HL-RMS Development

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GOALS

- Integrate new science and test different modeling approaches to make an easier transition into RFC operations
- Provide feedback-requirements to the development of an operational DMS
- HL-RMS is not intended to be an operational application in an RFC or WFO environment

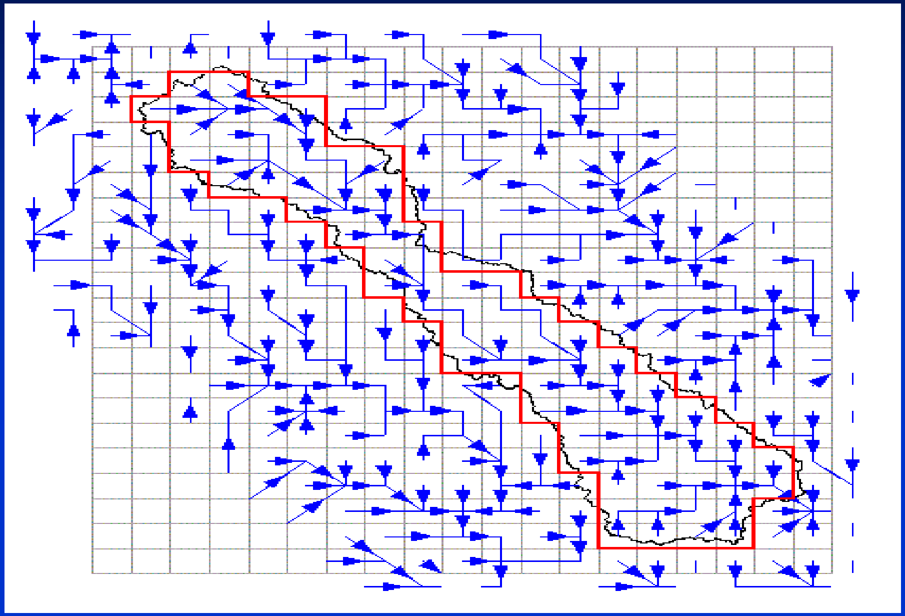
MOTIVATION

- Integrate spatial data sources into river runoff modeling to improve hydrologic forecasting
- DMIP and a long-term experience suggests that there are advantages and disadvantages of distributed and lumped approaches in an operational application
- Need for more flexibility in hydrologic modeling at different space-time scales

Available Tools and Models

- Parametric data
  - Generate model parameter grids (HRAP)
  - Generate river network connectivity file
- Water balance/snow models
  - SNOW-17
  - Sacramento
  - API
- Routing techniques
  - Hillslope kinematic routing
  - Channel kinematic routing

Transform input grids into channel order vector

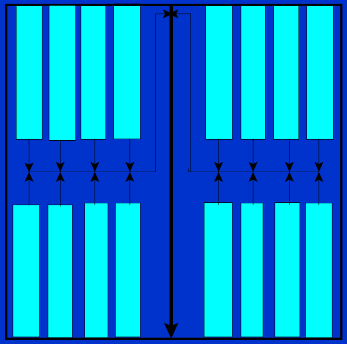


Connectivity File

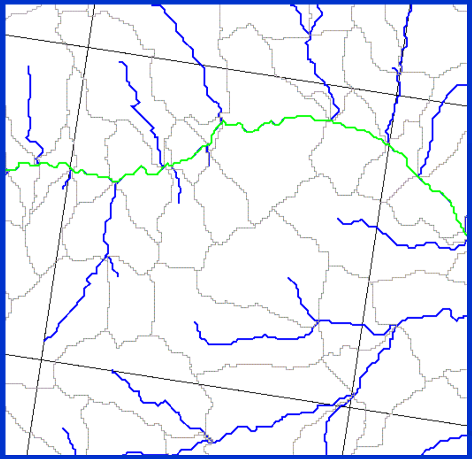
Pixels in channel	Connectivity order
1	2
2	3
3	5
4	5
5	7
6	9
7	15
8	10
9	15

Overland and Channel Network Definition

- Kinematic routing of overland and channel flow
- Conceptual representation of hillslopes within a grid cell



Conceptual hillslopes and stream network



Actual grid cell stream network

Available Options for Analyses

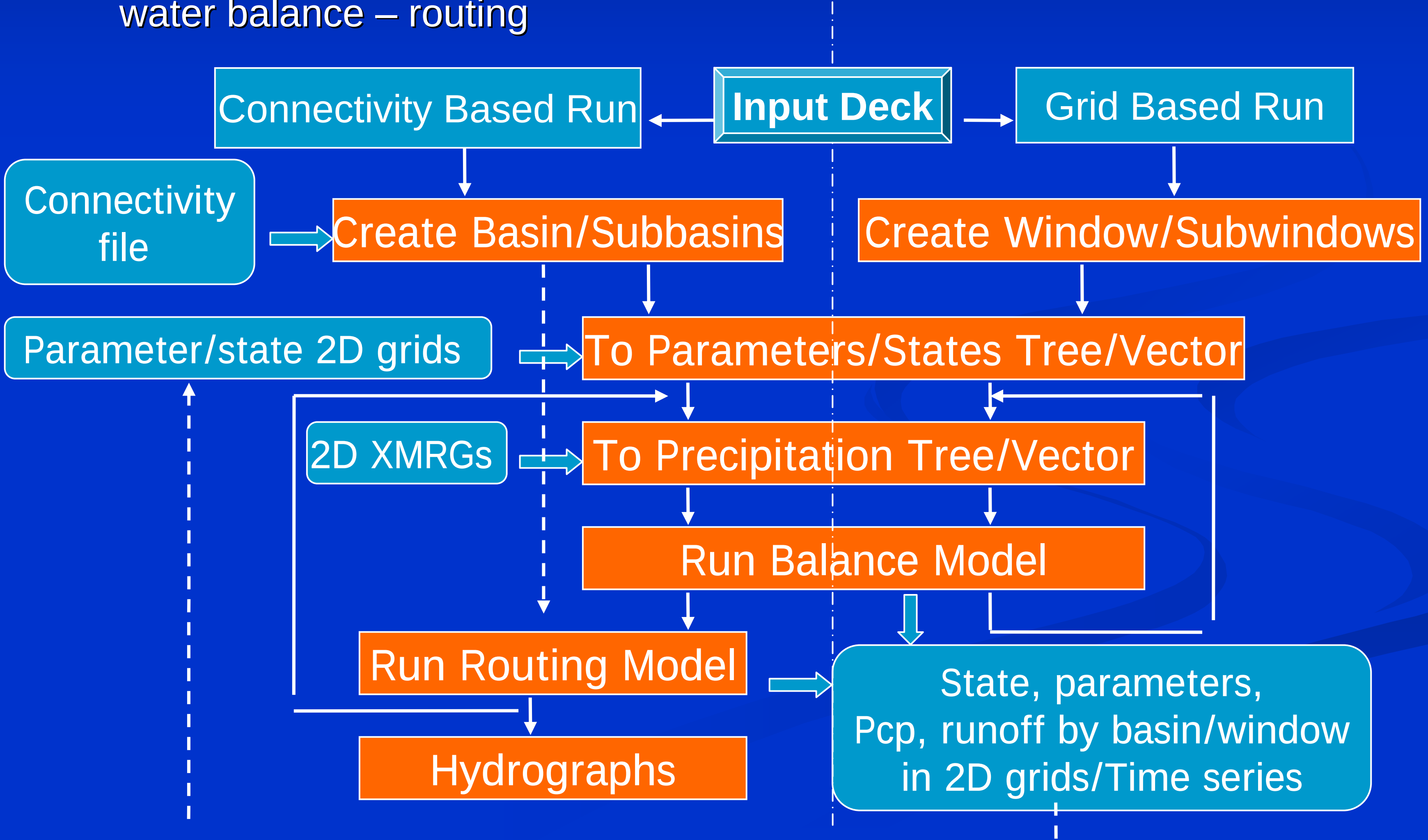
- Parameter, state, and rainfall modifications (MOD)
  - Replace grids for selected basins by a desired constant values
  - Multiply grids for selected basins by a desired factor
- Space – Time scales
  - Water balance: Defined spatial averaging;
    Routing: Connectivity scale
  - Water balance and Routing for a defined time interval (> 1hr)
- Distributed – Lumped options
  - Water balance: Distributed; Routing: Distributed
  - Water balance: Distributed; Routing: Lumped
  - Water balance: Lumped; Routing: Distributed
  - Water balance: Lumped; Routing: Lumped

