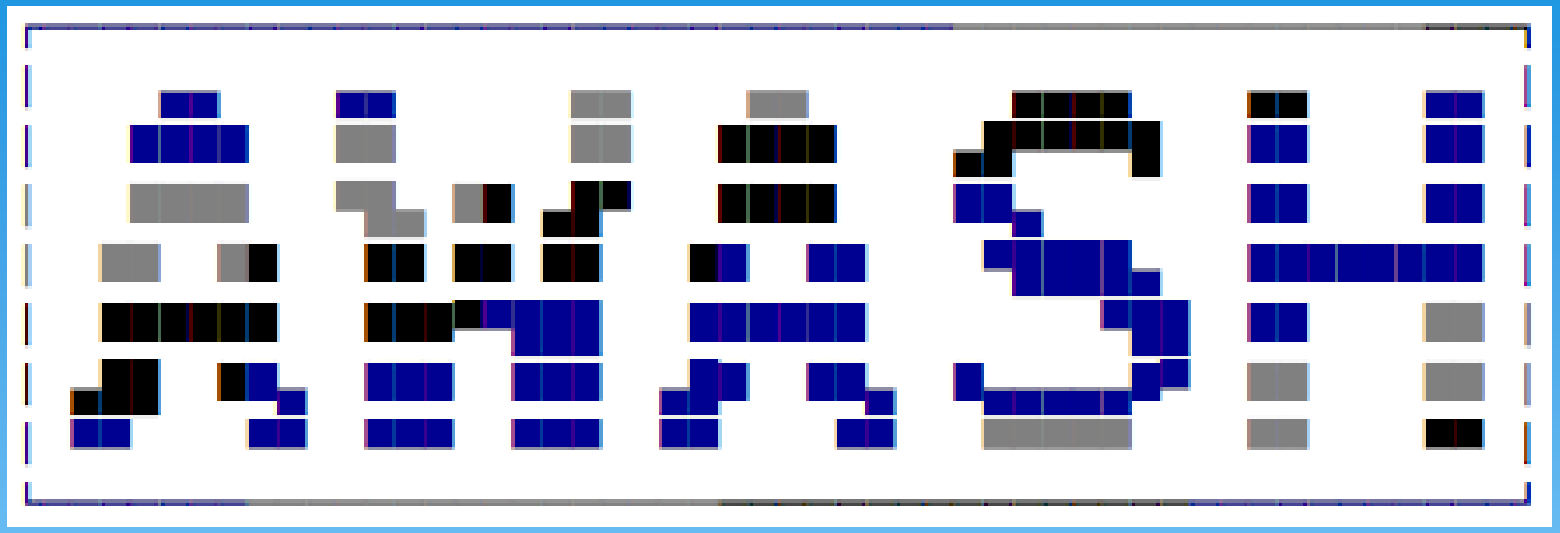


Modeling Overview

Overview of the model

Contents:

* Overview of the model
* Examples of AWASH in action
* Getting involved

Model objective

Explore interactions between water, food and energy systems from a national perspective

* In response to specific types of climate changes
* In response to economic factors
  * GDP growth rate , Global Energy prices, Global Food demand
  * Investment climate – financing, rates, private vs public action
* In response to demographic factors
  * Migration, Age distribution, income ….
* In response to property rights models – water rights /others
* In response to conservation technologies
* In response to energy policy – renewables, carbon tax, biofuels
* In response to agricultural policy or diet preferences – crop insurance etc

Model Elements

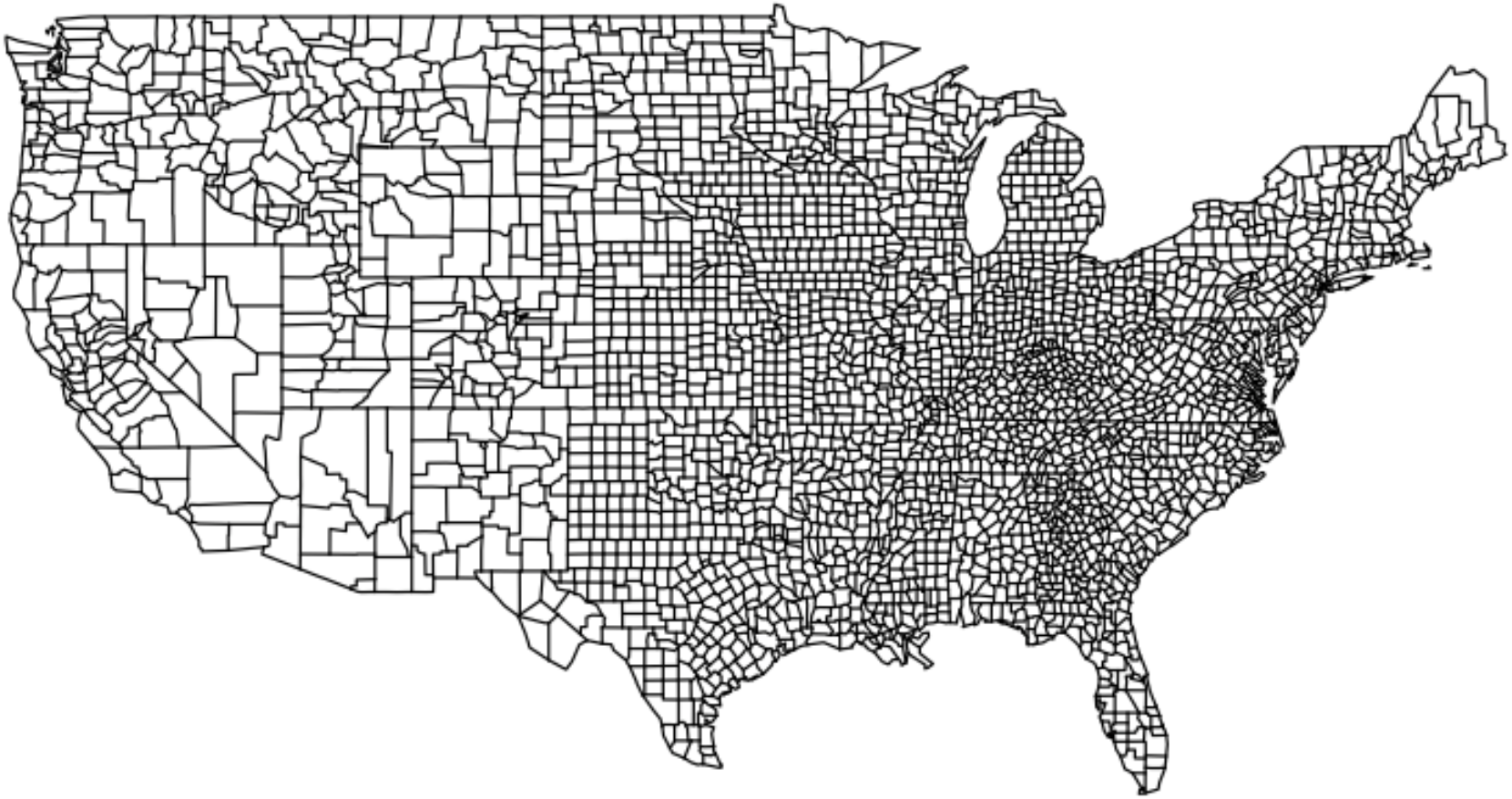
- **Populations**: consume water, electricity, food
- **Power plants**: consume water, biofuels; produce electricity
- **Agriculture**: consume water, energy; produce food, biofuel
- **Water:** consume energy

