

The background of the slide is a high-speed photograph of water splashing, creating a dynamic and textured blue surface with many small droplets and bubbles.

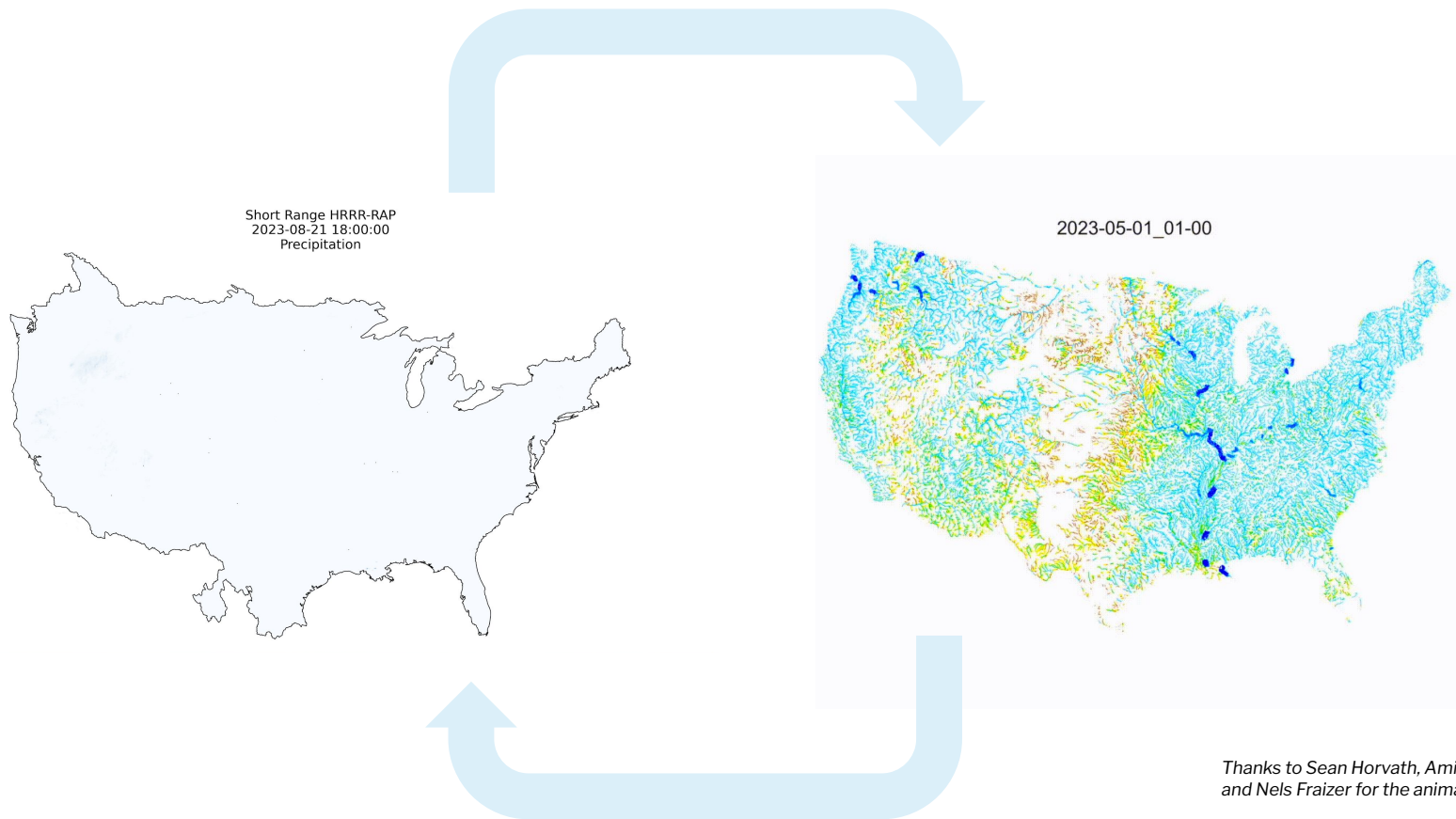
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Current State of the NOAA Next Generation Water Prediction Enterprise Hydrofabric System

