Simulation of hydrologic and water quality processes in watershed systems using linked **SWAT-MODFLOW-RT3D** model

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Colorado State University

SWAT 2015
PULA / SARDINIA / ITALY

Motivation Improve groundwater flow and solute transport processes in SWAT

Method Link SWAT with physically-based, spatially-distributed groundwater models

Outline

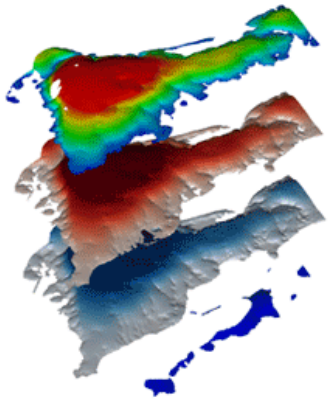
- Model Overview
- Model Code
- Modeling Linkage
- Applications: Klamath Basin, OR
  Little River Watershed, GA

Model Description

Linking 3 Models:

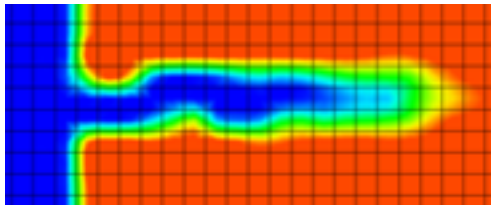
SWAT

MODFLOW



- Groundwater model
- 3D finite difference

RT3D



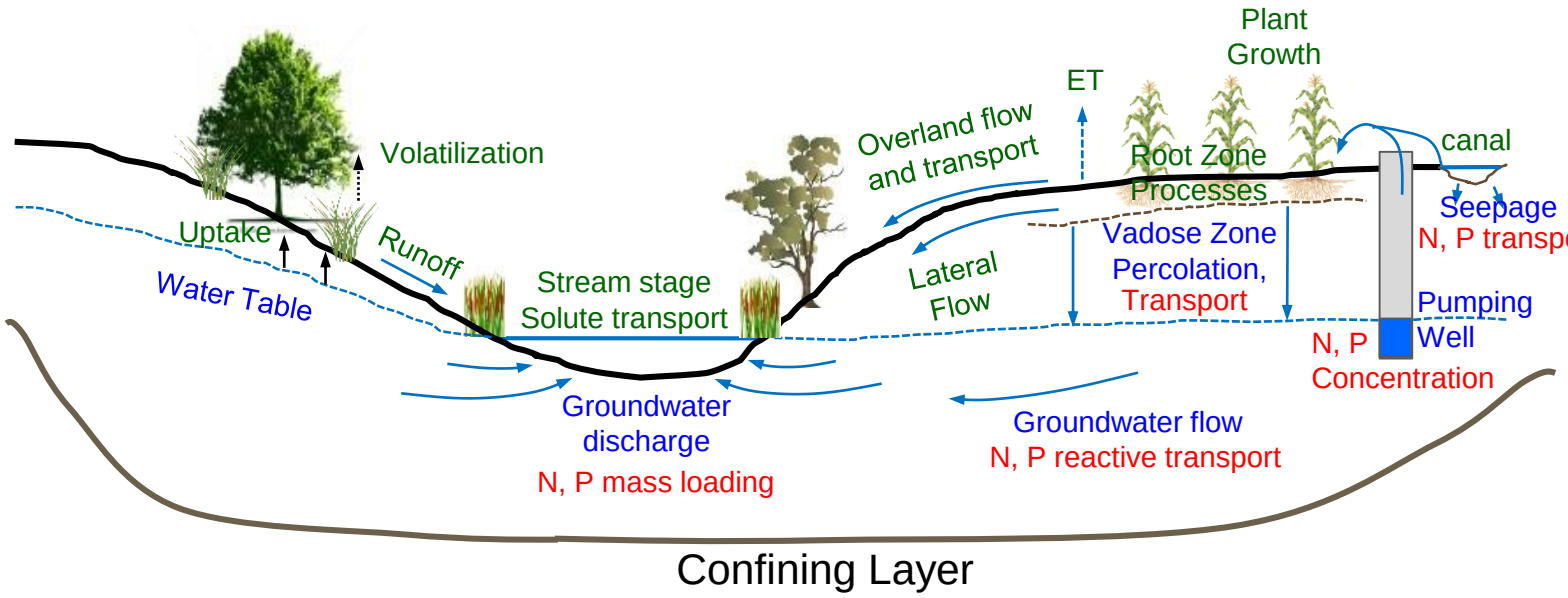
- Reactive transport
- 3D finite difference

