A simple large-scale routing scheme for seasonal streamflow predictions that includes reservoir characteristics

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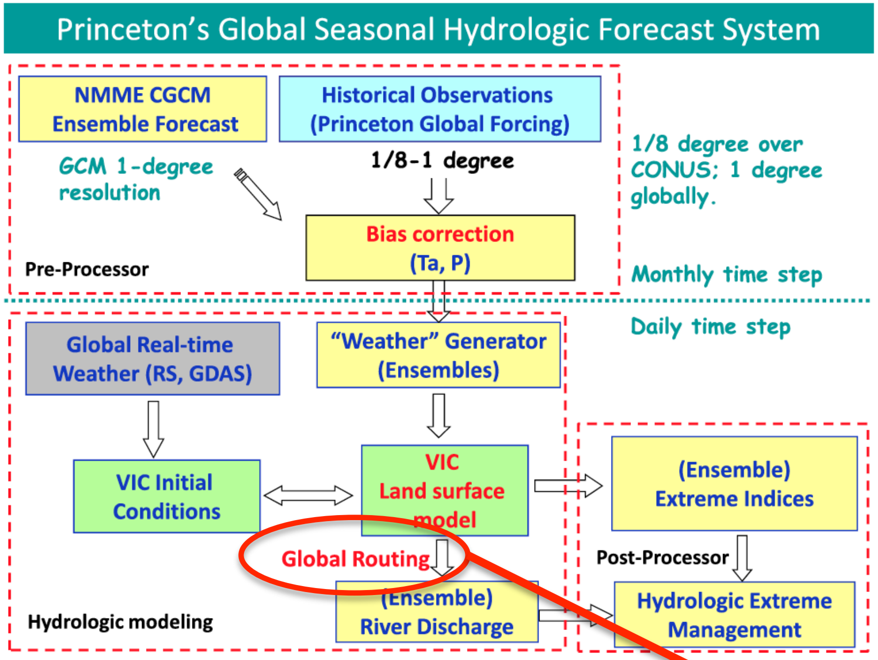
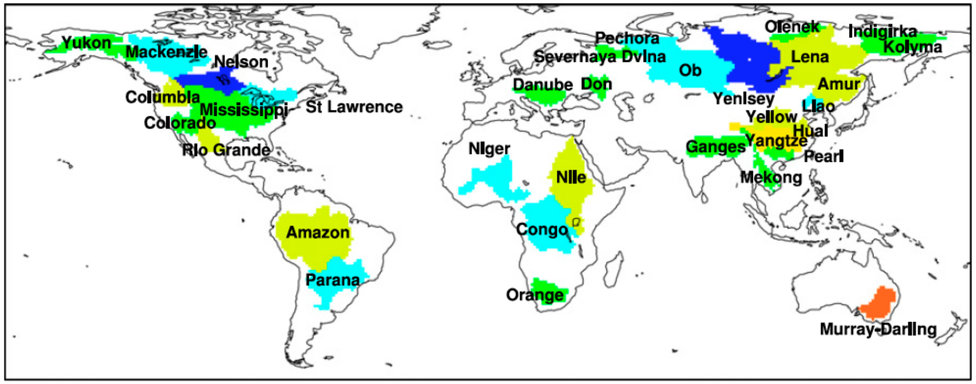
Large-Scale Seasonal Streamflow Forecasts



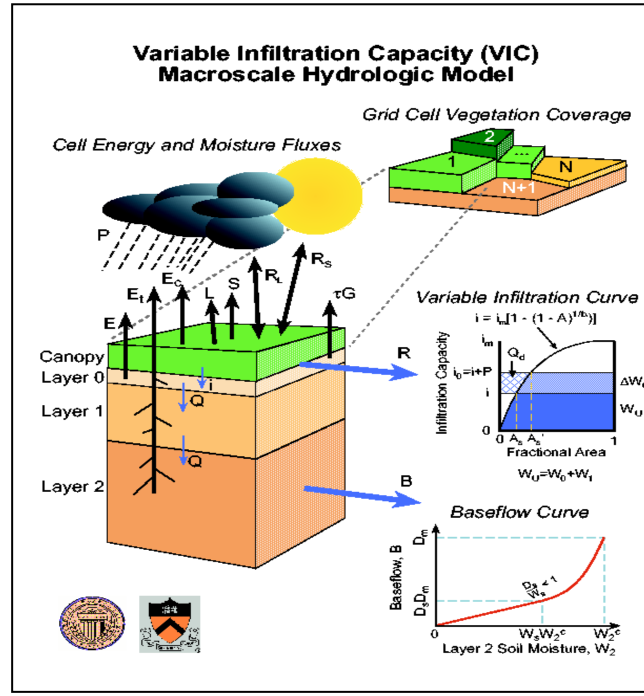


Yuan et al., 2015, BAMS

Seasonal streamflow forecasts can provide the needed information for reservoir management, yet large-scale forecasts rarely consider reservoir management.

