COASTAL COUPLING
COMMUNITY OF PRACTICE

ANNUAL MEETING

Coastal Coupling Community of Practice
May 23, 2023

Access to Meeting Materials
WiFi: Coastal Coupling
Password: co@$t2C0@$T!

Welcome

ED CLARK ▪ MAY 23, 2023

Director, National Water Center

Deputy Director, NOAA's Office of Water Prediction

Coastal Coupling

MARK OSLER ▪ MAY 23, 2023
Senior Advisor for Coastal Inundation and Resilience, NOAA

Advancing predictive capabilities

By enabling coastal coupling

As a community of practice


Thank you!

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FACILITATED DISCUSSION

DORI STIEFEL, PhD

Coastal Coupling Community of Practice Annual Meeting
May 23, 2023

Seasonal to Multidecadal Climate Variability, Predictability and Change

Thomas L. Delworth, Division Lead, SD Group
Presented by: Matthew Harrison,
Oceans&Cryosphere , NOAA Geophysical Fluid Dynamics Laboratory

Coastal Coupling Community of Practice Meeting
May 23, 2023

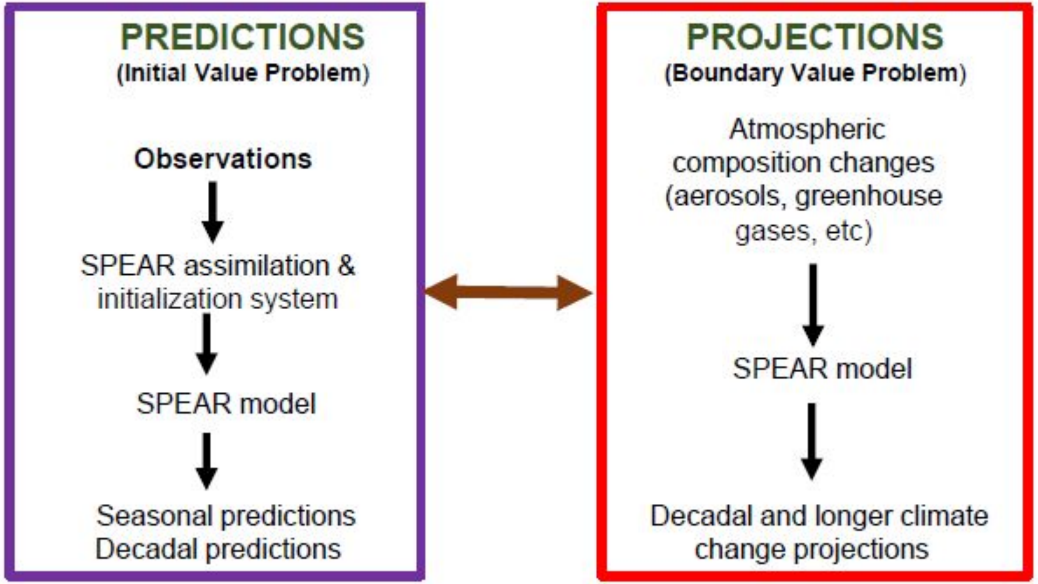
SPEAR Seasonal to Multi-decadal Prediction and Predictability

Improve understanding of phenomena on seasonal to multidecadal time scales leading to …

development of leading edge computer models and prediction/projection systems resulting in …

improved "seamless" predictions and projections.

- **Predictions**: How tropical Pacific ocean temperature (El Nino) will evolve in coming months
- **Projections:** How the statistics of Pacific ocean temperatures (El Nino) will change in response to increasing greenhouse gases



SPEAR Seasonal to Multi-decadal Prediction and Predictability

GFDL SPEAR:
Seamless system for **P**redictions and **EA**rth system **R**esearch

MOM6 ocean
AM4 atmosphere
LM4 land
SIS2 sea ice

	Atmos resolution	Ocean resolution	Computational Cost *(CPU hours per year on GAEA)*	CPU cost for 10,000 model years
SPEAR_LO	100 km	100 km	1,600	20 million
SPEAR_MED	50 km	100 km	6,400	64 million ★
SPEAR_HI	25 km	100 km	40,000	400 million
SPEAR_HI_25	25 km	25 km	56,300	563 million

Where does 10,000 years come from?
Typical number of simulation years for model development, reforecast cycle, or large ensemble of climate change simulations

Delworth et al., 2020

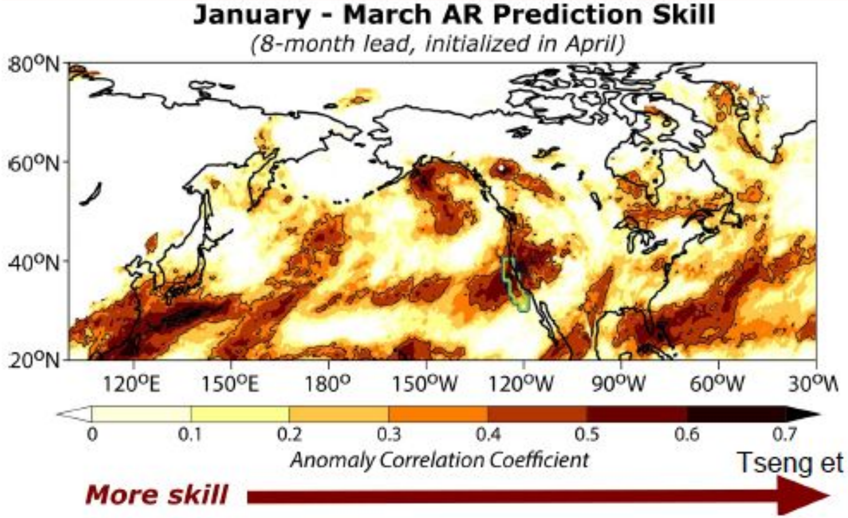
SPEAR Seasonal to Multi-decadal Prediction and Predictability

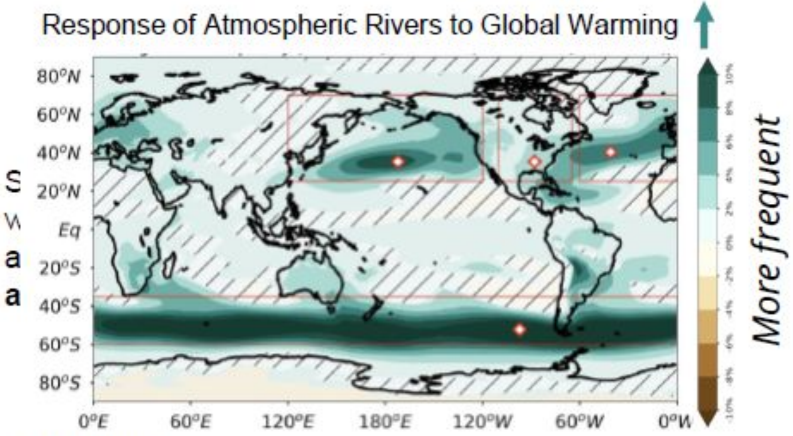
Real-time experimental seasonal predictions (North American Multimodel Ensemble, NMME)

- informs NOAA seasonal outlook
- informs National Hurricane Center seasonal hurricane outlook
- experimental sea level prediction

Decadal predictions (World Meteorological Organization, coordinated project through UKMO)

Predictability research from subseasonal to decadal (from MJO to Southern Ocean predictability)





Tseng et al., 2021, 2022

*This capability is being transitioned to **NWS** through the Weather Program Office*

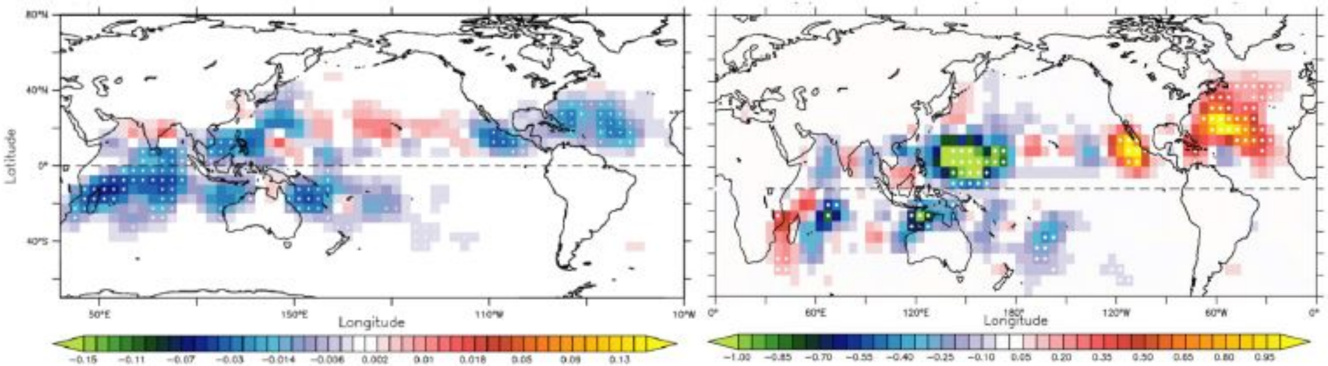
SPEAR Seasonal to Multi-decadal Prediction and Predictability

- Large ensembles with SPEAR to project changes in climate and extremes.
- 30 members running from 1921 to 2100 means 180 yrs * 30 ens members = 5400 model years
- Rich data sets for probing climate chang
- Data publicly available (google search for SPEAR Large Ensembles)

Effect of CO_2 increase

Murakami, 2022

Simulated TC changes 1980-2018 (red means more storms)

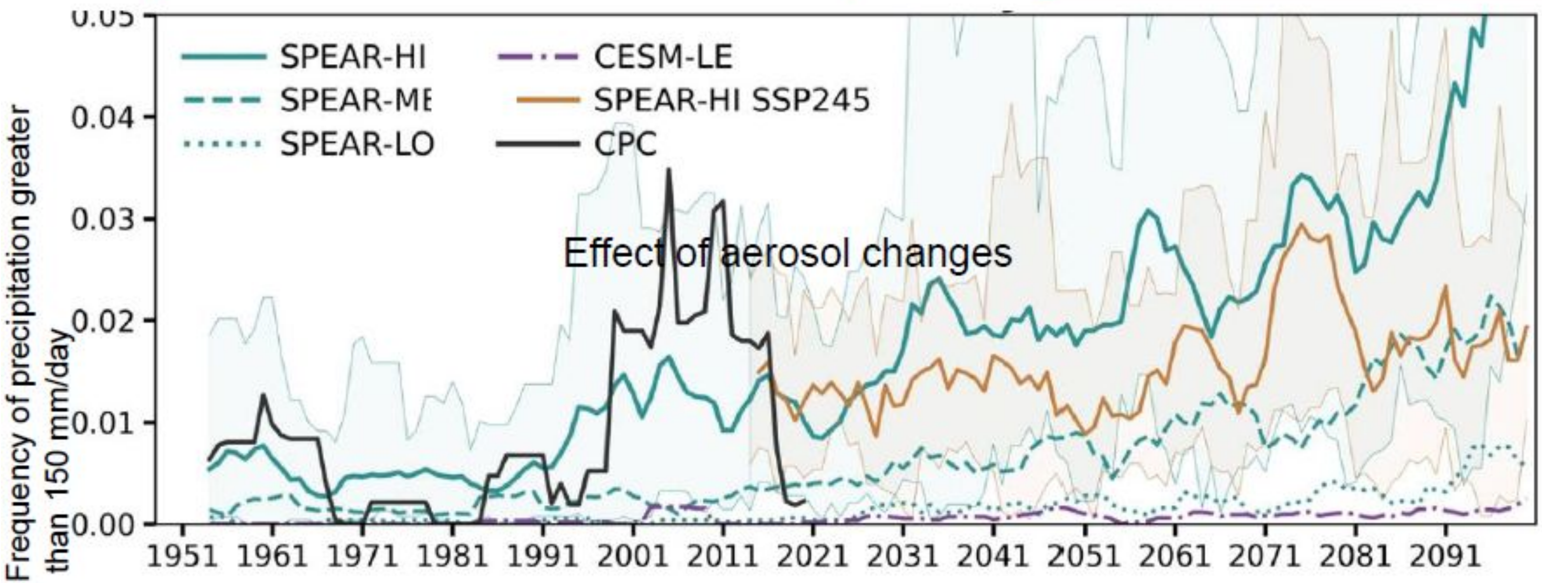


SPEAR Seasonal to Multi-decadal Prediction and Predictability

SPEAR makes seasonal tropical cyclone predictions … and projects multidecadal changes in TCs due to radiative forcing changes.

NE US Extreme Precipitation

Crucial information for a Climate Ready Nation and Climate Risk Assessment



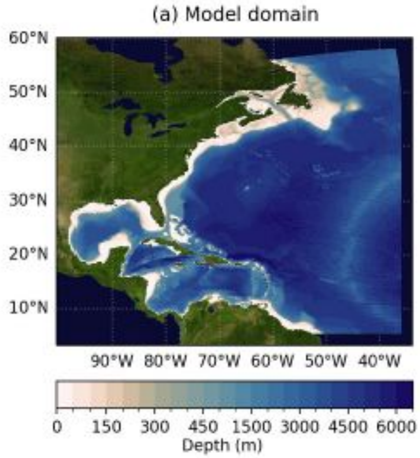
Jong et al., 2023

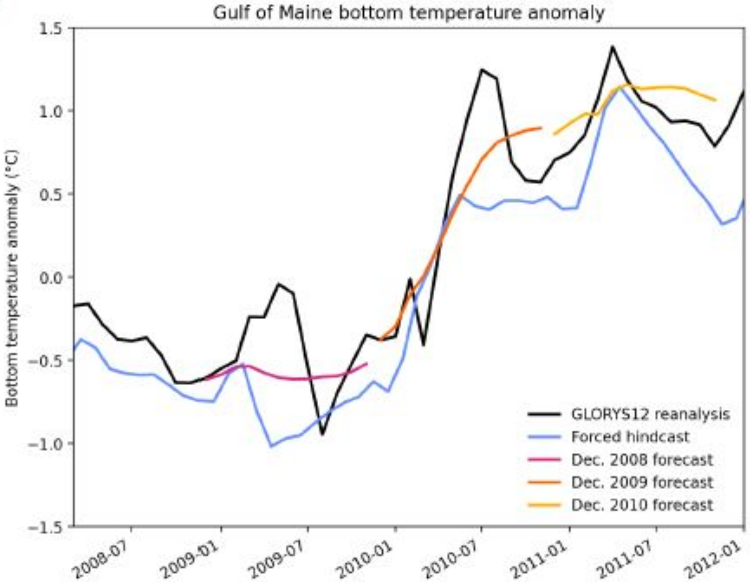
Fewer storms More storms

Coastal Coupling Community of Practice, May 23, 2023

Down-scaling with the MOM6 ocean model

- 1/12° horizontal resolution regional model of the Northwest Atlantic, with ocean (MOM6)and sea ice (SIS2)
- optional biogeochemistry (COBALT) components
- Currently running:
    - Reanalysis-forced hindcast simulation with BGC (submitted to GMD)
    - 1-year seasonal forecasts forced by GFDL SPEAR global seasonal forecasts
    - 25+ year retrospective forecast evaluation
- Additional longer-term forecasts and projections in pre–





THANK YOU

MATTHEW HARRISON
Physical Scientist, Geophysical Fluid Dynamics Laboratory
NOAA
matthew.harrison@noaa.gov


05:00

Coastal Storm Modeling System

JASON CALDWELL
Research Hydraulic Engineer
U.S. Army Corps of Engineers
raymond.j.caldwell@usace.army.mil

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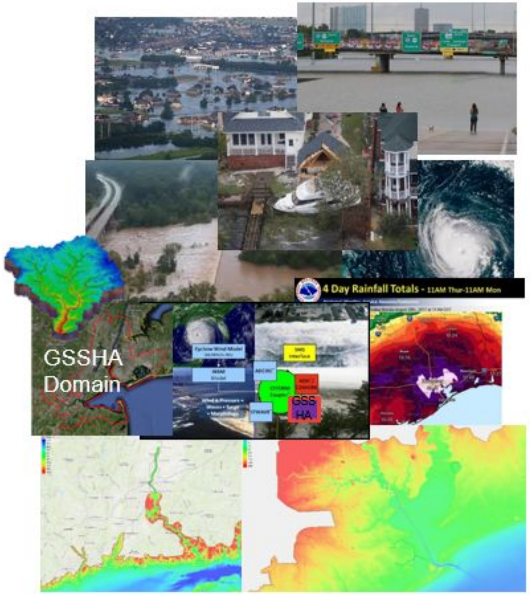
USACE Perspectives on Compound Flooding

- There is a need for reliable, accurate and validated (translatable) tools and best practice/guidance that can be applied on projects - must be able to first quickly assess if (and to what extent) Compound Flooding is a consideration, and ONLY then, invest in analysis
- There is a need for both loose and fully coupled (two-way dynamical coupling) coastal surge/wave and inland rainfall-induced flow models.
- Full coupling may only be needed in very specific geographic and physical settings and for rapid forecasting needs. (Present one-way coupled models may be good enough from an engineering perspective)
- There is a need to extend present Compound Flooding considerations to antecedent conditions as well as future conditions (e.g. climate change)
- Groundwater interactions are also required for certain areas and projects
- A National Coastal/Inland Flood Hazards System - provides readily available standardized national level data & statistics

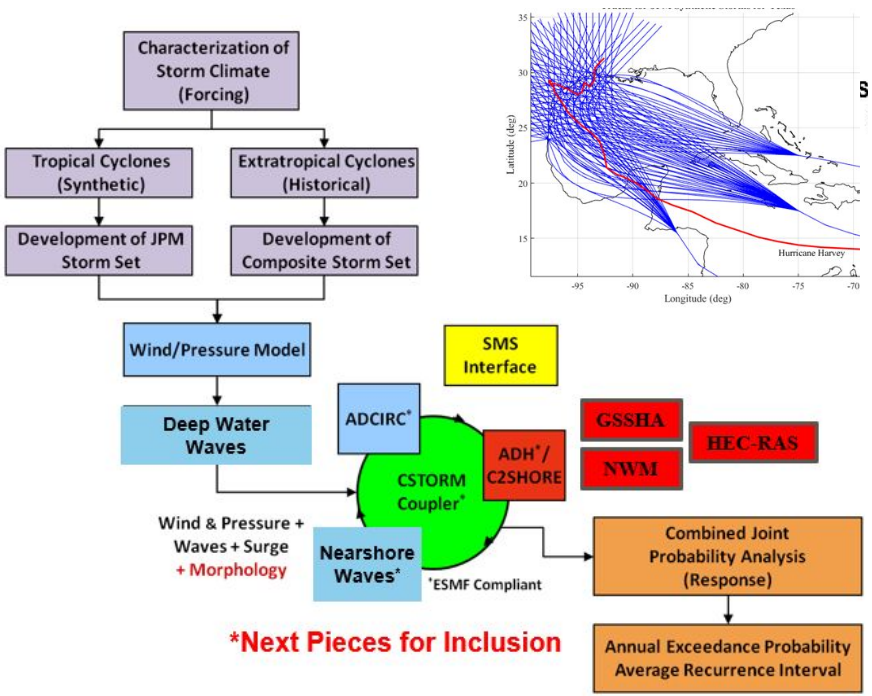


Combined Joint Probability of Coastal Storm Hazards (JPM-OS + CSTORM):

Forcing
- Tropical cyclones
- Extratropical cyclones
- **Other storm types/events ***
- **Rainfall ***

Response
- Water level (storm surge, astronomical tide, SLC)
- **Runoff ***
- Currents
- Wave height, peak period, direction
- Wind speed, direction
- **Precipitation ***

660 Synthetic Storms



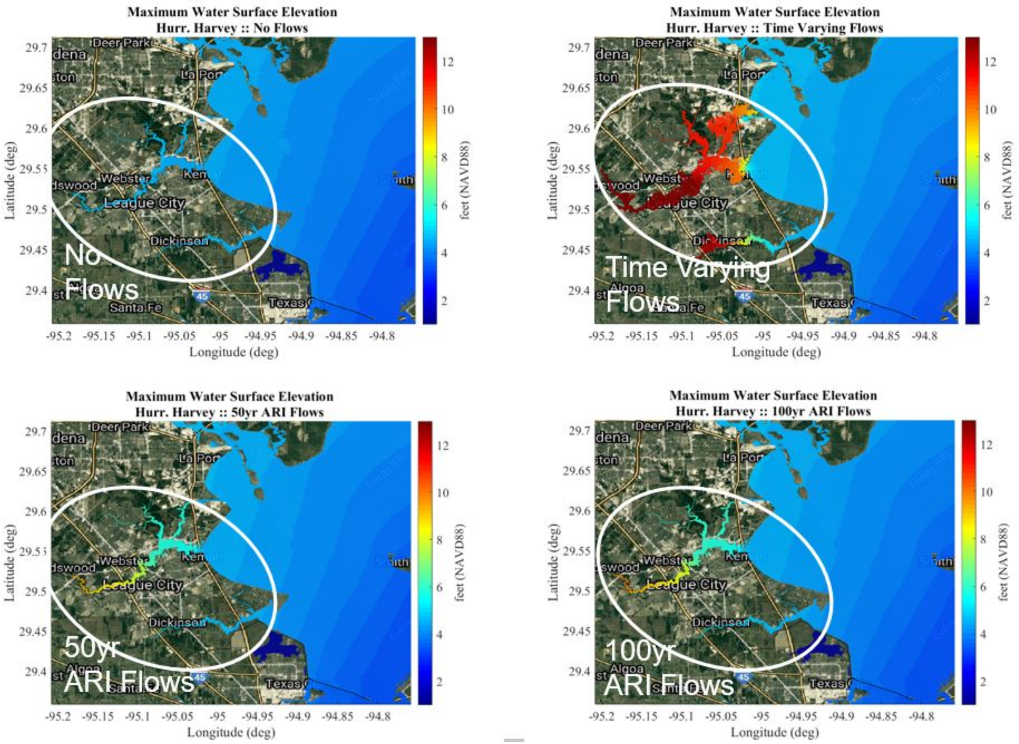
Onyx		Jim		Thunder		Conrad	
Cray XC40/50		SGI Ice X		SGI Ice X		Cray XC40	
6.06 PFLOPS		4.66 PFLOPS		5.62 PFLOPS		2.0 PFLOPS	
4,810 nodes	44 cores/node	3,456 nodes	36 cores/node	3,216 nodes	36 cores/node	1,523 nodes	32 cores/node
211,640 processors		124,416 processors		115,776 processors		48,736 processors	

Optimized HPC Resources (including "cloud")

High-resolution, highly skilled numerical models in a tightly integrated, coupled, modeling system with Plug-n-Play design for expandable and upgradeable workflows.

Hurricane Harvey (CF Modeling Example)

- Images show impacts to maximum total water levels including river flows in Clear Creek + Dickinson Bayou areas of Texas
- ADCIRC (coastal surge) + HEC-RAS/HMS (river flows)
- Comparison of AEP-driven flows and time varying flows



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THANK YOU

JASON CALDWELL
Research Hydraulic Engineer
U.S. Army Corps of Engineers
raymond.j.caldwell@usace.army.mil

Advancing Global STOFS 2D^{+}: NOAA's *Fast* Integrated Multi-Scale Multi-Process Operational Water Level Model

Joannes Westerink[1], Maria Teresa Contreras-Vargas[1], Coleman Blakely[1], Al Cerrone[1], Guoming Ling[1], Dam Wirasaet[1], Shintaro Bunya[2], Zach Cobell[3], Juan Gonzales[4], William Pringle[5], Kendra Dresback[6], Chris Szpilka[6], Randy Kolar[6], Ed Myers[7], Greg Seroka[7], Saeed Moghimi[7], Liujuan Tang[7], Yuji Funakoshi[7]

[1]University of Notre Dame, [2]University of North Carolina at Chapel Hill, [3]Water Institute of the Gulf, [4]Caricoos, [5]Argonne National Laboratory, [6]University of Oklahoma at Norman, [7]NOAA NOS/OCS Silver Spring MD

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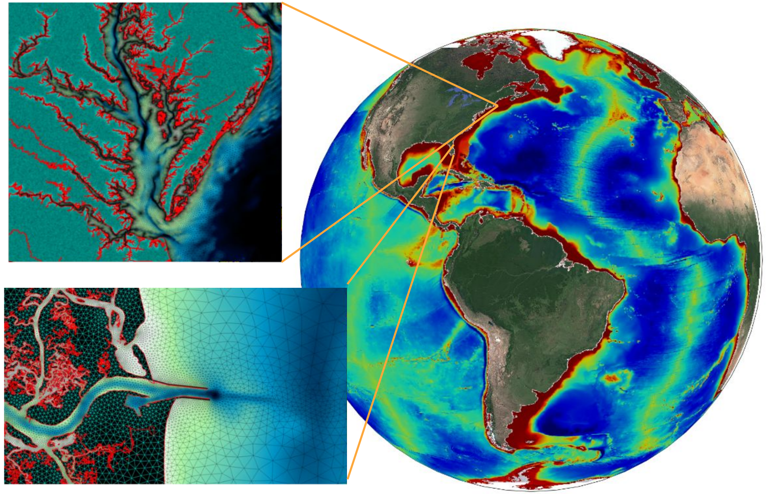
Global STOFS 2D: *v1.0 currently in operation*

GFS-FV3 Global Atmospheric Model

ADCIRC Circulation

CICE Global Sea Ice Model



At NCEP https://polar.ncep.noaa.gov/estofs/glo.htm

At Notre Dame https://dylnwood.github.io/GESTOFS-develop/

- Mesh resolution varies between 25 km to 2.5 km globally and 80 to 120 m in ***all*** U.S. coastal waters and floodplains
- **Most *accurate* published global model with an M_2 tide deep water error of 1.95 cm**
- U.S. East/Gulf of Mexico coast M_2 tide errors **R^2 = 0.9848**, **average absolute error = 2.5 cm**, and a **normalized RMS error = 0.089**
- **Runs *fast* in 2.4 wall clock minutes per day of simulation on 2400 TACC Frontera cores**

Global STOFS 2D^{+}: *Thermohaline engine transitioning to operations*

GFS-FV3 Global Atmospheric Model

ADCIRC Circulation with Ice

2D^{+} SWE with baroclinic pressure gradient term

HYCOM 3D Global Circulation Model

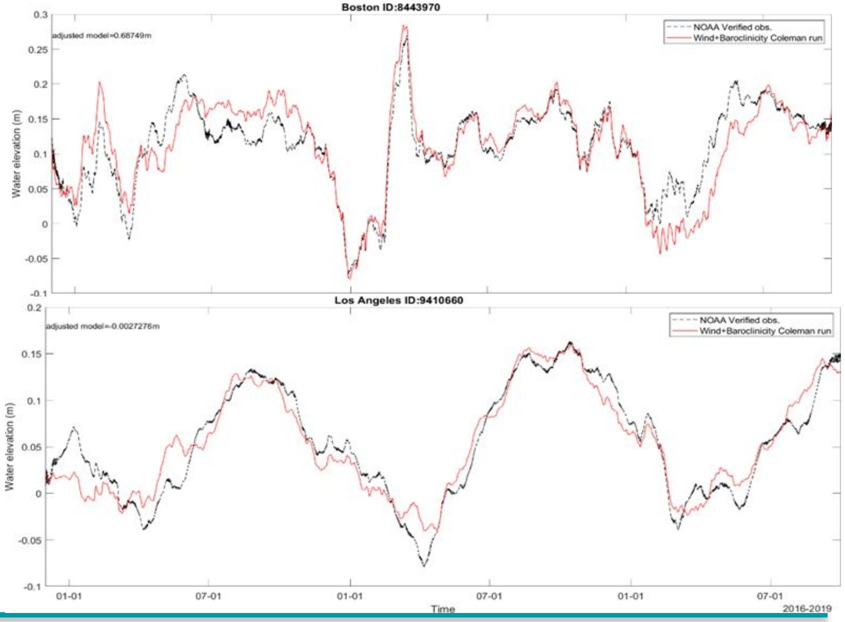
CICE Global Sea Ice Model

Coupling of ***ADCIRC***, ***GFS-FV3***, ***CICE*** and ***G-RTOFS/HYCOM using downscaling*** over a unified domain on heterogeneous meshes/grids

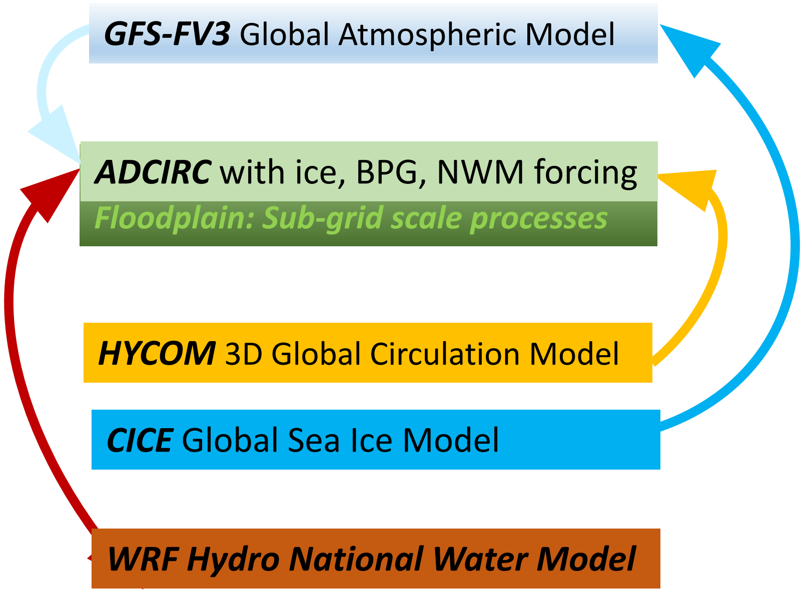
$$\frac{\partial \boldsymbol{u}}{\partial t} + (\boldsymbol{u}\cdot\nabla)\boldsymbol{u} + f\mathbf{k}\times\boldsymbol{u} = -\nabla\left[\frac{p_s}{\rho_0} + g(\zeta - \zeta_{EQ} - \zeta_{SAL})\right] + \frac{\nabla M}{H} - \frac{\nabla D}{H} - \frac{\nabla B}{H} + \frac{\tau_s}{\rho_0 H} - \frac{\tau_b}{\rho_0 H} - \mathcal{F}_{IT}$$

- Baroclinic pressure gradient (BPG):

$$\nabla B = \int_{-h}^{\zeta}\left(g\nabla\left[\int_z \frac{\rho - \rho_0}{\rho_0}\right] dz\right) dz$$

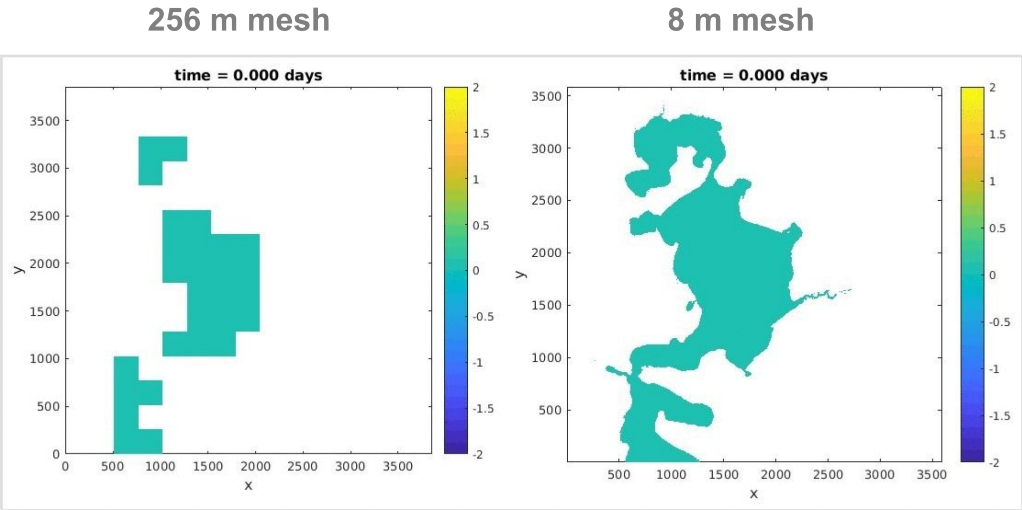


Global STOFS 2D+ with NWM coupling and sub-grid scale floodplain



Coupling of ***ADCIRC*** and ***NWM*** at external and internal network connections with ***rainfall***

Development of sub-grid scale (SGS) methods across the coastal floodplain



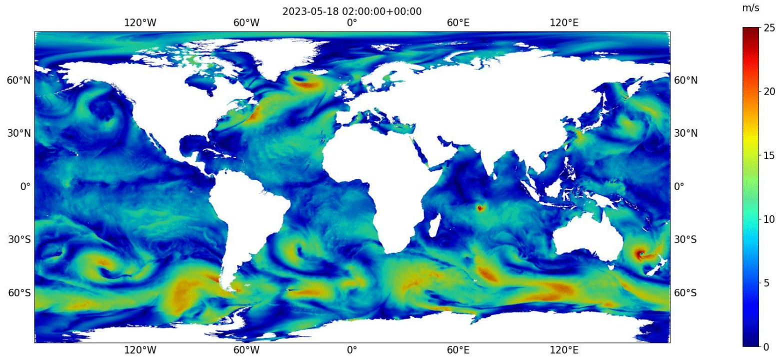
Subgrid scale (SGS) methods with 256 m mesh are 32000 x faster than 8 m mesh

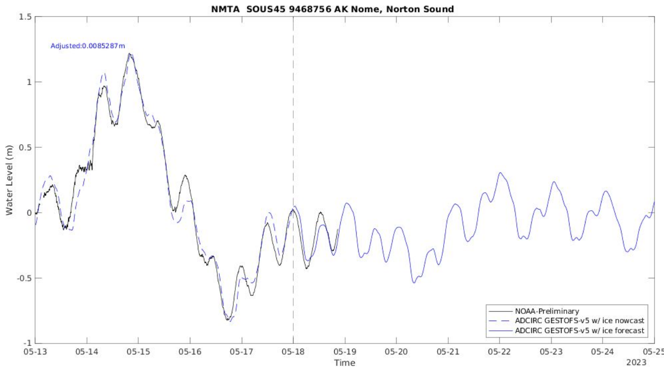
Resolution matters but is expensive / small scale channels and features

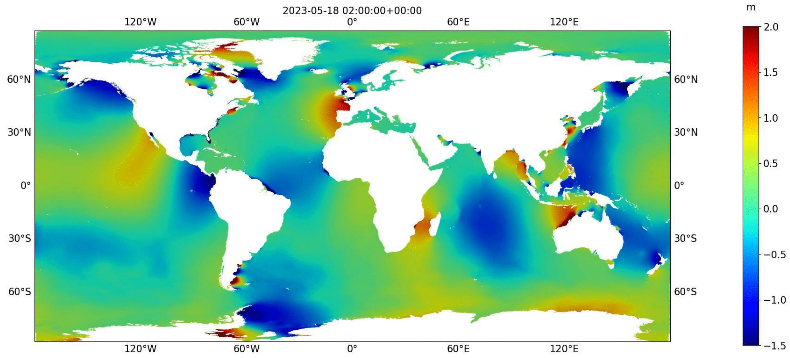
Thank you from the Global STOFS 2D+ team

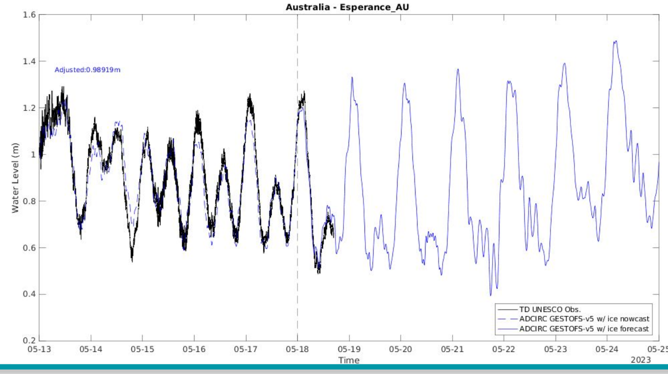
For daily forecasts with prior 5 day nowcasts comparisons to data: https://dylnwood.github.io/GESTOFS-develop/

For references please see coast.nd.edu or contact us at jjw@nd.edu









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THANK YOU

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Piloting a Model Visualization System at the Northeastern Regional Association of Coastal Ocean Observing System Based on Tools from the Pangeo Community Platform for Big Data Geoscience

