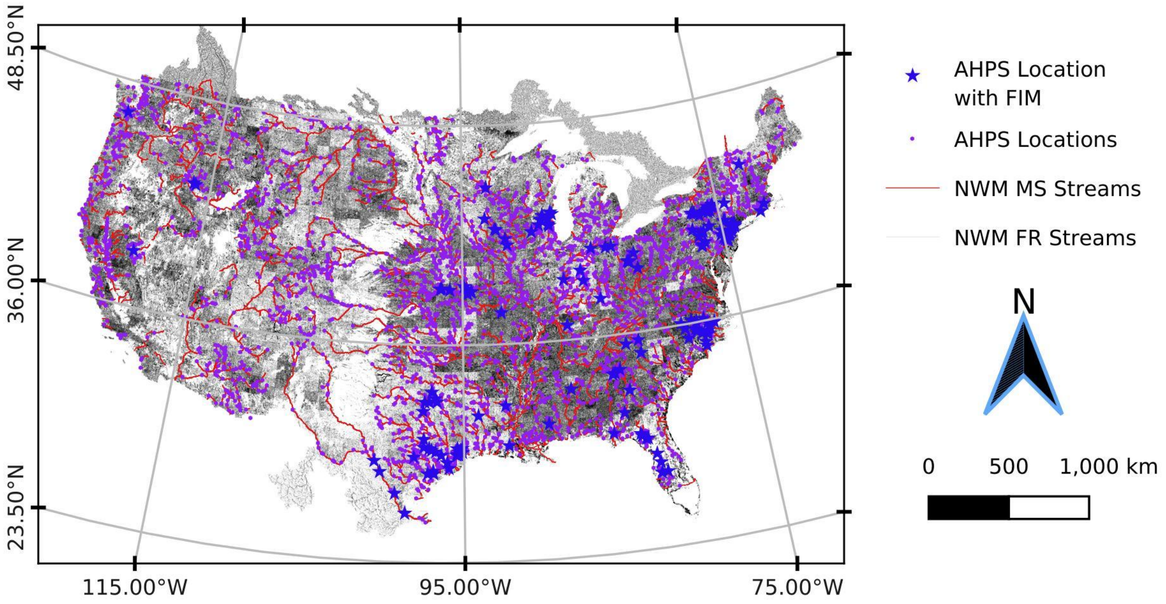
NOAA Office of Water Prediction Flood Inundation Mapping

Computing Height Above Nearest Drainage with Lower Resolution Stream Networks Improves the Performance of Flood Inundation Maps

Fernando Aristizabal, Greg Petrochenkov, Fernando Salas, Brian Avant, Bradford Bates, Trevor Grout, Ryan Spies, Nick Chadwick, Zachary Wills, Jasmeet Judge

National Water Model (NWM)



- FR = Full Resolution. Entire NWM stream network
- MS = Mainstems. 4% of FR network. All streams at or downstream of AHPS points

