Using a Single HRU SWAT Model to Examine and Improve Representation of Field-Scale Processes

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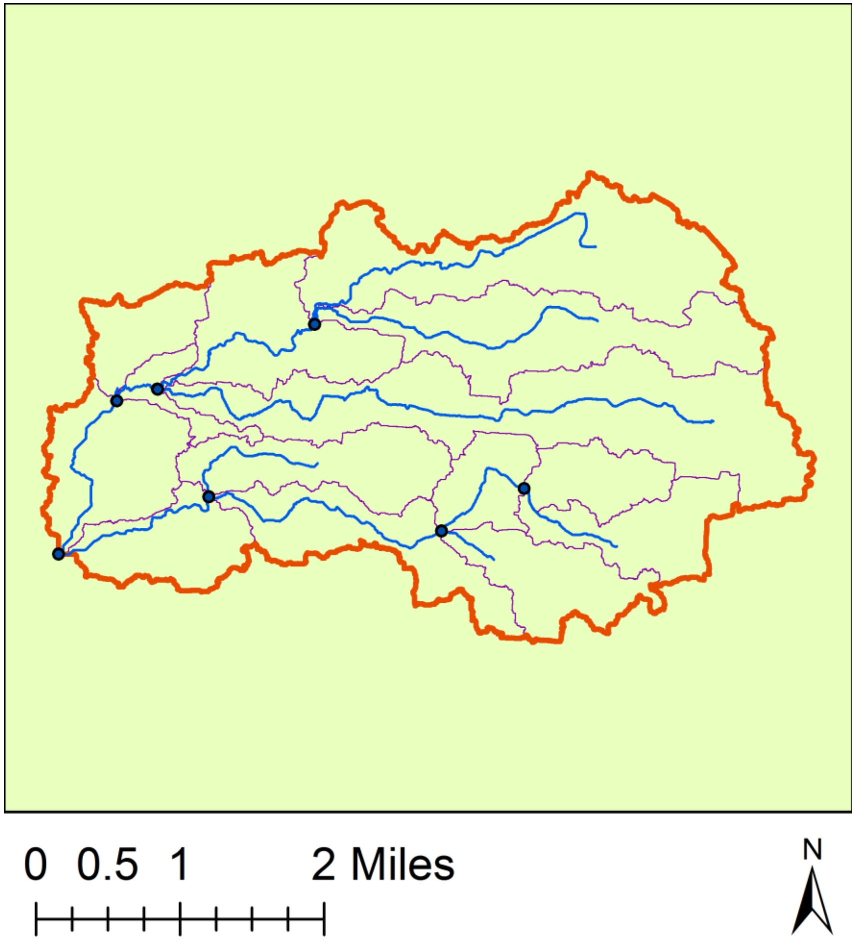
SWAT is a Watershed Scale Model

- Modeling goal is usually to predict water and loads at the watershed outlet
- But simulation starts in the HRUs.



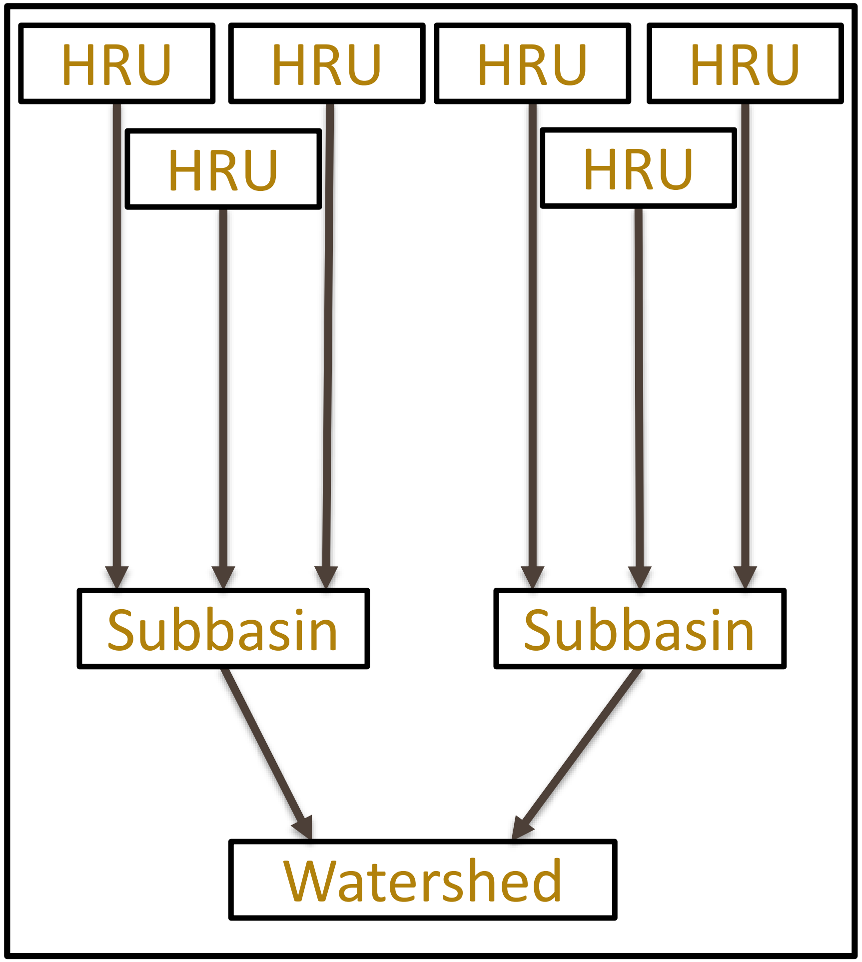
SWAT simulates processes in HRUs, and aggregates them in subbasins

Landscape Processes

- Infiltration
- Tile Drainage
- Plant Growth
- Nutrient use
- etc.

