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Identifying the Optimal Spatial Resolution of LiDAR Derived Elevation Data for Continental Scale Flood Inundation Mapping Applications

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Office of Water Prediction Flood Inundation Mapping

Streamflow Forecasts

3,600 -> 2.8 million

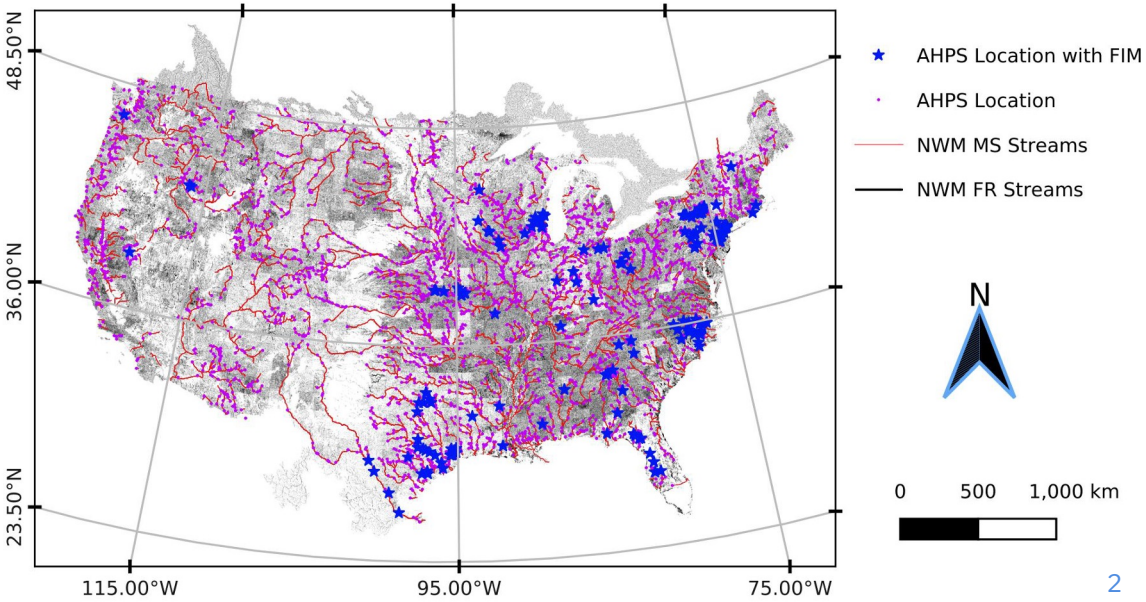
HAND FIM Forecasts

200 -> 2.8million

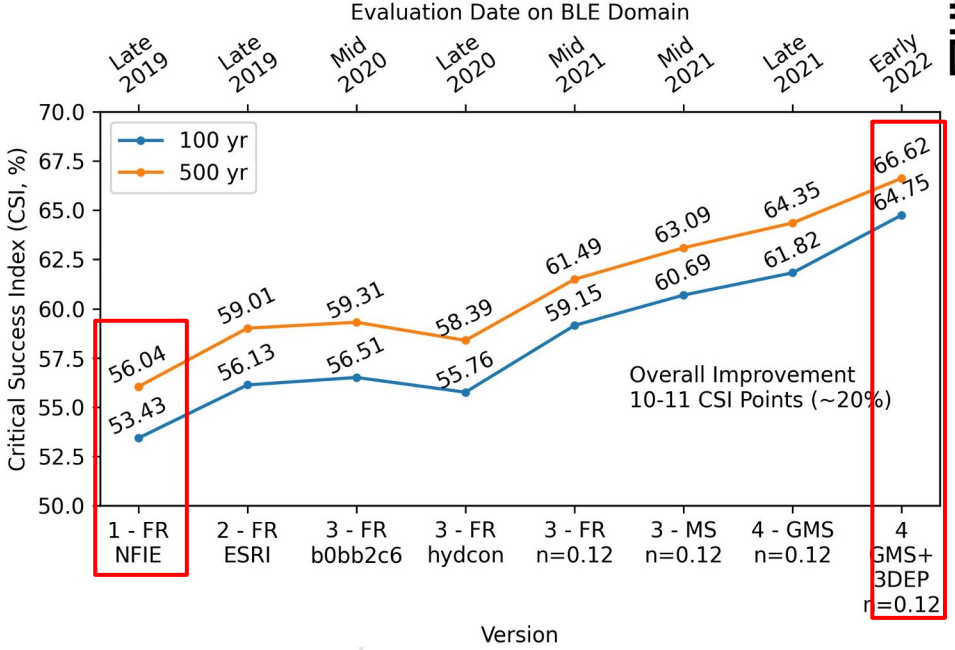
@ 10m resolution

National Water Model (NWM)
+
Synthetic Rating Curves (SRCs)
+
Height Above Nearest Drainage (HAND)
=
Inundation Extents & Depths

**@ 10m spatial resolution,
hourly time steps,
and multiple forecast horizons.**



OWP FIM Improvements



Extending Height Above Nearest Drainage to Model Multiple Fluvial Sources in Flood Inundation Mapping Applications for the U.S. National Water Model

ESSOAr
Earth and Space Science Open Archive

noaa-owp/inundation-mapping
HAND + FIM + EVAL

Advances Employed

- Hydro-conditioning
  - AGREE-DEM
- Manning's n adjustments
  - Two-tiered parametrization
- Updated input data
  - NHDPlusHR
  - NWM Hydrofabric V2.1
  - 3DEP DEMs
- Multiple fluvial inundation sources

level path delineation

LiDAR Derived Elevation - 3D Elevation Program (3DEP)

Legacy DEMs: NHDPlusHR DEMs

HAND FIM

DEM Source?

