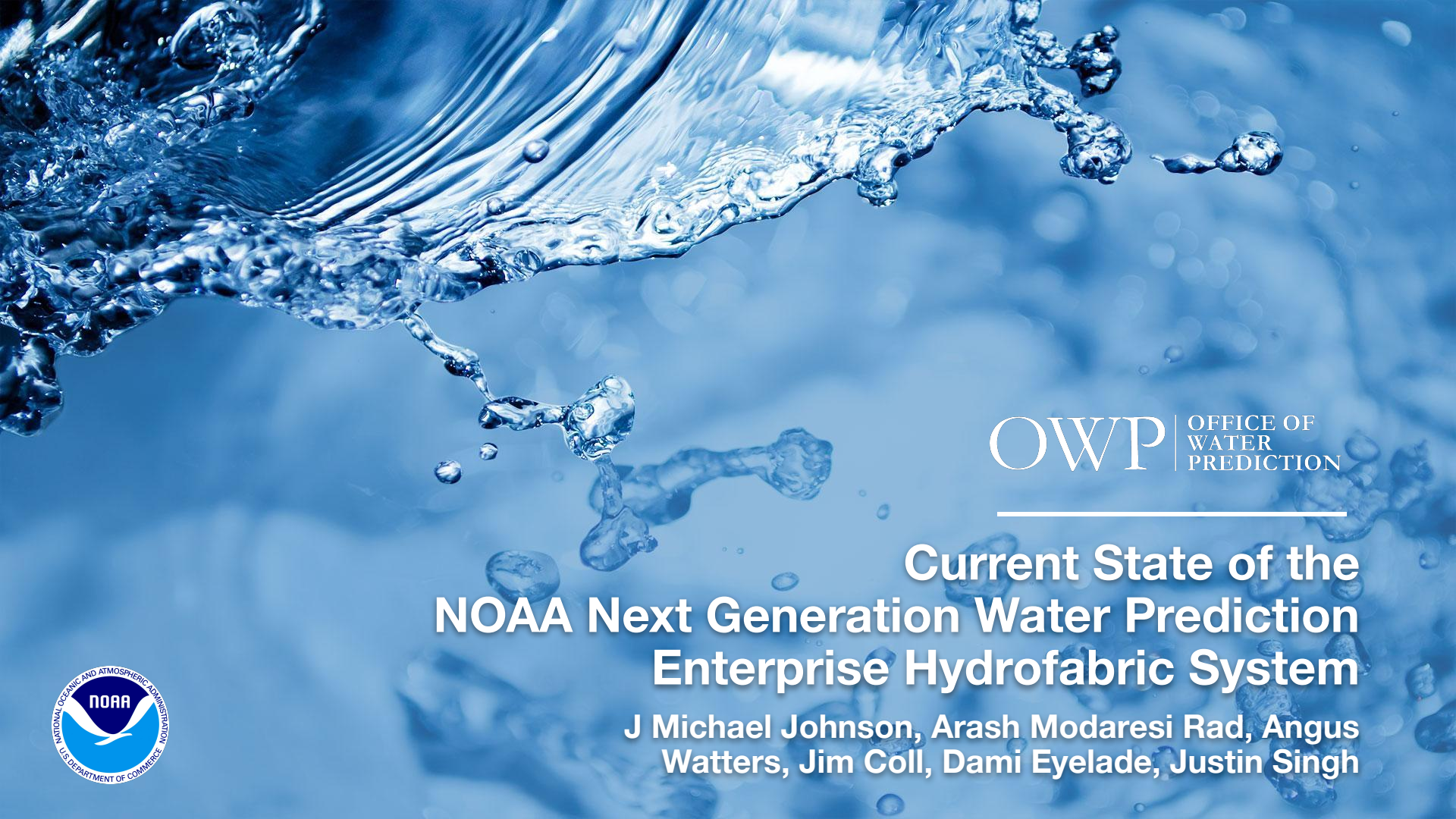
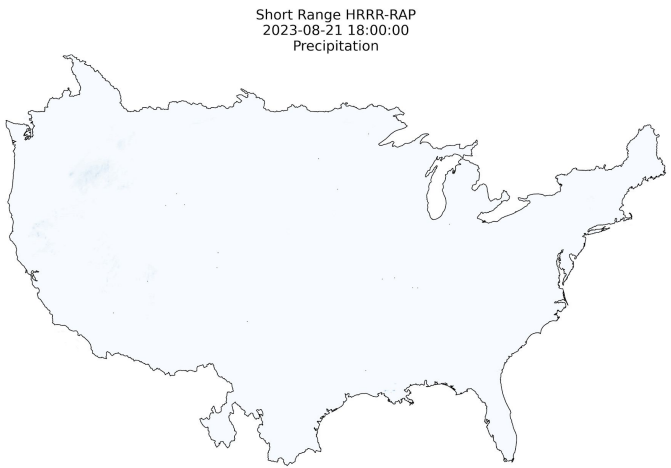


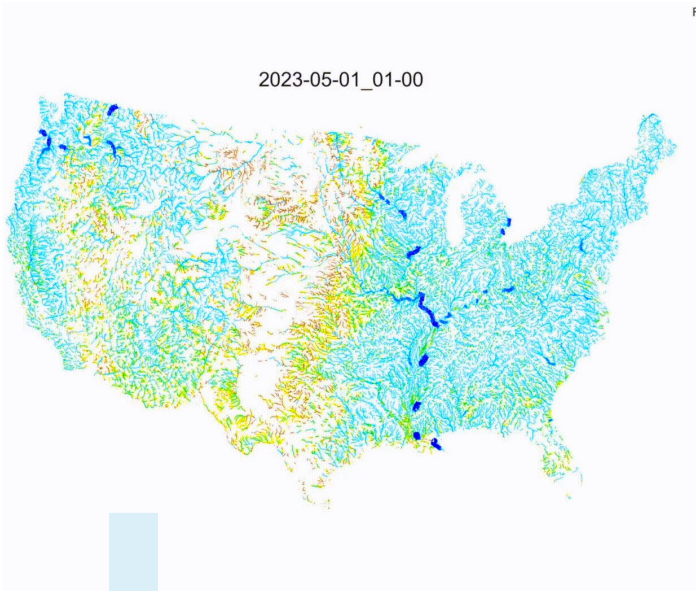
OWP | OFFICE OF WATER PREDICTION

Current State of the NOAA Next Generation Water Prediction Enterprise Hydrofabric System

