SWAT-CUP……. New Features

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Eawag: Swiss Federal Institute of Aquatic Science and Technology
- Calibration,
- Validation,
- Sensitivity analysis (One-at-a-time and global),
- Uncertainty analysis,
- Visualize the watershed and outlet locations,
- Parallel processing
SWAT-CUP

TxtInOut

New SWAT Inputs

Parameters

SWAT_Edit.exe

SWAT2009.exe

SWAT_Extract.exe

Output

SWAT Outputs

PSO

SUFI-2

MCMC

ParaSol

GLUE
Issues w.r.t Calibration of Distributed Watershed Models

- Parameterization
  *(most important, difficult, and neglected aspect of calibration)*
- Positioning observed outlets in SWAT
  *(causes the biggest headache in calibration)*
- Time constraint
  *(makes some projects impossible to build and run)*
- Objective function definition
  *(most surprising aspect of calibration)*
- Non-uniqueness (Uncertainty)
  *(most difficult part to quantify and communicate)*
- Parameter conditionality
  *(most disappointing aspect of calibration)*
Parameterization
Parameterization

\[ \text{x__<parname>.<ext>__<hydrogrp>__<soltext>__<landuse>__<subbsn>__} \]

Slope

Where \( x = \)

\( v__ \) means the existing parameter value is replaced by a given value,

\( a__ \) means the given value is added to the existing parameter value, and

\( r__ \) means the existing parameter value is multiplied by \((1+\text{the given value})\);
## Parameterization

### Soil parameters

<table>
<thead>
<tr>
<th>Parameter identifiers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r__SOL_K().sol</td>
<td>K of all soil layers in all HRUs</td>
</tr>
<tr>
<td>r__SOL_K(1).sol</td>
<td>K of Layer 1 of all HRUs</td>
</tr>
<tr>
<td>r__SOL_K(1).sol____FSL</td>
<td>K of layer 1 in HRUs with soil texture FSL</td>
</tr>
<tr>
<td>r__SOL_K(1).sol____FSL__PAST</td>
<td>K of layer 1 of HRUs with soil texture FSL and landuse PAST</td>
</tr>
<tr>
<td>r__SOL_K(1).sol________PAST__1-15</td>
<td>K of layer 1 of subbasin 1 to 15 in HRUs with landuse PAST</td>
</tr>
<tr>
<td>v__SOL_K(1).sol_____________0-10</td>
<td>K of layer 1 for HRUs with slope 0-10</td>
</tr>
</tbody>
</table>
## Parameterization

### Management parameters

<table>
<thead>
<tr>
<th>Parameter identifiers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>v__HEAT_UNITS{rotation no,operation no}</td>
<td>Management parameters that are subject to operation/rotation must have both specified</td>
</tr>
<tr>
<td>v__CNOP{[],1}.mgt</td>
<td>change an operation's parameters in all rotations</td>
</tr>
<tr>
<td></td>
<td>[] means every rotation that has the specified operation.</td>
</tr>
<tr>
<td>v__CNOP{2,1,plant_id=33}.mgt</td>
<td>Operation filters could be applied as shown</td>
</tr>
<tr>
<td>v__CNOP{[],1,plant_id=33}.mgt</td>
<td>The changes are applied to crop 33 only</td>
</tr>
<tr>
<td>v__CNOP{[],1,plant_id=33}.000010001.mgt</td>
<td>To modify just one file, it could be given as shown</td>
</tr>
</tbody>
</table>
## Parameterization

### Rainfall parameters

<table>
<thead>
<tr>
<th>Parameter identifiers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>v__precipitation(1){1977300}.pcp1.pcp</td>
<td>(1) means column number 1 in the pcp file {1977300} specifies year and day</td>
</tr>
<tr>
<td>v__precipitation(1-3){1977300}.pcp1.pcp</td>
<td>(1-3) means column 1, 2, and 3 {1977300} specifies year and day</td>
</tr>
<tr>
<td>v__precipitation( ){1977300,1977301}.pcp</td>
<td>( ) means all columns (all stations) {1977300,1977301} means 1977 days 300 and 301</td>
</tr>
<tr>
<td>v__precipitation( ){1977001-1977361,1978001-1978365,1979003}.pcp</td>
<td>( ) means all columns from day 1 to day 361 of 1977, and from day 1 to day 365 of 1978, and day 3 of 1979</td>
</tr>
</tbody>
</table>
## Parameterization

*par_inf.txt*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lower Value</th>
<th>Upper Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r__CN2.mgt</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>v__ALPHA_BF.gw</td>
<td>0.4</td>
<td>1.4</td>
</tr>
<tr>
<td>v__GW_DELAY.gw</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>v__GWQMN.gw</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>v__GW_REVAP.gw</td>
<td>0.02</td>
<td>0.1</td>
</tr>
<tr>
<td>v__ESCO.hru</td>
<td>0.02</td>
<td>0.1</td>
</tr>
<tr>
<td>v__OV_N.hru</td>
<td>0.02</td>
<td>0.1</td>
</tr>
<tr>
<td>v__SLSUBBSN.hru</td>
<td>1.0</td>
<td>8.0</td>
</tr>
<tr>
<td>v__HRU_SLP.hru</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>v__CH_N2.rte</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>v__CH_K2.rte</td>
<td>29.5</td>
<td>96.7</td>
</tr>
<tr>
<td>v__ALPHA_BNK.rte</td>
<td>0.38</td>
<td>1.16</td>
</tr>
<tr>
<td>r__SOL_AWC(1).sol</td>
<td>-0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>r__SOL_K(1).sol</td>
<td>-0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Global parameterization**
Parameterization

par_inf.txt

r__CN2.mgt________AGRR____12,13,19,21   -0.1  0.1
r__CN2.mgt________FRST___12,13,19,21    -0.2  0.1
......

t__SOL_BD().sol________12,13,19,21       -0.02 0.01
t__SOL_AWC().sol________12,13,19,21      -0.04 0.1
......

v__EPCO.hru            0.18  0.32
v__ESCO.hru            0.4   0.6
v__SLSUBBSN.hru        3.8   120
......

r__CN2.mgt________AGRR____1-11,14-18,20,22,23  -0.26  -0.1
r__CN2.mgt________FRST___1-11,14-18,20,22,23  -0.3   0.2
r__SOL_BD().sol________1-11,14-18,20,22,23   -0.04  0.05
r__SOL_AWC().sol________1-11,14-18,20,22,231 -0.5   -0.3
Observed Outlet Positioning

The biggest calibration headache!
Time Constraint

Calibration takes a long time!

Build projects with coarser resolution

- Not run enough times to properly calibrate or do uncertainty analysis
  - Grid computing
  - Cloud computing
  - Parallel processing

Rouholahnejad, Elham et al.

*Parallelizing SWAT Calibration in Windows using SUFI2 Program*

Environmental Modelling and Software, March 2011
The graph shows the speedup of two systems, Alberta and Danube, on Server 1 as a function of the number of processors. The ideal speedup is represented by the black line with triangles. Alberta's performance is indicated by the red line with crosses, and Danube's performance is shown by the blue line with triangles.

Key specifications:
- 24 CPU
- 16 GB RAM
- Danube: 69,875
- Alberta: 2,698
Number of processors

Speedup

1:1 line
SWAT project with 2698 file
SWAT project with 69,875 file
Future Development

- Parallel Processing on GPU!
- More visualization
- More optimization algorithms
- More features as requested by users…….