Current Large-scale model setup

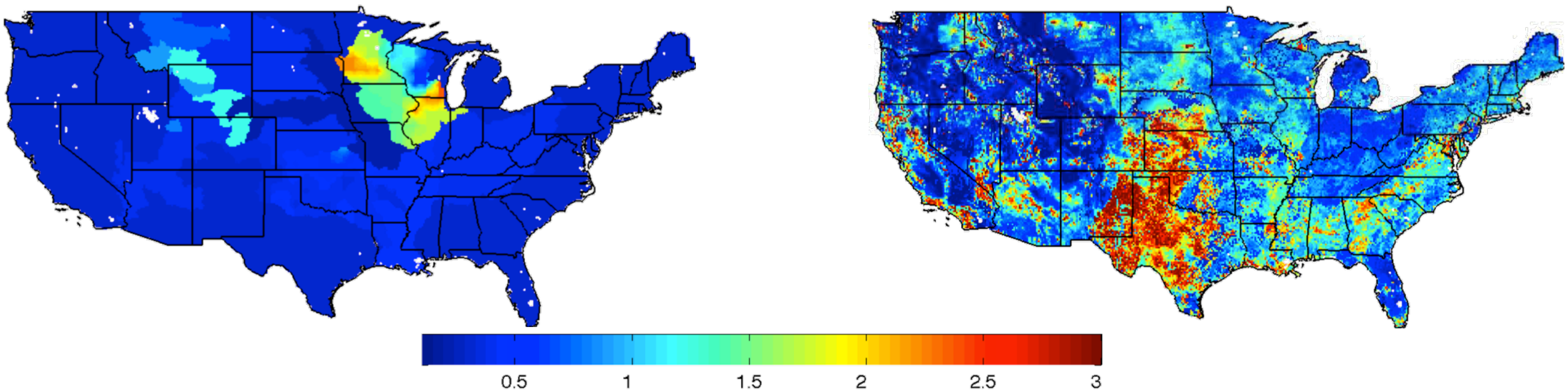
- Variable Infiltration Capacity (VIC) model
  - Water Balance Mode, Daily time step
  - Forcing NLDAS
  - Grid Calibration
  - Routing – Lohmann Model



Second Layer Depth (m)

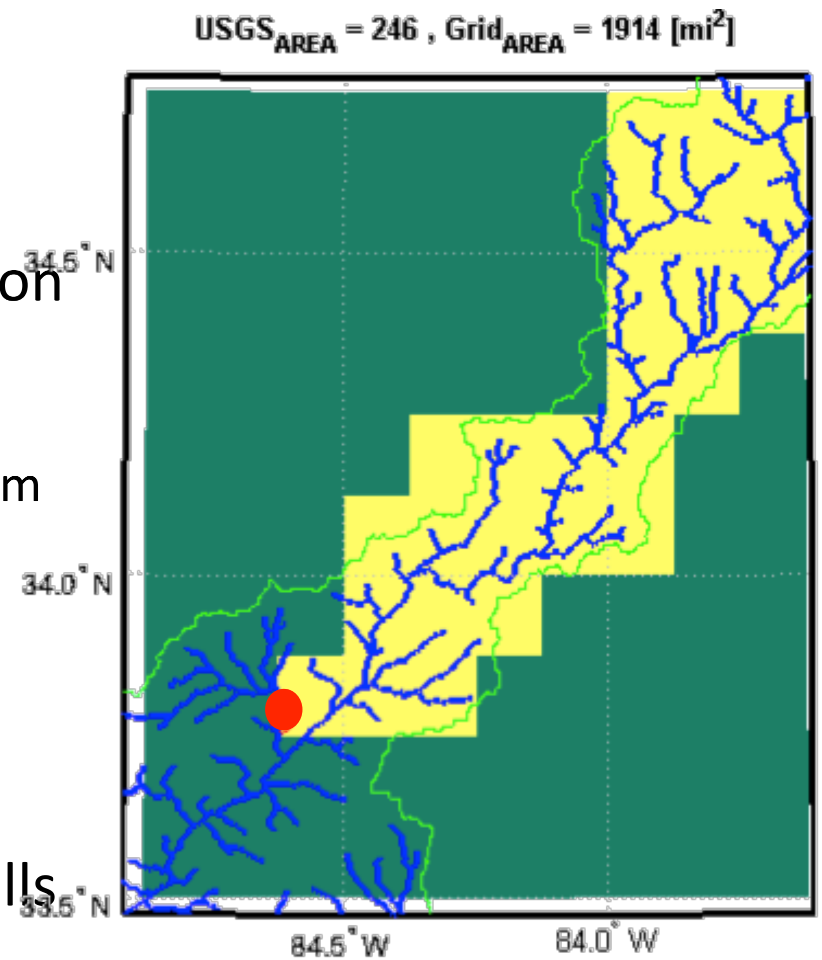
Previous Calibration

Grid Calibration



Current Routing schemes

- (Lohmann et al. 1998)
  - Unit Hydrograph for sub-grid routing dynamics
  - Green's function Solution to linearized Saint –Venant equation
    - Parameters, Wave Velocity, Diffusivity
    - Average Stream Length in grid from data
  - Computationally Efficient
- In practice
  - V,D constant
  - Same unit hydrograph for all cells
  - Problem with small basins



