Hydraulic groundwater modeling

- Week 3

- From field application to simulation

Exemplary field application

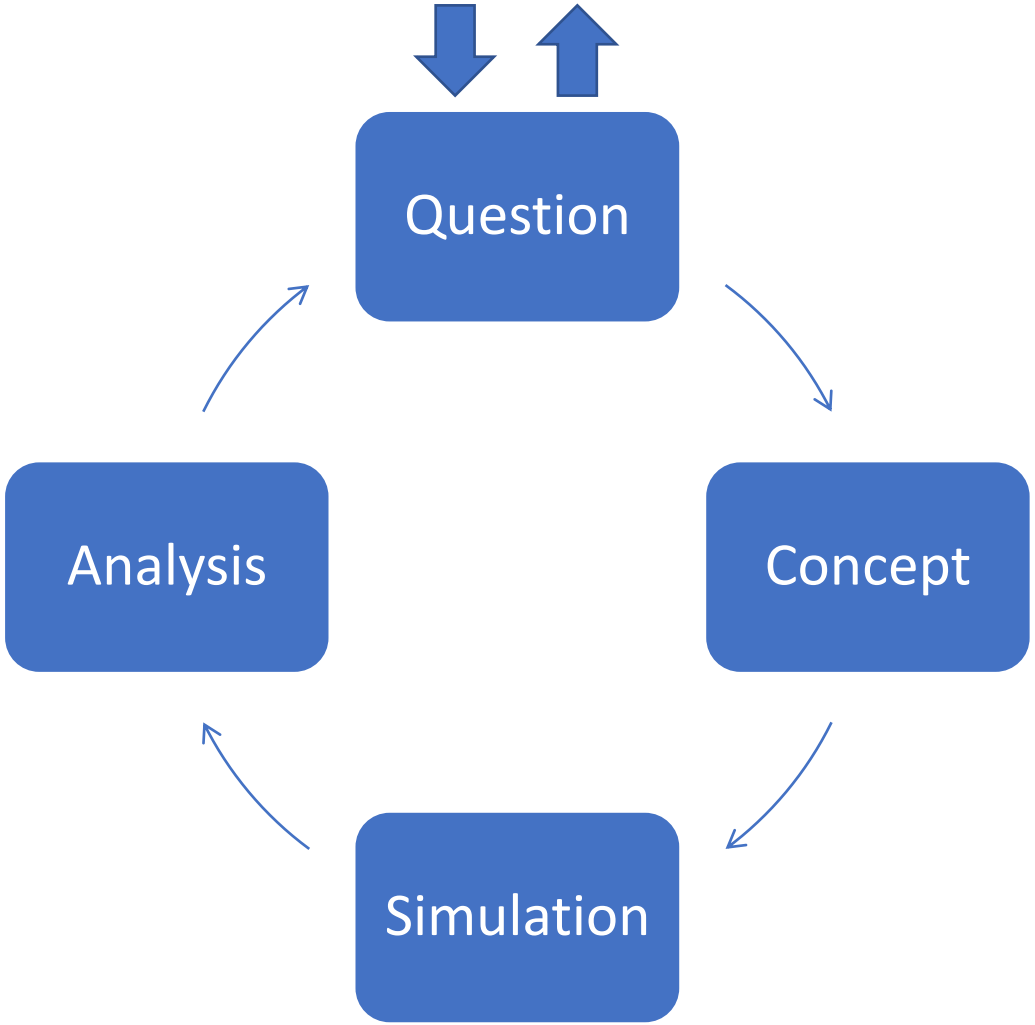
- Planing or analysis of tracer tests
- Design of „pump and treat“-applications
- Calculating groundwater levels at different pumping rates
- Optimizing well locations
- And many more

