Plug In Water Quality Modules in the SWAT Model

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Outline

- Plug in water quality modules
- Integrating water quality modules into SWAT
- Model verification and evaluation
Plug In Water Quality Modules

Water Quality Modules
- Water temperature
- General constituents
- Nutrients
- Contaminants
- Mercury

HEC-RAS
HEC-ResSim
AdH
SRH-2D
Watershed Models
Plug In Water Quality Modules

- Water Model
  - Flow
  - Sediment
  - WQ Transport
    - TEMP.dll
    - GC.dll
    - NSMI.dll
    - NSMII.dll
    - CSM.dll
    - HgSM.dll
    - New.dll
Water Quality Data

Water Quality Analysis
Nutrient Simulation Module I (NSMI)
Nutrient Simulation Module I (NSMI)

- **State variables (16)**
  - Algae (phytoplankton, benthic)
  - Nitrogen (OrgN, NH4, NO3)
  - Phosphorous (OrgP, TIP)
  - Carbon (POC, DOC, DIC)
  - Organic matter (POM, POM
  - CBOD
  - DO
  - Alkalinity
  - Pathogen

- **Derived variables**
  - Algal biomass
  - TON, TKN, TN, DIP, TOP, TP, TOC, CBOD
  - Light attenuation, oxygen reaeration rate, pH
Contaminant Simulation Module (CSM)
Contaminant Simulation Module (CSM)

- Multi-media kinetics
  - Water column
  - Underlying sediment layer

- Multiple phase partitioning (equilibrium and non-equilibrium)
  - Water
  - DOC (Dissolved Organic Carbon)
  - Algae
  - Organic matter
  - Inorganic solids

- Eight (8) biochemical transformation processes
  - Ionization (5 species)
  - Degradation
  - Hydrolysis
  - Photolysis (Photodegradation)
  - Volatilization

- User-defined extra reaction (second-order)
- Transformations and daughter products
Soil and Water Assessment Tool

Weather (precip, air temp, etc.)

Watershed outlet

Watershed
- land cover, soil, slope

Surface and shallow groundwater flow

In-stream & lake processes

Point sources

Watershed outlet
Contaminant Simulation Modules in SWAT

- Atmosphere
  - Deposition: Wet and dry
  - Water inputs: External loadings
  - Water outputs: Wash off, Plant

- Landscape
  - Top soil layer
  - Multiple soil layers
  - Leaching
  - Overland flow
  - Lateral flow
  - Baseflow
  - Groundwater

- Aquatic
  - Stream
  - Water inputs: Lateral flow, Baseflow
  - Water outputs: Stream

- Plant
  - Overland flow
Model Testing and Verification - Proof of Concept
Lower Minnesota River Watershed
Mainstem HEC-RAS Model
Modeled and Observed Flow

RM 3.5 at Senlhi

- Observed
- Simulated

Monthly Streamflow (m³/s)

- 0
- 100
- 200
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000


Daily Streamflow (m³/s)

- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000

Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08 Jan-09 Jul-09 Jan-10 Jul-10
Modeled and Observed NO$_3$+NO$_2$

NOx Load

NOx concentration

Load_Obs
Load_SWAT
NOx_Obs
NOx_SWAT

kg/day
HEC-RAS Modeled and Observed Data

- Nitrogen (NO₃) (mg/l): Observed and modeled data for the years 2001 to 2006.
- Ammonium Nitrogen (mg/l): Observed and modeled data for the years 2001 to 2006.
- Organic Nitrogen (mg/l): Observed and modeled data for the years 2001 to 2006.
Modeled and Observed DIP

DIP load

- Load_obs
- load_SWAT

DIP concentration

- DIP_Obs
- DIP_SWAT
HEC-RAS Modeled and Observed Data

![Graph of Orthophosphate (mg/l) and Organic Phosphorus (mg/l)](C:\MNriver\RAS\101413\LMNRRAS.wq03)

Legend:
- Obs: Minnesota Lower 5601.1
- Organic Phosphorus (mg/l)
- Orthophosphate (mg/l)
Integrated Watershed and Riverine Modeling Systems

SWAT

NSMI

CSM

HEC-RAS

Graphical Editor

Selected Data Set: /MINNESOTA - LOWER/2337.0 DS BOUNDARY/DISSOLVED OXYGEN/01JA...

Date/Time | Original (mg/l) | Estimate/Entry (mg/l) | Revised (mg/l)
---|---|---|---
30Sep2000, 24:00 | 9.93 | 9.93 | 9.93
07Oct2000, 24:00 | 11.35 | 11.35 | 11.35
14Oct2000, 24:00 | 13.65 | 13.65 | 13.65
21Oct2000, 24:00 | 10.00 | 10.00 | 10.00
28Oct2000, 24:00 | 8.70 | 8.70 | 8.70
04Nov2000, 24:00 | 8.06 | 8.06 | 8.06
18Nov2000, 24:00 | 6.02 | 6.02 | 6.02
25Nov2000, 24:00 | 5.65 | 5.65 | 5.65
02Dec2000, 24:00 | 5.76 | 5.76 | 5.76
09Dec2000, 24:00 | 6.03 | 6.03 | 6.03
16Dec2000, 24:00 | 6.89 | 6.89 | 6.89
23Dec2000, 24:00 | 7.76 | 7.76 | 7.76
Summary

- Water quality modules (NSM and CSM) have been integrated into SWAT
  - Further testing and verification
  - Refining model linkage

- Weakness of the SWAT in-stream and water body processes
  - Simplified hydrological routing
  - Simplified water quality processes

- Linked SWAT and riverine (HEC-RAS) modeling system in support of environmental and ecosystem studies
Questions/Comments?

Thank You

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