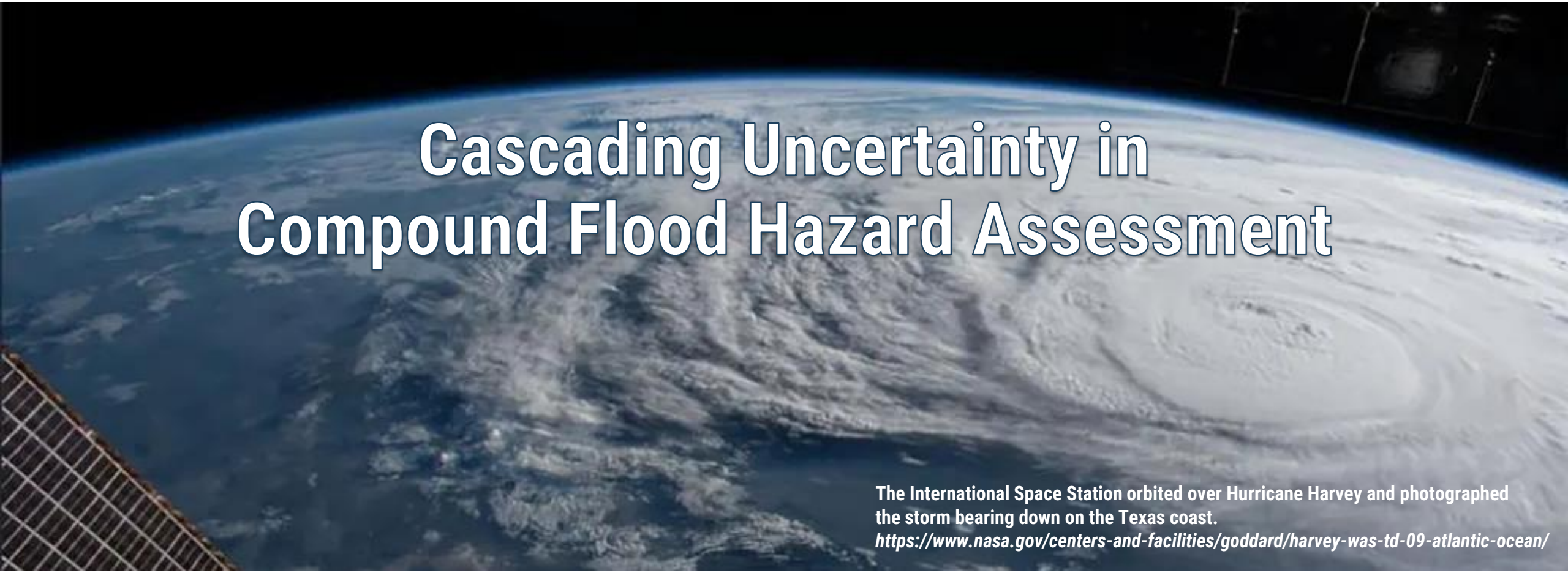
Cascading Uncertainty in Compound Flood Hazard Assessment



The International Space Station orbited over Hurricane Harvey and photographed the storm bearing down on the Texas coast.
https://www.nasa.gov/centers-and-facilities/goddard/harvey-was-td-09-atlantic-ocean/

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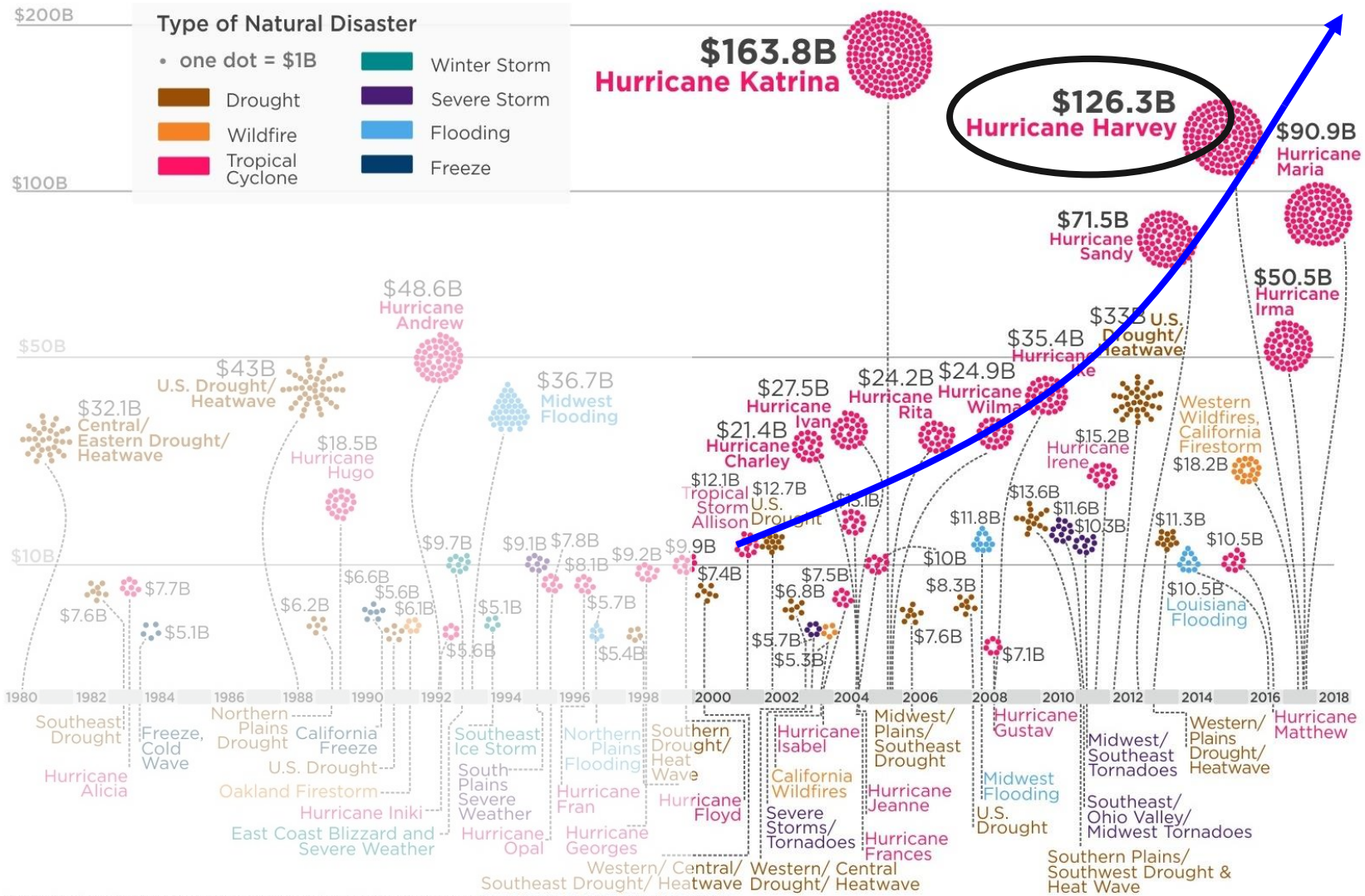
Notre Dame, Indiana
October 02, 2023

Most expensive disasters in the U.S.



