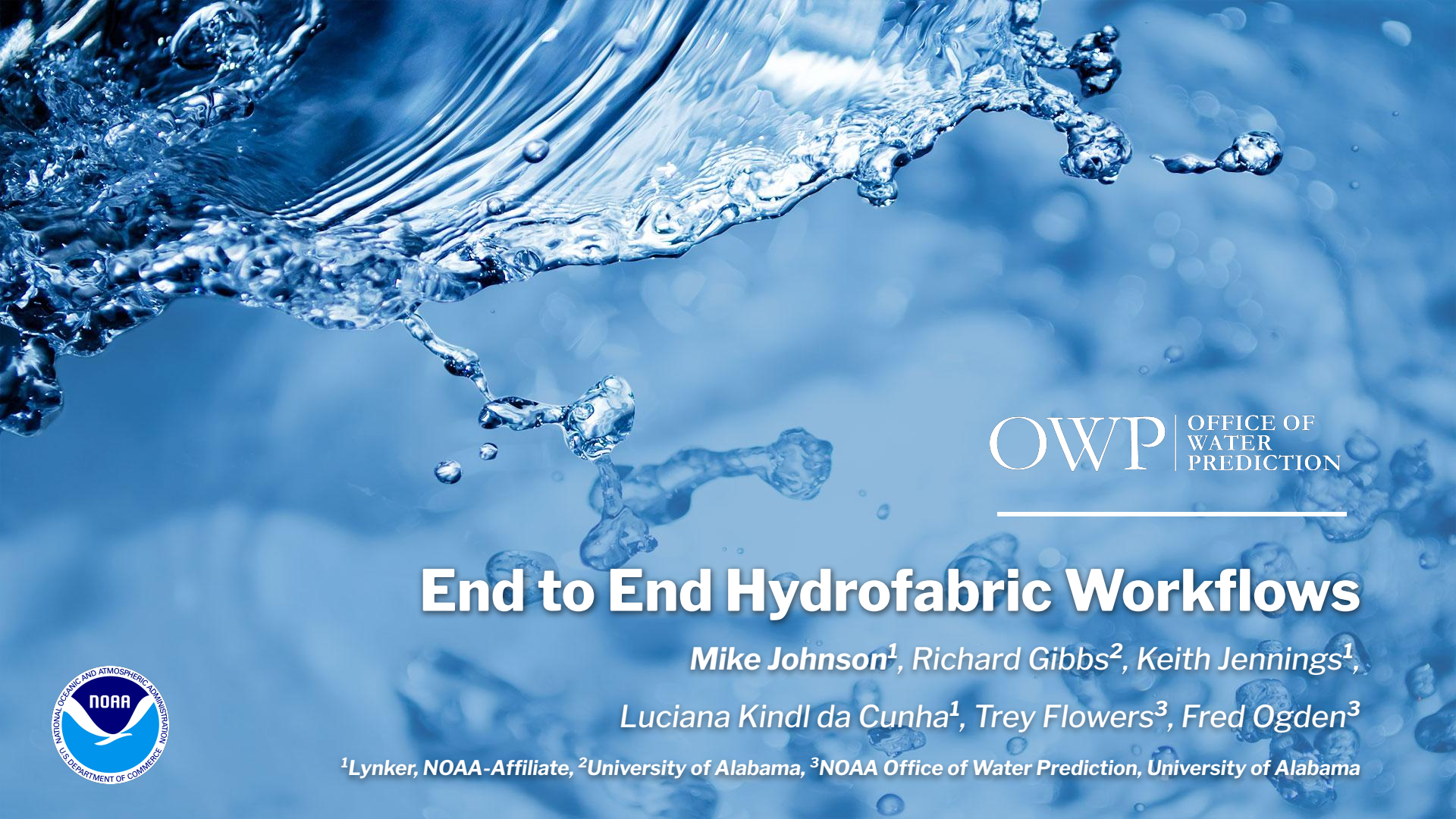


OWP | OFFICE OF WATER PREDICTION

# End to End Hydrofabric Workflows

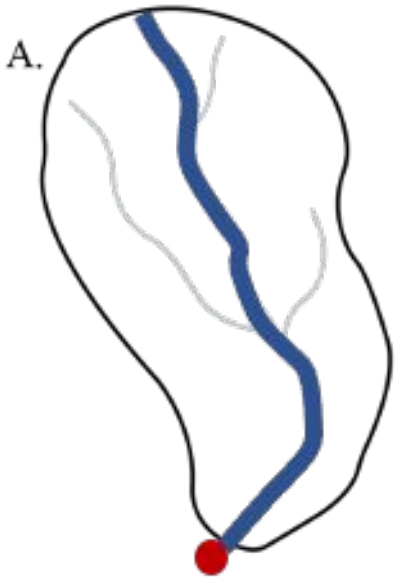
**Mike Johnson**[1], *Richard Gibbs*[2], *Keith Jennings*[1],

*Luciana Kindl da Cunha*[1], *Trey Flowers*[3], *Fred Ogden*[3]

[1]*Lynker, NOAA-Affiliate,* [2]*University of Alabama,* [3]*NOAA Office of Water Prediction, University of Alabama*

