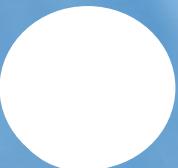




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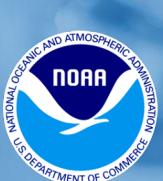




Joint Computational Domain Partitioning Rainfall-Runoff Models with Hydrologic (Kinematic) Streamflow Routing Models

Exploring the orchestration of catchment rainfall-runoff models alongside kinematic streamflow routing models in the same computational domain.

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Stream Flow Routing Domain

Just-in-time routing

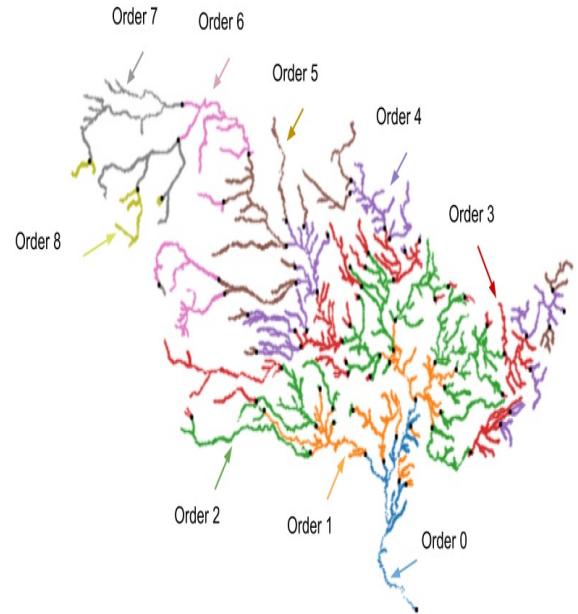
- Calculate first the headwater reaches of edges of the longest network
- Followed by all reaches below headwaters, etc.
- Orchestrate the computation so each dependency is computed just-in-time before it is needed downstream
- **Provides best theoretical potential speedup**



Streamflow Routing Refinement

- Group the reaches into subnetworks
 - Balances the practical impact of many parallel calls
- Higher order subnetworks are computed prior to lower order subnetworks

Note order in this sense is topological order



Color denotes subnetworks of common reverse network order

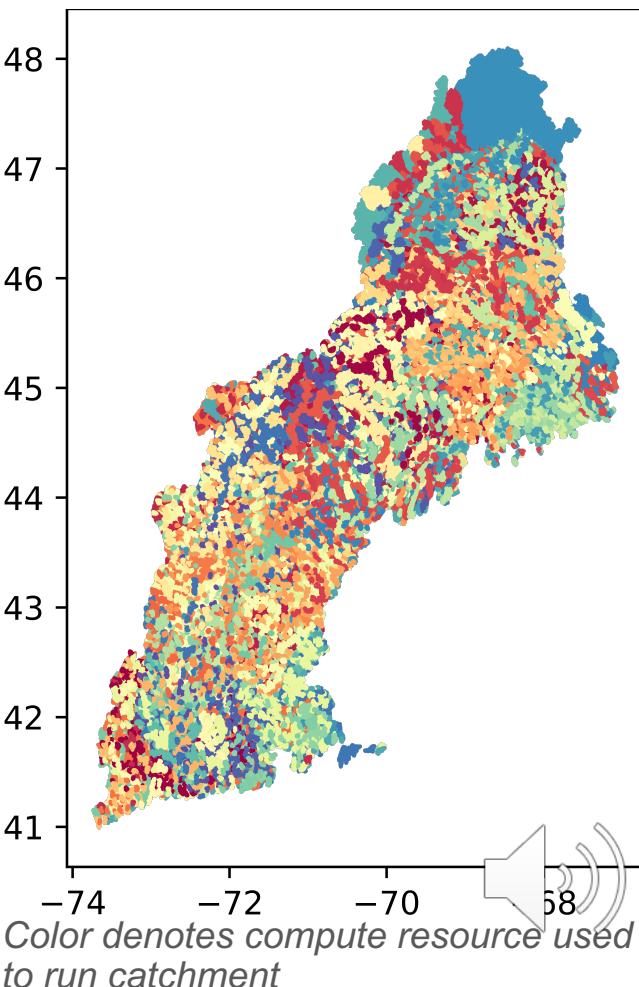


Catchment rainfall-runoff (Naïve)

- Topological Sort (from tailwater to headwater)
- Guarantees dependency order
- Organizes around stream order
- Catchment network fragmented across compute resources
- Imposes excessive communication requirements between compute resources
- 60 day simulation in 19.24 minutes



