A-Priori Parameter Differences and Their Impact on Distributed Hydrologic Modeling Using SAC-SMA

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Overview

- Background
- Applications
- Results
- Conclusions

Background

Parameter requirements for hydrologic modeling

- Lumped modeling
  - uniform value for a basin
  - relative easier to be optimized by manual and/or automatic calibration methods as compare to distributed modeling
  - less work

Background *Cont.*

Parameter requirements for hydrological modeling

- Distributed modeling
  - requires gridded parameter estimation
  - more difficult to calibrate than for lumped case

Background *Cont.*

Need for *a priori* parameter estimation procedures for distributed modeling

- available observed data cannot support calibration of unique model parameter for individual grid cell
- good initial parameters estimation is important in keeping parameter consistency across regions/basins

Background *Cont.*

Use measured soil property data and land cover data to estimate *a-priori* model parameters

- Improve initial estimates of conceptual model parameters
- Constrain calibration so that parameter adjustment occurs within a range of values to maintain conceptual consistency
- Provide physically consistent spatially variable parameters in smaller basins for flood modeling

Background *Cont.*

Available Land Cover Data

– Global Land Cover Characterization (GLCC) data
– The 2001 National Land Cover Data Set (NLCD)

Available Soil Data

The Natural Resources Conservation Service of the USDA has established three soil geographic data bases and related soil maps

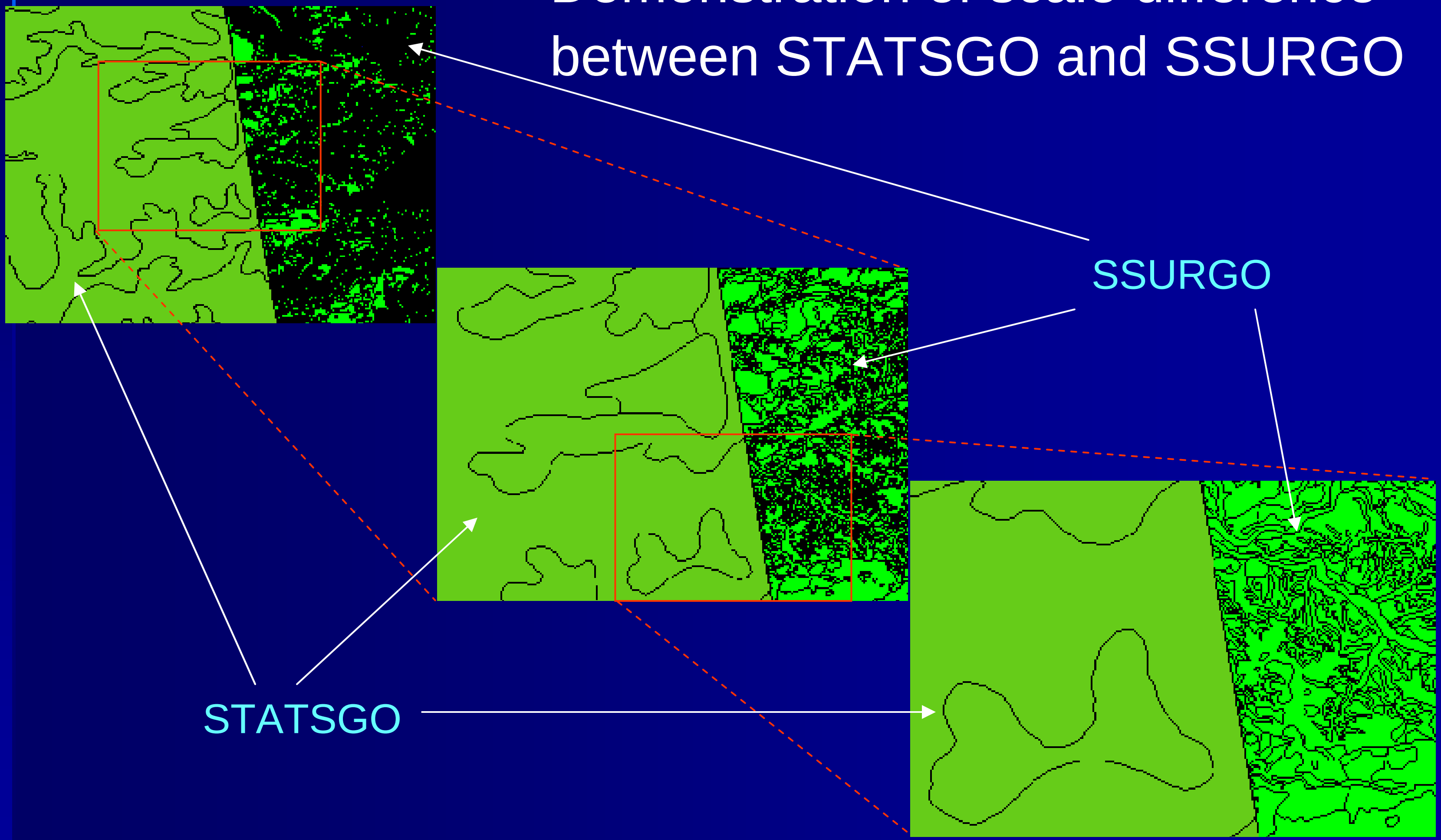
– Soil Survey Geographic (**SSURGO**) data base
– State Soil Geographic (**STATSGO**) data base
– National Soil Geographic (**NATSGO**) data base

Background *Cont.*

- **Soil Data**
  - ***NATSGO:***
    - scale is 1:5000K
    - used primarily for national and regional resource appraisal and planning
  - ***STATSGO:***
    - scale is 1:250K
    - polygon size is about 100-200 km^2
  - ***SSURGO:***
    - scale is 1:24K
    - polygon size is about 20 km^2
    - partially available for CONUS; will be completed in 2008

Background *Cont.*

Demonstration of scale difference between STATSGO and SSURGO



Background *Cont.*

The Model and Parameters:

– SAC-SMA: the rainfall runoff component used in HL-RDHM, research distributed hydrologic model developed in the NWS Hydrology Lab.

– 16 parameter grids need to be provided.

Background

Cont.