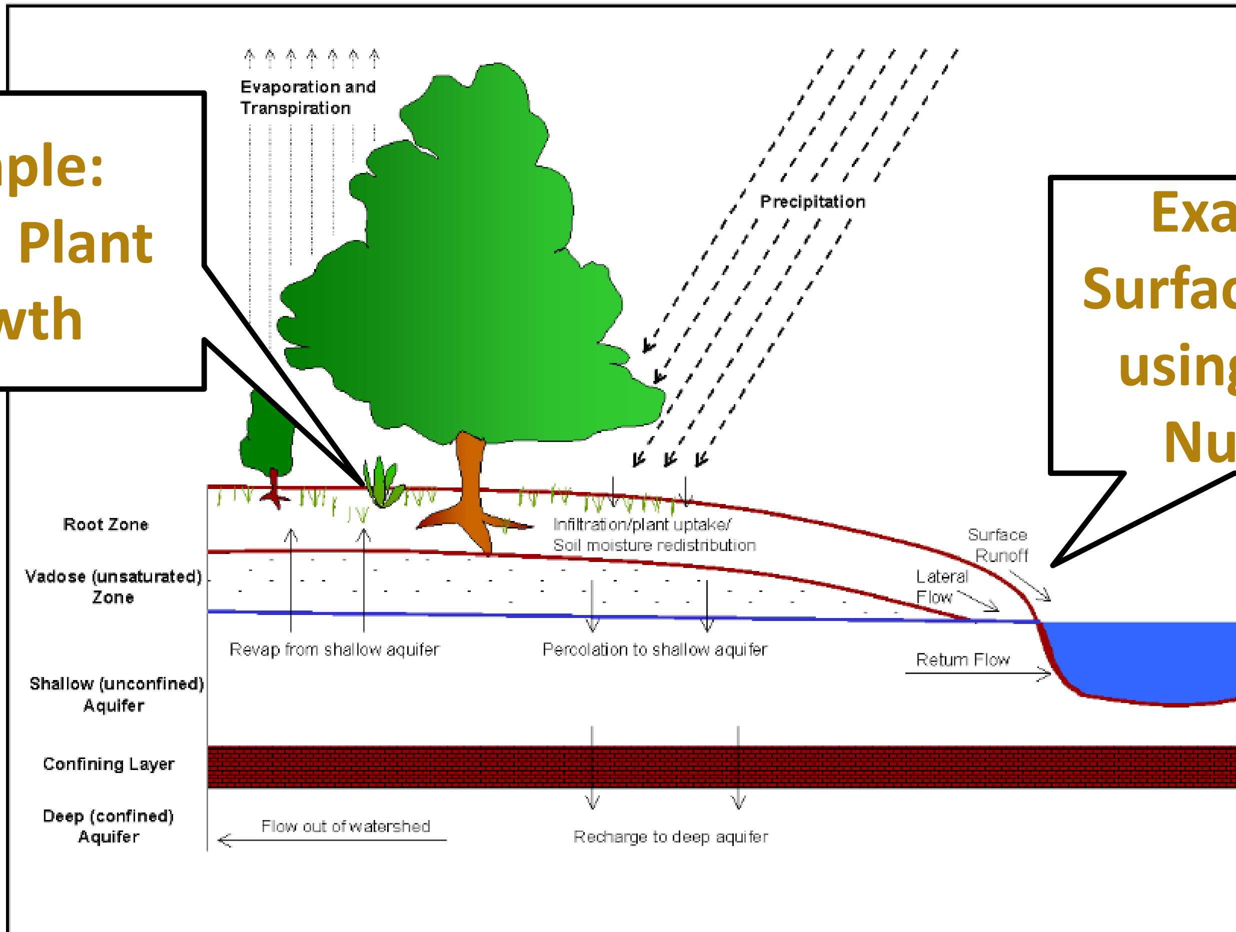
Channel Processes

- Water routing
- Nutrient routing
- And others…



HRU processes: Some have standard methods with years of evaluation.

Example: Annual Plant Growth

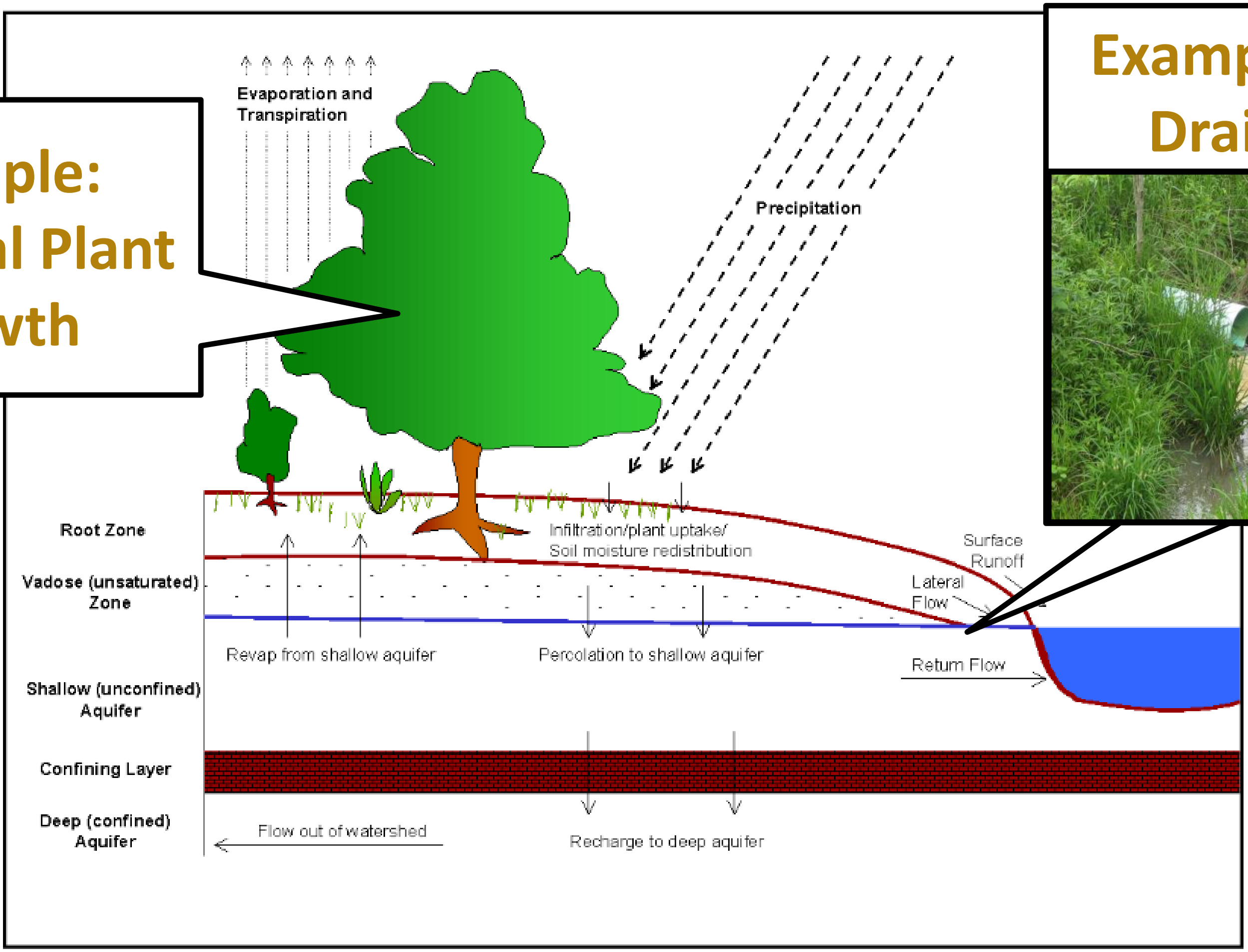


Example: Surface runoff using Curve Number

Image Source: SWAT 2009 Theoretical Documentation

HRU processes: Some have had little evaluation or need to be improved.

Example: Perrenial Plant Growth



Example: Tile Drainage

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Image Source: SWAT 2009 Theoretical Documentation

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- etc.

Channel Processes

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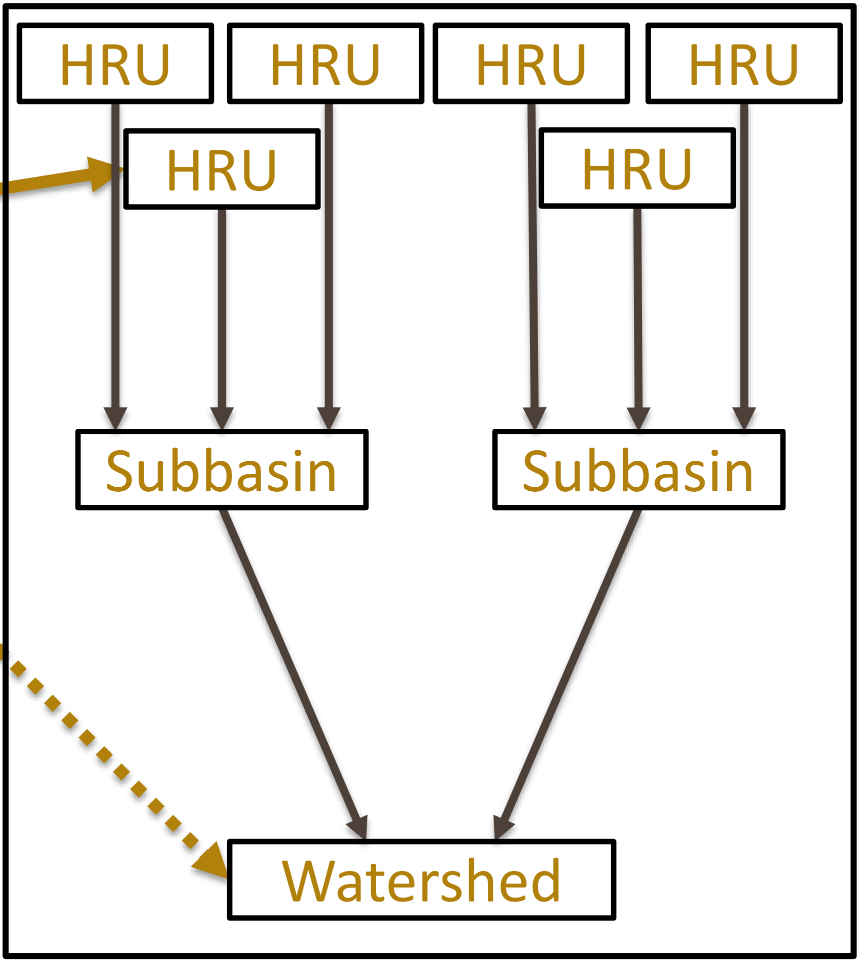

