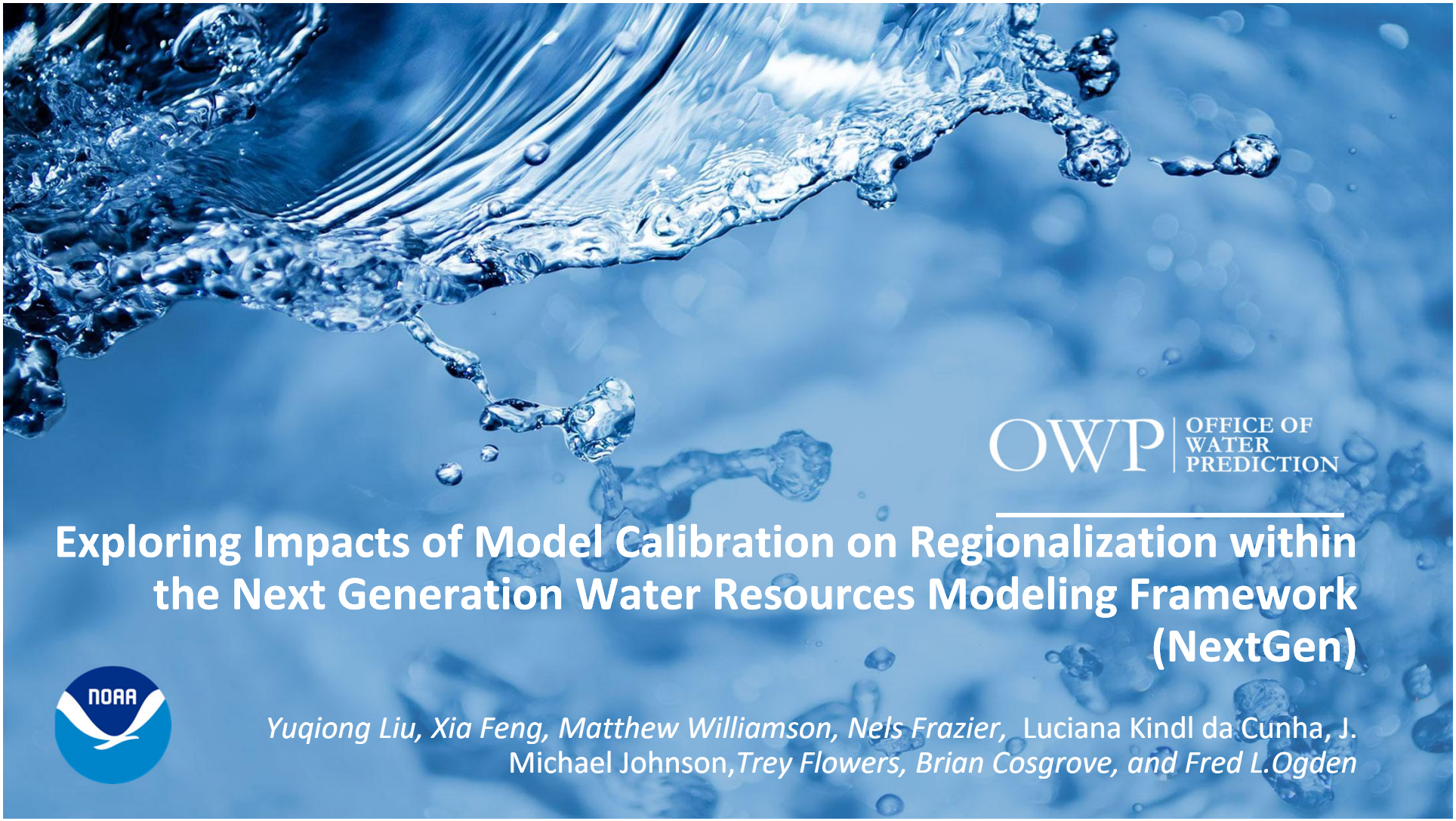

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Exploring Impacts of Model Calibration on Regionalization within the Next Generation Water Resources Modeling Framework (NextGen)

Yuqiong Liu, Xia Feng, Matthew Williamson, Nels Frazier, Luciana Kindl da Cunha, J. Michael Johnson,*Trey Flowers, Brian Cosgrove, and Fred L.Ogden*

Motivation

Regional/continental hydrologic modeling depends on **proper regionalization** to identify model and parameters for uncalibrated areas, which in turn depends on **robust calibration**

Methodology

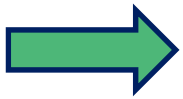
Run and evaluate different **calibration/regionalization experiments within NextGen** (in terms of model formulation, objective function, calibration/regionalization algorithm etc.)

