

What's new in FEFLOW 6.1

The release of FEFLOW 6.1 marks a significant milestone for both developers and users: With FEFLOW 6.1, the migration to the new Standard user interface has been completed and it is now possible to perform all modeling tasks without the Classic user interface that has been used for more than 20 years. The entire functionality from mesh generation via simulation to postprocessing is now available in the redesigned, modern user interface first introduced with the previous version FEFLOW 6.0. Having the complete tool set available within one single interface makes modeling with FEFLOW even more productive and intuitive.

Besides providing all of the tools and capabilities known from the Classic user interface, FEFLOW 6.1 also features a substantially extended range of functionality. This page presents the highlights of the new version in an overview of the most important new features and improvements.

Calibration Reference

Observation points - if provided with accompanying reference data - can be used to show the deviation between observed data and computed results, including the absolute deviation and a comparison to the individual user-defined confidence interval. Scatter plots - known from the Classic user interface - give an overview of the general calibration quality and show basic statistical numbers (mean error, root mean square error, standard deviation).

Expression Editor

The usage of mathematical expressions via FEFLOW's Expression Editor is a powerful new general-purpose feature in FEFLOW 6.1. It incorporates the "Debug" and "Spatial Operations" features of FEFLOW Classic but its capabilities go much further. User-defined expressions can be used to create selections, to assign parameter values or to define new model properties derived from available process data (e.g., to calculate groundwater drawdown).

The easy-to-use Expression Editor handles arbitrary mathematical expressions not unlike the already familiar definition of chemical reactions or expression-based groundwater recharge. Users of the Classic user interface may already be familiar with this tool from the definition of chemical reactions or expression-based groundwater recharge.

Time-Varying Material Properties

For the definition of time-varying material properties, FEFLOW 6.1 provides multiple settings and convenient import and assignment options:

Time-varying values can be assigned manually if a parameter has been made transient before. Manual assignment from time series is also available following the same workflow as for the assignment of transient boundary conditions. Automatic map-based assignment via the Parameter Association dialog supports multiple data formats: Map data can be assigned to the currently selected time, different attribute fields can be assigned to different time stages, time/value pairs can be linked to a parameter and time-series files can also be joined to imported maps. Additionally, assignment via the new Expression Editor is also supported.

Discrete Features

As in earlier versions, Discrete Features (DF) can be added to models to represent highly conductive one- or two-dimensional features, such as tunnels, pipes, drains, faults or fractures. Starting with

FEFLOW 6.1, Discrete Features (DF) are grouped in the Data panel to allow easy access to visualization and editing functionality. The features can be named to facilitate their identification during the modeling process.

Significantly, it is now possible to create arbitrary-type 1-dimensional Discrete Features connecting nodes on different slices, e.g., to represent inclined boreholes.

Material Properties for Unsaturated Flow

FEFLOW 6.1 provides comfortable editing options for the definition and assignment of the material properties required for unsaturated/variably saturated flow modeling via Richards' equation. The relationships between capillary pressure and saturation and between saturation and hydraulic conductivity can be defined via Spline Models or via one of the available Empirical Models.

Selective Mesh Smoothing

In many cases, refining the finite-element mesh locally becomes necessary during the modeling process. Local mesh refinement can lead to a loss in mesh quality as ill-shaped elements result at transitions between refined and nonrefined areas. With the new selective mesh smoothing tool, the mesh quality can be restored where needed, while maintaining the original position of boundary conditions and other features that should not move.

Selective smoothing is also useful to improve the general mesh quality directly after the mesh generation process, maintaining the location of nodes placed on supermesh polygon boundaries, lines, and points.

Map-Data Handling

Major improvements have been implemented to make the usage of database information more flexible. An immediate preview of attribute tables is now available as well as the possibility to filter/select map data by user-defined SQL selection queries. It is also possible to join additional related information from other database files to existing maps. While in FEFLOW 6.0 map-based node or element selections were limited to 2D maps, version 6.1 also allows to create selections based on 3D map geometry.

Multilayer Wells

Multilayer wells have been improved both in terms of numerical computation and data handling.

Screened well sections are now modeled as discrete features which significantly improves the control of the borehole-internal mass- and heat-transport calculations. Introducing the borehole radius as a new model parameter, it is now possible to account for the actual flow resistance of narrow boreholes.

To facilitate the data handling, FEFLOW allows the Multilayer well import from map files, directly using the elevations of the top and bottom end of the well screen to identify the correct model slices for the boundary-condition assignment.