List of SAC-SMA Parameters

No.	Parameter	Description	Unit	Ranges
1	**UZTWM**	The upper layer tension water capacity	mm	10–300
2	**UZFWM**	The upper layer free water capacity	mm	5–150
3	**UZK**	Interflow depletion rate from the upper layer free water storage	day^{-1}	0.10–0.75
4	**ZPERC**	Ratio of maximum and minimum percolation rates		5–350
5	**REXP**	Shape parameter of the percolation curve		1–5
6	**LZTWM**	The lower layer tension water capacity	mm	10–500
7	**LZFSM**	The lower layer supplemental free water capacity	mm	5–400
8	**LZFPM**	The lower layer primary free water capacity	mm	10–1000
9	**LZSK**	Depletion rate of the lower layer supplemental free water storage	day^{-1}	0.01–0.35
10	**LZPK**	Depletion rate of the lower layer primary free water storage	day^{-1}	0.001–0.05
11	**PFREE**	Percolation fraction that goes directly to the lower layer free water storages		0.0–0.8
12	*PCTIM*	Permanent impervious area fraction		
13	*ADIMP*	Maximum fraction of an additional impervious area due to saturation		
14	*RIVA*	Riparian vegetarian area fraction		
15	*SIDE*	Ratio of deep percolation from lower layer free water storages		
16	*RSERV*	Fraction of lower layer free water not transferable to lower layer		

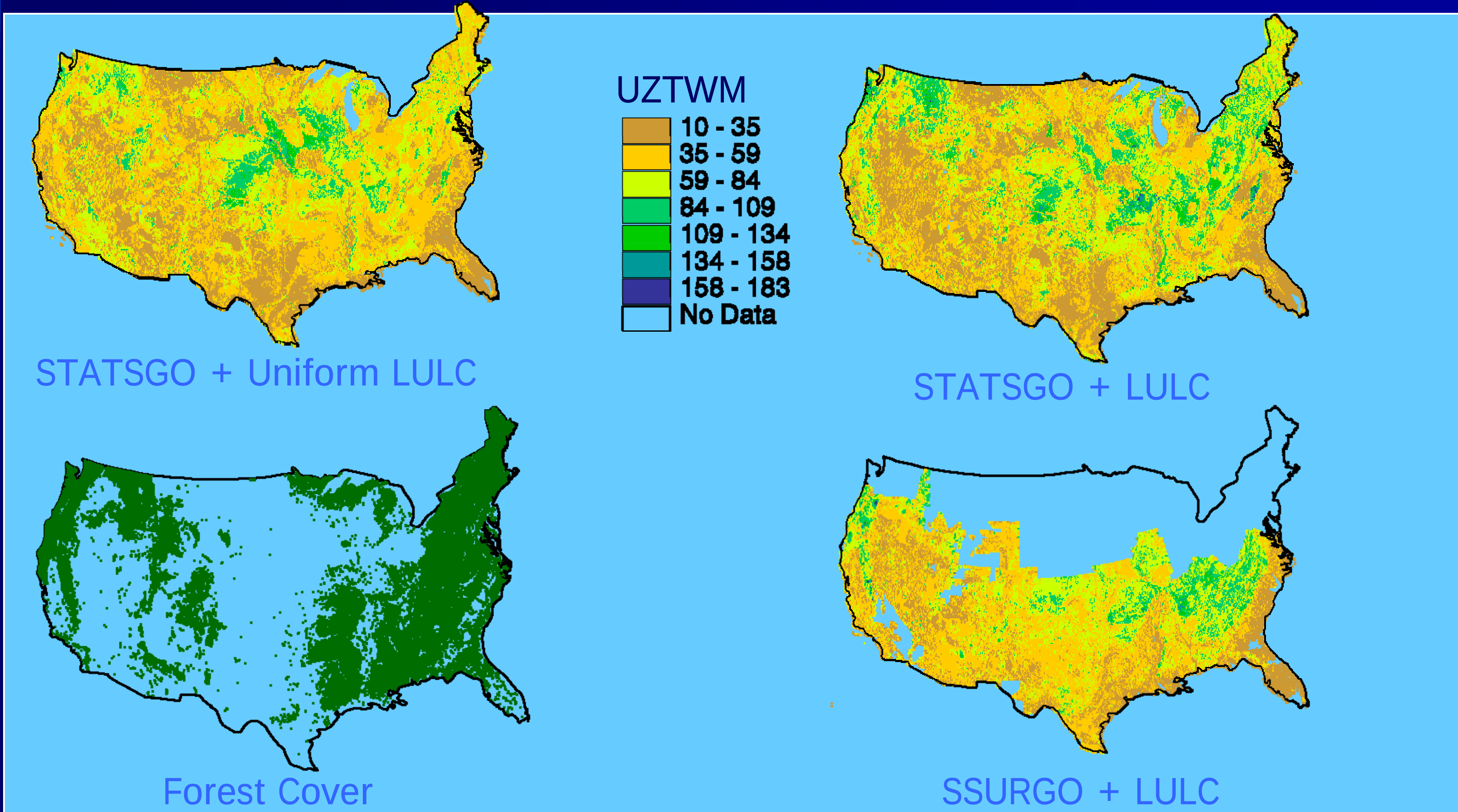
Background *Cont.*

Objective estimation procedure that can produce spatially consistent and physically realistic values for 11 of the 16 SAC-SMA parameters

- STATSGO + Assumed spatially constant “pasture or range land use” under “fair” hydrologic conditions, (Koren et al. 2000, 2003)
- STATSGO + Spatially variable land use land cover data
- SSURGO + Spatially variable land use land cover data, (Anderson et al., 2005, Zhang et al., 2008)

Applications

SAC-SMA Parameter: UZTWM

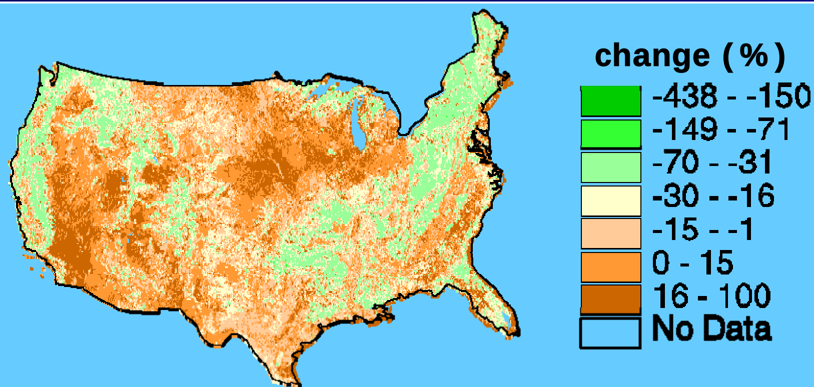


Forest cover increases upper zone tension water

Applications

Cont.

