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Capturing Compound Flooding

For Operational and Research Settings

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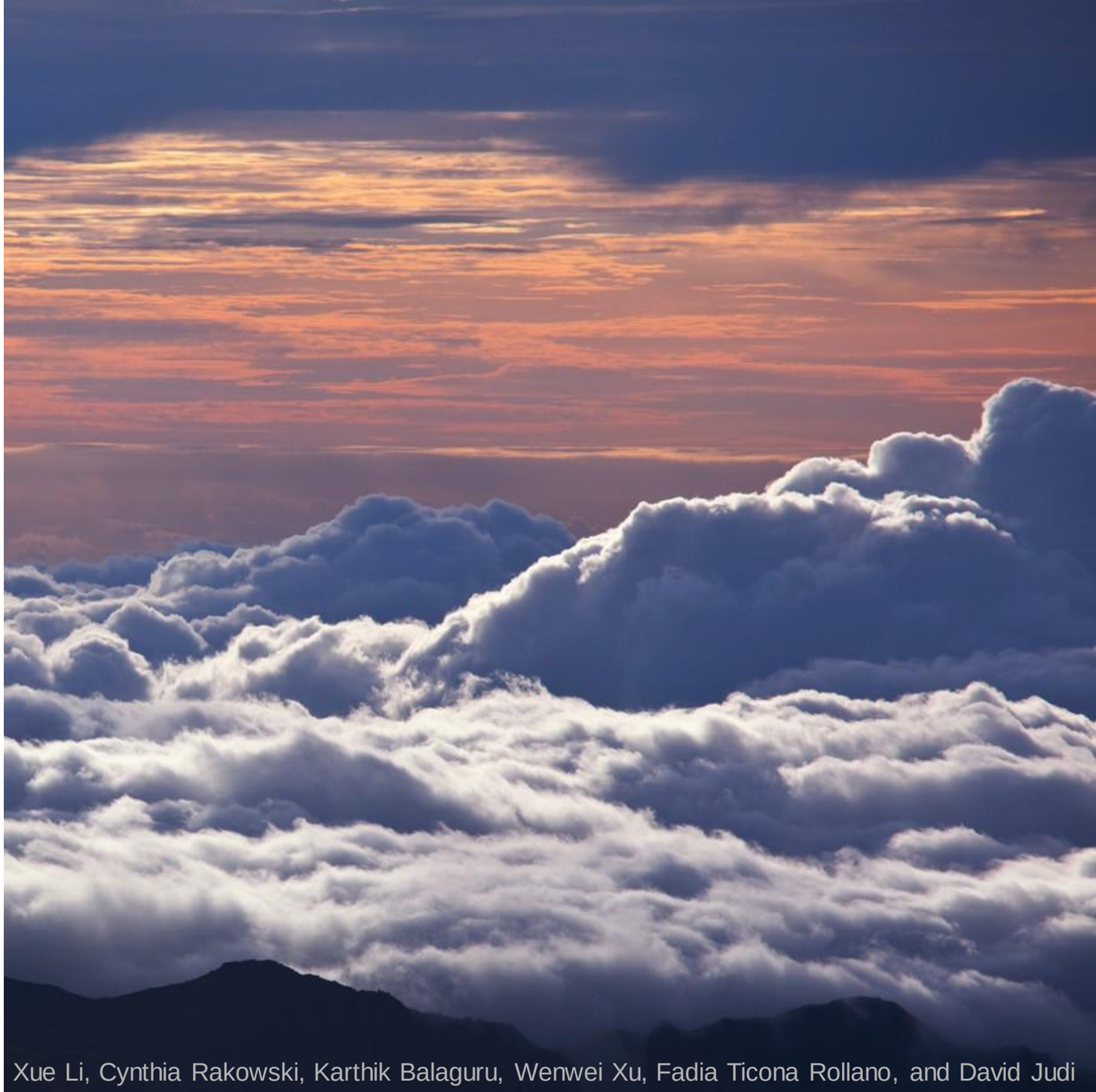


Xue Li, Cynthia Rakowski, Karthik Balaguru, Wenwei Xu, Fadia Ticona Rollano, and David Judi

Outline

- Background
  - PNNL flood modeling capabilities
- Compound flooding simulation pipeline
- Use cases
  - Operational setting
  - Research setting
- Next steps

Background

- Flood is amongst the most prevalent natural disasters resulting in billions of dollars in damage each year.

- To capture the true impact and gain a full picture of flood risk within the coastal zone, all components of flooding (compound flooding) must be considered simultaneously.

- Risks related to compound flooding are expected to change as a result of increasing sea levels and changes in the frequency and intensity of extreme weather events.