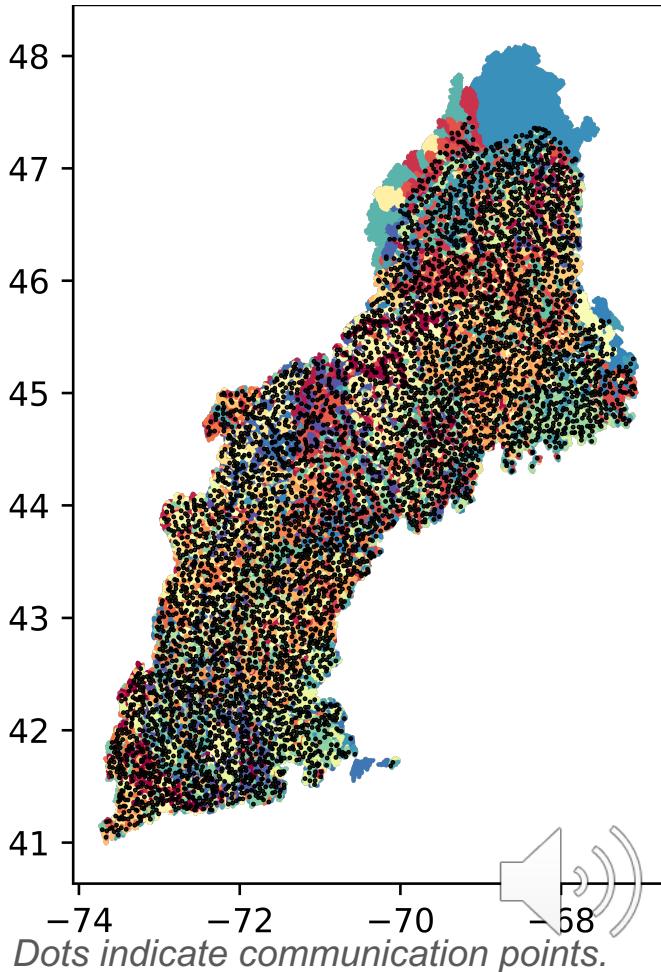
Huc01 Partitioning using Toposort



Problems with Toposort

- 5949 out of 7570 nexuses require communication
- **That is almost 79% of the domain!**
- Two issues
 - Balancing the number of catchments per partitions
 - Stream order organization

Huc01 Partitioning using Toposort

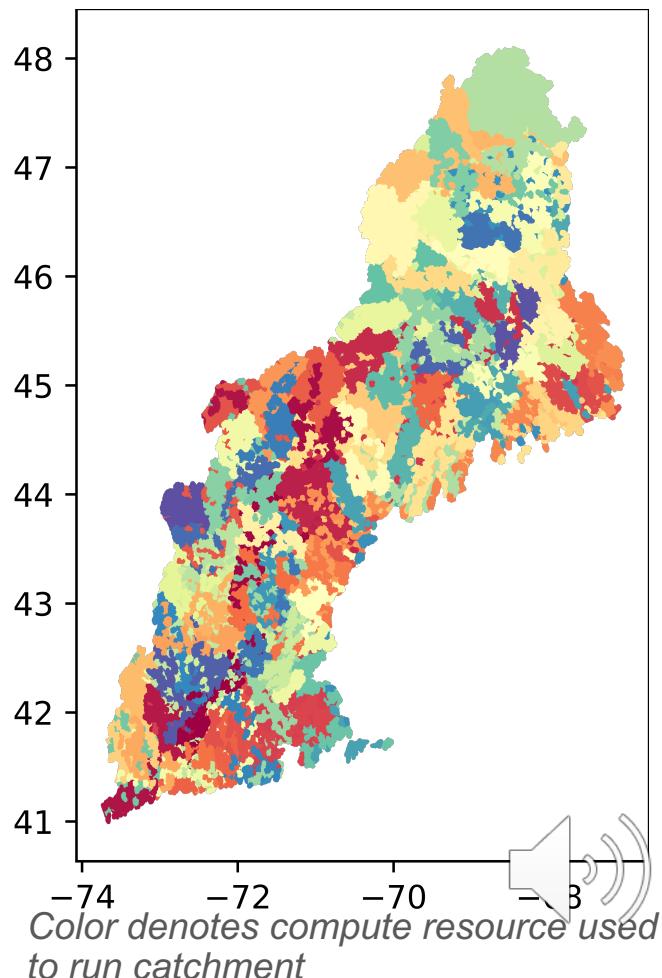


Catchment rainfall-runoff (Better)

- Depth first search (from tailwater to headwater)
- Organizes around nested basins
- Catchment network coalesced to compute resources
- Maintains topology within each partition
- **60 day simulation in 12.78 minutes, 34% faster!**

Spatial organization impacts the the parallel domain partitioning of rainfall-runoff models!