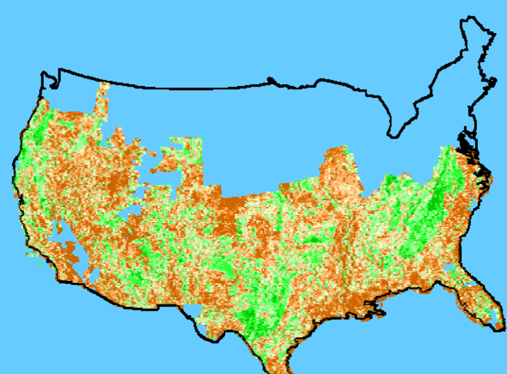
Percentage Change as Compared to STATSGO+uniform LULC: UZTWM



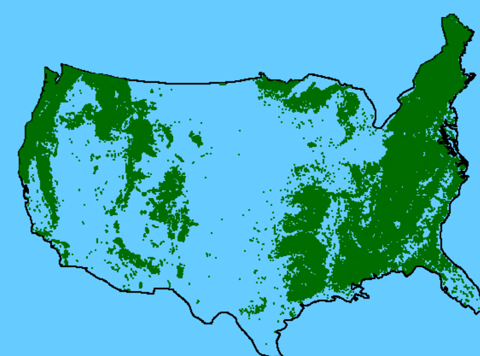
STATSGO + LULC

$$\frac{\text{uniform} - \text{variable}}{\text{uniform}} \%$$

Forest cover increases upper zone tension water

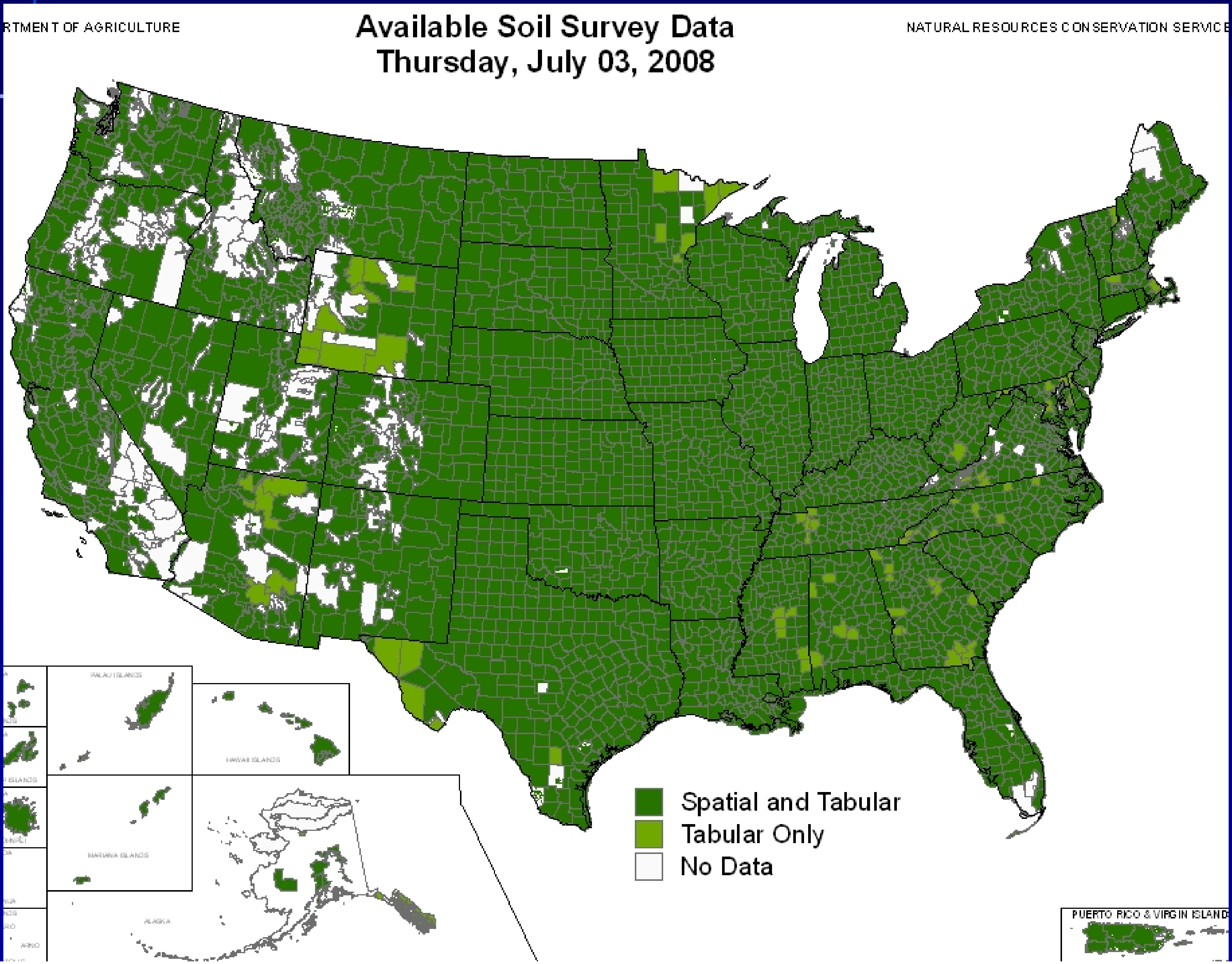


SSURGO + LULC



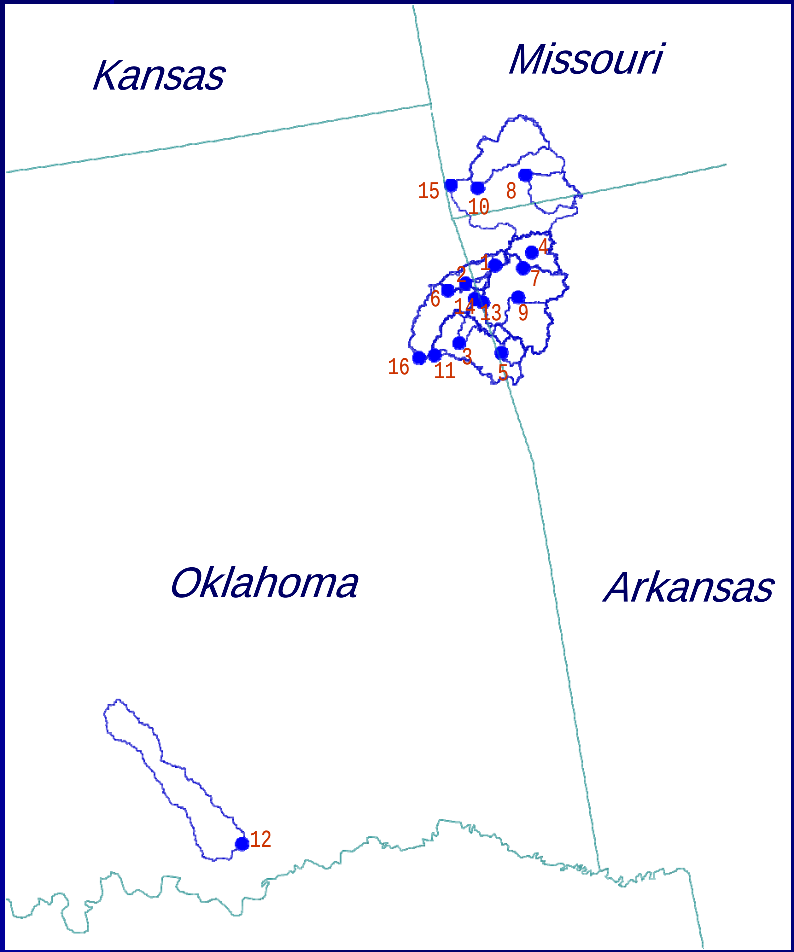
Forest Cover

Available SSURGO Data Coverage



Applications *Cont.*

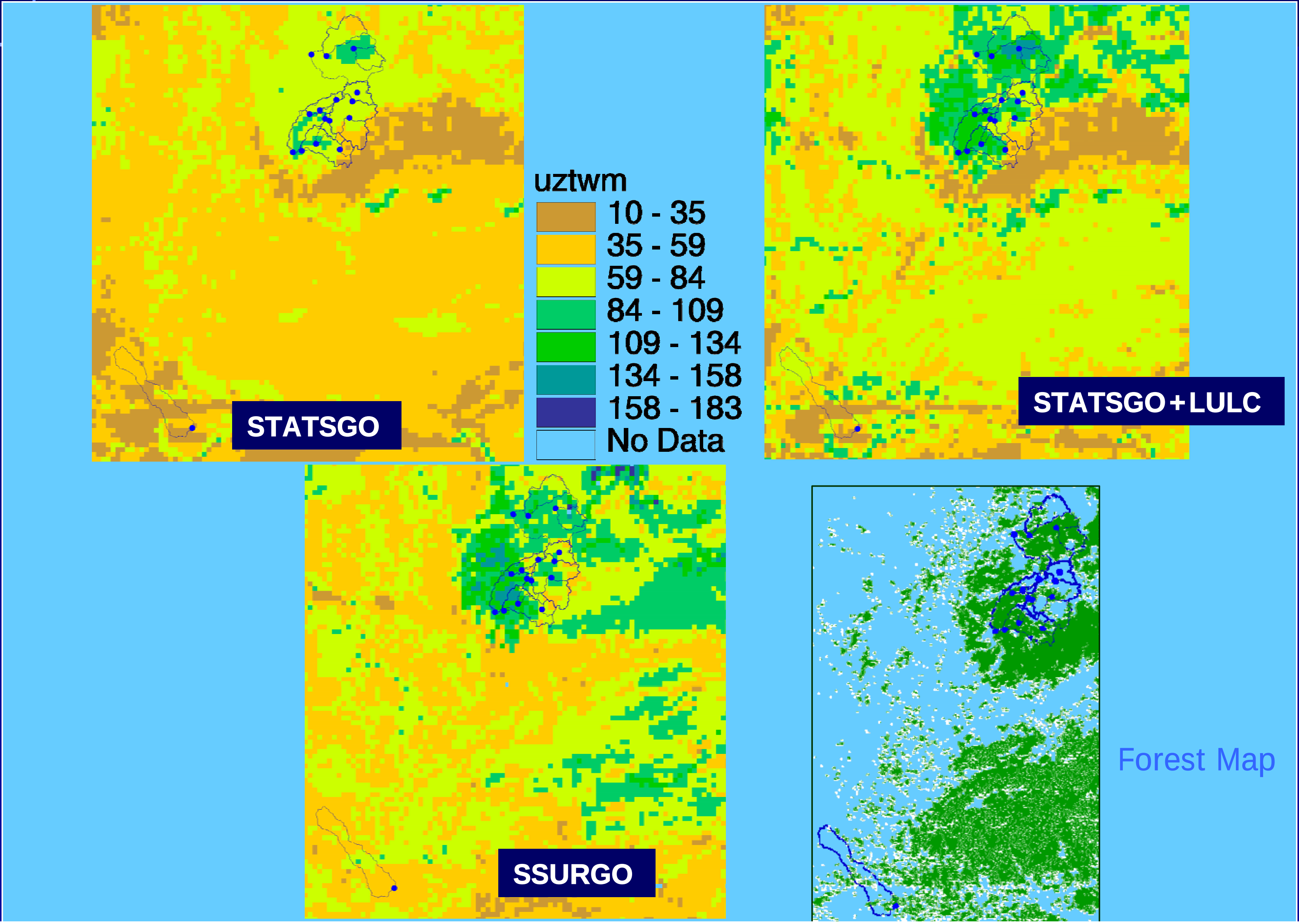
Study Basins



No.	Short Name	Station Name	Area (km2)
1	SPRINGT	Flint Creek at Springtown, AR	37
2	WSILO	Sager Creek near West Siloam Springs, OK	49
3	CHRISTI	Peacheater Creek at Christie, OK	65