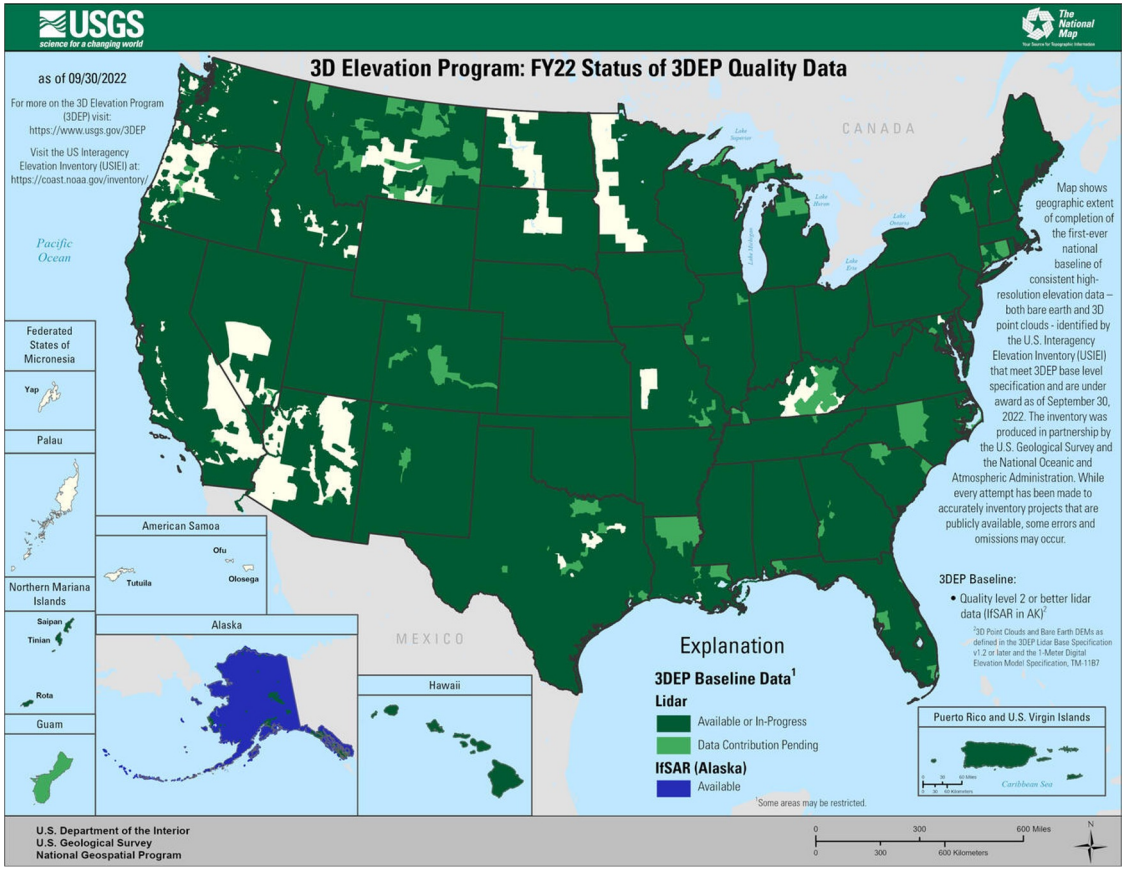
DEM Resolution?

