THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Leveraging HEC-RAS Data to Resolve Channel Bathymetry for Flood Modeling

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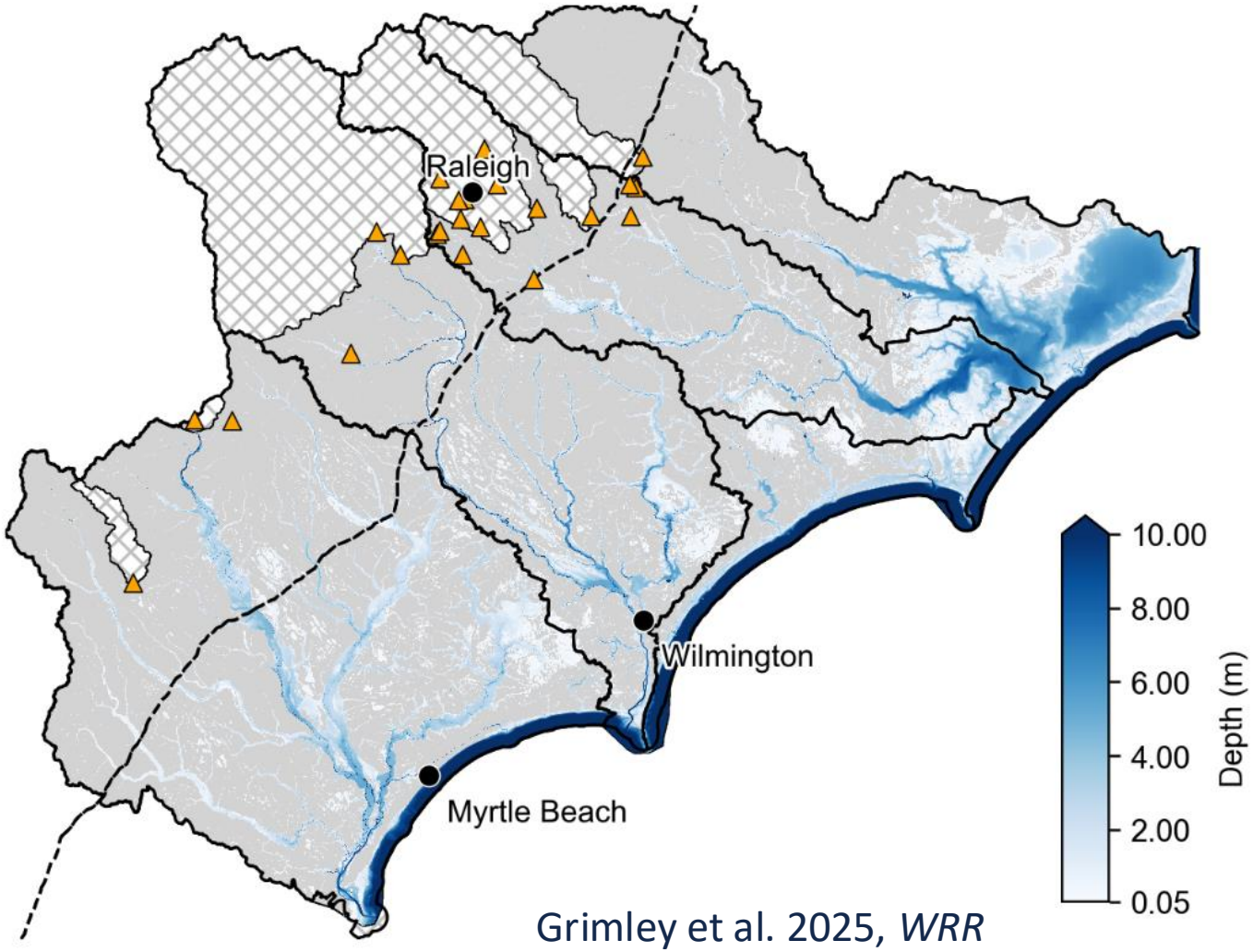
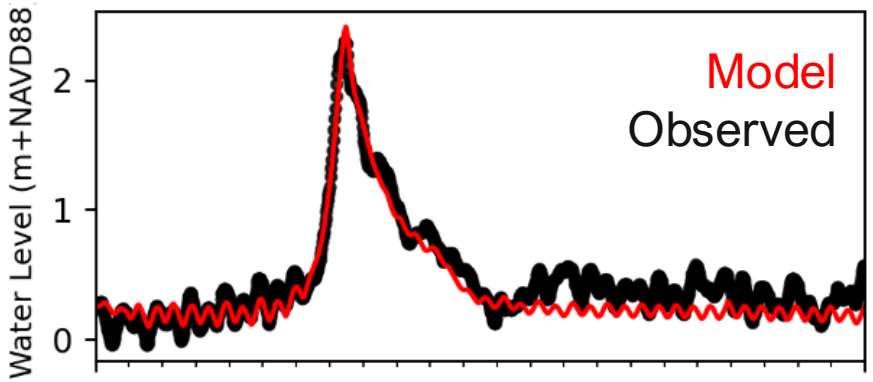
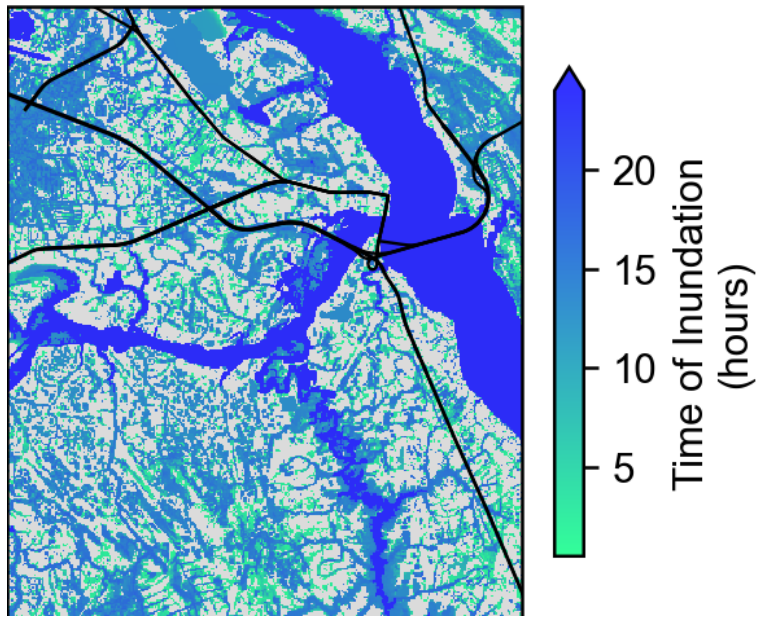
UNC COLLEGE OF ARTS AND SCIENCES
Earth, Marine and Environmental Sciences

A primary goal for flood modelers is to create a model that gives reasonable predictions of inundation.



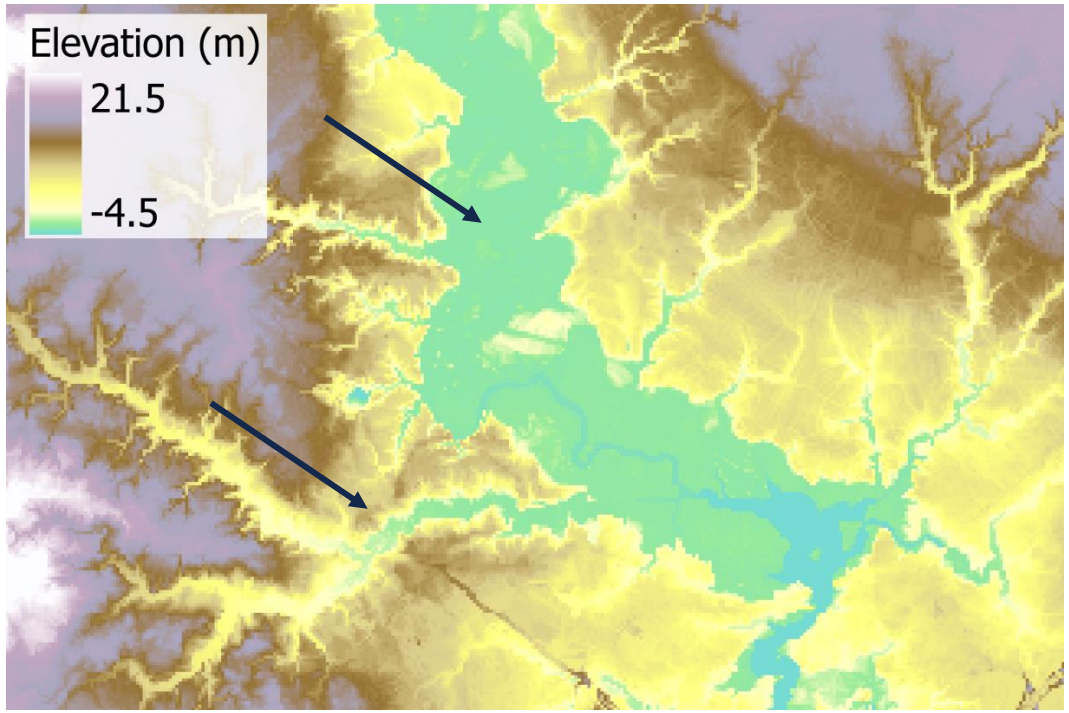
Grimley et al. 2025, *WRR*





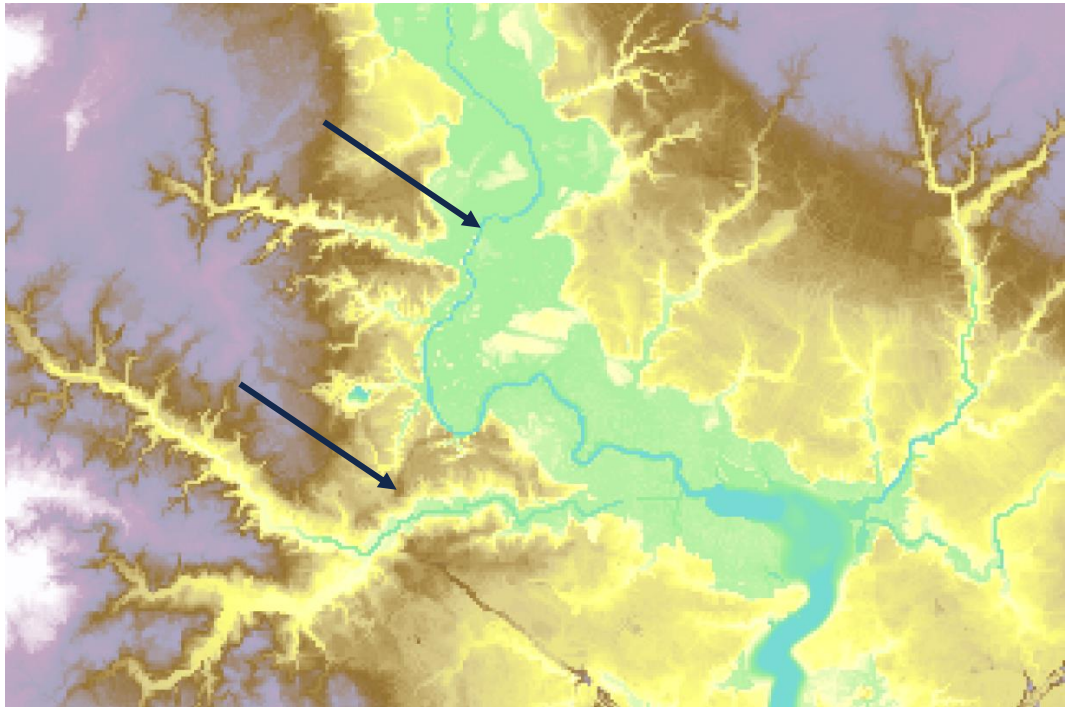
Resolving channels in riverine and coastal flood models is a small part of the entire process, but it is an important one.

What we have:



vs.

What we want:



My dissertation research focused on characterizing the role of compound processes on tropical cyclone flood hazards.

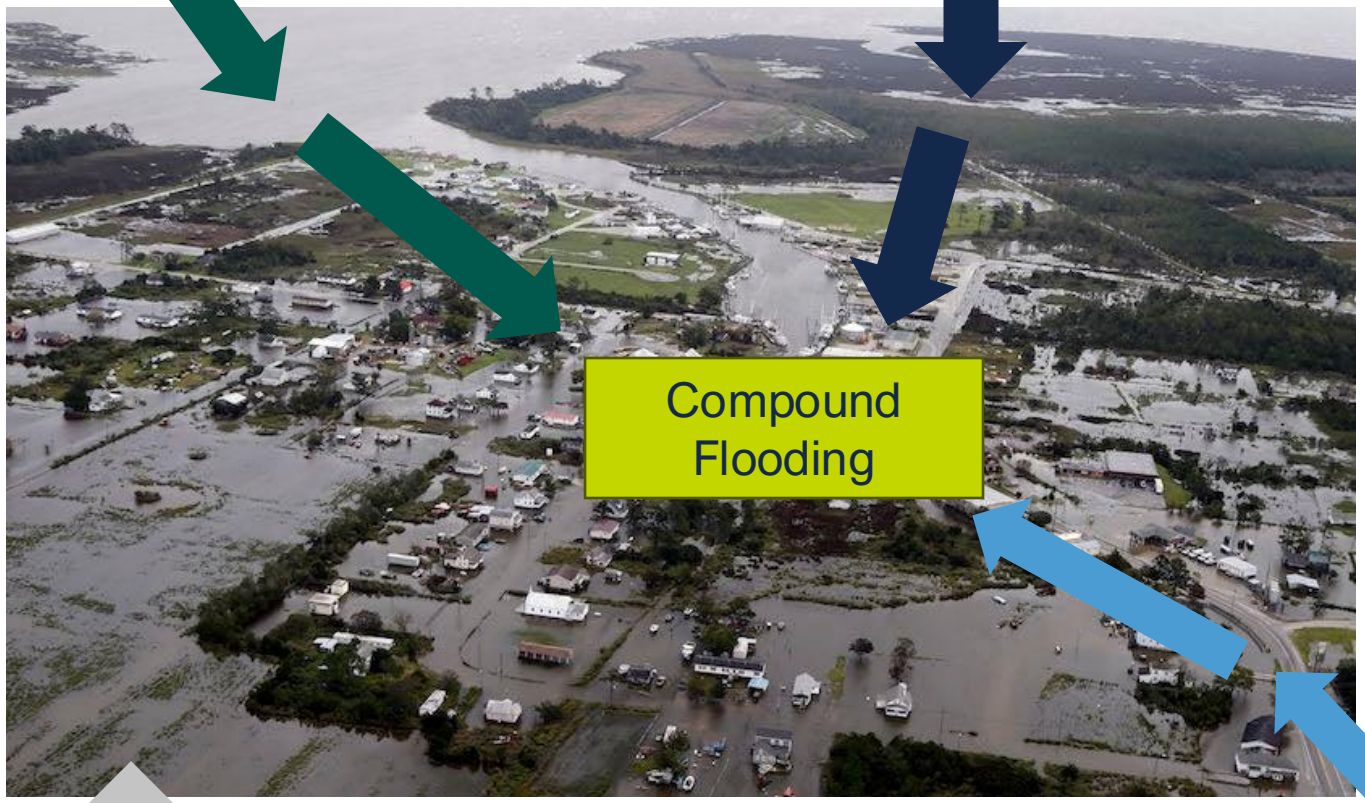


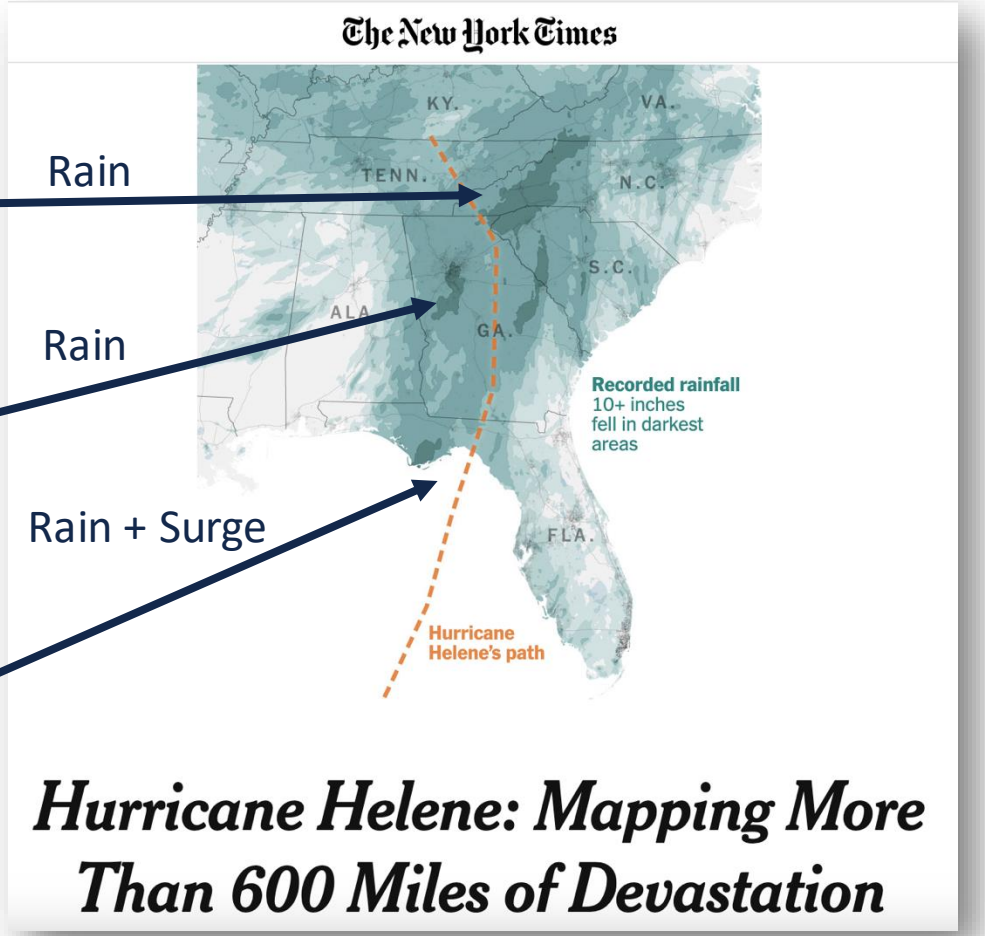
Photo: AP Photo/Steve Helber

Tropical cyclones have generated record levels of flooding. However, assessing the full impact of TCs is challenging because of their size.