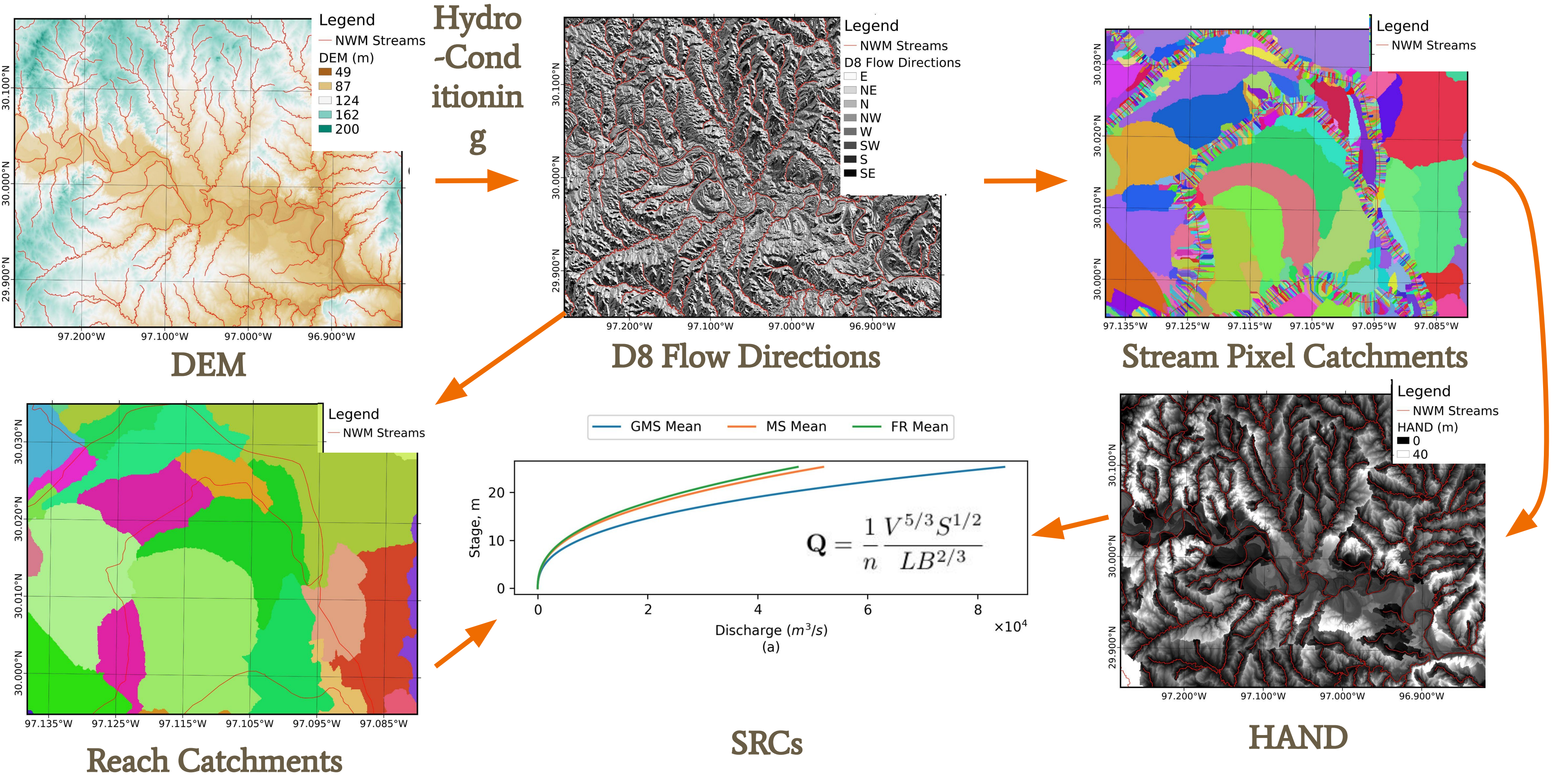
Legacy System

- Advanced Hydrologic Prediction System (AHPS)
- ~3.6k Forecast locations
- ~200 with FIM

National Water Model

- 2.8 million forecast points
- CONUS, HI, and PR
- 5.5 million km of river lines
- Available every hour
- Multiple forecast horizons
- Retrospective analysis (1979-2020)

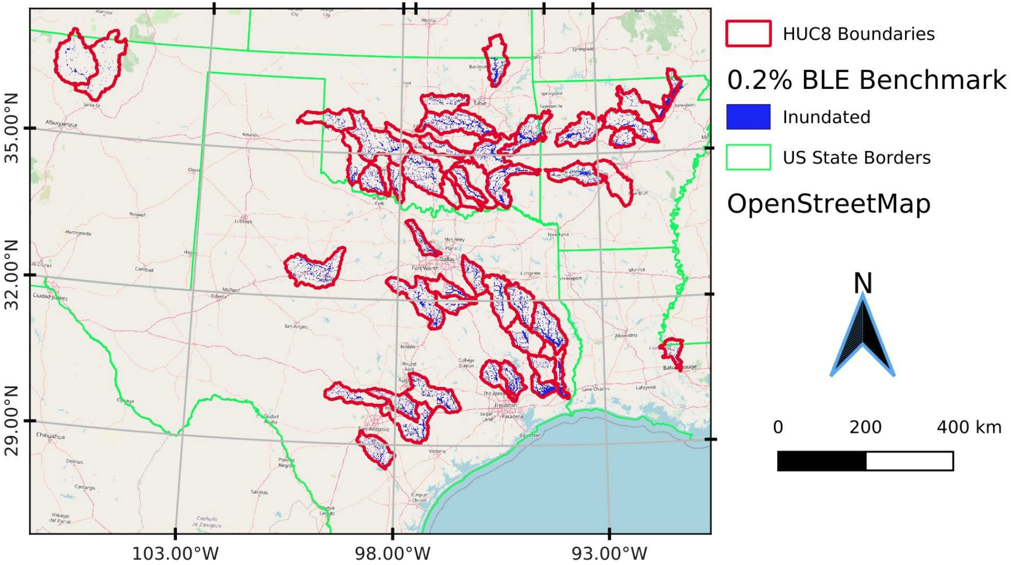
Height Above Nearest Drainage + Synthetic Rating Curves



