Graphical User Interface for Rapid Set-up of SHETRAN Physically-Based River Catchment Model

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Software availability

Name of software: Graphical User Interface for SHETRAN
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Availability: Limited version (34 x 34 grid) available free at http://www.ceg.ncl.ac.uk/shetran
Available since: April 2008
Learning materials at: http://www.ceg.ncl.ac.uk/shetran
Software required: Windows operating system. HDF viewer (e.g. HDFView)

Abstract

The SHETRAN physically-based distributed rainfall-runoff modelling system gives detailed simulations in time and space of water flow and sediment and solute transport in river catchments. It is therefore a powerful tool for studying hydrological and environmental impacts associated with land-use and climate change. A Graphical User Interface (GUI) has been developed that allows a catchment data set to be set up quickly using a minimum of information. The GUI has an algorithm for the automatic generation of river channel networks from a DEM and has access to libraries of soil and vegetation parameters.

1. SHETRAN

SHETRAN is a physically-based distributed model (PBDM) for water flow, sediment and solute transport in river catchments (Ewen et al. 2000) which includes hydrological components for simulating: rainfall interception by vegetation; evaporation and transpiration; snowpack formation and snowmelt; overland and channel flow; variably saturated subsurface flow; and river/aquifer interactions. It solves the governing, physics-based, partial differential equations for flow and transport on a rectangular finite difference grid. Examples applications include: Birkinshaw (2008) for water flow; Birkinshaw and Bathurst (2006) for sediment transport; and Birkinshaw and Ewen (2000)

for nitrate and solute transport. Typical uses are for studying hydrological and environmental impacts associated with land-use and climate change.

SHETRAN is written in Fortran and runs on Microsoft Windows. The models uses text based input files and produces two main outputs (Figure 1): (1) a text file containing the discharge at the catchment outlet; and (2) an HDF5 (Hierarchical Data Format) file containing the detailed results the user requested in one of the input files. HDF5 is an open-standard format and HDF5 files can be read and visualized using a wide range of tools, including some free tools such as HDFView.

SHETRAN requires distributed physical information about the catchment, and being a PBDM it is notoriously difficult to set up, often requiring weeks of preparatory work before the first test simulations can be run for a new catchment.

2. SHETRAN Graphical User Interface

A Graphical User Interface (GUI) has been developed which allows SHETRAN to be set up rapidly, even by non-expert users. The GUI uses the minimum of information, which results in various limitations. However, the purpose of the GUI is not to create a final data set, only a prototype set that gives a starting point for detailed work. The main limitations are that the soils must be represented as vertically uniform and the sediment and solute transport modules are switched off.

The minimum spatial data requirements for the GUI are a Digital Elevation Map (DEM; in ARC ASCII grid format) and a mask showing the extent of the catchment. Optionally, vegetation and soil map data can be included. Vegetation and soil parameters values can be selected from libraries or chosen individually. The vegetation library has 7 types (e.g. grass, deciduous forest, urban), and the soil library twelve types (e.g. clay, loamy sand, peat).

The GUI, written using Microsoft .NET Visual Basic and C#, has four pages for data input: (a) ‘grid’ (spatial data); (b) ‘vegetation’; (c) ‘soil’; and (d) ‘other’, including time series data for rainfall and evaporation). Once checks have been made that all the data are present and valid an XML (eXtensible Markup Language) file is written. The GUI then launches the ‘Prepare Executable’ (Figure 1) which reads the XML file, generates the river channel network, and writes the standard SHETRAN input files. The GUI then launches a SHETRAN simulation.

3. River Network Generation

A key part of the GUI is the automatic generation of the river channel network. Commonly used procedures for extracting drainage networks from a DEM are based on the algorithm of Jenson and Domingue (1988). However, in SHETRAN, the river channels are assumed to run along the edges of grid cells, so a more complicated algorithm is needed.

The network generation algorithm uses a DEM and mask. The drainage area upstream of each corner between cells is calculated. A channel is initiated at a corner when this upstream drainage area is greater than the minimum contributing area (the only parameter for the algorithm), and the channel runs from corner to corner until it reaches the outlet of the catchment or joins another channel. The elevations and widths of the channels are calculated automatically depending on the upstream contributing area.

4. Conclusions

SHETRAN is a powerful tool for studying rainfall-runoff for river catchments, including hydrological and environmental impacts associated with land-use and climate change, but it is difficult and time consuming to set up for new catchments. A Graphical User Interface (GUI) has been created that quickly and easily creates a prototype data set and runs a simulation of water flow. The data set created by the GUI can be used immediately as the starting point for creating more detailed data sets, making the whole process of starting to use SHETRAN far less difficult and time consuming for new users.

A limited version of SHETRAN and the GUI are available free (restricted to 34 by 34 grid cells). A one-year water flow simulation on a 34 by 34 cell catchment runs in about 2 minutes.

References

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Figure 1 Flow chart for SHETRAN and the SHETRAN GUI.