Message to take home

NextGen's **heterogeneous** process representation offers flexibility in **model and parameter identification at catchment level** to achieve best results

The Next Generation Water Resources Modeling Framework (NextGen)

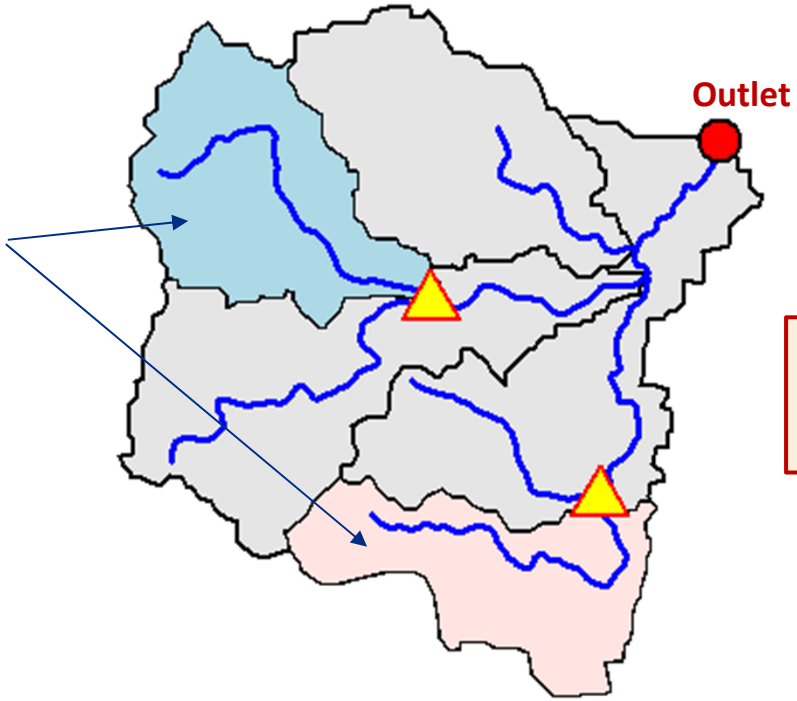
- Features a **model-agnostic** modular modeling environment with a plug-and-play interface
- Incorporates **multiple modules** for each hydrologic process
- Supports **heterogeneous** process representation
- Facilitates collaborative **community** development



Multiple model calibration & regionalization experiments

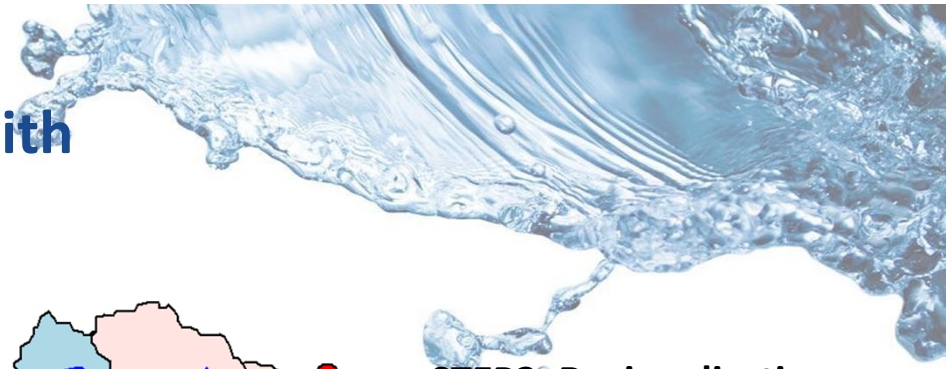
Model/Parameter Identification with NextGen

2 calibratable catchments
2 USGS gages



Question: How to identify appropriate model and parameters for each catchment (in order to simulate flow at the outlet)?

Model/Parameter Identification with NextGen – cont.

