

Assimilation of High Resolution Elevation Data For Continental Scale Flood Inundation Mapping Derived from Height Above Nearest Drainage

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November 22, 2022

Abstract

The National Water Model (NWM) currently requires the post-processing of forecast discharges to produce forecast flood inundation maps (FIM) that support the National Weather Service's mission of protecting life and property. Height Above Nearest Drainage (HAND) is a means of detrending digital elevation models (DEM) by normalizing elevations to the nearest, relevant drainage line (creeks, rivers, etc). It's worthy of producing high-resolution FIMs at large spatial scales and frequent time steps using reach-averaged synthetic rating curves. Current operational capabilities support 10 meter (1/3 arc-second) spatial resolution DEMs sourced from the National Elevation Dataset (NED). The 3D Elevation Program (3DEP) managed by the United States Geological Survey (USGS) publishes a variety of gridded elevation datasets at 1 m, 3 m (1/3 arc-second), 5 m, and 10 m (1/9 arc-second) among others. While the 1/3 arc-second product provides seamless coverage across CONUS, the remaining products lack full spatial support with respect to that of the NWM. However, 3DEP is actively publishing additional data with national coverage scheduled for 2023. We seek to investigate the efficacy of assimilating higher resolution 1 m and 3 m (1/3 arc-second) data derived from light detection and ranging sensors (Lidar). These Lidar derived datasets not only represent higher horizontal resolution but also have improved vertical accuracy when compared to the NED. We seek to utilize Py3DEP from the HyRiver ecosystem of tools to retrieve 3DEP data. HAND derived FIMs will be evaluated against high-fidelity HEC-RAS 1D inundation maps for 100 year and 500 year events. Possible skill enhancements can be observed from having terrain information that better agrees with those of the benchmark HEC-RAS datasets. Lidar terrain data can better resolve fine scale features that flood inundation extents may be very sensitive to. Additionally, we would investigate mosaicing techniques to deal with processing units (hydrologic unit codes) of heterogeneous data availability. This can involve resampling DEM's to create seamless rasters within units. Lastly, we can investigate the effect of Lidar data on synthetic rating curves as well as consider the latest hydro-conditioning techniques from GeoFlood for stream line delineation on Lidar data.



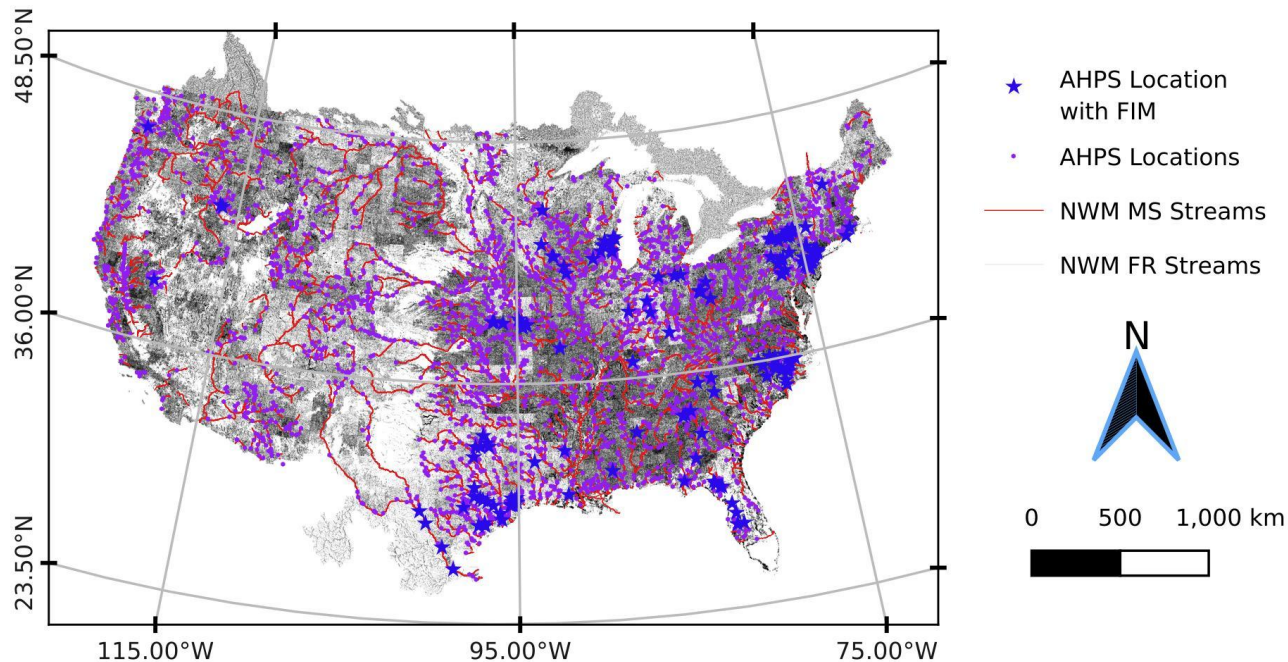
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National Water Model



