Incorporation of Landscape Processes in a Watershed/River Basin Scale Model

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Grassland Soil and Water Research Laboratory

Objectives

1) Develop a simple yet realistic model for Landscape Processes and Incorporate into the SWAT watershed model

2) Compare and validate 4 landscape delineation methods at the USDA-ARS Station G experimental watershed at Riesel, Texas

3) Test model's capability of simulating Hortonian and Saturation Excess

4) Realistically simulate riparian zones, flood plains, potholes, variable source areas

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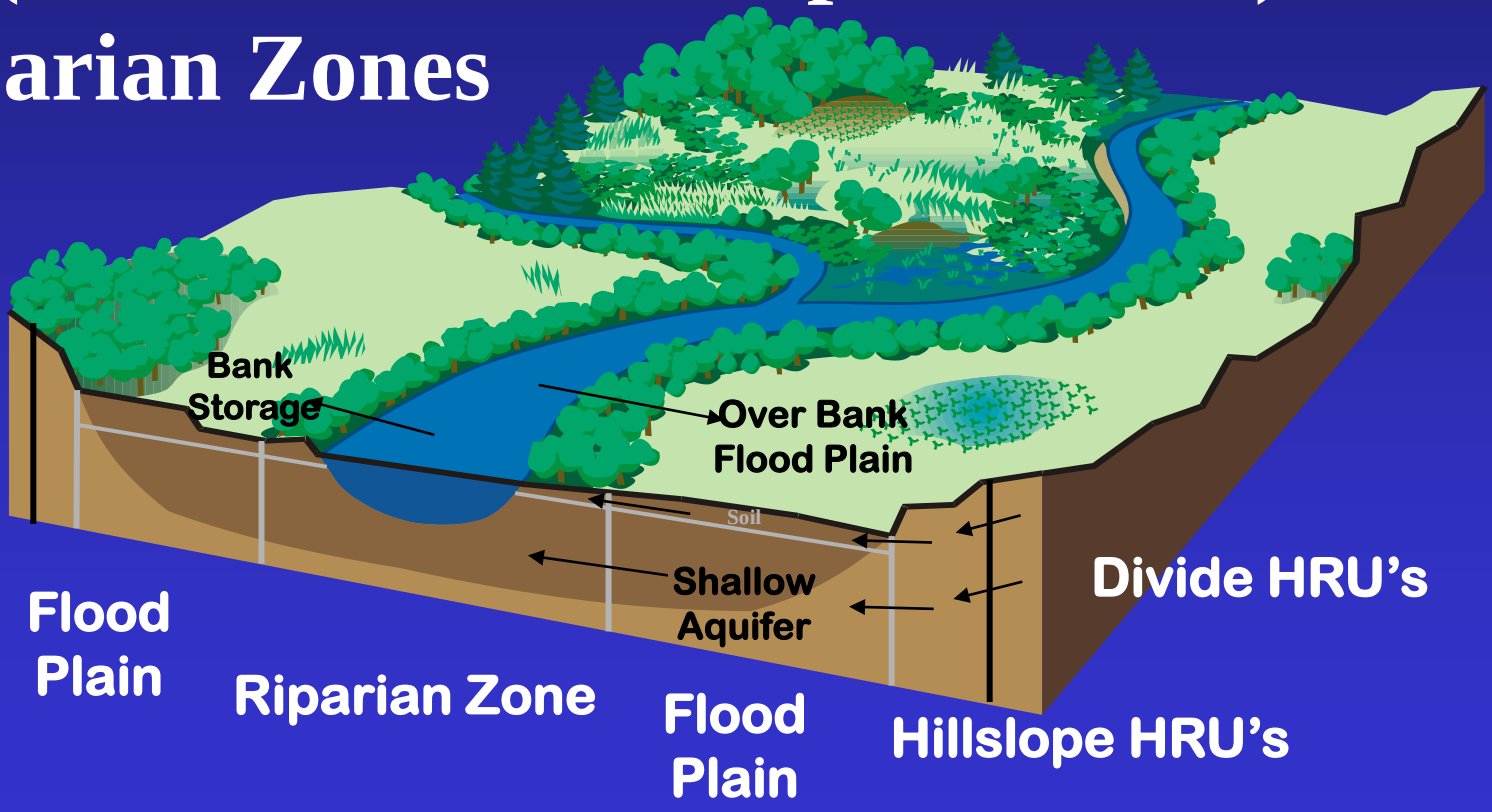
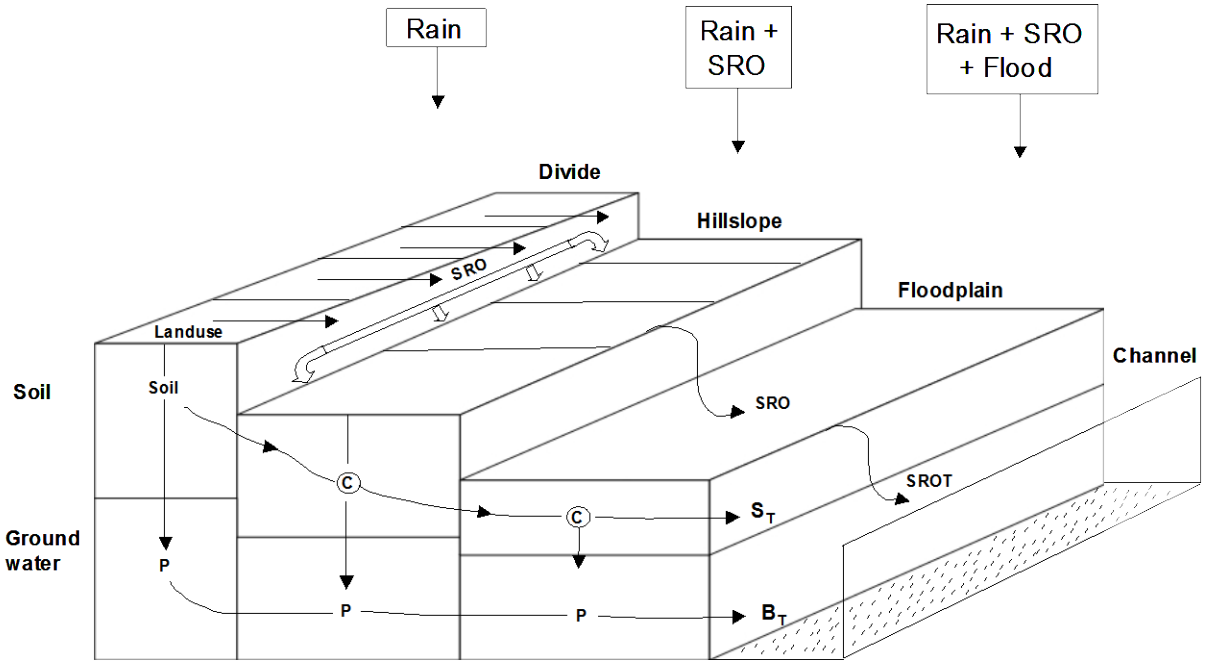
Landscape Routing