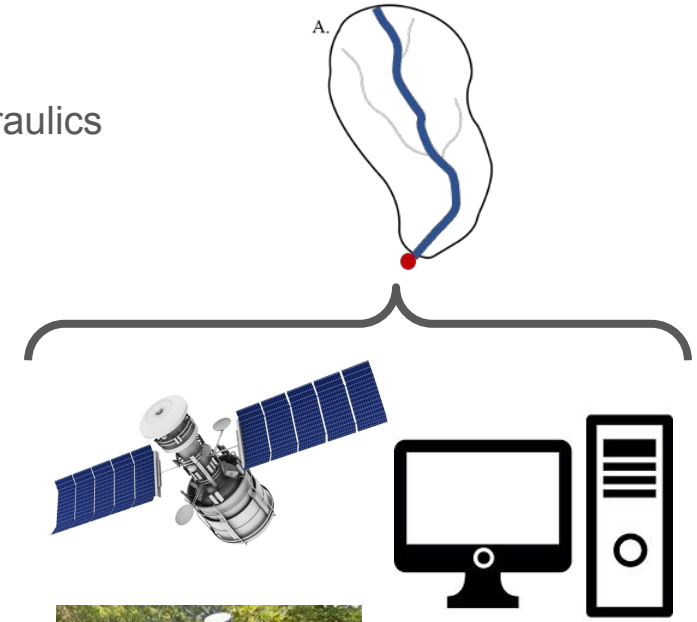
# What is a “Hydrofabric”

1. The blue line **features** (flowpaths) and per-flowline catchments geometries
2. flowline/catchment **topologies**
3. **Attributes** to support routing and rainfall-runoff modeling)
4. The **software** and data models to make the creation of these open, reproducible, and flexible.



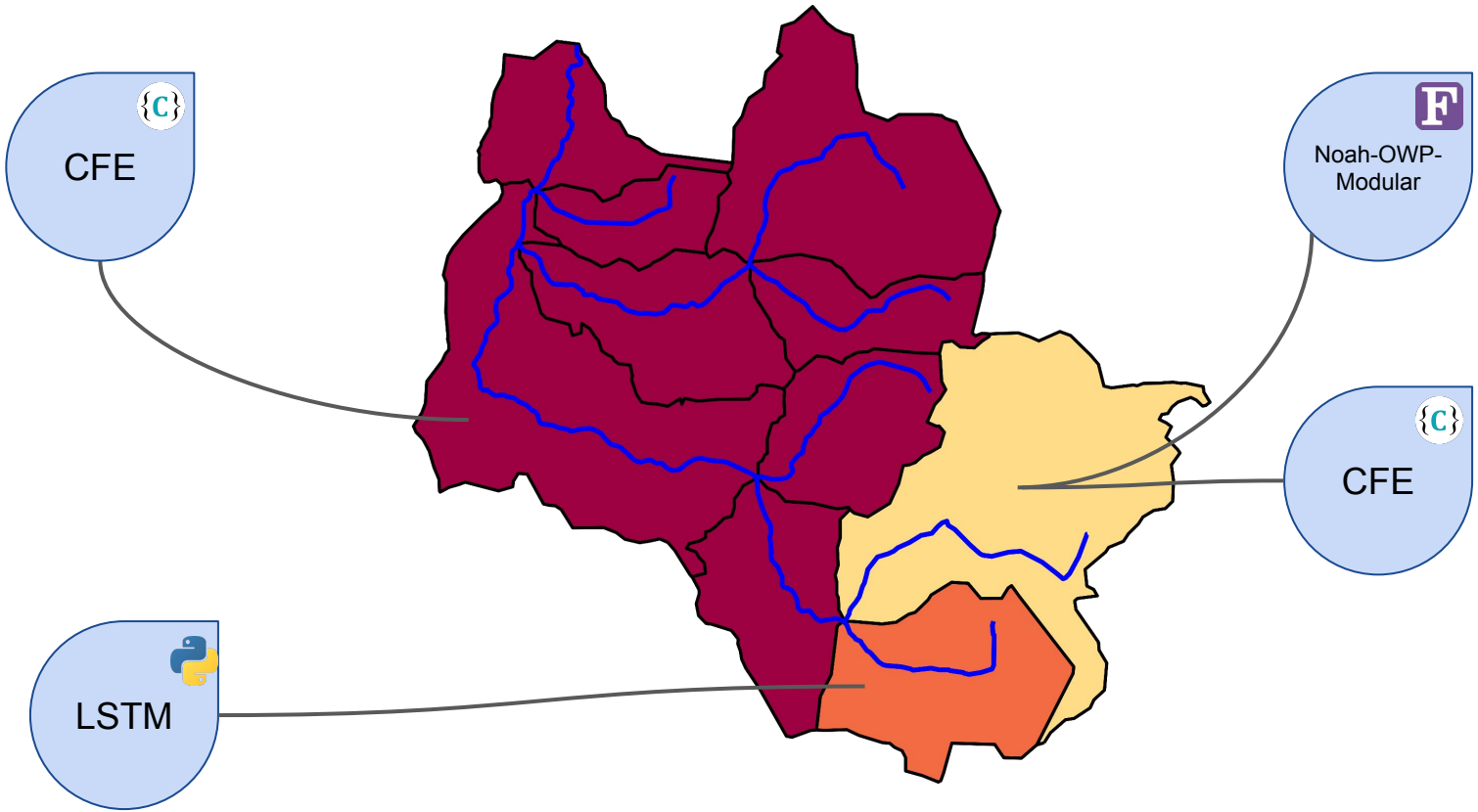
# What is a “Hydrofabric”