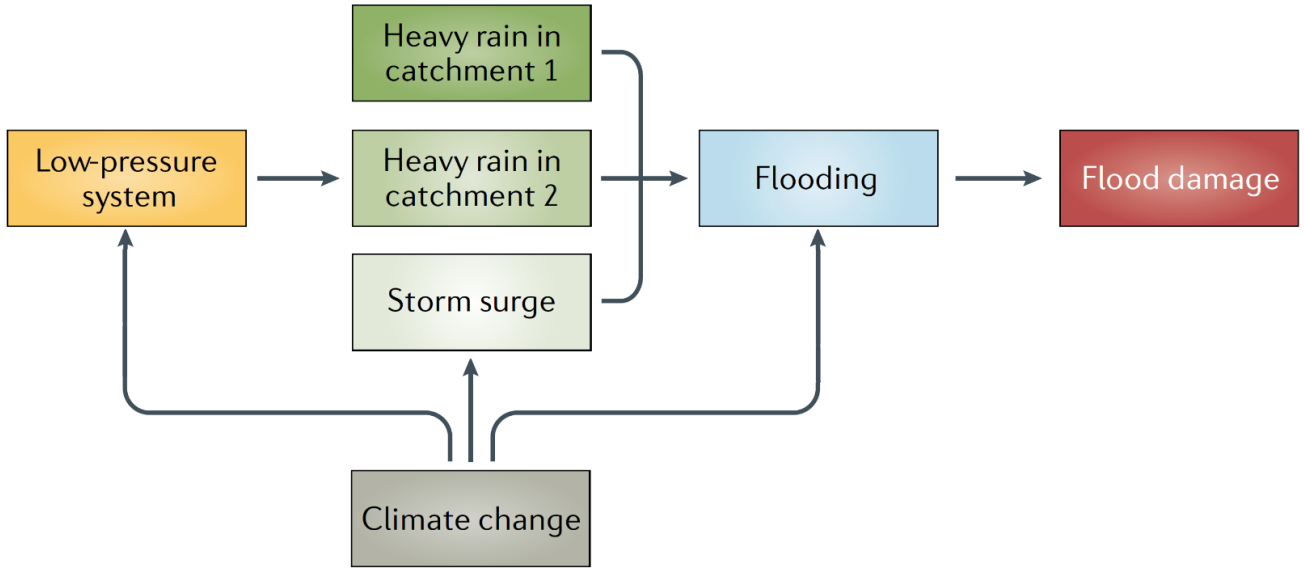
Note: For Visualization purposes we are showing 5 Billion-dollar and above weather and climate disasters

Article & Sources:
https://howmuch.net/articles/most-expensive-naturals-disasters-in-usa
NOAA National Centers for Environmental Information

howmuch.net

Compound flood hazards

- Compound flooding (CF) results from a **combination of multiple drivers or hazards** that can produce larger flood impacts than those from isolated drivers.



Schematic of compound coastal flooding.

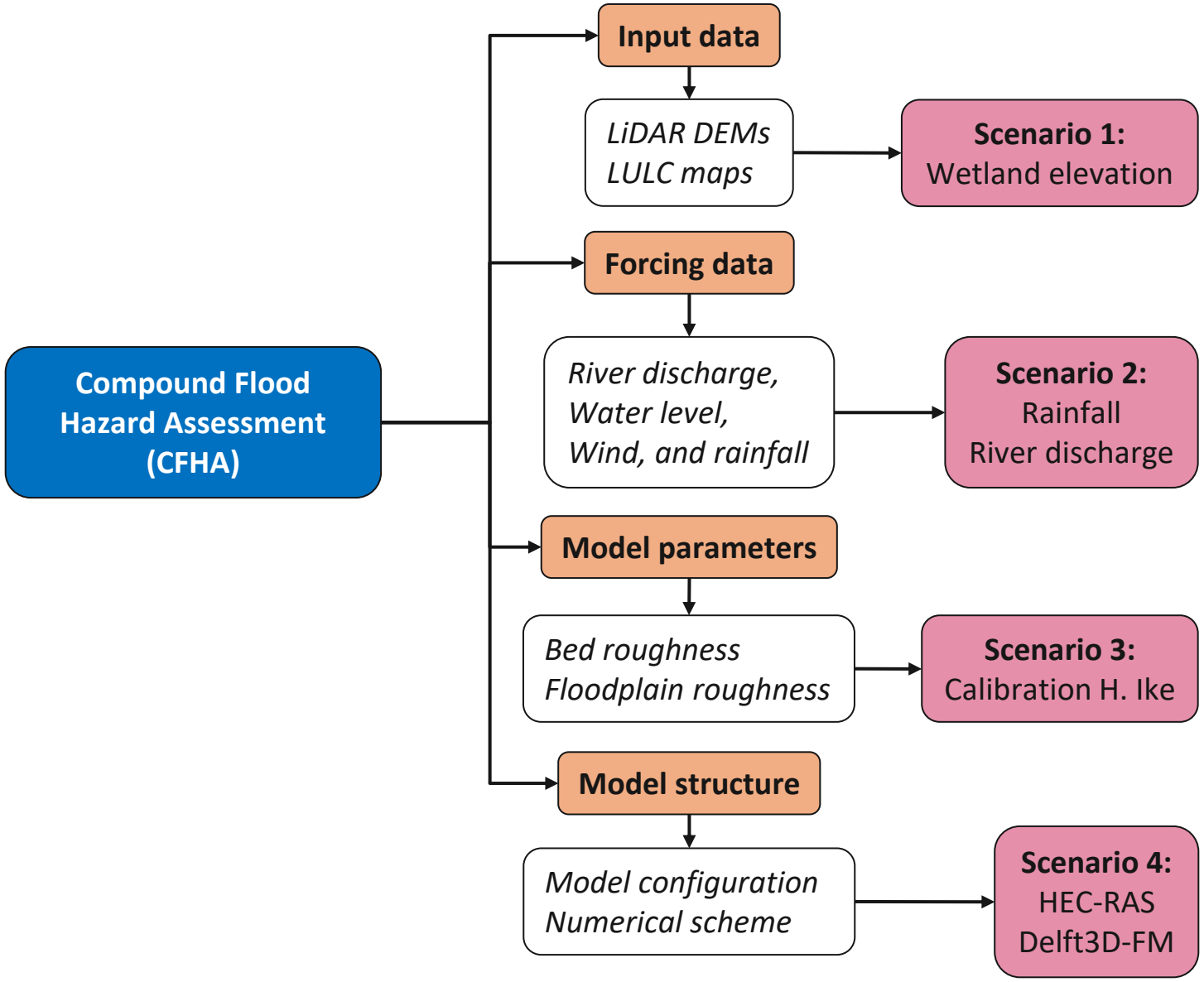
Zscheischler et al., 2020. A typology of compound weather and climate events. https://www.nature.com/articles/s43017-020-0060-z

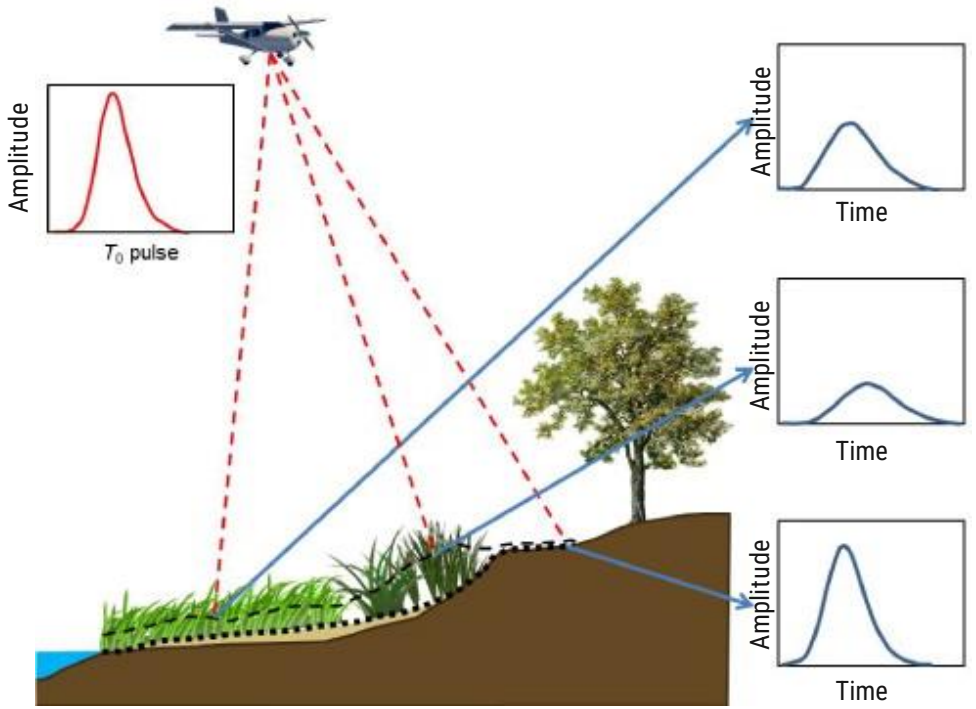
Hurricane Harvey (August 2017)

Compound flooding in Houston, TX.

