Developments in SWAT modelling

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Environmental Modelling

- SWAT model
- SWAT use in the Limpopo basin > SWAT-CUP
- New developments:
  - Link SIMGRO – SWAT
  - Rainfall-runoff module for shallow groundwater levels in SWAT
  - Crop factors
- Discussion
Introduction to SWAT

- ‘Soil and Water Assessment Tool’ basin scale, distributed, physically based model based on the water balance
- Developed mid ‘90 by USDA Agricultural Research Service and Texas A&M AgriLife research in Texas, USA, designed to

  “Predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions”

http://www.swat.tamu.edu
GIS environment

GIS environment with input data processing and display.

- Input Data:
  - Watershed Definition
  - HRU Definition
  - Raw GIS Data
  - Soils
  - Weather Stations and Time Series

- Processing and Display:
  - SWAT Databases
  - Parameterization
  - Editing Calibration
  - SWAT Model
  - Run
  - Output Maps
  - Output Tables and Charts

- ArcGIS

- Sub-basin:
  - Crop growth
  - Evaporation
  - Infiltration
  - Percolation
  - Groundwater
  - Nutrients
  - Sediment

- River:
  - Flow
  - Sediments
  - Transport
  - Water quality processes

- Outlet:
  - Flow
  - O2
  - NH4
  - HNO3
  - Org. N
  - H2PO4
  - Org. P
  - Sediments
  - Algae
  - C/BOD
SWAT model applied to Limpopo basin

Limpopo basin
Main goal:

- To set up the SWAT model for the Limpopo River basin, focussing on smallholder farming
- Modelling different irrigation and fertilizer application management scenarios for smallholder farms
- Linking crop production to hydrology
- Framework: water for food
Observed vs simulated stream flow – using SWAT-CUP2012

Nash-Sutcliffe\(^1\) = 0.35
\(R^2 = 0.47\)

Nash-Sutcliffe\(^1\) = -0.07
\(R^2 = 0.11\)

\(^1\) Nash-Sutcliffe efficiency coefficient: assess the predictive power of hydrological models
### SWAT application – Limpopo River basin

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Management operation Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I BS</td>
<td>No irrigation, no fertilizer appl. Baseline</td>
</tr>
<tr>
<td>II IA</td>
<td>Application of irrigation Auto irrigation (plant water stress)</td>
</tr>
<tr>
<td>III FA</td>
<td>Application of fertilizer Manure as fertilizer (100 kg/ha/year)</td>
</tr>
<tr>
<td>IV CS</td>
<td>Appl. of fertilizer and irrigation Manure as fertilizer (100 kg/ha/year) and auto irrigation (plant water stress)</td>
</tr>
</tbody>
</table>

### SWAT-CUP2012 analysis Hupsel

SWAT-CUP analysis monthly time step see above on a daily time step did not work well
Results – Scenario analysis

SWAT – strengths and weaknesses

Strengths
- Combination of upland and channel processes into one simulation package
- Applicable for many case studies in different environments
- Water quality
- ‘User friendly’ by its ArcGIS interface

Weaknesses
- Simplification of reality
- Many inputs and outputs can be overwhelming
- Insufficient scientific understanding
- Weak in regional hydrology
- Shallow groundwater conditions
New developments

Regional hydrology:
- Link SWAT and SIMGRO

Shallow groundwater levels:
- Use other rainfall-runoff concept

Crop Kc factor concept
- Use reference crop evapotranspiration and Kc factors for other crops

Model selection

Project goal
- Ideal schematisation
  (hydrological and hydraulic processes)
  Consider the scenarios to analyse
  Is the regional hydrology important?

- Study area
- Available data
- Time and money

Acceptable schematisation

Select type of model(s)
- SWAT or SIMGRO?
Regional hydrological system

SWAT
water quality

SIMGRO
water quantity
Integration of SIMGRO and SWAT model at the time scale of both groundwater models, being in general one day.

Exchange of fluxes:
- drainage flux
- seepage / leakage

Data transfer using same procedure as in Querner (1993):

\[
\text{SIMGRO } \leftrightarrow \text{ SIMWAT } \quad \text{......} \quad \text{SWAT}
\]
Shallow groundwater levels

The Wageningen Lowland Runoff Simulator (WALRUS): application to the Hupsel Brook catchment and Cabauw polder

C. C. Brauer, P. J. J. F. Torfs, A. J. Teuling, and R. Uijlenhoet

Modelling rainfall-runoff processes in lowland catchments

Hydrol. Earth Syst. Sci. Discuss., 11, 2091–2148, 2014
www.hydrol-earth-syst-sci-discuss.net/11/2091/2014/
doi:10.5194/hessd-11-2091-2014
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In SWAT, there is no feedback from surface water to groundwater.

Use this module in SWAT.

Challenge > describe the surface water level in SWAT.

### Shallow groundwater levels

<table>
<thead>
<tr>
<th>Surface water</th>
<th>Groundwater</th>
<th>Shallow groundwater levels</th>
</tr>
</thead>
</table>

#### Crop factor concept

SWAT uses heat units for crop growth and potential evapotranspiration.

Use the reference evapotranspiration (ET0) to calculate the actual evapotranspiration through the following steps:

1. The potential evapotranspiration for a particular crop is derived from the reference crop evapotranspiration using crop factors. A crop factor is a correction factor containing all variation of evapotranspiration with crop type, growth stage or management practice (Allen et al., 1998).

2. Actual evapotranspiration of each crop is determined, depending on the moisture content in the root zone.
SWAT code:

Fortran – version 588 (Feb. 2013)
version 591 (April 2013)

........
version 622 (June 2014)
version 629 (30 Sept 2014)

Updates available very frequently !!
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