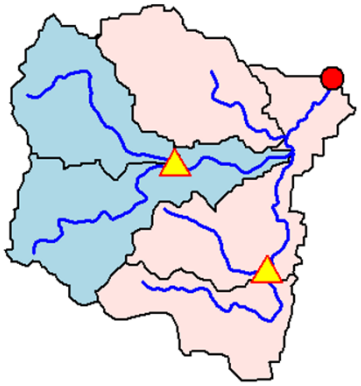


STEP1 : Calibration

In gaged catchments, identify a model and optimize parameters so model simulates observations well

Calibration Configurable Components

- Model
- Parameters
- Objective function
- Optimization algorithm



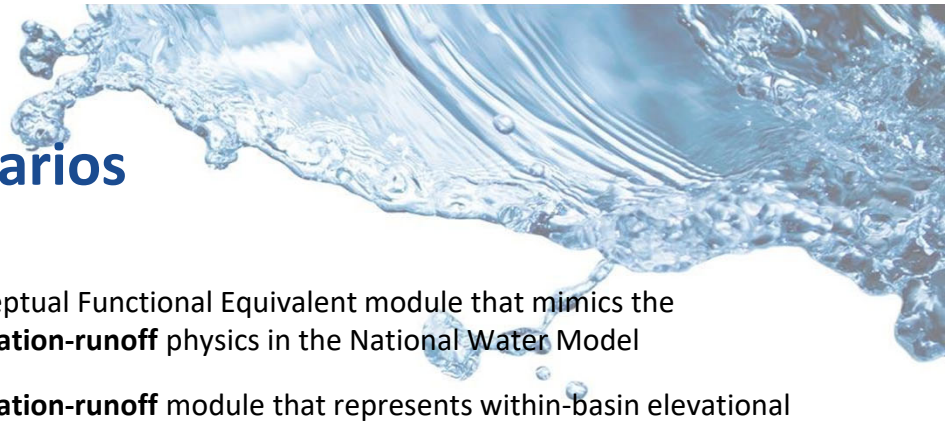
STEP2: Regionalization

From the calibrated catchments, identify the best donor of model/parameters for each uncalibrated catchment (receiver) based on physical & spatial similarities

- Physical attributes
- Distance measure
- Donor-receiver pairing algorithm

Regionalization Configurable components

Calibration & Regionalization Scenarios



Calibration — Model scenarios (3)

Other processes (e.g., snowmelt, ET, routing) are not calibrated

- **CFE** — Conceptual Functional Equivalent module that mimics the **infiltration-runoff** physics in the National Water Model
- **TOPMODEL** — **infiltration-runoff** module that represents within-basin elevational variability with Topographic Wetness Index (TWI)
- **Mixed** — Heterogeneous implementation with selection of model based on the performances of CFE and TOPMODEL at a given catchment

Calibration — Objective function scenarios (2)

Optimization algorithm: Dynamically Dimensioned Search (DDS)

- **KGE** — Kling-Gupta Efficiency (Gupta et al., 2009)
- **NSE** — Nash-Sutcliffe Efficiency (Nash and Sutcliffe, 1970)

Regionalization — Physical attribute scenarios (2)

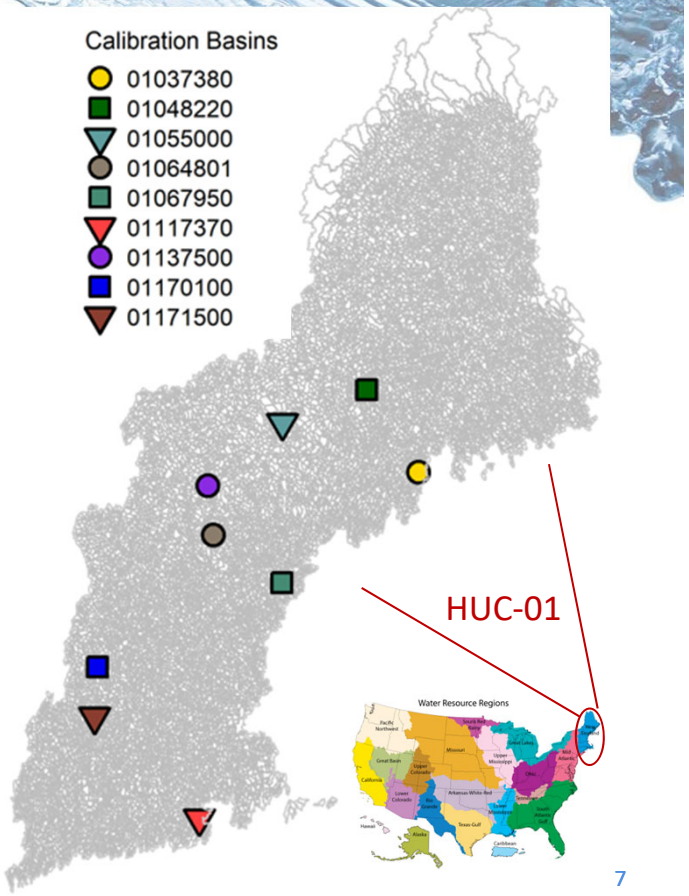
Distance measure: Gower (Gower, 1971)
Attributes preprocessed w/ PC analysis

