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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Perennial Riparian Buffers for Bioenergy: A Flood-resilient Climate Adaptation for Agricultural Landscapes

Presented by: **Ganesh R. Ghimire** (ghimiregr@ornl.gov), Yan Liu, Sudershan Gangrade, Henriette I. Jager, Shih-Chieh Kao, Esther Parish, and Christopher DeRolph

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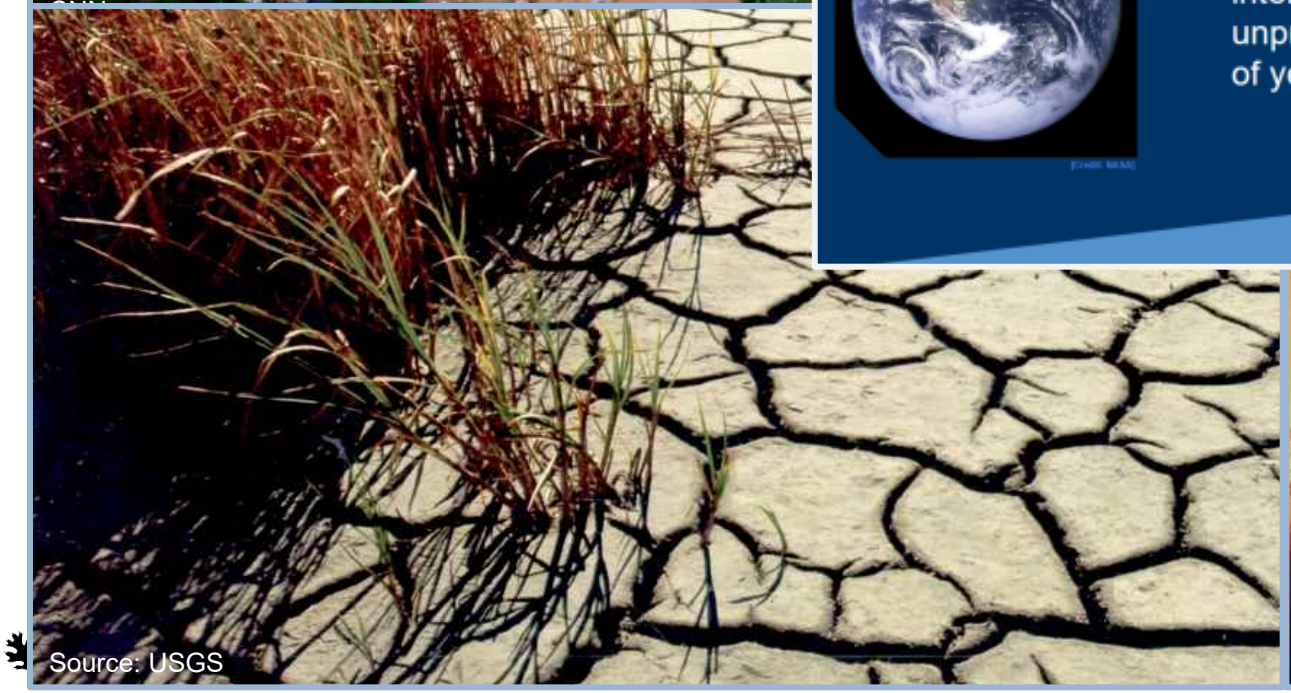
ICR23 Innovations in Climate Resilience

Source:

Source: Patrick T. Fallon/AFP via Getty



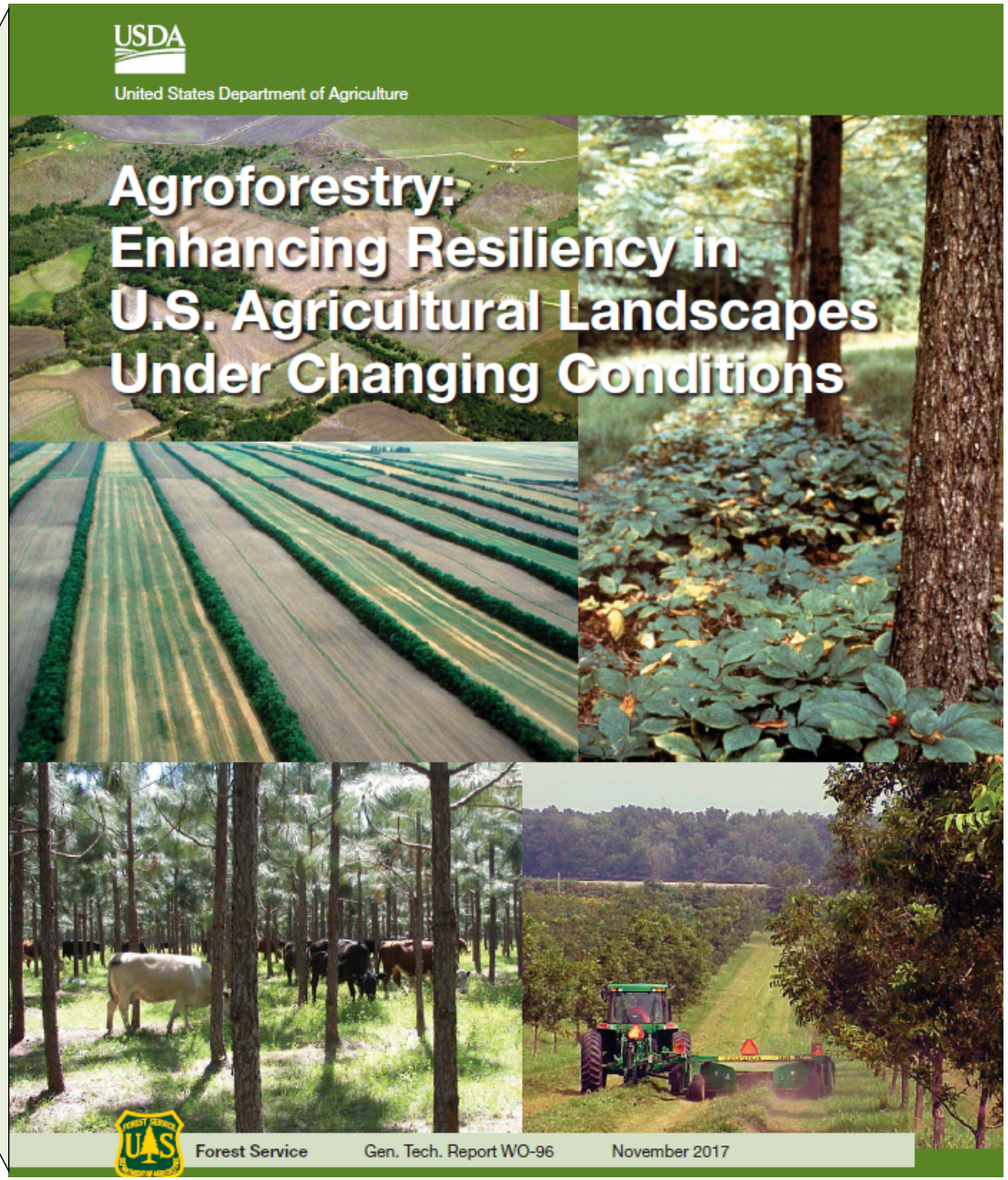
Source: USGS

Source: Josh Edelson / AFP - Getty Images

Climate resilience and adaptation strategies are needed at flood-prone areas of agricultural landscapes

Jager et al. 2020

Figure 1. Quincy, Illinois, 20 June 2008. Fields of corn are flooded, and crops may be ruined for the year by the flooding waters of the Mississippi River in southern Illinois. Photograph: Robert Kaufmann/Federal Emergency Management Agency Photo Library.