Video source: JH photography.
https://www.youtube.com/watch?v=zva7Hjg2xvY&ab_channel=JHPhotography

Sources of uncertainty



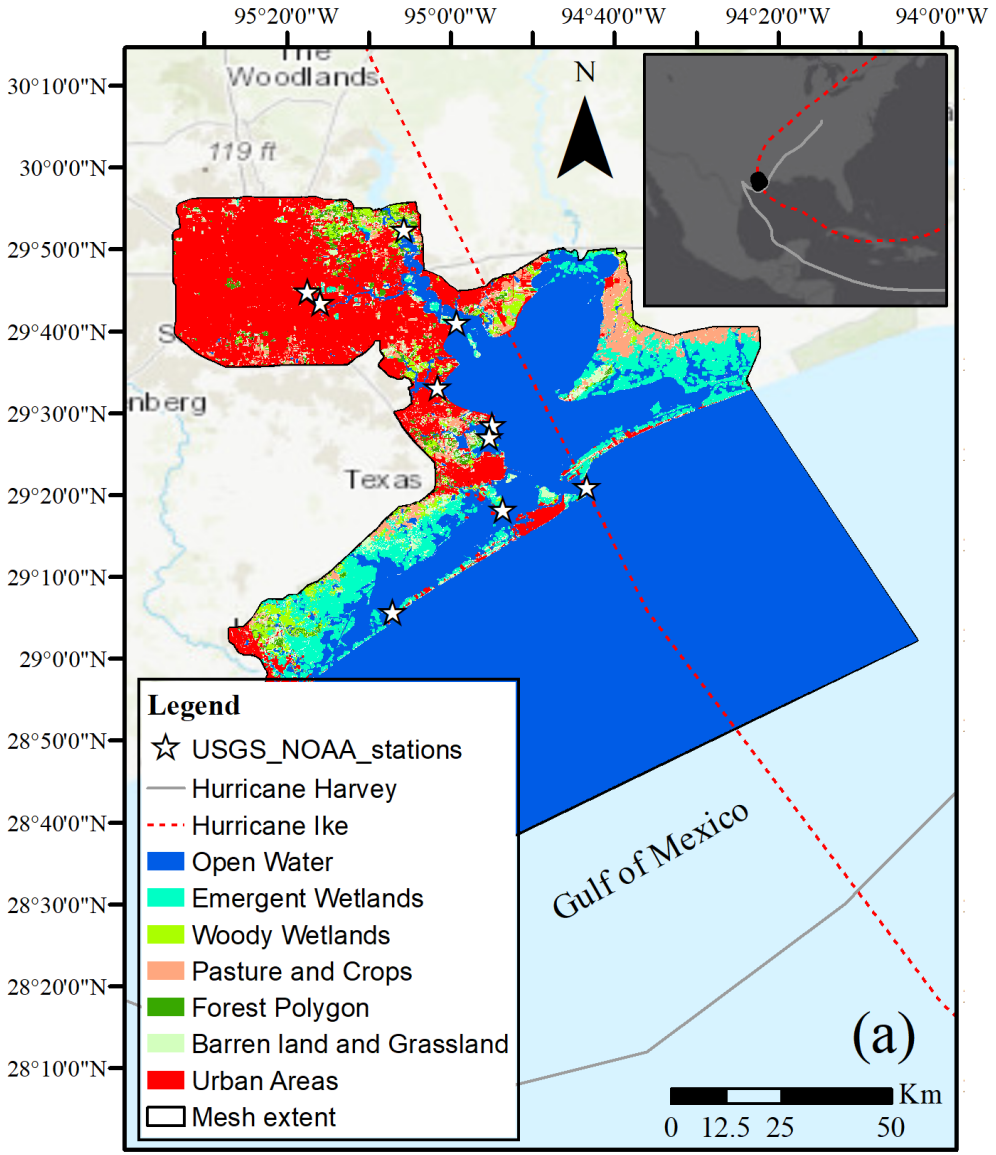


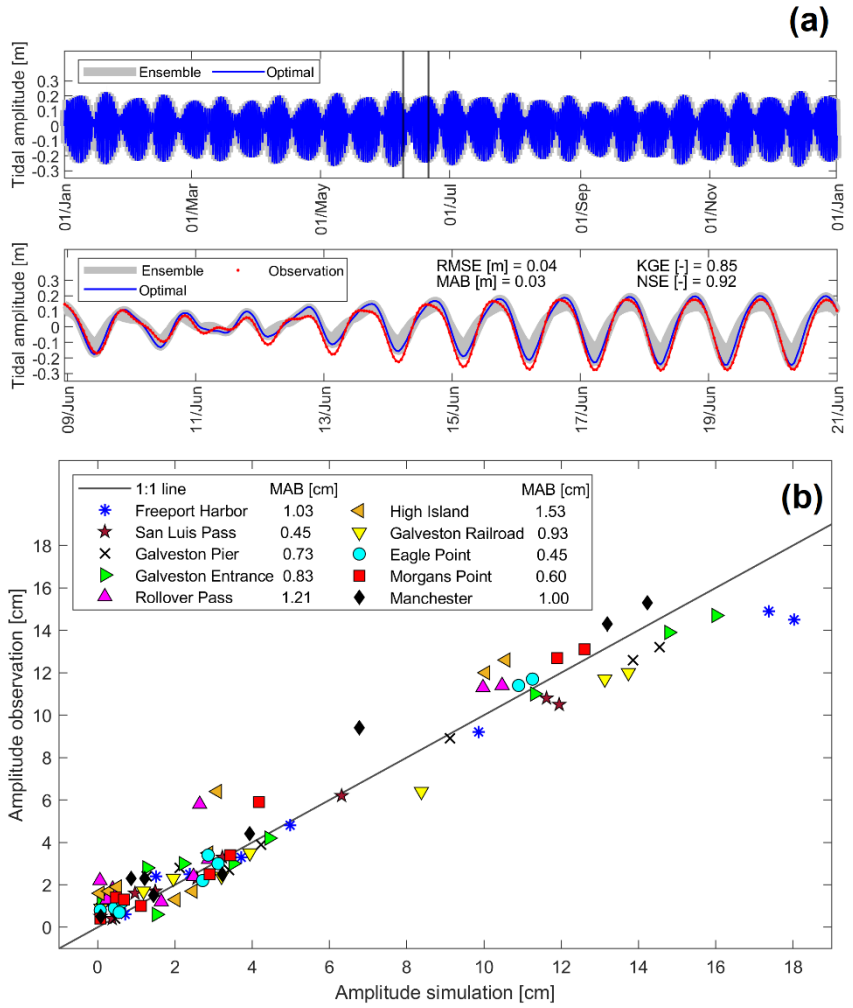
LiDAR flight over coastal wetlands.

