Worldwide Use of SWAT: 2012 Update

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Literature, Technological, and Networking Factors Driving SWAT Use

- SWAT website
- Extensive & rapidly expanding literature
- Open software and comprehensive documentation
- GIS interfaces; other interfaces/software
 SWAT-CUP is a key software development
- Workshops and conferences

 wide range of modeling methods/results
 extensive networking opportunities



SWAT Literature

- SWAT literature database:
 - https://www.card.iastate.edu/swat_articles/
 - also accessible via link at SWAT website
 - Citation info/abstracts for peer-reviewed journal articles
- Range of articles included in database
- Currently 1005 peer-reviewed articles logged in database
 - ~70 more identified that will incorporated soon
 - ~1,050 of those 1,075 are SWAT-related articles
 - Other relevant papers included
 - 216 different journals currently represented in database



Top 6 SWAT Cited Papers (Web of Knowledge; July 17, 2012)

1) Arnold, Srinivasan, Muttiah, and Williams. 1998. Large area hydrologic modeling and assessment part I: model development. *JAWRA* 34(1): 73-89.

- Cited 950 times: #1 all-time in JAWRA; Jeff also co-author on #3, 4, & 10 top-cited JAWRA papers

Moriasi, Arnold, Van Liew, et al. 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Trans. ASABE. 50(3): 885-900
 Cited 291 times: #8/9 all-time in *Trans. ASAE/ASABE*

3) Gassman, Reyes, Green, Arnold. 2007. The soil and water assessment tool: Historical development, applications, and future research directions. Trans. ASABE. 50(4): 1211-1250

- Cited 281 times: #10 all-time in *Trans. ASAE/ASABE*



Top 6 SWAT Cited Papers (Web of Knowledge; July 17, 2012)

- 4) Arnold, Allen, & Bernhardt. 1993. A comprehensive surface-groundwater flow model. J. Hydrol. 142(1-4): 47-69.
 Cited 274 times; #25 all-time in Journal of Hydrology
- 5) Arnold & Fohrer. 2005. SWAT2000: current capabilities and research opportunities in applied watershed modeling. *Hydrol. Process*. 19(3): 563-572.

- Cited 254 times; #7 all-time in Hydrological Processes

6) Santhi, Arnold, Williams JR; et al. 2001. Validation of the swat model on a large river basin with point and nonpoint sources. 37(5): 1169-1188.

- Cited 240 times; #3 all-time in Hydrological Processes



http://swatmodel.tamu.edu/





SWAT GIS Interfaces

Interface	Platform	Comments
SWAT/GRASS	GRASS	Original interface
AVSWAT	ArcVIEW 3.x	AVSWAT-X includes SSURGO Soils and other enhancements
BASINS	ArcVIEW 3.x	USEPA software package with multiple models
ArcSWAT	ArcGIS 9.x	Many enhancements versus AVSWAT
ArcAPEX	ArcGIS 9.x	Supports applications of APEX imbedded within SWAT simulations
SWAPP	ArcVIEW 3.x	Another APEX-SWAT interface
AGWA	ArcVIEW 3.x / ArcGIS 9.x	Different versions exist for different platforms
MWSWAT	MapWindow	Public domain software; may be of particular interest to SWAT users in developing countries
CRP-DSS	ArcIMS / ArcGIS	For Conservation Reserve Program analyses

Modified SWAT Models

Model	Description
SWAT-G	Improved flow estimates for German low mountain conditions
ESWAT	Extended SWAT; enhanced hydrology & streamflow components
SWIM	Developed from SWAT and MATSALU models
SWAT-DEG	Simulates channel degradation processes more accurately
SWAT _{BF}	Forested watershed processes for Canadian Boreal Plain
SWAT-K	Multiple modified modules for Korean conditions including interfaces with MODFLOW and SWIM models
SWAT-VSA	Re-conceptualized approach for variable source area hydrology
SWAT-WH	Effects of water harvesting systems in southeast Tunisia
SWAT-N	Modified nitrogen cycling routine based on DNDC model
SWAT-WB	Modified model with alternative water balance approach
SWAT- landscape	Experimental version designed to represent landscape processes more accurately







Asia

 Intensive use in China, India, Iran, South Korea

 Increasing numbers of applications being reported in peer-reviewed literature, especially in China
 Modified versions also being used; e.g., SWAT-K (SWAT-Korea)

 Networking via conferences, workshops, "schools"
 Other strategic networking: e.g., Eawag (Switzerland) with Iranian institutions



China SWAT Applications

- Over 100 Chinese SWAT studies published in English peer-reviewed literature; majority in last five years
- Several of the studies feature adaptations of SWAT to better simulate the specific watershed conditions
- Initial review performed by Feng Huang of China Agricultural Univ. Beijing, China (64 peer-reviewed studies; spring 2011)