J Michael Johnson, Arash Modaresi Rad, Angus Watters, Jim Coll, Dami Eyelade, Justin Singh

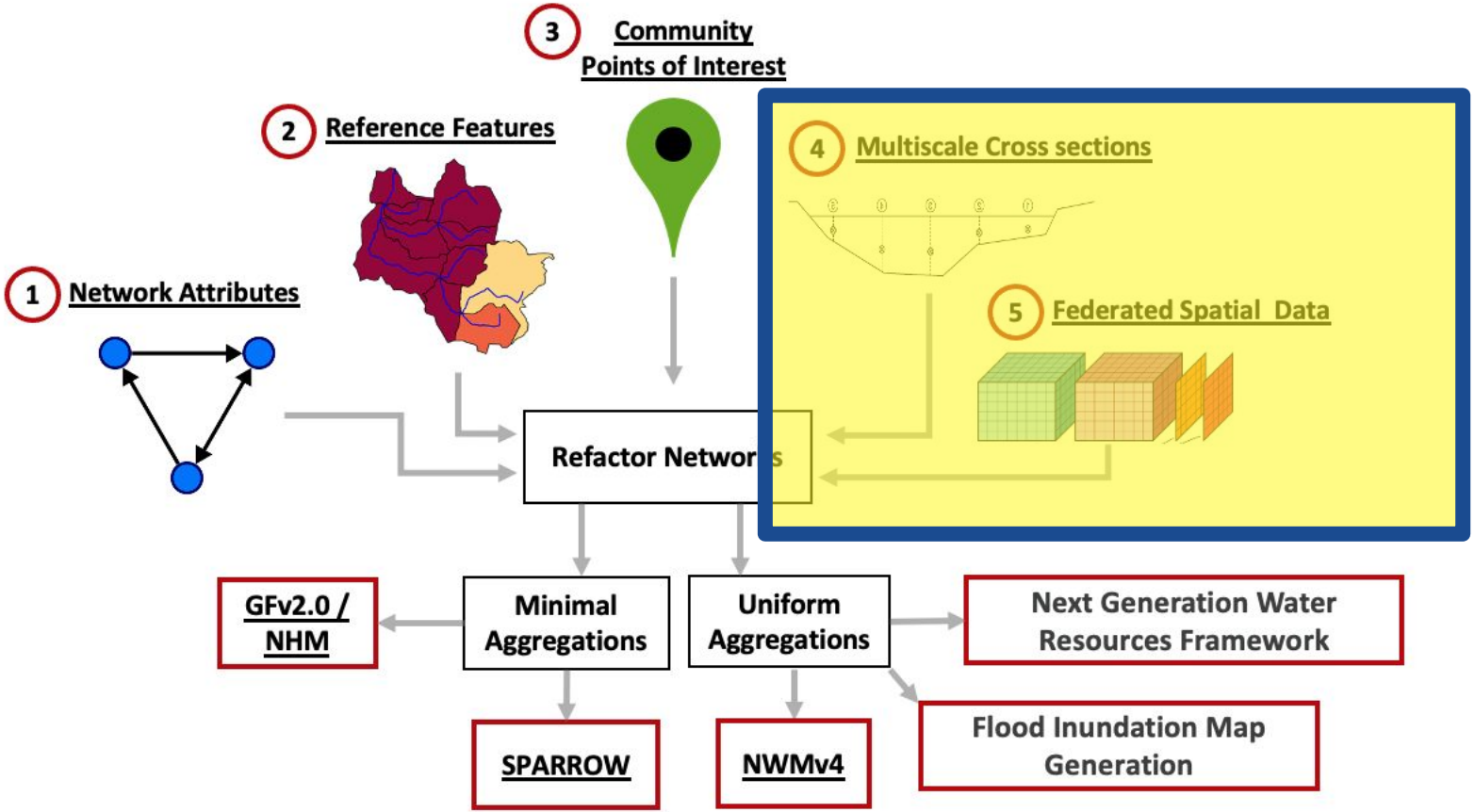
Meaningful strides towards a nationally consistent hydrofabric that is more FAIR, robust, and reproducible.





Thanks to Sean Horvath, Amin Torabi, and Nels Fraizer for the animations.

The Enterprise System

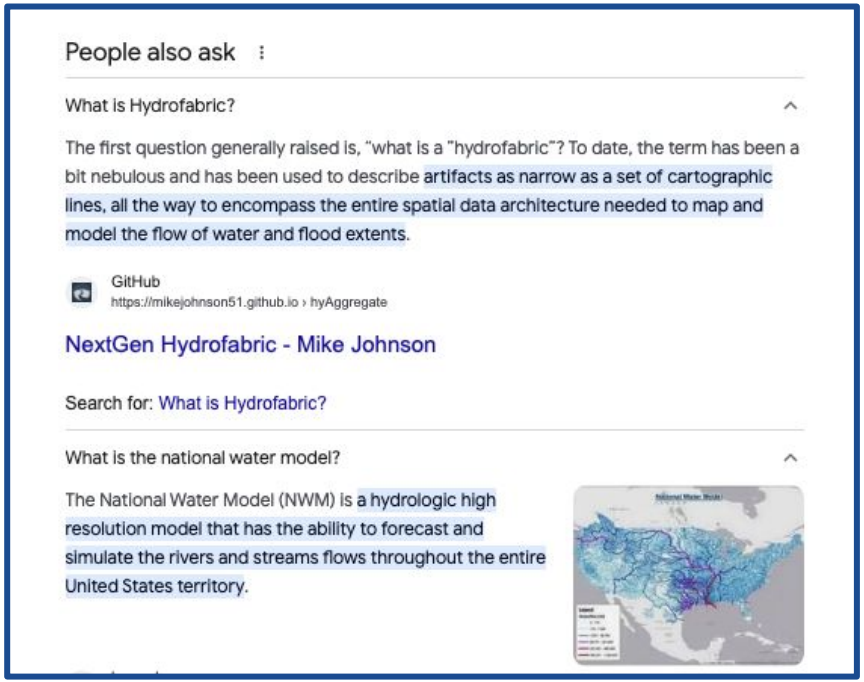


Last year

Talked about **concepts and software development**. If you missed those: a quick start guide is available here:

https://noaa-owp.github.io/hydrofabric/articles/

This year we are going to talk about our **additional capabilities and the performance/scalability** of the system



