mizuRoute

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Outline

- Background
  - CTSM hydrology
  - CTSM water and land management
- Recent progress
  - Network routing over the CONUS
  - Network routing for the planet
  - Lakes/reservoirs
- Next steps

CTSM hydrology

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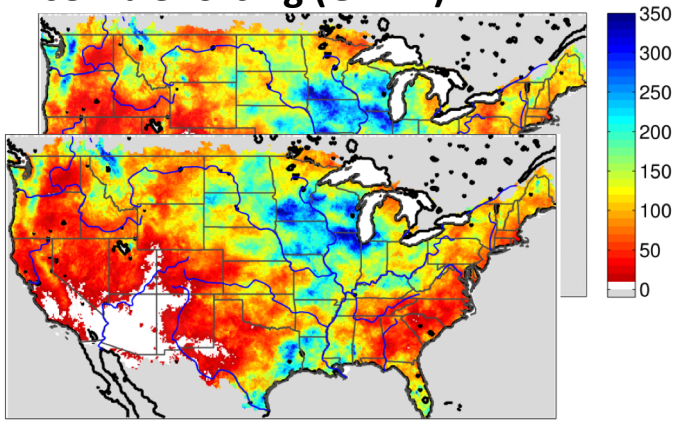
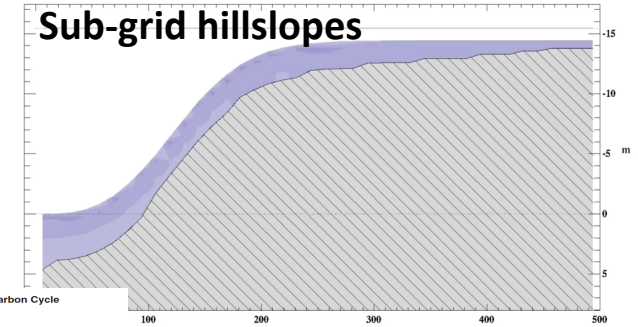
Ensemble forcing (GMET)



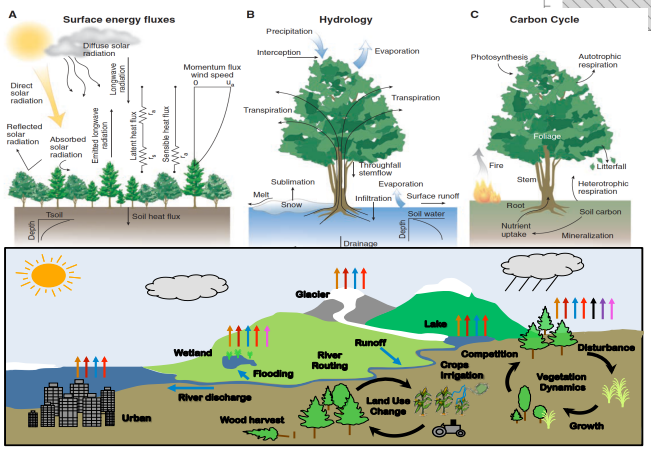
Clark and Slater, 2006; Newman et al., 2015

Sub-grid hillslopes

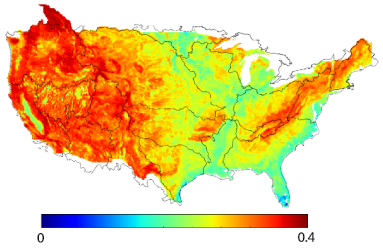


Swenson et al., in prep

CTSM

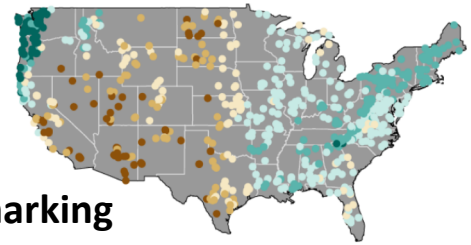


Large-domain parameter estimation



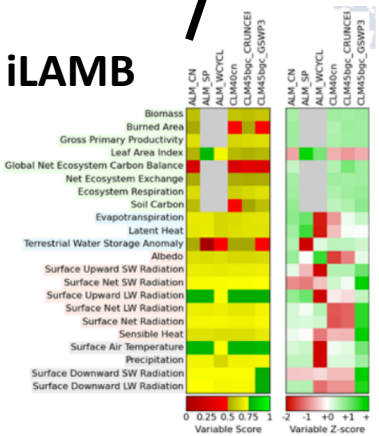
Mizukami et al., 2017

Model benchmarking



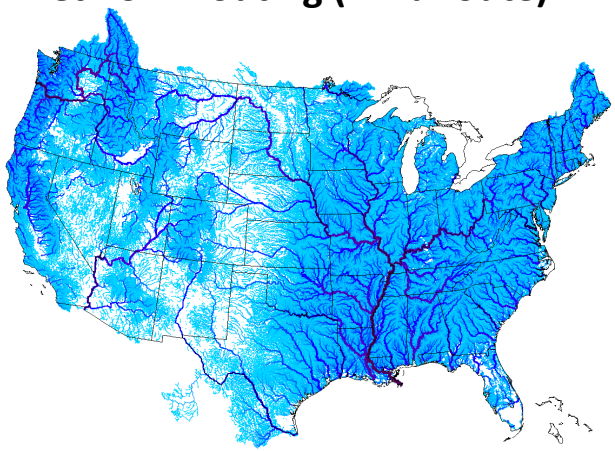
Addor et al., 2017; Newman et al., 2017

iLAMB



Hoffman et al., 2017

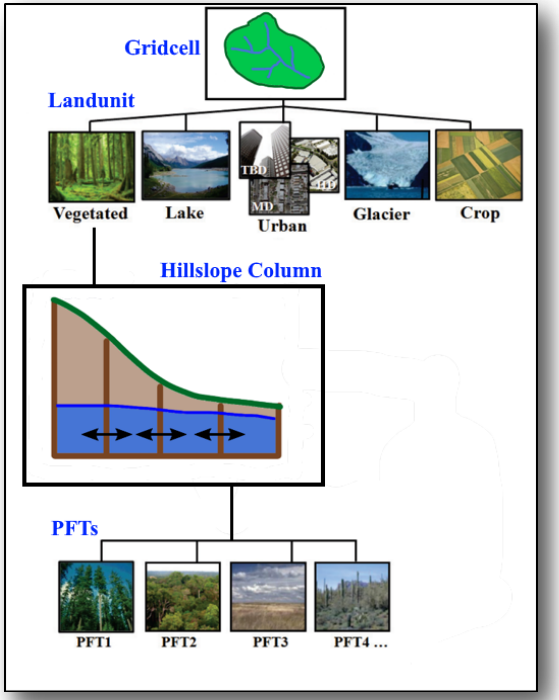
Network Routing (mizuRoute)