Requirements for a new routing scheme

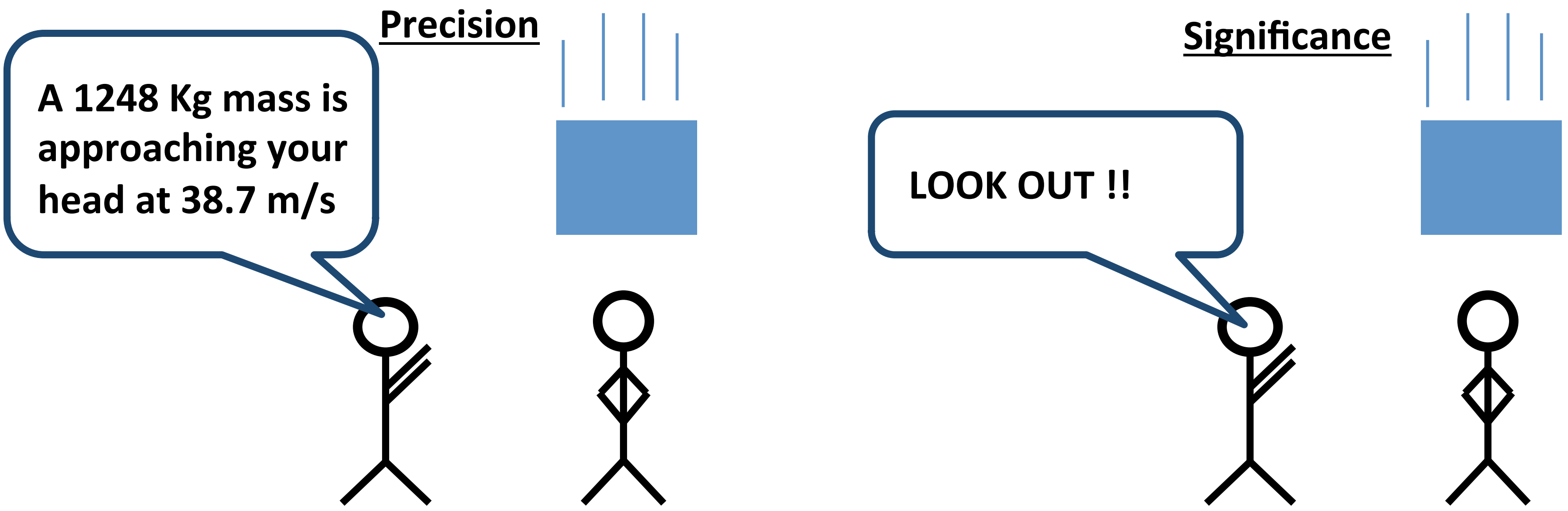
Computationally efficient

Capture sub-grid routing dynamics and river networks

Regional or no parameterization

Flexibility to seamlessly integrate reservoirs

Reasonable scope for seasonal prediction



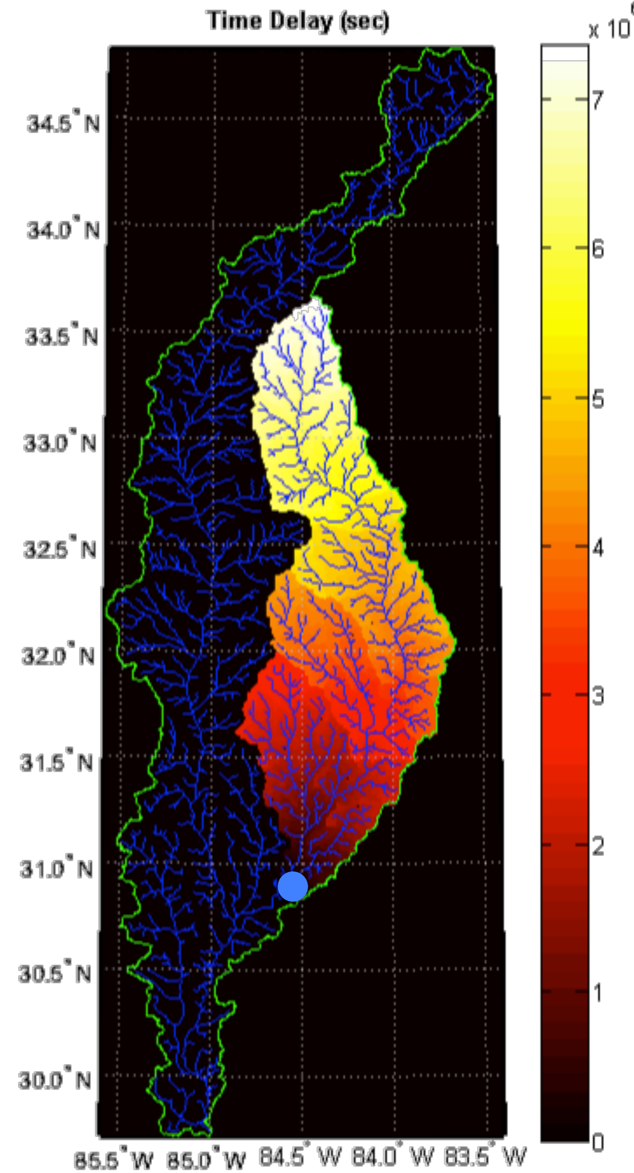
Develop a simple and efficient method for routing and reservoirs that captures the significance.

Algorithm to account for sub-grid river networks

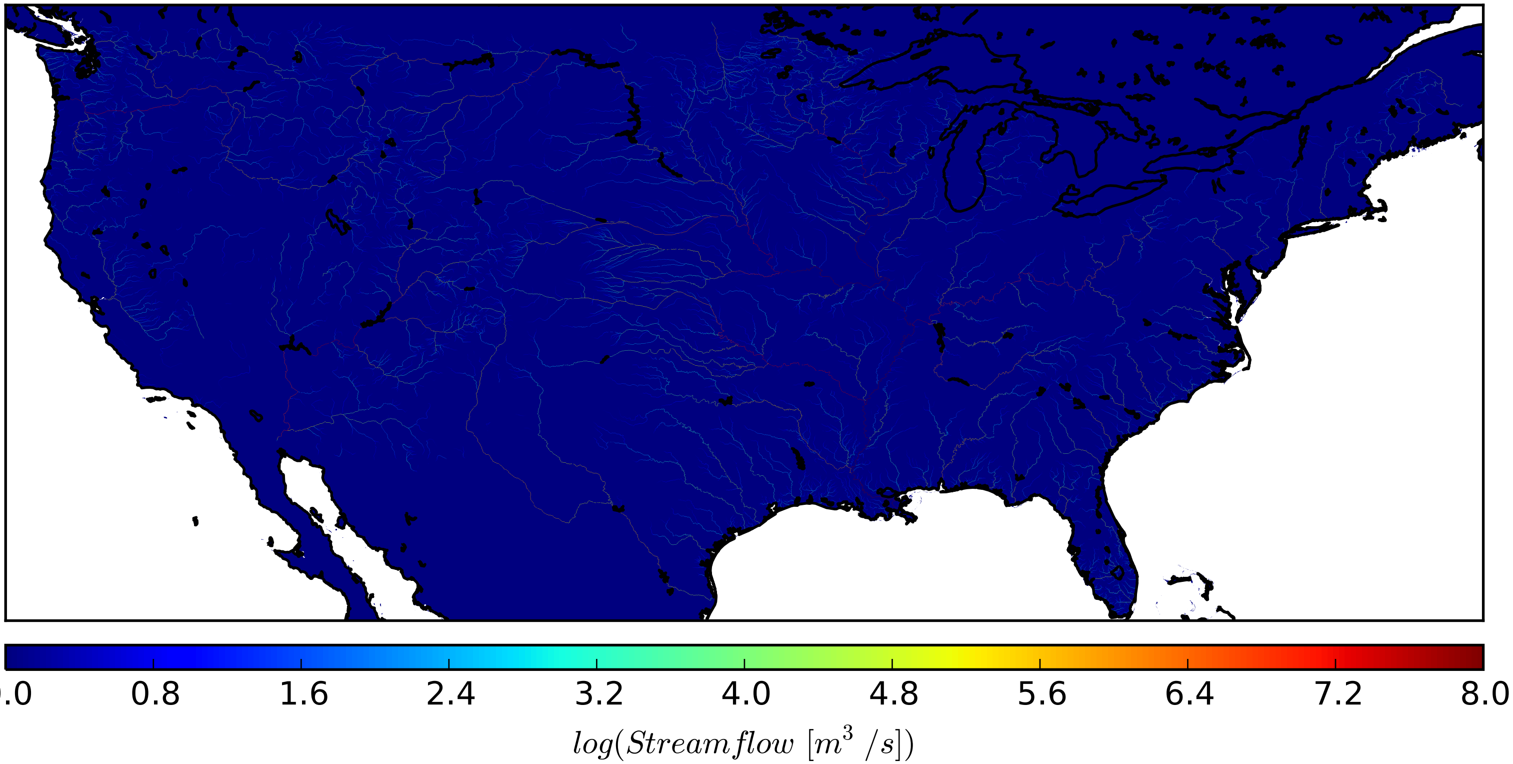
- (Gong et al. 2009)
  - Based on Time delay