- Landscape Positions
  (Flood Plain, Hillslopes, Divide)
- Riparian Zones



Landscape Units

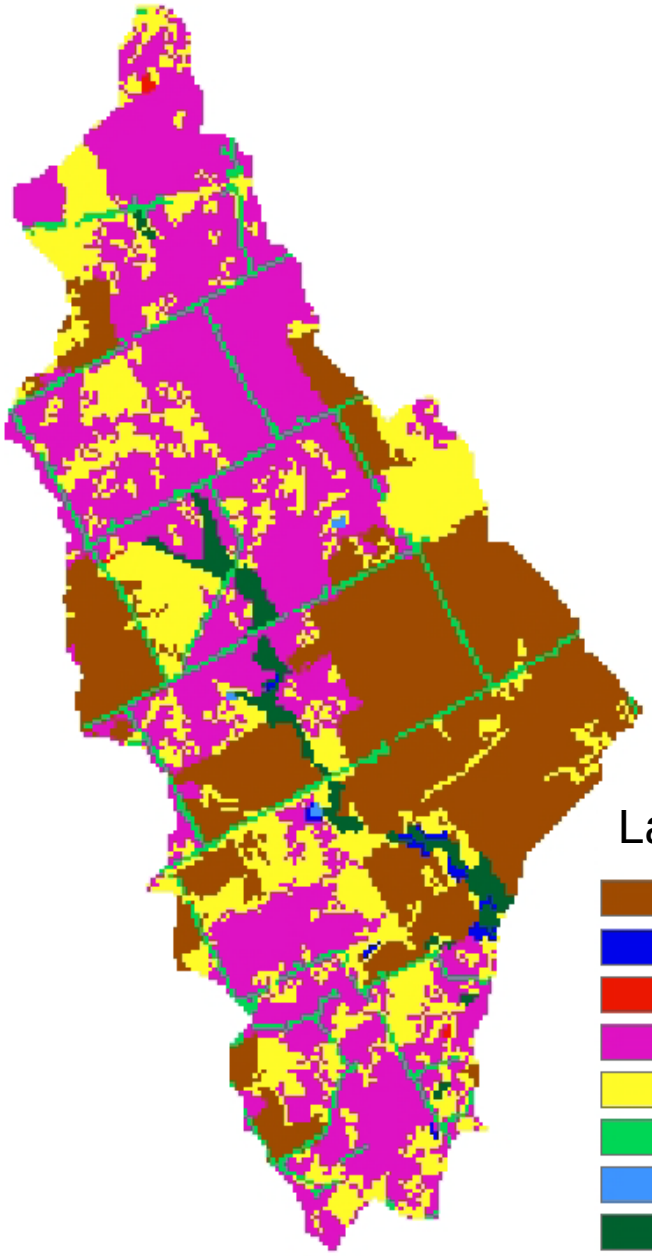


B_T= Groundwater Total
SRO = Surface Runoff Total
S_T = Lateral Soil Flow Total

Location and instrumentation of Grassland Soil and Water Research

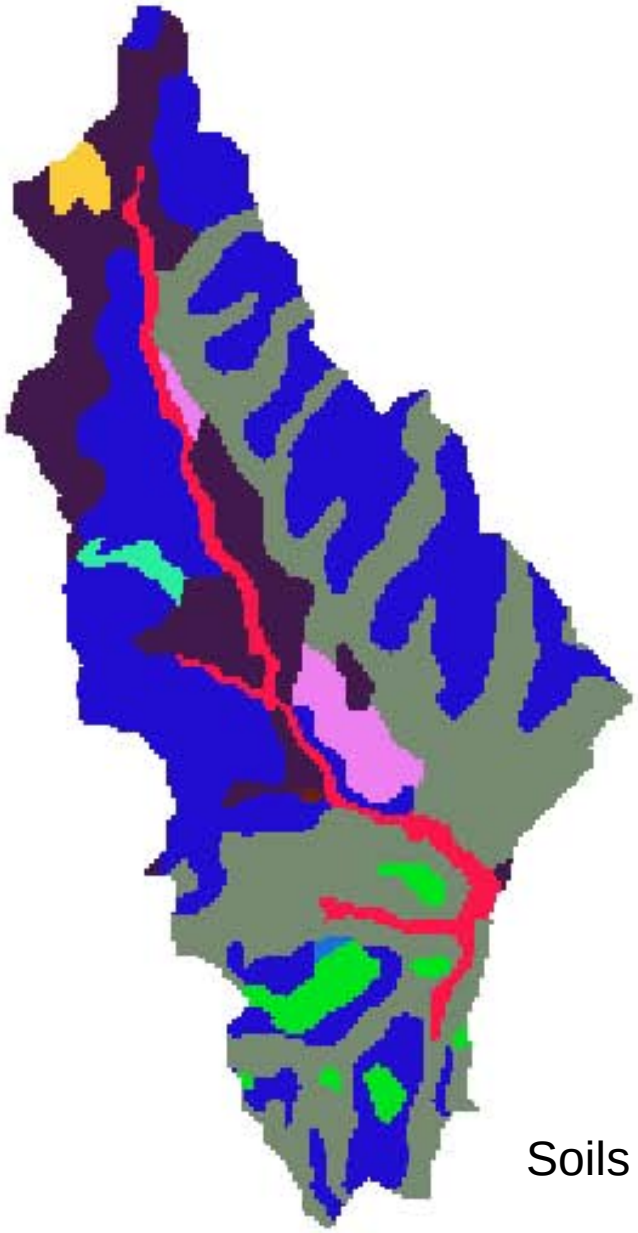
Riesel G Watershed

- 1,734 ha
- 890 mm Mean Annual Rainfall
- Houston Black Clay Soil
- Low Permeability when Wet (1.5 mm/hr)
- Soil Cracks – Preferential Flow
- Pasture and Tilled