4	CAVESP	Osage Creek near Cave Springs AR	90
5	DUTCH	Baron Fork at Dutch Mills, AR	105
6	KNSO2	Flint Creek near Kansas, OK	285
7	ELMSP	Osage Creek near Elm Springs, AR	337
8	POWELL	Big Sugar Creek near Powell , MO	365
9	SAVOY	Illinois River at Savoy AR	433
10	LANAG	Indian Creek near Lanagan, MO	619
11	ELDO2	Baron Fork at Eldon, OK	795
12	BLUO2	Blue River near Blue, OK	1233
13	SLOA4	Illinois River South of Siloam Springs, AR	1489
14	WTTO2	Illinois River near Watts, OK	1645
15	TIFM7	Elk River at Tiff City, MO	2258
16	TALO2	Illinois River near Tahlequah, OK	2484

Applications *Cont.*

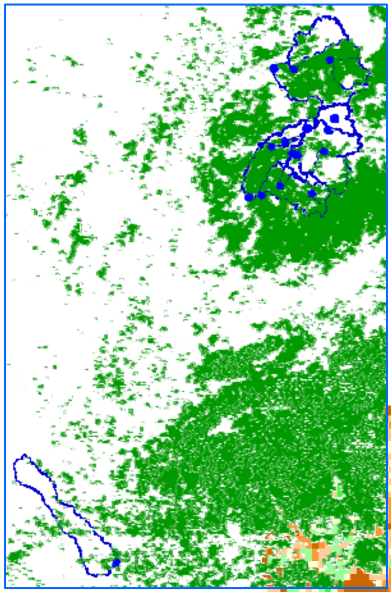
SAC-SMA Parameter within Study Basins: UZTWM