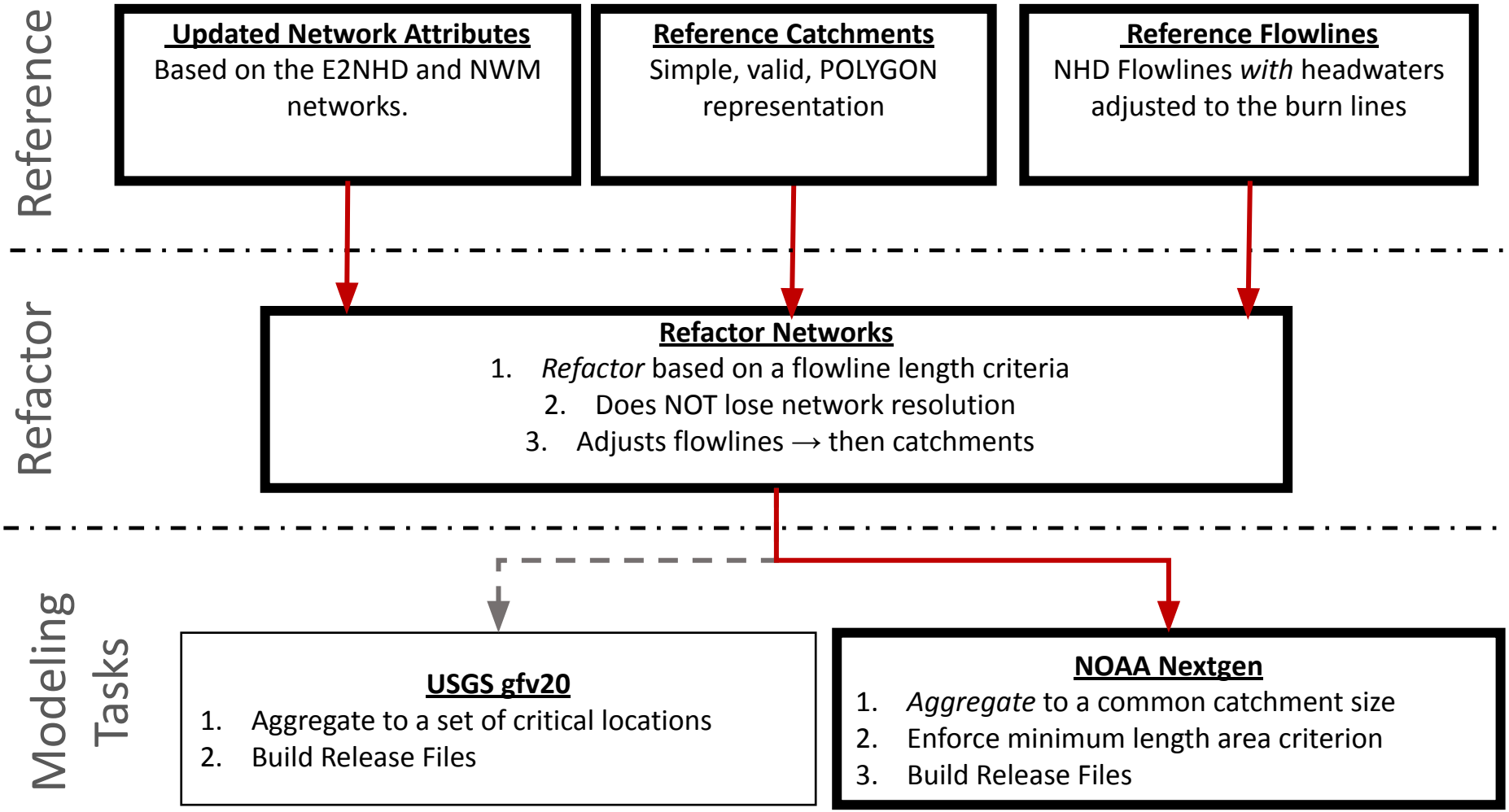
1) Features **define** the *computational elements* for hydrology/hydraulics
2) Topologies **link** data together for space/time processing
   a) (modular elements that act as a whole)
3) Attributes **provide** the *information* for model execution
   a) (physics based, conceptual and ML/AI)
4) Software and data models **develop** community standards, reproducibility, and flexibility to support analysis at scale