Model Description

Linking 3 Models: SWAT

MODFLOW

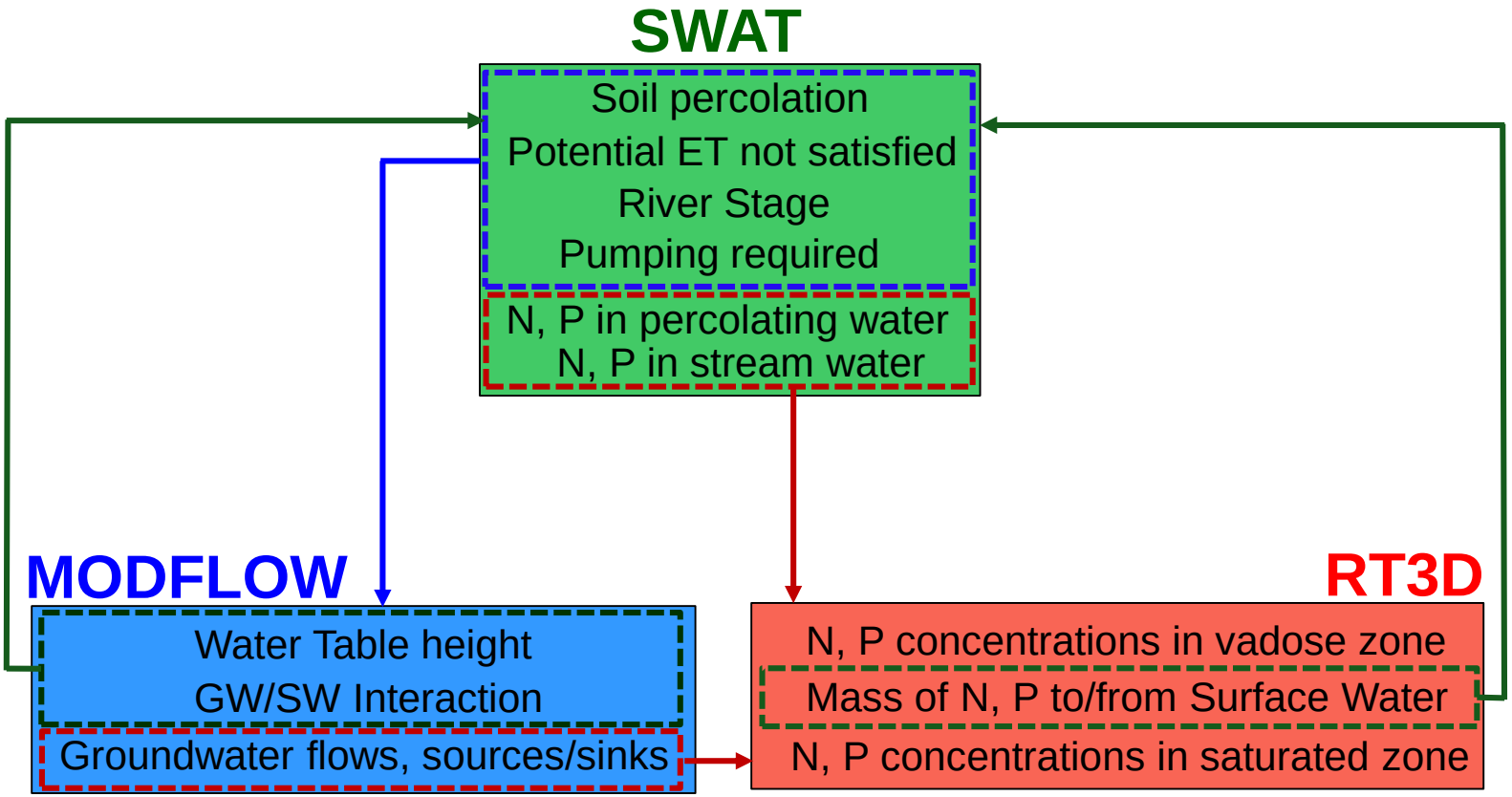
RT3D



Model Description

Linking 3 Models:

Daily Interactions



SWAT Code Modification

simulate

Years

Days

command

1: subbasin (hru calculations)

19: MODFLOW / RT3D

Map SWAT variables → MODFLOW Grid

Recharge (soil percolation)