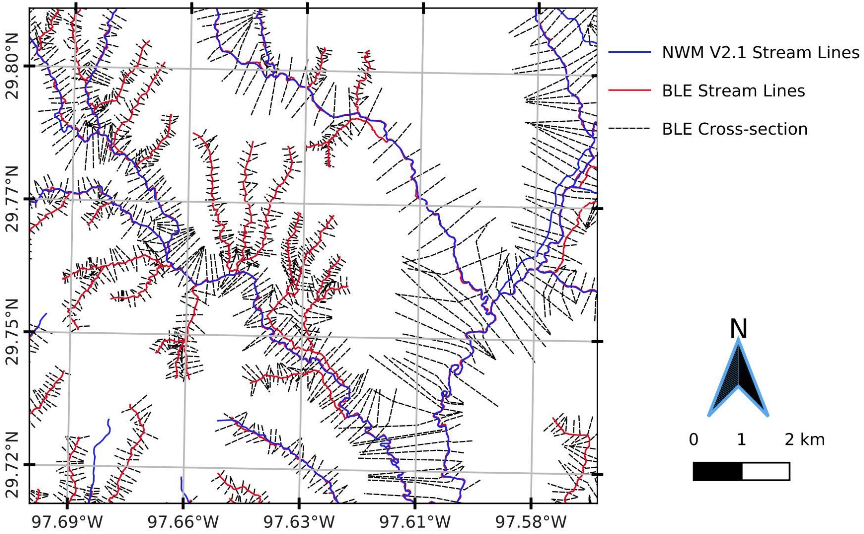
Hydro-Conditioning

Operation	**Description**	**References**
Buffering	Processing unit is buffered to avoid edge effects	Gesch et al., 2002
Stream network enforcement	AGREE DEM	W. Saunders & Maidment, 1995; W. K. Saunders & Maidment, 1996; Mizgalewicz & Maidment, 1996; Hellweger & Maidment, 1997; Quenzer & Maidment, 1998; Baker et al., 2006
Levee Enforcement	Burning NLD	USACE et al., 2020
Pit filling	Filling of pits	Barnes (2018); Zhou et al. (2015)
Local minimum elevation	Sampling of local min and smoothing	W. Saunders, 1999
Stream thalweg smoothing	Enforce monotonically decreasing elevations	Garousi-Nejad et al. (2019)
Flow Directions	D8	Tarboton et al., 2009; Tesfa 410 et al., 2011; Wallis et al., 2009; Tarboton, 2005; Survila et al., 2016; Y. Liu et al., 2016
FIM Stream Network	Derive the FIM stream network using NWM seed points. Split reaches to 1.5km max distance	Wallis et al., 2009; Tarboton, 1997, 2005; Garousi-Nejad et al., 2019; Godbout et al., 2019; Zheng, Maidment, et al., 2018