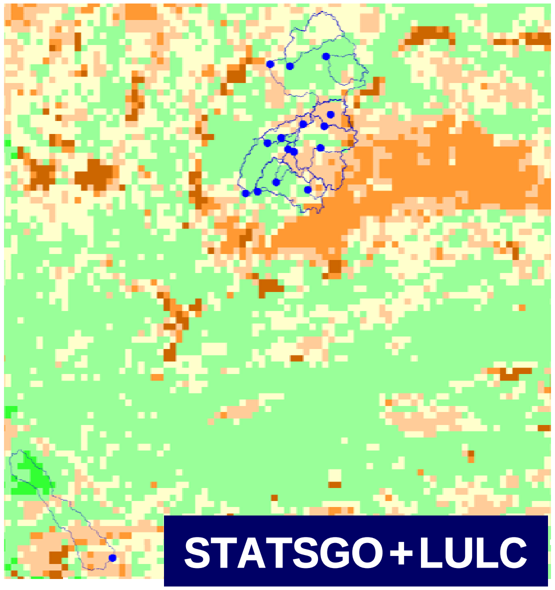
Applications *Cont.*

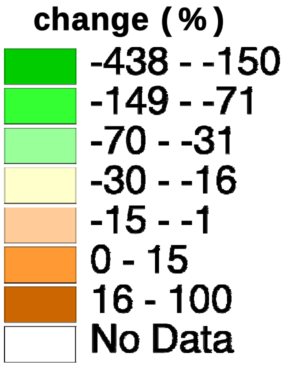
SAC-SMA Parameter within Study Basins: UZTWM

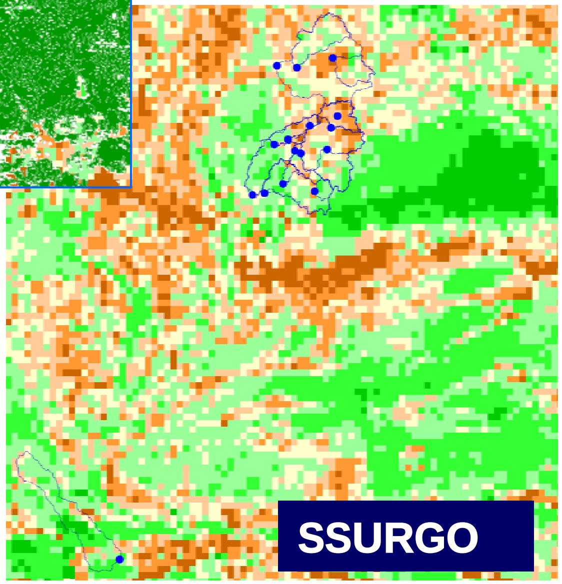
Percentage Change as Compared to STATSGO+uniform LULC



