



Simulating the Spatial Distribution of Hydrologic Processes: TIN-based Distributed Modeling

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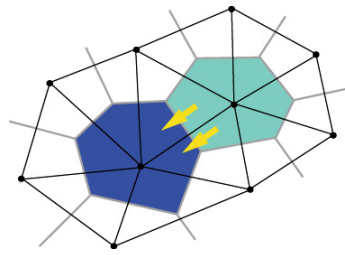
Outline

1. Motivation
2. TIN-based Distributed Modeling
3. Hydrological Processes
4. Calibration and Validation Studies
 - a. Baron Fork basin
 - b. Blue River basin
5. Conclusions



Motivation

- Reduce computational elements through the use of TIN models.
- Utilize highest resolution DEM, watershed and rainfall available.
- Physically-based hydrologic processes of large-scale watersheds.

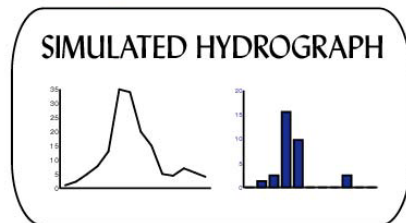
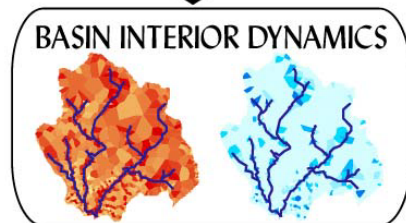


