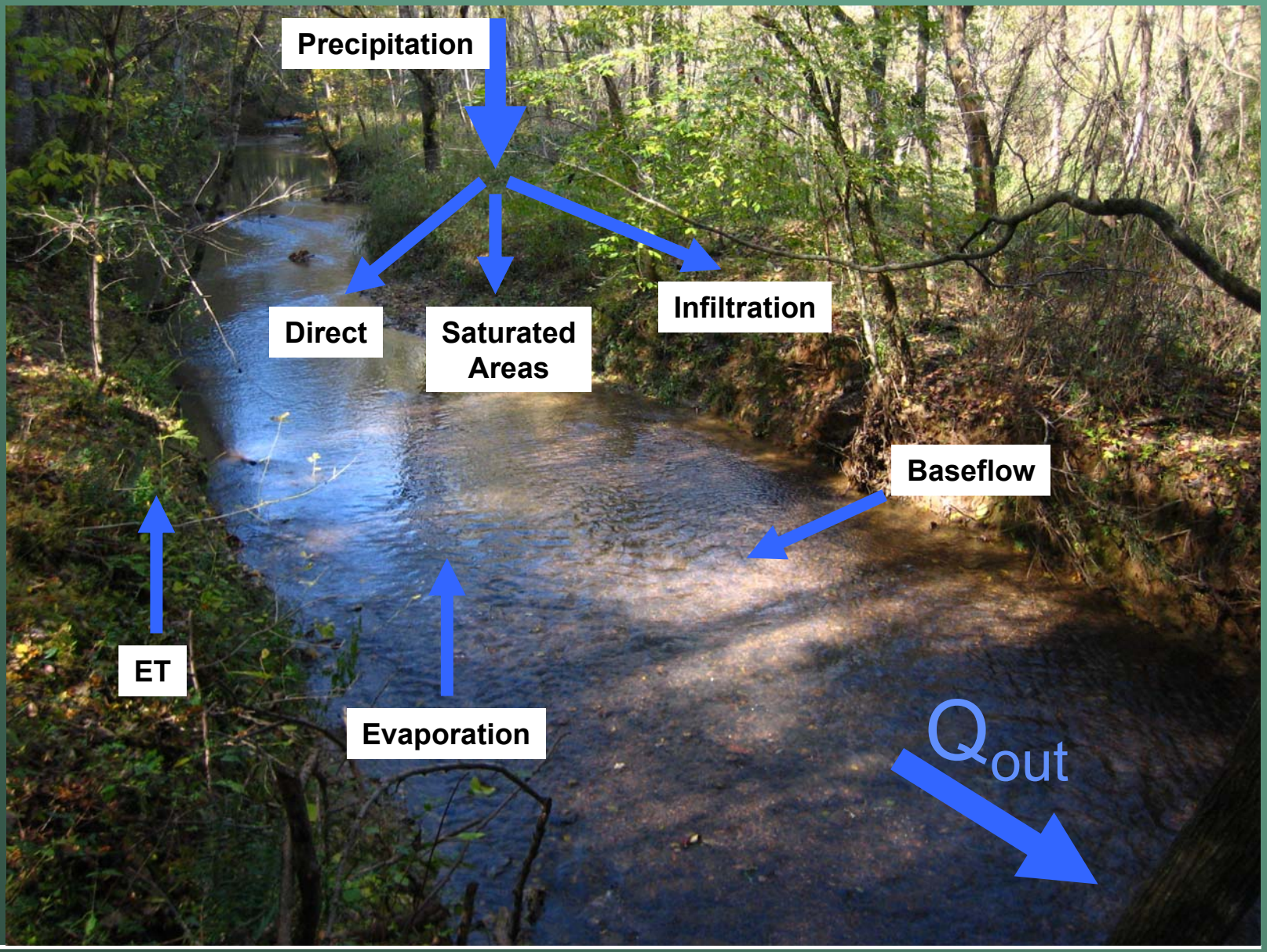
Implications of SSURGO versus STATSGO data for modeling daily streamflow in Kentucky

Tanja N. Williamson, PhD
USGS Kentucky Water Science Center
Kenneth R. Odom, PhD, PE
USGS Alabama Water Science Center

U.S. Department of the Interior
U.S. Geological Survey

Water Cycle



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TOPMODEL Overview

- TOPography-based hydrological MODEL
- Developed by Beven and Kirkby, 1979
- "Physically-based watershed model that simulates the variable-source-area concept of streamflow generation." (Wolock, 1993)
- Three fundamental assumptions
  - Steady-state recharge to the groundwater
  - Hydraulic gradient of the water table is approximately equal to the surface slope
  - Transmissivity profile decreases exponentially with depth

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Beven, K.J. and M.J. Kirkby. 1979. A physically based, variable contributing area model of basin hydrology. *Hydrological Sciences Bulletin*, v. 24, pp. 43-69.

