C-SWAT: A Modified Revision of SWAT Using Consolidated Input Files

Haw Yen[1,2], Mehdi Ahmadi[3], Michael J. White[1]
Xiuying Wang[2],Jeffrey G. Arnold[1]
Javier M. Osorio Leyton[2]

[1] Grassland, Soil & Water Research Laboratory, USDA-ARS
[2] Blackland Research & Extension Center, Texas A&M University
[3] Department of Civil and Environmental Engineering, Colorado State University

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Outline

- Overview
- Soil and Water Assessment Tool (SWAT)
- General Calibration Process
- Structure (format) of SWAT Input Files
- Case Study & Results
- Discussion & Conclusion

Overview

- Development of complex watershed models
  - Evaluate impact from climate changing, various human activities on issues
- Advanced technology in computer science
  - Complex watershed simulation models
    - Distributed in space & process-based
    - Long term simulations with ***large amount of input data***
    - *High resolution input datasets*
- *Iterative processes*
- *SWAT discretization (Basin-Subbasin-HRU)*
  - *SWAT with 10K HRUs = 2hrs ; 1K iterations = 8d*

Objectives

- Modify SWAT input structure to consolidate HRU and subbasins into single file for each category to enhance the computational speed of SWAT model.

Structure (format) of SWAT Input Files

SWAT Input Files	
HRU Level File	Structure Group
*.chm	II
*.gw	I
*.hru	I
*.mgt	I & III
*.ops	IV
*.sep	I
*.sol	I & II
Subbasin Level File	Structure Group
*.pnd	I
*.rte	I & II
*.sub	I & II
*.swq	I
*.wgn	I & II
*.wus	II

Structure I

Each row contains only one parameter value

000010001.hru - Notepad

File Edit Format View Help

```
.hru file Watershed HRU:1 Subbasin:1 HRU:1 Luse:CCRN Soil: MI007 Slope 0-1 8/25/2013 12:00:00 AM ArcSWAT 2012.10_0.10
       0.0111605     | HRU_FR : Fraction of subbasin area contained in HRU
         121.951     | SLSUBBSN : Average slope length [m]
           0.003     | HRU_SLP : Average slope stepness [m/m]
           0.140     | OV_N : Manning's "n" value for overland flow
           0.000     | LAT_TTIME : Lateral flow travel time [days]
           0.000     | LAT_SED : Sediment concentration in lateral flow and groundwater flow [mg/l]
           0.000     | SLSOIL : Slope length for lateral subsurface flow [m]
           0.000     | CANMX : Maximum canopy storage [mm]
           0.653     | ESCO : Soil evaporation compensation factor
           0.471     | EPCO : Plant uptake compensation factor
           0.000     | RSDIN : Initial residue cover [kg/ha]
           0.000     | ERORGN : Organic N enrichment ratio
           0.000     | ERORGP : Organic P enrichment ratio
           0.000     | POT_FR : Fraction of HRU are that drains into pothole
           0.000     | FLD_FR : Fraction of HRU that drains into floodplain
           0.000     | RIP_FR : Fraction of HRU that drains into riparian zone
```

Ln 1, Col 1

Structure II

Each row contains more than one parameter value

000010001.chm - Notepad

File Edit Format View Help

```
 .chm file Watershed HRU:1 Subbasin:1 HRU:1 Luse:CCRN Soil: MI007 Slope: 0-1 8/24/2013 12:00:00 AM ArcSWAT 2012.10_0.10
Soil Nutrient Data
 Soil Layer                :          1      2      3      4      5      6      7      8      9     10
 Soil NO3 [mg/kg]          :       0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 Soil organic N [mg/kg]    :       0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 Soil labile P [mg/kg]     :       5.00   5.00   5.00   5.00   5.00   5.00   5.00   5.00   5.00   5.00
 Soil organic P [mg/kg]    :       0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
 Phosphorus perc coef      :      10.00  10.00  10.00  10.00  10.00  10.00  10.00  10.00  10.00  10.00
```