Design decisions

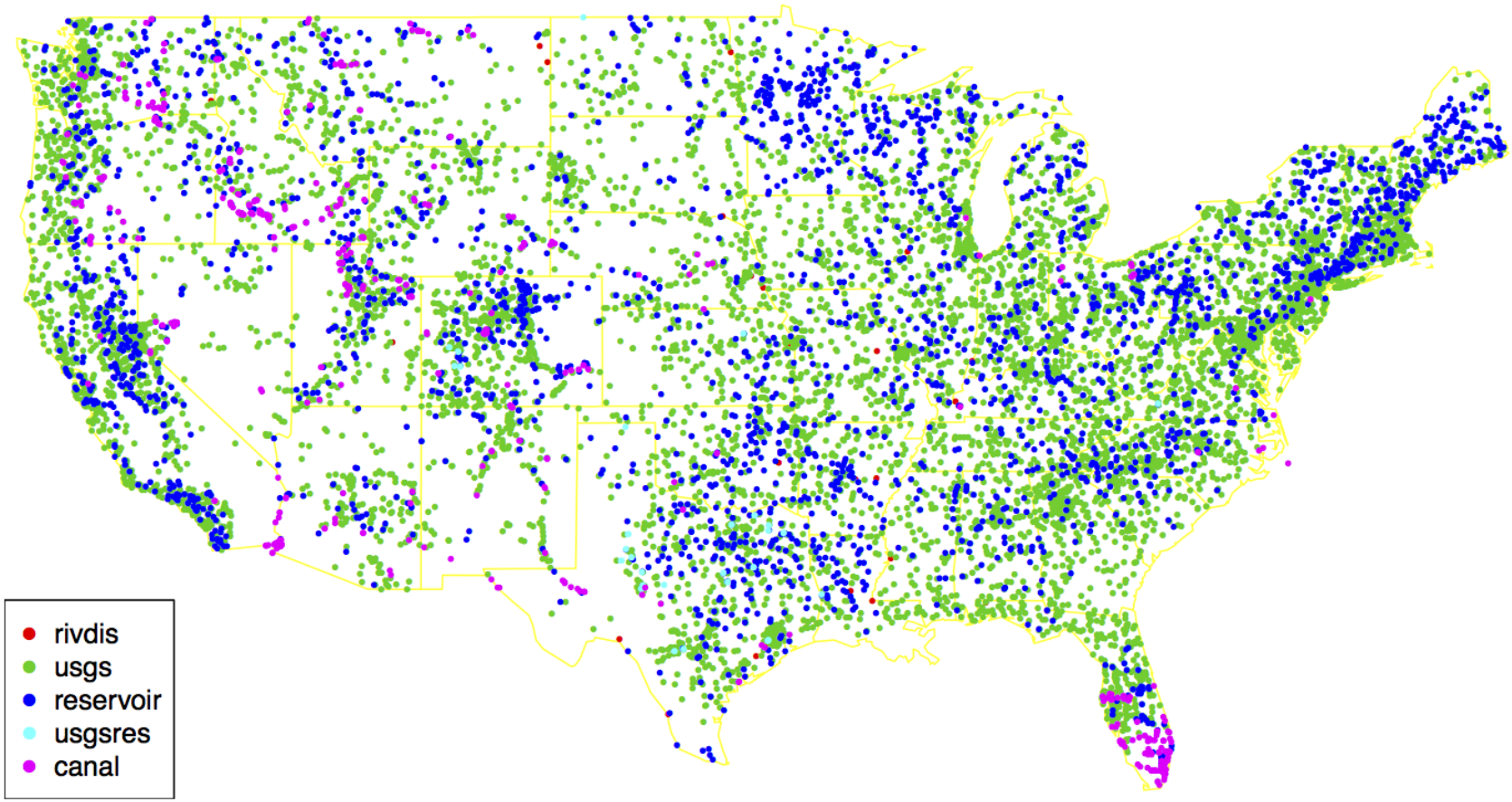
* Modeled at a county-month scale for whole US
* Multiple networks of interactions
  * Counties to neighboring counties
  * Other transport networks (water, electricity)
* Treat arbitrary “resources”: water, energy, products
  * Solve for production, imports and exports, storage, prices
* Interested in spatiotemporal optimization
  * Short-term optimization of production distribution
  * Long-term optimization of capacity expansion
  * Multiple objective functions to consider

Basic model scale

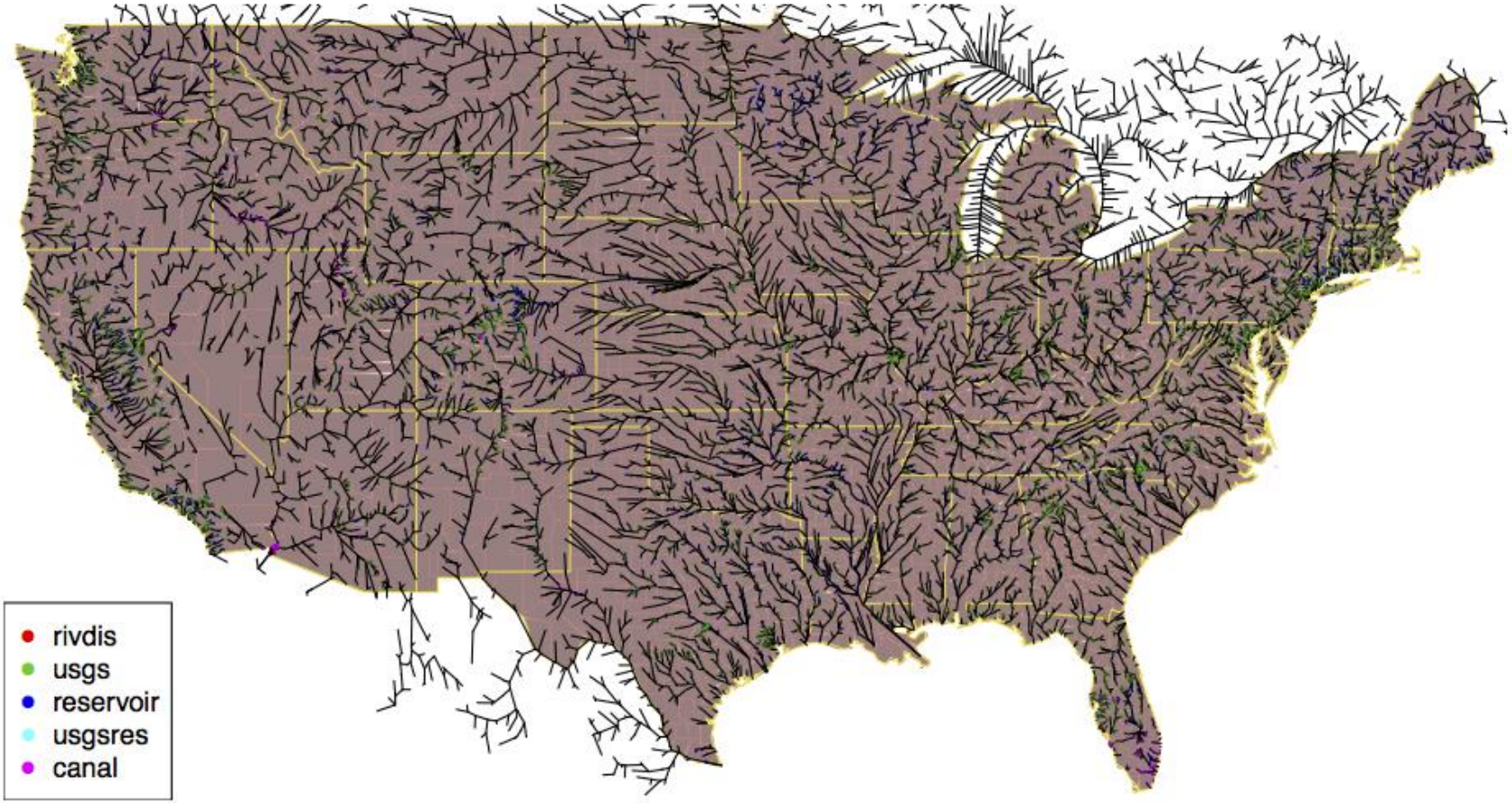
* Monthly, 1949 – 2009, and climate futures