Wolock, David M. 1993. Simulating the variable-source-area concept of streamflow generation with the watershed model TOPMODEL. *USGS WRI 93-4124.*

Variables

Variable	STATSGO	SSURGO
Ksat	Mean [K_{sat}-H, K_{sat}-L] (in hr^{-1})	K_{sat}-R (µm sec^{-1})
Available Water Capacity	Mean [AWC-H, AWC-L]	AWC-R
Field Capacity	SSURGO	FC-R
Porosity	$1 - \frac{\text{Mean}[\rho_b\text{-H}, \rho_b\text{-L}]}{2.65}$	Satiated Water Content - R
Depth	Profile Depth (in)	K_{sat} > 1 µm sec^{-1} (cm)
Conductivity Multiplier	$\frac{K_{sat}\text{-H profile mean}}{K_{sat}\text{-L profile mean}}$	$\frac{K_{sat}\text{-H surface}}{K_{sat}\text{-L depth}}$

SSURGO data queried in ACCESS (guided by Paul Finnell and Jim Haagen)

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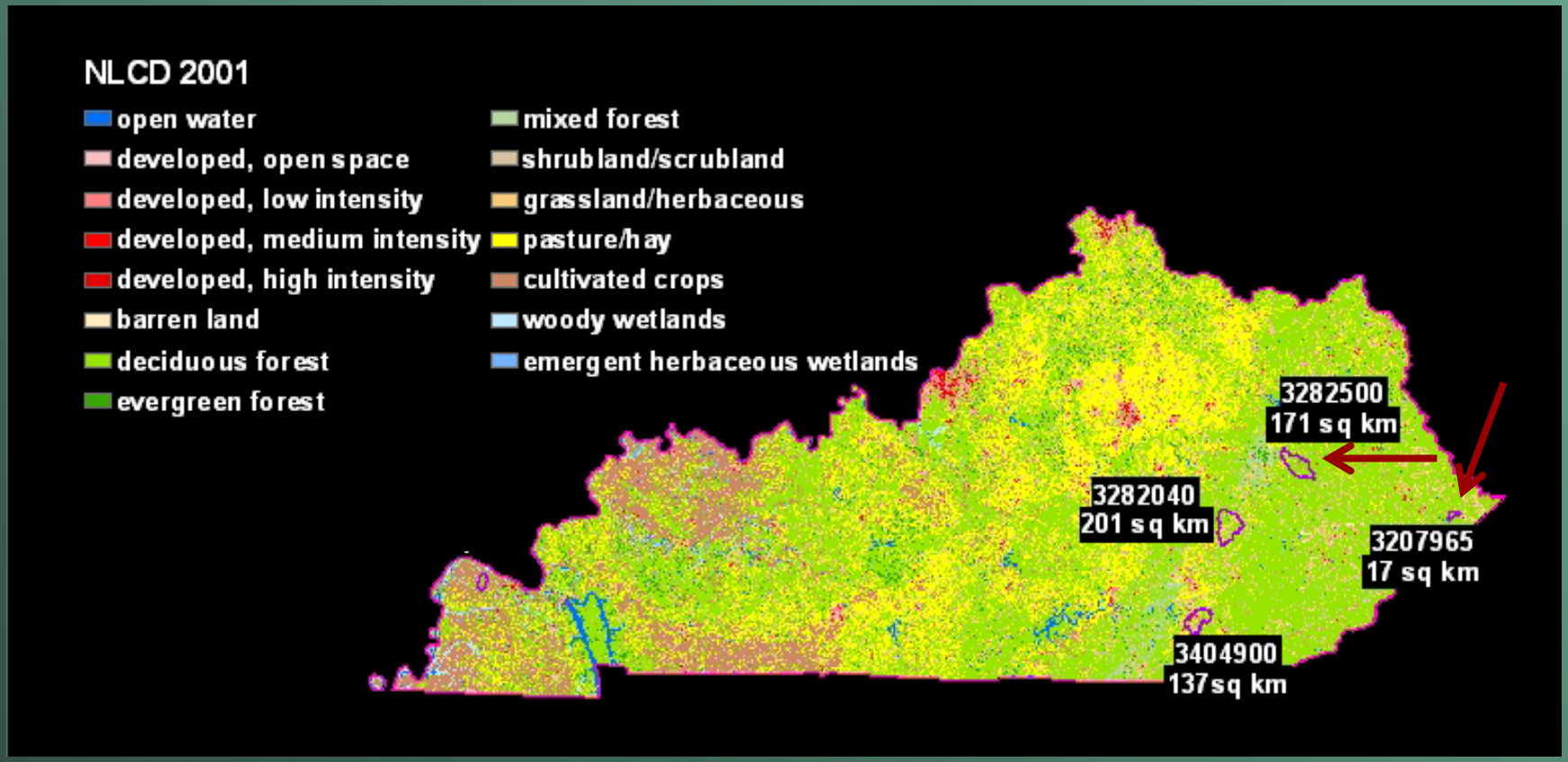
Basin characteristics



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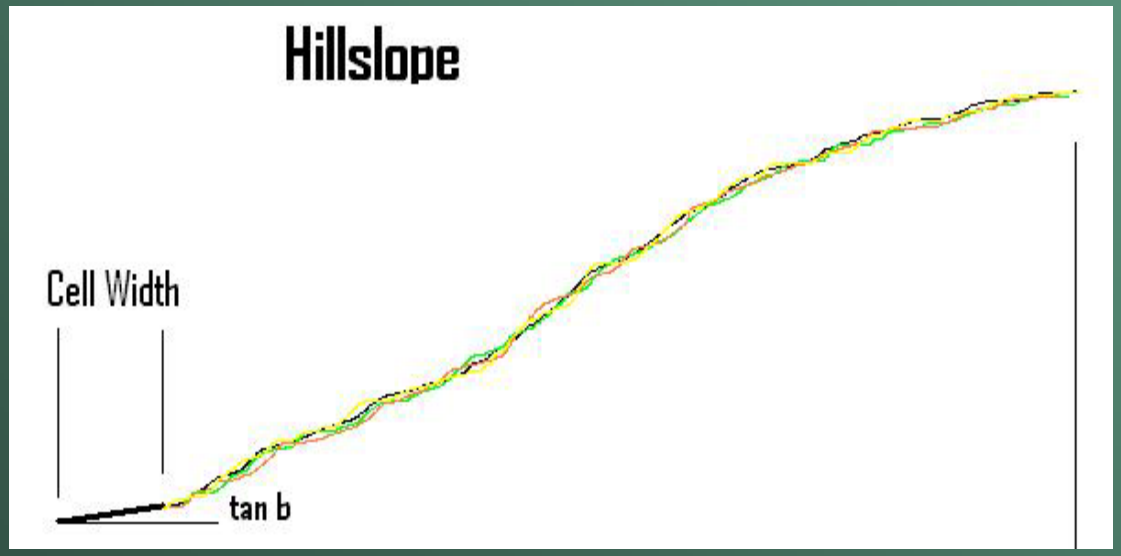
TOPMODEL compound topographic index