Base Level Engineering

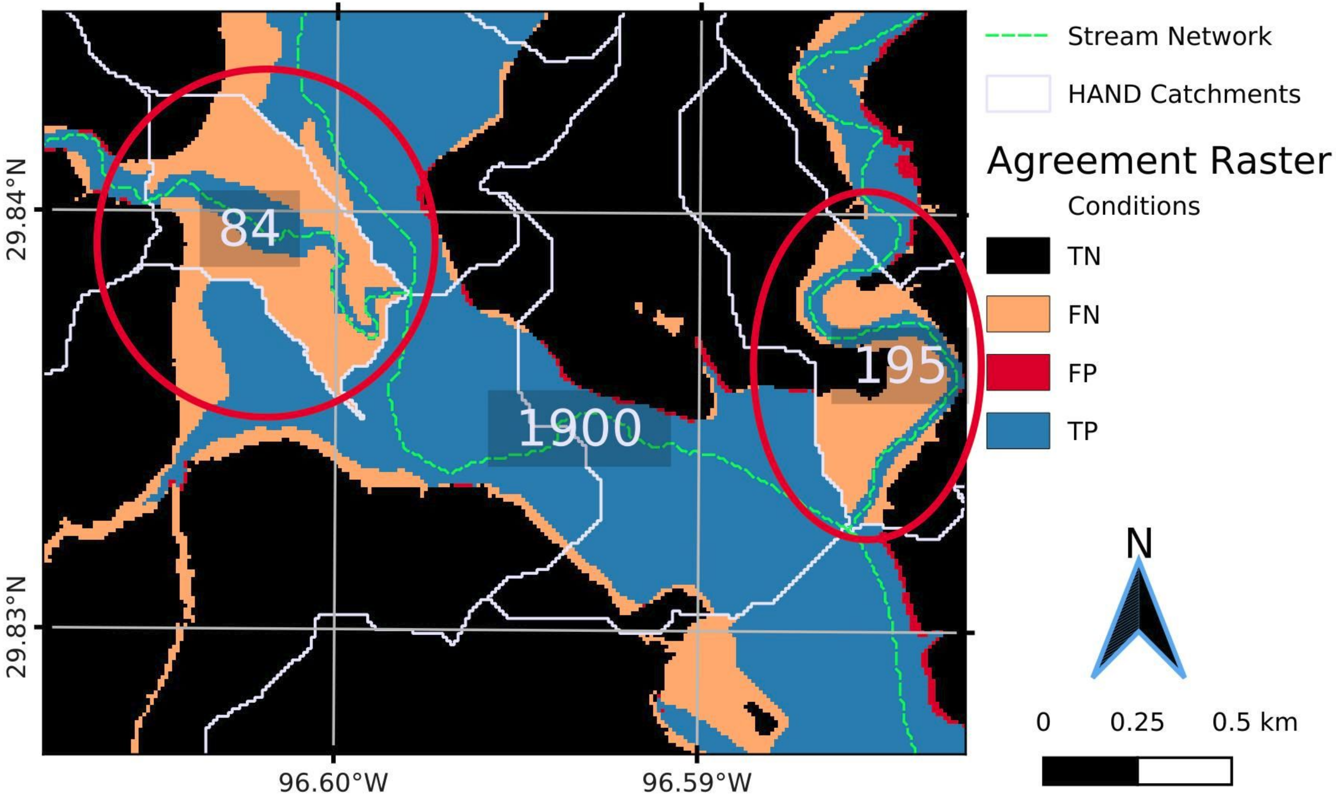


49 HUC8 BLE Sites
Across 9 States
HEC-RAS 1D

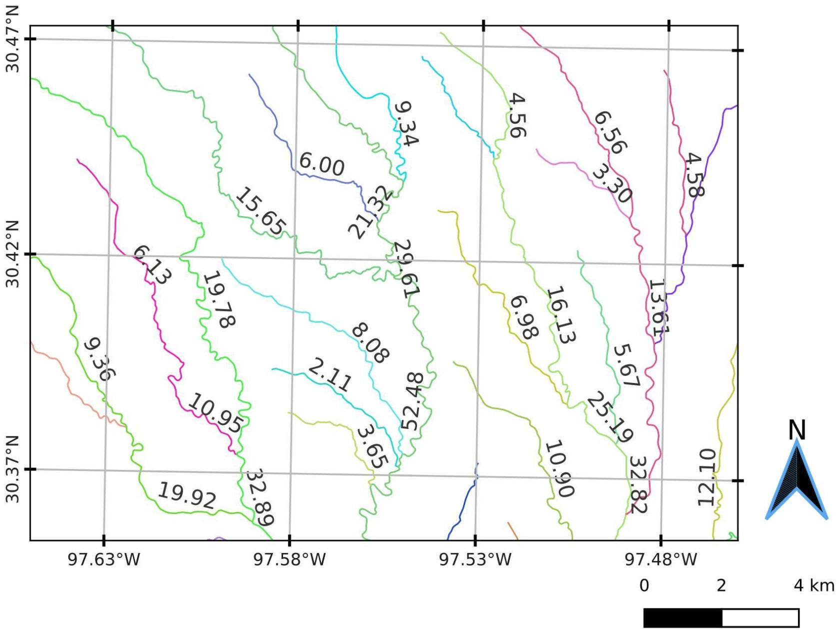