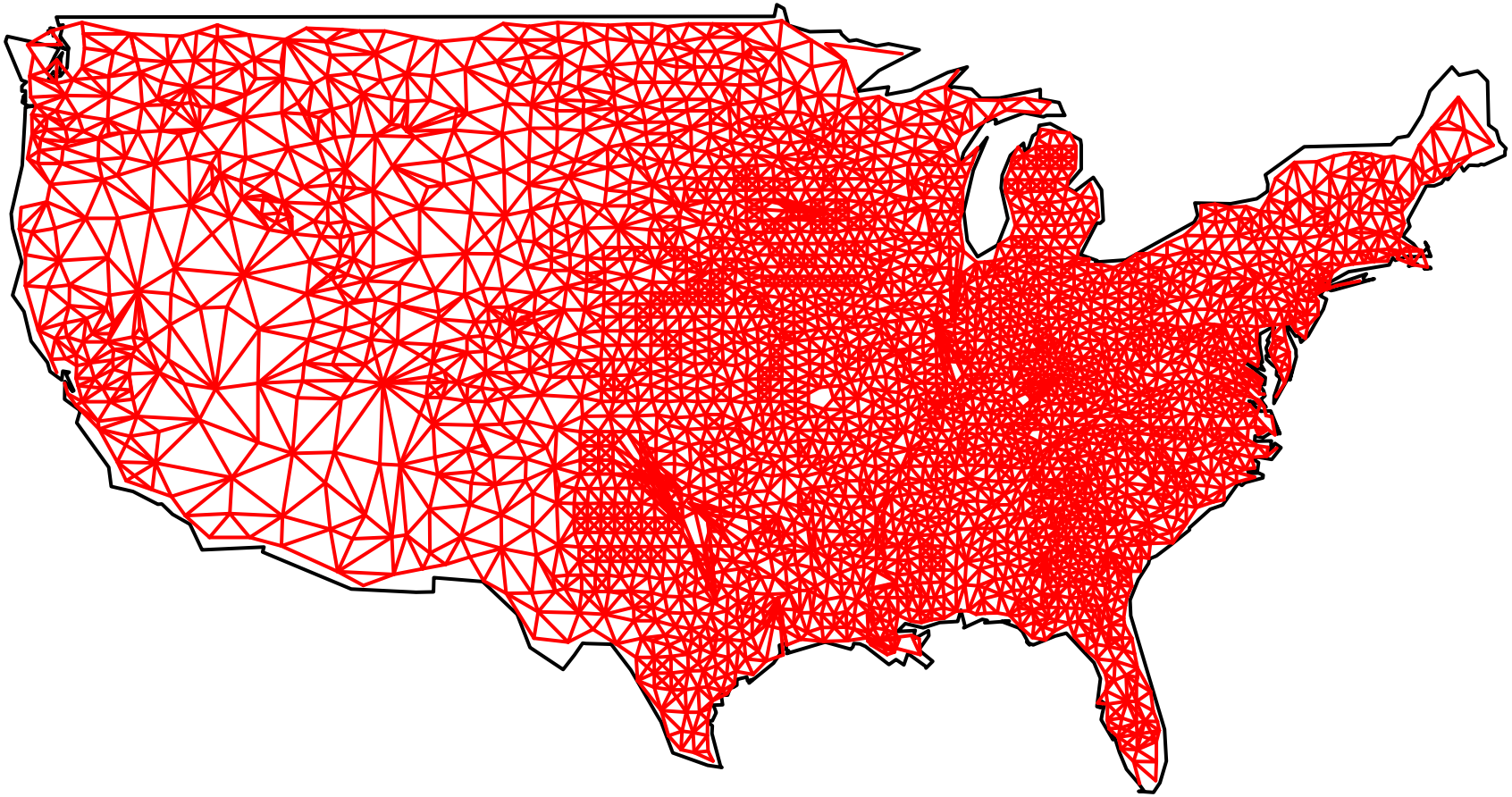
Flow Gauges, Reservoirs, Cross-border canals