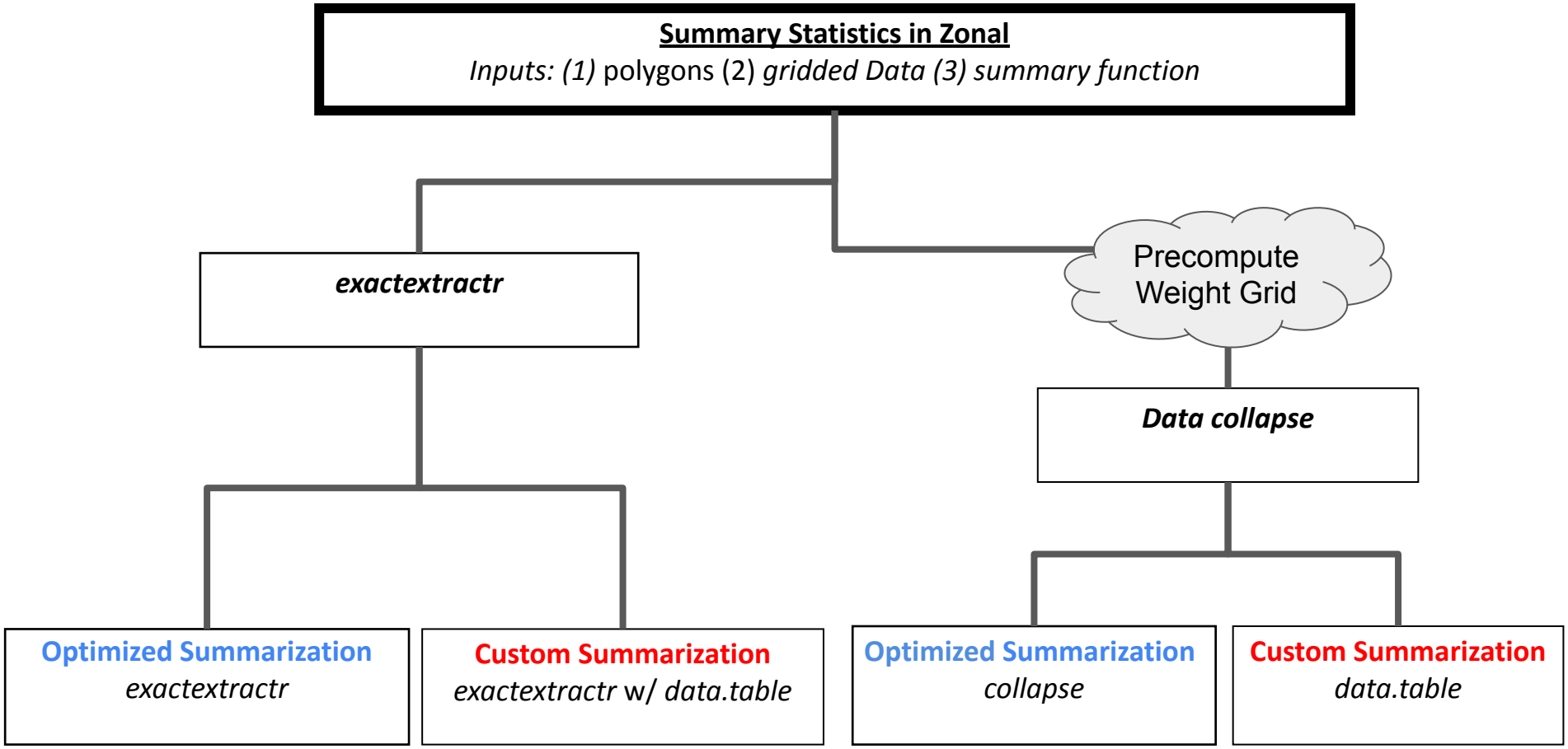



Internet of Water COALITION

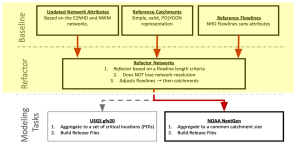
# Right Tool in the Right Place for the Right Reason




Reference
Refactor
Modeling Tasks
Updated Network Attributes
Based on the E2NHD and NWM networks.
Reference Catchments
Simple, valid, POLYGON representation
Reference Flowlines
NHD Flowlines with headwaters adjusted to the burn lines
Refactor Networks
1. Refactor based on a flowline length criteria
2. Does NOT lose network resolution
3. Adjusts flowlines → then catchments
USGS gfv20
1. Aggregate to a set of critical locations
2. Build Release Files
NOAA Nextgen
1. Aggregate to a common catchment size
2. Enforce minimum length area criterion
3. Build Release Files

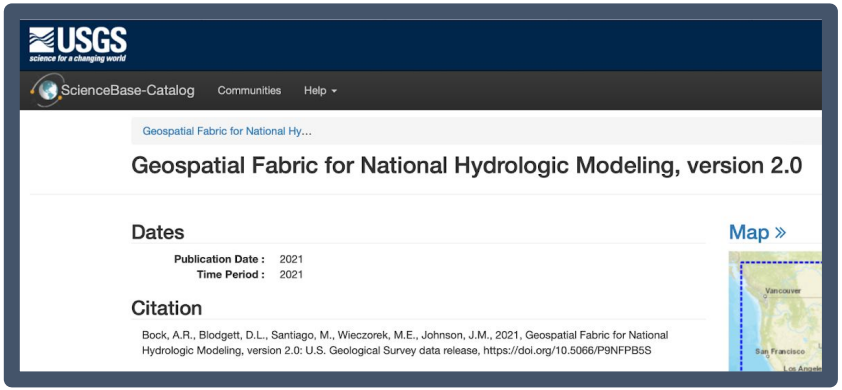

Summary Statistics in Zonal
Inputs: (1) polygons (2) gridded Data (3) summary function
exactextractr
Precompute Weight Grid
Data collapse
Optimized Summarization
exactextractr
Custom Summarization
exactextractr w/ data.table
Optimized Summarization
collapse
Custom Summarization
data.table