Literature

1. Garoujsi-Nejad et al, 2016
2. Zheng et al, 2018
3. Li et al, 2022
4. Speckhann et al, 2017

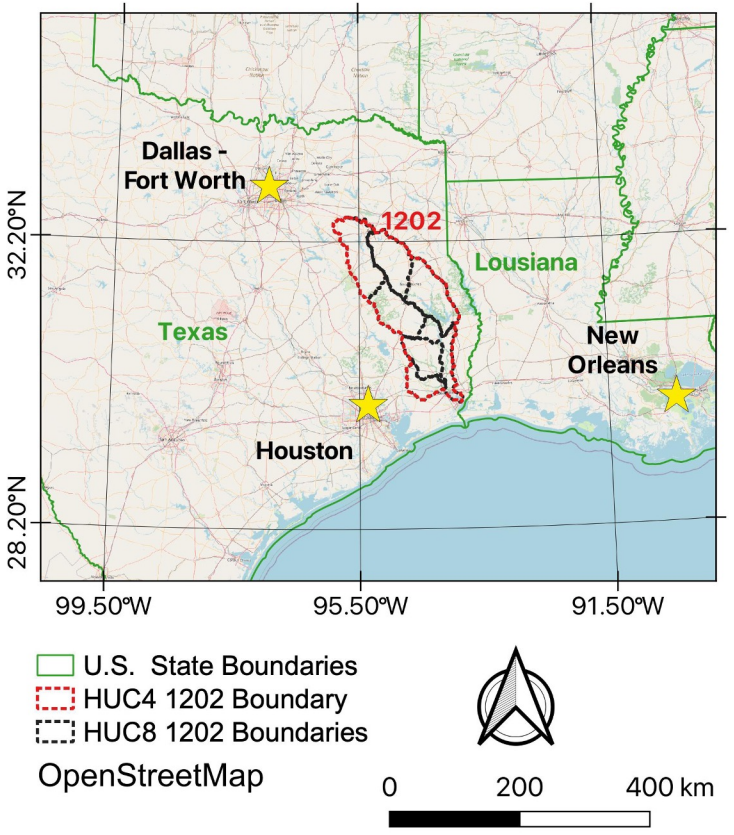
Limitations

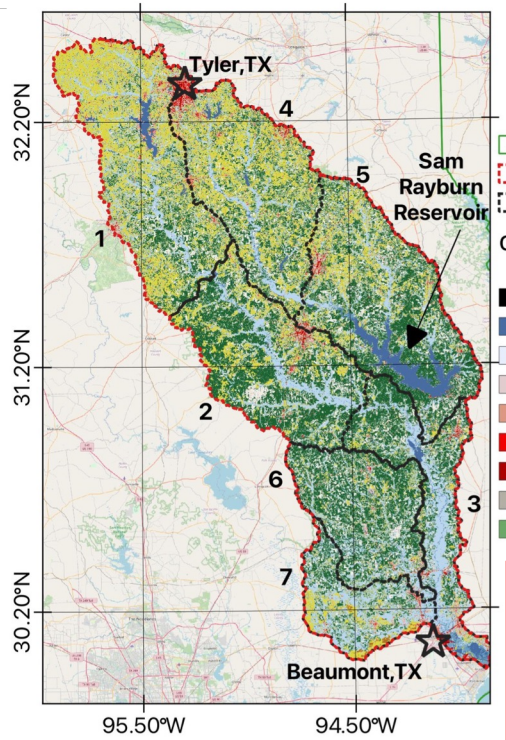
1. Experimental design (conflating of factors)
2. Limited domains
3. Divergent methods and parameterizations



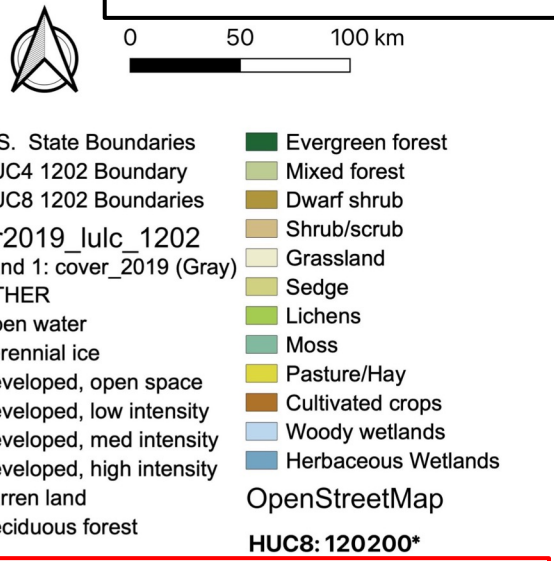
Study Area - Neches River Subregion

Validation Source:
Base Level Engineering (BLE) HEC-RAS 1D 100/500yr Extents





Developed Total (7.3%)
Reservoirs (15 for 2.5%)



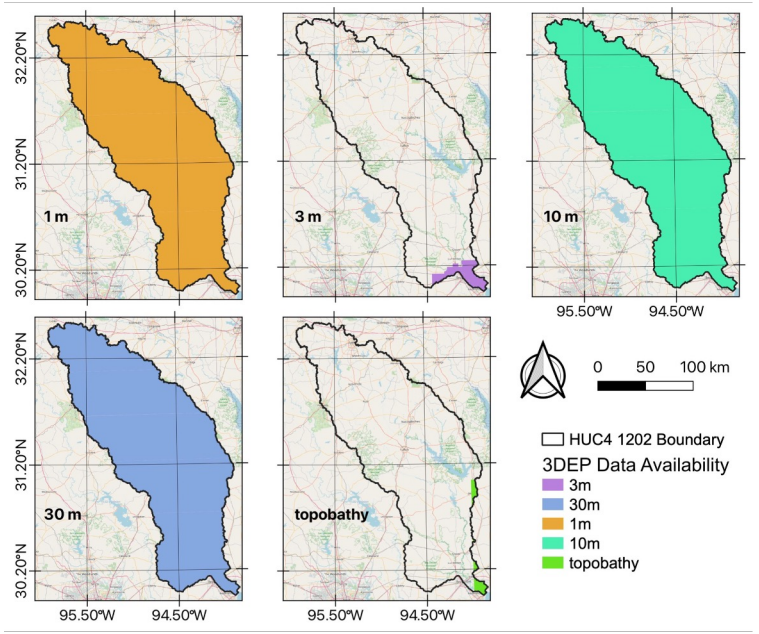
Top 4 Categories (76.5%)