Forest Cover

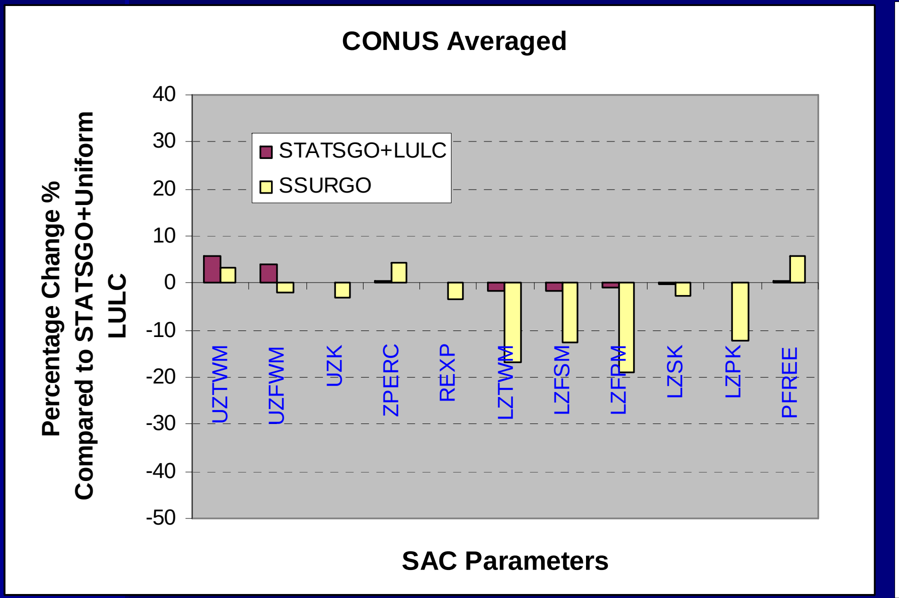


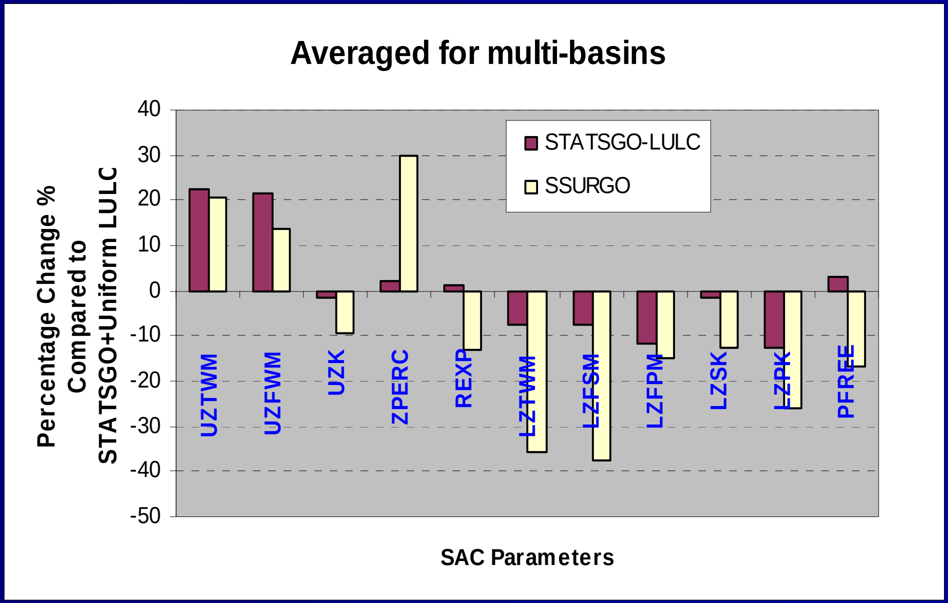




Applications *Cont.*

Percentage Changes of Averaged SAC-SMA Parameters

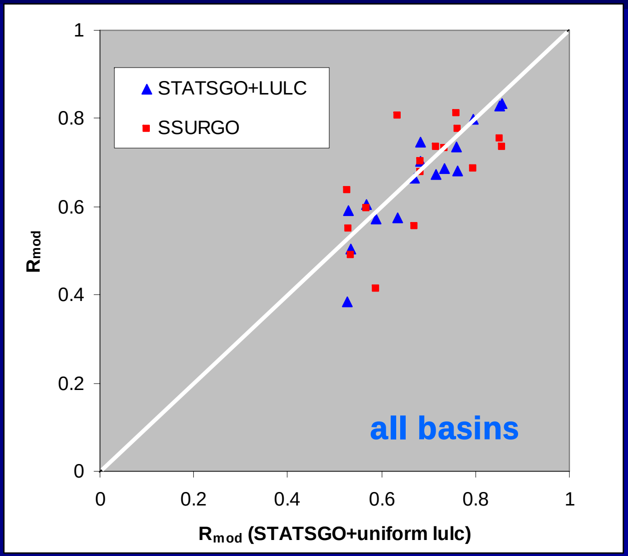


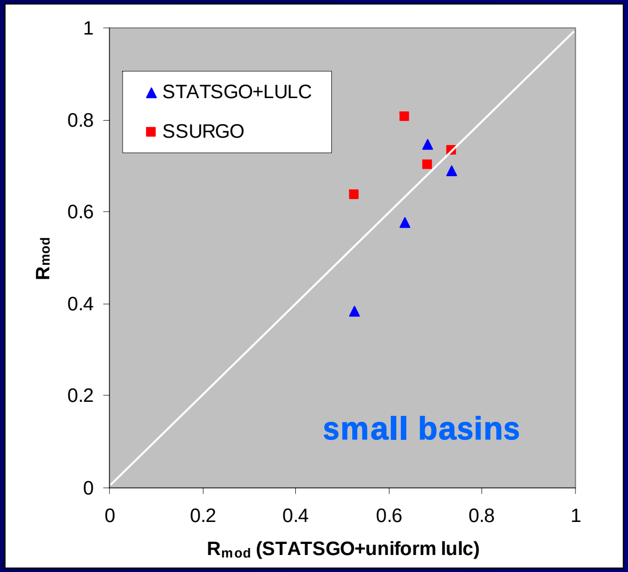


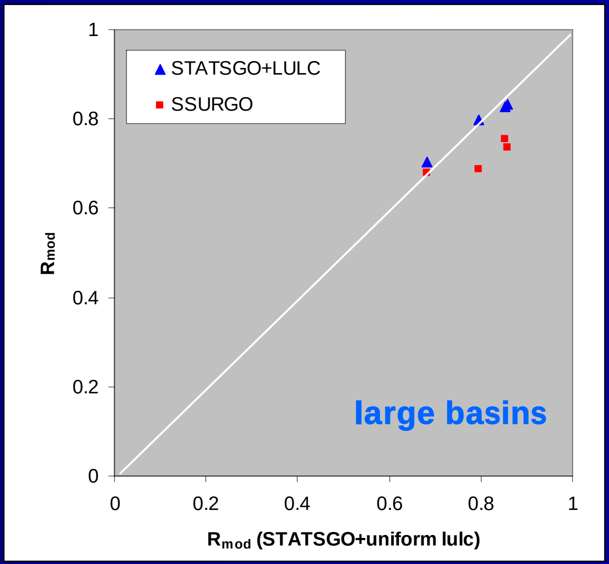
Results

Overall

R_m: Modified correlation coefficient. It is calculated by reducing normal correlation coefficient by the ratio of the standard deviations of the observed and simulated hydrographs.





