C-SWAT: An Easy Way to Save SWAT Computational Time by Consolidating Input Files

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

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

October 15, 2015
International SWAT Conference 2015
Purdue University
West Lafayette, Indiana, USA

Texas A&M AgriLife Research

Outline

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

Texas A&M AgriLife Research

Overview

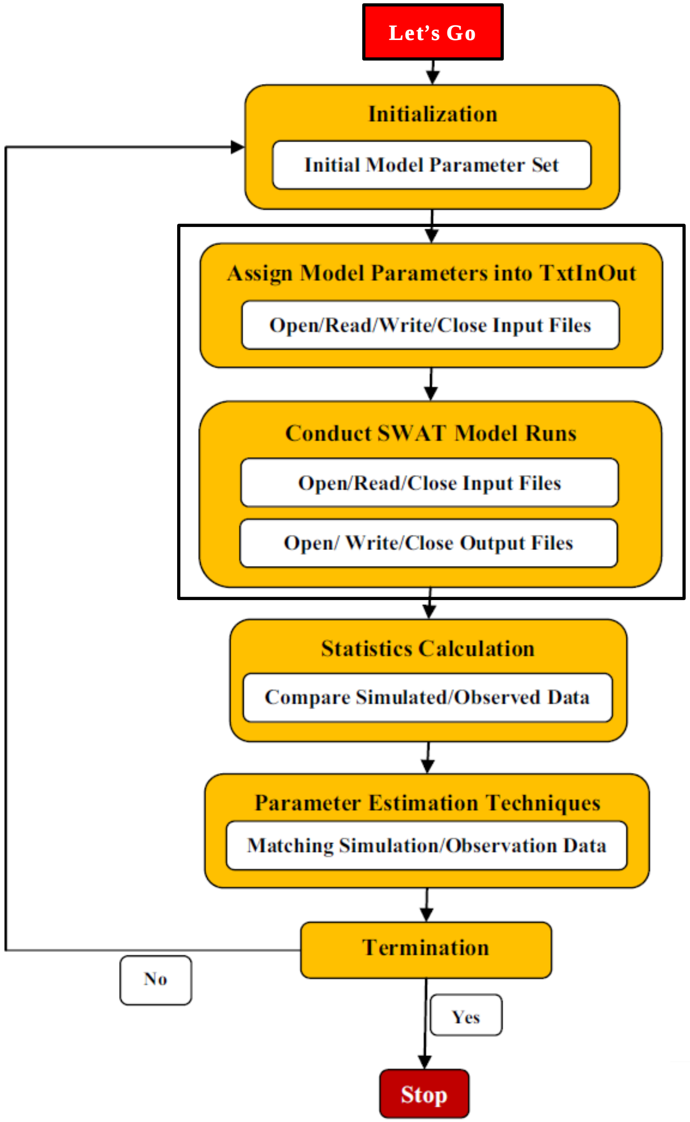
- Development of complex watershed models
  - Evaluate impact from climate changing, various human activities on issues such as:
    - Availability of water resources
    - Water quality
    - Watershed management

- Advanced technology in computer science
  - Complex watershed simulation models
    - Distributed in space & process-based
    - Long term simulations with ***large amount of input data***