Landuse

- AGRR
- FRSD
- FRSE
- HAY
- RNGE
- URLD
- WATR
- WETF



Soils

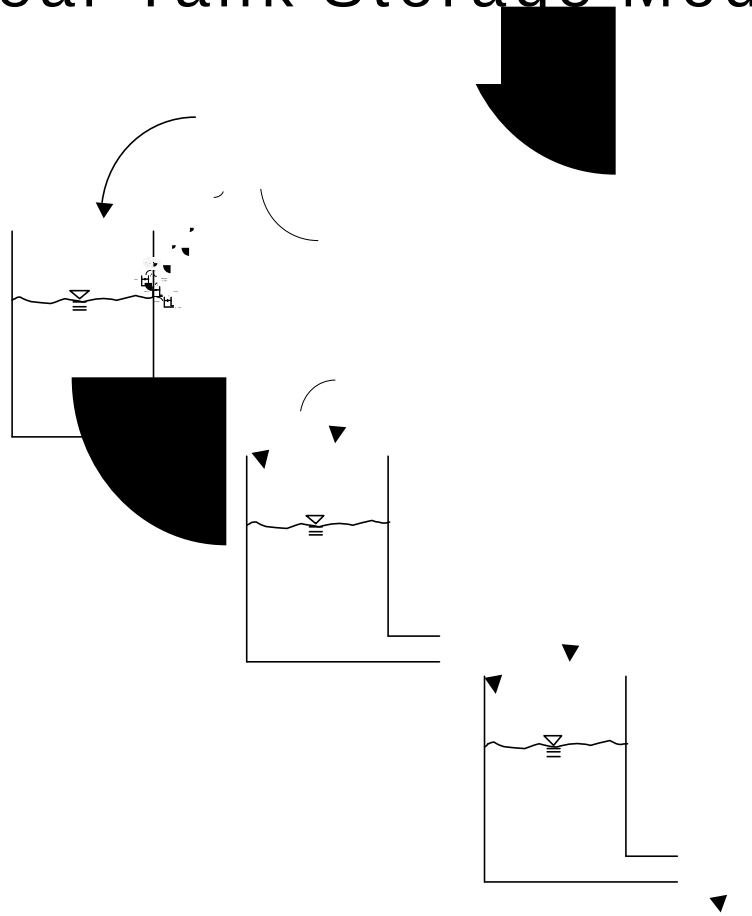
Surface Runoff/Runon

- Manning's Equation
  1 m Overland Flow Strip
- $V = (q_s)^{0.4}\ s^{0.3} / n^{0.6}$
- Infiltration = f(Flow length, travel time, saturated conductivity)

Lateral Soil Flow

- Kinematic Storage Model for each Soil Layer
- $$Q_{lat} = 0.024 \cdot \left(\frac{2 \cdot SW_{ly,excess} \cdot K_{sat} \cdot slp}{\phi_d \cdot L_{hill}} \right)$$

Groundwater Flow
Linear Tank Storage Model

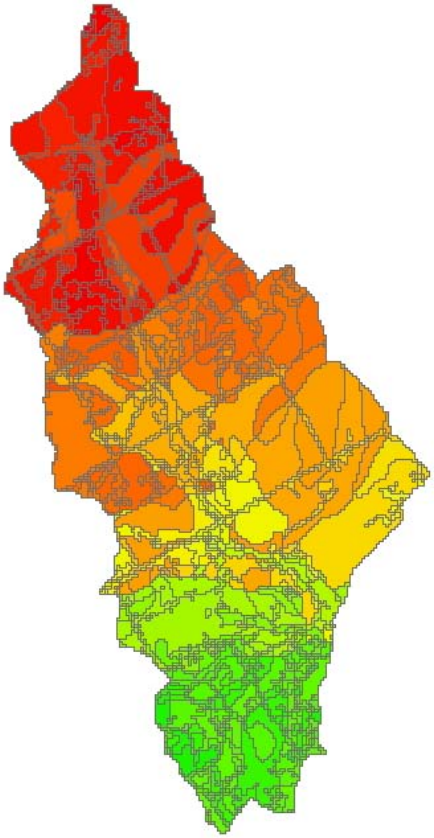


Implementing Landscape Structure (.sub file)

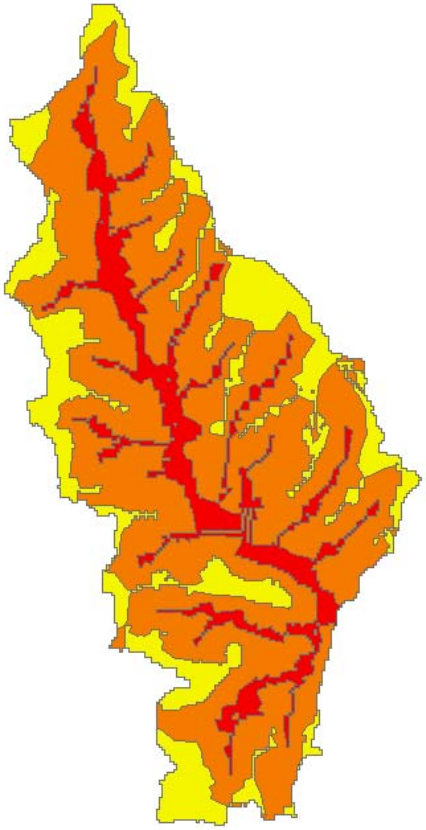
```
3   3   !LUTOT, HRUTOT
!Landscape Unit Routing
LU          1    1    1    1  0.00  0.00     !Cmd, Hydout, LU, 0, frout,overfr
riesel1.gw
 riesel1.hru  riesel1.mgt   riesel1.solchemical.chm
LU          1    2    2    1  0.00  0.00     !Cmd, Hydout, LU, 0, frout,overfr
riesel1.gw
 riesel2.hru  riesel2.mgt   riesel1.solchemical.chm
LU          1    3    3    1  0.00  0.00     !Cmd, Hydout, LU, 0, frout,overfr
riesel1.gw
 riesel3.hru  riesel3.mgt   riesel1.solchemical.chm
Route       2    4    2    1  5.00  0.00     !Cmd, Hydout, LU, Hydin, Dep Storage
Add         3    5    2    4
Route       2    6    3    5  5.00  0.00     !Cmd, Hydout, LU, Hydin, Dep Storage
Add         3    7    6    3
Stream      4    7
Finish      0
```