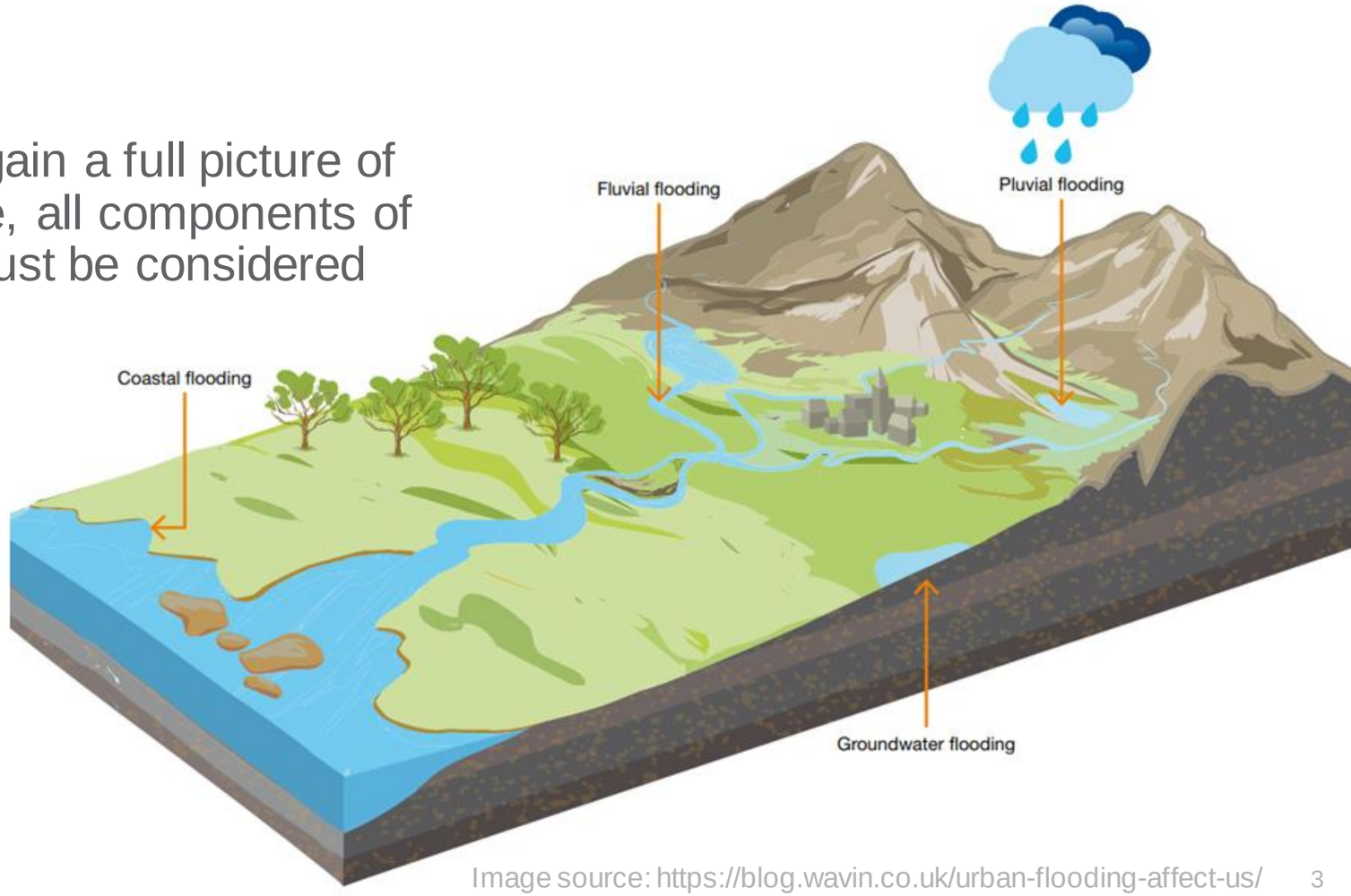
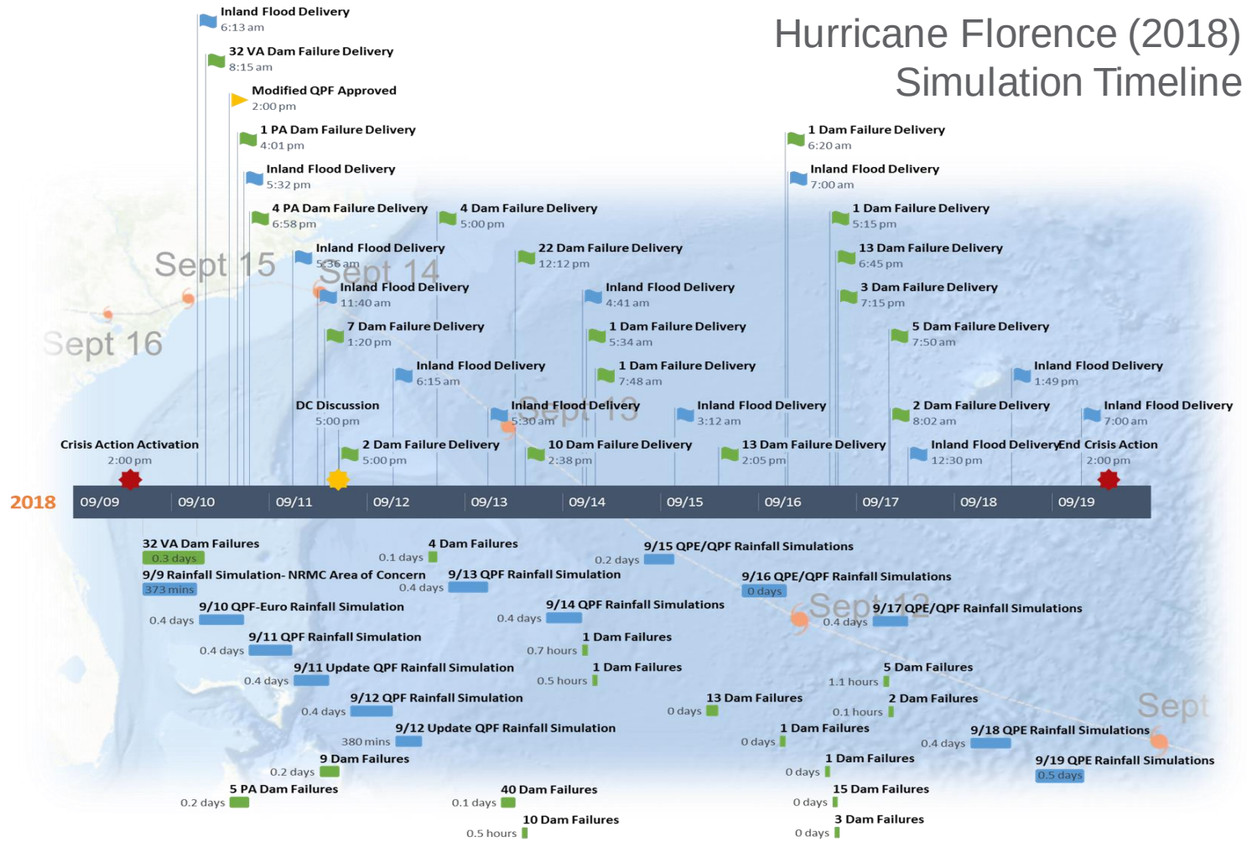


