Understanding and modeling the interaction of Groundwater and Surface Water on large spatial and temporal scales

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Questions

• What makes the GW-SW interaction at the regional scale different from smaller scales?
• What are the relevant processes of the GW-SW interaction at the regional scale?
• What process descriptions (models in the broadest sense) are suitable to the regional scale to provide adequate results?

1. Integrated Water Resources Management IWRM

An integrated view on the water cycle must account for relations between:

• Sources and sinks (flow and transport)
• Suppliers and consumers
• Ecological and economical flows
• ...
  ➔ Large distances - long travel times

2. Political and Socio-Economic requirements

• Political Framework
  – E.g. the European Water Framework Directive ➔ RBMPs
• International Programs
  – e.g. HELP: Hydrology for the Environment, Life and Policy
  – E.g. Global Water Initiative
  – ...
• Transboundary Water Management Issues & Conflicts
  – ...

3. Climate Change

Global

Local
• The **basic processes** are essentially the same on all scales, however,
  - The relative relevance of different processes changes
  - For practical reasons many processes must be neglected or simplified
• Development of process descriptions for the large scale can either
  - Start from an analysis of the essential processes
  - Start from the objectives of large scale modeling and available data etc.

![Diagram of River Aquifer Plan View](image)

**The „point“ scale**

- Direct, detailed measurement of physical, chemical and biological properties is possible and thus
- Detailed quantitative description of processes is possible

![Diagram of Cross Section and Plan View](image)

**The „local scale“**

- Increasing influence of adjacent aquifers and water bodies
- Larger distance between observations:
  - assumptions on distribution of properties
  - spatial interpolation and aggregation
  - increasing heterogeneity
  - increasingly lumped process description

![Diagram of Cross Section and Plan View](image)

**The „sub-catchment scale“**

- Low spatial frequency of observations
- Increasing relevance of topographical effects and regional flow
- Alluvial valley fills may no longer be the most important aquifer

![Diagram of Cross Section and Plan View](image)

**Regional Scale: Example: Neckar Catchment, Germany ~14000 km²**

![Diagram of Regional Scale](image)

**Relevant Processes and Process Descriptions**

- **Point:** ~10⁻¹ m²
- **Local:** ~10⁵ m²
- **Sub-Catchment:** ~10⁶ m²
- **Regional:** ~10¹² m²
**Process descriptions and Models**

3 main options:

1. Full upscaling of process descriptions
2. Replace "processes" by "balances": \( in = out + storage \) …
3. Define specific process descriptions for the regional scale including:
   - Spatially distributed, enhanced concepts to estimate groundwater recharge and "base flow" on the regional scale
   - Consideration of processes in the deep unsaturated zone
   - Multi-criteria model development, calibration and validation

**Coupling Approach in RIVERTWIN**

- Groundwater recharge
- Groundwater discharge (Baseflow + Heads)
- MODFLOW
- Vertical differentiation of the groundwater system

**Conclusions**

- The analysis of GW-SW interaction at the regional scale is necessary to meet the requirements of IWRM, WFD and investigations concerning the effect of Global (Climate) Change.

- Detailed, physically based process descriptions might not be required for most practical regional scale management problems, however they may increase some cases increase options for validation and thereby increase predictive capabilities and decrease uncertainty of models.