Clark et al., 2008; Mizukami et al., 2016

CTSM development

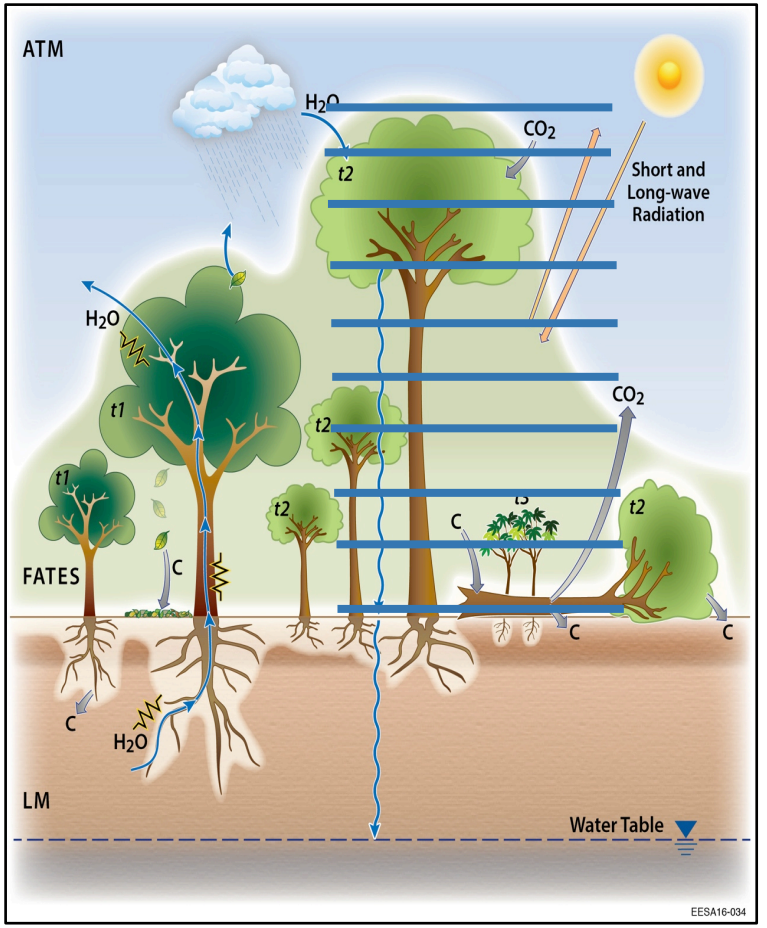
- Ecosystem vulnerability and impacts on carbon cycle and ecosystem services
- Sources of predictability from land processes
- Impacts of land use and land-use change on climate, carbon, water, and extremes
- Water and food security in context of climate change, climate variability, and extreme weather



Lateral fluxes of water

Water and land management

Ecosystem Demography / Multi-layer canopy



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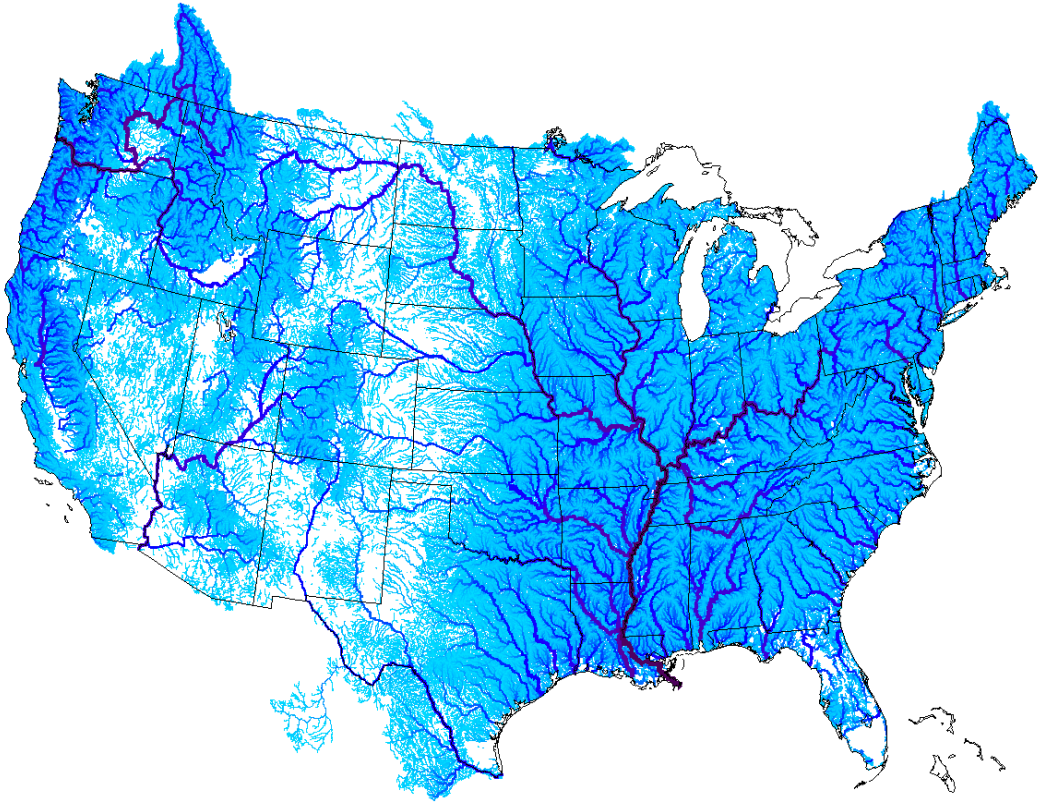
Digital river networks (NHD+)

SUMMA/mizuRoute simulations of mean annual runoff for the NHD++ network



- mizuRoute configured for the NHD++ network (~2.7M streams)
- Major overhaul of mizuRoute to navigate the NHD++ network and generate information on reach characteristics to support multiple routing models
- Implemented a topological numbering scheme (Pfafstetter coding system) to
  - Simplify filtering of the river network
  - Enable efficient network-based domain decomposition procedures
  - Enable hydrologic prediction across scales

Problems: Heterogeneous network; broken links
Advantages: Widespread community use; efforts to improve the network