Motivation for the model

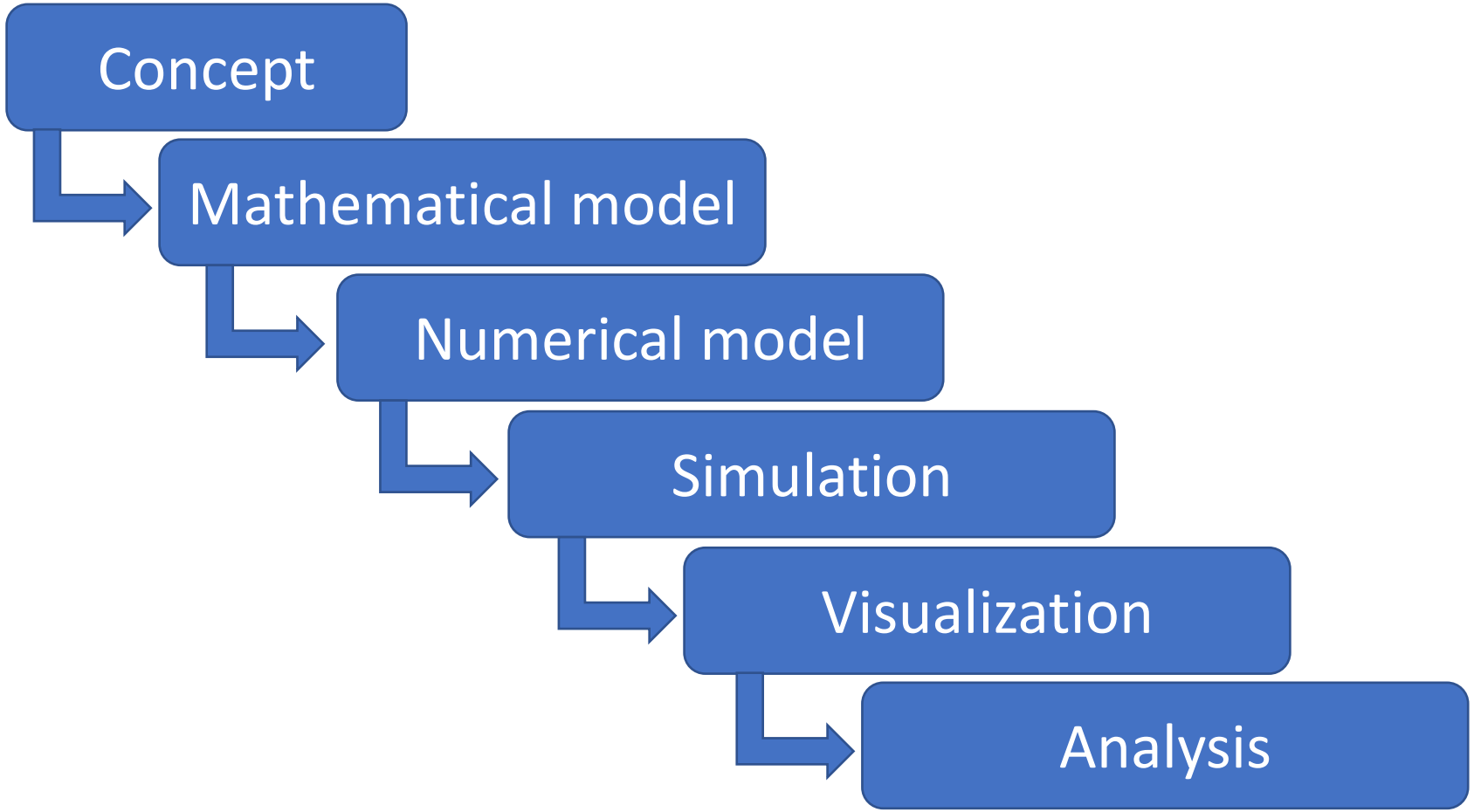
- What is the goal of the model?
  - Try to formulate the aim of the model as precise as possible

- What are the requirements to achieve this aim?
  - Mathematical model / physical processes
  - Geometry
  - Parameters
  - Boundary/initial conditions

Basic workflow



Workflow in more detail



Modeling best practices

- THINK! (before you start and everytime after)
- Document your work from the beginning
- Test early and often (even small changes)
- Visualize results from the start