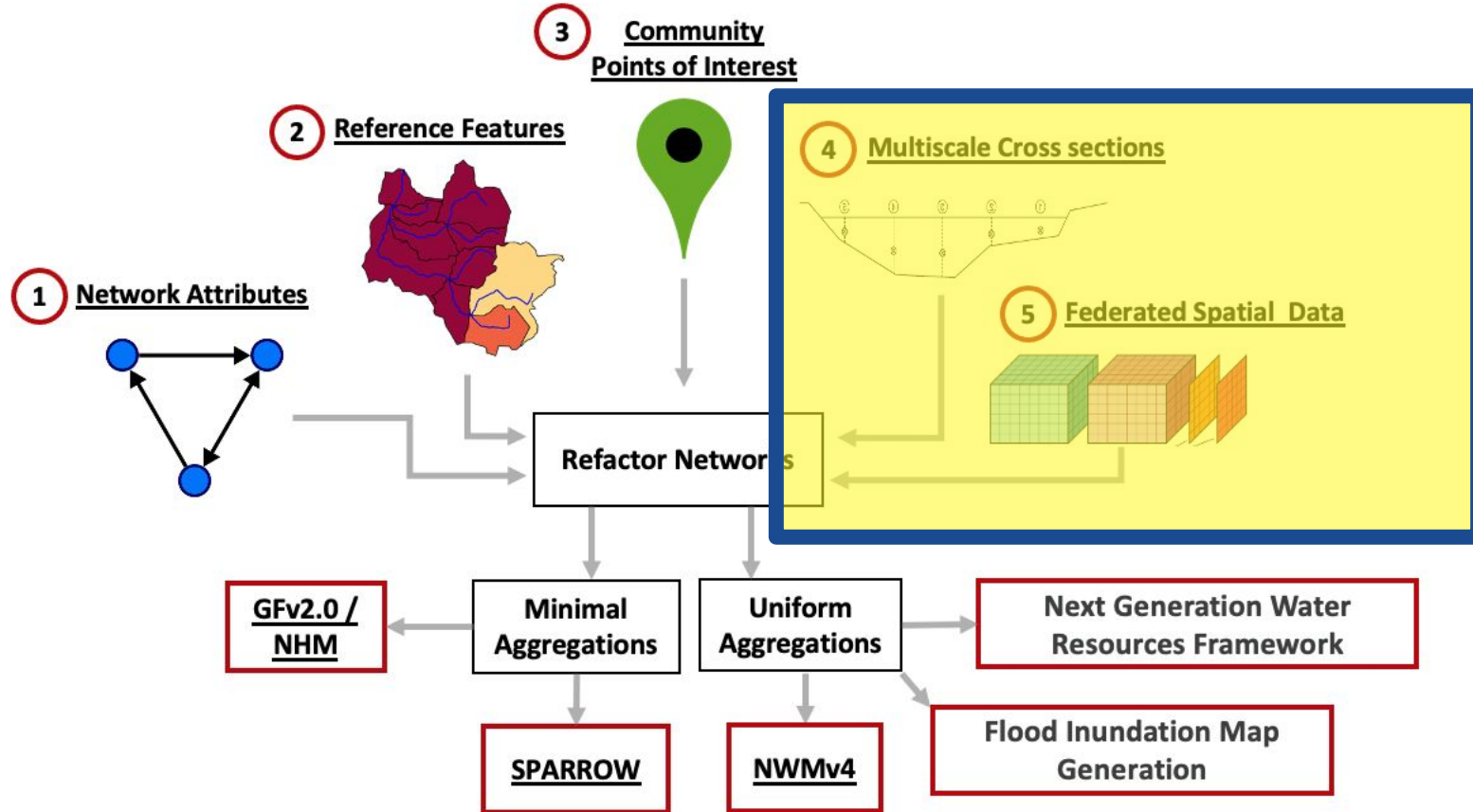
J Michael Johnson, Arash Modaresi Rad, Angus
Watters, Jim Coll, Dami Eyelade, Justin Singh



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



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

People also ask

What is 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.



GitHub

<https://mikejohnson51.github.io/hyAggregate>

NextGen Hydrofabric - Mike Johnson

Search for: What is Hydrofabric?

What is the national water model?

The National Water Model (NWM) is a hydrologic high resolution model that has the ability to forecast and simulate the rivers and streams flows throughout the entire United States territory.