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Single HRU SWAT Model

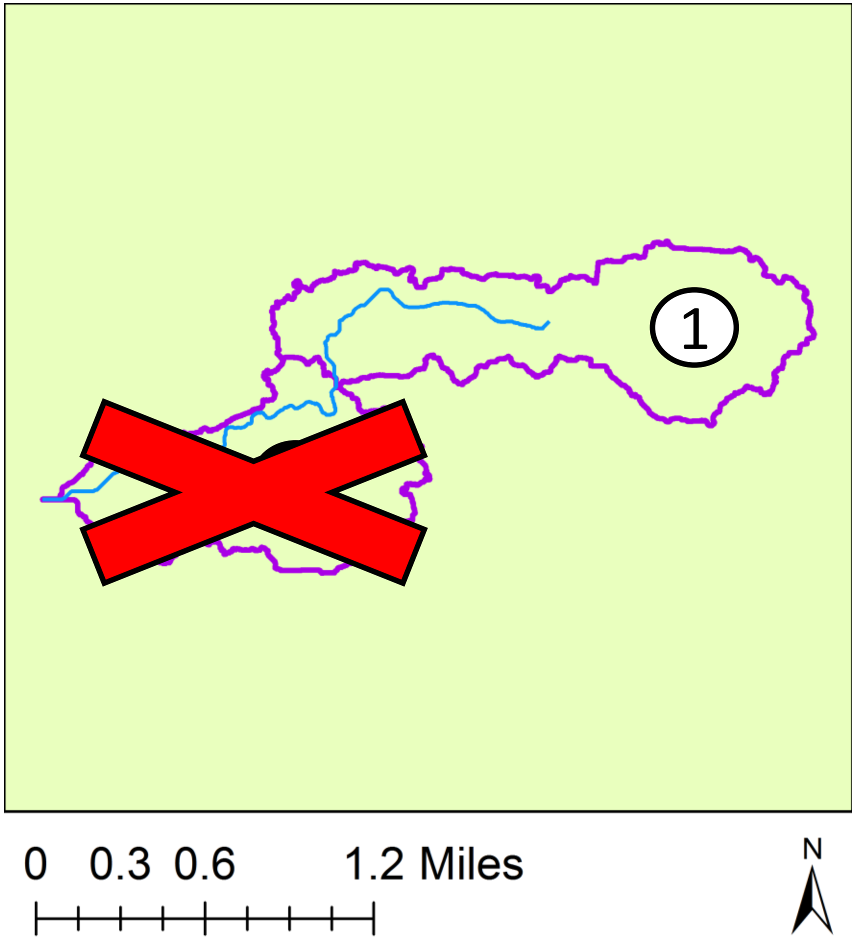
Goal of this presentation

- Demonstrate how to set up a single HRU model for evaluating HRU processes
- Show how a single HRU model was developed to evaluate and improve process for two case studies
  - Perennial plant growth
  - Tile drainage processes

How to set up a single HRU model

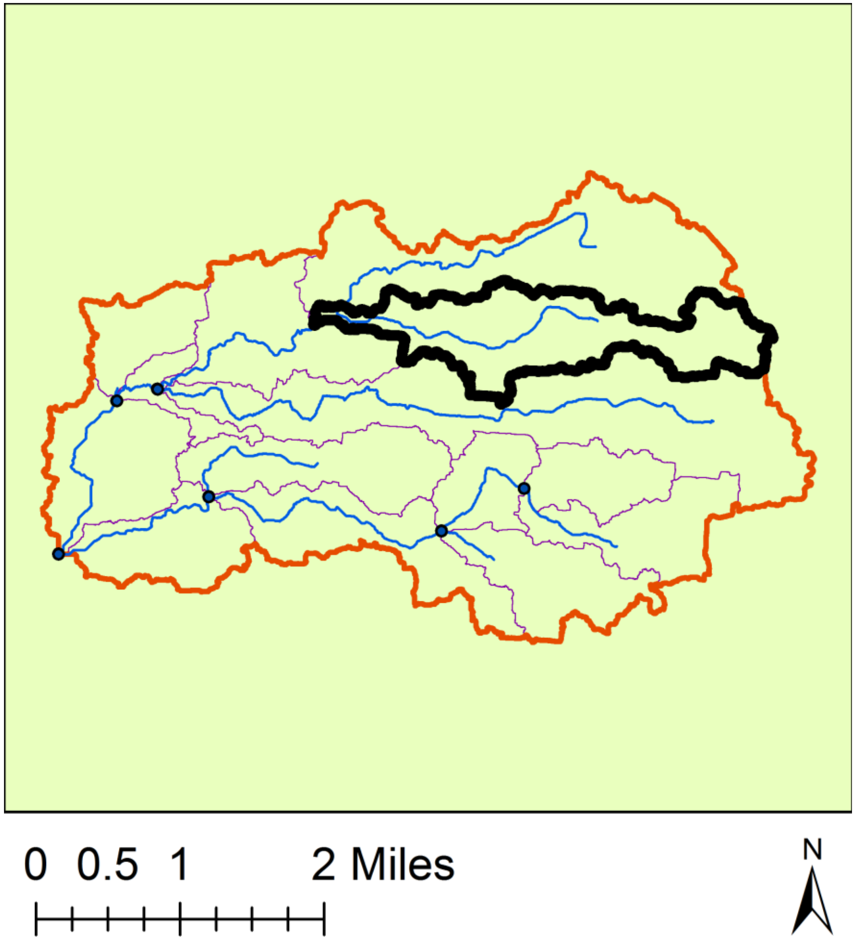
Method 1 – Process from Scratch

1. Set Up in ArcSWAT (or another interface)
2. Delineate 2 subbasins (one the area of interest and one “dummy” subbasin)
3. Move TxtInOut files to separate folder
4. Delete files referring to “dummy” subbasins



