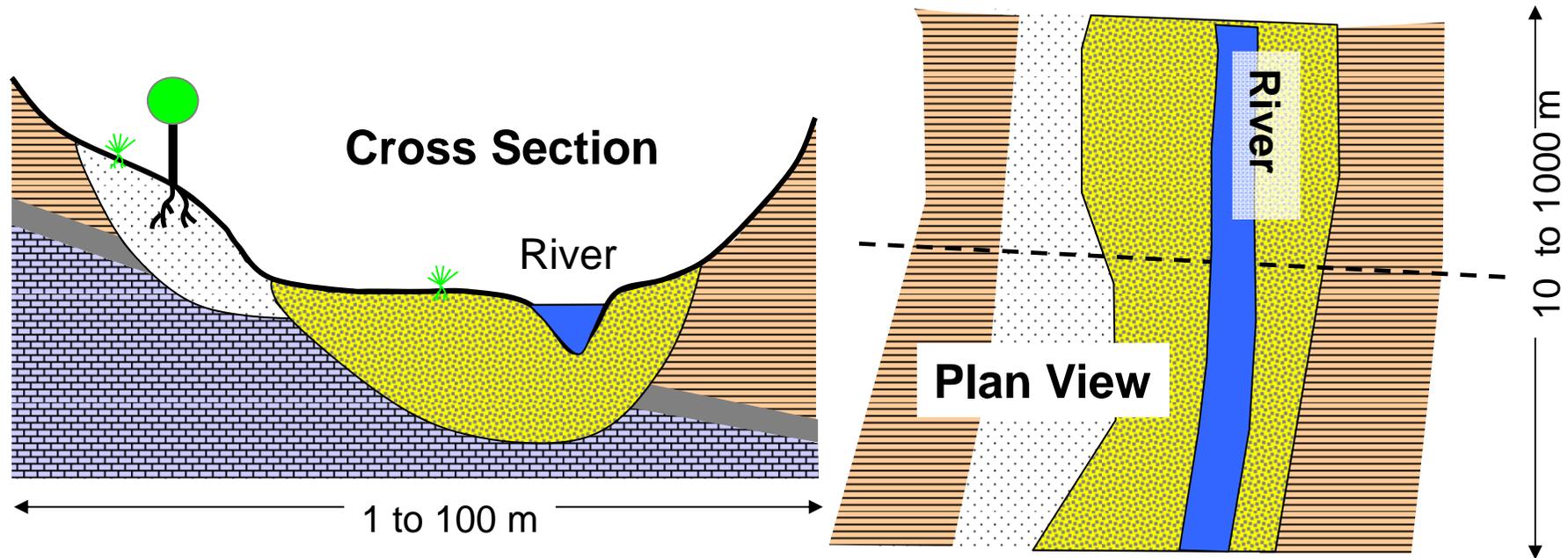


Plan View / Map



- Detailed quantitative description of **processes** is possible, but
- The main processes driving the interaction take place outside the area of interest