NO_3 concentration in percolation water

Stream stage

Run MODFLOW

Run RT3D

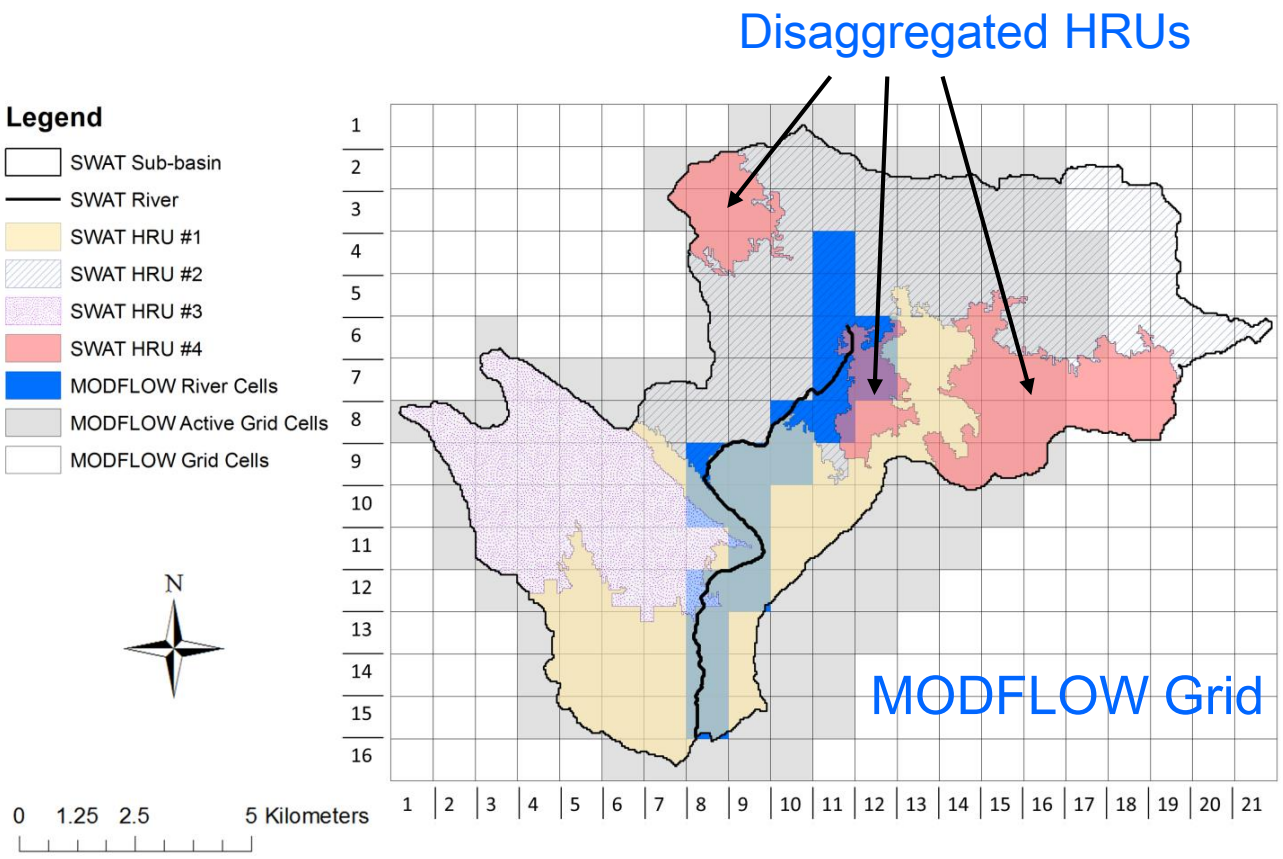
Map Grid → SWAT

GW Discharge → Subbasin streams

NO_3 loading → Subbasin streams

2: Route

Model Linkage



1. HRU → DHRUs
2. DHRUs → Grid Cells
3. River Cells → Subbasin

JAVA code →

map_dhru2grid.txt

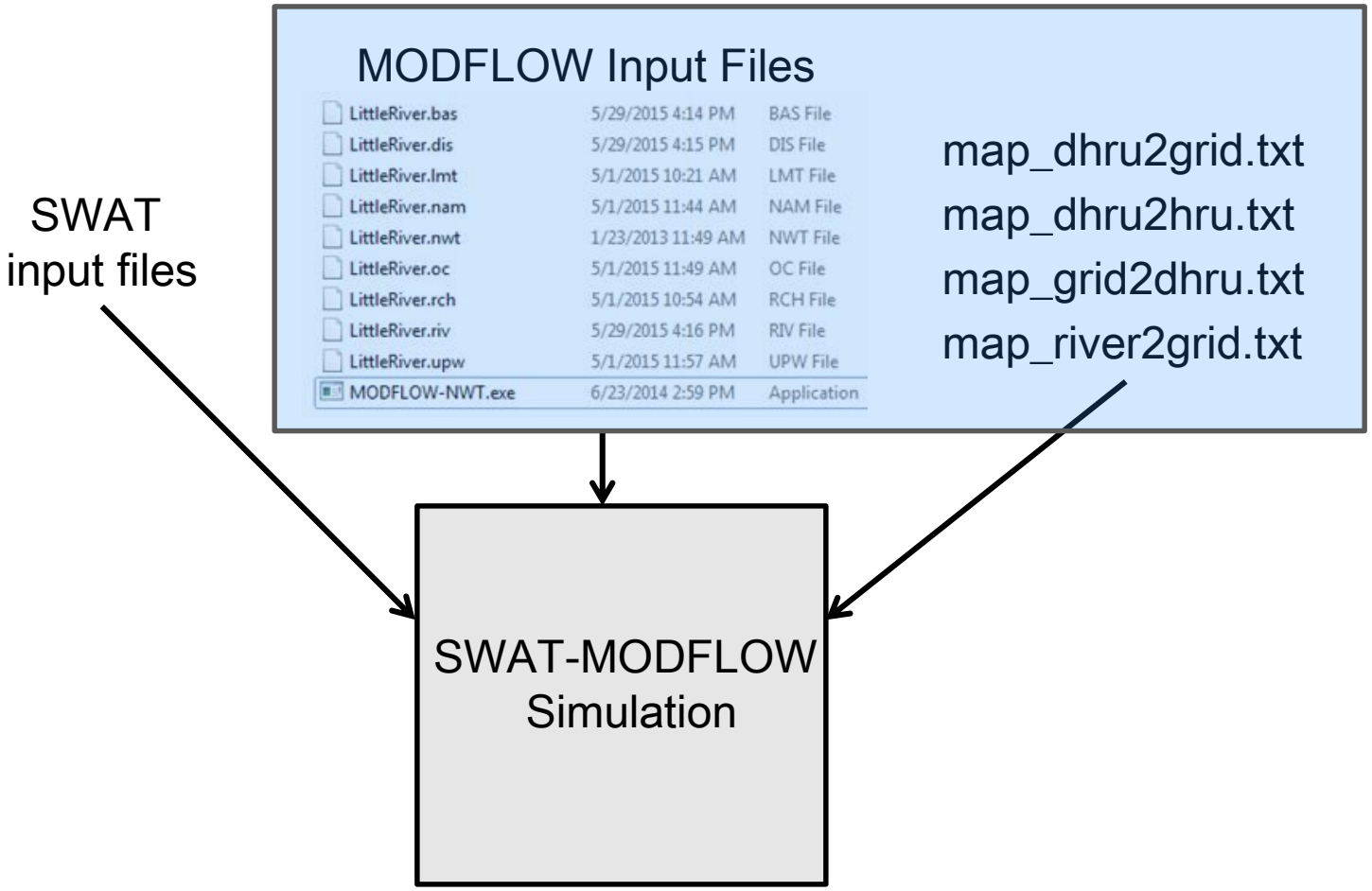
map_dhru2hru.txt

map_grid2dhru.txt

map_river2grid.txt

Model Linkage

User Interface



Klamath Basin, Oregon

SWAT-MODFLOW-RT3D

- Model Overview
- Model Code
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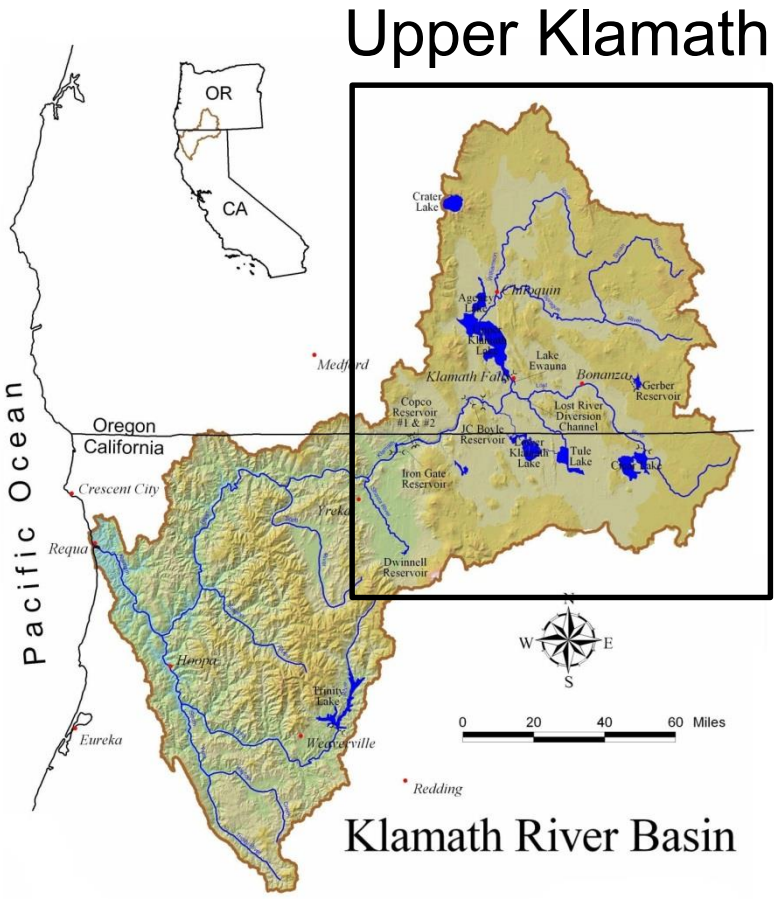
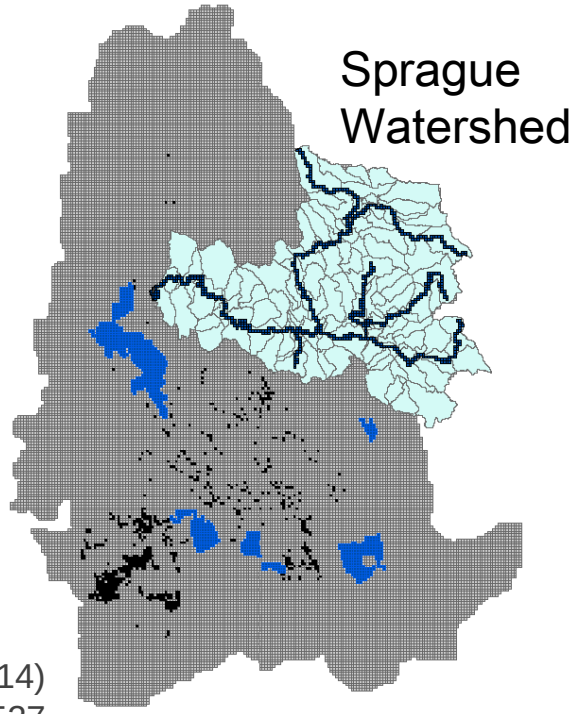
- **Klamath Basin, OR**
- Little River, GA