The Current Coverage

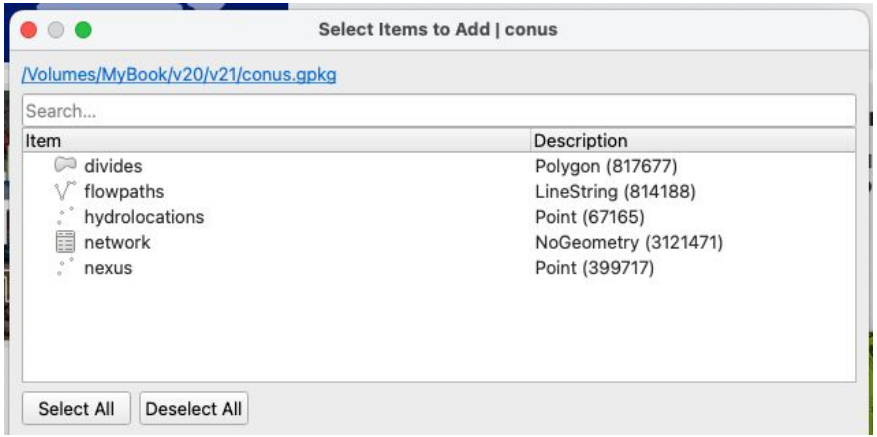
Version 2.0 was released in October

- Improved Geometry
- New distribution
- More attributes/capabilities
- Consolidated Workflows
- Lots of bug fixes
- Internal/Coastal Catchments

Covers CONUS

2024 will focus on North America Expansion using NGA TDX-hydro

https://noaa-owp.github.io/hydrofabric/articles/data.html



The Data System

- All cloud native
  - GPKG (CONUS and VPU)
  - Parquet (directory and VPU)
  - FGB (CONUS)

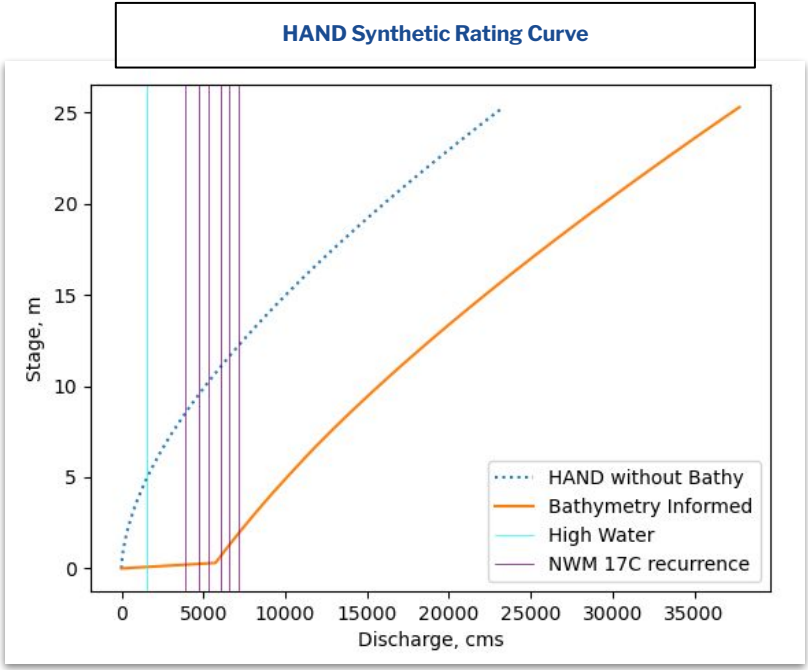
- Lives at www.lynker-spatial.com

Use Statistics (*as of 11/16/2023):*

- 1,100 unique users
- 35,000 downloads

Need(s) for River Corridor Representation

Flood Inundation Mapping



Thanks to the Flood Inundation Mapping team for the image.

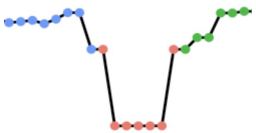
Routing

Thanks to DongHa Kim and the inland routing team for the animation.