100yr and 500yr Stream Flows at Cross-sections intersected with NWM reaches

HAND Catchment Boundary Limitations

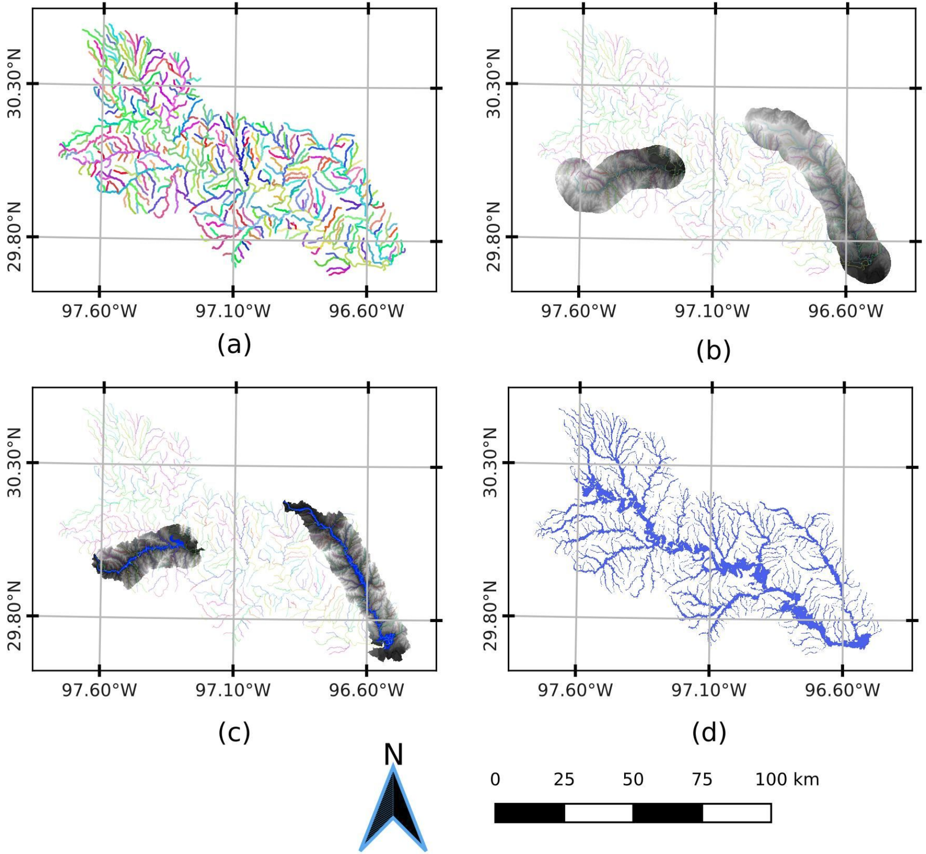


Generalized Mainstems (GMS)