MODFLOW Model

- USGS (2012)
- 1970-2004
- 100,000 grid cells

SWAT Model



Records et al (2014)
Hydrol. Earth Syst. Sci. 18: 4509–4527

Klamath Basin, Oregon

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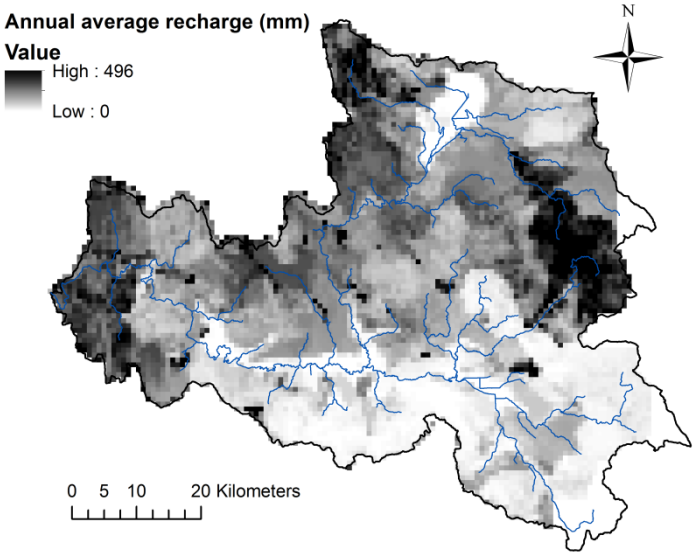
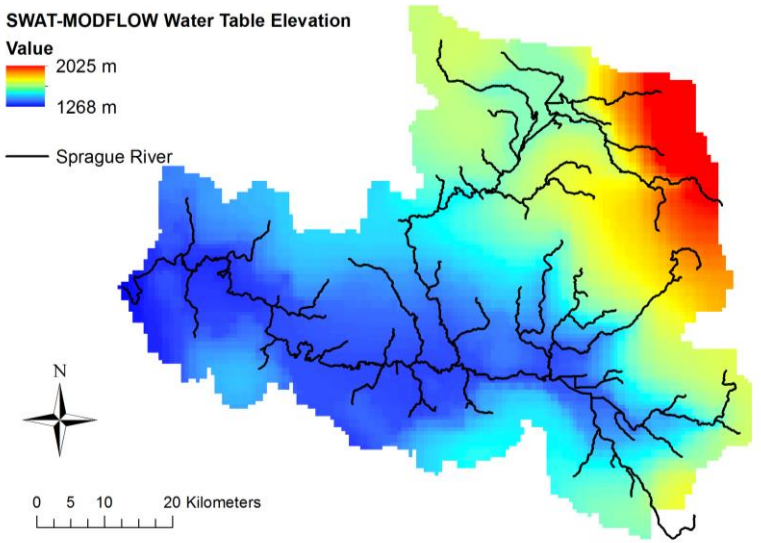
Simulation Results