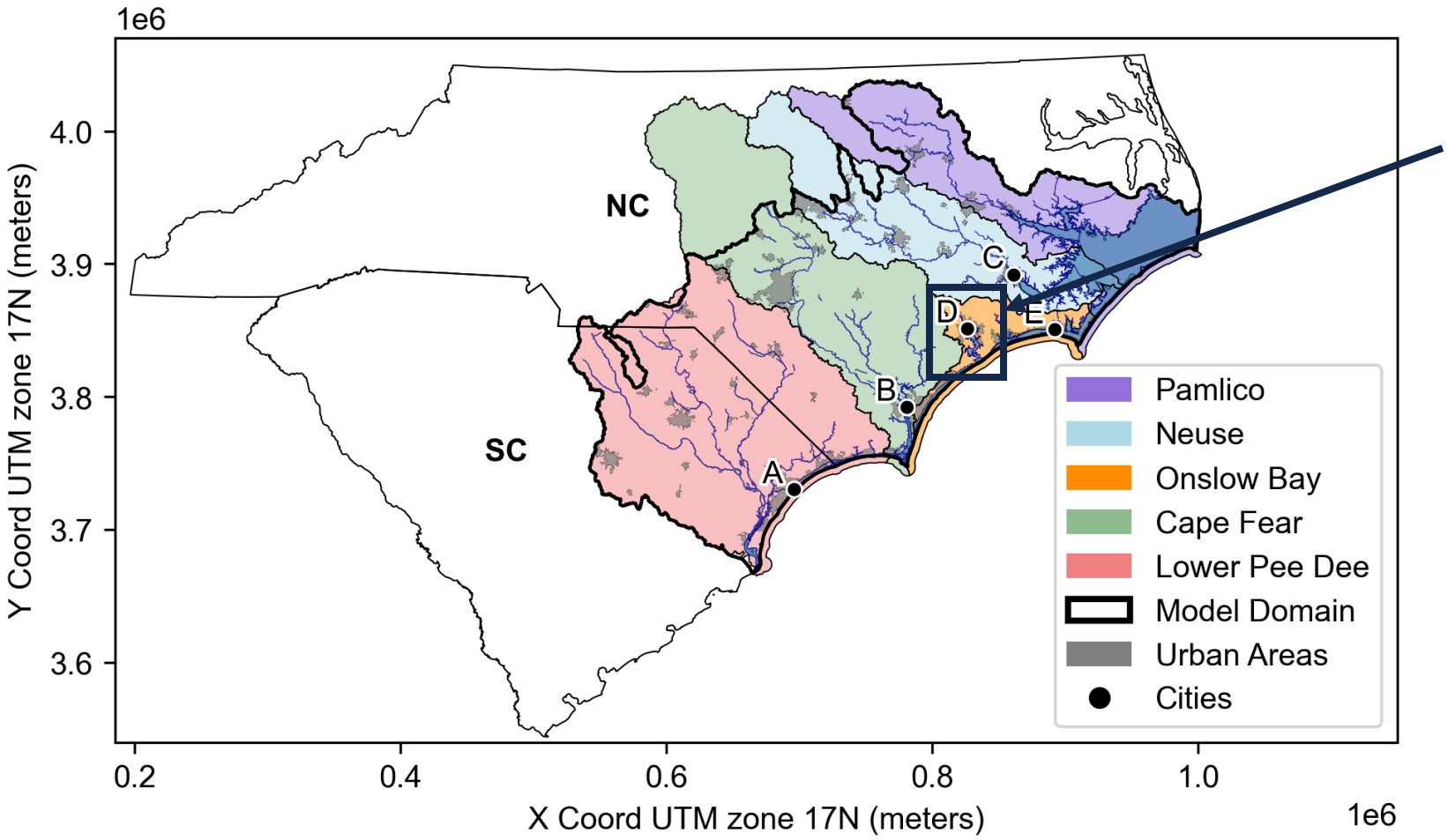
Rain

Rain

Rain + Surge

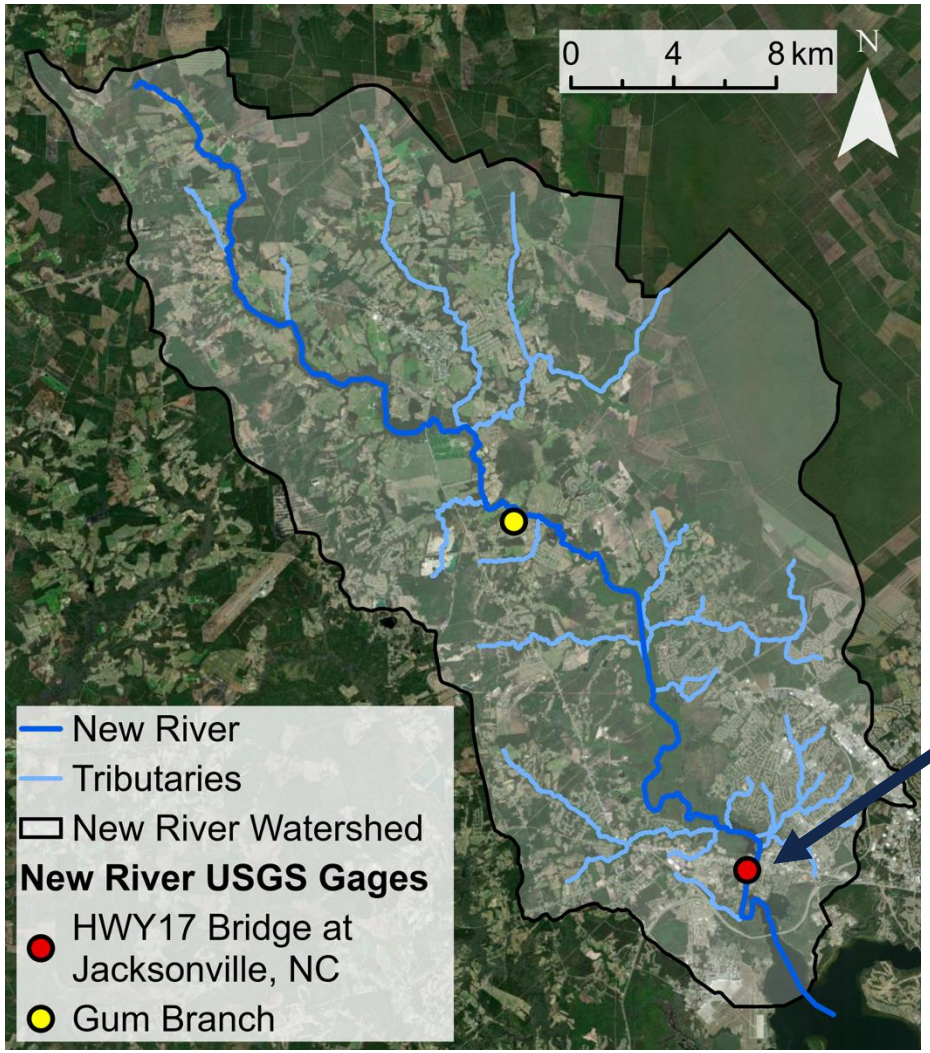


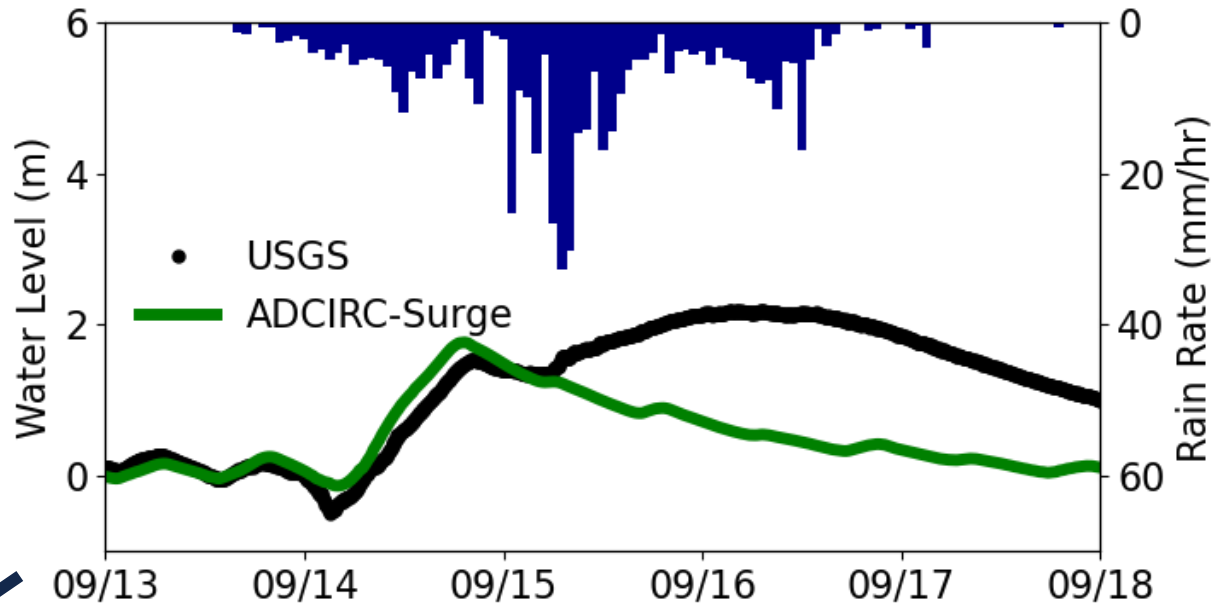
Presentation Outline



1. New River watershed
2. Multiple watersheds
3. Next steps

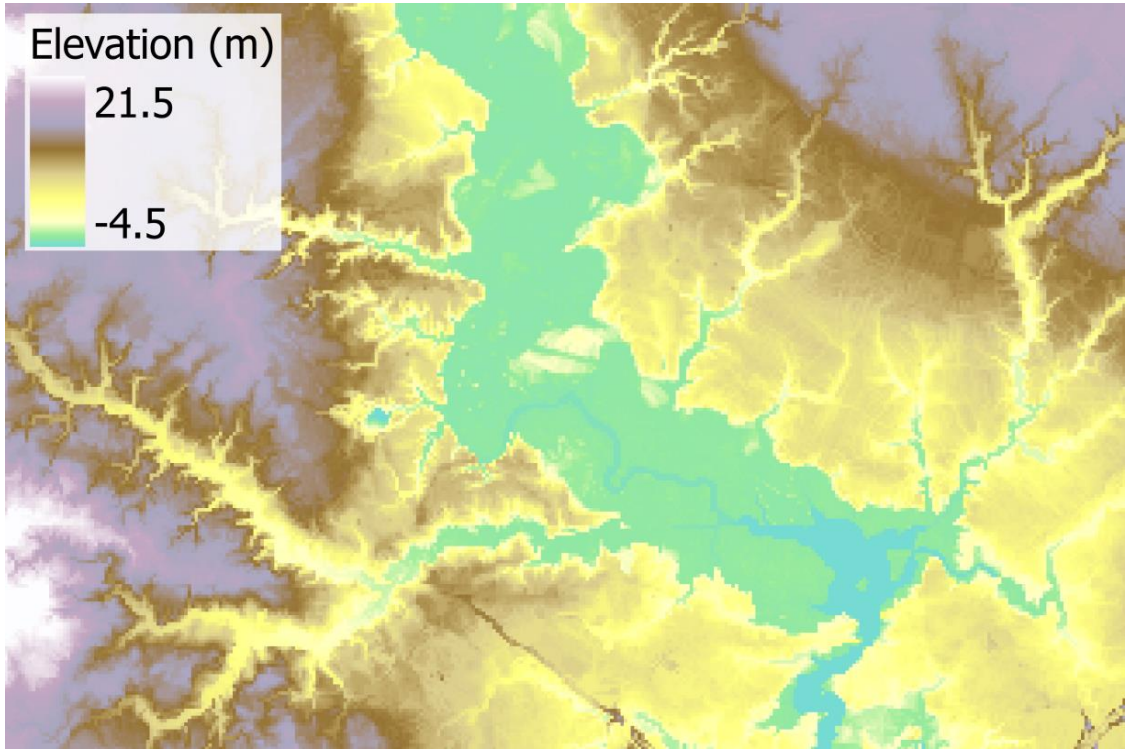
Runoff and coastal processes combined to exacerbate total water levels in the New River Watershed during Hurricane Florence (2018).





How do we use existing models and data to improve compound flood predictions?

We used nationally available elevation datasets to construct an inundation model (LISFLOOD-FP) to simulate compound flooding with modeled storm surge (ADCIRC) as the downstream boundary condition.



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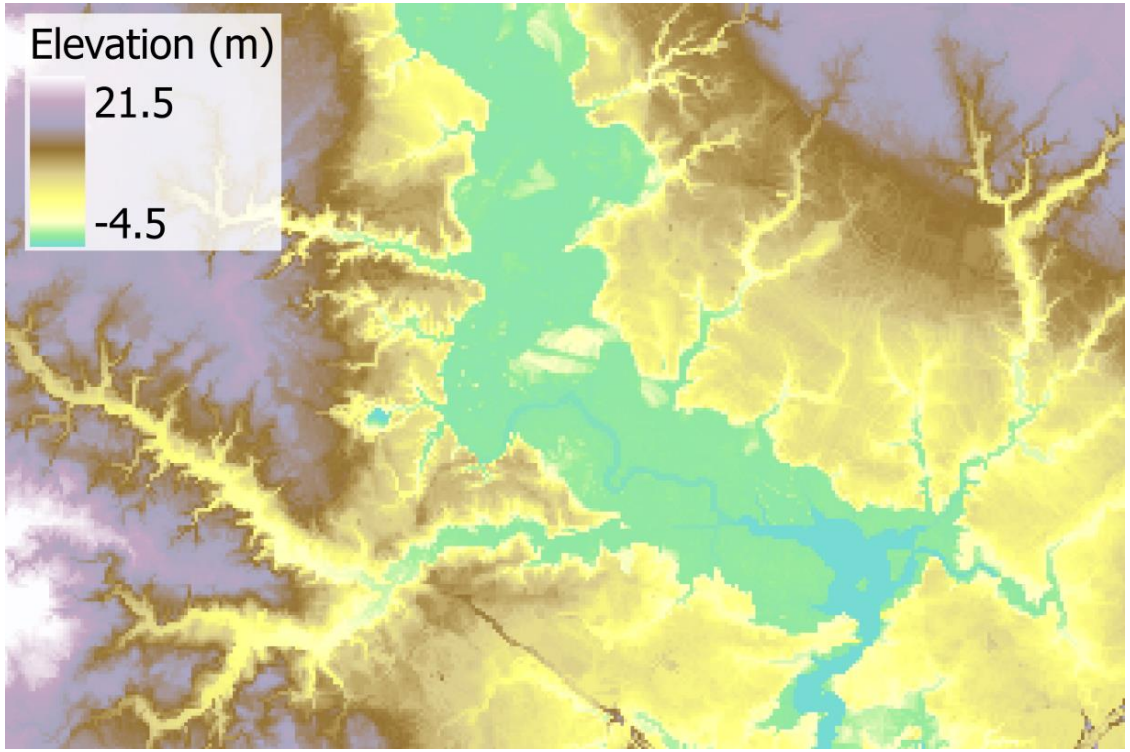
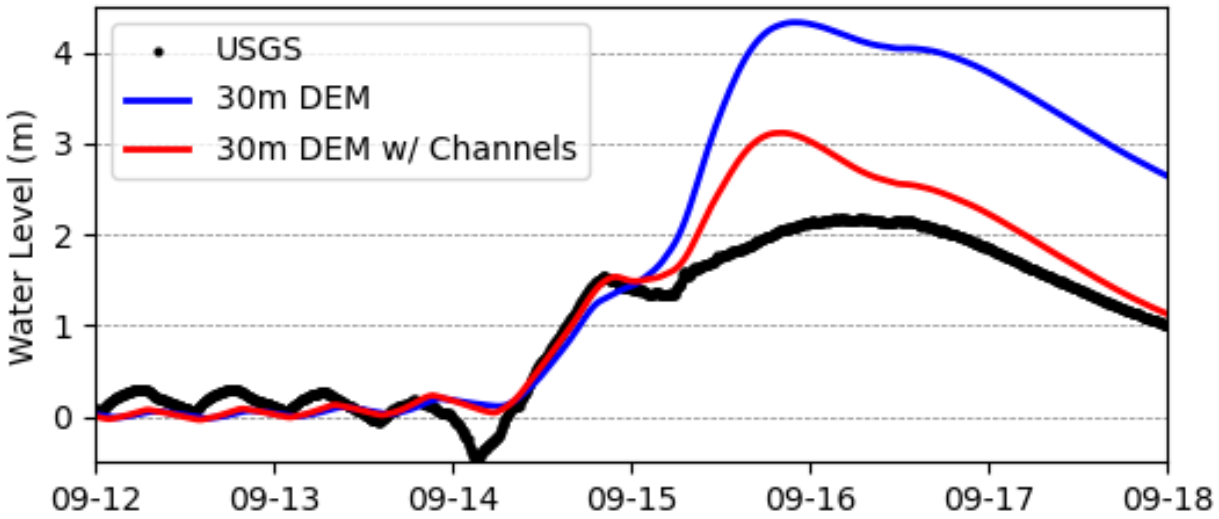
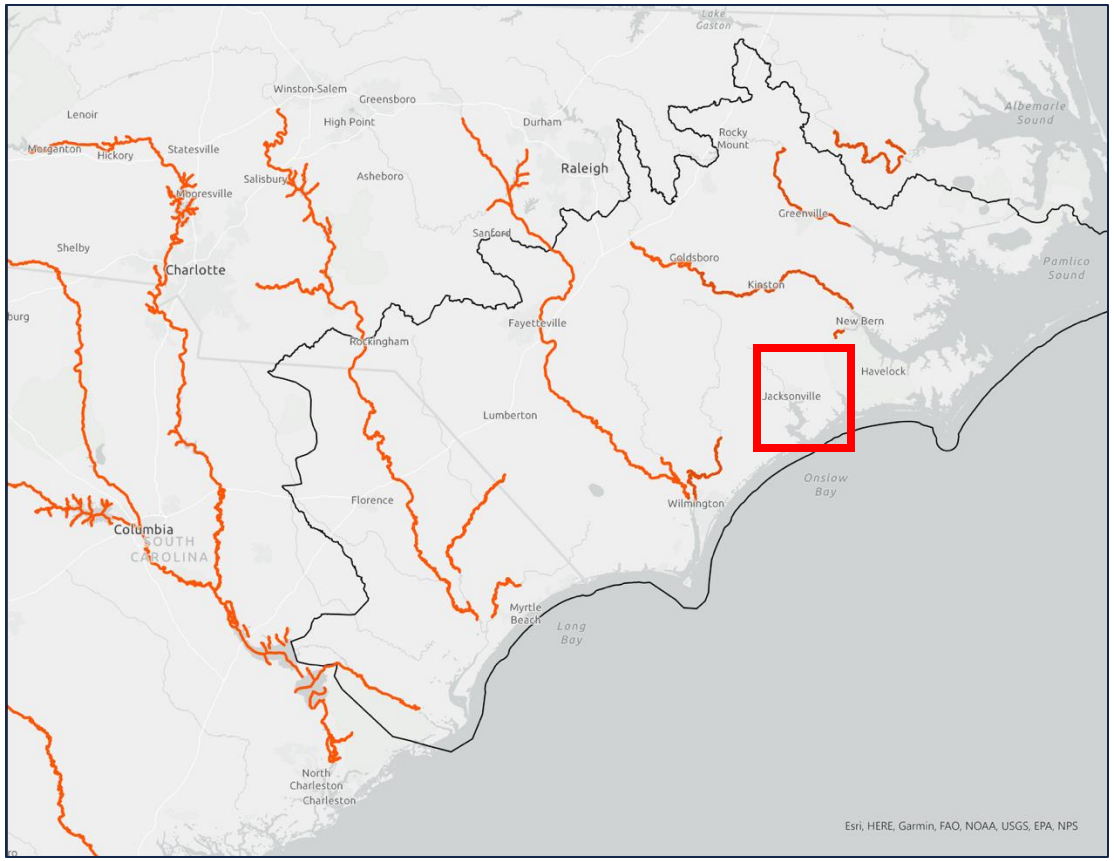




To define the river network in the inundation model, we needed basic channel shape information (i.e., width, depth).



