# Improving ML models for flood estimation during Hurricane Ian

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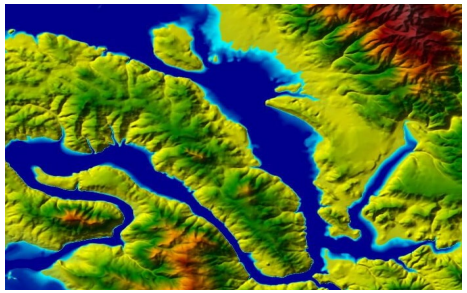
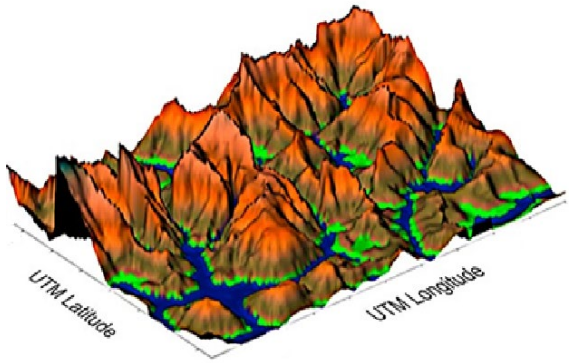
# Physically-based



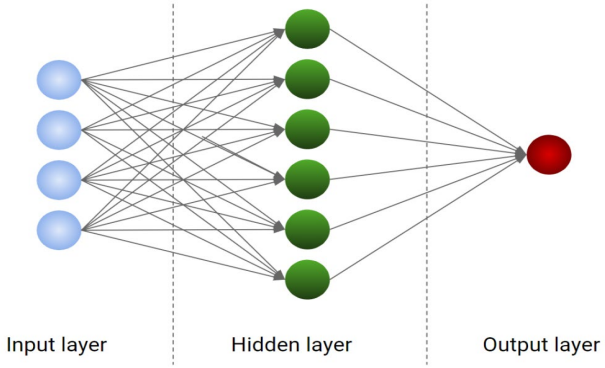
(Ming et al., 2020; Sridhar et al., 2021; Zahura et al., 2020; Kalyanapu et al., 2011; Towe et al., 2020; Fernández-Pato et al., 2016; Costabile et al., 2017; Costabile et al., 2017; Kalyanapu et al., 2011; Ming et al., 2020; Sridhar et al., 2021; Zahura et al., 2020; Hou et al., 2020; Mark et al., 2004; Zhang & Guo, 2014; Towe et al., 2020)

# Morphologic-based




(Bates, 2022; Bates et al., 2005)

# Data-driven




(Khosravi et al., 2018; Guo et al., 2021; Zahura et al., 2020; Löwe et al., 2021; Mishra et al., 2022; Mosavi et al., 2018)

# Flood models

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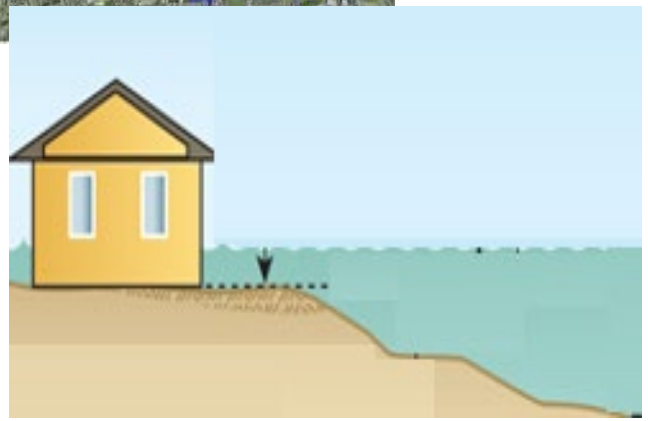
# Research gap & Objectives

