

HYDRUS – Vadose Zone Modeling

Simulating One-, Two- and Three-Dimensional Water Flow, and Heat and Solute Transport in Variably Saturated Porous Media

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HYDRUS is a Microsoft Windows based modeling environment for analysis of water flow and solute transport in variably saturated porous media. It includes the stand-alone public domain **HYDRUS-1D** software package for one-dimensional applications, and the **HYDRUS** package for two and three-dimensional problems. New versions of both software packages were recently released (Šimunek et al., 2005, 2006). **HYDRUS** is a major upgrade and extension of the popularly used HYDRUS-2D/MESHGEN-2D software package (Šimunek et al., 1999). The new version has a completely new graphical environment for both **two-** and **three-dimensional applications**, and as such should provide users with much more flexibility and ease of use than the original HYDRUS-2D.

The one- and multi-dimensional packages both numerically solve the Richards equation for saturated-unsaturated water flow and convection-dispersion equations for heat and solute transport. The flow equation incorporates a sink term to account for water uptake by plant roots. The solute transport equations consider convective-dispersive transport in the liquid phase, as well as diffusion in the gaseous phase. The transport equations also include provisions for nonlinear nonequilibrium reactions between the solid and liquid phases, linear equilibrium reactions between the liquid and gaseous phases, zero-order production, and first-order degradation reactions, including sequential first-order decay chains. In addition, physical nonequilibrium solute transport can be accounted for by assuming a two-region, dual-porosity type formulation which partitions the liquid phase into mobile and immobile regions. The software packages additionally consider attachment/detachment theory, including the filtration theory, to enable simulations of the transport of viruses, colloids, and/or bacteria. The one- and two-dimensional versions also include a Marquardt-Levenberg type parameter optimization algorithm for inverse estimation of soil hydraulic, heat, and/or solute transport and reaction parameters from measured transient or steady-state flow and/or transport data.

Interactive graphics-based user interfaces support data-preprocessing, generation of finite element meshes, and graphic presentation of the results.

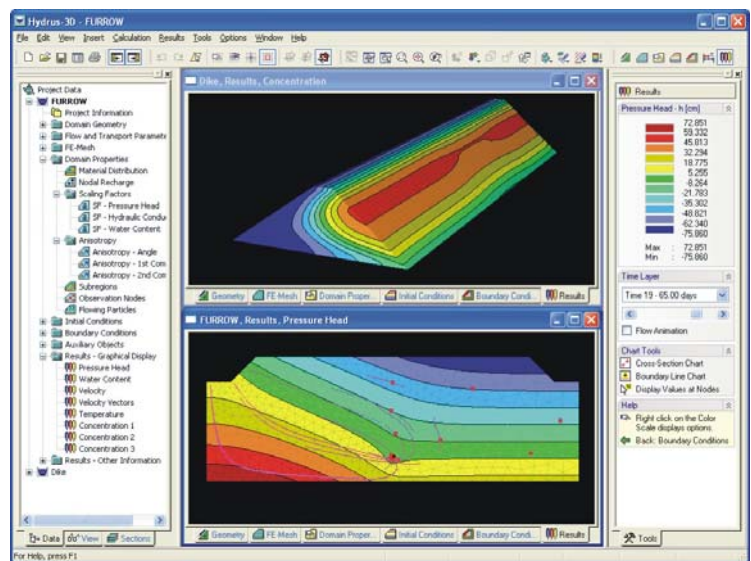
New Features in the Computational Modules:

- Water flow in a dual-porosity system allowing for preferential flow in fractures or macropores while storing water in the matrix.
- Root water uptake with compensation.
- Spatial root distribution functions of *Vrugt et al.* (2002).
- Soil hydraulic property models of *Kosugi* (1995) and *Durner* (1994).
- Transport of viruses, colloids, and/or bacteria using an attachment/detachment model, filtration theory, and blocking functions.
- A constructed wetland module (only in 2D).
- A major ion chemistry module (only in 1D).
- A carbon dioxide transport module (only in 1D).
- The hysteresis model of *Lenhard et al.* (1991) to eliminate pumping by keeping track of historical reversal points.

- New print management options.
- Dynamic, system-dependent boundary conditions.
- Flowing particles in two-dimensional applications.
- Actual and cumulative fluxes across internal meshlines.

New Features of the Graphical User Interfaces:

- Completely new GUI based on Hi-End 3D graphics libraries.
- MDI architecture – multiple projects and multiple views.
- New organization of geometric objects.
- Navigator window with an object explorer.
- Many new functions improving the user-friendliness, such as drag-and-drop and context sensitive pop-up menus.
- Improved interactive tools for graphical input.
- Saving Cross-Sections and Mesh-Lines for charts within a given project.
- Display Options – all colors, line styles, fonts and other parameters of graphical objects can be customized.
- Extended print options.
- Extended information in the Project Manager (including project preview).
- Many additional improvements.



For the most current information and status updates on **HYDRUS**, please visit <http://www.hydrus3d.com>. Documentation and the software itself (only a demo version of **HYDRUS**) can be downloaded freely from this site.

References:

- Šimunek, J., M. Šejna, and M. Th. van Genuchten, The HYDRUS-2D software package for simulating two-dimensional movement of water, heat, and multiple solutes in variably saturated media. Version 2.0, *IGWMC - TPS - 53*, International Ground Water Modeling Center, Colorado School of Mines, Golden, Colorado, 251pp., 1999.
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- Šimunek, J., M. Th. van Genuchten, and M. Šejna, The **HYDRUS** Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media, **Technical Manual**, Version 1.0, PC Progress, Prague, Czech Republic, 2006a.
- Šimunek, J., M. Šejna, and M. Th. van Genuchten, The **HYDRUS** Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media, **User Manual**, Version 1.0, PC Progress, Prague, Czech Republic, 2006b.