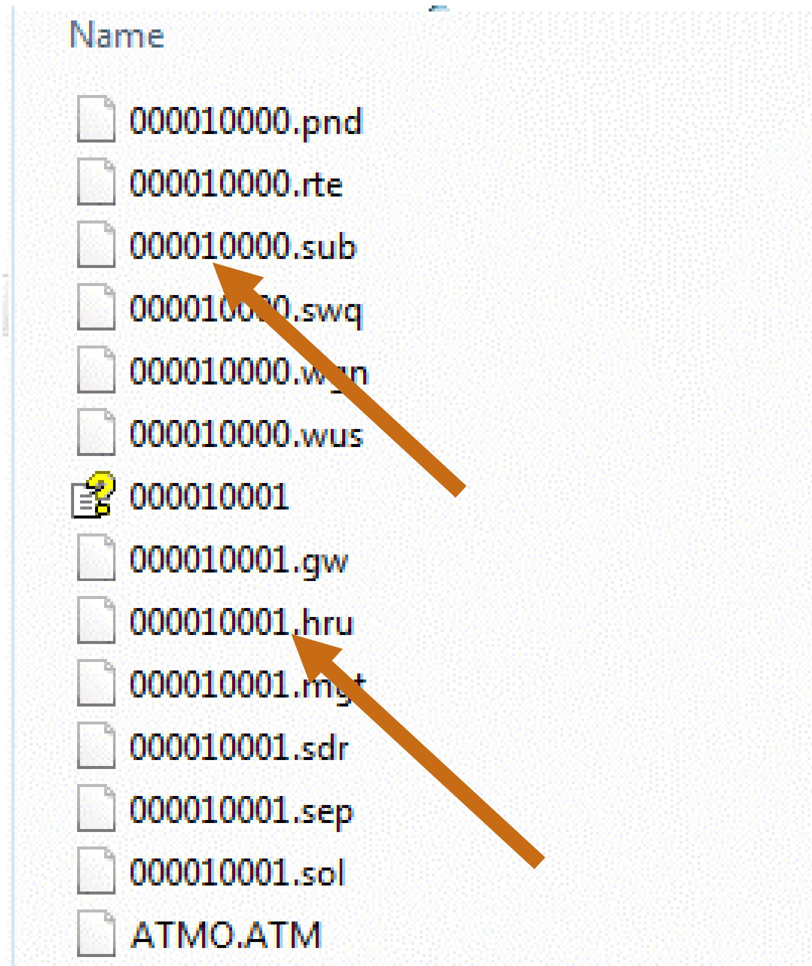
Method 2 – Use existing model

- Start with a calibrated watershed model
- Determine what subbasin and HRU are wanted for analysis
- Copy files from TxtInOut which only refer to the HRU in question



Method 2 – Rename Files

- Renumber files so that your HRU is subbasin 1, HRU 1
- Example: Subbasin 2, HRU 5
- 000020000.sub → 000010000.sub
- 000020005.hru → 000010001.hru



Method 2 – Modify HRU File

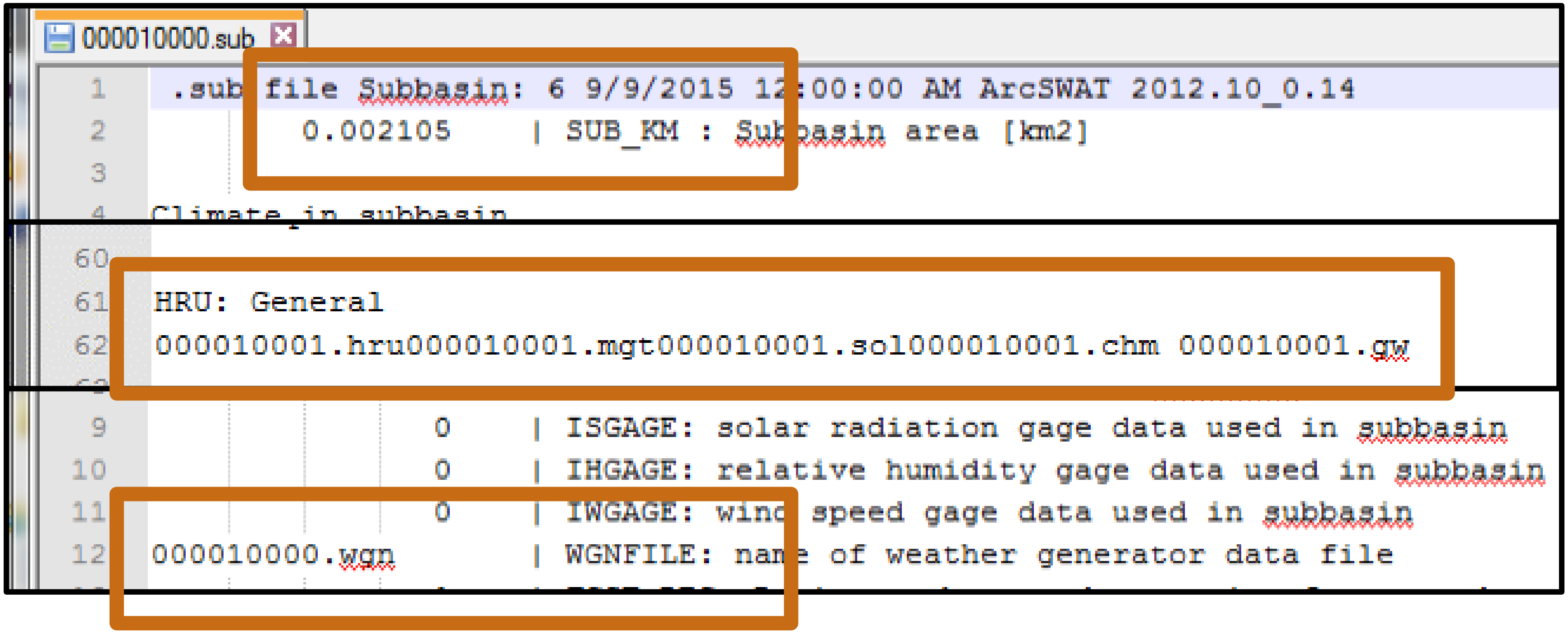
- In 000010001.hru, change HRU_FR in to 1, to take up 100% of subbasin

000010001.hru

```
 .hru file Watershed HRU:2 Subbasin:2 HRU:1 Luse:AGRR Soil: 633185 Slope: 0-
                 1       | HRU_FR : Fraction of subbasin area contained in HRU
           121.951       | SLSUBBSN : Average slope length [m]
             0.007       | HRU_SLP : Average slope stepness [m/m]
             0.140       | OV_N : Manning's "n" value for overland flow
             0.000       | LAT_TTIME : Lateral flow travel time [days]
             0.000       | LAT_SED : Sediment concentration in lateral flow and
             0.000       | SLSOIL : Slope length for lateral subsurface flow [m]
```

Method 2 – Modify Subbasin File

- Change 000010000.sub area and references to any other HRU


000010000.sub

```
.sub file Subbasin: 6 9/9/2015 12:00:00 AM ArcSWAT 2012.10_0.14
        0.002105    | SUB_KM : Subbasin area [km2]

Climate in subbasin

HRU: General
000010001.hru000010001.mgt000010001.sol000010001.chm 000010001.gw

              0    | ISGAGE: solar radiation gage data used in subbasin
              0    | IHGAGE: relative humidity gage data used in subbasin
              0    | IWGAGE: wind speed gage data used in subbasin
000010000.wgn      | WGNFILE: name of weather generator data file
```

Methods 1 and 2 – Modify fig.fig

```
Subbasin   1   1   1                 Subbasin: 1
        000010000.sub
Route      2   2   1   1
        000010000.rte000010000.swq
Finish     0
```

Resulting input.std

```
Subbasin Input Summary:
   Sub    Latitude Elev(m)   #HRUs Ponds Elevbnds
   1      39.02    238.71    1

HRU Input Summary Table 1:
   Sub    HRU    Area(ha) Slope SlpLgth(m)   Ovrlnd_N
   1      1      0.21     0.007 121.95       0.140

HRU CN Input Summary Table:
   Sub    HRU    Area(ha) LULC  Soil      CN1   CN2
   1      1      0.21     AGRR  Cobbsfor 64.0  80.8

HRU Input Summary Table 2:
   Sub    HRU    Area(ha) SoilName     Hydgrp    MaxRtDpth
   1      1      0.21     Cobbsfork    C         2000.00
```