1. Evergreen Forest (31.1%)
2. Pasture/Hay (17.2%)
3. Woody Wetlands (16.7%)
4. Mixed Forests (11.4%)

HyRiver - Py3DEP

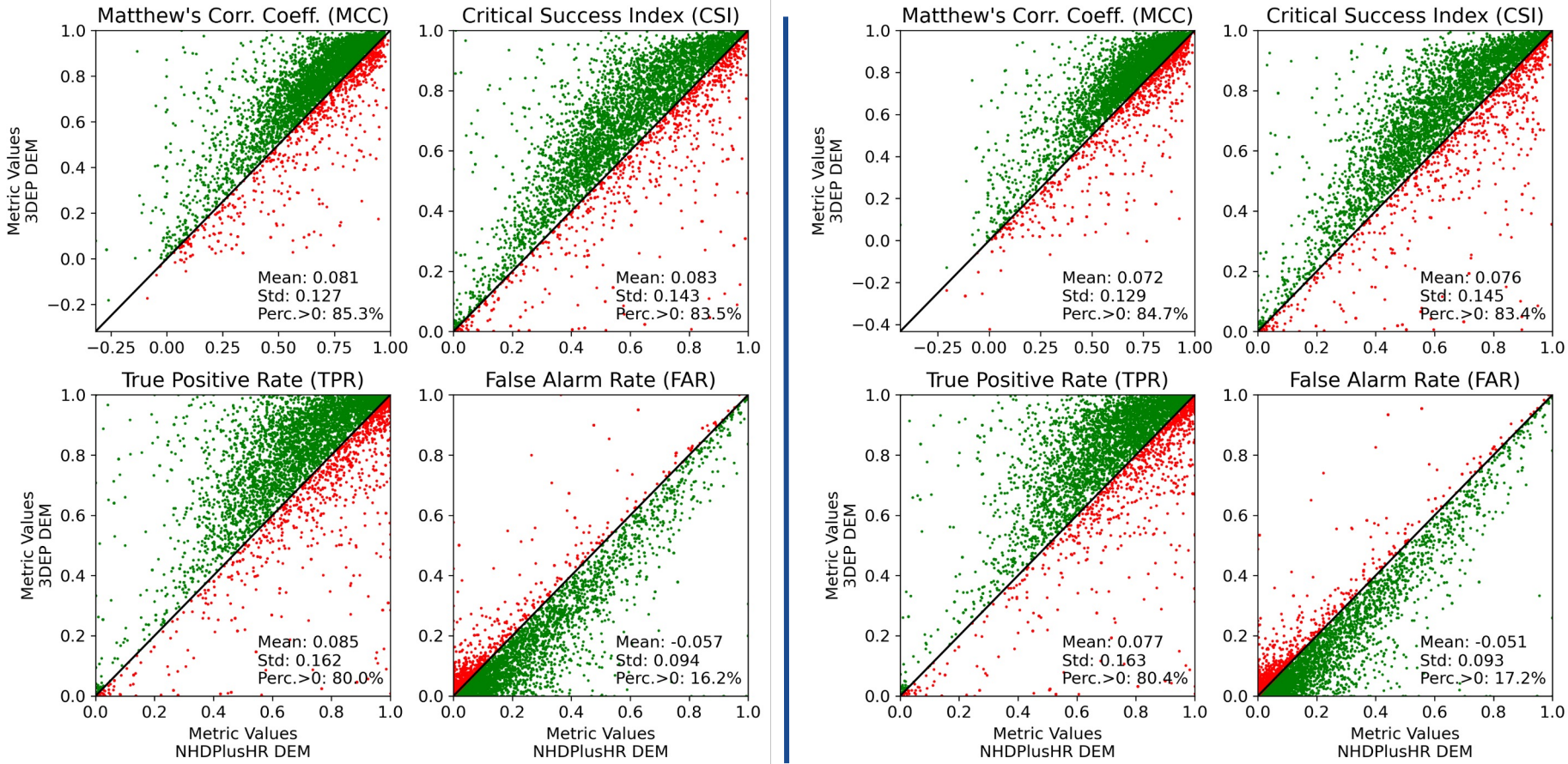
HyRiver
Taher Chegini

- An open-source Python package
- Access to the static and dynamic 3DEP web service:
  - Static: The National Map's staged DEM data at multiple resolutions
  - Dynamic: DEM and other topographic attributes such as slope and aspect at any resolution
- Elevation profile along any given line segment (e.g., NHD flowlines)
- Checking 3DEP data availability at different resolutions