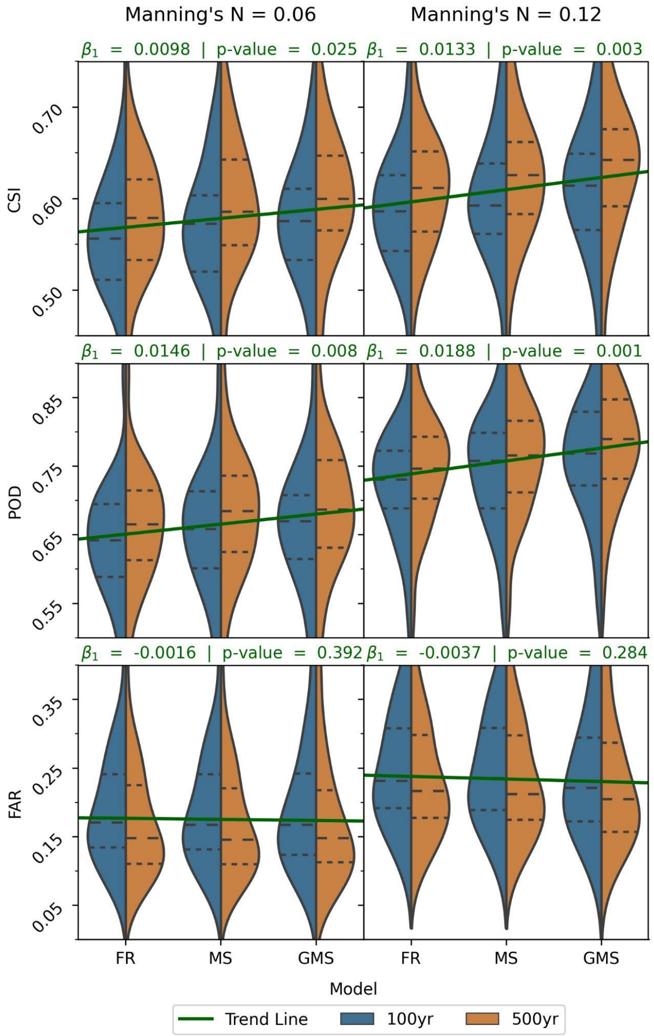


<u>Arbolate Sum</u>

Cumulative Distance of All Upstream Reaches

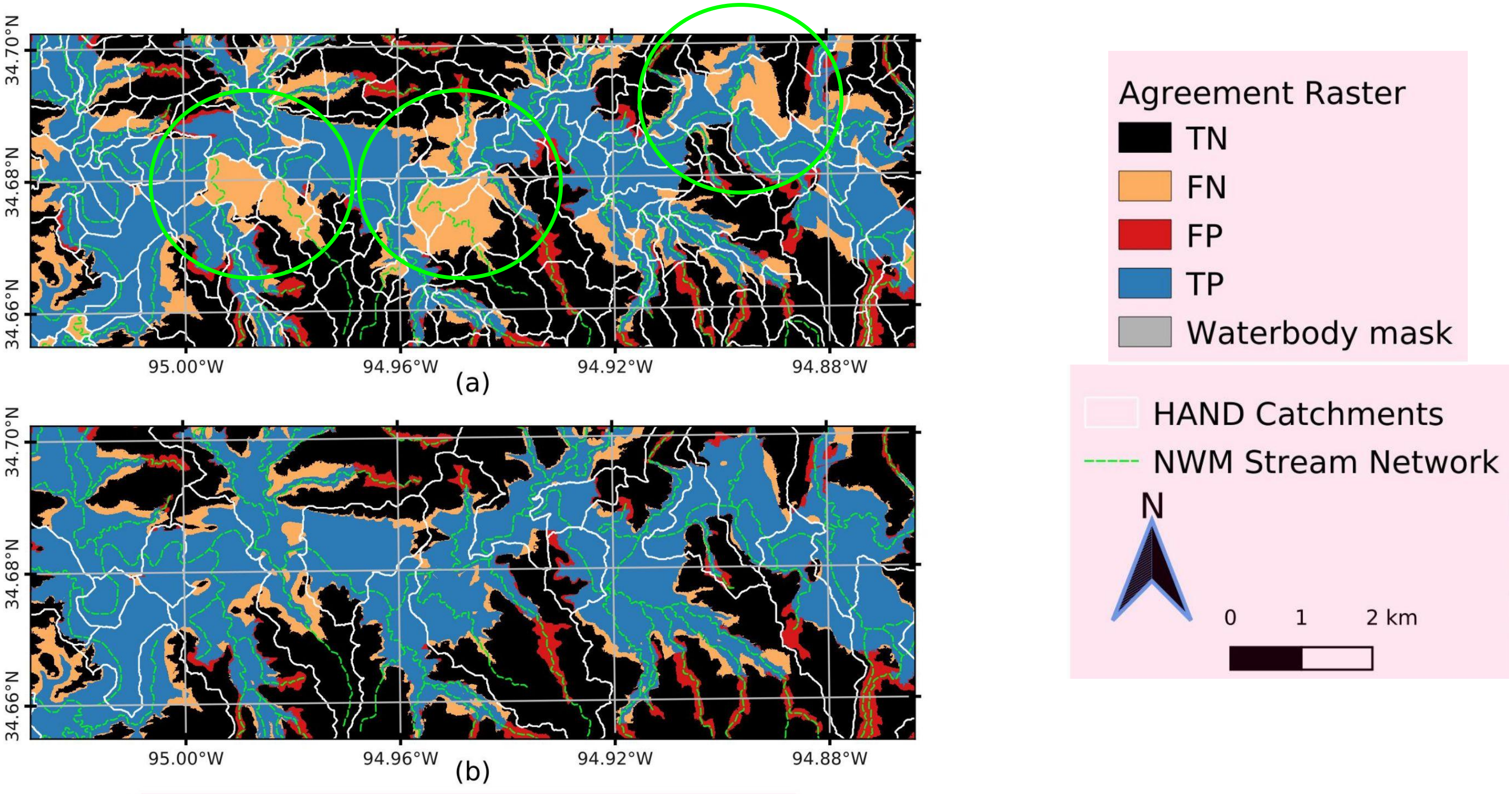


Results

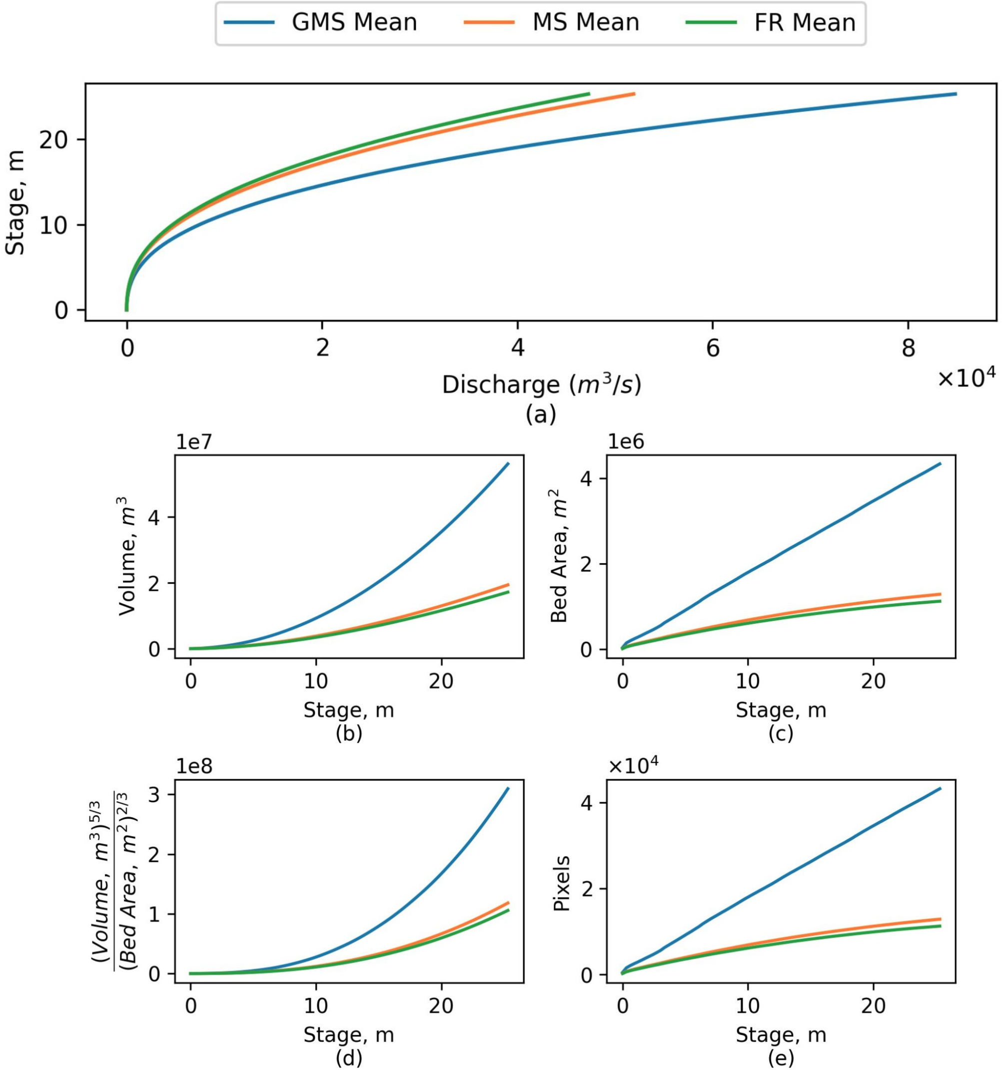


Manning's N = 0.06
Manning's N = 0.12
β1 = 0.0098 | p-value = 0.025
β1 = 0.0133 | p-value = 0.003
β1 = 0.0146 | p-value = 0.008
β1 = 0.0188 | p-value = 0.001
β1 = -0.0016 | p-value = 0.392
β1 = -0.0037 | p-value = 0.284
CSI
POD
FAR
0.70
0.60
0.50
0.85
0.75
0.65
0.55
0.35
0.25
0.15
0.05
FR
MS
GMS
FR
MS
GMS
Model
Trend Line
100yr
500yr