- **HLR** — Hydrologic Landscape Regions (Wolock et al., 2004) 11 attributes in climate, topography, soil, geology, and land cover
- **CAMELS** — Catchment Attributes and Meteorology for Large-sample Studies (Addor et al., 2017); 22 attributes

Total number of scenarios: 3 x 2 x 2 = 12

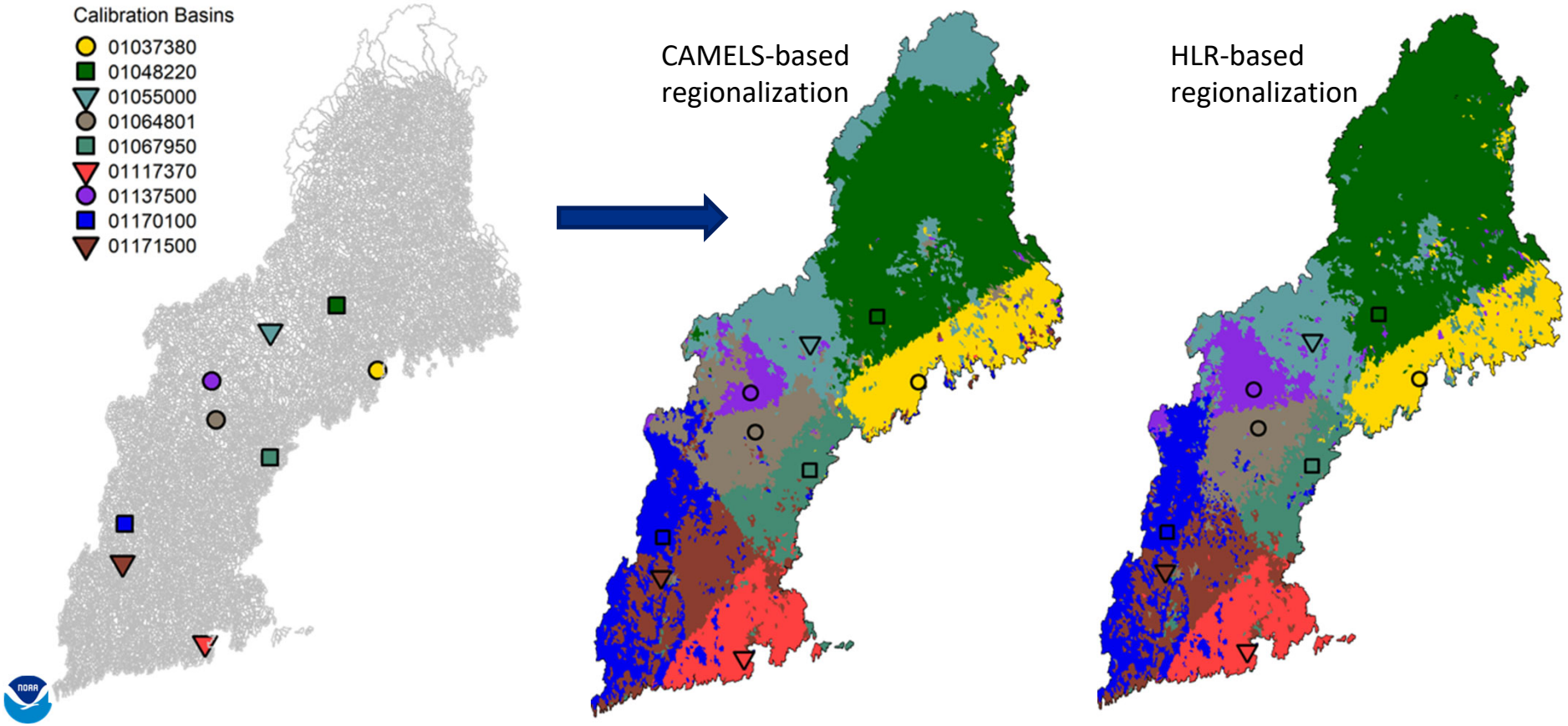
Experimental Setup

- **Study area**
  - New England region (HUC-01); 14,632 catchments