TOM SHYKA
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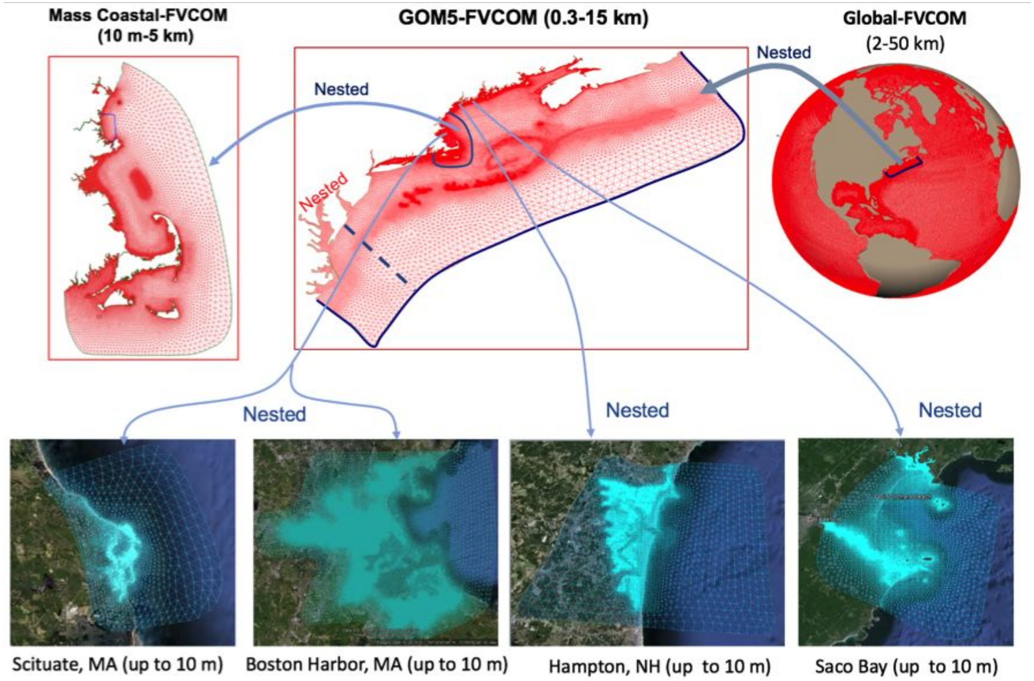
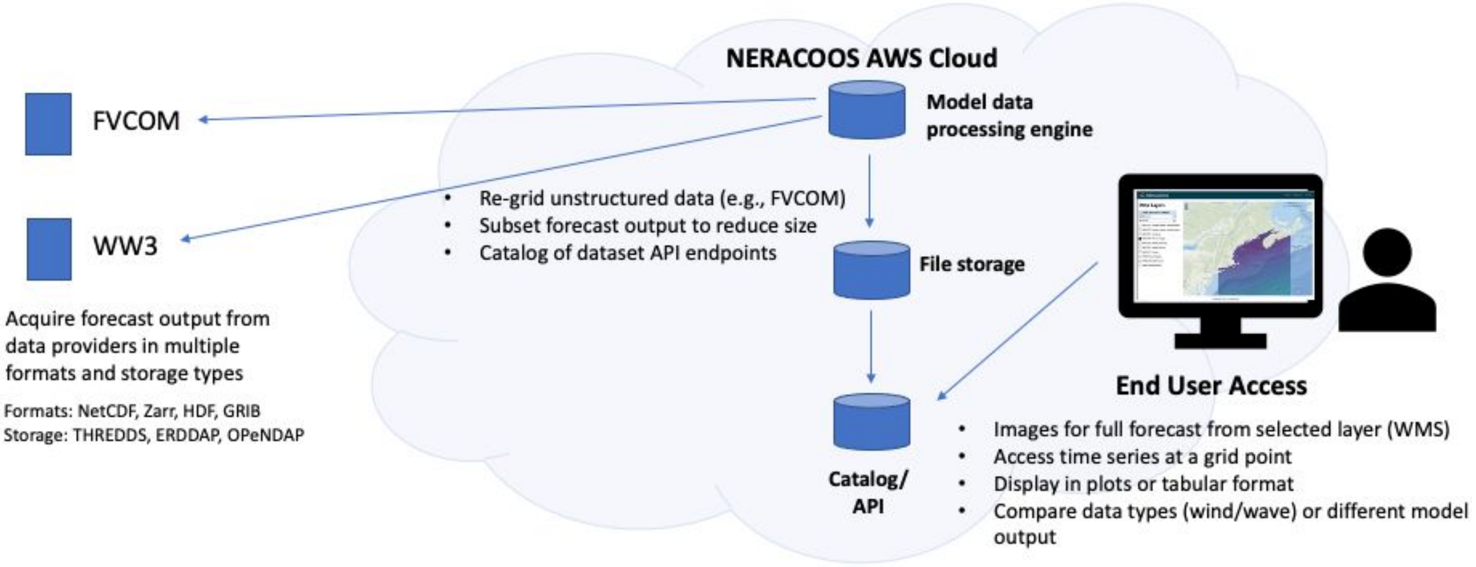
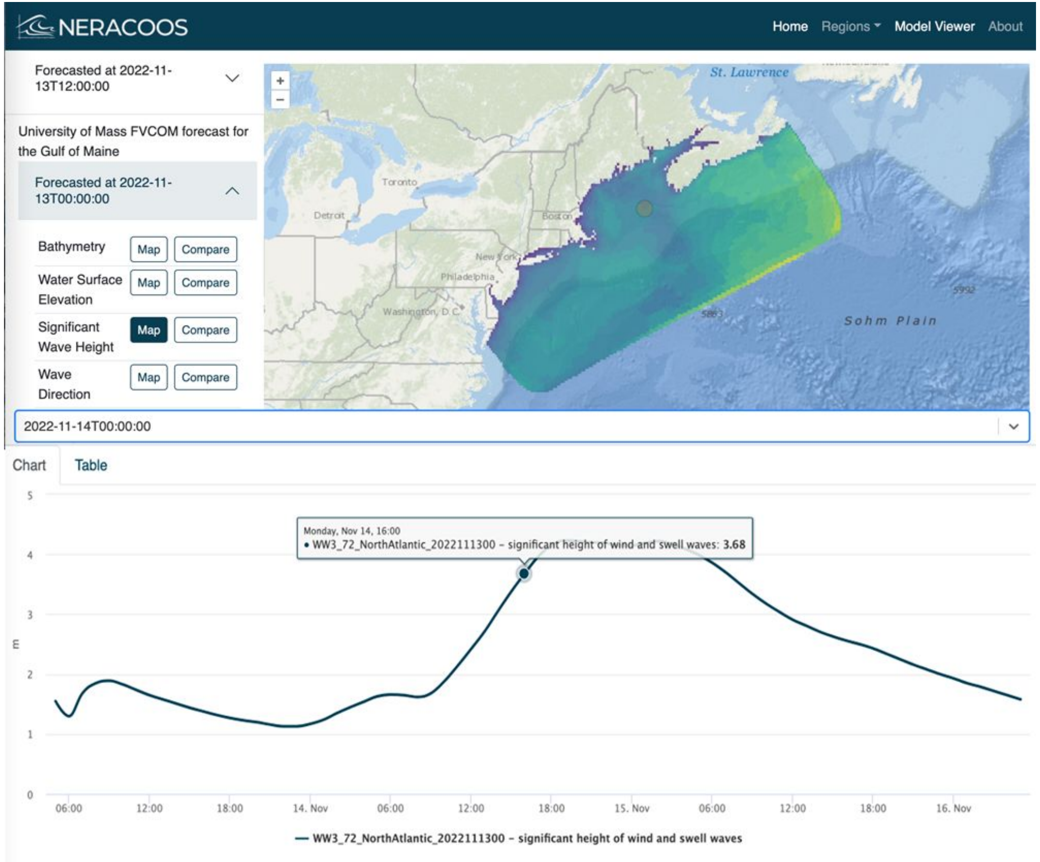
Piloting a Model Visualization System Based on Tools from the Pangeo Community



Model Forecast Visualization Process



PANGEO STAC SpatioTemporal Asset Catalog pygeoapi Open Geospatial Consortium


NERACOOS
Home
Regions
Model Viewer
About
Forecasted at 2022-11-13T12:00:00
University of Mass FVCOM forecast for the Gulf of Maine
Forecasted at 2022-11-13T00:00:00
Bathymetry
Map
Compare
Water Surface Elevation
Map
Compare
Significant Wave Height
Map
Compare
Wave Direction
Map
Compare
St. Lawrence
Toronto
Detroit
Boston
New York
Philadelphia
Washington, D.C.
Sohm Plain
2022-11-14T00:00:00
Chart
Table
Monday, Nov 14, 16:00
• WW3_72_NorthAtlantic_2022111300 – significant height of wind and swell waves: 3.68
m
0
1
2
3
4
5
06:00
12:00
18:00
14. Nov
06:00
12:00
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15. Nov
06:00
12:00
18:00
16. Nov
WW3_72_NorthAtlantic_2022111300 – significant height of wind and swell waves

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NOS Coastal Modeling Portfolio Manager
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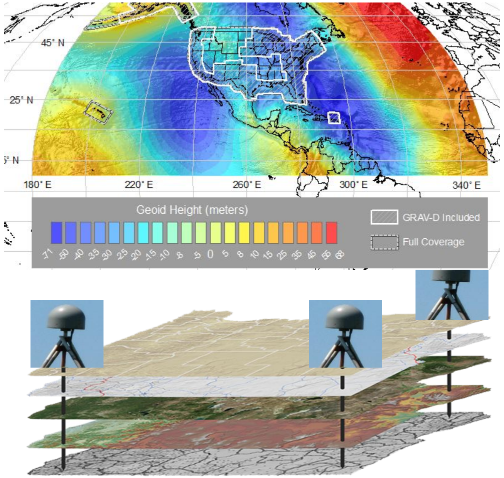
NOS Modeling

Safe, Efficient Navigation	Coastal Resilience	Accurate 3D Positioning
		
Emergency Response	Inundation and Water Level	Datum Transformation

Navigation (and more): NOAA Operational Forecast Systems (OFS):

Workhorse for NOS models & model uses

Safe & efficient navigation

- Water levels for under-keel clearance
- Currents for right-of-way, maneuverability
- Precision Marine Navigation S100 Standards

Coastal Resilience

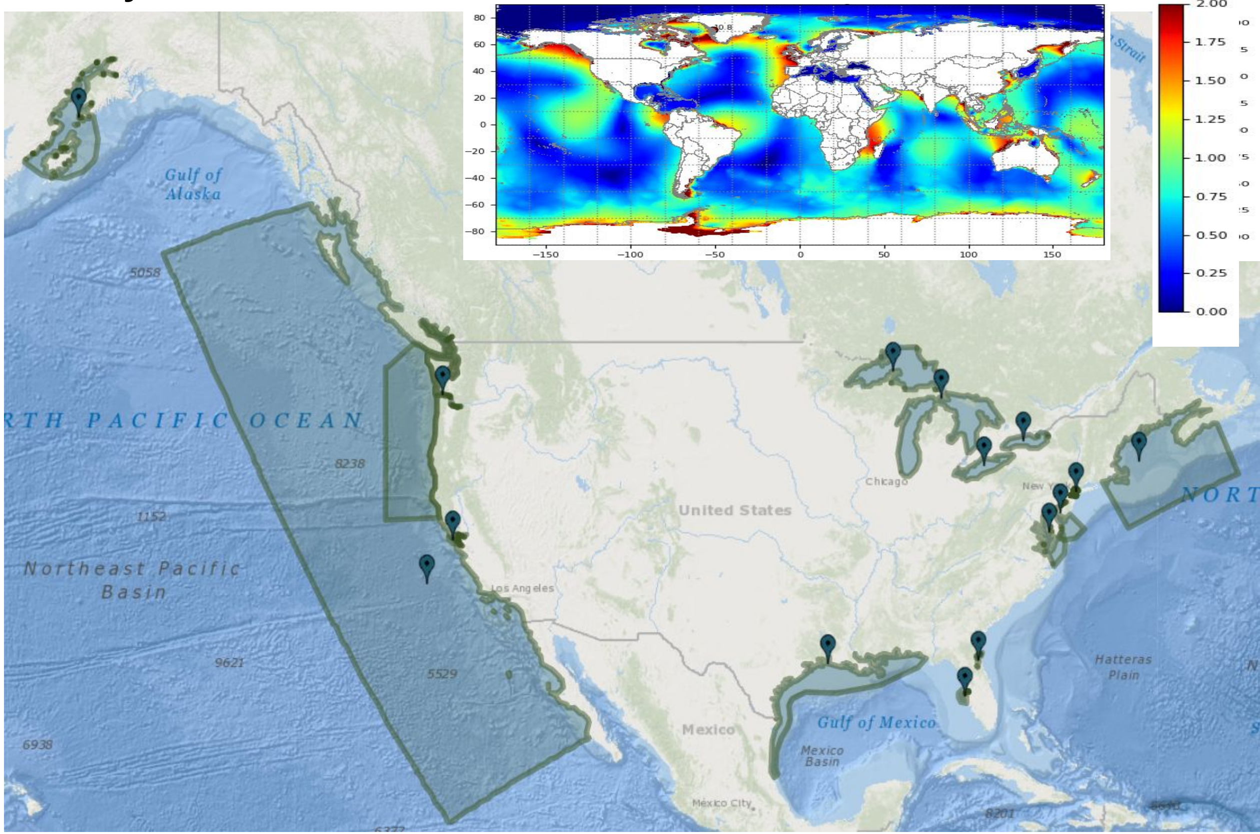
- Storm surge and inundation

Emergency response

- Supports trajectory models for Hazmat spills (OR&R)
- Search & Rescue
- Homeland Security

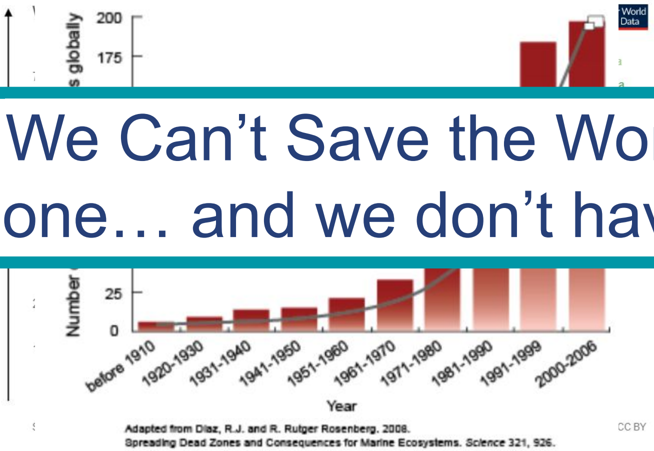
Ecological applications

- Hypoxia, HABs, pathogens, etc.



It’s Up To Us To Protect Lives And Livelihoods Of Those On Our Coast

Stakeholder Driven Products



We Can’t Save the World Alone… and we don’t have to

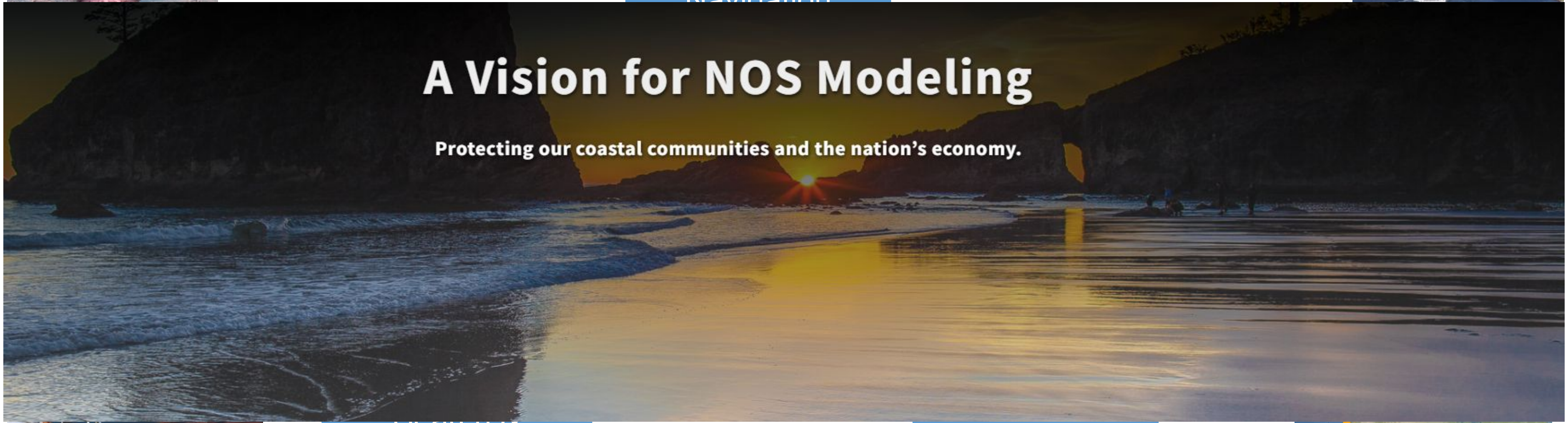
Increasing Requirements

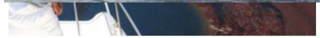
Community Modeling

VISION

NOS coastal circulation models work with our community modeling partners to deliver a national forecast capability that provides accurate, reliable, and timely coastal predictions that inform a wide range of decision-support user needs

Safe, Efficient Navigation





Search & Rescue

Resilience

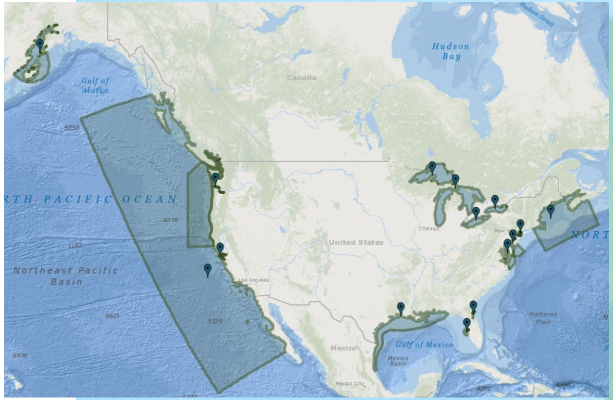
Mapping & Coastal Mngmt

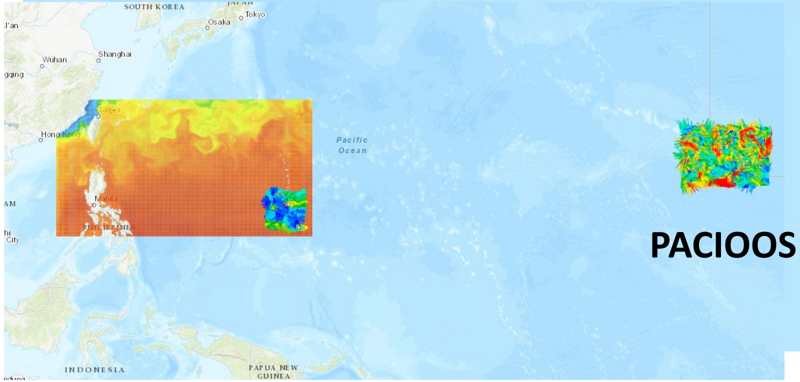
Protecting our coastal communities and the nation's economy

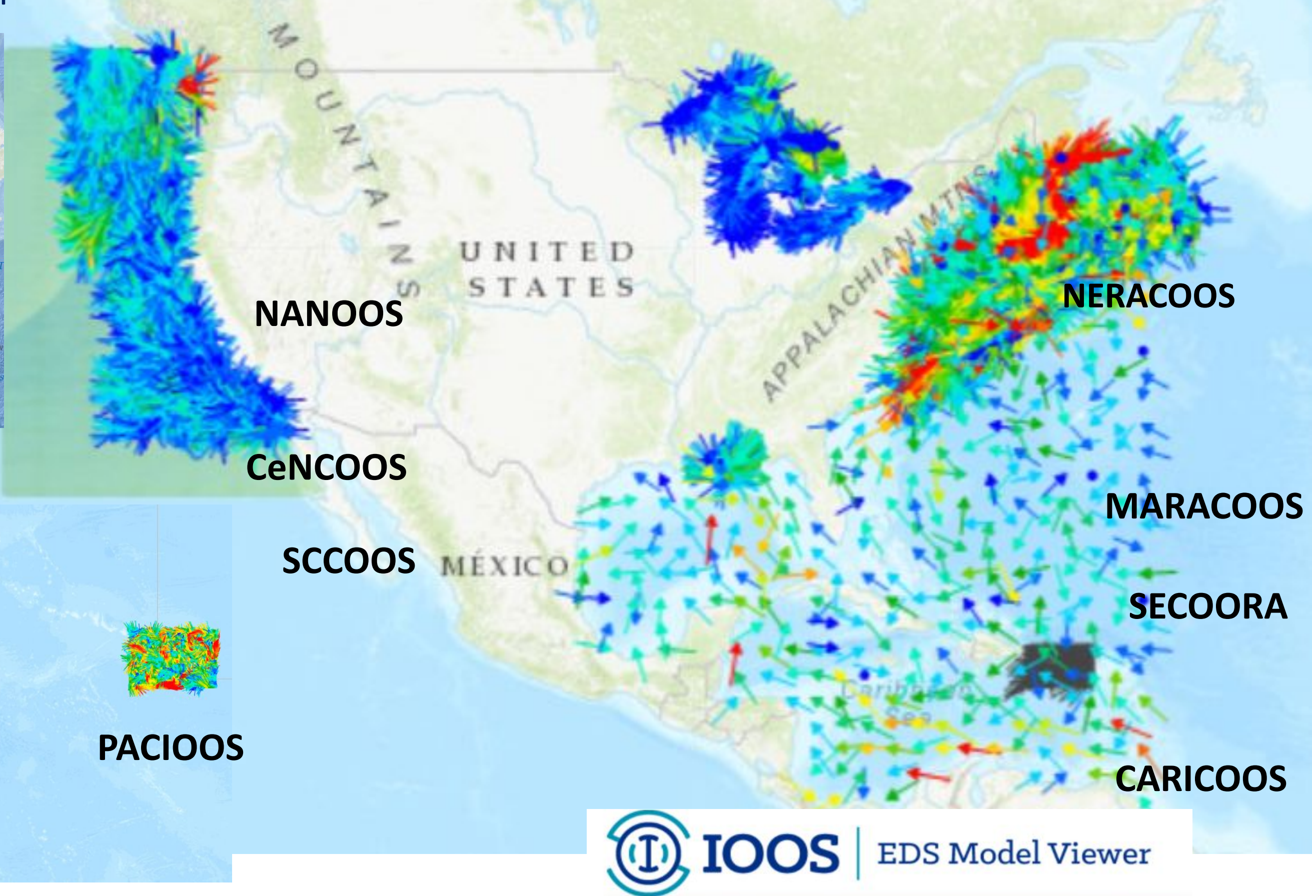
NOS Development, Operations, and Community Modeling Efforts

Models Operated by External Partners

Current Operational Forecast System





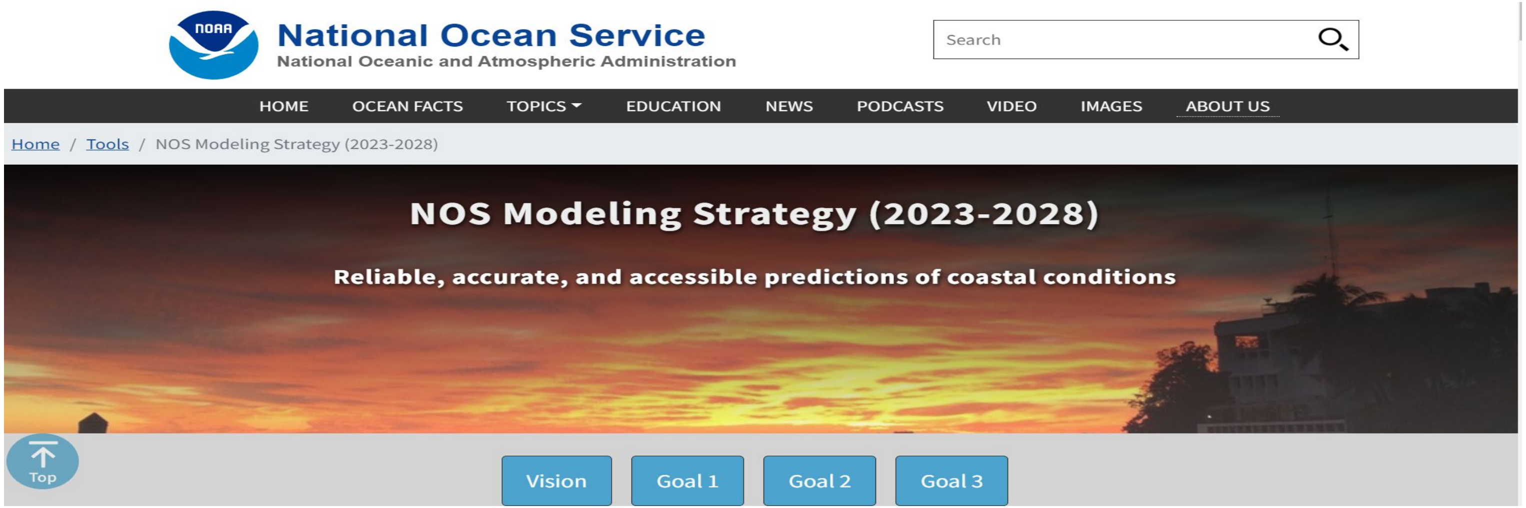


A gathering of government, academic, and private industry to enhance collaboration and make the NOAA and NOS Modeling Vision, along with the visions of external partners, a reality

Final Report

92 Cross line office NOAA scientists, 96 from academia, over 10 from the private sector and representation from each IOOS Regional Association

NOS Modeling Strategy

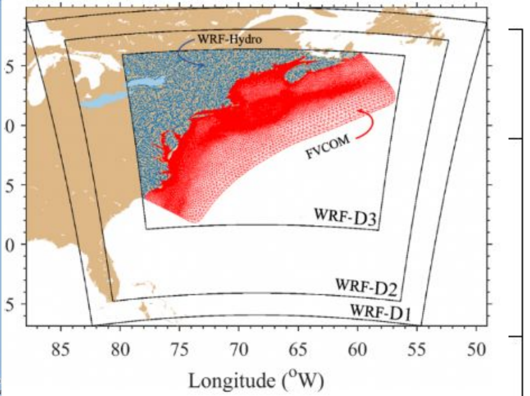


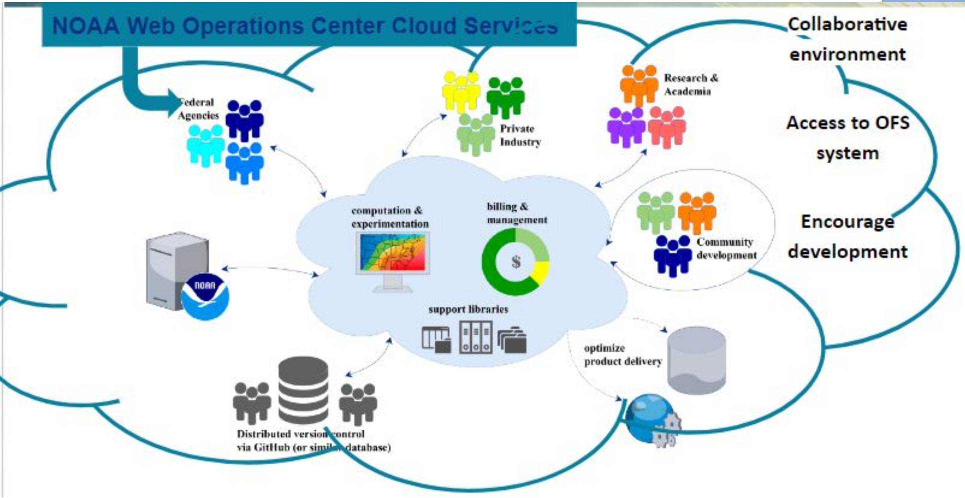
1. Address User Needs through Partnerships (community engagement)
2. Community Modeling Approach (crowd sourcing solutions)
3. Issue National Ocean Service Predictions (reliable coastal and ocean modeling information)

BIL

- Deliver 3D regional/national coastal models (including Great Lakes) and develop shared cyberinfrastructure
- To understand compound flooding and predict impacts, through Coupled NextGen National Water Model and 3-D coastal models

posed SECOFS domain. The rough outlines of the existing NECOFS and so shown. The new SECOFS will mostly cover the gaps between NECOFS ut will also cover Caribbean. The final coverage of SECOFS will be ing the project in consultation with OCS, CO-OPS and IOOS.





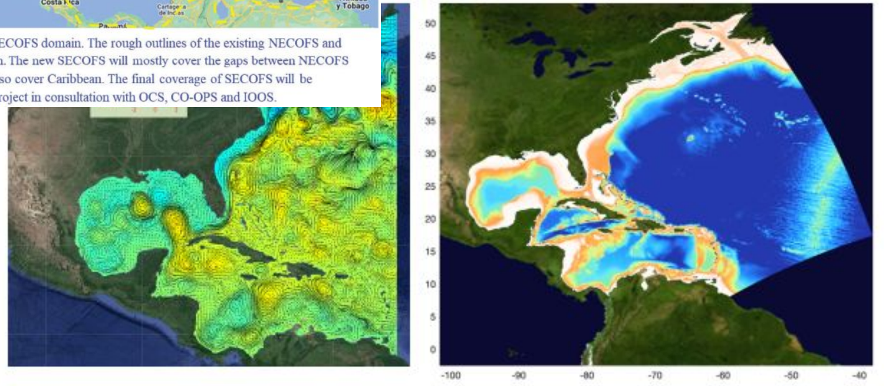


Figure 1: Domains covered by existing models run by the ECCOFS team. Left: Surface current forecast from the Coupled Northwest Atlantic Prediction System (CNAPS). Right: Domain and bathymetry of the Rutgers West Atlantic (WATL) model.

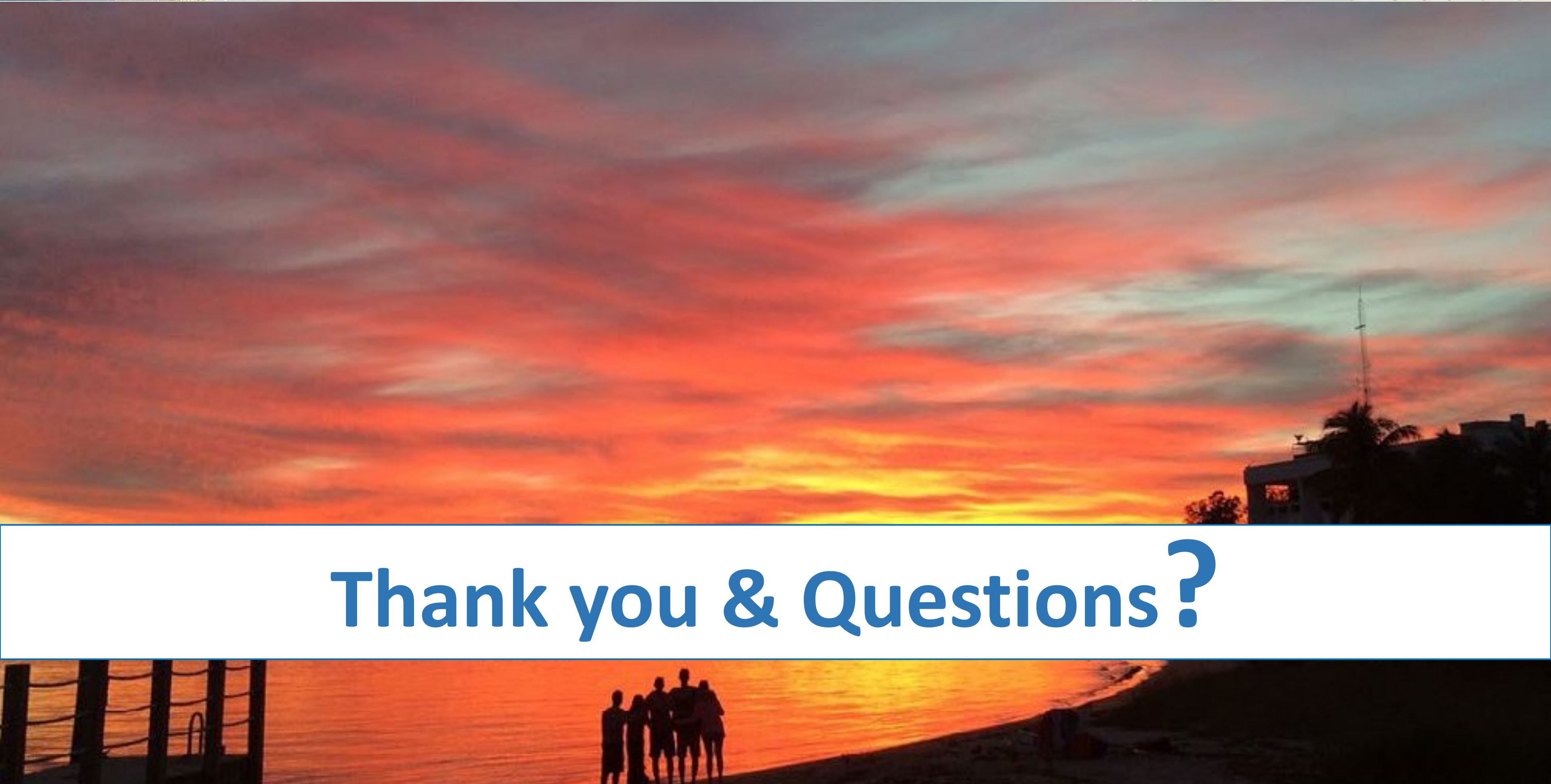
probabilistic storm surge forecast.

Coastal and Ocean Modeling Testbed (COMT)

Funds transition oriented projects in the extramural community **(new NOFO coming in late 2023)**

Mission: To use applied research and development to accelerate the transition of scientific and technical advances from the coastal ocean modeling research community to improved operational ocean products and services (i.e. via research to operations and also operations to research).

Thank you & Questions?



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John L. Wilkin

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jwilkin@rutgers.edu @johnlwilkin john.wilkin

Community Modeling Insights and Opportunities

How Community Modeling Can Support NOAA's Ocean and Coastal Missions

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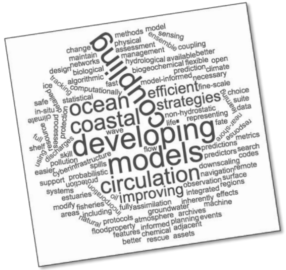
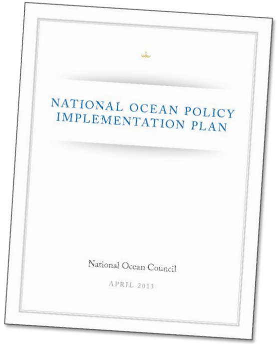
We have made tremendous progress

The ROMS community has championed open collaboration since 2004



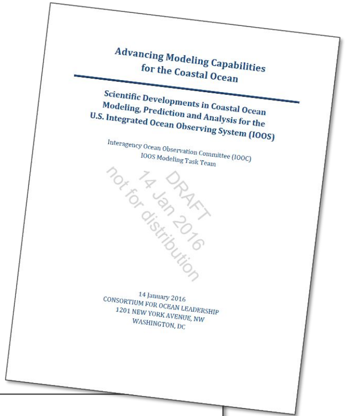
We have made tremendous progress

- Community consensus on R&D priorities
- Embrace of open science
  - source code, data, FAIR principles
- Collaborative development environments
  - GitHub, user forums …
- Advanced integration frameworks
  - JEDI* , ESMF*/NUOPC and UFS*


NATIONAL OCEAN POLICY
IMPLEMENTATION PLAN

National Ocean Council

APRIL 2013

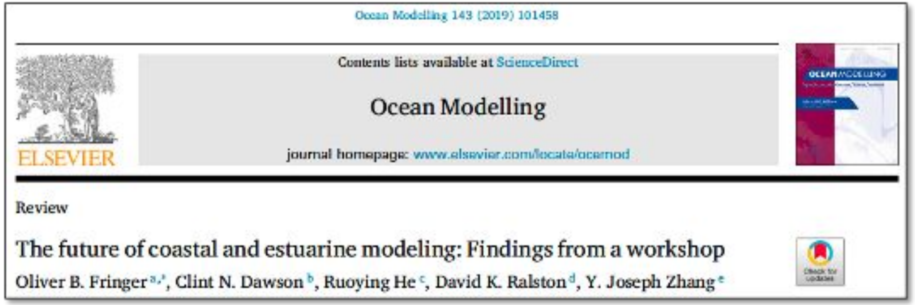

Advancing Modeling Capabilities
for the Coastal Ocean

Scientific Developments in Coastal Ocean
Modeling, Prediction and Analysis for the
U.S. Integrated Ocean Observing System (IOOS)

Interagency Ocean Observation Committee (IOOC)
IOOS Modeling Task Team

DRAFT
14 Jan 2016
not for distribution

14 January 2016
CONSORTIUM FOR OCEAN LEADERSHIP
1201 NEW YORK AVENUE, NW
WASHINGTON, DC


Ocean Modelling 143 (2019) 101458

Contents lists available at ScienceDirect

Ocean Modelling

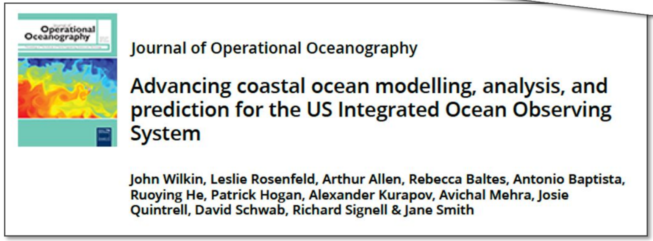
journal homepage: www.elsevier.com/locate/ocemod

ELSEVIER

Review

The future of coastal and estuarine modeling: Findings from a workshop

Oliver B. Fringer[a,*], Clint N. Dawson[b], Ruoying He[c], David K. Ralston[d], Y. Joseph Zhang[e]


Journal of Operational Oceanography

Advancing coastal ocean modelling, analysis, and prediction for the US Integrated Ocean Observing System

John Wilkin, Leslie Rosenfeld, Arthur Allen, Rebecca Baltes, Antonio Baptista, Ruoying He, Patrick Hogan, Alexander Kurapov, Avichal Mehra, Josie Quintrell, David Schwab, Richard Signell & Jane Smith

*Joint Effort for Data Assimilation Integration; Earth System Modeling Framework Unified Forecast System

We have made tremendous progress

What next?

- Coupled/integrated Earth System and Biosphere Modeling
  - our Communities of Practise still lack a common lexicon, appreciation of peer science needs, and interoperable tool-set
  - hydrology, waves, littoral zone, ocean, atmosphere, BGC/ecosystems
- Facilitating external research should be an Operational deliverable …
  - open parallel operational environments / sandbox for experimentation
- Capacity development
  - write students and postdocs into every proposal
  - rescue the best undergrads from particle physics
  - focused workshops / training / test-beds / doing not talking

COASTAL COUPLING
COMMUNITY OF PRACTICE

THANK YOU

John L. Wilkin

Professor, Department of Marine and Coastal Sciences
Rutgers, The State University of New Jersey
jwilkin@rutgers.edu @johnlwilkin john.wilkin

Operational Forecast Systems

PAT BURKE ▪ MAY 23, 2023
Oceanographic Division Chief, NOAA/NOS/CO-OPS

Operational Forecast Systems

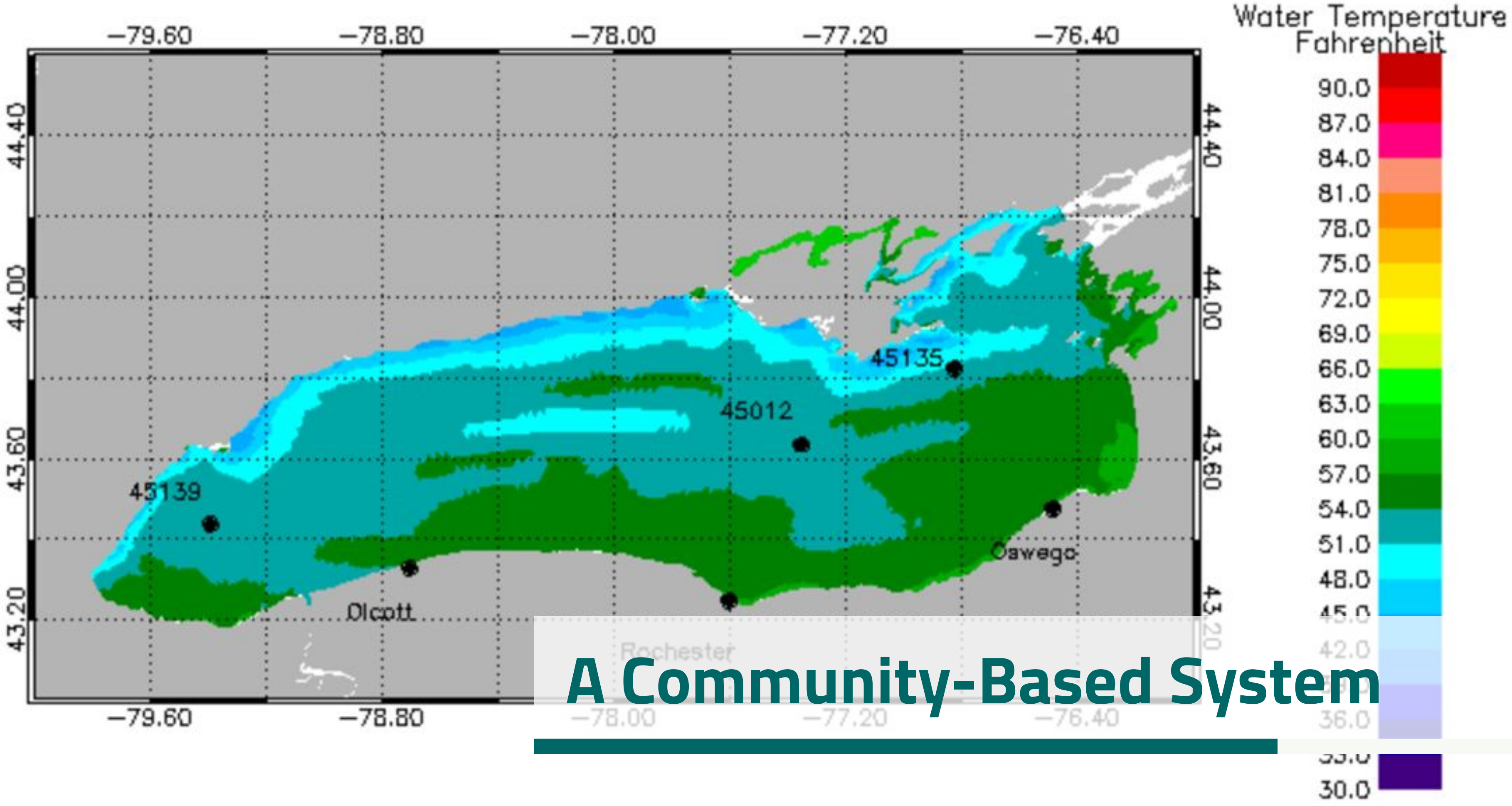
Why OFS?