tRIBS Model Framework

TIN-BASED INPUT

TIN - Points

- VORONOI CELLS
- GEOMETRY
- SLOPES
- FLOW DIRECTIONS
- FLOW PATHS



RASTER-BASED INPUT

Soils

Land Use

Water Table Depth

Rainfall - radar

POINT DATA

Meteorological Information

Resampling Routine

Global Simulator

Rainfall - Runoff Transformation

Time-Invariant

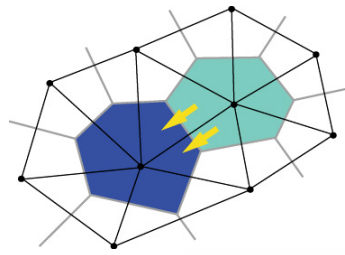
Initialization

Time-Dependent

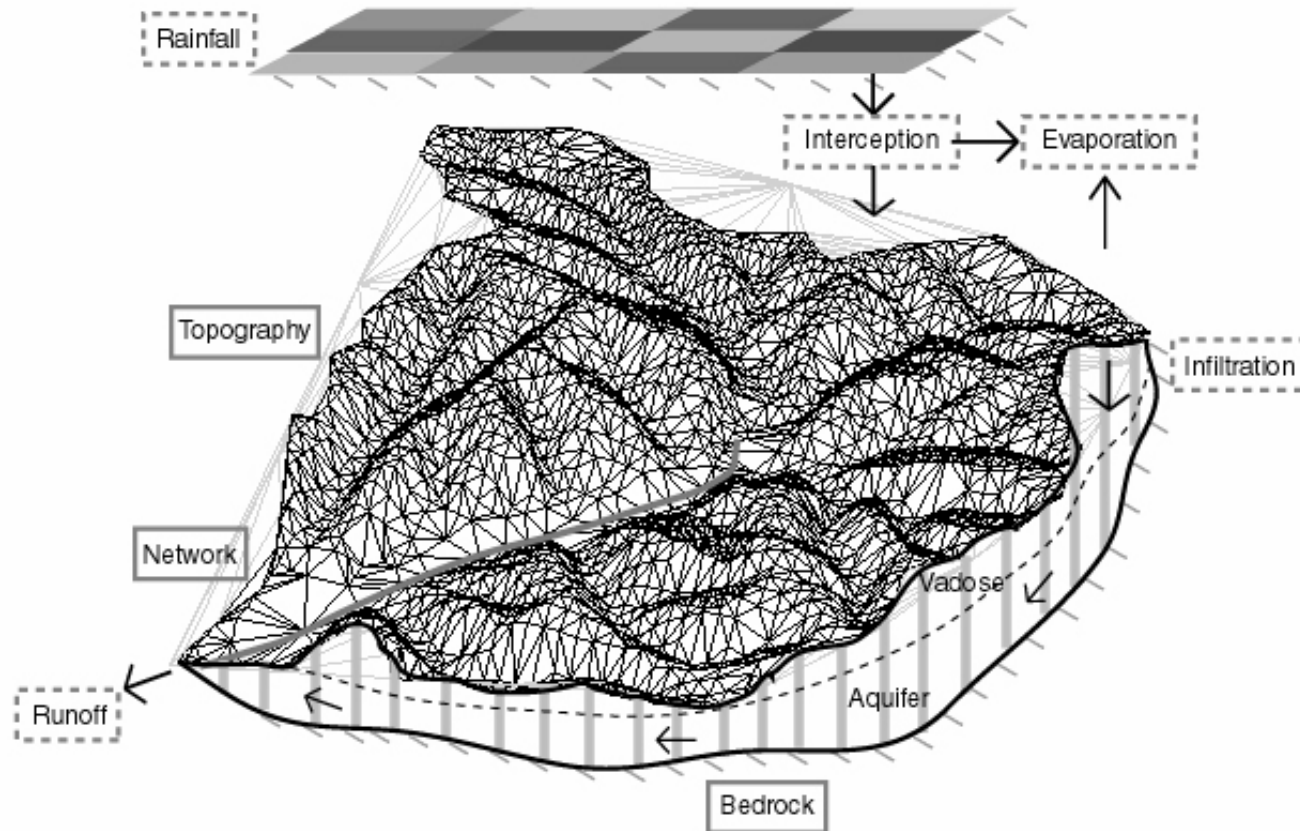
Update

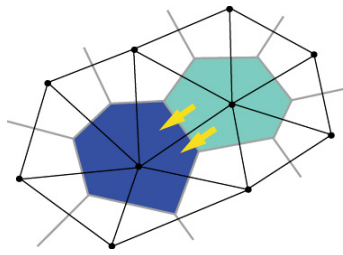
Update

- WETTING FRONT
- TOP FRONT
- WATER TABLE
- MOISTURE CONTENT
- RUNOFF GENERATION

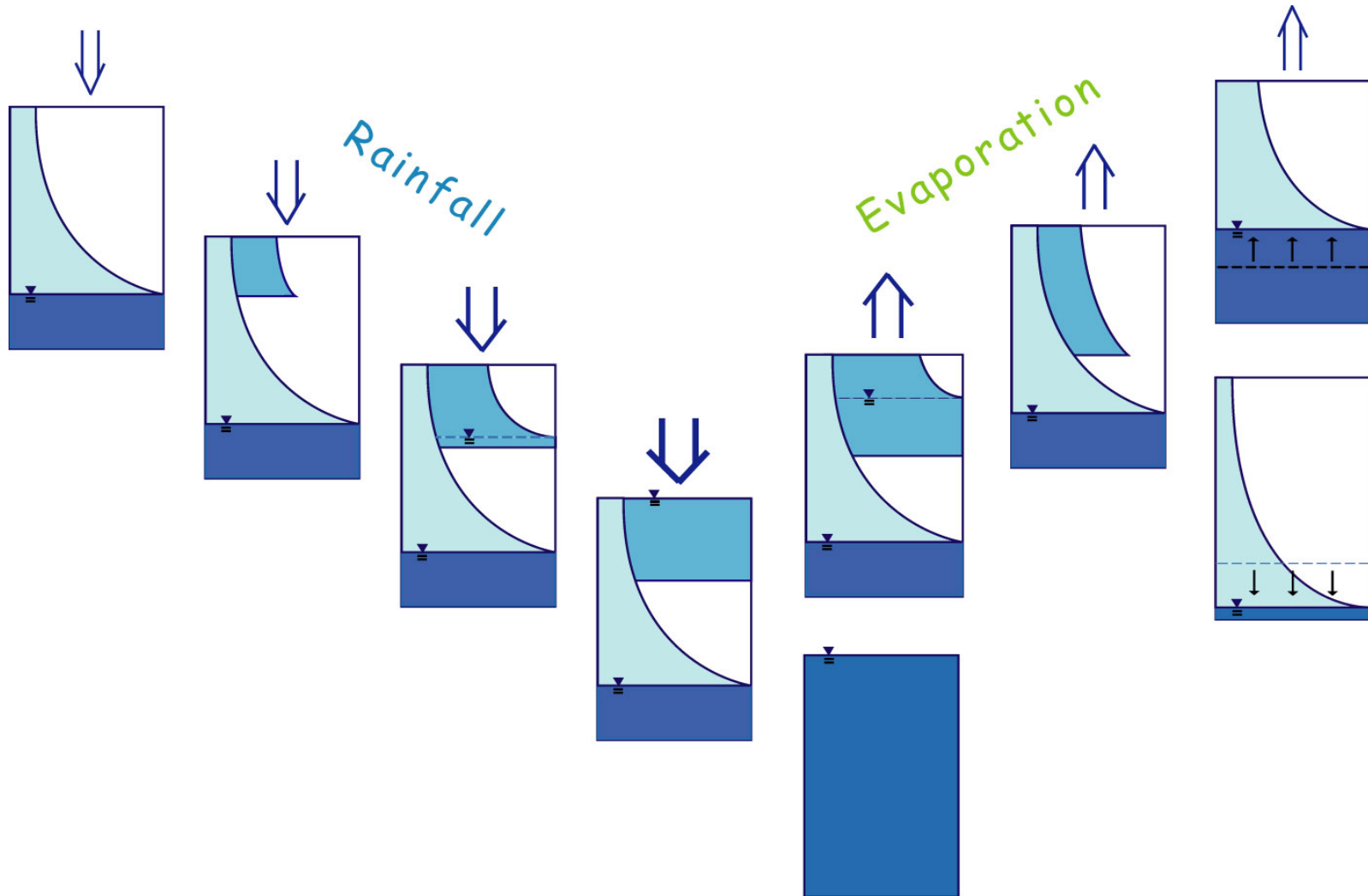


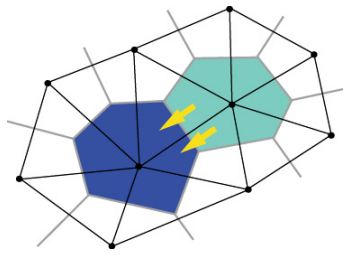
tRIBS Model Framework





Basic wetting and drying cycle





Interception modeling

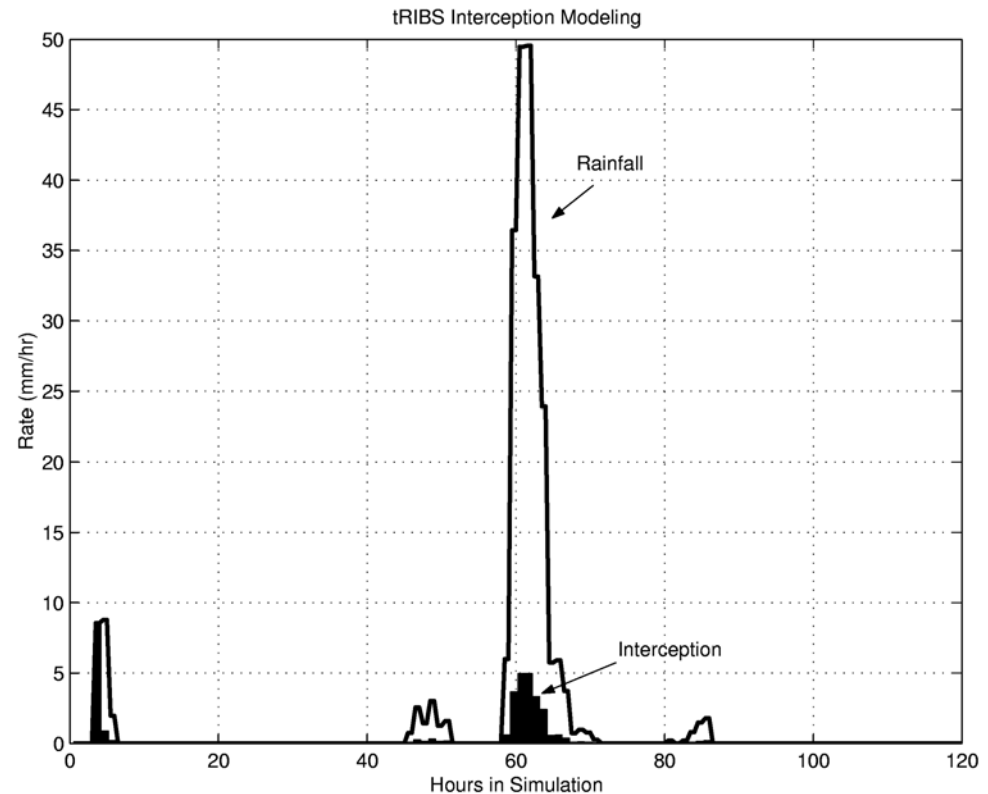
Two methods in tRIBS:

- Canopy storage (Gray)

- Canopy water balance (Rutter)

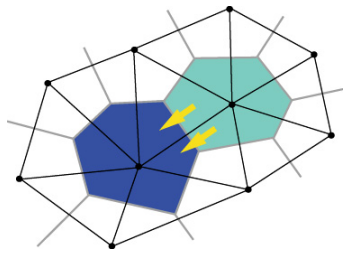
Land use parameterization

Storage, evaporation and throughfall of intercepted water modeled



Canopy storage method

9/24/96 Storm Event, Peachester



Evapotranspiration modeling

Four methods in tRIBS:

Penman-Monteith equation

Deardorff equation

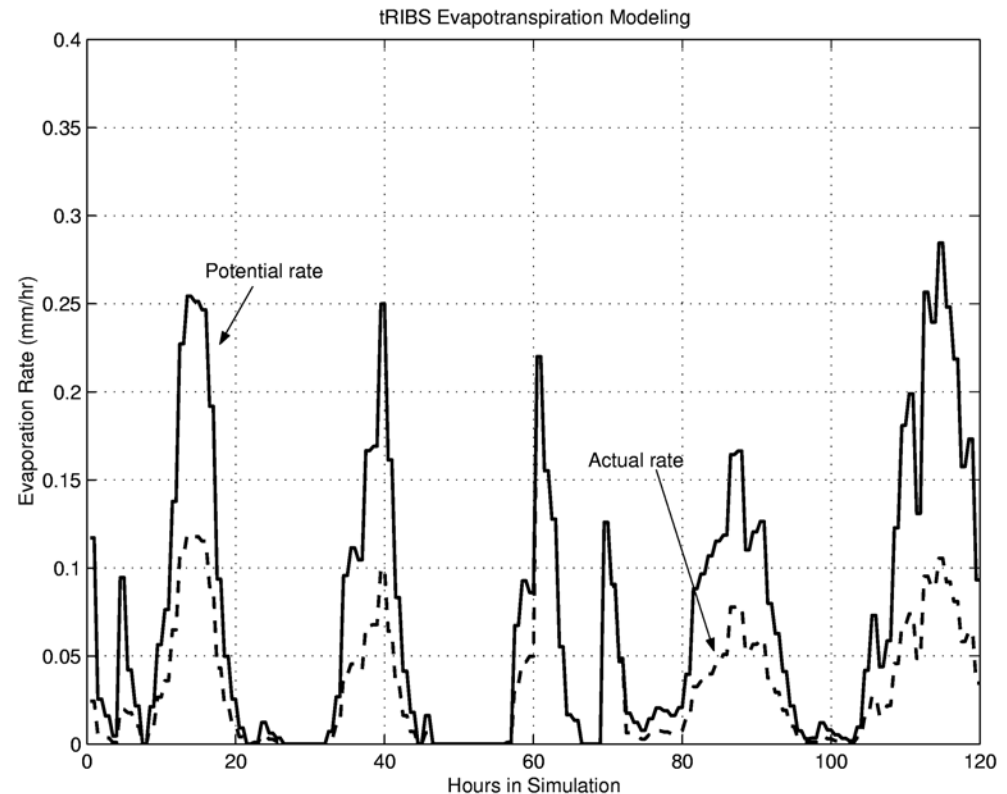
Priestley-Taylor equation

Pan evaporation data

Land use and soil texture
parameterization

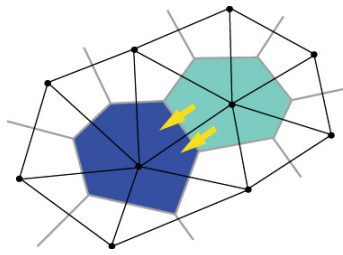
Wet canopy evaporation,
transpiration from plants,
bare soil evaporation.