Remote sensing-based channel width dataset do not capture the river network in our study area (e.g., NARWidth, Merit-Hydro)

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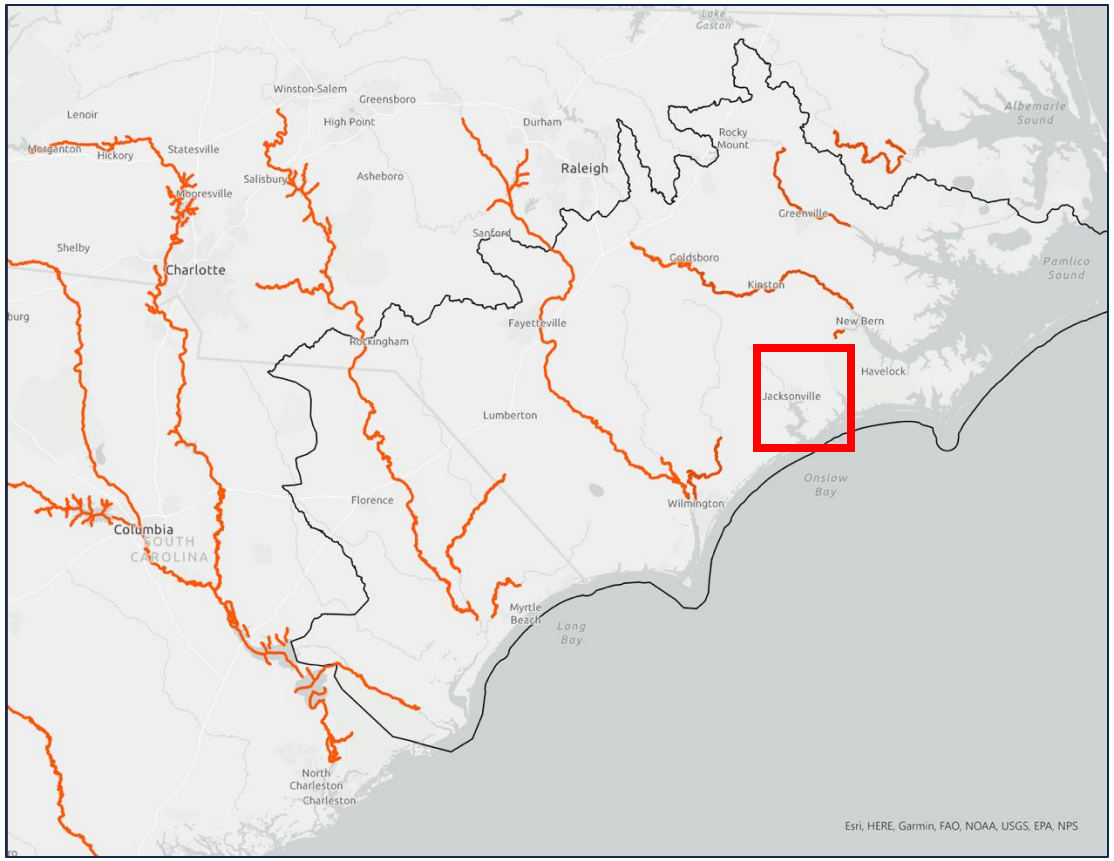

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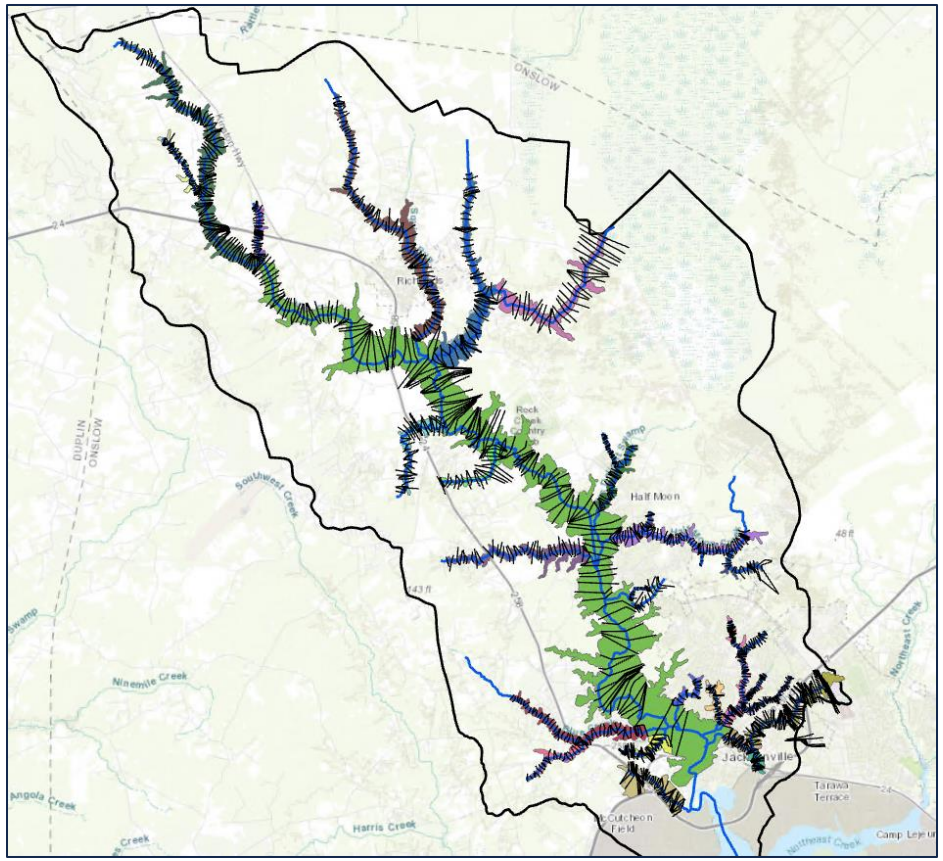
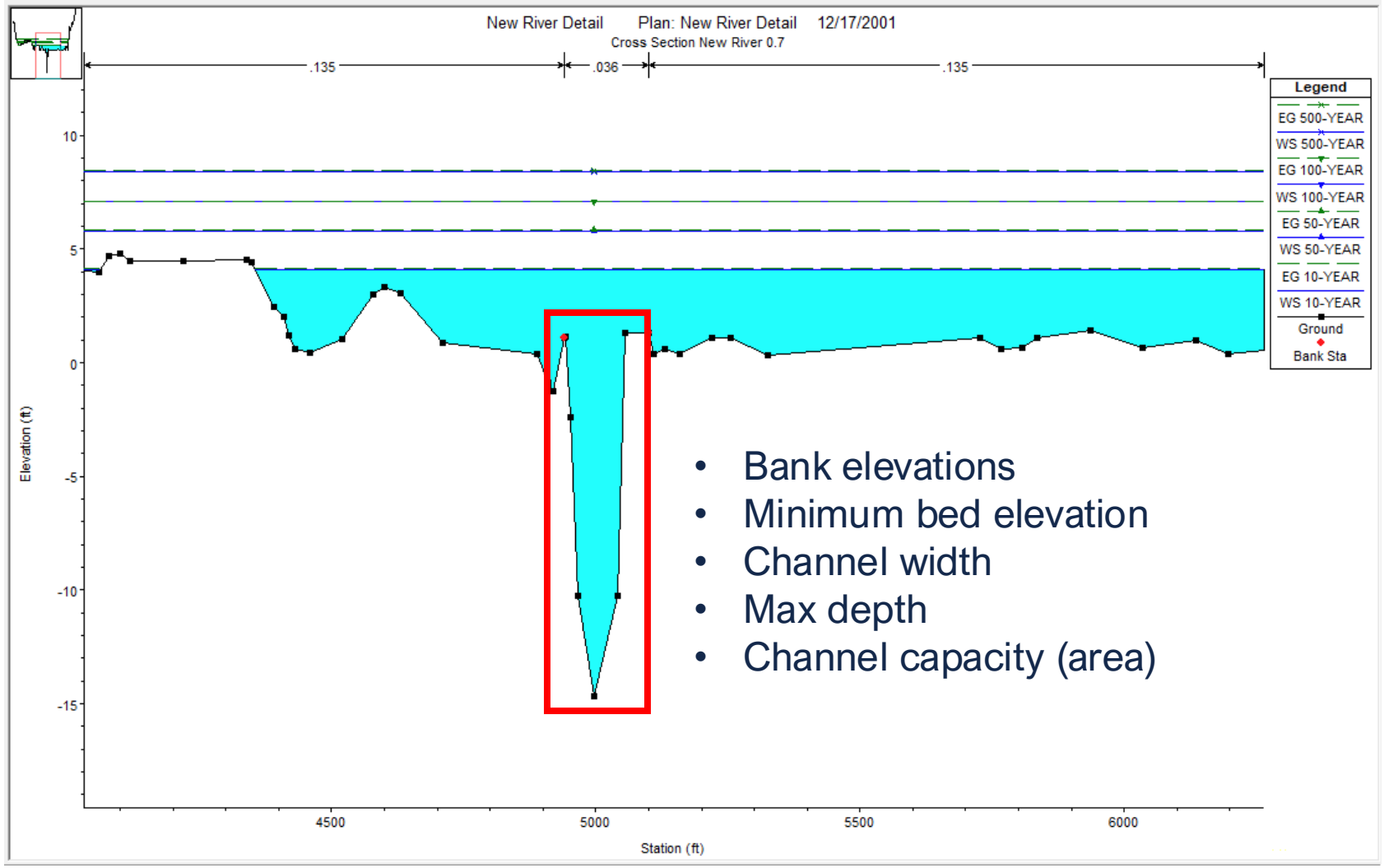
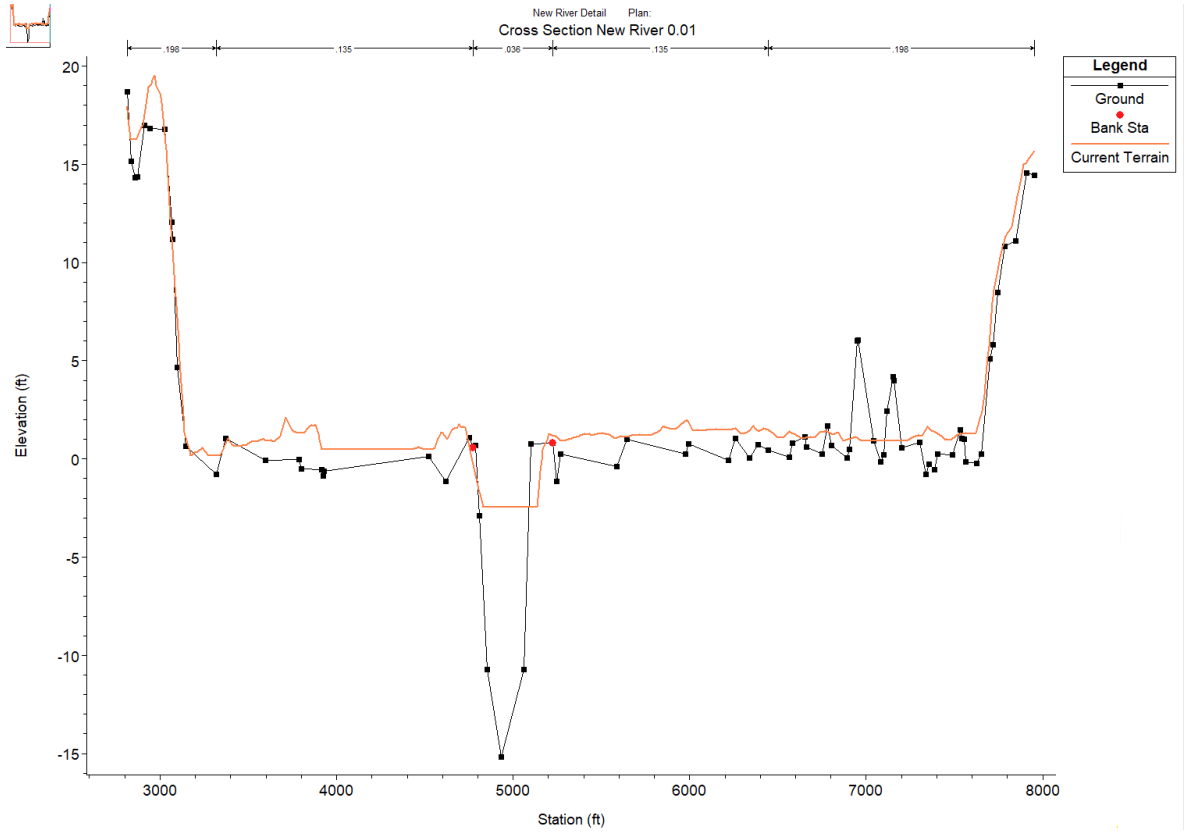


There are over 30 unique HEC-RAS 1D river models used for floodplain mapping in the study area.

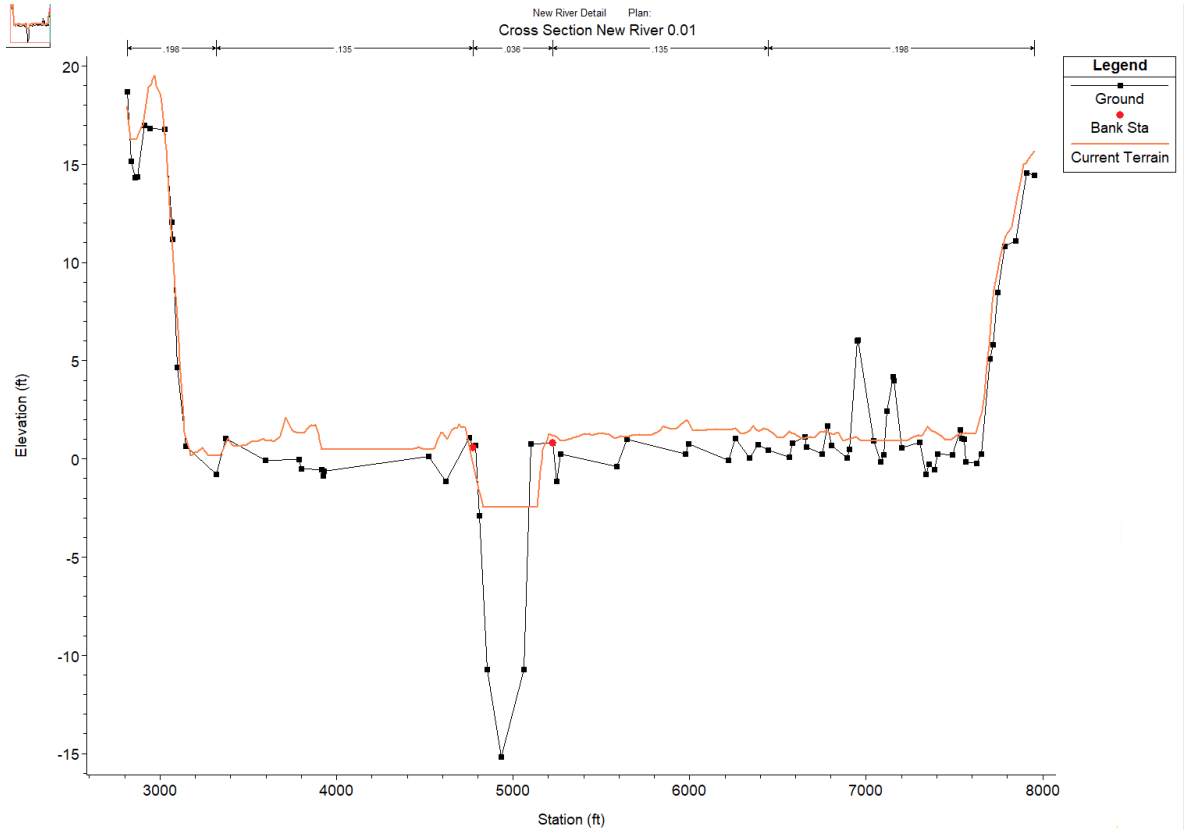
We decided to leverage channel information from HEC-RAS cross-sections which are a combination of field surveys and LiDAR.