The Pfafstetter coding system

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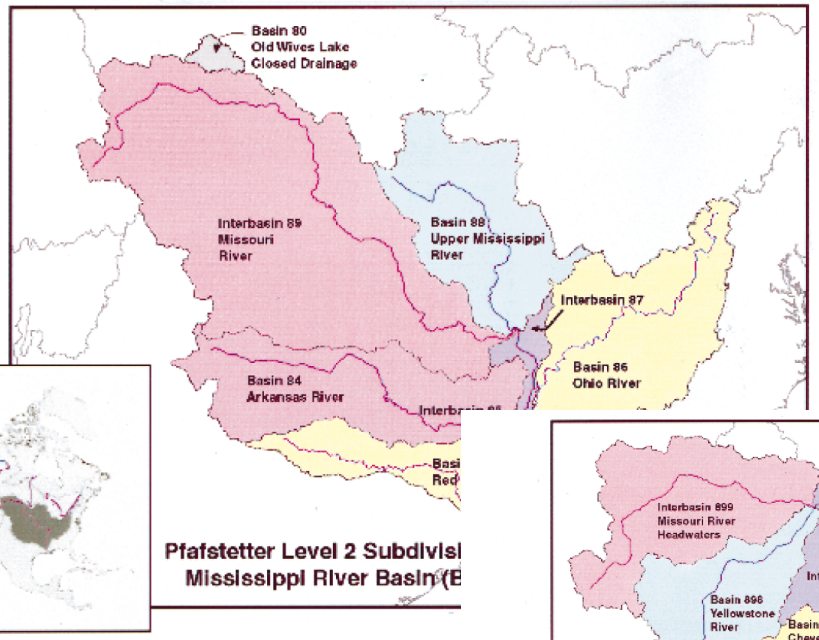

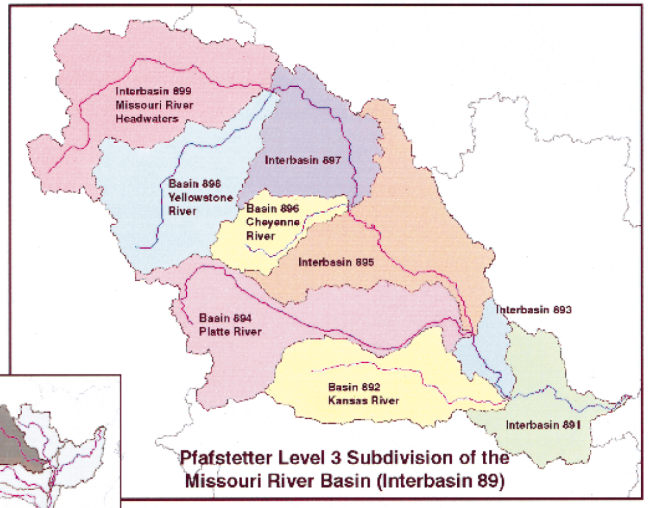

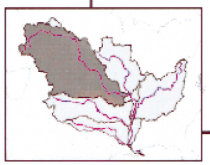

Verdin and Verdin, Journal of Hydrology, 1999

The Pfafstetter coding system (NHD+)

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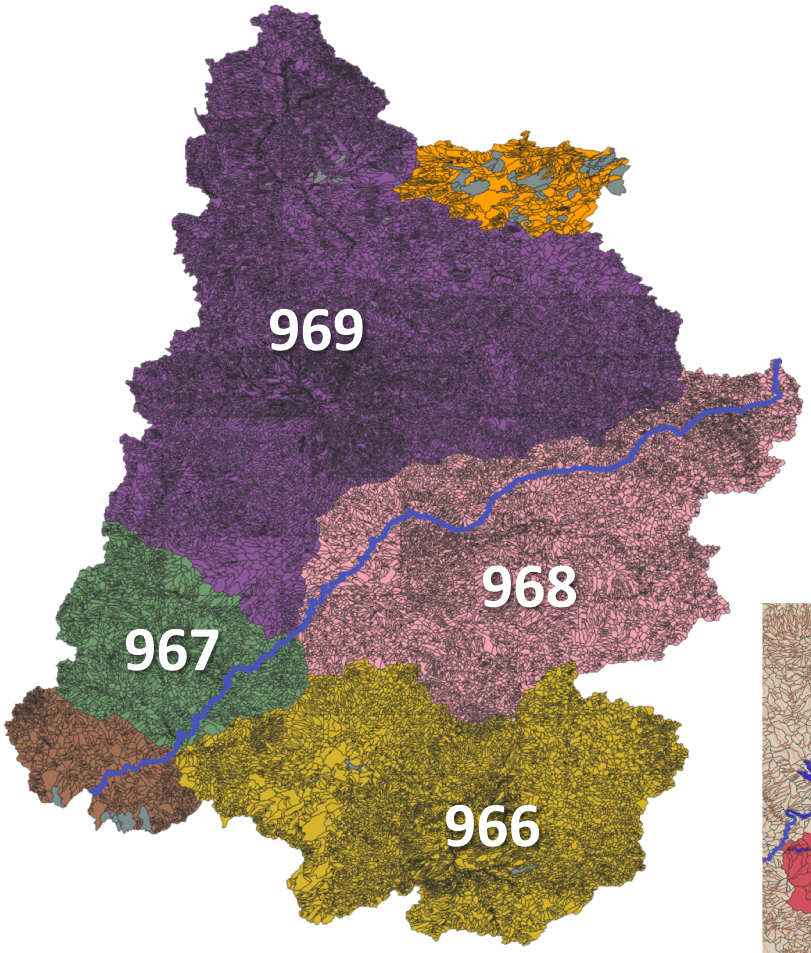
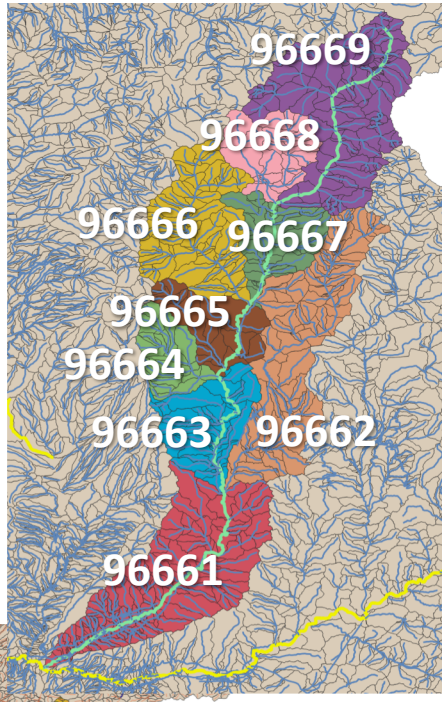
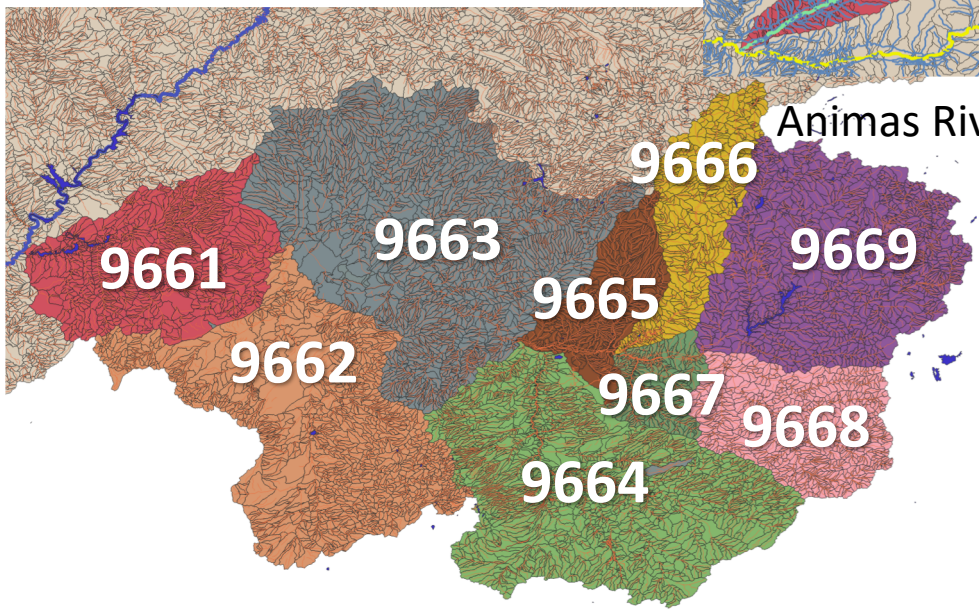