Soil-moisture dependence



Penman-Monteith method

9/24/96 Storm Event, Peacheater



Energy and radiation modeling

Net Radiation Components

Incoming shortwave

Incoming longwave

Outgoing longwave

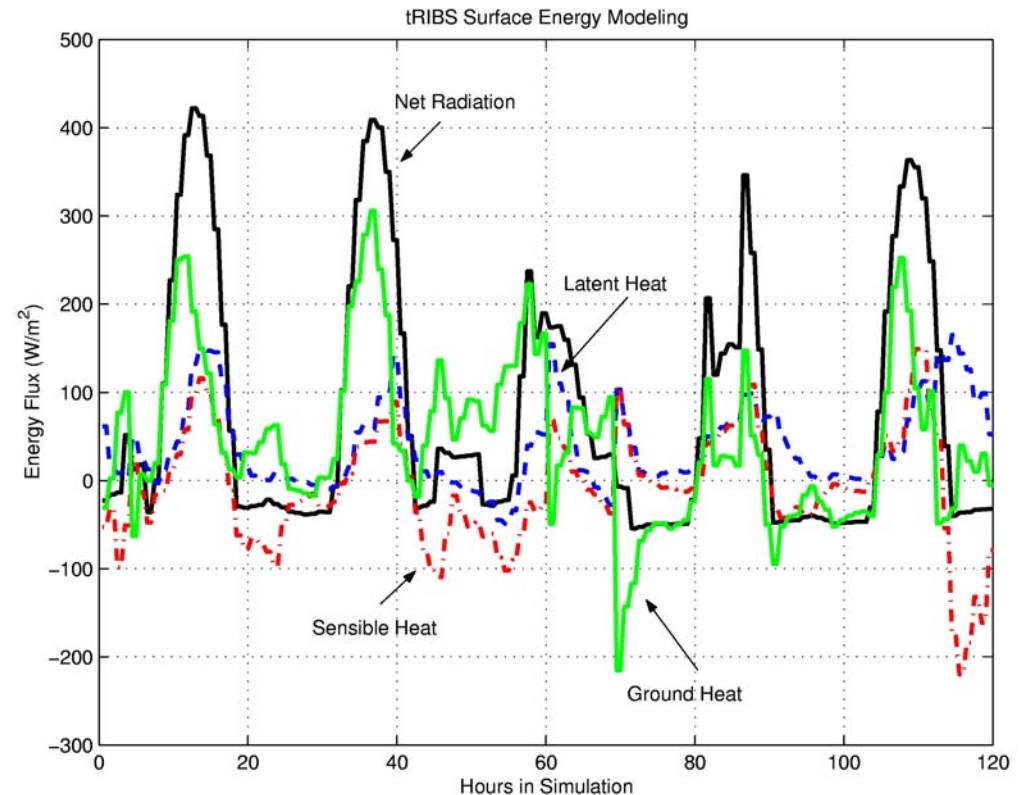
Energy Flux Components

Latent Heat Flux

Sensible Heat Flux

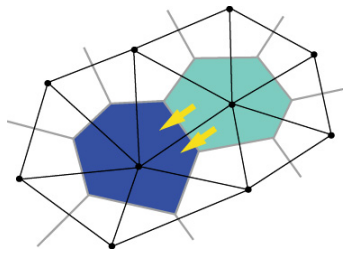
Ground Heat Flux

Net Radiation



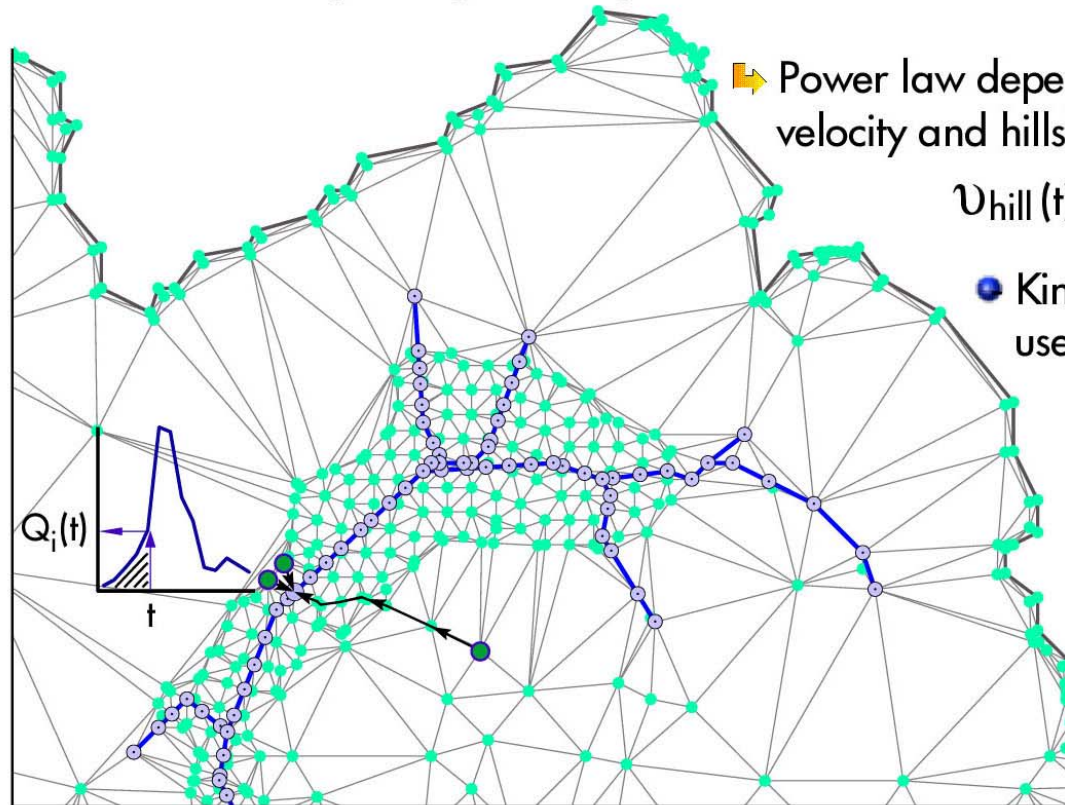
Energy Balance

9/24/96 Storm Event, Peacheater



Hydraulic channel routing

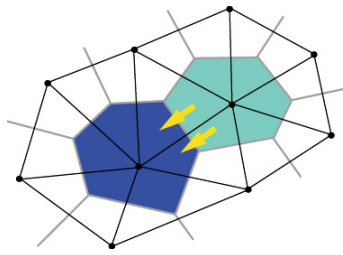
- The travel path consists of a hillslope fraction and a stream fraction
- Hydrologic routing model is used for the hillslope part