$$CTI = \ln\left(\frac{upslope\ contributing\ area}{\tan\ slope}\right)$$



Grid cells with the same CTI are hydrologically similar

Calculations need not be performed on every single grid cell.

High values of CTI → High potential for saturation
Low values of CTI → Low potential for saturation

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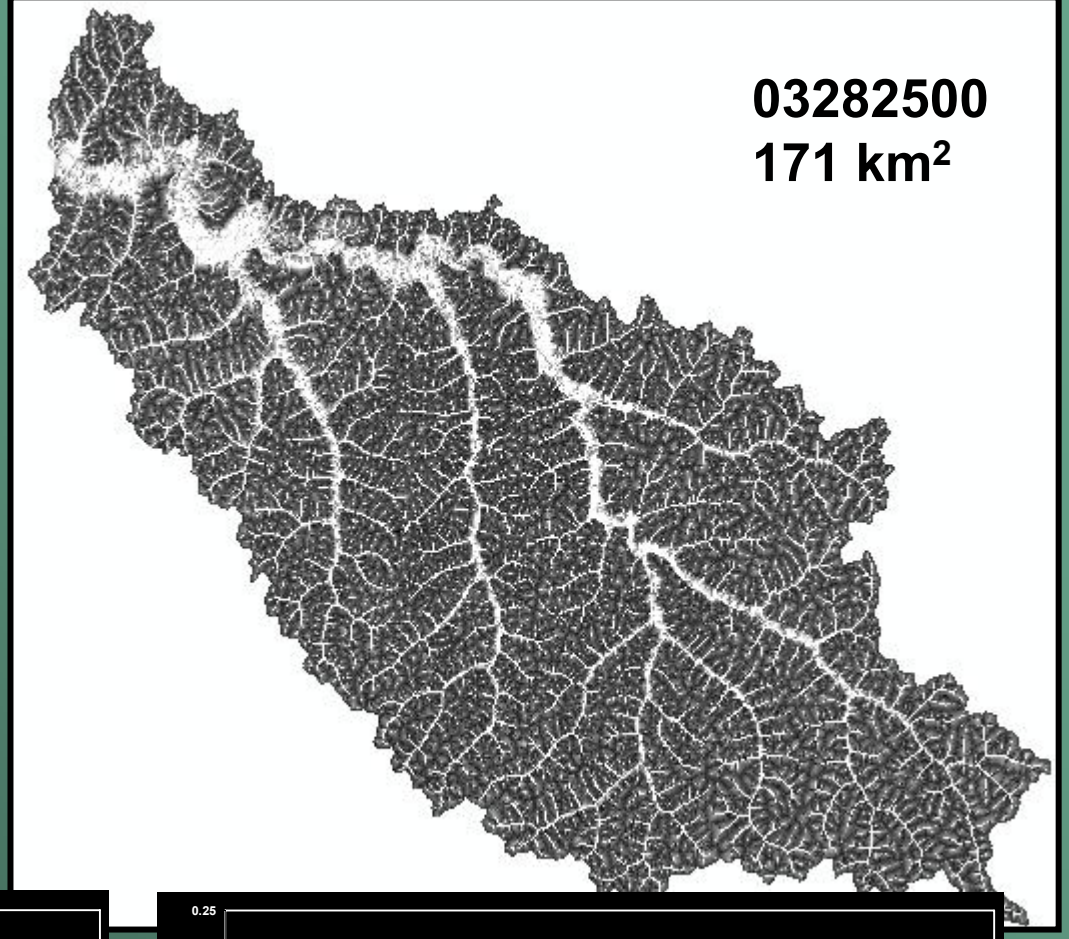
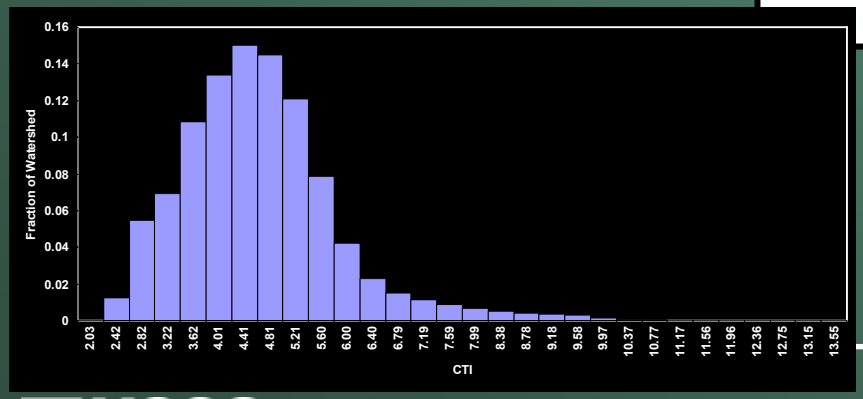
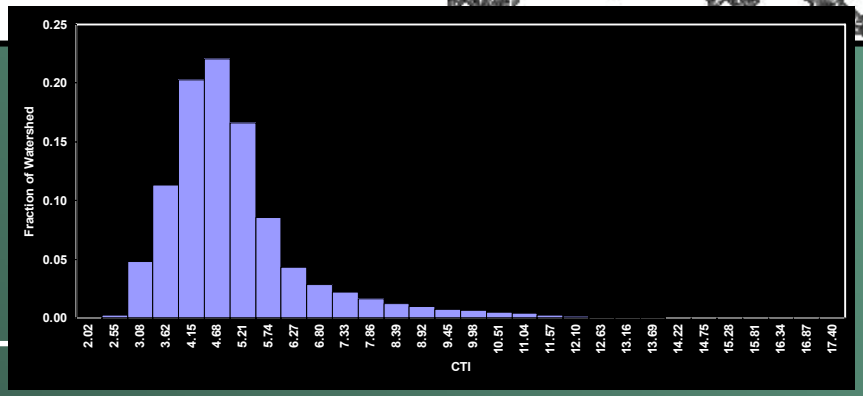
Compound Topographic Index