ARS – Station G (Brushy Creek) at Riesel, Texas 1,734 ha

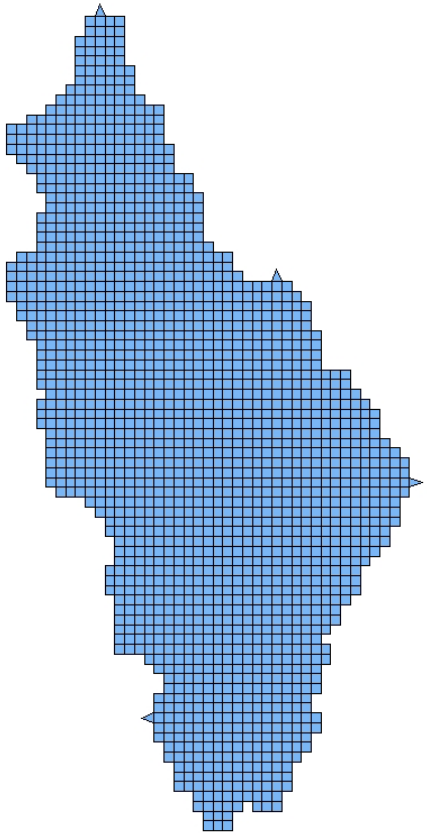
Lumped
One soil, landuse slope



HRU's
Lumped soil/landuse overlay, no landscape routing



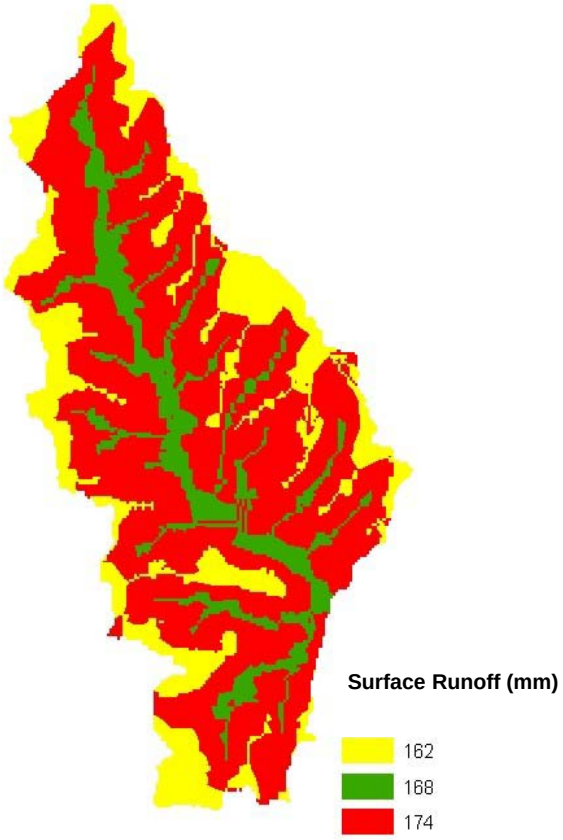
Catena
Three landscape units, divide Hillslope, valley bottom



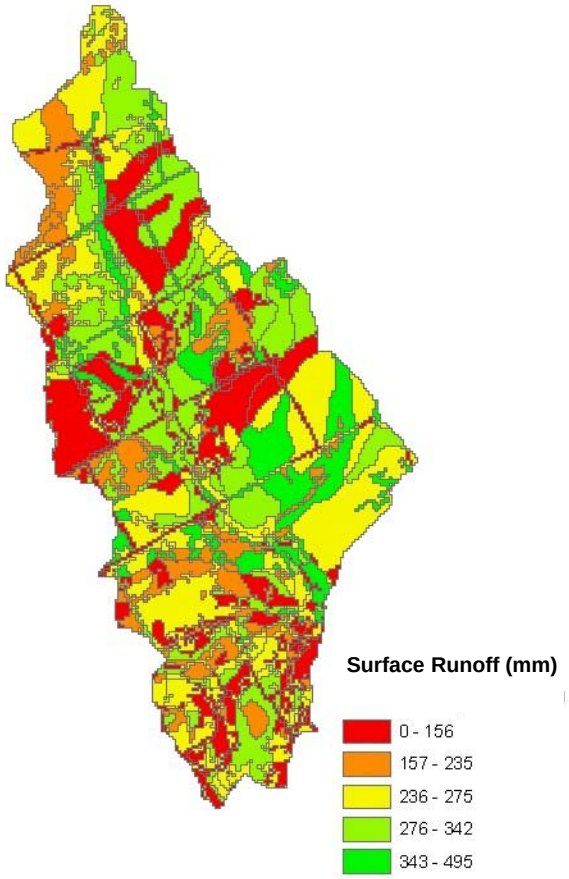
Lumped
One soil, landuse slope

Average Annual Surface Runoff (mm)

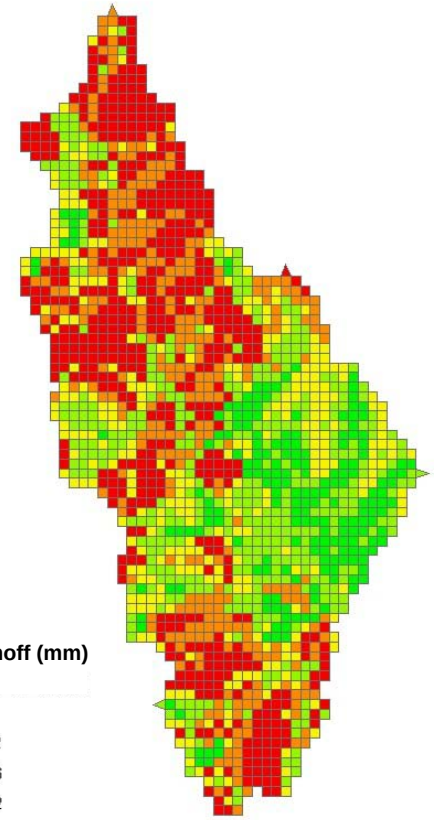
Catena



HRU's

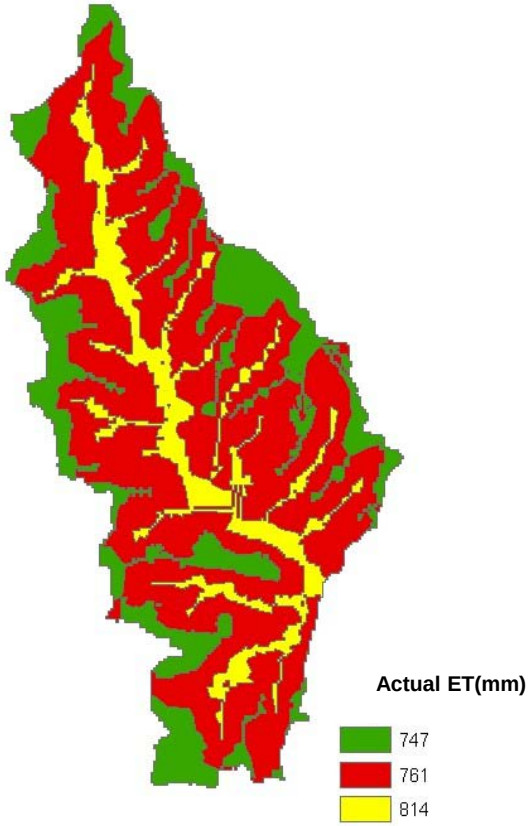


Distributed (grid)

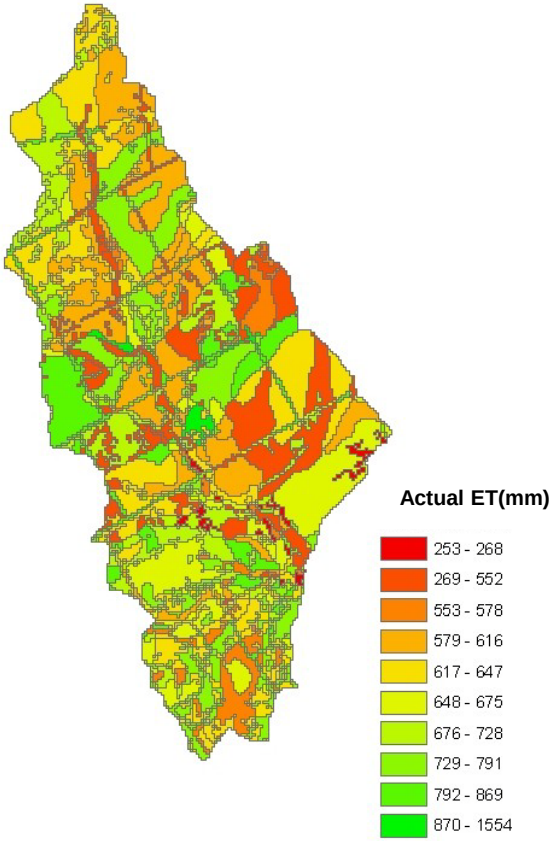


Average Annual Actual ET (mm)