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

Height Above Nearest Drainage (HAND) Method

Digital Elevation Model (DEM)

80.1	80.2	80.3	82.1	82.1
80.1	80	80	80.5	82.1
81.2	80.8	79	78.6	79.5
82.1	79.3	78.3	78	76.2
82.1	80.5	79.2	76.1	76

- Height Above Global Datum -

Relative Elevation Model (REM)

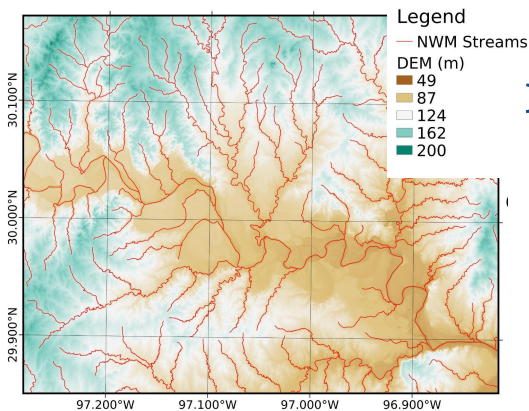
0.1	0.2	0.3	2.1	2.1
0.1	0	0	0.5	2.1
1.2	0.8	0	0.6	1.5
2.1	1.3	0.3	0	0.2
4.1	1.5	1.2	0.1	0