Colorado River above Lees Ferry



Animas River

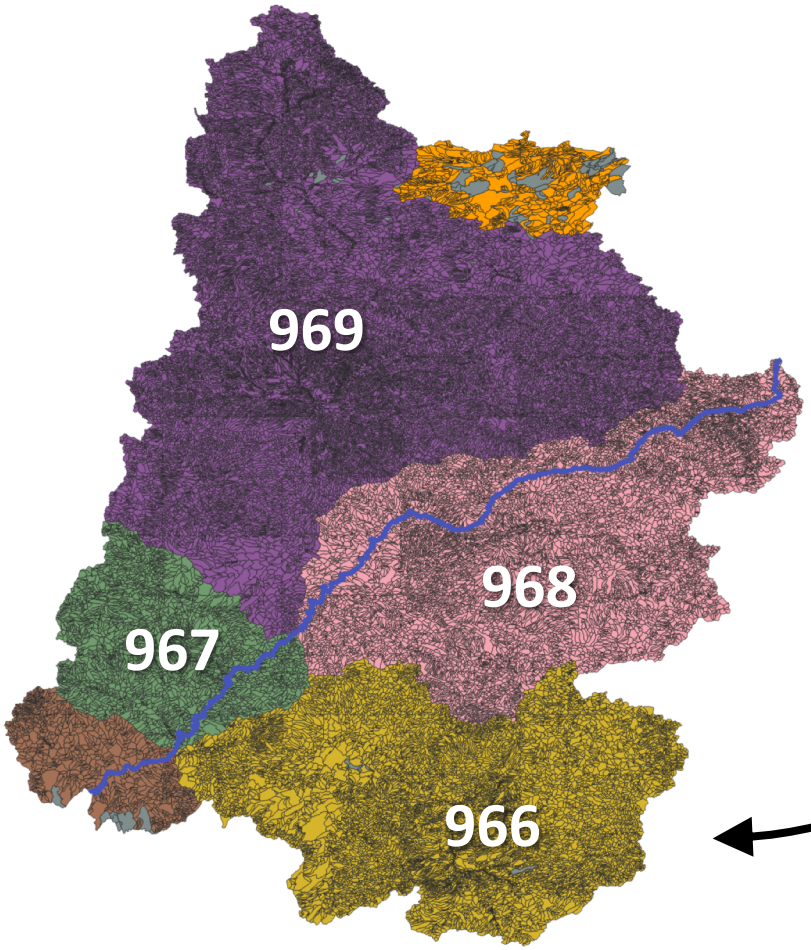


San Juan River

Pfafstetter applications

- Subsetting
- Parallelization
- Aggregation

Application 1: Subsetting



Colorado River above Lees Ferry

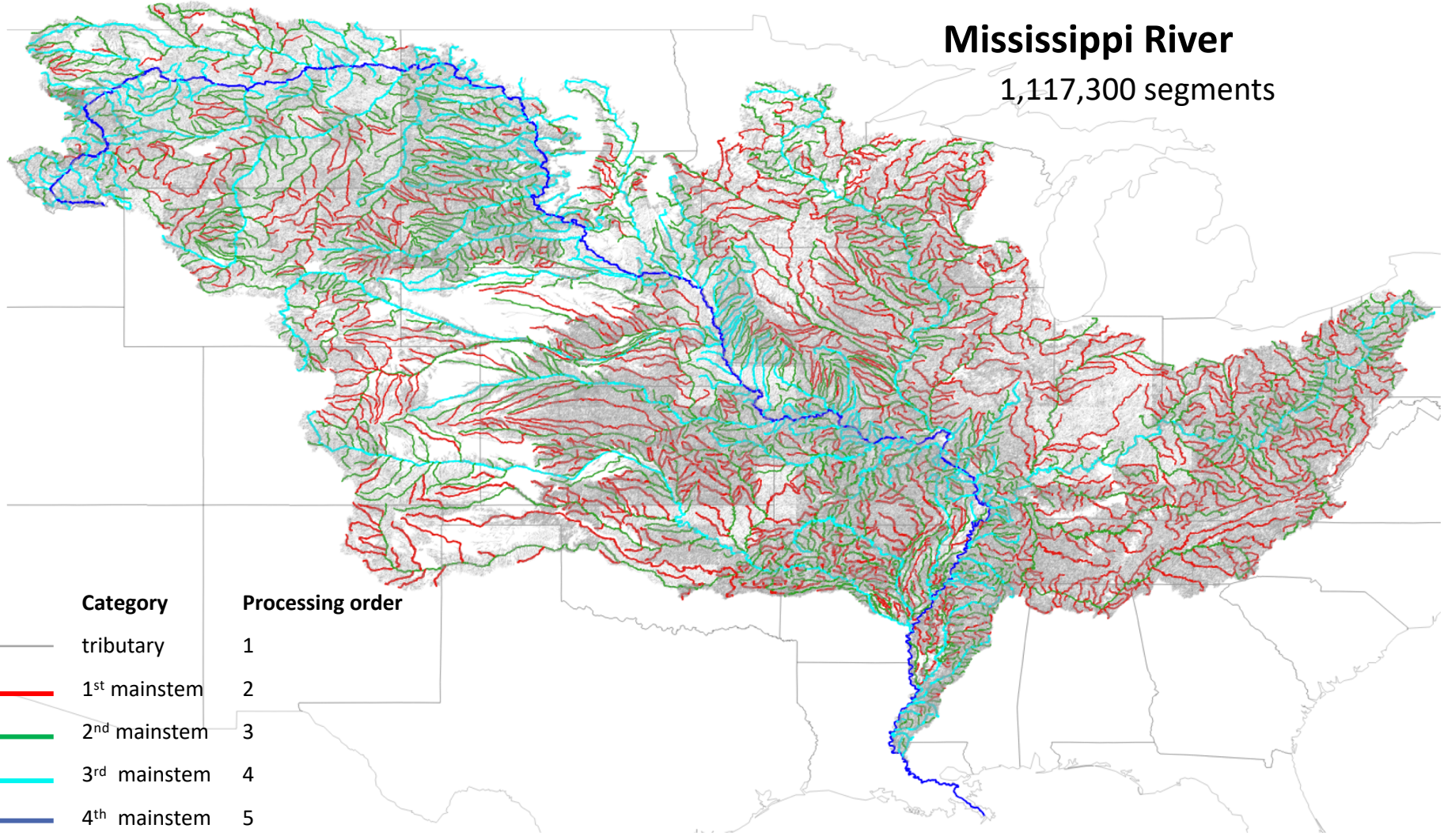
All basins starting with '96' are in the Colorado River basin

The San Juan River includes all reaches starting with '966'

Application 2: Parallelization

Pfafstetter numbering system helps classify stream segments into "mainstem" and "tributary" that can be processed independently

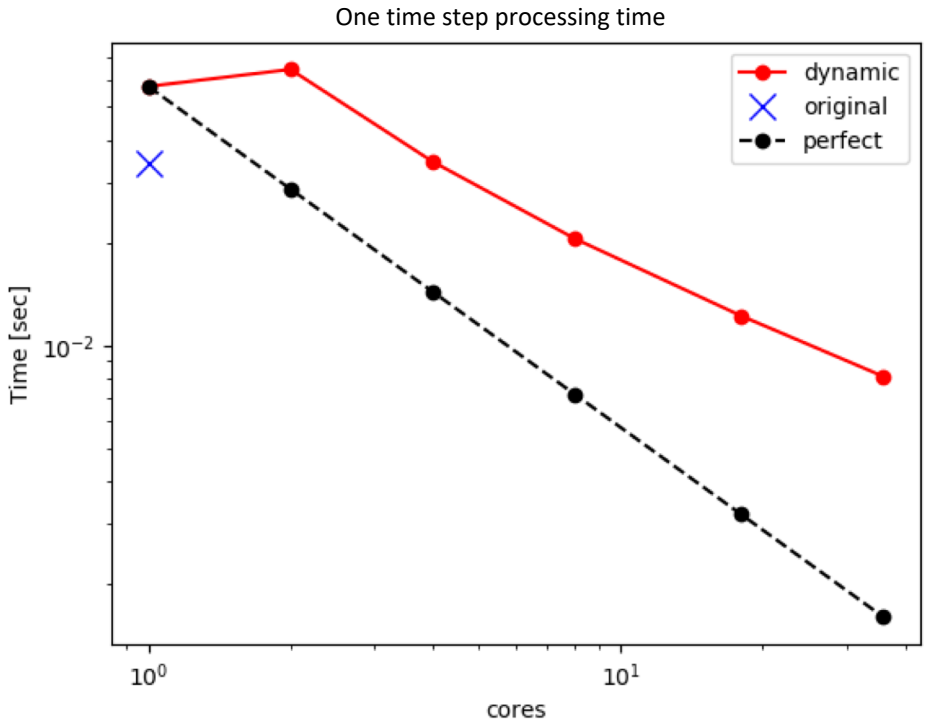
Parallel processing with OpenMP or/and MPI