Image source: https://blog.wavin.co.uk/urban-flooding-affect-us/

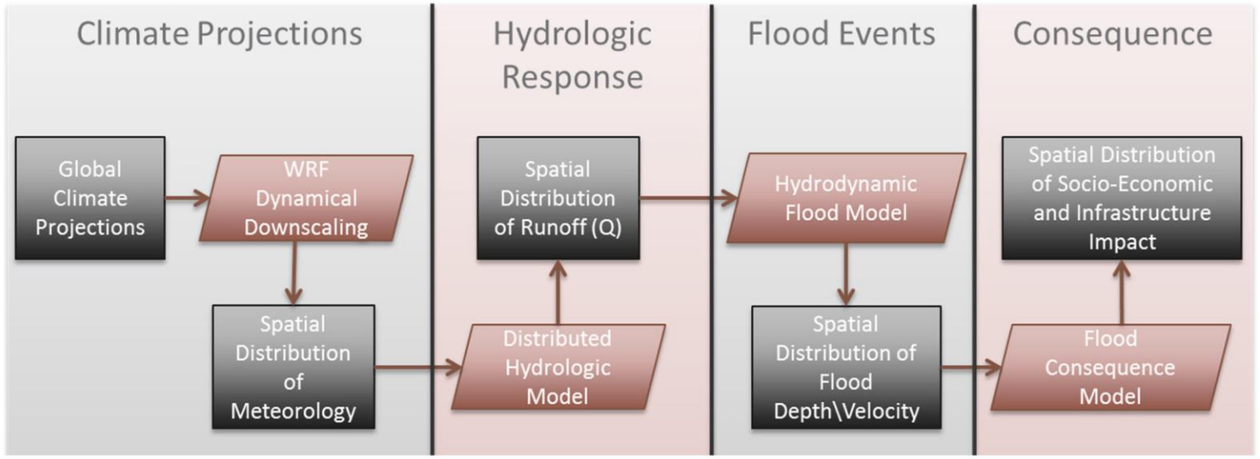
Background

- PNNL flood modeling capabilities
  - Rapid Infrastructure Flood Tool (RIFT)
  - Physics-based 2D hydrodynamic model, state-of-the-art numerical techniques, and computing resources
- Operational use
  - RIFT has been utilized to enhance situational awareness in the emergency response community for over 15 years
  - Provide spatial awareness of flood hazards within minutes to hours
  - Extreme precipitation, dam failure, spring snowmelt, etc.
- Research use
  - RIFT usage has been extended to research contexts exploring flood consequences under different climate conditions