Recent Developments

- HL-RMS structure improvements
- Enhance science within HL-RMS
- Large area application: testbed for step-by-step implementation
- Improve model parameter estimation techniques
- Visualization

HL-RMS Structure Improvements

- Incorporate object-oriented approach: classes of channel connectivity, simulation node, grid and time series data to make HL-RMS better modular system
- Change data interaction between different components, e.g., grid – vector, water balance – routing



Connectivity Based Run

Input Deck

Grid Based Run

Connectivity file

Create Basin/Subbasins

Create Window/Subwindows

Parameter/state 2D grids

To Parameters/States Tree/Vector

2D XMRGs

To Precipitation Tree/Vector

Run Balance Model

Run Routing Model

State, parameters, Pcp, runoff by basin/window in 2D grids/Time series

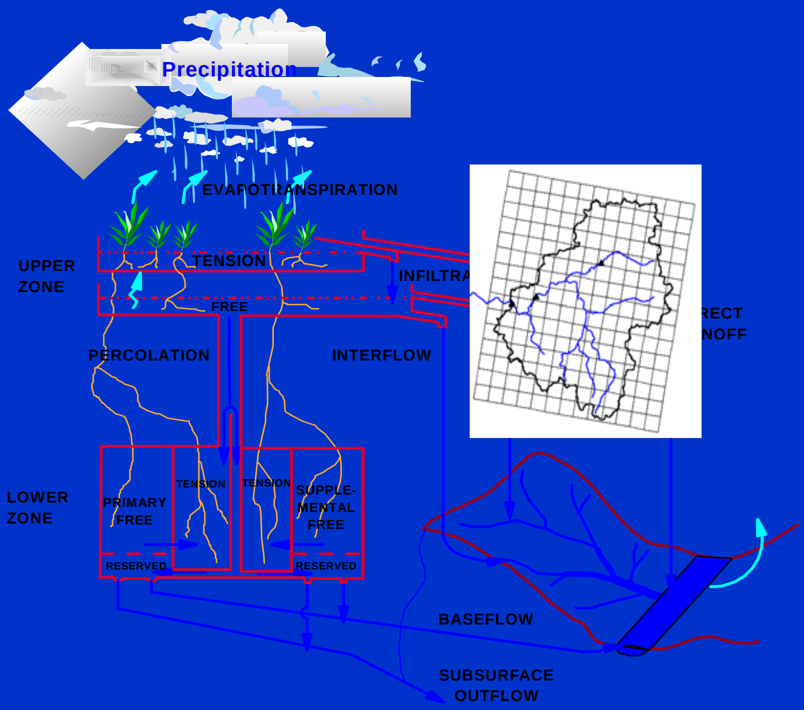
Hydrographs

Enhance HL-RMS science

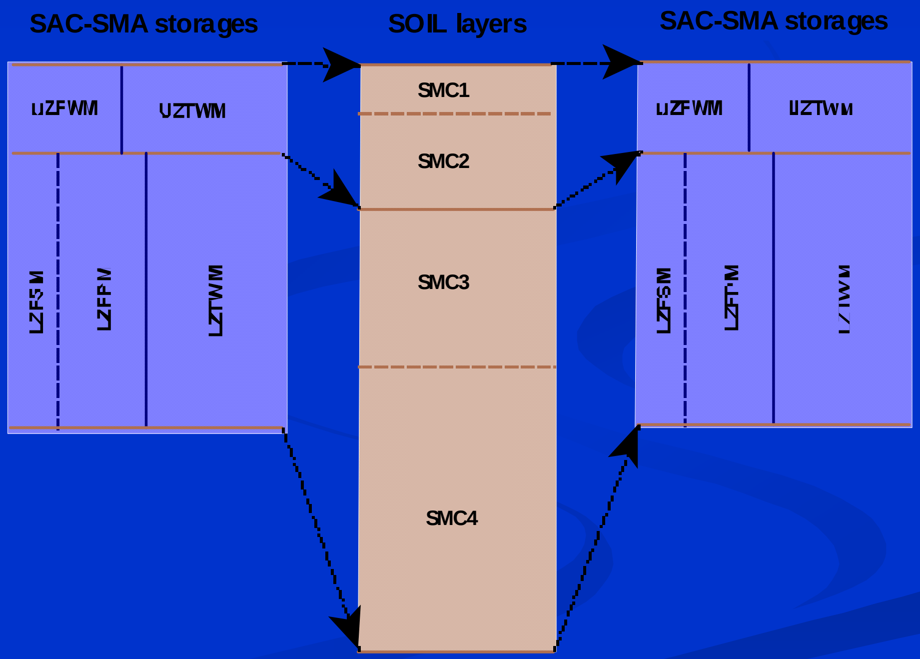
- Added SNOW-17 operation. Tests were performed for the Juniata River basin
  - Issues: air temperature and parameter grids, snow cover treatment
- On-going work on Muskingum-Cunge channel routing implementation
  - Issues: Efficiency-stability at stream sources
- FFG tools: define flood peaks grid, compute frequency of current flow and grid of hits based on desired flood frequency
  - Details will be provided in Seann Reed presentation
- VAR assimilation
  - Details will be provided in Dong-Jun Seo presentation
- Integrate combined heat and moisture exchange parameterization with the frozen ground component