$$t = \sum_{i=1}^{n} \frac{l_i}{V_i} \qquad V_i = V_{45} \cdot \sqrt{\tan b_i}$$

Given *t*, this algorithm can be used to determine the distance the water travels and can be applied for the whole domain not just a single gauge.



Move water through the system using a V_{45} and sub-grid topography

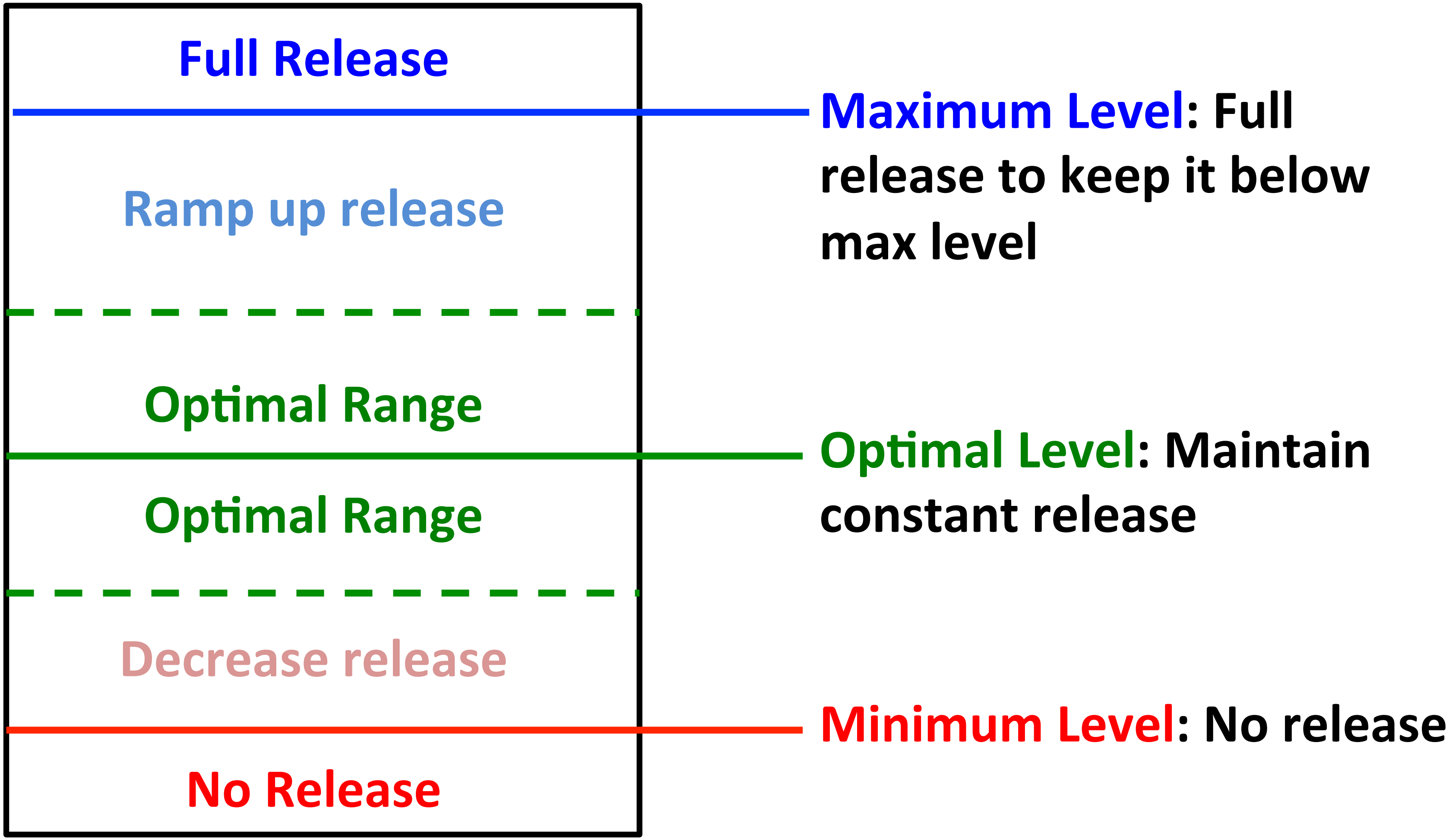


VIC 1/8th (450s) degree model routed at 30s hydrosheds (1-km) over the U.S.