Heterogeneous Data Sources to meet applications needs

https://noaa-owp.github.io/hydrofabric/articles/07-channel-geometry.html

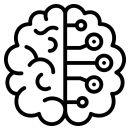
Digital Elevation Models



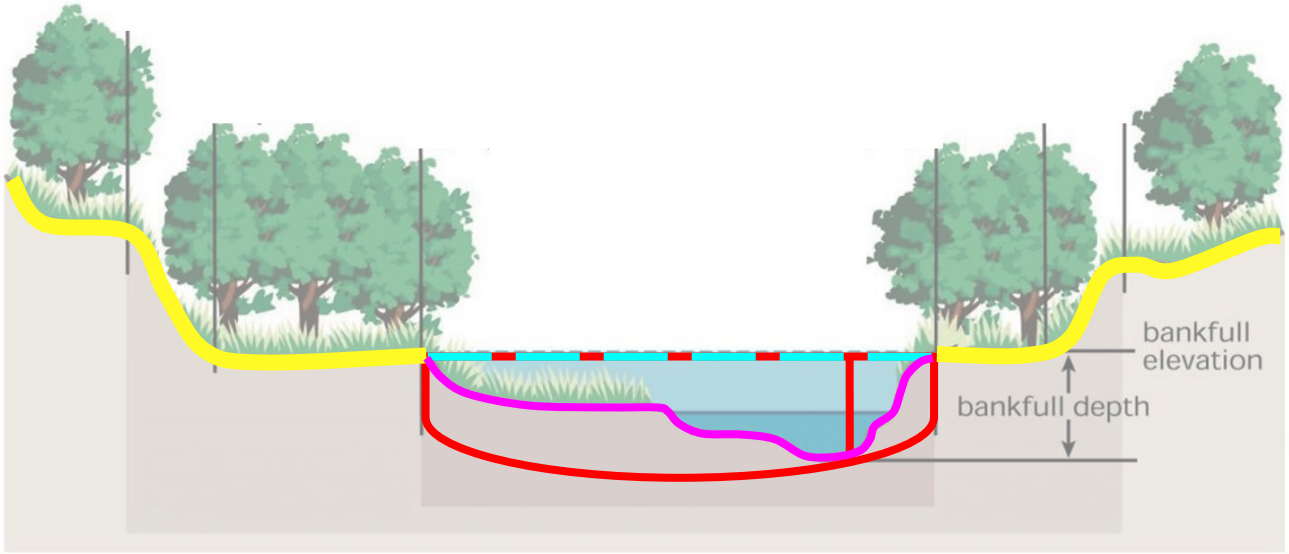
Data Fusion

OpenStreetMap

Machine Learning



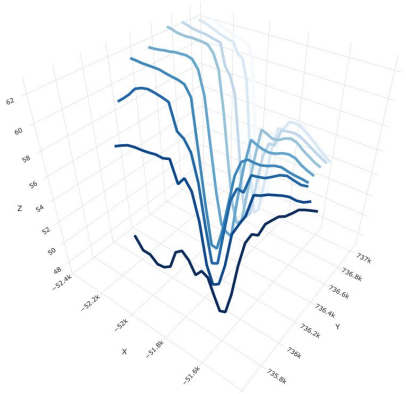
Surveys



Results to date

https://mikejohnson51.github.io/hydrofabric3D/

Digital Elevation Models



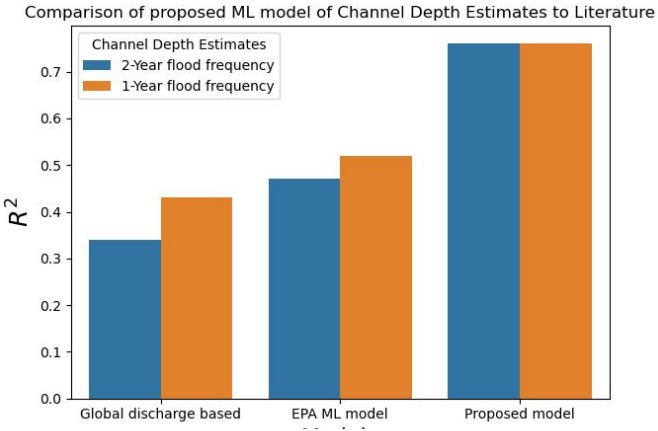
CONUS wide DEM transects

> 10 transects/flowpath

> A 10 meter DEM

> A 1.7 GB cloud-native file

Machine Learning

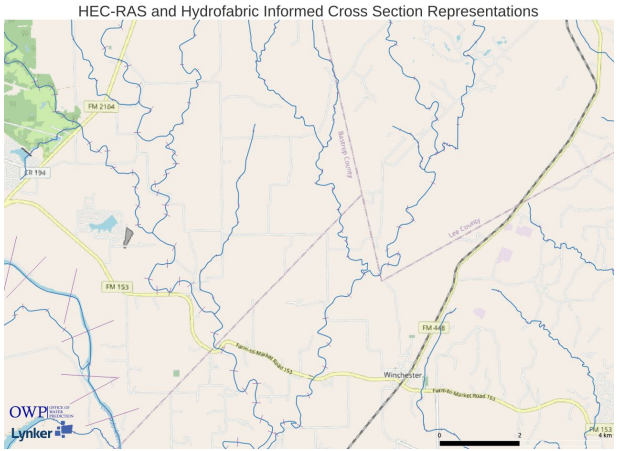


CONUS wide channel width & depth

> ~Estimated for ~2.7 million reference reaches

> Higher accuracy than predecessors

Surveys



HEC-RAS

> 10,520 models, 2.54 GB file/directory

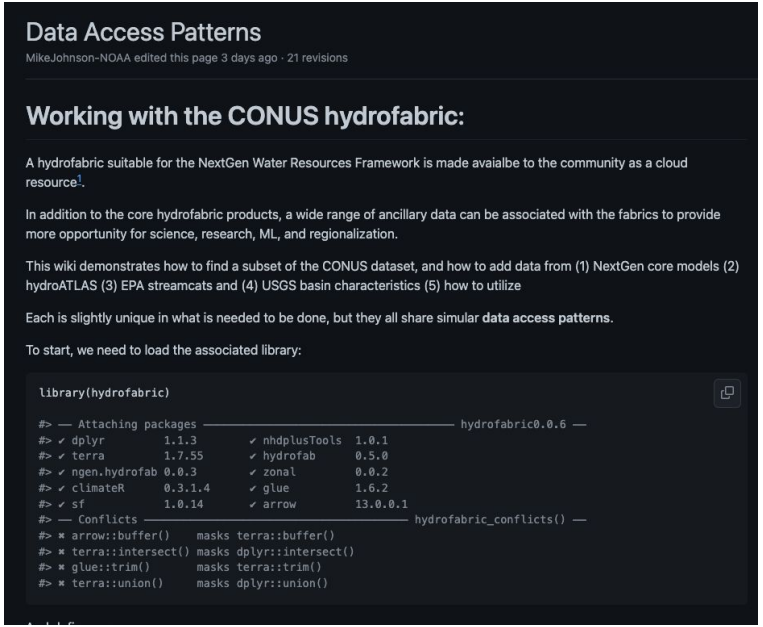
eHydro

> ~100,000 models,1.5 GB file/directory

Federated, accessible data

Provide access to **100,000's precomputed and raw data sources** along with **methods to appropriately rescale and summarize** these to a hydrofabric