# A New National Data Product
*(reference data)*




A nationally consistent and authoritative set of baseline and reference features that ensure **computational elements** are:

1. Topologically
   a. (water flows where it should)
2. Geometrically
   a. (space is represented as it should be)
3. Hydrologically
   a. (headwaters start where they should)




**Valid**

USGS science for a changing world

NATIONAL WEATHER SERVICE

OWP | OFFICE OF WATER PREDICTION

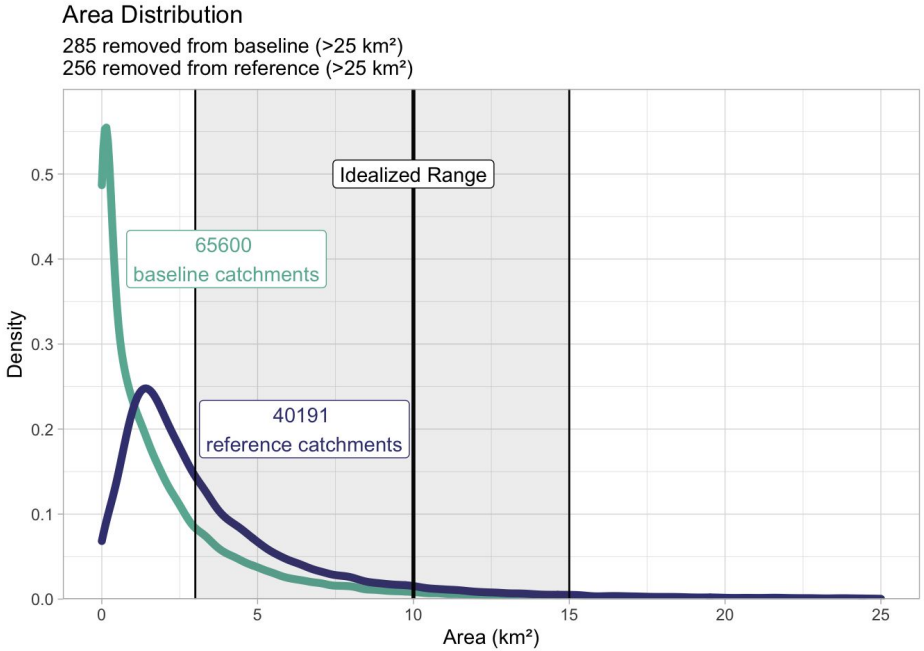
NCAR

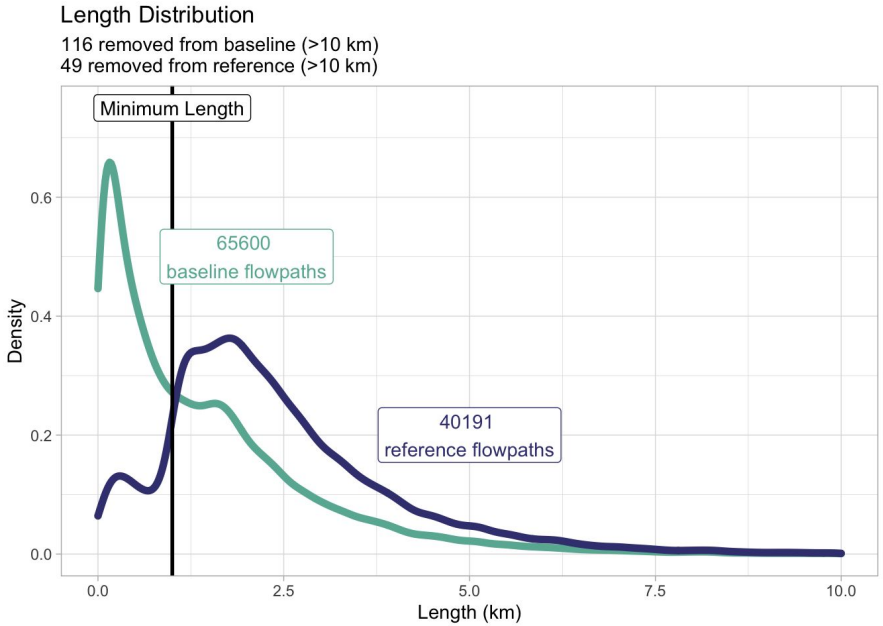
USGS NAWQA

Lynker

# Appropriate Scale

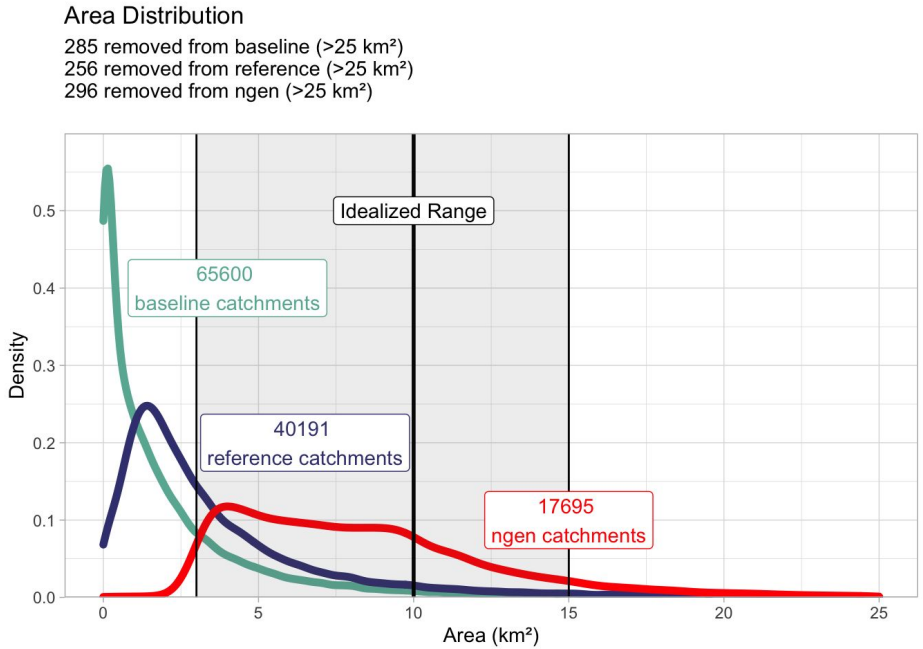
Runoff processes occur on a scale of 3-10 sqkm
Routing is stable on >1km length reaches