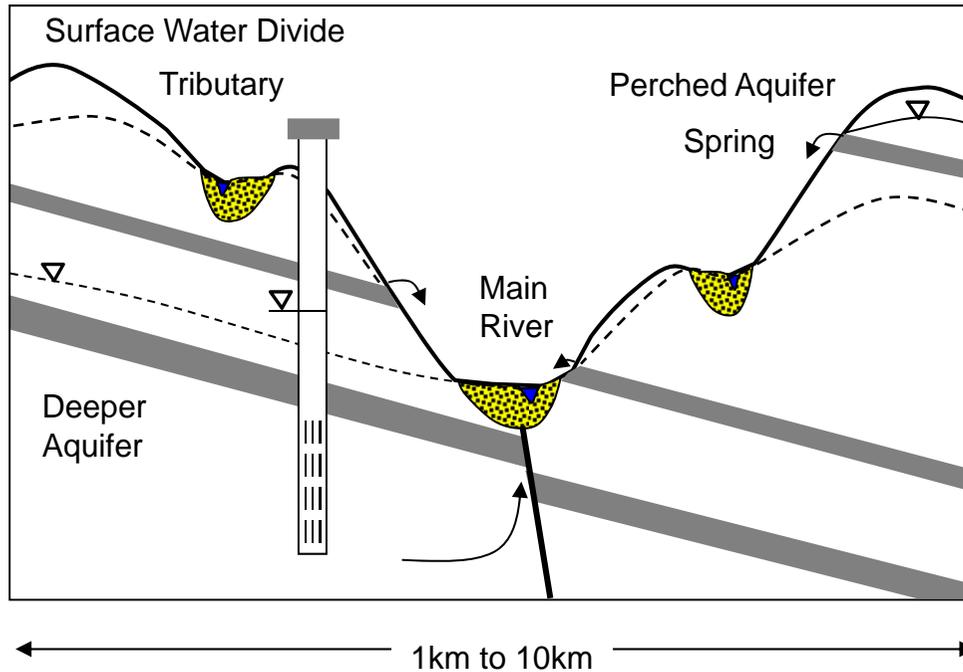
The „local scale“



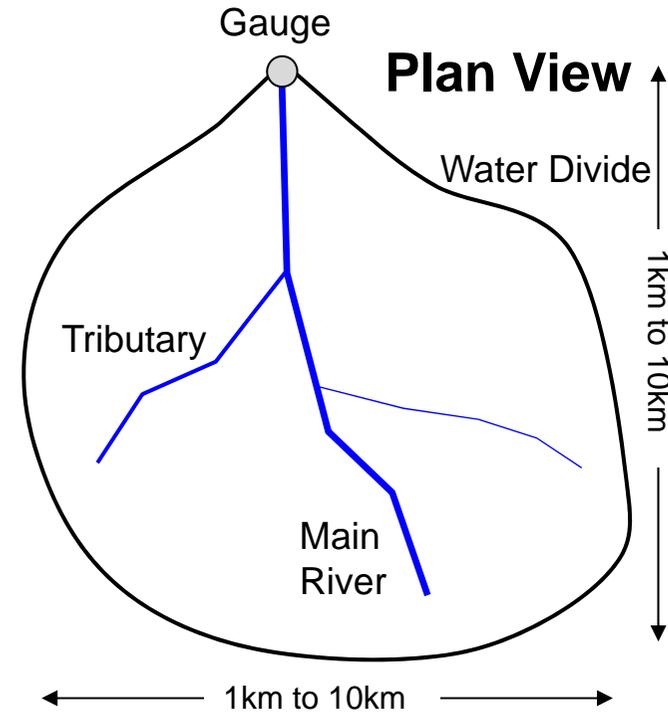
- Larger variety of geological formations and stream channel characteristics
 - In practice: larger distances between observations
- ⇒ Variability / Heterogeneity increases, density of observations decreases

The “small-catchment scale”