**Extent**

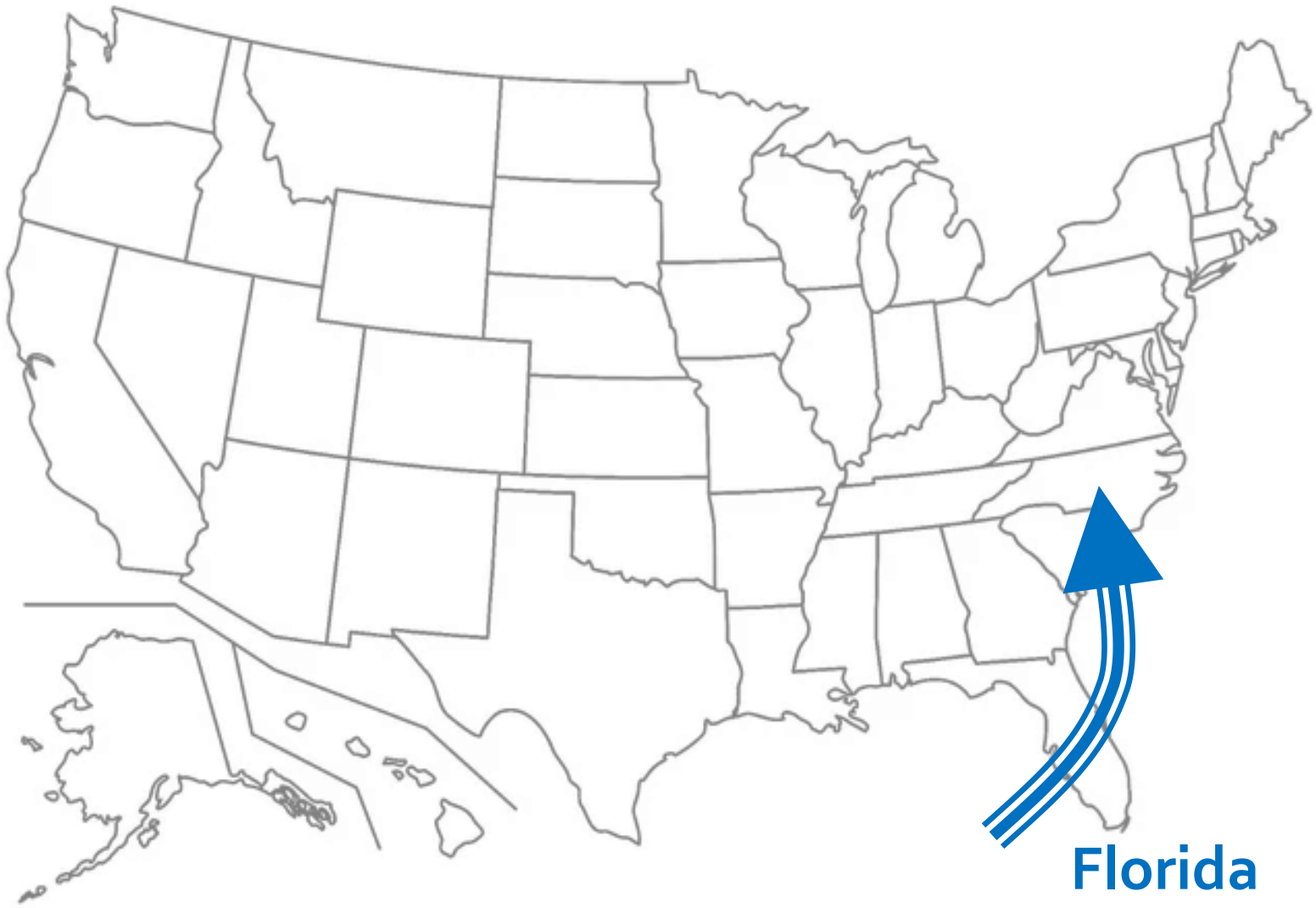
**Depth**

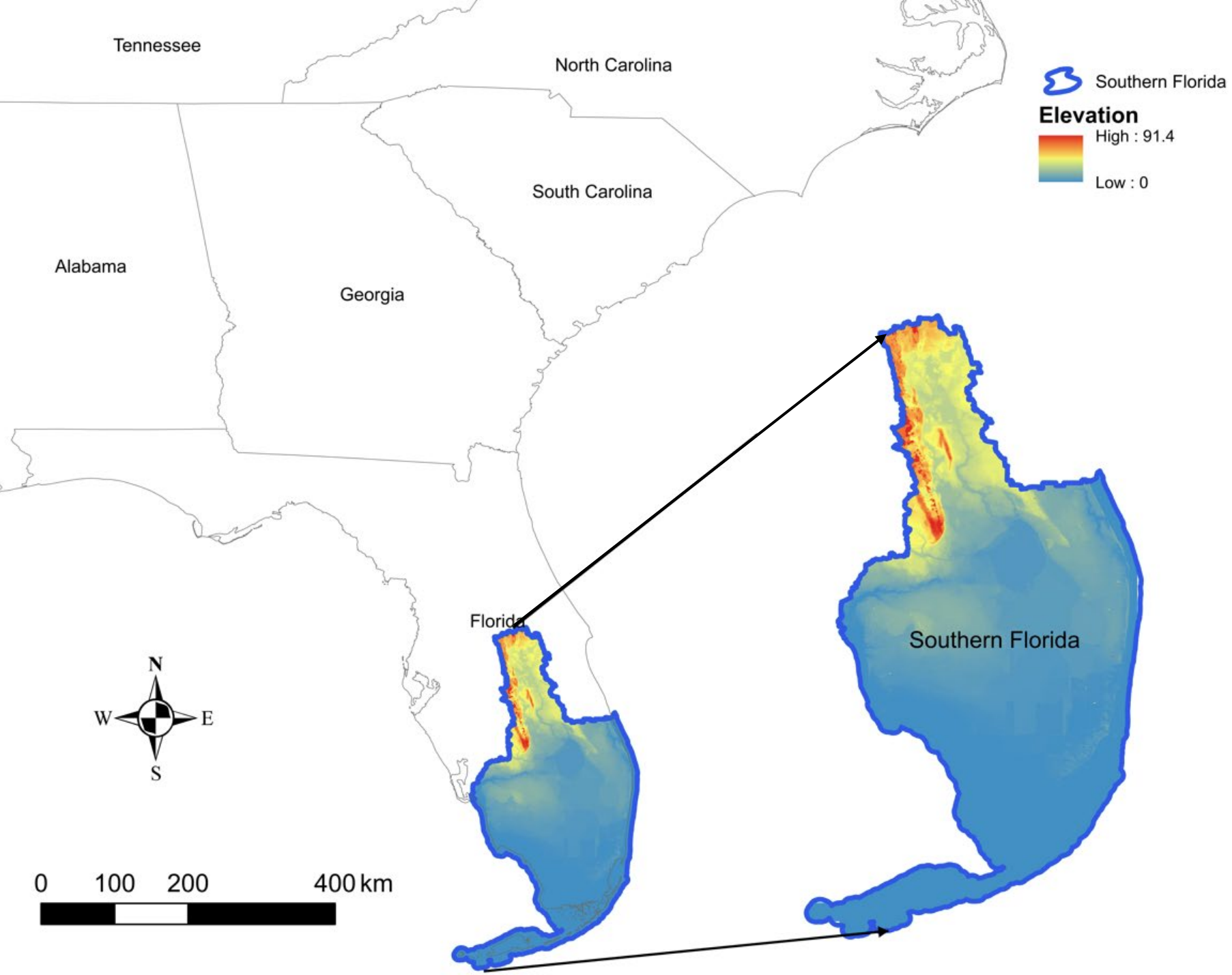


**Fast** and **accurate** model for flood **depth** estimations

Merz et al., 2010; Chang et al. 2022; Elkhrachy 2022; Löwe et al. 2021; Guo et al. 2021; Hosseiny et al. 2020; Zahura et al. 2020; Khosravi et al., 2018; Rahmati et al., 2016; Rezaie et al., 2022; Youssef et al., 2022