County River Network

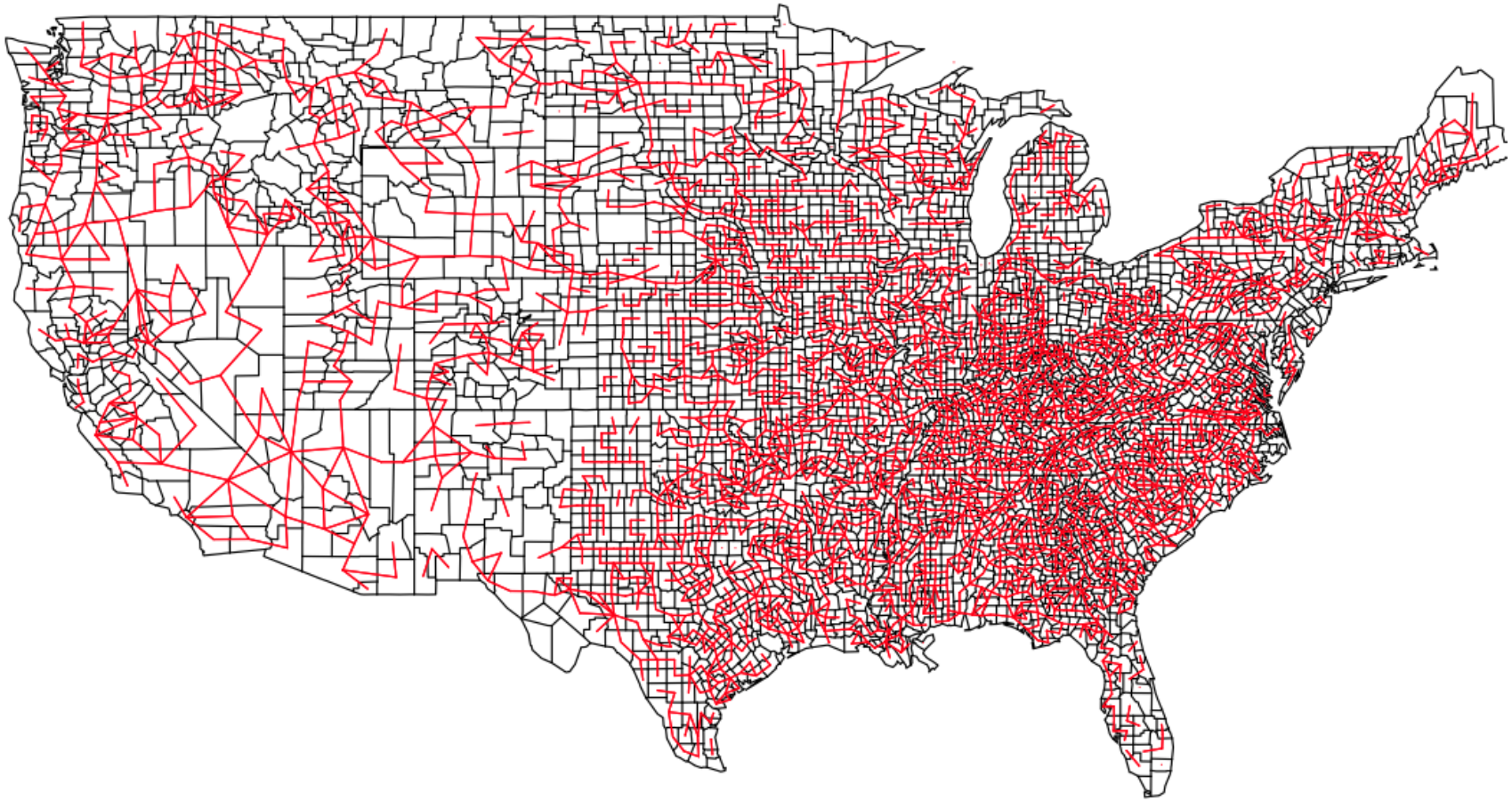


County Transportation Network

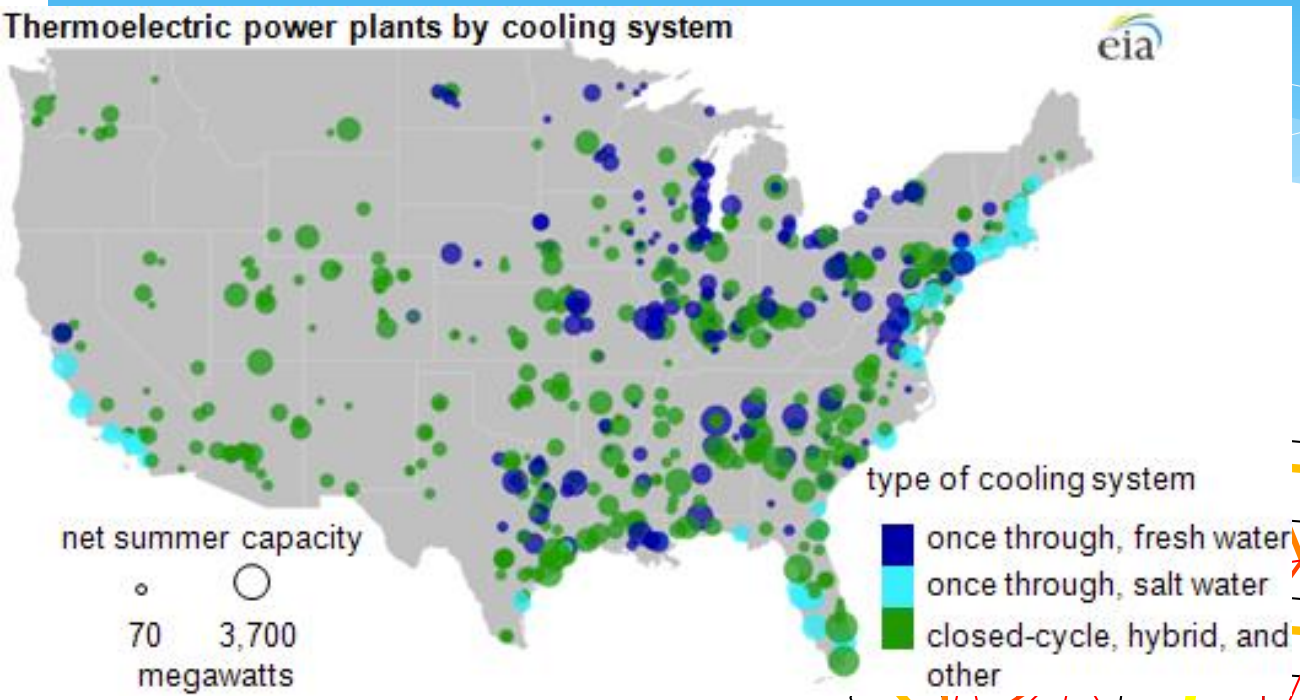


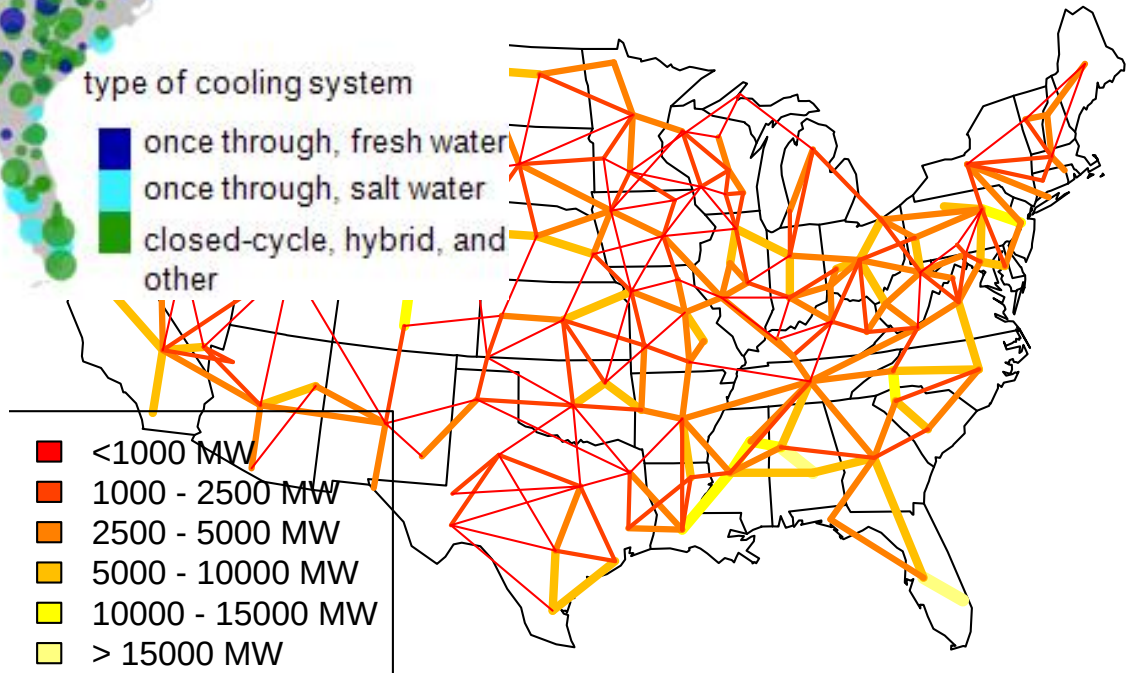
Electricity Grid

* County-level representation of TIGER high-voltage lines

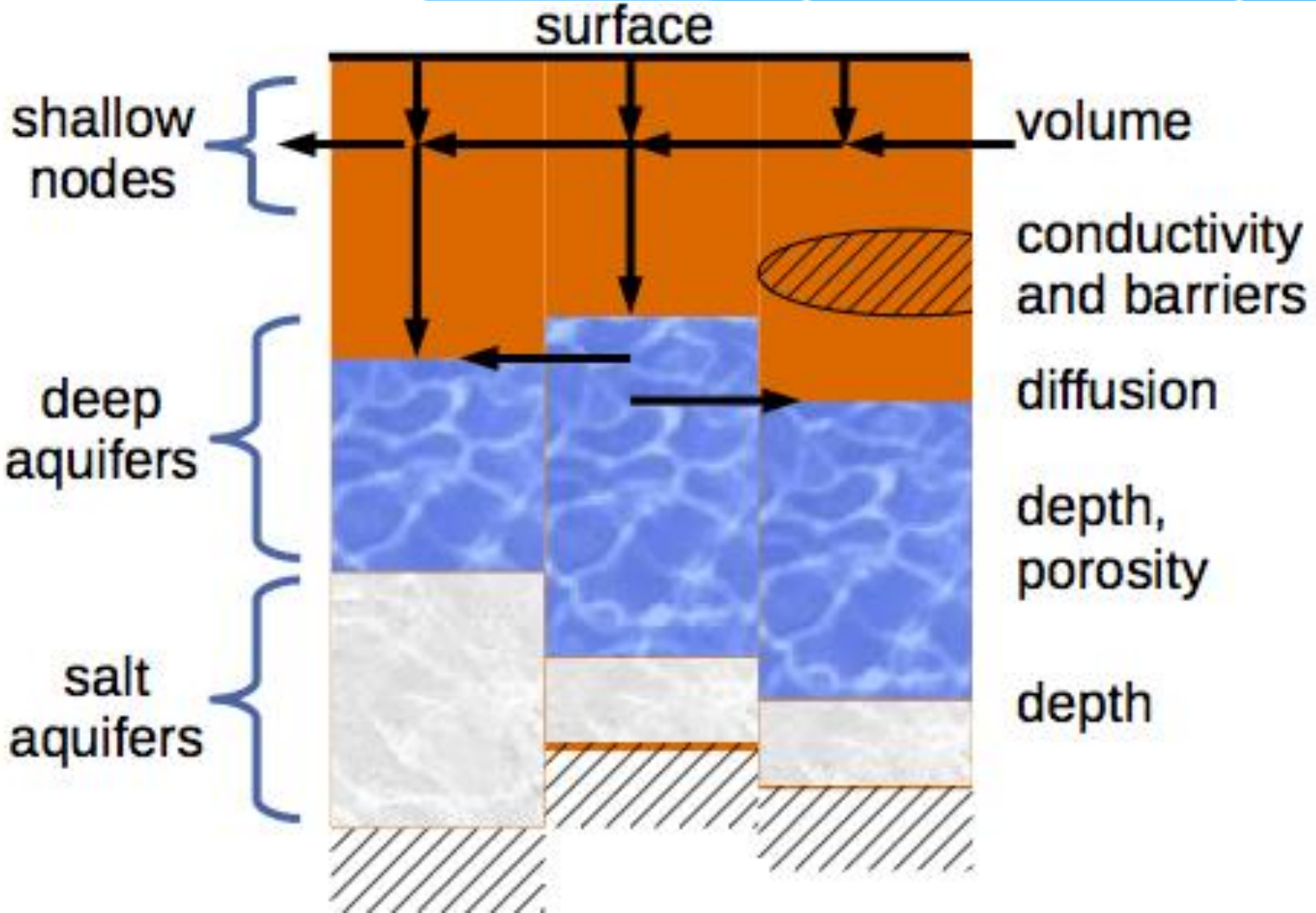


Electricity Grid





Groundwater Network



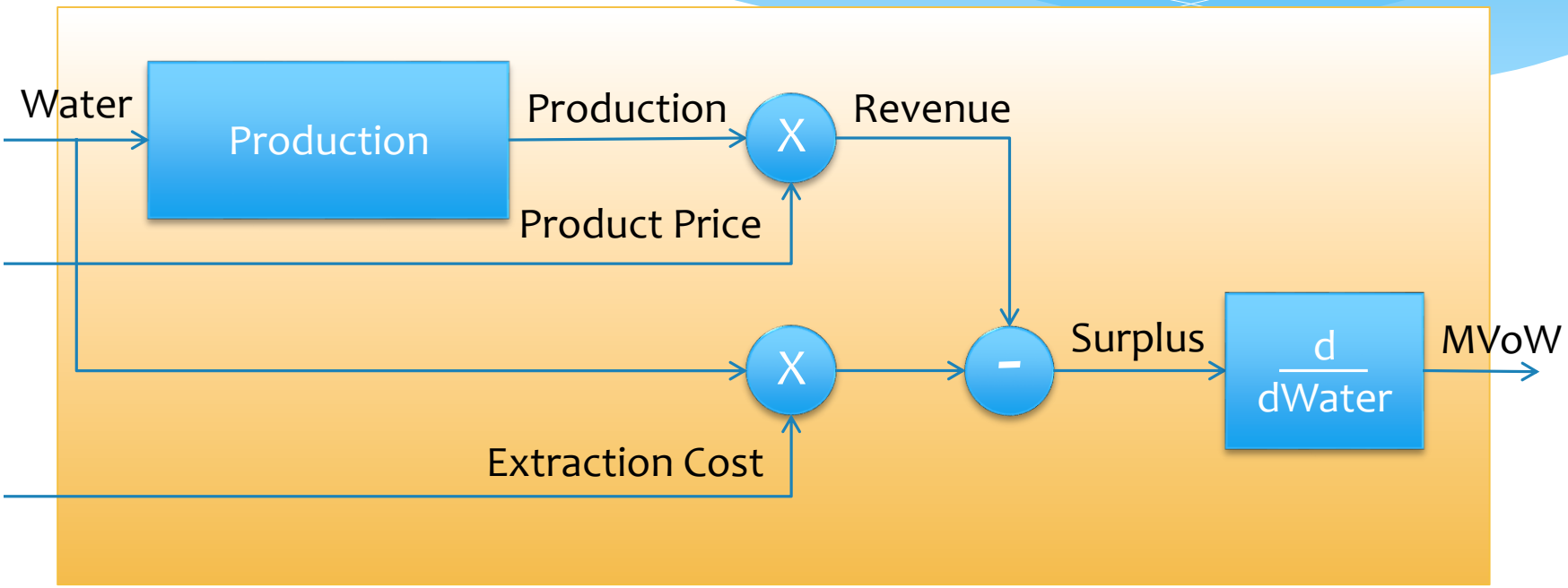
Implementing environmental flows

* Unmodified monthly flows from VIC
* Recommendations follow flow-duration curve

Medium tributaries	<15% change to monthly Q_{50}, to upper season range monthly Q_{30} to Q_{50}, and to lower seasonal range monthly Q_{50} to Q_{70} (summer-fall) or monthly Q_{50} to Q_{75} (winter-spring)
Large rivers	**<20% change** to seasonal flow range Q10-Q50; **<15% change** to monthly median; <15% change to Q50-Q75
Headwaters and Creeks	No change to low flow range monthly Q_{50} to Q_{99} (summer-fall) or monthly Q_{70} to Q_{99} (winter-spring)
Small rivers and Medium tributaries	No change to low flow range monthly Q_{70} to Q_{99} (summer-fall) or monthly Q_{80} to Q_{99} (winter-spring)