Overview of Applications/Statistics for Chinese Studies

Basins	No. of applications	Field and No. of Appl.	Cali. NSE	Cali. R ²	Valid. <i>NSE</i>	Valid. R ²
Yellow	23	Climate and land use change (6); hydrology assess(3); Auto-calibration(2); pollutant loading (2); input uncertainty (2);irrigation (2).crop growth (1);	0.58- 0.94	0.54- 0.88	0.46-0.87	0.76- 0.84
Yangzte	18	Pollutant loading (7);input uncertainty (5);climate and land use change (2); hydrology assess (2);model compare (1); impoundment (1)	0.45- 0.96	0.50- 0.96	0.40-0.95	0.60- 0.96
Hai	9	Hydrology assess (2);climate change (1);pollutant loading (1); irrigation (1); input uncert. (1);impoundment (1); interface (1);delineation (1)	0.62- 0.95	0.76- 0.97	0.67-0.91	0.61- 0.93
Southwest	4	Climate and land use change (3); hydrology assess (1)	0.75	0.5	0.91	0.3
Northwest	3	Climate and land change (1);hydrology assess (1);input uncertainty (1)	0.85	0.73- 0.89	0.82	0.68- 0.85
Songliao	3	Hydrology assess (1); input uncertainty (1); delineation(1)	0.16- 9.27	0.57- 0.58	0.18-0.25	0.44- 0.72
Huai	2	Impoundments (2)	-5.04- 1.00	0.00- 1.00	0.36-0.97	0.48- 1.00
Southeast	1	Interface (1)				
Pearl	1	Pollutant loading(1)	0.87	0.87	0.86	0.87

Information compiled by Dr. F. Huang, Department of Soil and Water Sciences, China Agricultural Univ. Beijing, China



Zhanghe Irrigation District (ZID) Modified SWAT Study



Source: Xie & Cui 2011. Development and test of SWAT for modeling hydrological processes in irrigation districts with paddy rice. *Journal of Hydrology* 396(1-2): 61-71. Doi: 10.1016/j.jhydrol.2010.10.032.

Schematic of Rice Paddy Water Balance Dynamics



Source: Xie & Cui. 2011. Development and test of SWAT for modeling hydrological processes in irrigation districts with paddy rice. *Journal of Hydrology* 396(1-2): 61-71. Doi: 10.1016/j.jhydrol.2010.10.032.



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Iran SWAT Applications

- ~20 studies reported in the SWAT peer-reviewed literature
- Studies include applications for BMP assessments, climate change impacts, nitrate impacts on groundwater, and effects of different precipitation sources
- Studies also performed for entire country

 blue/green water assessment and climate change







Faramarzi et al. 2008. Modelling blue and green water resources availability in Iran. *Hydrological Processes* 23(3): 486-501.



Location / Year of SWAT Workshops Held to Date in Iran



Sources: Dr. Karim Abbaspour, Eawag, Dübendorf, Switzerland; Dr. Samira Akhavan, Bu-Ali Sina University, Hamadan, Iran;



From the SWAT training workshop in Teheran during July 13-14, 2011

India SWAT Applications

- >30? studies reported in the SWAT peer-reviewed literature
- Studies include BMP assessments, climate change, irrigation applications, biofuel crop assessments



Southeast Asia

 Expanding use in Southeast Asia
 -Mekong River Commission: pioneered use of SWAT in region for Lower Mekong River system (started ~2003)

- Several SWAT applications have also been published for specific watershed studies
 -Especially in Thailand and Vietnam
- Southeast Asia SWAT conferences / schools -2009: Chiang Mai, Thailand; 2011: Ho Chi Minh City, Vietnam; 2013: Bogor, Indonesia



Lower Mekong River Basin SWAT Application (SWAT streamflow results reported for ~60 gauges)

Rossi et al. 2009. Hydrologic evaluation of the lower Mekong River basin with the Soil and Water Assessment Tool model. *Int. Agric. Engr.* J. (IAEJ) 18(1-2): 1-13 IAEJ. 18(1-2): 1-13







Presentation of certificates to all trainees



Guangzhou, China, July 24-30, 2011

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and Water Conservation











Some organizers, lecturers, facilitators and other participants give reflections when approaching the end of the conference.

Latin America

• Articles published in English peer-reviewed journals:

- Brazil: 1; Chile: 4; Ecuador: 1; Uruguay: 1
- Mexico: 13 (most for watersheds that span U.S.-Mexico border)
- World Bank analysis performed for Bolivia with SWAT
 Blue/green water and climate change analyses
- 60 studies in Brazil reviewed by Garbossa et al. (2011)
 Mostly non-journal articles; >90% in Portuguese
 Data limitations key problem for many studies
 Model testing results were still generally successful



Africa

- Use of SWAT increasing
 - Over 40 studies published in English peer-reviewed literature; most within past three years
 - majority in eastern Africa (Ethiopia, Uganda, Kenya, & Tanzania)
 - some in northern Africa and South Africa
 - recurring theme: problems with data limitations
- Eawag application for entire African continent
 - analysis of "blue" vs. "green" water resources
 - Schuol et al. 2008. Assessing the impact of climate change on water resources in Iran. *Water Resources Research.* 45: 1-16.



Future Developments

1) Look for continued expanding use including modified versions of the model

2) Range of problems that SWAT will be applied to will also expand; e.g.:

- more urban applications

- expanded BMP scenarios

3) More review papers planned