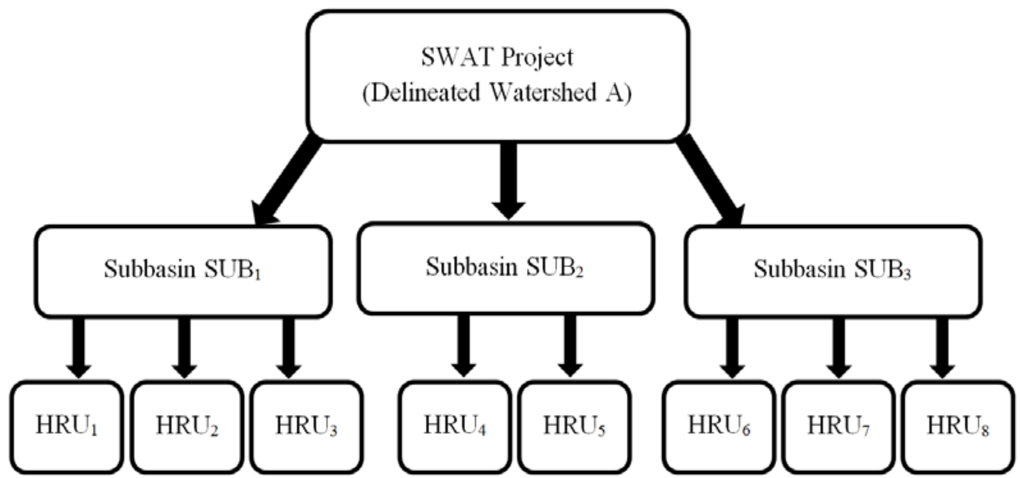
Soil and Water Assessment Tool

- Soil and Water Assessment Tool (SWAT)
  - Developed and maintained by USDA-ARS at Temple, Texas
    - Leading scientist – Dr. Jeffrey G. Arnold
  - GIS interface supported by Texas A&M university
    - ArcSWAT
  - Large-scale watershed management & forecast
    - Surface/subsurface runoff
    - Sediment transportation
    - Nutrients processes (nitrogen, phosphorus)
    - Pesticide losses
    - Bacteria/pathogens
  - More than 1,800 journal articles in literature

General Calibration Process



Potentially Computational Expensive



Structure (format) of SWAT Input Files

Texas A&M AgriLife Research

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

Allchm.txt
Allgw.txt
Allhru.txt
Allmgt01.txt
Allmgt02.txt
Allops.txt
Allsep.txt
Allpnd.txt
Allrte.txt
Allsub.txt
Allswq.txt
Allwgn.txt
Allwus.txt

No Panic!
Can be copy/paste directly from *.mdb file without any change~ ~ ~

Structure I

TEXAS A&M AGRILIFE RESEARCH

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

allhru.txt - Notepad

File Edit Format View Help

```
oid  subbasin  hru  landuse  soil  slope_cd   hru_fr  slsubbsn  hru_slp  ov_n  lat_ttime  lat_sed  slsoil  canmx  esco  epco  rsdin  e
1    1    1    CCRN  MI007  10  0.0111605  121.951  0.003  0.14  0  0  0  0  0.653  0.471  0  0  0  0  0
2    1    2    SOYB  MI007  10  0.0243558  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
3    1    3    SOYB  MI007  10  0.1025797  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
4    1    4    SOYB  MI007  10  0.1062471  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
5    1    5    SOYB  MI007  10  0.0986144  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
6    1    6    CORN  MI007  10  0.1203409  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
7    1    7    CORN  MI007  10  0.1470582  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
8    1    8    CORN  MI007  10  0.154641   121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
9    1    9    CORN  MI007  10  0.1087085  121.951  0.014  0.14  0  0  0  0  0.9  0  0  2  1.3  0  0
10   1    10   BROS  MI007  10  0.0088069  121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
11   1    11   BROS  MI007  10  0.0041851  121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
12   1    12   BROS  MI007  10  0.0153556  121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
13   1    13   BROS  MI007  10  0.019616   121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
14   1    14   BROS  MI007  10  0.0091381  121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
15   1    15   BROS  MI007  10  0.0053293  121.951  0.014  0.1   0  0  0  0  0.9  0  0  2  1.3  0  0
```

