



HydroVIS - Providing a Cloud Based Framework for Processing and Synthesizing Large Scale Model Outputs into Actionable Intelligence

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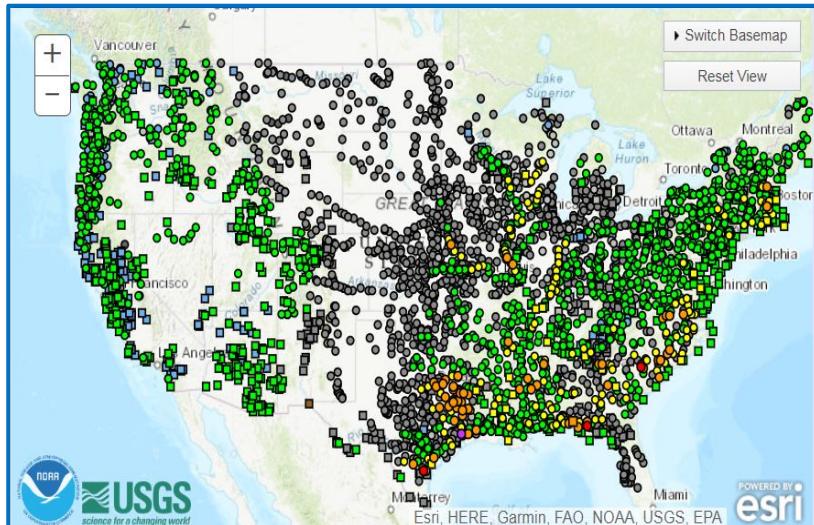


² NOAA Federal, Geospatial Intelligence Division, Office of Water Prediction, National Water Center, Tuscaloosa, AL.

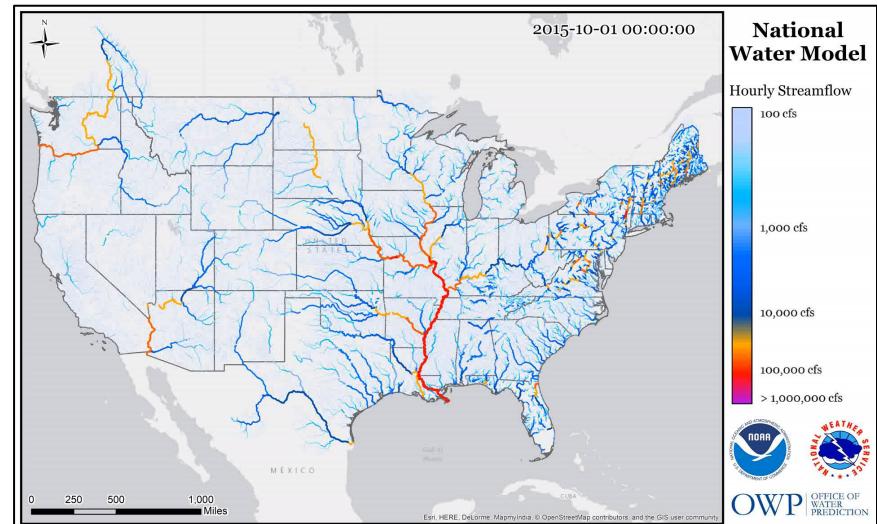
¹ NOAA Affiliate, Lynker, Geospatial Intelligence Division, Office of Water Prediction, National Water Center, Tuscaloosa, AL.

National Water Model Overview

- The NWM revolutionizes how hydrologic guidance is developed and delivered, providing both complementary and first-time coverage and outputs
- Most recent NWM upgrade, v2.1 in April 2021