By setting the Velocity equal to zero, it creates a reservoir

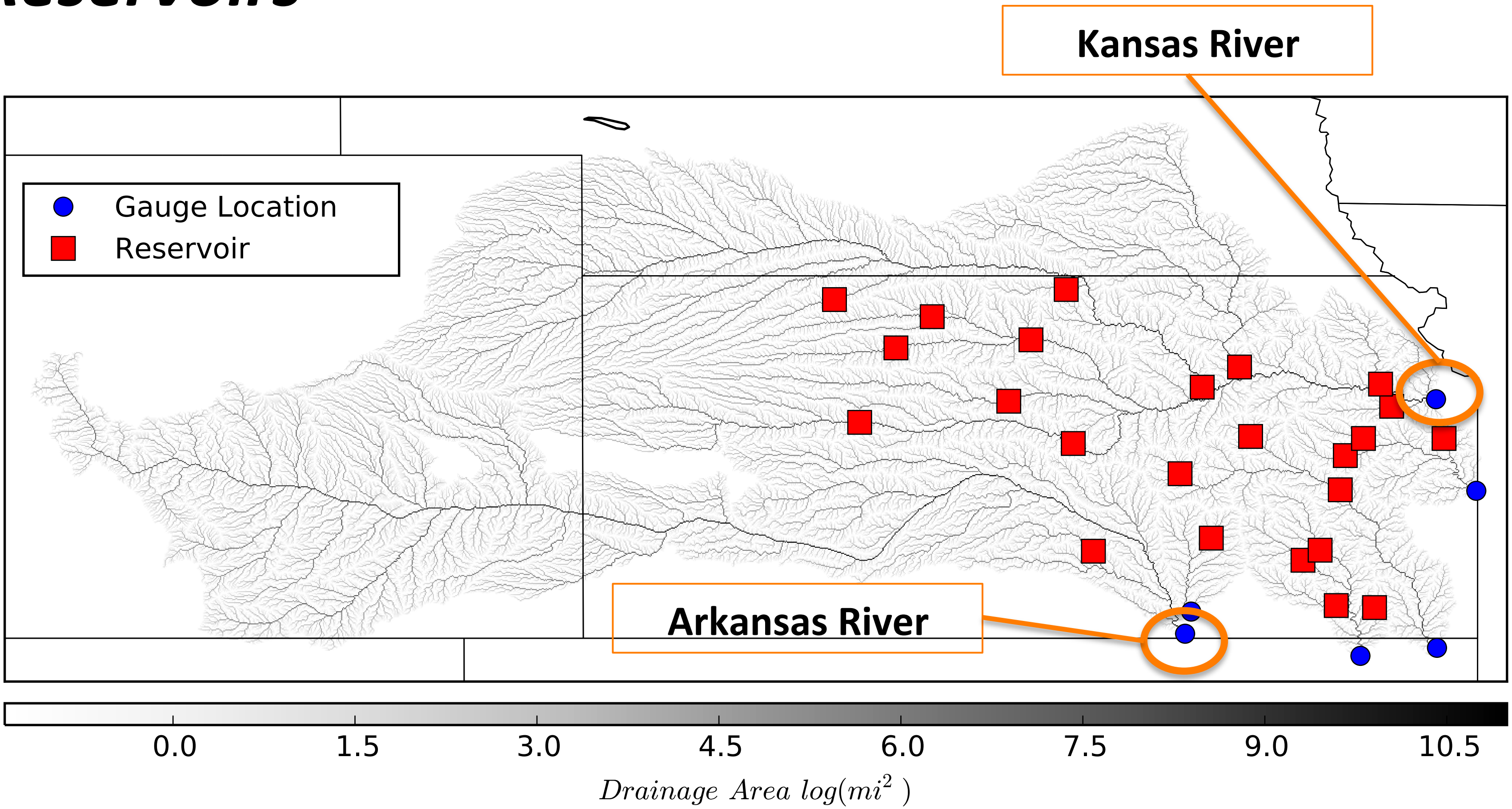
Simple Reservoir Model

Inputs: Maximum volume, latitude and longitude



Releases and levels are parameterized relative to the volume of the reservoir

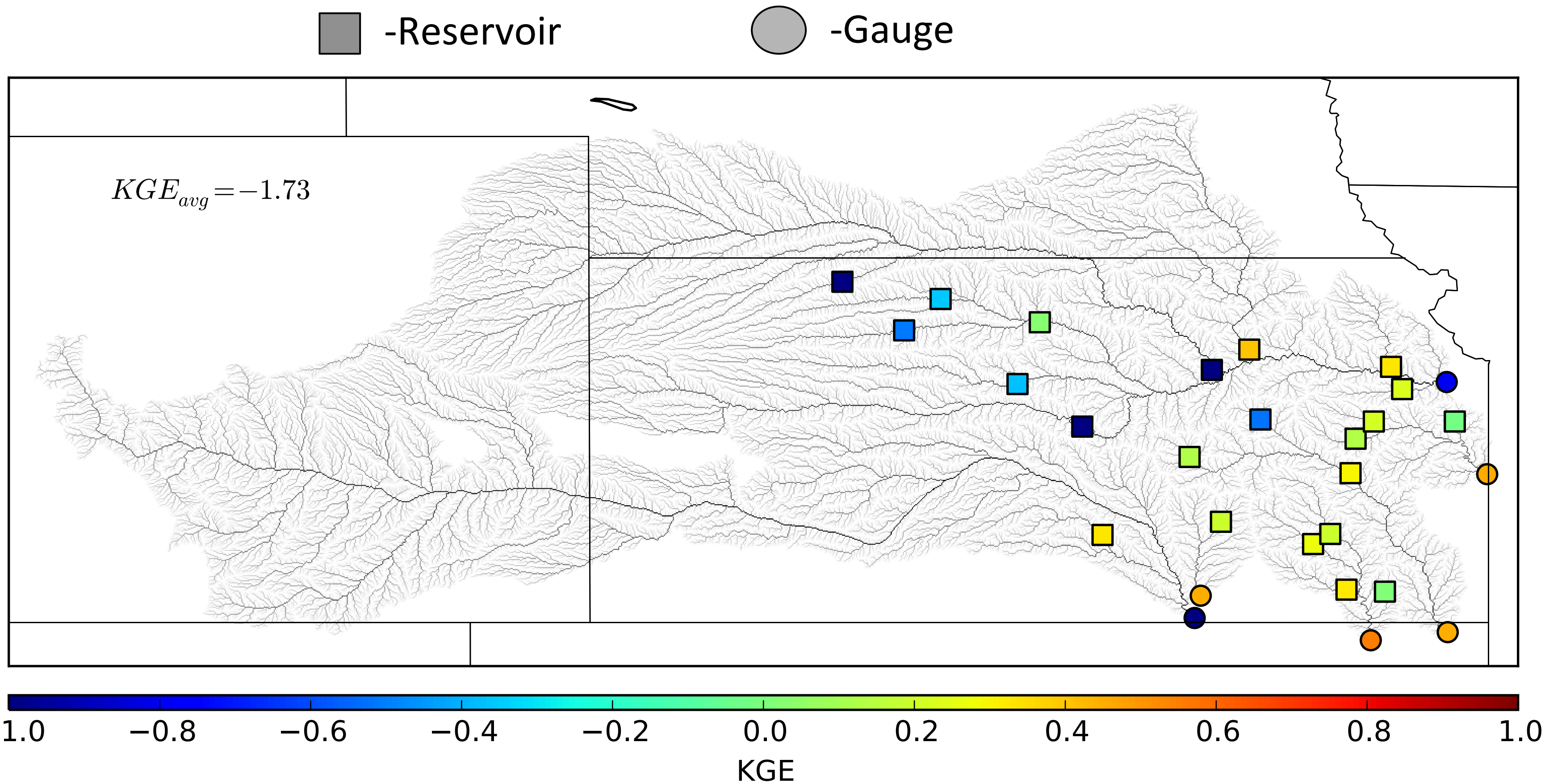