↳ Power law dependence between hillslope velocity and hillslope outlet discharge

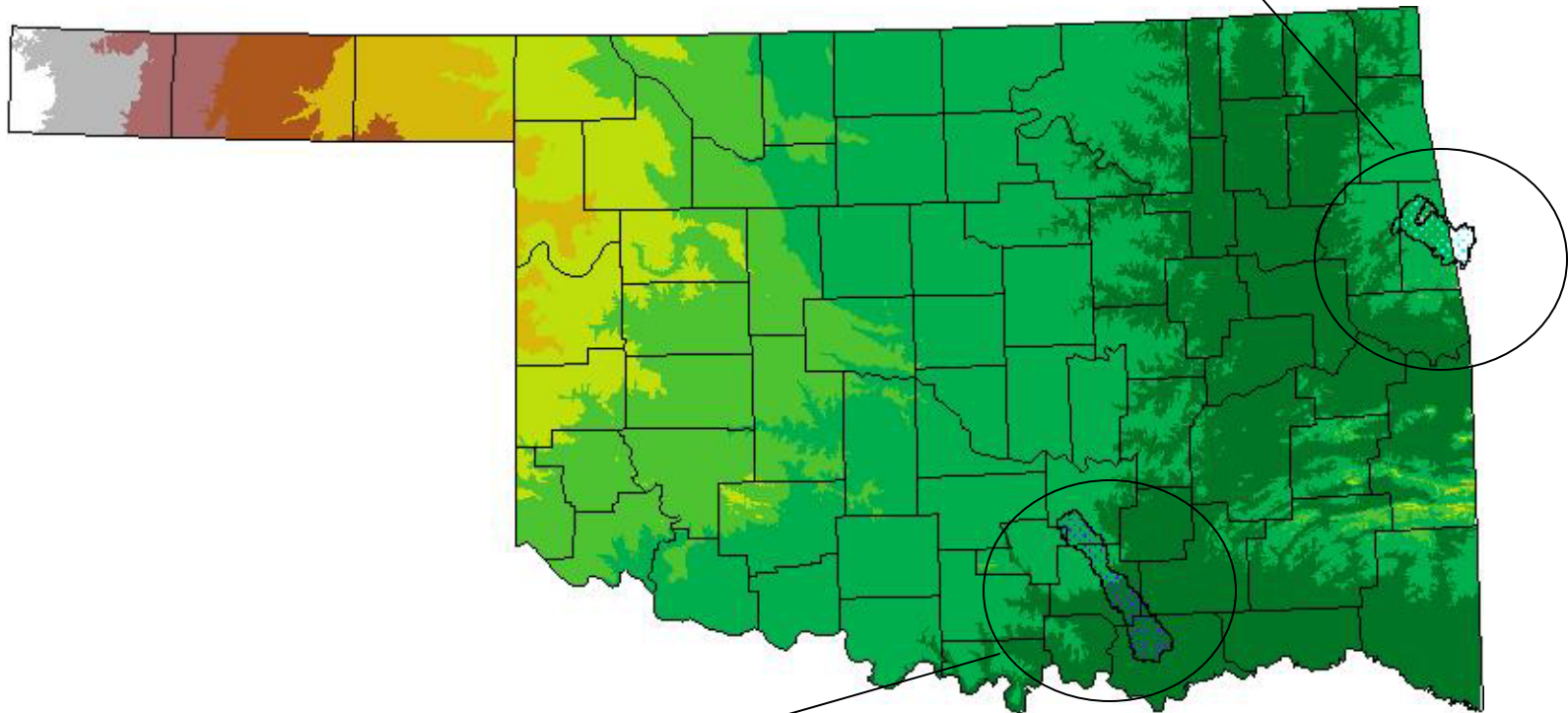
$$v_{\text{hill}}(t) = C_v Q_i(t)^r$$

- Kinematic routing model is used for the channel part

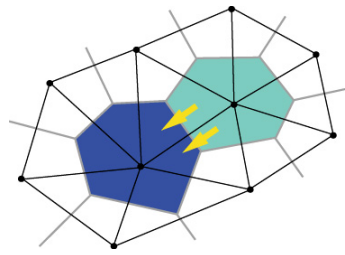


Study Watersheds

Baron Fork and Peacheater
Creek in Ozark Plateau



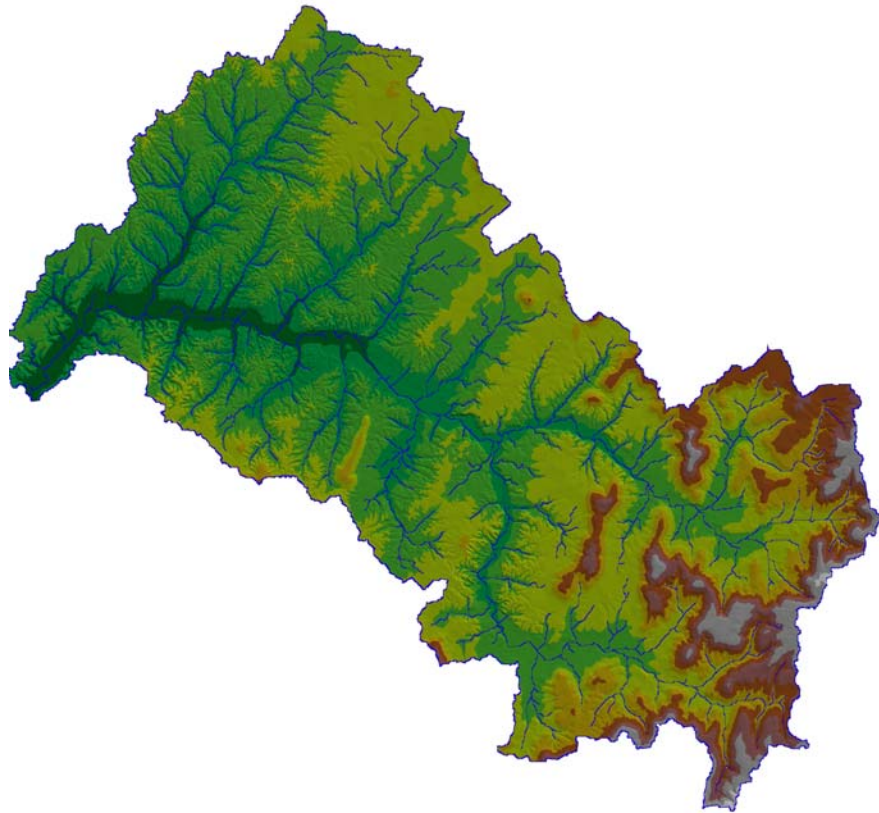
Blue River in the
Central Lowlands



TINs and Landuse

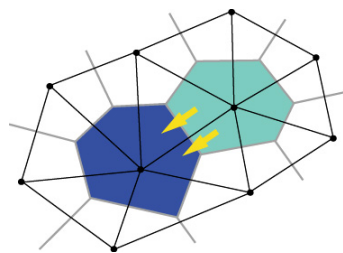
Baron Fork Watershed

808 square kilometers

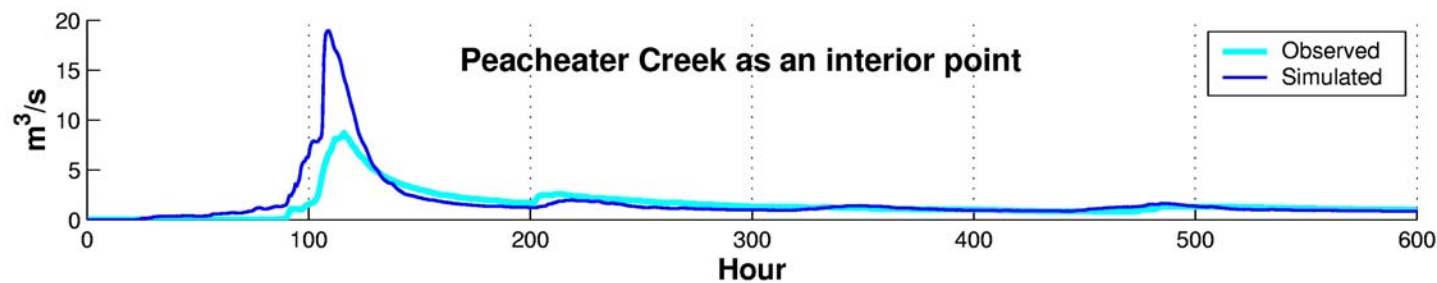
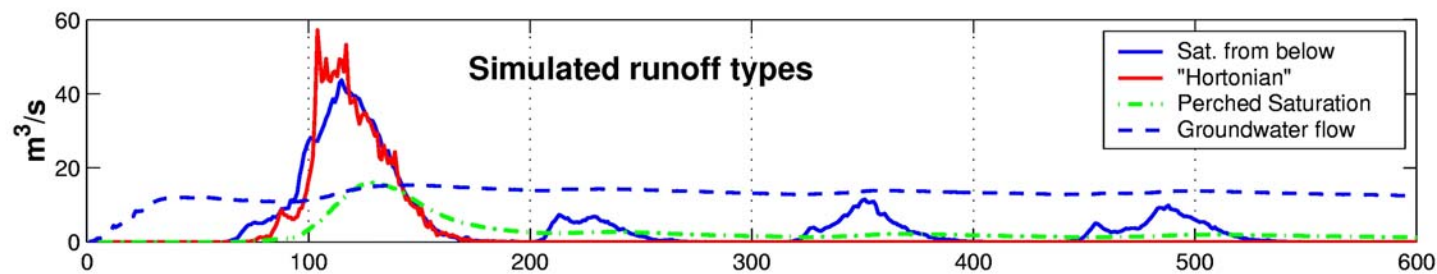
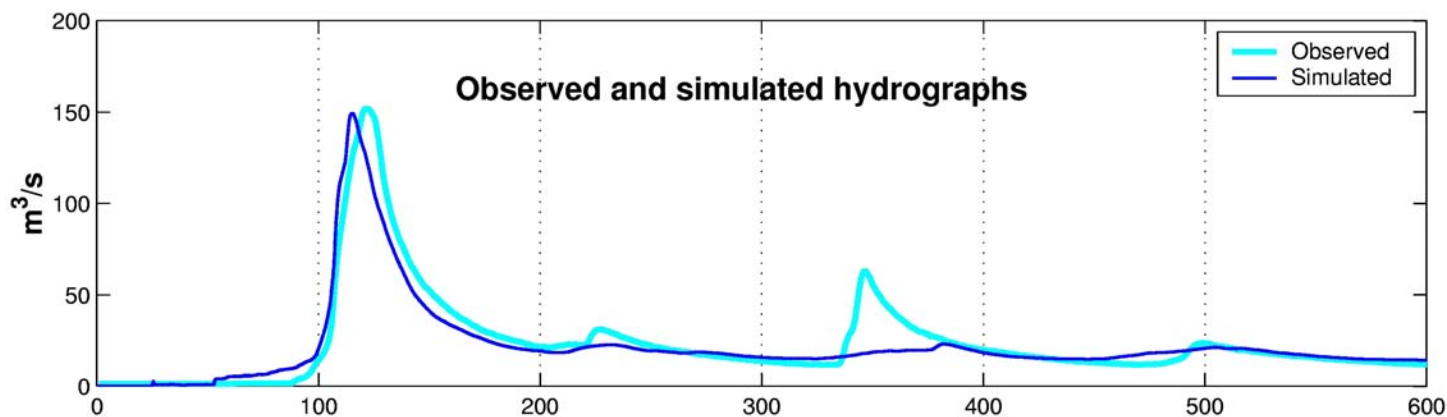
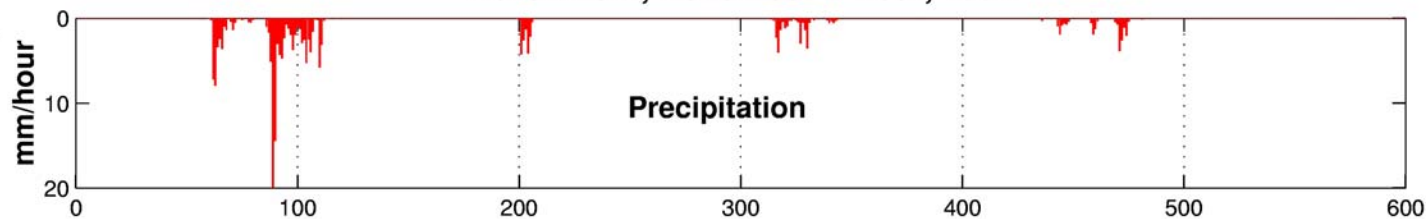


TIN has 6% nodes of raster DEM
DEM nodes = 897,949
TIN nodes = 54,438

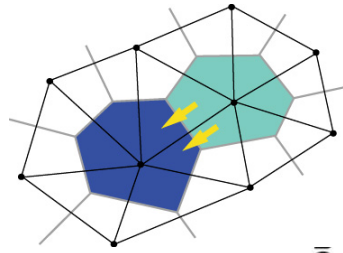
Baron Fork: Calibration



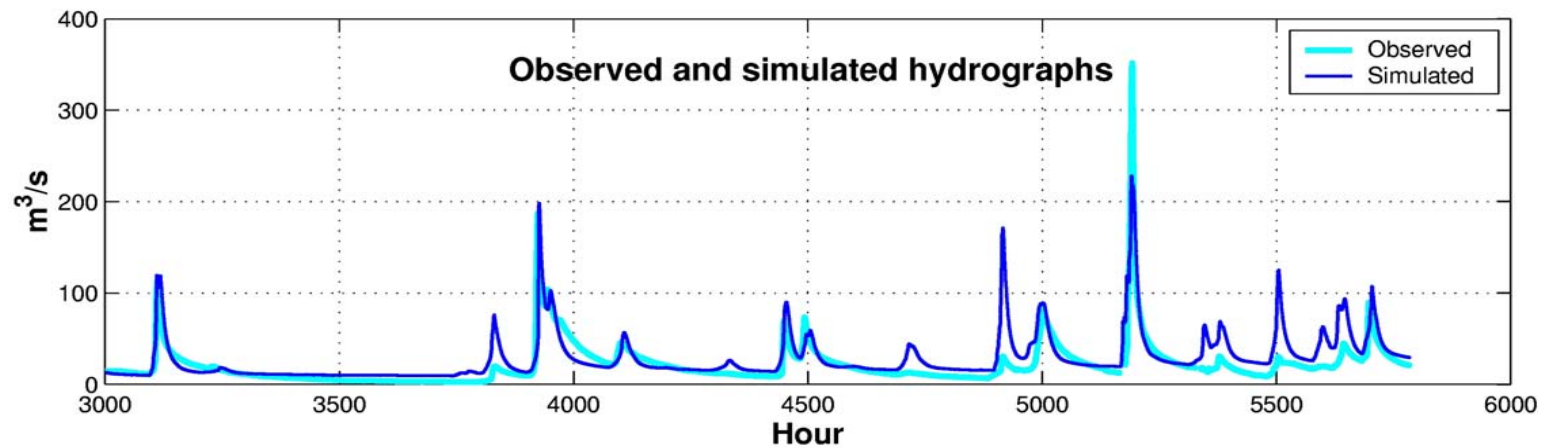
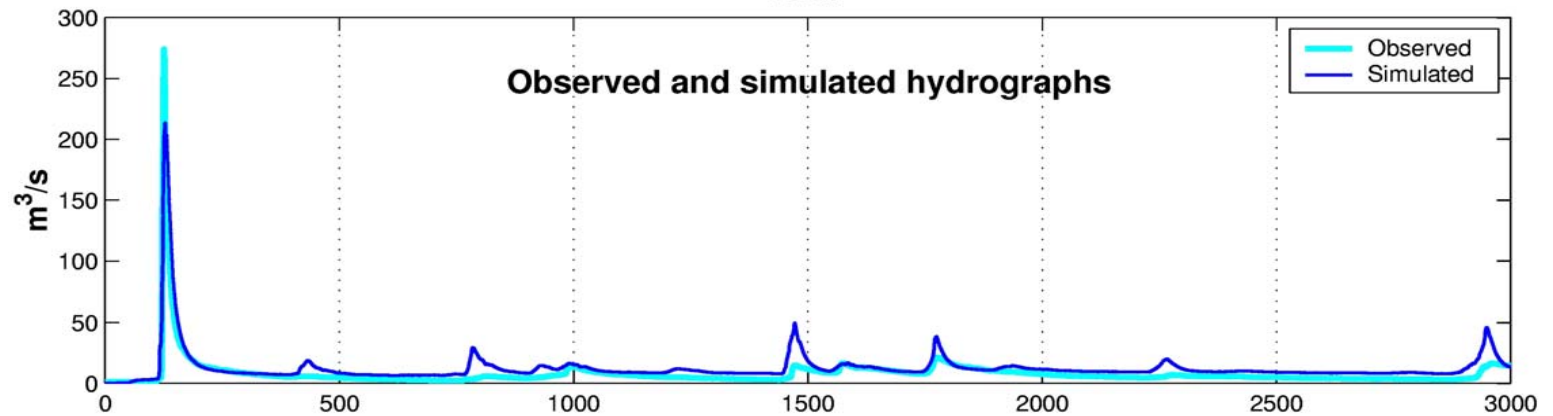
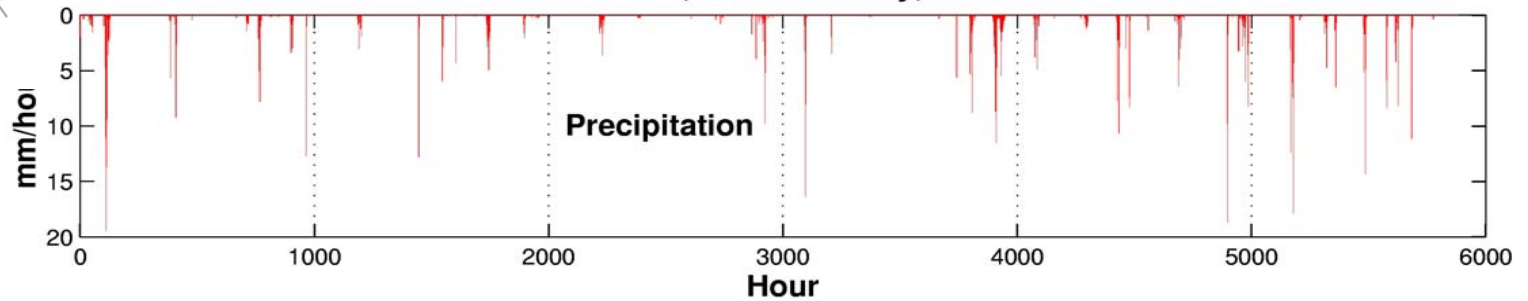
Baron Fork, November 1–25th, 1994