Hurricane Florence (2018) Simulation Timeline

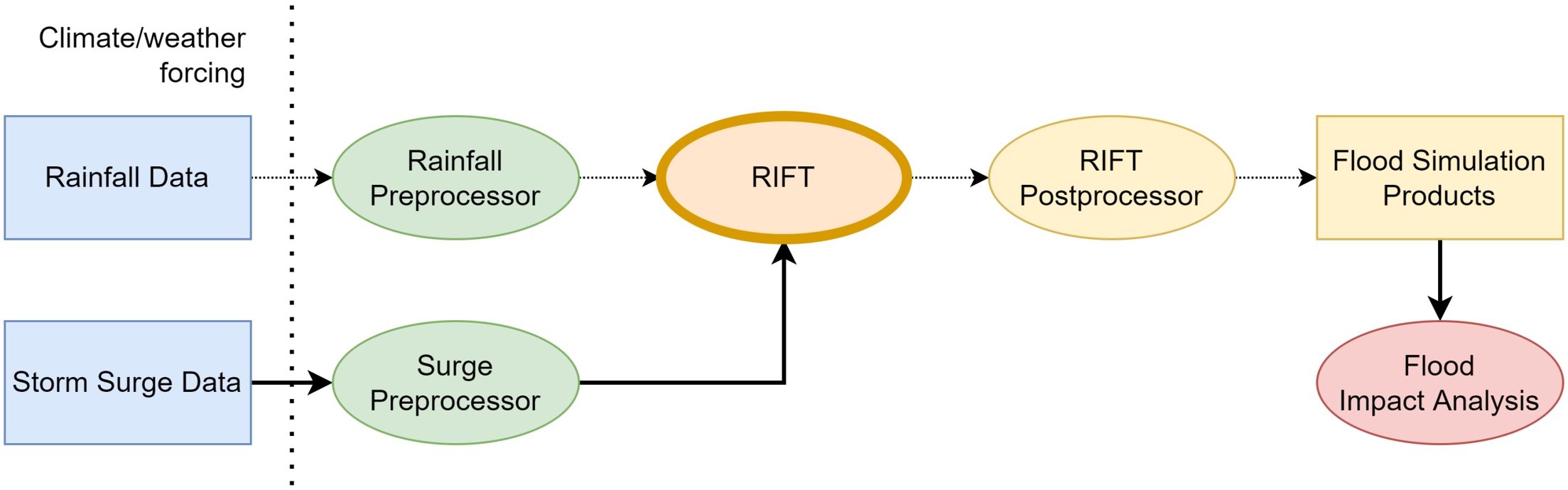


Flood impact estimation framework for future climate (Judi et al. 2018)



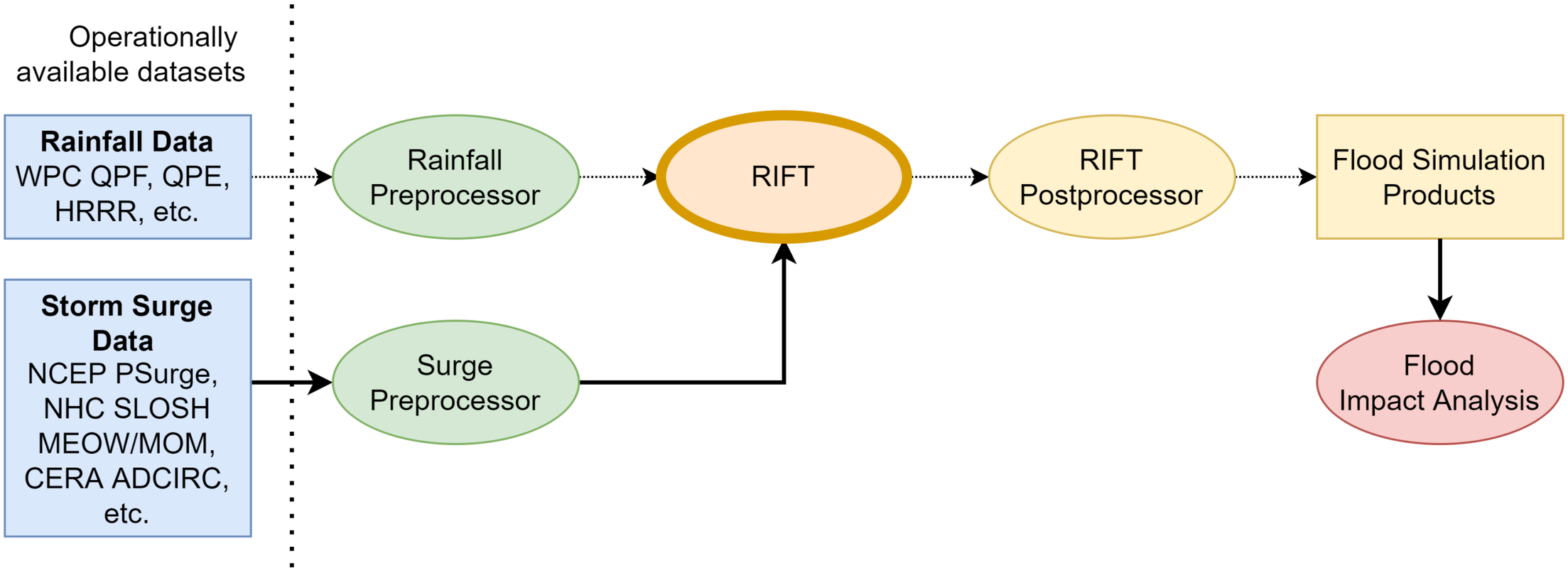
Judi, D., Rakowski, C., Waichler, S., Feng, Y., & Wigmosta, M. (2018). Integrated Modeling Approach for the Development of Climate-Informed, Actionable Information. Water, 10(6), 775. https://doi.org/10.3390/w10060775

