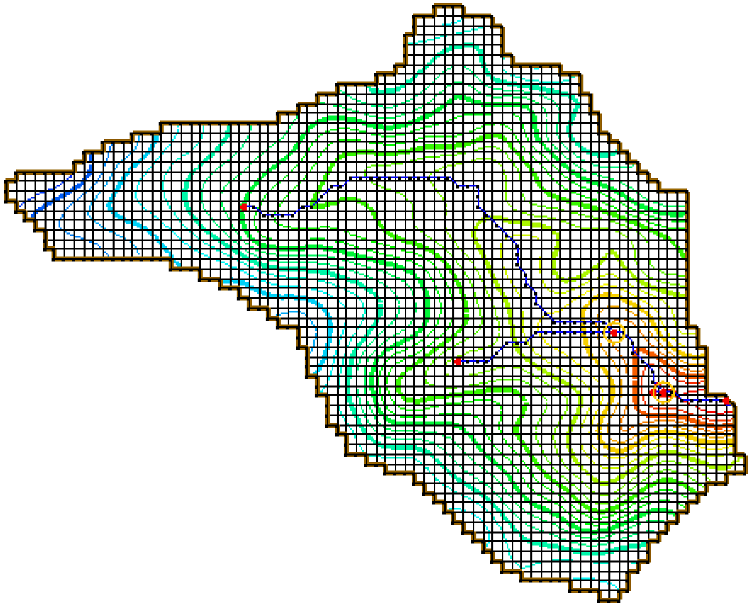
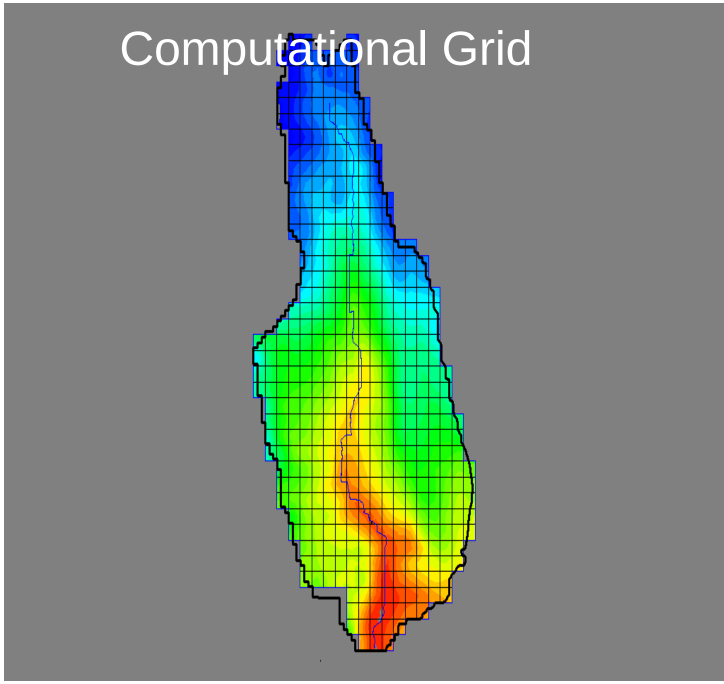
What is GSSHA?

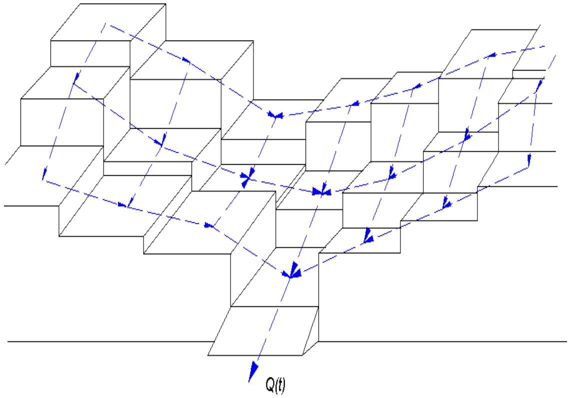
- GSSHA is a complete watershed simulation and management model used for hydrologic, hydraulic, sediment and quality simulation and management.
- GSSHA is a fully distributed, physics based model that utilizes a grid to represent the watershed.
- GSSHA is a product of the US Army ERDC
  - Maintained
  - Supported
  - Distributed



How does GSSHA Work?

- GSSHA works on a uniform spatial grid.
- Basic equations of mass, energy, and momentum conservation are solved with finite volume and finite difference techniques.
- Point processes are solved at the grid level.
- Point responses are integrated to get the system response.

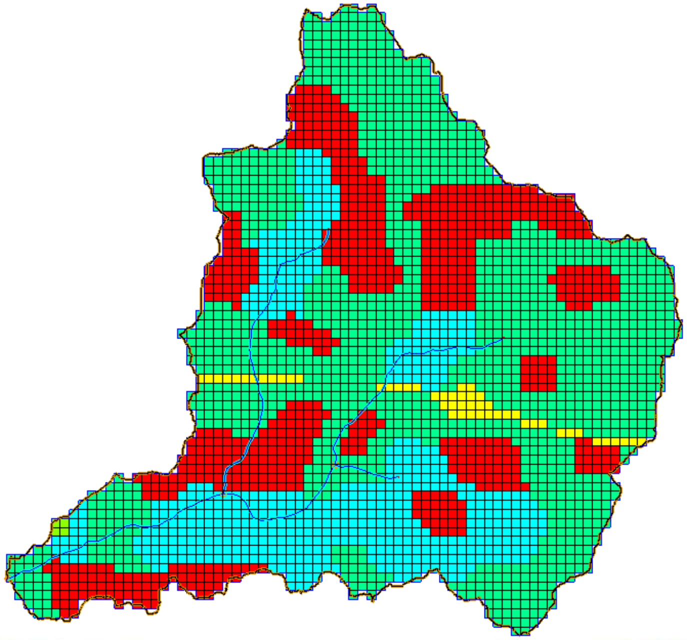




Why Does This Matter?