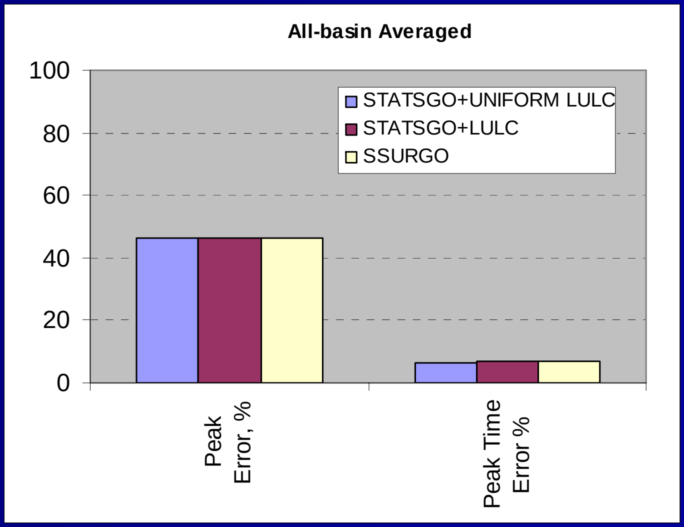


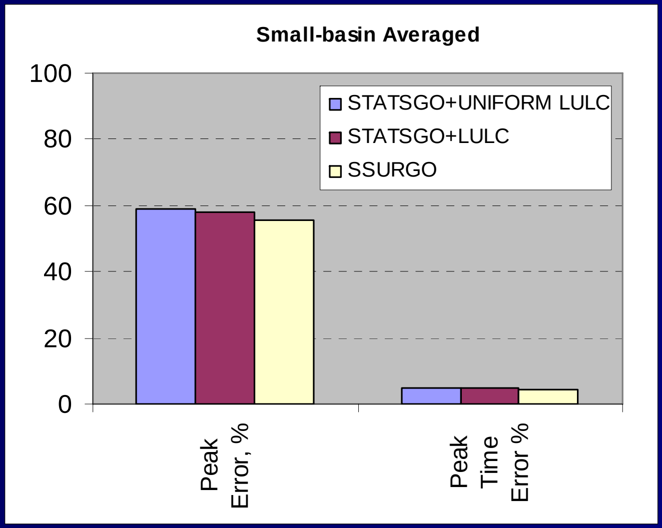
Results

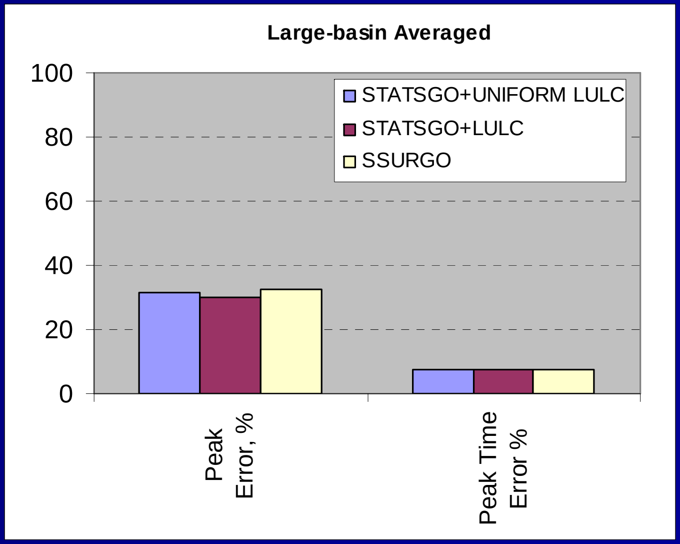
Cont.

Event-based Statistics

Peak Error and Peak Time Error



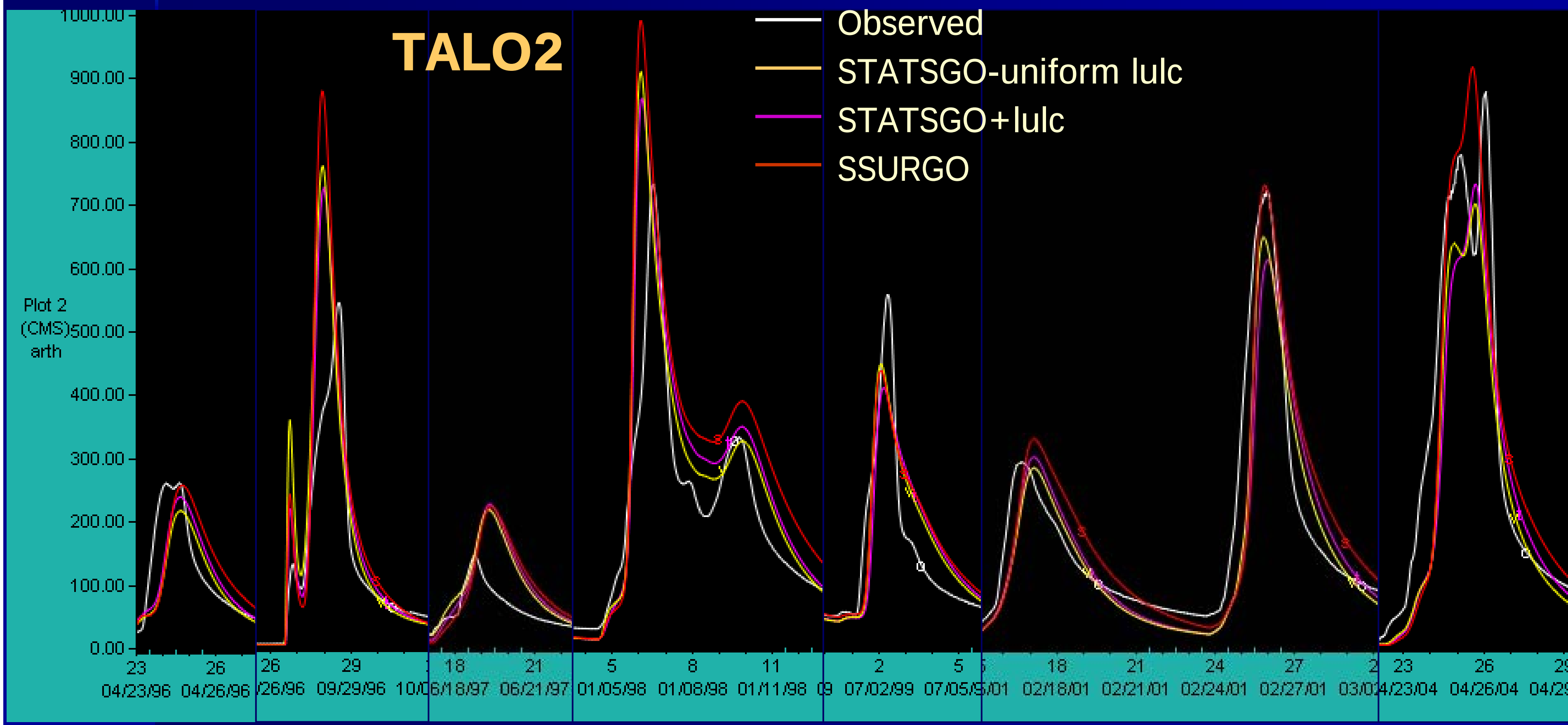




Results

Cont.