RFC AHPS ~3,600 Points



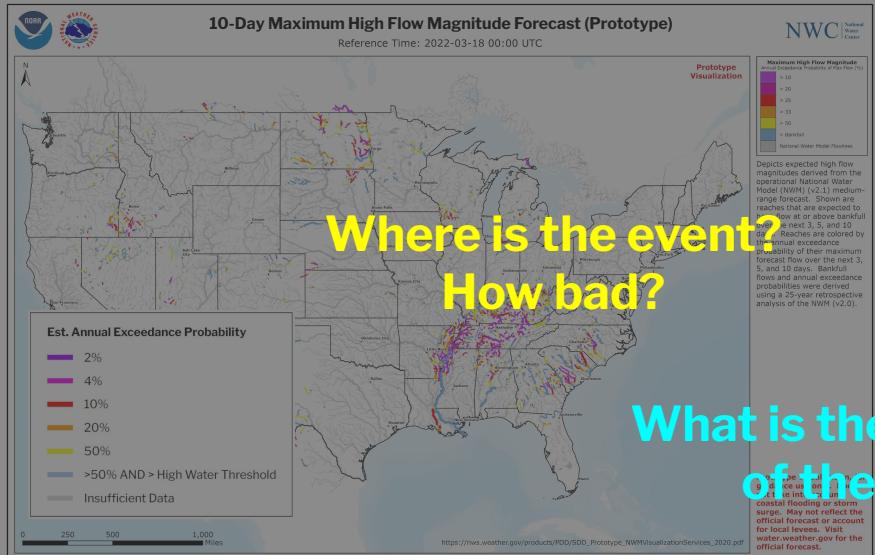
NWM 2.7 Million River Segments

National Water Model Outputs

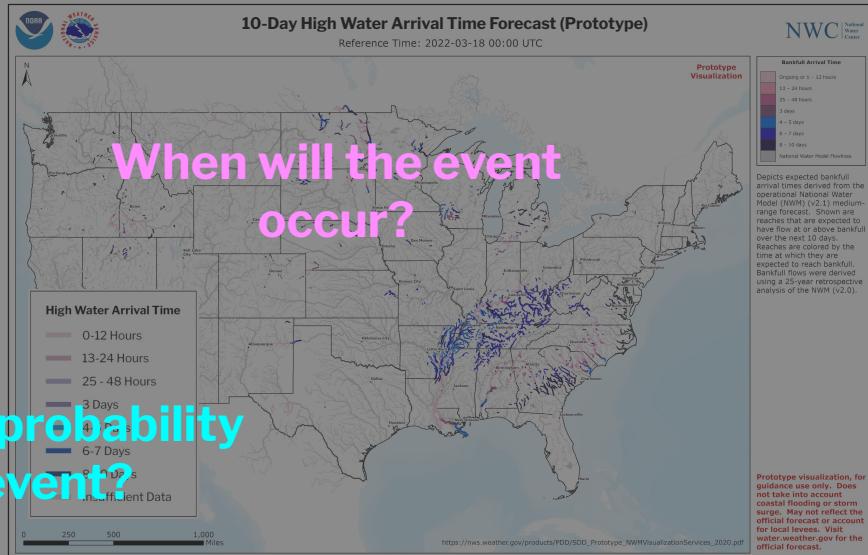
NWM Configuration	Ensembles	Timesteps	Daily Runs	Total Daily Timesteps	Total Daily Precipitation Rasters	Total Features
Analysis and Assimilation	1	1	24	24	576	66,641,712
Short Range	1	18	24	432	186,624	1,199,550,816
Medium Range	7	240/204	6	8784	12,859,776	24,390,866,592

In a single day, the NWM produces **~25.7 billion data points and ~12.9 million gridded datasets for CONUS** that we are interested in processing. In total, we receive about **.5 TB per day** of NWM data

Synthesizing National Water Model Output



10-Day High Flow Magnitude



10-Day High Water Arrival Time

Experimental NWC Visualization Services

Reference Services

RFC Services

- AHPS Max Stage
- RFC Routed Streamflow

NWM High Water Services

- High Flow Magnitude Services
- High Water Arrival Time Services
- High Water Probability Services

NWM Rapid Onset Flooding Services

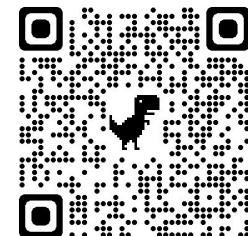
- Rapid Onset Flooding Services
- Rapid Onset Flooding Probability Services

Domains

- CONUS
- Hawaii
- Puerto Rico and U.S. Virgin Islands

Configurations

- Past AnA (14-Day)
- AnA (Nowcast)
- SRF (18-Hour)
- MRF (3, 5 and 10-Day)