Ln 1, Col 1

Structure III

Format in MGT files

000030002.mgt - Notepad

File Edit Format View Help

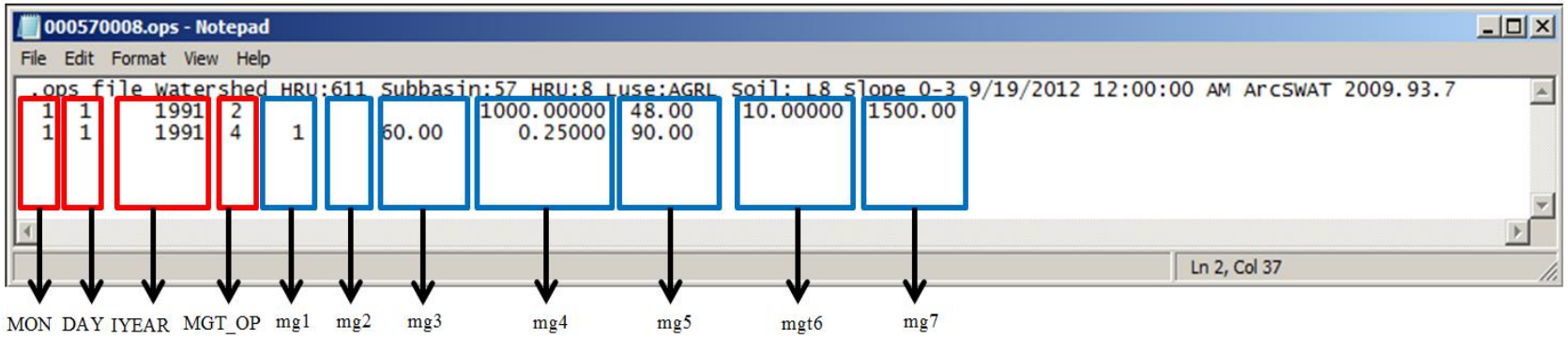
```
 .mgt file Watershed HRU:77 Subbasin:3 HRU:2 Luse:CSOY Soil: MI002 Slope: 0-1 8/27/2013 12:00:00 AM ArcSWAT 2012.10_0.10
             0     | NMGT:Management code
Initial Plant Growth Parameters
             0     | IGRO: Land cover status: 0-none growing; 1-growing
             0     | PLANT_ID: Land cover ID number (IGRO = 1)
          0.00     | LAI_INIT: Initial leaf are index (IGRO = 1)
          0.00     | BIO_INIT: Initial biomass (kg/ha) (IGRO = 1)
          0.00     | PHU_PLT: Number of heat units to bring plant to maturity (IGRO = 1)
General Management Parameters
          0.00     | BIOMIX: Biological mixing efficiency
         85.71     | CN2: Initial SCS CN II value
          1.00     | USLE_P: USLE support practice factor
       1200.00     | BIO_MIN: Minimum biomass for grazing (kg/ha)
         0.000     | FILTERW: width of edge of field filter strip (m)
Urban Management Parameters
             0     | IURBAN: urban simulation code, 0-none, 1-USGS, 2-buildup/washoff
             0     | URBLU: urban land type
Irrigation Management Parameters
             0     | IRRSC: irrigation code
             0     | IRRNO: irrigation source location
         0.000     | FLOWMIN: min in-stream flow for irr diversions (m^3/s)
         0.000     | DIVMAX: max irrigation diversion from reach (+mm/-10^4m^3)
         0.000     | FLOWFR: : fraction of flow allowed to be pulled for irr
Tile Drain Management Parameters
      1200.000     | DDRAIN: depth to subsurface tile drain (mm)
        48.000     | TDRAIN: time to drain soil to field capacity (hr)
        24.000     | GDRAIN: drain tile lag time (hr)
Management Operations:
             1     | NROT: number of years of rotation
Operation Schedule:
  5 15          6 114          0.00000
  5 15          6 113          0.00000
  5 16          1  56       1473.00000  0.00   0.00000 0.00  0.00  0.00
  5 17          3   1          5.00000  0.00
  5 17          3   2          6.00000  0.00
 10 10          5              0.00000
 11  1          6 114          0.00000
```