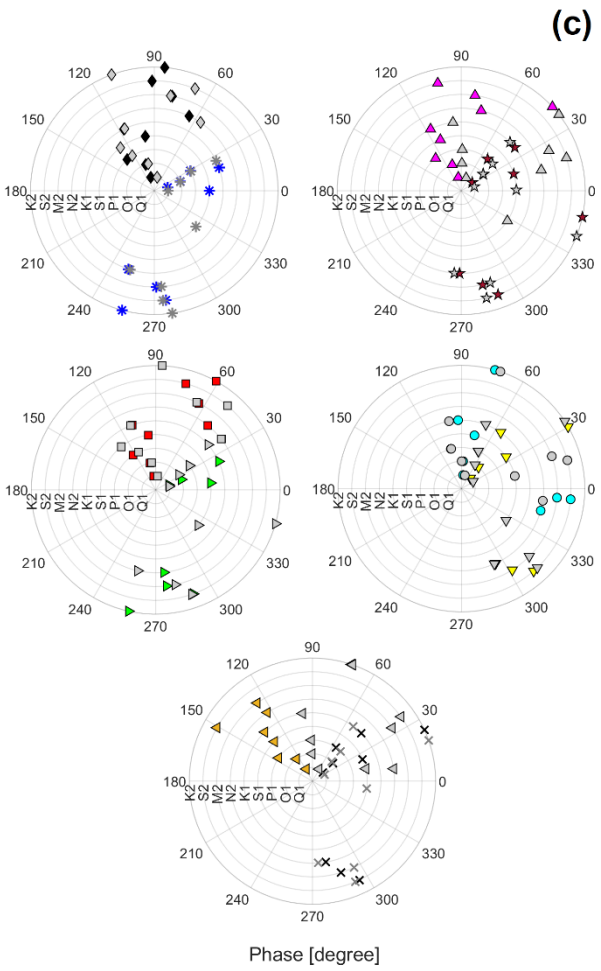
Rogers et al., 2016. https://doi.org/10.2112/SI76-010

Holmquist and Windham-Myers, 2021. A Conterminous USA-Scale Map of Relative Tidal Marsh Elevation. https://doi.org/10.1007/s12237-021-01027-9