1. HydroSheds HydroAtlas
2. EPA StreamCat
3. USGS Summaries
4. NOAA NextGen Formulations
5. NOAA NWM v2.1 Flood Frequencies
6. 3DEP/NHDSnapshotNational DEM, FDR, FAC
7. Oakridge National TWI
8. climateR-catalogs (*> 110,000 datasets, Polaris, Sentinel, Landsat, *DAS)*



Data Access Patterns

MikeJohnson-NOAA edited this page 3 days ago · 21 revisions

Working with the CONUS hydrofabric:

A hydrofabric suitable for the NextGen Water Resources Framework is made avaialbe to the community as a cloud resource[1].

In addition to the core hydrofabric products, a wide range of ancillary data can be associated with the fabrics to provide more opportunity for science, research, ML, and regionalization.

This wiki demonstrates how to find a subset of the CONUS dataset, and how to add data from (1) NextGen core models (2) hydroATLAS (3) EPA streamcats and (4) USGS basin characteristics (5) how to utilize

Each is slightly unique in what is needed to be done, but they all share simular **data access patterns.**

To start, we need to load the associated library:

```
library(hydrofabric)

#> ── Attaching packages ──────────────────────────────────── hydrofabric0.0.6 ──
#> ✔ dplyr         1.1.3       ✔ nhdplusTools  1.0.1
#> ✔ terra         1.7.55      ✔ hydrofab      0.5.0
#> ✔ ngen.hydrofab 0.0.3       ✔ zonal         0.0.2
#> ✔ climateR      0.3.1.4     ✔ glue          1.6.2
#> ✔ sf            1.0.14      ✔ arrow         13.0.0.1
#> ── Conflicts ─────────────────────────────────────── hydrofabric_conflicts() ──
#> ✖ arrow::buffer()    masks terra::buffer()
#> ✖ terra::intersect() masks dplyr::intersect()
#> ✖ glue::trim()       masks terra::trim()
#> ✖ terra::union()     masks dplyr::union()
```

https://github.com/NOAA-OWP/hydrofabric/wiki/Data-Access-Patterns

Subsetting Tools

Subsets by:

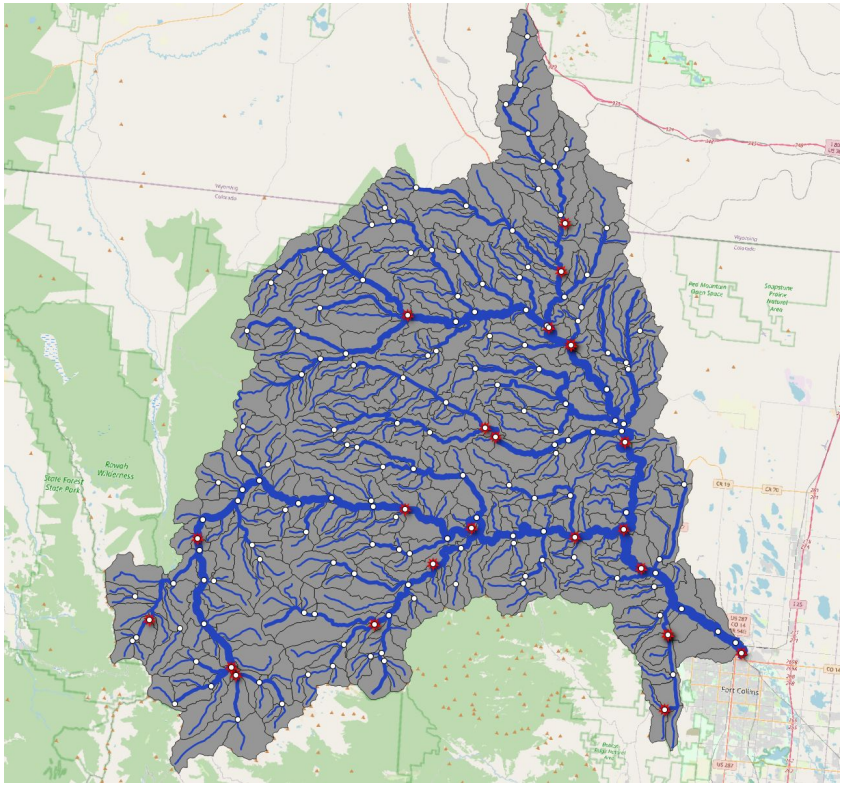
- Hydrolocation
- NLDI feature
- XY
- COMID
- ID/divide_id

Filtering Options:

- Bounding Box
- Shapefile Mask
- Path Length
- Mainstem Path Length
- Upstream Area

Methods:

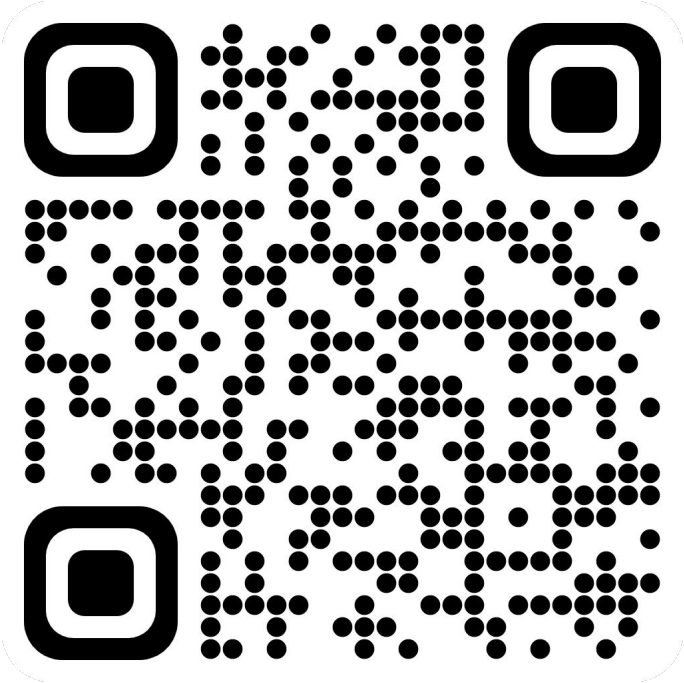
- R utility
- CLI
- Beta QGIS option



CAMELS

> At 516 CAMELS basins we used these tools to provide a fully reproducible set of basins with incremental and total basin hydroAtlas attributes.