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Single HRU SWAT Model

Resulting input.std (cont.)

```
HRU Input Summary Table 3:
   Sub    HRU    Area(ha) Urban Irrig DrainTiles
   1      1      0.21                 x

HRU Input Summary Table 4 (Groundwater):
   Sub    HRU    Area(ha) GWdelay(days), GWalpha(days)
   1      1      0.21     31.000         0.048

Tributary/Main Channel Characteristics
         |-------------Tributary--------------------
   Sub    Length(km)   Slope Width(m)  Cond(mm/hr)
   1      0.01         0.000 0.03      0.0000
```

Example 1 – Perennial Crop Growth

- No parameters available for simulating the perennial bioenergy crops *Miscanthus* and upland switchgrass

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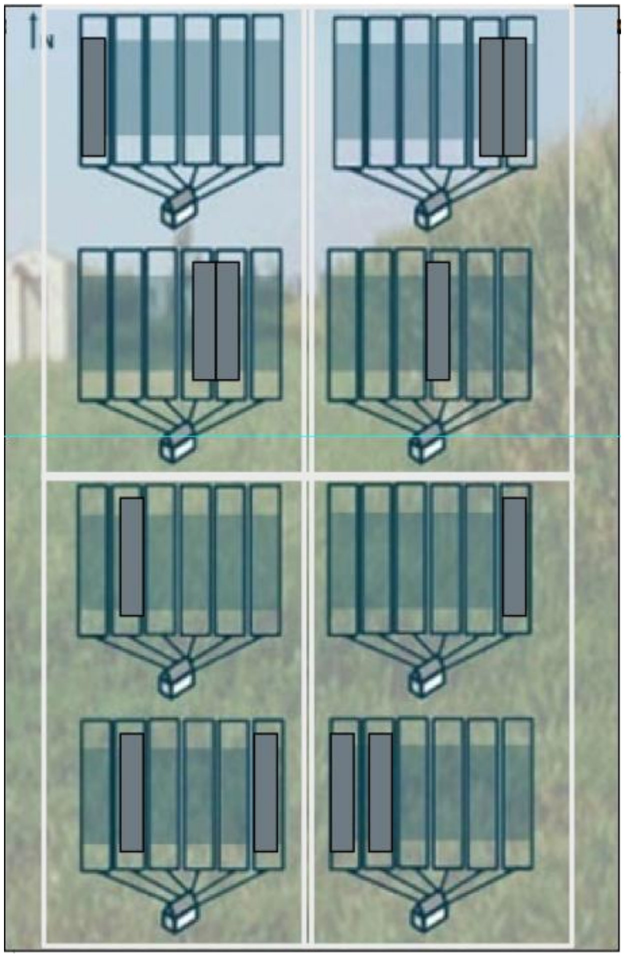
Trybula, E. M., Cibin, R., Burks, J. L., Chaubey, I., Brouder, S. M., & Volenec, J. J. (2014). Perennial rhizomatous grasses as bioenergy feedstock in SWAT: parameter development and model improvement. *GCB Bioenergy*. doi:10.1111/gcbb.12210

Data were collected at Purdue's Water Quality Field Station



- Field tour available Thursday of this site

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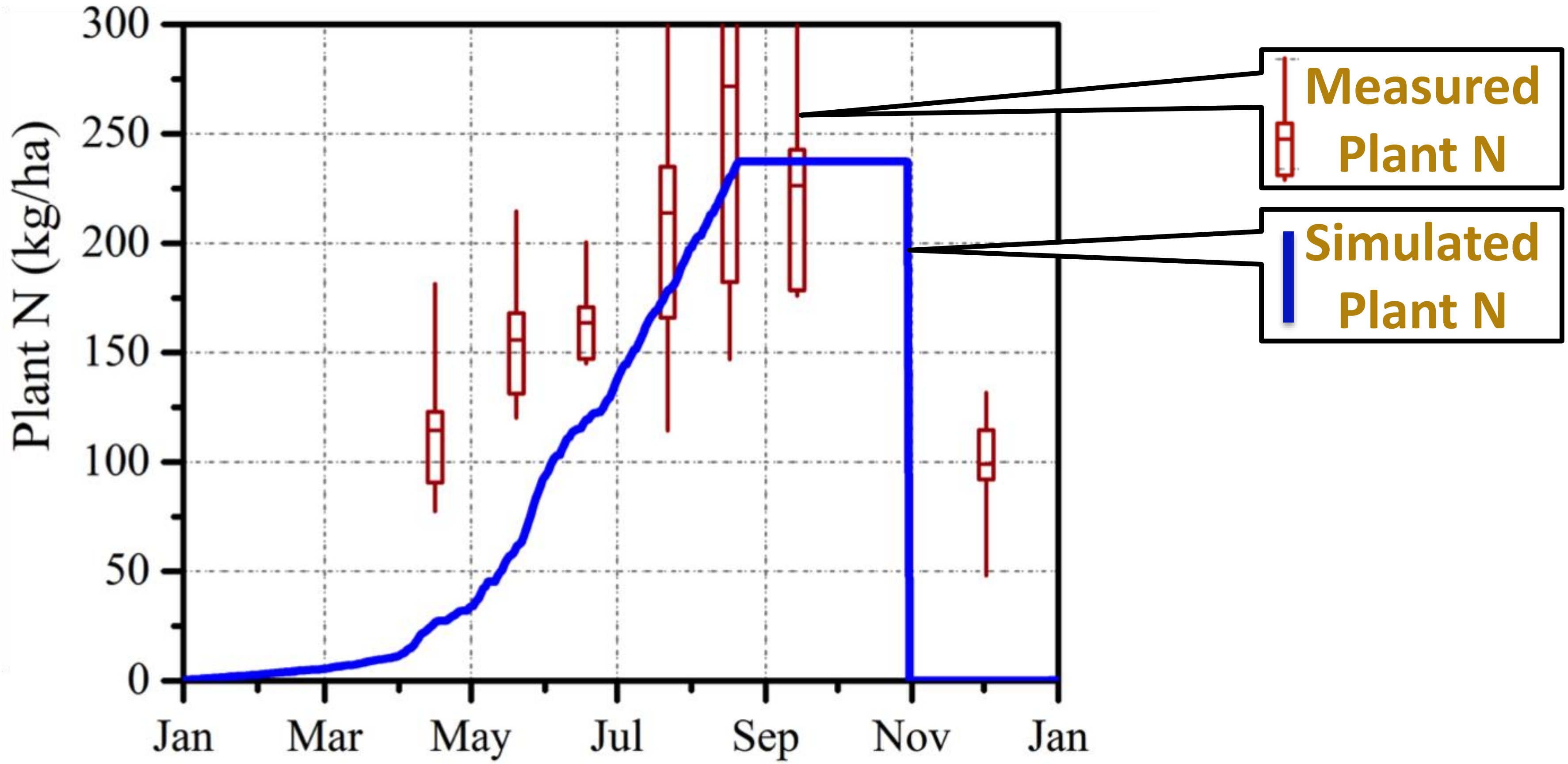
Single HRU SWAT Model

Plant biomass and nutrient content was measured throughout the season

Examples:

- Biomass
- Plant N & P
- Biomass yield
- Field residue after harvest

Simulated single HRU Plant N was plotted against measured Plant N



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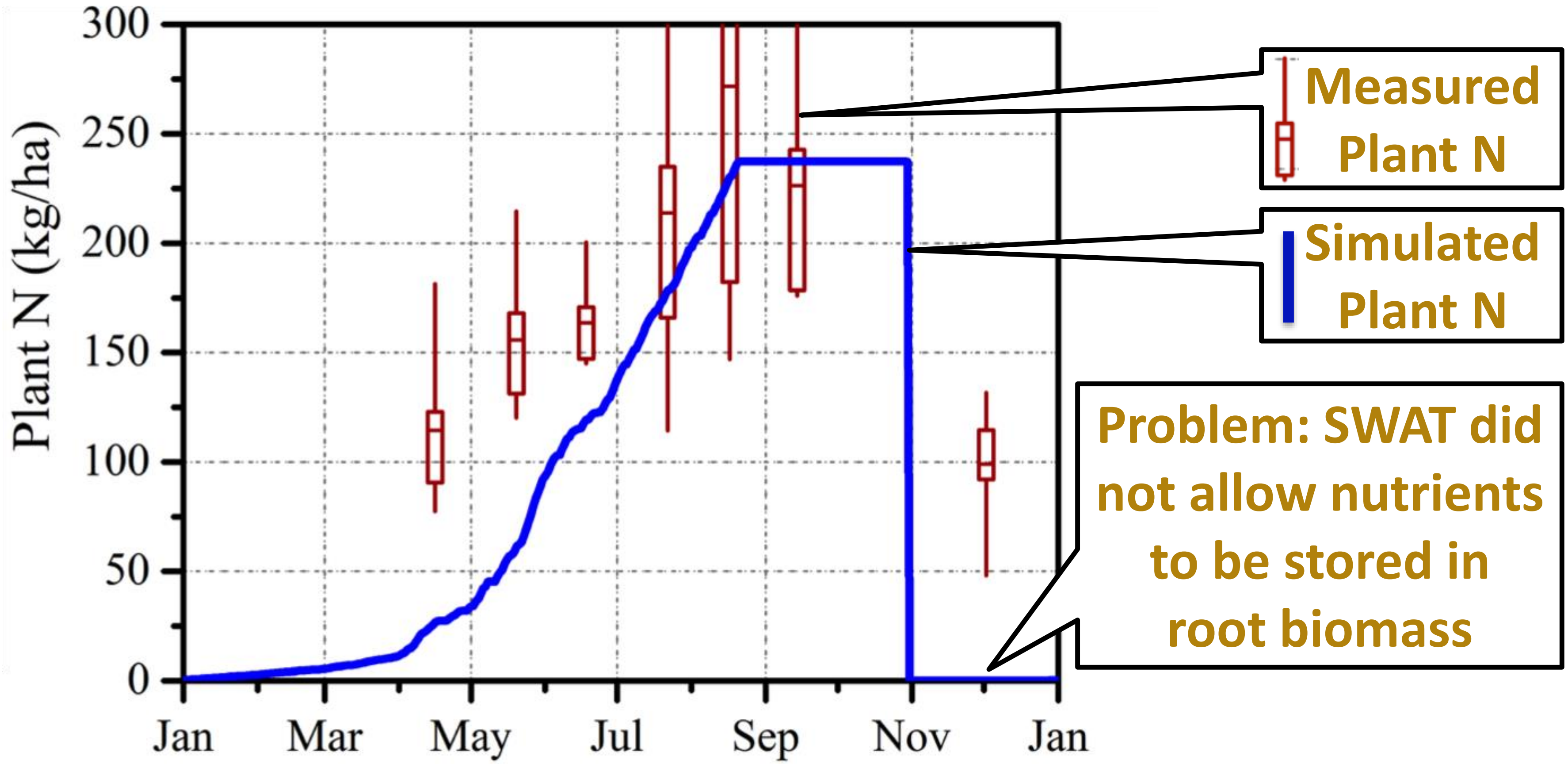
Single HRU SWAT Model

Even with measured parameters, plant N was not well simulated by SWAT.



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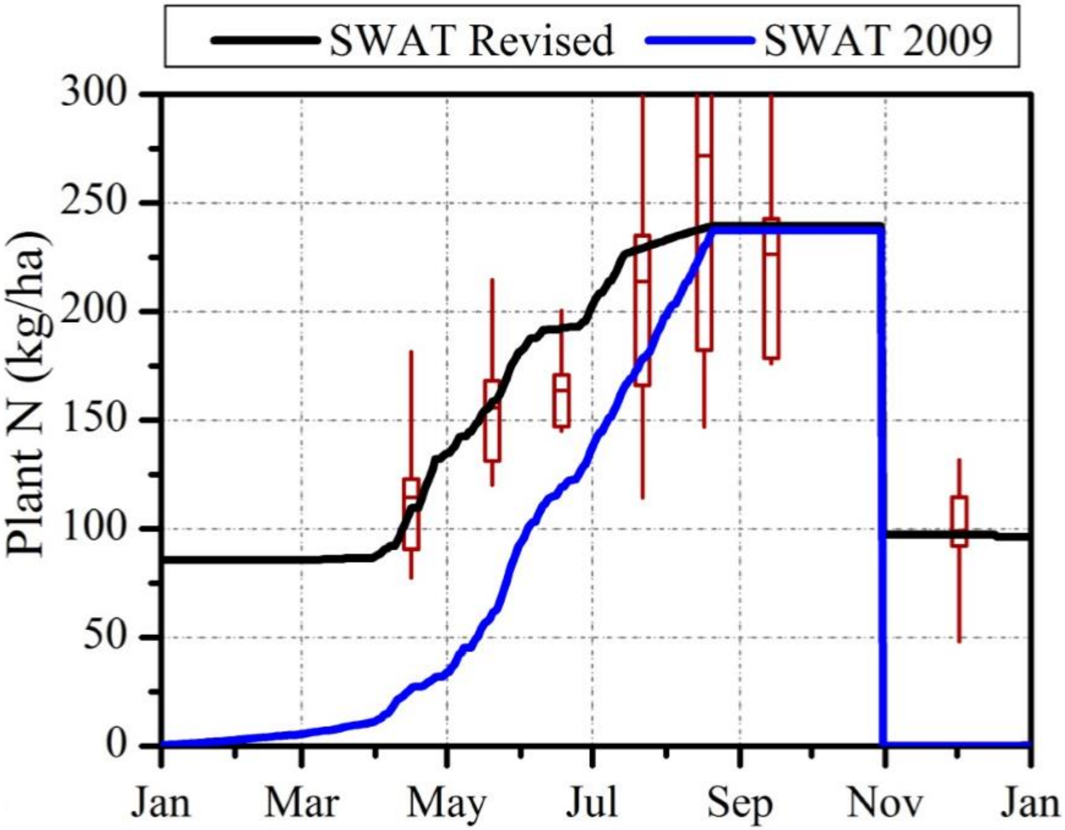
Single HRU SWAT Model

Improved growth algorithms maintain below-ground biomass at harvest.



The Single HRU model allowed for extensive testing of the existing and improved plant growth algorithm with field-measured data.