Model calibration: tidal propagation

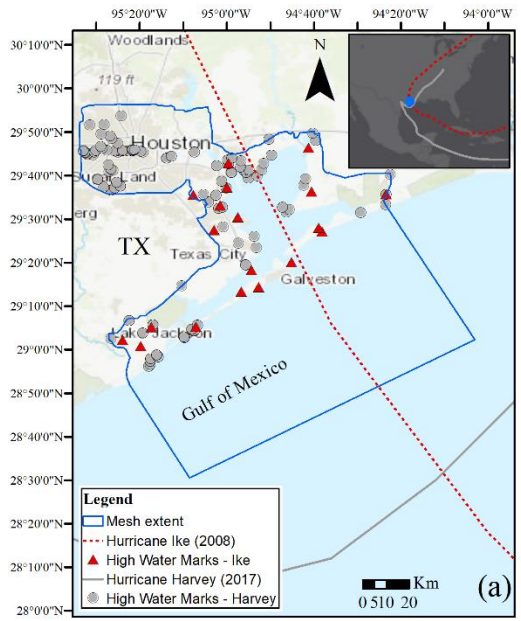


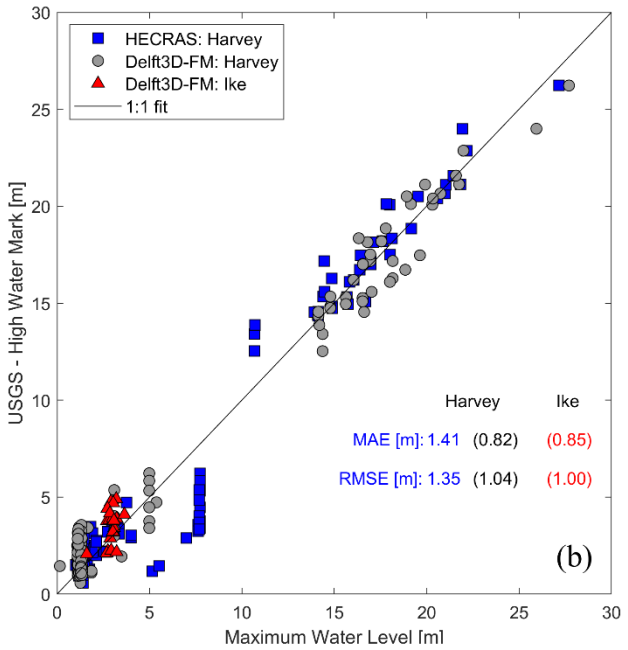


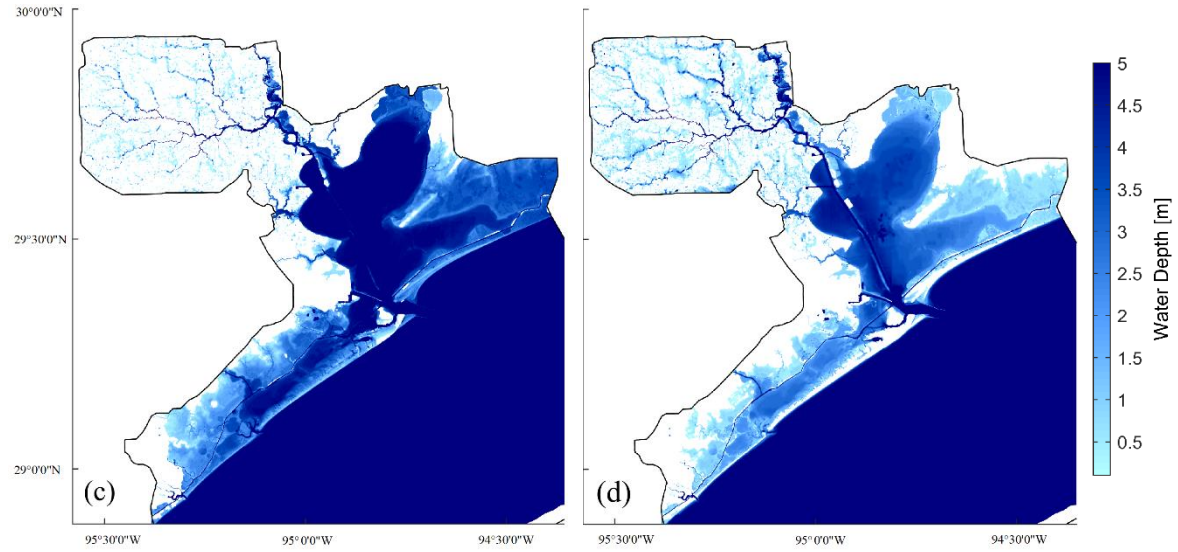


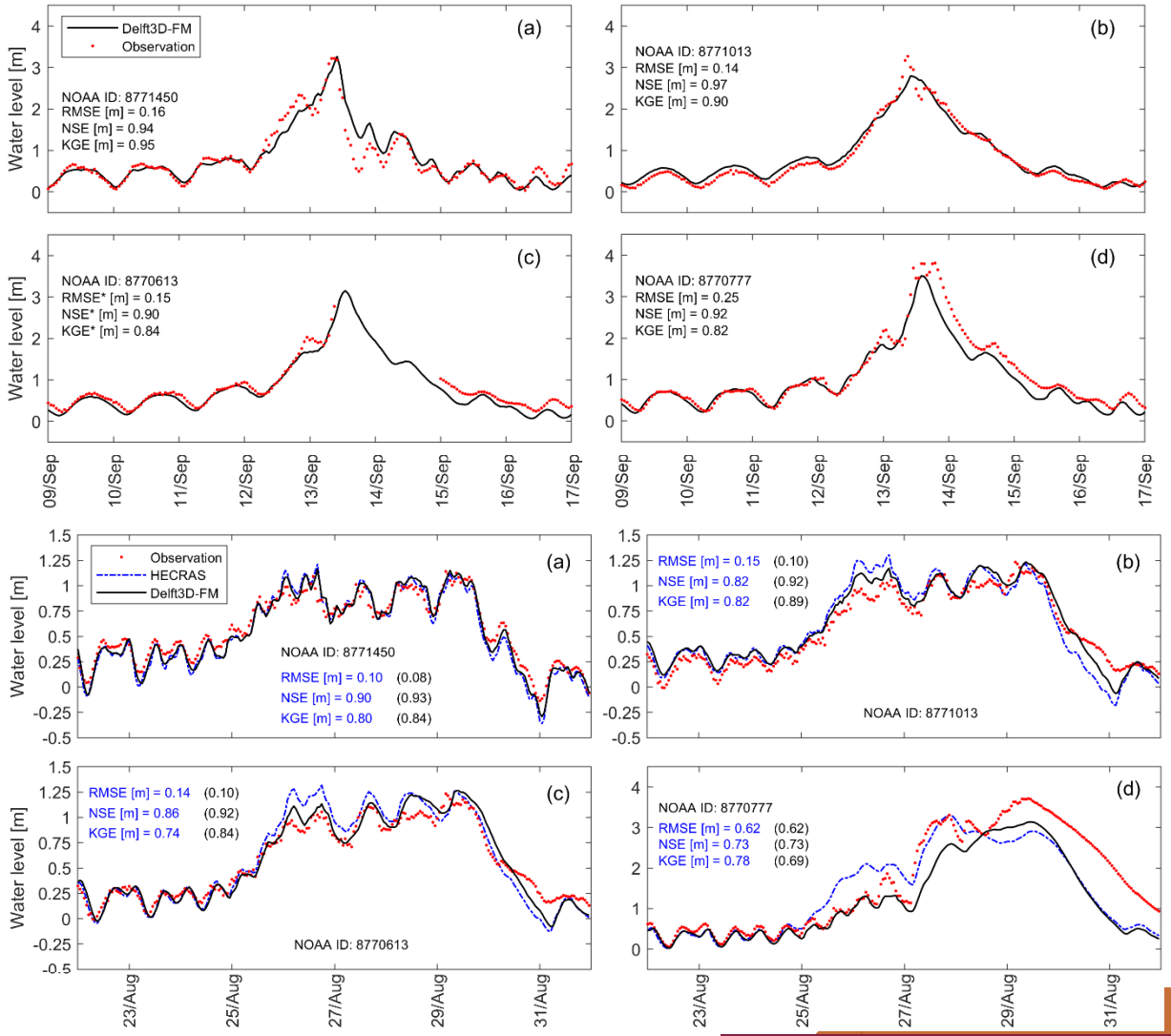
Calibration of tidal amplitude and phase for 1-year of model simulation.

Model calibration: time-series and flood extent





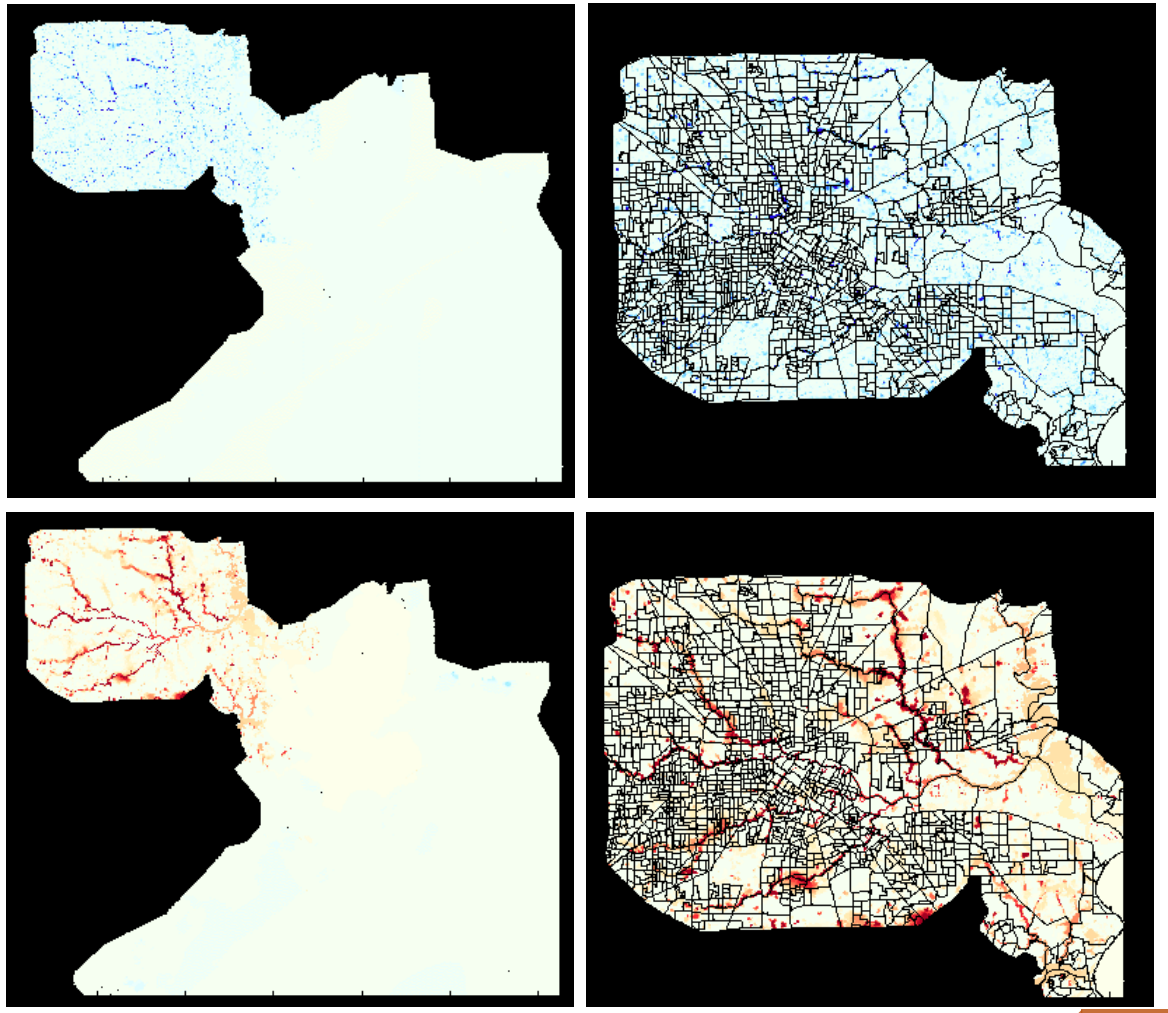




Spatiotemporal variation of residuals

Compound Flood Hazard Assessment (CFHA)

- **Scenario 1:** Wetland elevation
- **Scenario 2:** Rainfall River discharge
- **Scenario 3:** Calibration H. Ike
- **Scenario 4:** HEC-RAS Delft3D-FM