Heat-Moisture Transfer Component

- Storage-type water balance model
- Layer-structured heat transfer model
- Soil-based transformation of model states



Sacramento model (SAC-SMA)

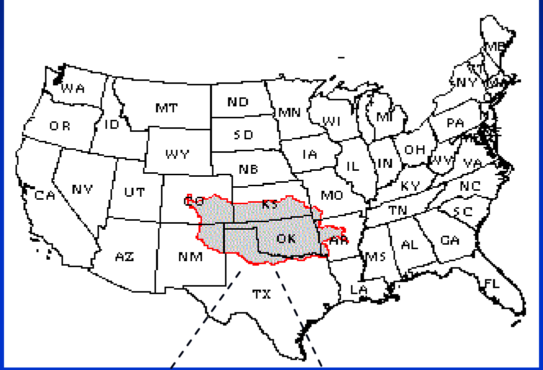


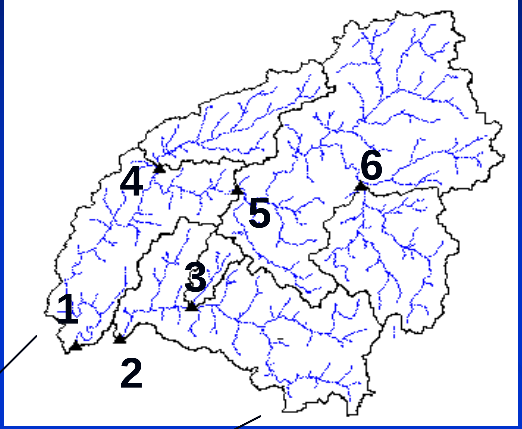
Schematic of moisture/heat states recalculation

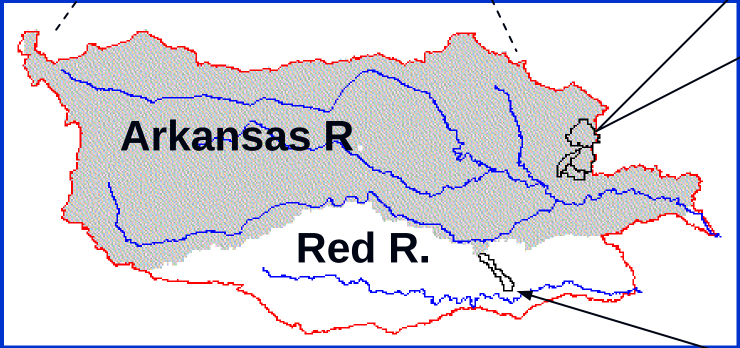
Large Area Application: testbed for step-by-step implementation

- Evaluate HL-RMS over large basins with different level of parameter refining: a priori, regionally scaled, lumped-scaled (tests are performing for Arkansas and SRBC areas)
- Identify intermediate and guidance products to forecast offices, and high-level users and decision makers, e.g., high-resolution grids of surface runoff depth, soil moisture and temperature
- Help to define the most critical basins/forecast points to work on distributed version (comparing lumped & distributed run outputs, input-output analysis)

Test region in the Arkansas-Red River basin





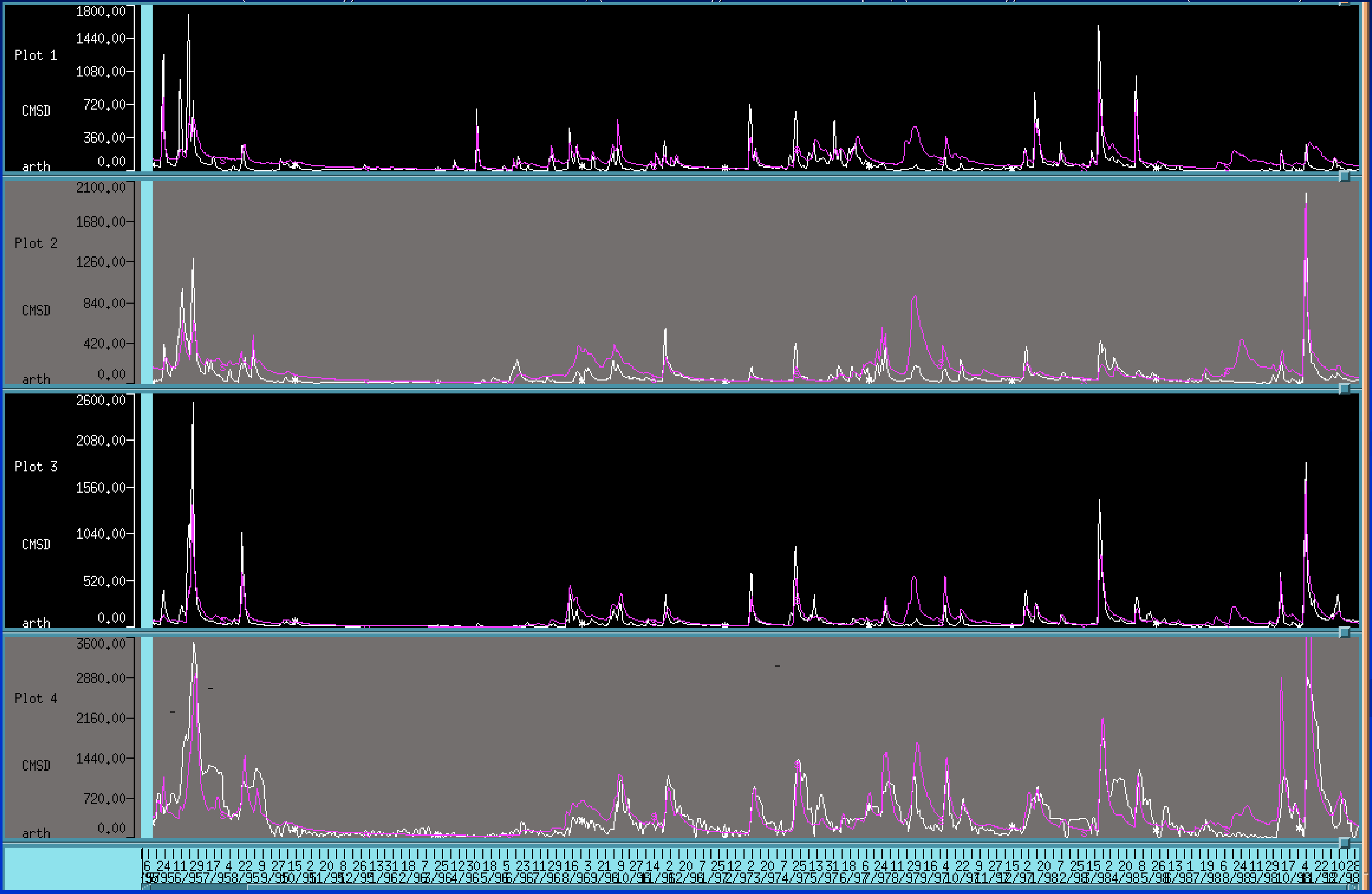


1.	Tahlequah (Illinois River),	2484 km^2
2.	Eldon (Baron Fork River),	795 km^2
3.	Christie (Peacheater Creek),	65 km^2
4.	Kansas (Flint Creek),	285 km^2
5.	Watts (Illinois River),	1645 km^2
6.	Savoy (Illinois River),	433 km^2