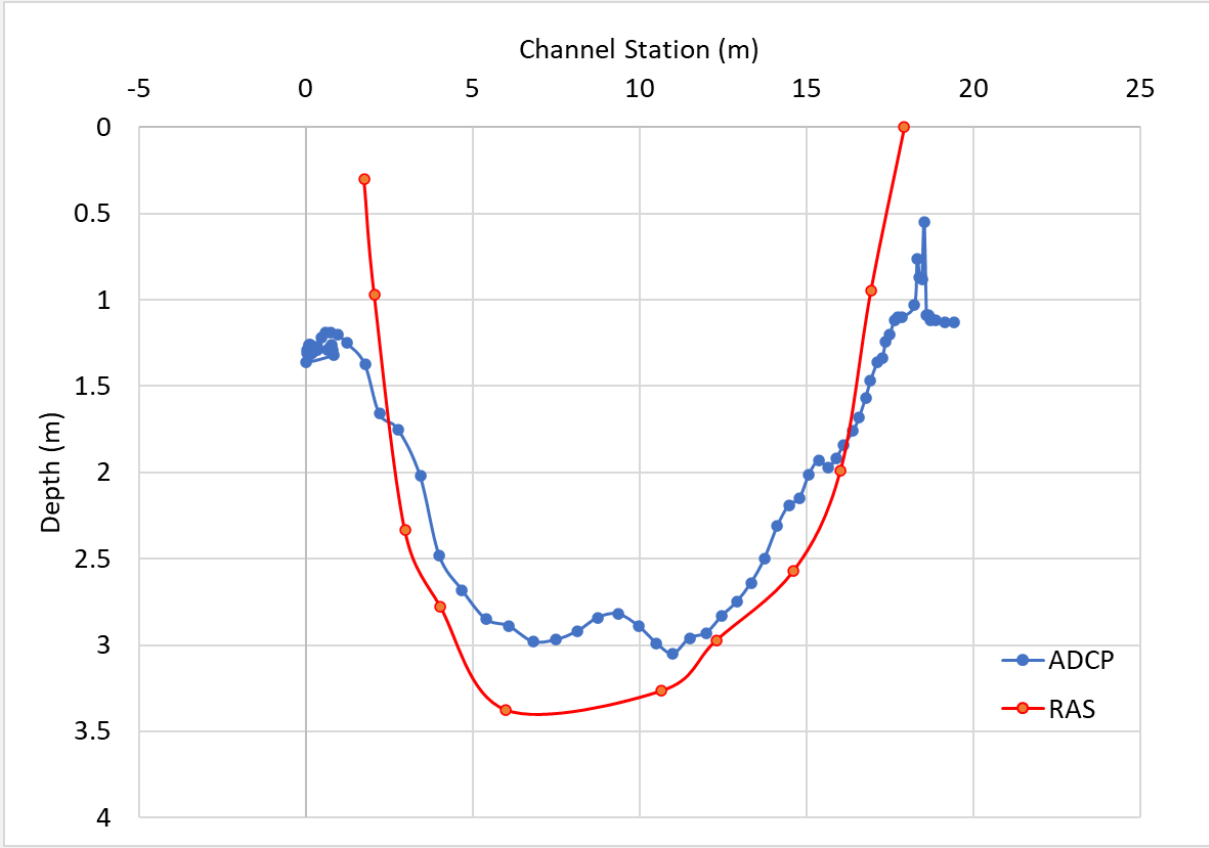
The **RAS data** (black) aligns well with the **2020 LiDAR data** (orange).



The **HEC-RAS data** (black) aligns well with the **2020 LiDAR data** (orange).

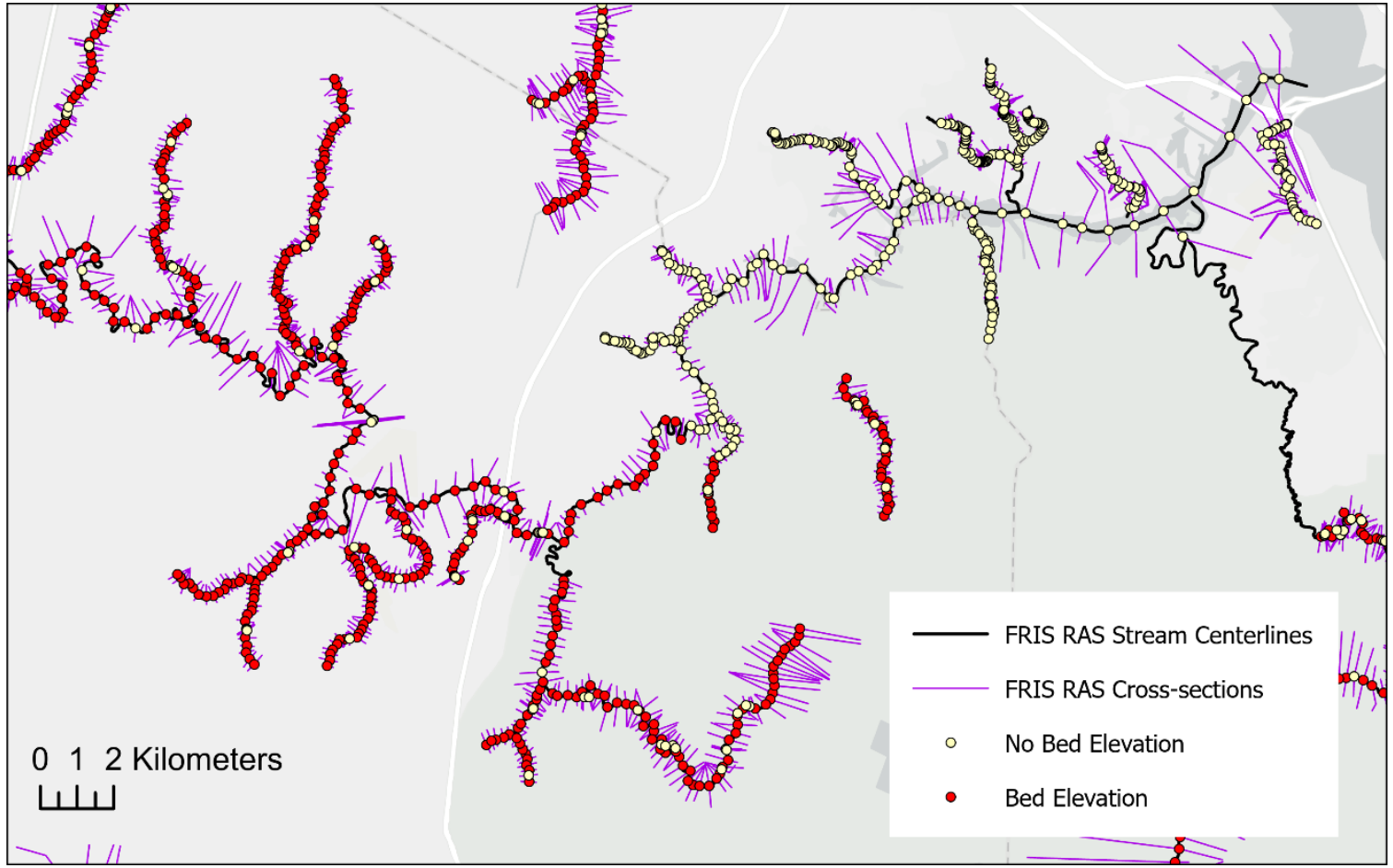


The **HEC-RAS channel** (red) shape and capacity are similar to **ADCP measurements** (blue).



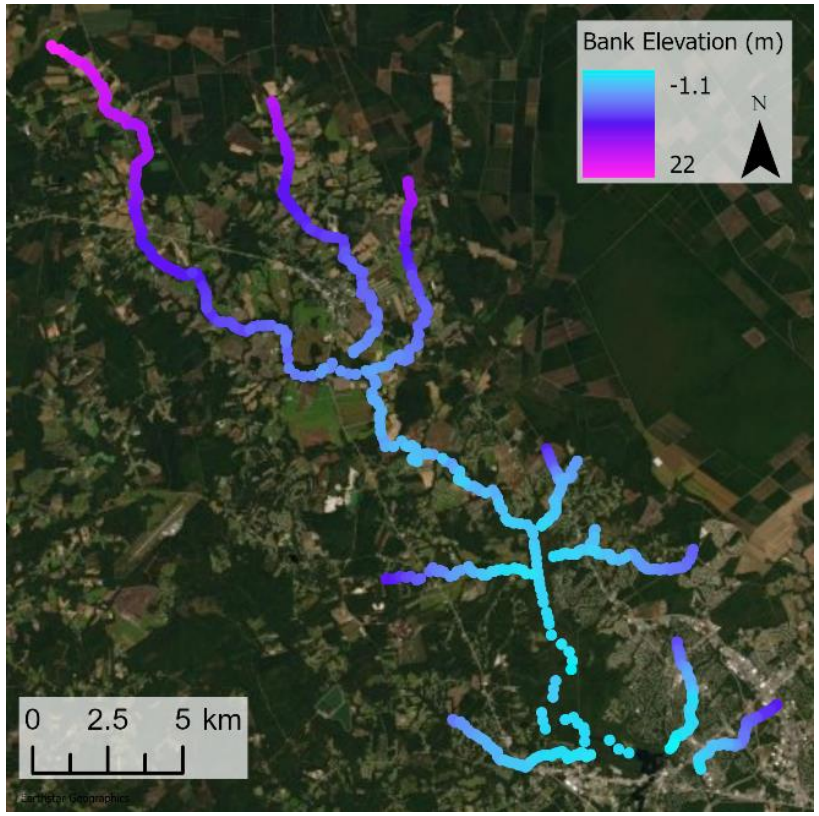
In NC, there are two ways to get HEC-RAS channel information

- Minimum bed elevation points
  - Created from stream centerline and cross-section shapefile
  - Only available for some rivers
- Detailed cross-section
  - From HEC-RAS geometry files
  - No automated way to get this data into a useable format
  - Issues when geospatial coords not in the file and must be assigned

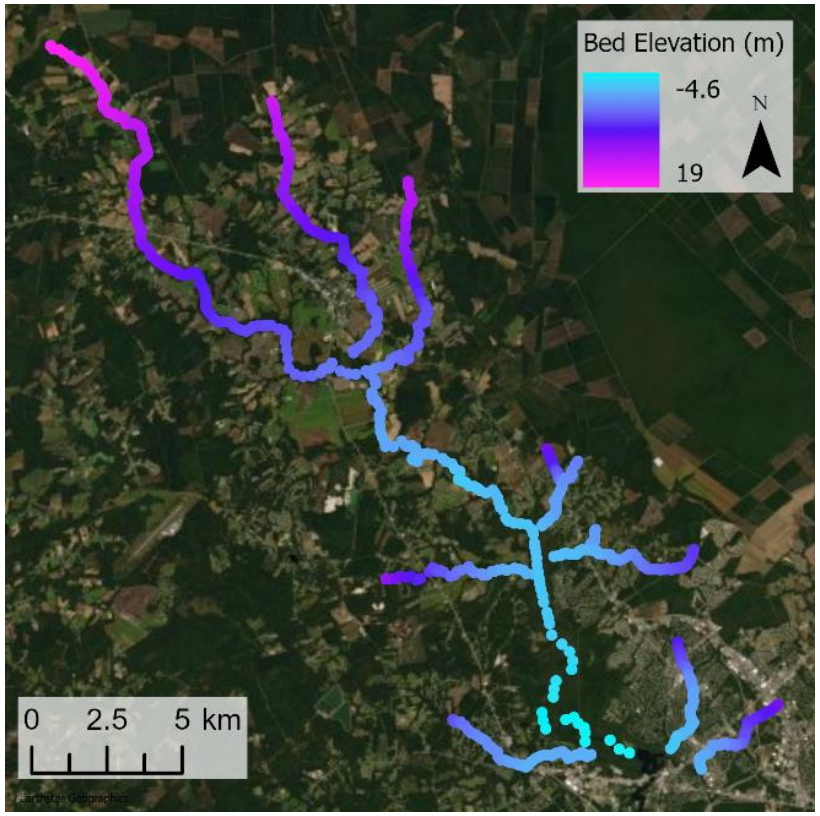


We extracted HEC-RAS channel information from georeferenced models of the major rivers and creeks in the New River watershed.