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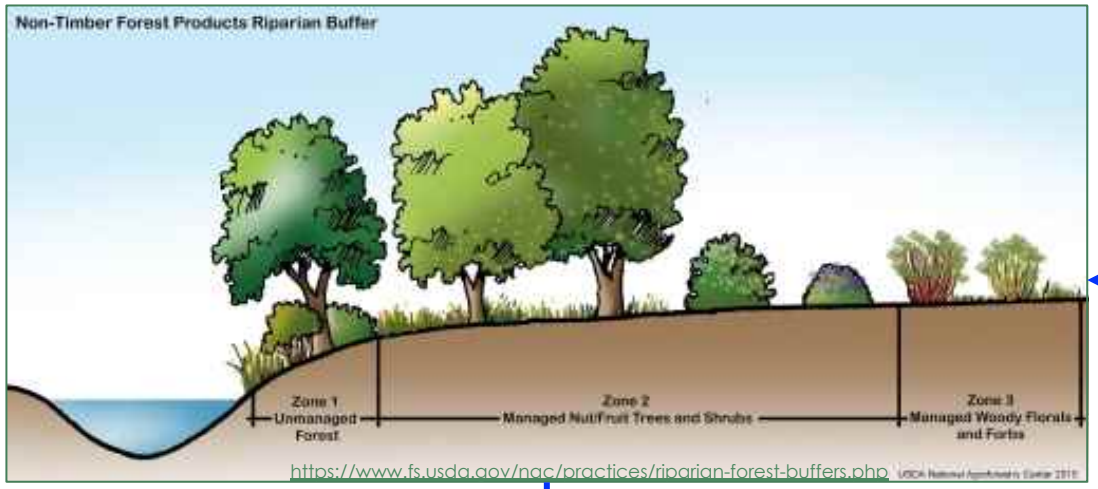
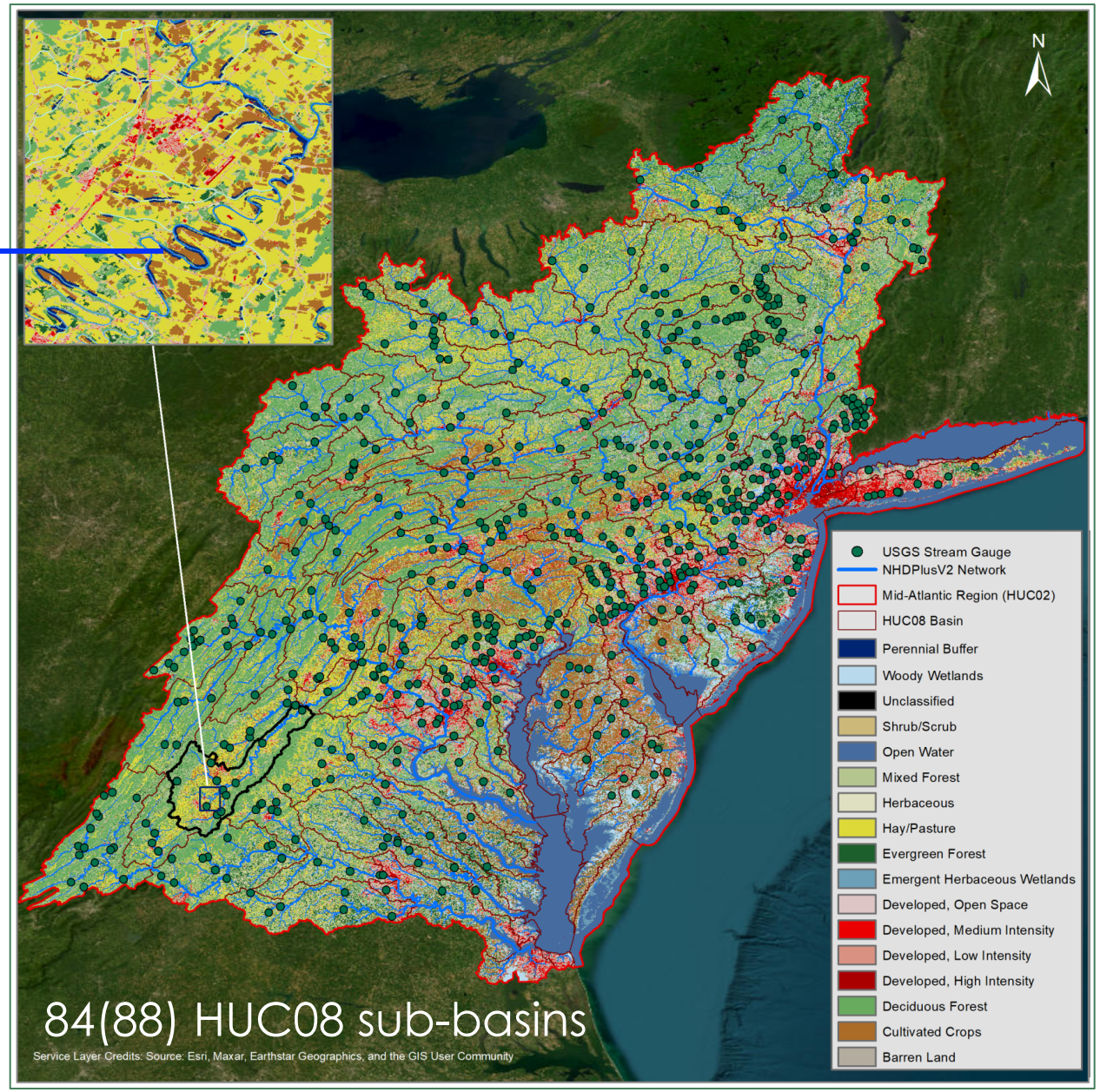
Mid-Atlantic region serves as an excellent testbed for studying the climate resiliency of agricultural landscapes





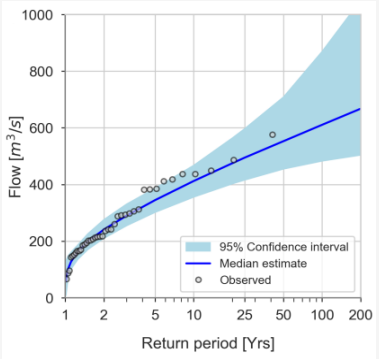
Hierarchical modeling framework can support the assessment of flood-resilient adaptation strategies

Ensemble Streamflow Projections

- **CMIP6 GCMS**(6 projections)
- Regional downscaling (**dynamical downscaling** with bias correction by **Daymet**)
- **VIC** runoff simulation
- Runoff routing with **RAPID**

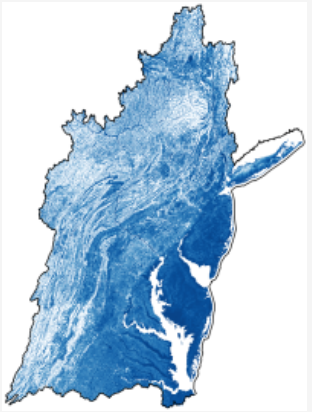
Flood Frequency Analysis

- Multiple **extreme value distributions** for planting-growing season (March – June) across NHDPlusV2 network