Blue (Blue River), 1233 km^2

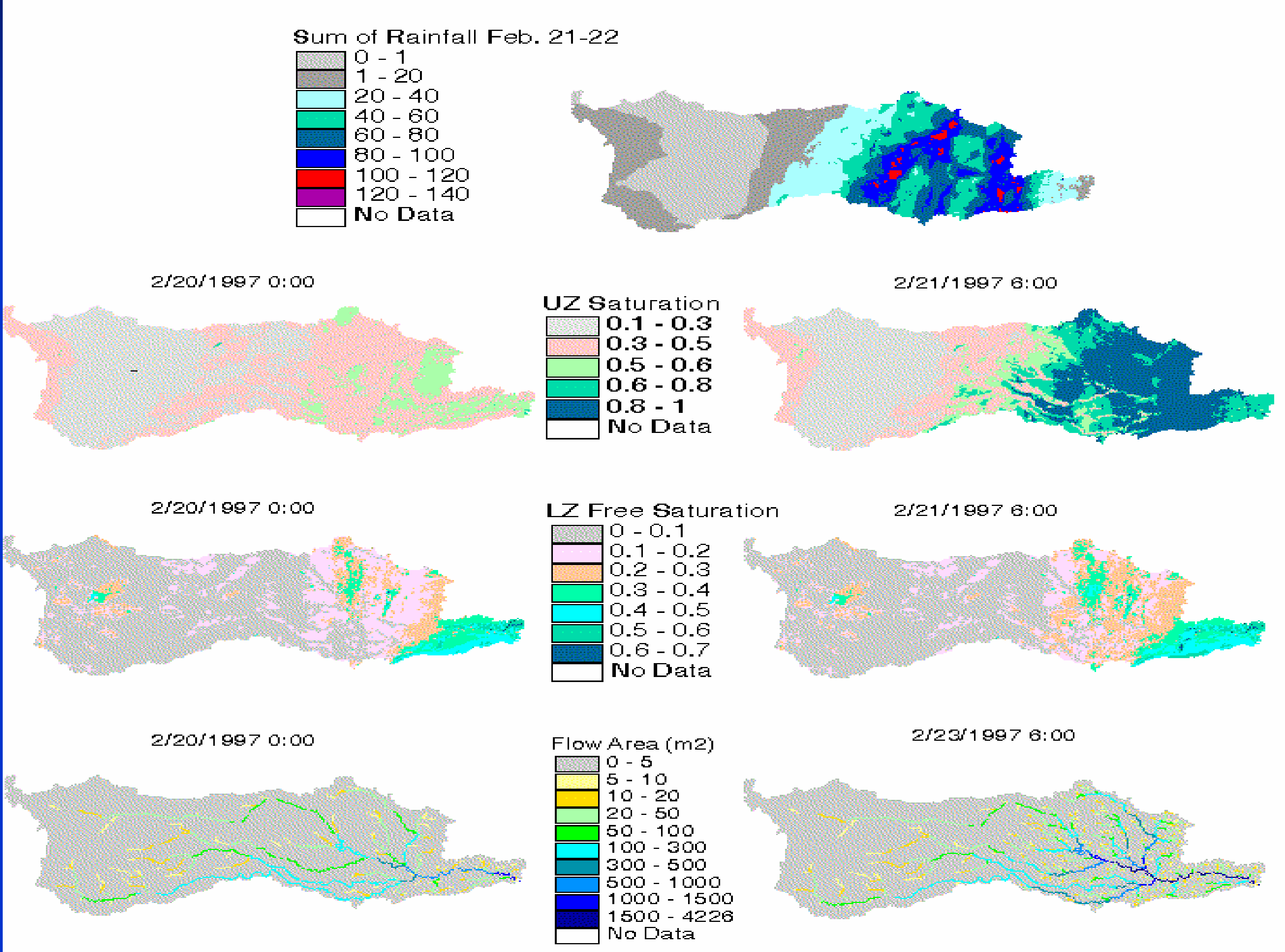
Large-scale tests

Observed (white) & simulated (red) hydrographs for Arkansas basin (from the top to bottom):
Canadien at Calvin (72396 km^2), Arkansas at Arkansas City (113217 km^2), Cimarron at Ripley (46566 km^2), Arkansas at Tulsa (193253 km^2)



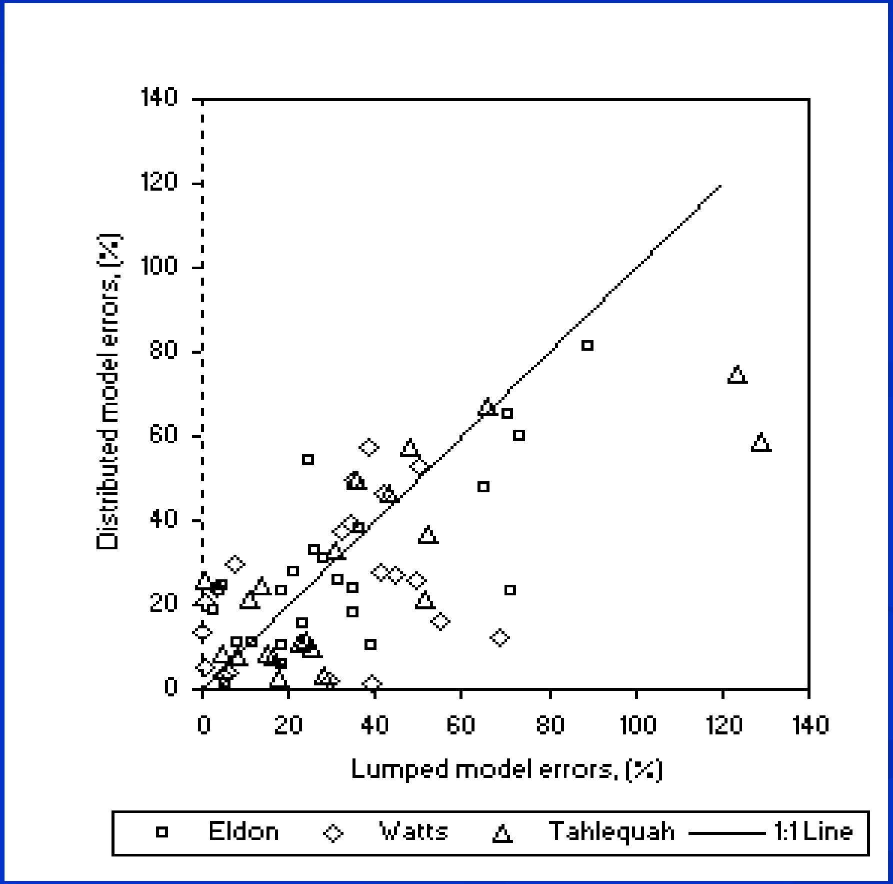
Large-scale tests

Simulated water balance model (UZ & LZ) and channel routing (Flow Area) states over the Arkansas River basin before and after a storm; cumulated rainfall are shown at the top