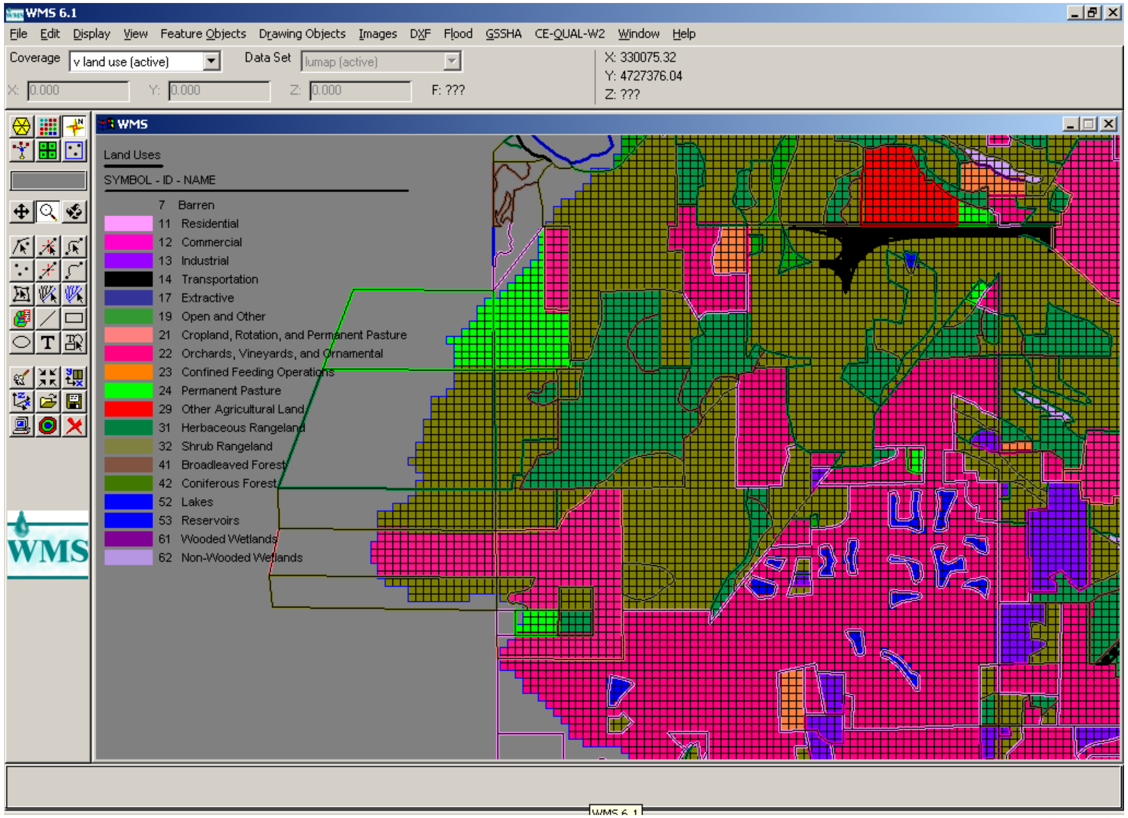
Spatial variability.

Physically based parameters.



Spatial Variability

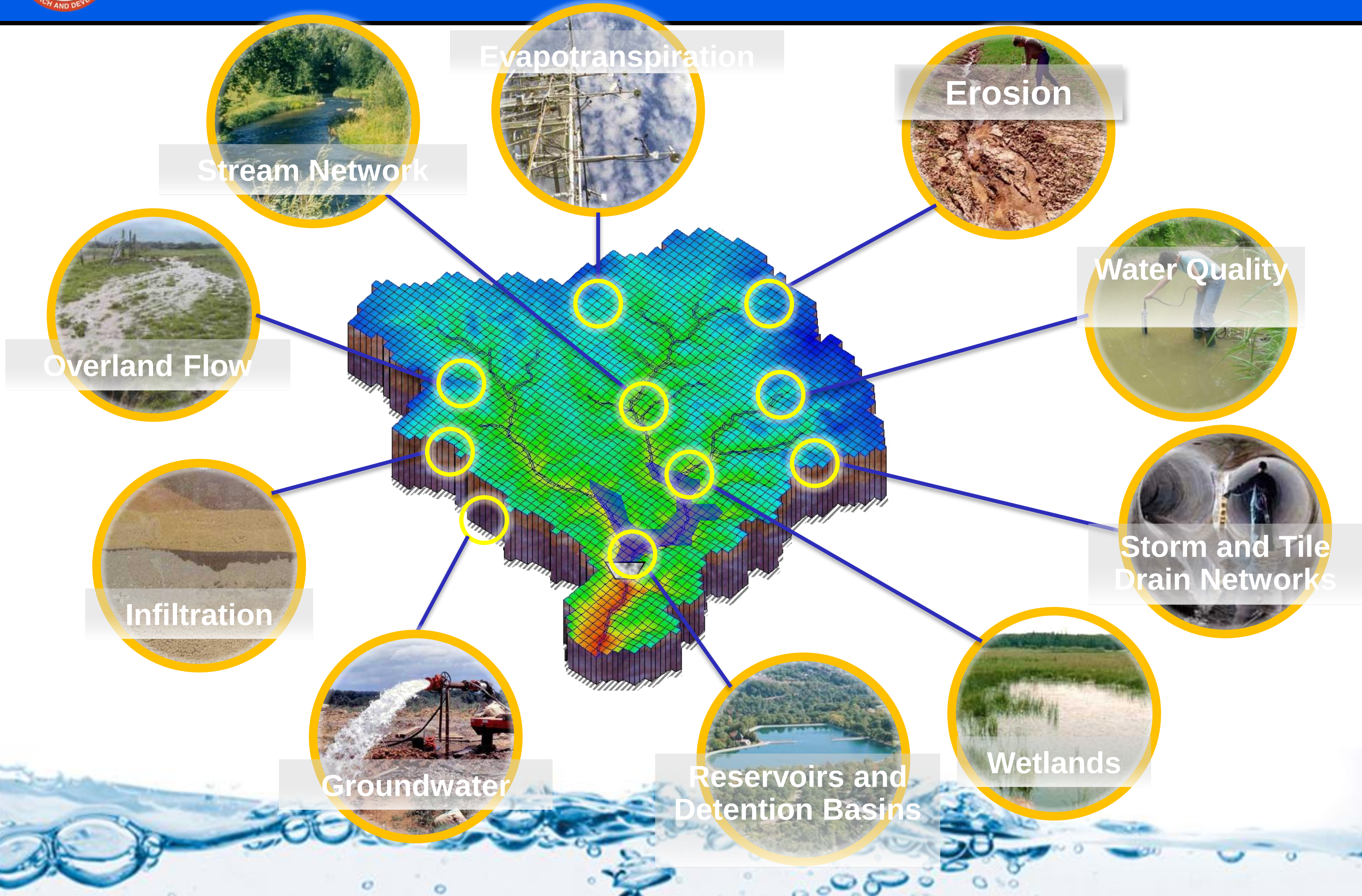
Explicitly include spatially heterogeneous features, such as varying land use, source areas, BMPs, etc.