1m 3DEP → Bilinear Interpolation → 3, 5, 10, 15, 20m DEMs

100yr 3DEP vs NHDPlusHR DEMs @ 10m 500yr



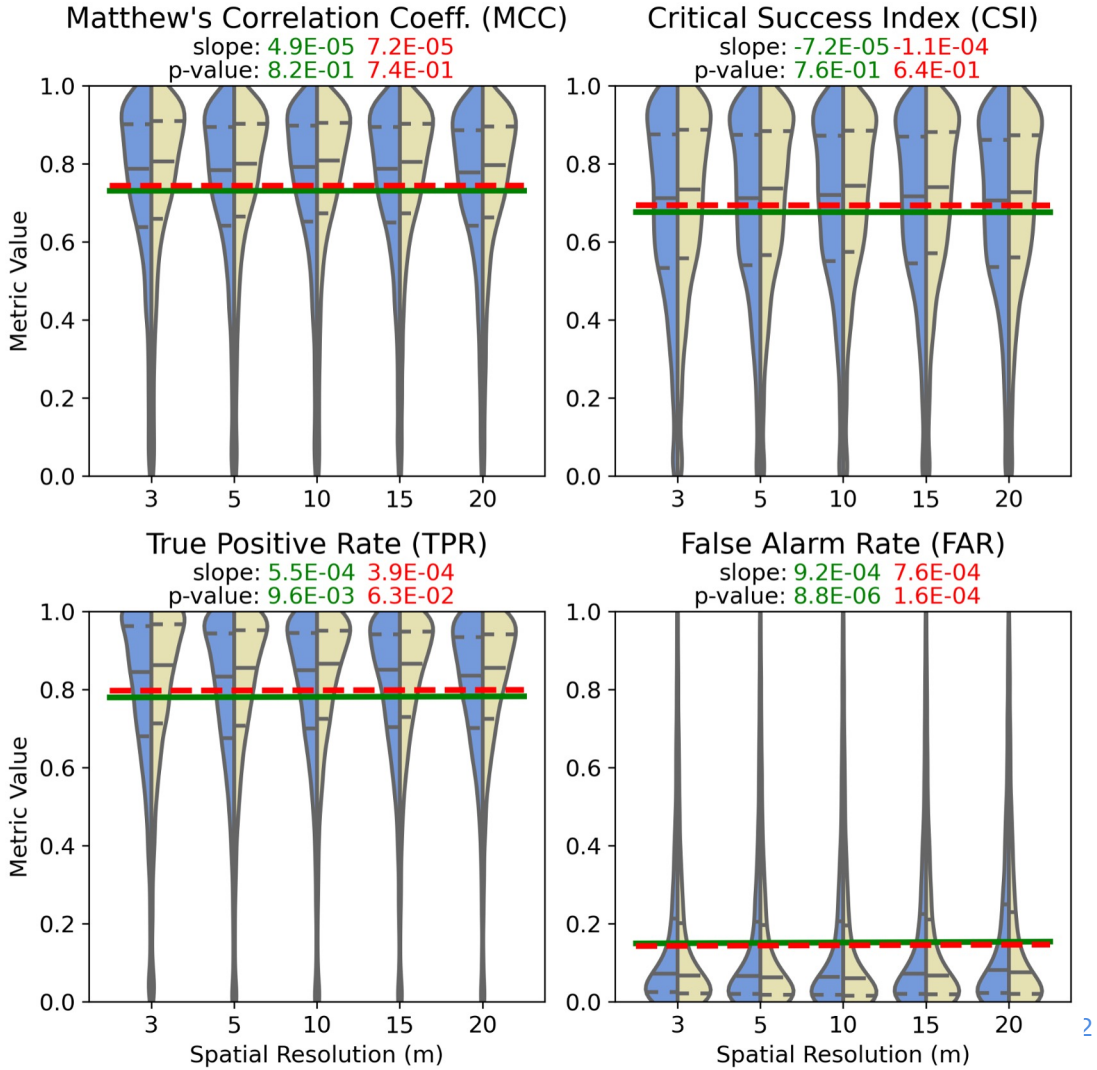
Metric Value Difference (3DEP - NHDPlusHR DEM)
- Improvement or no change (difference >=0)
- Reduction (difference<0)

NWM Catchments n = 5438

Metric Value Difference (3DEP - NHDPlusHR DEM)
- Improvement or no change (difference >=0)
- Reduction (difference<0)