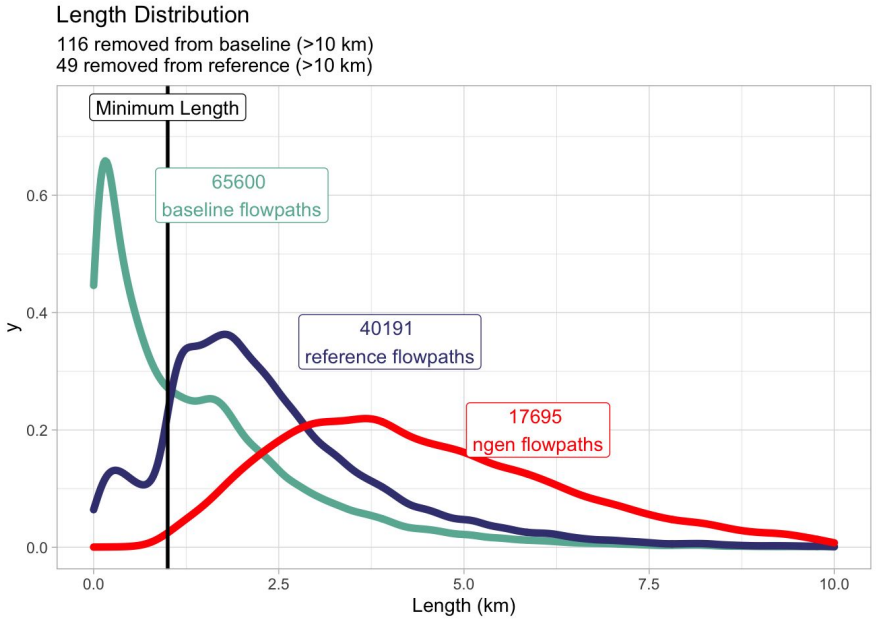


# Appropriate Scale

## Nextgen is a *distribution based* modeling task



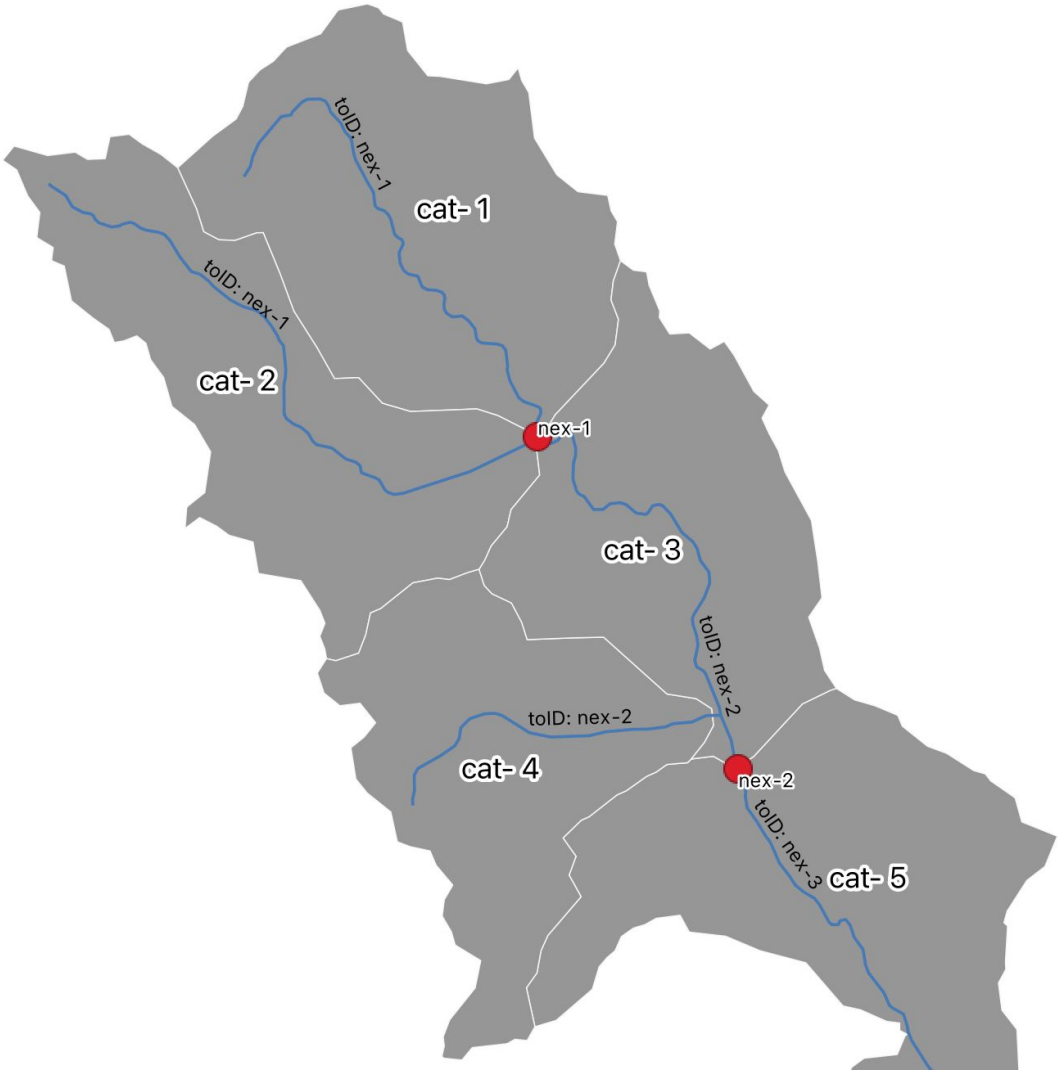



# Topology

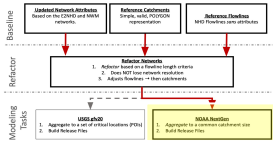
**Action**: Moving away from *flowline-to-flowline* model towards *area-to-point* model. Points are "**nexus**" locations that can be *inferred* from the network or *explicit*

**Reason**: be more compliant with the HY_Features conceptual model for representing surface water components.

**Advantage**: the ability to use multi-scale networks, leverage community efforts in hydrologic addressing and representation, to develop and utilize a more concrete data model



# Attribute Rich Workflows




Designing open-source data catalogs and efficient processing tools moves

- Currently ~15,000 data sets can be accessed and processed with any variant of a hydrofabric **catchment** set
- So far - we have routines to mirror the CAMELs dataset and those needed to the most current OWP-supported model formulations

## OpenDap Catalog

« Explore the Docs »

Data Catalog · R Interface · Request Feature

One of the biggest challenges with Earth System and spatial research is extracting data. These challenges include not only finding the source data but then downloading, managing, and extracting the partitions critical for a given task.

Services exist to make data more readily available over the web but introduce new challenges of identifying subsets, working across a wide array of standards (e.g. non-standards), all without alleviating the challenge of finding resources.

In light of this, `opendap.catolog` provides three primary services.