Streamflow in Kansas is greatly impacted by Reservoirs



24 major reservoirs, with some operational data.

Two major tributaries of the Kansas and Arkansas rivers.

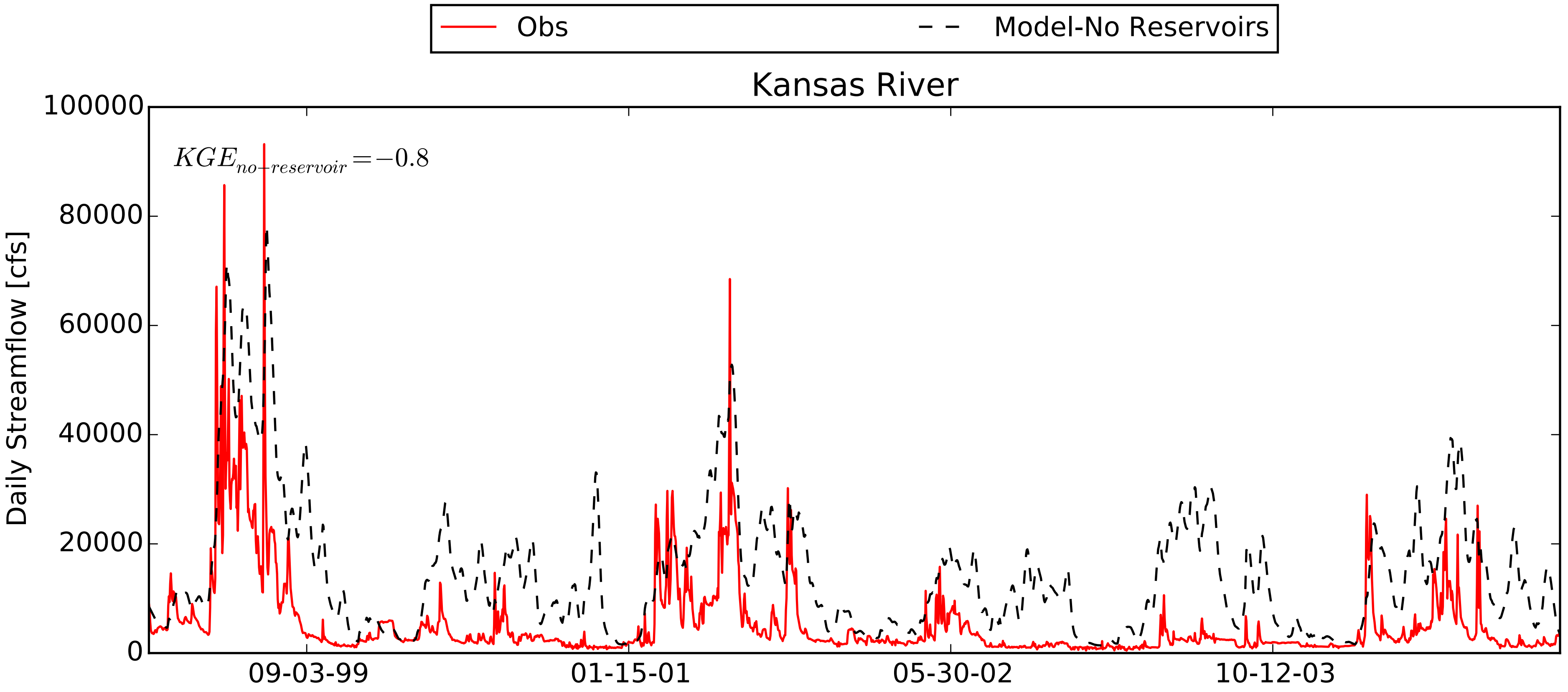
Model streamflow without reservoirs does ok, but has limitations