Varying Spatial Resolution

KDE: 100yr
KDE: 500yr
Trendline: 100yr
Trendline: 500yr



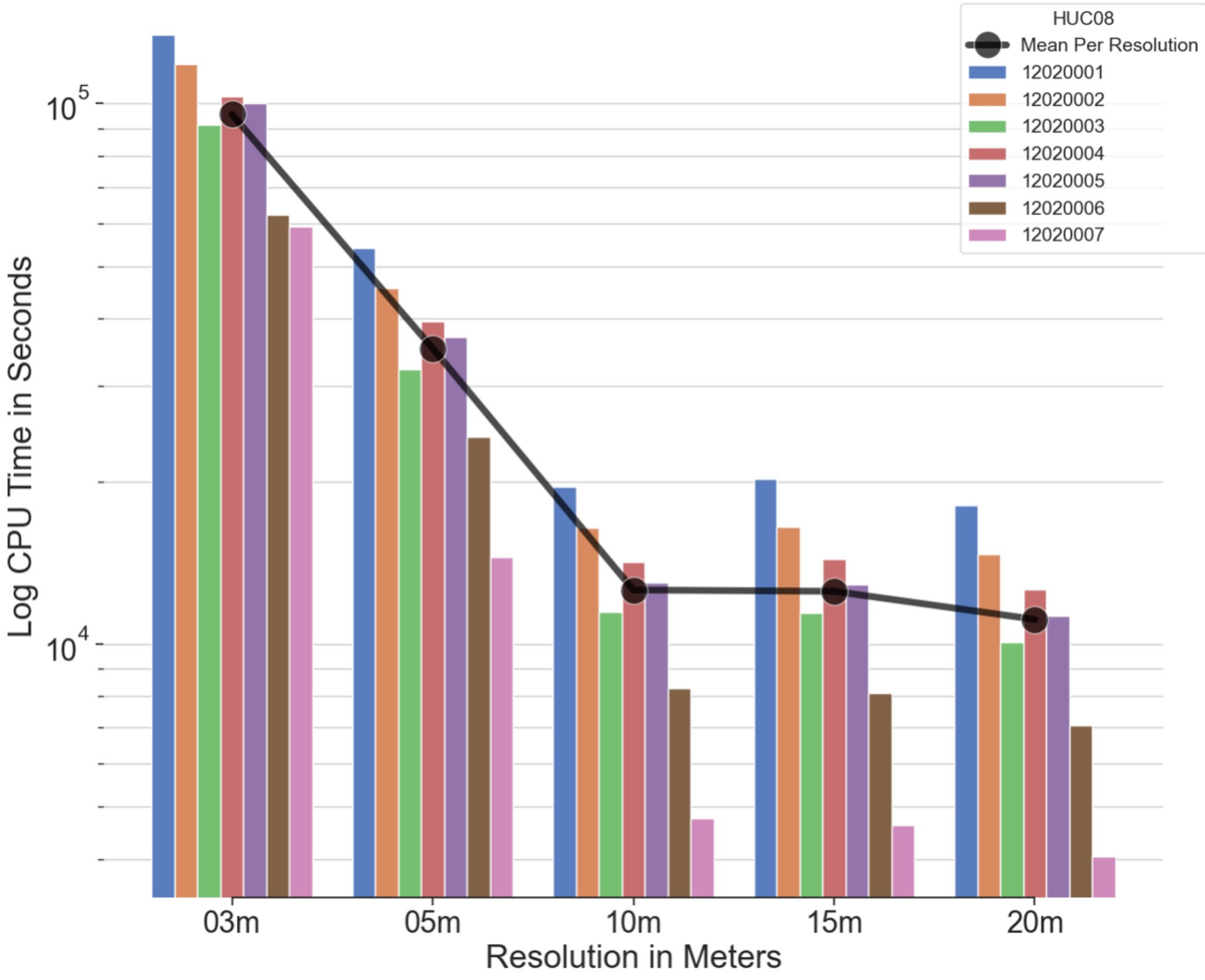
Processing Time

Number of Pixels $\propto$ resolution^{-2}

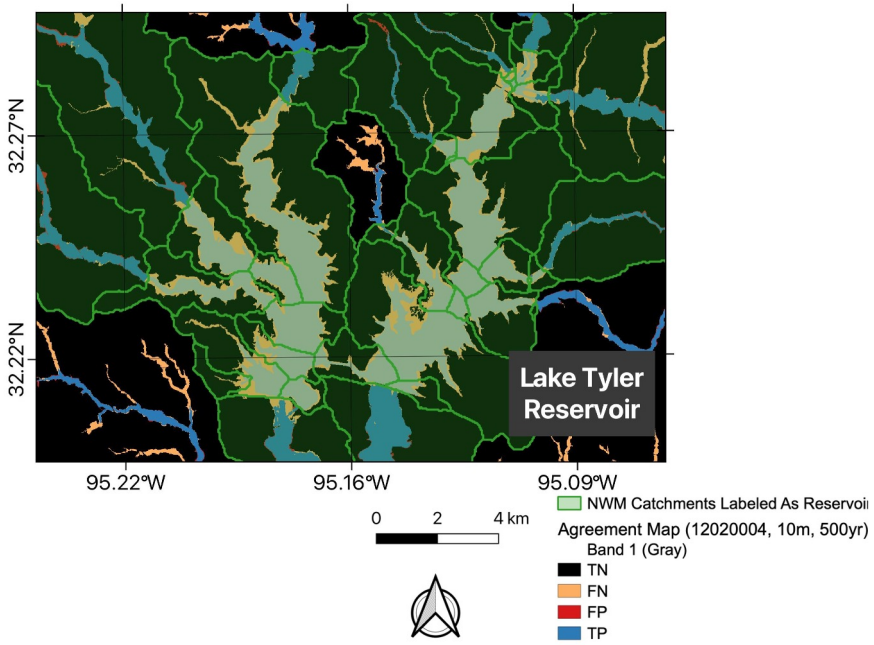
Between HUC variance explained by stream density and HUC area

