Bienvenue !!
Welcome
Willkommen

Recent SWAT Developments and Future Directions
2013 - UN International Year of Water Cooperation

- Increasing Demand for Water – decreasing availability
- 6-8 Million People Die Annually from water related disasters and diseases
- 3.5 planets Earth would be needed to sustain a global population with the current European/N. American lifestyle
- Next 40 years – population growth of 2-3 billion and increase in food demand of 70%
- Agriculture accounts for 70% of freshwater withdrawals

780 Million People do not have access to clean water
and almost 2.5 Billion do not have access to adequate sanitation

Global Water Scarcity by River Basin
148 countries have international basins within their territory
  • 276 transboundary river basins in the world (46% of world)
  • 90% of wastewater in developing countries flows untreated
  • 80% of water worldwide is not collected or treated

Almost 450 Agreements on international waters were signed between 1820 and 2007

Transboundary river basins by continent:
- Africa: 64
- Asia: 60
- Europe: 68
- North America: 46
- South America: 38
SWAT and other water resource models can provide science-based decision support for water management, land use and management, climate change, food production, and bio-energy production.

Our work is having tremendous impact on global water resources management.
TOPICS:

(1) Landscape Processes (riparian, floodplain, overland routing and sediment),
(2) Channel Processes (sediments and pollutants),
(3) Nutrients, Carbon, and Bacteria (uplands),
(4) Plant Growth,
(5) Version Control and Modular Systems, and
(6) Tools (GIS, climate interpolation, crop generator, autocalibration & uncertainty).

• Special Issue: Hydrological Sciences Journal 53(5)
(1) Landscape processes

- Two papers (Arnold et al., 2010, Bosch et al., 2010) published on landscape routing (Riesel (TX) and Gibbs farm (GA))
- Landscape routing still under development
- Nadia Bonuma (Bonuma et al., 2013) included sediment transport capacity approach and used landscape routing (Brazil)
- Hendrik Rathjens, Martin Volk, Jeff Arnold develop grid version that include landscape routing (Little River Basin (GA))
(2) Channel processes

- Improved channel sediment routing (Balaji and Peter Allen)
- More realistic bed and bank erosion, bed and wash load, and improved flood plain deposition
- Improved BOD and dissolved oxygen (still using the modified QUAL2E approach)
- Biofilm module – Sabine and Jose
(3) Nutrients, carbon and bacteria

- C-FARM (Kemanian et al., 2010) and CENTURY (Zhang et al., 2013) included in SWAT for carbon dynamics
- Improved soil phosphorus routines
- Improved and validated tile nitrate routines
- Bacteria – refined and validated, in-stream component developed
(4) **Plant Growth**

- Plant growth – parameterized forest and energy plants – Jim Kiniry is leading
- Plant competition (water, light, and nutrients)
- Modified plant growth algorithm for the tropics (Michael Strauch and Martin Volk)
- Reworked management operation scheduling – minor mgt file changes but more robust
- Real time soil moisture and plant status – Jaehak Jeong
(5) Version control and modular systems

• Version control – Nancy uses on daily basis
  1) Backup versions and notes
  2) Filemerge
  3) CoLab-access trunk and other versions

• Modular code – JRW Library of modules
  Efficient platform for development
  Provide spatial and temporal framework
  Facilitate parallelization
(6) Tools (GIS, climate interpolation, crop generator, autocalibration & uncertainty)

- ArcSWAT and MapWindows continued development
- Web-based interfaces – HAWQS, eRAMS, BASHYT
- Web-based spatial BMP tools - Mazdak
- SWAT-CUP - Karim
- SWAT Check - Mike White
TOPICS:

(1) Landscape Processes (riparian, floodplain, overland routing and sediment)

(2) River/landscape Continuum AND In-Stream processes, Flood plains, riparian, stream aquifers (spatial, flow sediments, nutrients and biology) + emergent contaminants (antibiotics, hormones, metals, pesticides).

(3) Plant Growth, competition, crop management

(4) New technology (web based/training, Super computers, GIS, sensitivity, autocalibration, optimization, uncertainty analysis).
(1) Landscape Processes

Martin Volk, Nicola Fohrer, David Bosch, Hendrik Rathjens, Louis Thibodeaux, Xuesong Zhang

- Gridded landscape version at Tifton. Dynamic wetness index.
- Vertical profile transport of emerging contaminants
- Improved Lowland processes – tile and groundwater
- Century carbon validation
(2) River Landscape Continuum and In-Stream Processes
Peter Allen, Jose Miguel Sanchez Perez, Mike White, Sabine Sauvage, Balaji

- Channel erosion, transport/deposition, pool/riffle
- Floodplain and riparian processes
- Particulate and dissolved organic carbon - biofilm
- Contaminant transfer – in-stream Kd
- Finite element groundwater model and MODFLOW link
- Rice paddy irrigation
(3) Plant growth and crop management
Phil Gassman, Indrajeet Chaubey, Claire Baffaut, Michael Strauch, Jeff Arnold

- Updating crop parameters into single database
- Plant competition validation and development of agroforestry module
- Bioenergy crop improvements and stover removal
- Tropical conditions modifications
- Realistic planting and applications as a function of heat unit and time distribution
(4) New Technology
Karim Abbaspour, Jaehak Jeong, Srini

- Objective function constraints
- Model structure uncertainty
- Sensitivity analysis routines
- Continue modularization
- Incorporate remotely sensed ET
OUTCOMES/SUGGESTIONS:

(1) Web-Site for Developers
(2) Archive test data sets
(3) Easy access to version code
(4) Developer’s manual and workshops
What it is:

• A Library of Modules to: 1) honor Jimmy who developed many of the core processes all the models are built on and 2) move away from “proprietary ownership” to a truly global library supported and maintained at Temple.