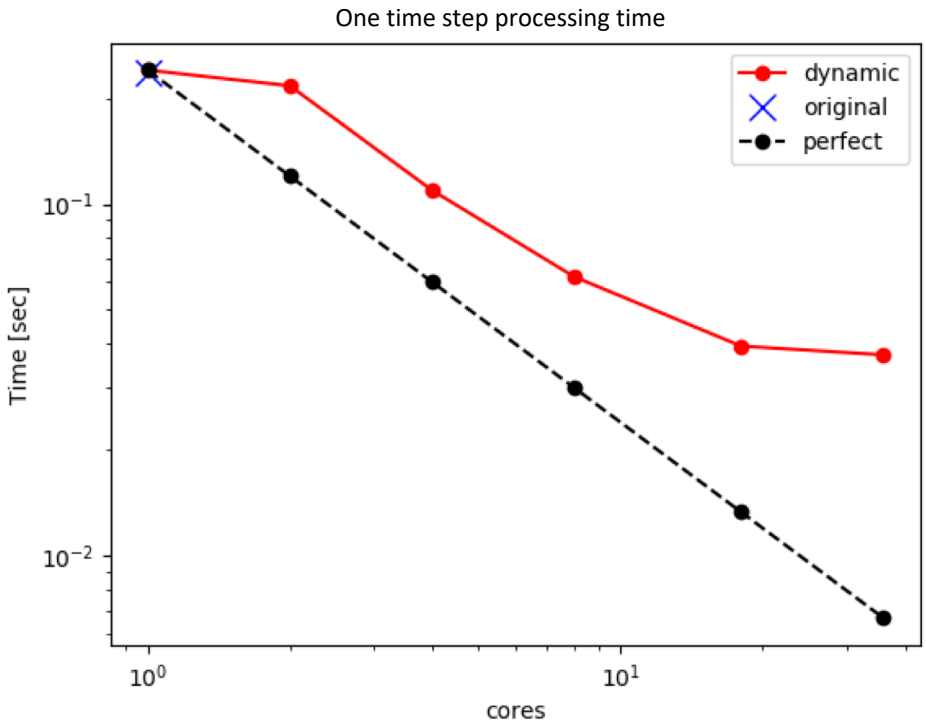
Application 2: Parallelization

OpenMP Scaling

Unit hydrograph routing



Kinematic wave routing

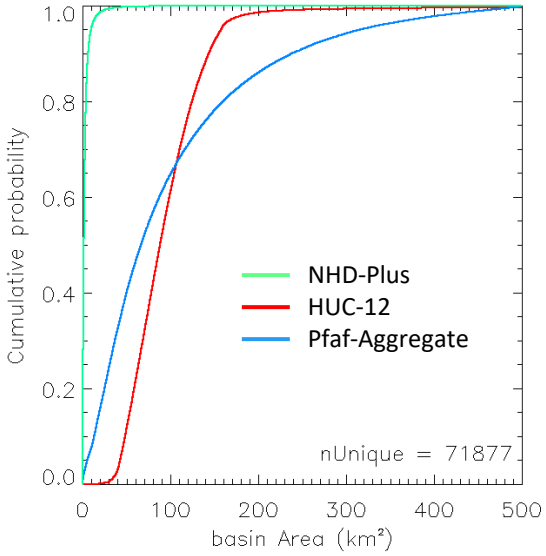


Application 3: Aggregation

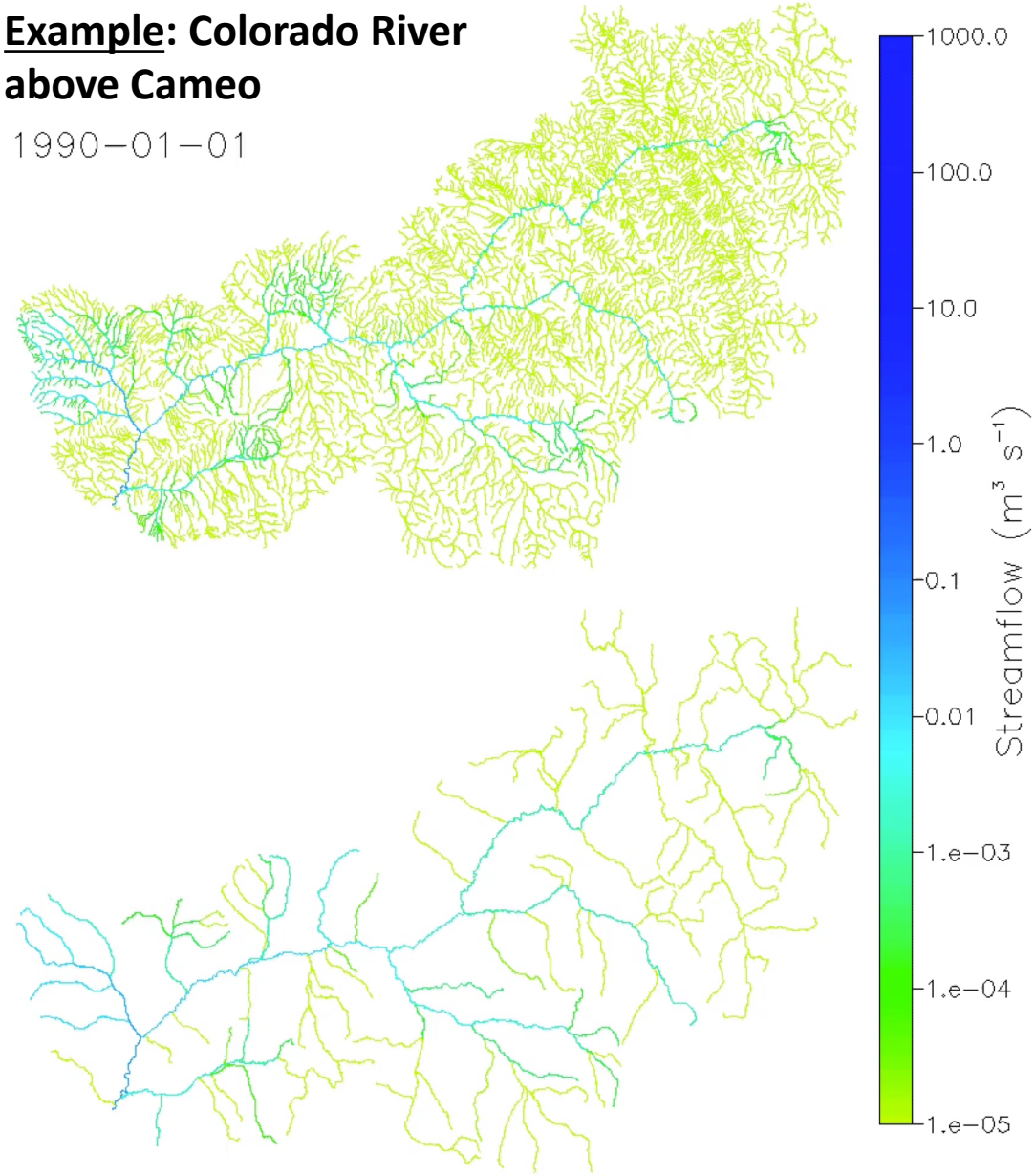
Can aggregate basins at a given Pfafstetter level, and route using the same underlying network

- *Aggregation is basin-specific, so have greater resolution in specific areas (adaptive in time, e.g., as a storm passes through)*
- *Supports "computationally frugal" model instantiations (for ensemble forecasting, parameter estimation trials, etc.)*