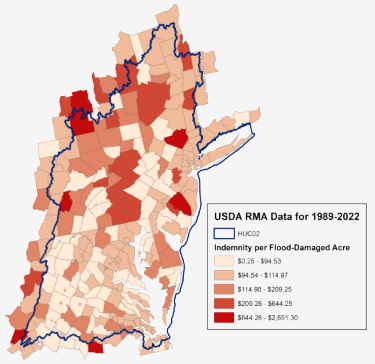
HAND-based Flood Inundation Mapping

- High-resolution **HAND** raster development
- Flood inundation depth and extent raster creation



Crop Insurance Modeling

- Historical indemnity data
- Estimation of **avoided crop insurance** due to harvested perennial buffer



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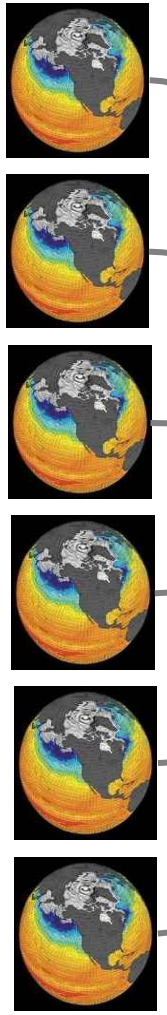
DOE's 9505 ensemble hydroclimate projections data provide the basis for the study

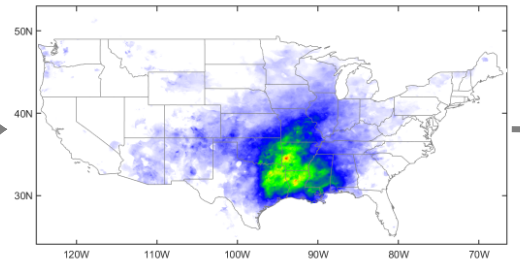
Climate Models

(6 GCMs)



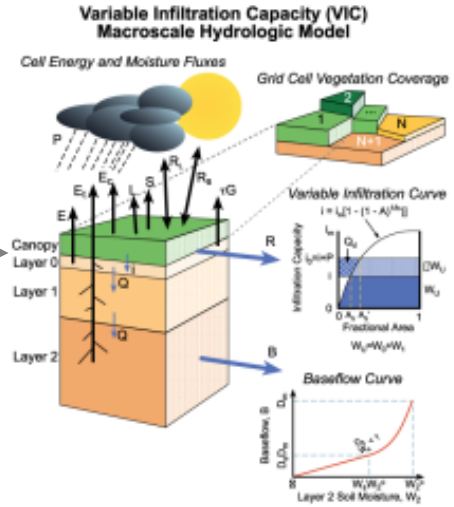
Downscaling and Bias Correction

Dynamical downscaling with RegCM



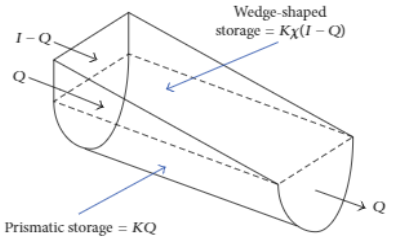
Hydrologic Modeling

Variable Infiltration Capacity (VIC)



Streamflow Routing

Routing Application for Parallel computation of Discharge (RAPID)