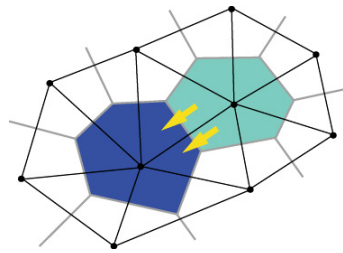
Baron Fork: Validation



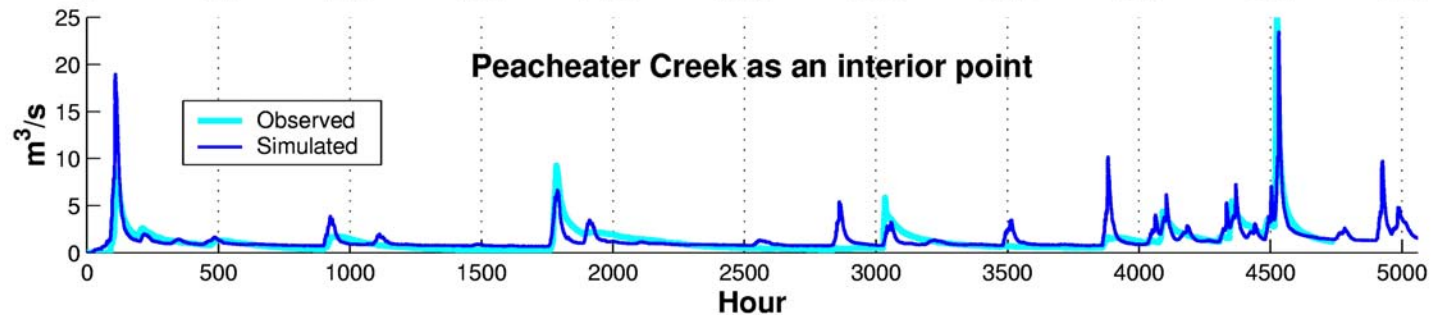
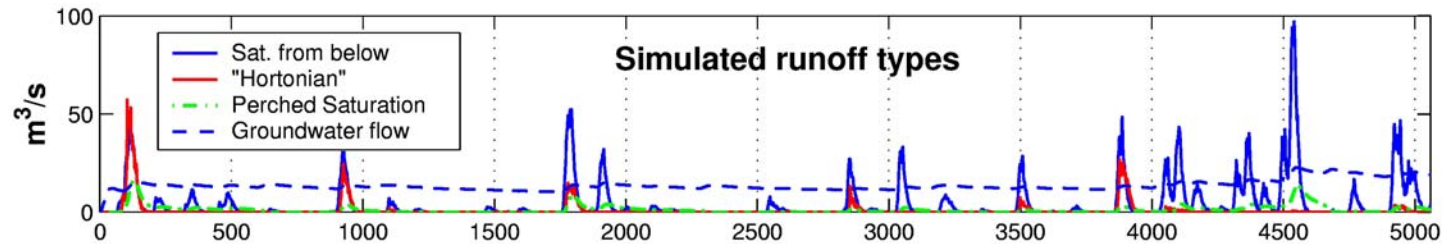
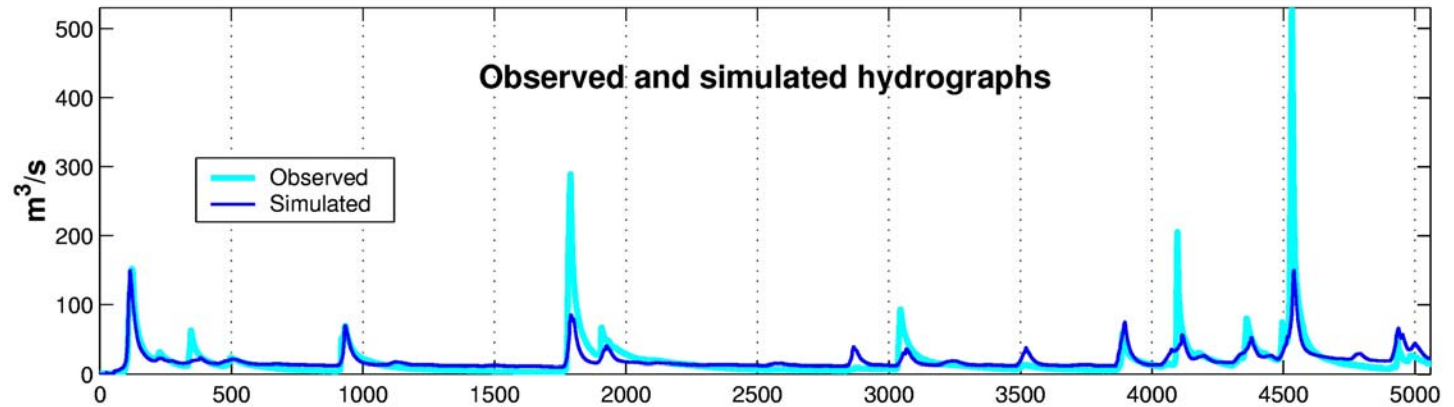
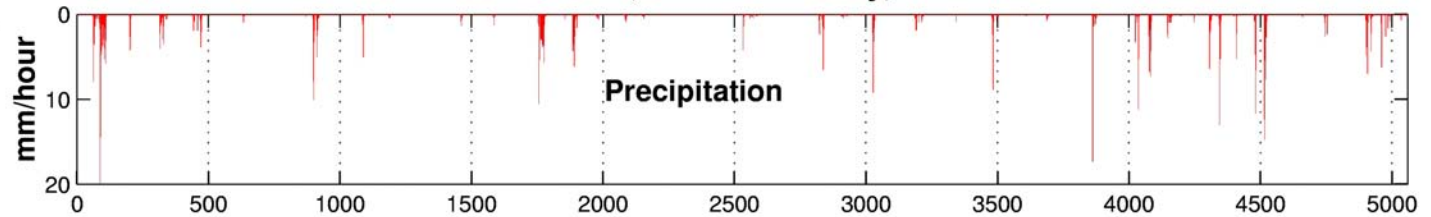
Baron Fork, October–May, 1998–99



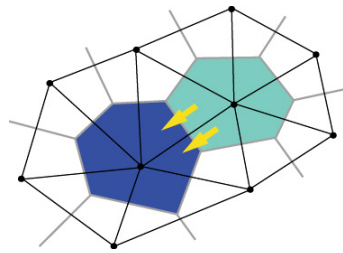
Baron Fork: Validation



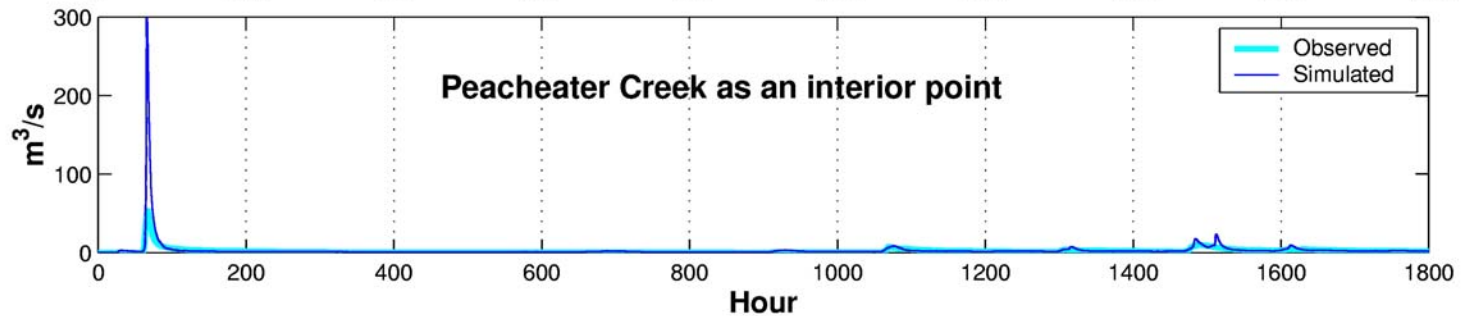
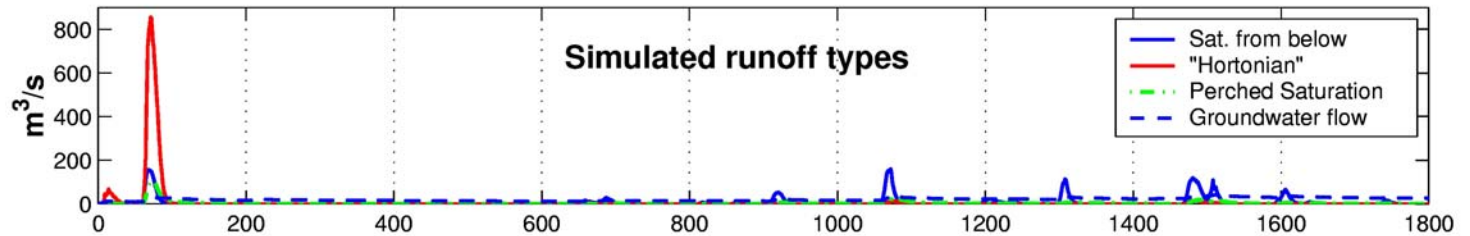
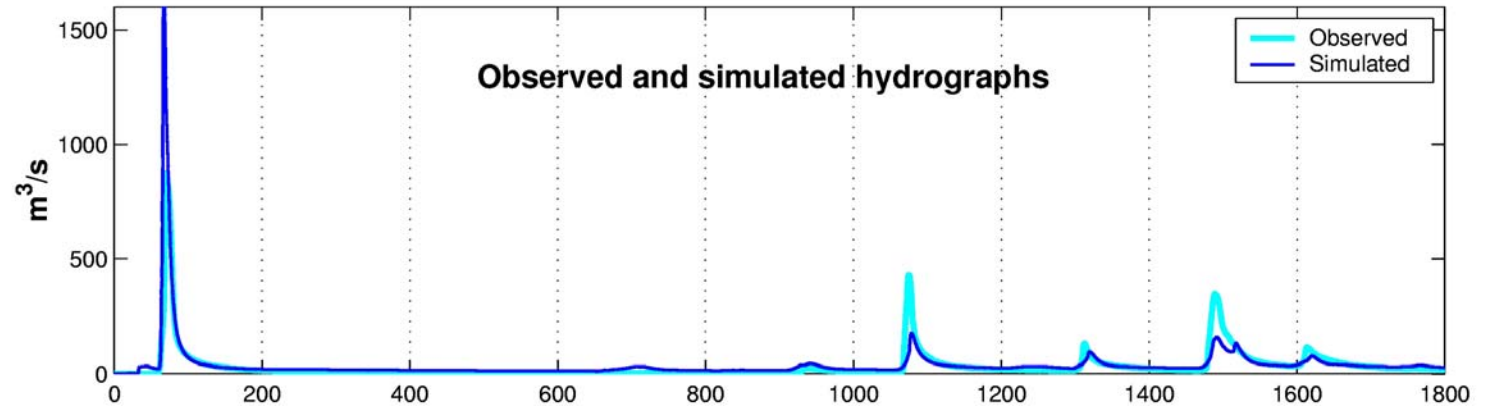
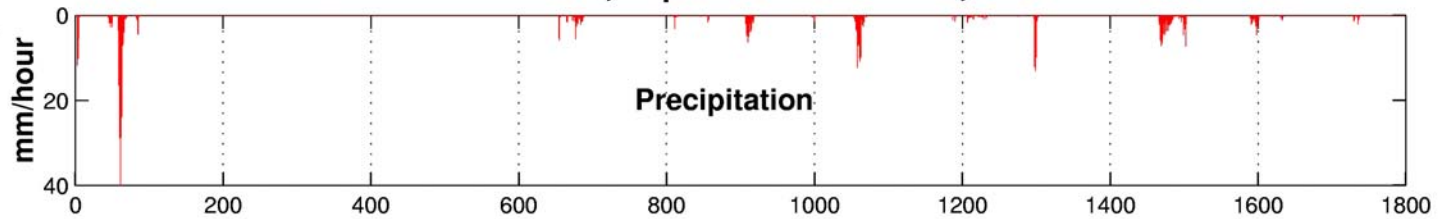
Baron Fork, November–May, 1994–95