  - 9 calibration basins (122 catchments)
  - 239 validation basins (uncalibrated but regionalized)
- **Evaluation**
  - Period: 10/01/2013 – 09/30/2016, 3 water years
  - Forcing: Analysis of Record for Calibration (AORC)
  - Validation data: USGS hourly streamflow
  - Metrics: KGE, NSE, PBIAS (absolute percent bias), CORR (Pearson correlation)



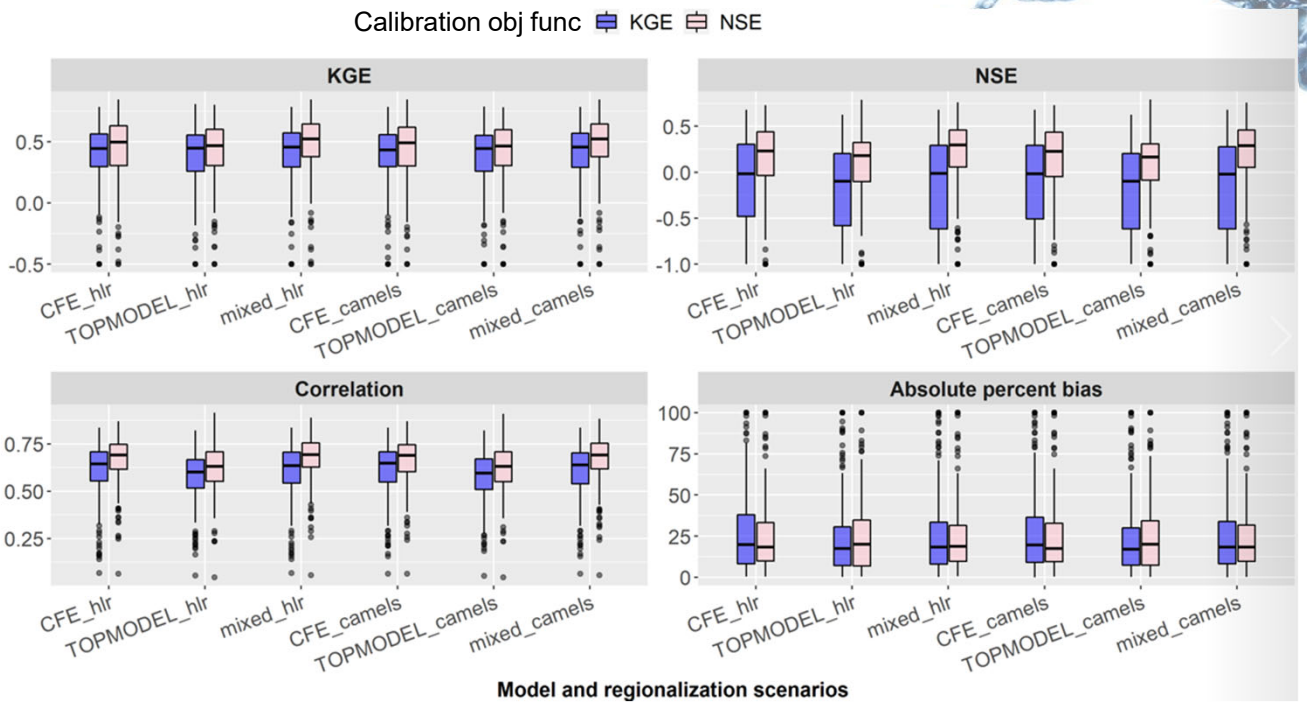
Donor-Receiver Pairing from Regionalization