Not so good Model

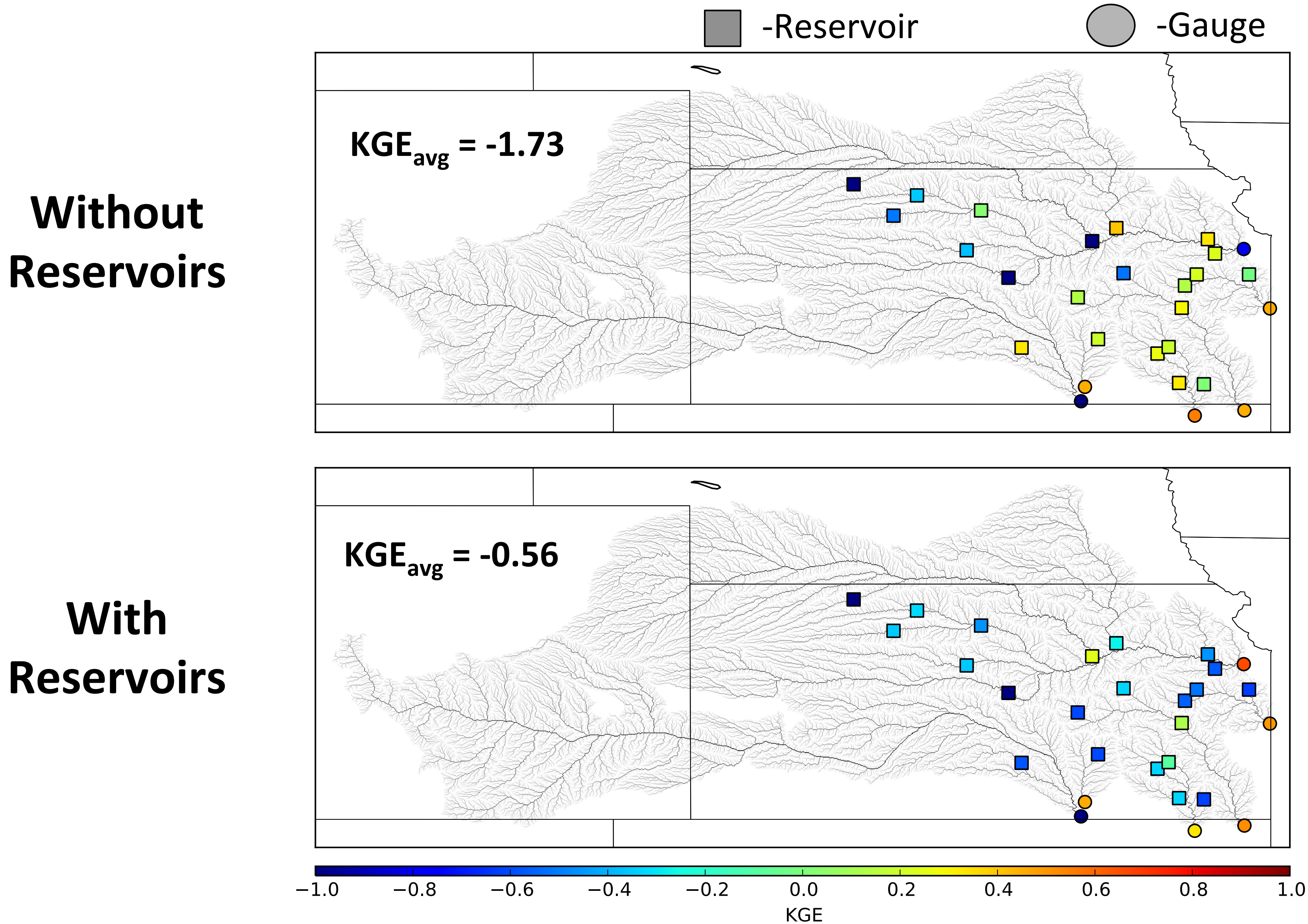
Perfect Model

Kansas River Streamflow is over predicted by the model, but it is heavily controlled by reservoirs