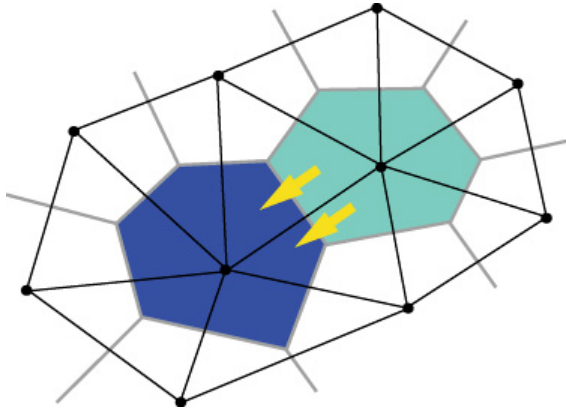


Baron Fork: Validation



Baron Fork, September–December, 1996

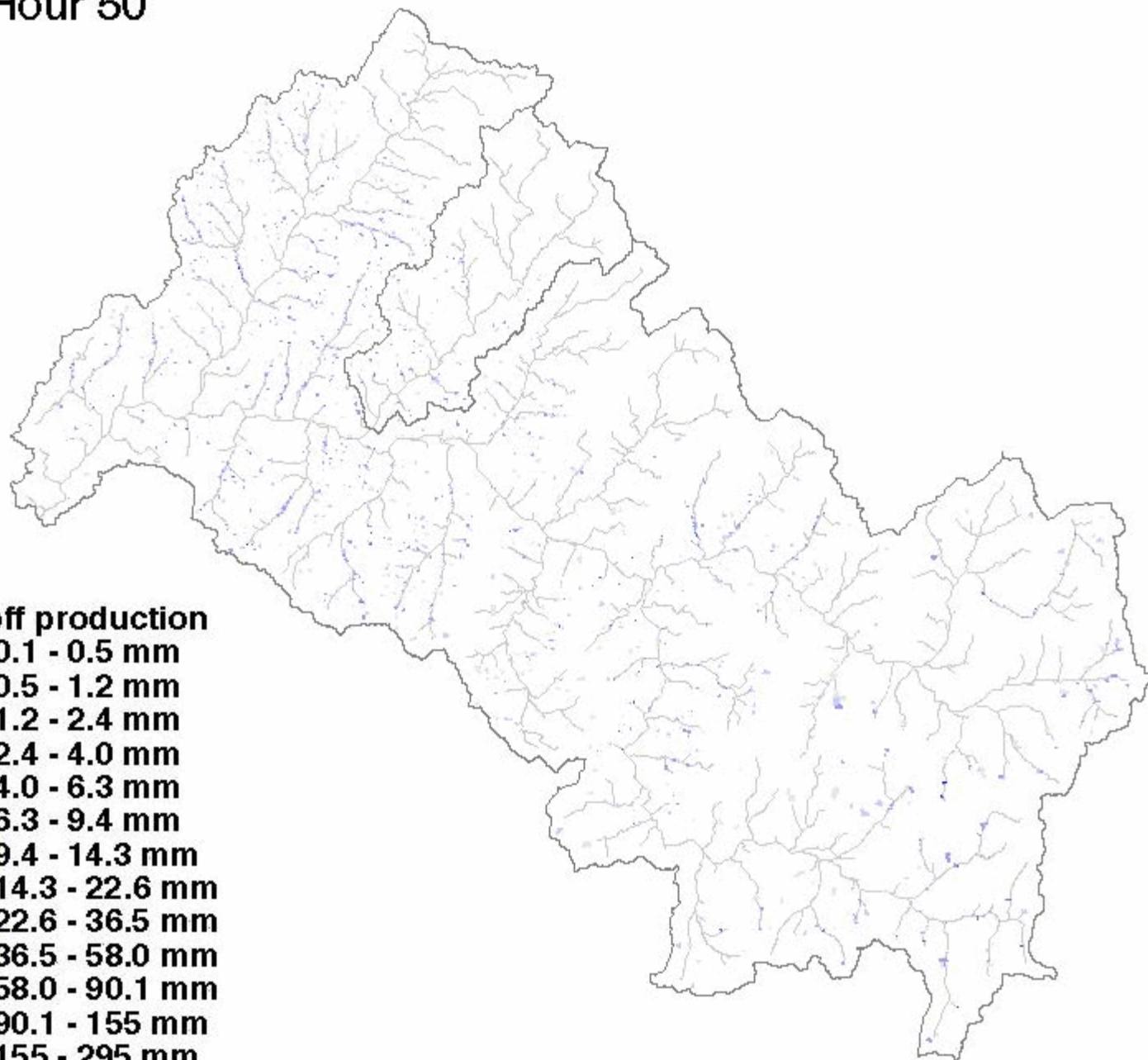
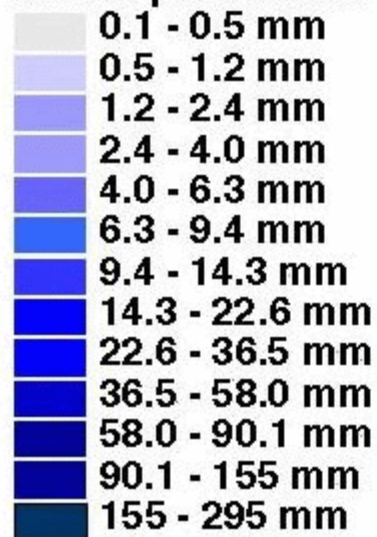


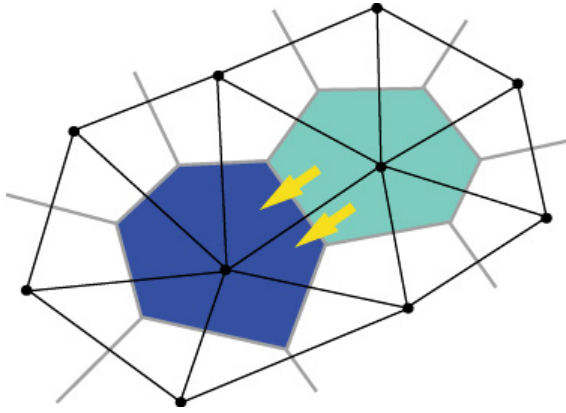


Runoff Production Animation

Hour 50

Runoff production

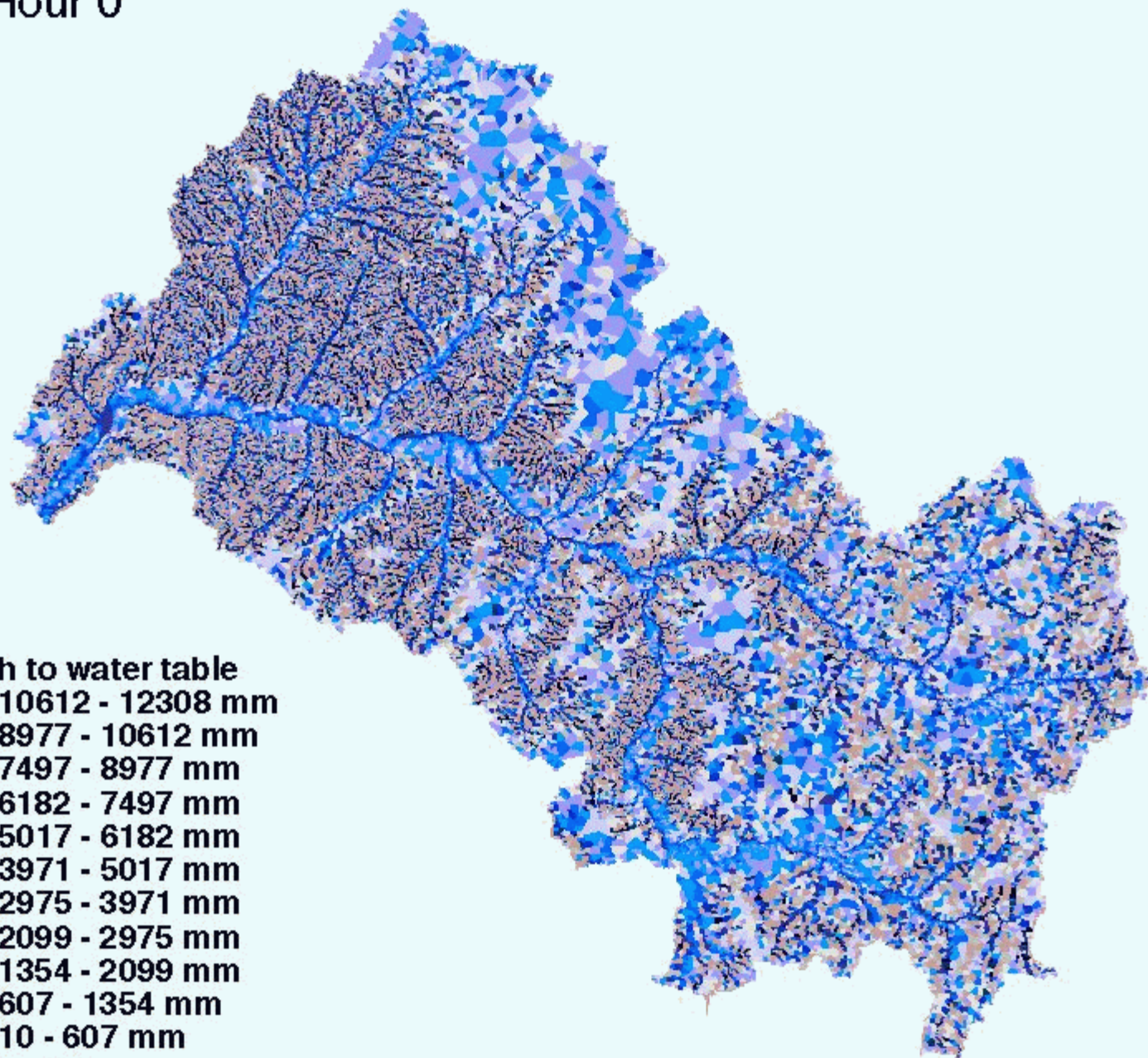
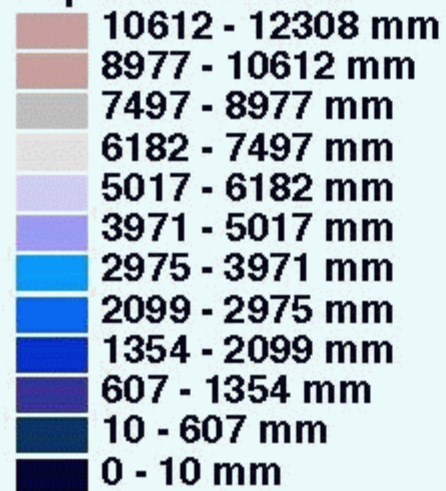