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

allchm.txt - Notepad

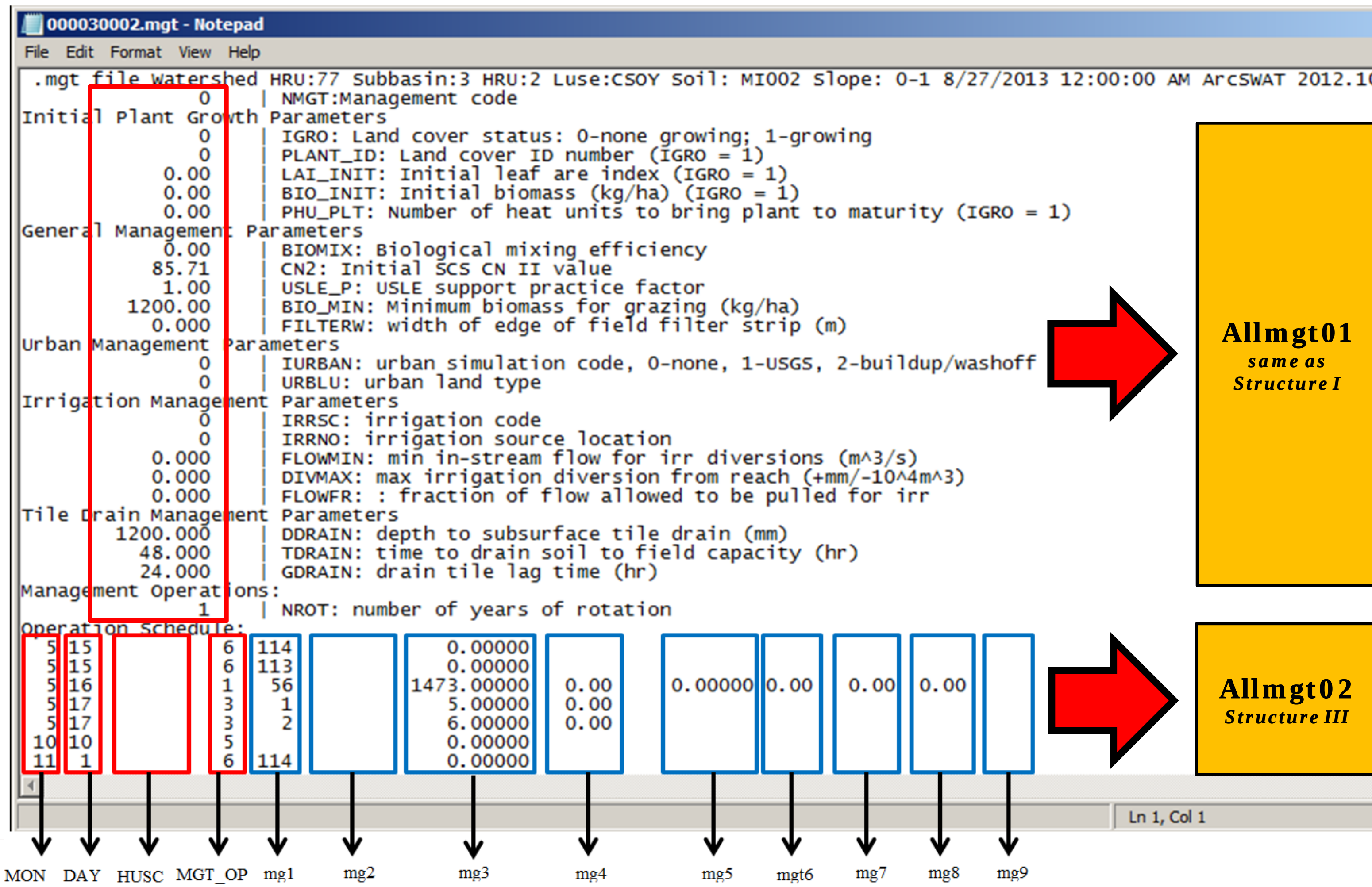
File Edit Format View Help

iod	subbasin	hru	landuse	soil	slope_cd	sno31	sno32	sno33	sno34	sno35	sno36	sno37	sno38	sno39	sno310	sorgn1	sorgn2	sorgn3	sorgn4	sorgn5	sorgn6	sorgn7	sorgn8	sorgn9	sorgn10
1	1	1	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	2	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	3	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	4	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	5	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	1	6	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	1	7	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1	8	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	9	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	1	10	CCRN	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	11	SOYB	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1	12	SOYB	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	1	13	SOYB	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1	14	SOYB	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	1	15	SOYB	MI007	01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ln 1, Col 1