03207965
17 km^2







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Scaling Parameter *m*

$$S_x = \overline{S} + m\left(\overline{CTI} - CTI_x\right)$$

S – saturation deficit
CTI – compound topographic index
m –controls range of variability in saturation deficit

As *m* ↑, variability in *S* ↑ and water table gradient ↑

due to increased effect of topography

this attenuates peak flow and steadies base flow

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What did we compare?

- Model with SSURGO data optimized with *m*
- Model with STATSGO data
  - SSURGO optimized *m*
  - optimized *m* for STATSGO
- Compared "optimized" *m* with that calculated from SSURGO data (10-m grid)

$$m = \frac{porosity - \theta_{fc}}{f} \qquad f = \frac{\ln(conductivity\ multiplier)}{soil\ depth}$$

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Comparison of Scaling Factor *m*

Site	Drainage Area	SSURGO Calculated m	SSURGO Optimized m	STATSGO Optimized m
03207965	17 km^2	4.0	12	17
03404900	137 km^2	4.0	9	9
03282500	171 km^2	6.8	8	10
03282040	201 km^2	5.8	8	7

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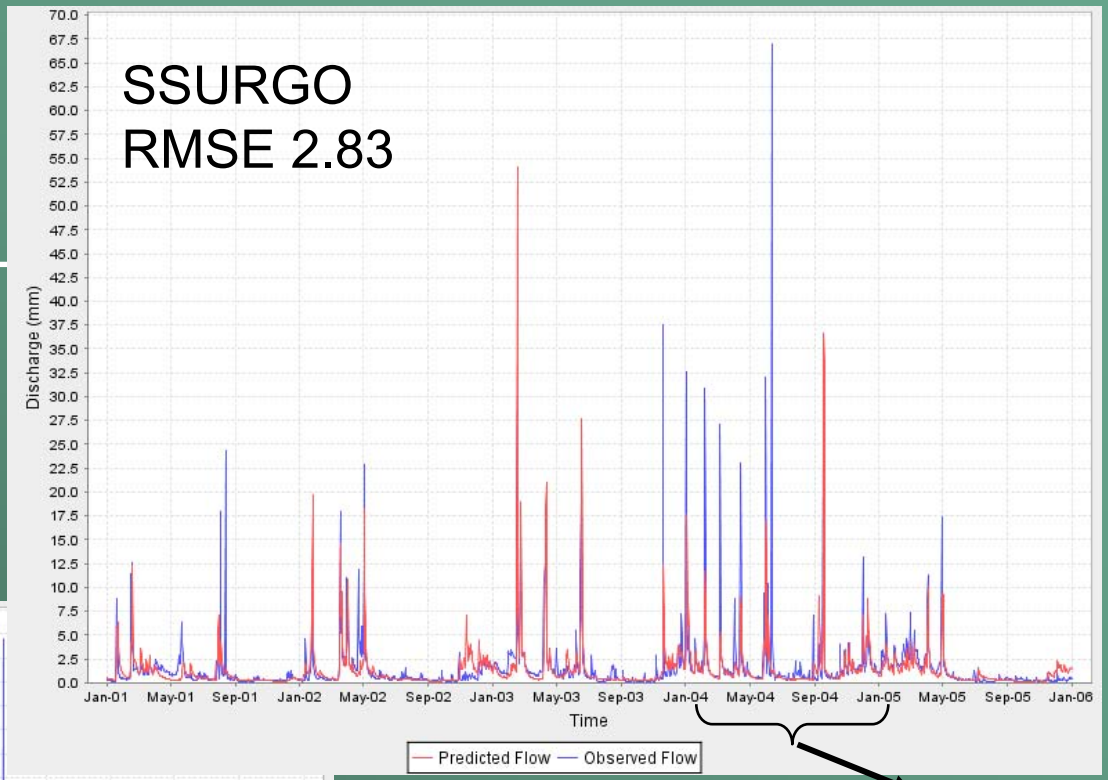
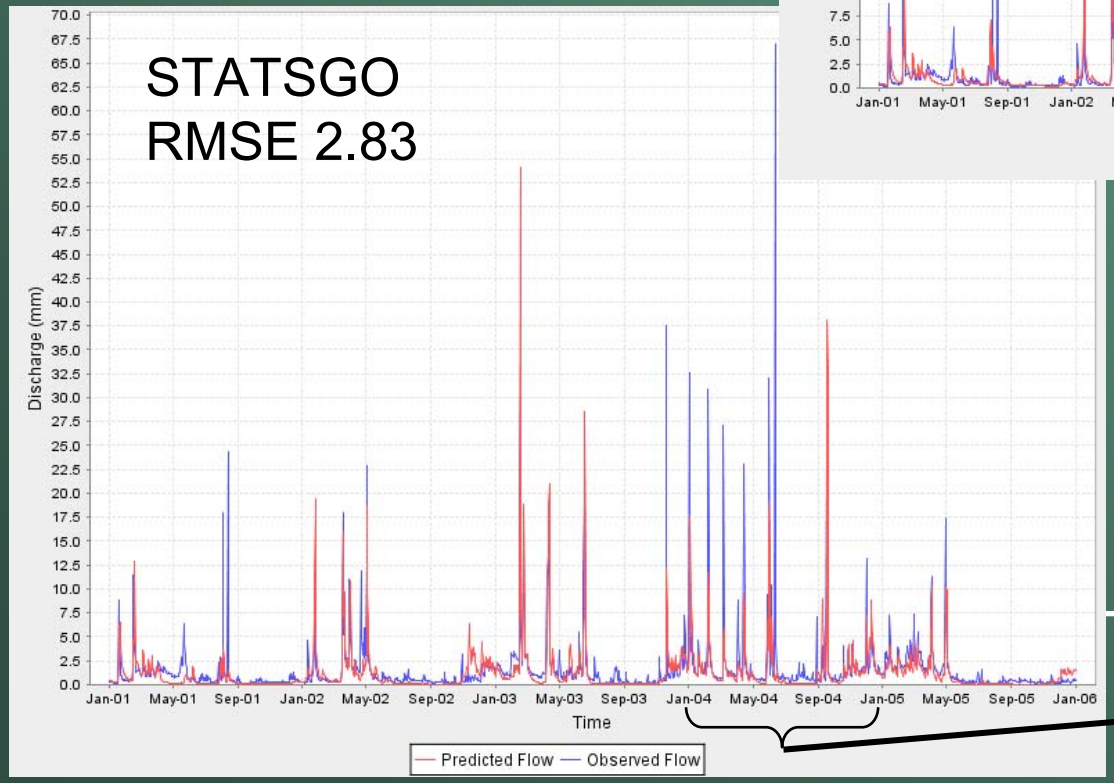
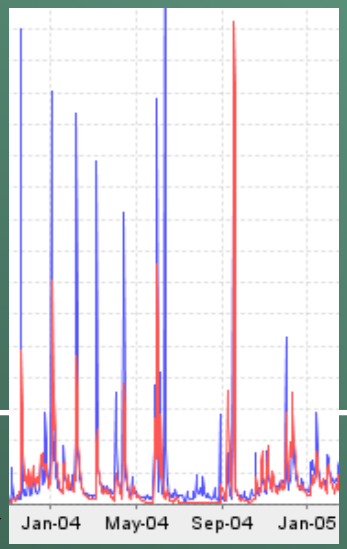
Hydrographs