# Flood Event: Hurricane Ian






# Study Area

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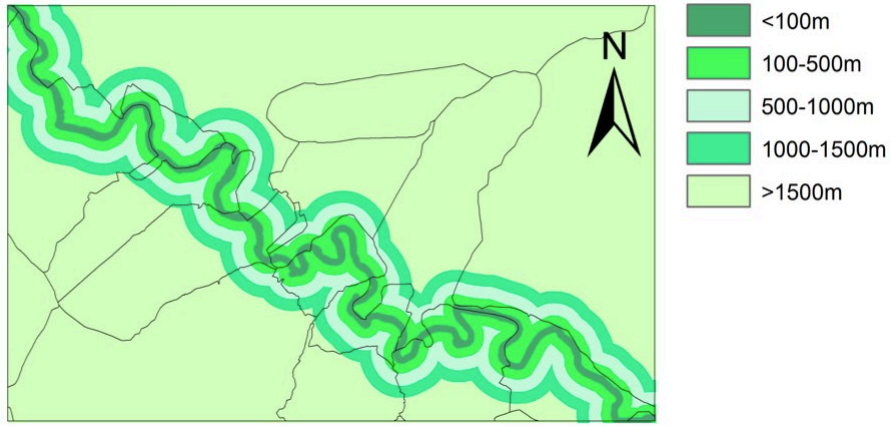
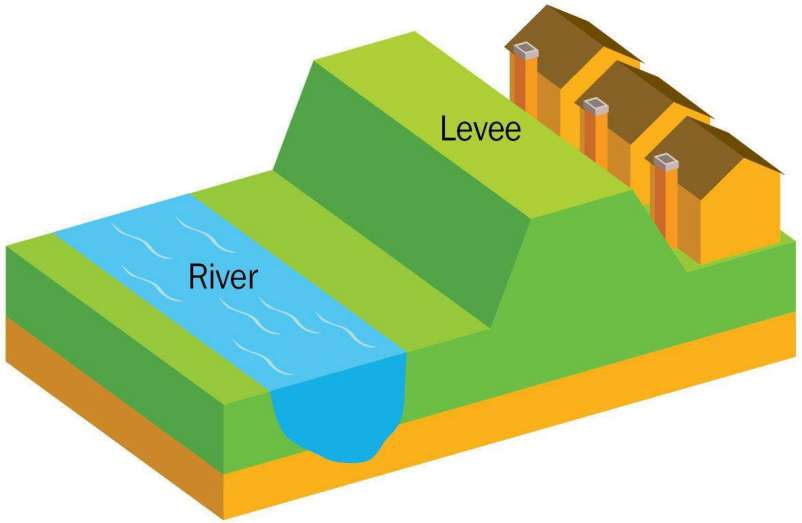
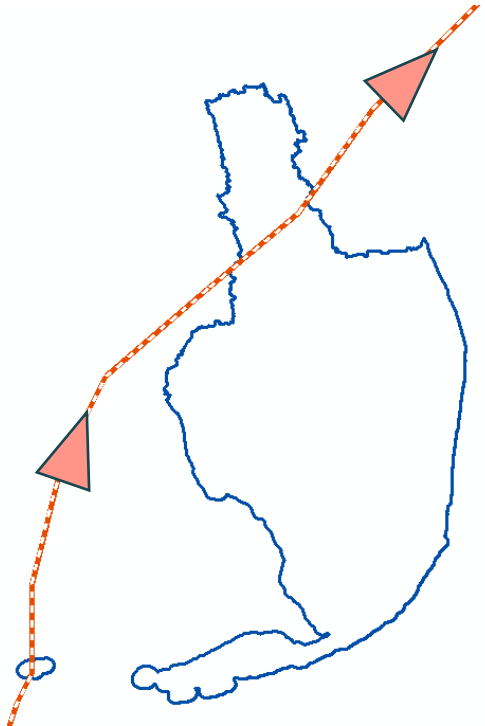
# Geographic location