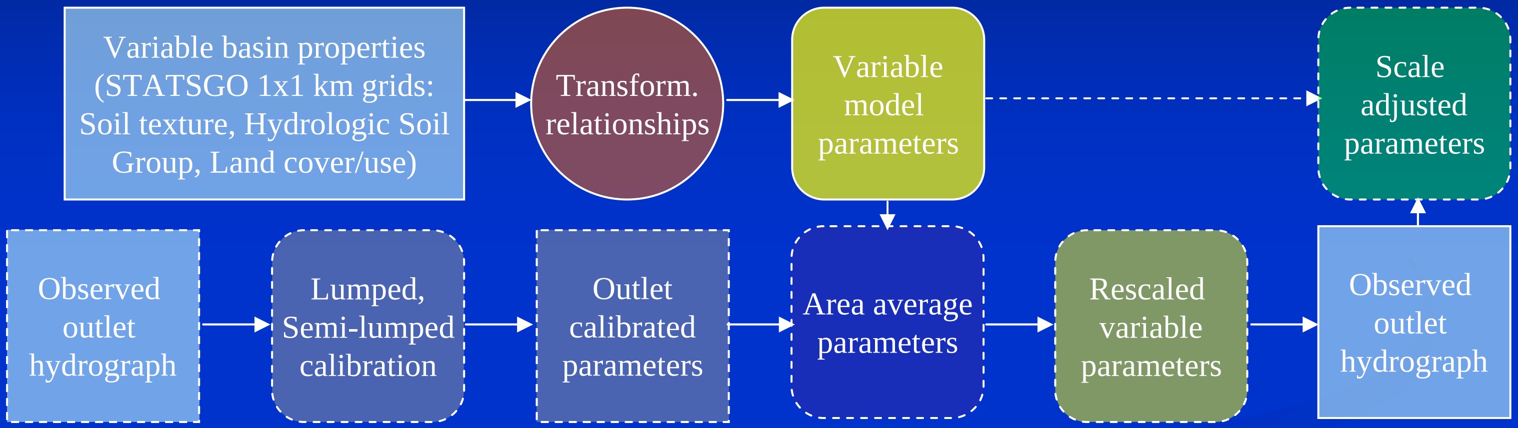
Selected headwater basins test

Absolute flood peak errors (%) from distributed and lumped runs over three basins



PARAMETERIZATION

Water balance parameters



Variable basin properties (STATSGO 1x1 km grids: Soil texture, Hydrologic Soil Group, Land cover/use)

Transform. relationships

Variable model parameters

Scale adjusted parameters

Observed outlet hydrograph

Lumped, Semi-lumped calibration

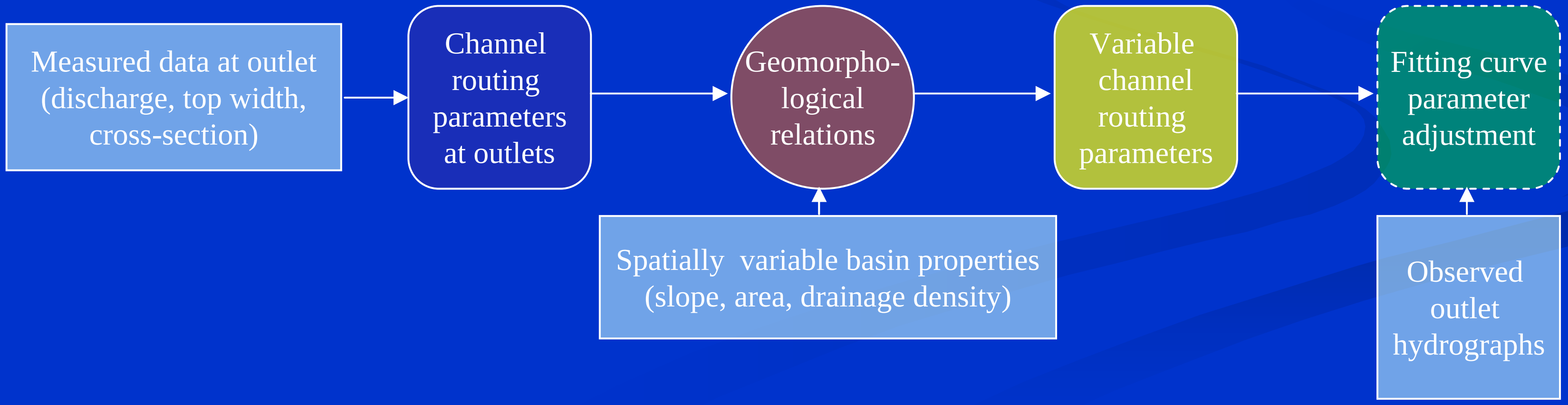
Outlet calibrated parameters

Area average parameters

Rescaled variable parameters

Observed outlet hydrograph

Channel routing parameters



Measured data at outlet (discharge, top width, cross-section)

Channel routing parameters at outlets

Geomorpho-logical relations

Variable channel routing parameters

Fitting curve parameter adjustment

Spatially variable basin properties (slope, area, drainage density)