Marine Navigation

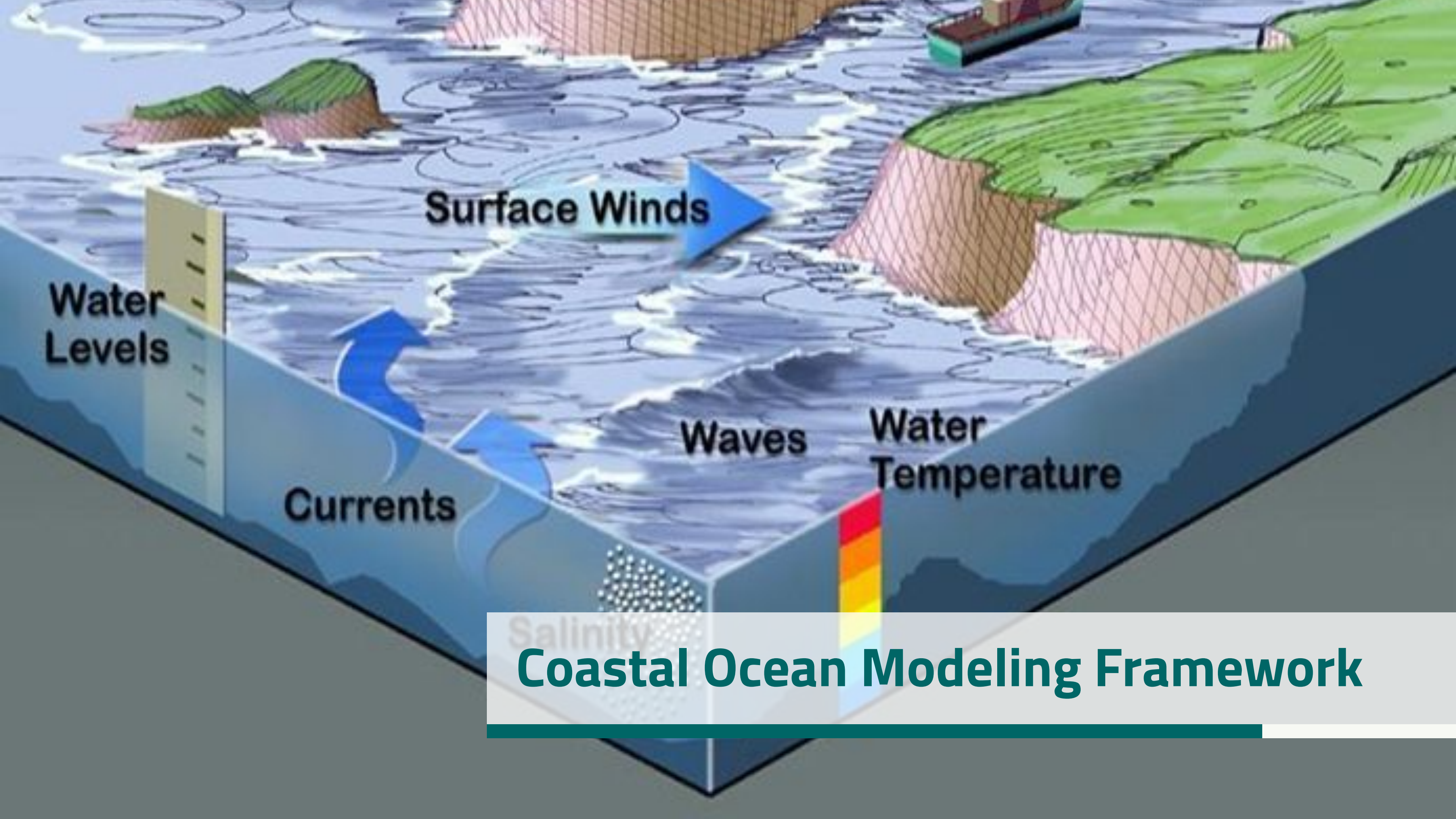
Emergency Response

Great Lakes Ice Forecasts

Environmental Management



A Community-Based System



Coastal Ocean Modeling Framework

Challenges & Emerging Requirements

Next for OFS?

Thank you!

https://tidesandcurrents.noaa.gov/forecast_info.html

COASTAL COUPLING

COMMUNITY OF PRACTICE

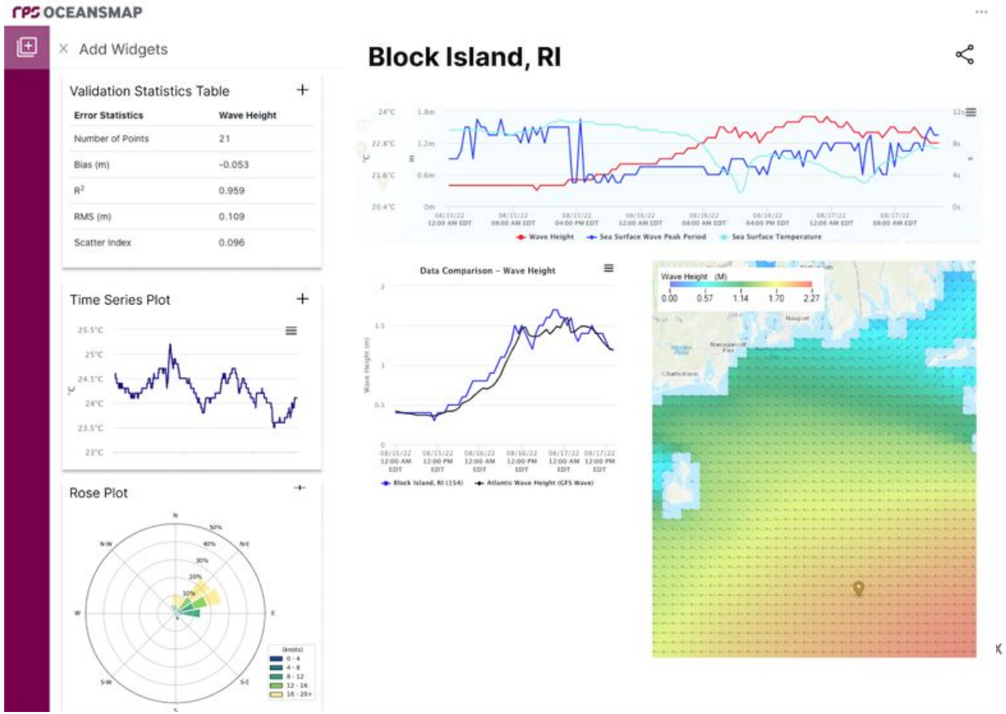
KELLY KNEE

Executive Director of Ocean Science at RPS North America
kelly.knee@rpsgroup.com

Coastal Coupling Community of Practice Annual Meeting
May 23, 2023

OCEANSMAP: A DATA ECOSYSTEM FOR SUPPORTING COLLABORATION AND DECISION MAKING

- Collaboration
- Common Operational Picture
- Oil Spill Planning & Response
- Search and Rescue
- Offshore Operations
- Mission Planning
- Protected Species Observation
- Navigation
- PFAS
- Flood Hazard Mitigation & Response
- Observation system management
- Public/Private/Hybrid

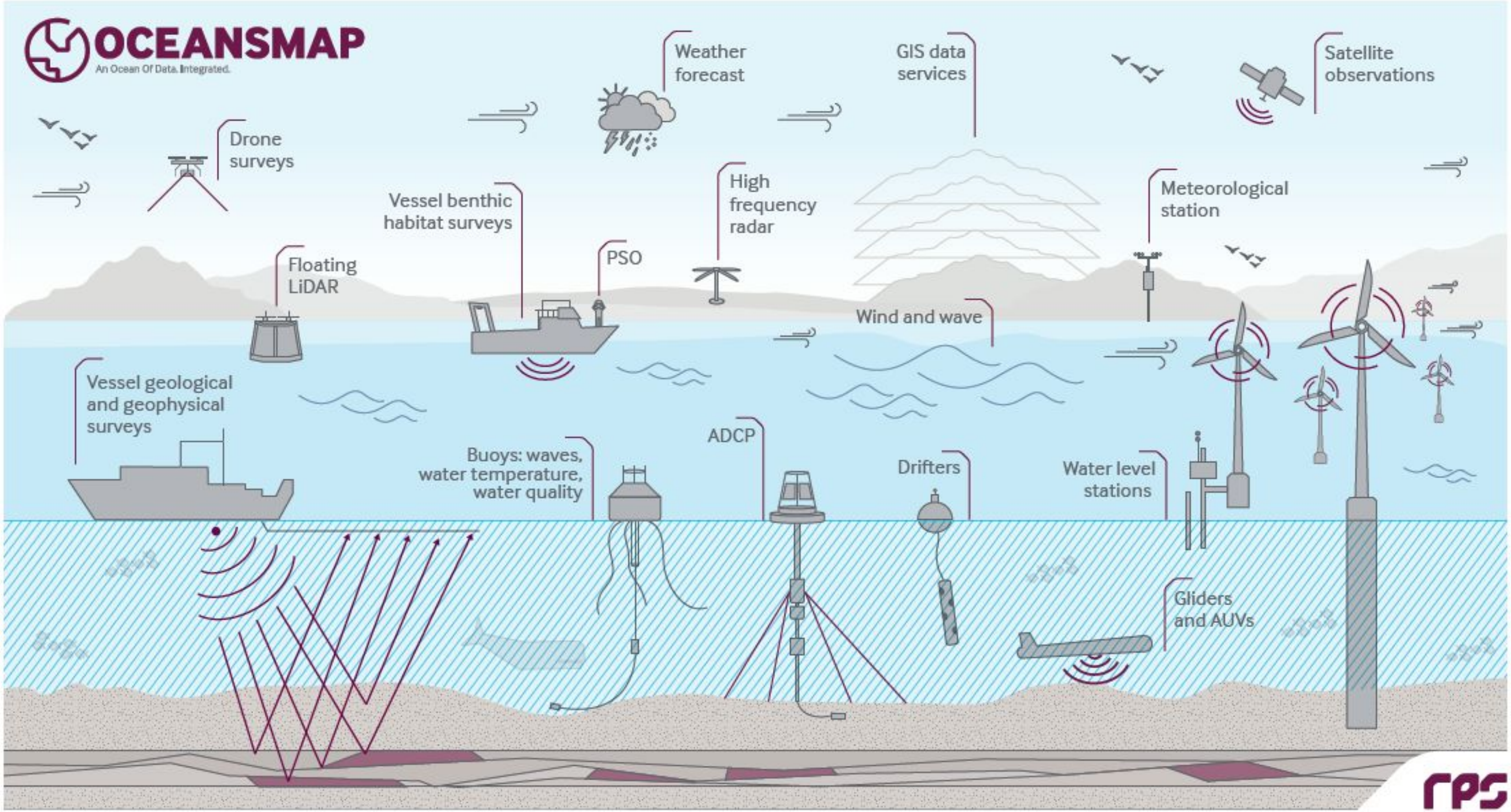


WHAT IS OCEANSMAP?

OceansMap unlocks the power of data by translating data into insight and enabling users to make informed decisions.

It is a data ecosystem; behind the UI a collection of harvesters, processors, and services brings together environmental data and forecasts from disparate sources, applies community standards, and ensures availability for visualization, analysis and decision support

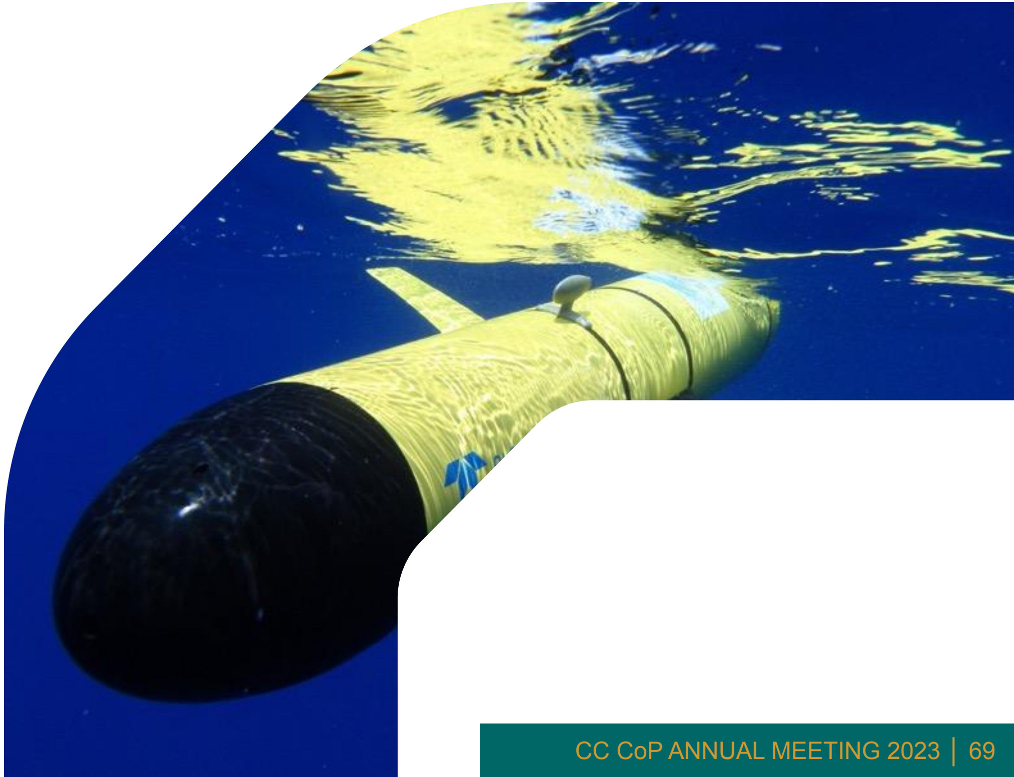
Data management, maritime planning, water quality, operational response - regardless of your application, OceansMap makes met-ocean data easy.


OCEANSMAP
An Ocean Of Data. Integrated.
Drone surveys
Weather forecast
GIS data services
Satellite observations
Vessel benthic habitat surveys
High frequency radar
Meteorological station
PSO
Floating LiDAR
Wind and wave
Vessel geological and geophysical surveys
Buoys: waves, water temperature, water quality
ADCP
Drifters
Water level stations
Gliders and AUVs
rps

OCEANSMAP

Underlying Principals

- storage
- discoverability
- accessibility
- compliance
- visualization



IOOS DATA MANAGEMENT & CYBERINFRASTRUCTURE

a robust, services-oriented system that includes tools to aggregate, quality-control, and monitor data from a variety of observational and numerical model assets, including:

- *in situ* and remotely-sensed observation and model data
- centralized, standards-based data access services
- approved common data formats such as NetCDF
- adherence to the IOOS metadata requirements
- real-time quality control (QARTOD)
- cloud infrastructure for storing data, hosting services and webapps
- IOOS catalog registration
- Archiving
- Continuity of operations, infrastructure O&M, collaboration

COLLABORATION WITH NOS / CO-OPS:
DATA INTEGRATION AND WEB-BASED MODEL VALIDATION TOOL FOR NOAA CO-OPS

Goals:

1. **Facilitate decision making** - integrate real-time observations and model forecasts
2. **Provide consistency** – data access and presentation
3. **Improve communication** – validation & uncertainty

Audience:

1. CO-OPS navigation customers
2. Offshore wind energy industry
3. Regional WFOs and their customers

COLLABORATION WITH NOS / CO-OPS:

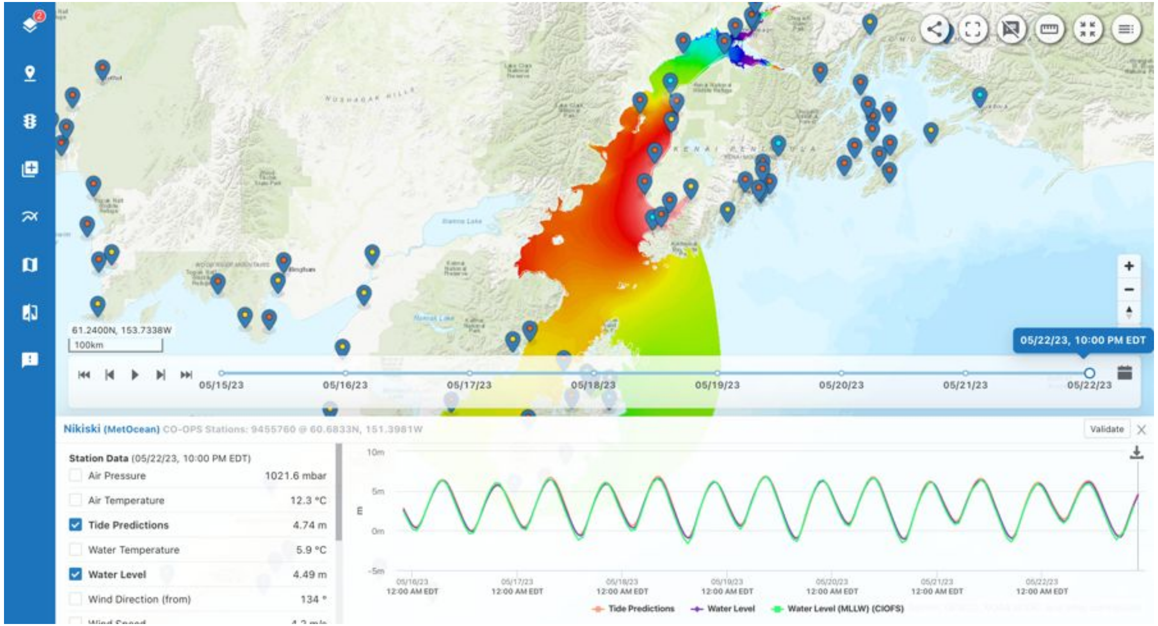
DATA INTEGRATION AND WEB-BASED MODEL VALIDATION TOOL FOR NOAA CO-OPS

Products to be Transitioned

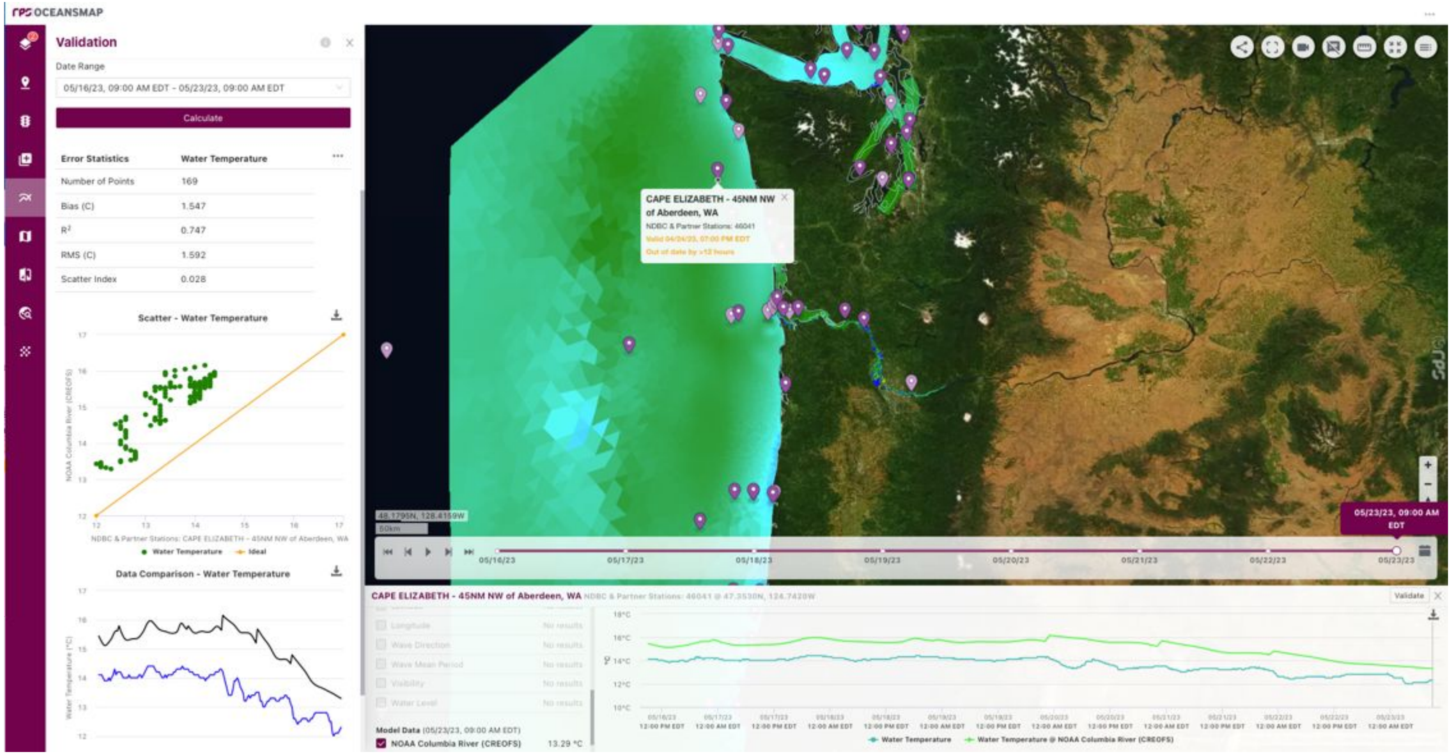
1. Operational TDS
2. OceansMap

Status

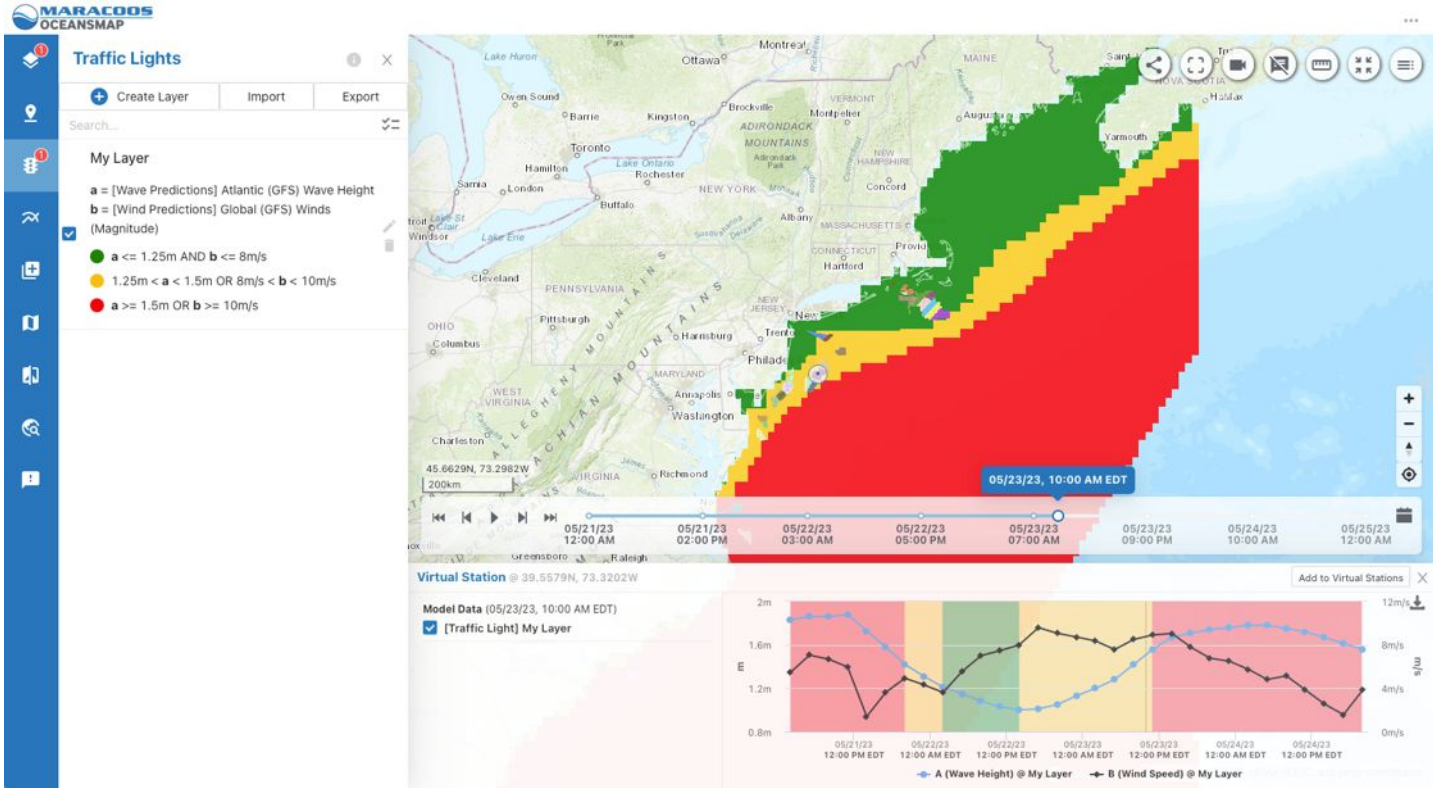
1. Deployment testing ongoing
2. Final stakeholder engagement



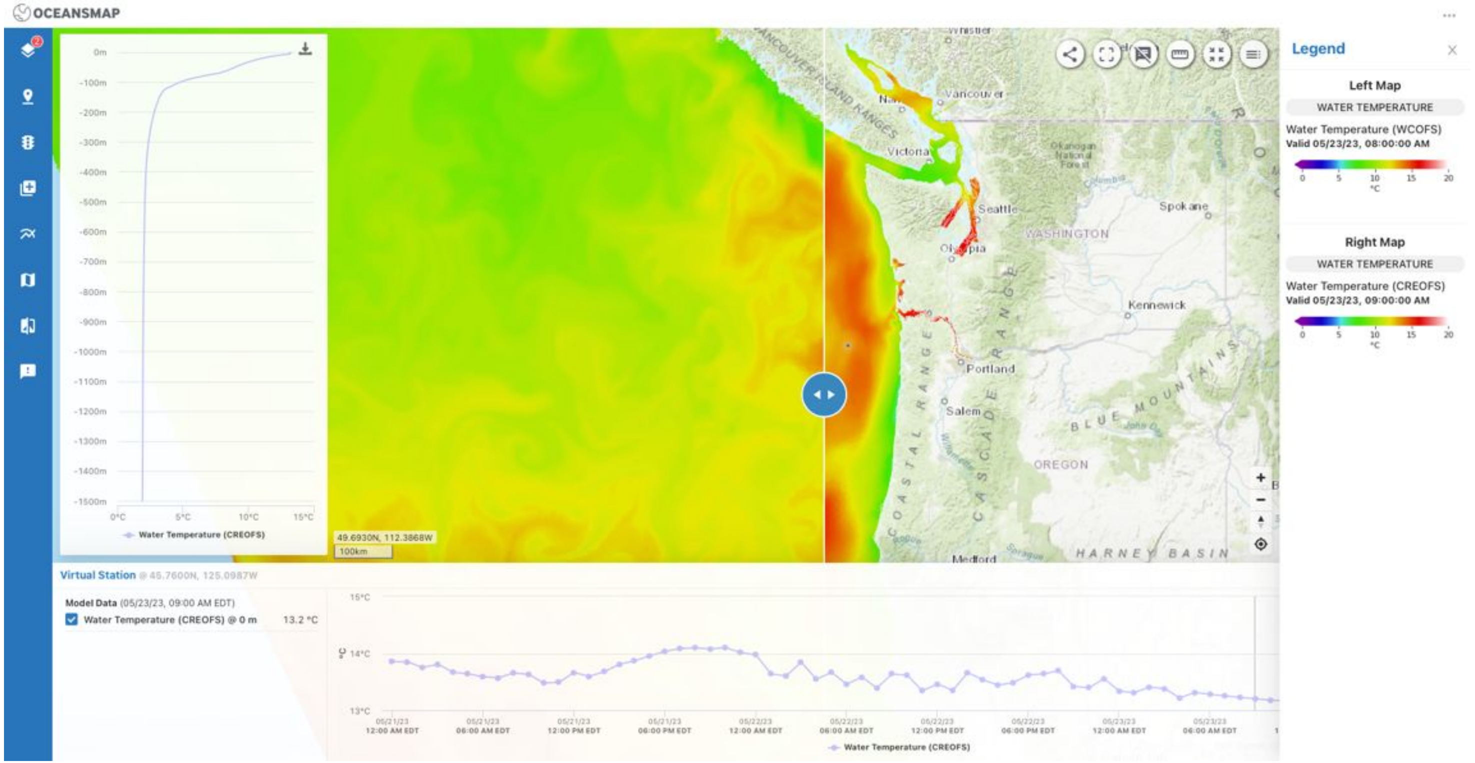
CO-OPS OCEANSMAP TOOLS: VALIDATE



CO-OPS OCEANSMAP TOOLS: MULTI-VARIATE ANALYSIS



CO-OPS OCEANSMAP TOOLS: COMPARE



THANK YOU

KELLY KNEE
Executive Director of Ocean Science at RPS North America
kelly.knee@rpsgroup.com

COASTAL COUPLING
COMMUNITY OF PRACTICE

LUNCH BREAK

We will resume at 1:30 PM CT


Minutes
Seconds
90:00

OWP | OFFICE OF WATER PREDICTION

NWM version 3.0 and NextGen

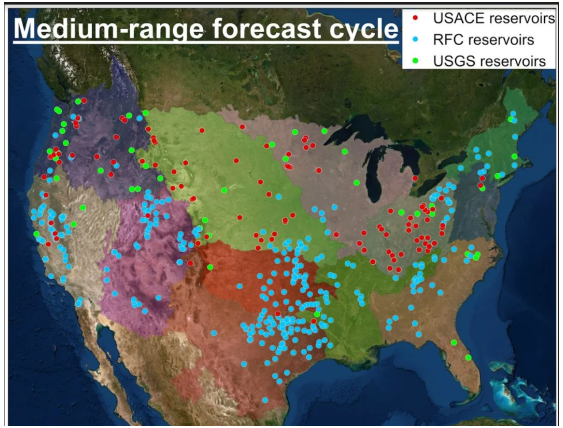
Dr. Trey Flowers

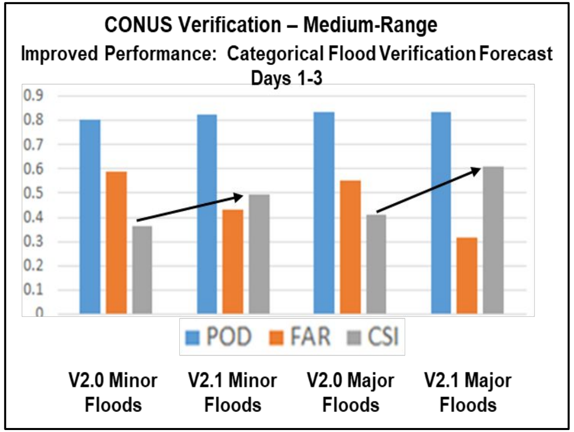
Director, Analysis and Prediction Division

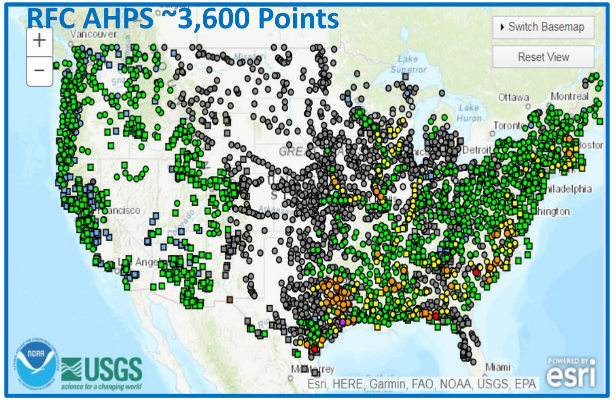
NOAA

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, v3.0 planned for July/August 2023
- Skill improvement version over version







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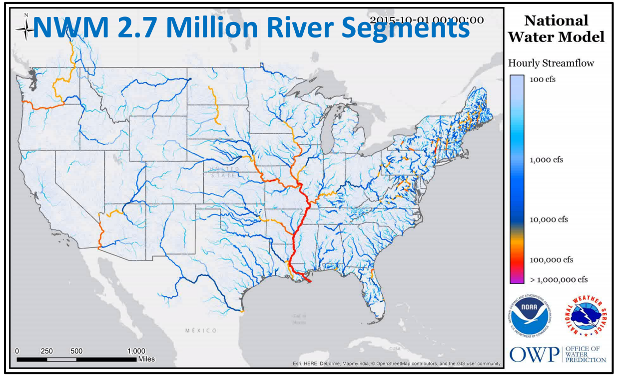
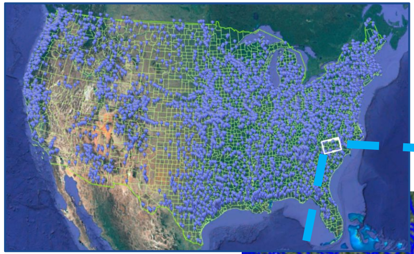
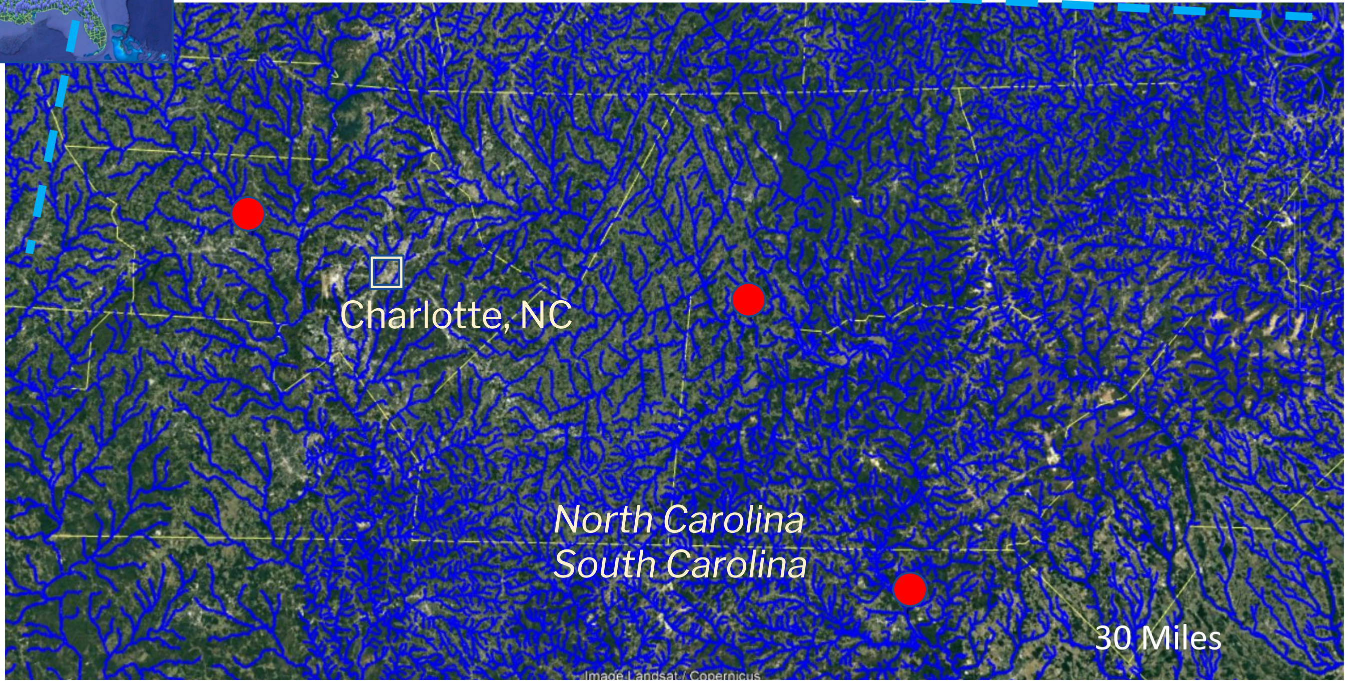


NWM: Filling the Forecast Coverage Gap



Coverage example over the Carolinas



- Population > 3 million in this region, much of which is more than 30 miles away from the nearest RFC forecast point (circles at right)
- NWM complements existing RFC forecasts by providing guidance over a very dense set of stream reaches (blue at right)

Enhancing the NWM: Development Trajectory

v.1.0/ 1.1/1.2

Foundation: 2016-2018

- First-ever NOAA water forecast model running on operational supercomputer
- 2.7 million reaches

v.2.0/ 2.1

Upgrades: 2019-2021

- Hawaii, medium range ens., physics upgrades, improved modularity, MPE ingest
- Expansion to PR and Great Lakes
- Reservoir modules, forcing upgrades, open-loop, and improved Hawaii forcing

v.3.0

Coming Soon: 2023

- Total water level
- Expansion to Alaska
- NBM forcing
- Improved runoff module, parameters, calibration and hydrofabric upgrades

v.4.0

Future Upgrade: 2025

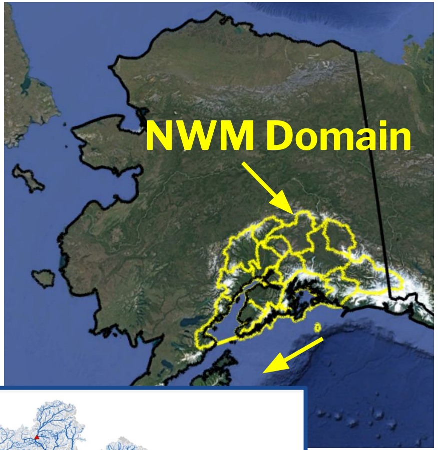
- Use of NextGen Framework - heterogeneous modeling, improved modularity, expanded community development

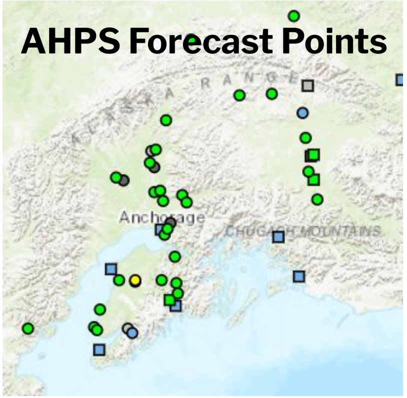
NWM v3.0: New Alaska Domain

Overarching Goal: Provide complementary and first-time hydrologic guidance for Alaska’s Cook Inlet, Copper River Basin and Prince William Sound Regions

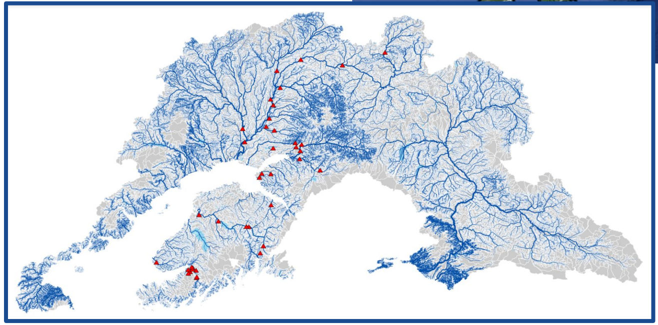
NWM Alaska Summary

- Close coordination with Alaska Pacific RFC
    - Assimilation of APRFC glacial dam lake (GDL) outflow forecasts
    - Customized model and forcing configurations
- Guidance for 390k stream reaches complements RFC AHPS sites
- Total water level guidance for AK coast in Version 4.0 of the model