Cross Section

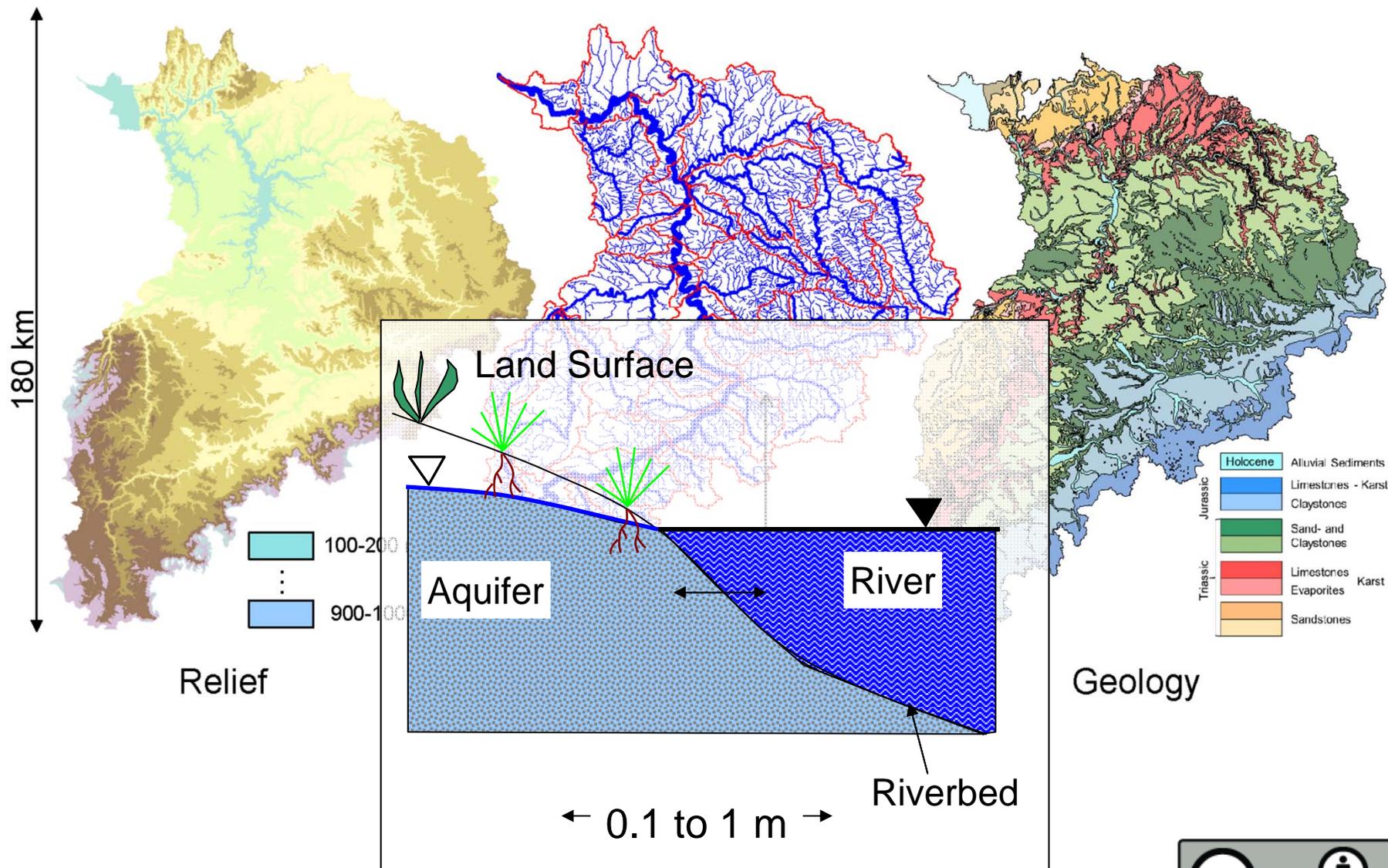


Plan View



- Much less dense observations → generalisation, “lumped” process descriptions required
- **Focus moves away from the stream-aquifer interface**

Regional Scale: Neckar Catchment, Germany ~14,000 km²



Is GW-SW interaction at the regional scale different from smaller scales?

- Yes:
 - Extremely increasing variety of different settings: geology, river bed characteristics, relief etc.
 - Extremely limited possibility to observe properties and dynamics
 - The importance of processes at the stream aquifer interface decreases, while the importance of “catchment processes” increases,
 - Different processes become “dominant” (?)
 - No:
 - Essentially, the processes remain the same
 - Neither relevance nor dominance of processes changes - only our ways to observe and describe them differ
- ⇒ The difference between GW-SW interaction at different scales is mainly a difference in perspective and largely determined by practical limitations.
- ⇒ From a **practical point of view**, GW-SW interaction on the regional scale is extremely different from local scales!

Questions

- 1. Do we have the knowledge and the tools to analyse, describe and model GW-SW interaction at the regional scale?**
2. Is GW-SW interaction at the regional scale different from smaller scales?

Results of the review

- **Hydrological research at the regional / large scale:**
Surface water hydrology >> groundwater hydrology > GW-SW
 - **Research on GW-SW interaction:**
point scale & local scale >> small catchment scale >> regional/large scale
 - **Research on the transfer of knowledge / tools between scales:**
Point to local to small catchments scale: yes, to the regional scale: no
- ⇒ The topic “GW – SW interaction at the regional / large scale” is hardly addressed **explicitly** in the literature
- **But: a large number of model concepts** for integrated modelling of groundwater and surface water exist

Models that can be used for GW-SW interaction at the regional scale

- **Loosely coupled schemes**

- individual models for groundwater and surface water exchanging results through interfaces (typically: MODFLOW +)
- Advantages: relatively easy to set up and apply
- Disadvantages:
 - Specification of the interfaces: Model geometry and parameterization
 - Difficulties to adjust differing concepts to discretizing space and time

- **Fully coupled schemes or “physics-based models”:**

- simultaneous solution of the equations governing surface and subsurface flows (**HydroGeoSphere, Parflow, ...**)
- Advantages: no need to specify interfaces, very well suited for the task
- Limitations: Data required for parameterization, (computational costs)

Trends in regional scale model applications with GW-SW interaction

- Still very few coupled models $>1000 \text{ km}^2$ (**journal literature!**)
- Loose coupling schemes dominate
- Fully coupled models are developing rapidly, but so far they don't seem to have entered the domain of practical management
- Most regional scale integrated models are only calibrated / validated for **either** discharge (the majority) **or** piezometric head

Conclusions

- GW-SW interaction at the regional scale is hardly directly addressed in the literature
- Many model concepts were developed - but few regional scale applications are published (→ no “established” model concept yet)
- Fully coupled models provide the solution to most conceptual problems but their feasibility in practical management applications has yet to be proven
- **Very little guidance is available on how to observe, analyse and model GW-SW on the regional scale**
- **A review of GW-SW at the regional scale is an unrewarding task!**
 - The topic touches immediately all the big unresolved questions of hydrology (e.g. how complex do models have to be, how to deal with uncertainty, how to do interdisciplinary science ...)
 - The author of the review has to convey mostly unsatisfactory messages