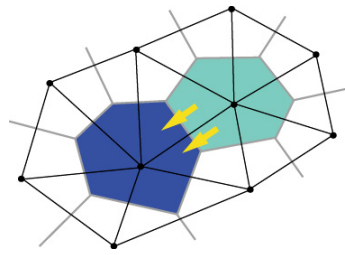


Groundwater Dynamics Animation

Hour 0

Depth to water table

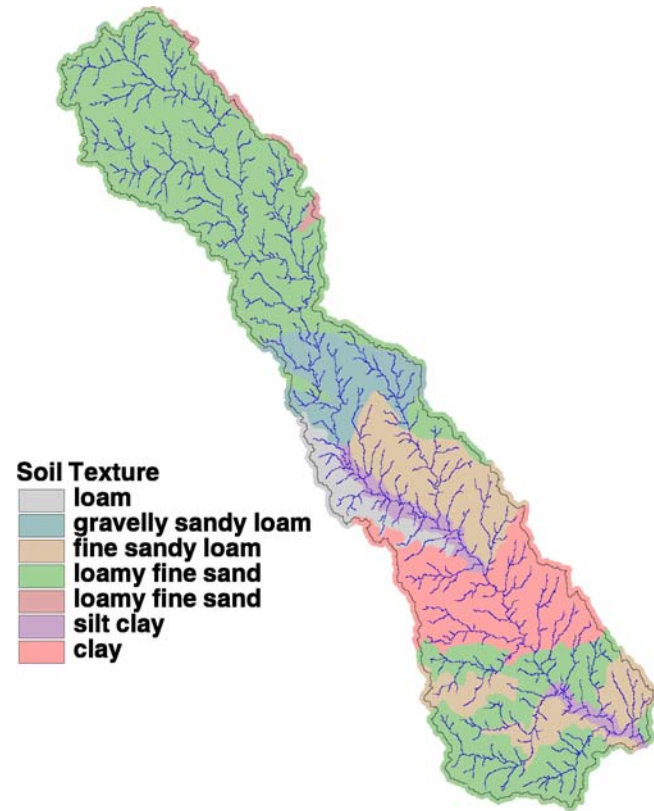
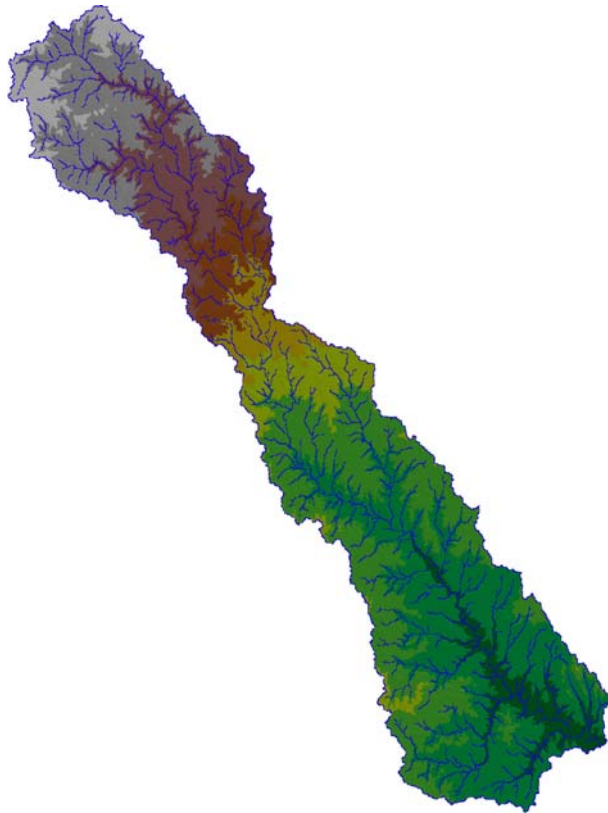




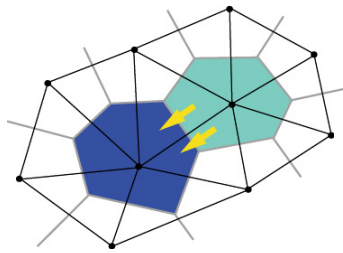
TINs and Landuse

Blue River Watershed

1236 square kilometers

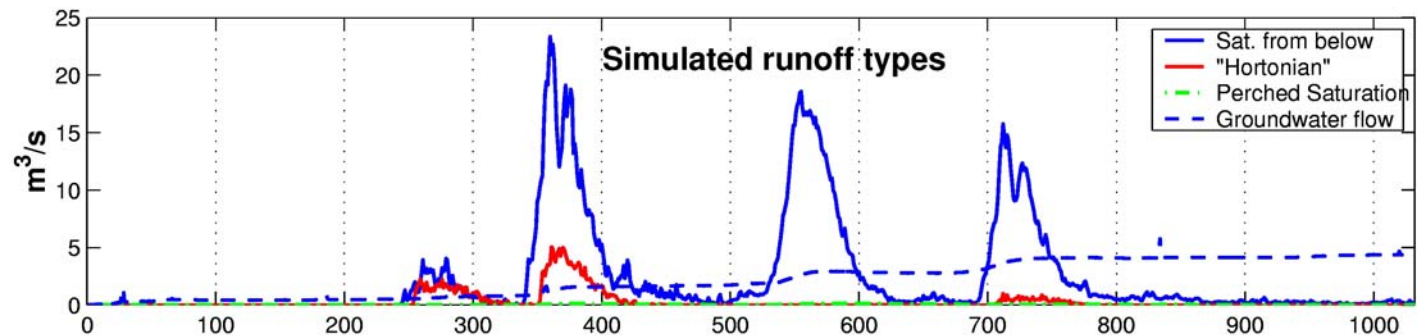
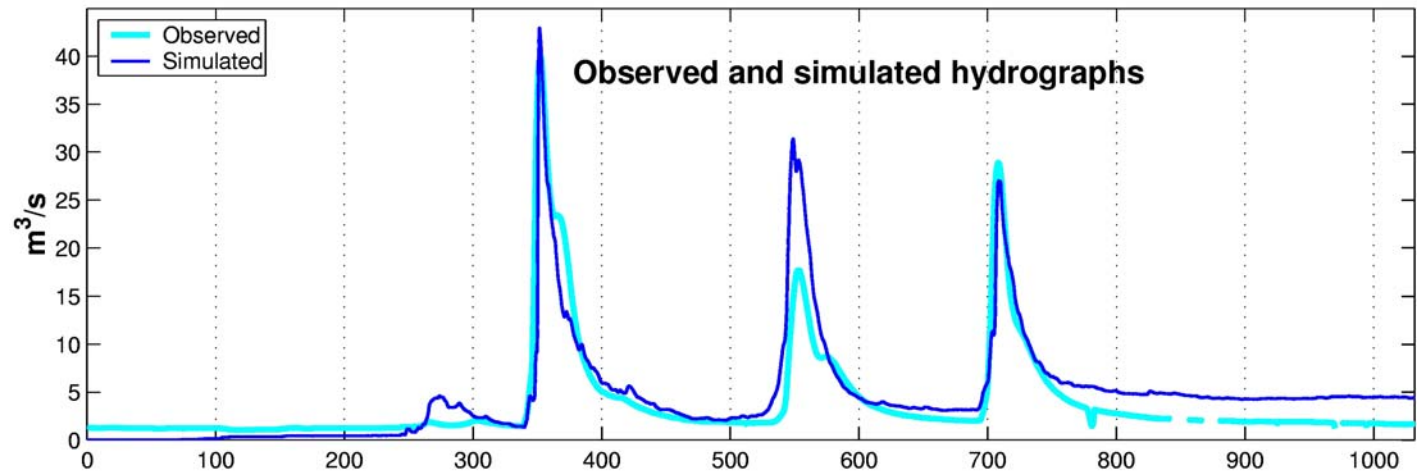
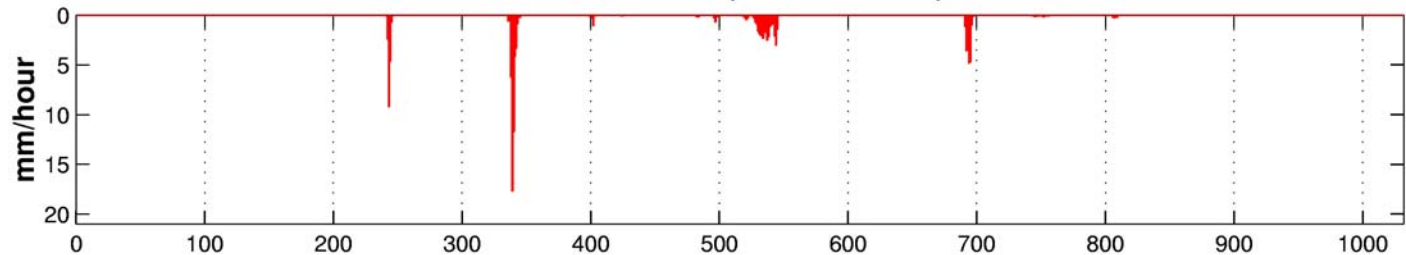


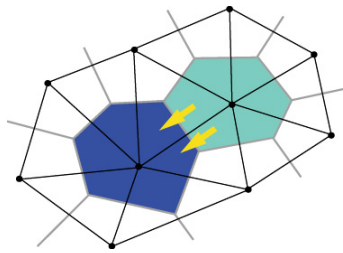
TIN has 2% nodes of raster DEM
 DEM nodes = 1,372,999
 TIN nodes = 23,536