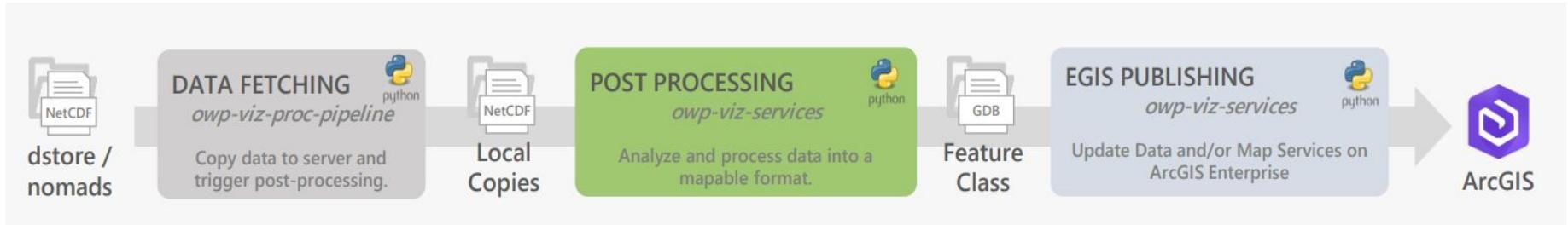


Can be found at <https://maps.water.noaa.gov/server/rest/>



On Premises Visualization Processing

- Custom python software developed in house
- Watches, fetches, processes, and publishes data
- File based
- Running on Windows VM
- Limited by VM size and capacity
- Ran at specific time intervals



HydroVIS, Moving to the Cloud



S3: Store NWM, RFC forecasts and FIM input and output.



Lambda: Ingest datasets into RDS. Manages SQL commands. Publishes map.



SNS: Event notification when data arrives.



RDS: Postgres (PostGIS enabled) DB analyzes and hosts data for maps

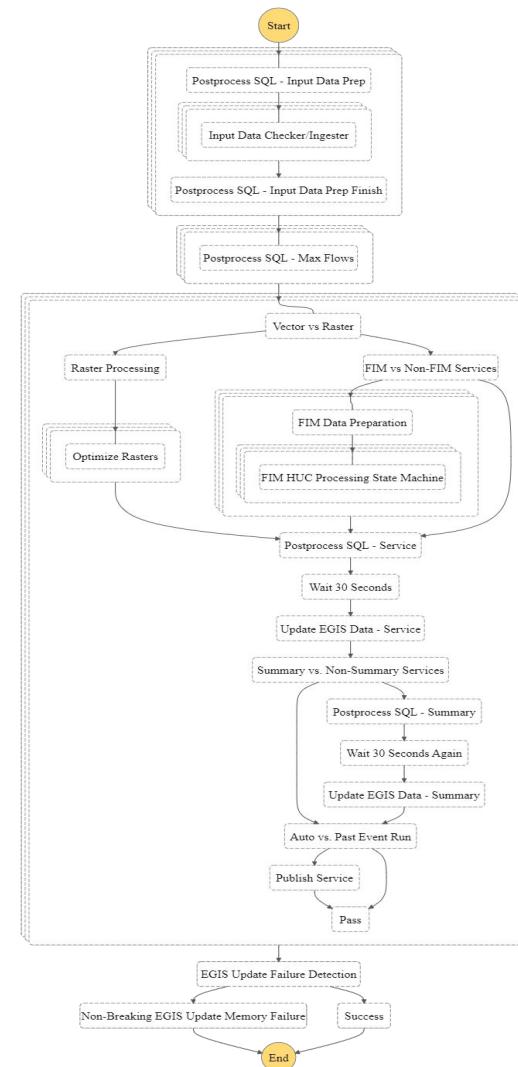


Step Functions:

Orchestrates data ingest, processing, and publishing between AWS services



EC2: Host ESRI EGIS dissemination platform

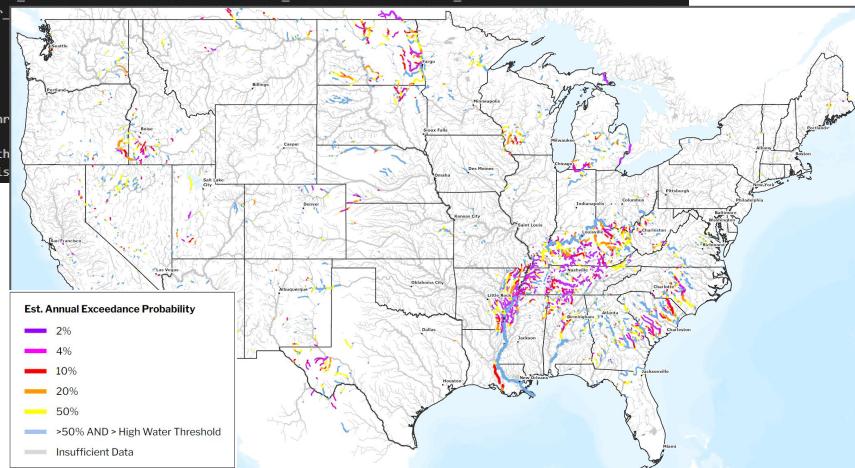


DB Based Visualization Services

Generic Pipeline Steps *NWM Example*

1. NWM Configuration Added to S3 Bucket
2. All Configuration Files Ingested to DB
3. For Each Service in Configuration:
 - a. {parent}.sql executed (if applicable)
 - b. {service}.sql executed
 - c. {final}.sql executed (if applicable)
 - d. Service Published/Updated on EGIS

```
WITH high_flow_mag AS (
  SELECT
    maxflows.feature_id,
    maxflows.maxflow_18hour AS max_flow,
    CASE
      WHEN maxflows.maxflow_18hour >= thresholds.rf_50_0_17c THEN '2%':text
      WHEN maxflows.maxflow_18hour >= thresholds.rf_25_0_17c THEN '4%':text
      WHEN maxflows.maxflow_18hour >= thresholds.rf_10_0_17c THEN '10%':text
      WHEN maxflows.maxflow_18hour >= thresholds.rf_5_0_17c THEN '20%':text
      WHEN maxflows.maxflow_18hour >= thresholds.rf_2_0_17c THEN '50%':text
      WHEN maxflows.maxflow_18hour >= thresholds.high_water_threshold THEN '>50%':text
      ELSE NULL::text
    END AS recur_cat,
    thresholds.high_water_threshold AS high_water_threshold
  FROM cache.max_flows_srf maxflows
  JOIN derived.recurrence_flow_conus thresholds ON maxflows.feature_id = thresholds.feature_id
  WHERE thresholds.high_water_
)
SELECT
  channels.feature_id,
  high_flow_mag.max_flow,
  high_flow_mag.recur_cat,
  high_flow_mag.high_water_thr,
  channels.geom
FROM derived.channels_conus ch
JOIN high_flow_mag ON channels
```

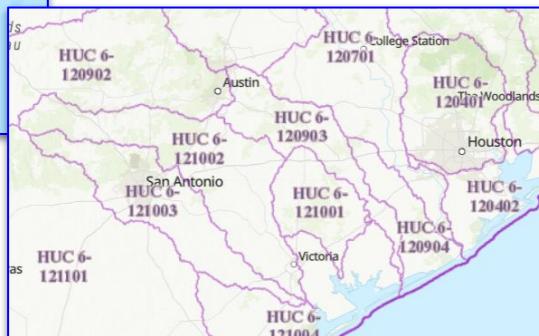


Forecast Flood Inundation Mapping (FIM) Services



2188 HUC8 Units

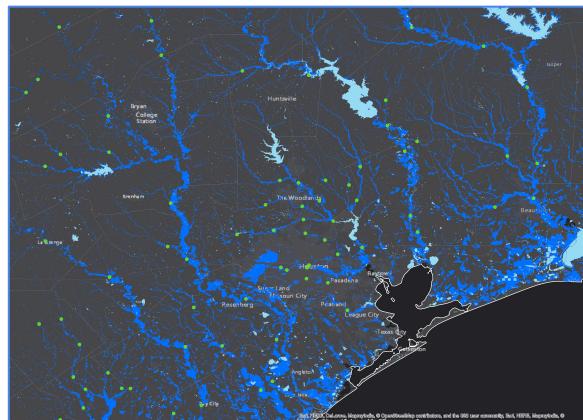
HUC8 units provided by
USGS Watershed Boundary
Dataset (WBD)



~ 1,350 sq. mi. / HUC8 Unit

HAND Flood Inundation Maps are generated by local raster computation and only where high water is forecast

**~ 3,000 hucs per hour
~ 93,000 hucs per day**



**HAND rasters and Rating Curves
stored by HUC8 unit**

Step Functions and Lambdas - Parallelization on Steroids

Step 1 (**Lambda**):

- Determine the HUC8s that need processing.
- Write out streamflow data into HUC8 streamflow files.
- Split HUC8 array into 10 nested arrays.