Ln 1, Col 1

MON DAY HUSC MGT_OP mg1 mg2 mg3 mg4 mg5 mgt6 mg7 mg8 mg9

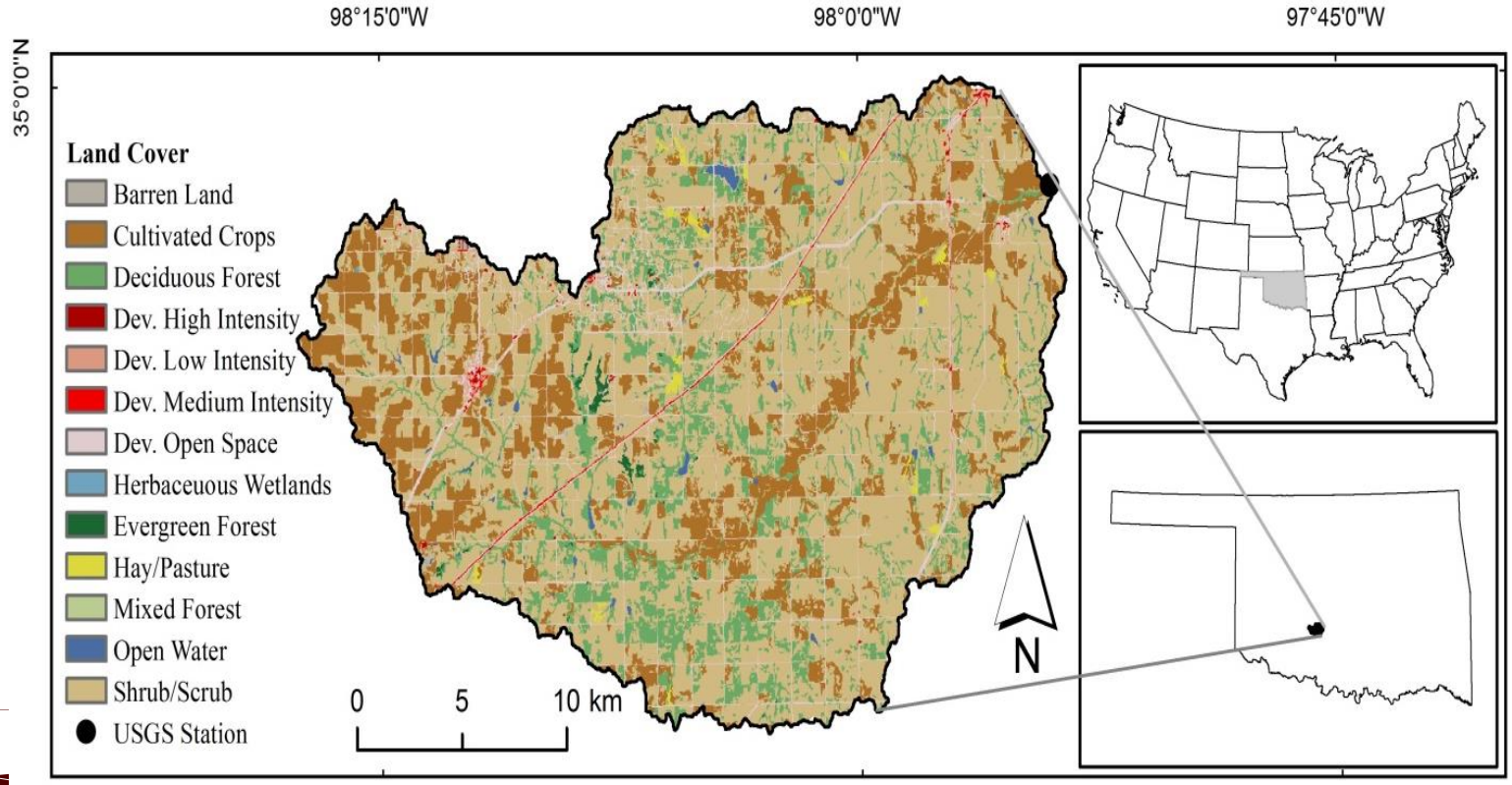
Structure IV

Format in OPS files



Case Study Area

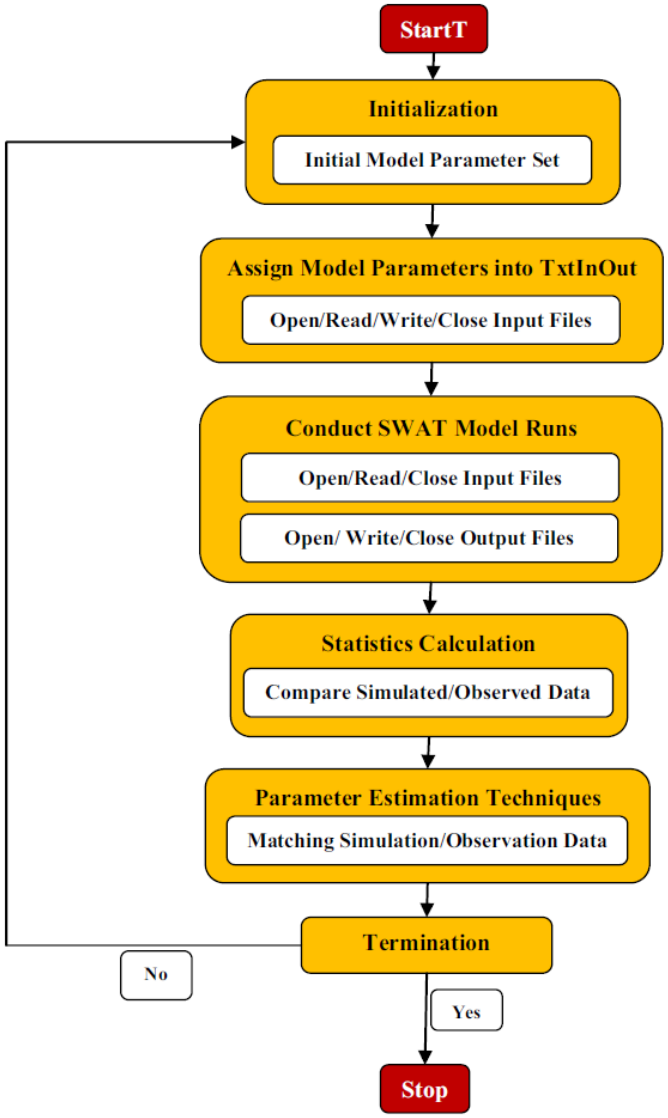
- Little Washita River Basin