The Current Coverage

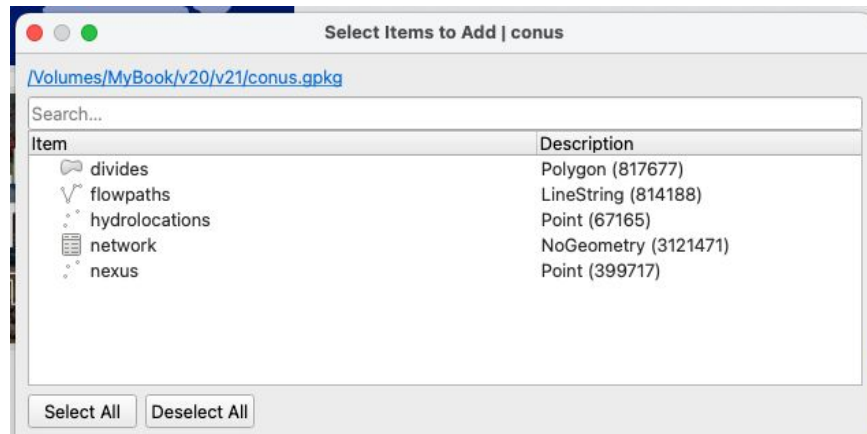
Version 2.0 was released in October

- 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



https://www.lynker-spatial.com/#v20/

Lynker An Employee-Owned Company lynker-spatial / v20

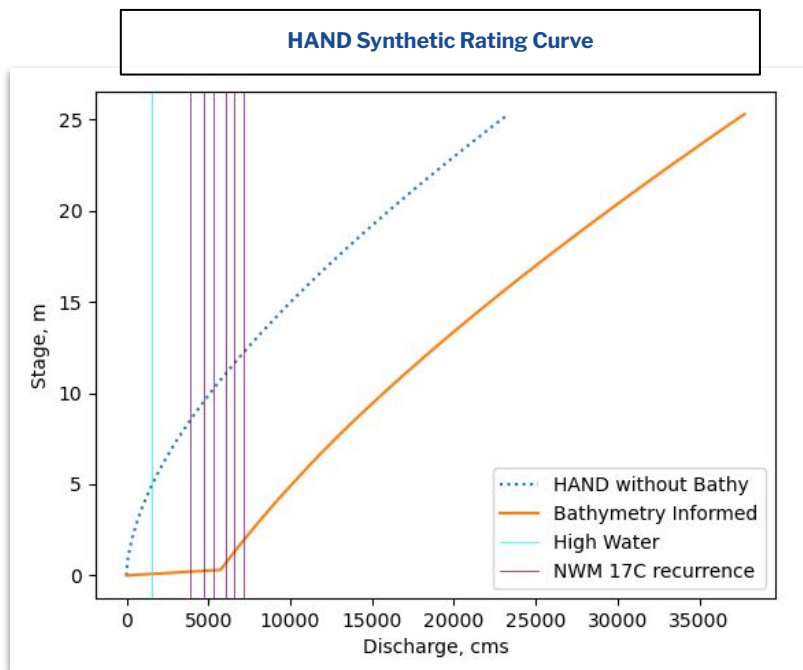
Show 50 entries

Object
3D/
fgb/
gpkg/
model_attributes/
conus.gpkg
conus_model_attributes.parquet
conus_net.parquet

Showing 1 to 7 of 7 entries

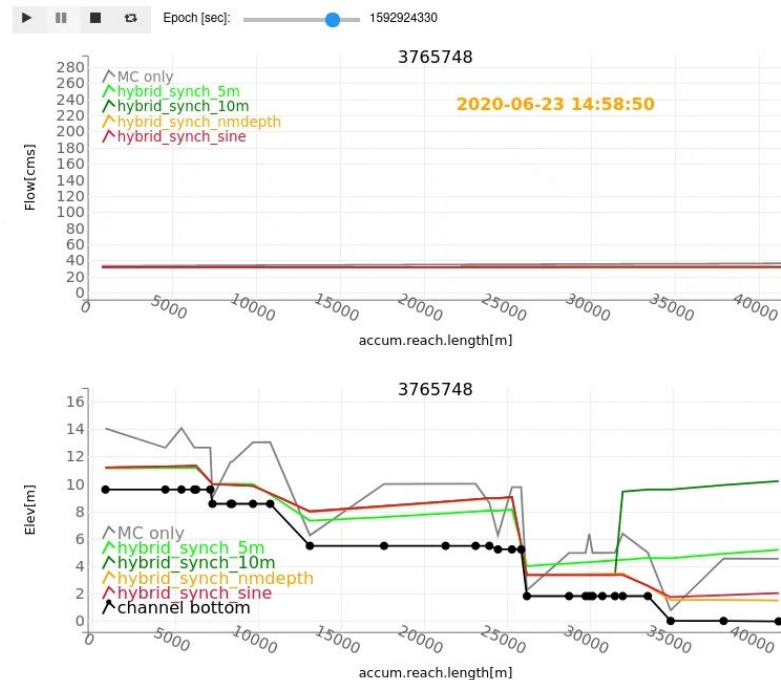
Need(s) for River Corridor Representation

Flood Inundation Mapping



Thanks to the Flood Inundation Mapping team for the image.