### Links

Browse source code

Report a bug

### License

Full license

MIT + file LICENSE

### Citation

Citing opendap.catalog

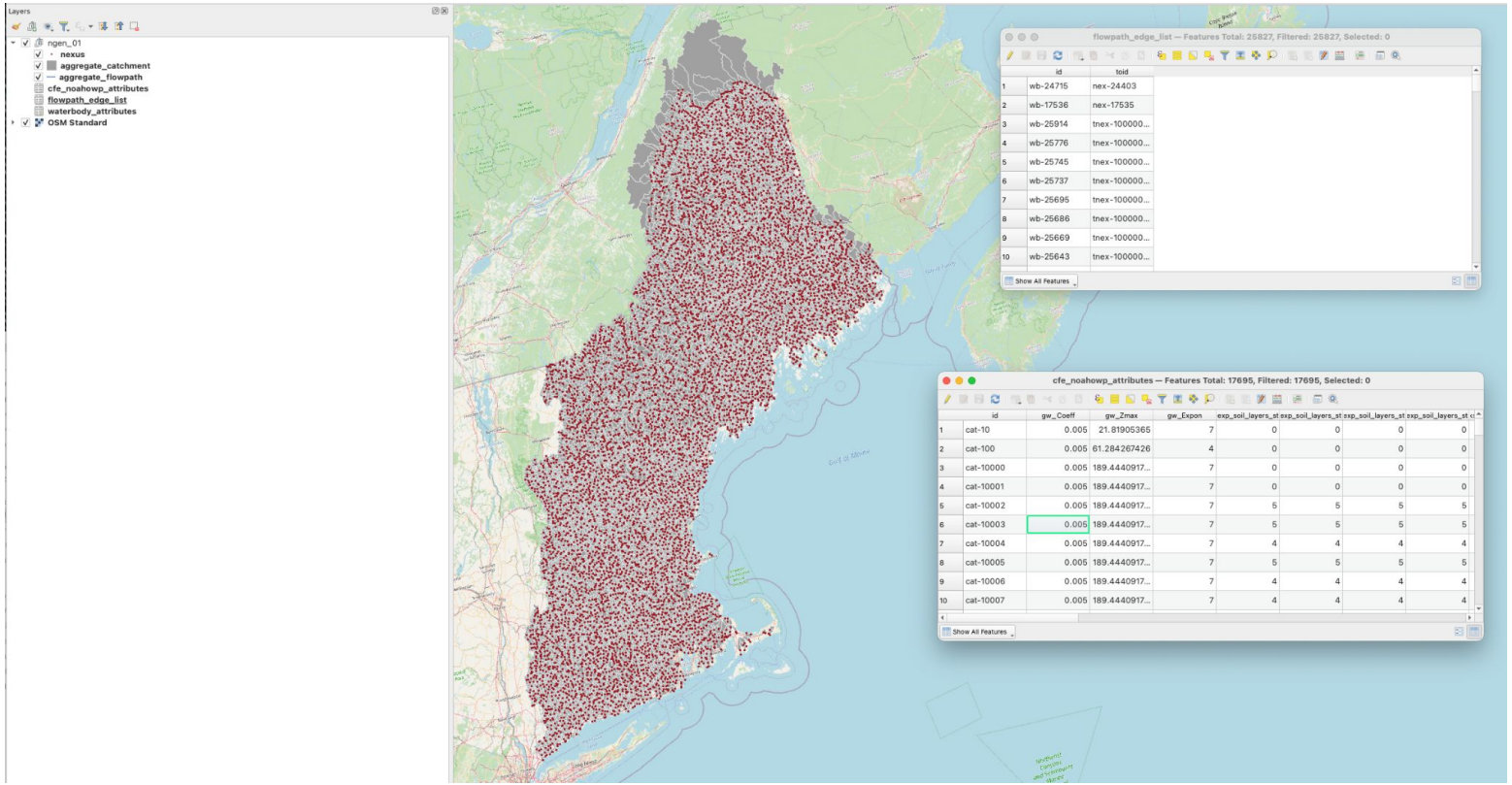
### Developers

Mike Johnson

Author, maintainer

### Dev status

# What will the data look like?



# Modular / Software

*greater public good and more easily reused*

## Modular Code

- Reference Fabric
  ***USGS-R/nhdplusTools***

- Refactored Fabric
  **dblodgett-usgs/hyRefactor**

- Ngen features and representation
  **NOAA-OWP/hyAggregate**

- Attribute Creation
  **NOAA-OWP/zonal**
  **mikejohnson51/opendap.catalog**

NOAA-OWP/hydrofabric

The hydrofabric package is an collection of R packages designed for disparate hydrologic modeling tasks.

All packages share underlying design philosophies and data structures.

- nhdplusTools for network manipulation
- hyRefactor for network refactoring
- hyAggregate for Ngen data creation and releases
- opendap.catalog remote data access and discoverability
- zonal rapid catchment parameter summarization

# Described in greater detail here:
*https://noaa-owp.github.io/hyAggregate*



## NextGen Hydrofabric

### What is it and how do we get there?


Mike Johnson[1]


## What is a hydrofabric?

The first question generally raised is, "*what is a "hydrofabric*"? To date, the term has been a bit nebulous and has been used to describe artifacts as narrow as a set of cartographic lines, all the way to encompass the entire spatial data architecture needed to map and model the flow of water and flood extents.

Here, a "Ngen Hydrofabric" will include the following four parts:

1. The blue line (flowpaths) and per-flowline catchments **feature**
2. The flowline/catchment **topologies**
3. **Attributes** to support routing and runoff modeling
4. The **software** and **data models** to make the creation of these open, reproducible, and flexible.