Physically Based Parameters

- Values are based on physical conditions in the computational element.
  - requires less calibration data
  - extendible beyond calibration range
- The tie to physical conditions provides a means to logically alter parameters based on changing conditions.
  - land use changes
  - project alternatives
  - climate change

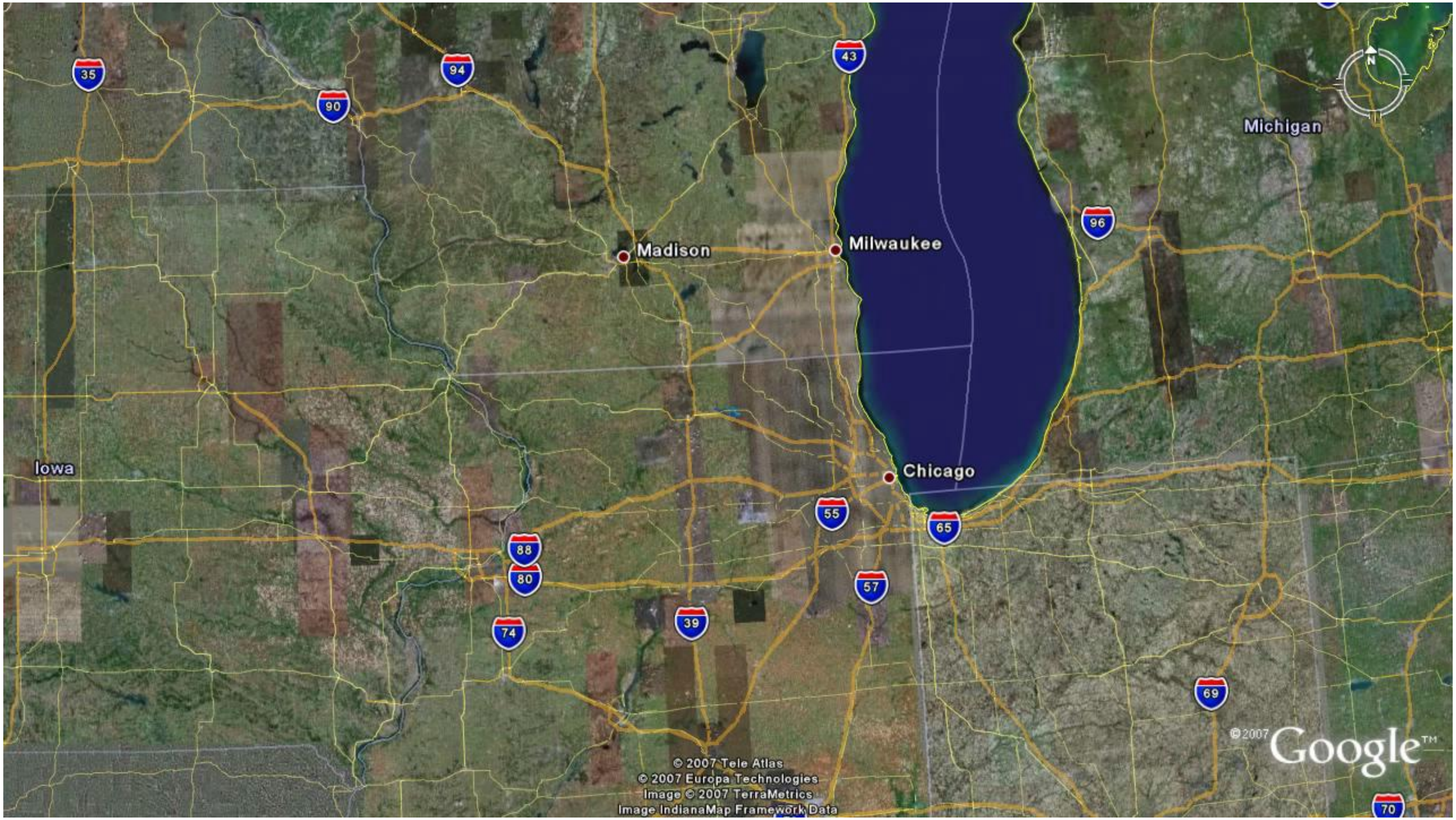
Watershed Modeling Capabilities



What make GSSHA Different?

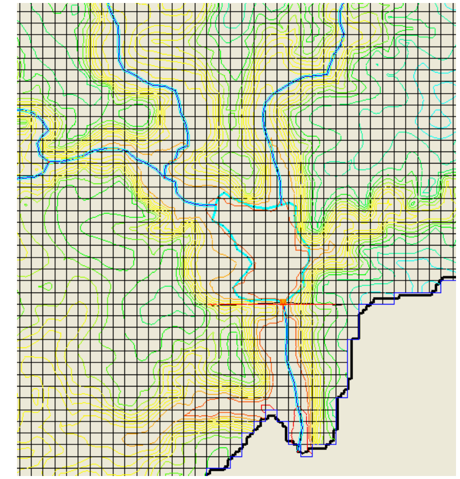
- GSSHA is a fully integrated watershed model with overland flow, lateral groundwater and channel routing with sediment and contaminant transport all fully integrated.
  - Full integration of processes allows a higher level of analysis.
  - Feedbacks between overland, channels, reservoirs, and the groundwater.
- GSSHA routes water, sediments, and contaminants through the watershed.
  - For many processes flow path is important.
    - Sediment
    - Water quality
    - BMPs
    - Interaction with flow impediments
      - levees, dikes, roads, buildings, wetlands, detention basins, etc.

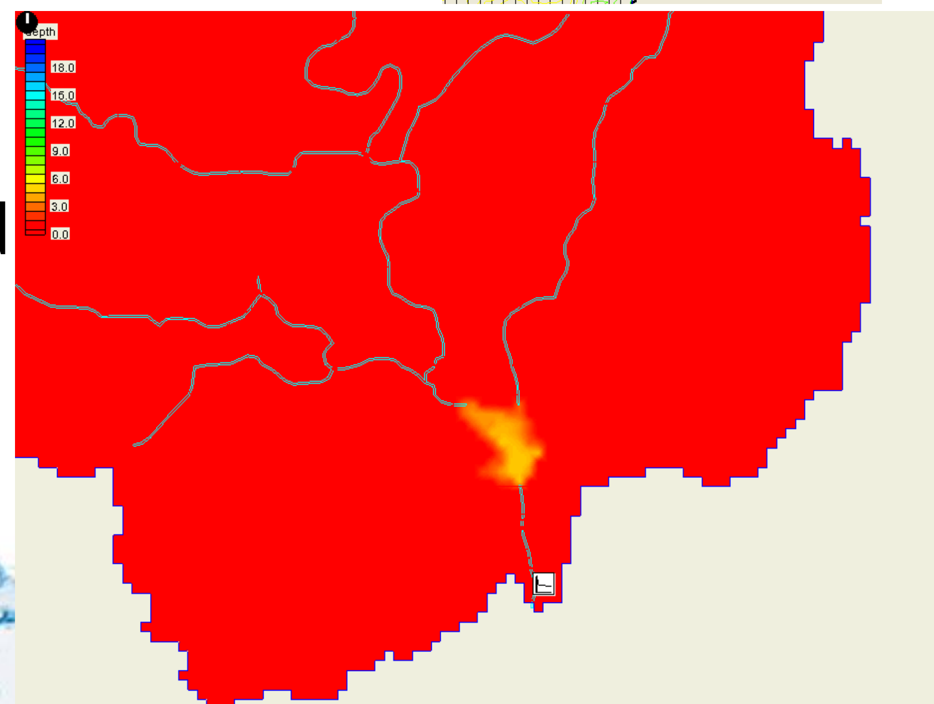
Central Kishwaukee Flooding



Reservoirs

- Reservoirs exist in the channel and on the overland flow domain.
- Reservoirs are dynamic and expand and contract on the overland flow plane and in the channel.
- Sediments can deposit and erode within the reservoir, depending on it's stage.