Compound flooding - simulation pipeline



- An offline coupling process for storm surge integration was added to the original RIFT flood modeling pipeline implemented in HPC@PNNL
- A new Flood Impact Analysis component was added to further interpret flood simulation outputs (e.g., population at risk)
- Pipeline tools were implemented in Python

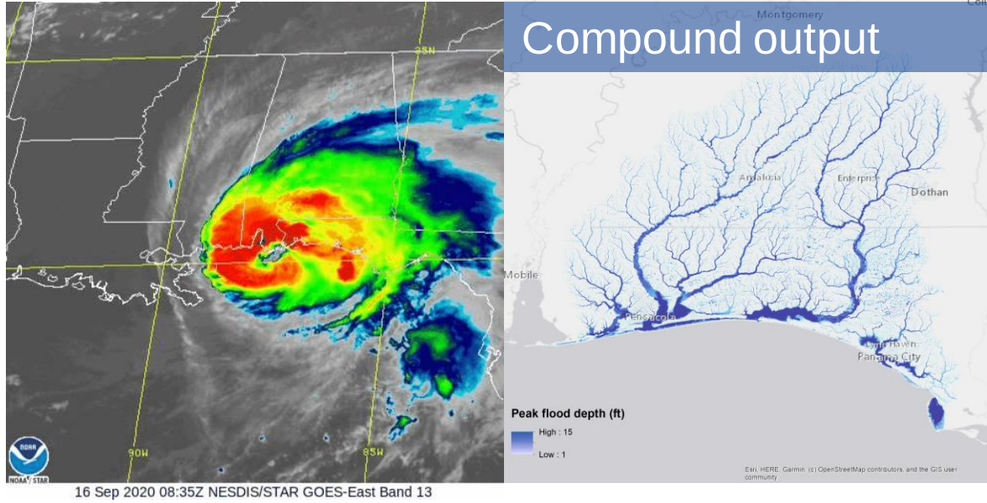
Use case - operational

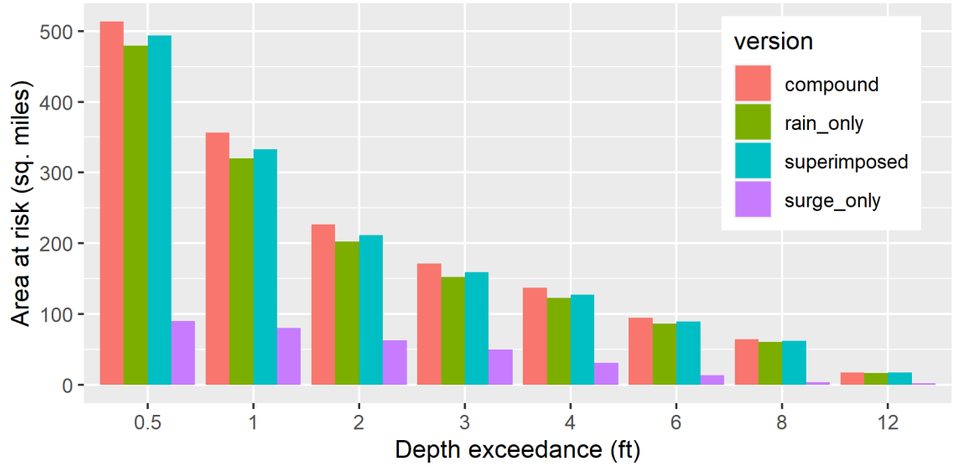


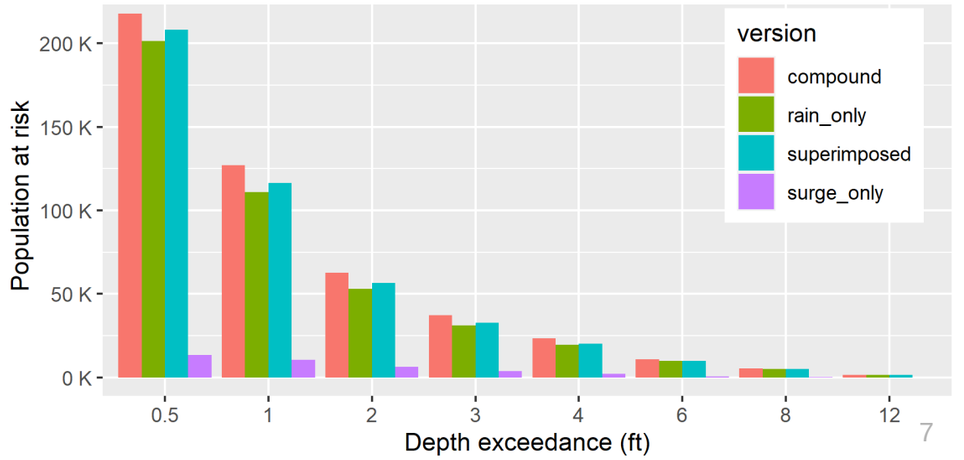
- Twice-a-day flood forecasting in medium resolution before/during extreme weather events
  - Capable of covering the whole Gulf or Atlantic coast
- Timely harvest the latest forcing data
- Adding compound flooding options for hurricane season 2022