Available in SWAT 2012 and later

Single HRU SWAT Model

Example 2 – Tile Drainage

- Moriasi et al. (2012) implemented the Hooghoudt and Kirkham equations into the tile drain routine
- Method has been tested at the watershed scale
- No published testing of tile flow directly

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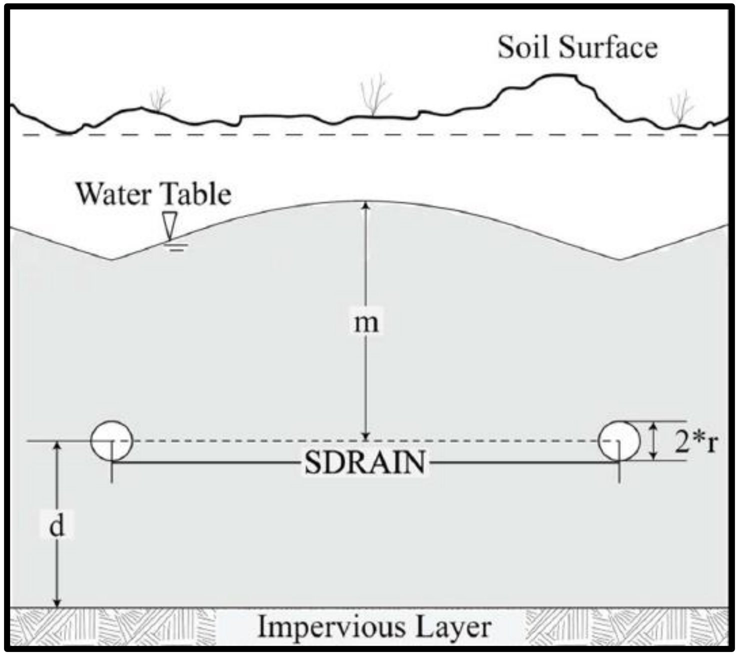
Moriasi, D. N., Rossi, C. G., Arnold, J. G., & Tomer, M. D. (2012). Evaluating hydrology of the Soil and Water Assessment Tool (SWAT) with new tile drain equations. Journal of Soil and Water Conservation, 67(6), 513-524. doi:10.2489/jswc.67.6.513

Example 2 – Tile Drainage Equations

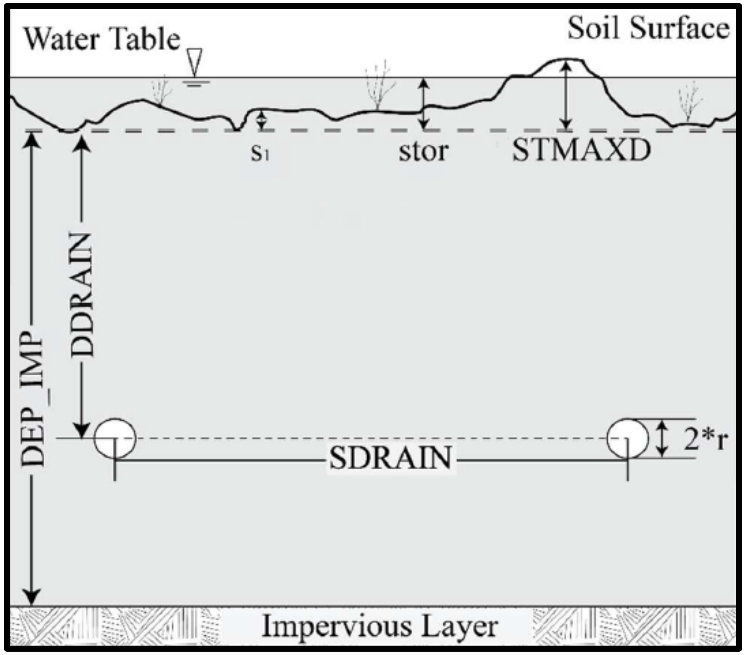
Hooghoudt

$$q = \frac{8\pi K_e d_e m + 4K_e m^2}{C(SDRAIN^2)}$$



Kirkham

$$q = \frac{4\pi K_e(stor + DDRAIN - r)}{g(SDRAIN)}$$



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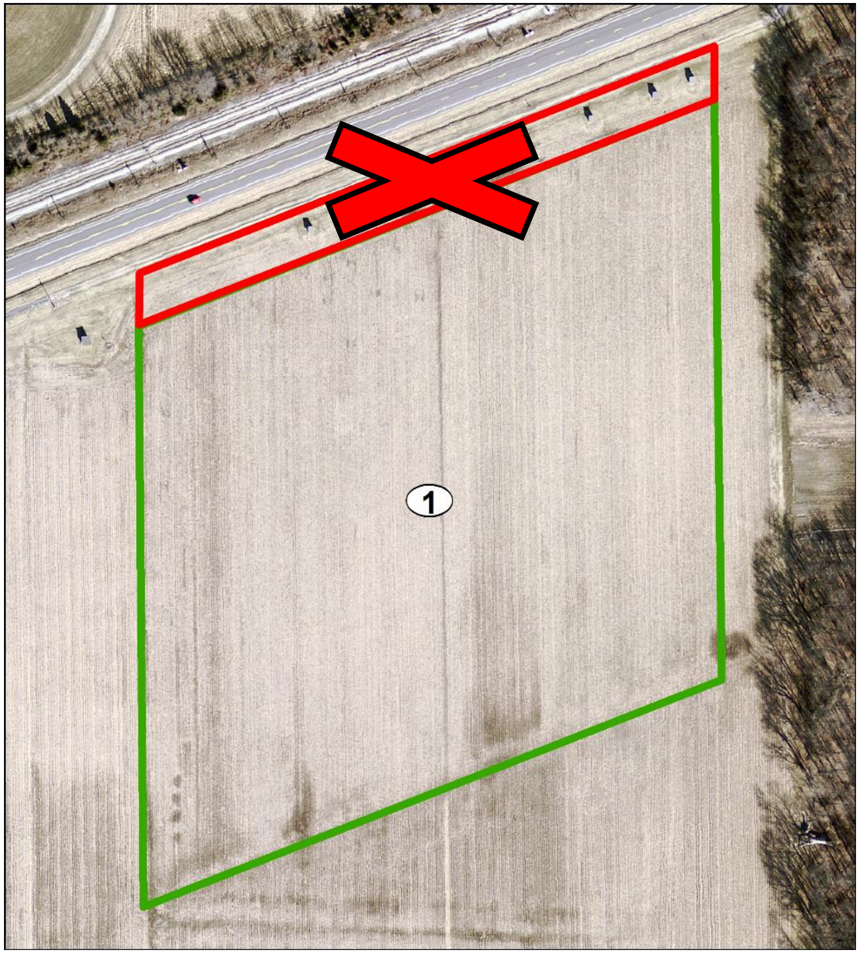
Single HRU SWAT Model

Example 2 – Tile Drainage

- Tiled field delineated as a subbasin
- “Dummy” subbasin was created and eliminated.
- Modeled for 16 years



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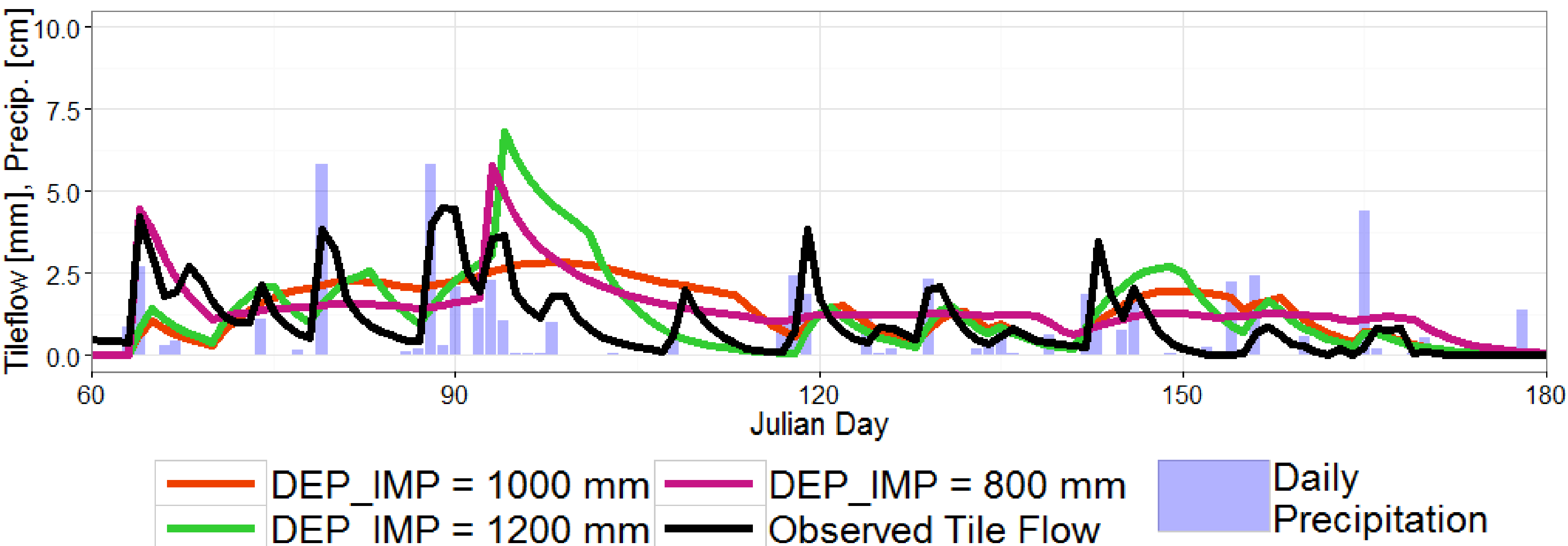
Single HRU SWAT Model