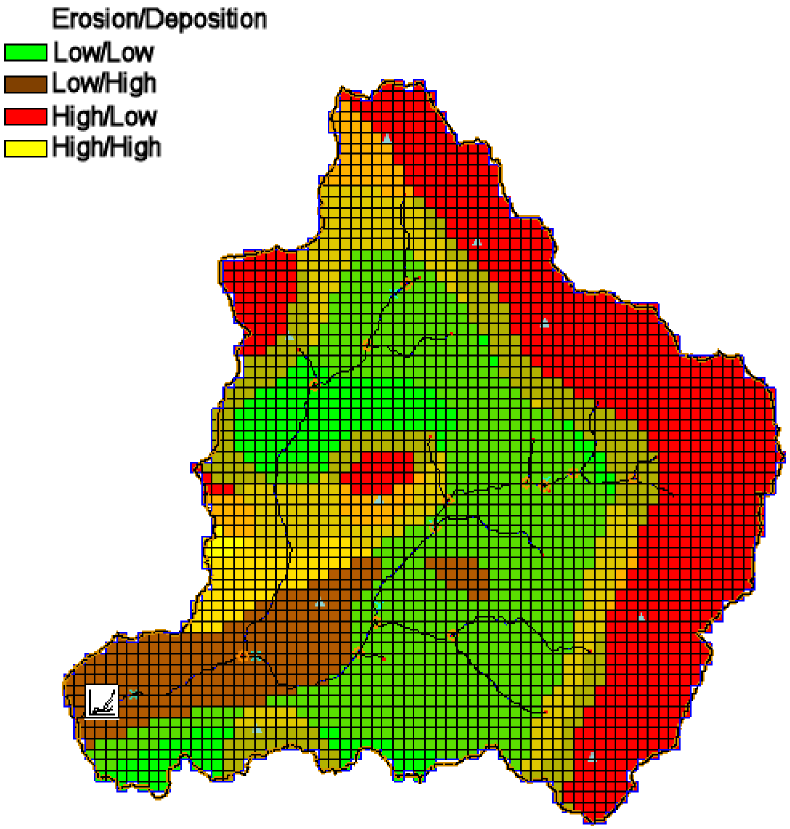


What Applications Can GSSHA be Used For?

- General hydrologic studies
- General hydraulic studies
- Urban hydrology
- Determining sediment load
- Determining constituent load
- Urbanization
- Ecosystem restoration
- Management practices

Sediment Transport

- Event based erosion and deposition model (not USLE-based)
  - Overland
  - Streams
- User-defined sediment properties

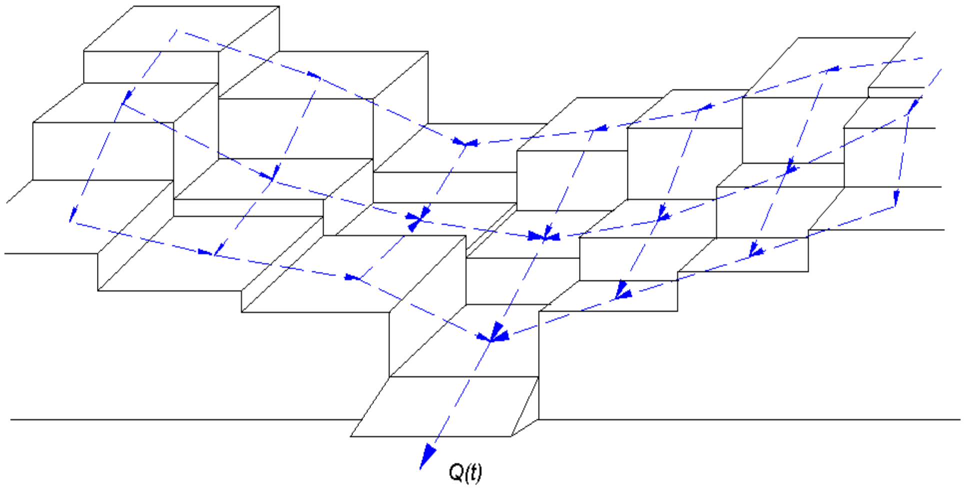


GSSHA Sediment Transport

- GSSHA simulates sediment transport like you understand sediment transport with a physics based approach.
- Simulation of sediment erosion from the overland plane
- Transport across overland plane including deposition and re-entrainment
- Transfer into channels
- Channel routing of bed and wash loads
- Routing of sediments through reservoirs
- Landscape evolution with the capability to do multi-decadal simulations

Overland Sediment Transport

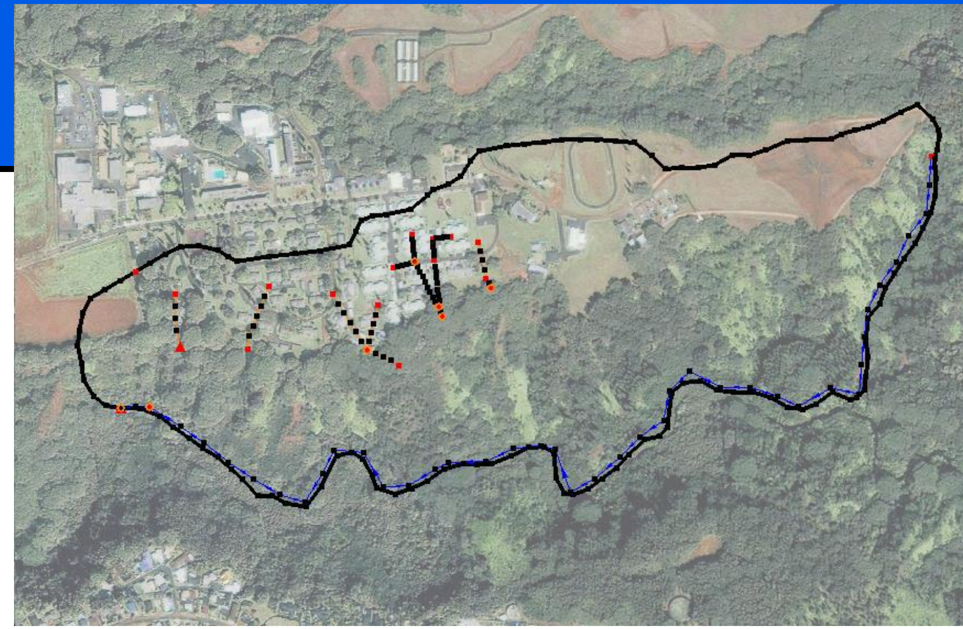
- Any number of sediment particles
  - Size
  - Specific gravity
- Sediment detachment
  - Raindrop impact
  - Overland flow limits
- Transport Capacity
  - Kilinc-Richardson
  - Engelund-Hansen
  - Multiple shear stress formulas
- Deposition