Amazon Web Services

- EC2: t3. 2xl
  - 7 cores
  - 32GB RAM
- GP3 SSD Volume
  - 3000 IOPS
  - 125 Throughput

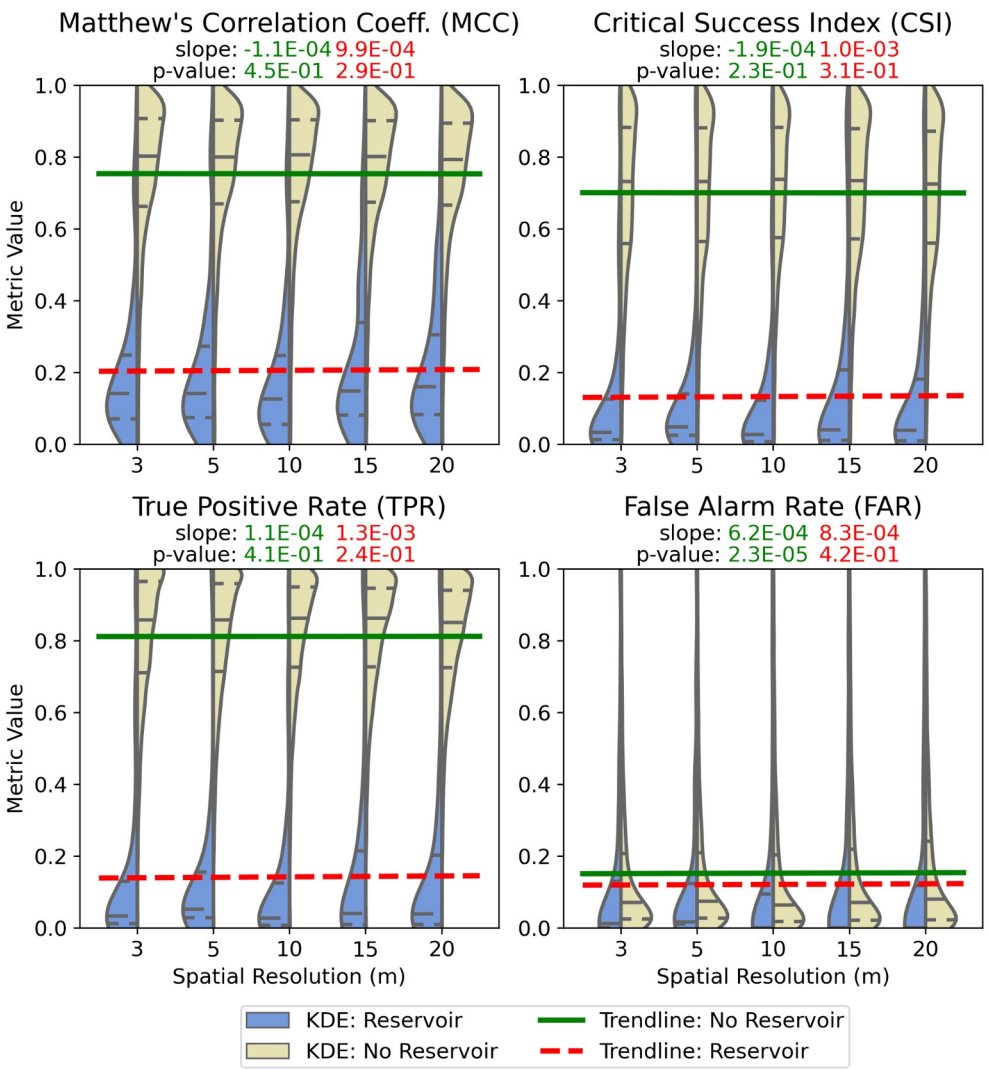


Reservoirs



Catchment Scale Covariates Examined

- DEM Source
- DEM Spatial Resolution
- Reservoir Intersecting Catchment
- Dominant Inundated Land Cover/Land Use
- Horton-Strahler Stream Order
- Channel Slope
- Channel length
- Catchment geometric area