An stylized model element

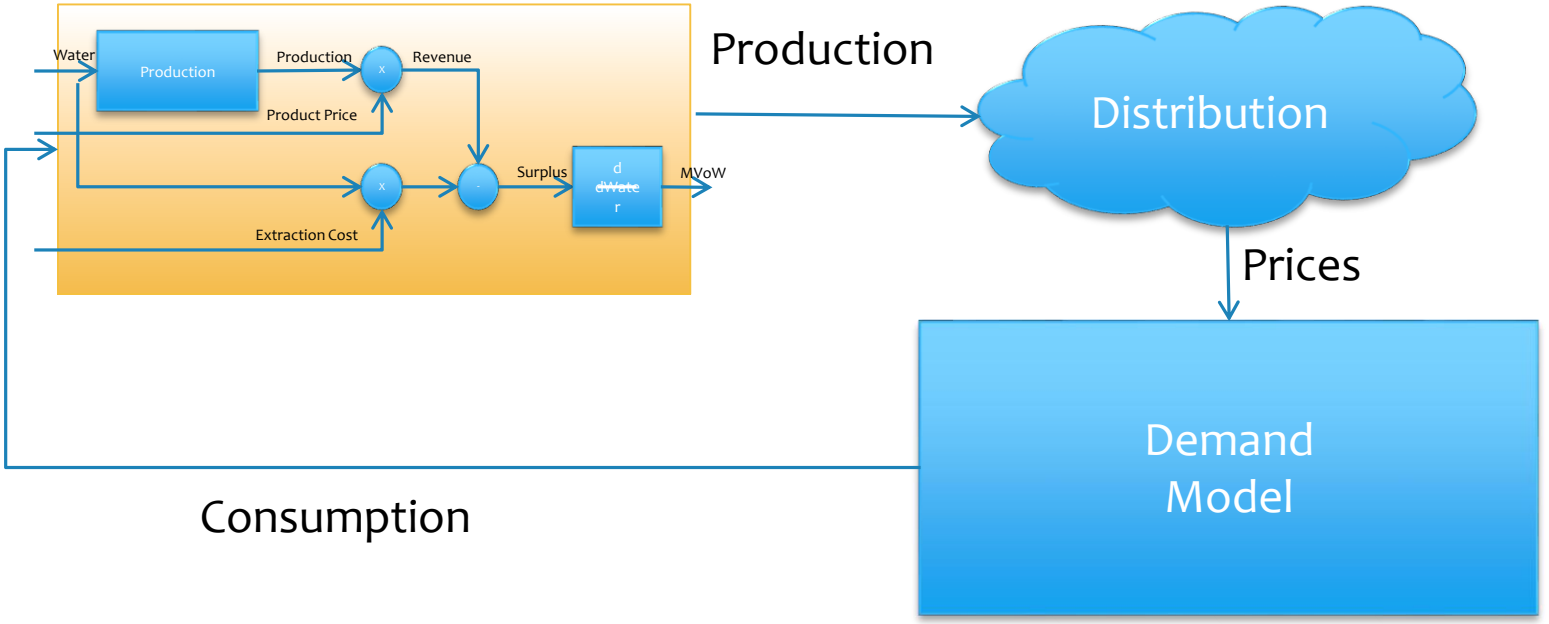
* A value-of-water optimization



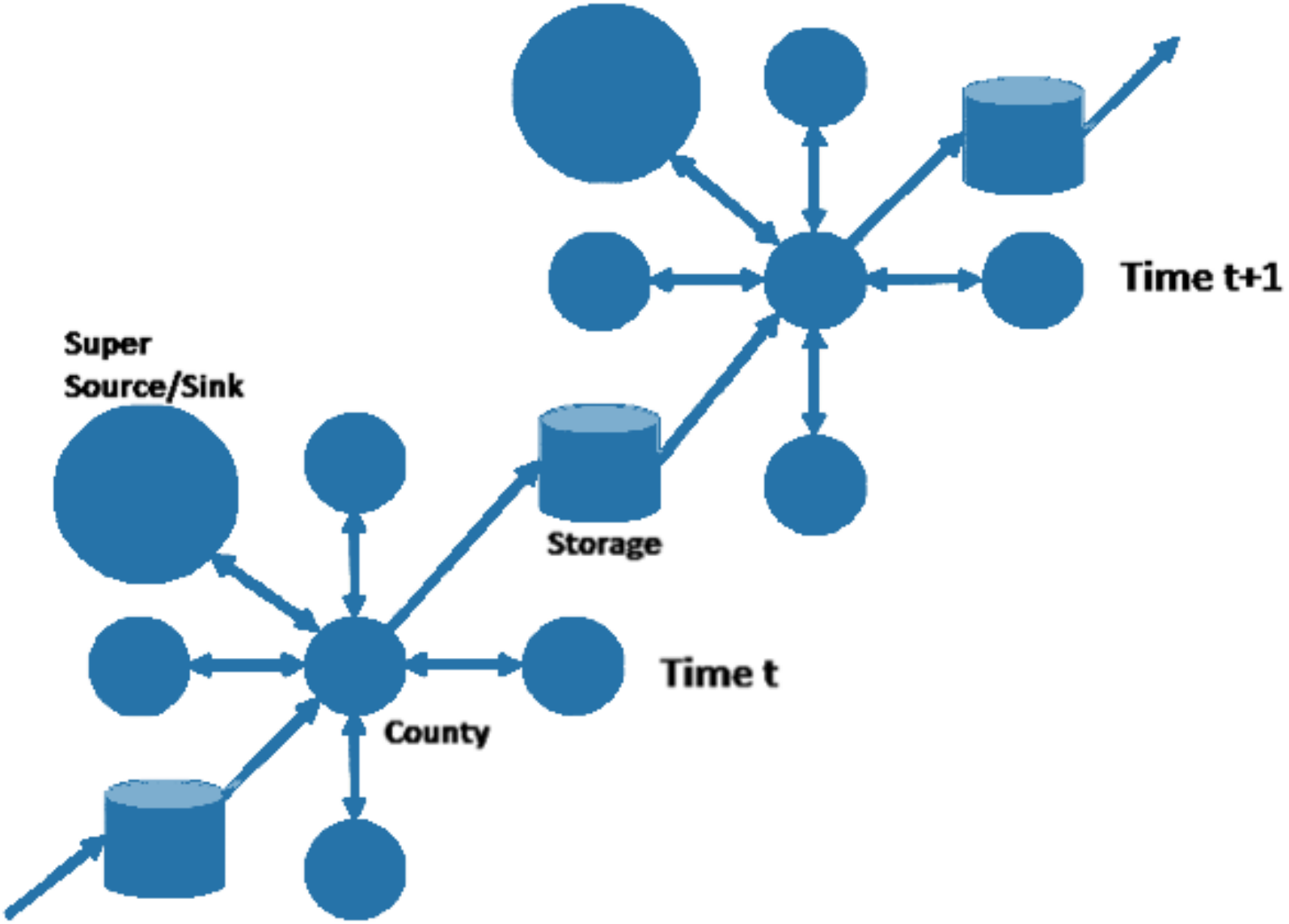
* Maximize total producer profits, assuming fixed prices and costs, realistic water supply, and an omnipresent market.

Adding distribution and demand

* Determine the best locations for production and consumption, given demand.



Model Space and Time



An integrated modeling framework

* Component-based framework (Mimi in Julia)
  * Inputs from outside the model:
  * Inputs from other components:
  * Inputs from optimization:

* Able to validate components individually and swap them out and have multiple variants.
  * Existing Mimi components for climate, biodiversity, disease, conflict, natural disasters
* Linear programming optimization (Gurobi)
  * Automatic construction of LP matrices