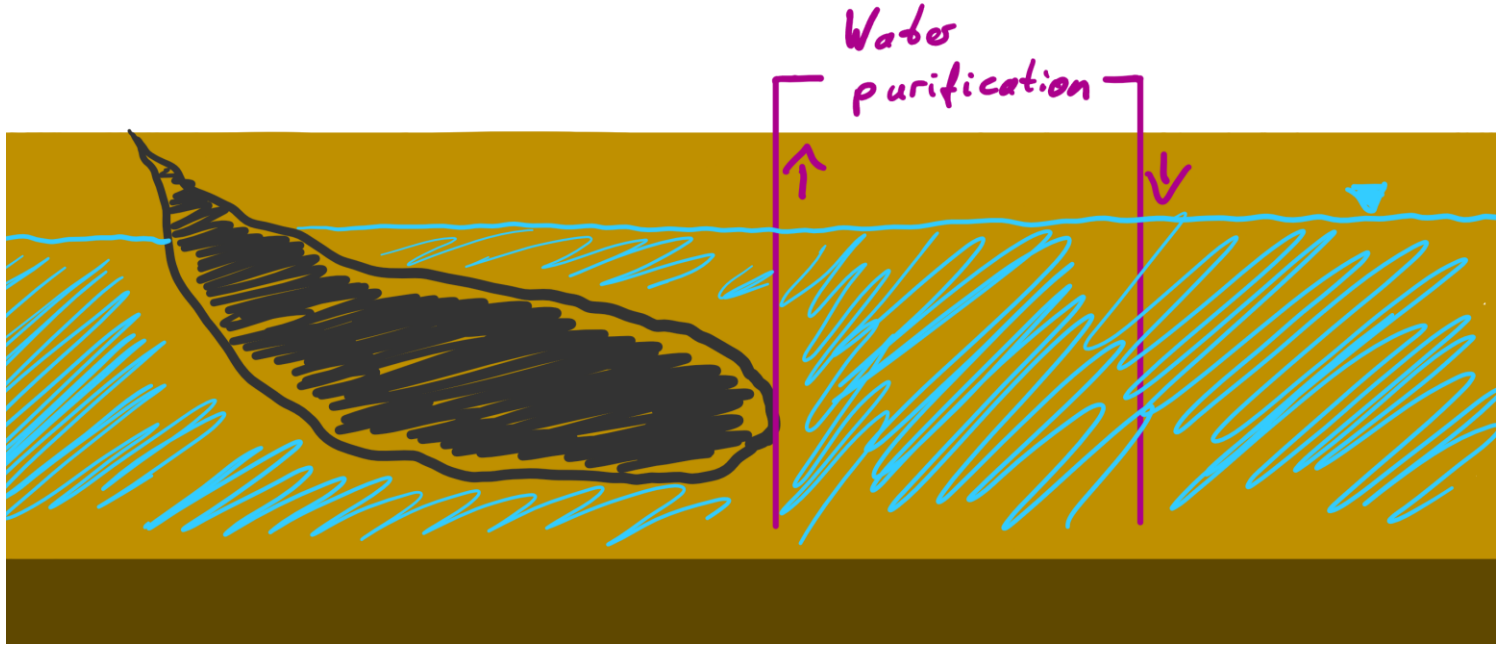
(Painful) modeling experience

- Most mistakes are trivial
  - E.g., wrong sign, wrong unit, mixing up files,…
- … and difficult to find.
- Just because the result looks correct, it does not mean it is correct.
- If it looks wrong, there is probably a mistake.
- Setting up the model is only the first step.
  - Make realistic time estimations!