Catena



HRU's



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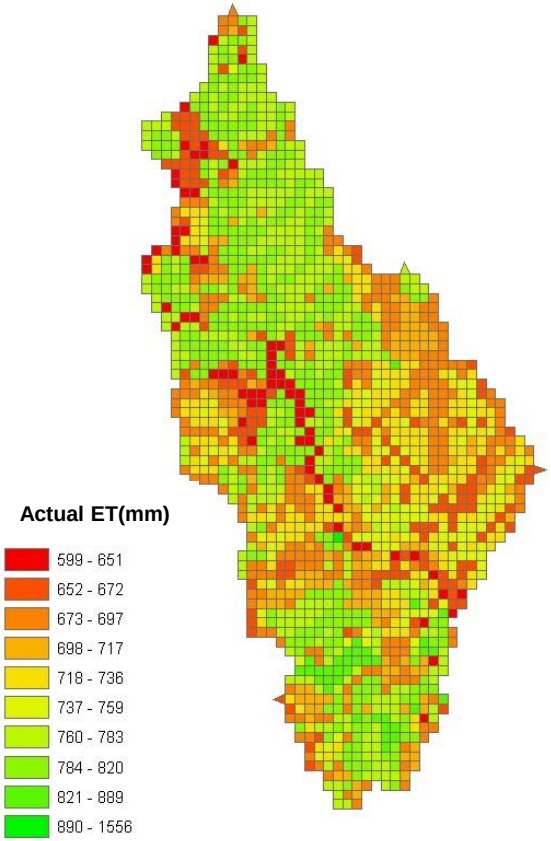


Calibration and Validation
Daily Flow – Station G

- Shuffled Complex Evolution Method Variables
  Sat conductivity, Roughness storage, AWC

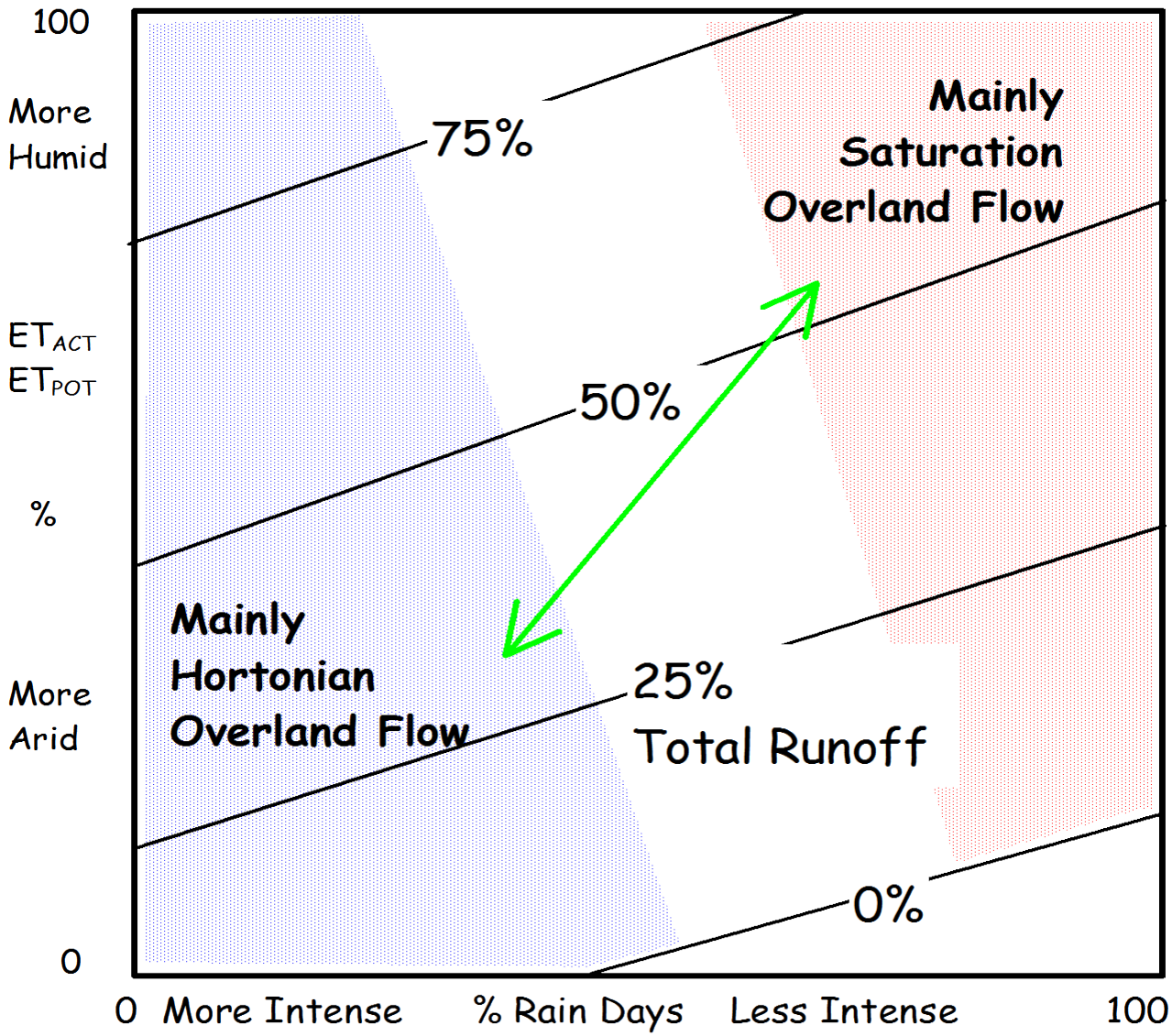
- Calibration Period – 1968-1974
  N-S Coef - Range from 0.65-0.70

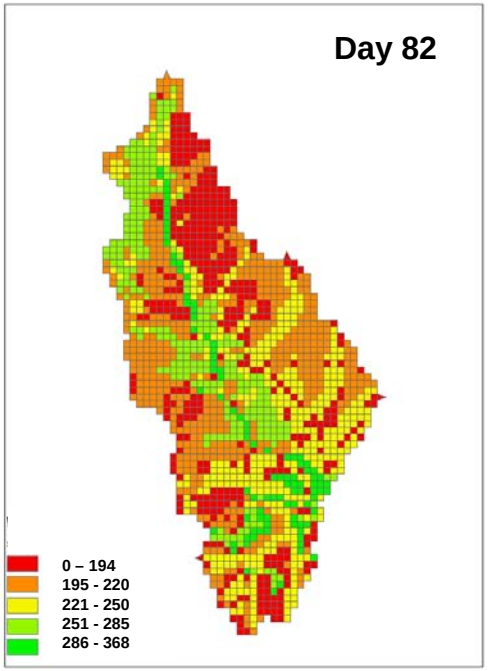
- Validation Period – 1975-1981
  N-S Coef - Range from 0.65-0.70