CONUS-wide aggregation



Example: Colorado River above Cameo



Application 3: Aggregation

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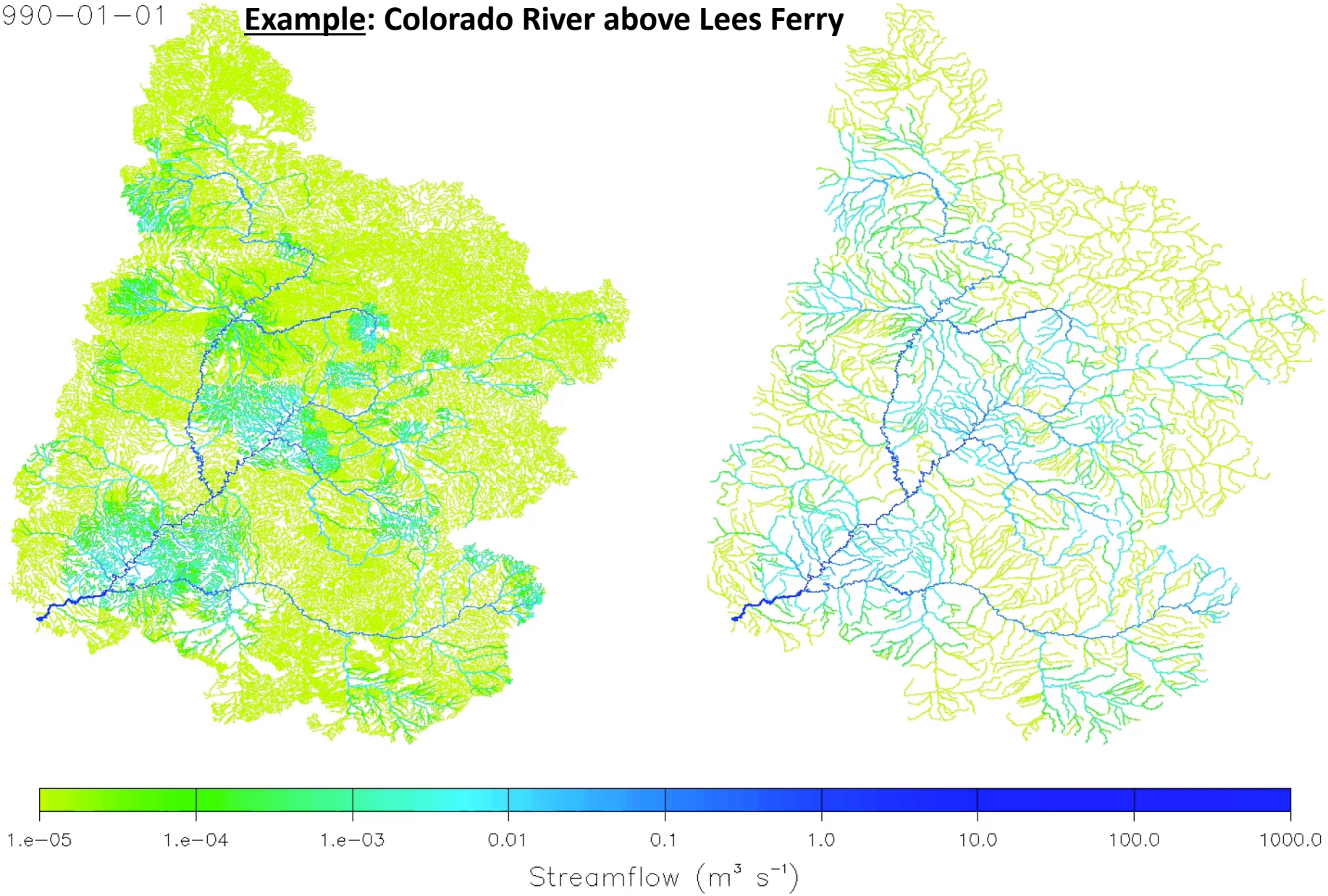
Example: Colorado River above Lees Ferry