- Height Above Local Channel
(i.e. nearest drainage) -

Geospatial

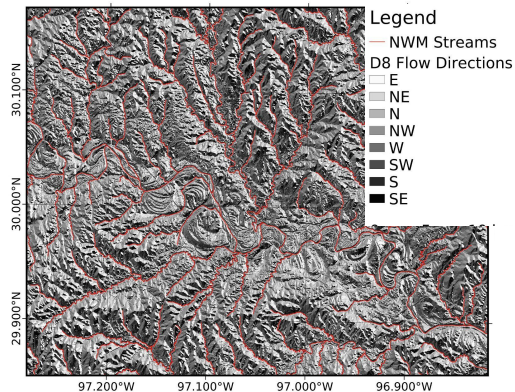
Processing

Height Above Nearest Drainage + Synthetic Rating Curves

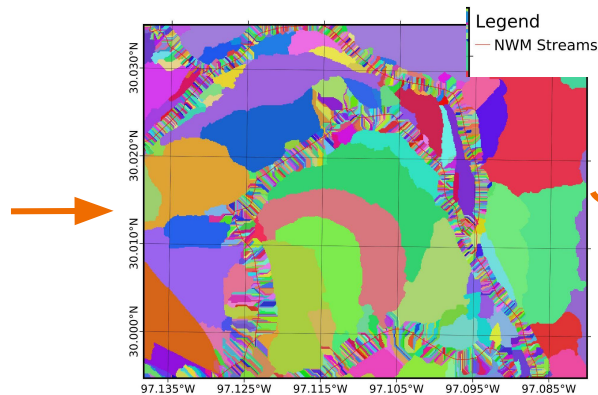


DEM

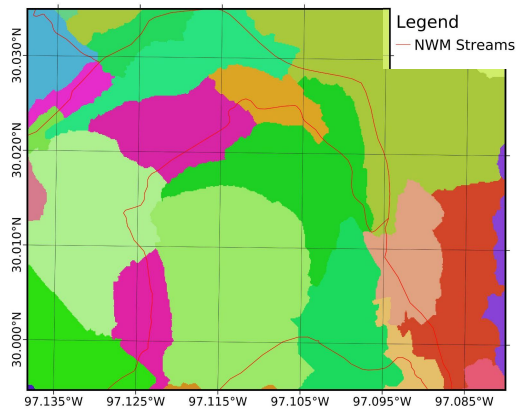
Hydro-Con
ditioning



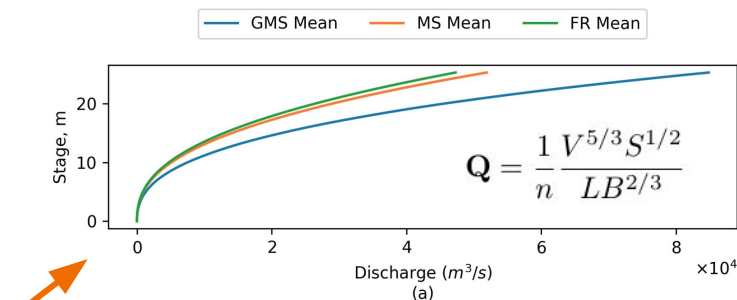
D8 Flow Directions



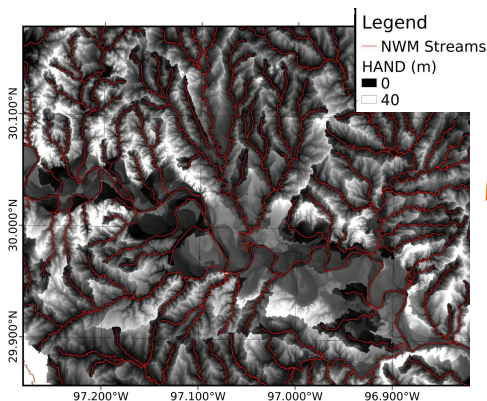
Stream Pixel Catchments



Reach Catchments



SRCs



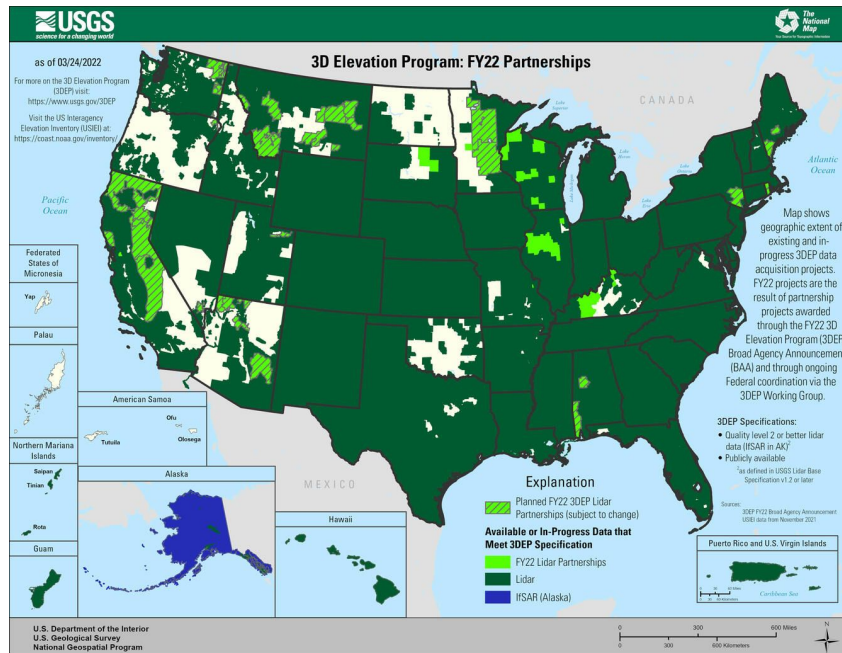
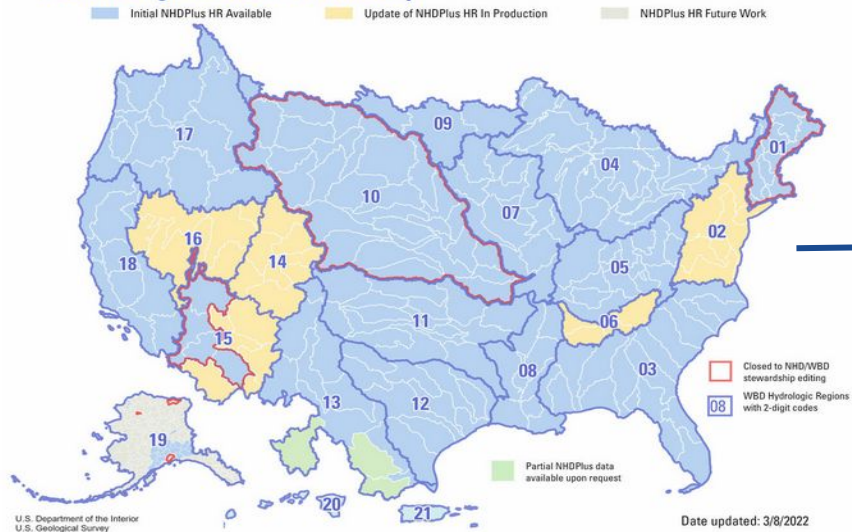
HAND