Skill Improvement



Rating Curve Bias



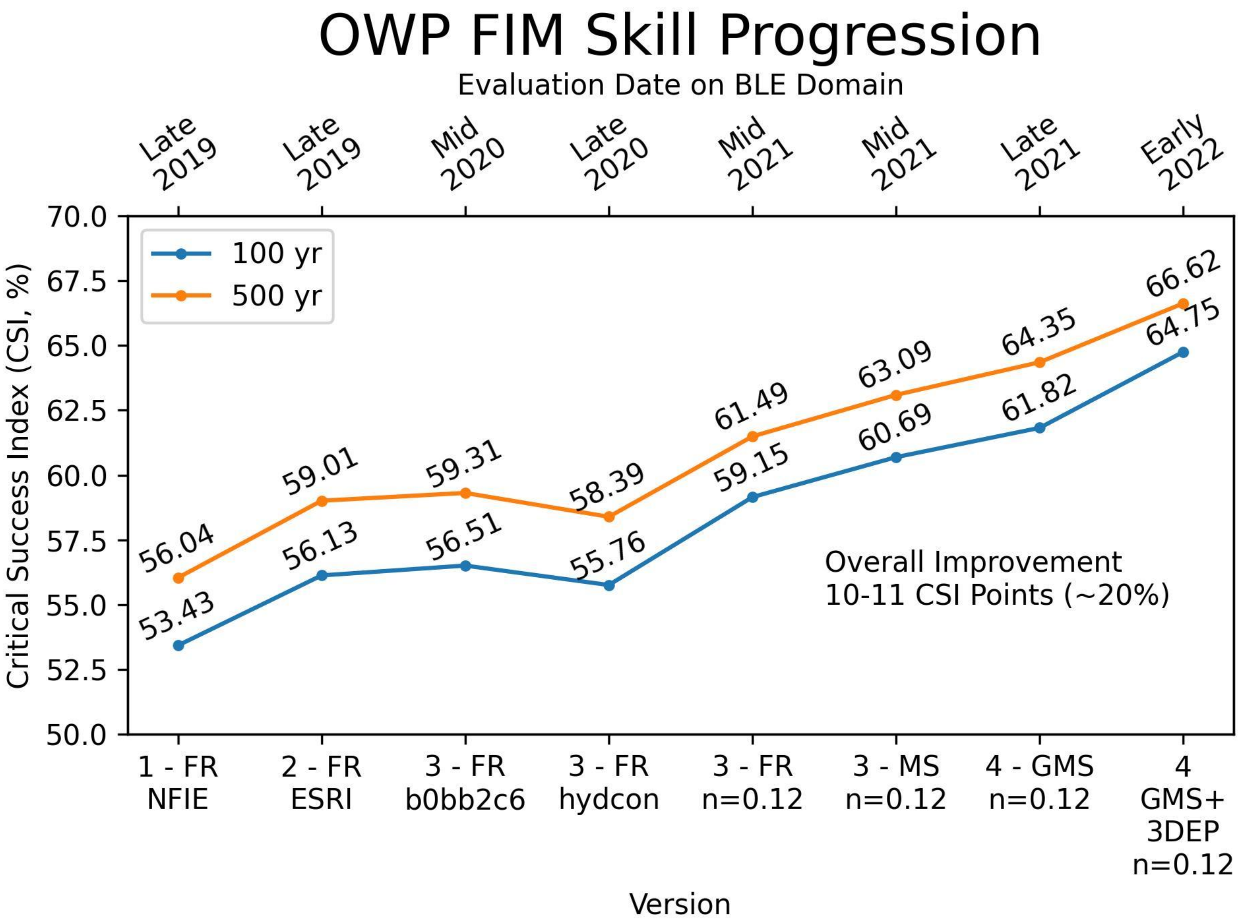
$$\mathbf{Q} = \frac{1}{n}\frac{V^{5/3}S^{1/2}}{LB^{2/3}}$$

AGU Frontiers in Hydrology Meeting Puerto Rico

FIM Skill Comparison for NHDPlusHR DEM and 3DEP DEM @ 10m Resolution

Tentative Results

	CSI				POD				FAR			
	n=0.06		n=0.12		n=0.06		n=0.12		n=0.06		n=0.12	
	NHD	3DEP	NHD	3DEP	NHD	3DEP	NHD	3DEP	NHD	3DEP	NHD	3DEP
100 yr	57.96	**62.55**	61.82	**64.75**	66.33	**71.30**	74.61	**80.00**	17.87	**16.40**	23.51	**22.74**
500 yr	60.75	**64.65**	64.35	**66.62**	68.63	**72.85**	68.63	**81.16**	15.89	**14.82**	21.48	**21.19**


OWP FIM Skill Progression
Evaluation Date on BLE Domain
Late 2019
Late 2019
Mid 2020
Late 2020
Mid 2021
Mid 2021
Late 2021
Early 2022
Critical Success Index (CSI, %)
70.0
67.5
65.0
62.5
60.0
57.5
55.0
52.5
50.0
100 yr
500 yr
56.04
59.01
59.31
58.39
61.49
63.09
64.35
66.62
53.43
56.13
56.51
55.76
59.15
60.69
61.82
64.75
Overall Improvement
10-11 CSI Points (~20%)
1 - FR NFIE
2 - FR ESRI
3 - FR b0bb2c6
3 - FR hydcon
3 - FR n=0.12
3 - MS n=0.12
4 - GMS n=0.12
4 GMS+ 3DEP n=0.12
Version

Conclusions

- HAND suffers from small catchment boundaries introduced by tributaries that constrict extents and bias rating curves.
- Reducing the scale of HAND computation to stream networks of reduced drainage density and unit Horton-Strahler stream order mitigates these issues by making larger catchments and rating curve corrections.
- MS reduces the scale of HAND computation for 4% of the country, while GMS does the same for the entire country with comparable gains. Hence there is a diminishing returns effect for drainage order methods.
- Updating to the latest 3DEP dataset resampled to 10m spatial resolution improves FIM skill.

More Resources

ESSOAr

Earth and Space Science Open Archive

Reducing Horton-Strahler Stream Order Can Enhance Flood Inundation Mapping Skill with Applications for the U.S. National Water Model

GitHub

NOAA-OWP/inundation-mapping

@Fernando-Aristizabal

Questions