Routing

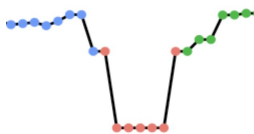


Thanks to DongHa Kim and the inland routing team for the animation.

Heterogeneous Data Sources to meet applications needs

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

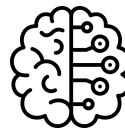
Digital Elevation Models



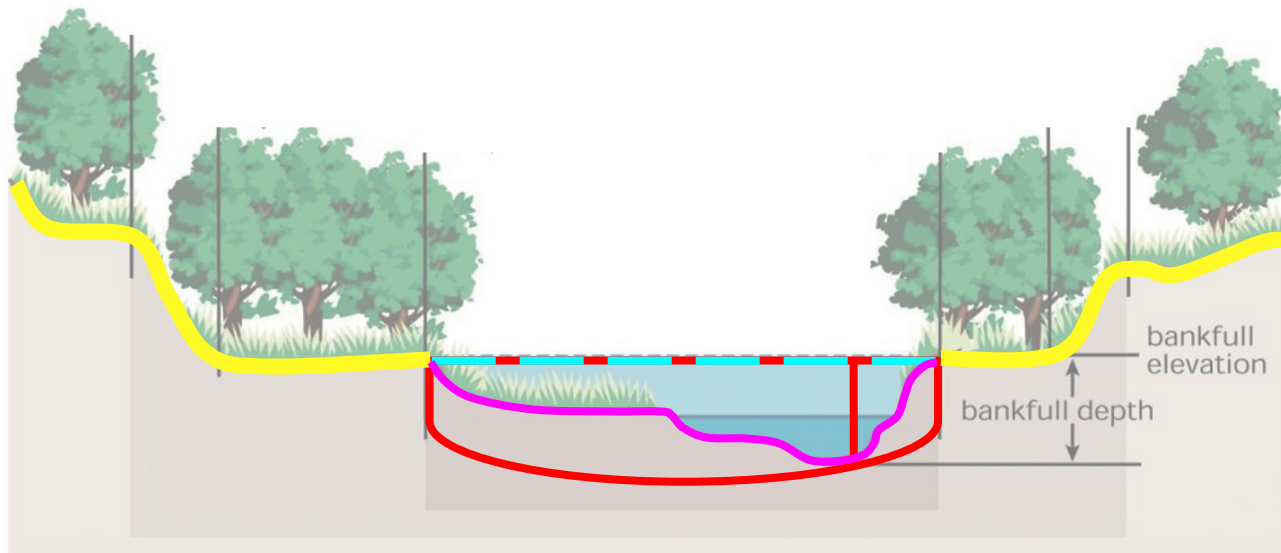
Data Fusion



Machine Learning



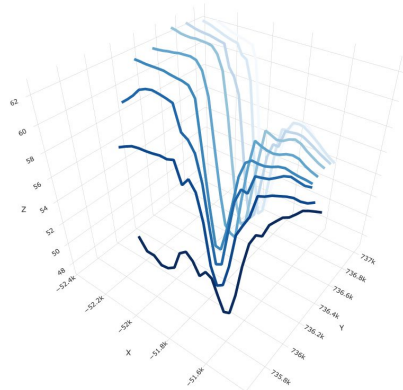
Surveys



Results to date

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

Digital Elevation Models

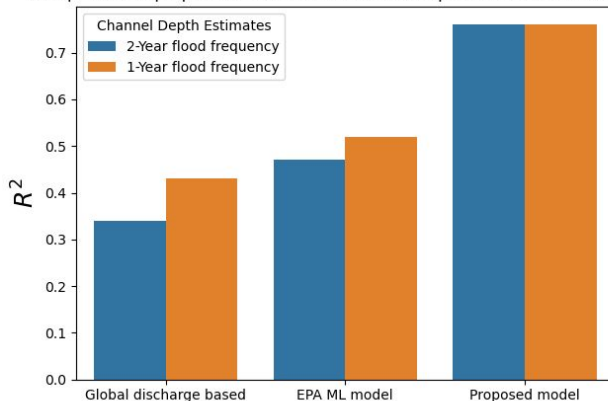


CONUS wide DEM transects

- > 10 transects/flowpath
- > A 10 meter DEM
- > A 1.7 GB cloud-native file

Machine Learning