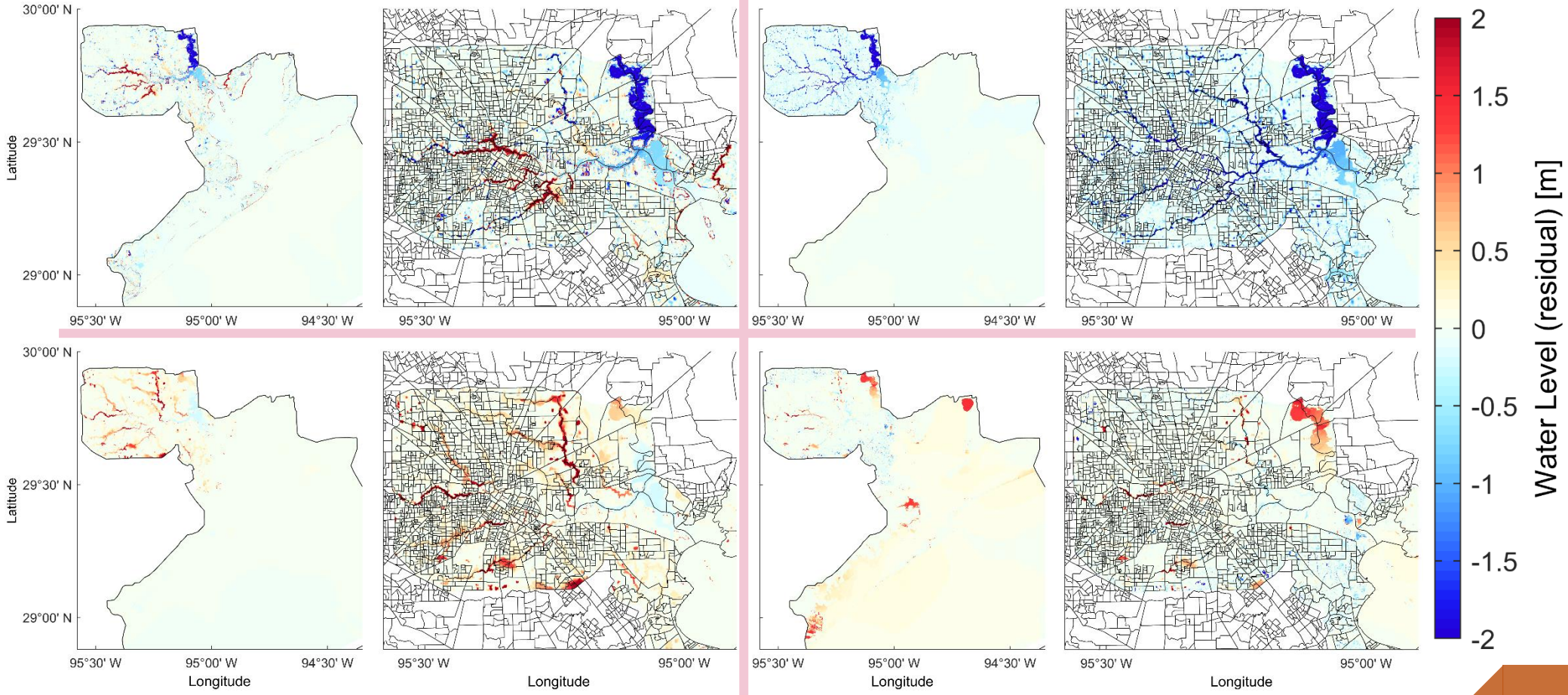


Residuals between model scenarios and baseline: Delft3D-FM as the best model.