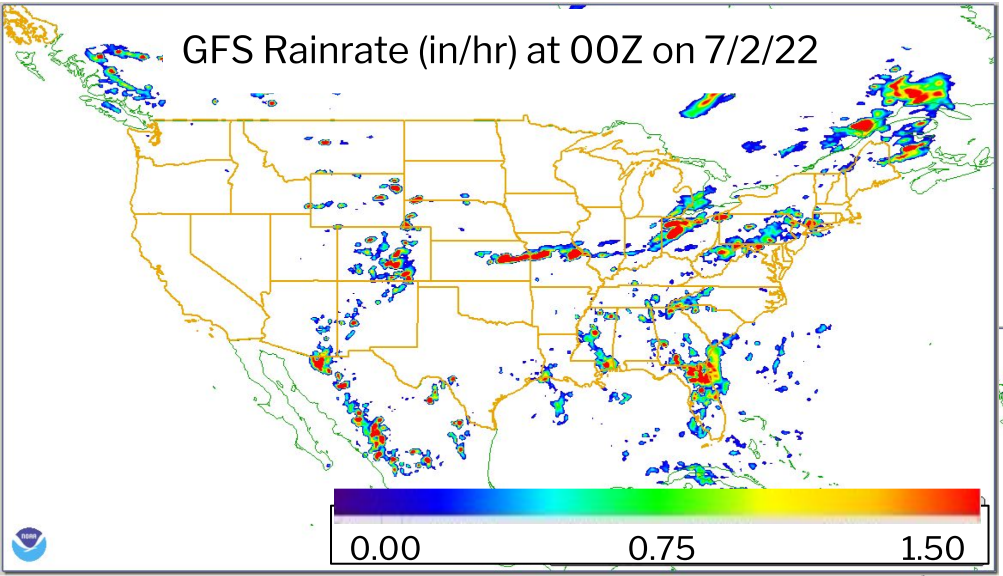




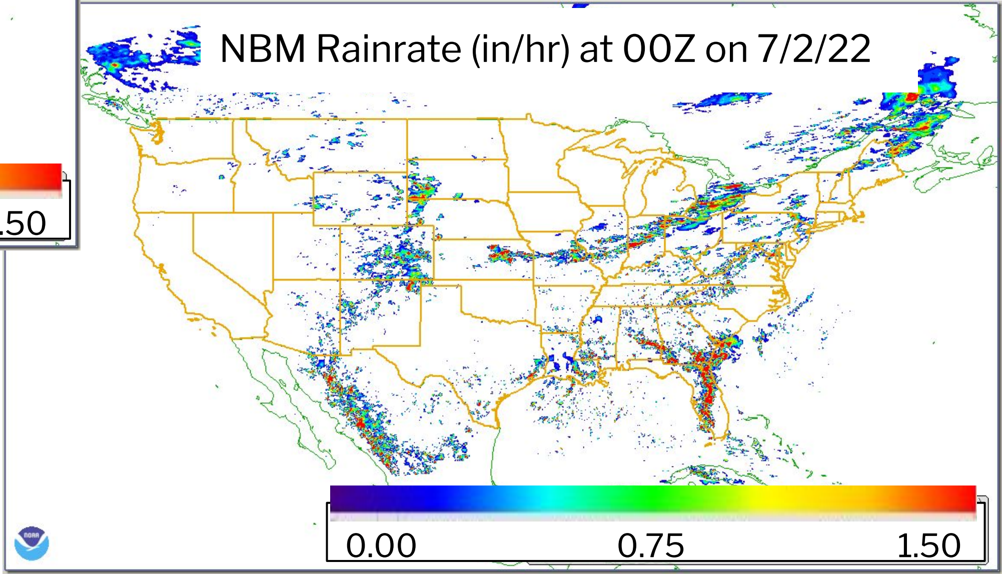
Dense network of NWM hydrologic guidance



NWM v3.0: New Forcing (National Blend of Models)



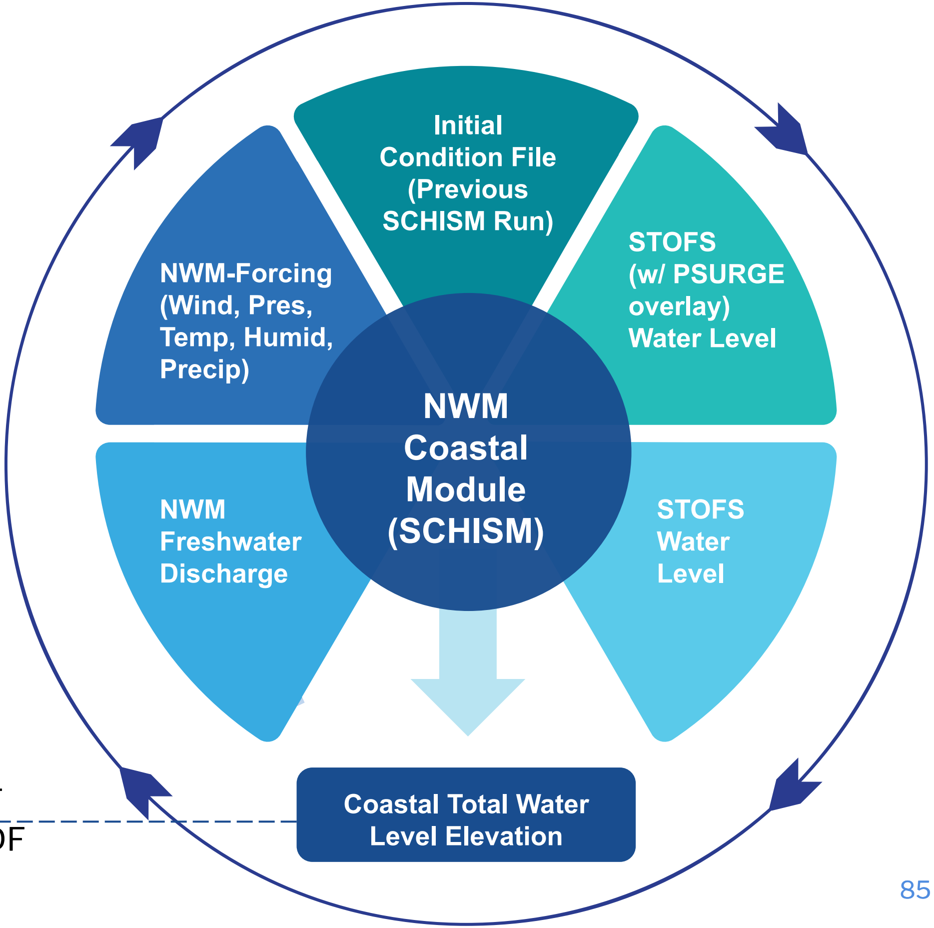
- Added for CONUS via new 10-day CONUS forecast configuration, complementing existing GFS-forced configuration
- Use of NBM enhances coordination with NWS Centers and Field offices



- NWM v3.0 features first-time NWM use of the NBM as forcing
- Implemented for both CONUS and Alaska domains

NWM v3.0: New Total Water Level Forecasting Capability

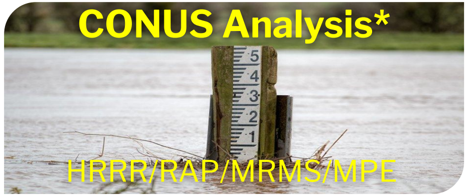
- With version 3.0, NWM TWL guidance complements existing regional forecasts over *CONUS-wide, Hawaii, and PR/VI domains*
- This new freshwater-estuary-ocean coupling leverages the NWM, SCHISM, STOFS & PSURGE, executes in both Analysis and Forecast modes.
- P-Surge 10% exceedance forecast used as boundary forcing, aligning with NHC practices
- Ongoing Field coordination has been extremely valuable (SHEF data format, transfer, ingest)



End Users

SHEF
NETCDF

NWM v3.0 Operational Cycling on WCOSS



Lookback Range 3-28 hrs

Including open loop (non-DA) members

18 Hour Forecast

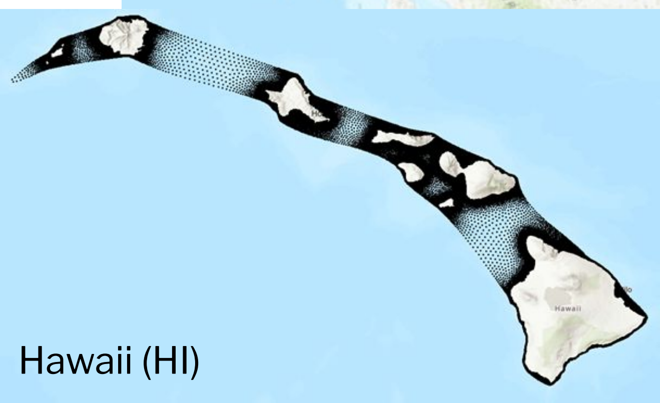
~10 Day Ens Forecast

Including open loop (non-DA) member

30 Day Ensemble Forecast

NWM v3.0 Total Water Level Domain Coverage

TWL output is masked at depths greater than 5 meters offshore, extends to 10 meter topographic height inland

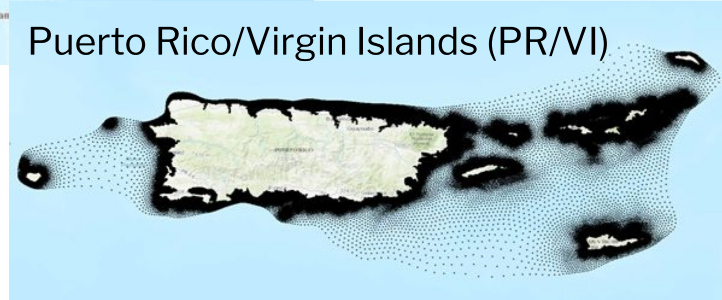


<u>Average Resolution</u>

Atlantic Coast: 75 m

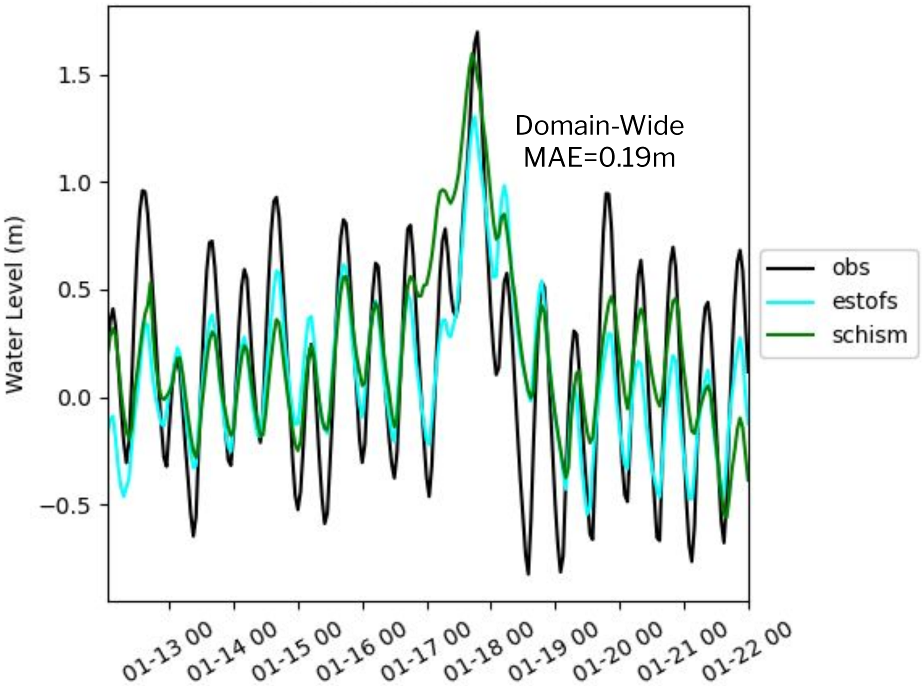
Pacific Coast: 50 m

PR-VI and HI: 30 m

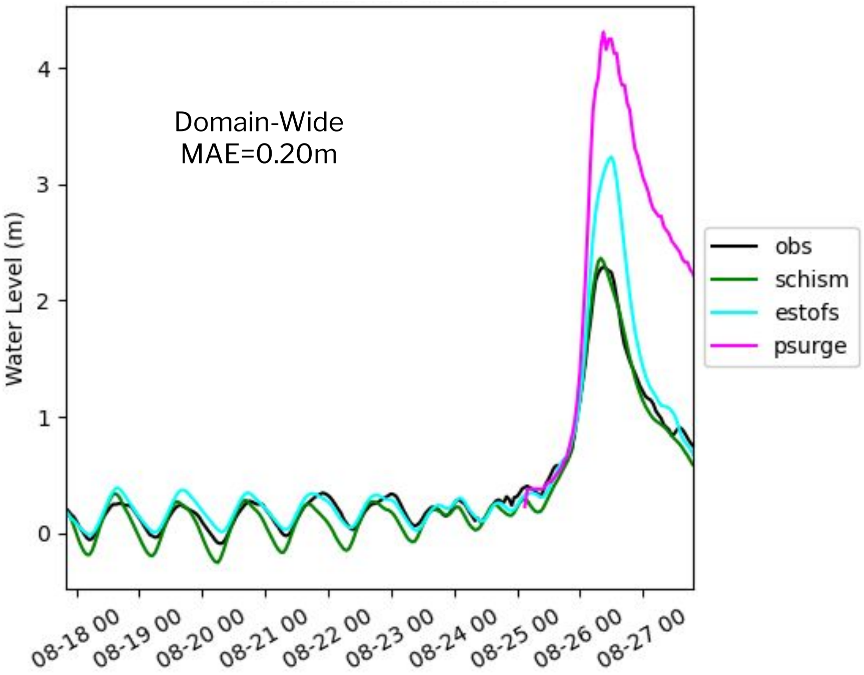


NWM Coastal Retrospective Evaluation: Storm Event Time Series

January 2022 Nor'easter
NWM TWL Output for Turkey Point, Hudson River, NY (TKPN6)



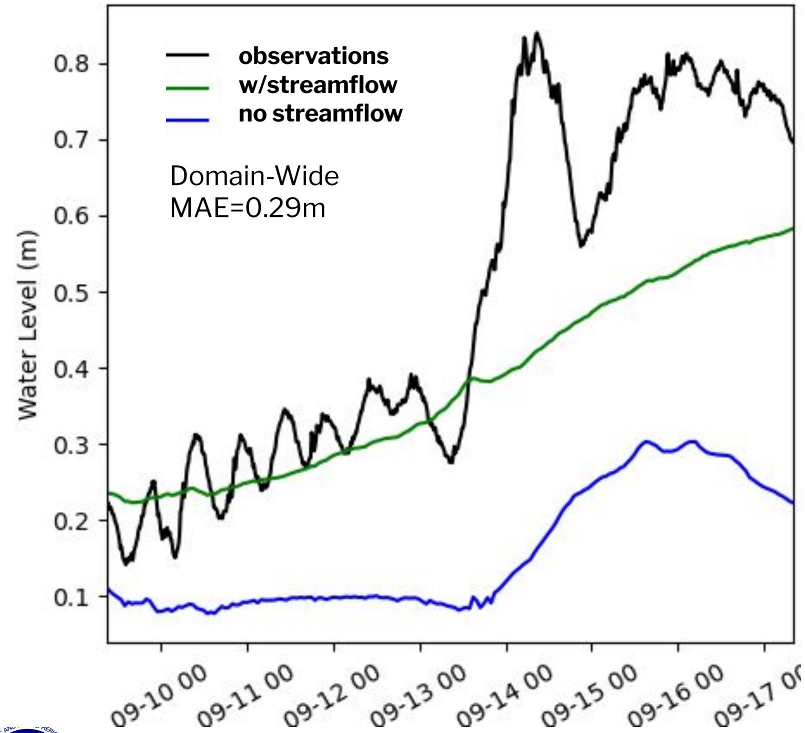
Hurricane Harvey
NWM TWL Output for Port Lavaca, TX (VCAT2)



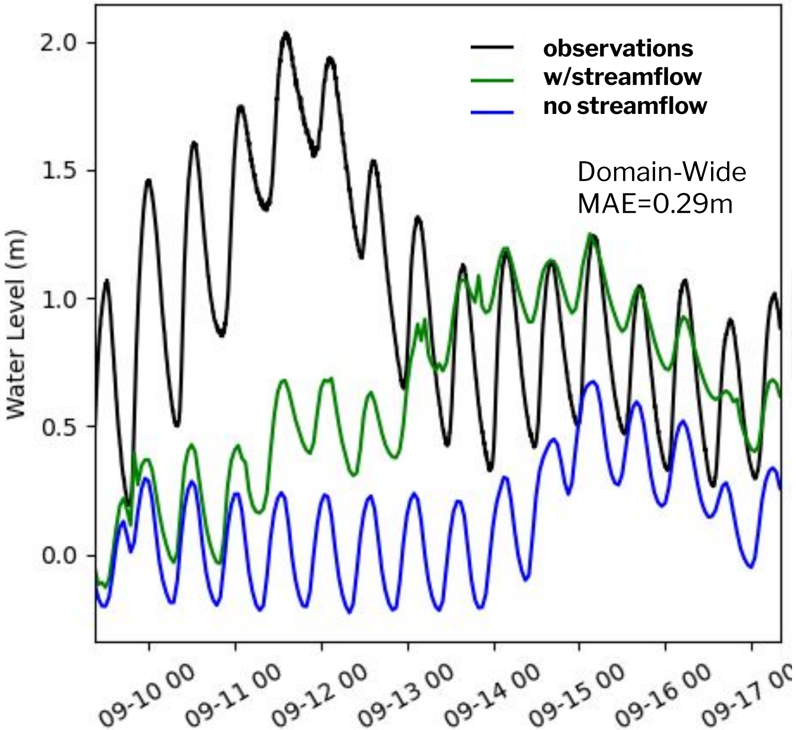
- **NWM Coastal module simulates 2022 Nor'easter and Harvey peaks at these sites with good accuracy**

NWM Coastal Retrospective Evaluation: Storm Event Time Series

Hurricane Florence 2018
NWM TWL Output for Roanoke River near Westover NC (WESN7)



Hurricane Florence 2018
NWM TWL Output for Potomac River at Georgetown, DC (GTND2)



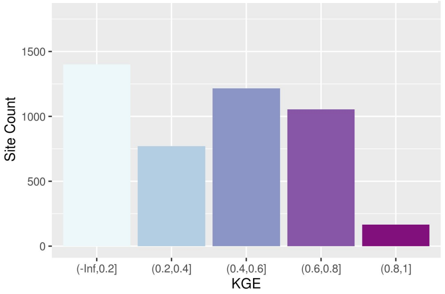
- Inclusion of freshwater in NWM coastal simulations improves simulation of water level (TWL)

How did we do?

OWP | OFFICE OF WATER PREDICTION

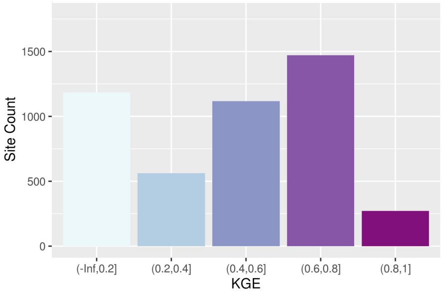
NWM v3.0 Retrospective Improvement: CONUS

V1.2
Distribution of KGE



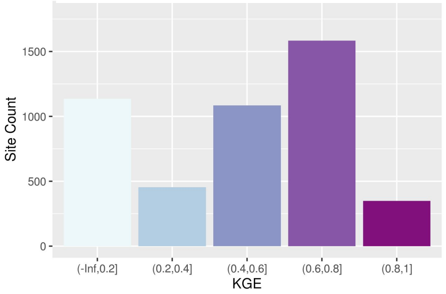
26% have KGE >= 0.6

V2.0
Distribution of KGE



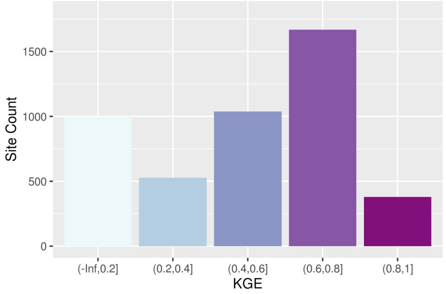
38% have KGE >= 0.6

V2.2
Distribution of KGE



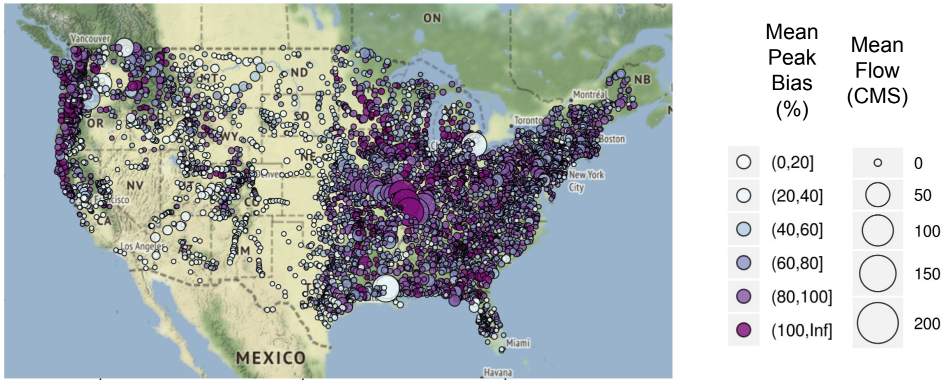
42% have KGE >= 0.6

V3.0
Distribution of KGE



44% have KGE >= 0.6

NWM v3.0 Streamflow KGE at
USGS Gauges (WY 2014-2016, AORC Forcing)

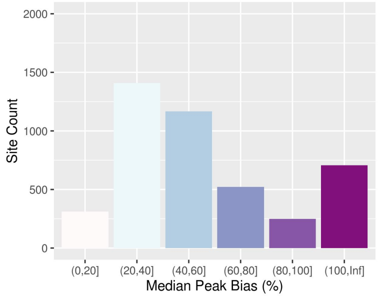


- **Streamflow KGE continues to improve at USGS gauged basins**
- **Simulation is for WY2014-2016 (validation period) and uses AORC forcing data**
- **No assimilation of streamflow or reservoir observations**

NWM v3.0 Retrospective Improvement: CONUS

V1.2

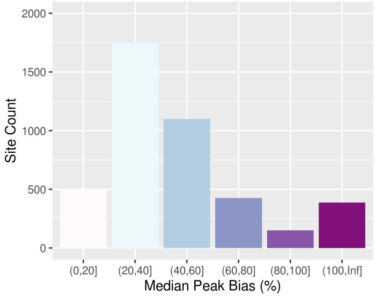
Distribution of Peak Bias (%)



39% have Peak bias < 40%

V2.0

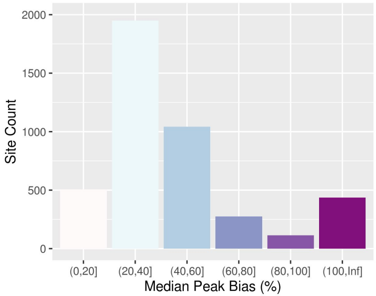
Distribution of Peak Bias (%)



52% have Peak bias < 40%

V2.2

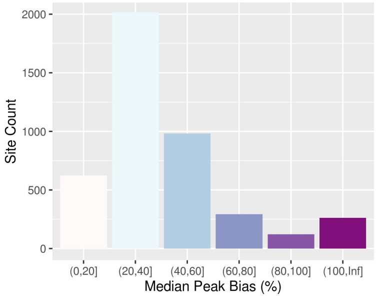
Distribution of Peak Bias (%)



57% have Peak bias < 40%

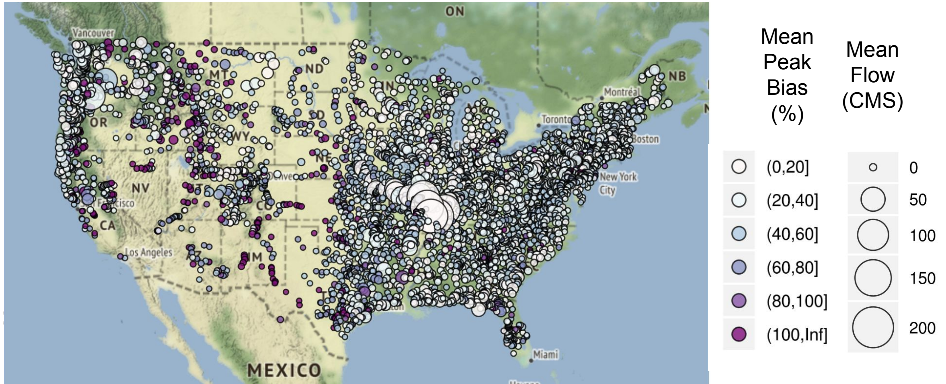
V3.0

Distribution of Peak Bias (%)



61% have Peak bias < 40%

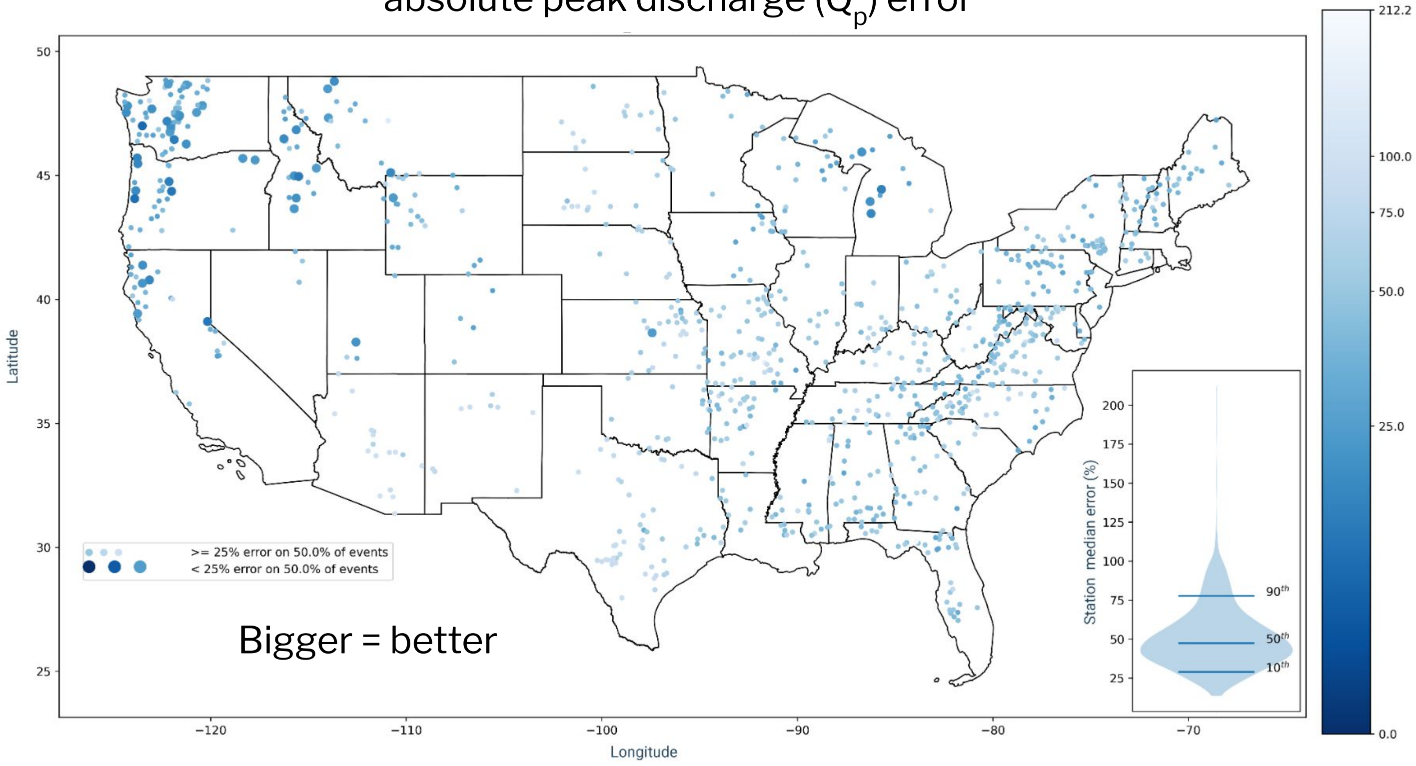
NWM v3.0 Streamflow Peak Bias (%) at
USGS Gauges (WY 2014-2016, AORC Forcing)



- **Streamflow peak bias (%) continues to improve at USGS gauged basins**
- **Simulation is for WY2014-2016 (validation period) and uses AORC forcing data**
- **No assimilation of streamflow or reservoir observations**

Known Geographic Variability in Performance

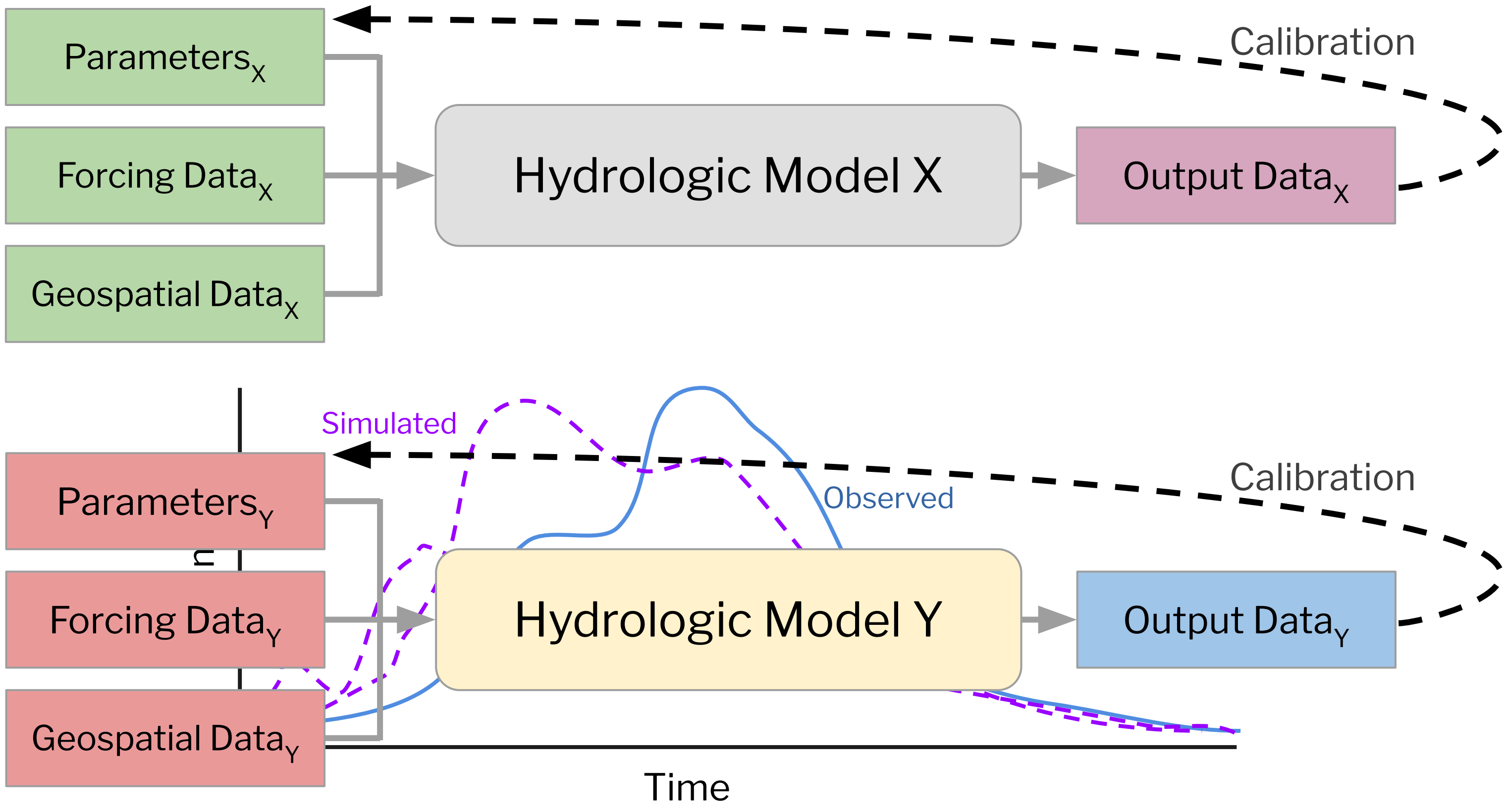
CONUS NWM V2.0 median warm season event-scale absolute peak discharge (Q_p) error



There has to be a better way

NOAA OWP | OFFICE OF WATER PREDICTION

A Major Time Investment



Forcing Data: More Formats, More Problems

- Traditional workflow: different models, different files/formats/columns/etc.
- Large, upfront time investment

Model X

```
950  1.0
   .0000000  .0000619  .0000328
   .0000000  .0000647  .0000325
   .0010000  .0000619  .0000330
   .0010000  .0000560  .0000333
   .0010000  .0000457  .0000348
   .0005000  .0000323  .0000356
   .0005000  .0000156  .0000356
   .0000000  .0000000  .0000356
   .0005000  .0000000  .0000351
```

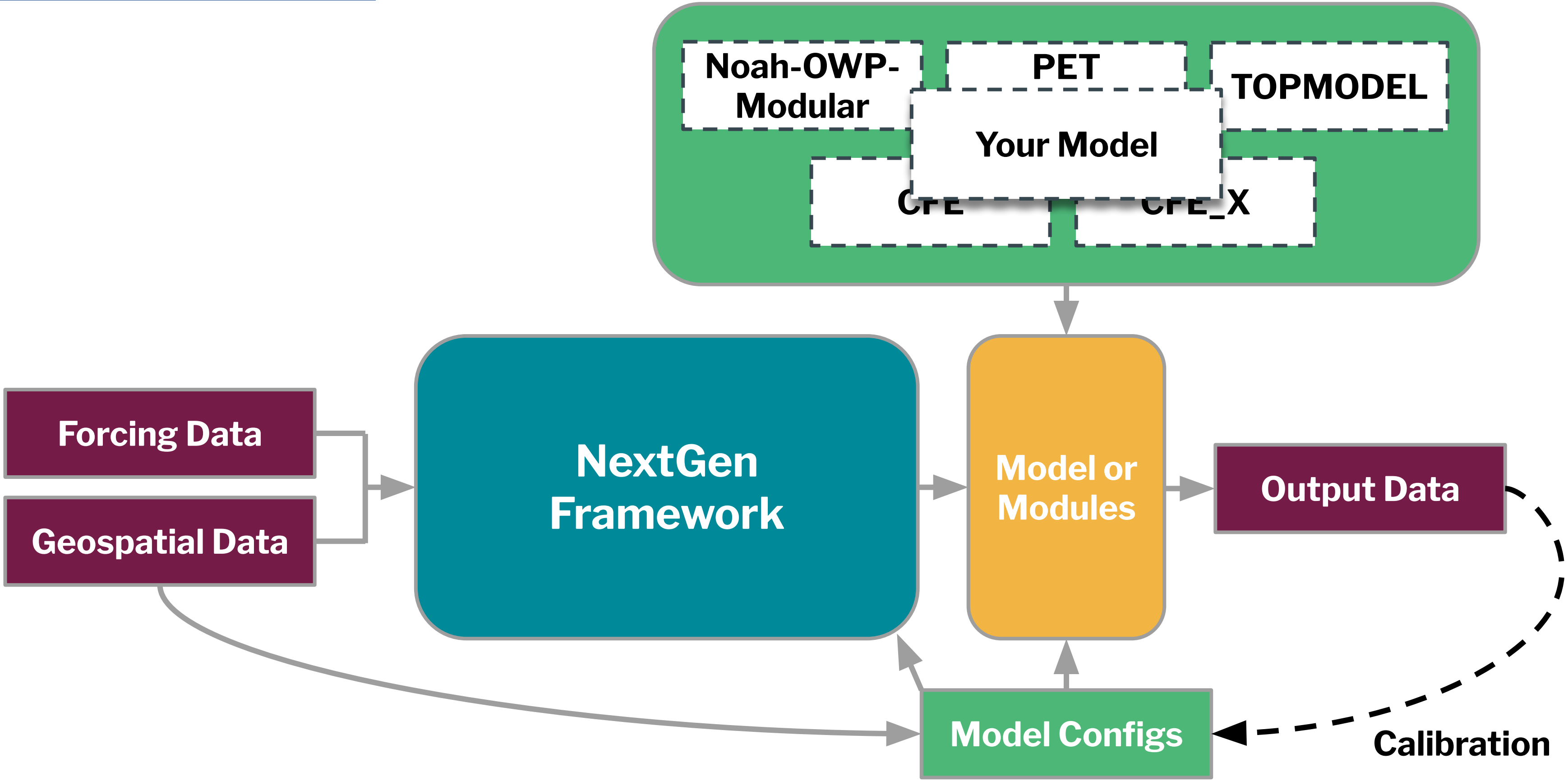
Model Y

```
-------------------------------------------------------------------------------------------------------------------------------
 UTC date/time        windspeed      wind dir        temperature      humidity       pressure        shortwave      longwave        precipitation
yyyy mm dd hh mi      m s{-1}        degrees         K                %              hPa             W m{-2}        W m{-2}         kg m{-2} s{-1}
-------------------------------------------------------------------------------------------------------------------------------
1998 01 01 06 30    5.6300001144  178.0000000000  263.9499816895  86.0999984741  1002.0000000000  0.0000000000  281.0000000000  0.0000000000
1998 01 01 07 00    6.7399997711  178.0000000000  264.7500000000  84.6999969482  1001.0000000000  0.0000000000  282.0000000000  0.0000000000
1998 01 01 07 30    6.2600002289  180.0000000000  265.1499938965  84.6999969482  1001.0000000000  0.0000000000  241.0000000000  0.0000000000
1998 01 01 08 00    6.0500001907  176.0000000000  265.4499816895  84.4000015259  1000.0000000000  0.0000000000  216.0000000000  0.0000000000
1998 01 01 08 30    5.7600002289  192.0000000000  265.4499816895  83.0000000000  1000.0000000000  0.0000000000  215.0000000000  0.0000000000
```