(based on Physical & Spatial Similarities)



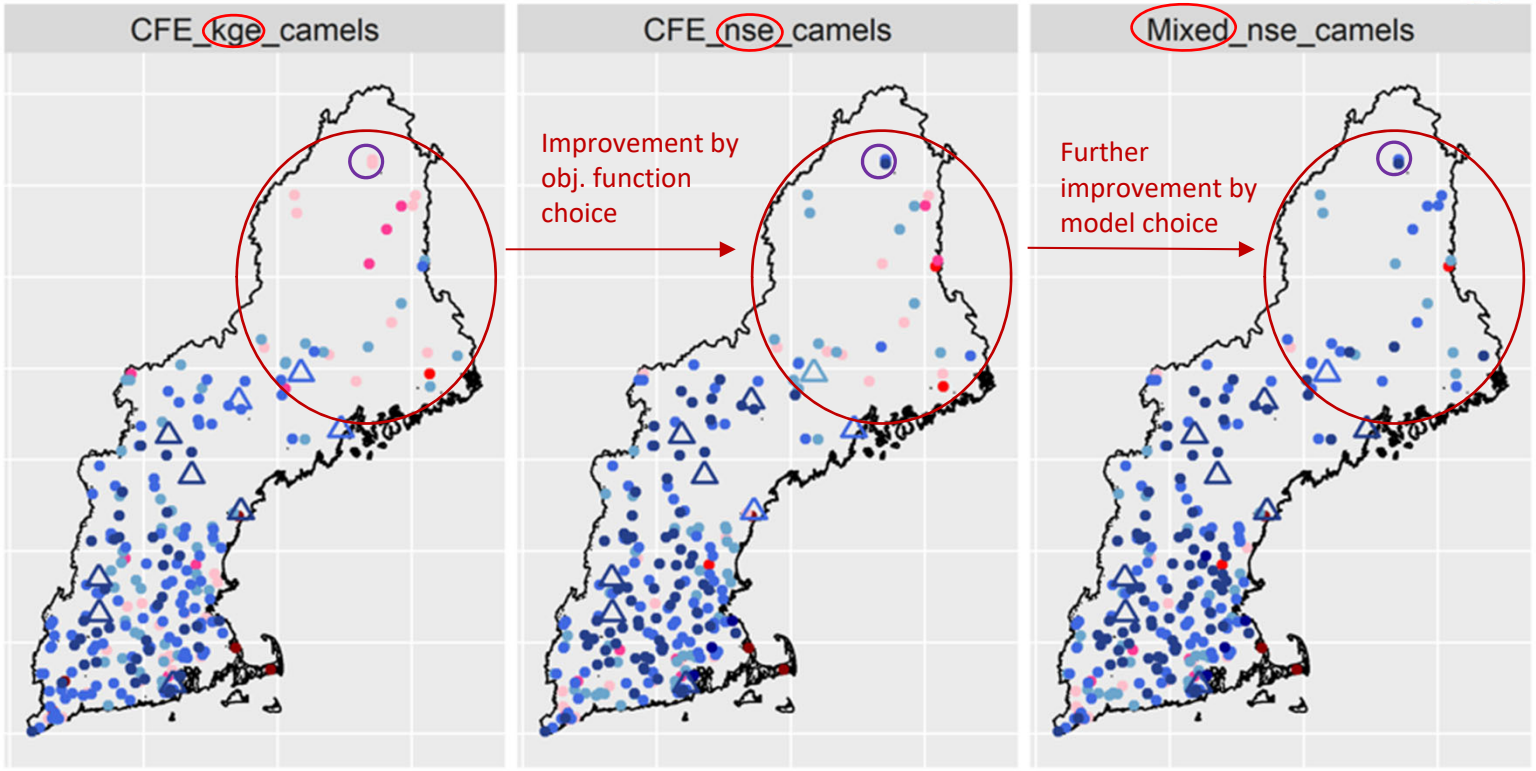
Streamflow Results at Validation Basins: Comparison by Objective Function

- NSE-based calibration outperforms KGE-based calibration at validation basins
- The mixed (heterogeneous) model generally outperforms uniform implementations of CFE and TOPMODEL
- The two regionalization scenarios (HLR vs CAMELS) perform very similarly in all cases