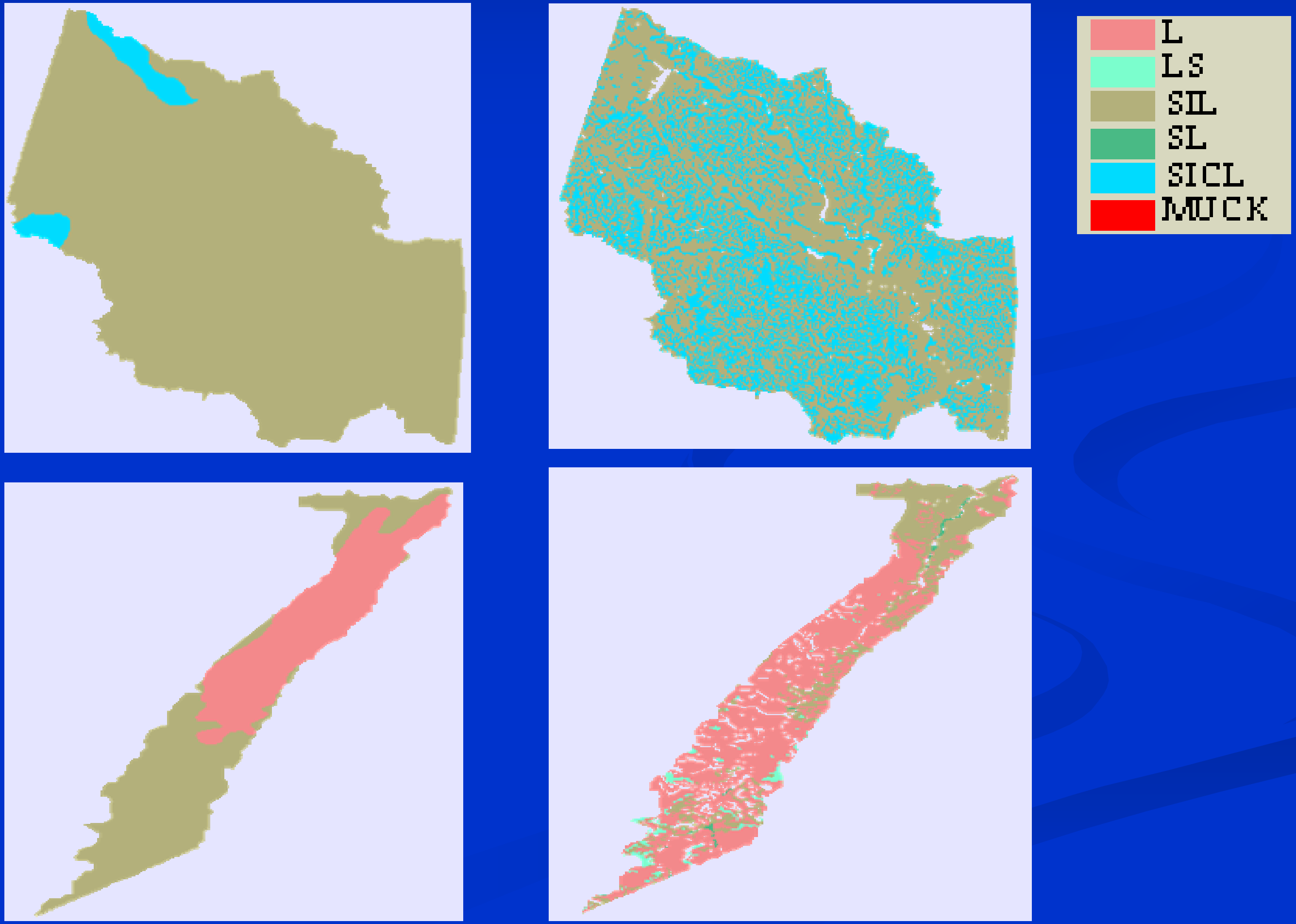
Observed outlet hydrographs

Improve Model Parameter Estimation Techniques

- Use higher resolution/quality GIS data (from STATSGO to SSURGO)