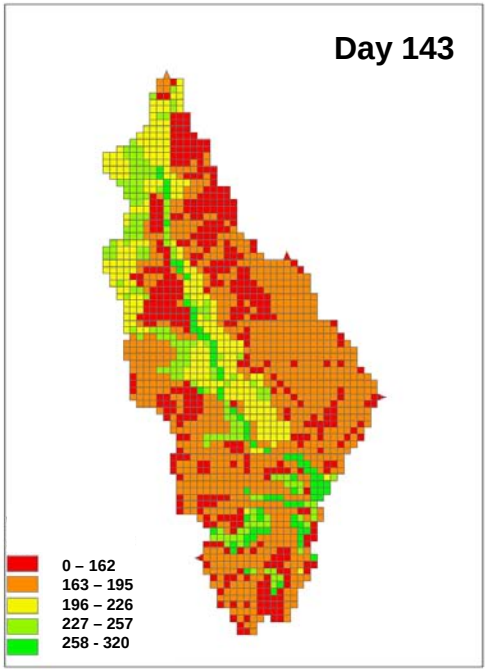
- Little variation in statistics

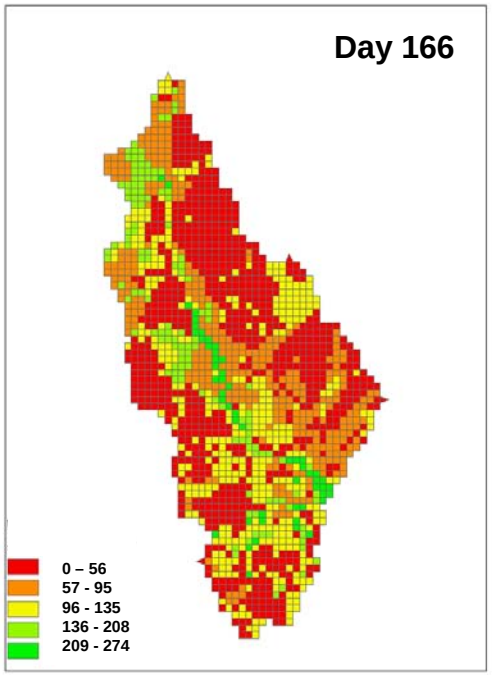
- Lumped – Required variables slightly out of realistic range – extreme differences in cropped and pasture

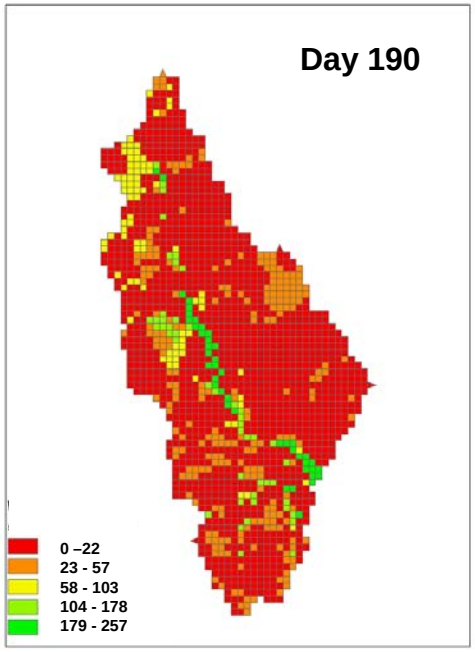
Generalised dependence of Runoff Coefficient and Style of Overland Flow on Arid-Humid scale and on Storm Rainfall Intensities