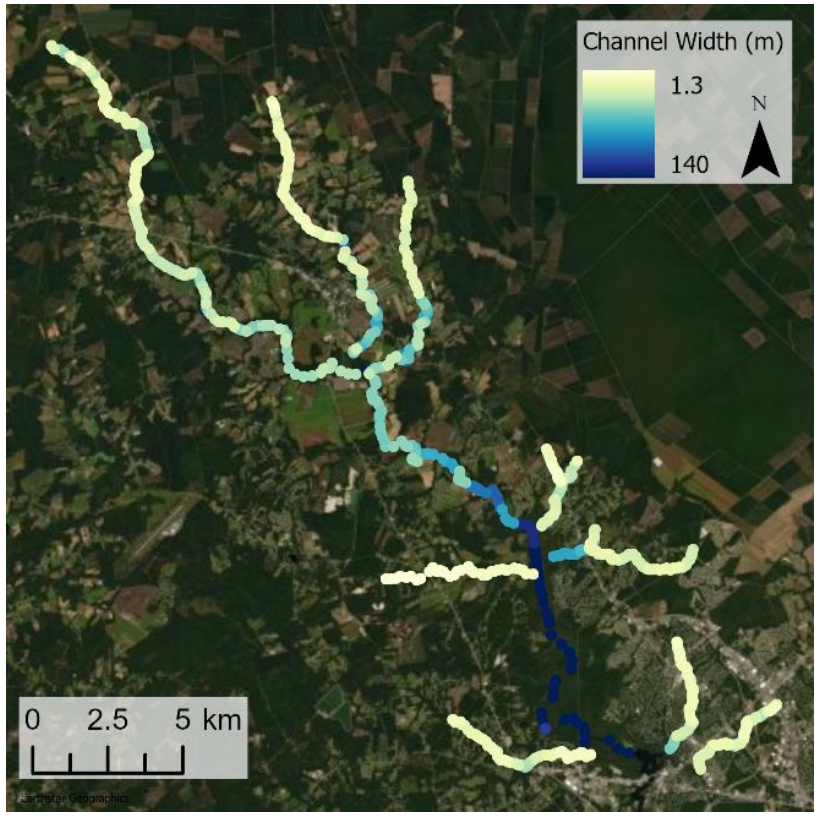
Maximum Bank Elevation



Minimum Bed Elevation

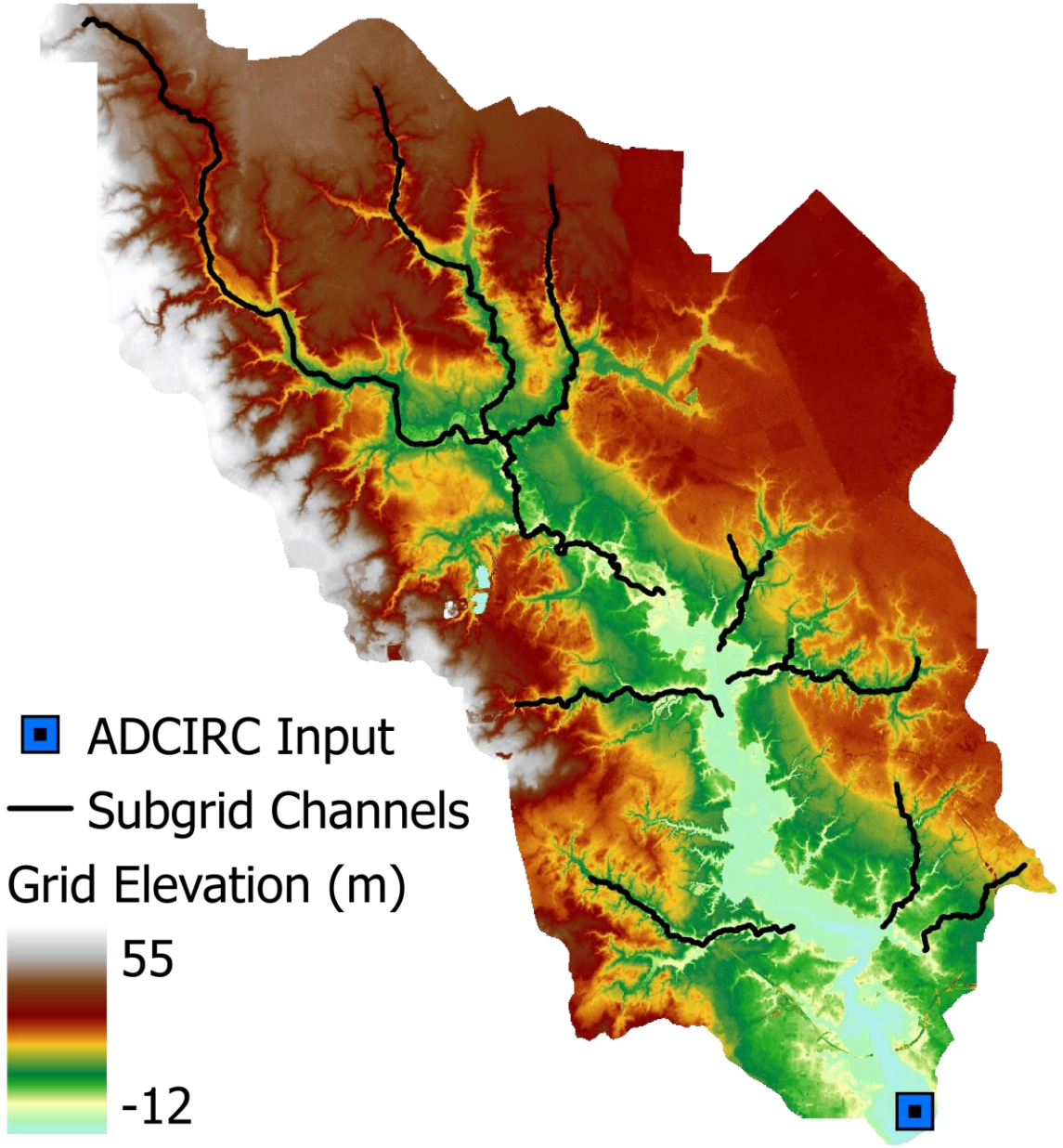


Channel Width



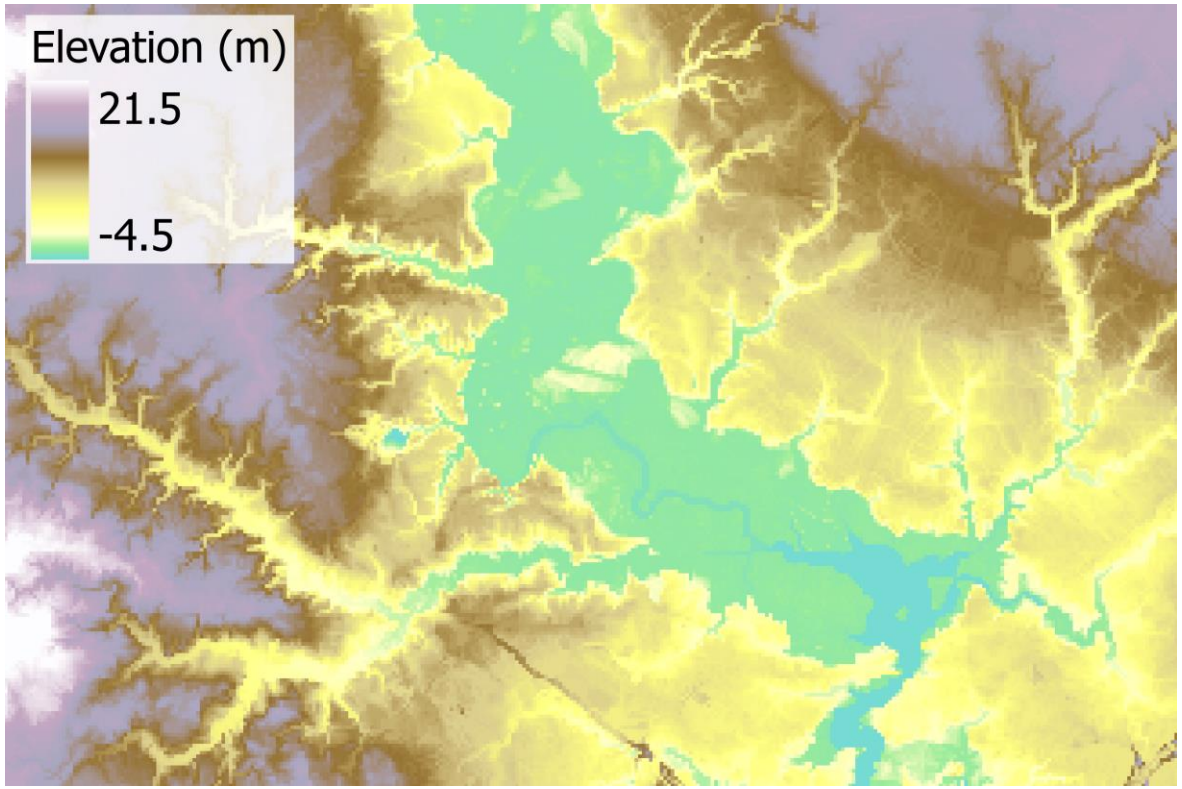
The HEC-RAS-derived channel maximum depth and width are used to resolve the LISFLOOD-FP subgrid channels.

- Modeled in 1D
- Widths less than the 2D grid resolution (30 m)
- Assumes rectangular channel

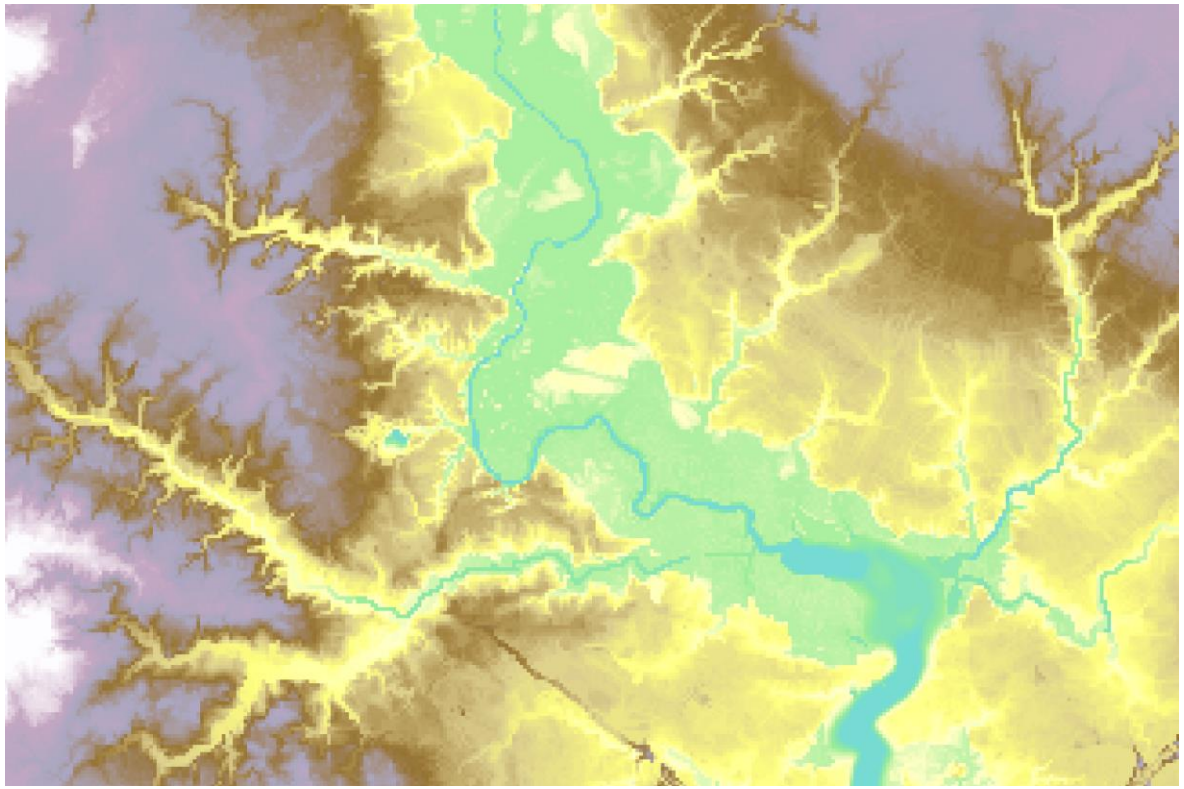


The HEC-RAS minimum bed elevation is “burned” into the DEM used to assign the LISFLOOD-FP 2D grid.

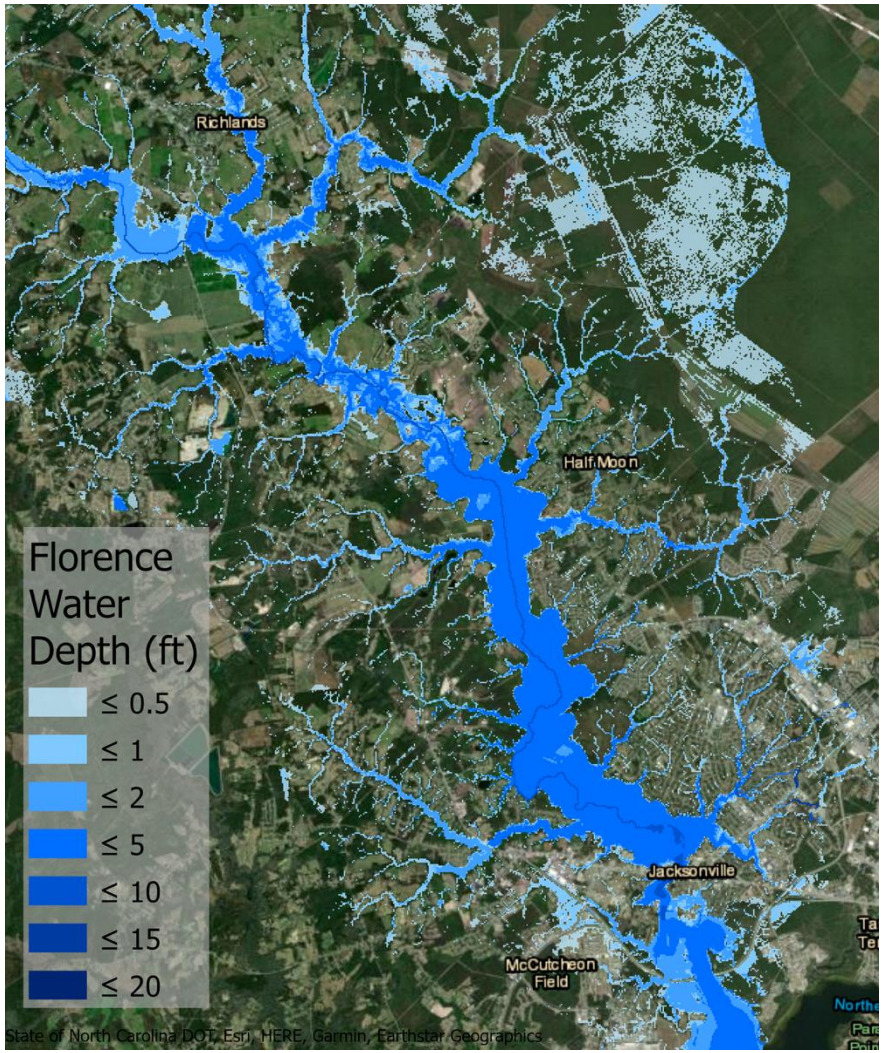
30m DEM

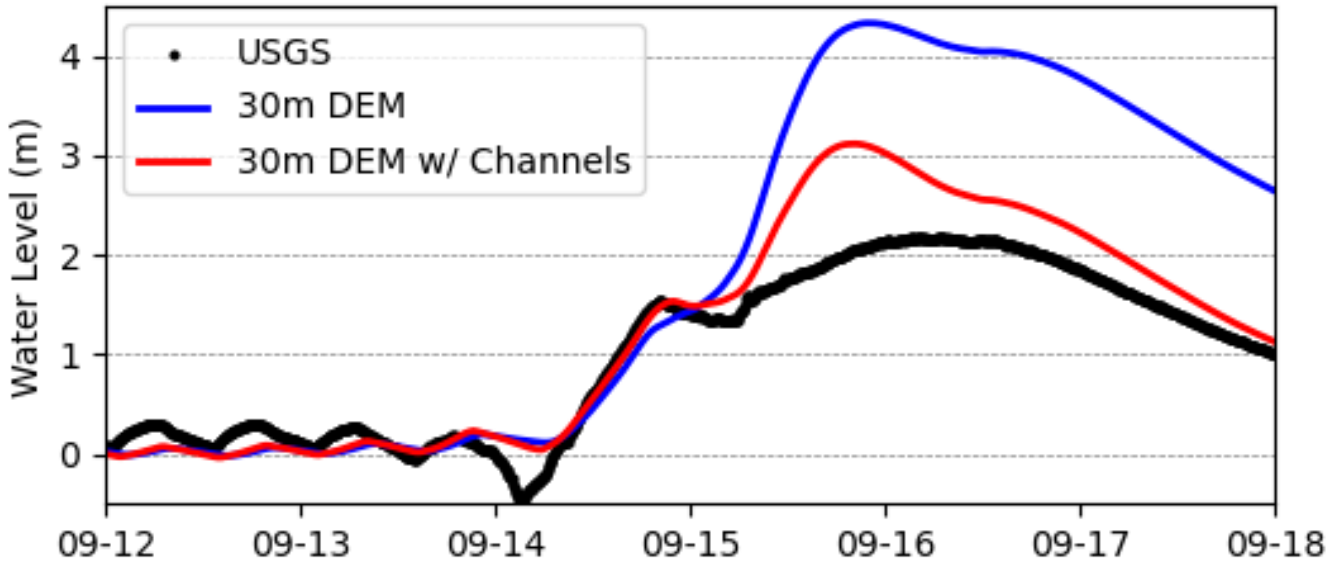


30m DEM with channels



Resolving channels in the flood model improves total water level predictions for Hurricane Florence… but getting the data for is a challenge.





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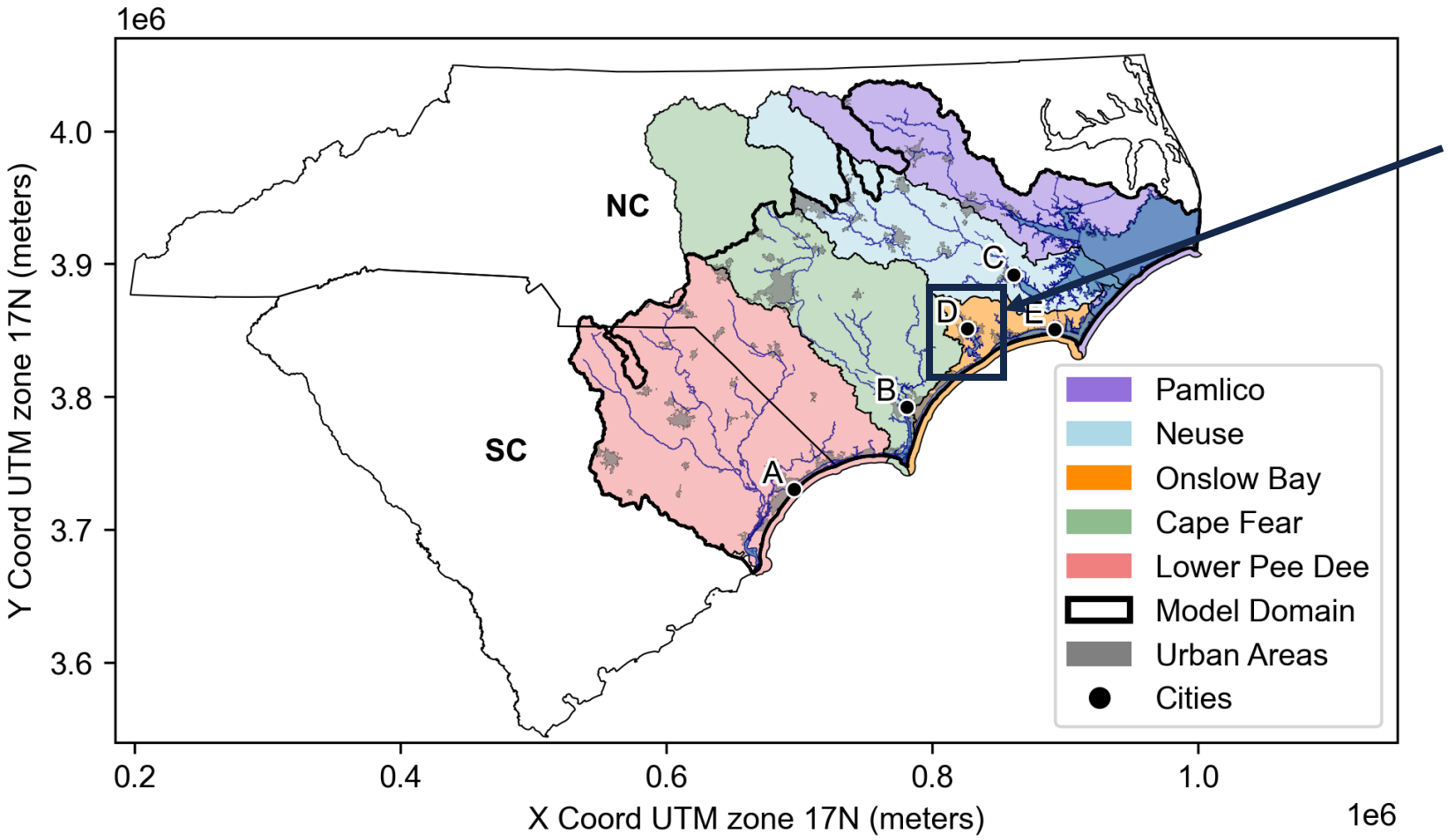
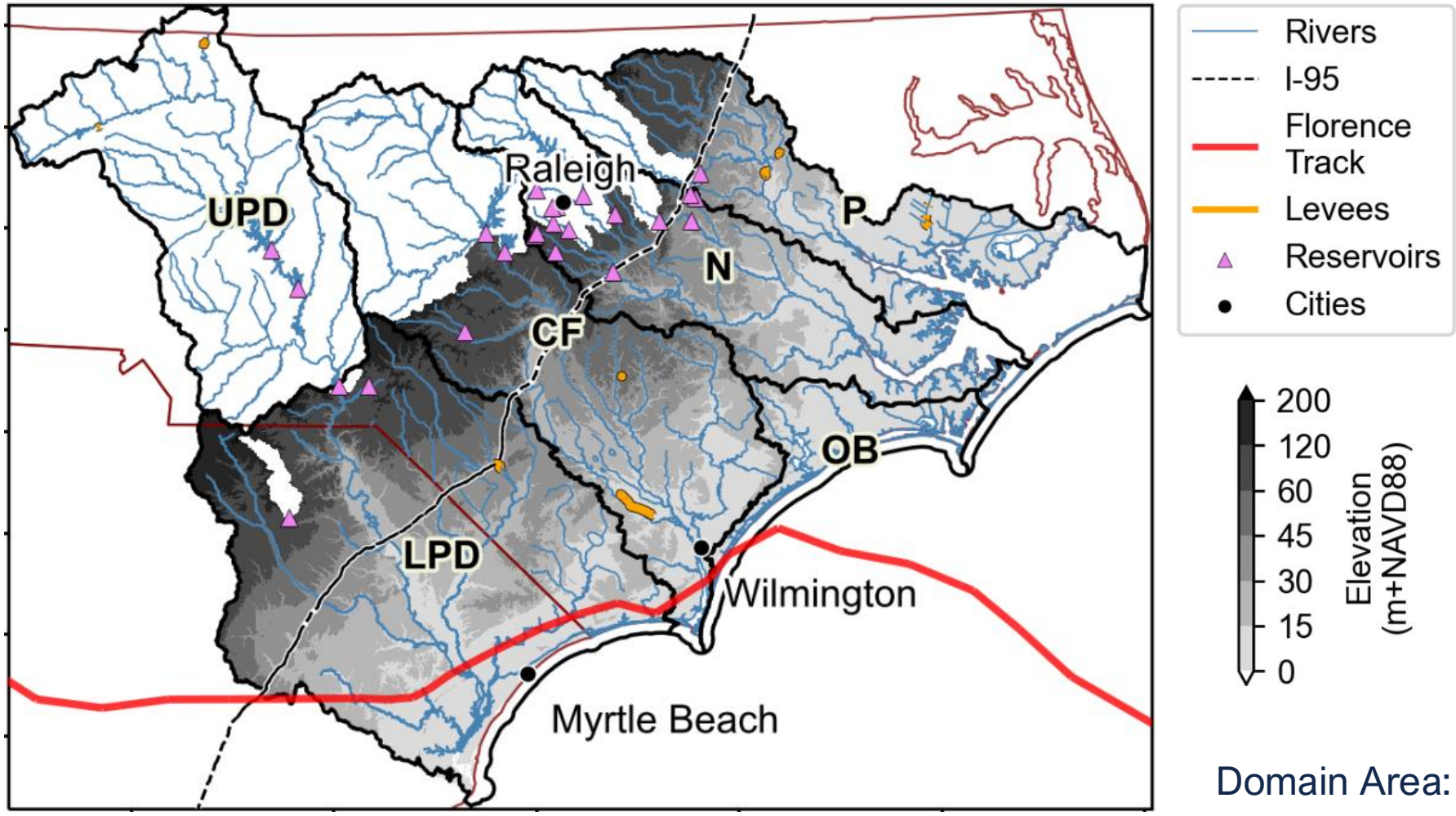


1. New River watershed
2. Multiple watersheds
3. Next steps

We built a 2D hydrodynamic model (SFINCS) to simulating tropical cyclone flooding across the eastern Carolinas.