Model A

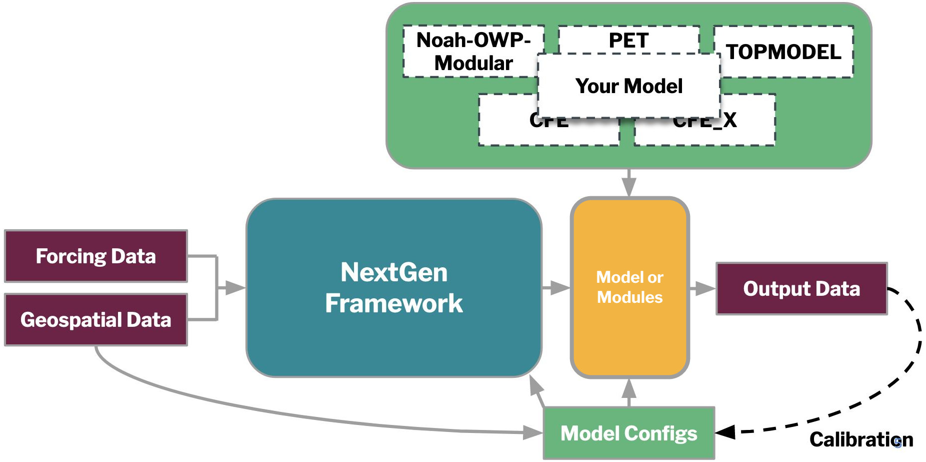
```
time,APCP_surface,DLWRF_surface,DSWRF_surface,PRES_surface,SPFH_2maboveground,TMP_2maboveground,UGRD_10maboveground,VGRD_10maboveground,precip_rate
2015-12-01 00:00:00,0.0,361.20001220703125,0.0,100530.0,0.010499999858438969,287.5,-2.6000001430511475,0.0,0.0
2015-12-01 01:00:00,0.0,361.20001220703125,0.0,100610.0,0.009800000116229057,287.3000183105469,-2.700000047683716,-0.30000001192092896,0.0
2015-12-01 02:00:00,0.0,361.20001220703125,0.0,100600.0,0.009099999442696571,286.6000061035156,-2.799999952316284,-0.6000000238418579,0.0
2015-12-01 03:00:00,0.0,357.6000061035156,0.0,100570.0,0.008700000122189522,285.5,-2.9000000953674316,-0.9000000357627869,0.0
2015-12-01 04:00:00,0.0,357.6000061035156,0.0,100590.0,0.008399999700486660,284.3000183105469,-2.6000001430511475,-0.30000001192092896,0.0
```

Simplify the process

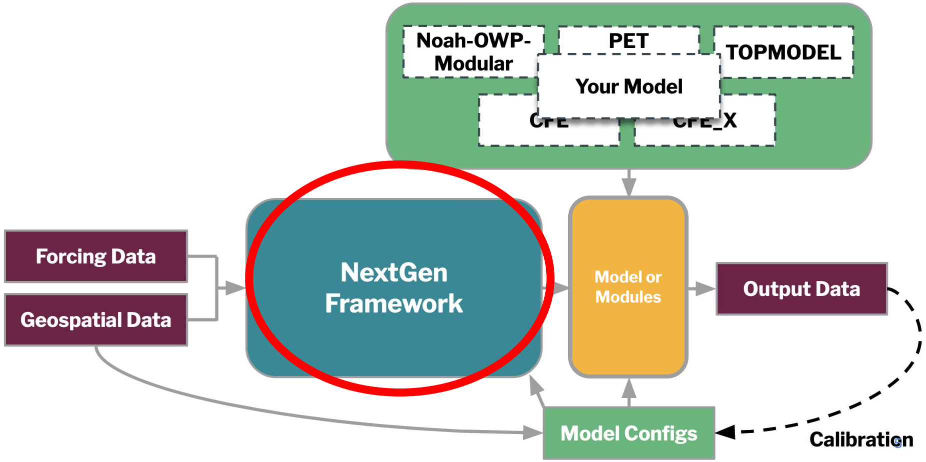


A few advantages of this approach

- Language- and model-agnostic
- Standard forcing and geospatial formats
- Easy model coupling via the Basic Model Interface
- Saves model setup time
- Lets you run different model and module sets (formulations) in a single instance



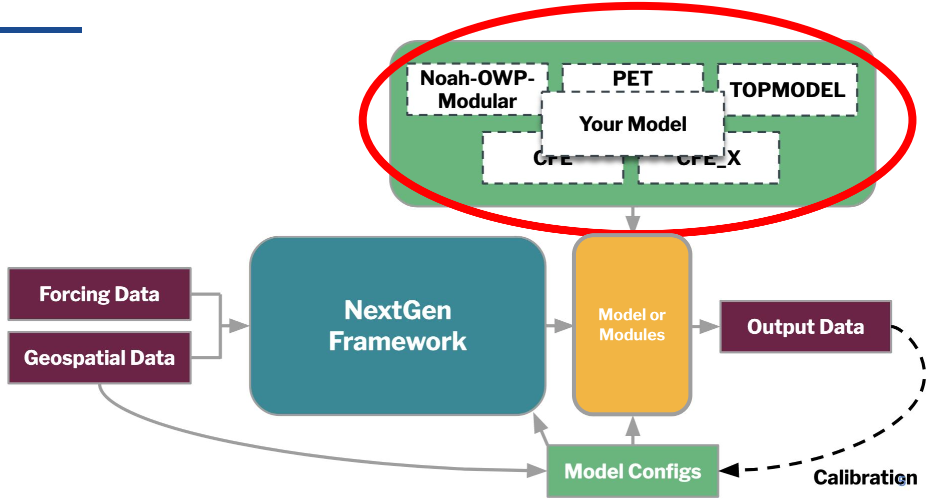
Quick component overview: framework



The **framework** is the heart of NextGen

- Controls model runtime and execution
- Reads input data and passes it to the models
- Couples models via Basic Model Interface functions
- Writes output data from models

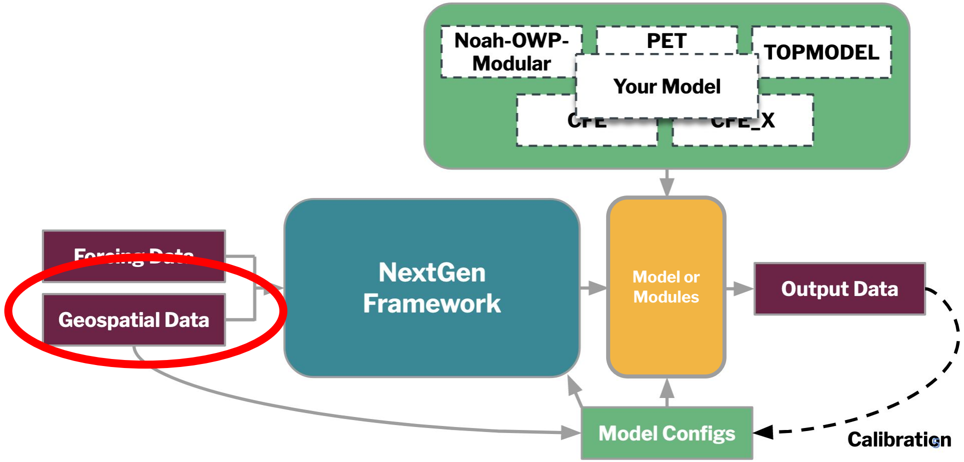
Quick component overview: formulations



Formulations are the coupled model sets running in a given location

- Surface processes (Noah-OWP-Modular, PET, Snow-17)
- Subsurface processes (CFE, TOPMODEL, Sac-SMA, LGAR)
- Machine learning (LSTM)
- Initialized by the model engine using configuration files generated from the hydrofabric

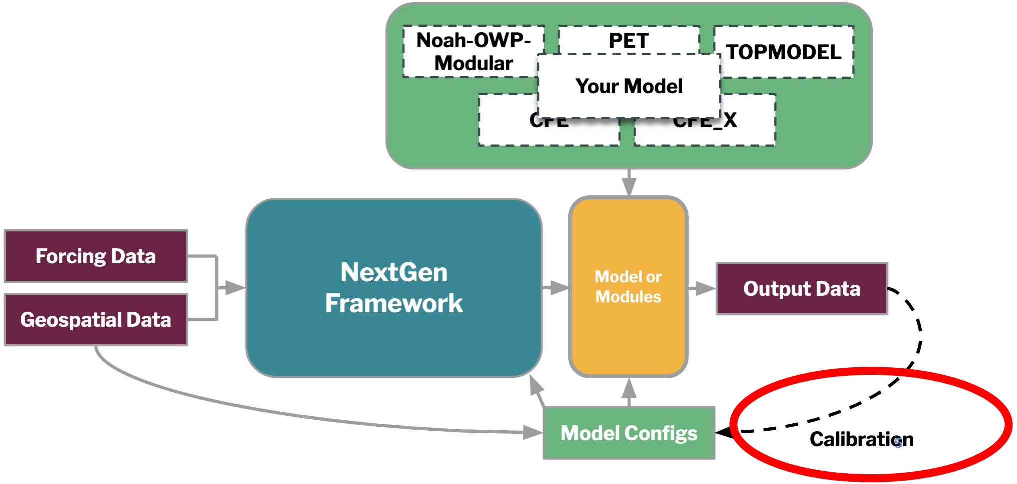
Quick component overview: hydrofabric



The **hydrofabric** defines the model domain, network connectivity, and basin attributes

- Created using fully open-source tools
- Derives data from publicly available sources using multi-dataset catalog
- https://noaa-owp.github.io/hydrofabric/index.html

Quick component overview: calibration

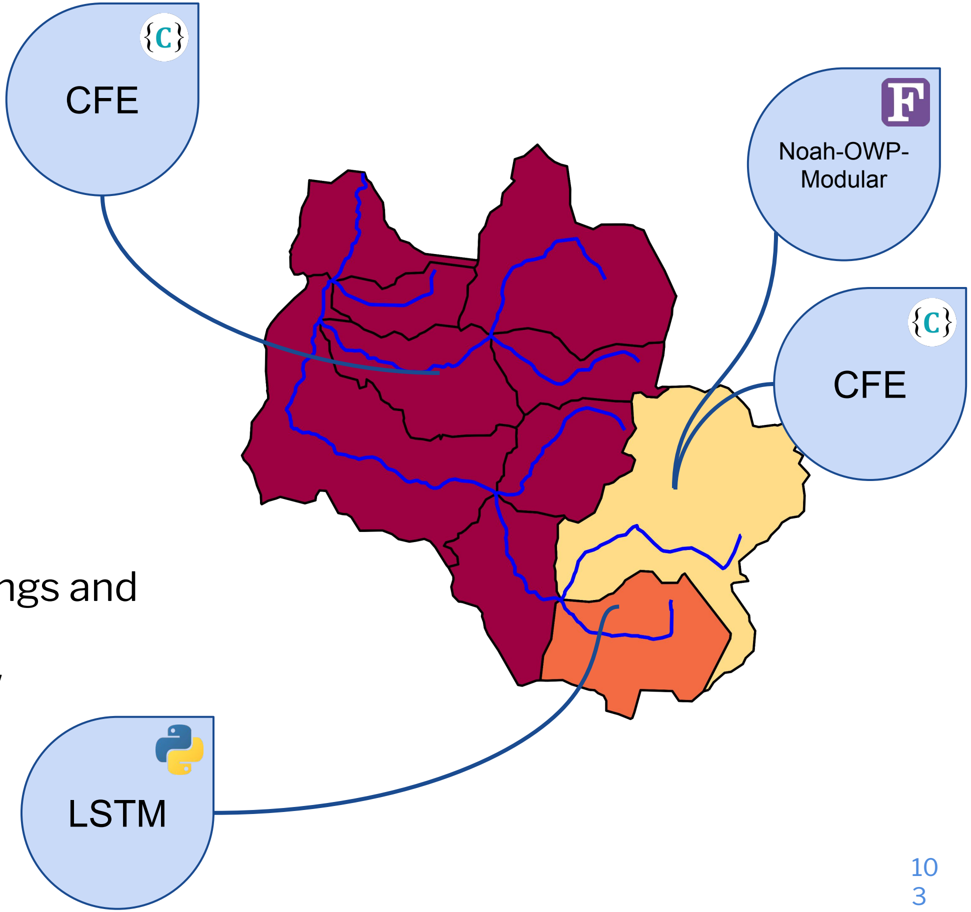


ngen_cal is a model-agnostic calibration package

- User can choose models, domains, time periods, default values, objective functions, and algorithms
- Relies on novel application of BMI functions to set parameters
- Compares output to USGS streamflow observations

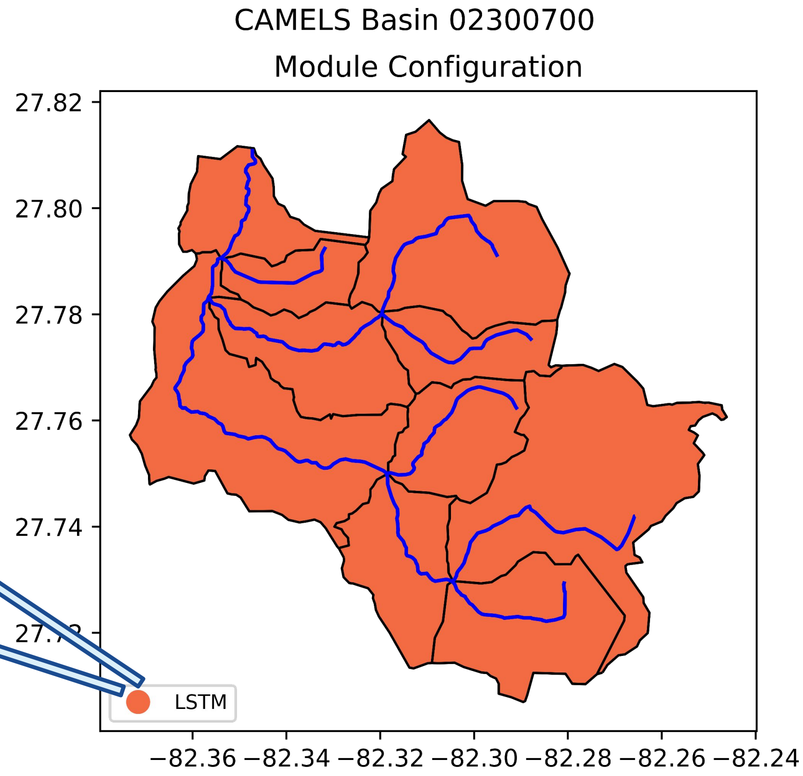
A Heterogeneous Modeling Approach

- NextGen pieces we need
  - Hydrofabric
  - Formulations
  - Configuration files
- Run experiments with NextGen
  - A single model formulation
  - A formulation built from 2 modules
  - Multiple formulations
- Advantages
  - Save time: from months to minutes
  - Reuse as much as possible (e.g. forcings and hydrofabric)
  - Reproducible, open-source workflow

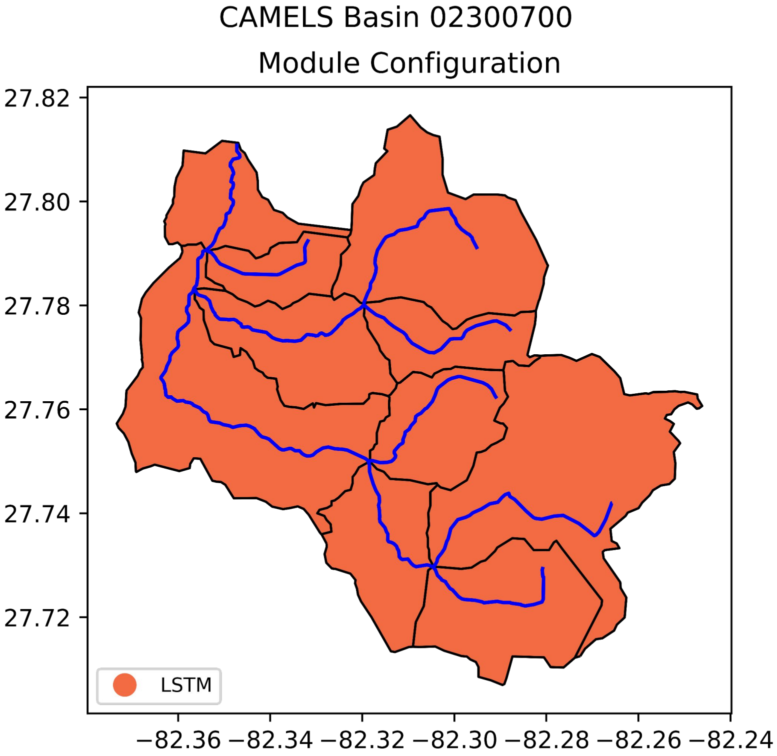


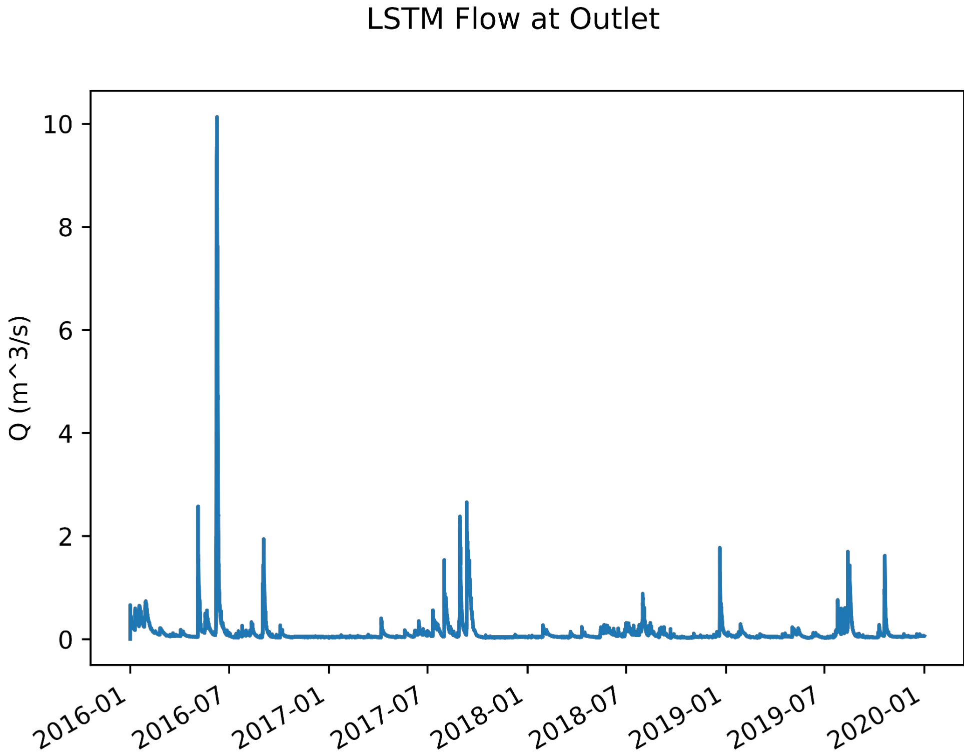
Hydrologic Modeling Using NextGen - LSTM

```
{
    "global": {
        "formulations": [
            {
                "name": "bmi_python",
                "params": {
                    "model_type_name": "LSTM",
                    "init_config": "../LSTM/{{id}}.yml",
                    "main_output_variable": "land_surface_water__runoff_depth",
                    "variables_names_map": {
                        "atmosphere_water__time_integral_of_precipitation_mass_flux": "RAINRATE"
                    },
                    "uses_forcing_file": false,
                    "allow_exceed_end_time": true,
                    "fixed_time_step": true,
                    "python_type": "bmi_lstm.bmi_LSTM"
                }
            }
        ],
        "forcing": {
            "file_pattern": ".*{{id}}.*.csv",
            "path": "../forcing",
            "provider": "CsvPerFeature"
        }
    },
    "time": {
        "start_time": "2016-01-01 00:00:00",
        "end_time": "2019-12-31 23:00:00",
        "output_interval": 3600
    },
```

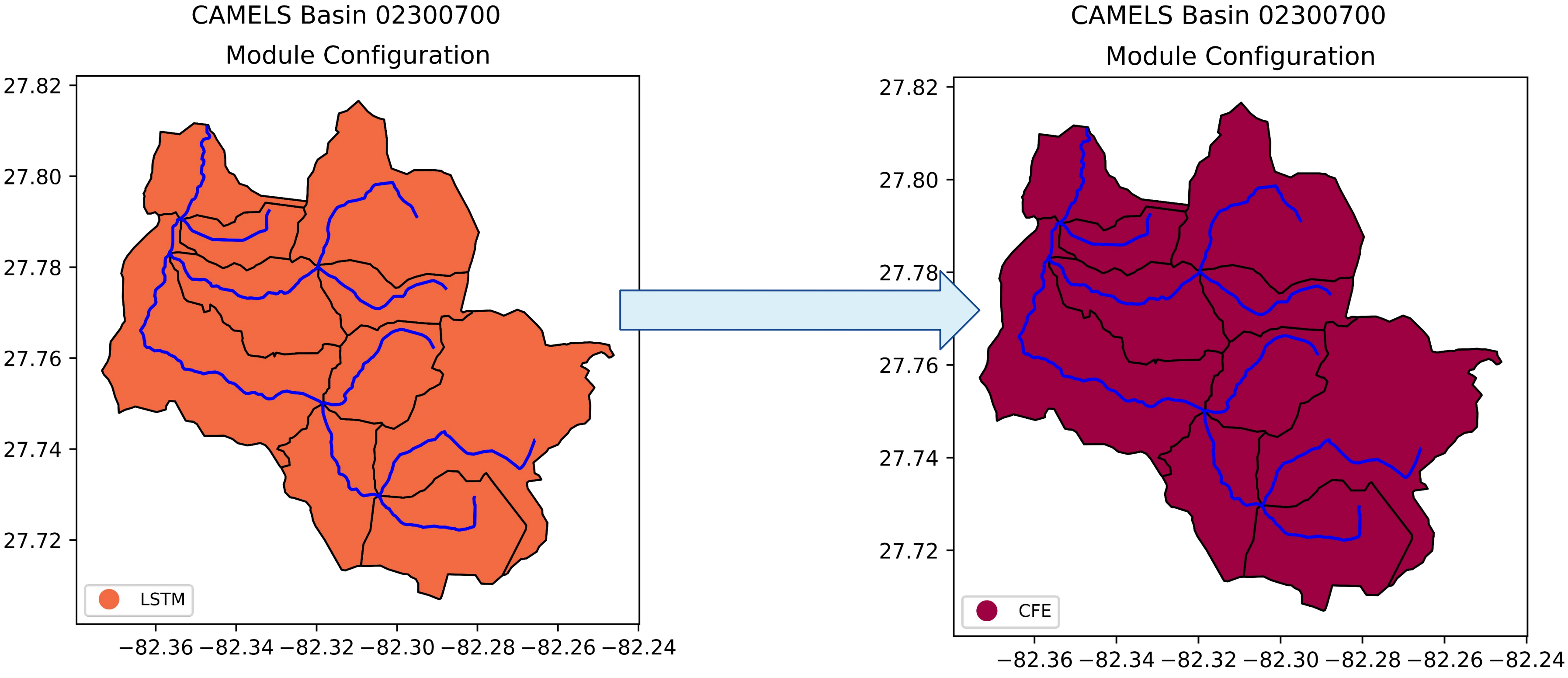


Hydrologic Modeling Using NextGen - LSTM Output



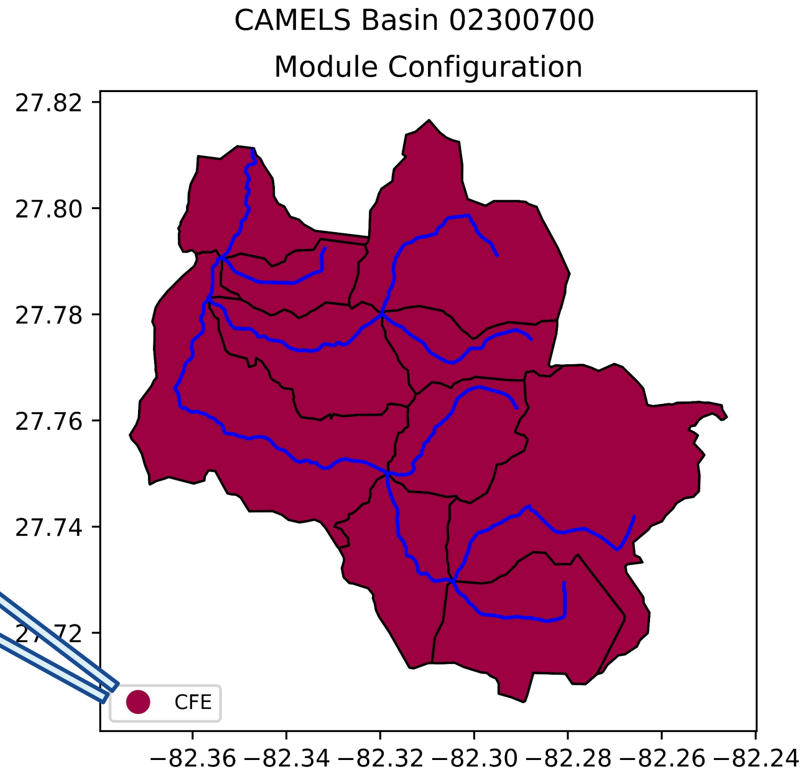


Hydrologic Modeling Using NextGen - Changing Formulations from LSTM to CFE

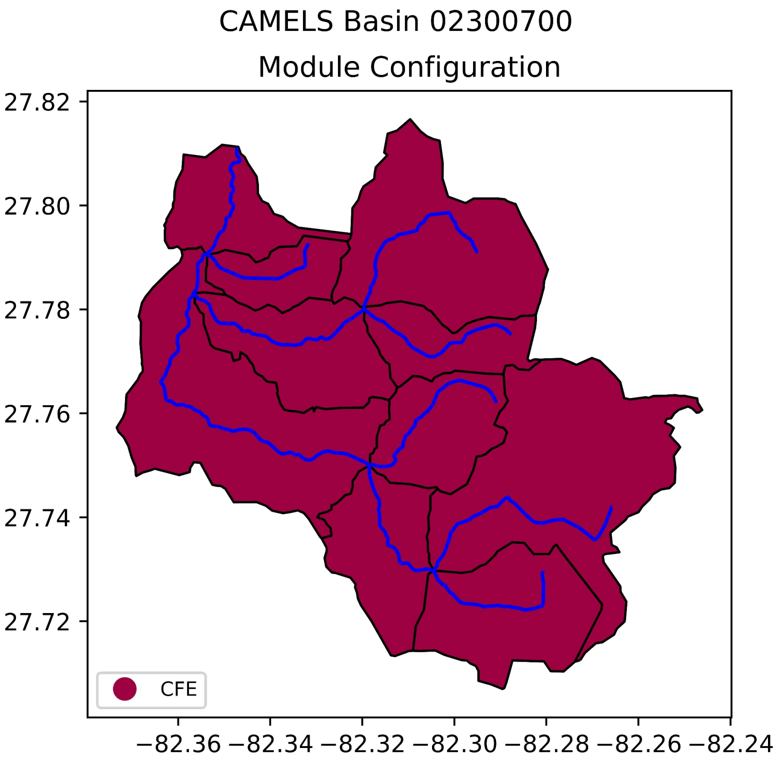


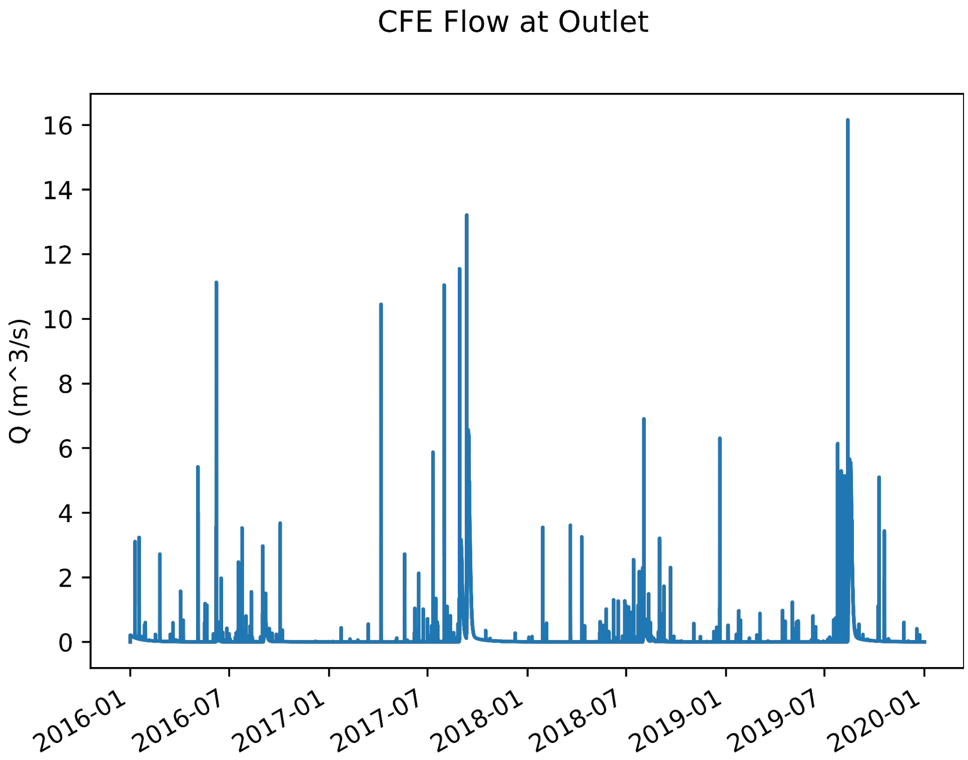
Hydrologic Modeling using NextGen - CFE Example

```json
{
    "global": {
        "formulations": [
            {
                "name": "bmi_c",
                "params": {
                    "model_type_name": "CFE",
                    "init_config": "CFE/{{id}}_bmi_config_cfe_pass.txt",
                    "main_output_variable": "Q_OUT",
                    "variables_names_map": {
                        "atmosphere_water__liquid_equivalent_precipitation_rate": "RAINRATE"
                    },
                    "model_params": {},
                    "uses_forcing_file": false,
                    "allow_exceed_end_time": true,
                    "fixed_time_step": true,
                    "library_file": "../lib/libcfebmi.dylib",
                    "registration_function": "register_bmi_cfe"
                }
            }
        ],
        "forcing": {
            "file_pattern": ".*{{id}}.*.csv",
            "path": "forcing",
            "provider": "CsvPerFeature"
        }
    },
    "time": {
        "start_time": "2016-01-01 00:00:00",
        "end_time": "2019-12-31 23:00:00",
        "output_interval": 3600
    }
}
```

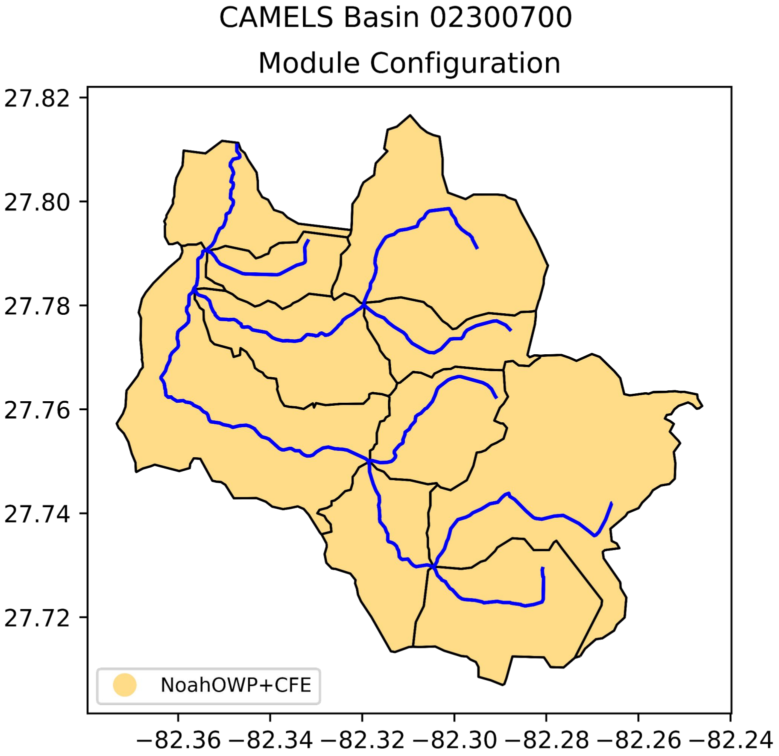


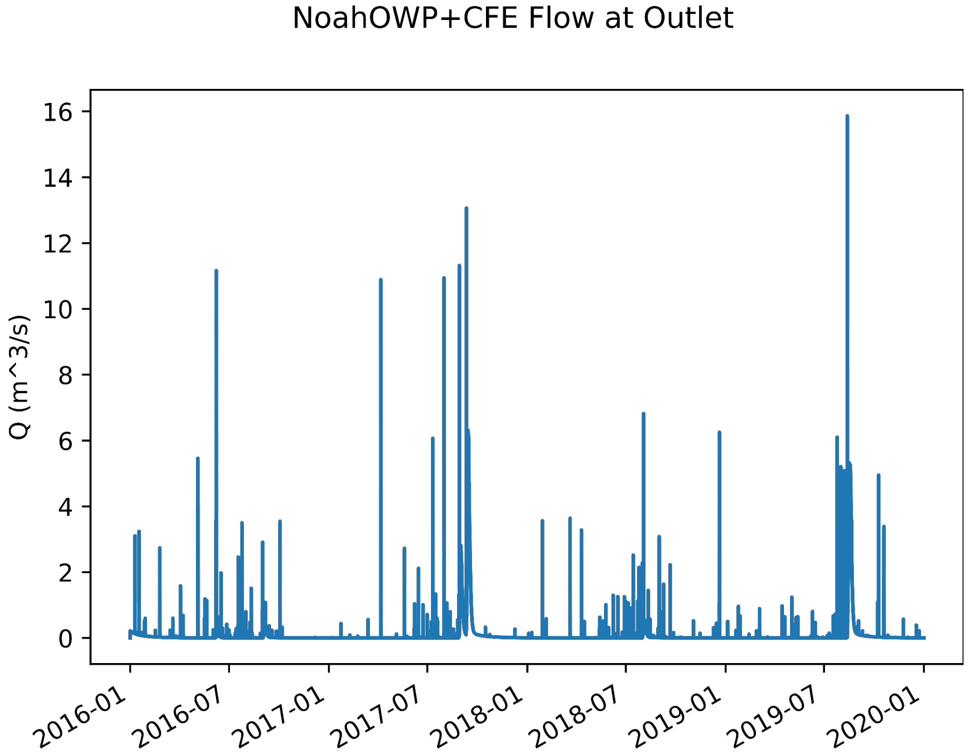
Hydrologic Modeling using NextGen - CFE Output



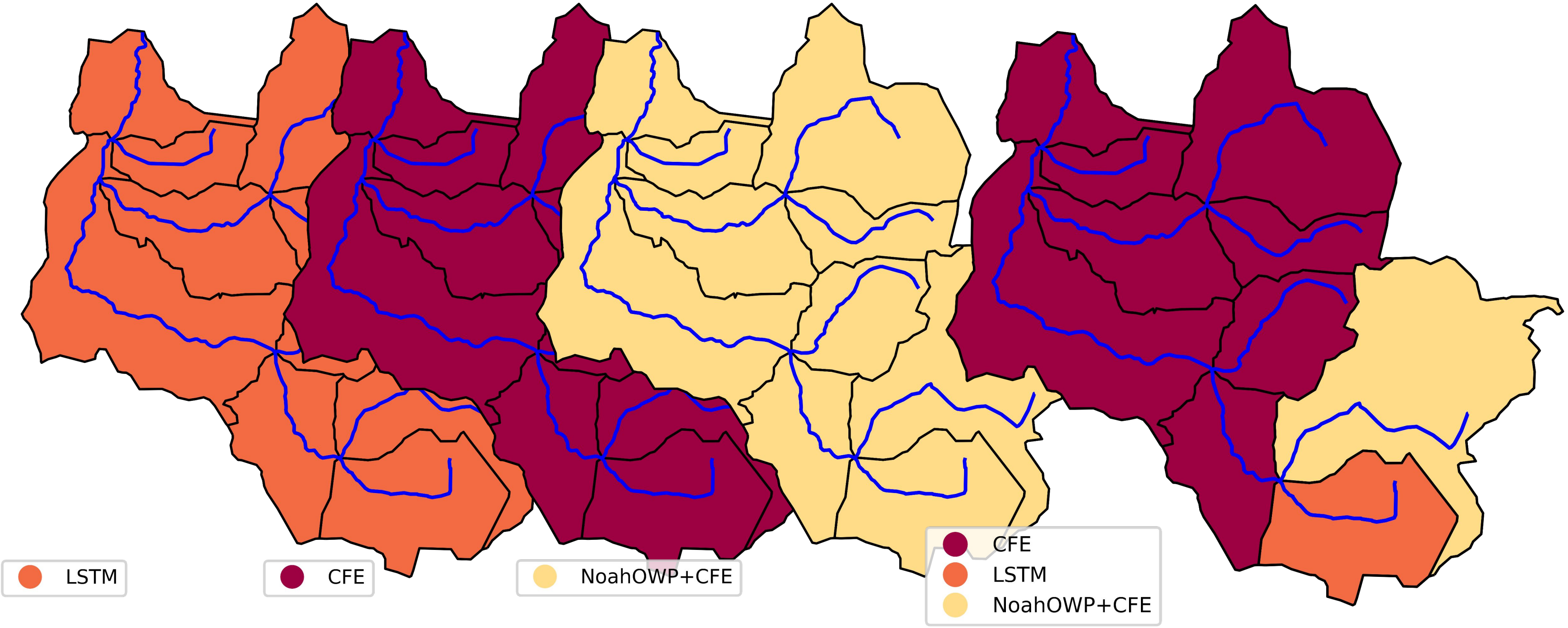


Hydrologic Modeling Using NextGen - NoahOWP + CFE Output

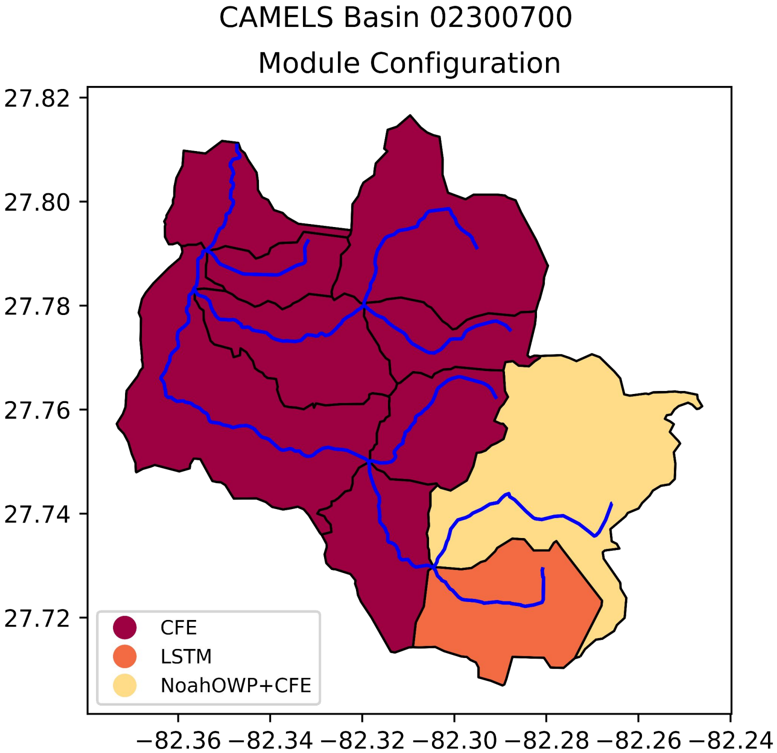


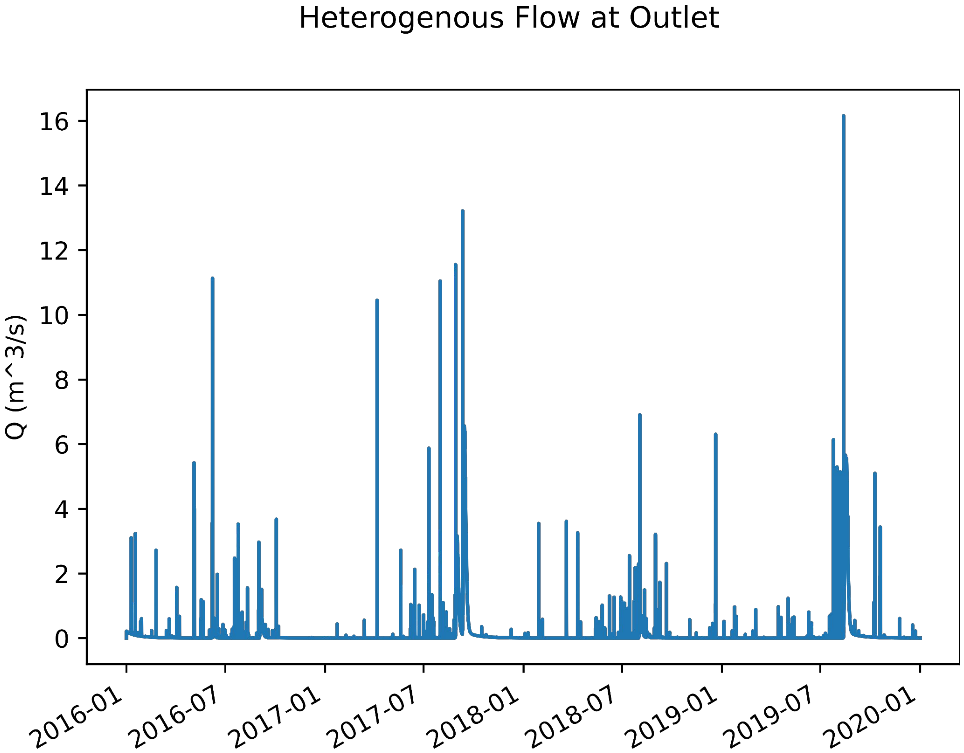


Hydrologic Modeling Using NextGen - Right Tool in the Right Place for the Right Reason



Hydrologic Modeling Using NextGen - Heterogeneous Formulation Output





With Great Power Comes Great Responsibility

Let's consider for a moment some of what is required to use NextGen:

- Ensure the right forcing data is available
- Build the expected BMI module libraries and save them to the expected directories
- Build the NextGen executable and install/save to the expected directory
- Write a detailed realization configuration file in a text editor
- Ensure BMI module configs, NextGen realization config, forcings, and hydrofabric files are in the right directories for execution
- Use the correct syntax for the command to start execution

And to perform calibration of NextGen using our ngen-cal utility:

- Everything above for NextGen itself
- Recall the specific algorithms and options that are supported
- Write a detailed calibration configuration file by hand in a text editor

And to evaluate formulation performance:

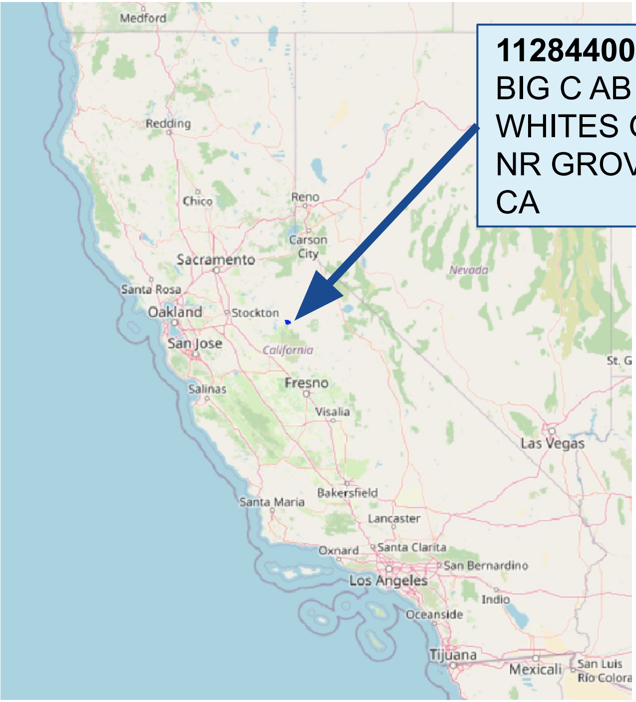
- Everything above for NextGen and calibration
- Specify objective functions, optimization algorithms, evaluation metrics, time periods, etc.
- Specify observation datasets
- Execute evaluation and display results

All of this can be done.