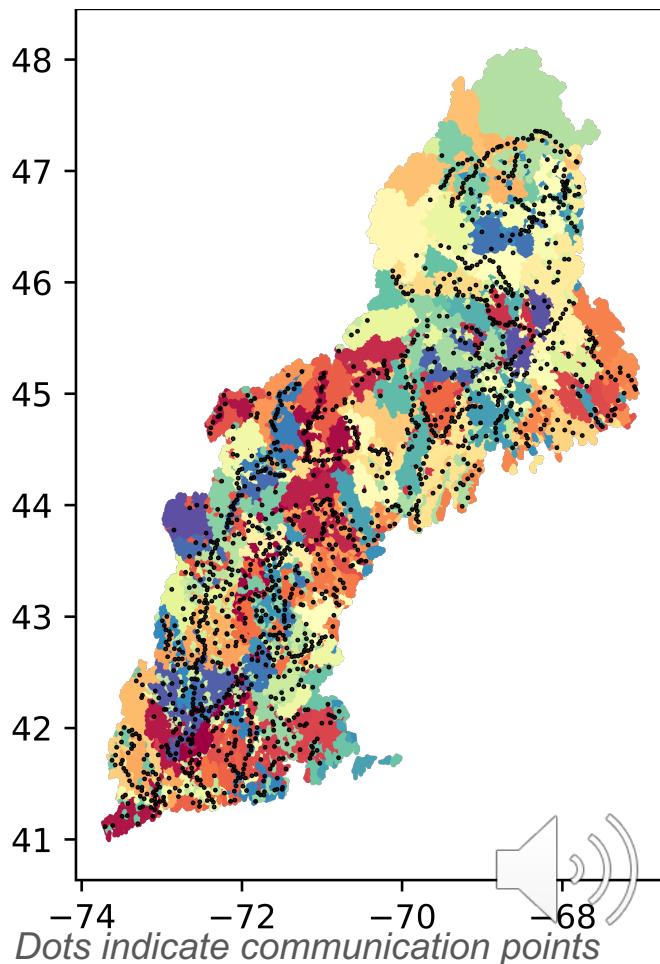
Huc01 Partitioning using DFS



Catchment rainfall-runoff (Better)

- 1446 out of 7570 nexuses require communication
- **That is only 19% of the domain!**
- Still some poor communication boundaries due to the arbitrary cut off of number of catchments per resource