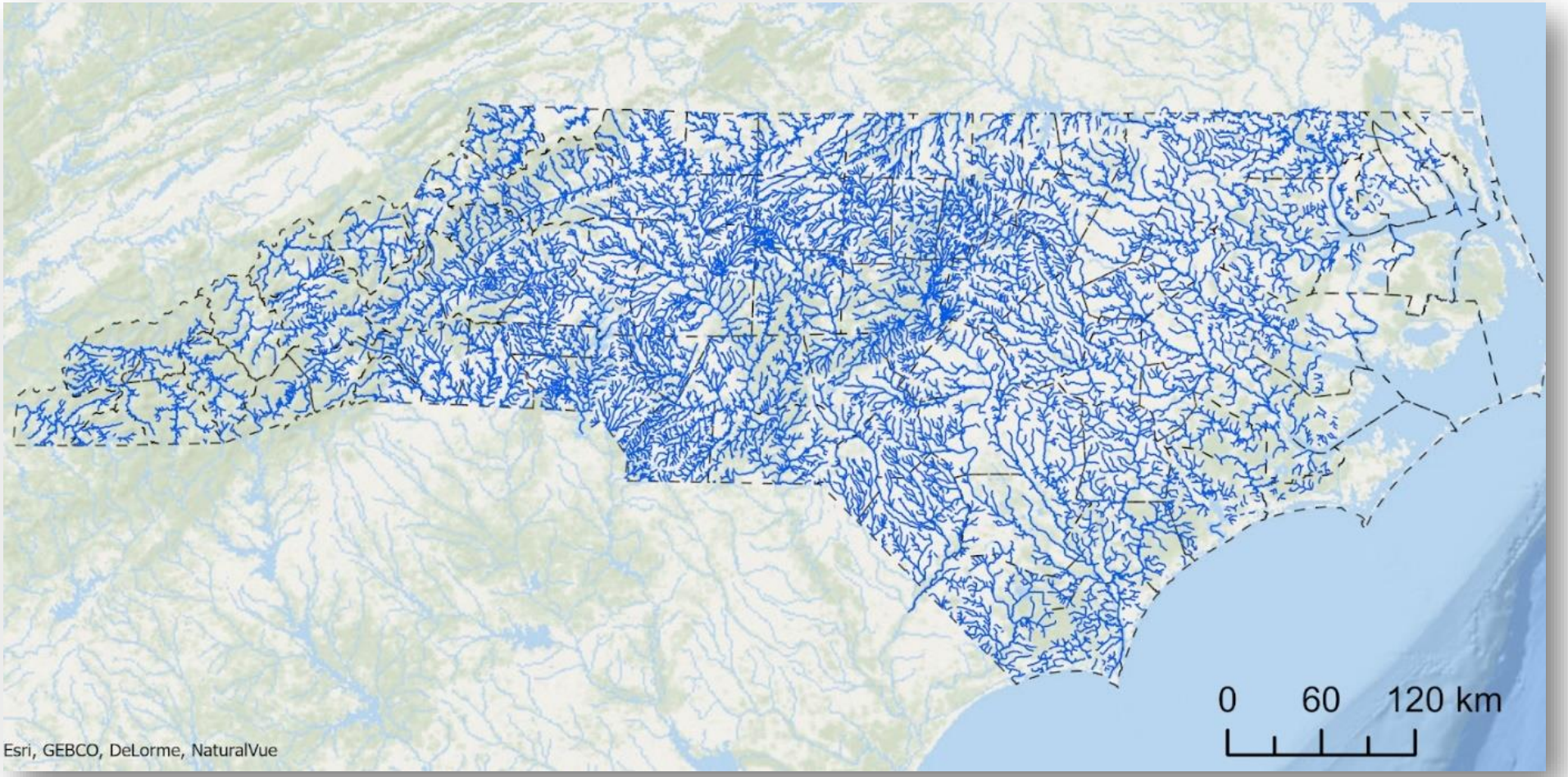


Grimley et al. 2025, *WRR*

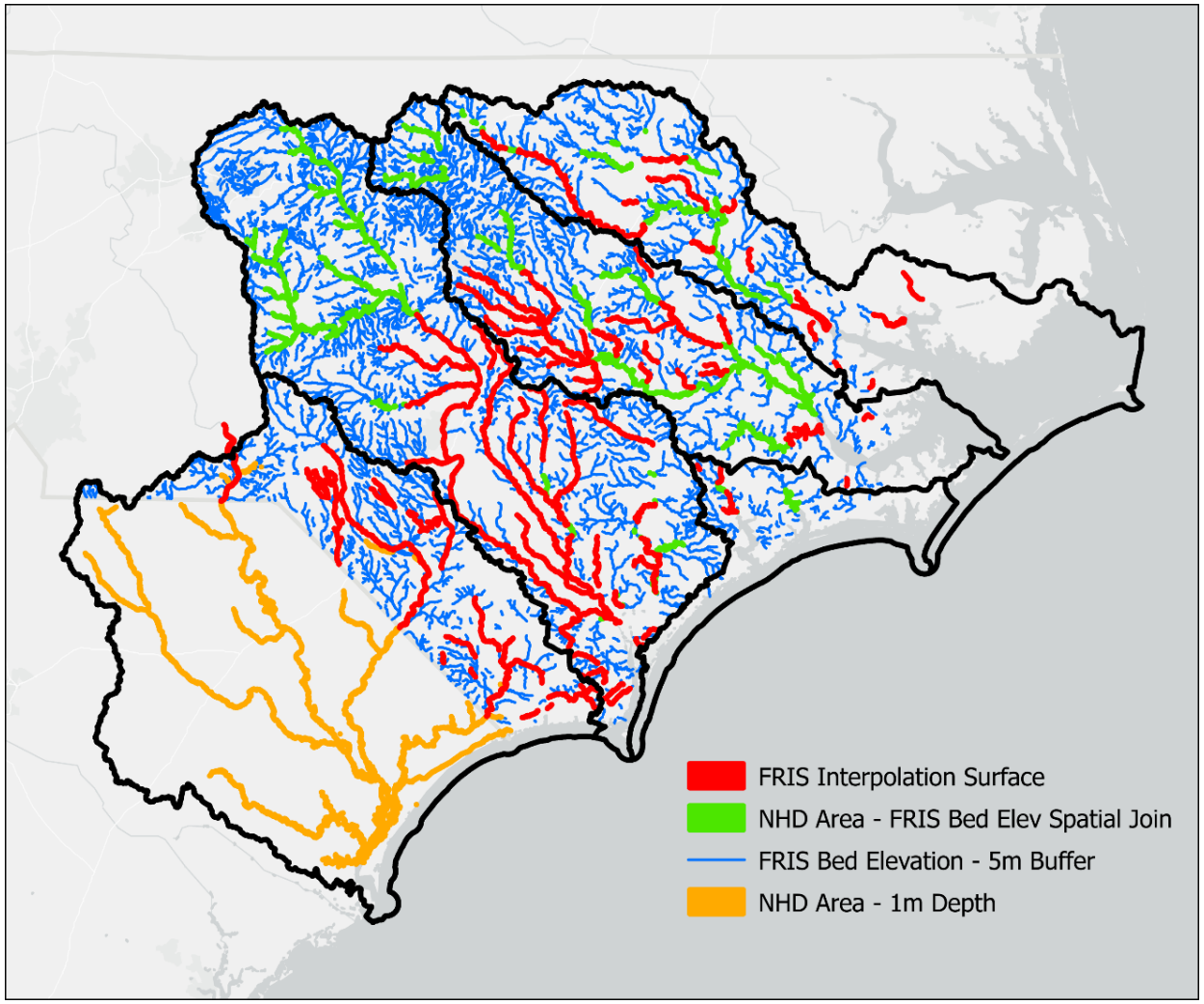
Domain Area: 77,655 sq. km.

There are over 39,000 mapped streams in NC – each with a separate HEC-RAS model (archived by the state) amounting to hundreds of thousands of river cross-sections.

***while HEC-RAS models exist for most states, they are not always easily accessible

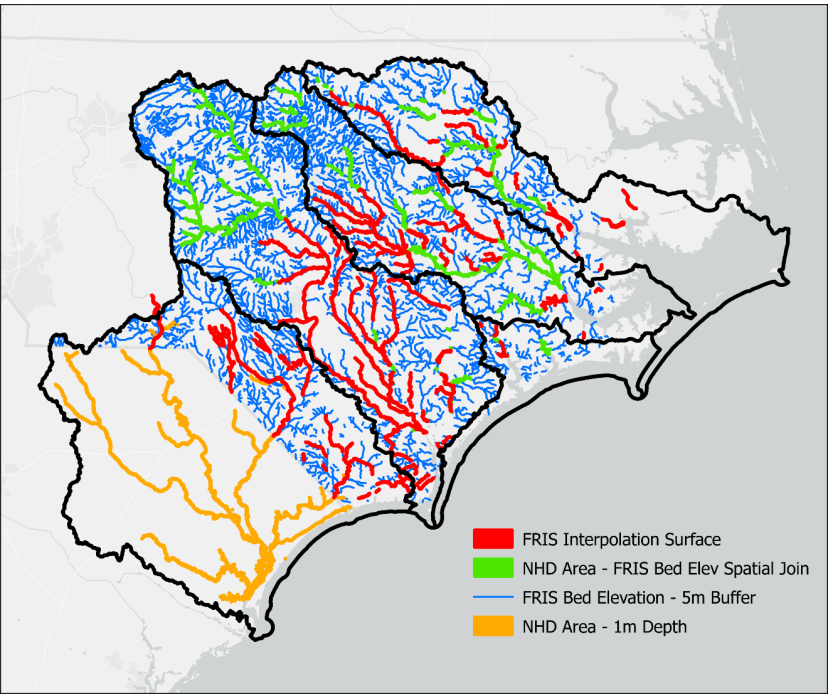


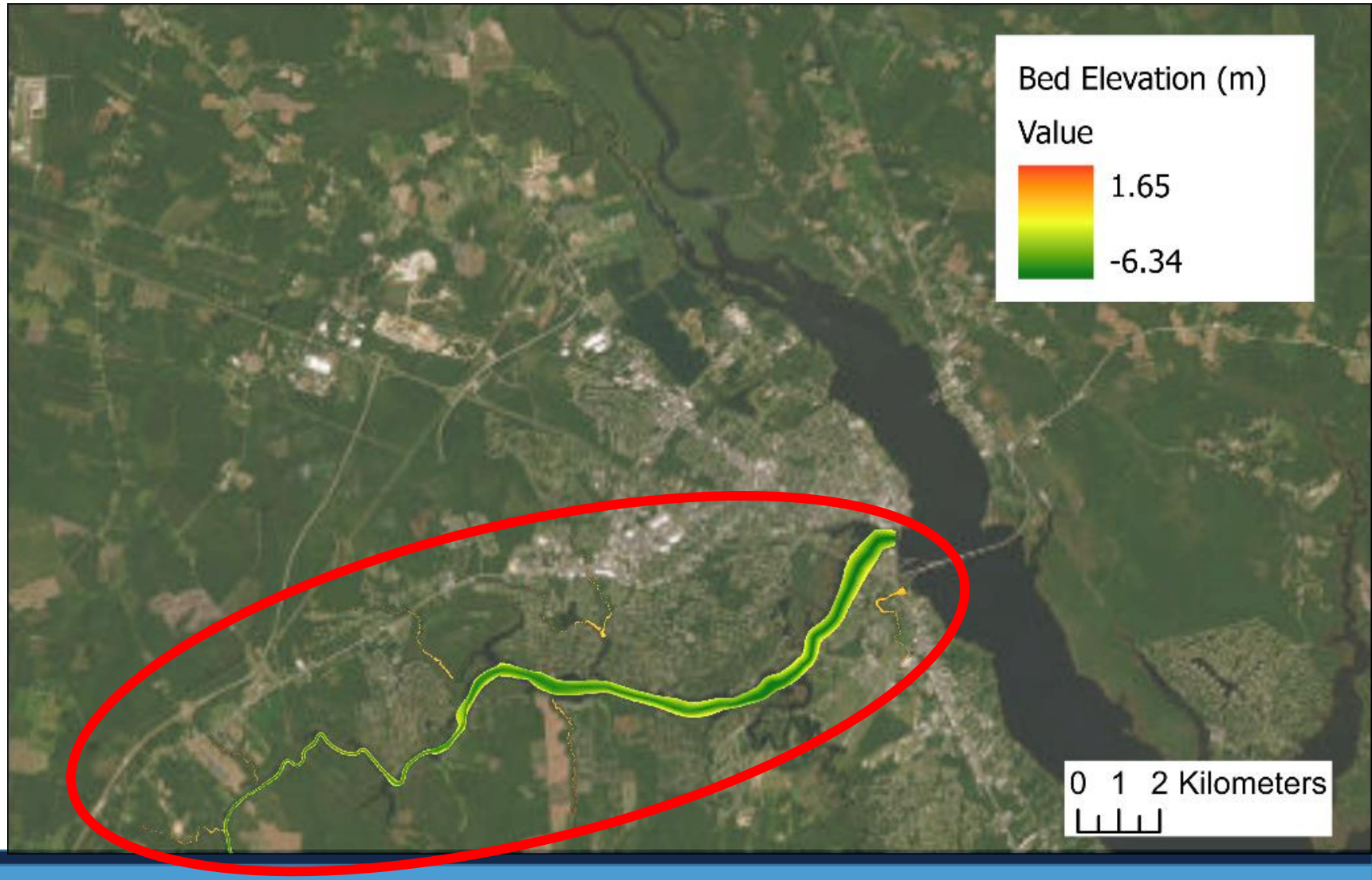
We created a 5 m topobathymetric DEM that includes elevations extracted from HEC-RAS models for many rivers across the domain.



Grimley, L., A. Sebastian (2025). *Topobathymetric Digital Elevation Models (DEM) for Flood Modeling in the Carolinas*. DesignSafe-CI. https://doi.org/10.17603/ds2-mzc8-s589

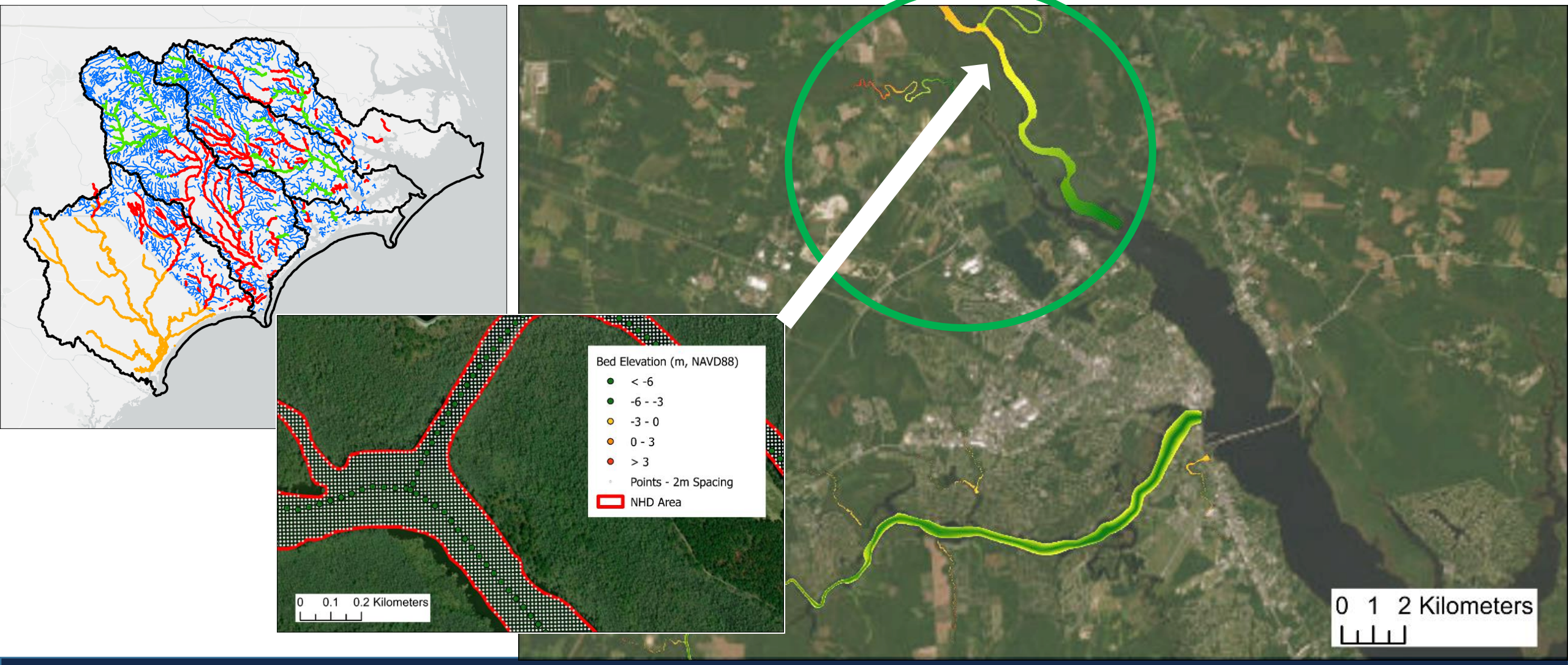
For the main river stems that were georeferenced, I used the RAS Mapper to generate an **interpolation surface** of the channel.