Annual Recharge



Water Table Elevation



Klamath Basin, Oregon

SWAT-MODFLOW-RT3D

Model Overview

Model Code

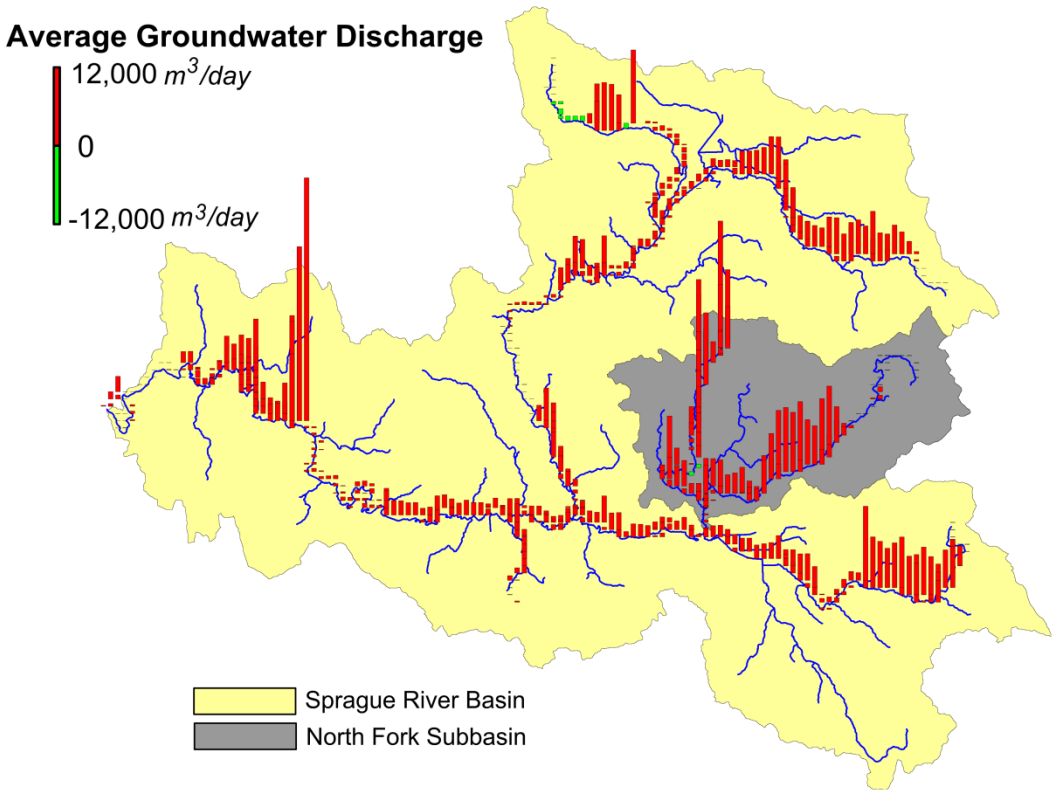
Model Linkage

Klamath Basin, OR

Little River, GA

Simulation Results

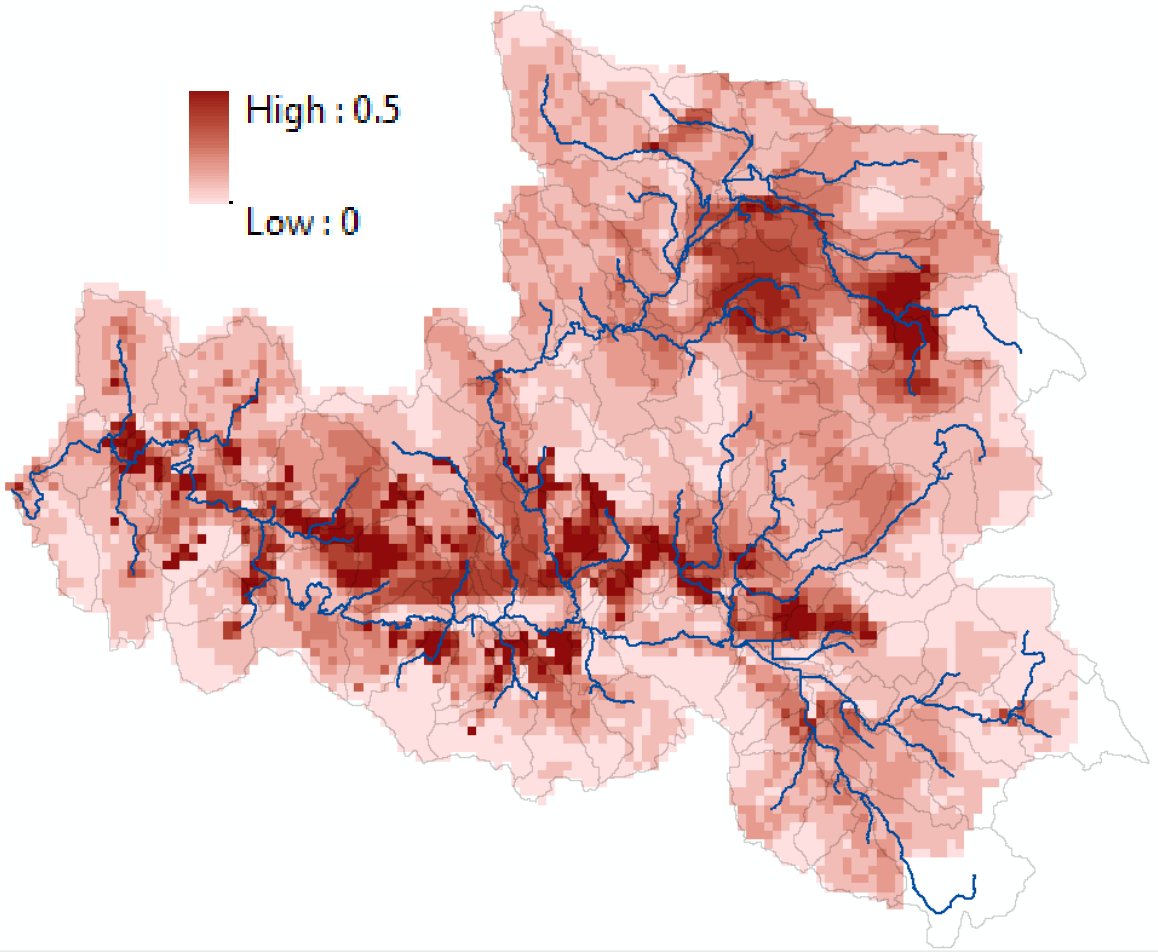
Groundwater Discharge to Streams



Klamath Basin, Oregon

Simulation Results

Nitrate Concentration in Groundwater



Klamath Basin, Oregon

SWAT-MODFLOW-RT3D

Model Overview

Model Code

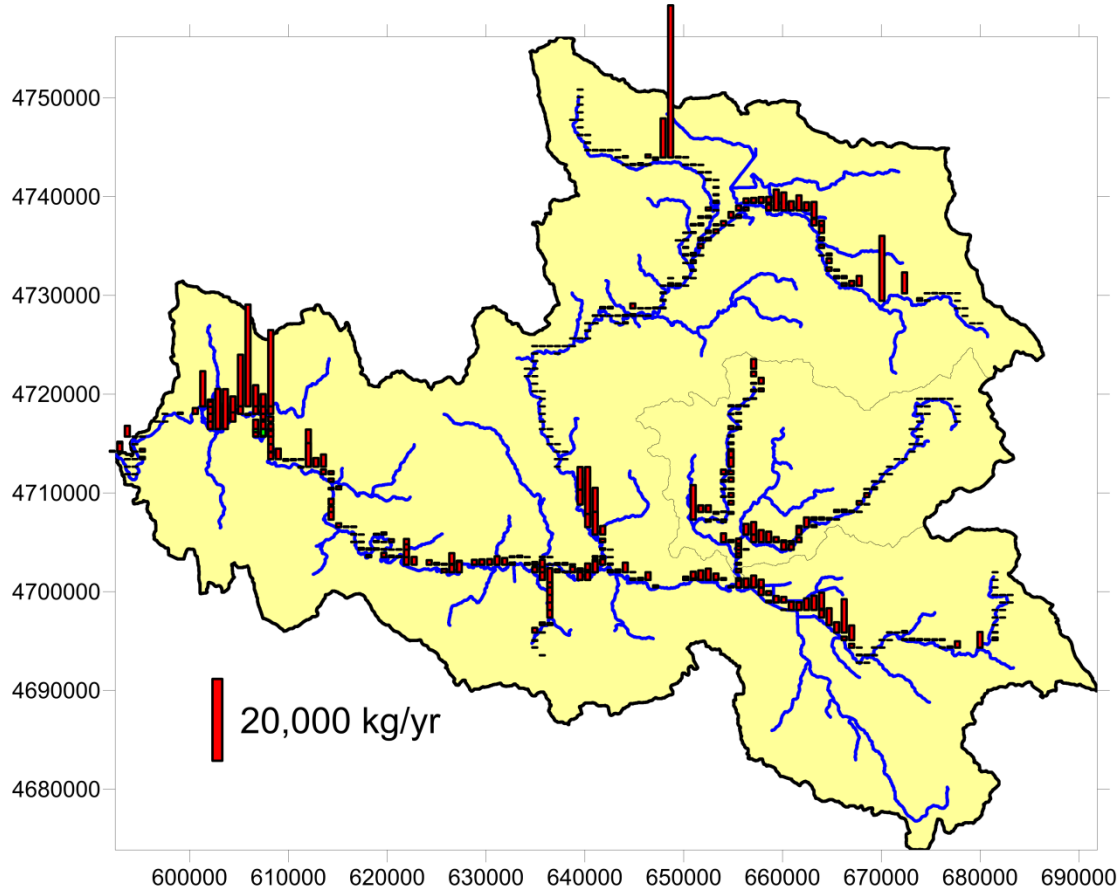
Model Linkage

Klamath Basin, OR

Little River, GA

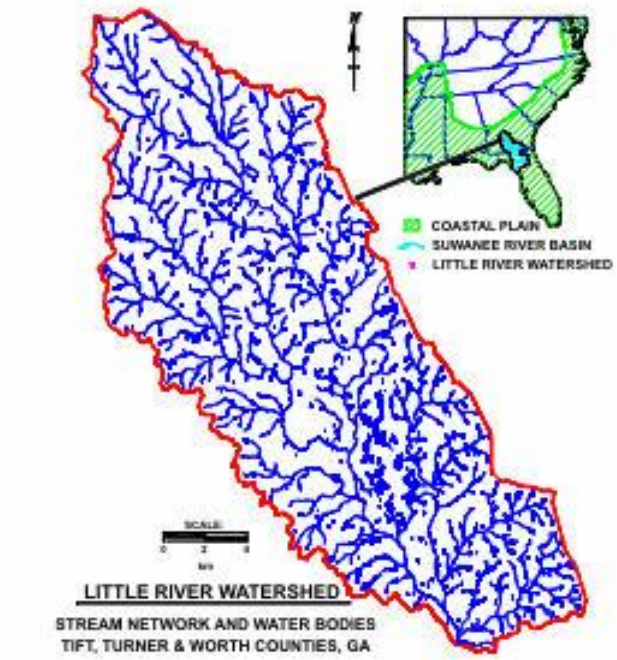
Simulation Results

Groundwater Nitrate Loading to Streams



Little River Watershed, GA