  - Oklahoma, USA
  - 611 km²

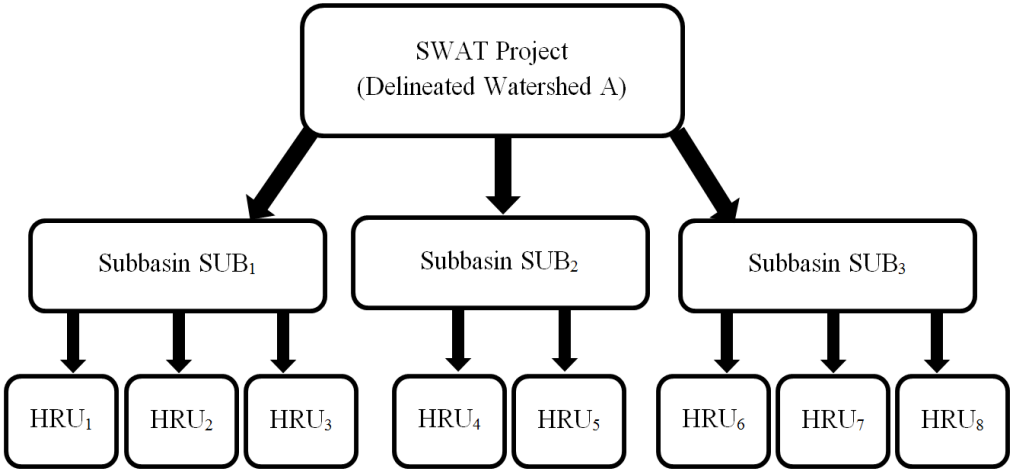


Case Study Area

- Normal SWAT project
  - 75 Subbasins
  - 394 hru
  - Total 3148
- C-SWAT Project
  - 7 hru
  - 6 Subbasin
  - Total 43 files
- 98% fewer files

