11 - Evaluation of Hydrological Models in Low Runoff Ratio Regions: Next Generation Water Resources Modeling Framework vs National Water Model v3.0

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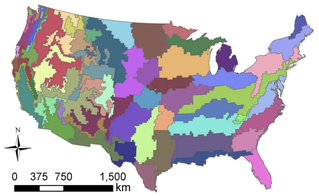
I. Introduction

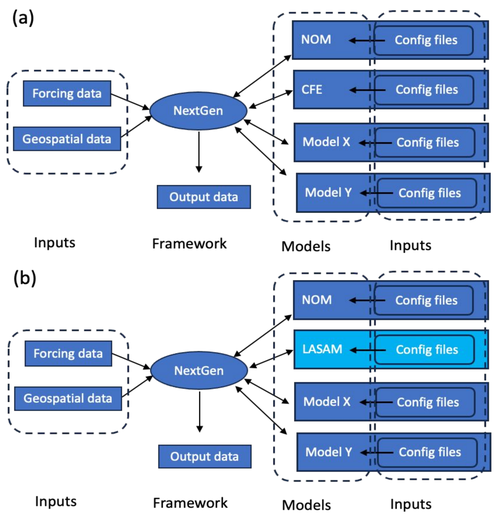
- Accurate streamflow prediction is essential for flood warning & control, water resource planning and management
- Diverse hydroclimatic regions across the United States present a significant challenge for any single hydrologic model to accurately forecast stream flows
- There is no single hydrologic model that can be formulated to capture all dominant hydrologic processes at such a range of scales



Sixty-four regions based on monthly temperature and precipitation normals from PRISM data, 1981–2018
Carbone, G.J., Gao, P. & Lu, J. Regionalization of hydroclimate variables in the contiguous United States. *Theor Appl Climatol* **155**, 4767–4779 (2024).

II. NextGen Framework

Next Generation Water Resources Modeling Framework (NextGen[1]) is a standards-based language- and model-agnostic framework. NextGen allows to run a mosaic of surface and subsurface models in a single basin comprised of 10s-100s sub-catchments.

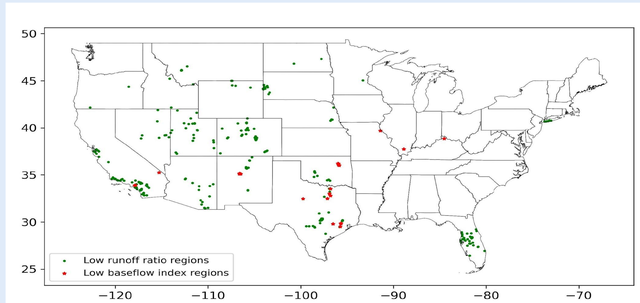


Schematics illustrating the setup of two formulations: hydrologic model CFE[2] (a), and hydrologic model LASAM[3,4] (b).
CFE (Conceptual Functional Equivalent to WRF-Hydro-based NWM).
LASAM (Lumped Arid/Semi-arid Model is a catchment model, which uses Layered Green & Ampt with redistribution (LGAR) infiltration scheme to calculate infiltration)

Even region-specific models can fall short: How we make them work

V. Field sites

- 280 HUC08 basins with a Low Runoff Ratio. Basins with LRR <= 20% and area <= 150 sq. km
- 25 HUC08 basins with low Baseflow Index. Basin with BFI <= 15% and area <= 100 sq. km



VI. Results

A carefully calibrated and selected mosaic of models running in the NextGen Framework outperforms the operational NWM 3.0 in retrospective simulations

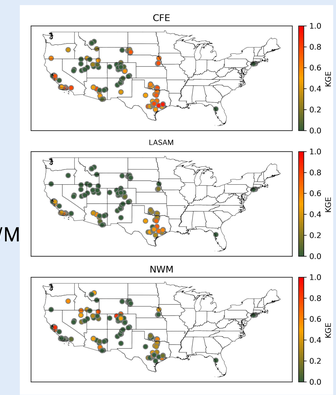


Fig. 1: Maps showing the KGE values for CFE (v2.0 with Schaake runoff scheme), LASAM, and NWM 3.0 for regions with LRR