Streamflow Results at Validation Basins: Spatial distribution

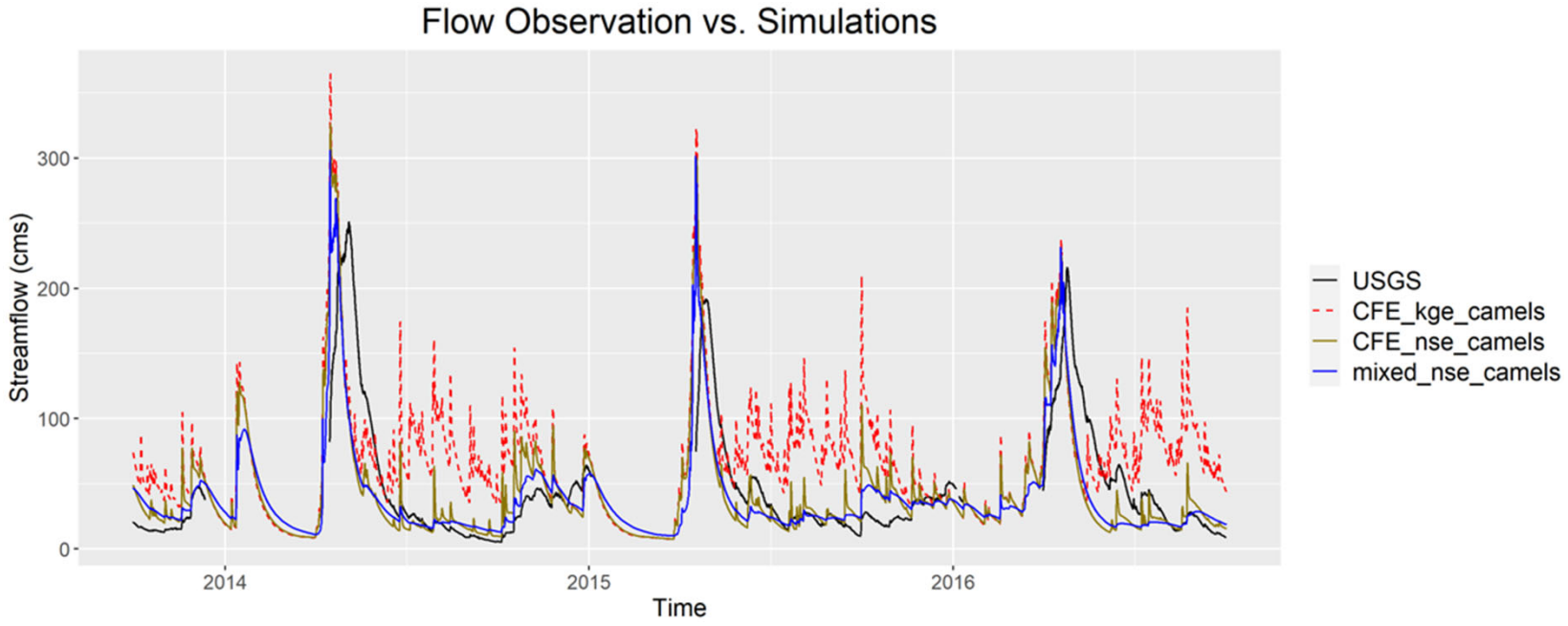
Kling-Gupta Efficiency (KGE)



Dots: validation basins
Triangles: calib. basins

Validation at 01013500 (Fish River near Fort Kent, Maine)

scenario	model	calib_obj_func	reg_scenario	KGE	NSE	CORR	PBIAS
CFE_kge_camels	CFE	kge	camels	0.07	-0.30	0.51	64.2
CFE_nse_camels	CFE	nse	camels	0.69	0.41	0.69	6.1
mixed_nse_camels	mixed	nse	camels	0.73	0.56	0.76	11.5



Take-home Messages & Future Work

- NextGen's heterogeneous process representation offers flexibility in optimal model and parameter identification at catchment level
- Proper calibration can play a critical role in regionalization studies and hence should not be discounted
- Future work
  - Expand to other regions and contiguous US
  - Enhance NextGen calibration/regionalization capabilities
  - Explore other calibration/regionalization options

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Thank You!

Yuqiong Liu

Yuqiong.Liu@noaa.gov

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