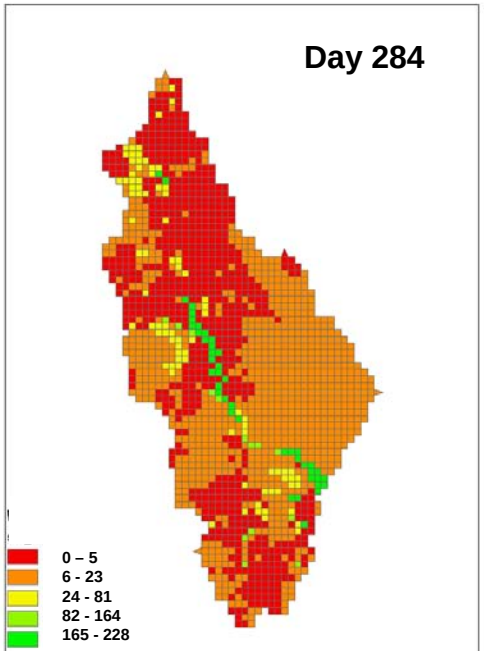






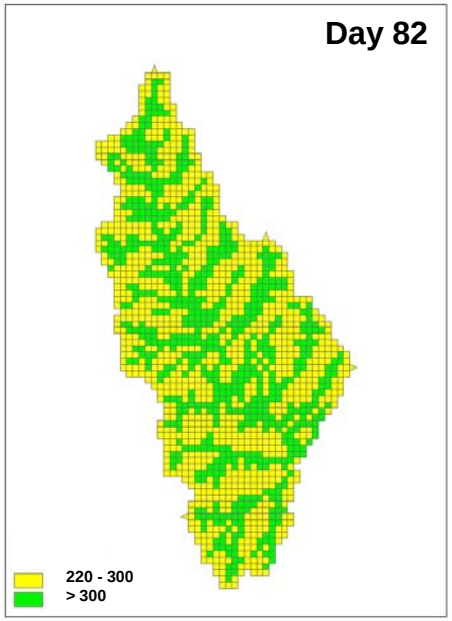


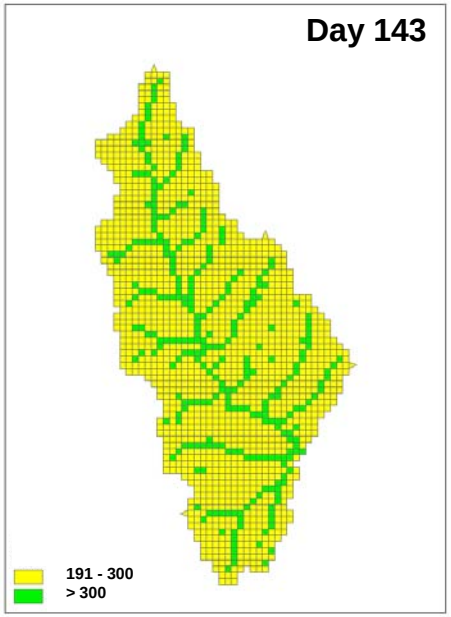


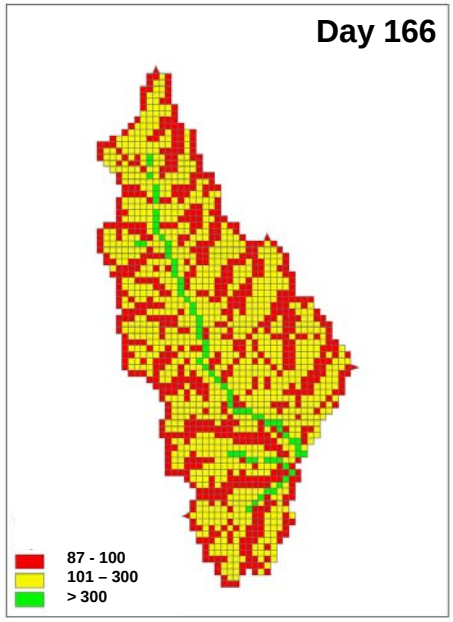


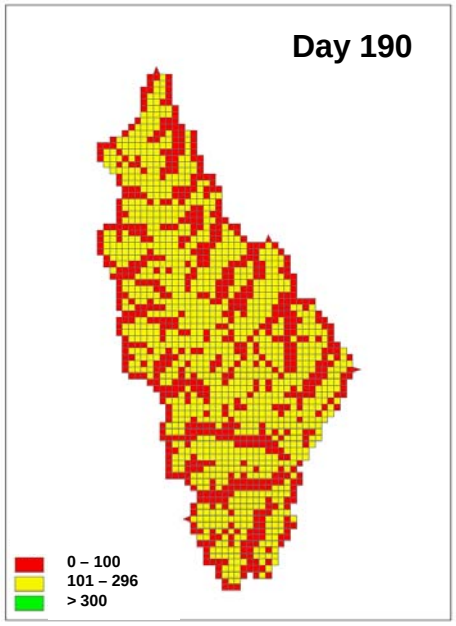
Soil Water (mm)

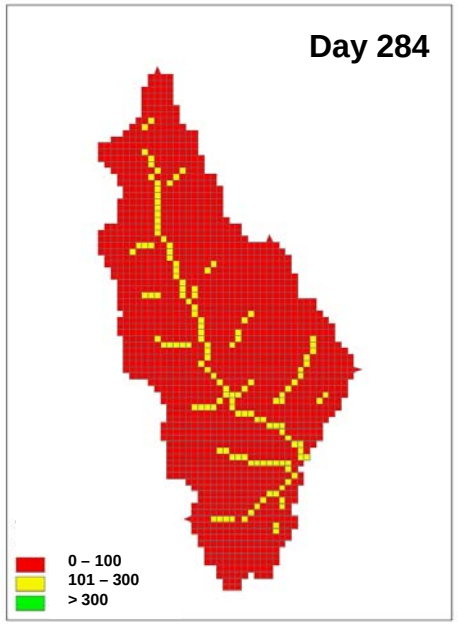
Hortonian flow
Variable soil/landuse
Surface flow dominated
Brushy Creek Riesel – 1,734 ha
(1 ha cells)
FC = 100 mm, Sat = 314 mm











Soil Water (mm)

Variable source
Subsurface flow dominated
Brushy Creek Riesel – 1,734 ha
(1 ha cells)
FC = 100 mm, Sat = 314 mm

Delineation of HRU's

- Large Scale Applications

Delineate HRU's by:

- Distance to Stream
- Stream Order
- Filter Strips – Buffering
- Riparian Zones

- Develop simple algorithms and do not route across HRU's

Conclusions

- **Grids – Too computationally intensive for large basins. Possible to use 4x4 km^2 cells in Upper Mississippi Basin (400,000 km^2 or 40,000,000 ha)**
- **HRU's - Can be lumped and simplified with average buffering and distance to streams – HRU's defined by landscape position (distance to stream, stream order, etc)**
- Catena – Simple and preserves landscape routing. Require HRU's within landscape units
- Small grids suitable for APEX fields – simulate individual terraces, potholes, buffer strips, and riparian zones
- Small watersheds can be linked directly to REMM model

Future Developments

- Kinematic Wave Equation for Overland and Channel Routing between Landscape Units
- Sediment and Nutrient Routing Across Landscape
- Testing at Gibbs' Farm Watershed in Tifton, GA with Riparian Zones
- Testing on Larger Watersheds with Defined Flood Plains – Landscape/River Continuum
- GIS Interface and Documentation

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SOFTWARE UPDATES
ArcSWAT (9/21/2009)
Version 2.3.4 for ArcGIS 9.3 SP1,
Version 2.1.6 for ArcGIS 9.2 SP6
SWATeditor (6/18/2009)
Version 2.1.5 for ArcGIS 9.2; Companion to ArcSWAT
SWAT-CUP
MapWindow-SWAT
VizSWAT Software
SWAT2005 available for download
UPCOMING EVENTS
SWAT Workshops (2/8-2/12/2010) Beginner, Advanced, and Advanced Data Processing for ArcSWAT
2010 International SWAT Conference (8/2-8/6/2010)
Ilsan, Korea
2nd International SWAT-SEA (1/4-1/7/2011)
Ho Chi Minh City, Vietnam
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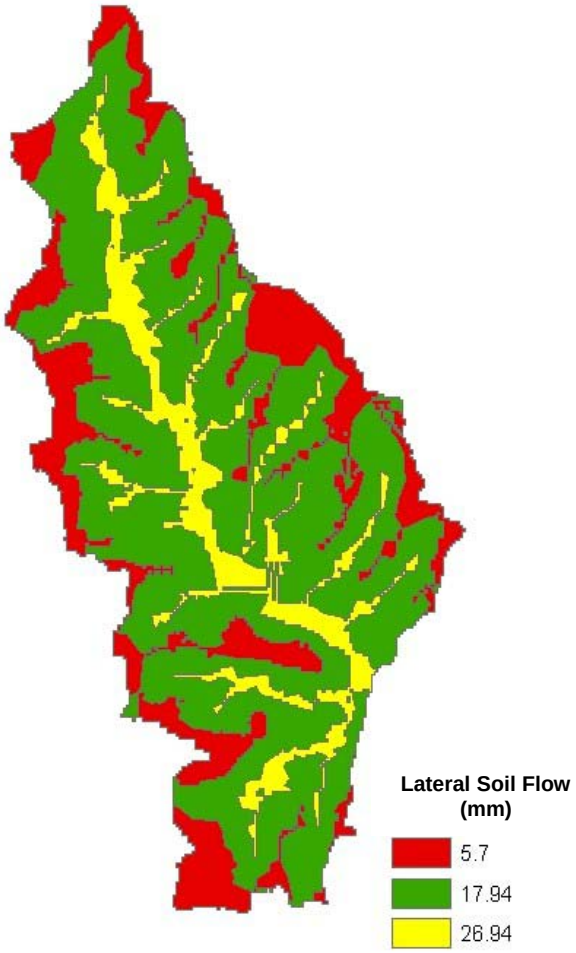
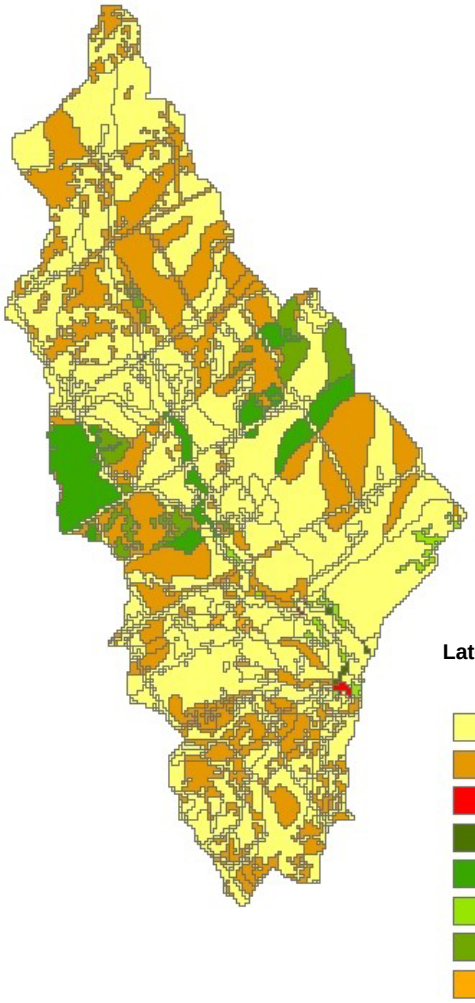
Average Annual Lateral Soil Flow (mm)