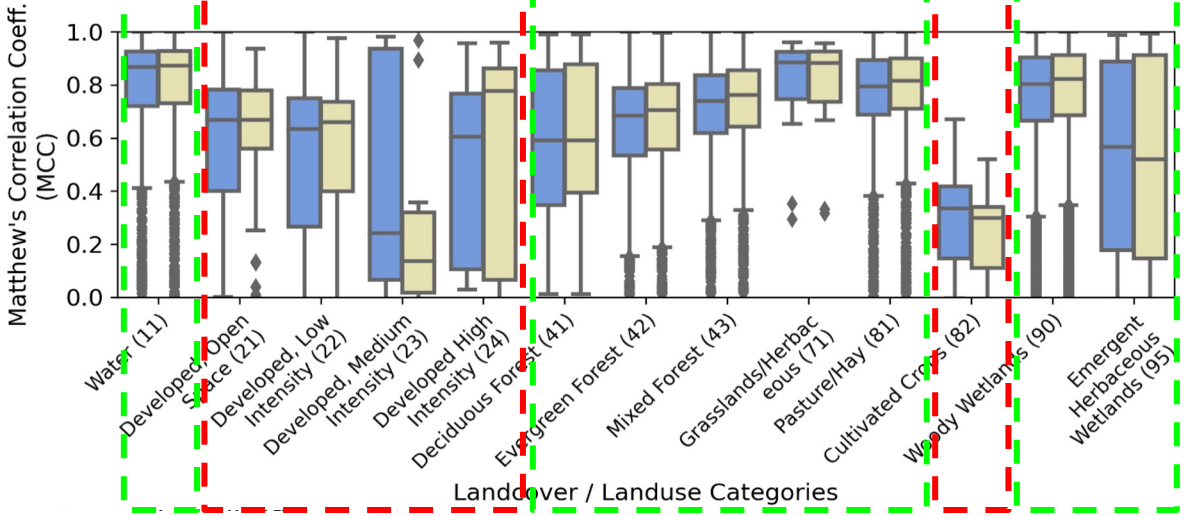
Magnitude
100yr 500yr

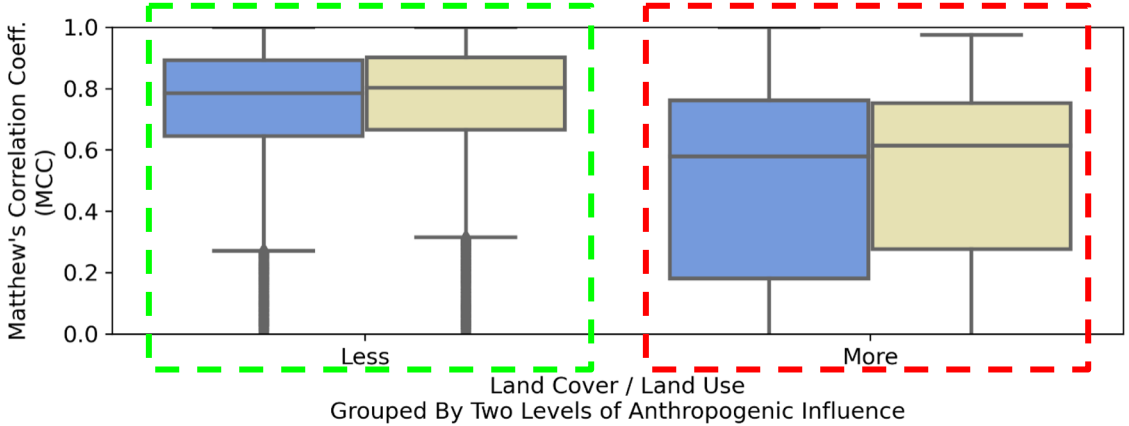
Landcover

Dominant Inundated Landcover By Catchment

Anthropogenic Influence

Less	More
Water (11)	Developed, Open Space (21)
Deciduous Forest (41)	Developed, Low Intensity (22)
Evergreen Forest (42)	Developed, Medium Intensity (23)
Mixed Forest (43)	Developed, High Intensity (24)
Grassland/Herbaceous (71)	Cultivated Crops (82)
Pasture/Hay (81)	
Woody Wetlands (90)	
Emergent Herbaceous Wetlands (95)	





MCC ~ 0.74*** - 0.23***(Grouped LULC) + 0.013***(Magnitude) + 0.01 (Grouped LULC:Magnitude)

*** p-value ≤ 0.001

Conclusions

- High Quality ***LiDAR Derived DEMs Enhance FIM Skill*** when compared to NHDPlusHR DEMs both at the 10m spatial resolution.
- ***3DEP DEMs*** resampled from 1m to 3, 5, 10, 15, and 20m ***had no detected effect on FIM skill*** for this study area characterized by low slopes and high prevalence of rural/natural areas.
  - However, DEM Resolution could interact with other factors not controlled for in this study.
  - ***DEM spatial resolution has a significant influence on the CPU time*** required in computing HAND.
- The presence of ***catchments that intersect with reservoirs is the most significant factor*** in explaining the among catchment metric variation.
  - This is due to a lack of reservoir flooding being accounted for currently.
- Performance of HAND based ***FIM is possibly better in NLCD land covers associated with less anthropogenic influence*** than developed or cultivated regions.
- ***More research is needed across broader domains of study*** with more factors being controlled for to better understand the influence of DEM spatial resolution on the skill of HAND based FIMs.

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Thank You!

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