MODEL TRAINING & OPERATIONAL DEPLOYMENT

EC JRC & WMO

Brussels, December 2025

European Commission

MODEL TRAINING

- Organized by EC JRC for experts **with yellow sticker on their name tag**
- Held in break-out room
- Hands-on activity that will teach the basics of decision trees and random forests

OPERATIONAL DEPLOYMENT

- Organized by WMO & UMBC
- Held in plenary (this room)
- Role-playing activity to explore important considerations when using AI operationally for flood scenarios

Workshop – AI in Flood Management

WORLD METEOROLOGICAL ORGANIZATION

Session -1 Introduction

WORLD METEOROLOGICAL ORGANIZATION

What does the WMO do?

UN Specialized Agency for **weather, climate and water,** composed of 193 Member States and Territories, which aims to support the resilience and sustainable development of all nations, especially the most vulnerable, in the face of weather, climate and water events.

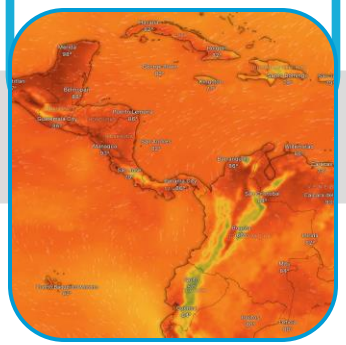
1950-2025 SCIENCE *for* ACTION

This Year we mark the 75th anniversary of WMO under the UN system

Observations

Data exchange & modelling

Forecast products



Service provision

Decision support

Research & Development, Standards, Capacity Dev, Education & Training, M&E

SUSTAINABLE DEVELOPMENT GOALS

UNITED NATIONS PARIS CLIMATE AGREEMENT SIGNING CEREMONY 22 APRIL 2016

SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

Members are represented by Permanent Representatives of the country - usually by Directors of NMHSs
(normal channel of communication as designated by Ministry of Foreign Affairs of the Member)

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WMO and AI

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Weather Climate Water

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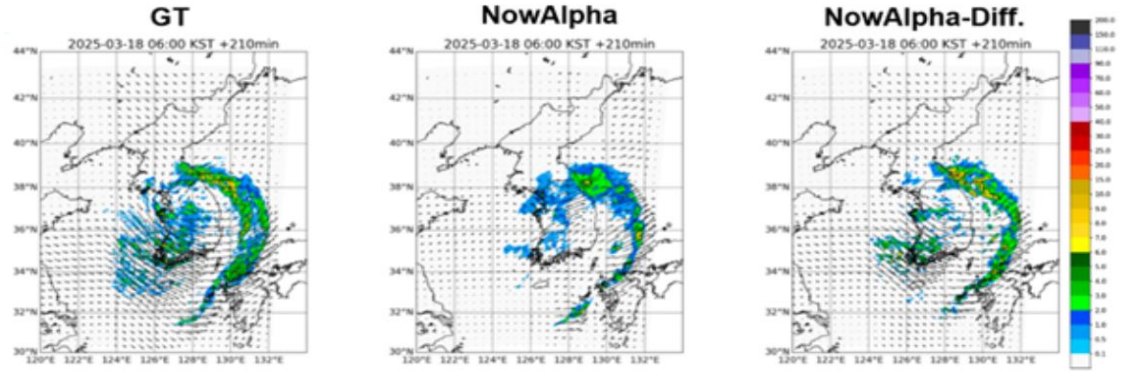
World Meteorological Congress endorses actions to promote AI for forecasts and warnings

PRESS RELEASE

AI for Nowcasting Pilot Project (AINPP)



210-min lead time (2025-03-18 06:00 KST) : KMA's improved 2025 diffusion-based model (right) captures the cyclonic pattern more realistically than the 2024 model (middle), consistent with GT (ground truth)

Working Group on Digital Transformation for Hydrology and Water Resources

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Session -2 Roleplaying

Setting the Scene

Floodmere basin spanning three provinces – Highspring, Midlands and Rivermouth
– Highspring (150,000); Midlands (500,000) and Rivermouth (350,000)

Economy: 30% Agriculture, 50% Large and small industries, 15% Services and 5% fisheries

Situation: Start of the wet season with possibility of heavy rainfall reported across the basin