Bolea et al. (2014), doi:10.1155/2014/197907

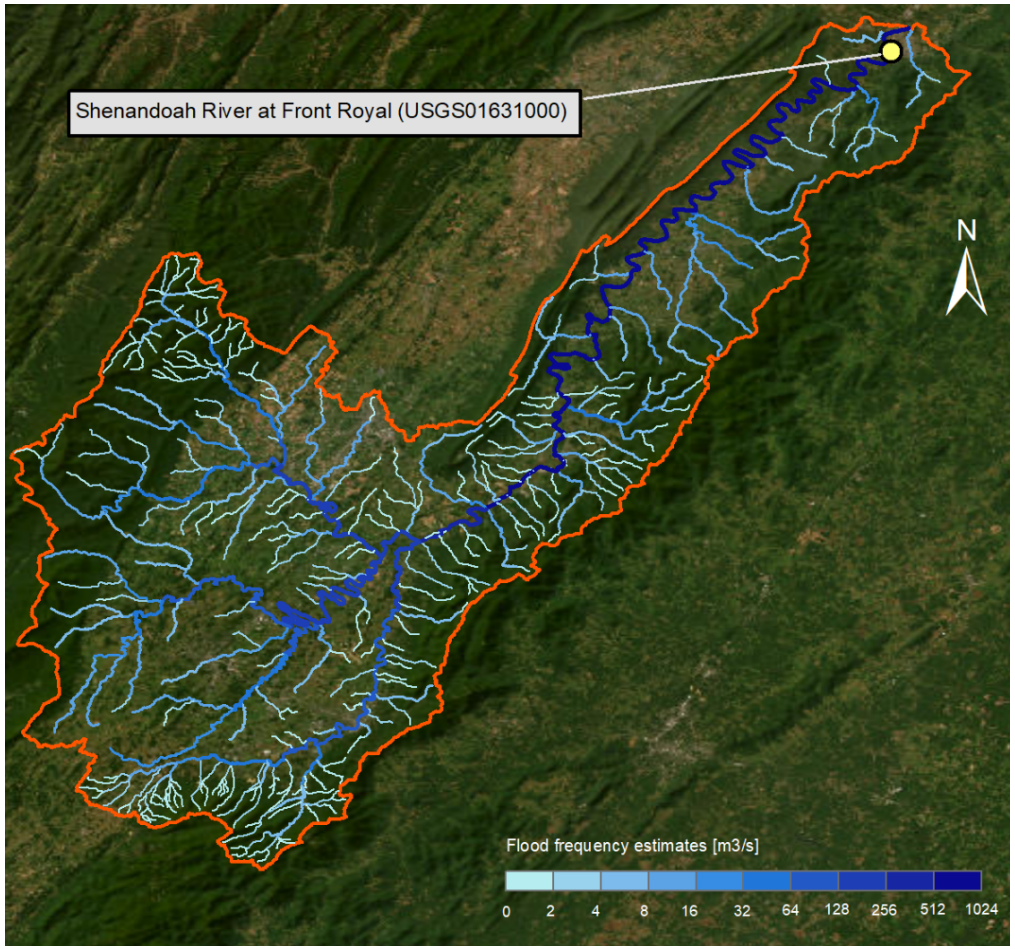
6-member ensemble

Baseline : 1980–2019; Future: 2020–2059 under SSP585 scenario

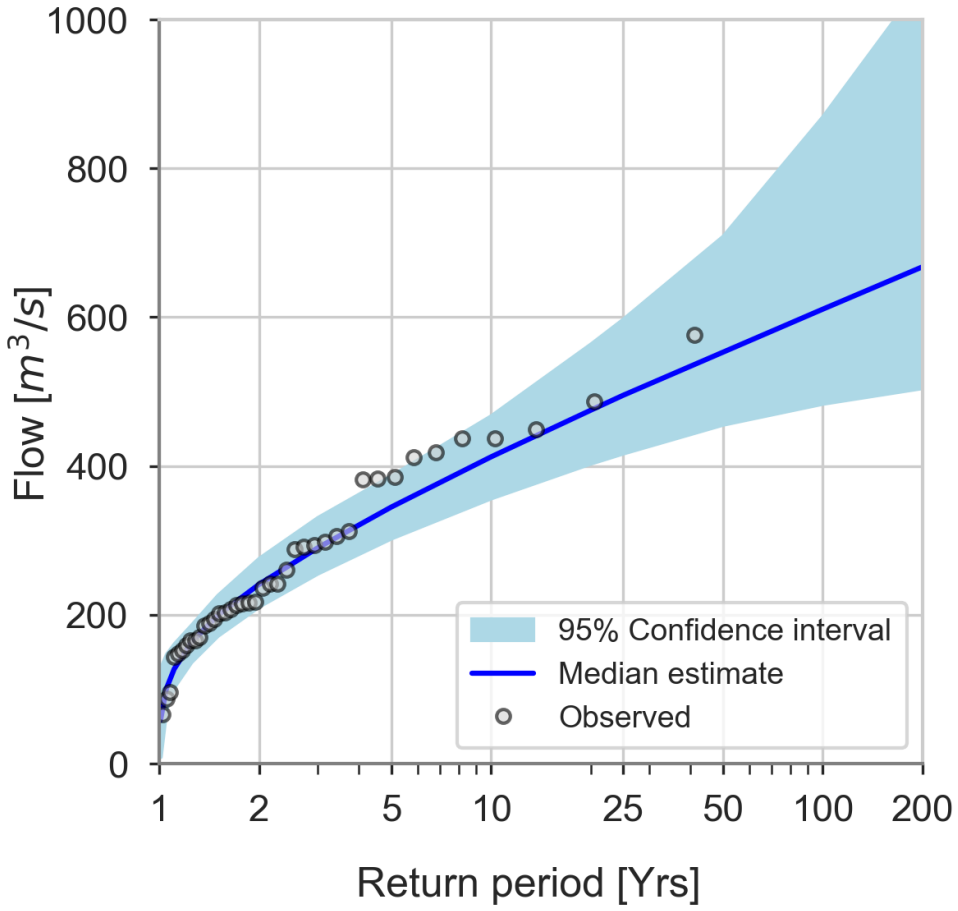
Source : WPTO SECURE Water Act Section 9505 Assessment Project

https://hydrosource.ornl.gov/dataset/9505V3
https://doi.org/https://doi.org/10.2172/1887712

Flood frequency analysis is conducted to estimate the change in projected flow extremes



Shenandoah Valley (HUC02070005)