Comparison of proposed ML model of Channel Depth Estimates to Literature

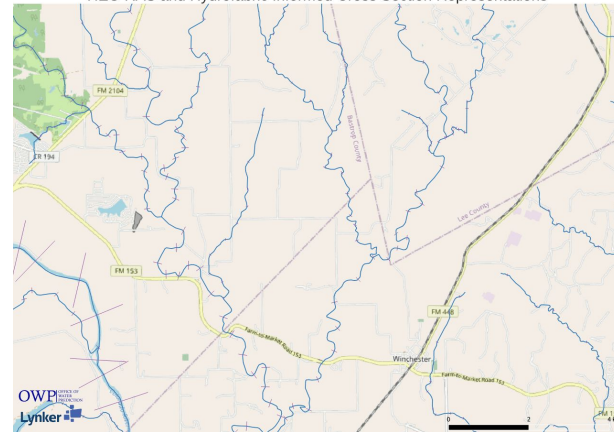


CONUS wide channel width & depth

- > ~Estimated for ~2.7 million reference reaches
- > Higher accuracy than predecessors

Surveys

HEC-RAS and Hydrofabric Informed Cross Section Representations



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 available to the community as a cloud resource¹.

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 similar 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:

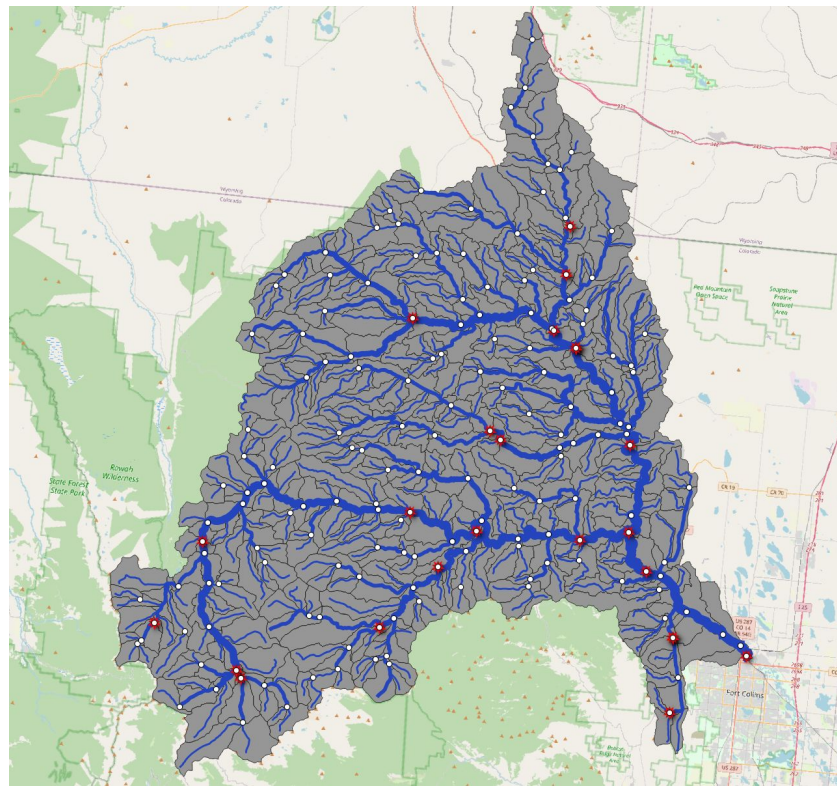
- Hydrolocation
- NLDI feature
- XY
- COMID
- ID/divide_id

Filtering Options:

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

Methods:

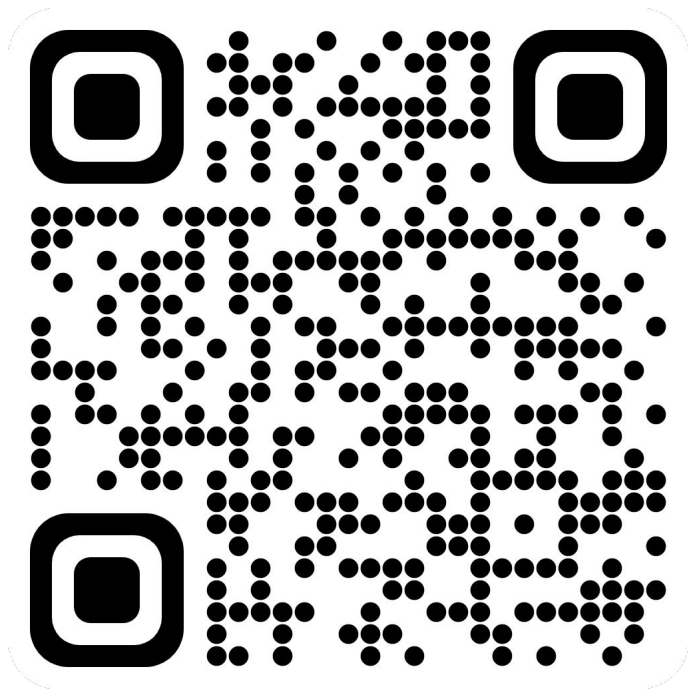
- R utility
- CLI
- Beta QGIS option



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)



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Thank You!



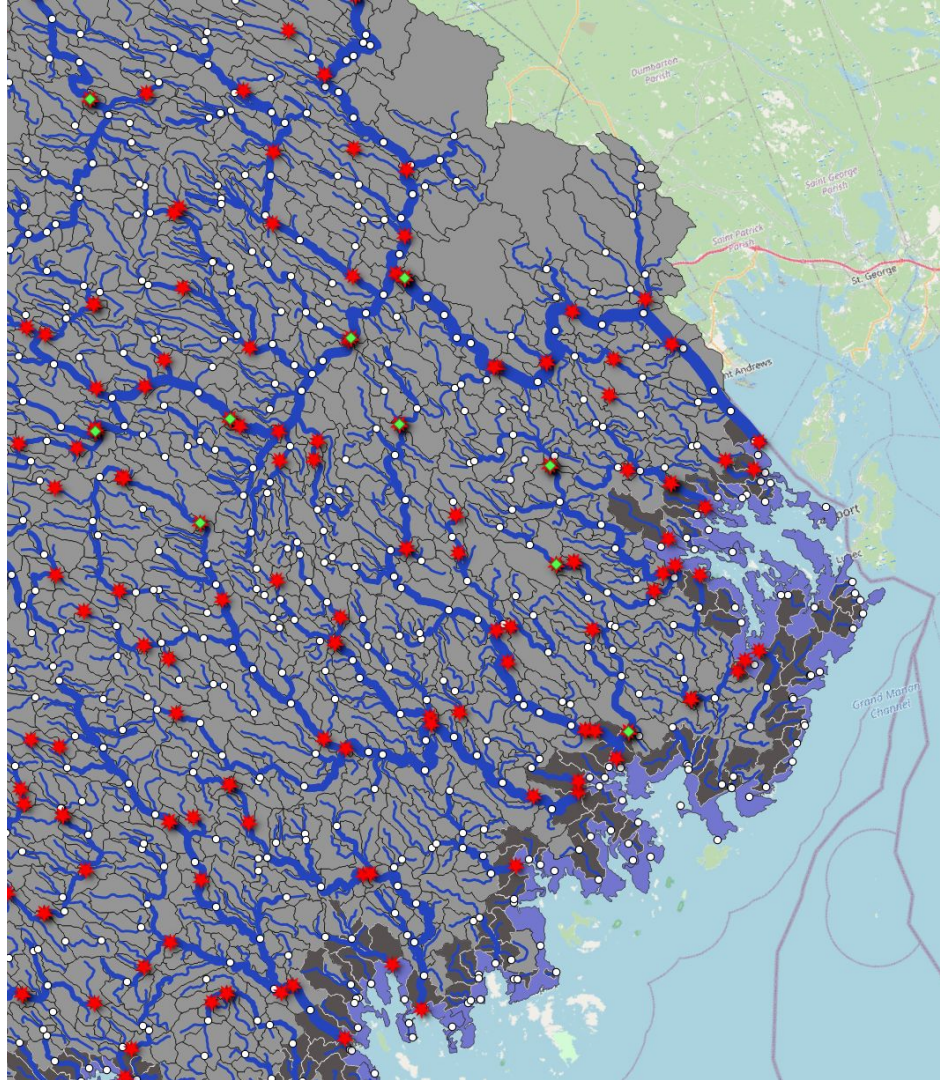
mike.johnson@noaa.gov



<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:

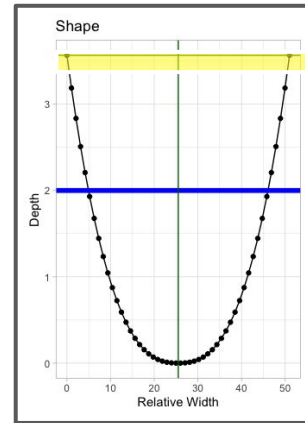
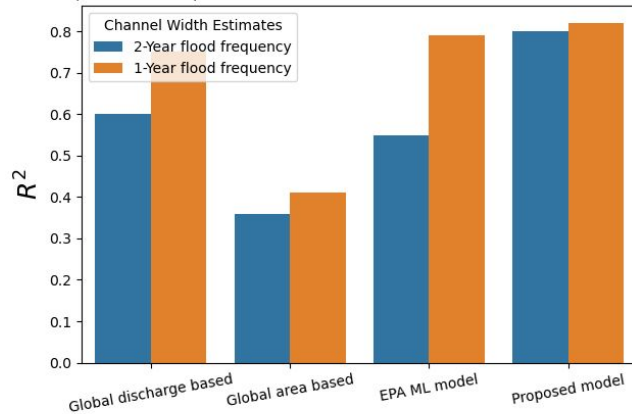
- Hydrographic network characteristics
- NWM 2.1 Flow characteristics
- EPA StreamCat characteristics
- TerraClimate
- Duke POLARIS soil data

ML outputs:

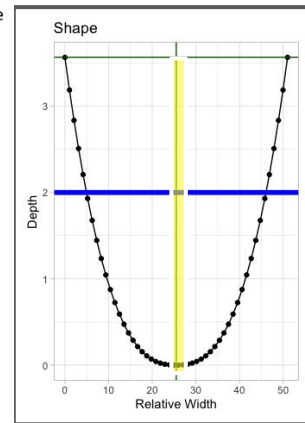
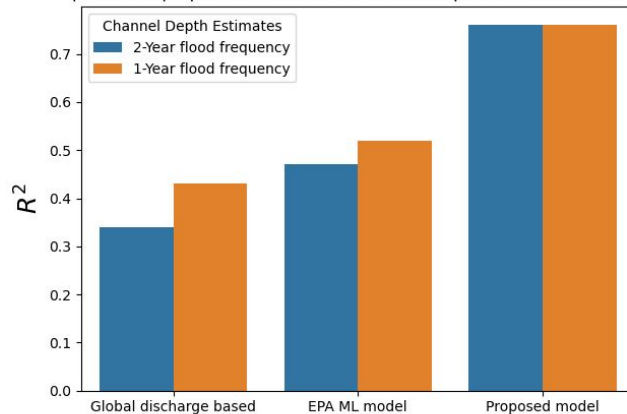
- Channel Shape (Dingman's R)
- Channel Depth (bankfull)
- Channel Width (bankfull)
- Roughness (Manning's)