Cell to Cell Advection of Suspended Sediments

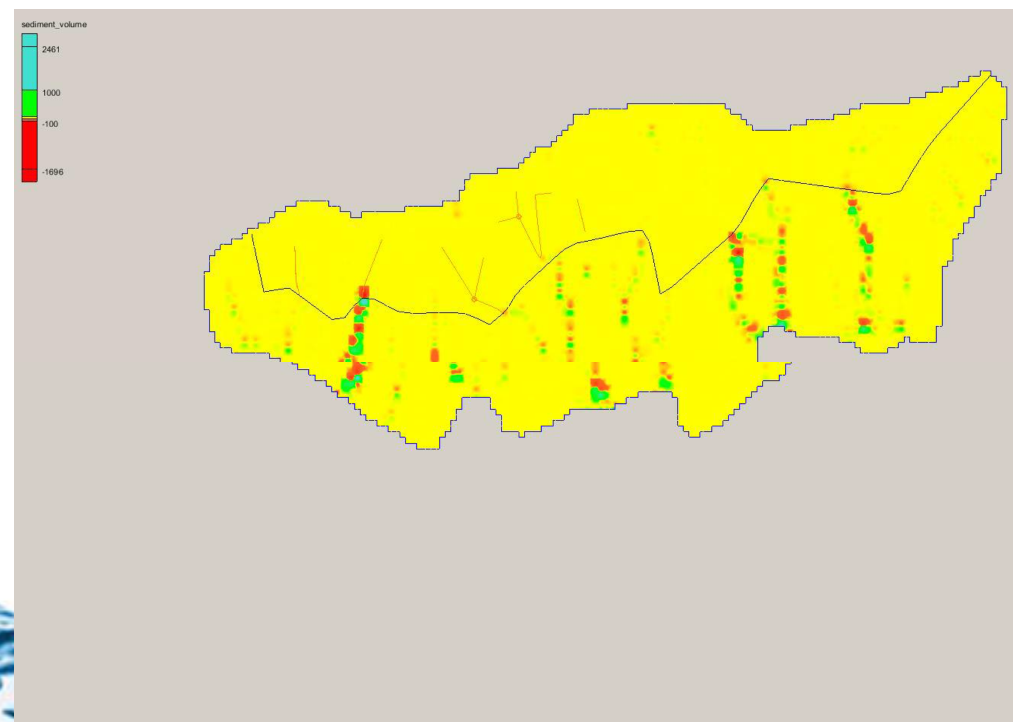
Overland Erosion Process in GSSHA

- Sediments are accounted for using three storages:
  - Parent material
  - Deposited materials
  - Materials in suspension
- Each pool has its own distribution of particles.
- Particle detachment
  - Rainfall impact
  - Overland shear.
- Deposited materials are assumed to erode first, then the parent material.
- If sufficient transport capacity is available, the eroded particles are transported to adjacent cells by advection.
- Deposition is computed with trap efficiency.
- Transport and deposition by particle size and density.
- Sediments reaching a stream segment are transported in the stream.
- Overbank flows can add sediments from the stream back to the overland.
- Elevations can be adjusted for erosion/deposition.



GSSHA shows you where, and how much, erosion and deposition occurs.

Resultant elevation changes can be fed back into the calculations.



Factors Affecting Detachment and Transport Capacity

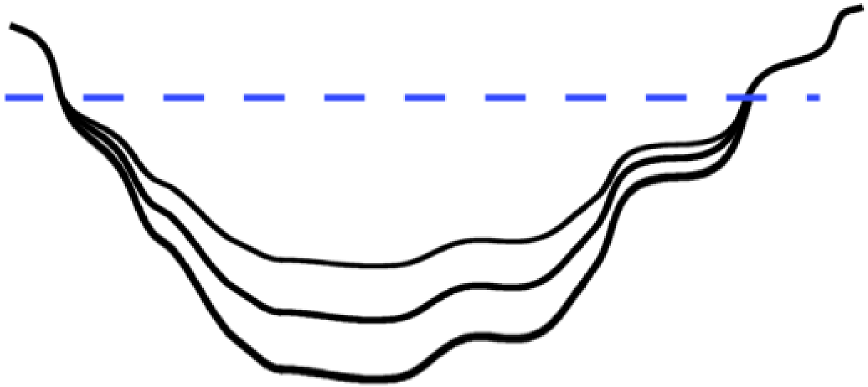
- Soil particle size – finer particles are more erodible.
- Cover conditions – any type of vegetative or manmade cover protects the particles from detachment and transport.
- Management actions – actions taken to prevent erosion, no-till, contour plowing, etc. lesson erosion.
- Erosive forces
  - Rainfall intensity
  - Discharge
  - Land surface or friction slope
  - Shear stress

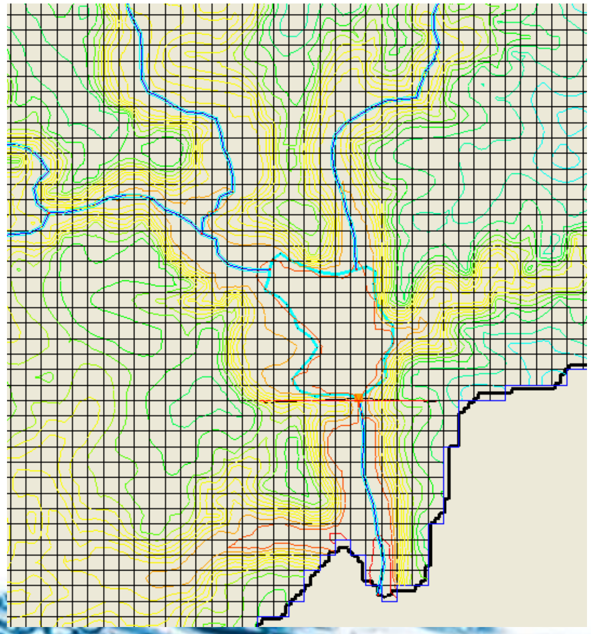
Transport Capacity

- Is the amount of sediment that the flow is capable of moving.
- The flow may not be capable of transporting all of the eroded material.
- The flow may be capable of transporting more than the eroded material.
  - In this case the transport capacity will not be satisfied.