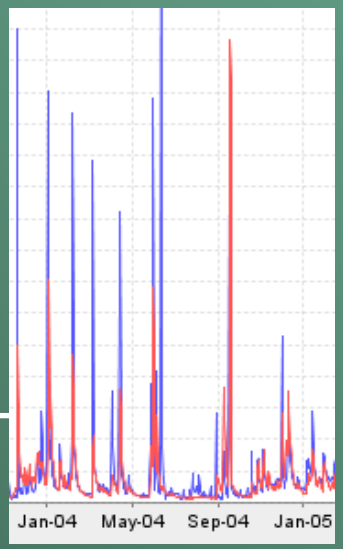
03207965 - 17 km^2

- No difference in RMSE
- Both catch peaks and low flows
- STATSGO seems to underestimate low flows



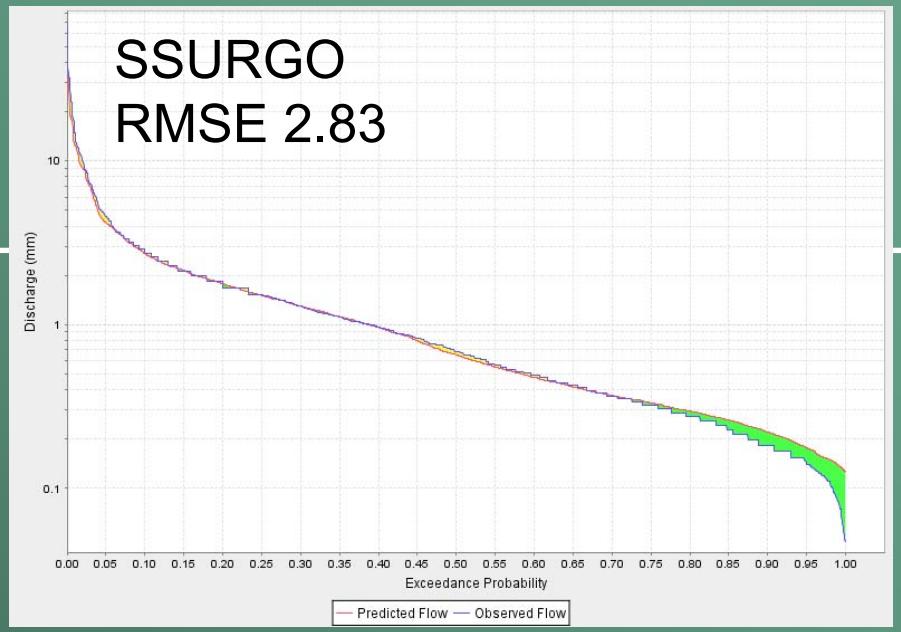




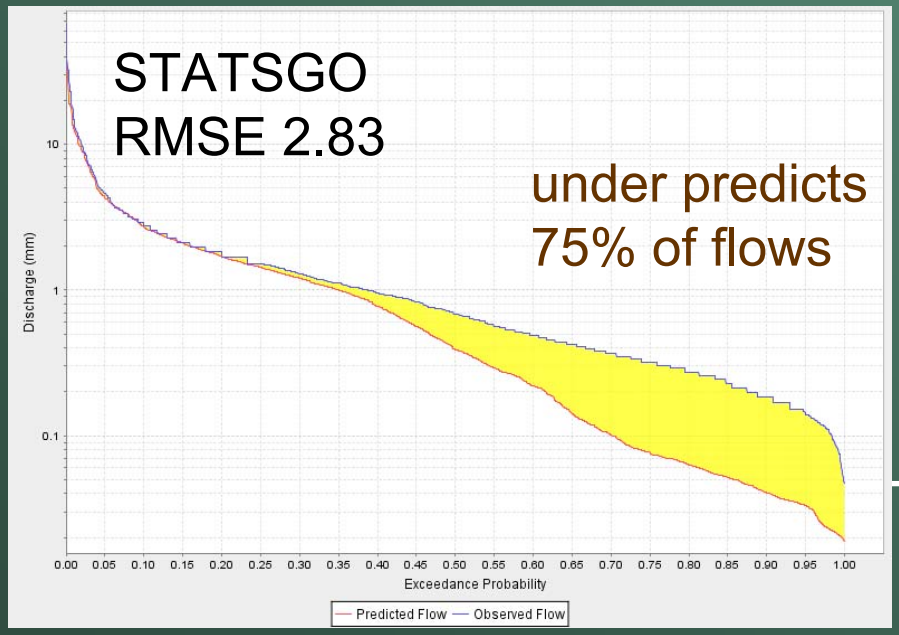


