Modeling of Irrigation, Water Flow, and Nutrient Transport in Soils (using the HYDRUS Software Packages)

Instructor

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OVERVIEW

Global food security is an ever-increasing, worldwide problem. Over the coming decades, a changing climate, growing global population, rising food prices, and environmental stressors will have significant yet highly uncertain impacts on food security. With almost a billion people around the world who do not have access to a sufficient supply of nutritious and safe food, establishing global food security is important not only to hundreds of millions of hungry people, but also to the sustainable economic growth of these nations. It is essential to increase agricultural productivity through the use of modern irrigation techniques and other agricultural practices and to assess the complex impact of climate change on food security.

Numerical modeling is becoming an increasingly important tool for analyzing complex problems involving water flow, nutrient transport in the unsaturated zone, and irrigation management. This course is designed to familiarize participants with the principles and mathematical analysis of variably-saturated flow and transport processes, and the application of state-of-the-art numerical codes to site-specific subsurface flow and transport problems.

COURSE DESCRIPTION

The course begins with a detailed conceptual and mathematical description of water flow and solute transport processes in the vadose zone. Alternative methods for describing and modeling the hydraulic functions of unsaturated porous media are also described.

"Hands-on" computer sessions provide participants an opportunity to become familiar with the Windows-based HYDRUS computer software packages, including several additional modules, such as ROSETTA. Emphasis is on the preparation of input data for a variety of applications, including flow and transport in a soil profile with a subsurface drip, modified atmospheric forcing and irrigation schemes. Course participants will have an opportunity to use the HYDRUS models for their own data.

COURSE SOFTWARE

The course introduces a new generation of Windows-based numerical models for simulating water, heat and/or contaminant transport in variably-saturated porous media. These include the HYDRUS-1D and HYDRUS (2D/3D) codes for one- and two-dimensional simulations, respectively, and the Rosetta code for estimating the soil hydraulic properties (and their uncertainty) from soil texture and related data. HYDRUS-1D and HYDRUS (2D/3D) are supported by interactive graphics-based interfaces for data-preprocessing, generation of unstructured as well as structured finite element grid systems, and graphic presentation of the simulation results.

COURSE HANDOUTS

Course material include lecture notes prepared by the instructor. Documentation of HYDRUS-1D and HYDRUS 2D/3D models can be downloaded from the HYDRUS website.
COURSE INSTRUCTORS

Dr. Jirka Šimůnek is a Professor of Hydrology with the Department of Environmental Sciences of the University of California Riverside. He received an M.S. in Civil Engineering from the Czech Technical University, Prague, Czech Republic, and a Ph.D. in Water Management from the Czech Academy of Sciences, Prague. His expertise is in numerical modeling of subsurface water flow and solute transport processes, equilibrium and nonequilibrium chemical transport, multicomponent major ion chemistry, field-scale spatial variability, and inverse procedures for estimating the hydraulic properties of unsaturated porous media.

He has authored and coauthored over 300 peer-reviewed journal publications, over 20 book chapters, and two books; and according to ISI has an h-factor of 55 and over 10,000 citations. His numeric models, HYDRUS-1D, HYDRUS-2D, and HYDRUS (2D/3D), are used by virtually all scientists, students, and practitioners modeling water flow, chemical movement, and heat transport through variably saturated soils.

Dr. Simunek is a recipient of the Soil Science Society of America’s (SSSA) Don and Betty Kirkham Soil Physics Award, Fellow of American Geophysical Union (AGU), American Society of Agronomy (ASA), American Association for Advancement of Sciences (AAAS), and SSSA, and the past chair of the Soil Physics (S1) of SSSA. He is a co-editor of Journal of Hydrology and Hydromechanics, an associate editor of Journal of Hydrology and Vadose Zone Journal, a former co-editor of Vadose Zone Journal, and a former AE of Journal of Hydrological Sciences and Water Resources Research.

COURSE DETAILED OUTLINE

HYDRUS-1D

Lecture 1: Vadose zone flow and transport modeling: An overview.
Lecture 2: The HYDRUS-1D software for simulating one-dimensional variably-saturated water flow and solute transport.
Computer session 1: HYDRUS-1D: Infiltration of water into a one-dimensional soil profile.
Computer session 2: HYDRUS-1D: Water flow and solute transport in a layered soil profile.

HYDRUS (2D/3D)

Computer session 3: HYDRUS (2D/3D): Subsurface line source.
Computer session 4: HYDRUS (2D/3D): Furrow infiltration with a solute pulse.
Lecture 4: Selected HYDRUS modules and applications.

The use of HYDRUS on participants' data

Lectures: Presentations of course participants of their own data and what they would like to accomplish using the HYDRUS software.
Computer session: Individual work by participants on their own datasets with an accessional help and under the guidance of the course instructor.
Lectures: Presentations of course participants of their HYDRUS simulations using their own data.