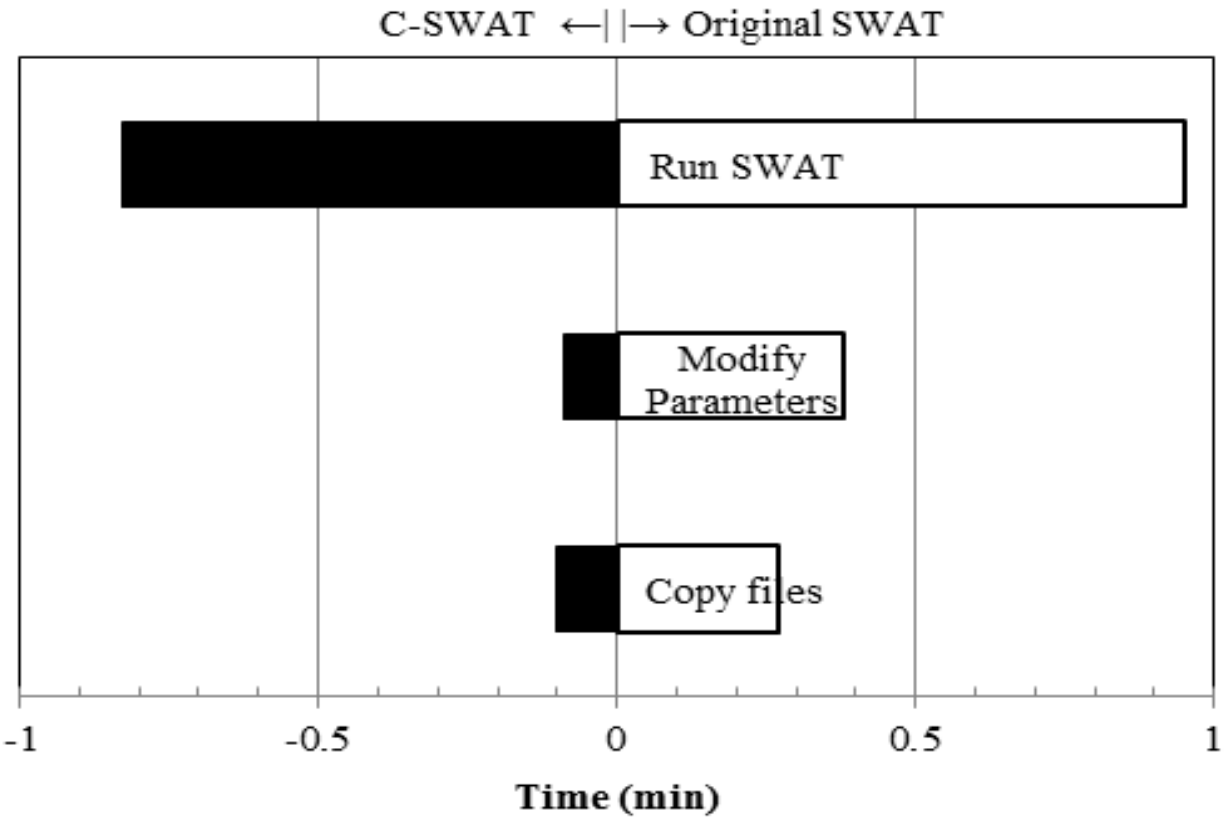
General Calibration Process





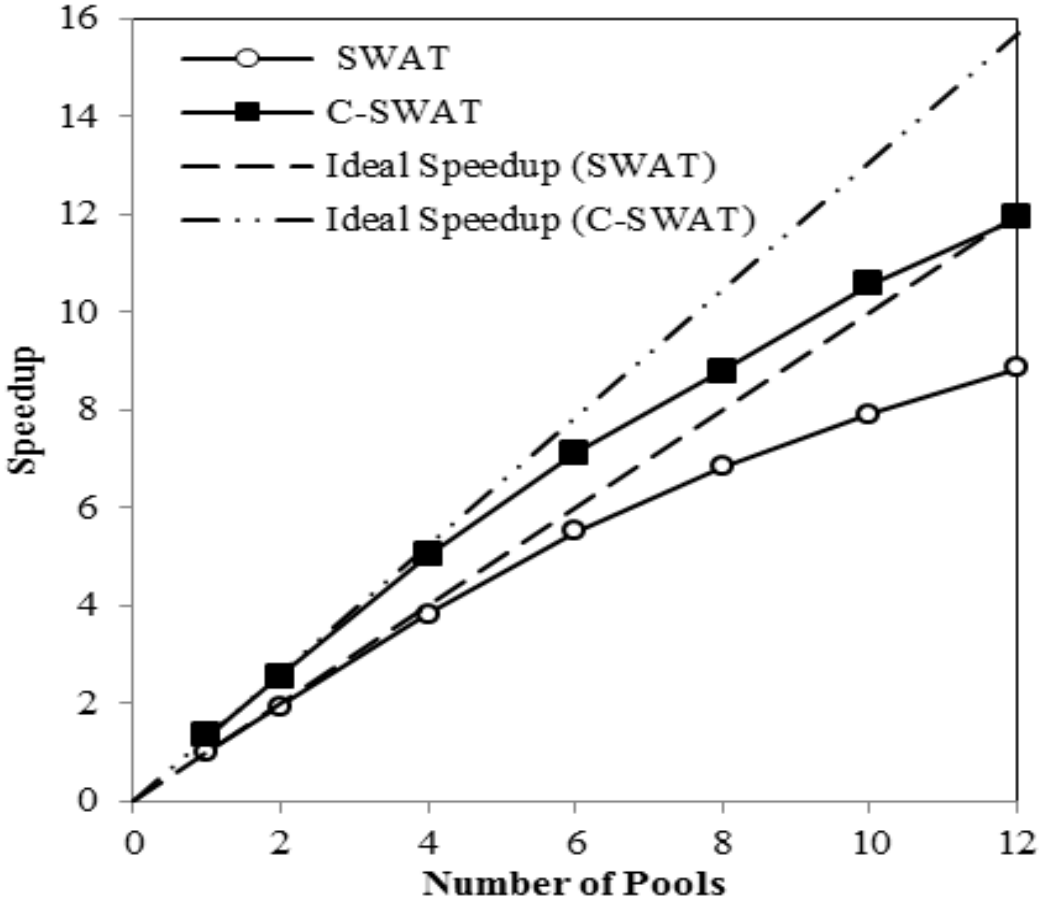
Results (1/2)

- Comparison of runtime spent on each conducted calibration



Results (2/2)

- Application of parallel computation



Discussion and Conclusion

- C-SWAT is no doubt a time/effort saver
  - Further improvement can be made by applying C-SWAT on large-scale watershed projects
  - Source code available (***Haw Yen***)
  - C-SWAT can be applied on other revisions

- The upcoming New Generation SWAT (modular code) will adopt the concept of C-SWAT
  - Input files will be consolidated
  - More associated modifications

Reference

- C-SWAT Theory & Development
  - Yen, H., M. Ahmadi, M. J. White, X. Wang, J. G. Arnold (2014) "C-SWAT: The Soil and Water Assessment Tool with Consolidated Input Files in Alleviating Computational Burden of Recursive Simulations." ***Computers & Geosciences***, 72, pp. 221-232.

- More Implementations
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  - Yen, H., R. T. Bailey, M. Arabi, M. Ahmadi, M. J. White, J. G. Arnold (2014) "The Role of Interior Watershed Processes in Improving Parameter Estimation and Performance of Watershed Models." ***Journal of Environmental Quality***, 43(5), pp. 1601-1613.

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Thanks for your attention!

Haw Yen, Ph.D.
Assistant Research Scientist
hyen@brc.tamus.edu

Texas A&M AgriLife Research