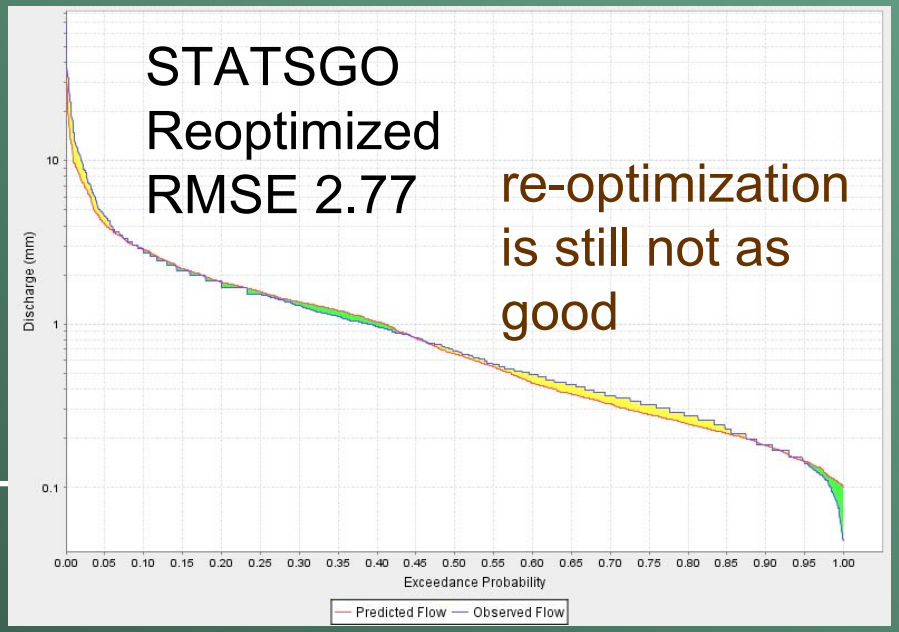
Flow Duration

03207965 – 17 km^2

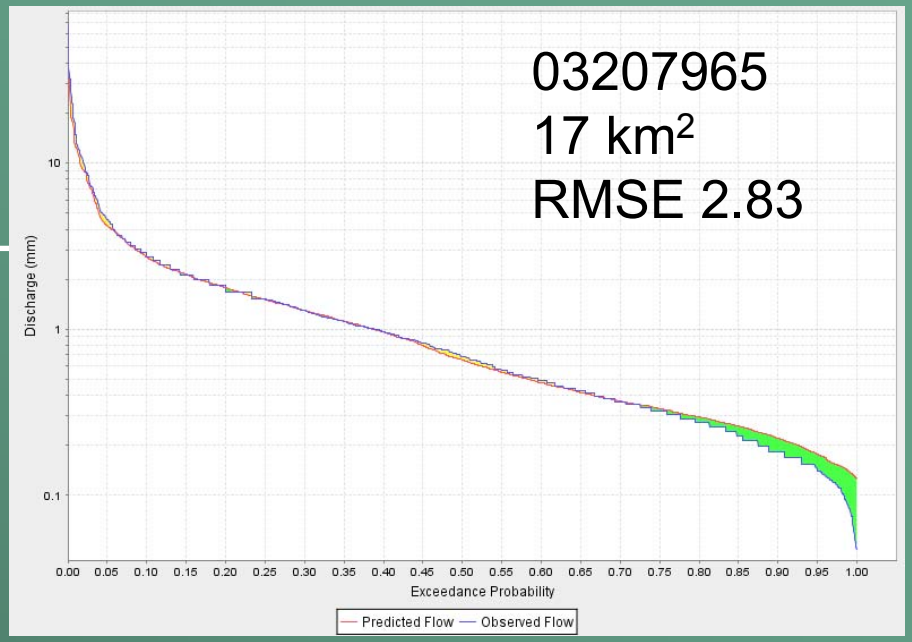


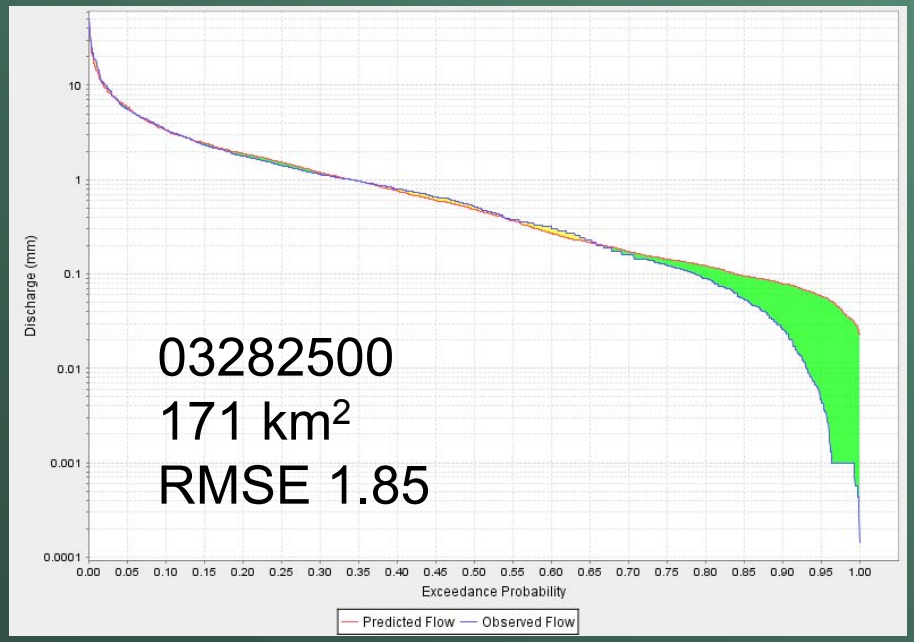
predicted matches observed for 75% of flows





Flow Duration
SSURGO optimized





- **Both catch peaks and low flows**