Maximum residual from flood hazard maps

Scenario 1:
Wetland elevation

Scenario 2:
Rainfall and River discharge

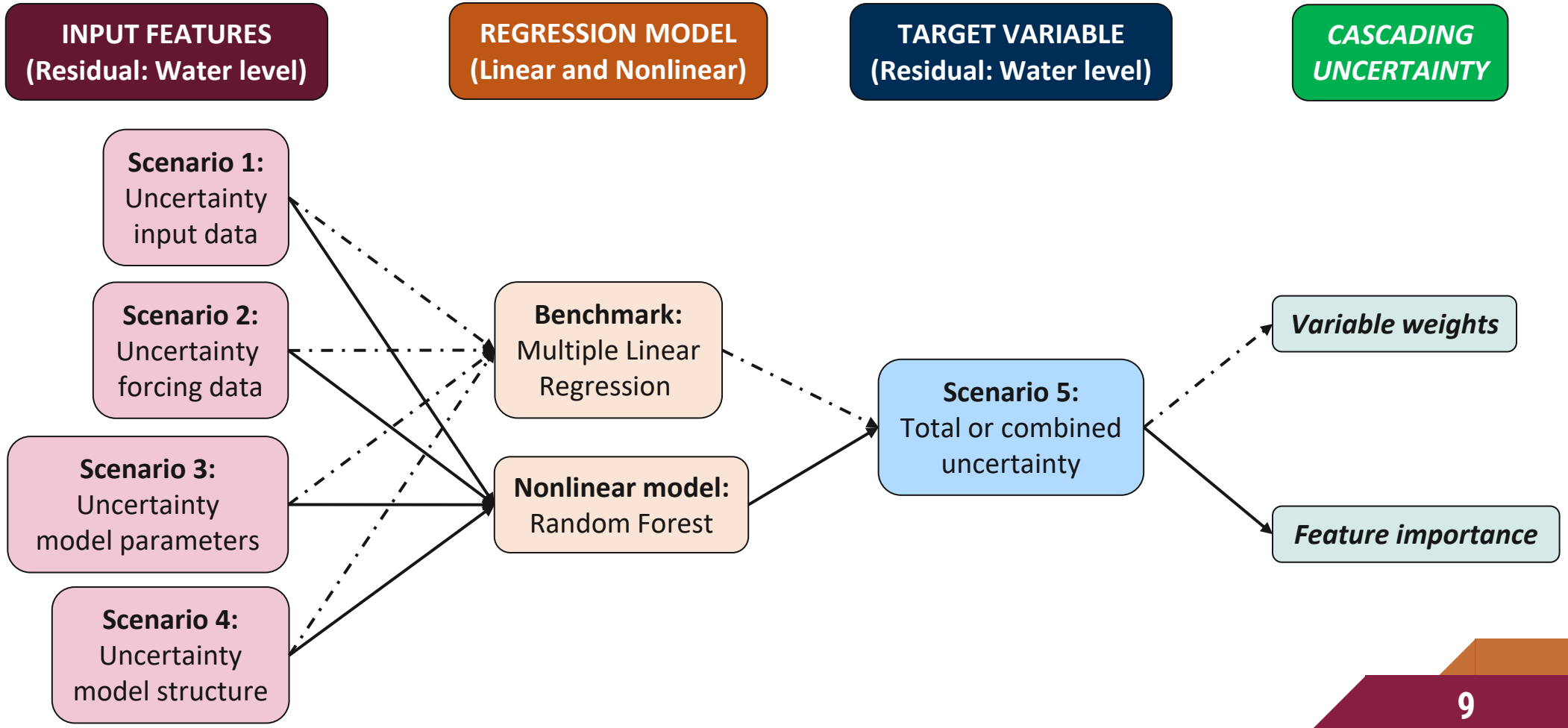


Scenario 3:
Calibration H. Ike

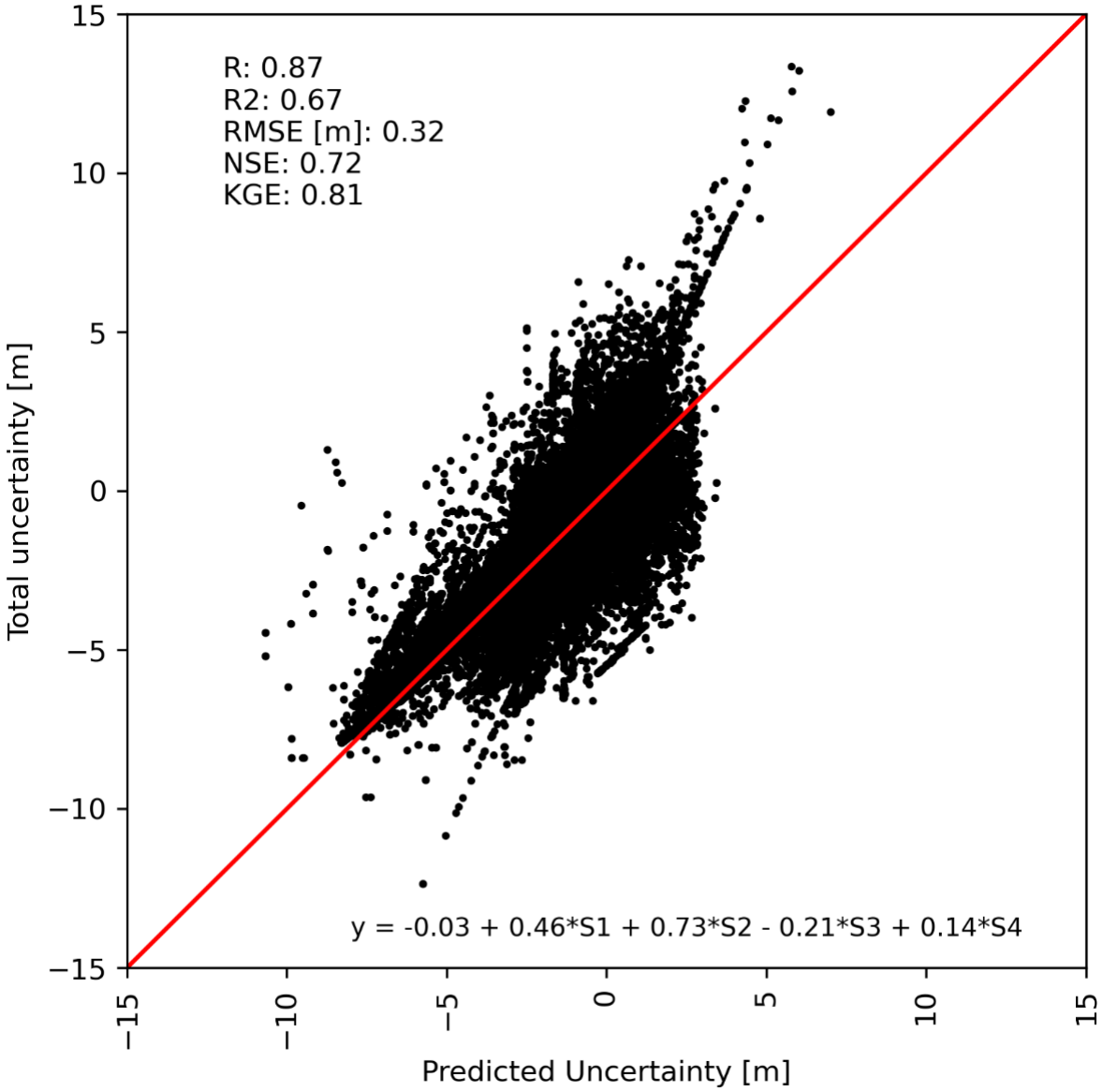
Scenario 4:
HEC-RAS vs. Delft3D-FM

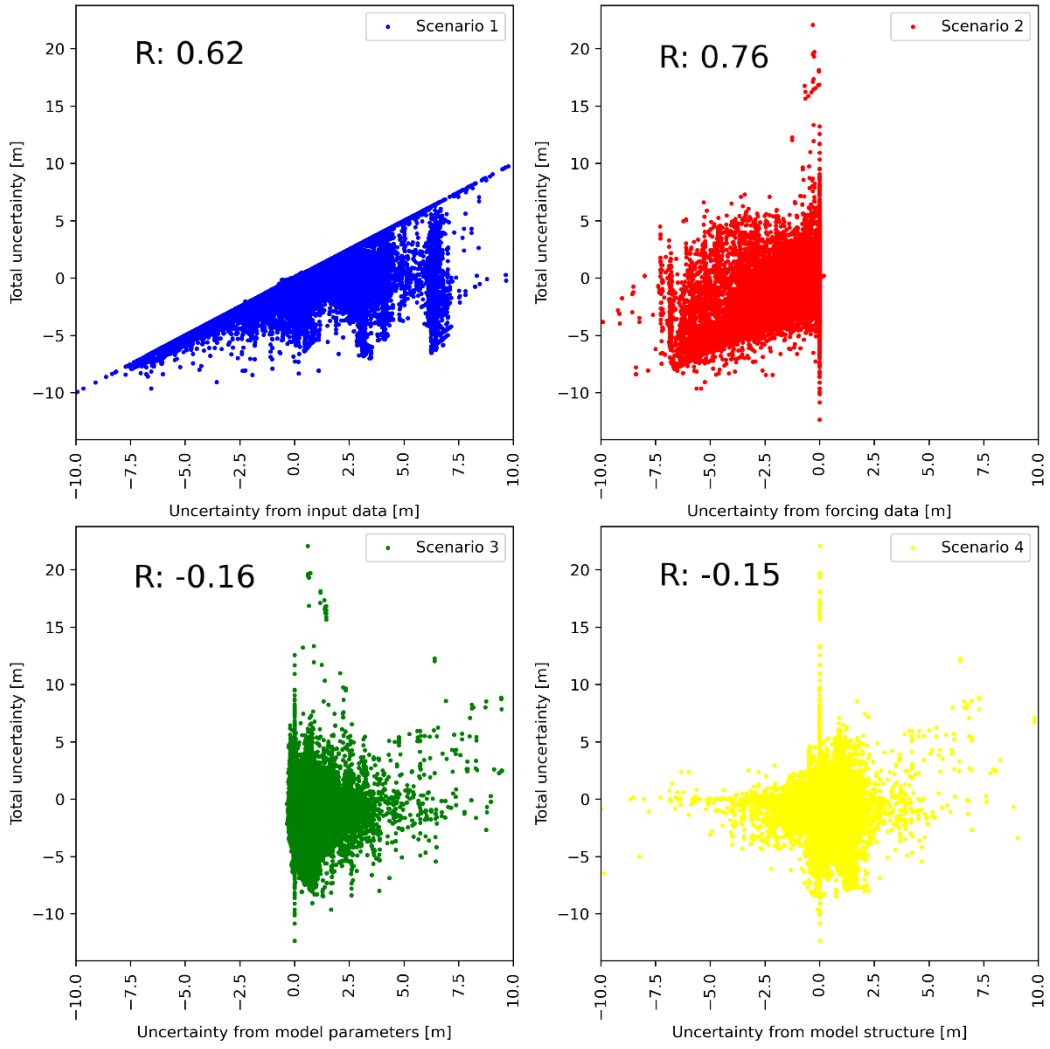
Analysis of cascading uncertainty

- The contribution of isolated sources of uncertainty and their cascading effect to total uncertainty can be characterized using nonlinear models (e.g., machine learning).