Structure III

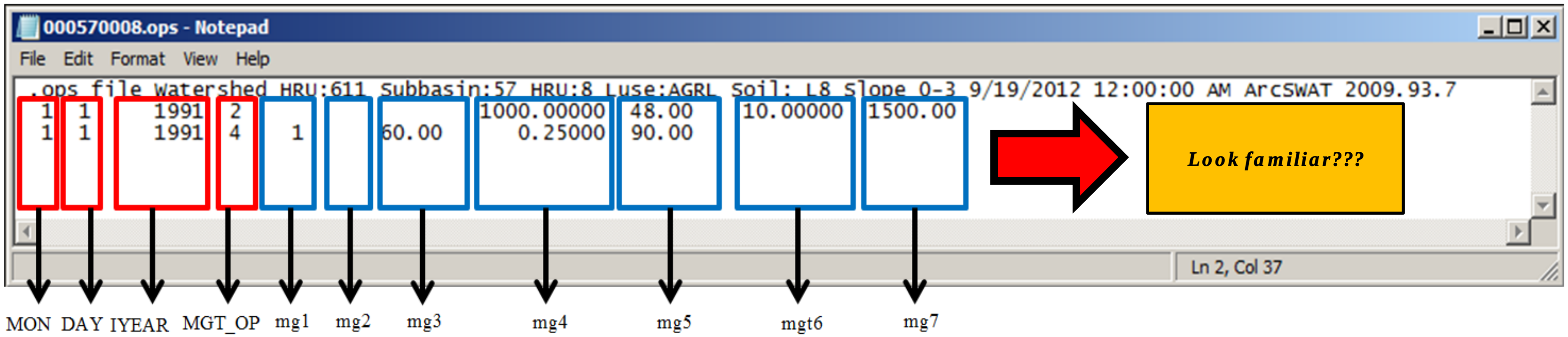
Format in MGT files



Structure IV

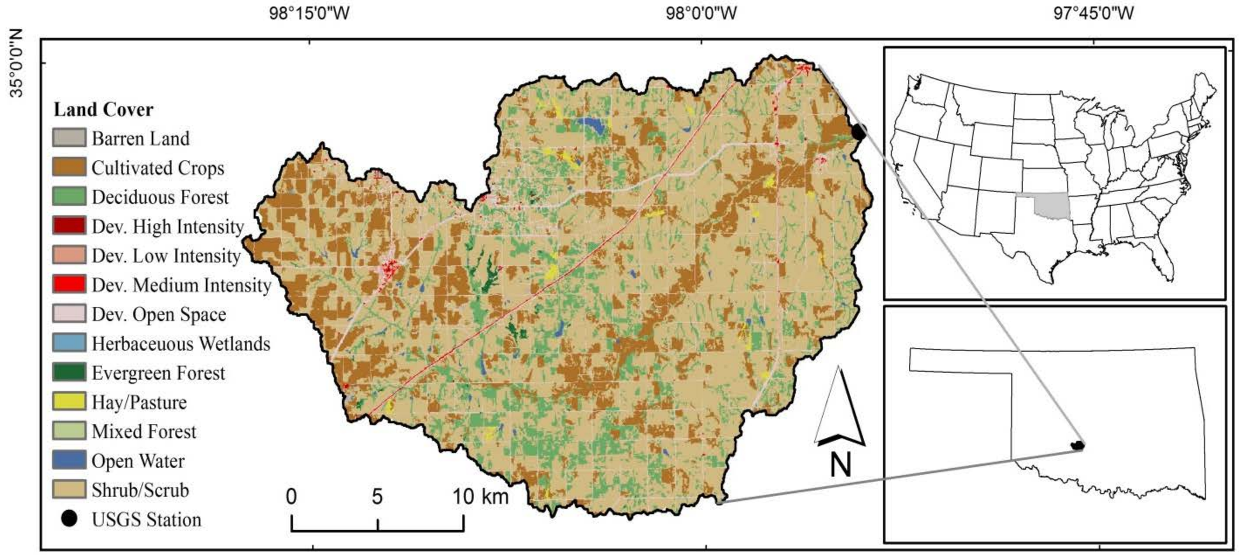
TEXAS A&M AGRILIFE RESEARCH

Format in OPS files



Case Study Area

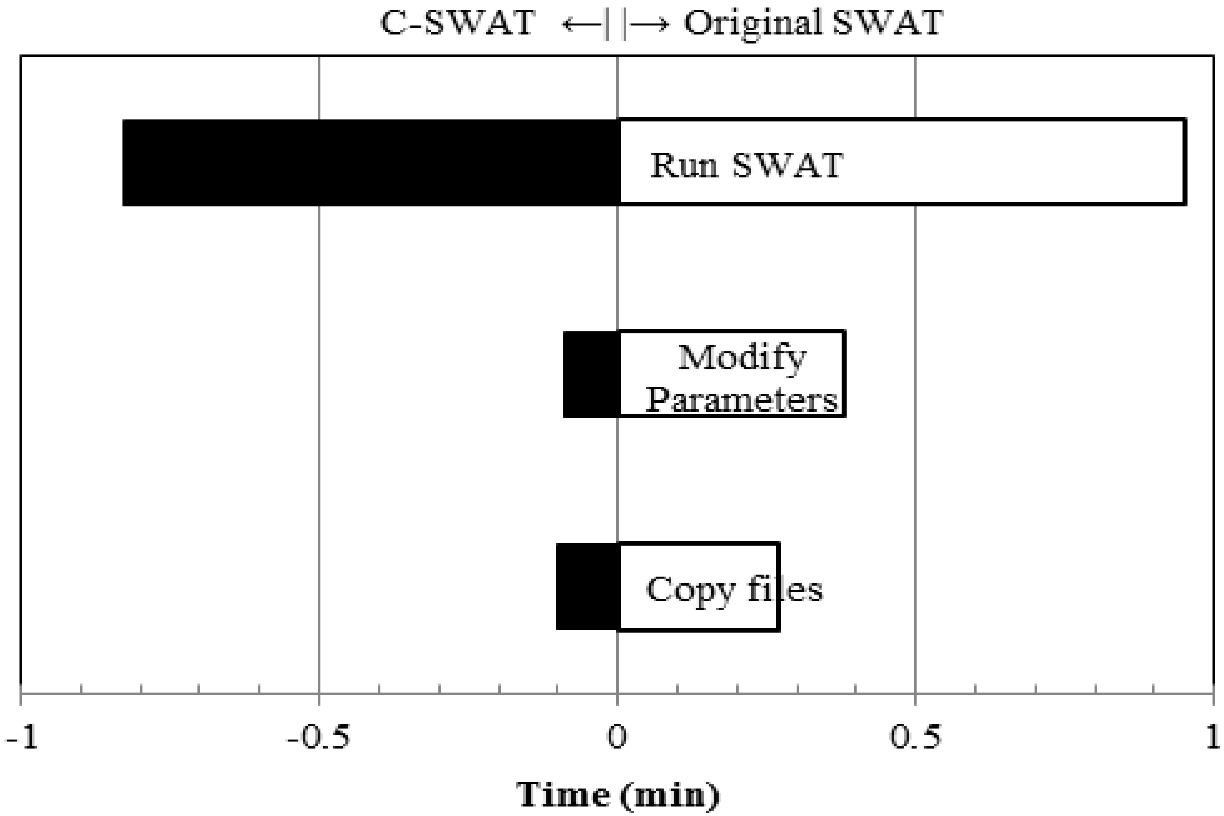
- Little Washita River Basin
  - Oklahoma, USA
  - 611 km^2
  - Available data (daily)
    - Streamflow (2006~2010)



Data Source: 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. DOI: 10.1016/j.cageo. 2014.07.017