Sediment in Streams

- Particles larger than sand (user specified) treated as bed load and routed with Yang's method
- Smaller particles treated as wash load – advection dispersion equation
- Stream cross sections adjusted for erosion and deposition
- Particles settle or can be passed through reservoirs



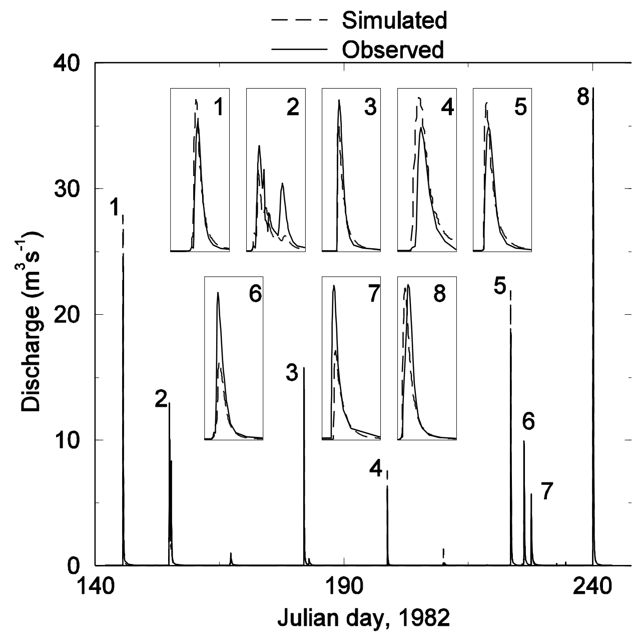


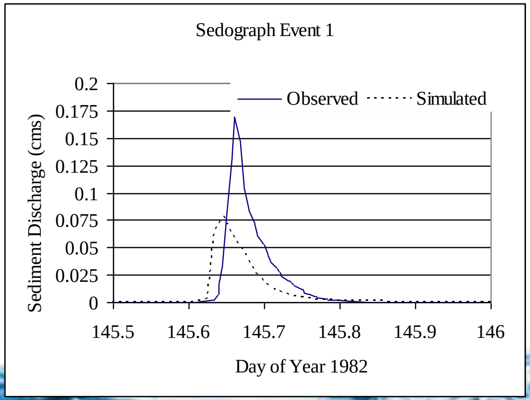
Interaction with Reservoirs

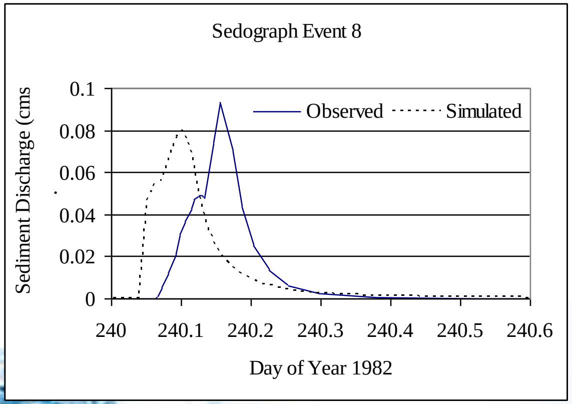
- Sands from overland plane into reservoir are deposited in boundary reservoir cells.
  - Reservoir boundary is dynamic.
- Sands from upstream channel network are removed from system and accounted for.
- Fines from overland and channels are accounted in reservoir, and can flow through.
- Reservoir is a completely mixed reactor.
- Fines settle in overland cells within the reservoir.
- Fines are discharged at the reservoir outlet.
- Since the reservoir is impeded in the overland flow grid regular erosion/transport/deposition occurs in exposed cells.

Continuous Simulations

- Simulates each event with memory of previous events
  - Erosion
  - Deposition
  - Changes in particle distribution
- Simulates events more than 4 orders of magnitude different without change in parameter values





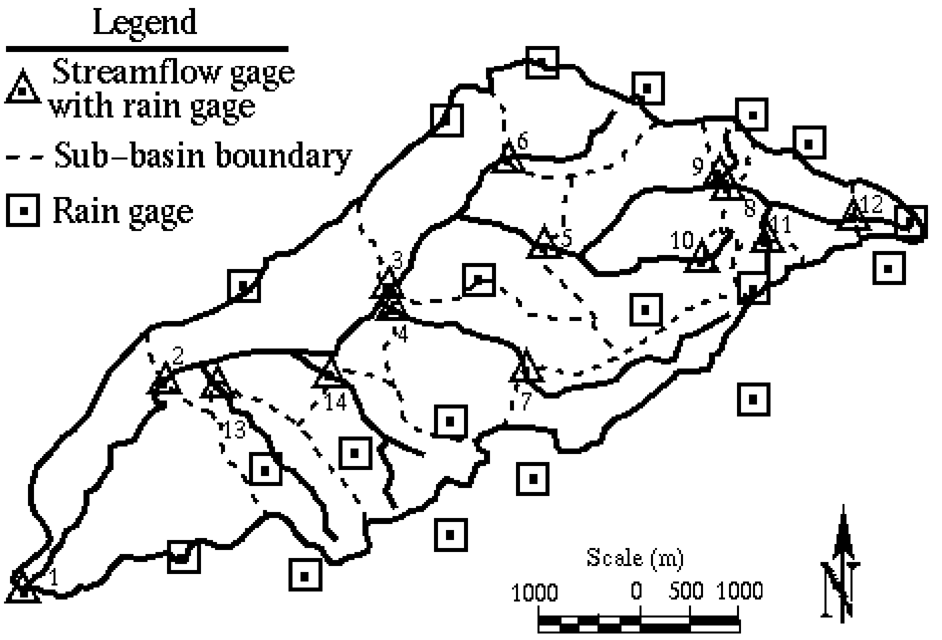


Example

Goodwin Creek Experimental Watershed near Oxford, Mississippi, est. 1981.