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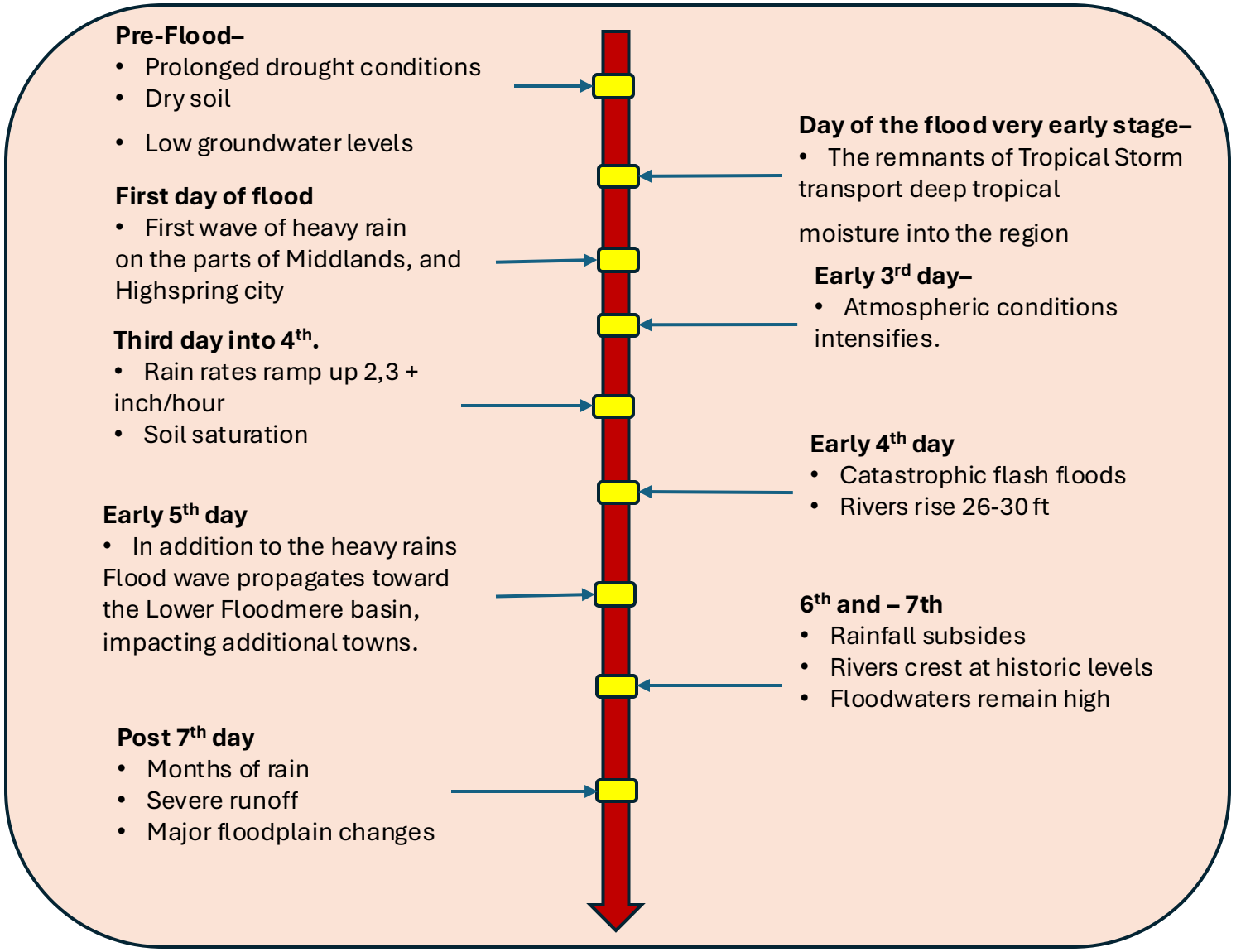
Setting the Scene

A perfect overlap of tropical moisture, jet-stream dynamics, geographic funneling, cooler temperatures, and storm-river alignment created an environment where rainfall was:

- Extremely intense
- Highly efficient (nearly all moisture condensed)
- Delivered directly along drainage paths



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Highspring

Population: *150,000*

Economy: *Primarily agriculture; dispersed rural communities; significantly elderly population*

Geography: *Hilly at stretches, with high possibility of landslides*

Potential flood impacts

Rapid rising water in narrow upstream tributaries which can lead to localized flash floods that overwhelm small rural bridges and farm access roads

Landslide risk increases sharply because saturated slopes fail. Several isolated communities become cut off

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Highspring

Potential flood impacts

Elderly residents in remote areas face mobility challenges, slowing evacuation efforts

Large agricultural areas are affected:

- *Early-season planting destroyed*
- *Livestock stranded*
- *Irrigation channels damaged*

Emergency communication can be poor at times due to limited network coverage in rural valleys

Local authorities must manage multiple simultaneous small-scale crises rather than one large one

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Midlands

Population: *500,000*

Economy: *50% large and small industries; major service and administrative centres*

Geography: *Flat urbanized floodplain intersected by the main river*

Potential flood impacts

Sudden surges can lead to rapid river overflow in densely populated commercial districts

Industrial zones near the river can experience:

- *Damage to machinery*
- *Contamination risks from stored chemicals*
- *Temporary shutdowns affecting employment and logistics*

Midlands

Potential flood impacts

High population density causes traffic congestion during evacuation

Several major urban drainage systems backflow, flooding basements, underpasses and public transit corridors

Critical infrastructure at risk:

- *Central water-treatment plant*
- *Two substations feeding industrial parks*
- *Emergency coordination centre*