Continental-domain routing

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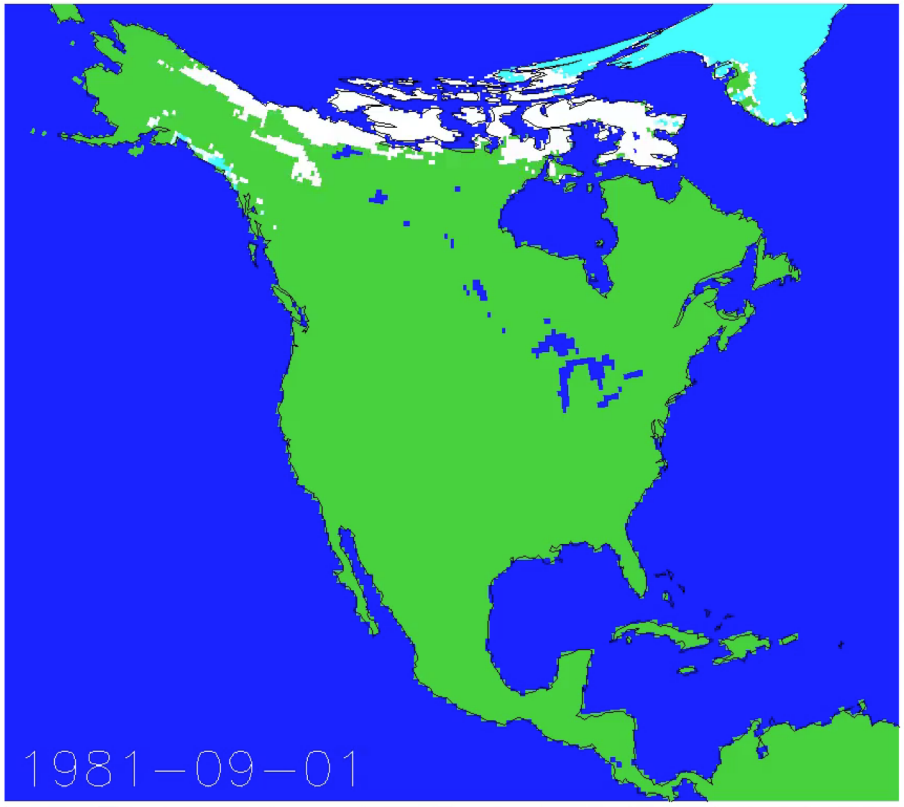
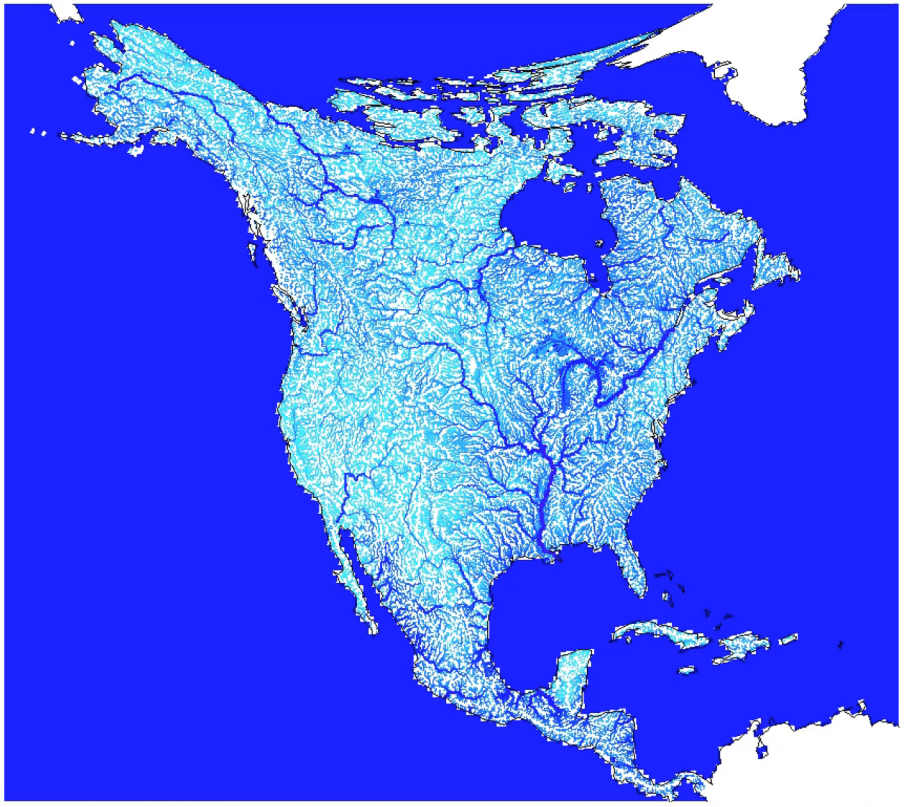
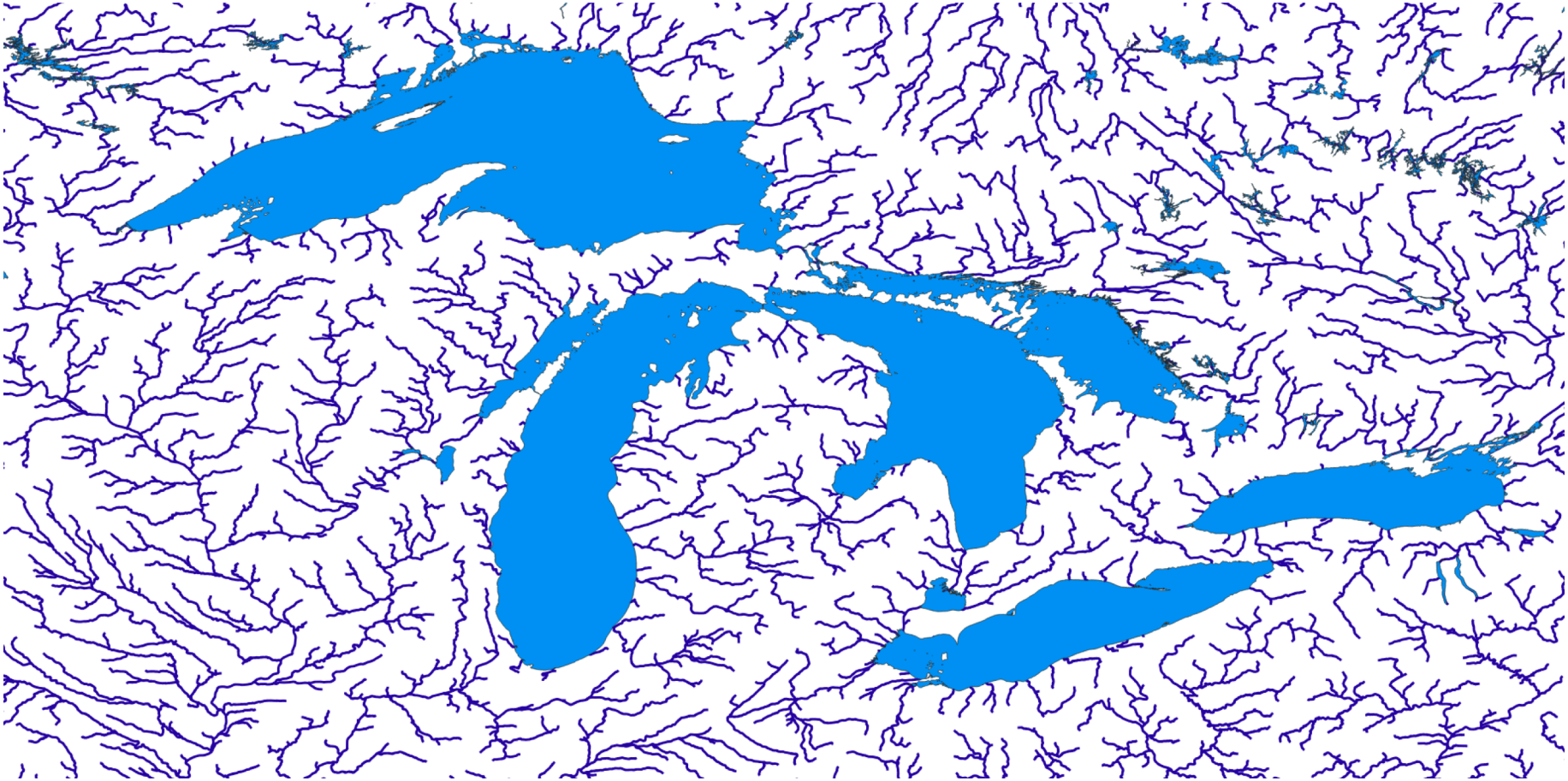
- Hydrologic Derivatives for Modeling and Applications (HDMA)
  - Digital river network developed by Kris Verdin for the catchment land model
  - Uses Pfafstetter coding system
  - Global dataset





Lakes/reservoirs

- Work underway to incorporate hydroLakes in mizuRoute
  - Intersecting HDMA stream segments with hydroLakes
  - Extracting mizuRoute lake attributes from hydroLakes
  - Initial simulations over the Great Lakes



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Next steps

- mizuRoute development
  - Complete Pfafstetter parallelization with MPI
  - Finalize new continental-domain test cases
- NHD+ aggregations
  - Complete NHD+ aggregations over the CONUS
  - Evaluate/improve aggregated NHD+ simulations
  - Evaluate scaling issues
- hydroLakes
  - Complete stream/lake intersections
  - Initial testing of lake simulations in mizuRoute
- Coupling
  - Refactor of mizuRoute driver
  - Upgrade to ESMF “re-gridders”
  - Integrate CTSM energy balance with mizuRoute water balance

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