Use case - operational

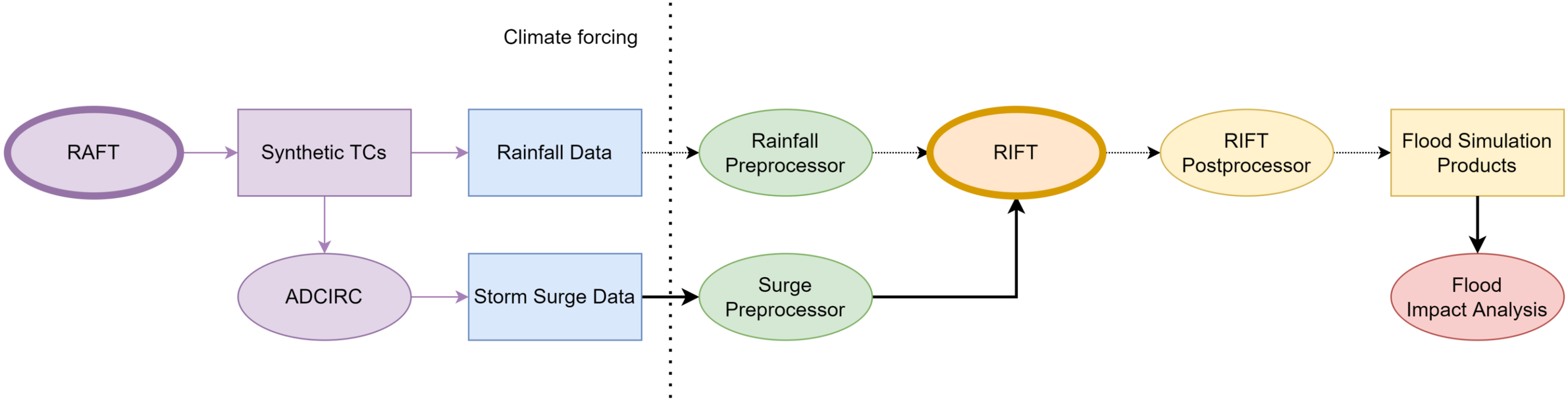
- Example – Hurricane Sally 2020 (retrospective analysis)
  - Surge input - CERA ADCIRC
  - Rainfall input - NCEP Stage IV precipitation estimates
- Four versions
  - Rainfall only, storm surge only, superimposed (maximum of the previous two), and Compound
- Impact analysis
  - Flood impacts summarized by peak flood depth exceedance
  - Estimated population at risk with the LANDSCAN conus_night dataset
- Non-linear outcomes from surge integration
  - Summary figures over coastal watersheds ->







Use case - research



- Research setting –
  - Explore flooding consequences from synthetic tropical cyclones developed under different assumptions for climate baseline (e.g., climate change, sea-level rise)
  - Evaluate changes in flood risk from different flood simulation ensembles