DEM Data Sources

NHDPlusHR vs 3DEP



NHDPlus High Resolution Availability



DEM Mosaicing and Retrieval

noaa-owp/inundation-mapping

- Acquire_and_preprocess_inputs.py
- User defined list of HUC4's and block size
- Acquires 3DEP data in parallel using Dask
- Mosaics blocks to VRT

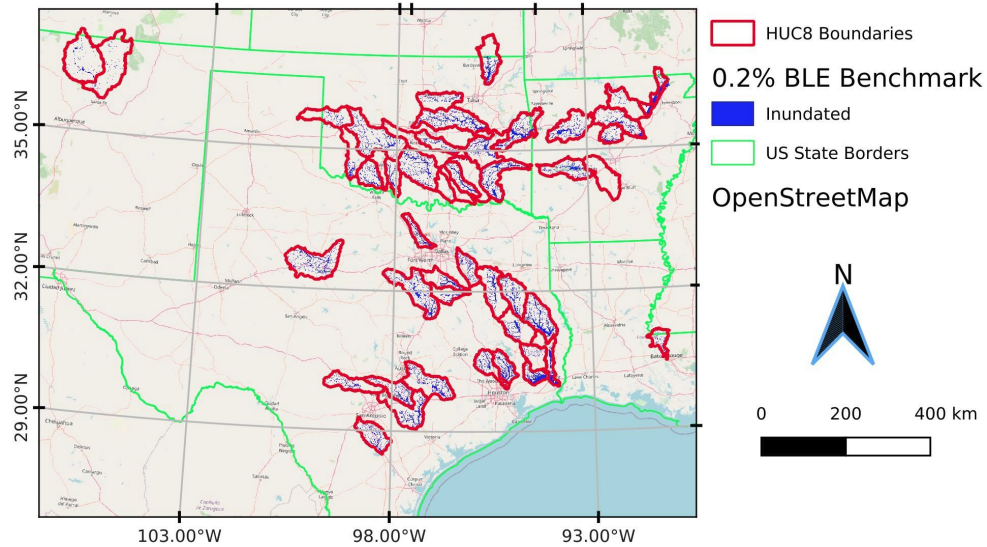
Py3DEP

Python API returning xarray

3DEPElevation (ImageServer)

- Querying
- Mosaicing
- Resampling
- Sources:
1,3,5,10,30m

Study Domain

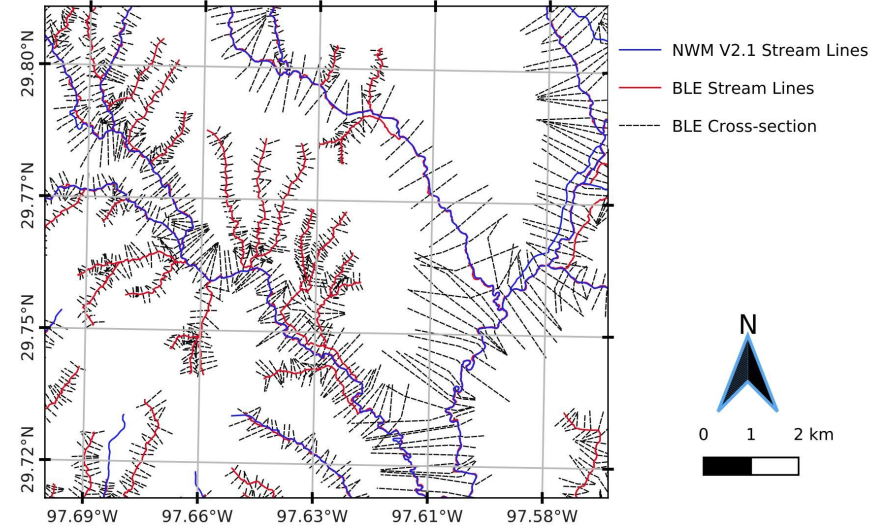


Source

Base Level
Engineering
(BLE)