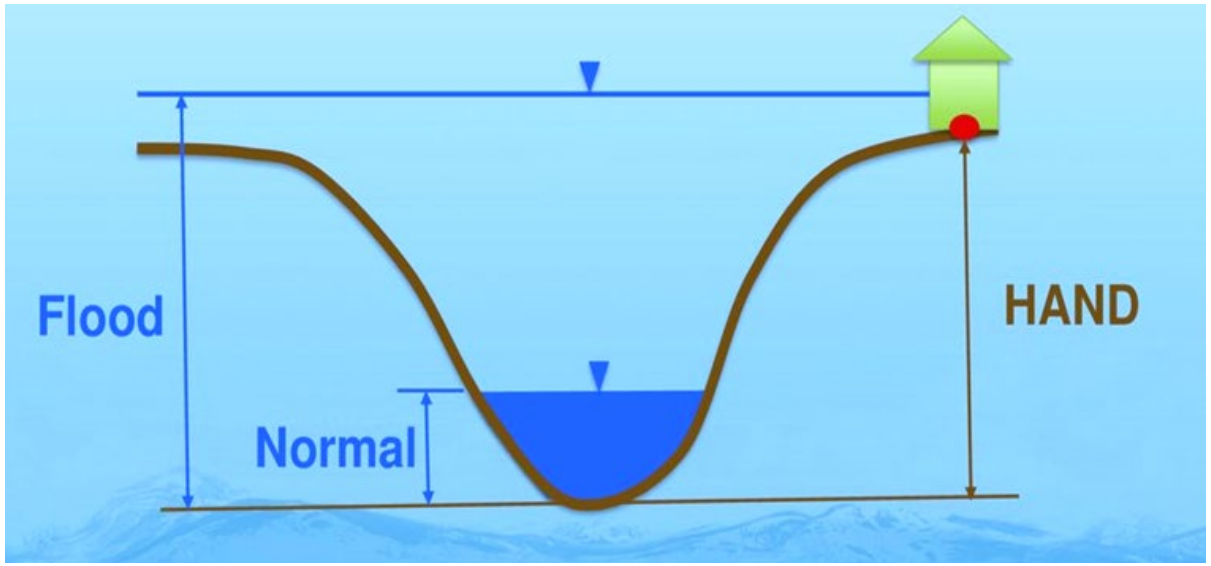




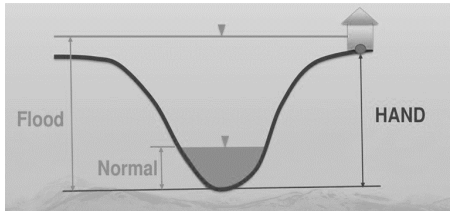

## Features



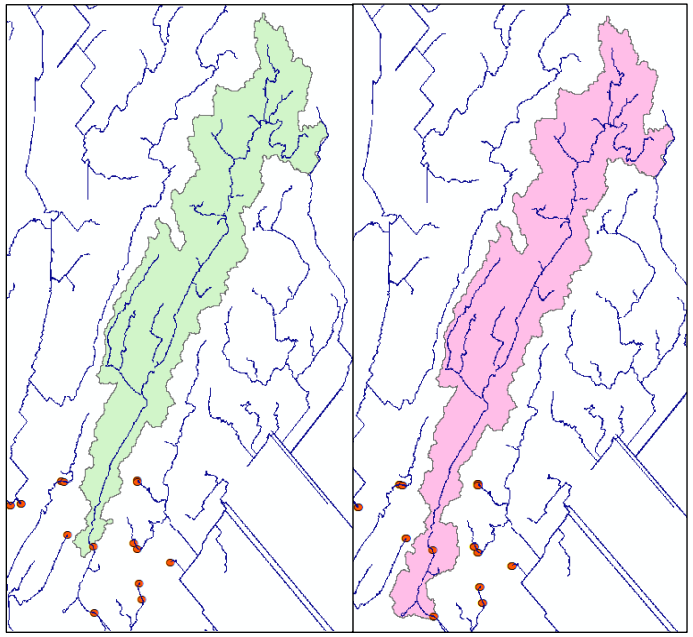
# Hydrologic



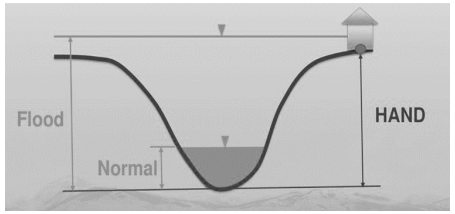

## Features

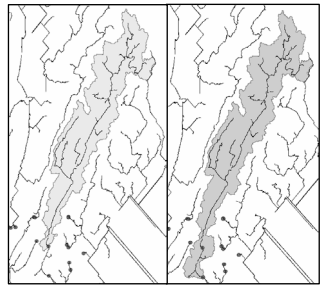



# Hydrologic

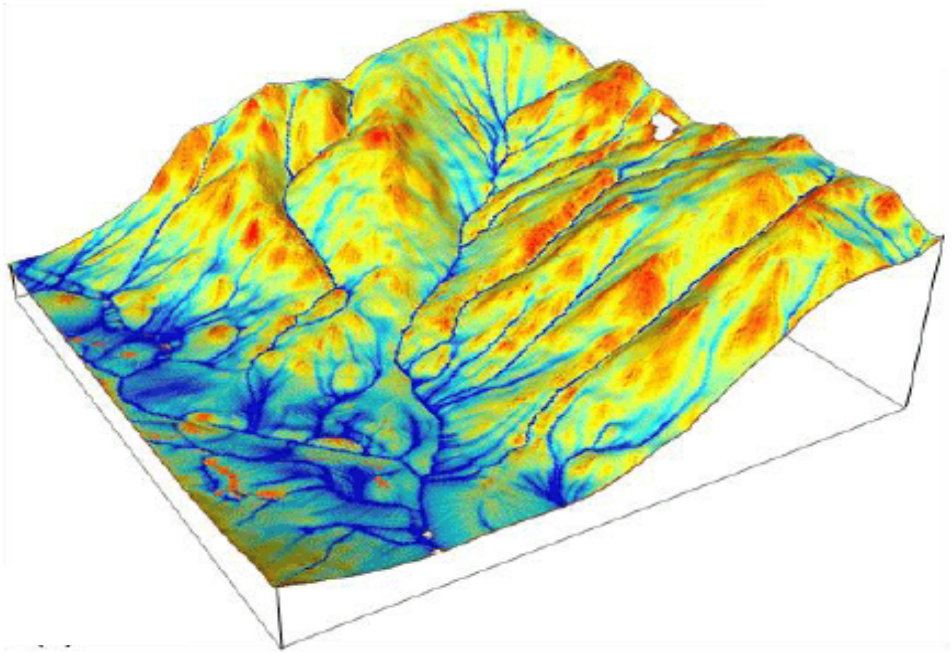


## Features



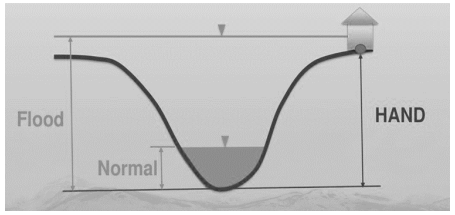



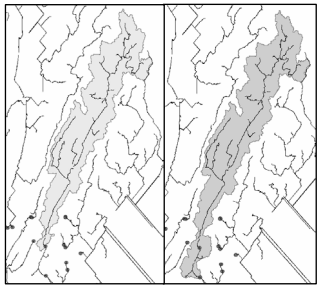
# Hydrologic

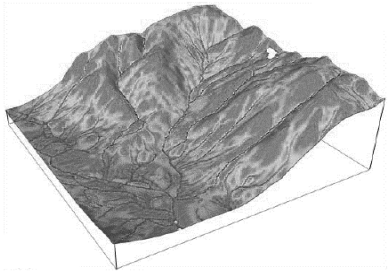


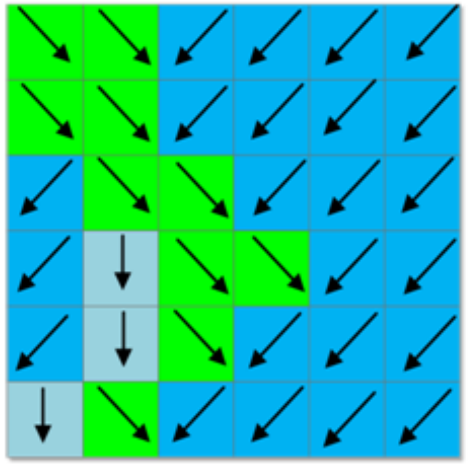
## Features

# Hydrologic







Flow Direction

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 2 | 2 | 1 | 1 | 0 |
| 0 | 4 | 5 | 2 | 1 | 0 |
| 0 | 0 | 8 | 8 | 1 | 0 |
| 0 | 1 | 0 | 11 | 10 | 0 |
| 0 | 2 | 12 | 12 | 1 | 0 |