Examples of AWASH in action

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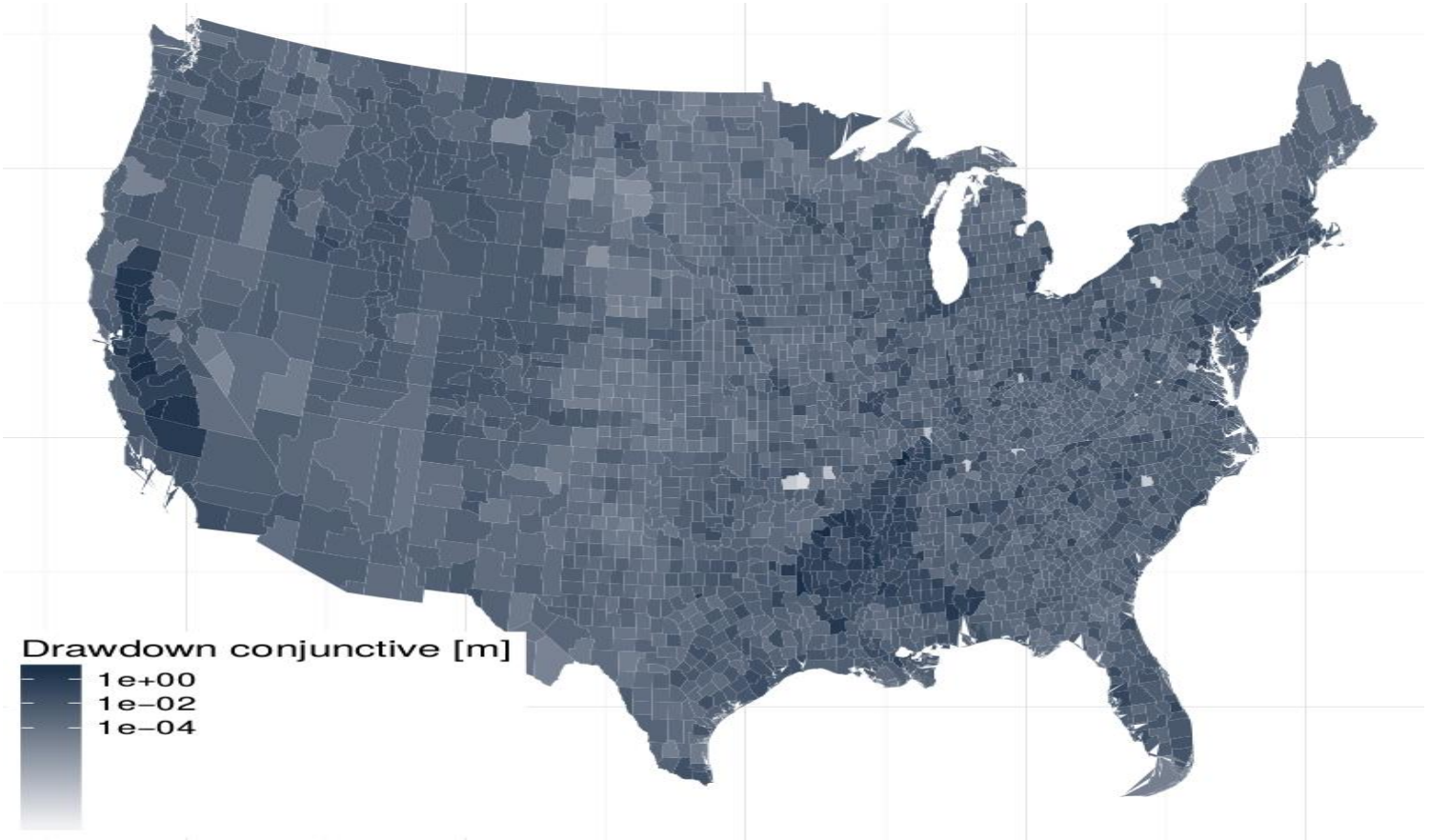
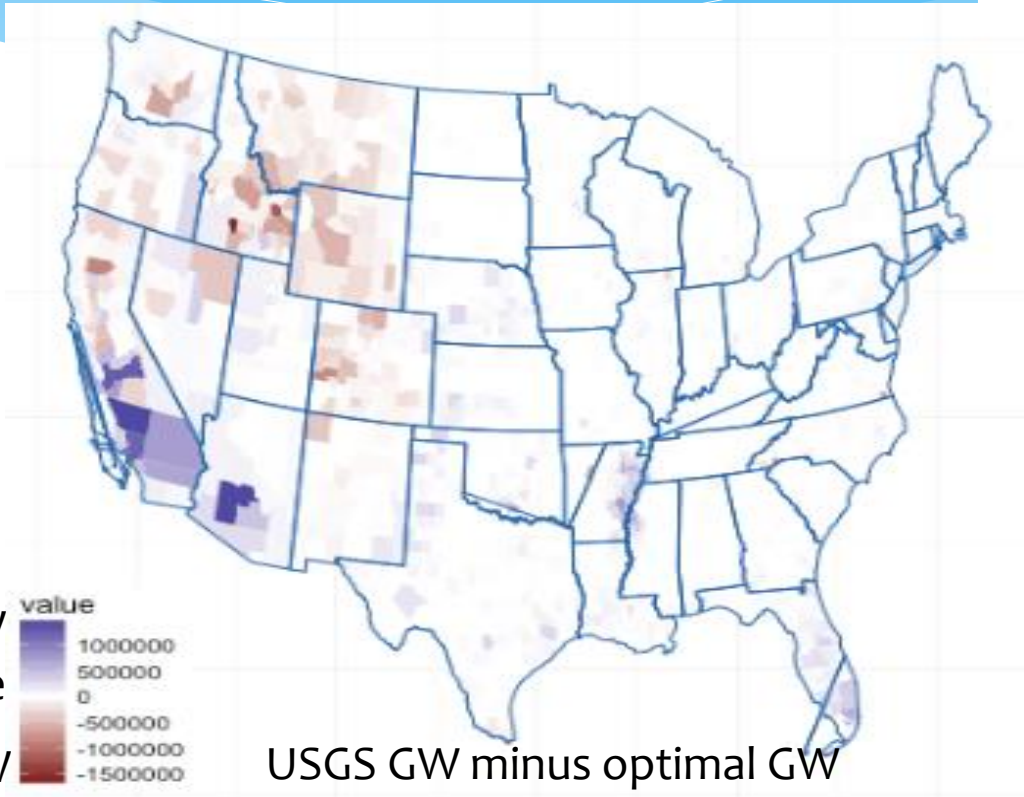
Current drawdown

* Accounting for surface water and reservoirs



Effects of optimization

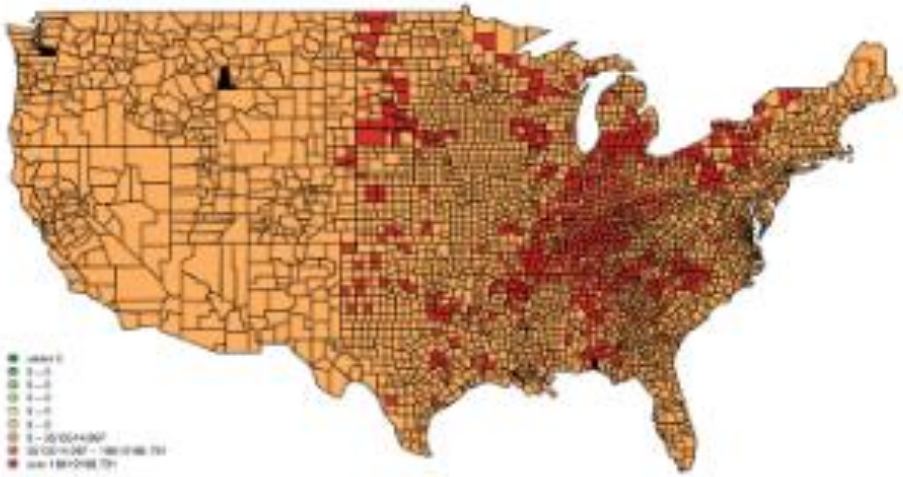
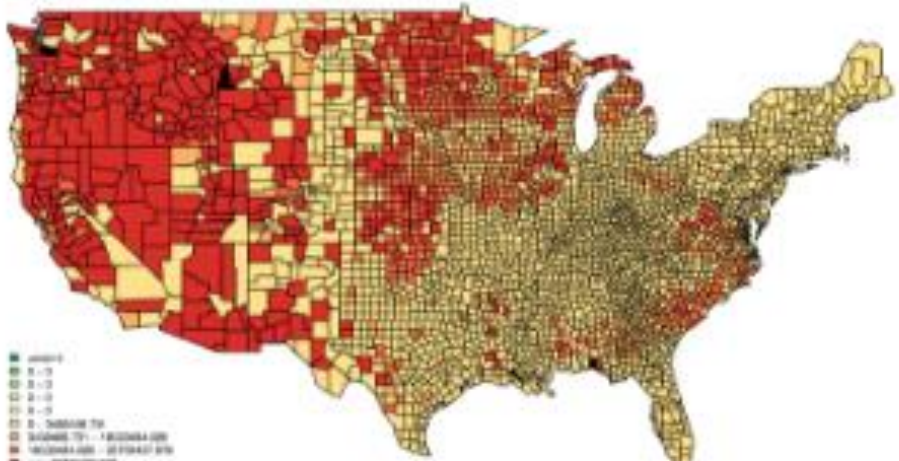
- Hold all water demands constant
- Minimize costs to satisfy demands over
  - Where to withdrawal from surface
  - Where to withdrawal from groundwater
  - When to release from reservoirs