Demonstration with a GEV distribution

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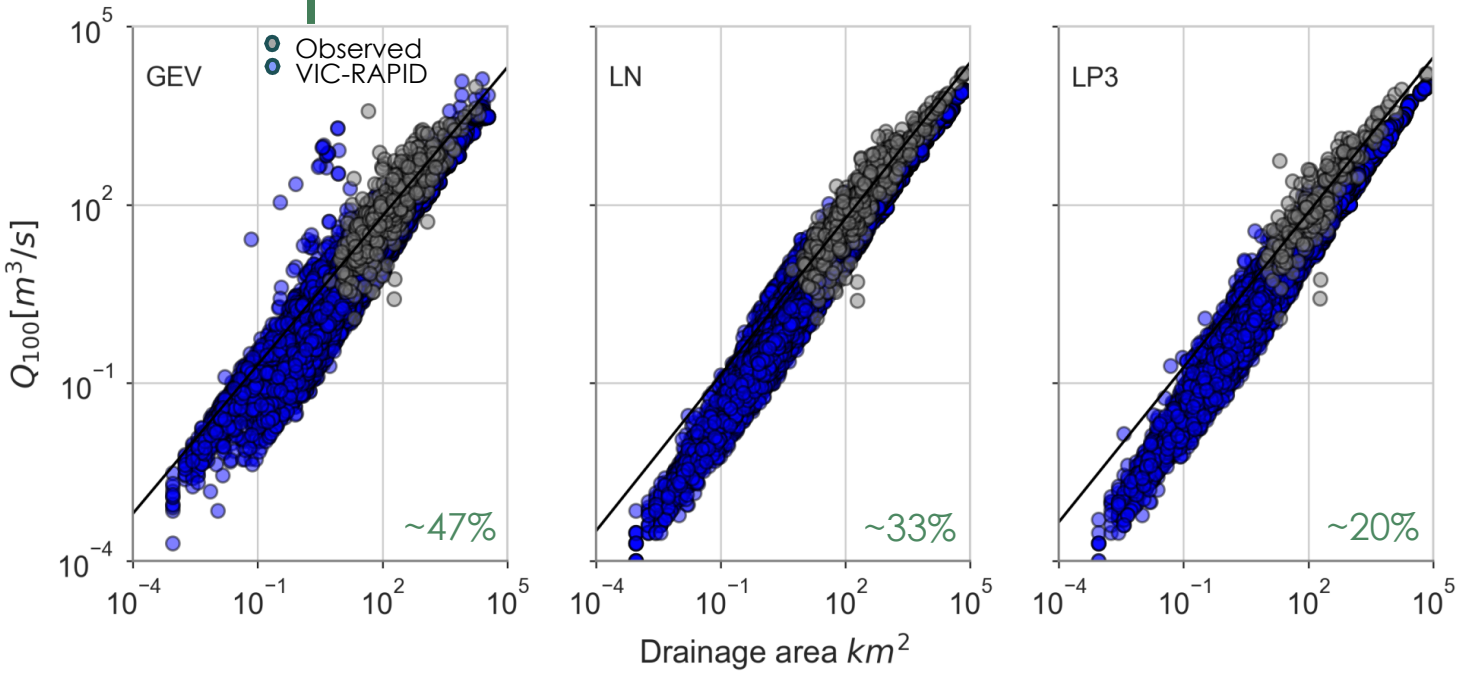
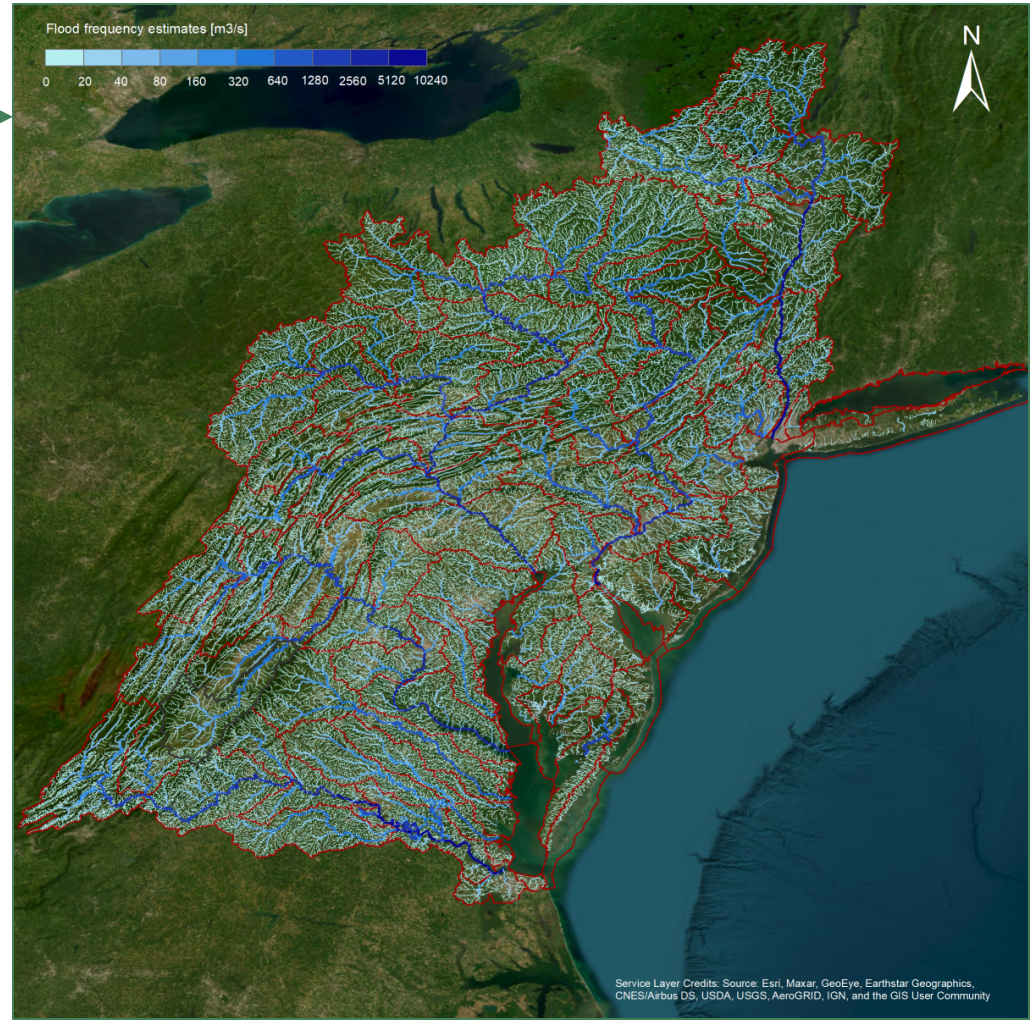
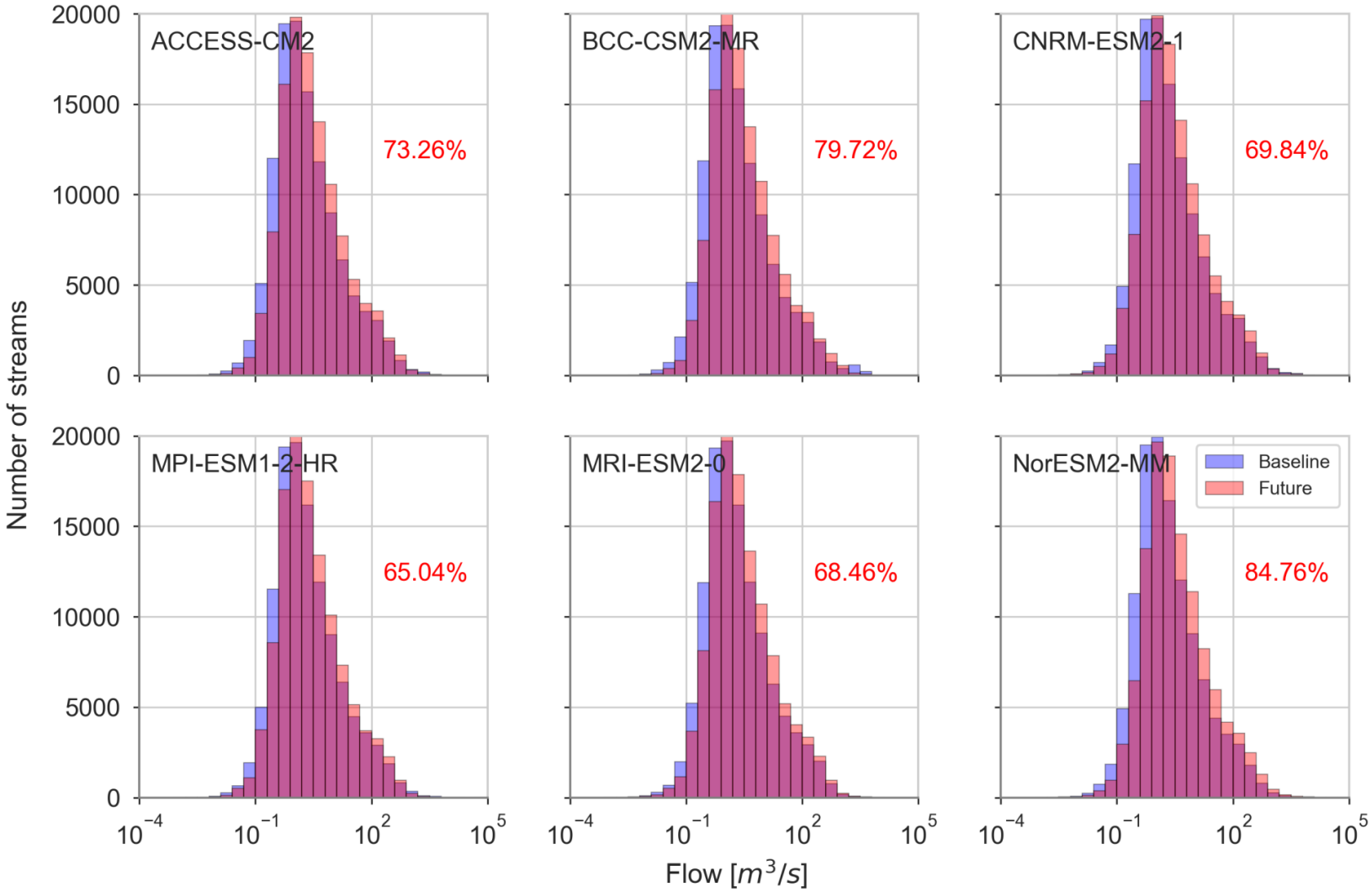
GEV distribution-based flood frequency estimates are used for inundation mapping in the region





- ~121,000 NHDPlusV2 river reaches across the Mid-Atlantic region

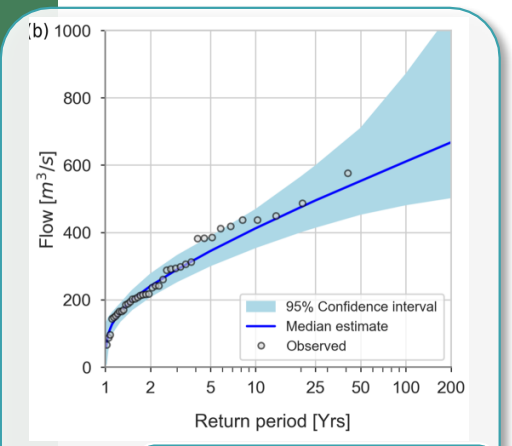
A large majority of stream reaches show increased flood frequency estimates across climate models



- Four return period (25, 50, 100, 200) flood estimates for six climate models at every river reach