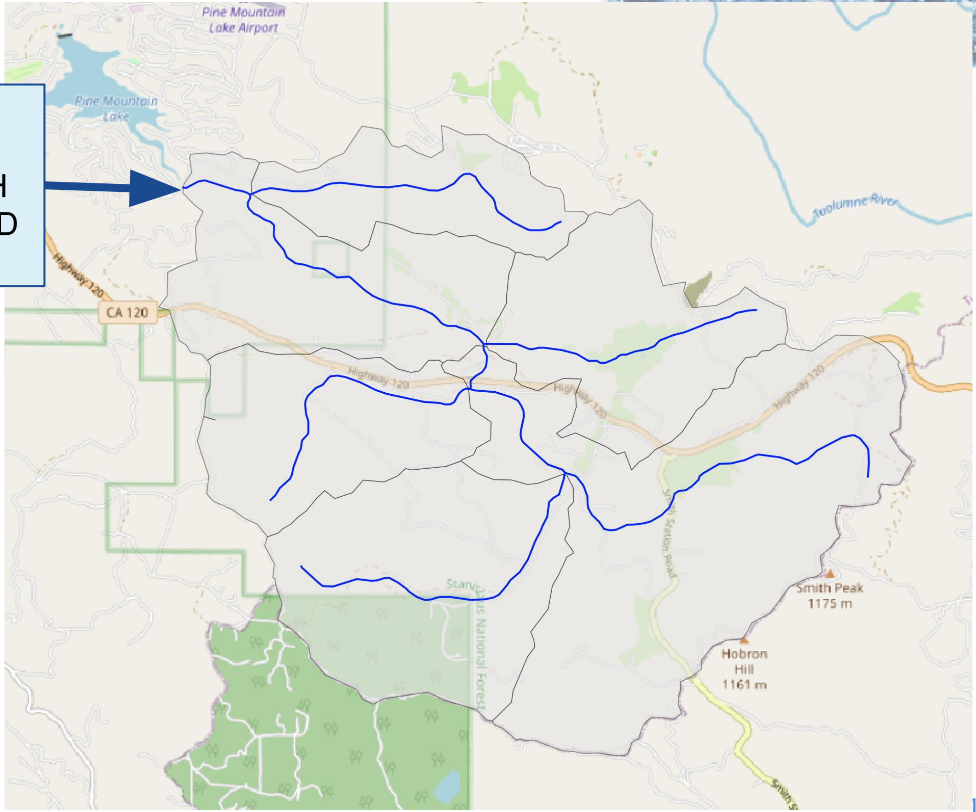
But can we make things easier/faster?

SPOILER ALERT!

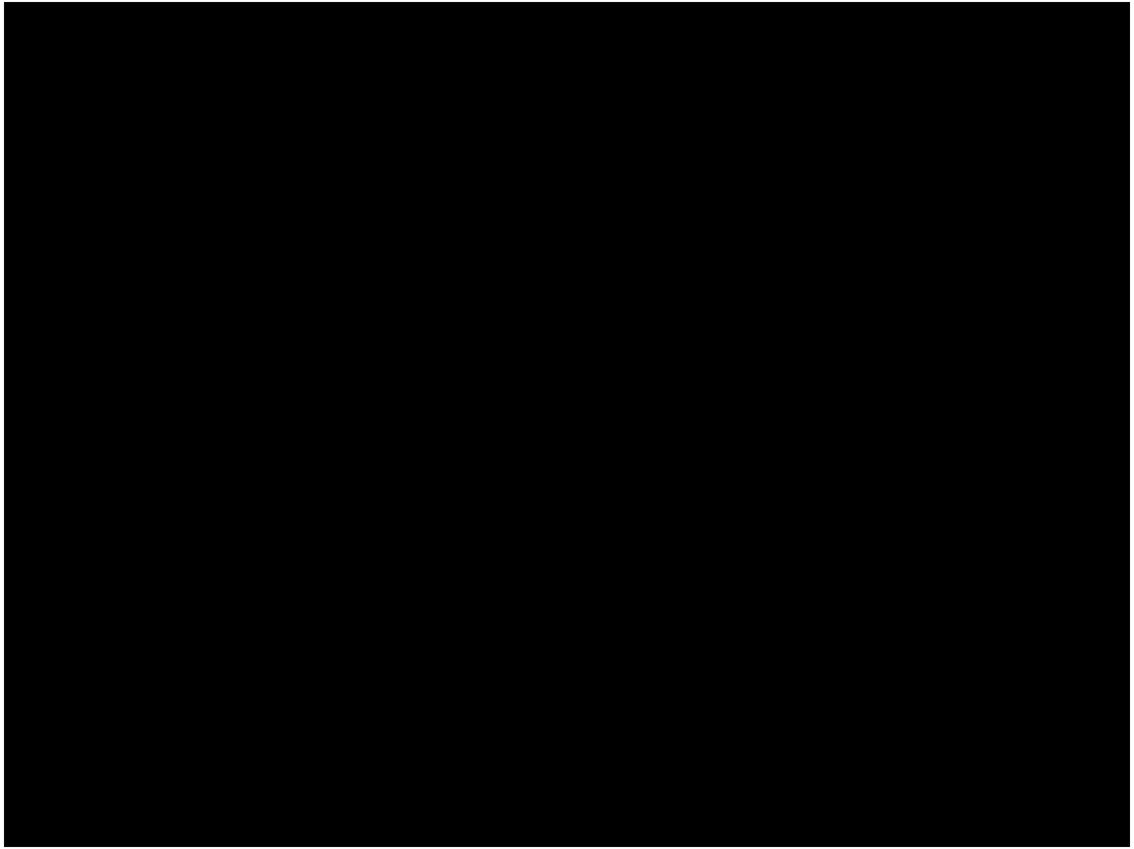
Case Study



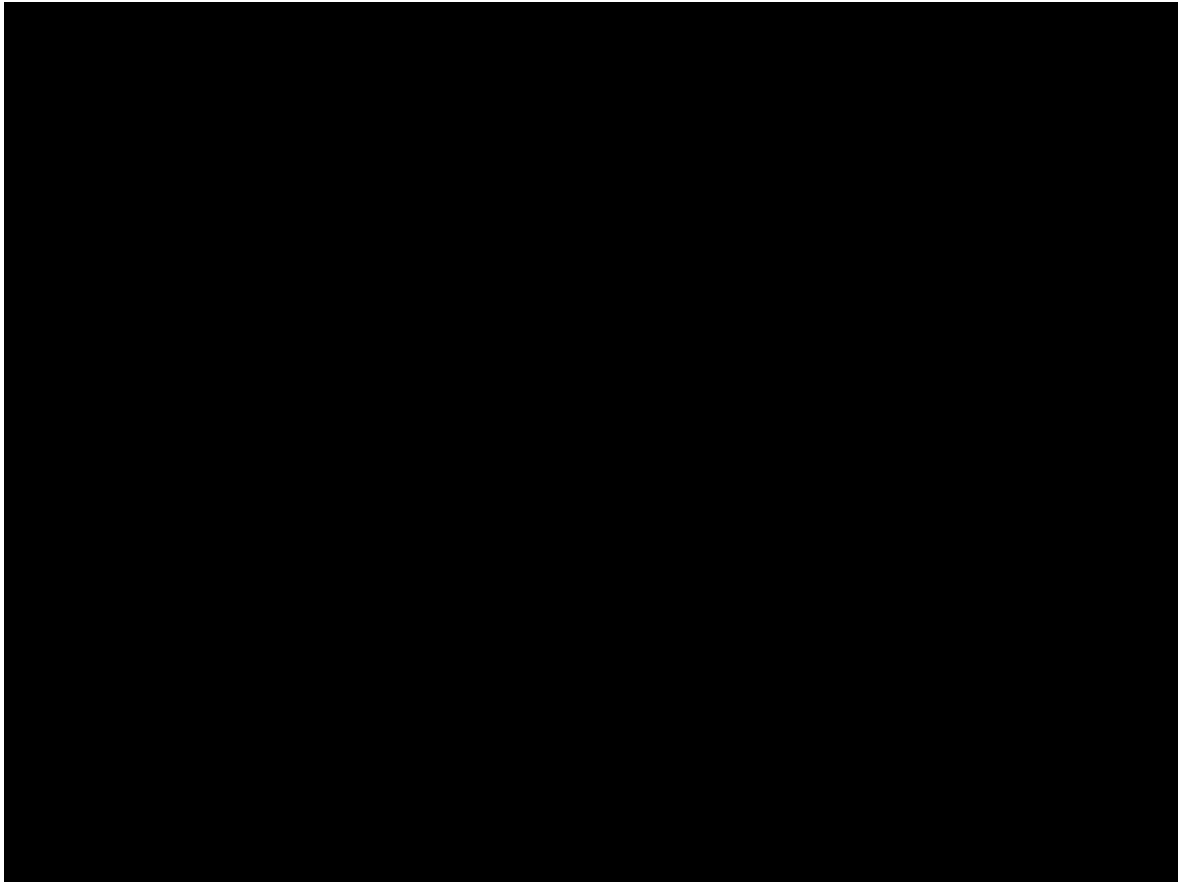
11284400
BIG C AB WHITES GULCH NR GROVELAND CA



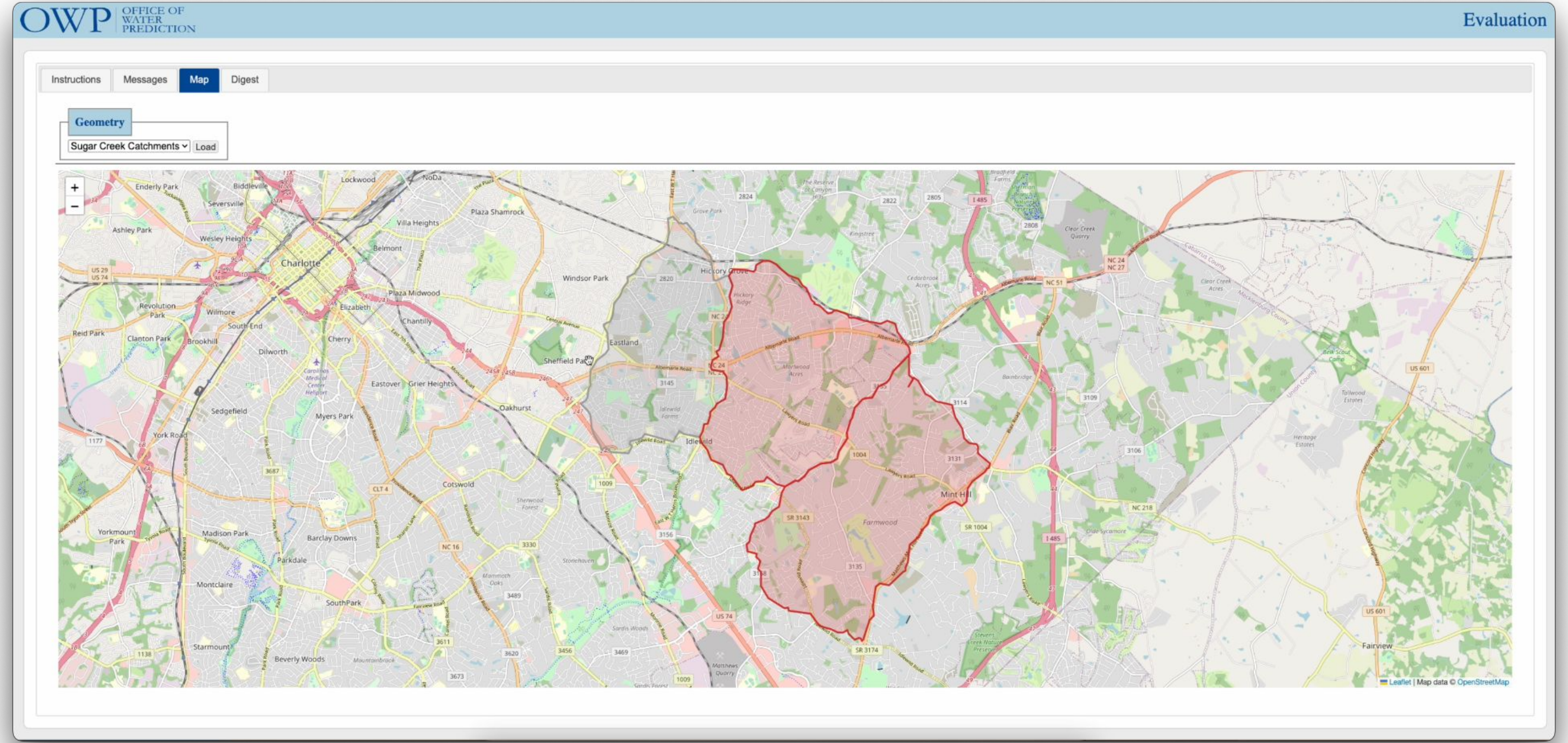
Easier Execution via NextGen Tools



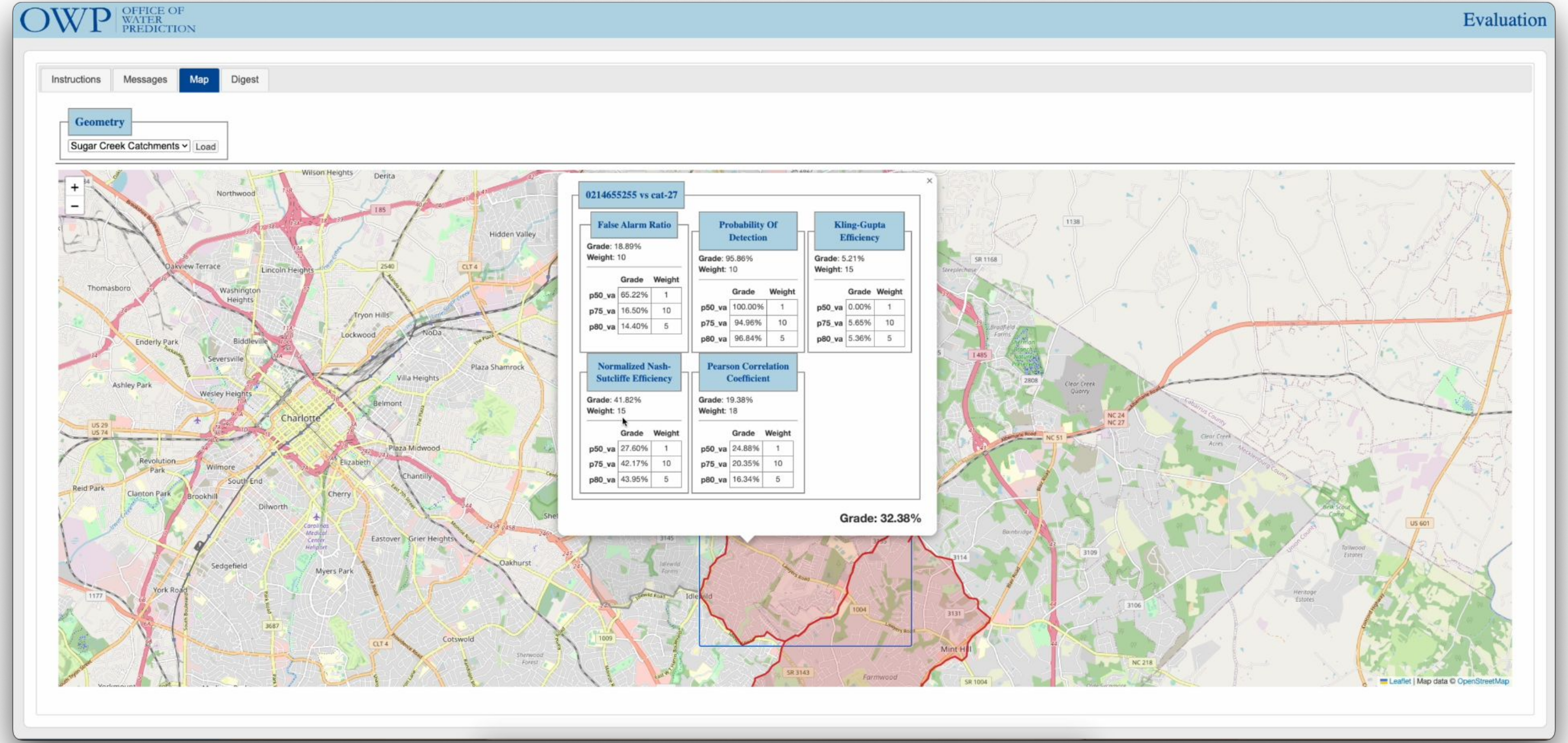
Calibration with NextGen Tools



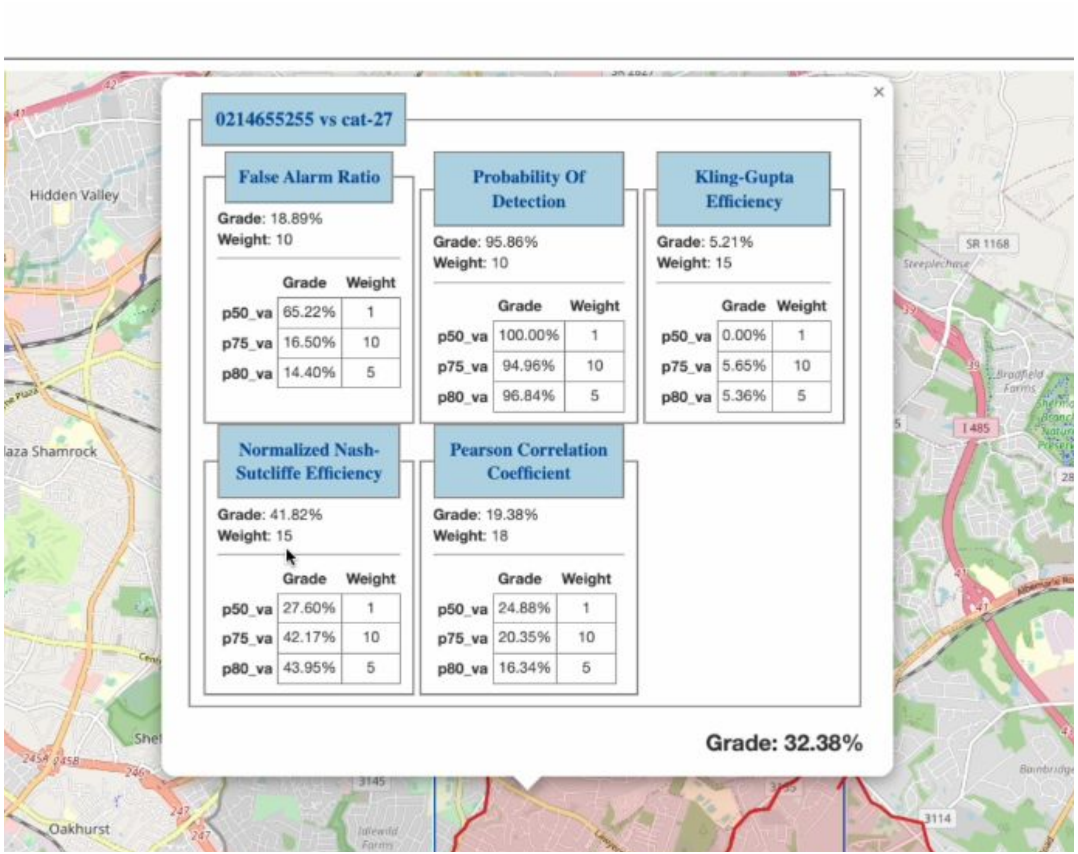
Evaluation with NextGen Tools



Evaluation with NextGen Tools



Evaluation with NextGen Tools



0214655255 vs cat-27

False Alarm Ratio

Grade: 18.89%
Weight: 10

	Grade	Weight
p50_va	65.22%	1
p75_va	16.50%	10
p80_va	14.40%	5

Probability Of Detection

Grade: 95.86%
Weight: 10

	Grade	Weight
p50_va	100.00%	1
p75_va	94.96%	10
p80_va	96.84%	5

Kling-Gupta Efficiency

Grade: 5.21%
Weight: 15

	Grade	Weight
p50_va	0.00%	1
p75_va	5.65%	10
p80_va	5.36%	5

Normalized Nash-Sutcliffe Efficiency

Grade: 41.82%
Weight: 15

	Grade	Weight
p50_va	27.60%	1
p75_va	42.17%	10
p80_va	43.95%	5

Pearson Correlation Coefficient

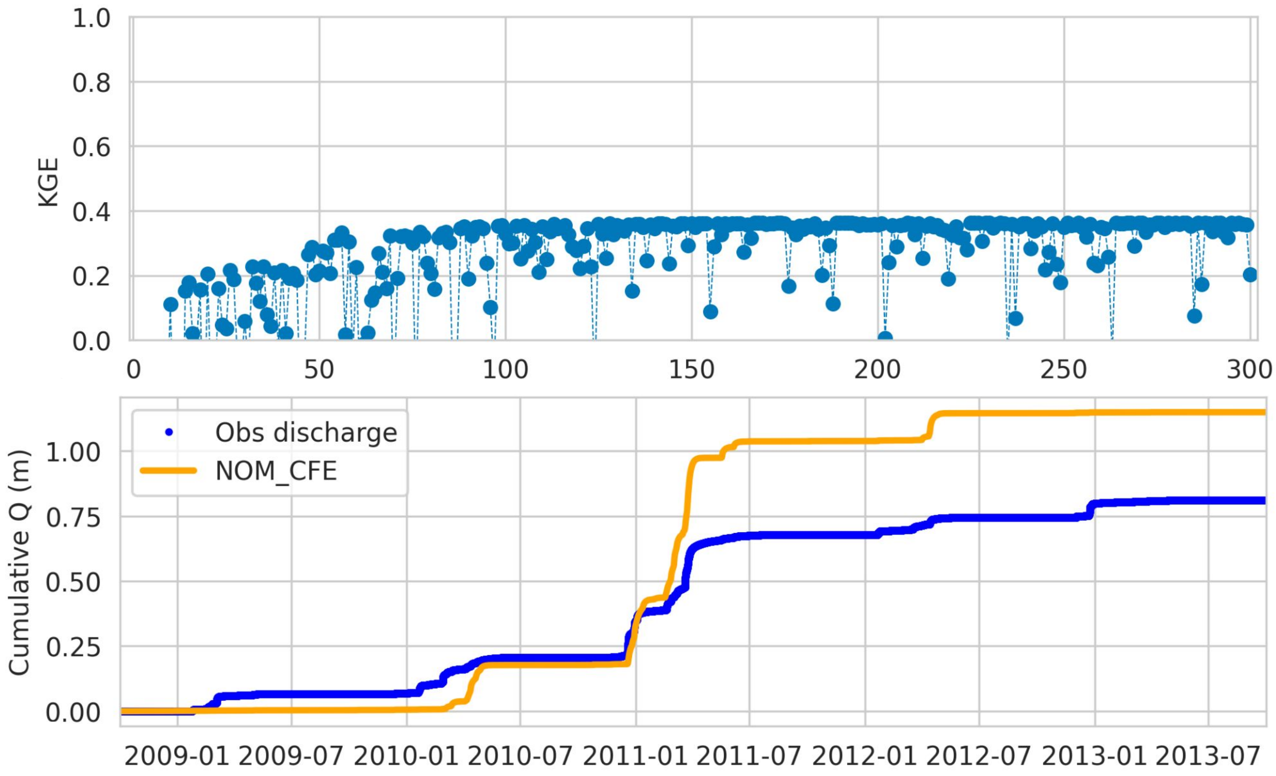
Grade: 19.38%
Weight: 18

	Grade	Weight
p50_va	24.88%	1
p75_va	20.35%	10
p80_va	16.34%	5

Grade: 32.38%

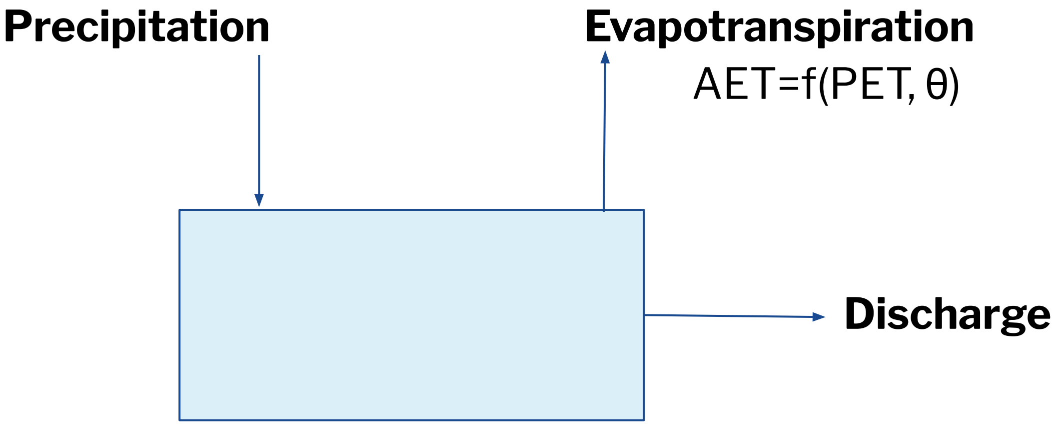
First calibration attempt: not promising

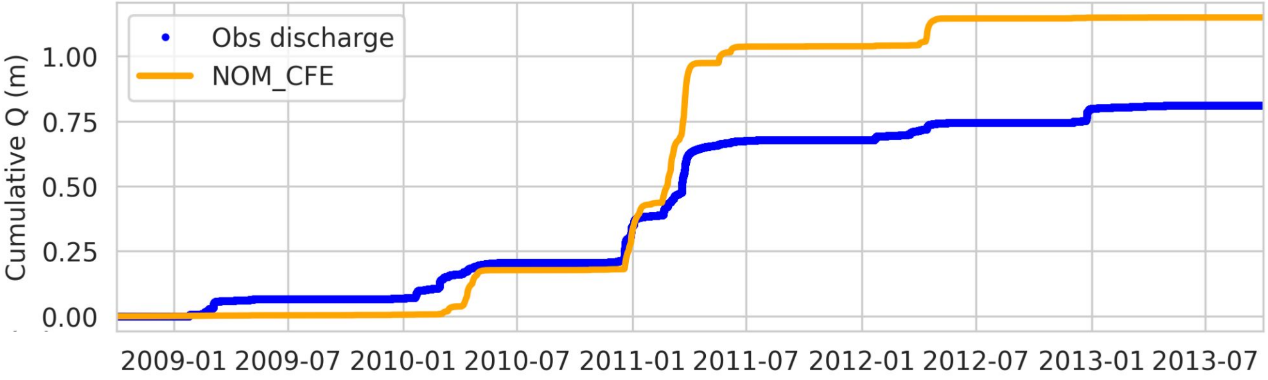
11284400 BIG C AB WHITES GULCH NR GROVELAND CA



KGE = 0.36

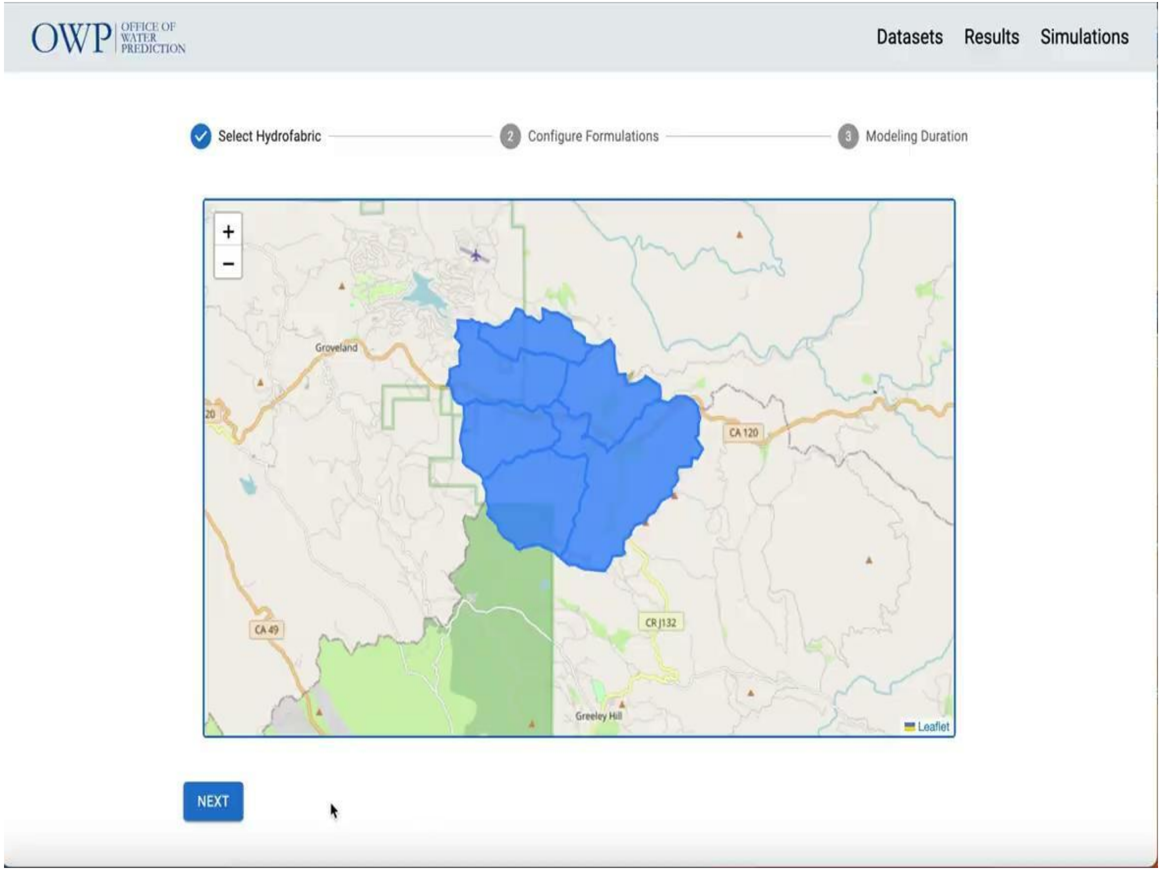
What is wrong? PET perhaps?