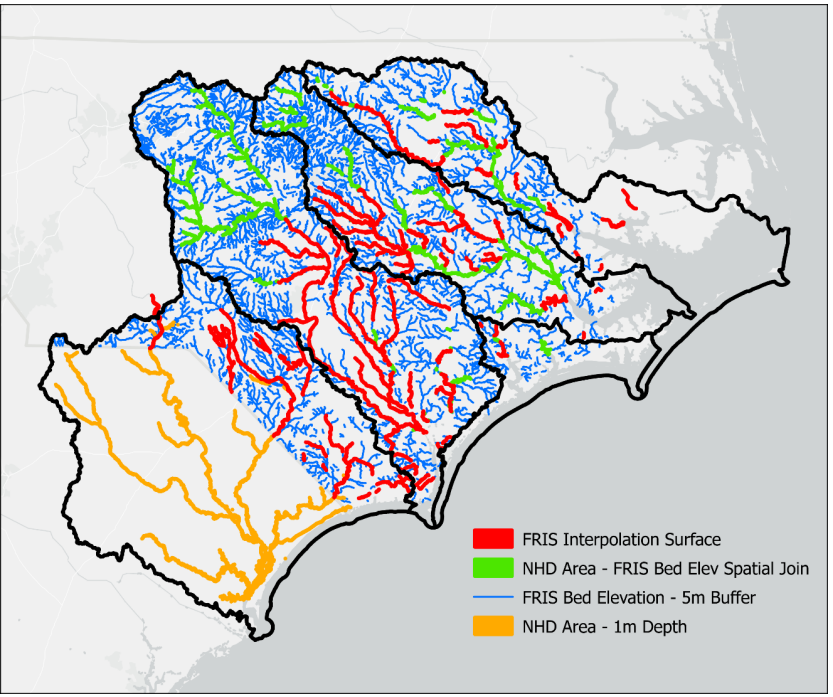


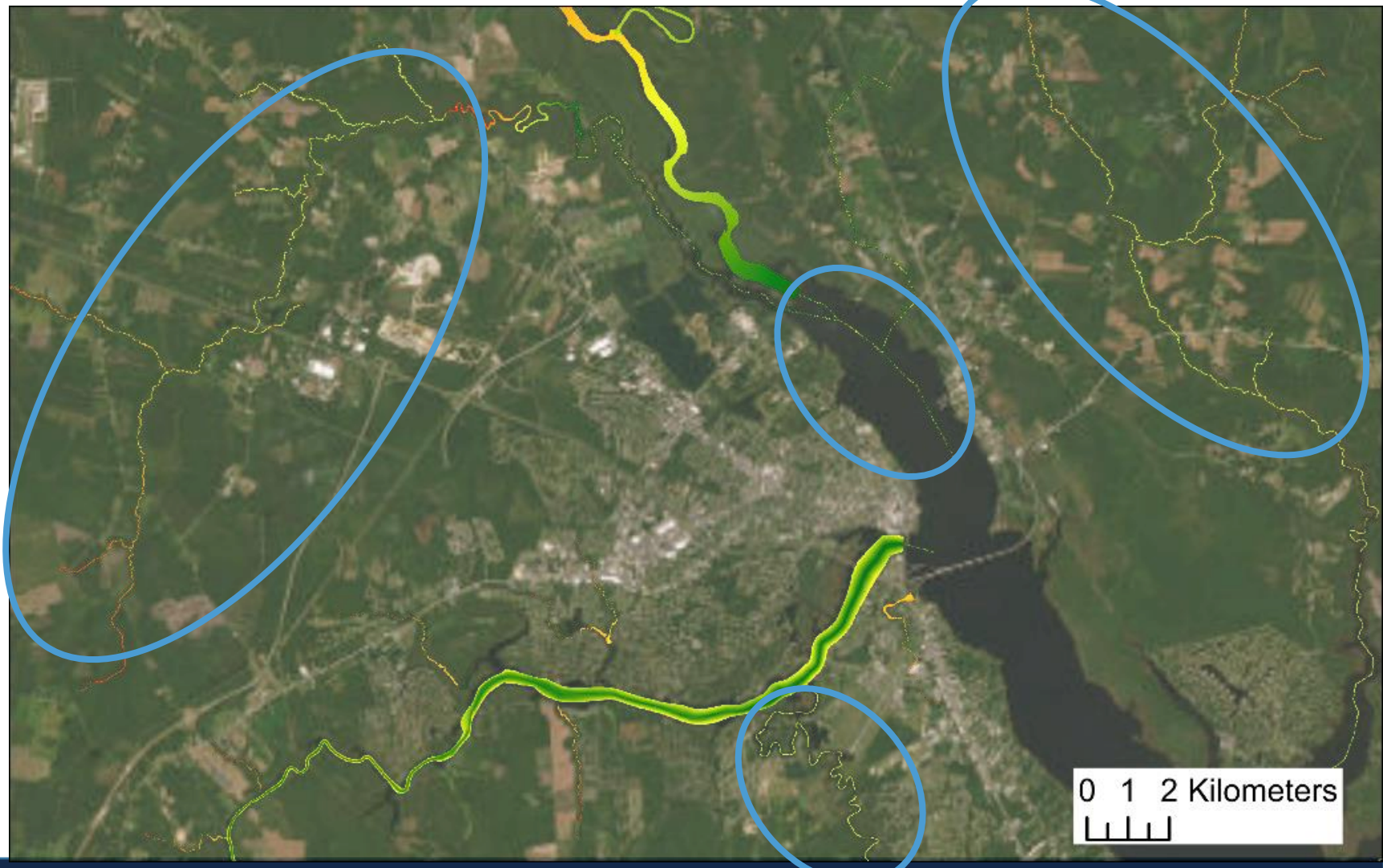
How to do this:
https://www.hec.usace.army.mil/confluence/rasdocs/hgt/latest/guides/export-channel-data-for-terrain

Next, I used the minimum bed elevation at each cross-section (point) and interpolated these to a grid of points within the NHD Area polygon.

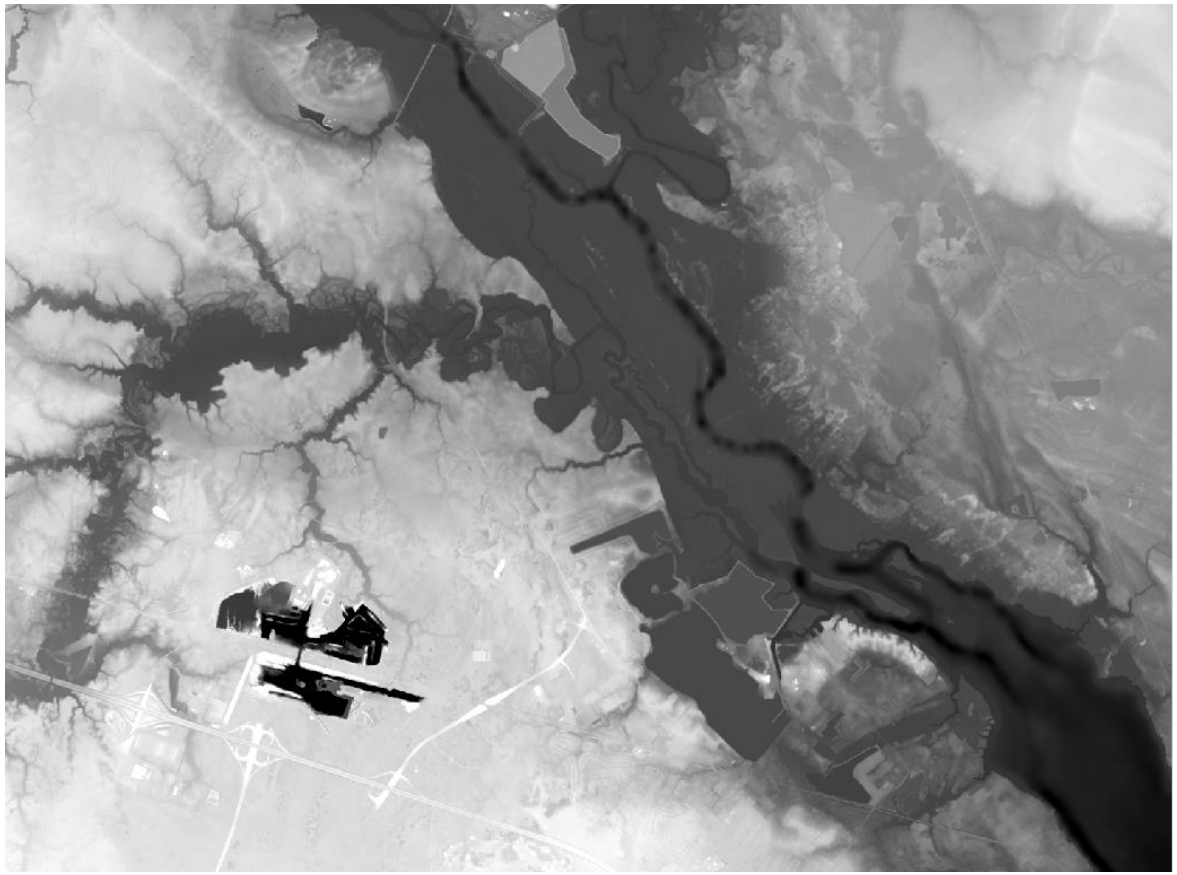


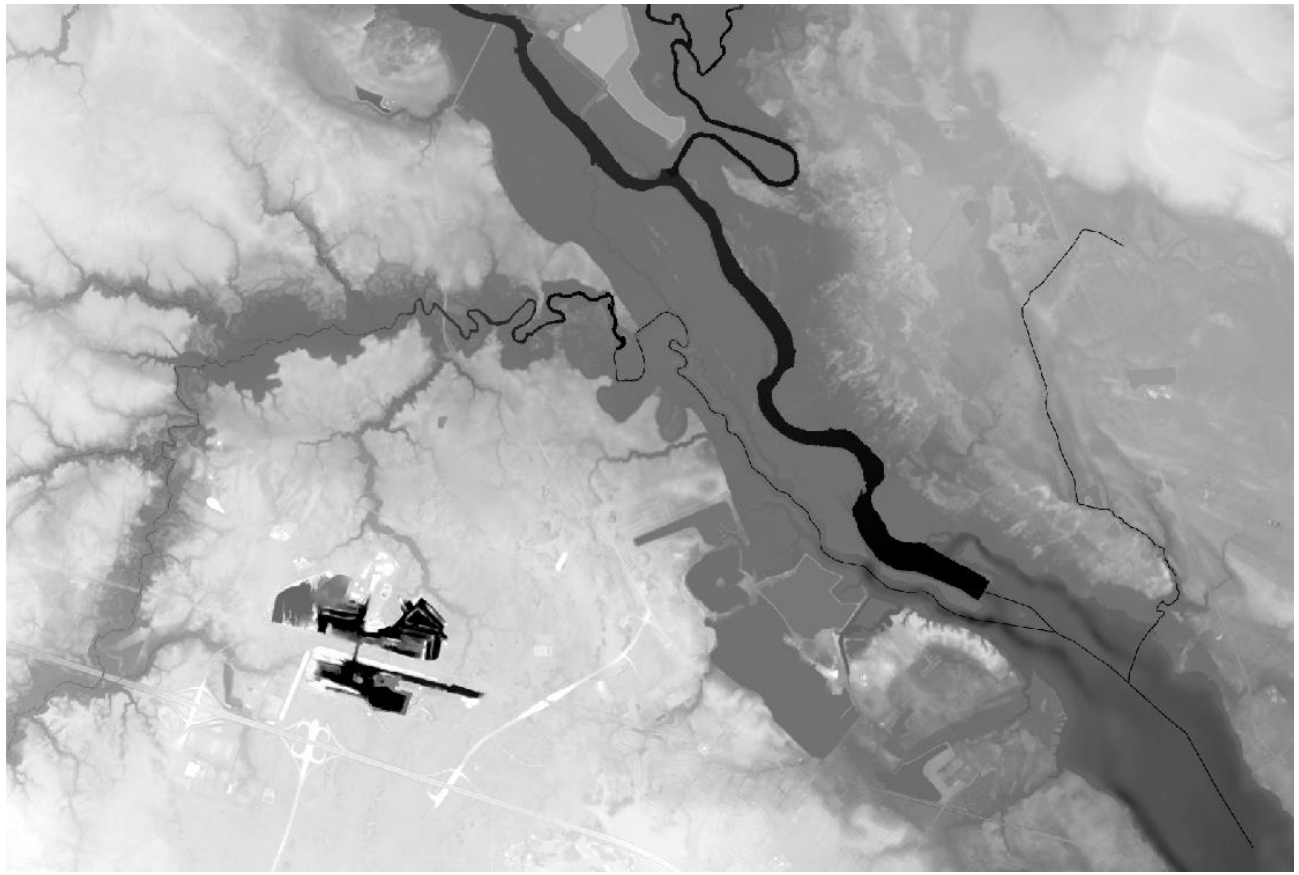
When there was no NHD Area coverage, I interpolated the minimum bed elevations along the centerline at points with a 5 m spacing.





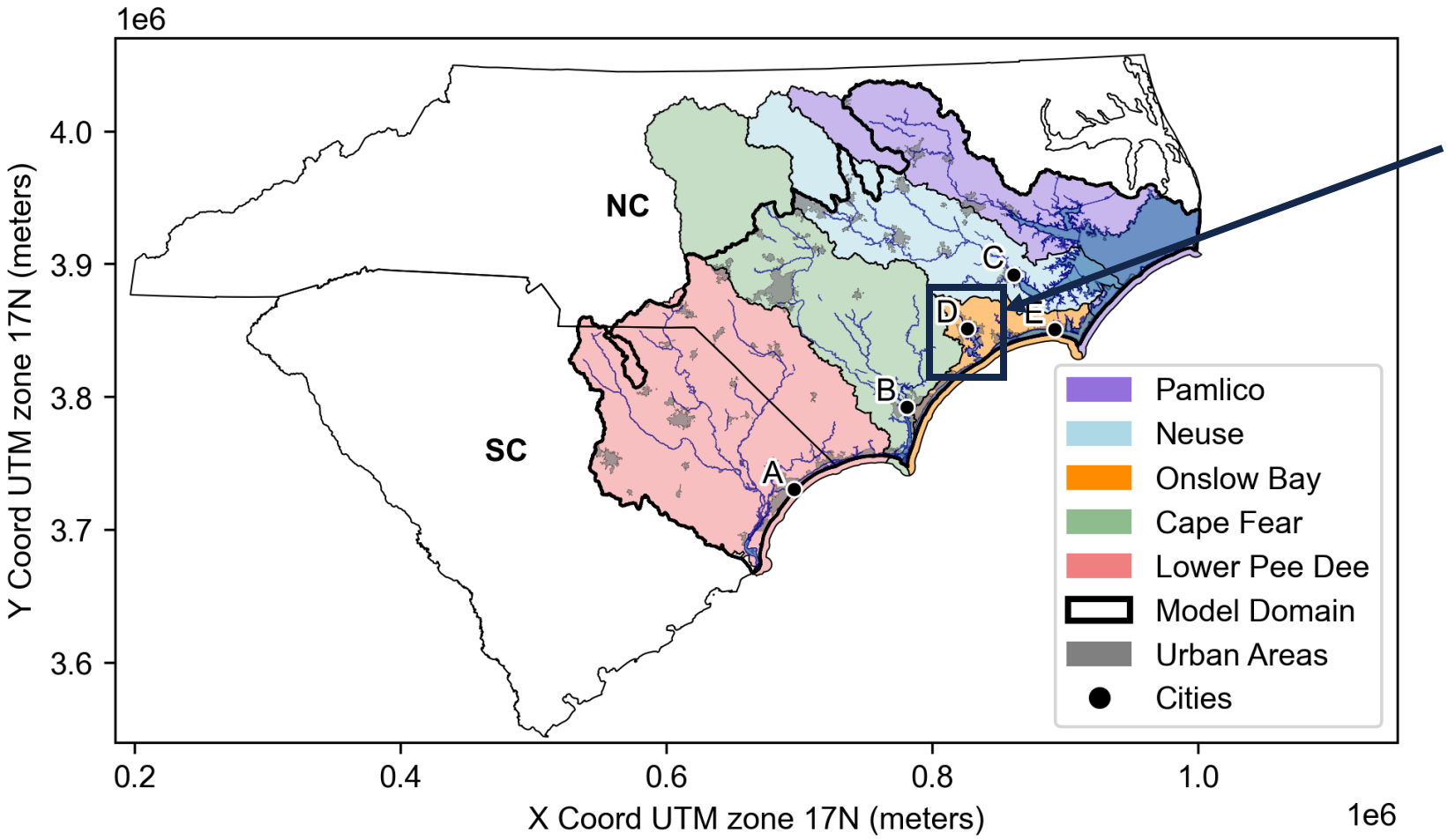
I merged these bathy rasters with the overland DEMs (e.g., CoNED, NED, state LiDAR, CUDEM) at a 5 m resolution with limited smoothing.