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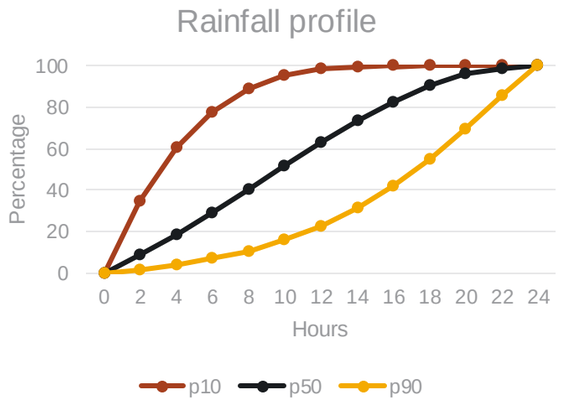
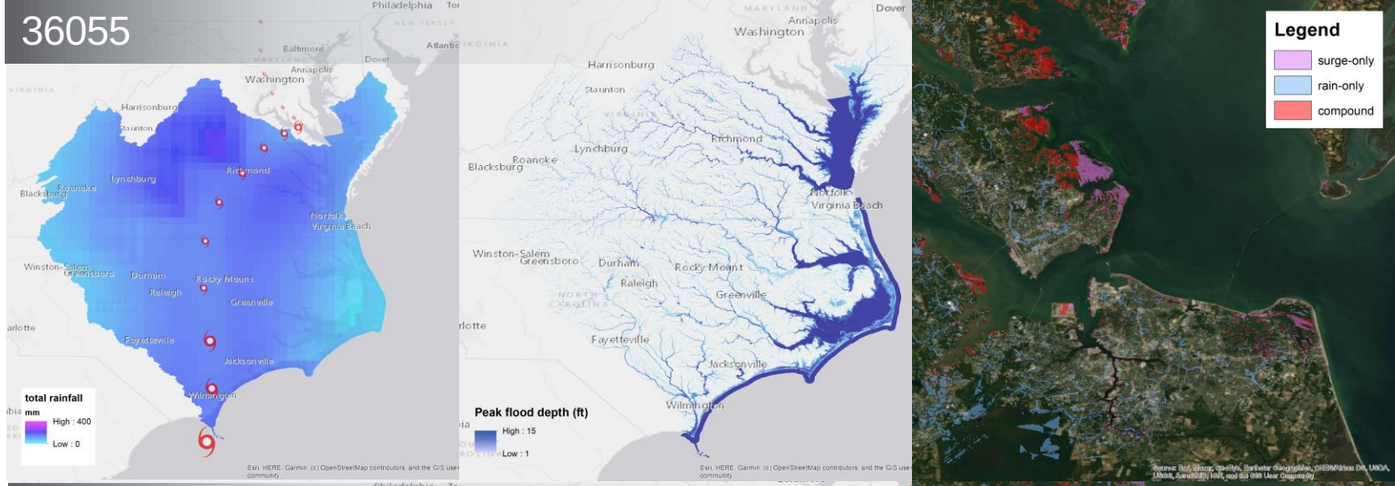
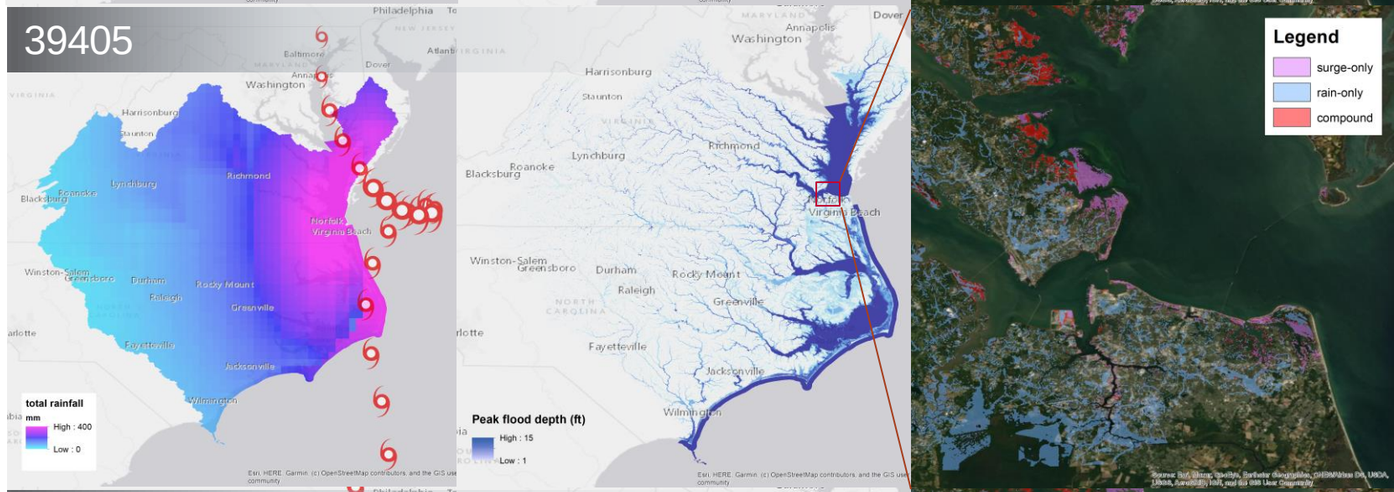
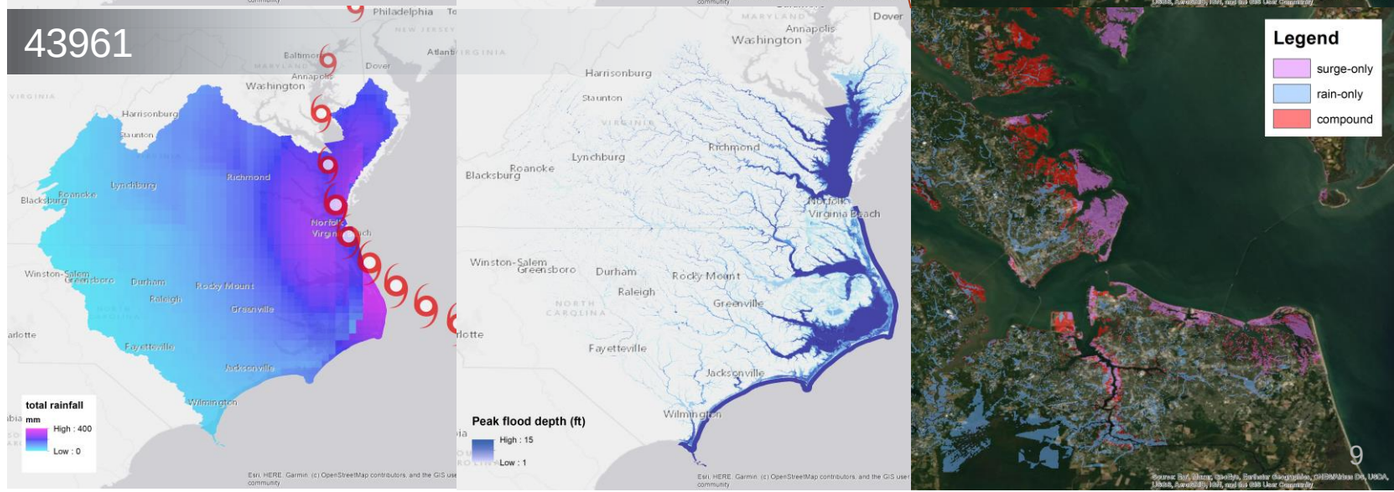