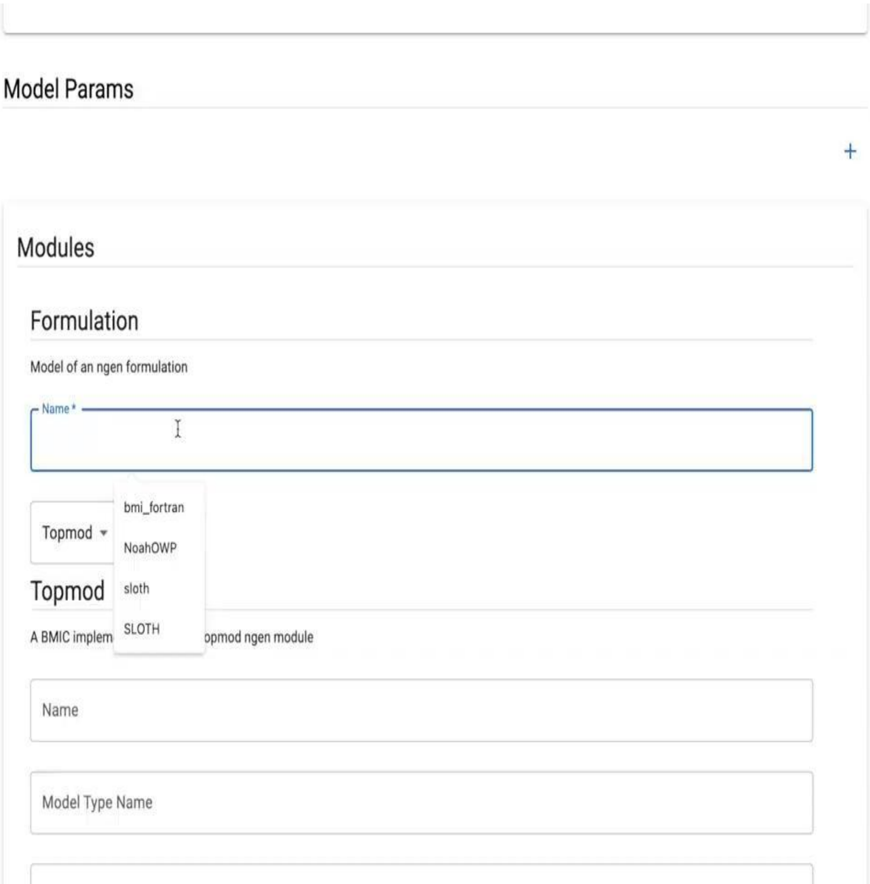


Overestimation of discharge

Selecting a Different Formulation



Second Formulation Calibration with NextGen Tools



Using different surface scheme improves simulation

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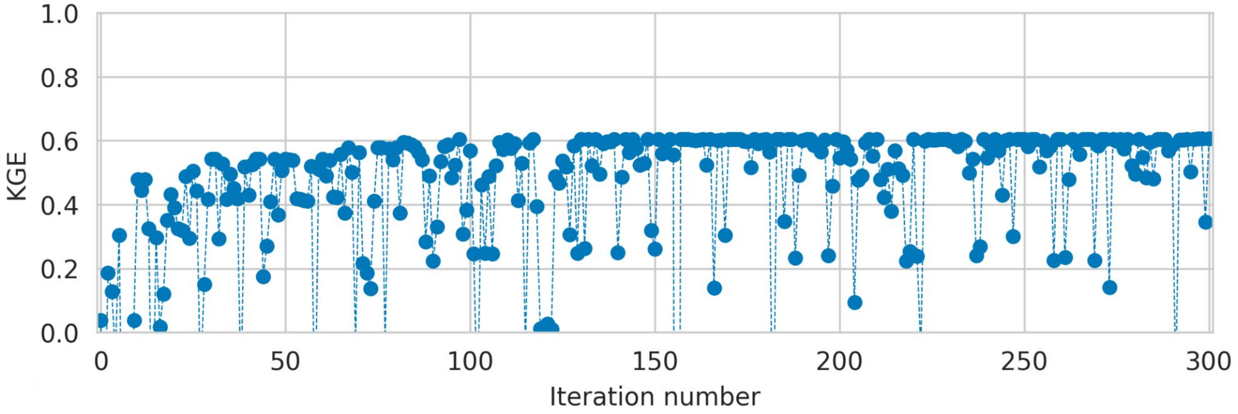
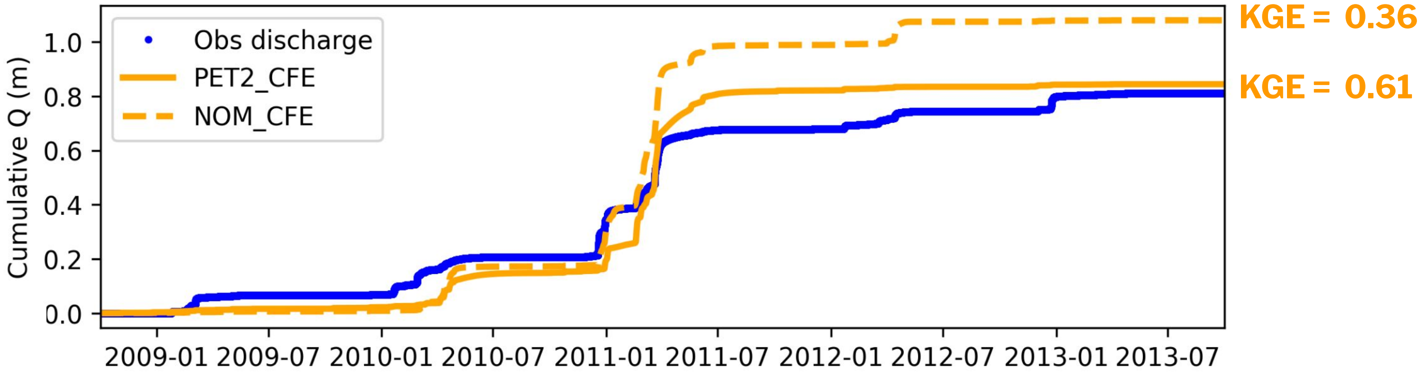


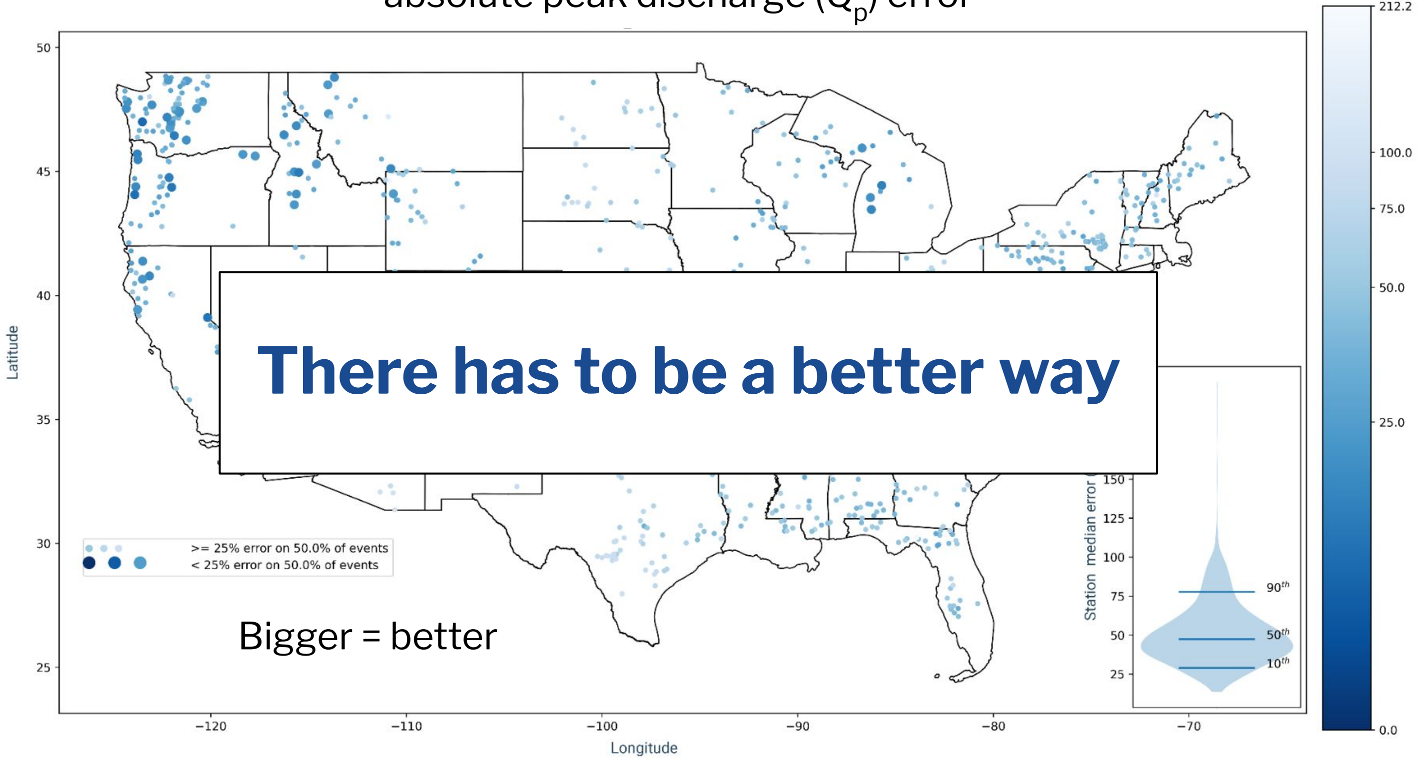


What This Does

- Provides a **single, guided interface** for model setup, calibration, execution, and evaluation
- Cleans up a lot of cognitive overhead, so the user can **focus on the domain science**
- Lets a user change the model for an experiment in **mere minutes** with a few clicks
- Enables **evidence-based decisions** - right model, right place, for the right reason
- Unlocks **scientific investigations** that weren't previously possible

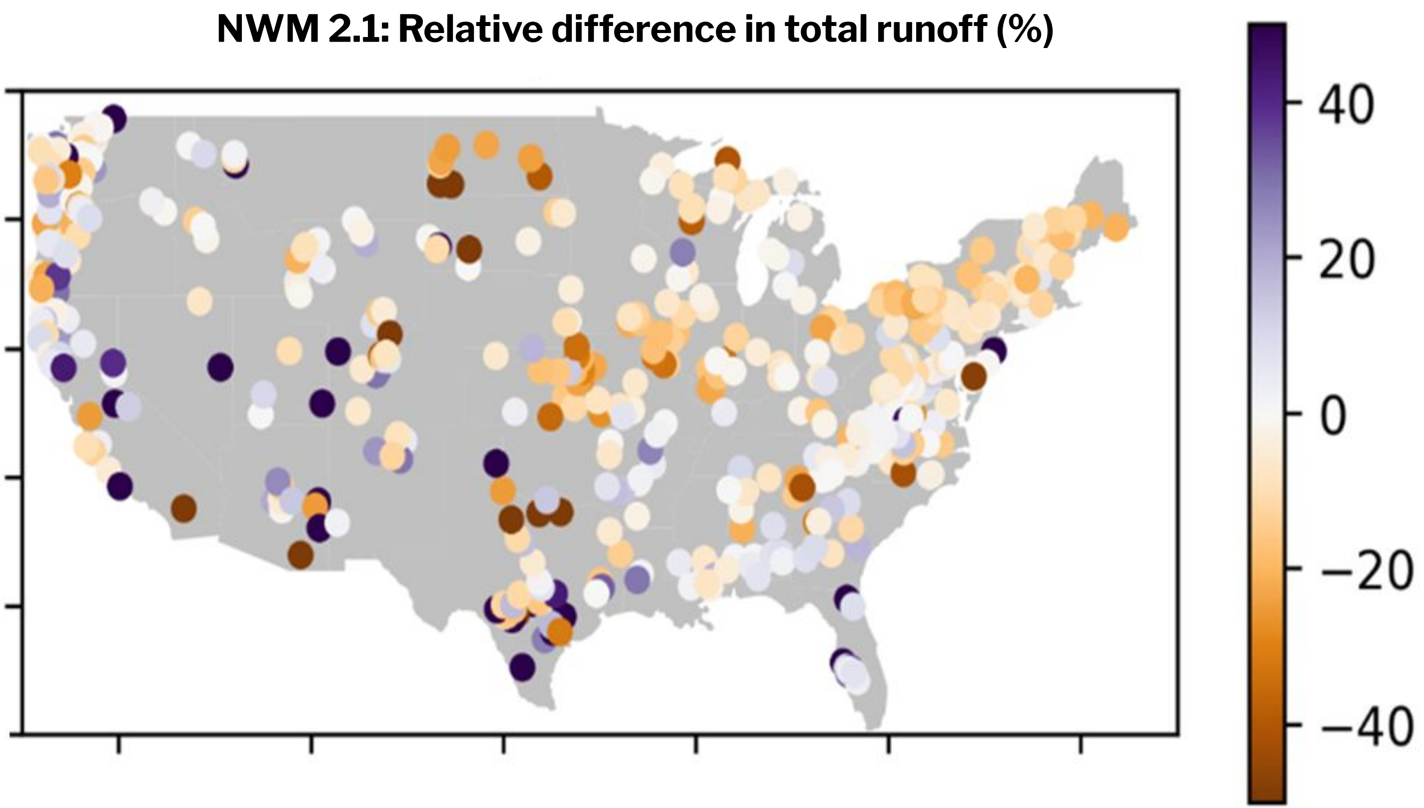
Back to the continental scale

CONUS NWM V2.0 median warm season event-scale absolute peak discharge (Q_p) error




SPOILER
ALERT!

From another angle



Continental-scale NextGen proof of concept

Our working hypothesis:
Heterogeneous model formulations will be more performant than a single-model configuration

Approach:

1. Implement multiple model formulations in NextGen framework at each basin
2. Pre-select surface model
3. Deploy simple model-agnostic calibration routine for multiple infiltration-runoff models
   a. Selection of Catchment Attributes and Meteorology for Large-sample Studies (CAMELS) basins
4. Compare preliminary calibrated formulation output to National Water Model 2.1 and observations

Too many formulations?

Noah-OWP-Modular

PET Modules

6 surface options

✖

TOPMODEL

CFE

CFE_X

3 infiltration-runoff options

=

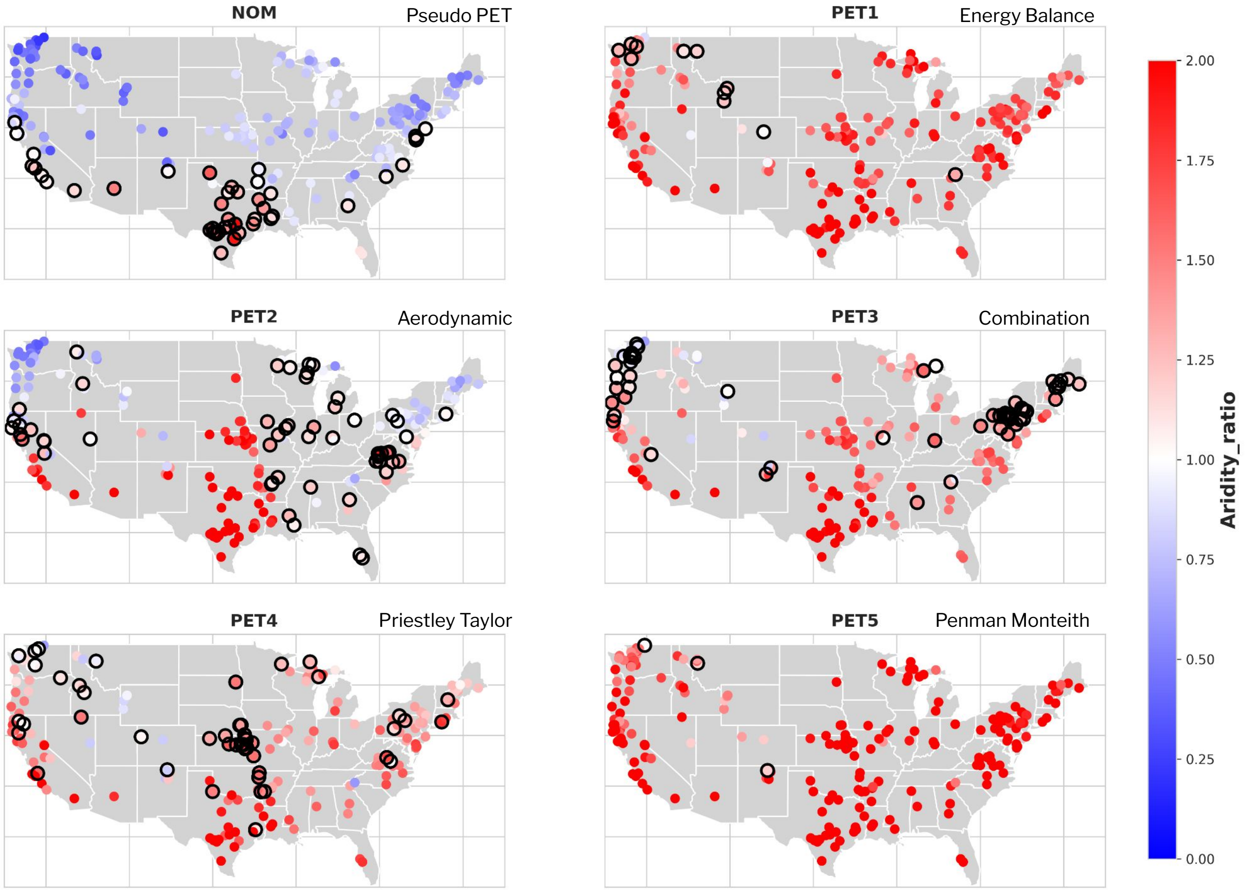
18 formulations

12,960 iterations per basin

Identifying the optimal surface routine

- Match formulation aridity index to CAMELS
- Aridity index=PET/Precip.
- Ratio=$AI_{ngen}/AI_{baseline}$

○ Aridity index ratio > 0.99 and closest to 1



Fewer iterations with pre-selected surface routine

Noah-OWP-Modular | PET Modules

6 surface options

✖

TOPMODEL | CFE | CFE_X

3 infiltration-runoff options

=

18 formulations
12,960 iterations per basin

Pre-Selected Routine

1 surface option

✖

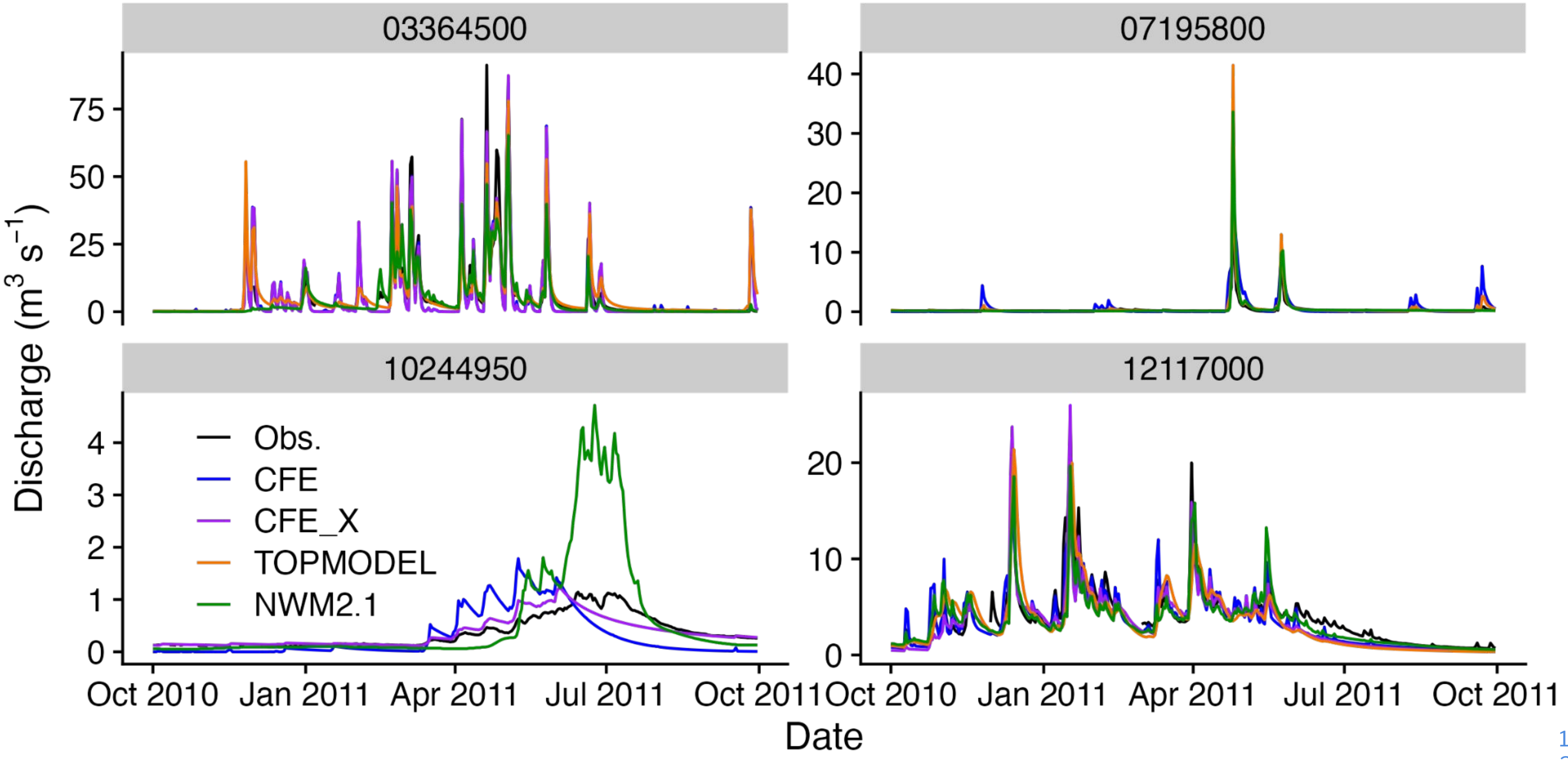
TOPMODEL | CFE | CFE_X

3 infiltration-runoff options

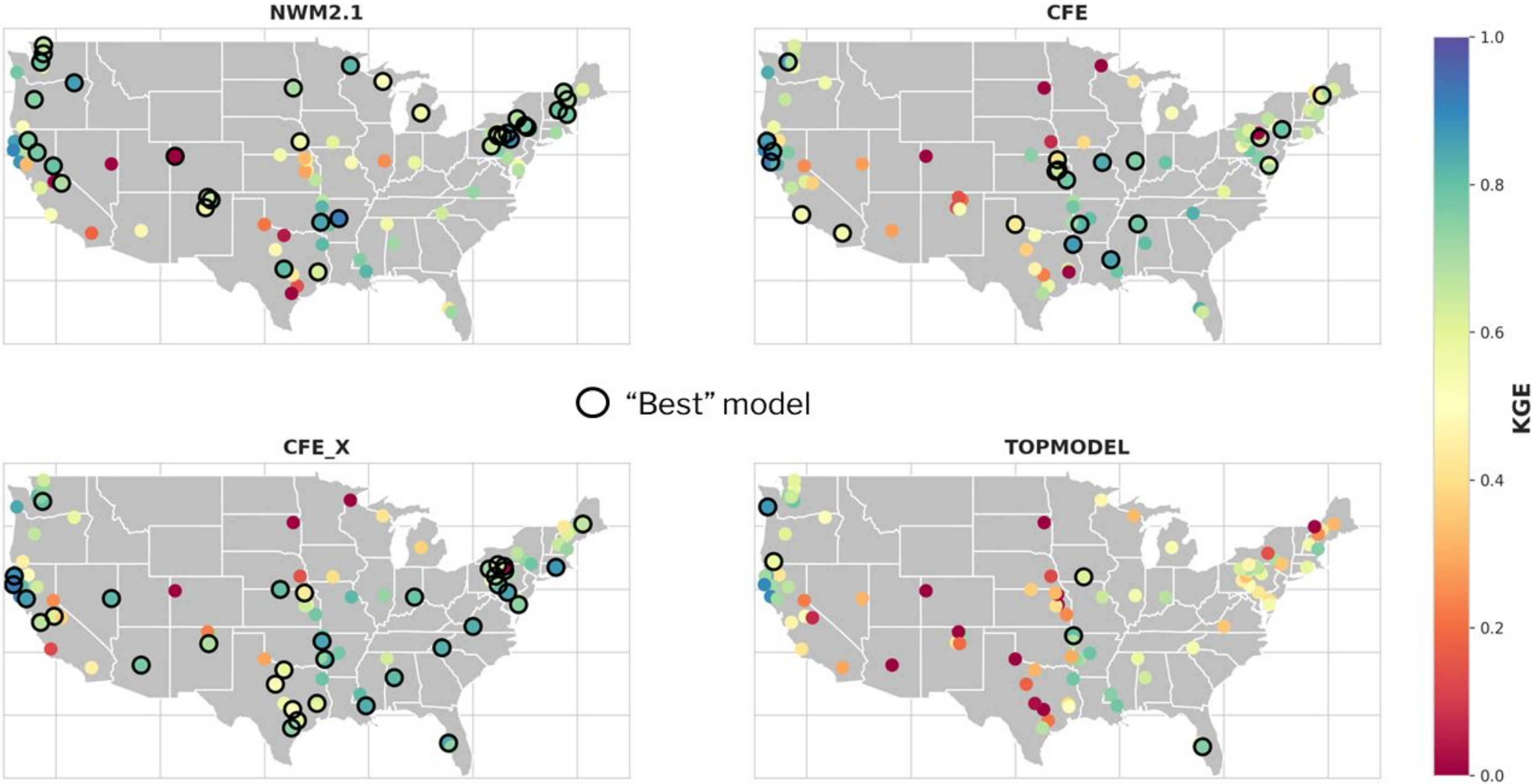
=

3 formulations
720 iterations per basin

Many traces, one modeling framework

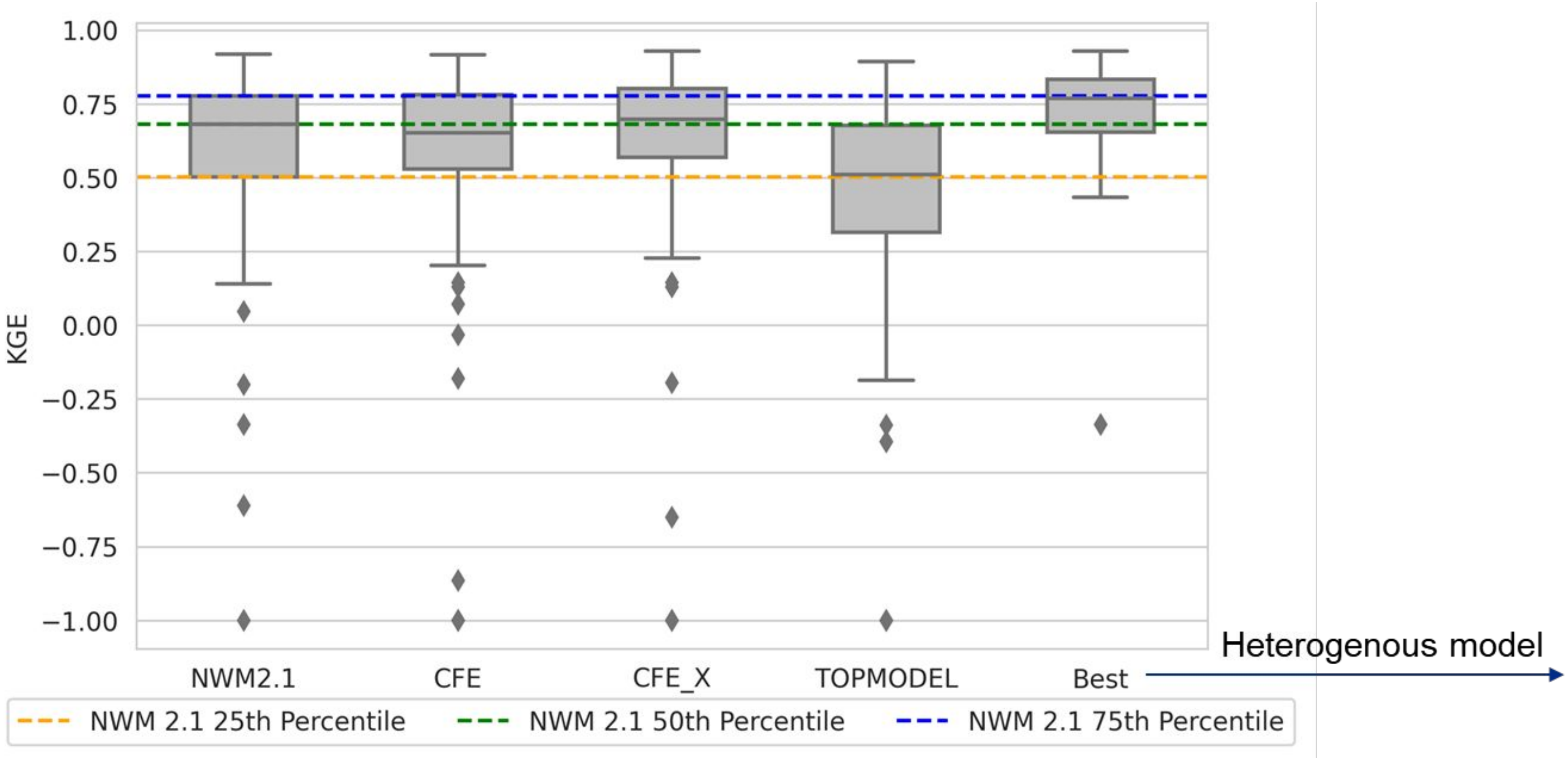


Spatially variable outcomes in performance



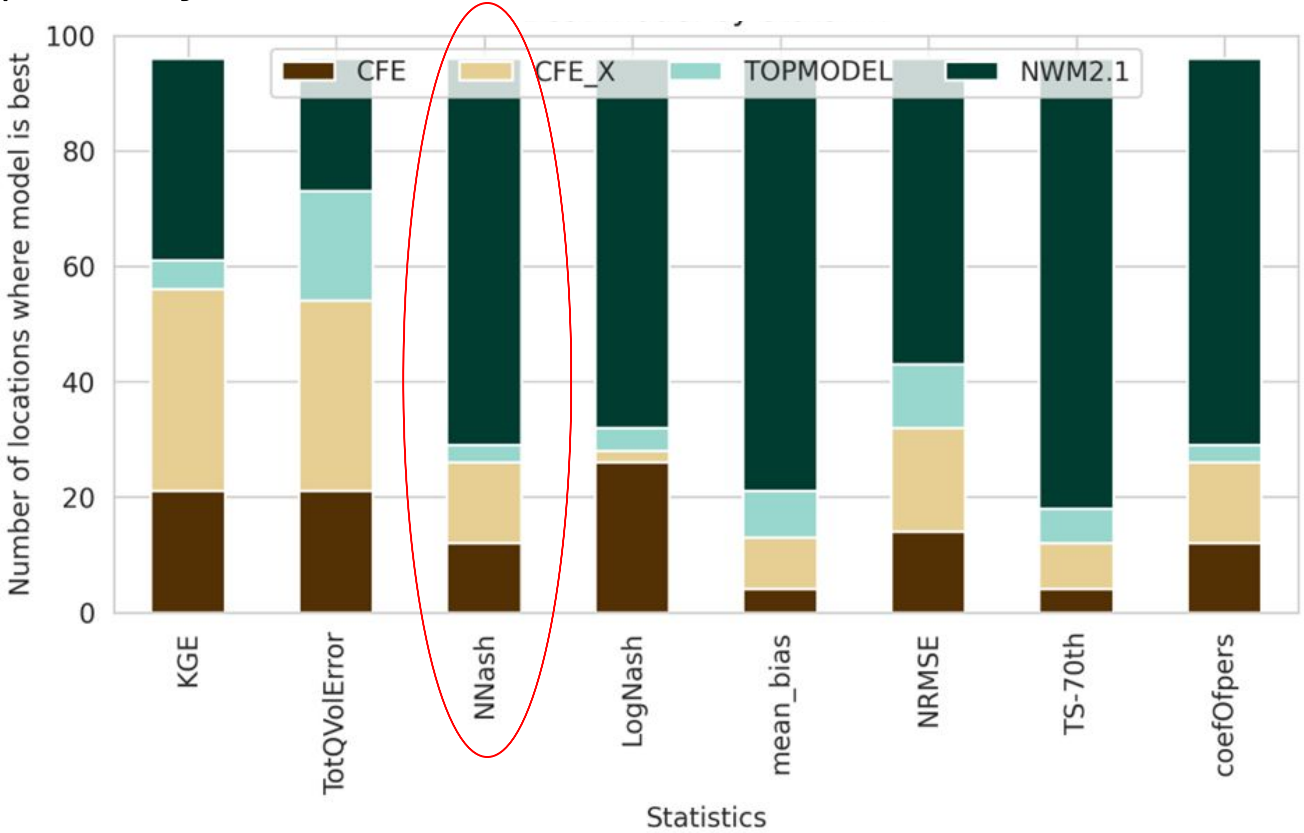
Heterogeneous formulations provide optimal performance

Heterogeneous approach: run the best model in each basin in the same framework (same forcing data, routing, hydrofabric, etc.)



Heterogeneous formulations provide optimal performance

We improved systematic bias in runoff for more than 70% of the locations!



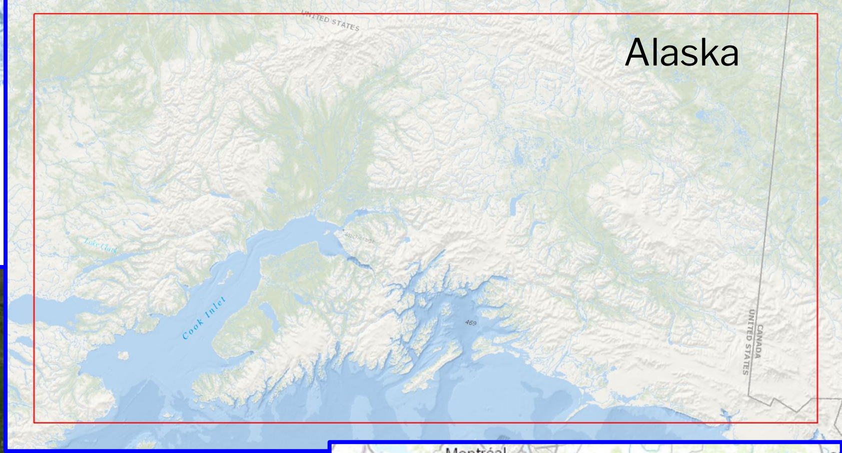
Integrating TWL into NextGen

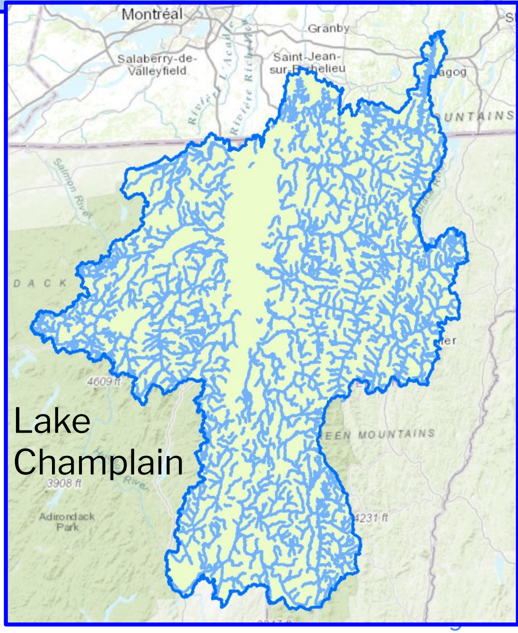
September 2023

Deliverables and Timelines

Major Deliverables	Major Milestones	Planned Start Date MM/YYYY	Planned Completion Date MM/YYYY
Total Water Level Forecast Capabilities Integrated into the Next Generation Water Resources Modeling Framework	BMI-compliant interfaces for D-FLOW and SCHISM	10/2022	09/2023
	Integration of hydrodynamic forcing data for the NWM v.3.0 Total Water Level forecasting domain into the NextGen Framework	10/2022	09/2023
	Calibrated and validated Total Water Level prediction model formulations using D-FLOW and SCHISM for the NWM v.3.0 Total Water Level domain integrated into the NextGen Framework	10/2023	03/2024
Expanded coverage of the Total Water Level forecasting capability into the Great Lakes/Lake Champlain and Alaska Domains	BMI-compliant D-FLOW and SCHISM models for the Great Lakes and Lake Champlain domains	10/2022	09/2023
	BMI-compliant D-FLOW and SCHISM models for the Alaska domain	10/2022	09/2023
	Integration of hydrodynamic forcing data for the Great Lakes/Lake Champlain and Alaska domains into the NextGen Framework	10/2022	09/2023
	Calibrated and validated Total Water Level prediction model formulations using D-FLOW and SCHISM for the Great Lakes/Lake Champlain and Alaska domains integrated into the NextGen Framework	10/2023	03/2024

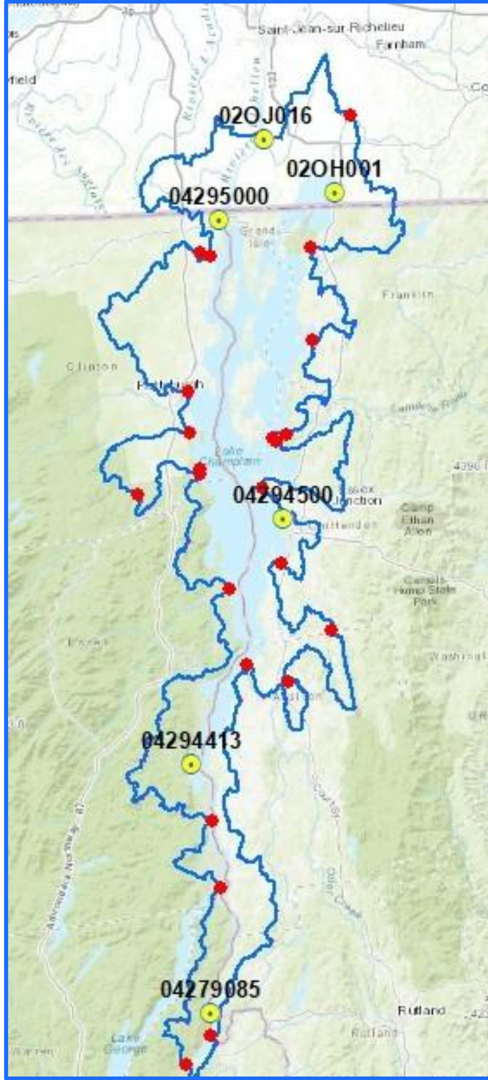
Additional Model Domains



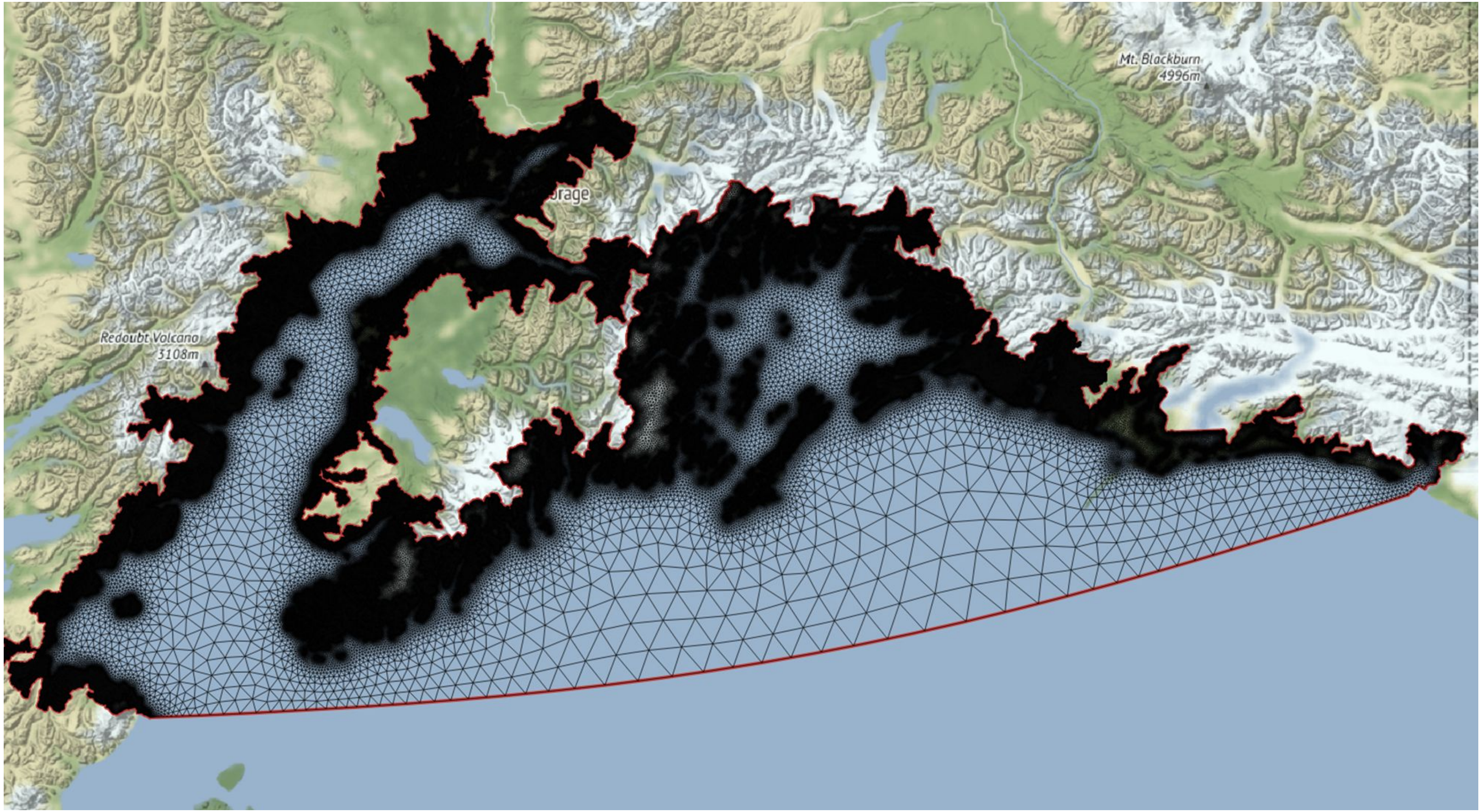


SCHISM/D-Flow FM Models of Lake Champlain

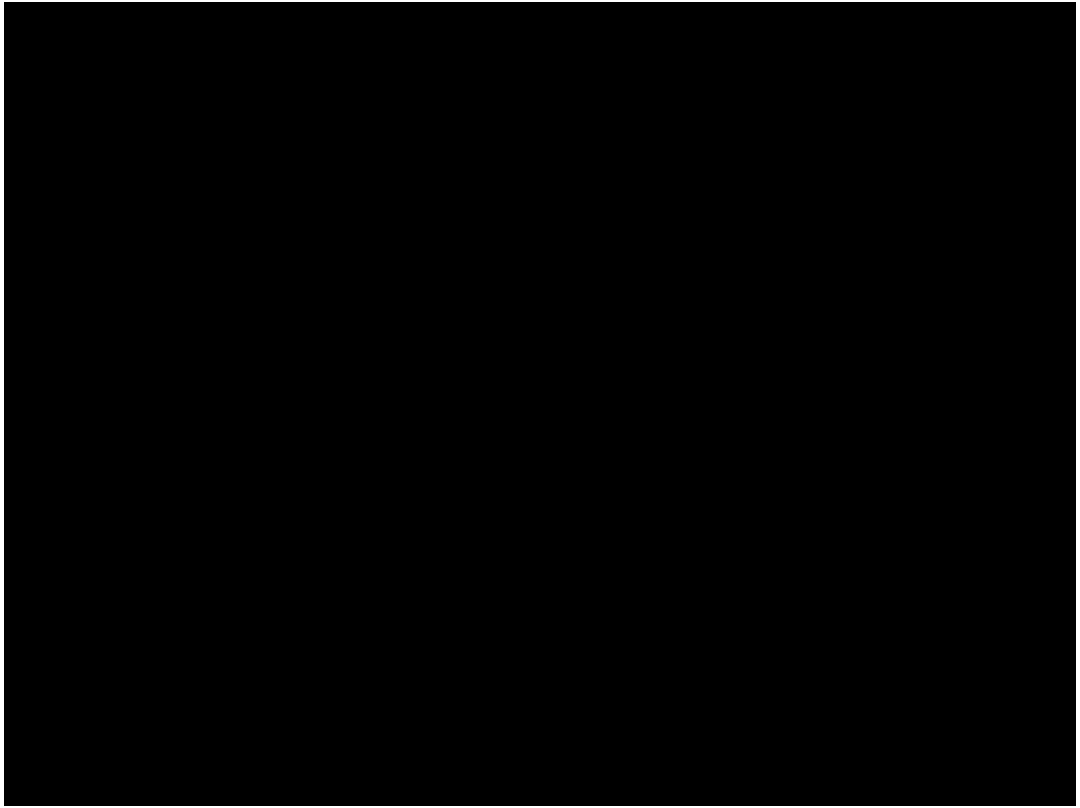
- Model mesh has 137,867 nodes and 271,650 elements
- Model domain includes lake and floodplain
- Inland model boundary follows extent of HUC12's
- Downstream water level boundary on Richelieu River at St. Jean Marina, QC
- Freshwater inflows from 21 main rivers and streams (red dots)
- Freshwater runoff from precipitation
- Atmospheric forcing from AORC wind and pressure data
- Simulation period: significant floods in Mar-Aug 2011
- Five stations for calibration/validation, one for downstream boundary (yellow circles)



Alaska Mesh (2,743,977 nodes; 5,401,930 elements)

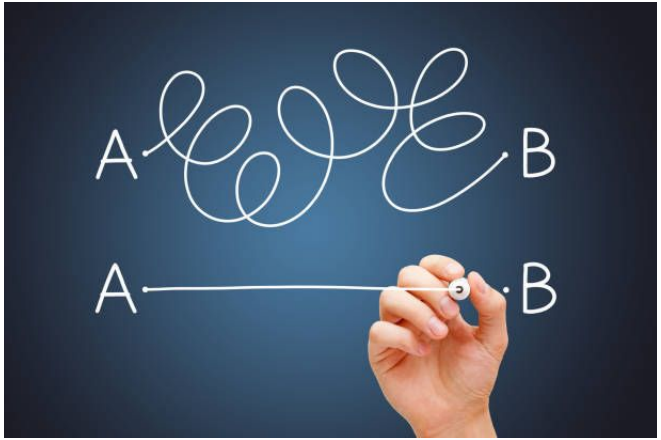


NWM in NextGen Framework



First CONUS demo of single formulation running in NextGen Framework

Next Generation Water Resources Modeling Framework - From Months to Minutes



NOAA is transforming water resources modeling

- Building common, **flexible** framework - model agnostic
- Community to work **collaboratively** on water resources science
- Leverages multi-lingual, open source, modular approach - **lowers the barrier**
- Unlocks **new scientific investigations**

NextGen simplifies development, testing, calibration, and evaluation

- Uses **common resources** - scientists focus on the science, not on the tedium
- New models configured, calibrated, executed, and evaluated in **minutes, not months**
- Enables **right tool** in **right location** for the **right reason**

Be a NextGen contributor!