Depth to Impervious Layer

- Controls two properties of soil profile: Depth to Impervious Layer and Permeability of the soil profile



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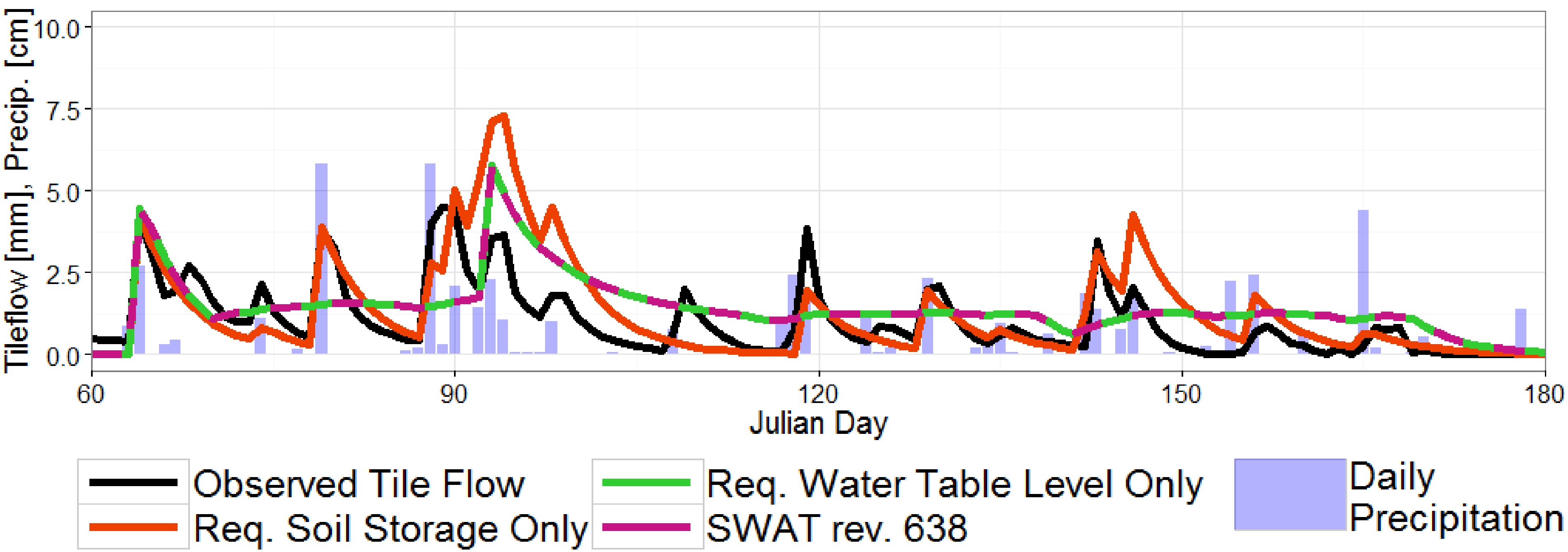
Effect of Kirkham Trigger

- Rev. 638 has two conditions to trigger Kirkham: Water Storage (storro) and Water Table (y1)



Single HRU SWAT Model

Example 2 – Effect of LATKSATF and Kirkham

Proposed changes:

- Changing parameters dictating using Kirkham over Hooghoudt
- DEP_IMP parameter controls depth to impervious layer AND seepage through layer

Example 3 – Improved physical representation of vegetative filter strip

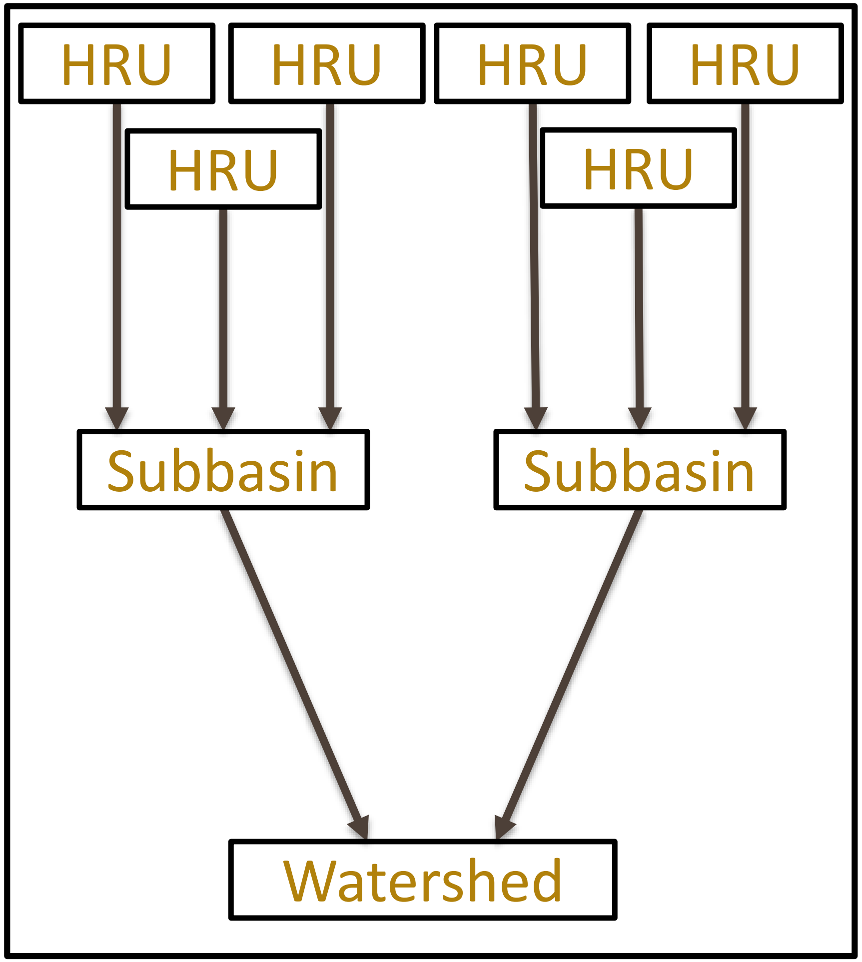
Presentation by Cibin Raj

Model Development Session (K2)

Friday October 16th at 1:30 PM

Conclusion: A Single HRU model is appropriate for testing HRU processes

- **HRU processes** should be evaluated at the **HRU level.**
- Single HRU models provide a rapid and efficient way to use field measurements to test and improve these processes.
- cmoloney@purdue.edu



Single HRU SWAT Model

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