Flow Accumulation

## Features

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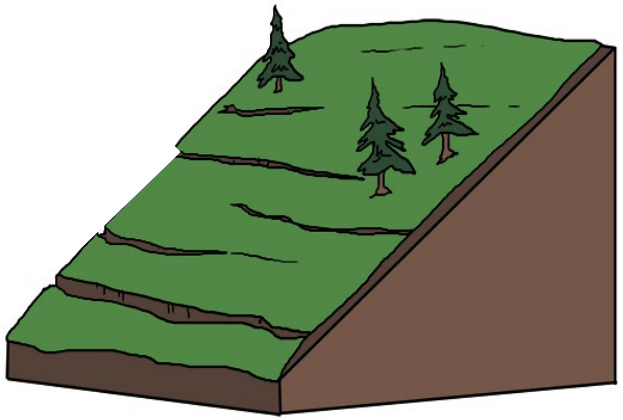
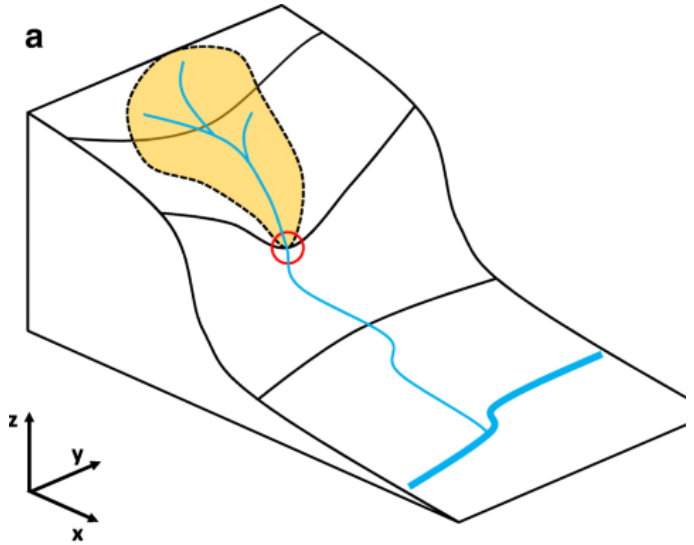
# Meteorologic

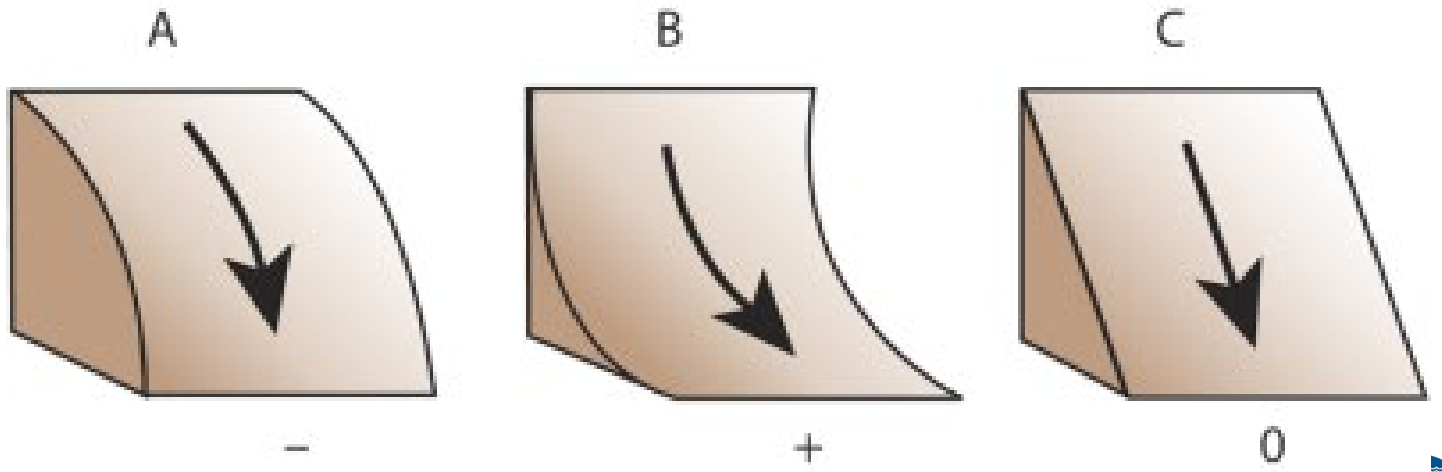

## Features

# Topographic






## Features

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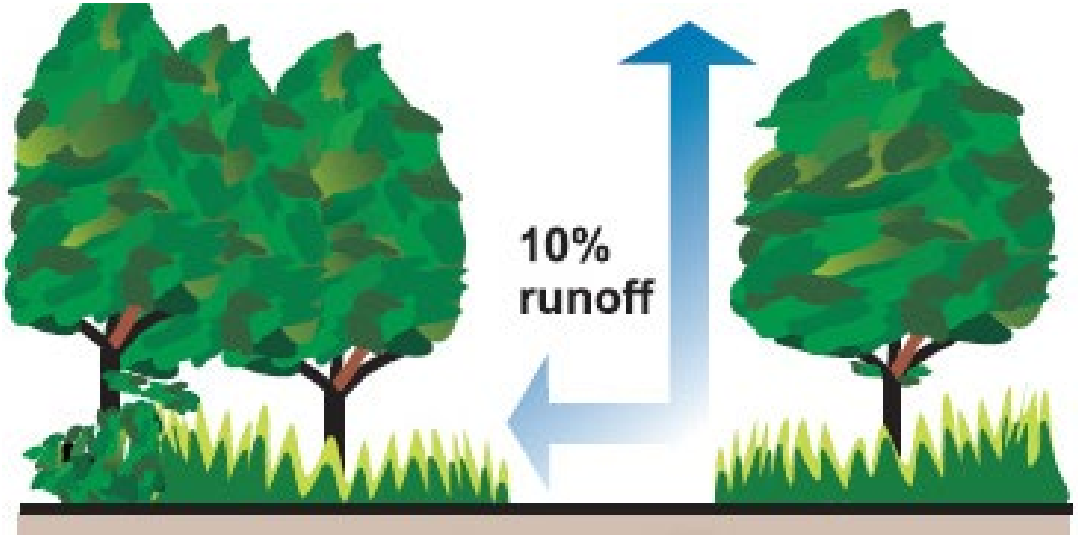
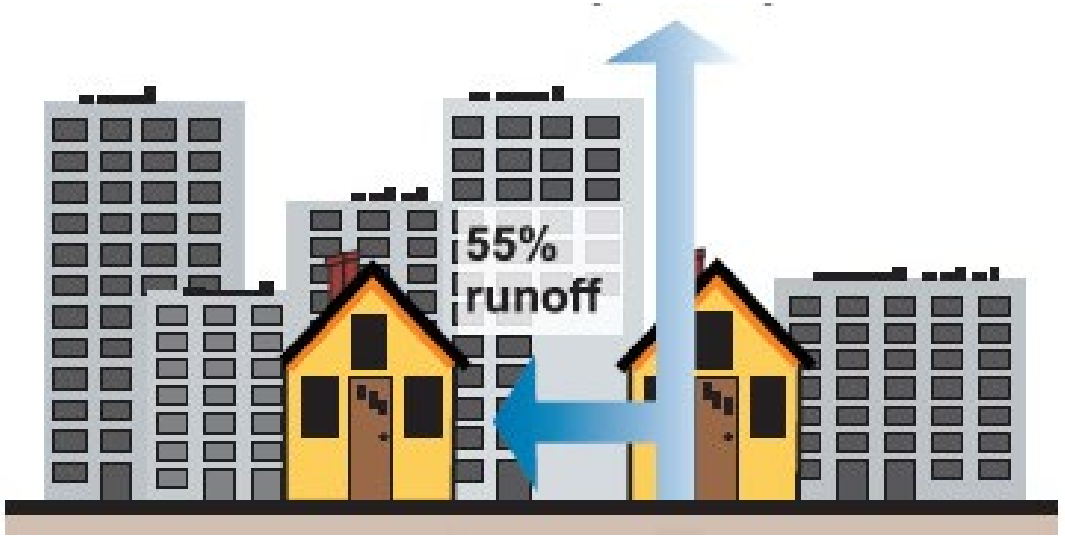
# Land surface