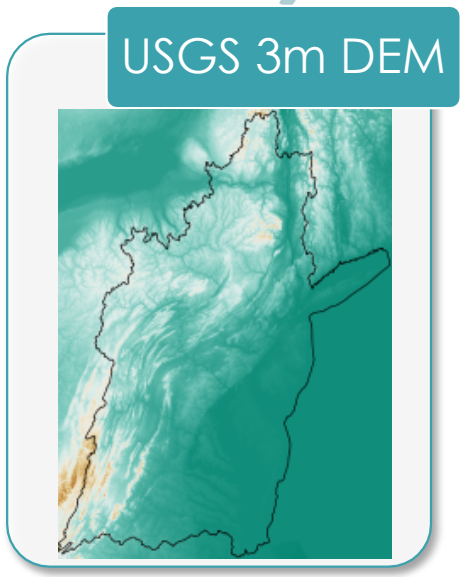
NOAA-NWC FIM3 workflow with the HAND approach at the core produces flood inundation maps

- 4 return periods (25, 50, 100, 200)
- ~121,000 river reaches
- Baseline (1980-2019) and future (2020-2059)



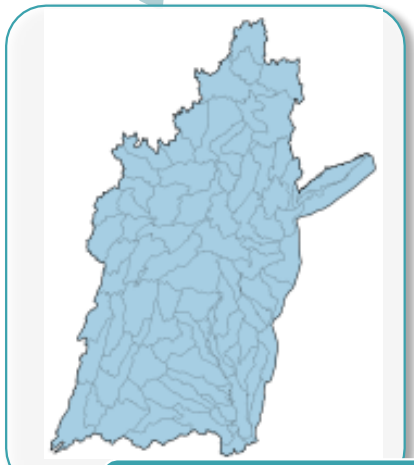
Flood frequency estimates

- 63,784 tiles
- 63874 billion cells
- Size: 155 GB



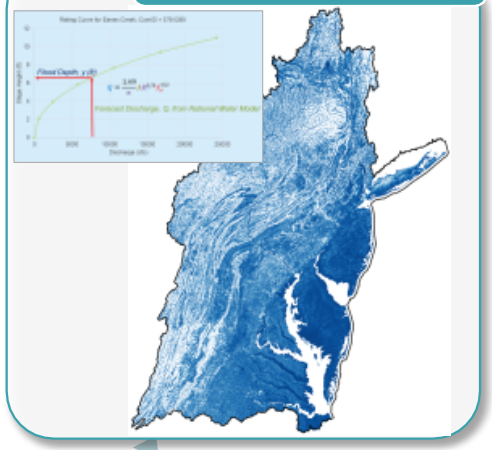
USGS 3m DEM

- Uses USGS 3m DEM
- NWM hydrofabric: NOAA NWC FIM3 workflow



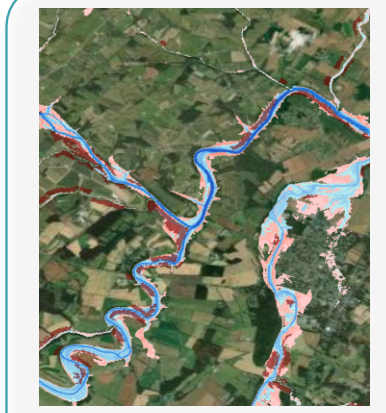
HUC8 hydrofabric

- Healed HAND raster
- Synthetic rating curve
- Size: 133 GB (HAND raster: 106GB)



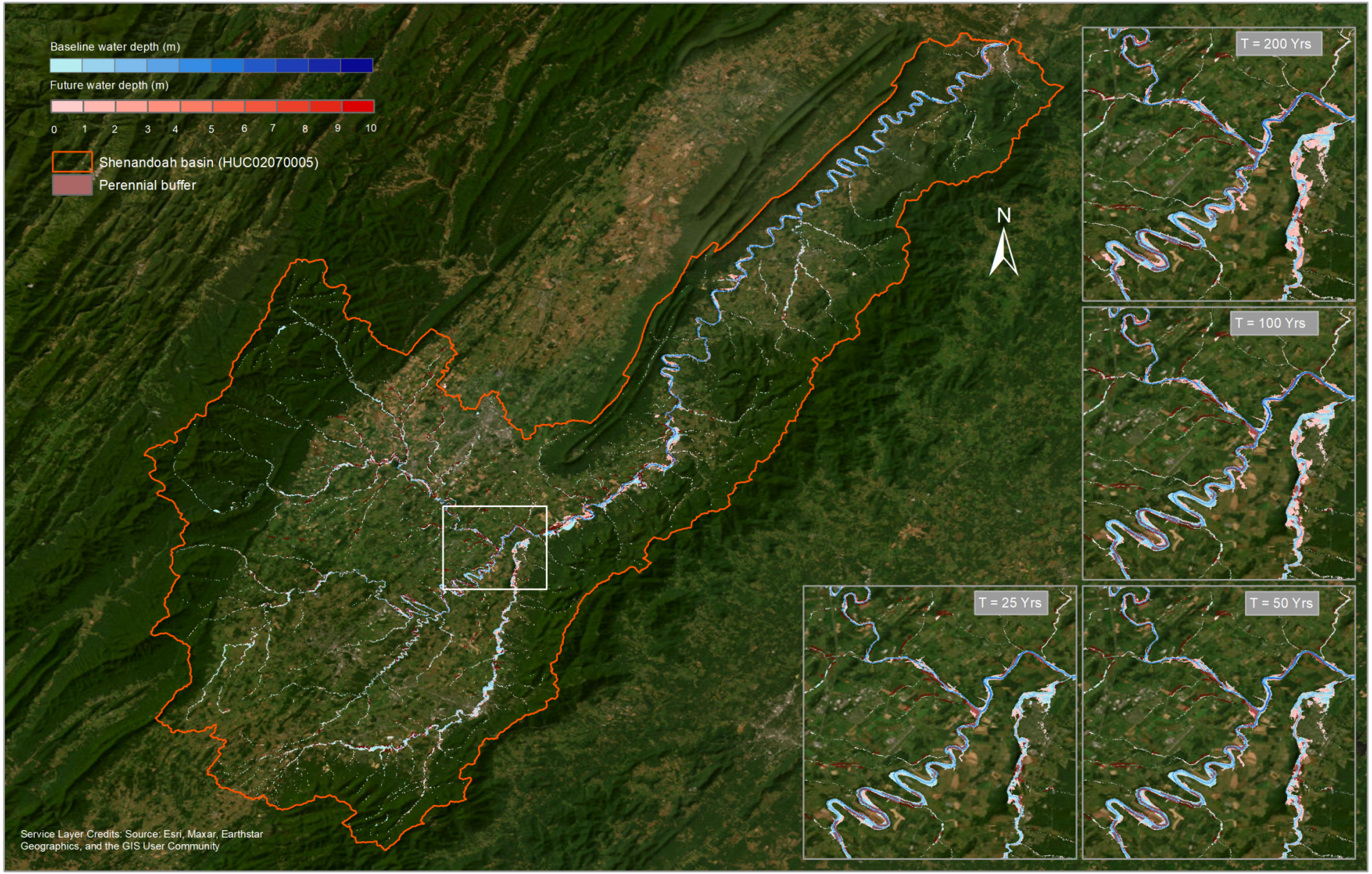
3m HAND raster

- Flood extent raster (46GB)
- Flood extent polygon (171 GB)
- Flood depth raster (379 GB)
- Number of maps: 84 x 2 x 6 x 4 = 4032