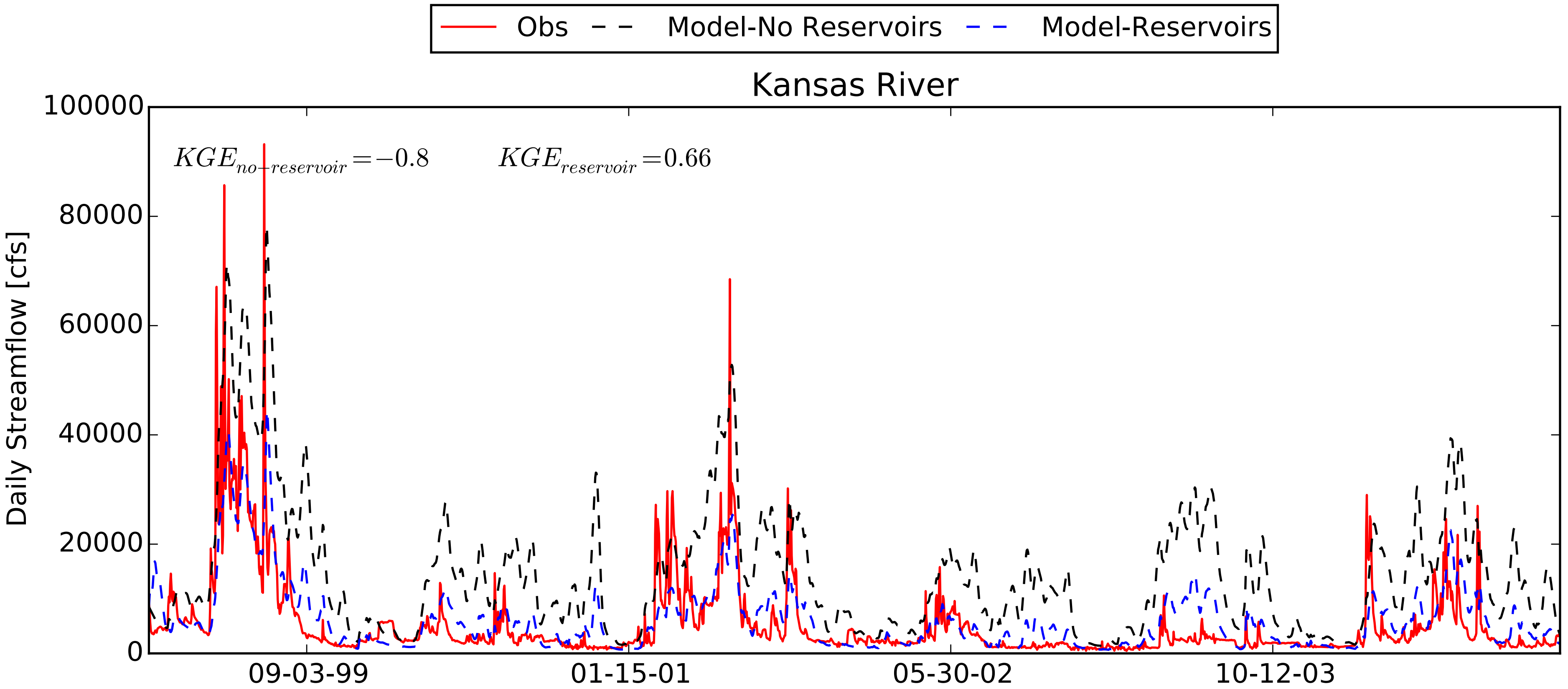


13 of the 24 reservoirs are within the Kansas River Basin

Adding reservoirs improves the KGE for most locations, but it is not perfect

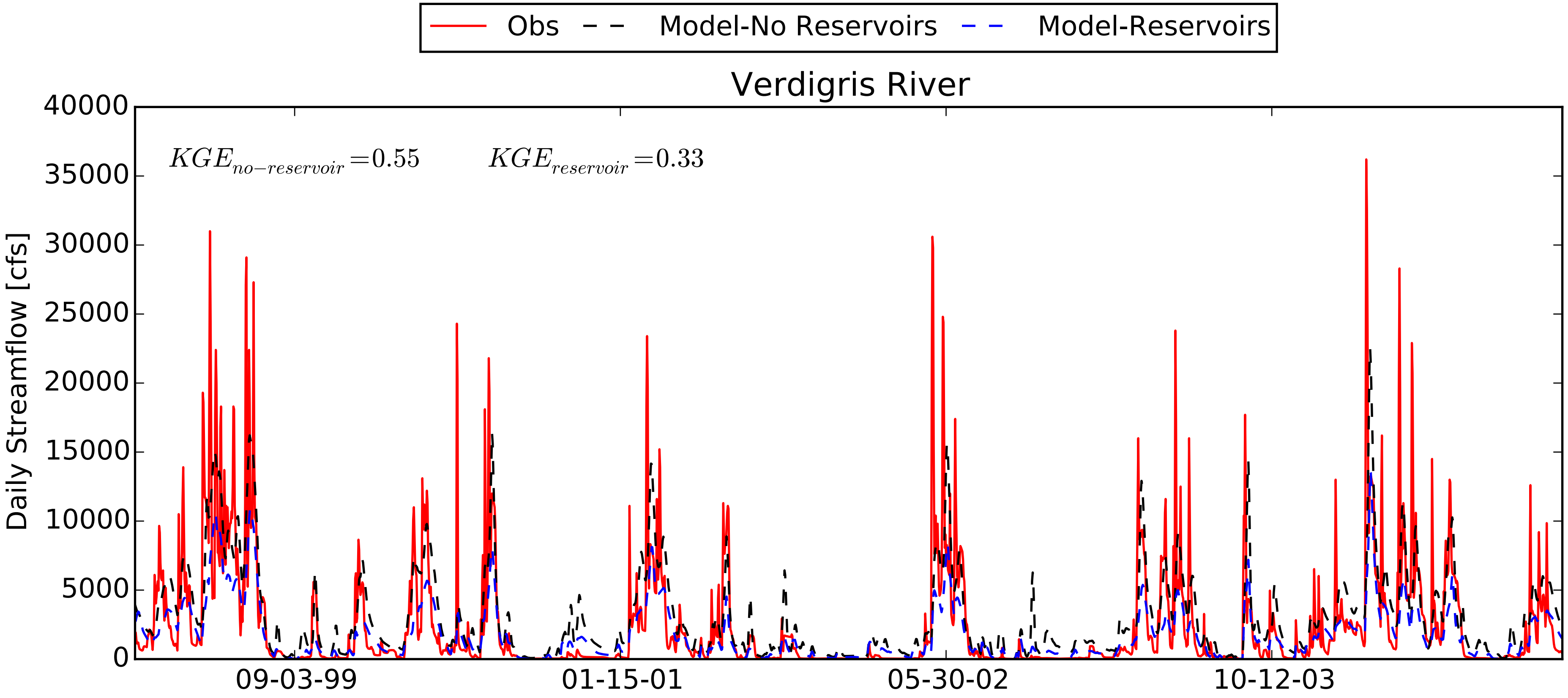


Modeled streamflow for the Kansas River shows improvement by adding Reservoirs



The Reservoirs account for other losses, although crude, it captures the main impact.

Not all locations showed improvement by adding reservoirs



The model was already under predicting streamflow, however, the correlation improved from 0.7 to 0.72.

Summary and Conclusions:

- **A routing scheme that moves water through the system provides the flexibility to account for reservoirs.**
- **The simple reservoir model shows improvement in the model.**
- **Further calibration of the model and reservoir model is needed.**
- **In addition to improving seasonal streamflow forecasts, this could be used for integrated social/economic/climate assessment.**