Manual assignment is possible using a convenient dialog to enter all required data (including time series as pumping rate).

Finally, new visualization styles are used to compare actual and virtual well radius to determine the optimal distance to neighboring nodes for an accurate drawdown calculation.

Borehole Heat Exchangers

Incorporating the experience gained over the past years in using Borehole Heat Exchangers (BHE) in FEFLOW Classic, new tools have been added and shortcomings of the existing approach have been eliminated in FEFLOW 6.1.

The new, separate BHE boundary condition allows a direct prescription of the inlet temperature (as constant or transient value) as well as defining differentials of power or temperature to represent the operation of heat pumps - without the need for additional plug-ins.

Furthermore, arbitrary connections between the feed and return pipes of different Borehole Heat Exchangers can be created to model parallel or serial connections in heat-exchanger arrays.

As for Multilayer wells, additional visualization styles are available to show the actual and virtual well radius. A third style acts as an indicator for the optimal nodal distance while designing the mesh for an accurate calculation of the absolute temperature at the borehole heat exchanger.

Budget Groups

Node selections stored in the Spatial Units panel can be used as budget groups. The summed calculated rate and period budgets can be displayed as time series in the Rate-Budget and Period-Budget charts, e.g., to calculate the flow balance along a river or to determine drained water volumes in dewatering scenarios, etc.

Evaluation of Internal Flows

Internal fluid flows can be calculated using the Flow-Rate panel (for evaluation of current flow rates) and the Flow-Volume panel (for accumulated flows over time). Flow rates are calculated by integrating the Darcy flux along a line (2D model) or over an area (3D model).

3D Stereoscopic Visualization

With the availability of affordable stereoscopic hardware (computer screens, TVs and projectors), the general application of 3D visualization is expected to become more common in the future. FEFLOW 6.1 is compatible with common 3D interface standards (shutter and polarizer technology) and support stereoscopic 3D view windows as well as the export of stereoscopic images and animations.

Model Encryption

For the protection of intellectual property, legal requirements or quality assurance, the FEFLOW 6.1 file formats have been equipped with an encryption option. Various password-protected access levels that restrict viewing, editing and export functionality can be defined for model (*.fem) and simulation-record (*.dar and *.dac) files.

Multiple Assignment

The new assignment tool Assign Multiple... allows a fast assignment of constant homogeneous values for one or multiple model properties at the same time.

Additional functionality

Results Evaluation and Visualization

FEFLOW 6.1 provides an extended set of tools and features for improved results evaluation and visualization.

- Isochrone areas of stream-/pathlines
- Simultaneous plot of streamlines and pathlines
- Elemental and nodal Darcy fluxes
- Stream function in 2D DAC files
- Content analysis: Consideration of discrete elements, content analysis of subdomains
- Period- (time-integrated) budget calculation
- Simultaneous monitoring of rate and period budget
- Adding of observation points in DAC files
- Deleting of selected time steps from DAC files
- Export of a 2D cross-sectional DAC file from a 3D results file

Mesh Operations

- Mesh import from (multiple) polygon files
- Mesh editing via Flip Edge and Move Node tools
- Mesh-property check via Auxiliary Data
- Triangle mesh generator: options to restrict/allow point insertion at all/outer supermesh segments
- Export of supermesh geometries as maps
- Geographic transformation
- Elevations: Validate option to verify slice elevations with regard to user-defined minimum distances

Improved Visualization

A number of improvements have been implemented to allow an even better visualization of the model data.

- Isolines with in-line labels, minor and major lines
- Visualization of the water table via view styles Zero-Pressure Isoline and Zero-Pressure Isosurface
- Polylines with in-line-labels
- (Slice-) Data-Trace views: Plotting the distribution of model properties along a 2D line within a slice or along an arbitrary 3D line (e.g., vertical temperature profile)
- Floating view windows
- Full-screen mode for view windows
- Text display as title, header and footer in view windows
- Calendar-time display
- Usage of selections as navigation reference for rotation and full view settings
- Coupled view navigation via definition of a positioning master view
- Transfer of legend settings between parameters
- Copying of all view-appearance settings
- Transfer of plot-style properties between parameters

Further Improvements

- Full (*.dac) and reduced (*.dar) results files can be saved in parallel
- User-defined selection of SAMG solver version
- Multiple options for anisotropy of hydraulic conductivity
- Setting parameters back to default values
- Undo for selections sensitive to target geometry
- Keeping the last status of a model file before saving in a backup file (*.bak)