- **Larger basin better predicts peak flows**
- **Smaller basin better predicts low flows**

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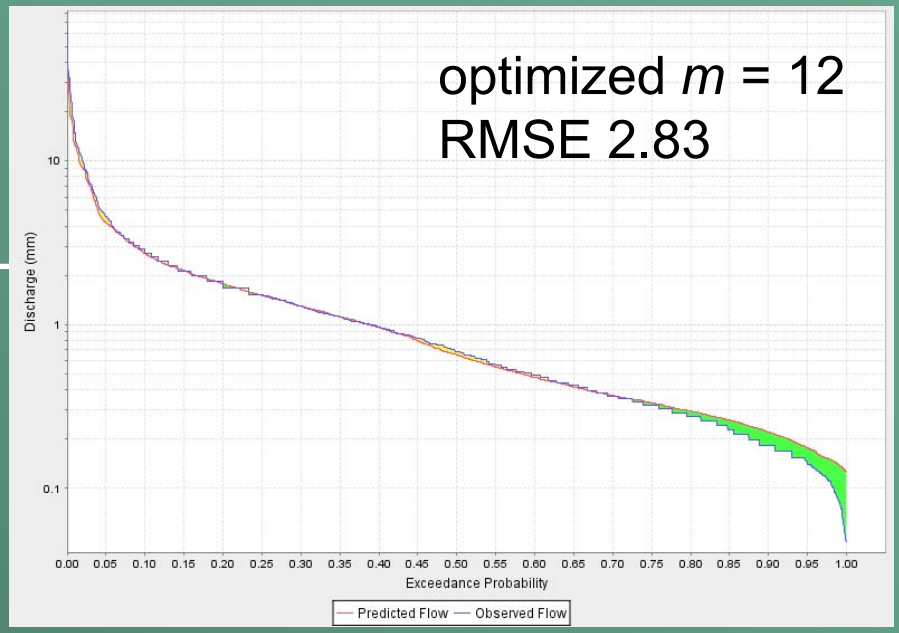
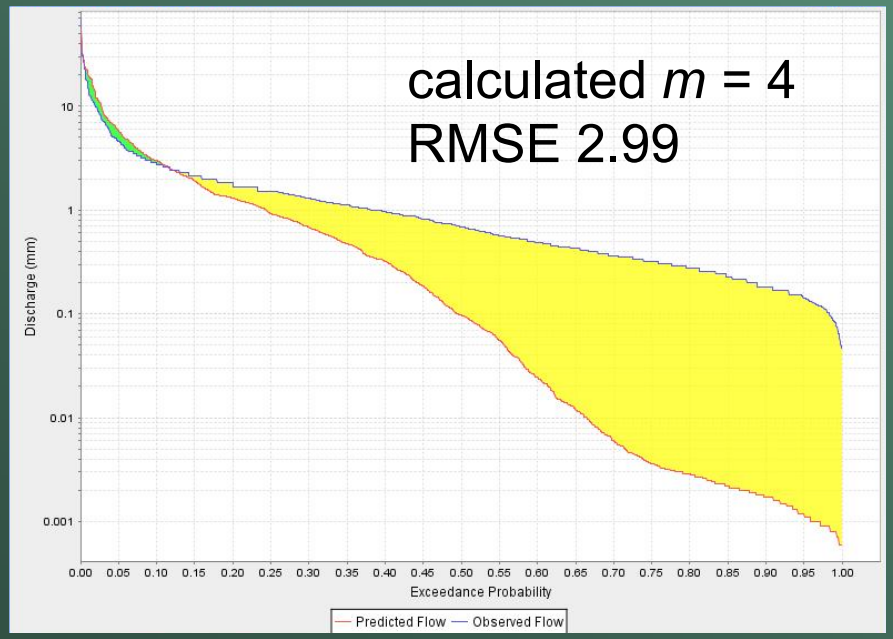
Flow Duration SSURGO