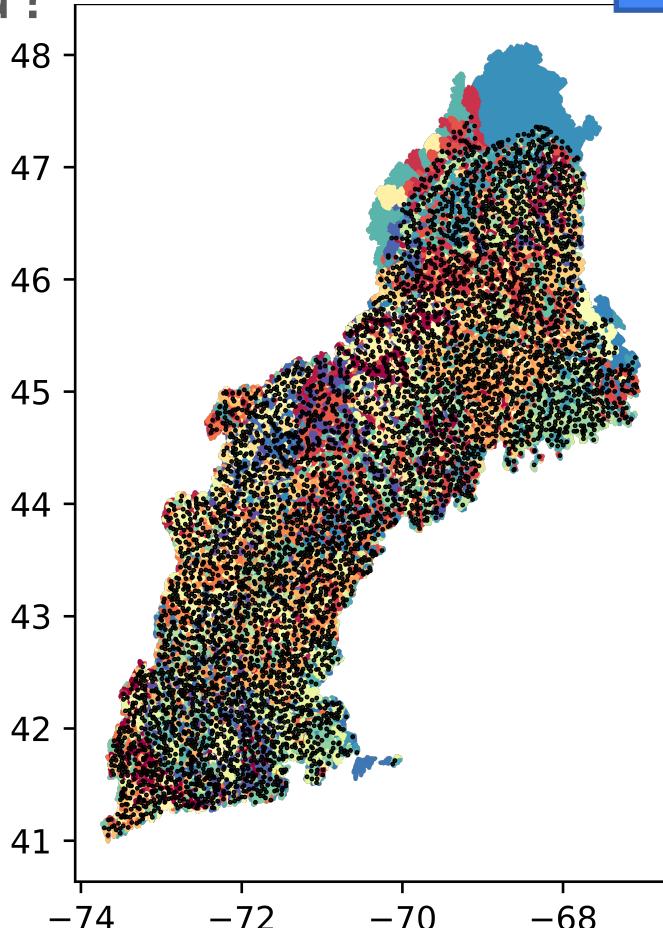
Huc01 Partitioning using DFS



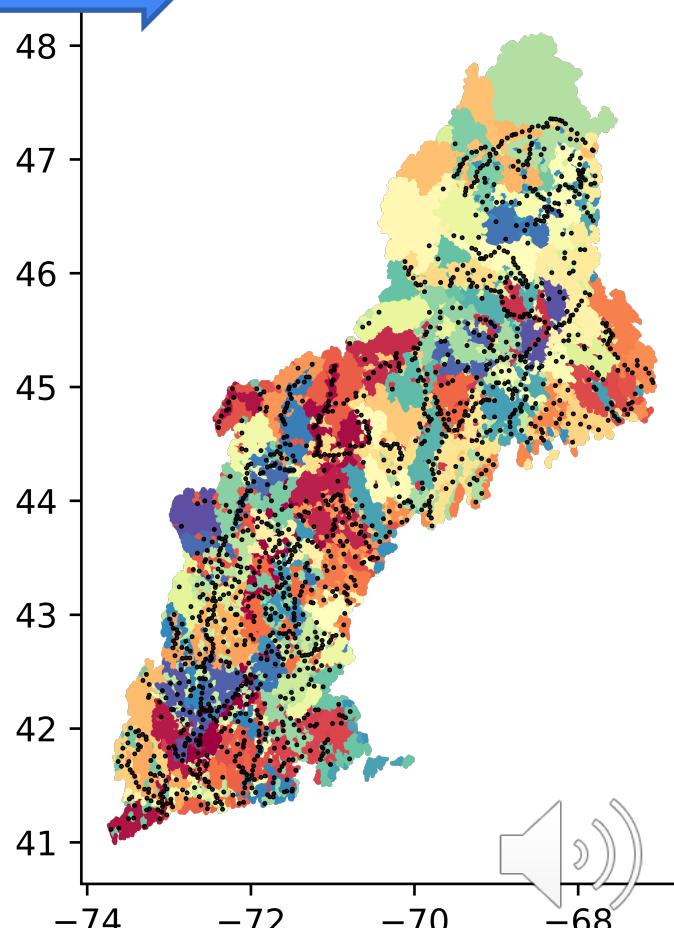
What changed?

- Now only 19% of the domain requires communication.
- **60% less communication!**
- **34% faster runtime!**

Topological Decomposition

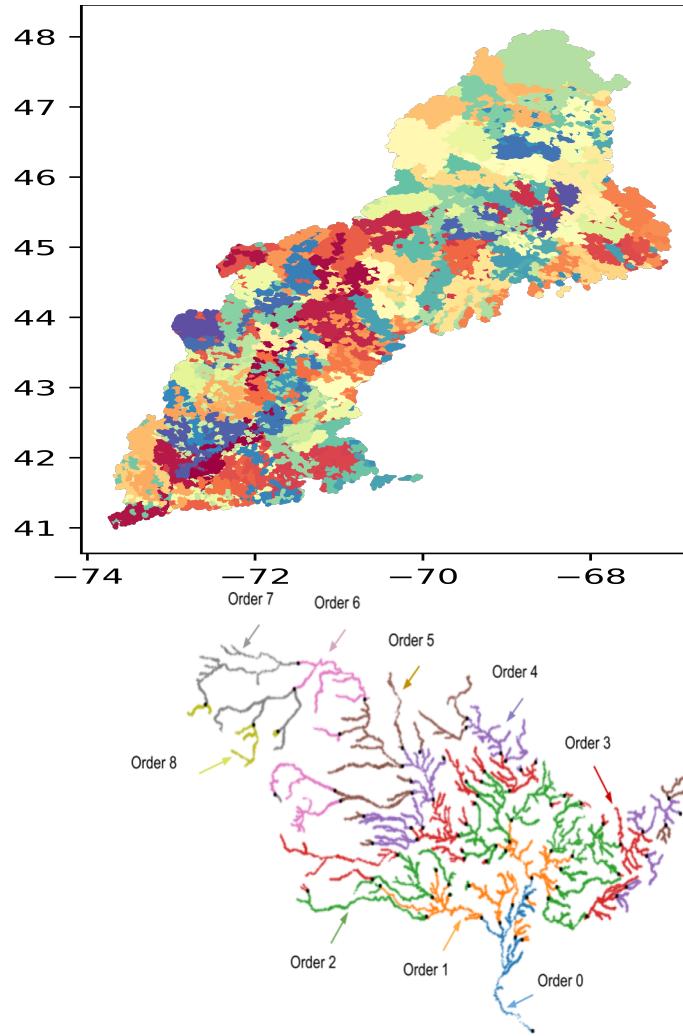


DFS decomposition



What's next?

- Combining the dependency graphs
- Isolate independent networks
- Assign groups of networks to compute resources
- Within each sub-network
 - Run all catchment models
 - Apply just-in-time routing
- Find optimal domain sizes per-order to reduce the downstream wait time on upstream results





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Thank You!



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<https://water.noaa.gov>

<https://github.com/noaa-owp/ngen>