Collaboration with **Grassland, Soil and Water Research Laboratory** (Katrin Bieger, Hendrik Rathjens)

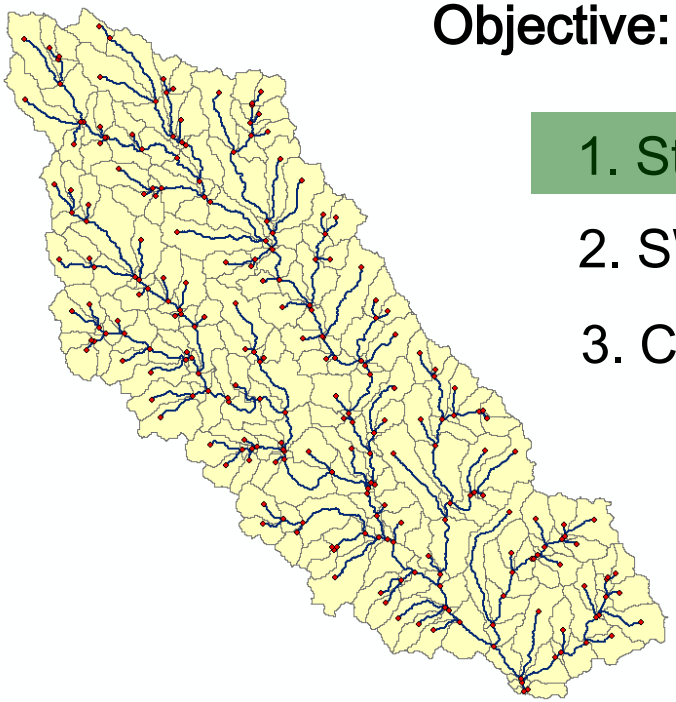


SWAT Model

http://nsidc.org/data/docs/daac/nsidc0329_smex03_little_river_micronet_ga.html

Little River Watershed, GA

Collaboration with **Grassland, Soil and Water Research Laboratory** (Katrin Bieger)



Objective: Couple SWAT with MODFLOW

1. Steady state MODFLOW model
2. SWAT-MODFLOW transient model
3. Calibration and Testing

Little River Watershed, GA

SWAT-MODFLOW-RT3D

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- Klamath Basin, OR
- **Little River, GA**

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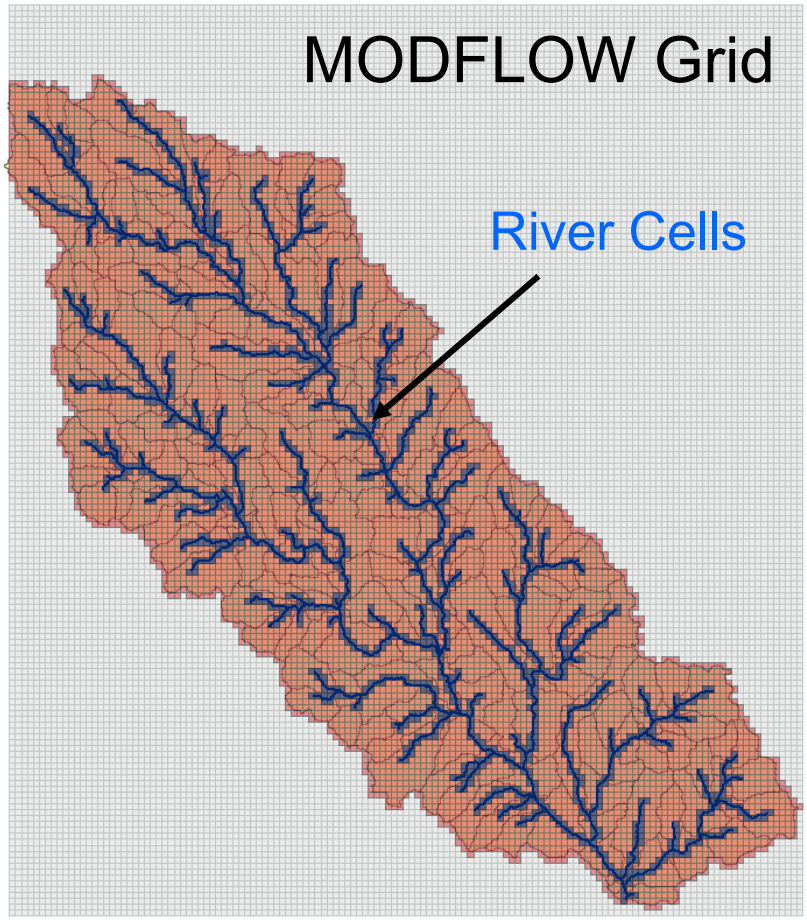
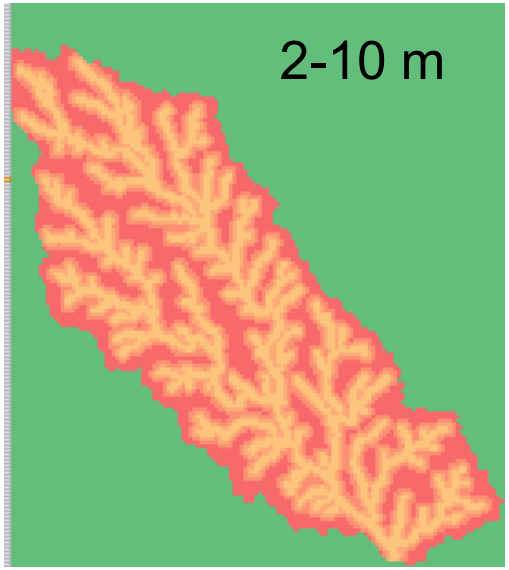