Resources



Key Collaborators

Core Developers
- **David Blodgett** (USGS)
- **Andy Bock** (USGS)

NOAA Support
- **Trey Flowers** (NOAA/NWS OWP)
- **Fred Ogden** (NOAA/NWS OWP)
- **Fernando Salas** (NOAA/NWS OWP)

Cloud Support
- **Zac Wills** (Lynker)

Use Case Development
- **Ahmad Jan** (NOAA/NWS OWP, Lynker)
- **Jason Ducker** (NOAA/NWS OWP, Lynker)
- **Nels Frasier** (NOAA/NWS OWP, Lynker)
- **Bobby Bartel** (NOAA/NWS OWP, Lynker)
- **Austin Raney** (NOAA/NWS OWP, Lynker)
- **Justin Singh** (NOAA/NWS OWP, Lynker)
- **Zahra Ghahremani** (Boise State, Lynker)
- **Sagy Cohen** (U. Alabama, CIROH)
- **Alemayehu Midekisa** (U. Alabama, CIROH)
- **Belize Lane** (Utah State)

Thank You!

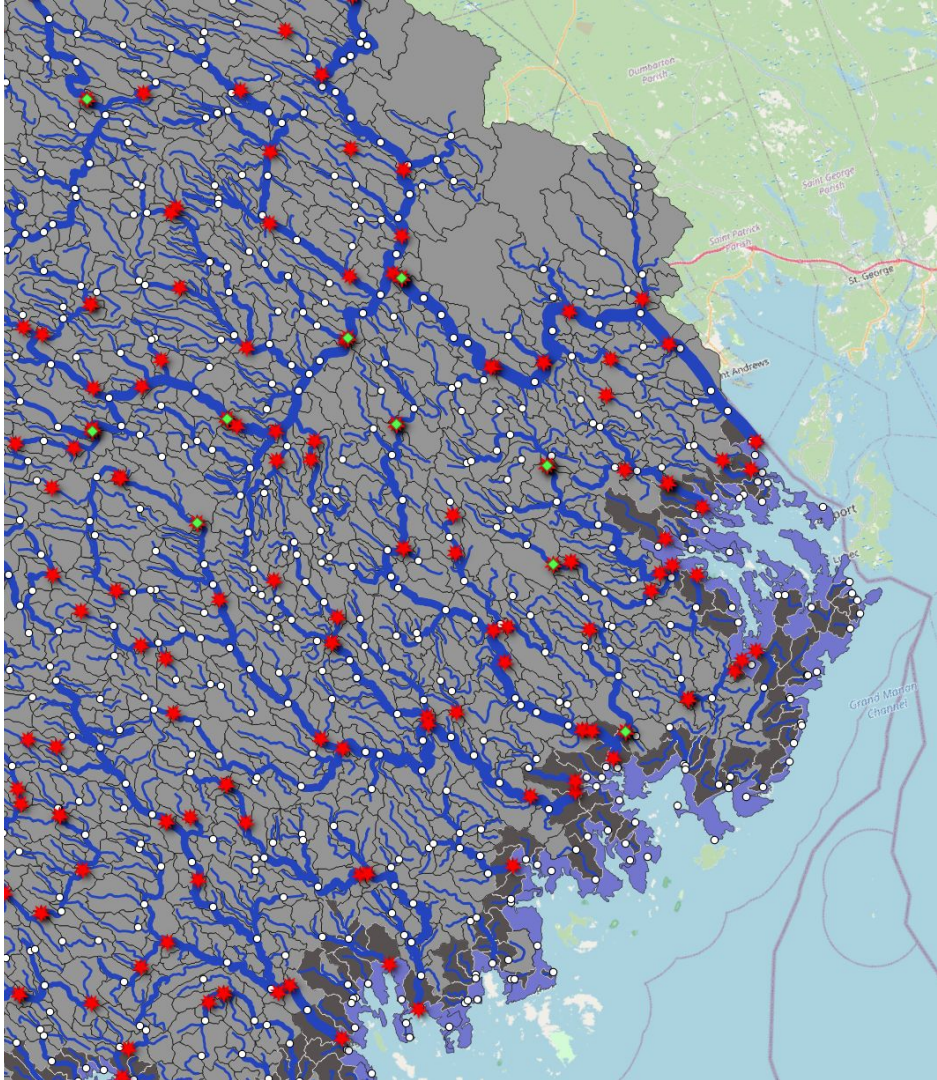
OWP | OFFICE OF WATER PREDICTION

mike.johnson@noaa.gov

https://water.noaa.gov

Cartography

- With any hydrofabric geopackage a set of QML files are used by default
- Fully customizable!
- Consistent cartography
- **Hydrofabrics should “Look and feel the same”**



Baseline CONUS wide Terrain Cross Sections

https://mikejohnson51.github.io/hydrofabric3D/

First baseline run took:

- **5 hours on personal computer**
  - **Using 10 transects per flowpath**
  - **A 10 meter DEM**
  - **ML Depths ONLY**
  - **Riparian zone based top-widths**
- **All are parameters in the generation workflows**

And Generated:

- **7,371,414** transects
- **76,977,094** samples points
- A **1.7 GB** cloud-native parquet file