03207965 – 17 km^2





- **Calculate m better estimates highest flows**
- **Calculated *m* overestimates smaller peak flows**
- **Calculated *m* underestimates 85% of flow**

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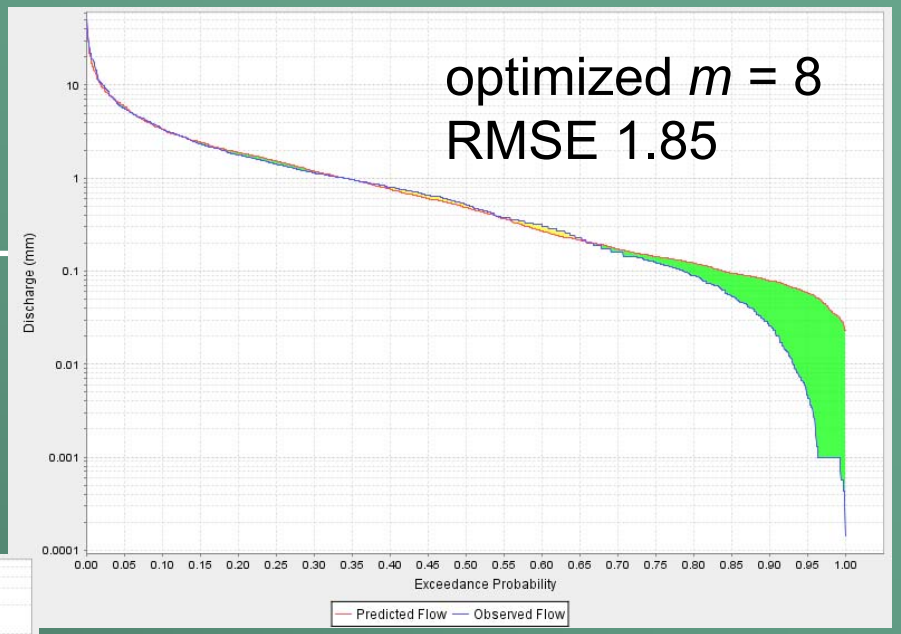
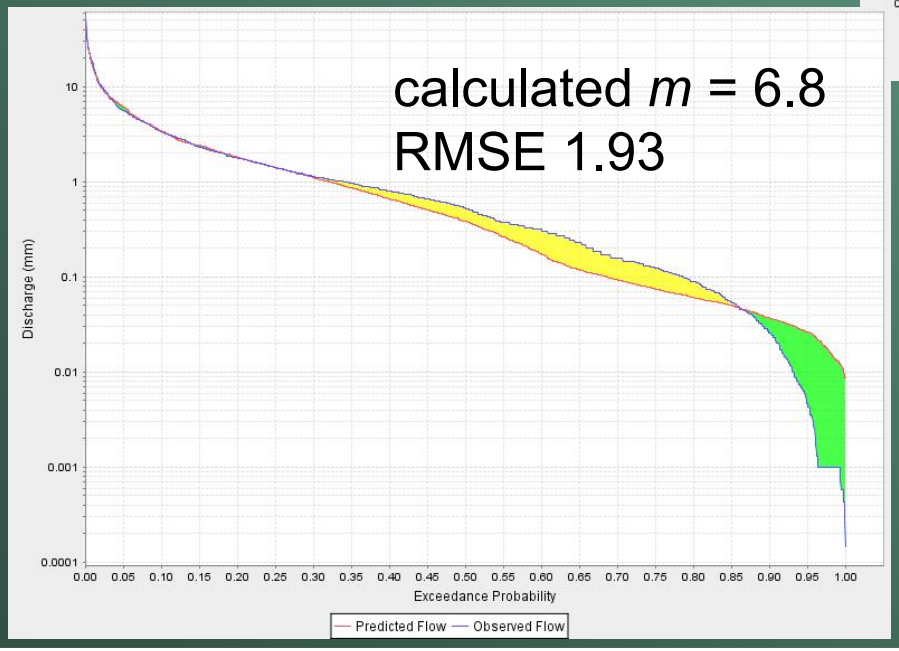
Flow Duration SSURGO

03282500 – 171 km^2





- **Calculated *m* successfully predicts peak flows**
- **Calculated *m* under predicts mid-range**
- **Both over predicts low flows**

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Implications

- SSURGO provides for assessment of hydrologically active layer instead of full soil profile.
- SSURGO provides better method of evaluating *conductivity multiplier*.
- *m*-factor is still optimization method but this takes more time (≈1300 basins)
- As drainage basin size increases, optimized *m* approaches calculated *m* from SSURGO data.

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Possible future work

- Could make spatial maps of root depth and PET.
- Alter input data to simulate changes in:
  - Withdrawals and discharges
  - Changes in agriculture
  - Changes in ET
  - Changes in climate
- Create statewide maps of hydrologic variables

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