Watershed Model Development for Assessment of Agricultural Land Use and Management

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Presentation Overview

• Watershed Model Development
  – History of ag watershed models
  – Technology drivers
  – Policy drivers
  – Impact

• National Conservation Assessment

• Science Impact

• International Impacts
History

Early Development
- Phase I - 1960's
  • Hydrology Lab Model
  • ACTMO
  • USLE
- Phase II - 1970's
  • CREAMS
  • HYMO

Model Expansion and Scaling
- 1980's
  • GLEAMS
  • EPIC
  • SWRRB
  • AGNPS
- 1990's
  • SWAT
  • Ann AGNPS
  • WEPP

Recent
- 2000's
  • APEX
  • SWAT Enhancements
Technology Drives Model Development

- 1950’s Universal Soil Loss Equation
- 1970’s GLEAMS field scale model in response to Clean Water Act
- 1990’s GIS, Internet and national databases
- 2000’s Supercomputers, Google, mobile phones
Technology

Mainframe computers
- Hydrology Lab Model
- ACTMO
- USLE

Micro and Mini Computers
- CREAMS
- EPIC
- SWRRB
- AGNPS

Personal Computer
- GLEAMS
- EPIC
- SWRRB
- AGNPS

GIS, National Databases, Internet
- SWAT
- Ann AGNPS
- WEPP

Web Interfaces, Supercomputers
- APEX
- SWAT Enhancements

Web Interfaces, Supercomputers
- APEX
- SWAT Enhancements
Policy Drivers

- Clean Water Act
- Soil and Water Conservation Act
- TMDL’s
- Farm Bill Debate – OMB Mandate
- Climate and Land Use Change

Phases:
- Early Development
- Expansion
- Scaling
- Recent
Model Philosophy

“Everything should be made as simple as possible. I have no interest in the laws of physics if they can’t be made simple”

Albert Einstein
Early Development - 1960’s

- Few Users – Building Block
  - Hydrology Lab Model
    - Water Yield Model
    - H. Holton
  - ACTMO – Ag Chemical Transport Model
    - C. Onstad et al
  - USLE – Universal Soil Loss Equation
    - Wischmeier and Smith
Early Development - 1970’s

CREAMS
Field scale, continuous time

HYMO

Individual Users – No National Assessments
Canada – Flood Routing
Model Expansion

- **CREAMS** – field scale model for runoff, erosion and chemical transport from agricultural management systems
- **EPIC** – a cropping simulation model
- **GLEAMS** – water quality events on agricultural fields
- **AGNPS** – non-point source pollution from agricultural systems
- **SWRRB** – basin scale simulation model for soil and water

**Users/Impact –**
- USDA – Flood control structures, watershed planning
- RCA – National Conservation Assessment – Edge-of-Field
Model Scaling

- **SWRRB** – basin scale simulation model for soil and water
- **SWAT** – large watershed scale
- **AGNPS** – non-point source pollution from agricultural systems
- **AnnAGNPS** – “annualized” non-point source pollution from agricultural systems
- **WEPP** – soil erosion, hillslope and small watershed
Model Scaling

• Users/Impact –
  o BASINS – TMDL’s
  o USDA – HUMUS Hydrologic Unit Model of the United States – first watershed based conservation assessment
  o USDA – Field Office Conservation Planning
Last Decade to Today

(Focus on Temple Models)

**SWAT Enhancements**

- Increased Spatial Detail – Basin models with over 100,000 hru’s – Landscape routing
- Improved Urban Modeling – Septics, impoundments, time step
- Autocalibration, uncertainty, web-based input development and scenarios
Last Decade to Today

APEX

Whole farm, small watershed

Carbon, greenhouse gases, manure management

Grazing, range, pasture, wind erosion
Users/Impact

- BASINS – SWAT was included as a watershed modeling tool for TMDL’s
- CEAP – Conservation Effects Assessment Project
  - Farm bill debate and development
  - RCA – Resource Conservation Appraisal
- International Applications – EU Water Quality Initiatives, Water Resource Assessment in Asia, Africa and South America
Environmental Response
Measuring the Environmental Benefits of Conservation

The Conservation Effects Assessment Project (CEAP)
Why CEAP?