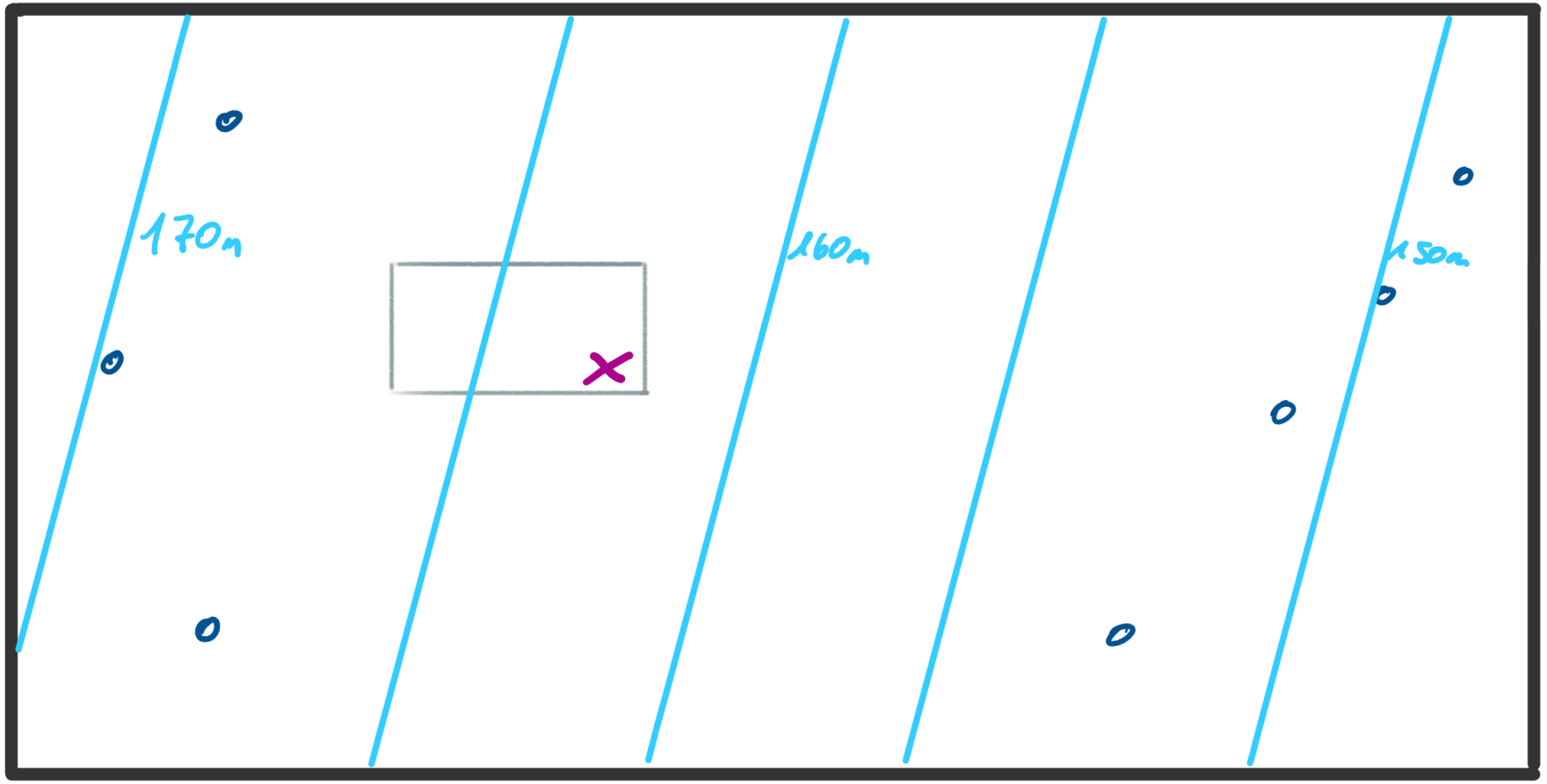
- Correct, meaningful models exist

Example: Pump and treat – the scenario

- Consider the following scenario:
  - At an old industrial plant a toxic substance infiltrated into the subsurface and contaminated the groundwater
  - You are in charge to propose the installment of a pump and treat setup



Example: Pump and treat – the location



Example: Pump and treat – the concept

- Aim:
  - Plan pump and treat setup
- Physical processes:
  - Groundwater flow modeling -> to obtain flow velocity
  - Transport modeling -> to describe contaminant distribution
  - Transient model(!) -> spatial resolution required?
  - Is the contaminant dissolved?
  - Does the contaminant influences flow behavior (density, viscosity?)
- Geometry:
  - Dimension and spatial resolution of modeled region?
  - Data available for boundary conditions?

Example: Pump and treat – the concept II

- Required parameters:
  - Transmissivity & storativity
  - Diffusion/dispersion; retardation, decay,…
  - Data available?
- Initial and boundary conditions:
  - Data available?
  - Background concentration?

- (without any claim to completeness)

Example: Pump and treat – the validation

- Reproduction of observed concentrations and groundwater levels
- Spread of the contaminat plume
- Reasons for disagreement?
  - Model
  - Measurement
- All relevant physical processes covered?
- Boundary conditons correct?

Example: Pump and treat – the problems

- Input parameterization was not correct
- Previously unknown heterogeneity in the subsurface
- Contamination spot wrongly estimated
  - False reports(?)
- Domain too large/too small
- Spatial and/or temporal resolution too fine/too coars
- … and so many more

Humor (and truth) about modeling

- https://blogs.egu.eu/divisions/gd/2019/07/03/it-doesnt-work-asking-questions-about-scientific-software/
- https://blogs.agu.org/magmacumlaude/2012/05/25/stages-of-numerical-modeling/
- https://en.wikipedia.org/wiki/All_models_are_wrong

Lessons learned

- How to tackle a modeling task (!)

- (A few) aspects to consider when starting with a model