Machine Learning for Synthetic Channel Shape

https://noaa-owp.github.io/hydrofabric/articles/07-channel-geometry.html

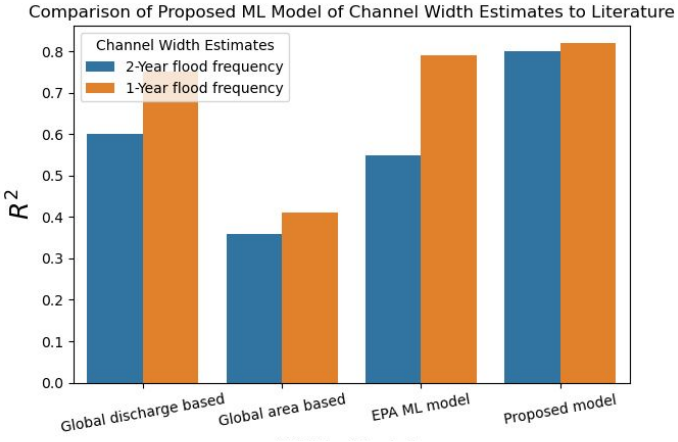
Build from reference hydrofabric

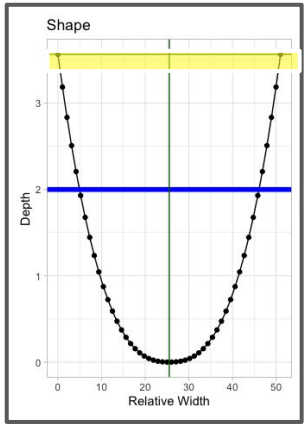
ML inputs:

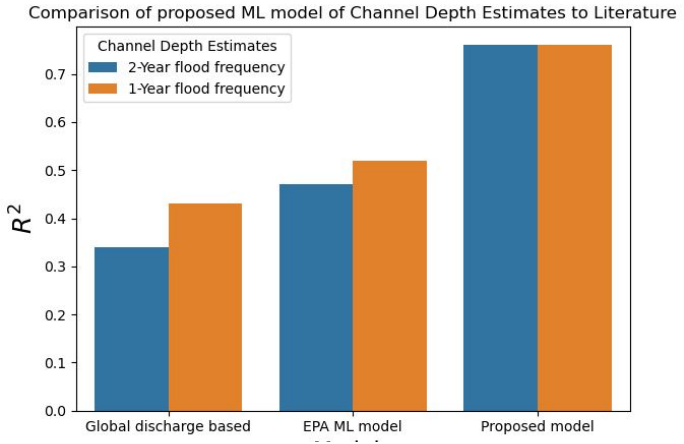
- Hydrographic network characteristics
- NWM 2.1 Flow characteristics
- EPA StreamCat characteristics
- TerraClimate
- Duke POLARIS soil data

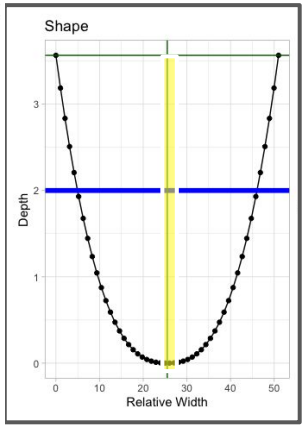
ML outputs:

- Channel Shape (Dingman's R)
- Channel Depth (bankfull)
- Channel Width (bankfull)
- Roughness (Manning's)