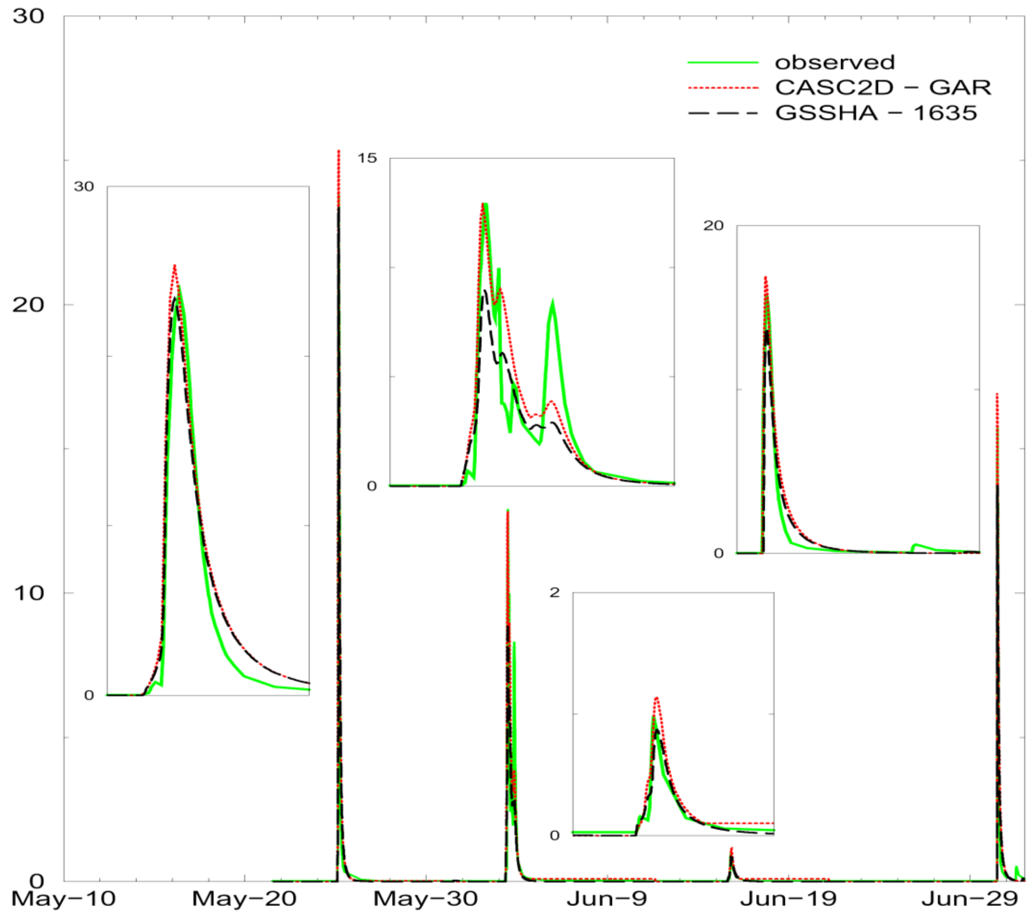
Operated by:

US Dept. of Agriculture, Agricultural Research Service, National Sedimentation Laboratory

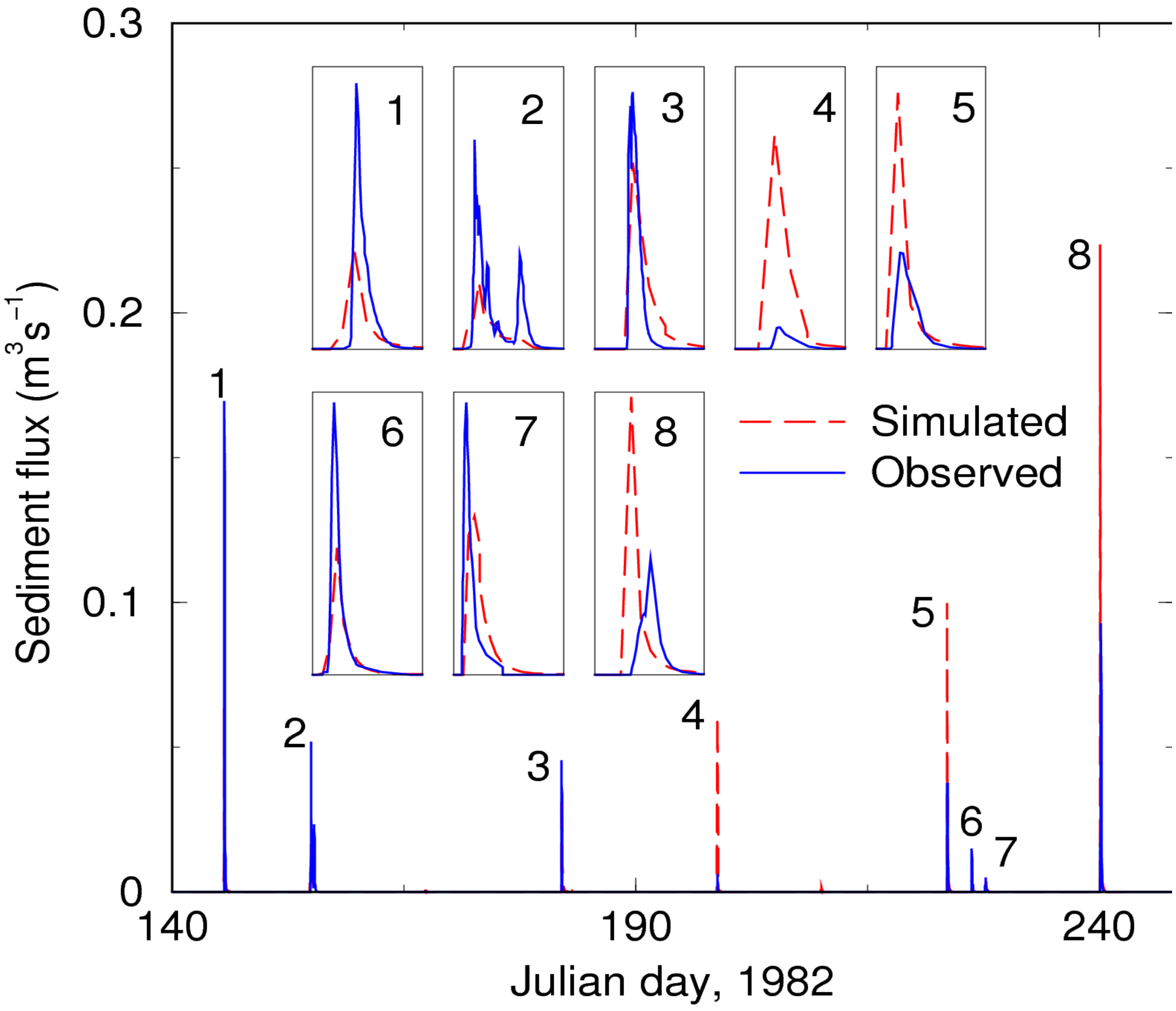


GSSHA Model Hydrologic Performance

Continuous calibration on Goodwin Creek Watershed Data Set (Senarath et al. 2000, *Water Resour. Res.*)