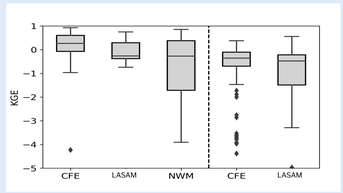


Fig. 2: Boxplot showing KGE values for each formulation during the calibration (from the best iteration) and validation periods for regions with LRR

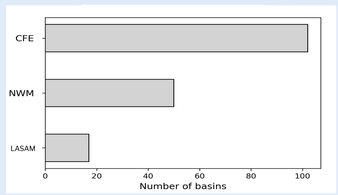


Fig. 3: Number of basins with best KGE for each model (most performant model) for regions with LRR

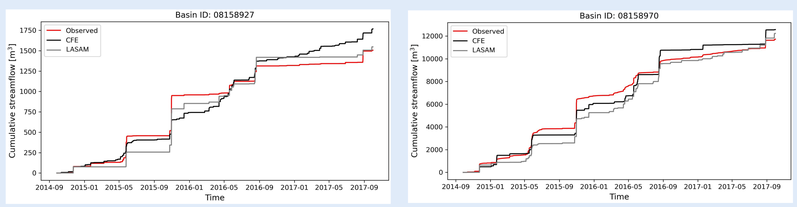


Fig. 4: Observed vs simulated cumulative streamflow for two selected basins where LASAM is the most performant model. The plots illustrate how LASAM accurately captures the flashy runoff behavior (peaks detection) compared to CFE.

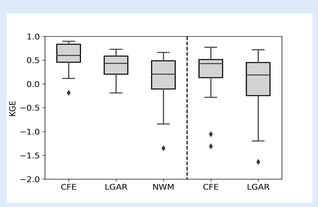
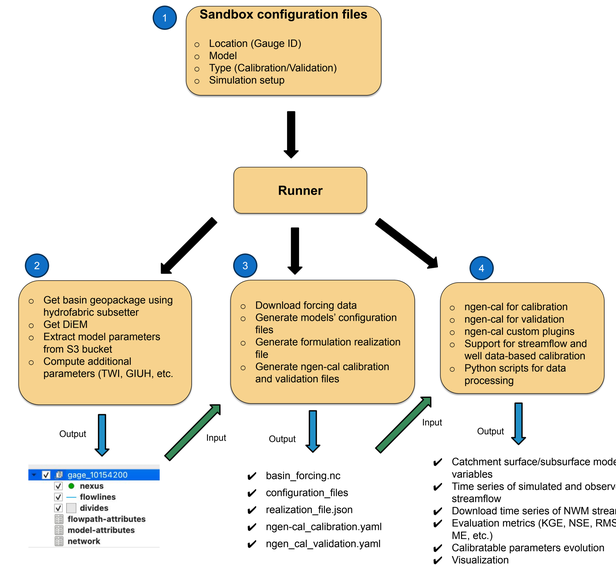


Fig. 5: Boxplot showing KGE values for each formulation during the calibration (from the best iteration) and validation periods for regions with low BFI

III. NextGen Calibration Sandbox [5,6,7,8]



Run command: python <path_to_ngen_cal_sandbox>/main.py option
OPTIONS = [-gpkg -forc -conf -run]

IV. Summary

- Evaluated the performance of models within the NextGen framework compared to the WRF-Hydro based NWM 3.0, focusing on regions with a low runoff ratio and low baseflow index
- Preliminary evaluation shows that models running within the NextGen framework outperform WRF-Hydro-based operational NWM
- Within the NextGen framework, similar to how model selection is tailored to each catchment's characteristics, the calibration strategy should be adapted to regional hydroclimatic conditions and models' processes to identify the most performant models
- In addition to parametric calibration performed here, process-based calibration strategies may enhance the performance of region-specific models

REFERENCES:

[1]https://github.com/NOAA-OWP/ngen
[2]https://github.com/NOAA-OWP/cfe
[3]https://github.com/NOAA-OWP/LGAR-C
[4]La Follette, P., Ogden, F. L., & Jan, A. (2023). Layered Green and Ampt infiltration with redistribution. *Water Resources Research*, 59, e2022WR033742. https://doi.org/10.1029/2022WR033742
[5]https://github.com/aikhattak/basin_workflow
[6]https://github.com/NOAA-OWP/ngen-cal
[7]https://github.com/jmframe/CIROH_DL_NextGen
[8]https://github.com/NOAA-OWP/hydrofabric

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