Use case - research

- Example
  - Area of interest
    - ✓ HUC4 0208, 0301, 0302, &0303
  - Three synthetic TC tracks passing AOI
  - Three rainfall temporal profiles
    - ✓ Front-load (p10), uniform (p50), & back-load (p90)
  - Four flood estimate versions
    - ✓ Rainfall only, storm surge only, superimposed & Compound







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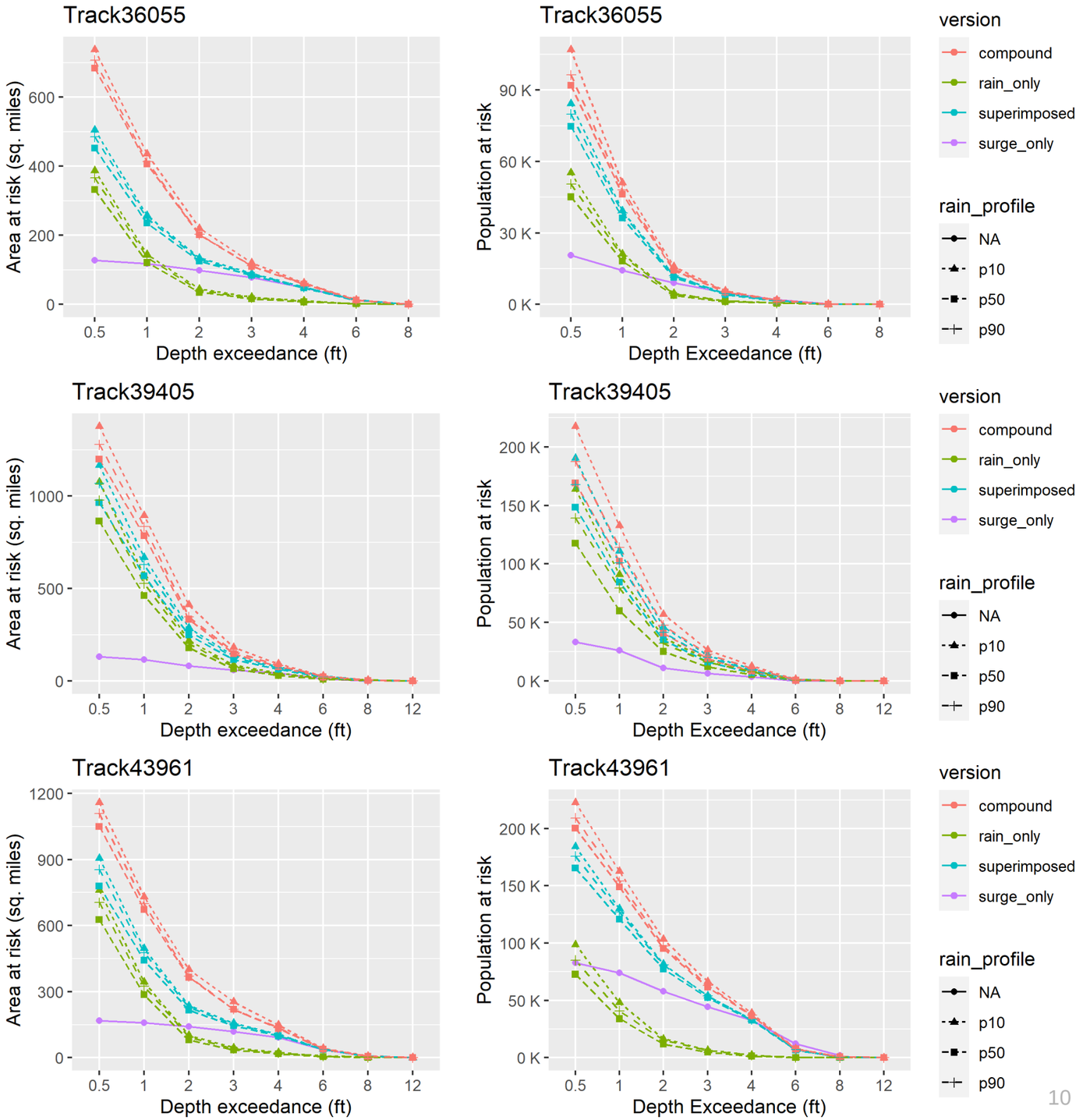
Use case - research

- More areas/population fall into higher impact zones with compound flooding effect simulated by the demonstrated pipeline
- Flood risk characterizations through ensemble simulations



Next steps

- Continue in cloud implementation
  - Overcome constraints from HPC resource availability
  - Core functions already implemented in the Microsoft Azure cloud environment
- Expand toolkits to support growing operational/research needs
  - Add interfaces to more forcing datasets
  - Incorporate additional flood impact assessment functions
  - Enhance surge integration timing options

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Thank you