What it is not:

• Not a building
• A software system that “magically” disaggregates models and automatically builds models

What it is:

• A library of modules OF the developers, BY the developers and FOR the developers
What it can do:

- Provide a platform for efficient model development – eliminates need to “rework” similar modules into multiple models
- Provide a spatial and temporal framework for model development
- Facilitate parallelization
- Ultimately, it will help define input databases
- Empower Developers!
Why has the SWAT modeling effort been successful?

- True team effort
- Stable developers base (Jimmy has anchored for 50 years)
- Philosophy – Open and Empower
- Empower Developers – JRW Library, Developer’s manual and training, coordinated global effort, Developer’s Workshops (Potsdam ’06 and Toulouse ‘13)
SPATIAL OBJECTS
(Modules)..

LANDSCAPE UNITS:
- HRU - PLANT & SOIL LAYERS
- SUBBASIN
- SHALLOW AQUIFER
- DEEP AQUIFER

ROUTING:
- CHANNEL
- RESERVOIR
- LANDSCAPE

ADD:
- ADD HYD

RECALL:
- RECAPEX
- RECYEAR
- RECONST
- RECMON
- RECDAY
- RECHOUR
SPECIAL OBJECTS
(Modules)

DATA SHARED BETWEEN SPATIAL OBJECTS:

SPATIAL MODULE
TEMPORAL MODULE
SYSTEM DRIVER

HYDROGRAPH
TIME
WEATHER
HRU OBJECTS (Modules)

HRU MODULES:

- Plant Growth
- Soil Water Routing
- Surface Runoff
- Mgt Operations
- Erosion
- Nutrients
- Pesticides
- Et
- Pathogens
- Septic Systems
- Soil Temp
- Structural Mgt Practices
- Carbon
- Surface Storage
- Others
DATA STRUCTURES (HRU)

INPUT DATA STRUCTURES:
- WEATHER
- TOPO HYD
- SOIL
- LAND USE
- MGT OPERATIONS
- STRUCTURAL OPERATIONS
- SUBSURF DRAINAGE
- SEPTICS
- SOIL TEST
- PLANT COMMUNITY
- PESTICIDES
- SNOW
- ATMOSPHERIC DEPOSITION
- FERTILIZER
- URBAN
- TILLAGE
- PLANT PARAMETERS

OUTPUT DATA STRUCTURES:
- HYDROGRAPH
- HRU SUBBASIN BASIN
- CHANNEL
- RESERVOIR
1. Continued testing and module additions to the JRW Library. Documentation and on-line training.
2. Movement of nitrate, soluble phosphorus and pesticides across the landscape. Landscape → River interactions
3. Biofilm and improved in-stream kinetics
4. Validation of large scale simulations (national and continental scale)
5. Web-based tools for running the model and scenario analysis
Plant community datafile
2 Number of communities in data file

TRGR 2
frse 8 1 1400. 1.0 100. 0.1 500. 25. 1. evergreen forest
ryeg 44 1 1400. 0.5 200. 0.15 60. 0. 1. rye grass ground cover
TUNL 7 Tunnel plant community with 7 plants
sonu 113 1 3400. 1.0 50. 0.1 8. 0. 1. sonu Sorghastrum nutans
bocu 114 1 3400. 1.0 50. 0.1 8. 0. 1. bocu Bouteloua curtipendula
soca 115 1 3400. 1.0 50. 0.1 8. 0. 1. soca Solidago canadensis
scsc 116 1 3400. 1.0 50. 0.1 8. 0. 1. scsc Schizachyrium scoparius
tral 117 1 3400. 1.0 50. 0.1 8. 0. 1. tral Tridens albescens
saaz 118 1 3400. 1.0 50. 0.1 8. 0. 1. saaz Salvia azurea
deil 119 1 3400. 1.0 50. 0.1 8. 0. 1. deil Desmanthus illinoiensis

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2006 Soil and Water Assessment Tool
Model Developer’s Workshop
October 3 - 6 2006
Potsdam Institute for Climate Impact Research
Potsdam, Germany

33 participants:
Australia, Canada, France, Germany, India, Italy, Netherlands, Spain, Switzerland, UK, USA
- Channel can be added across the valley bottom
- Multiple HRUs in the hill slope and valley bottom can be used
- Multiple “subwatersheds” with representative hill slopes can be used within a subbasin.

**Draft:** Peter Allen, Jeff Arnold, Martin Volk, 2012