## Features

# Soil

# Hydrodynamic

## Features

| Category | Feature | Source | Spatial resolution | Temporal resolution |
|---|---|---|---|---|
| **Geographic location** | Distance to rivers | NHDPlus | — | — |
| | Distance from storm track | | — | — |
| | Distance from the coastline | | — | — |
| **Hydrologic** | Height above nearest drainage (HAND) | NED | 10 m | — |
| | Drainage area | | — | — |
| | Flow accumulation | | — | — |
| | Topographic wetness index (TWI) | | — | — |
| **Meteorologic** | Rainfall depth | NCEI | — | Daily |
| | Wind speed | | | |
| **Topographic** | Elevation | NLCD | 10 m | — |
| | Ground slope | | | — |
| | Slope aspect invariability (ASPVAR) | | | — |
| | Curvature | | | — |
| **Land surface** | Imperviousness | NLCD | 30 m | — |
| **Soil** | Antecedent soil moisture | ERA5 | — | Daily |
| **Hydrodynamic** | Storm surge | NOAA Tides and Currents | — | Sub-hourly |

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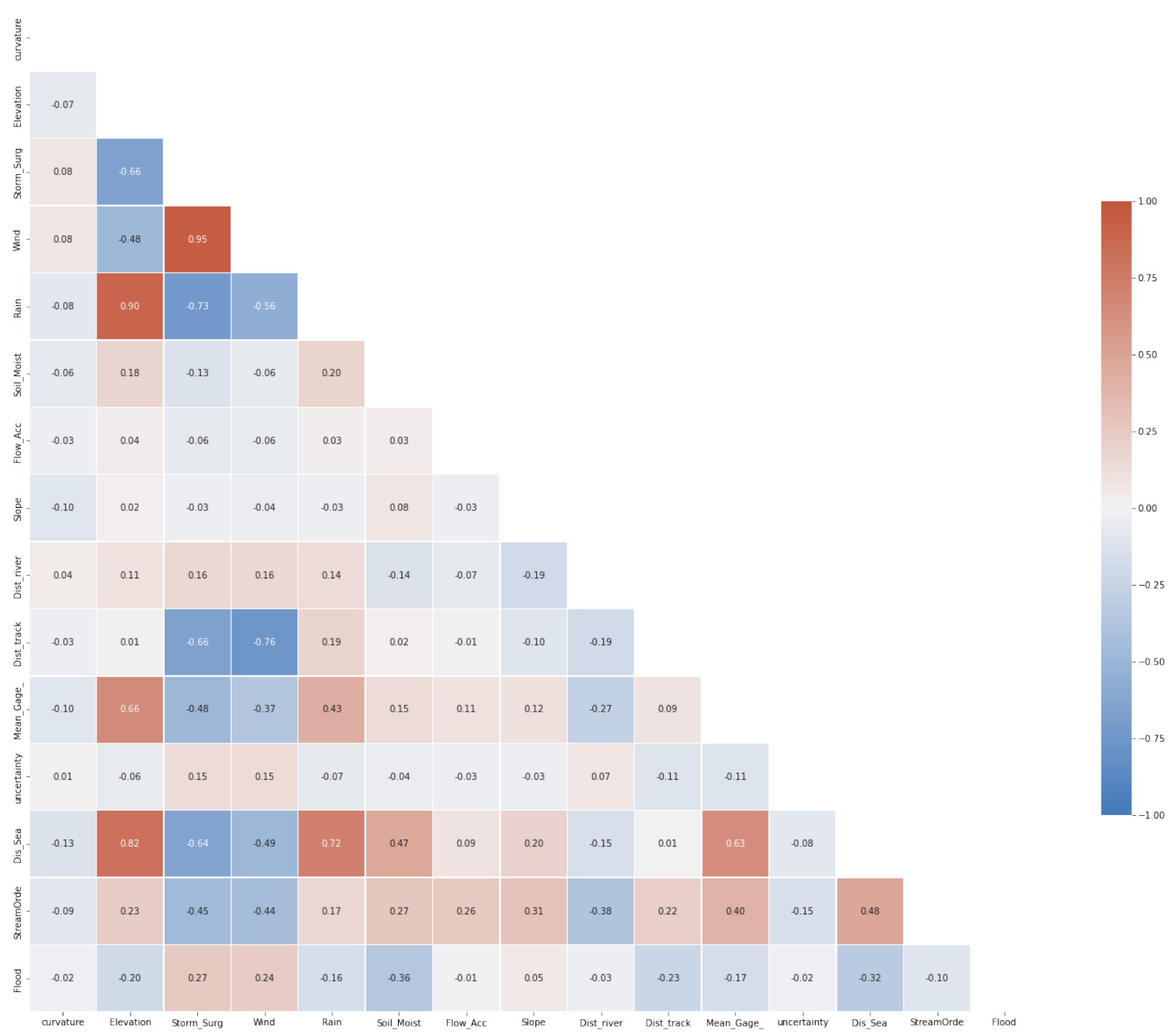