In this breakdown, features *define* the computational elements for hydrology and hydraulic modeling; topologies *link* data together for space/time processing (modular elements that act as a whole); attributes *provide* the information for model execution (physics based, conceptual and ML/AI model formulations); and software and data models *develop* community standards, reproducibility, and flexibility to support analysis at scale.

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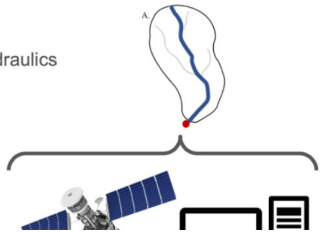

**USGS-R/nhdplusTools** NO CHANGES IN LOCATION OR NAME

**dblodgett-usgs/hyRefactor** (1) May move over to OWP, (2) may add aggregation to Points to hyAggregate, (2) may move to USGS, (3) may end up adding aggregation components of hyAggregate here

**mikejohnson51/hyAggregate (1)** May be split out into hyRefactor and hyRelease and kill? (1) May merge all hyRelease stuff here and call “ngen-hydrofabric”

**mikejohnson51/hyRelease** May kill this off when merged in to the next flavor of hyAggregate, or else it will grow with non-aggregation hyAggregate code and probably take the name “ngen-hydrofabrics”?

**mikejohnson51/zonal** Can move to OWP, but core logic many move to opendap.catalog once renamed

**mikejohnson51/opendap.catalog** This has grown well beyond the catalog artifacts, may move the I/O capabilities somewhere else along with zonal?

**JamesColl-NOAA/eHydRo** I was asked to add this - I don’t really know its history or future


# Coming soon:

1. CONUS Nextgen artifacts
2. CAMELs parameters for all USA Nextgen divides
3. Cloud based network navigation and subsetting
4. Product validation and reporting

# *Thank You!*


Mike Johnson

mike.johnson@noaa.gov

https://water.noaa.gov


NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

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