Catchment 3

Catchment 2

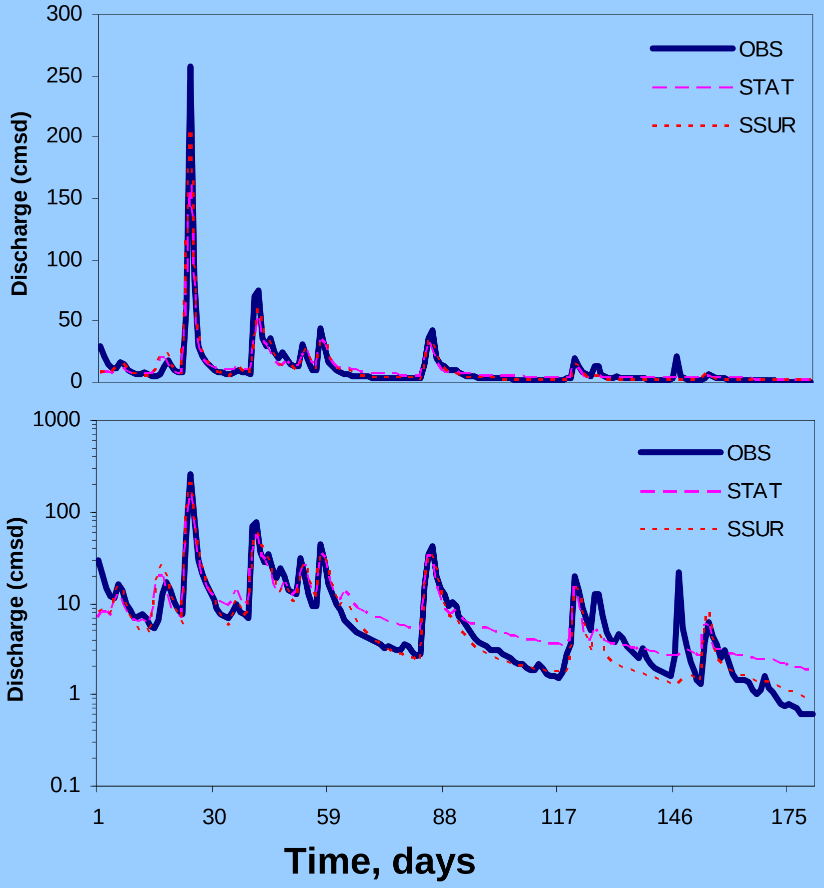


STATSGO

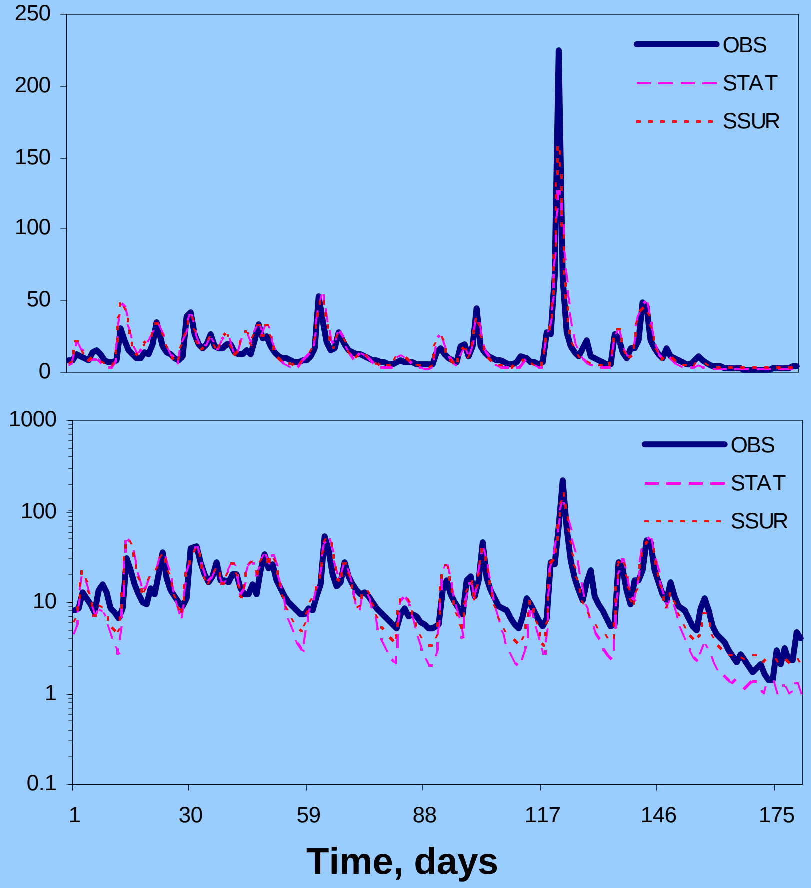
SSURGO

Improve Model Parameter Estimation Techniques (cont.)

- Use higher resolution/quality GIS data (from STATSGO to SSURGO)



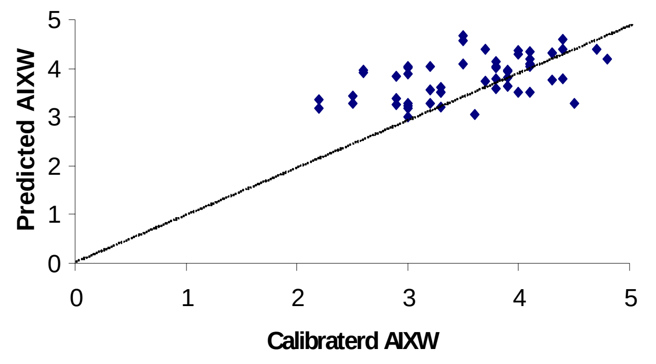
Catchment 3: 2–7/1975

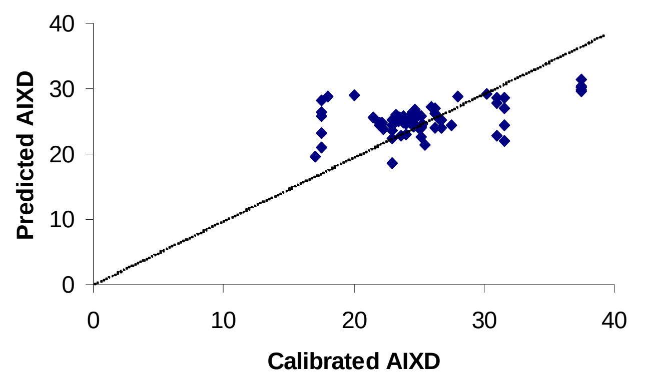


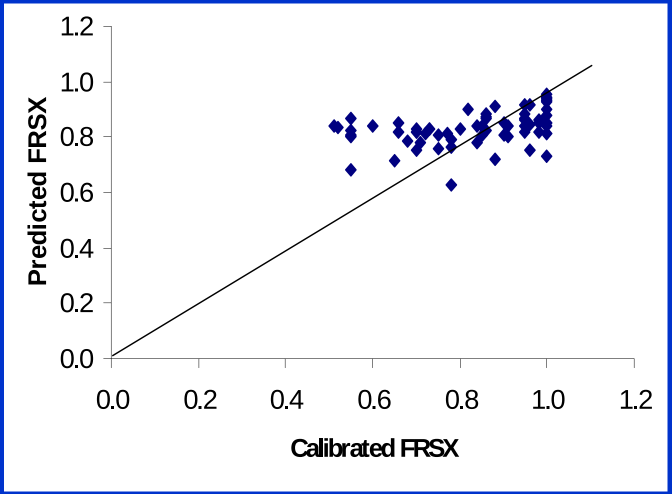
Catchment 2: 2–7/1974

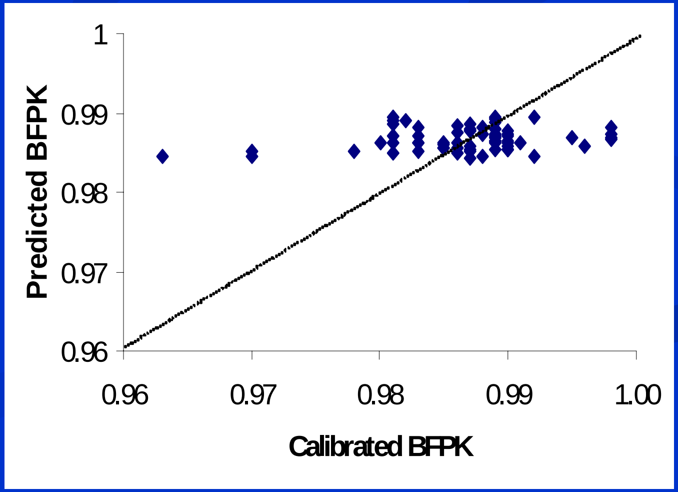
Improve Model Parameter Estimation Techniques

- Develop regional relationships between model parameters and physical properties, e.g., API model