FIM Data Preparation

1 Process

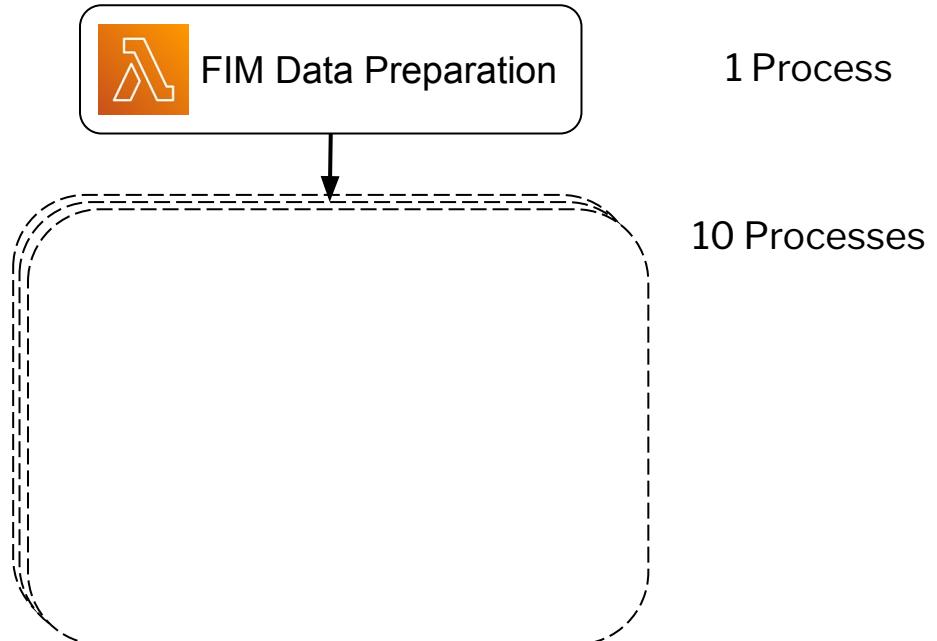
1 Total Process Currently

Step Functions and Lambdas - Parallelization on Steroids

Step 2 (**Step Function Map**):

- Dynamically distribute and monitor the 10 nested arrays into their own process

10 Total Processes Currently

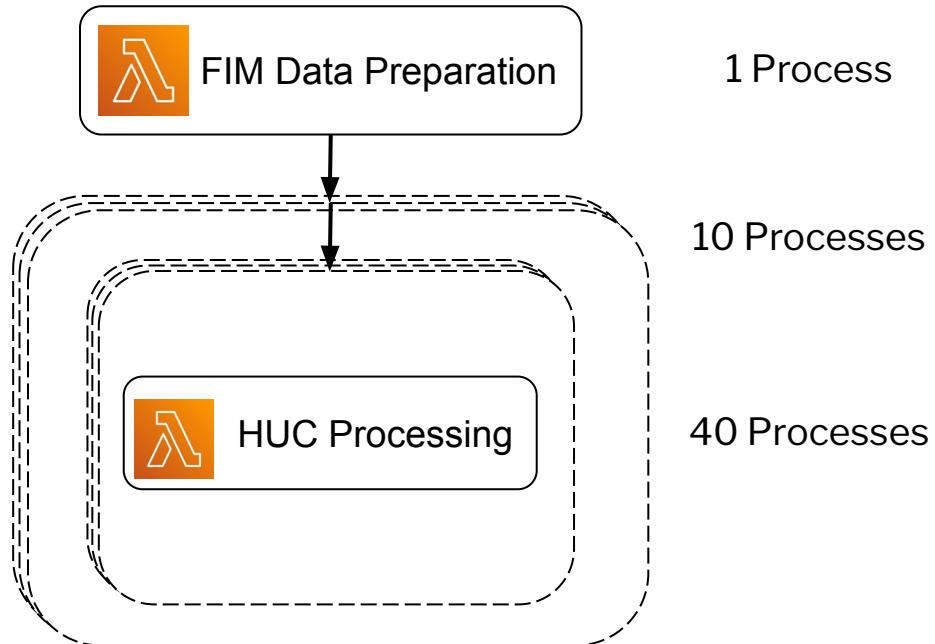


Step Functions and Lambdas - Parallelization on Steroids

Step 3 (Nested Step Function Map):

- Dynamically distribute and monitor 40 HUC8 processing lambdas at a time

400 Total Processes Currently



Step Functions and Lambdas - Parallelization on Steroids

FIM Processing		Map	Succeeded	-	00:05:18.652	Status	Succeeded	Type
	#0	MapIteration	Succeeded	-	00:05:18.652			
FIM Data Preparation		Task	Succeeded	Lambda	I...	Started After 00:05:10.444	Duration 00:00:20.914	
HUC Processing Map		Map	Succeeded	-	00:02:29.739			
		#0	MapIteration	Succeeded	-	Total 10	Not started 0	
		#1	MapIteration	Succeeded	-	Failed 0	Succeeded 10	
		#2	MapIteration	Succeeded	-	In progress 0	Aborted 0	
		#3	MapIteration	Succeeded	-			
		#4	MapIteration	Succeeded	-			
		#5	MapIteration	Succeeded	-			
		#6	MapIteration	Succeeded	-			
		#7	MapIteration	Succeeded	-			
		#8	MapIteration	Succeeded	-			
		#9	MapIteration	Succeeded	-			
					00:00:20.914			