• OMB requests for outcome-based reporting
• 2002 Farm Bill
  – significant increase in conservation funding
  – $4B in conservation payments
  – call for better accountability
• Assessment to guide design and implementation of conservation programs
CEAP – Vision for the Future
Science Based Policy

• Vision: enhanced natural resources and ecosystems through:
  – more effective conservation
  – better management of agricultural landscapes

• Goal: improve efficacy of conservation practices and programs by providing the science and education base
  – conservation planning and implementation
  – management decisions
  – policy

Maresch, et al., 2008, JSWC Vol. 63, No. 6, pp. 198A-203A.
Science Impact

- Over 1,060 journal publications on SWAT development and application
WORLDWIDE USE AND IMPACT
Worldwide Use of ARS Technology

Europe
- Extensive peer-reviewed & other publications
- EU level projects
  - EUROHARP: J. Environ. Monitoring; Vol. 11(3), 2009
  - EAWAG (Swiss Environ.)

Africa
- Use of SWAT increasing

Latin America
- 60 known studies in Brazil reviewed by Garbossa et al. (2011)
  - Over 90% in Portuguese literature
  - Data limitations key problem for many
  - Model testing results were still generally successful
- World Bank analysis performed for Bolivia with SWAT - Blue/green water and climate change analyses

Asia
- Intensive use in China, India, Iran, South Korea
  - Increasing numbers of applications being

Southeast Asia
- Emerging use in Southeast Asia
  - Mekong River Commission: pioneered use of SWAT in region for Lower Mekong River system (started ~2003)
  - SWAT streamflow results reported for ~60 gauges
- Southeast Asia SWAT conferences
  - 2009: Chiang Mai, Thailand
  - 2011: Ho Chi Minh City, Vietnam
  - 2013: Pattaya City, Thailand

World Bank analysis performed for Bolivia with SWAT - Blue/green water and climate change analyses
Brasil SWAT Studies
1999 to 2000

Distribution of Chinese SWAT studies in English peer-reviewed literature

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

SWAT studies performed for “blue watersheds”

Blue/green water study performed for “green basins”
Online Instructional Videos

http://swat.tamu.edu/education/instructional-videos/

SWAT Instructional Videos - Learning to use the Soil and Water Assessment Tool

These videos were created by Purdue University, in collaboration with Texas A&M, with funding from EPA.

Introduction

1. Introduction to SWAT and the Instructional Videos

Downloading and Setting Up ArcSWAT

2. Download and Install ArcSWAT
3. Folders and Files

Running the Lake Fork Example

4. Getting Started - Set up the initial project
5. Watershed Delineation
6. HRU Analysis
   - Overview and Land Use Definition
   - Soil and Slope Definition
   - HRU Overlay
7. Weather Data Input
8. Write and Edit Input Files
9. The SWAT Model Simulation
10. SWAT Output Files

Running and Evaluating SWAT in Your Watershed

11. Obtaining elevation, land use, and soil data for your watershed
12. Obtaining weather data from the National Climatic Data Center
13. Importing your weather data into SWAT
14. Modifying SWAT inputs - the HRU File
15. Modifying the inputs to represent tile drains
16. Downloading streamflow data from USGS
ArcSWAT - Lake Fork Example, HRU overlay

**HRU Analysis**

1. **Land Use** - Select and reclassify
2. **Soil** - Select and reclassify
3. **Slope** - reclassify
4. **Overlay** land use, soil, slope
THANK YOU
Quality Control – SWAT Checker

- Large Models are Difficult to Verify
- **AUTOCALIBRATION CAN CAUSE PROBLEMS**
- Identify Model Outputs out of Normal Ranges.
- Show Visual Representations of Model Outputs
- ftp://ftp.brc.tamus.edu/pub/outgoing/mwhite/SWAT_Check
CEAP – Assess impact of USDA conservation practices on the environment ($2B per year). Assessment to guide design and implementation of conservation programs.