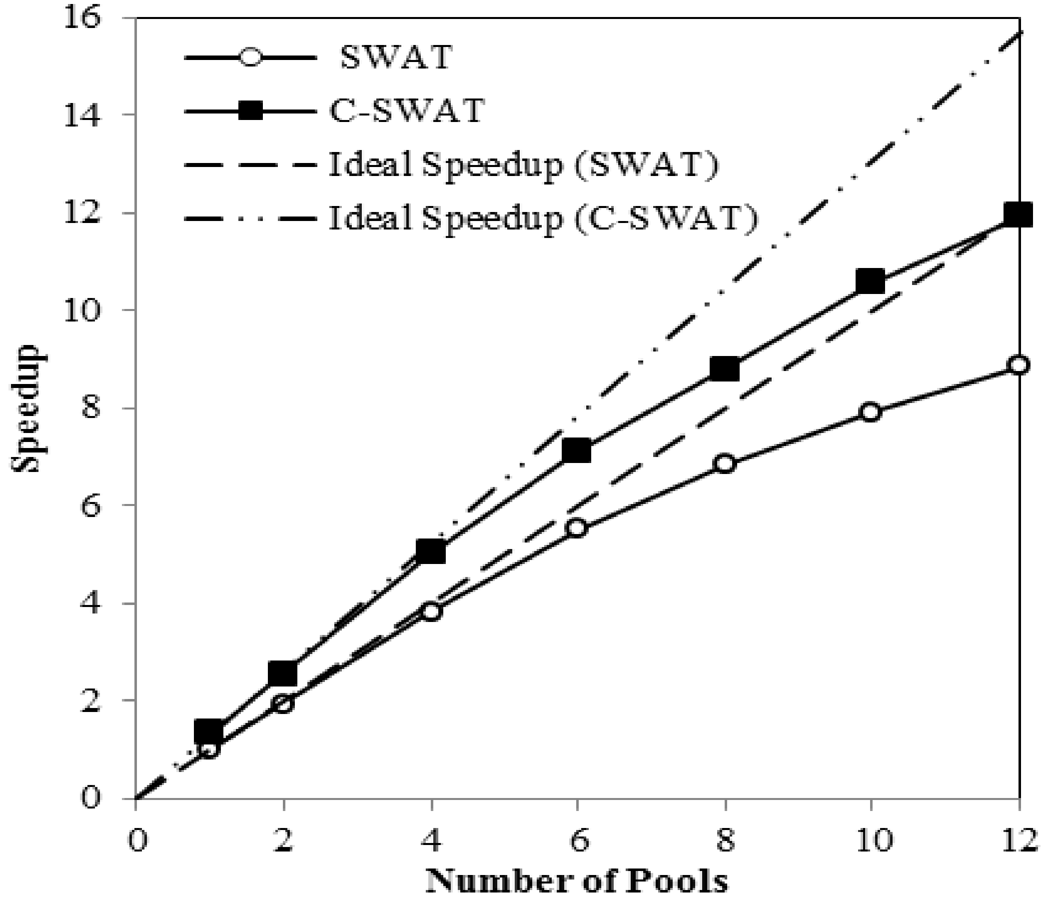
Results (1/2)

- 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
  - Yen, H., X. Wang, D. G. Fontane, M. Arabi, R. D. Harmel (2014) "A Framework for Propagation of Uncertainty Contributed by Input Data, Parameterization, Model Structure, and Calibration/Validation Data in Watershed Modeling." ***Environmental Modelling and Software***, 54, pp. 211-221.
  - 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.

Acknowledgement

- This study was funded by:
  - US Department of Agriculture– National Resources Conservation Service (USDA-NRCS) Conservation Effects Assessment Project (CEAP) – Wildlife and Cropland components.
  - International S&T Cooperation Program from the Ministry of Science and Technology of China (2012DFA91530)
  - National Natural Science Foundation of China (41161140353, 91325302)
  - First Youth Excellent Talents Program of the Organization Department of the Central Committee of the CPC
  - Fundamental Research Funds for the Central Universities (TD-JC-2013-2)

- Please do not forget that USDA is an equal opportunity employer and provider!

Thanks for your attention!

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

Texas A&M AgriLife Research