Introduction and latest progress of SWAT model

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SWAT - An Overview

- **SWAT** stands for **Soil and Water Assessment Tool**
- **Spatial Scale:** watershed or river basin developed by USDA.
- It focuses on 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 over long periods of time.
- **Data Organization:** sub-basins - hydrologic response units (HRU’s)
- **Some characters:**
  - natural mechanistic model.
  - Based on the DEM data to produce the watershed and sub-catchment.
  - Based on the precipitation data, soil data, land-use data and agricultural data to stimulate the runoff, SS, nutrient content.
  - Based on monitoring data to calibration and validation.
  - Enables users to study long-term impacts.
  - It can stimulated the daily resolution.

**Drawback**

A large amount data input
Model Components

Sub-model

- Hydrological sub-model
  - Water balance
  - Water movement

- Soil erosion sub-model
  - Muscle model

- Pollution load sub-model
  - Transportation and fate of N, P

SWAT

- Climate
- Hydrology
- Sediment
- Main channel processes
- Management practices

- Water quality
- Land cover
- Water bodies
Water balance

\[ SW_t = SW_0 + \sum_{i=1}^{t} (R_{\text{day}} - Q_{\text{surf}} - E_a - W_{\text{seep}} - Q_{\text{gw}}) \]

\( SW_t \): the final water content (mm)
\( SW_0 \): the initial soil water content on day \( i \) (mm)
\( t \): the time (days)
\( R_{\text{day}} \): the amount of precipitation on day \( i \) (mm)
\( Q_{\text{surf}} \): the surface runoff on day \( i \) (mm)
\( E_a \): the amount of evapotranspiration on day \( i \) (mm)
\( W_{\text{seep}} \): the amount of water entering the vadose zone from the soil profile on day \( i \) (mm)
\( Q_{\text{gw}} \): the amount of return flow on day \( i \) (mm)
Water movement in SWAT

Hydrological sub-model

Snow melt model

Infiltration model

Surface runoff model

Precipitation

Rain

Snow

Snow cover

Snow melt

Irrigation

Infiltration

Soil Storage

Soil water routing (10 layers)

Soil Evaporation

Plant Uptake and Transpiration

Lateral Flow

Percolation

Pond/Reservoir Water Balance

P/R Evaporation

Irrigation

P/R Outflow

P/R Seepage

Transmission Losses

Streamflow

Irrigation Diversion

Transmission Losses

Route to next Reach or Reservoir

Shallow Aquifer

Irrigation

Revap

Seepage

Return Flow

Deep Aquifer

Irrigation
Soil erosion sub-model

\[
\text{sed} = 11.8 \cdot (Q_{\text{surf}} \cdot q_{\text{peak}} \cdot \text{area}_{\text{hru}})^{0.56} \cdot K_{\text{USLE}} \cdot C_{\text{USLE}} \cdot P_{\text{USLE}} \cdot LS_{\text{USLE}} \cdot \text{CFRG}
\]

Sed: the sediment yield on a given day
Qsurf: the surface runoff volume (mm H$_2$O/ ha)
Q peak: the peak runoff rate (m$^3$/s)
Areahru: the area of the HRU (ha)
Kusle: the usle cover and the management factor
Pusle: the USLE support practice factor
Lusle: the USLE topographic factor
GFRG: THE coarse fragment factor

\[
K_{\text{USLE}} = f_{\text{csand}} \cdot f_{\text{cl-si}} \cdot f_{\text{orgc}} \cdot f_{\text{hisand}}
\]

\[
C_{\text{USLE, mn}} = 1.463 \ln[C_{\text{USLE, aa}}] + 0.1034
\]

\[
\text{CFRG} = \exp(-0.053 \cdot \text{rock})
\]

\[
LS_{\text{USLE}} = \left(\frac{L_{\text{hll}}}{22.1}\right)^m \cdot (65.41 \cdot \sin^2(\alpha_{\text{hll}}) + 4.56 \cdot \sin \alpha_{\text{hll}} + 0.065)
\]
SWAT tracks the movement and transformation of several forms of nitrogen and phosphorus in the watershed. Nutrients may be introduced to the main channel and transported downstream through surface runoff and lateral subsurface flow.

Nitrogen cycle
Phosphorus cycle

Mineral P

Stable ↔ Active ↔ Solution

Inorganic P fertilizer
Plant Uptake
Mineralization

Active → Stable

Organic P

Humic Substances
Organic P fertilizer

Residue
Plant residue

Active ↔ Stable

Decay

Residue Mineralization

Fresh
Soil database

Interpolation methods

```
load soil.txt; %导入国际制土壤质地文件 soil.txt
rot90(soil); %
b1=ans;
flipud(b1); %
c1=ans;
x=[0,0.02,0.2,2];
xx=0.05;
i=1;
n=1;
for j=3:3:231
    yy(i)=interp1(x,c1(i,j),xx,'spline'); %一维插值函数
    i=i+3;
    n=n+1;
end;
rot90(yy); %得到 < 0.05mm 土壤粒径累积百分含量 (垂向排列)

flipud(ans) %得到 < 0.05mm 土壤粒径累积百分含量 (垂向排列)
```
Some challenges ...

The missing data

- Warm-up period
- Calibration period
- Validation period
- Time sequence

Runoff

Discharge (m$^3$ s$^{-1}$)

Month

Observation
Best simulation

95PPU

Parameters
New SWAT inputs
SWAT_Edits
SWAT Outputs
SWAT_Emerald
Output

PSO

SUFI 2

MCMC

ParaSol

GLUE