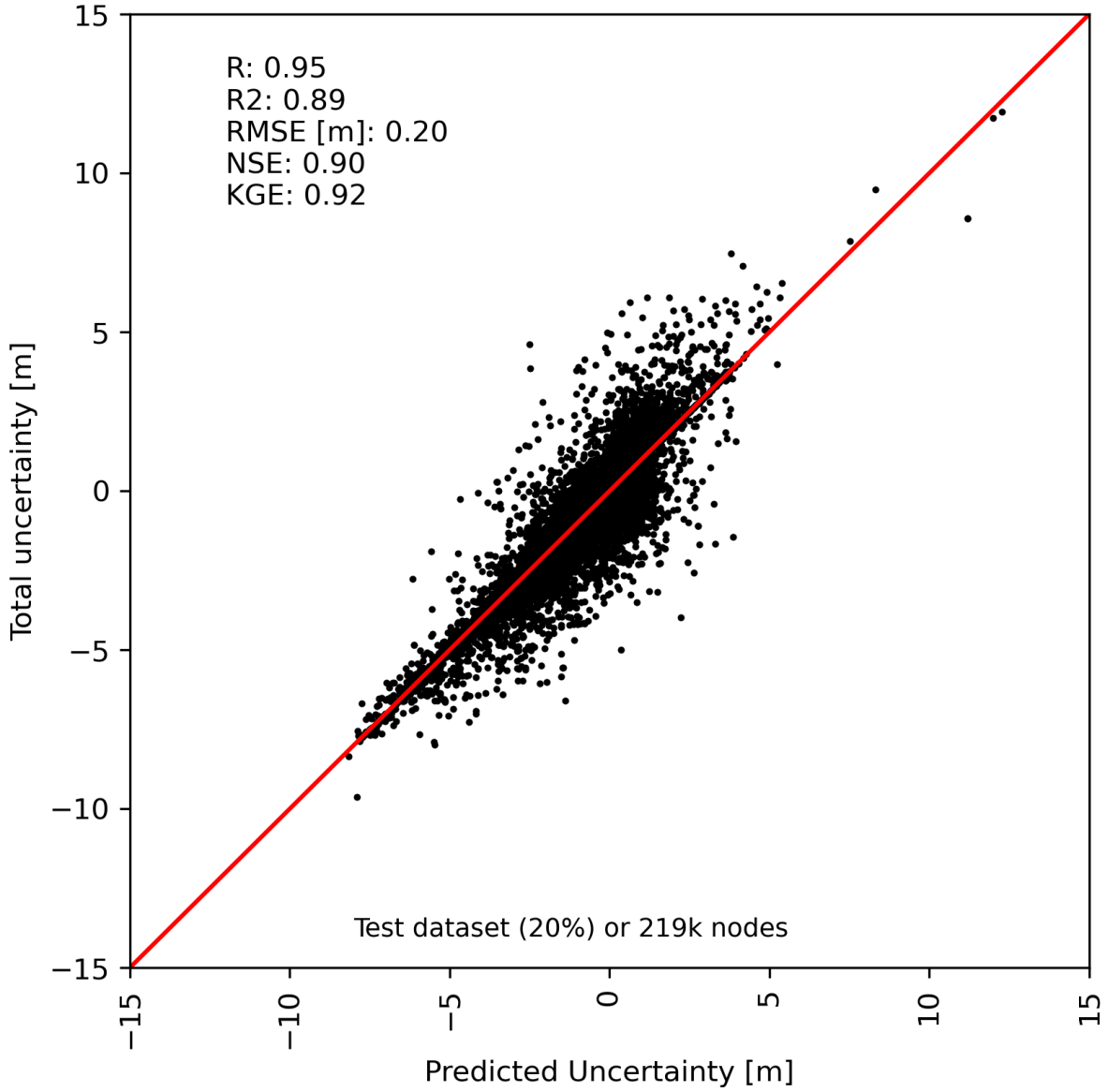


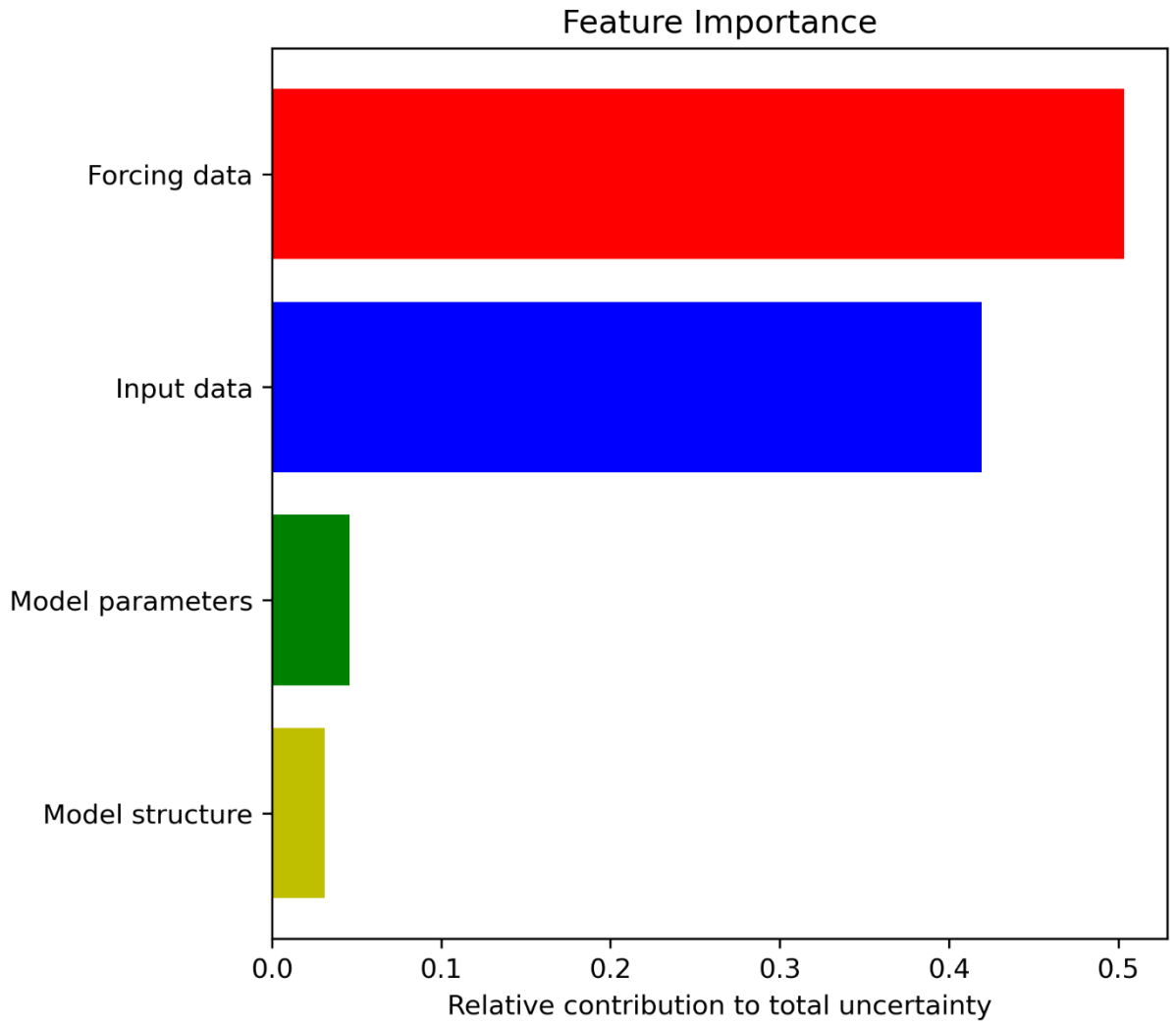
Linear regression to assess cascading uncertainty





Machine learning to assess cascading uncertainty





Take-home messages

1. Isolated **sources of uncertainty can synergize in cascade** thereby affecting the accuracy of CFHA.
2. Forcing data and input data are the **main contributors to total uncertainty (~90 %).**
3. Ongoing work is to quantify the relative **contribution of those categories to flood damage**.
4. How to account for all sources of uncertainties in CFHA? **Data assimilation!**

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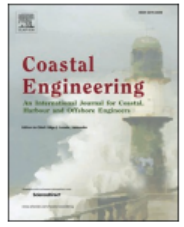

Check for updates

Accounting for uncertainties in compound flood hazard assessment: The value of data assimilation

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Questions?

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Notre Dame, Indiana
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