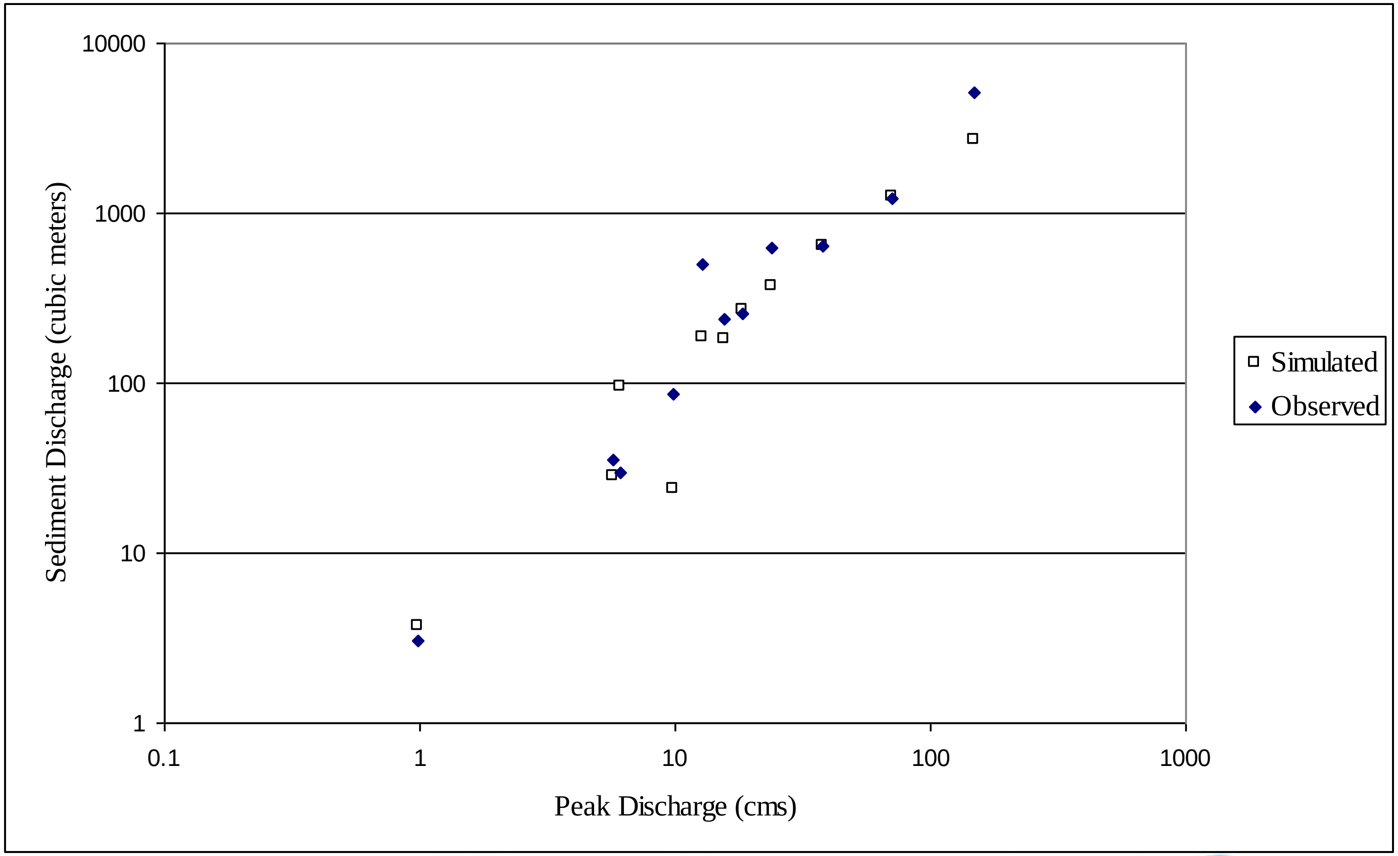


Suspended Sediment Calibration/Verification Results



Extended Simulations

- Model was capable of simulating events across 4 orders of magnitude in size.



Eau Galle River Flow and Sediment

2_EauGalle_1280x720.wmv

eg_sed_flux.wmv

Conclusions

- GSSHA is fully distributed, physics based watershed model that can be used for
  - Hydrologic analysis
  - Hydraulic analysis
  - Sediment transport
  - Water quality
- GSSHA fully integrates overland, channel, reservoirs, and groundwater and can simulate interactions and feedback between the domains.
  - Provides a higher level analysis that loose connections between models, like surface water hydrology to stream routing.
- GSSHA simulates the movement of sediments in this integrated format and can be used for many types of sediment studies.

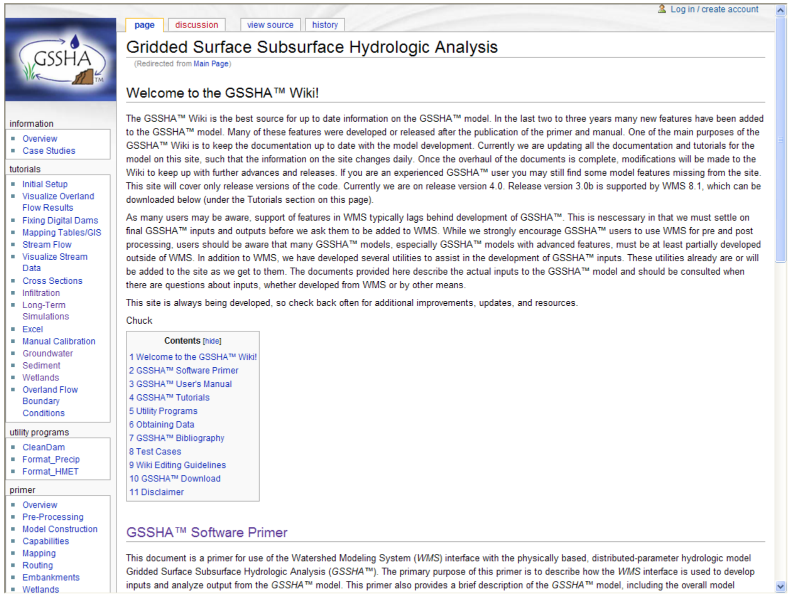
Further Information

GSSHA reference materials:

- http://www.gsshawiki.com/
- http://chl.erdc.usace.army.mil/gssha
  - Tutorials
  - Primer
  - Reference Manual
  - Download GSSHA Model

WMS reference materials:

- http://www.xmswiki.com/
- http://chl.erdc.usace.army.mil/wms



Additional Information

- www.gsshawiki.com
- Chapter 10 of the User's Manual on the GSSHA wiki.
  - Formulation
  - Suggested values of parameters
- Improved Soil Erosion and Sediment Transport in GSSHA, ERDC-SWWRP-TN-10-3
  - Formulation
  - Implementation in GSSHA
  - Model testing