Flood inundation maps

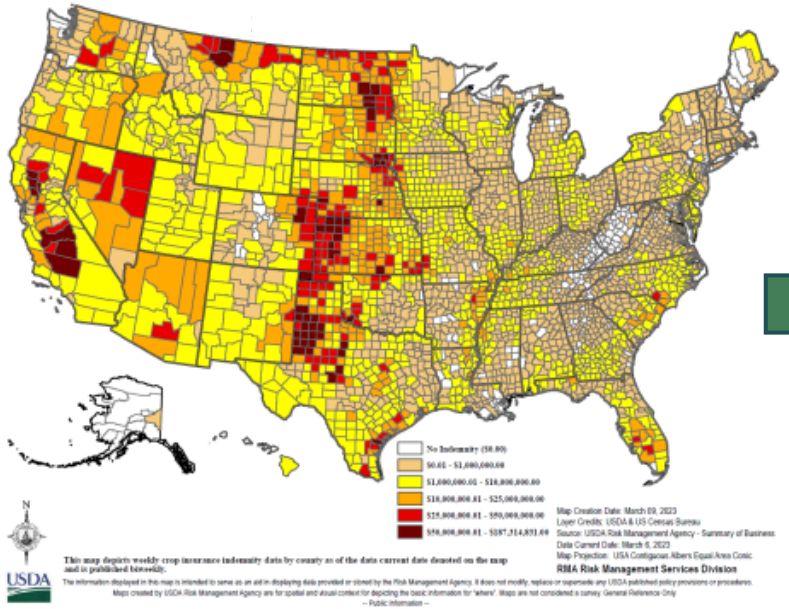
Climate models generally show increased flood inundation extents for the mid-term future

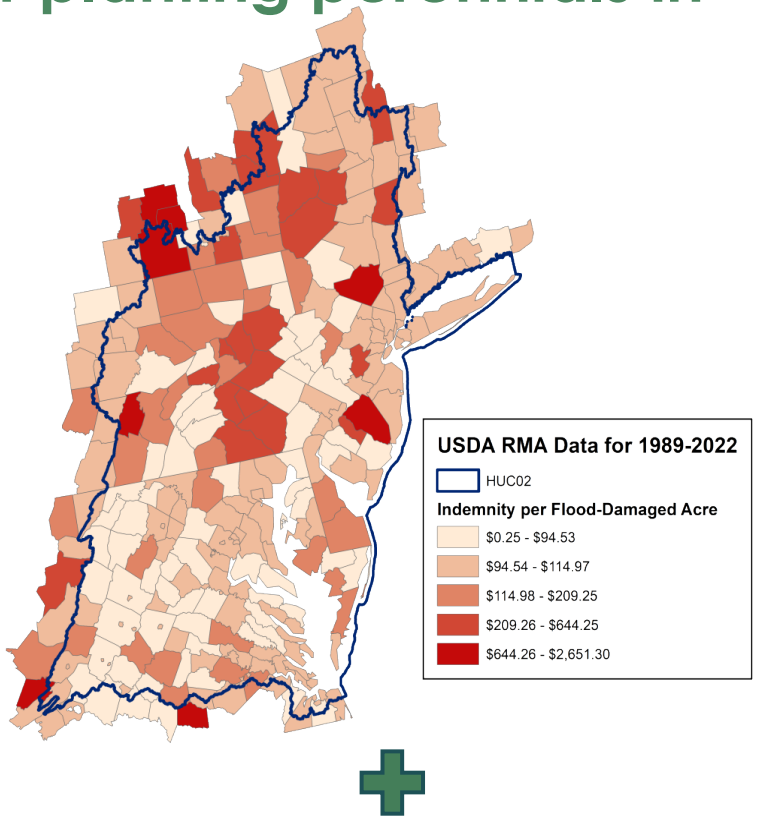


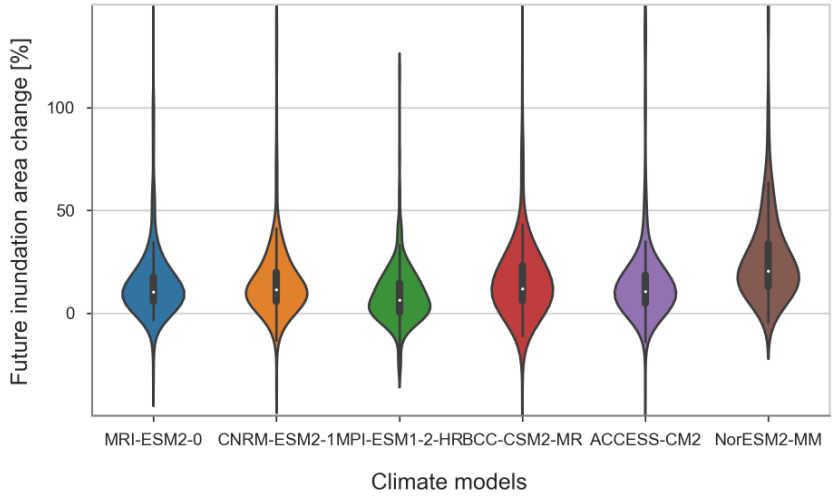
Crop insurance modeling can support assessments for planting perennials in identified flood-prone areas

Crop insurance modeling

- USDA Risk Management Agency (RMA) publishes US crop indemnity data at county scale biweekly
- Indemnity data for 34 years (1989-2022)
- Computed average indemnity payments using total lost acres over 34 years
- Insurance cost per acre assumed to remain the same in future