# Feature Selection

# Feature Selection

**PCA**

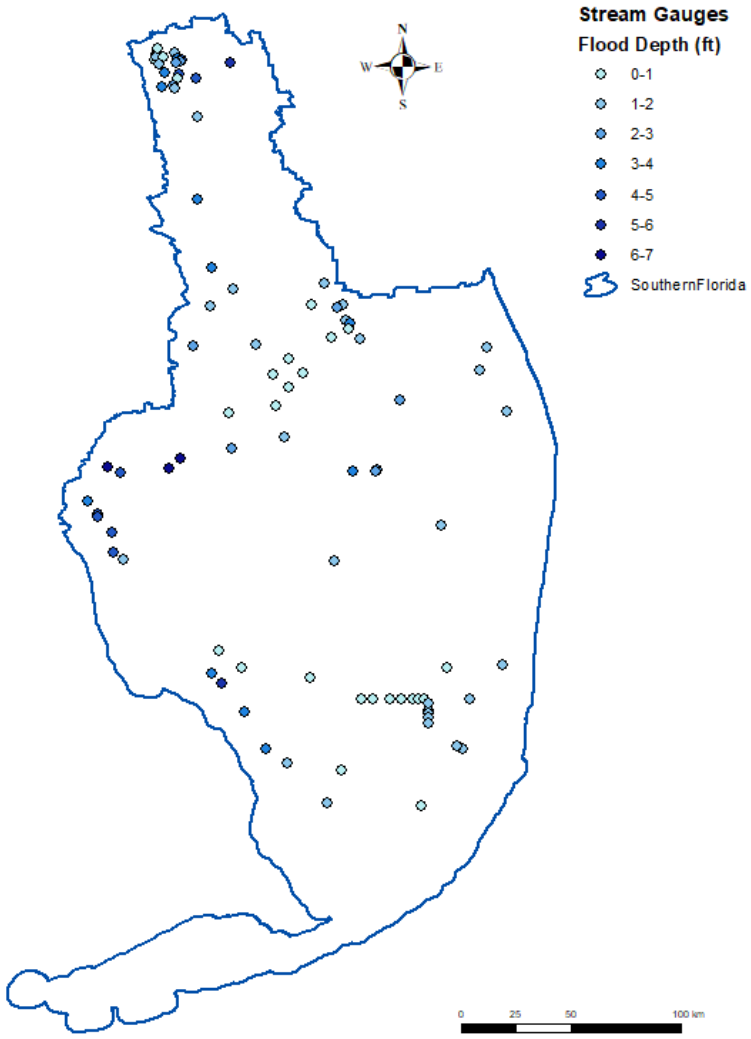
- Mean Gauge Height
- Distance to storm track
- Rain
- Distance to levee
- Distance to structures
- Soil Moisture
- Distance to river
- Stream Order
- Distance to Sea
- Wind
- Elevation
- Storm Surge
- Curvature
- Slope
- HAND
- Flow Accumulation

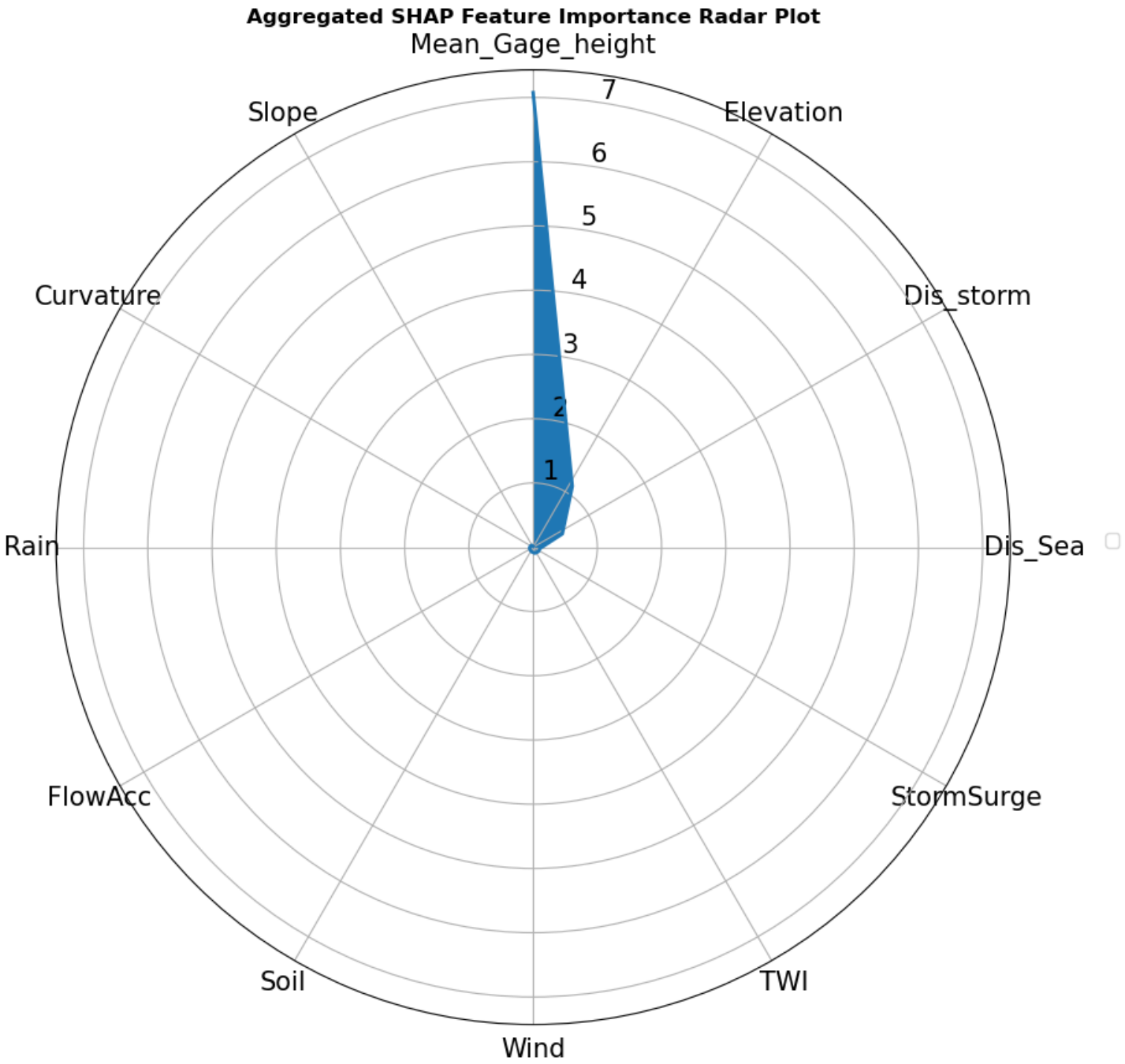
**ICA**

- Wind
- Distance to storm track
- Distance to river
- Mean gauge height
- Distance to levee
- Slope
- Flow accumulation
- Stream order
- Distance to structures
- Curvature
- Distance to sea
- Elevation
- Rain
- Soil moisture
- Storm surge
- HAND

