Demonstration of a Physically Based Distributed Watershed Water Quality Model (Gridded Surface Sub-Surface Hydrologic Analysis Model) - Eau Galle Watershed, Wisconsin.

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Discussion

- Development Objectives
- Gridded Surface Subsurface Hydrologic Analysis (GSSHA) Model
- Nutrient Sub-Model (NSM)
- Eau Galle Watershed Demonstration Study
- Summary
Development Objectives

- Develop a physically based watershed water quality model capable of simulating distributed flow, sediment, and nutrients.
- Capable of performing spatially and temporally varying fate and transport of nutrients on the watershed scale.
- Allow for multiple fine scale BMPs in a System-Wide context. (e.g., buffer strips, wetlands, landuse changes, etc.)
- Encompass as much of the hydrologic cycle as possible. (e.g. Overland, Channels, Soils (Vadose Zone), Groundwater, SW-GW interactions and Lakes).
GSSHA Model Components

GSSHA is a process based and option driven model. The hydrologic processes and methods used to simulate them in this study are listed below:

- Precipitation distribution: Thiessen polygon method
- Snowfall accumulation and melting: Energy balance
- Precipitation interception: Two parameter
- Overland water retention: Specified depth
- Infiltration: GAR (Green and Ampt with Redistribution)
- Overland flow routing: 2D diffusive wave equation
- Channel routing: 1D diffusive wave equation
- Evapotranspiration (ET): Penman-Montheith with seasonal canopy resistance
- Soil moisture in the vadose zone: Two layer model
- Nutrient fate and transport (via. Nutrient Sub-Model – NSM)
- Chemicals (e.g. Pesticides) (via. Contaminant, Transport, Transformation, & Fate – CTT&F Sub-Model)
NSM Model Components

Overland/Soils Module
- NH4, NO3, Organic Nitrogen (Dissolved and Adsorbed)
- PO4 and Organic Phosphorus (Dissolved and Adsorbed)

Channel Module
- NH4, NO3, Organic Nitrogen (Dissolved and Adsorbed)
- PO4 and Organic Phosphorus (Dissolved and Adsorbed)
- Dissolved Oxygen
- Algae Groups
  • Phytoplankton (Floating Algae)
  • Benthic or Periphyton (Submerged Attached Algae)

Plant Module (Terrestrial)
- EPIC formulations based upon the Heat Index Method
- EDYSLite (developed put not integrated within NSM yet)
NSM – Mass Transfer

\[ S_d = k_e \left( \frac{SIP}{\phi} - DIP \right) \]

\( S_d \) = mass transfer (ML\(^{-2}\)T\(^{-1}\))

\[ k_e = k_m + \frac{ai \theta}{\rho_b} \]  
(L/T or meters/day)

Based on diffusion processes

Based on soil detachment processes

Soil-WC Interface
Eau Galle Watershed

Upper Eau Galle Demonstration Sites

French Run ~ 25 acres
1 gage at outlet

Eight Mile Creek ~ 1 mi²
2 gages – One at confluence of upper streams and one at the outlet

Upper Eau Galle ~ 60 mi²
5 gages – 4 along the Eau Galle River (see figure) and one along Carr Creek
French Run

Landuse: Agricultural Row Crop (Corn)

Soil Texture: Silt Loam

Hyd. Cond. = 0.248
Hyd. Roughness = 0.44
K_m (DIP) = 0.008
K_m (NH4) = 0.001
K_m (NO3) = 0.006
French Run
Dissolved Inorganic P
May 2002 to October 2002

Red dots represent observed values, while blue lines represent simulated values.

Time (Julian Days)
0 100.00 120.00 140.00 160.00 180.00 200.00 220.00 240.00 260.00 280.00 300.00

DIP (g/s)
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
French Run
Dissolved Inorganic P
May 2002 to October 2002
French Run
Ammonium
May 2002 to October 2002

NH4 (g/s)

Time (Julian Days)
French Run
Nitrate
May 2002 to October 2002

NO₃ (g/s)

Time (Julian Days)
French Run
Nitrate
May 2002 to October 2002

Time (Julian Days)

NO3 (mg/l)
French Run
Dissolved Oxygen
May 2002 to October 2002

Time (Julian Days)
Eight Mile Creek

8-Mile Creek Watershed

Stream Reaches
0
1
2
3
4
5
No Data

Lulc
N/A
Forest
Pasture
Row Crop (Corn)
Dairy
No Data

US Army Corps of Engineers
Building Strong
Eight Mile Creek
May 2002 to October 2002

Flow (cms)

Time (Julian Days)

Observed
Simulated
Eight Mile Creek
May 2002 to October 2002

![Graph showing DIP (mg/l) over time (Julian Days)]
Eight Mile Creek
May 2002 to October 2002
Eight Mile Creek
May 2002 to October 2002
Upper Eau Galle

Discharge Output

Date (years)

Discharge (m$^3$/s)

EG 18.5 observed
EG 18.5 final cal
Upper Eau Galle

Sediment Output

6/2/2002 7:15 - 6/2/2002 12:00

6/21/2002 8:30 - 6/22/2002 4:45
French Run and Eight Mile Creek Flow, Sediment, and Nutrient model results compare favorably to observed data.

Upper Eau Galle Flow and Sediment compares favorably to observed data.

Upper Eau Galle Nutrient simulations need to be completed and compared to observed data.

Dynamic Landuse Module needs to be implemented in order to capture changing landuses throughout the simulation.

Need to integrate NSM with the GSSHA GW and Lakes modules.

Carbon Cycle Module needs to be completed such that Carbon Kinetics can be simulated.

More research needs to be done on the mass transfer mechanism of dissolved nutrients from the upper soil layer to the overland water column.