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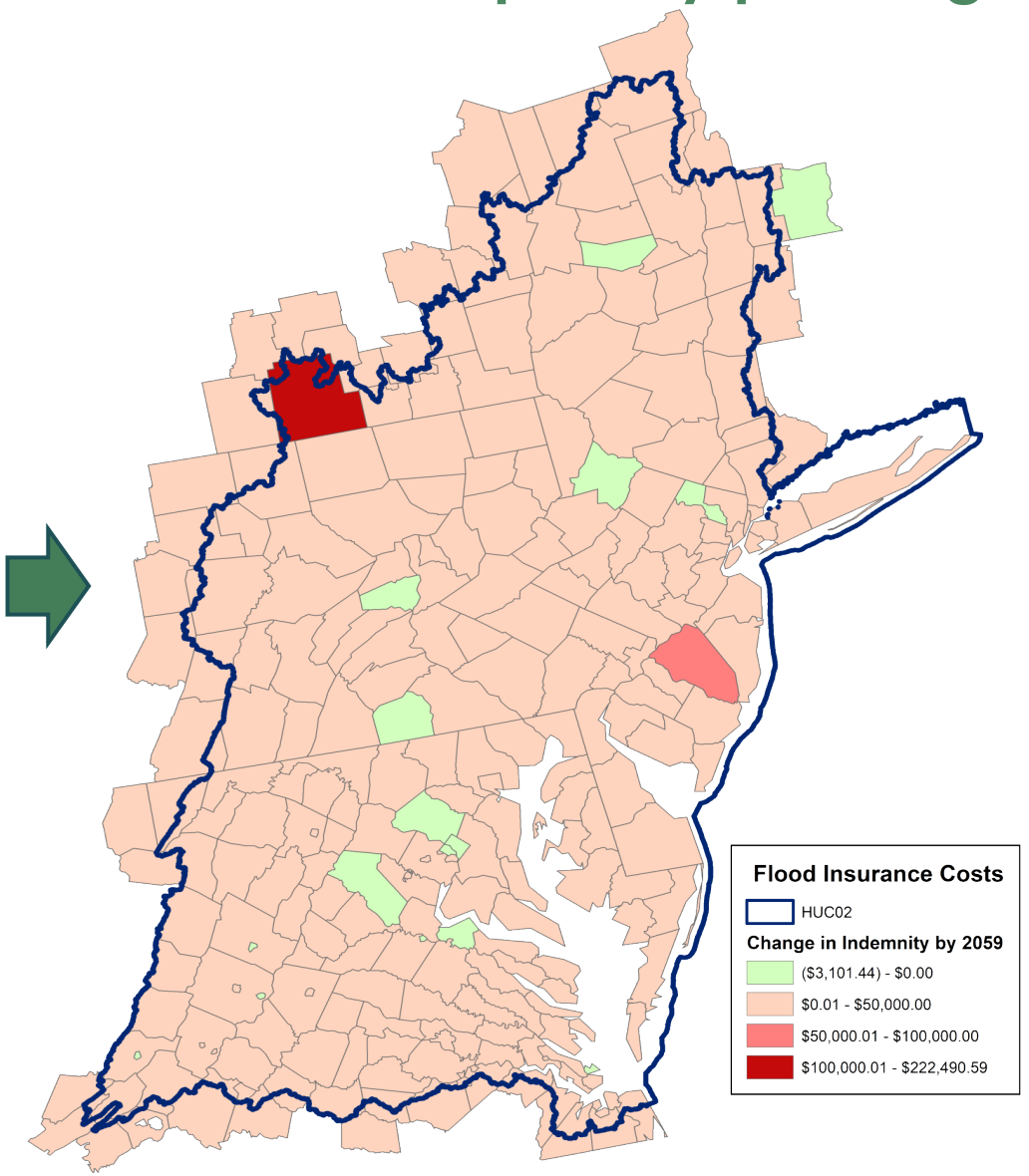
The framework allows estimating the avoided indemnities reaped by planting partially harvested buffers

Initial estimates based on the ACCESS-CM2 model outputs:

- Quantification of the avoided crop insurance cost from growing perennial biomass crops
- Average annual indemnity cost of $48,677 / county will increase to $53,532.
- Projected savings will exceed $50,000/year in two of 48 counties; $1.253 million/year across the region



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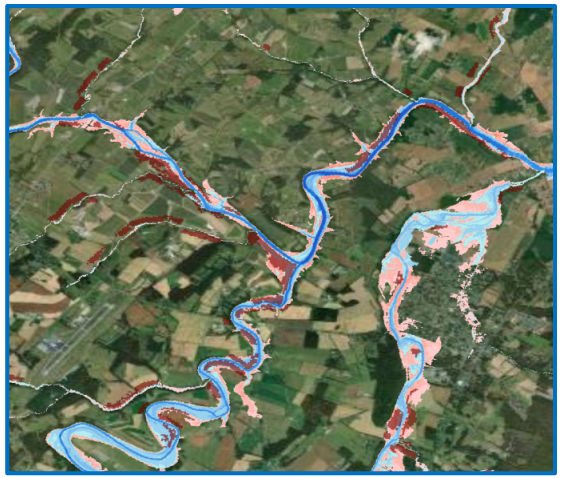
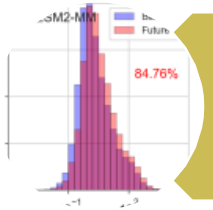
Takeaways

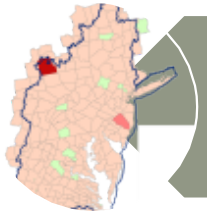


The hierarchical modeling framework can support the assessment of flood-resilient climate adaptation strategies.



A large majority of stream reaches across climate models show increased flood frequency estimates relative to baseline.

Climate models generally show increased flood inundation extents for the mid-term future.



Planting perennials in flood-prone areas can enhance flood resiliency and avoid annual crop loss insurance claims.

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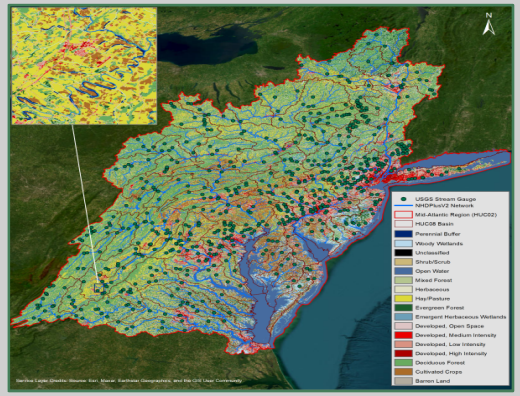

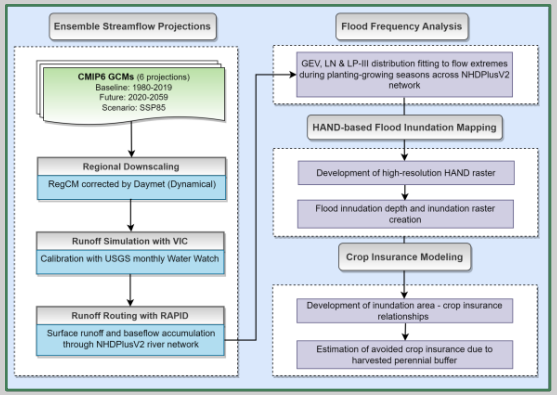

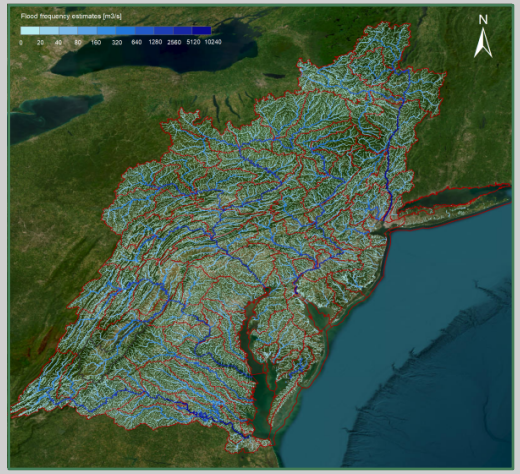

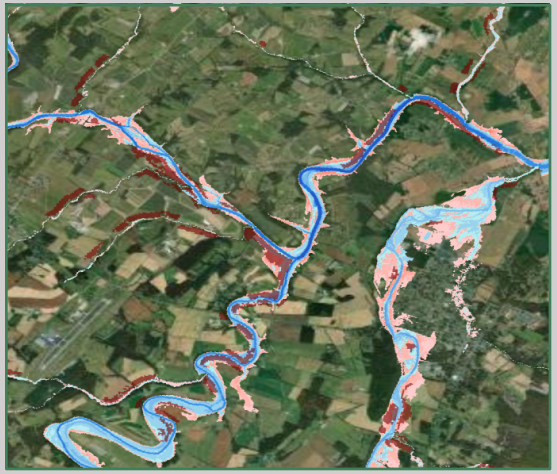

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Thank You!