Blue River: Calibration

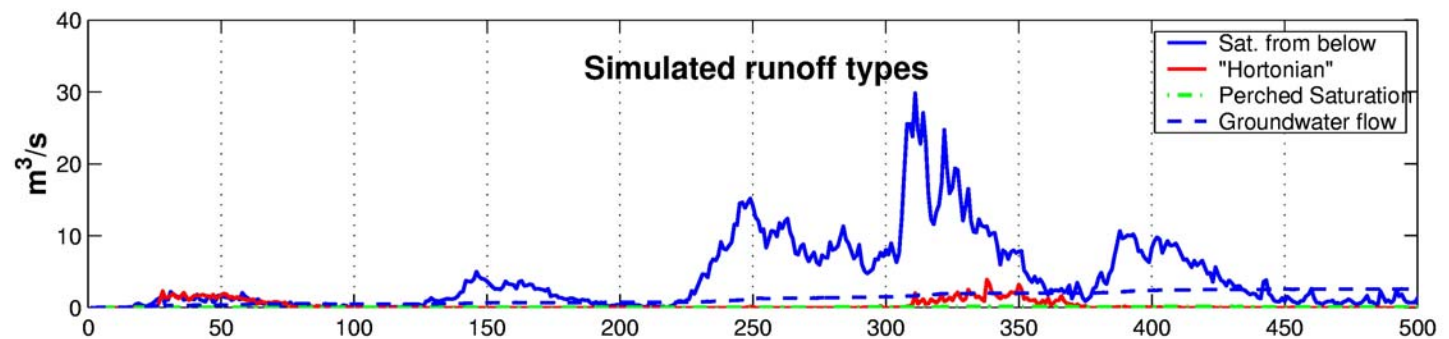
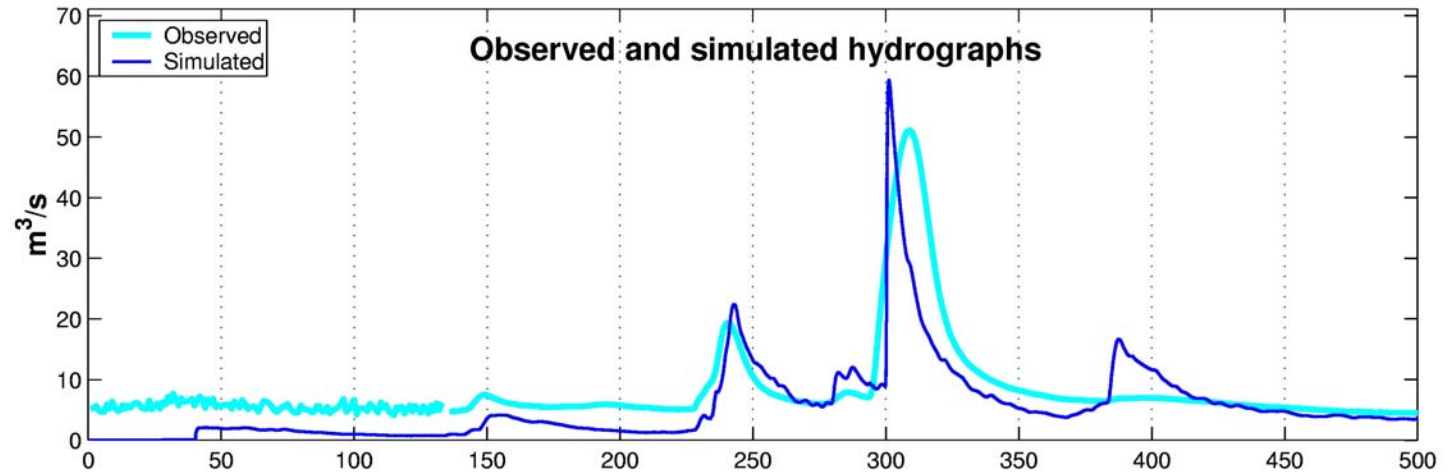
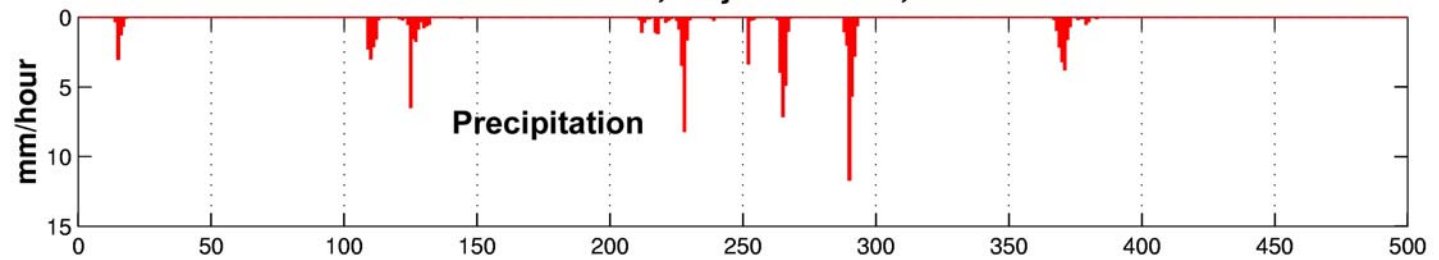
Blue River Nov 20, 1998 – Jan 1, 1999

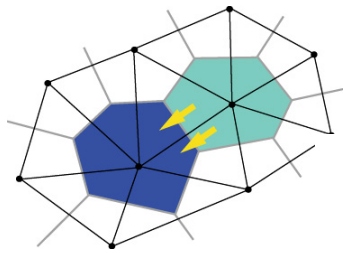




Blue River: Validation

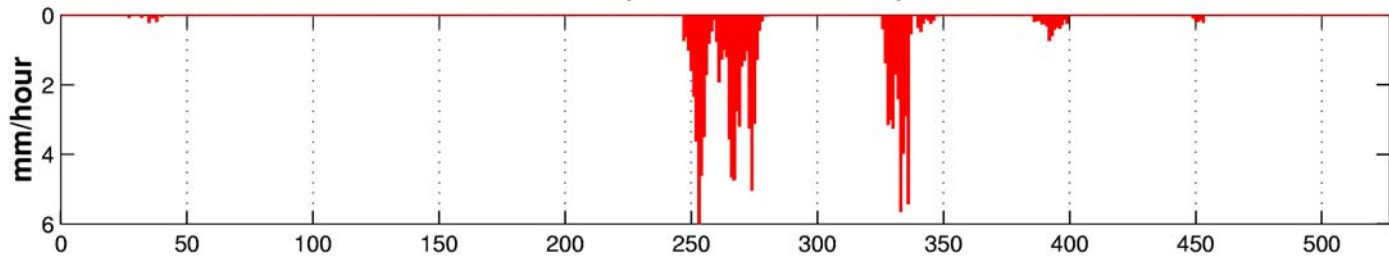
Blue River, May 15–June 4, 1997



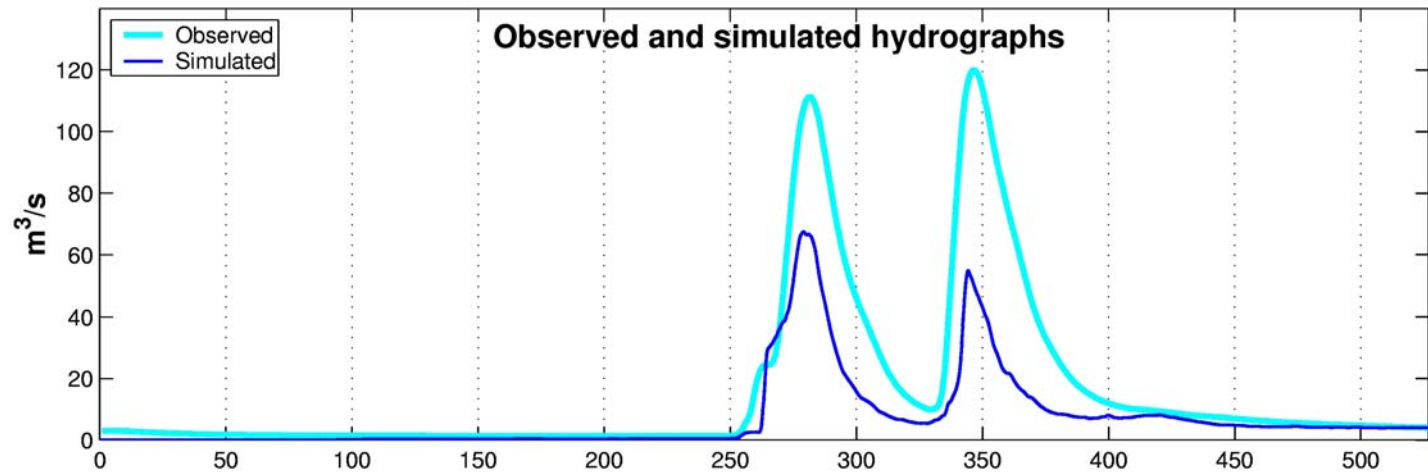


Blue River: Validation

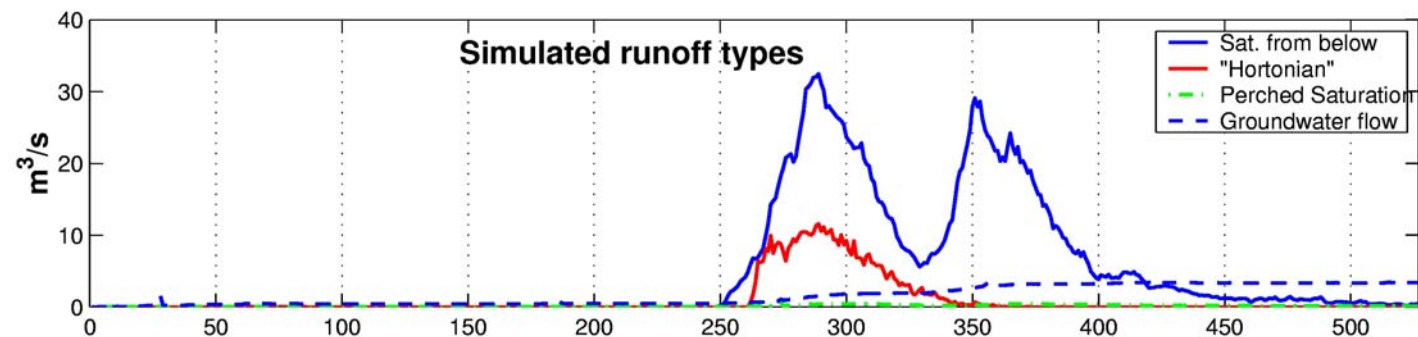
Blue River, December 10–31, 1997

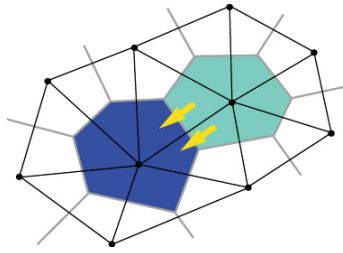


Observed and simulated hydrographs



Simulated runoff types





Soil Hydraulic Parameters: Blue River Basin

	K_0 , mm/hr	f , mm ⁻¹	Ar	UAr	ψ_b , mm	λ_0	θ_s	θ_r
Loamy Fine Sand	61	0.0010	600	800	-90	2.0	0.401	0.035
Gravelly Sandy Loam	50	0.0010	600	800	-90	0.38	0.501	0.041
Fine Sandy Loam	28	0.0010	400	500	-150	0.38	0.412	0.041
Loam	17	0.0007	400	500	-110	0.25	0.434	0.027
Silty Loam	6.8	0.0004	300	500	-208	0.23	0.486	0.015
Silty Clay	6.0	0.0002	100	200	-340	0.15	0.423	0.056
Clay	2.0	0.0002	100	200	-370	0.15	0.385	0.090



Conclusions

- TIN-based Distributed model applied to Baron Fork, Blue River and Illinois River at Watts (in progress).
- Calibration, validation at outlet and interior points.
- Model is capable of simulating the spatial distribution of hydrologic processes over large-scale catchments.