This “rough” estimate of channels improved flood model performance, reducing peak water level errors by 20 cm on average.
(Grimley et al. 2025, WRR)

Presentation Outline



1. New River watershed
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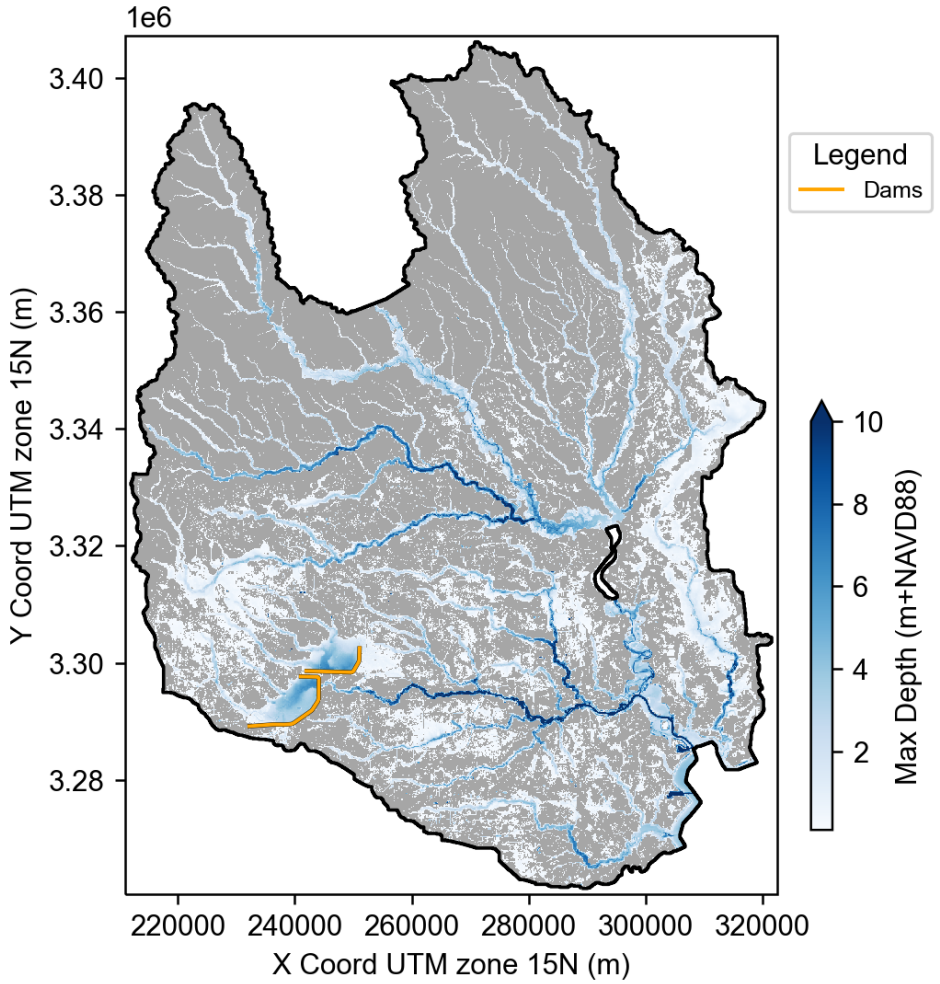
While the DEM has been useful for additional studies, we made many assumptions and there is a lot of room for improvement!

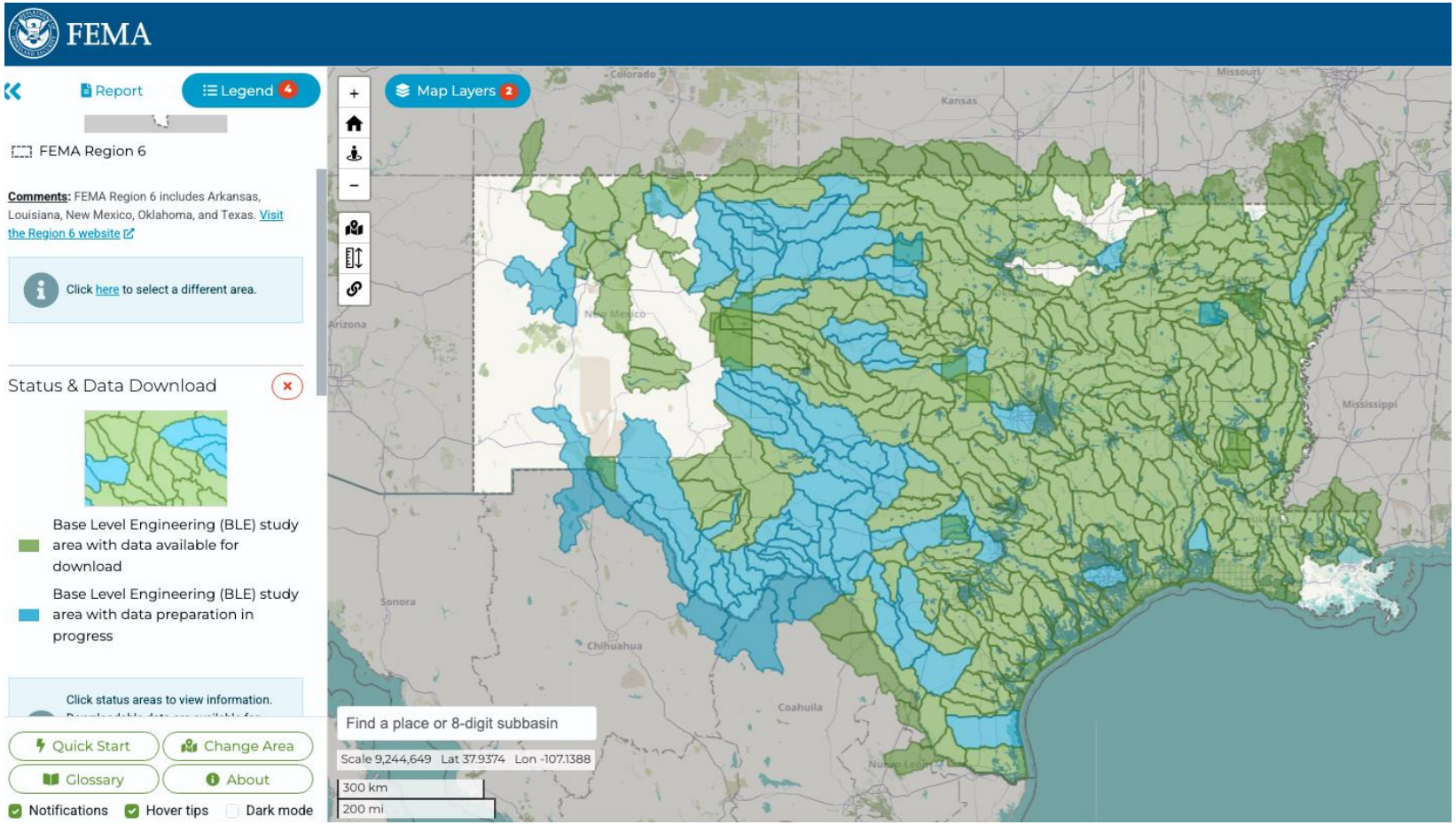
- Starting point for parameterizing channels in ADCIRC (S. Bunya at UNC)
- Quick building of flood models to support graduate research in NC and Houston, TX
  - Grimley, L (2025). *Topobathymetric Digital Elevation Model (DEM) for Flood Modeling in Harris County, TX*. DesignSafe-CI. https://doi.org/10.17603/ds2-21k1-sj54
- Comparison/validation of SWOT data or empirical models
- Specifying channel info in the model using maximum depth vs. channel capacity



There are a lot of opportunities to leverage HEC-RAS data, but there are some challenges that we need to address…

Getting the HEC-RAS models…

- Base Level Engineering HECRAS models are available for FEMA region 6 and 9 (Texas, Louisiana, Oklahoma, Arkansas, New Mexico, California, Nevada, Arizona) https://webapps.usgs.gov/infrm/estBFE/
- Harris County, Houston, TX https://www.hcfcd.org/Resources/Interactive-Mapping-Tools/Model-and-Map-Management-M3-System
- North Carolina HECRAS models https://fris.nc.gov/map
- As part of the Louisiana Watershed Initiative, they plan to have a model repository (https://watershed.la.gov/modeling-program)
- Iowa (https://www.mvr.usace.army.mil/Missions/Flood-Risk-Management/Silver-Jackets/Iowa-Flood-Risk-Model-Inventory/)



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Developing codes to automatically extract the data into a useable format

- https://github.com/mikebannis/parserasgeo (last updated 6 years ago)
- https://github.com/lgrimley/hecras_geometry (last updated 3 years ago)

Northeast Cape Fear River_US_(adj).g01

```
1   Geom Title=Geom 01 by CodeH2 for Windows
2   Program Version=4.10
3   Viewing Rectangle= 2329334.62 , 2359830.71 , 335613.17 , 301930.15
4
5   River Reach=NortheastCapeFea,Reach - 1
6   Reach XY= 344
7   2329907.878227133331265.056605113232998 4.60900462331166.635607843
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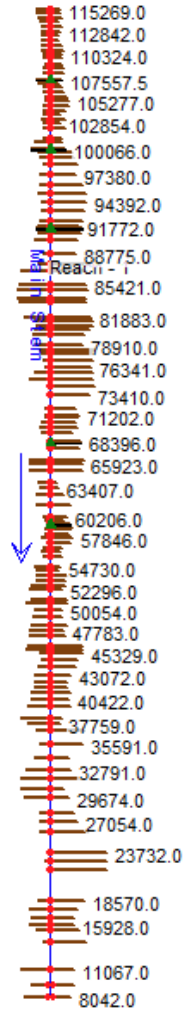
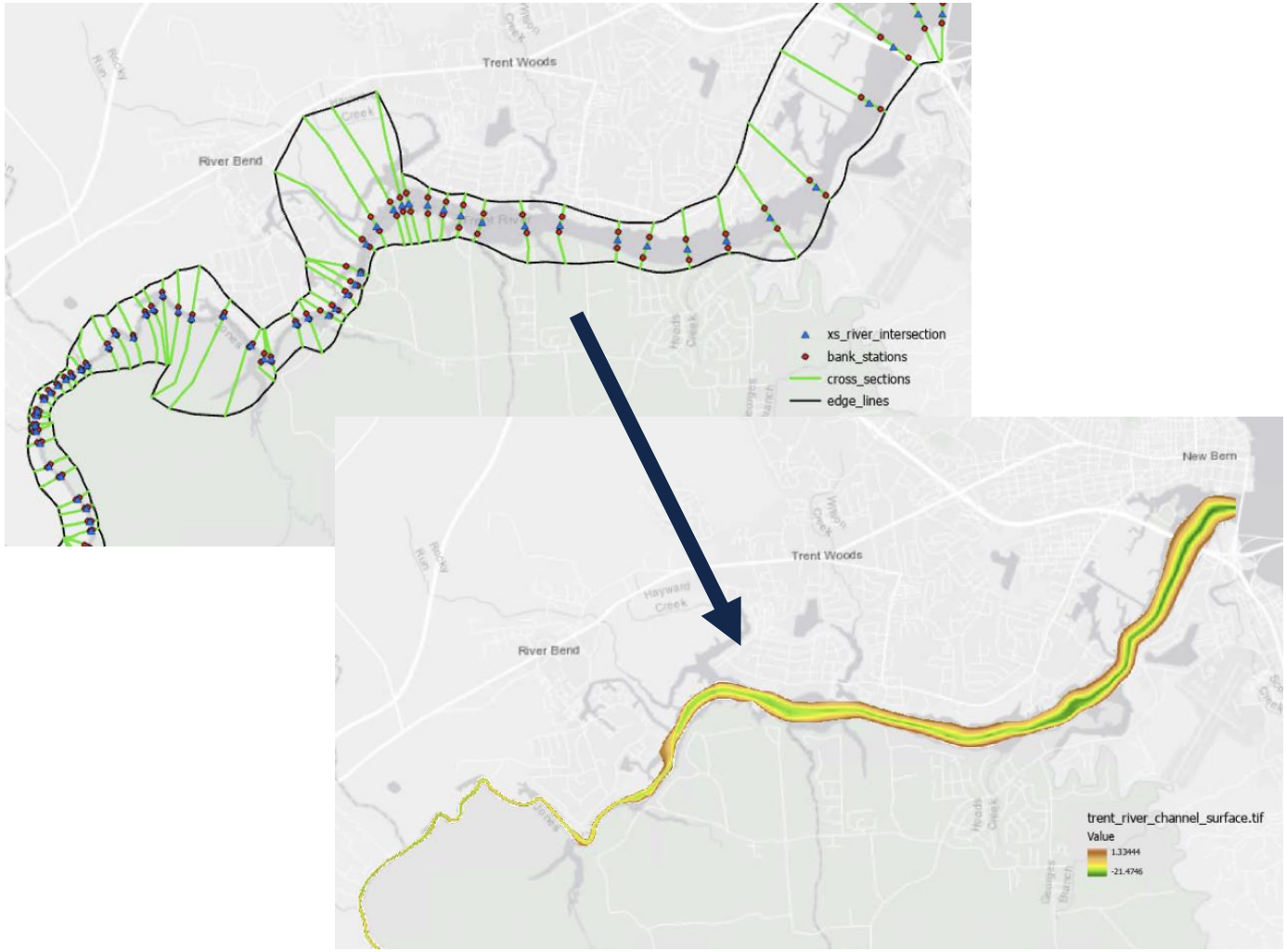
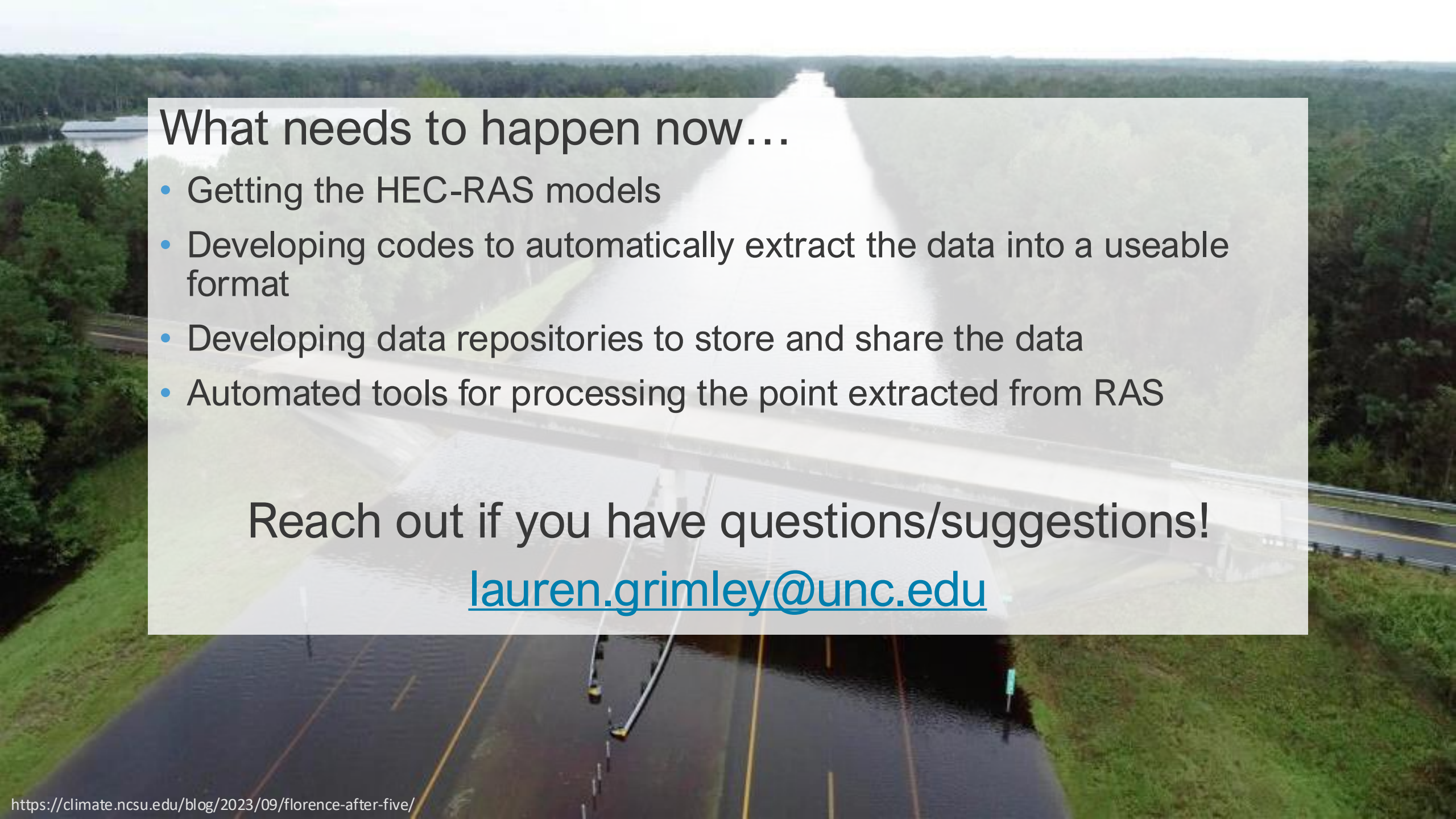


There are a lot of opportunities to leverage HEC-RAS data, but there are some challenges that we need to address…

- Developing data repositories to store and share the data
- Automated tools for processing the point extracted from RAS (e.g., interpolation)





What needs to happen now…

- Getting the HEC-RAS models
- Developing codes to automatically extract the data into a useable format
- Developing data repositories to store and share the data
- Automated tools for processing the point extracted from RAS

Reach out if you have questions/suggestions!

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https://climate.ncsu.edu/blog/2023/09/florence-after-five/