- https://github.com/NOAA-OWP …
  - /ngen
  - /ngen-cal
  - /hydrofabric
  - /noah-owp-modular
  - /cfe
  - /topmodel
  - /lstm
  - /evapotranspiration
  - /soilfreezethaw
  - /snow17
  - /sac-sma
  - /t-route

Thank You!

For more information: Dr. Trey Flowers

trey.flowers@noaa.gov

https://water.noaa.gov

NOAA

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15:00

An Overview of Current and Future of Web and Data Service Program

Modernizing Hydrologic Data Dissemination for The Office of Water Prediction

Sudhir Raj Shrestha

Chip Gobs, Gautam Sood and Fernando Salas

OWP | OFFICE OF WATER PREDICTION

May 23, 2023

Coastal coupling Community of Practice

Agenda

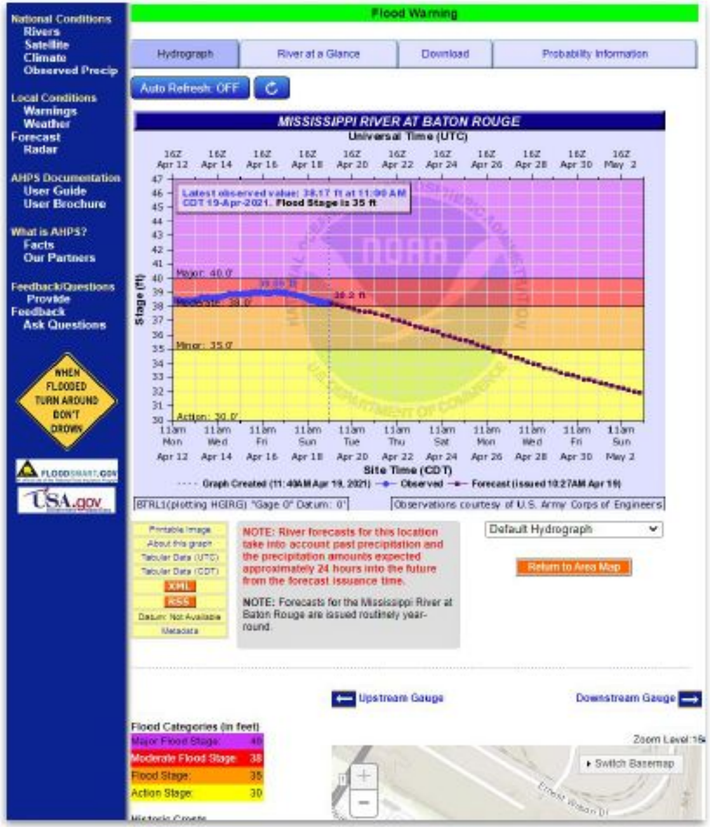
- Migrating AHPS to NWPS
- On-prem to Cloud
- Key Features/Functionality
- Interoperable Data delivery: APIs, Data Services
- Future Development and Collaboration

Migration of Advanced Hydrologic Prediction Services (AHPS) to cloud

AHPS is the main dissemination portal for WFO/RFC river forecast information - water.weather.gov

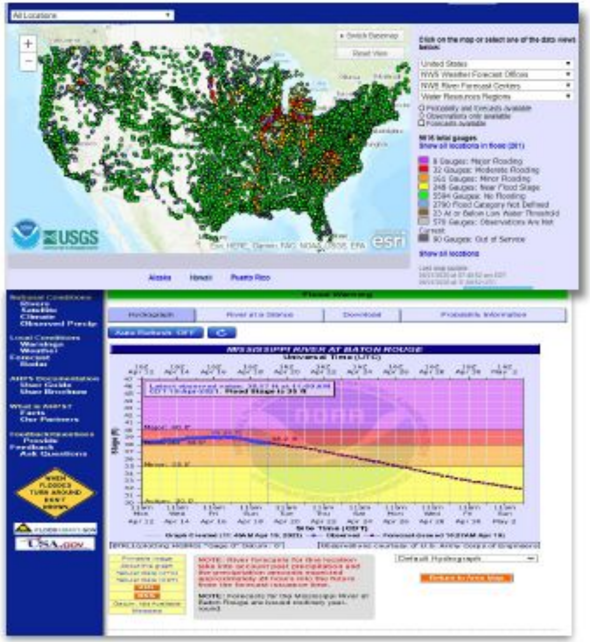
Main Functions

- Near Real-Time River Data and Forecast Information
- Probabilistic Information
- Static Flood Inundation Mapping (FIM) Libraries
- Precipitation Estimates (QPE)
- Data download



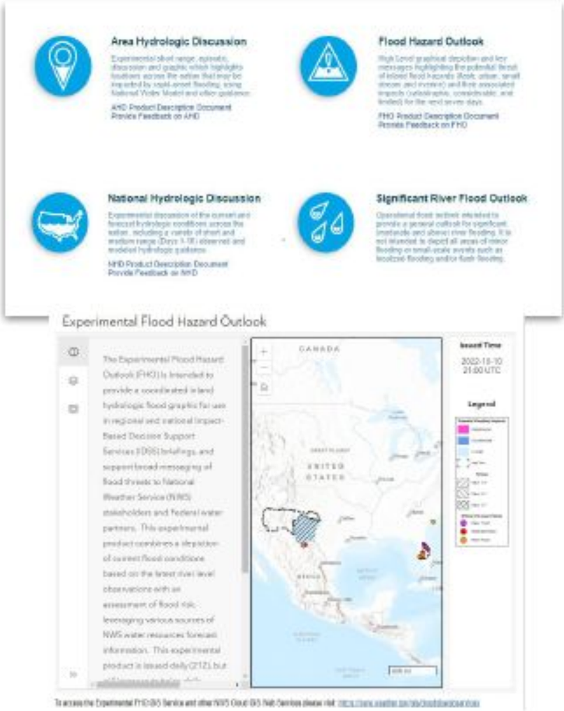
Integration of Hydro Program's Web Presence in NWPS

AHPS
water.weather.gov

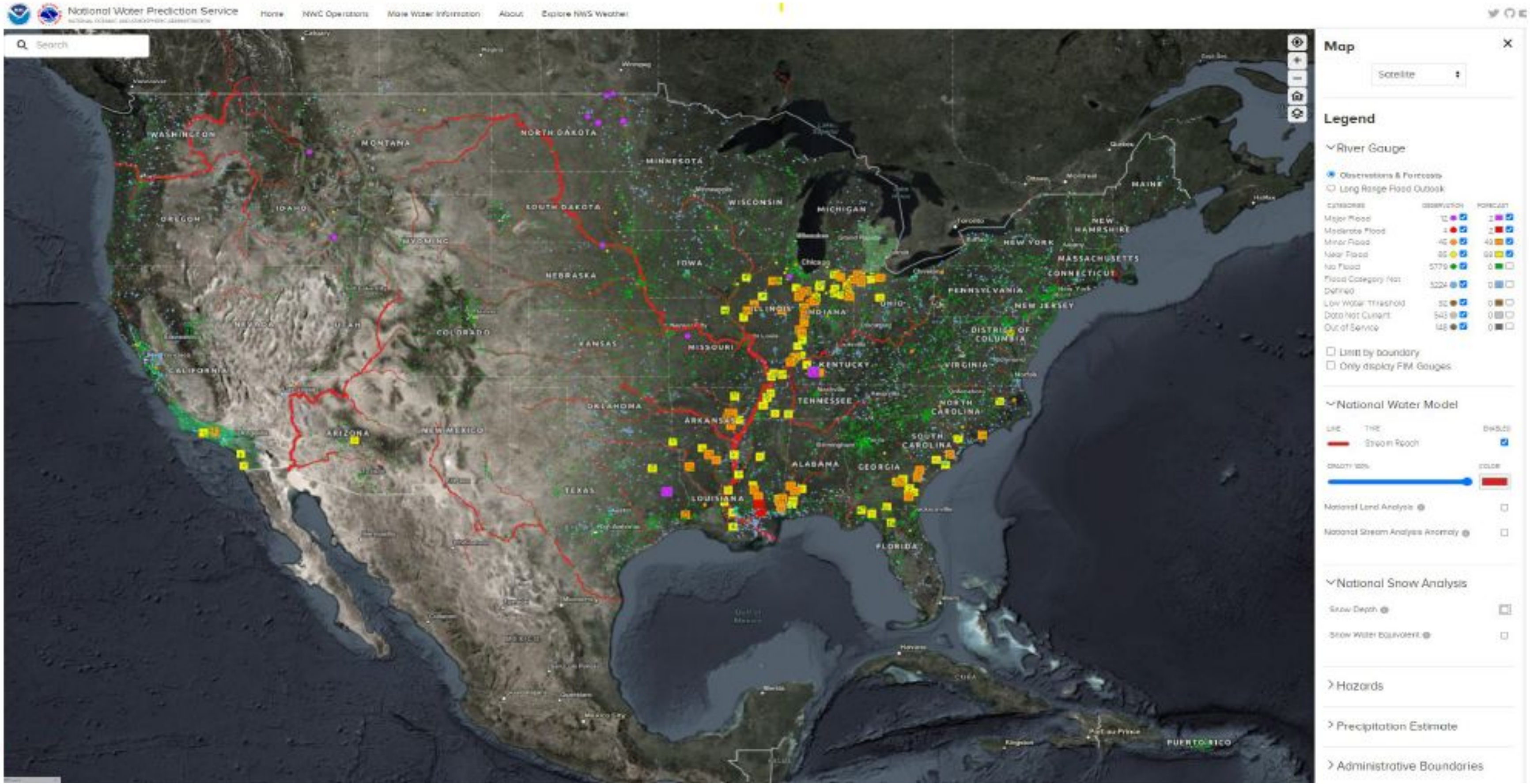


Office of Water Prediction
water.noaa.gov

NWC Experimental Products
weather.gov/owp



National Water Prediction Service (NWPS)



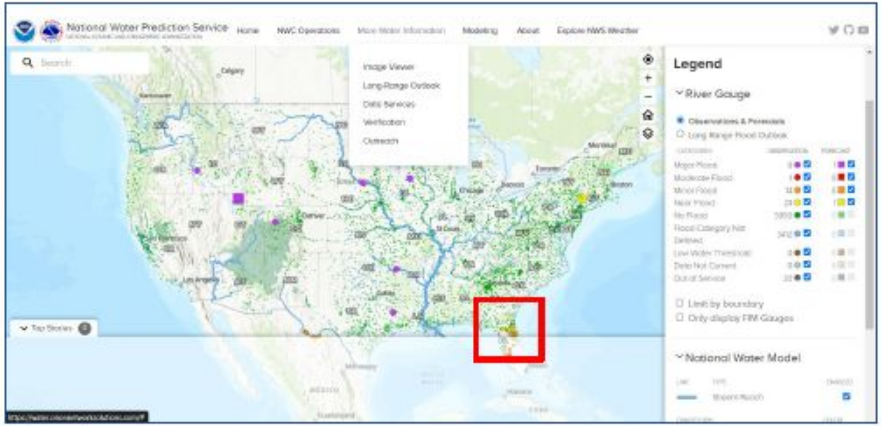
NWPS Main Functionality

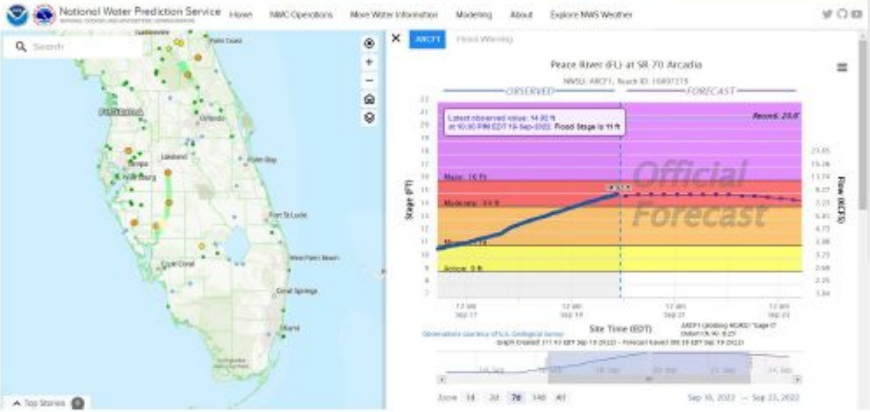
General Features:

- Mobile-friendly interface
- User friendly features and navigation
- API (Application Programming Interface) driven
- Service outlet for NWC Water Prediction Operations Division (WPOD)

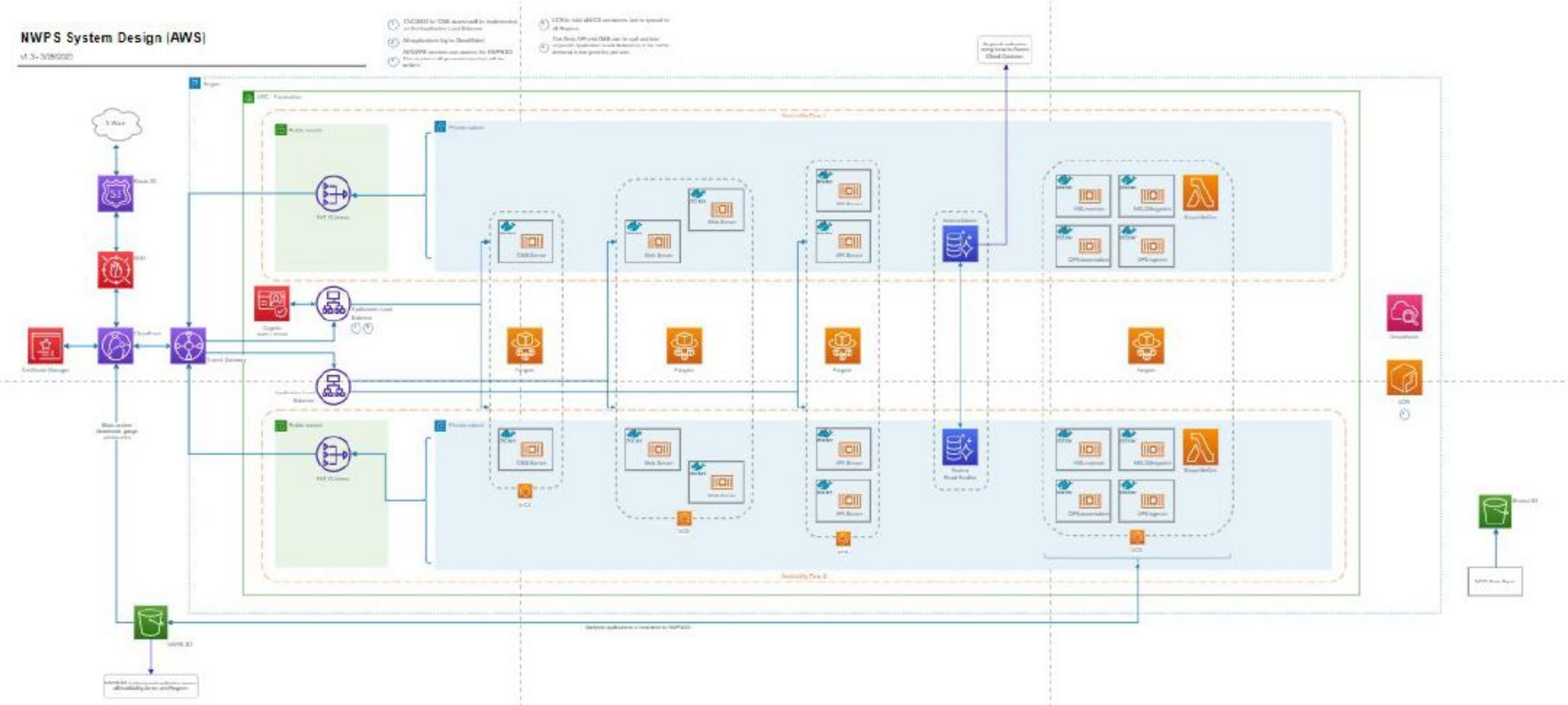
National Map Features:

- Current/forecast status icons with gauge location pages
- QPE Display with pixel data values
- NWM Data: Stream reach, National Land Analysis, National Stream Analysis Anomaly.
- National Snow Analysis: Snow Depth and Snow water Equivalent.
- FIM Forecast Data (Flood Map Guidance): RFC 5-Day Forecast, NWM Analysis, NWM 5-Day Forecast NBM Rainfall, NWM 5-Day Forecast GFS Rainfall





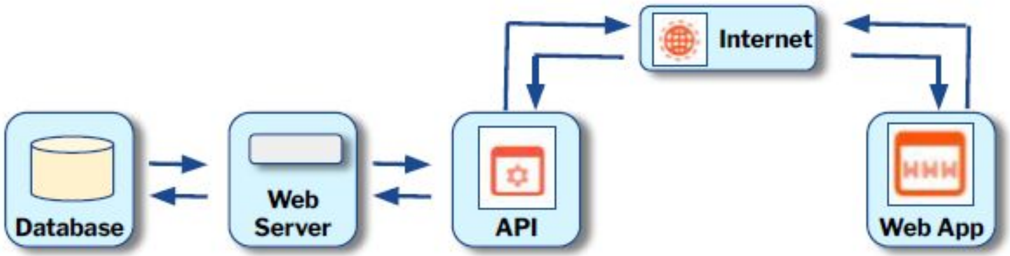
NWPS in AWS Cloud : System Architecture

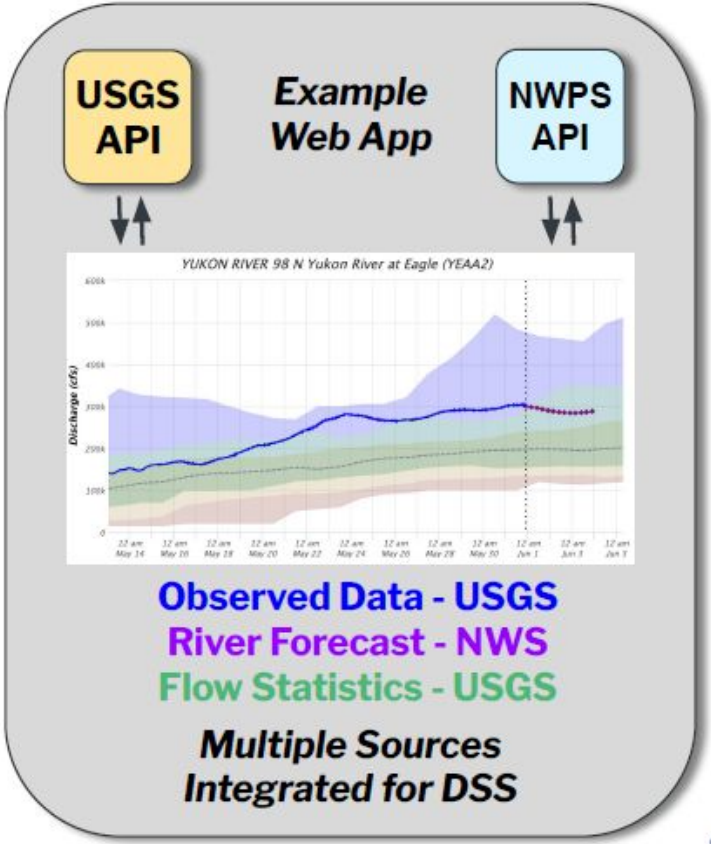


Data-Driven Application Programming Interfaces (APIs)

NWPS is an API-driven Web App for the dissemination of integrated water information across the NWS

Core Partners, Third Party APIs and Web Apps can leverage the NWPS API to integrate observations and forecast data into **<u>their own</u>** decision support tools.



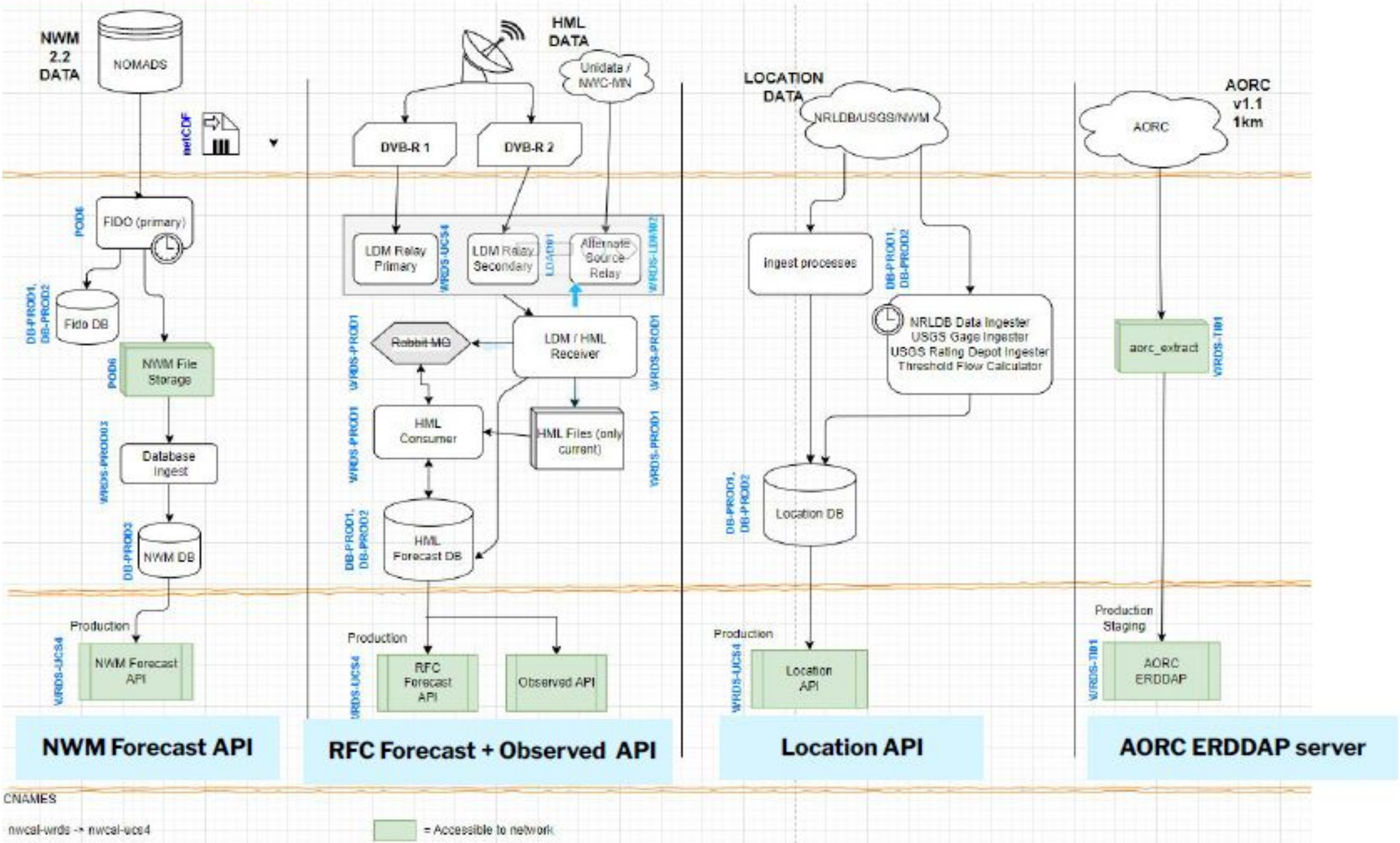


Enhancing Water Resources Data Service (WRDS)

WRDS is the expanding collection of feature-rich data services from the Office of Water Prediction (OWP) including:

- Hydrologic Location API
- River Forecast Center (RFC) Forecast API
- Stream Observation API
- National Water Model Forecast API
- Analysis of Record for Calibration (AORC) ERDDAP API
- Hydrologic Ensemble Forecast System (HEFS) API (upcoming)

Current Data Services Overview



Current Data Services Overview

NWM Forecast API

Datasets

NWM 2.2 Streamflow

Forecast type

- deterministic
  - short range
  - medium range
  - analysis assim
  - analysis assim extend
- ensemble
  - medium range
- best
  - analysis assim

Areal extent

- CONUS

Temporal Scope

- 30 days of data for a subset (9481) of locations
- 7 days for all other locations

Subsetting features

- Query by
  - NWS LID
  - USGS Station ID
  - NWM Feature ID
  - RFC
  - county
  - state
  - tag
  - HUC

  Subset by
  - nwm configuration
  - time
  - forecast type
  - ensemble member

RFC Forecast API

Datasets

RFC Forecasts from HML files

Areal extent

- CONUS
- Alaska
- Hawaii
- Guam
- Puerto Rico
- American Samoa
- US Virgin Islands

Temporal Scope

- Forecasts from 2008
- The availability of forecasts is spotty until 2010

Subsetting features

- Query by
  - NWS LID
  - USGS Station ID
  - NWM Feature ID
  - RFC
  - geo_RFC*
  - state
  - tag

  Subset by
  - time
  - flood category

Observed API

Datasets

Observations from HML files

Areal extent

- CONUS
- Alaska
- Hawaii
- Guam
- Puerto Rico
- American Samoa
- US Virgin Islands

Temporal Scope

- Observations from January 2022

Subsetting features

- Query by
  - NWS LID
  - USGS Station ID
  - NWM Feature ID
  - RFC
  - geo_RFC*
  - state
  - tag
- Subset by
  - time
  - physical element
  - type source
  - issuer (WFO)
  - NWS only gages

Location API

Datasets

- NWS Lid -> USGS Site Code -> NWM Feature ID crosswalk including metadata
- NWM 2.0 Recurrence Flows
- USGS Recurrence Flows
- NWS Thresholds
- NWS/USGS Rating Curves
- Stage/Flow Calculator

Areal extent

- CONUS
- Alaska
- Hawaii
- Guam
- Puerto Rico
- American Samoa
- US Virgin Islands
- Parts of Canada (NWM related gages)

Temporal Scope

- NWS/USGS metadata updated weekly
- Historical metadata is not kept

Subsetting features

- Query by
  - NWS LID
  - USGS Station ID
  - NWM Feature ID
  - RFC
  - geo_RFC*
  - state
  - tag

AORC ERDDAP

Datasets

Version 1.1 1km resolution dataset

Areal extent

- CONUS
- Alaska

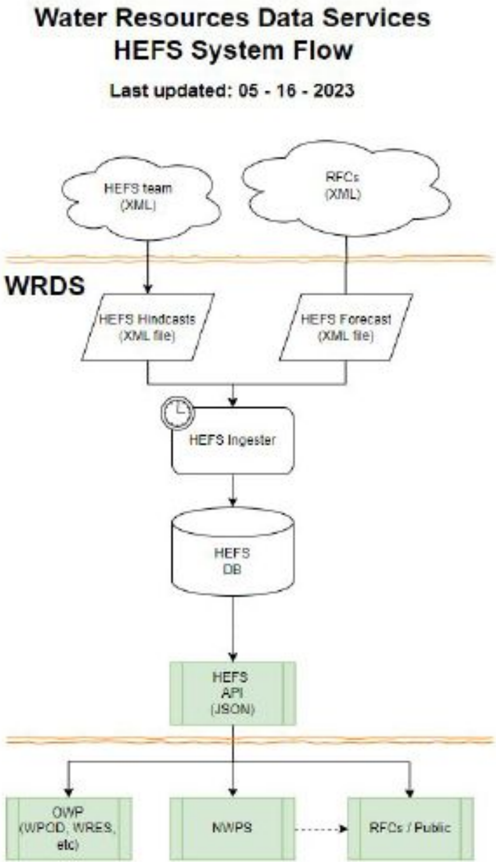
Temporal Scope

- February 1979 - August 2021

Subsetting features

- time
- lat/lon
- data type

Future: WRDS Services (HEFS)



Future Development and Dissemination

- National Water Prediction Service (NWPS)
- One stop Access to Data, APIs and web services in Cloud harnessing micro services
  - APIs : NWPS, HEFS...many more
    - Interoperability: OGC
      - Translation services
- Analysis Ready Cloud Optimized (ARCO) data
  - AORC, NWM
    - Chunked data
      - Zarr, netcdf, Kerchunk
- Data Dissemination via NOAA Open Data Dissemination (NODD) and HydroVIS

Thank You!

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https://water.noaa.gov

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NWPS StoryMap

Thank you!

Acknowledgement: Orion, NWS: NCO, ODIS, OOE, Field Office Staff

sudhir.shrestha@noaa.gov

For more information, please visit the following StoryMaps:

Modernizing Hydrologic Web Dissemination: AHPS to NWPS

A User's Guide to National Water Prediction Service (NWPS)

NWPS StoryMap

COASTAL COUPLING COMMUNITY OF PRACTICE

Patrick Tripp and Jonathan Joyce
Principal Software Engineers at RPS North America
patrick.tripp@rpsgroup.com

Coastal Coupling Community of Practice Annual Meeting
May 23, 2023

NWM API Background and Goals

- 2021: RPS was asked to create an API to provide access to the NWM forecast data.
- Facilitate subset of existing cloud-hosted (NODD) NWM forecast output for coastal model forcing.
- Understand the requirements and needs the coastal modeling community via community engagement (how to access the data, subset parameters, the NWM products of interest, etc.)
- Investigate optimizations of data formats for faster retrieval and/or improved hosting on cloud object stores.
- Collaborate on new approaches for data access.

Solution: Use the NODD hosted forecast data on AWS S3 using an implementation of the DAP protocol for data access.

Registry of Open Data on AWS

NOAA National Water Model Short-Range Forecast

agriculture · climate · disaster response · environmental · sustainability · transportation · weather

2.7 million datapoints for each forecast

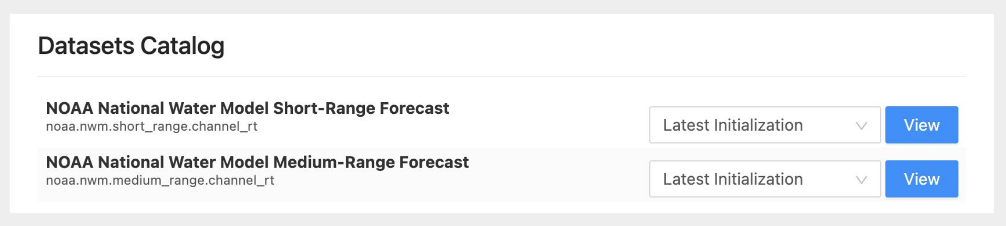
Previous River Forecast Points (~3600)

>>

NWM Streamflow Output Points (~2.7 mil)

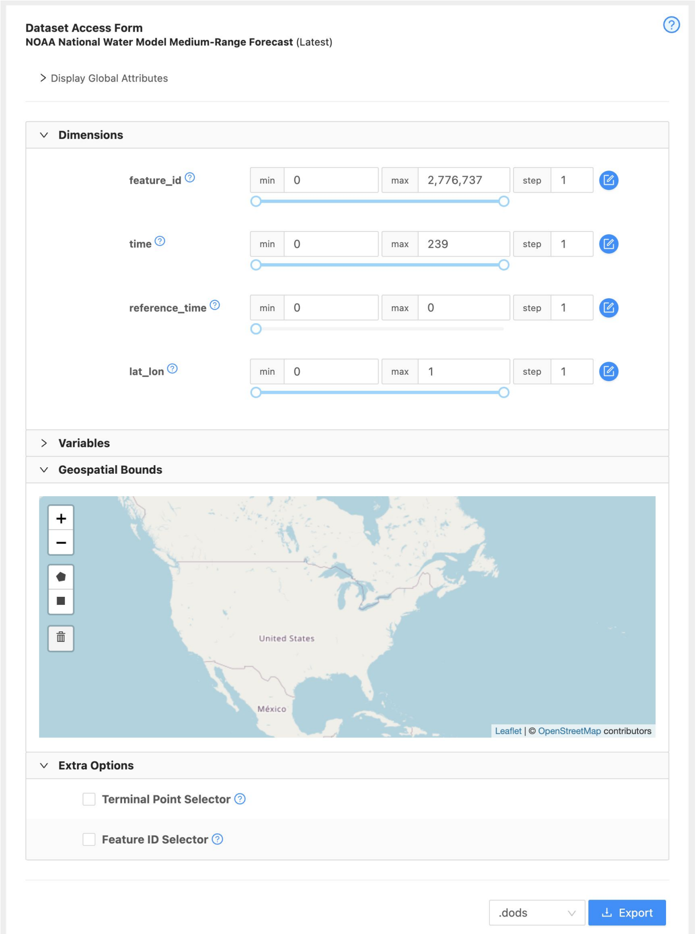
~3 orders of magnitude increase

Current capabilities



Selectable subset parameters:

- Feature ID selection
- Time range
- Reference Time
- Latitudes and longitudes of returned points
- Bounding box selection
- Terminal point retrieval
- Received output is in netCDF format
- Short-range and mid-range forecasts
- *Can use API directly without the Web UI



The future:

- RPS is committed to improving data access and updating the API.
- NWM 3.0 updates.
- Improve data access using lessons learned from the NextGen DMAC project prototyping.
- Upstream tracing.

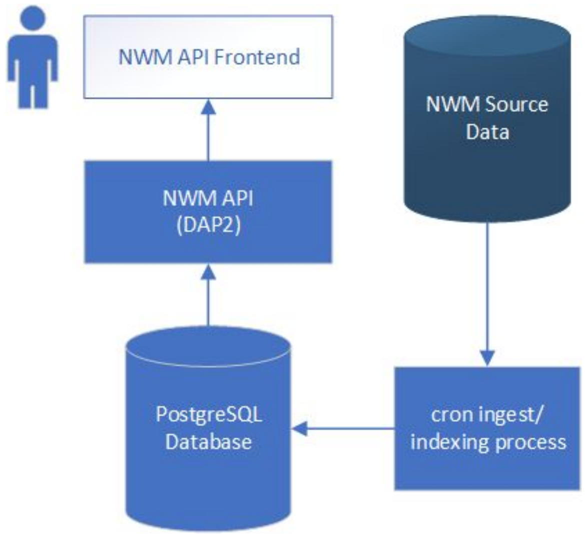
Needs:

- Feedback from the community regarding their needs. How do you use the data in your workflow?
- Users and testers. How can we improve things? Recommend capabilities and/or changes.
- Sharing of technical/implementation details, how do we go from point A to point B?

https://prototype.ioos.us/nwm

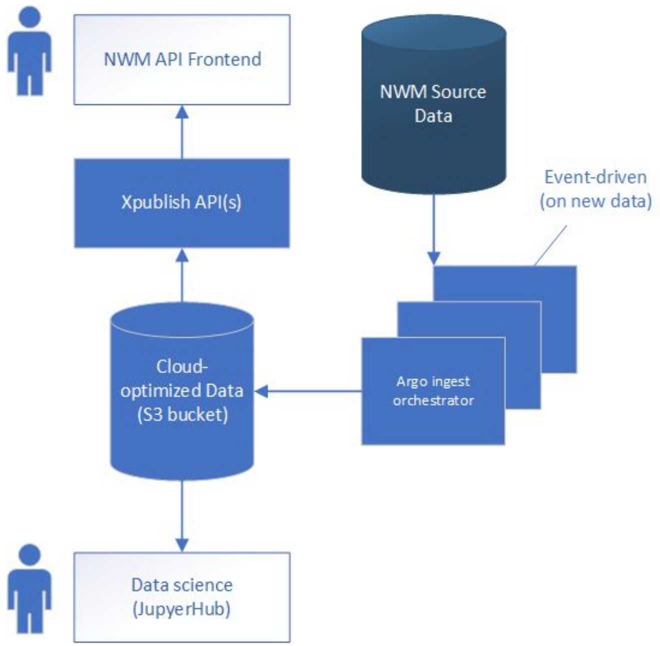
Existing API Infrastructure

- Serves indexed NWM data through a custom application and database
- 2300 lines of custom Python code
- Only supports NWM data
- Requires self-managed database
- Limited options for scaling
- Supports DAP2 protocol only
- Independent cron-based data indexing
- More info: https://github.com/asascience/DAPLite



Next-Gen DMAC Infrastructure

- Built on popular open-source libraries
- Optimizes data for cloud; entirely cloud-native
- Built to be scalable (runs on Kubernetes platform)
- General-purpose system(s) for making data FAIR
- Supports serving data through many different protocols, including OpenDAP
- Cloud-optimized data can be accessed directly for data science
- https://github.com/asascience-open/nextgen-dmac



Enhance Cloud Data Access

- Improve access to raw data by using “kerchunk” protocol to index data in buckets
- https://github.com/fsspec/kerchunk
- Keep optimized data up-to-date with the forecast output (run continuously)
- Provide standardized (OGC-compliant) API access to subset data
- Leverage community work: https://github.com/xpublish-community
- Continue to test and optimize performance using real use-cases from the community

COASTAL COUPLING
COMMUNITY OF PRACTICE

THANK YOU

Patrick Tripp and Jonathan Joyce
Principal Software Engineers at RPS North America
patrick.tripp@rpsgroup.com

ASK THE CoP ANYTHING

COASTAL COUPLING
COMMUNITY OF PRACTICE

THANK YOU!

Join us again tomorrow at 9:00 AM CT

Extra Slides


10:00


13:00


20:00


15:00