Comparison of Proposed ML Model of Channel Width Estimates to Literature



Comparison of proposed ML model of Channel Depth Estimates to Literature



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

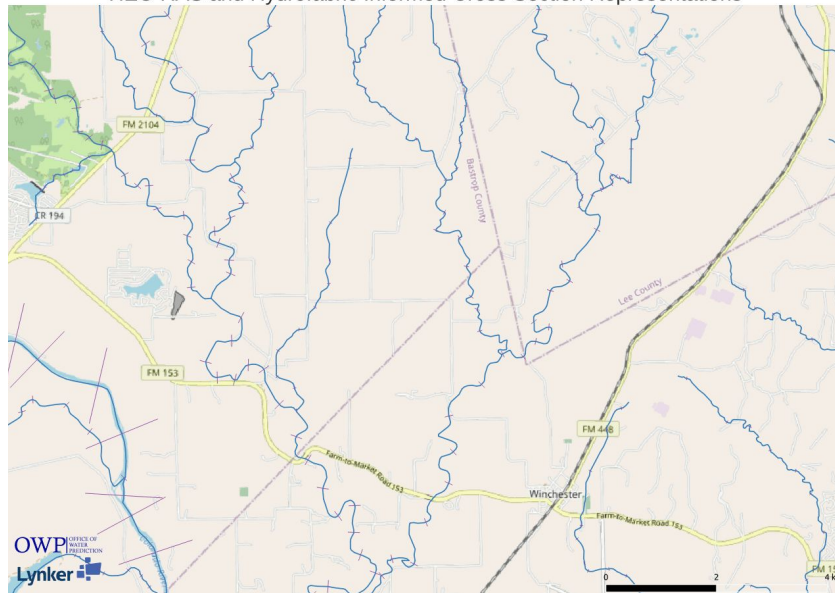
Findable - mainstem or ID

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



Baseline CONUS wide Terrain Cross Sections

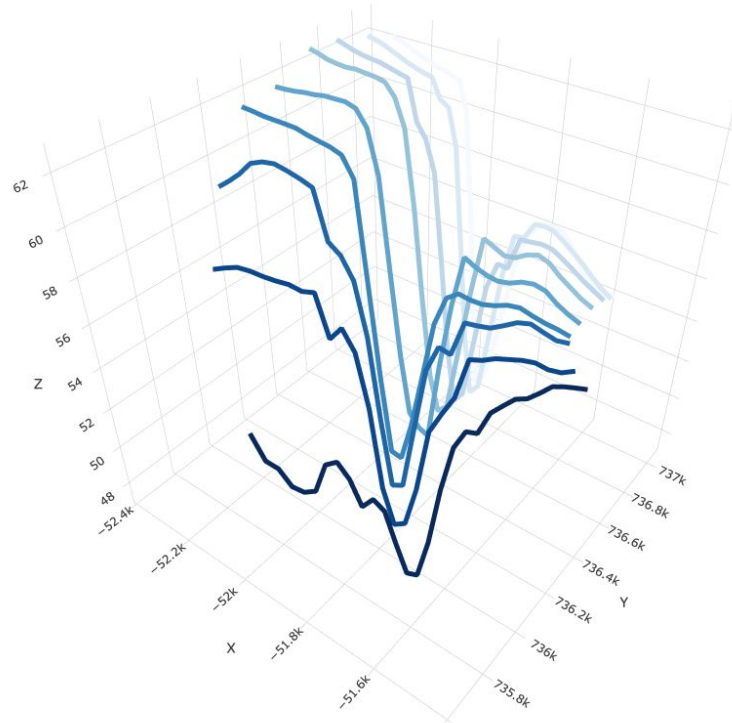
<https://mikejohnson51.github.io/hydrofabric3D/>

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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)

flowlines	
<u>id</u>	int
toid	int
mainstem	int
order	int
hydroseq	int
lengthkm	dbl
areasqkm	dbl
tot_drainage_areasqkm	dbl
divide_id	int
has_divide	lgl
geometry	dbl

divides	
<u>divide_id</u>	int
id	int
toid	int
ds_id	int
areasqkm	dbl
type	chr
has_flowline	lgl
geometry	dbl

WB	
id	int
<u>wb_id</u>	int
wb_area	dbl
wb_source	dbl
geometry	dbl

network	
id	int
toid	int
divide_id	int
ds_id	int
mainstem	int
hydroseq	int
wb_id	int
hl_id	int
hl_uri	chr
hf_source	int
hf_id	dbl
lengthkm	dbl
areasqkm	dbl
tot_drainage_areasqkm	dbl
type	chr
vpu	chr

hydrolocations	
<u>hl_id</u>	int
id	int
hl_reference	chr
hl_link	chr
hl_uri	chr
hl_position	chr
geometry	dbl

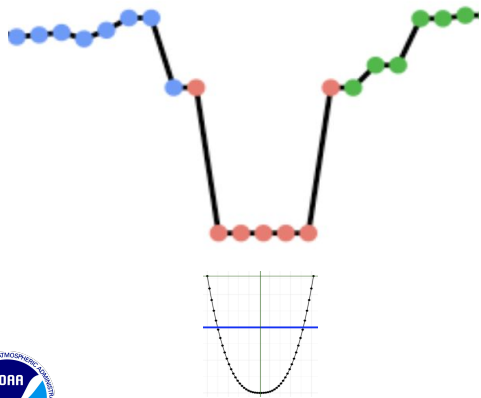
nexus	
<u>id</u>	int
toid	int
hl_id	chr
hl_uri	chr
type	chr
geometry	dbl

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

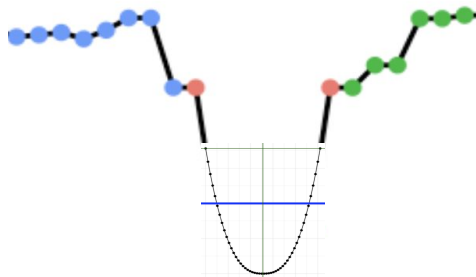
(A)

OR



(B)

OR



(C)