Aquifer Thickness



Little River Watershed, GA

SWAT-MODFLOW-RT3D

Model Overview

Model Code

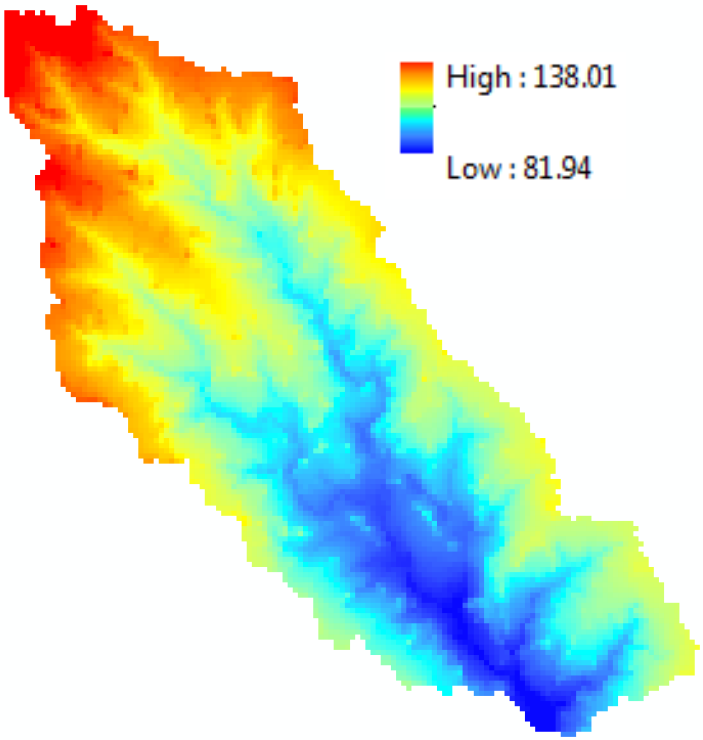
Model Linkage

Klamath Basin, OR

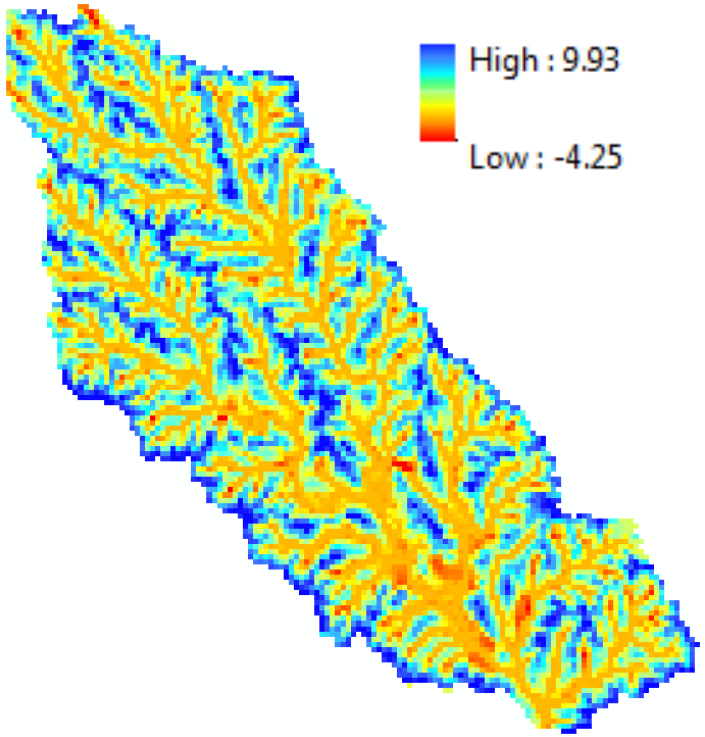
Little River, GA

Simulation Results (Steady Flow)

Groundwater Head



Depth to Water Table



Little River Watershed, GA

SWAT-MODFLOW-RT3D

Model Overview

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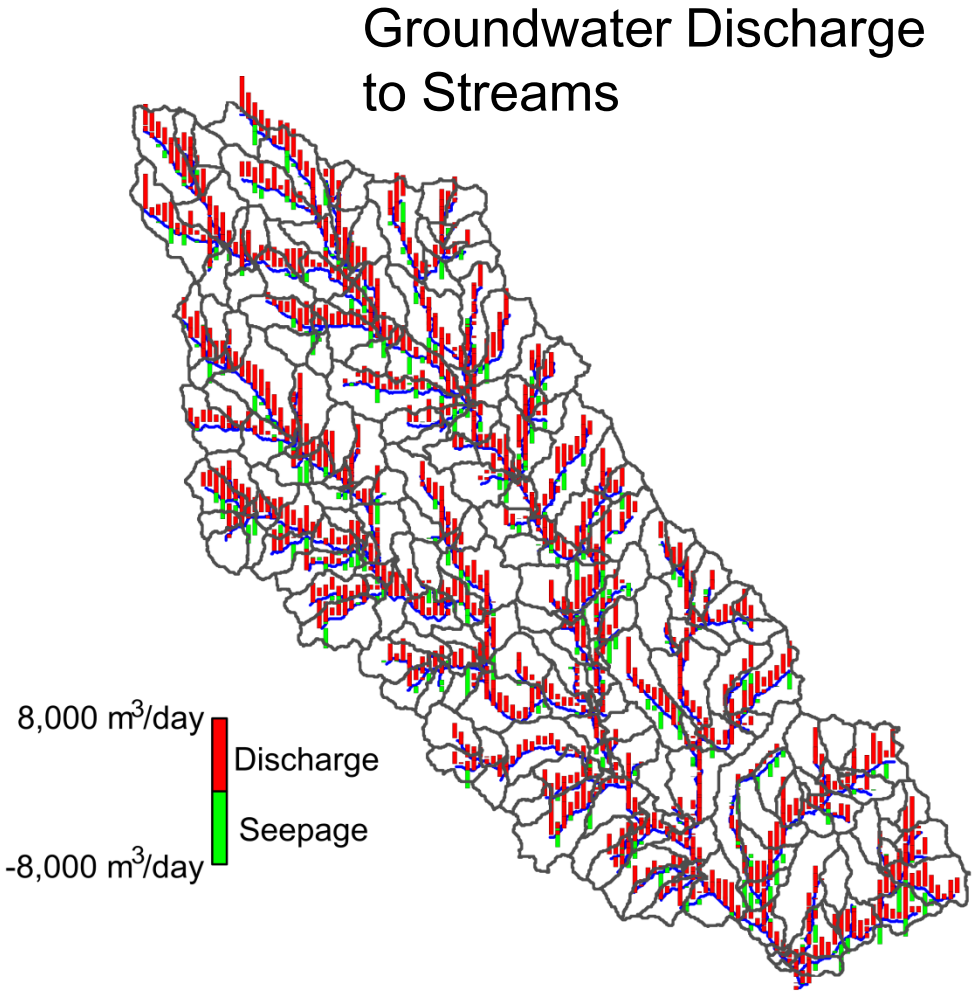
Klamath Basin, OR