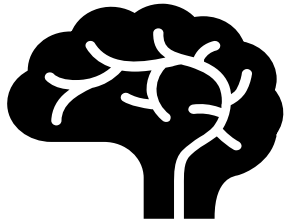
# Model 1 : Rivers

# Observed Flood Data




# ANN



| Train Data | Test Data |
|---|---|
| $R^2$: 0.97 | $R^2$: 0.88 |
| MAE: 0.69 (m) | MAE: 1.63 (m) |
| NRMSE: 0.28 | NRMSE: 0.33 |

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# Model 2 : Over land (floodplains)

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# Flood depth data

| Amount of vertical uncertainty | Uncertainty |
|---|---|
| Within ±0.05 foot. | Excellent (E) |
| Within ±0.10 foot. | Good (G) |
| Within ±0.20 foot. | Fair (F) |
| Within ±0.40 foot. | Poor (P) |
| More than ±0.40 foot. | Very poor (V) |

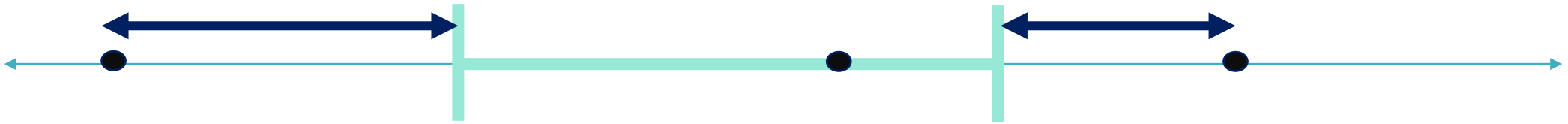
# Customized loss function

Standard loss function

```
R-squared for training dataset: 0.21
R-squared for test dataset: 0.05
```

Customized loss function

```
Train Custom R-squared: 0.87
Test Custom R-squared: 0.48
```



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Just HWMs

```
Train Custom R-squared: 0.87
Test Custom R-squared: 0.48
```

HWMs + Stream gauges

```
Train Custom R-squared: 0.94
Test Custom R-squared: 0.91
```

HWMs

- Uncertainty
- HAND
- Distance from river

Stream gauges

- Mean gauge height
- Levee

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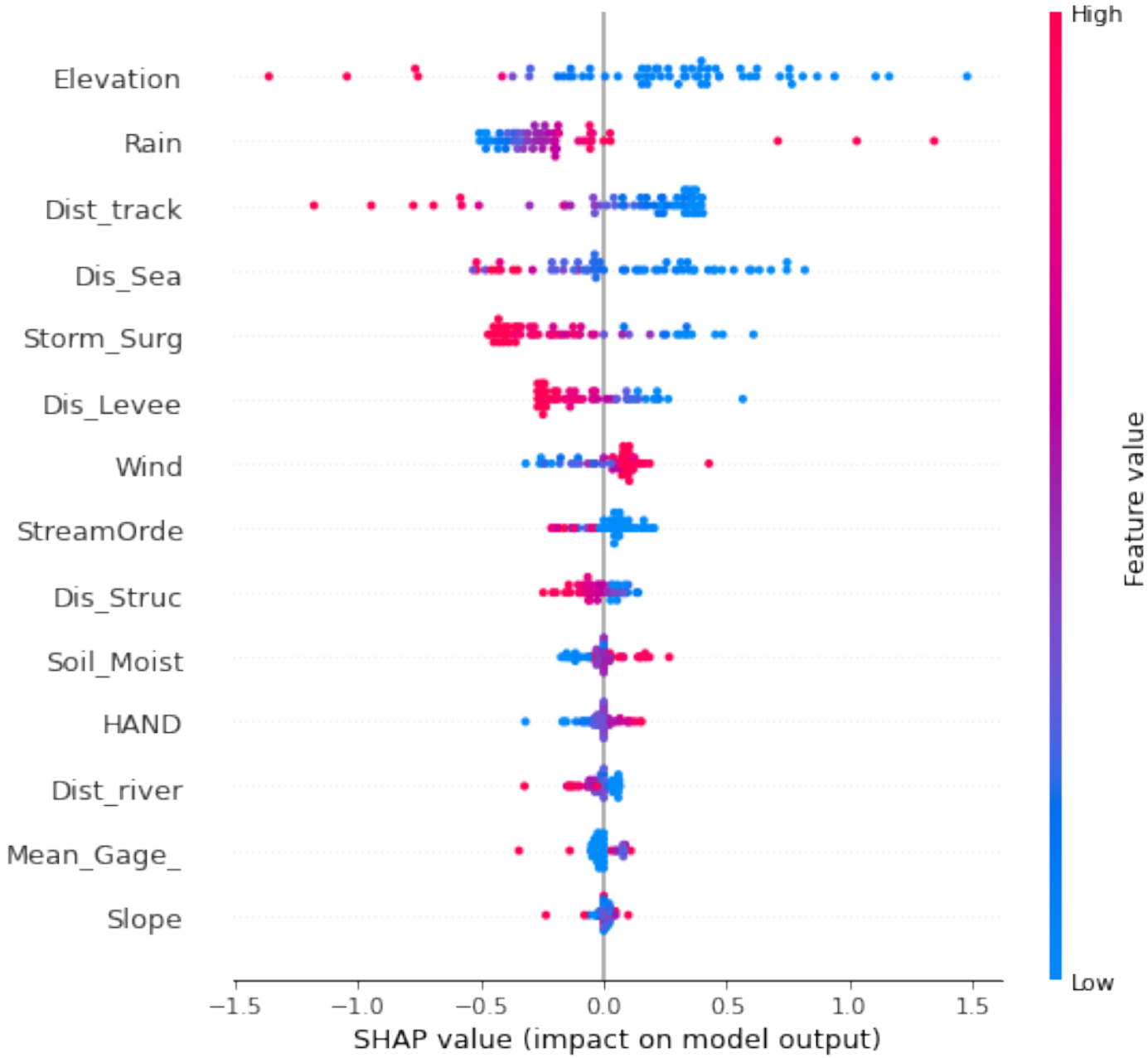


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# Future Directions

- **Transferability**
  - Transfer learning
  - Add new features
- **Uncertainty**
  - Investigate
  - Integrate the uncertainty quantification techniques

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# Thank you!

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