Modeling Subsurface Flow and Transport using FEFLOW
FEFLOW – More than Groundwater

More than „just“ groundwater:

• Subsurface Flow and Transport

FEFLOW handles groundwater flow and related processes in one software environment and one simulation model:

  o Variably saturated flow
  o Contaminant transport
  o Heat transport
  o Density-affected flow
  o Chemical reactions
  o And more...
FEFLOW – More than Groundwater

The software must be ...

- Easy-to-use and intuitive to quickly master everyday groundwater projects
- Powerful and comprehensive to model the complex subsurface processes
Flexible Meshes

- Finite Differences vs. Finite Elements
Flexible Meshing

- Triangular or quad elements (2D)
- Prisms or cuboids (3D)
- 3D or 2D horizontal / vertical / axisymmetric projection
- 1D and 2D for fracture / pipe / borehole flow
2D Model Projections

Horizontal projection

Vertical projection

Axisymmetric projection
Flexible Meshing

3D Geometry

...allows detailed models of complex geometrical structures
Physics

Groundwater and vadose-zone flow

- Saturated flow (Darcy law)
- Unconfined conditions (different approaches)
- Unsaturated / variably saturated flow (Richards equation)
- Fracture flow
- Density- and viscosity-dependent flow
Physics

Transport
- Heat transport (advection-conduction equation)
- Solute transport (advection-diffusion equation)
- Combined solute / heat transport
- Sorption, decay
- Multispecies simulation
- Kinetic reaction systems
Ease of Use

• User interface for preprocessing, simulation, and postprocessing
• GIS/CAD/ASCII file interfaces for import and export
• 2D/3D map support
• Advanced computational methods
  o Powerful mesh generators
  o Automatic time-stepping scheme
  o Algebraic multigrid solver
  o Parallelization
• …
Visualization

- 2D top / cross-section / data-trace views
- 3D views
- 2D / 3D map support
- 3D clipping and carving
- Live, interactive visualization during simulation run
- Hardware acceleration via OpenGL
- 3D stereoscopic display/projector support
Temporal Element Deactivation

- Elements of the finite-element mesh can be temporally deactivated and reactivated.
- Simulation of time-varying model domain geometry (e.g. open-pit simulation projects, long-term morphological changes, etc.).
FePEST: Parameter Estimation with PEST

• Interface between FEFLOW and PEST
• Part of FEFLOW installation
• Calibration, optimisation, predictive analysis and sensitivity analysis
• Latest versions of PEST.exe and PLPROC.exe accessible

• Features:
  • Pilot-point method
  • Constant values within specified zones
  • 2D and 3D models
  • Steady state and transient models (version 6.2)
  • Tikhonov regularization, SVD, SVD-Assist
Extensibility

• Open programming interface
  o Documented API interface
  o User can develop plug-ins for
    • Additional functionality
    • Workflow automation

• Application Examples
  o Groundwater / surface-water coupling
  o Integration of technical installations in geothermal modeling
  o Import of model properties
  o Export of model results

• Development Services
  o Plug-in development as a consulting service
Fields of Application

- Regional groundwater management
- Mine-water management
- Groundwater management in construction and tunneling
- Geothermal energy (deep and near surface, both open-loop and closed-loop systems)
- Remediation / natural attenuation
- Seepage through dams and levees
- Groundwater – surface water interaction
- Capture-zone delineation
- Saltwater intrusion
- Industrial porous materials

- … and many more