Little River, GA

Simulation Results



Colorado State University

SWAT-MODFLOW-RT3D

Model Overview

Model Code

Model Linkage

Klamath Basin, OR

Little River, GA

Summary

- SWAT-MODFLOW-RT3D model
- Applied to two watersheds
- GIS/Java Pre-processing tools for linkage
  - HRU → Disaggregated HRUs
  - DHRUs → Grid Cells
  - Grid Cells→ SWAT subbasins
- Developing: User Interface Hendrik Rathjens
  - Create simple MODLOW model
  - Create linkage files
- Public Domain (SWAT code)

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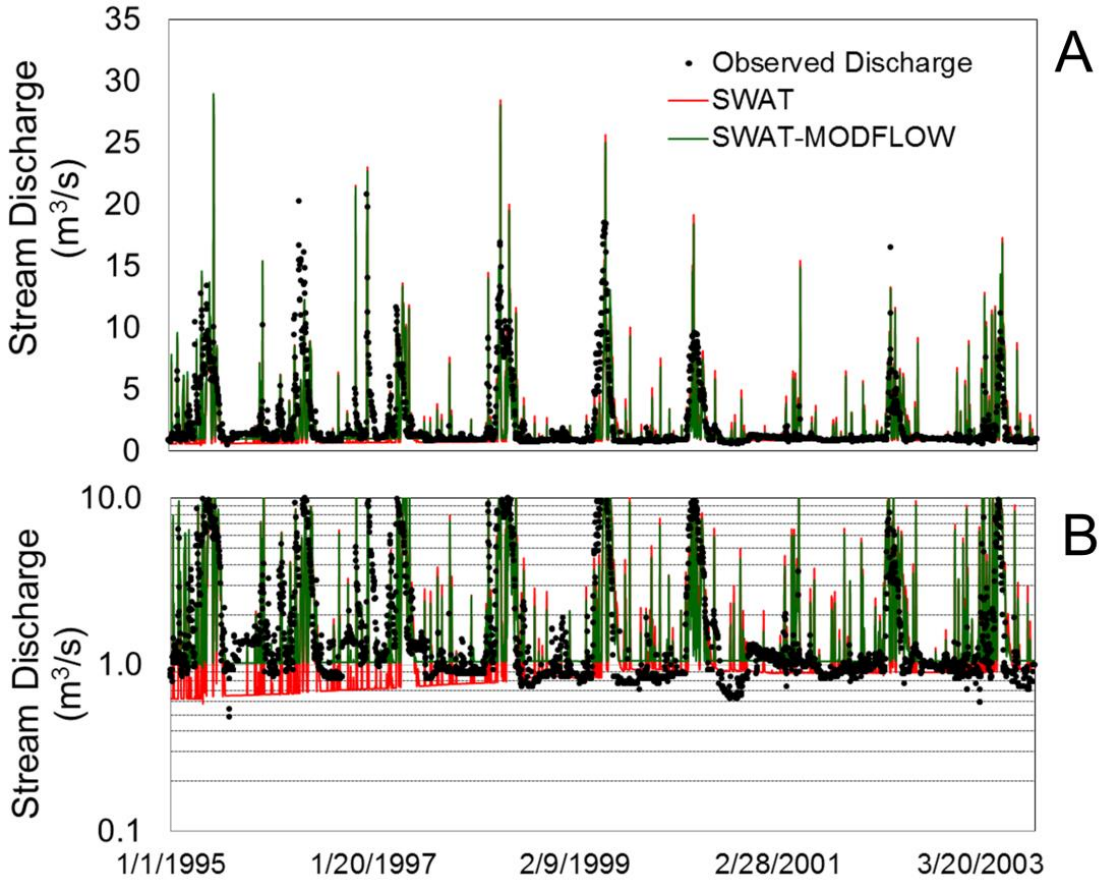
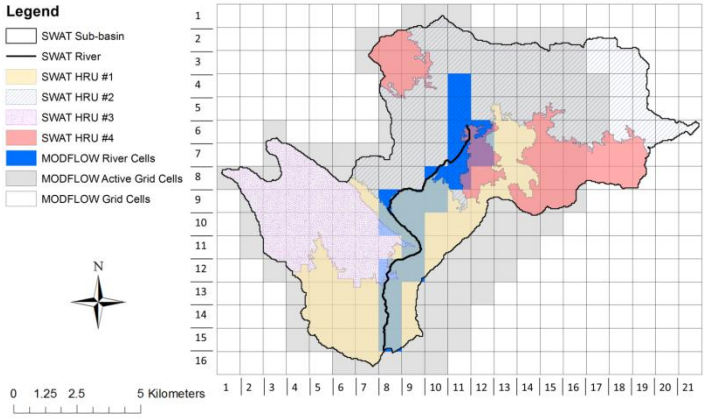
Thank you


A
B
Observed Discharge
SWAT
SWAT-MODFLOW
Stream Discharge (m3/s)
35
30
25
20
15
10
5
0
10.0
1.0
0.1
1/1/1995
1/20/1997
2/9/1999
2/28/2001
3/20/2003

Model Linkage



Intersections

1. HRU → DHRUs
2. DHRUs → Grid Cells
3. River Cells → Subbasin

map_dhru2grid.txt

1_DHRU_grid.csv

```
    6398          2
   11984      17163
 0.54409    0.45591
    6399          7
   11984      12010      12073      12074      12087      12158      12159
 0.75236    0.00447    0.02353    0.02250    0.05780    0.12420    0.01514
    6400          7
   11980      12010      12073      12087      12088      12135      12159
 0.01402    0.01263    0.02147    0.03220    0.00855    0.00853    0.90260
    6401          3
   11980      12135      12159
 0.83127    0.14357    0.02516
```