Entity

FEMA Region 6



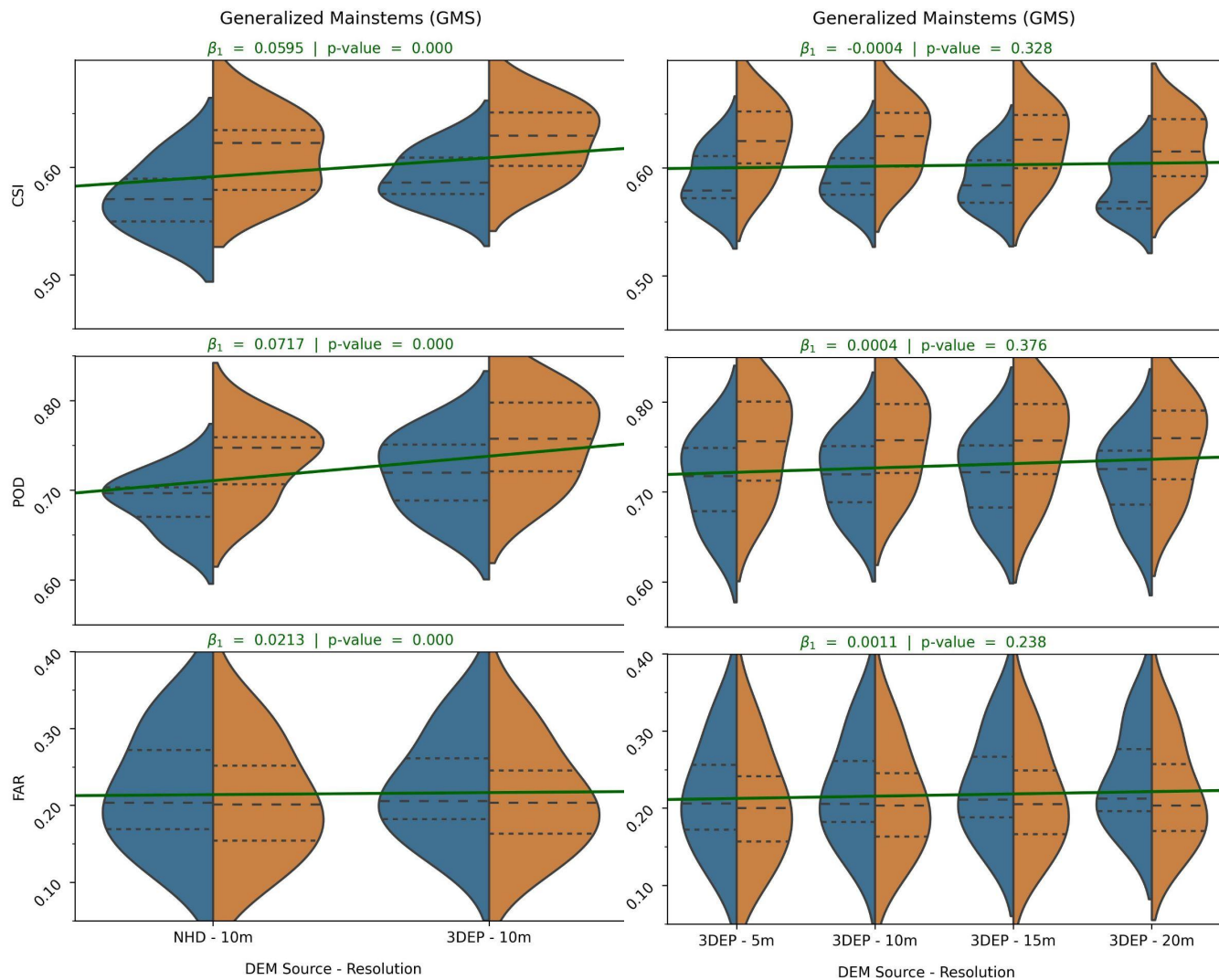
Model

HEC-RAS 1D

Magnitudes

100yr (1%)
500yr (0.2%)

Results



Conclusions

- Utilization of 3DEP DEM at 10m resolution likely improves FIM skill when compared to NHDPlusHR DEM
 - This is most likely due to the more rapid integration within 3DEP of enhanced vertical accuracy data from Lidar derived sources.
- Varying DEM resolution shows no clear relationship with FIM skill thus no current evidence to change resolution.

Future Work

- Evaluate regions by source availability
- Expand evaluations to more regions with more 1m Lidar availability
- Explore finer scale evaluations
 - Effects of higher spatial resolutions maybe more evident at more local scales



More Resources



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



Partners

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