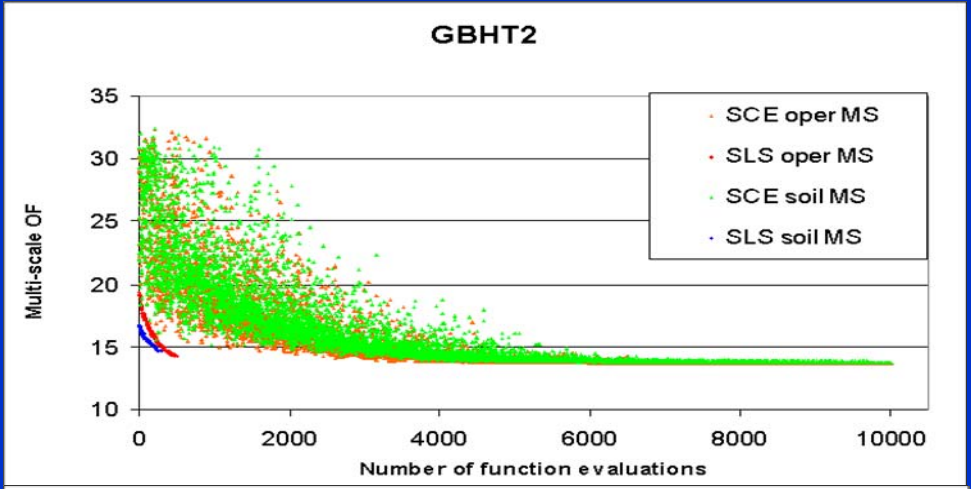


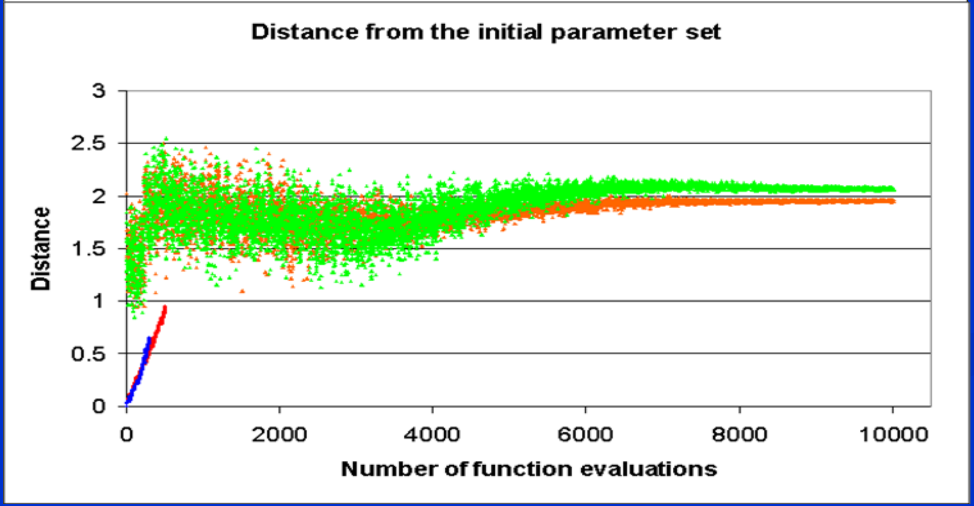




Improve Model Parameter Estimation Techniques (cont.)

- Evaluate an effective quasi-local parameter filtering using a priori estimates





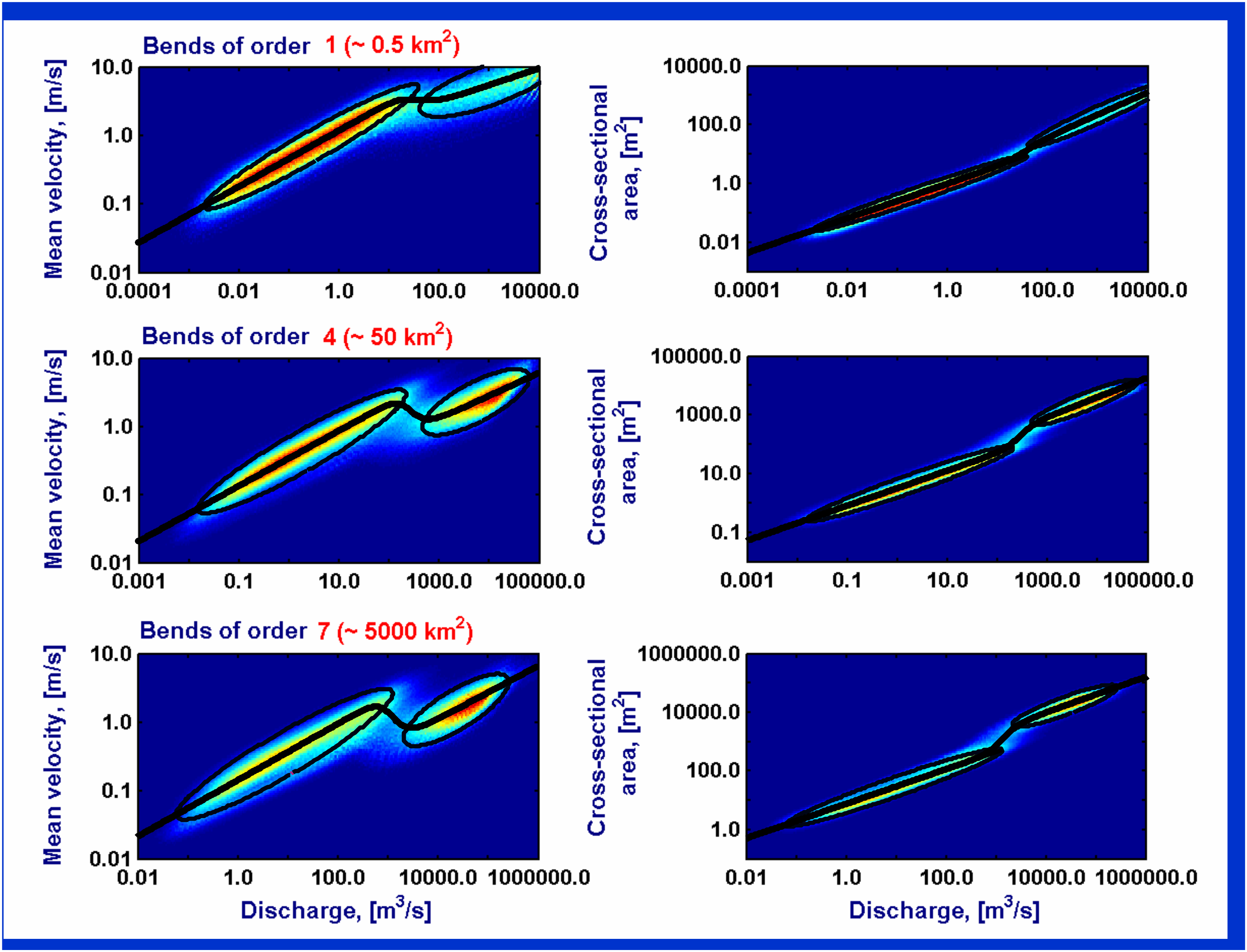
SLS is computationally extremely economical

SLS-refined parameters remain closer to the initial values

Improve Model Parameter Estimation Techniques (cont.)

- Develop new automatic calibration procedures for distributed model parameterization (U. of Arizona)
- Incorporate a probabilistic approach to define channel routing parameters (U. of Minnesota collaborative research)

A comparison of the probabilistic HG with the HG predicted from the mixed multiscaling model.



Geomorphologic Analysis Needed to Compute Scale-Dependent Hydraulic Geometry (HG)

1) Analyze channel planform as a function of scale.

2) Analyze channel geometry at bankfull as a function of scale.

3) Derive the morphology of synthetic meandering bends employing the linear theory of meandering rivers of *Johannesson and Parker* (1989).

4) Perform floodplain extraction over large domains from a Digital Elevation Model (DEM).

5) Perform floodplain half-width and transverse slope analysis as a function of scale.

Visualization

- Develop simple GUI to generate/modify the HL-RMS input card
- Incorporate graphic package to manage 1D and 2D graphics
- Generate output statistics, cumulative grids, and other products

Summary

- HL-RMS allows integration and testing new science/techniques in quasi-operational setting that will speed up their implementation into RFC operations