Collection of RAS and eHydro Data

HEC-RAS

> 10,520 models

> 78,847 individual objects

> 2.54 GB file/directory

eHydro

> ~100,000 models

> Rectified datum and data extraction

> 1.5 GB file/directory

Full substitutable at the define transects indexed to the reference hydrofabric

FAIR Data

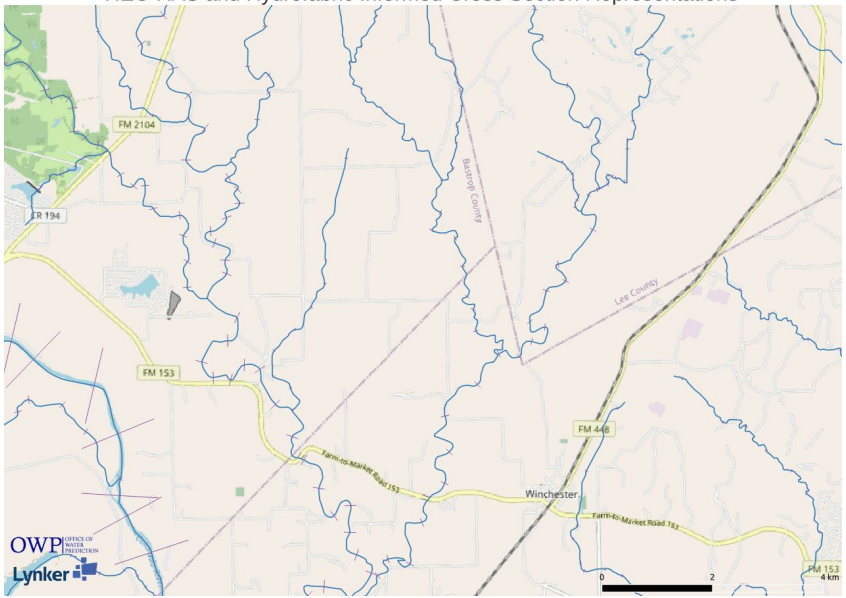
Findadable - mainstem or ID

Accessible via egress free s3

Interoperable with baseline data

Reusable for all efforts aligned to the enterprise effort

HEC-RAS and Hydrofabric Informed Cross Section Representations



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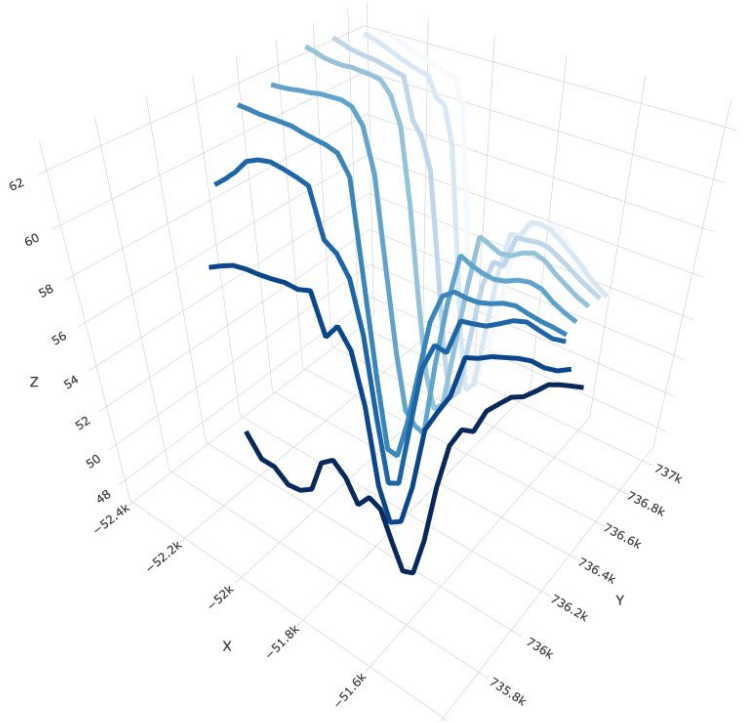
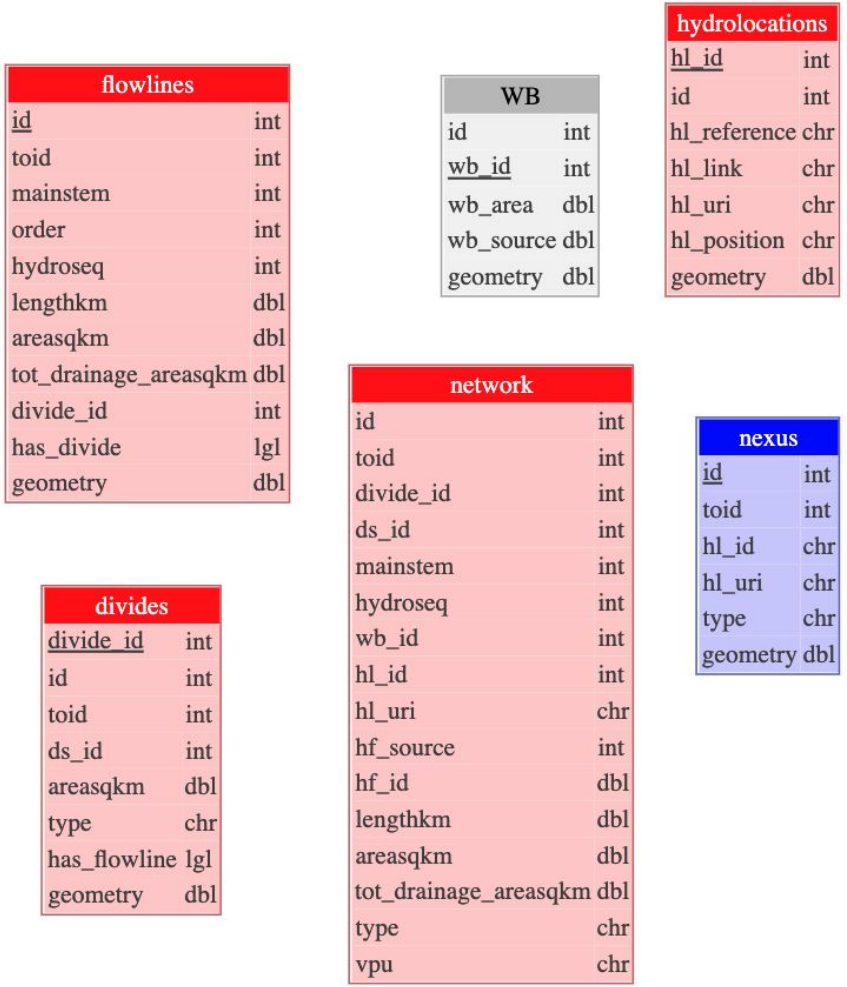


Cross section point cloud extracted from parquet files for the reach upstream of a gage. This cross section was built using a 10m cloud-based DEM (3DEP), and ML base hydraulic geometry. A monotonically decreasing depth is enforced.

The Data Model

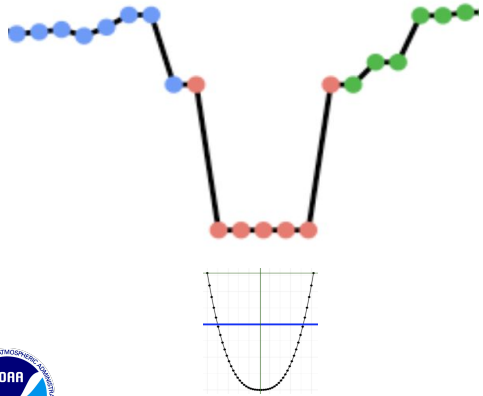
- Very similar to the new 3DHP spec with a slight bend towards modeling
- Vetted across the engaged NOAA and USGS modeling efforts
- Basis for interoperability (and all components of FAIR data)



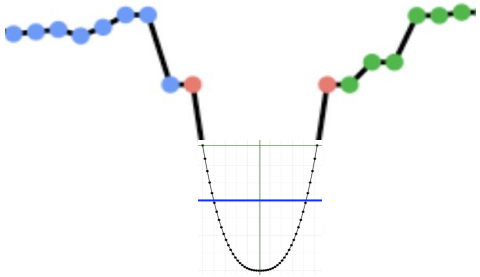
Terrain + Synthetic Channel Shape

Ongoing work is **refining and aligning these efforts** to provide integrated above and below waters cross sections everywhere in the domain

(A) OR



(B) OR



(C)