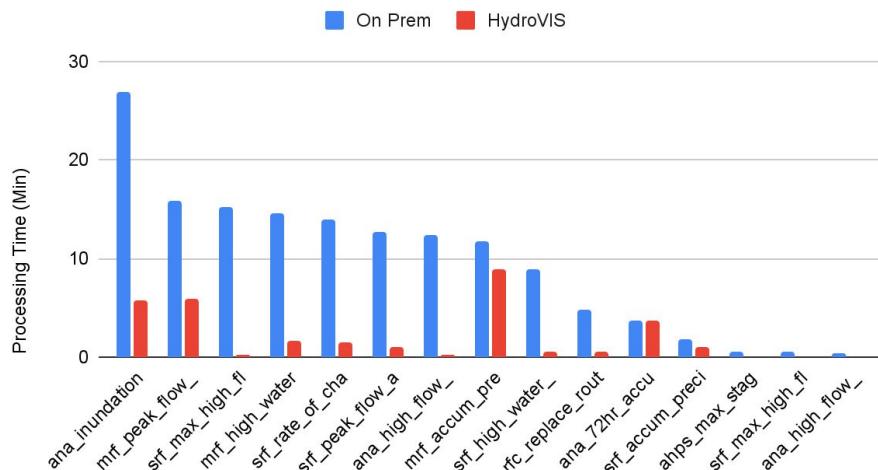
Outer Map Iterator

HUC 8 Map		Map	Succeeded	-	00:00:17.906	Status	Succeeded	Type
	#0	MapIteration	Succeeded	-	00:00:02.393			
	#1	MapIteration	Succeeded	-	00:00:06.91			
	#2	MapIteration	Succeeded	-	00:00:01.920			
	#3	MapIteration	Succeeded	-	00:00:01.388			
	#4	MapIteration	Succeeded	-	00:00:07.182			
	#5	MapIteration	Succeeded	-	00:00:01.920			
	#6	MapIteration	Succeeded	-	00:00:01.920			
	#7	MapIteration	Succeeded	-	00:00:01.388			
	#8	MapIteration	Succeeded	-	00:00:04.615			
	#9	MapIteration	Succeeded	-	00:00:10.73			
	#10	MapIteration	Succeeded	-	00:00:01.920			
	#11	MapIteration	Succeeded	-	00:00:01.920			
	#12	MapIteration	Succeeded	-	00:00:09.146			

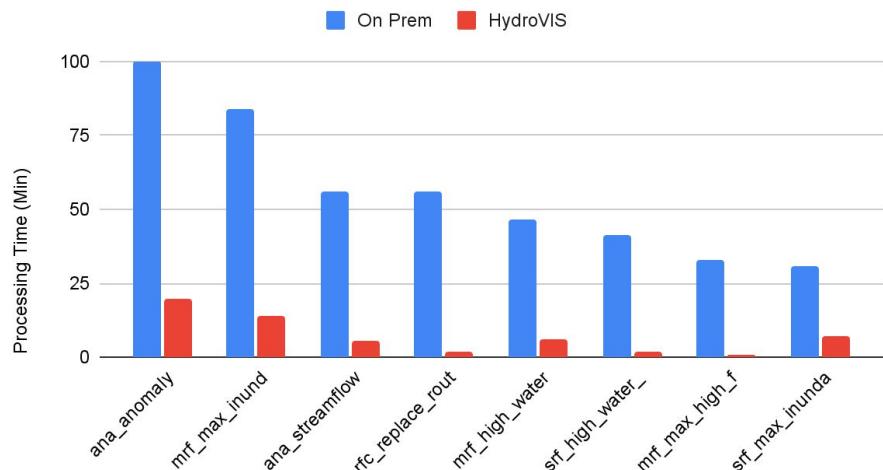
Nested Map Iterator

HydroVIS Efficiency Improvements

On Prem vs HydroVIS Processing (<= 30 minutes)



On Prem vs HydroVIS Processing (> 30 minutes)



80% decrease in processing time on average
16 x faster processing time on average
~72% code reduction





Thank You!



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<https://water.noaa.gov>

OWP | OFFICE OF
WATER
PREDICTION