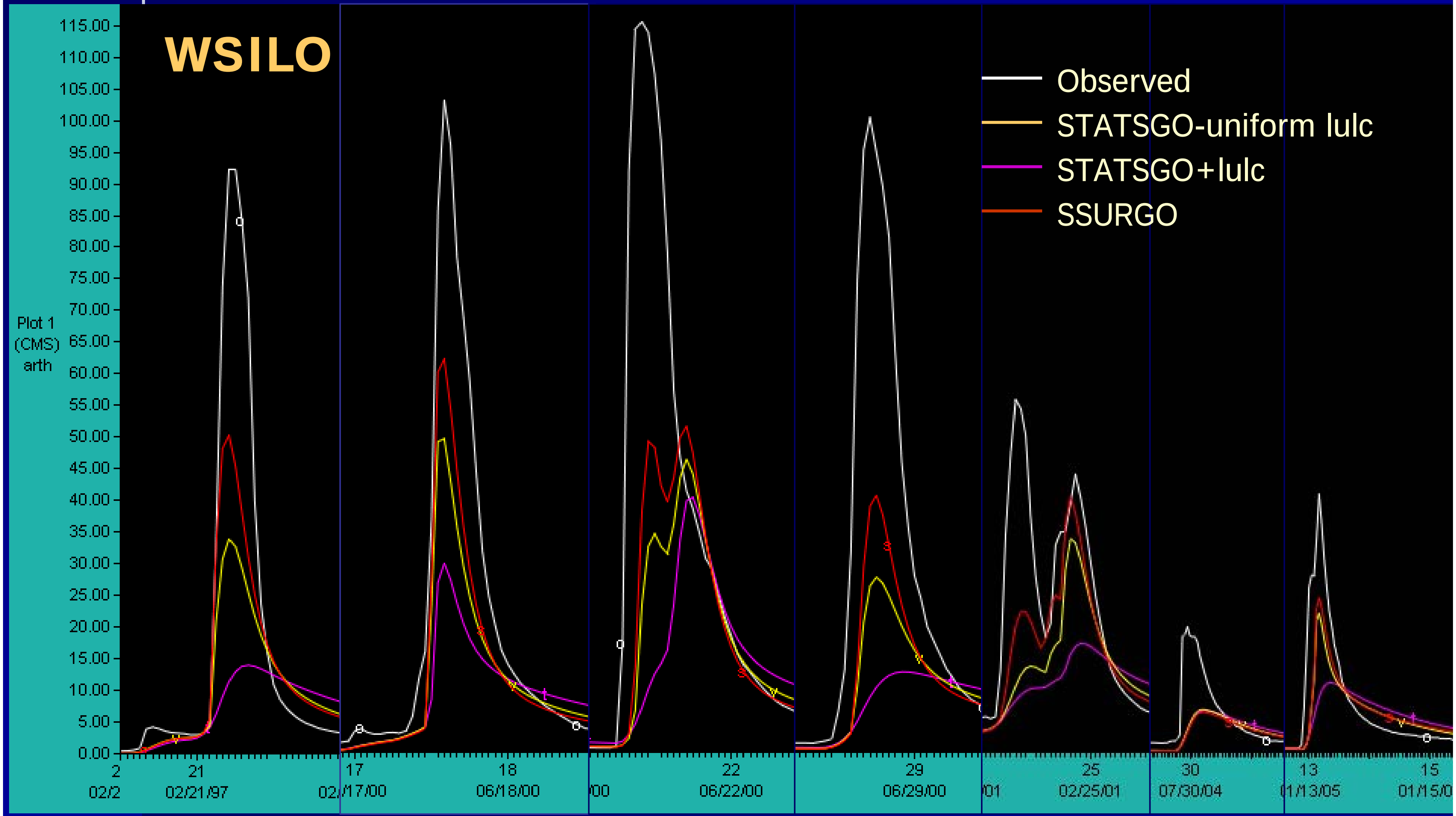
Comparison of flow simulations for TALO2 (2484 km²)



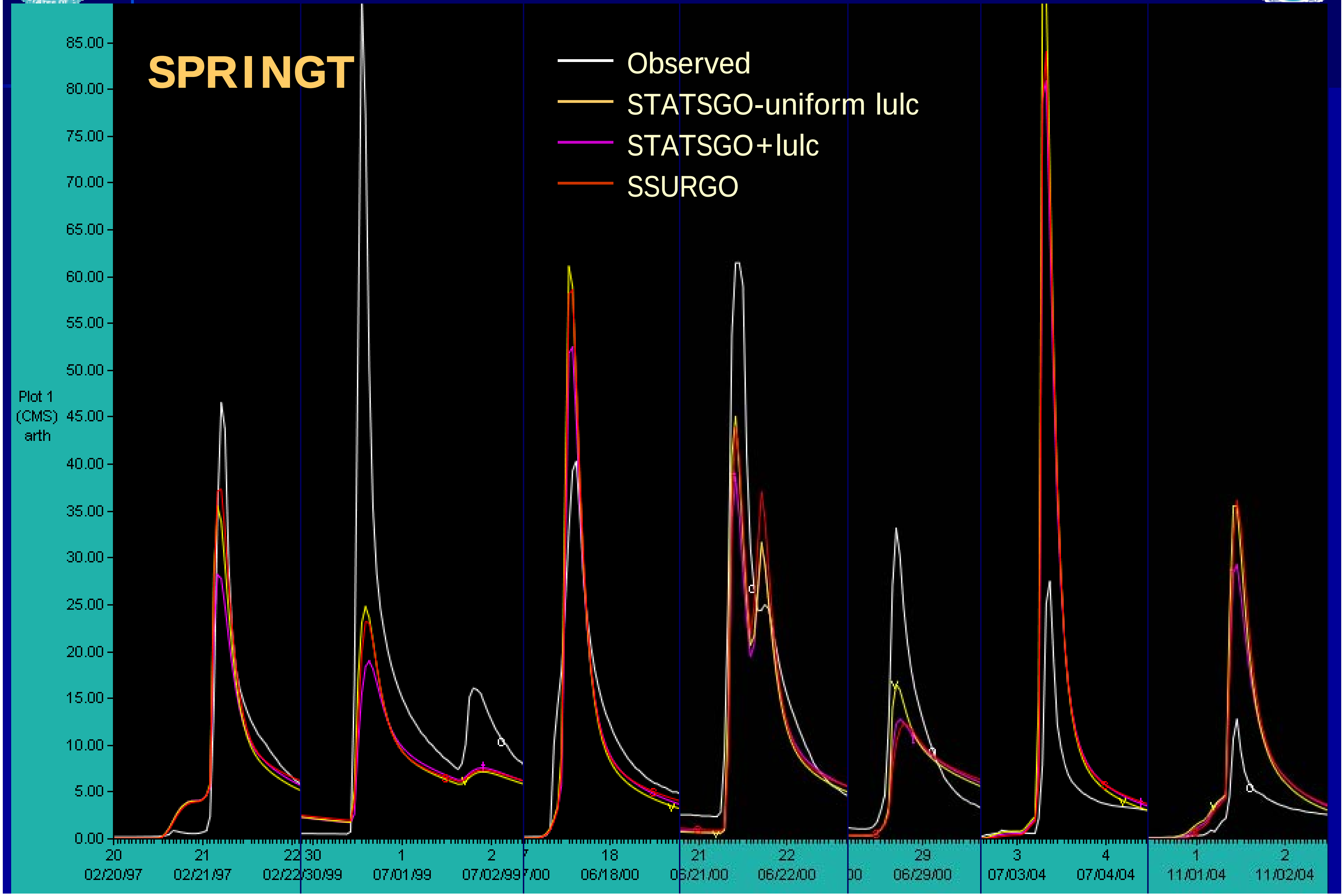
Results

Cont.

Comparison of flow simulations for WSILO (49 km2)



Comparison of flow simulations for SPRINGT (37 km2)



Conclusions

- Use of land cover data and higher resolution soil data results in different *a-priori* SAC-SMA parameters.
- Overall simulation results for three sets of *a-priori* parameters are similar.
- The effect of using higher resolution soil data and land use land cover data is different between smaller basins and larger basins. Improvements are mainly for smaller basins when SSURGO data are used. Generally similar results for large basins for three sets of a priori parameters.
- Improvement from using detailed soil data is greater than using gridded land cover data.
- Results suggest that the SSURGO based parameters are preferable for smaller scale applications.