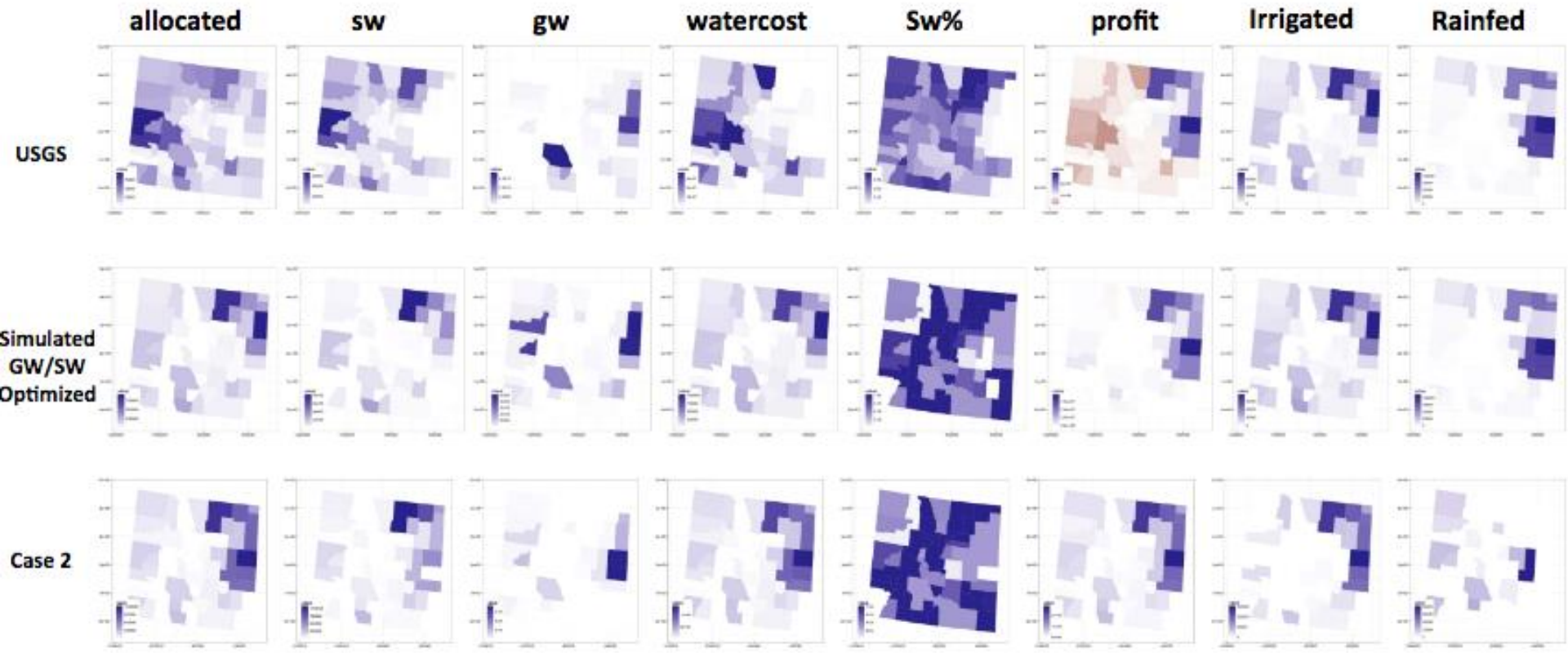
USGS GW minus optimal GW

	source	Nation2State	State2County
1	Surface	-0.0003828237112907648	-0.0256423807578361
2	Ground	0.0029084220380203763	0.0865761242404009

Allocation of agriculture

International Sales	Irrigated areas
Soybeans: 	Soybeans: 
Wheat: 	Wheat: 

Colorado Case Study



Getting involved

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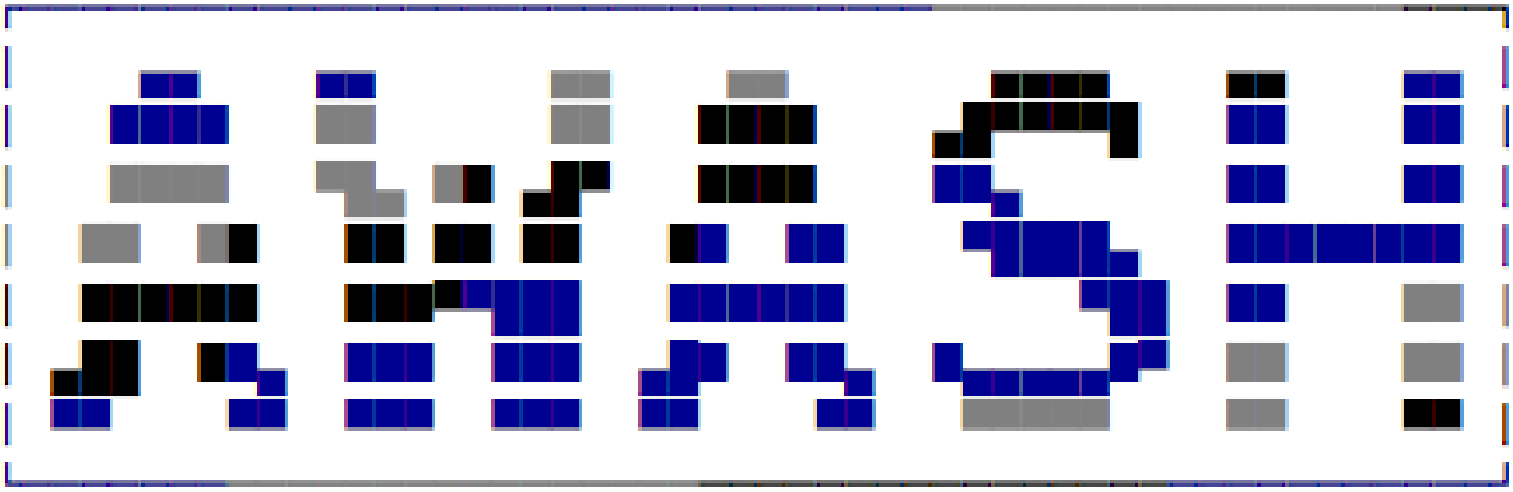
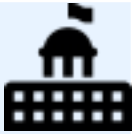
Our user interface

```
include("../src/nui.jl")
```



```
Welcome to AWASH, the America's Water Model, version 0.7.
```

Documentation!

Components	Tutorials
Agriculture 	Simulation 
Groundwater 	SW optimization 
Allocation 	Network data 
WaterNetwork 	Unmodified flows 
ReturnFlows 	Installation 
Reservoir 	Contributing 

We need help!

* Website
* Electricity Grid
* Brewery
* Automatic LP checking
* Cross-state compacts
* Biofuels
* Environmental flows