Catena



HRU'S



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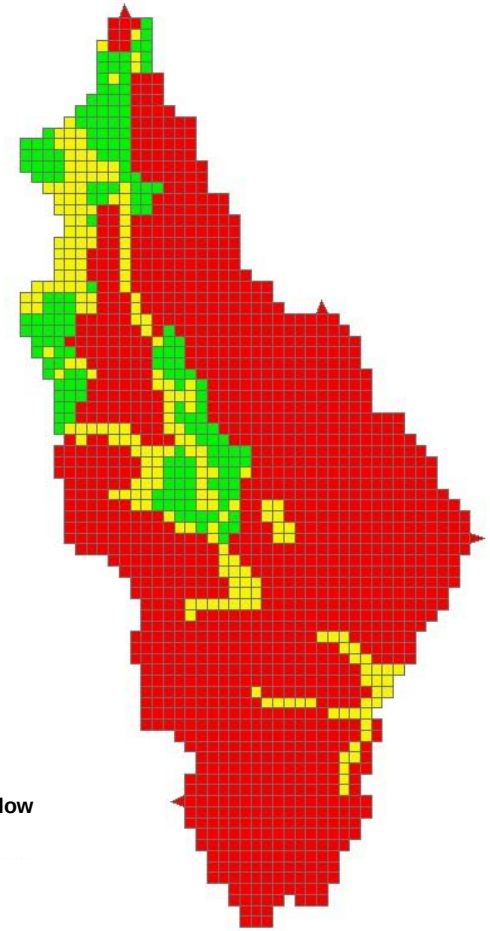

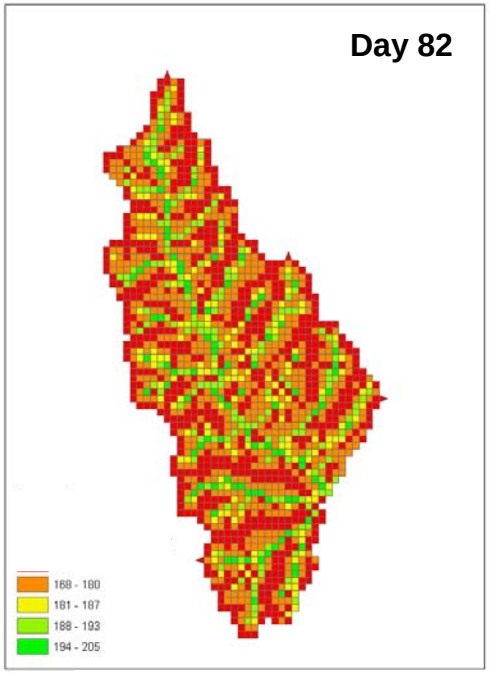

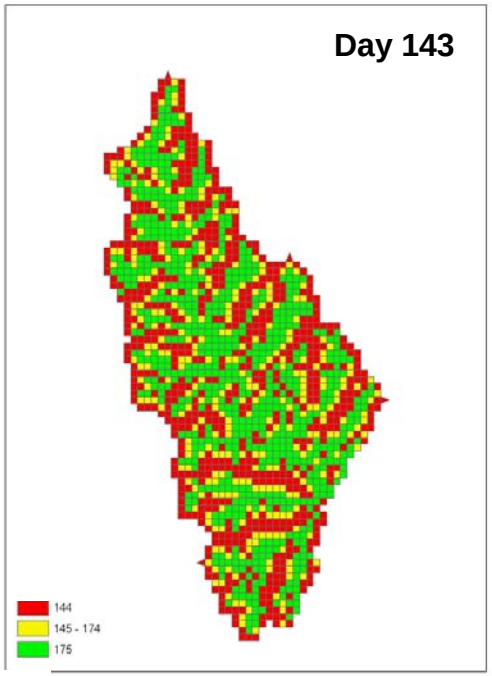

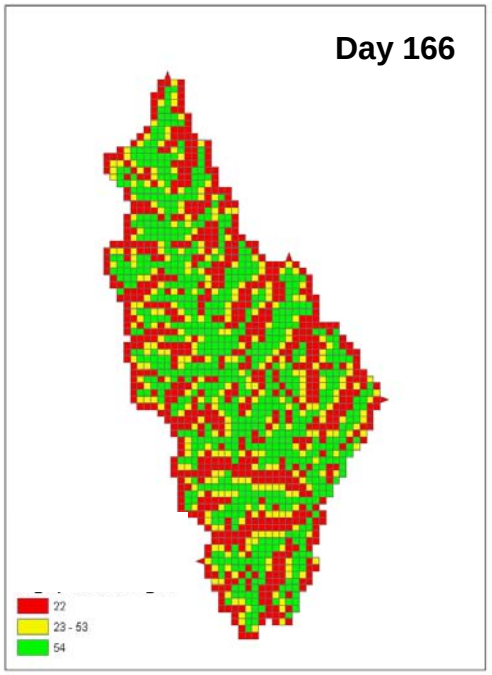

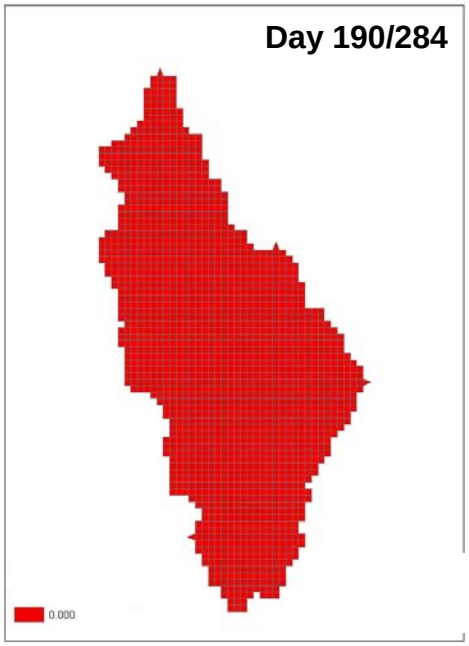

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Hortonian flow
Homogeneous soil/landuse
Surface flow dominated
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