Ongoing Research

US Army Corps of Engineers®

Urban Flood Demonstration Program

Development of a Moisture Content-Based Infiltration Method

Products

The product of this work unit is a numerically efficient, physically-based infiltration method that can be used to simulate the movement of water through unsaturated soils at multiple scales of simulation resolution.

Benefits

By providing an efficient and scalable means of simulating infiltration processes, numerical simulations of coupled surface water and groundwater systems, the method developed in this work unit will enable more computationally efficient simulations of surface water-groundwater interaction without sacrificing accuracy. Additionally, the method also holds the potential to allow for simulation of special cases such as macropore and desiccation crack infiltration that are not generally possible using current methods.

Issue

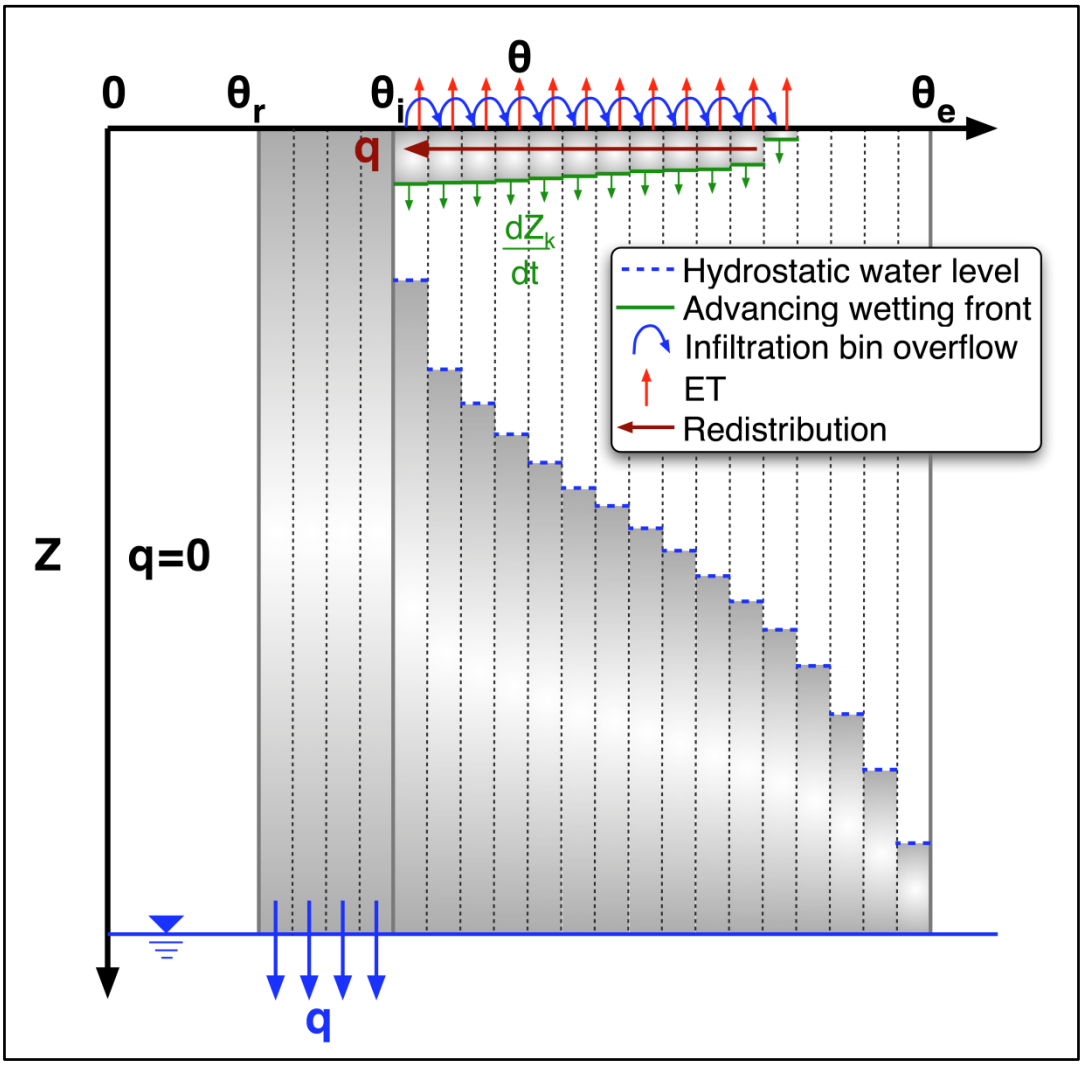
The entry and movement of water in unsaturated soil has been the subject of hydrologic research for over a century. Proper understanding and quantification of these physical processes can have significant impacts on the accuracy of hydrologic, agricultural and ecological predictions of natural systems. Over time, numerous equations have been proposed to mathematically describe the physical interactions between soil, water and air. Because of the complexity of these relationships, numerical methods must be used to solve them when they are employed in computational hydrologic models. However, even with modern numerical techniques, the computational burden of solving the infiltration problem remains high for some hydrologic applications, particularly those that simulate the behavior of large-scale surface and subsurface flow systems in coupled fashion and those that deal with special case situations such as the presence of preferential flow paths such as macropores and desiccation cracks.

Description

With support from the USACE's System-Wide Water Resource Development Program (https://swwrp.usace.army.mil), a new approximate solution to the general infiltration problem has been developed in an effort to improve the computational efficiency and robustness of one-dimensional vadose zone flow calculations in large-scale coupled surface and subsurface flow models. This method is a discretized moisture content infiltration and redistribution method wherein the range of moisture content within a given soil is discretized into vertically continuous, interactive bins. The entry and vertical motion of wetting and drying fronts in each bin are simulated by means of explicit infiltration approximations using capillary and gravitational driving forces. Wetting front advances within bins create pore water deficits that are satisfied by capillary-driven inter-bin flow. The method can simulate one-dimensional infiltration and drainage in homogeneous and layered soils, allowing for wider application of the method to real-world problems. Numerical stability and guaranteed mass conservation are inherently provided because the method precludes the need for nonlinear constitutive models estimated by the numerical solution of Richard's Equation (RE). Furthermore, this method has the potential to move beyond the strict REV requirement and can be expanded to simulate macroporosity, hysteresis effects, and areally averaged infiltration with or without high water tables.

The described method was conceived of and developed jointly by Drs. Cary Talbot and Fred Ogden and is called the Talbot-Ogden (TO) method. This work unit is specifically focused on implementing the TO method in the USACE's spatially distributed, physically-based hydrologic simulator, GSSHA (Gridded Surface-Subsurface Hydrologic Analysis)

and on improving the capability of the method to handle special case conditions of macropore and desiccation crack infiltration in homogeneous and layered soils.



The discretized moisture content method simulating infiltration by the movement of wetting fronts in "bins" representing a particular range of soil pore space.

Sponsor

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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