Disruption to supply chains spreads regionally because Midlands is the economic hub

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Rivermouth

Population: *350,000*

Economy: *Fisheries, services, river-port logistics*

Geography: *Broad delta-like floodplain highly vulnerable to overbank flooding*

Potential flood impacts

Receives the largest flood volume, with widespread inundation across low-lying neighbourhoods

Floodwaters move slowly, leading to flooding spread across several days (not like flash floods observed upstream)

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Rivermouth

Potential flood impacts

Port facilities shut down; this disrupts export-oriented businesses and cuts distribution chains;

Vulnerable populations – including low-income households in the floodplain – face major losses due to:

- *Fragile housing structures*
- *Limited access to vehicles for evacuation*
- *Lack of insurance coverage*

Schools, community centres and public spaces are generally used as temporary shelters

Water contamination issues arise, leading to heightened public health concerns

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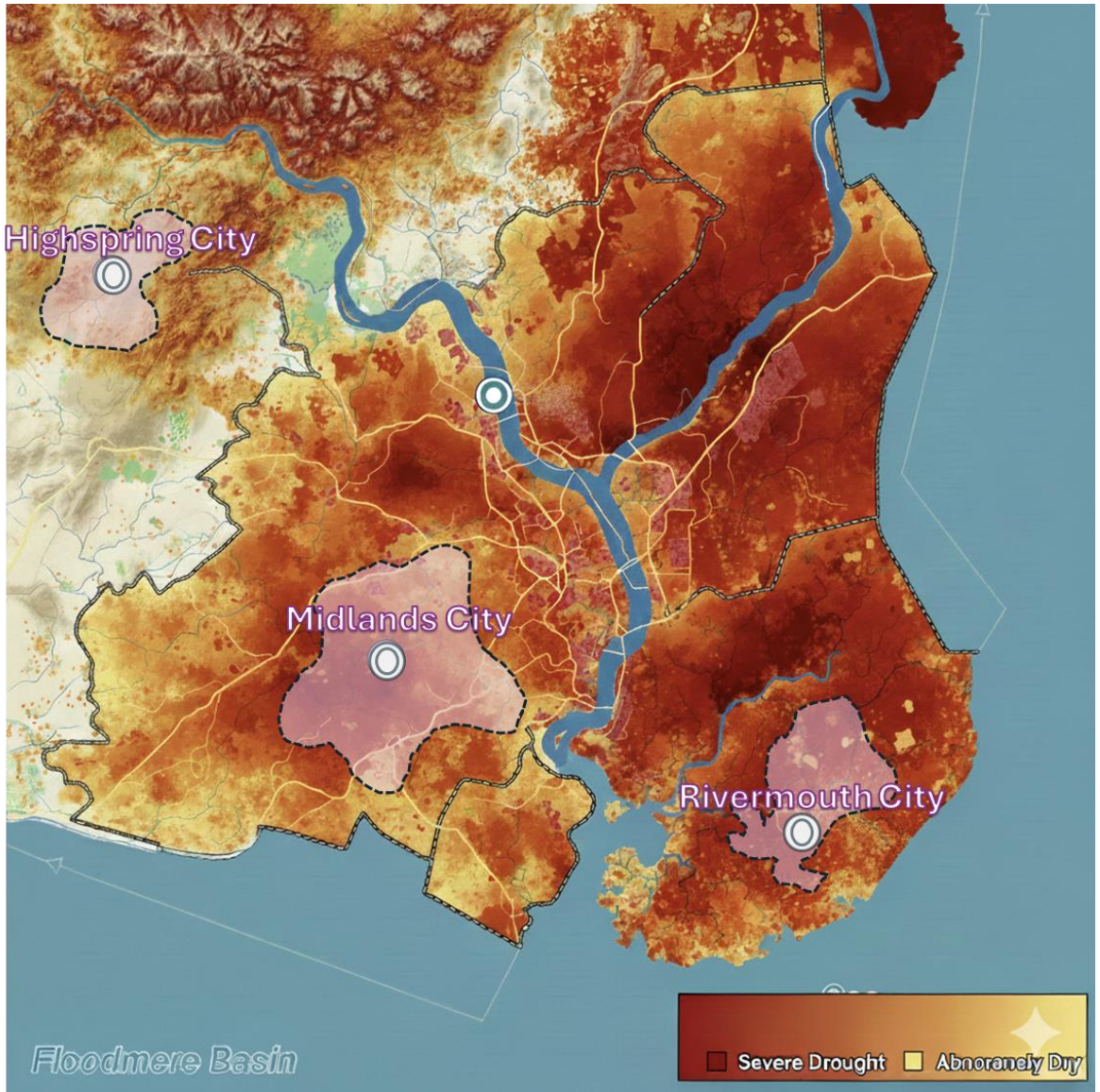
Example: Floodmere Basin Drought Map

Drought map prior to the floods



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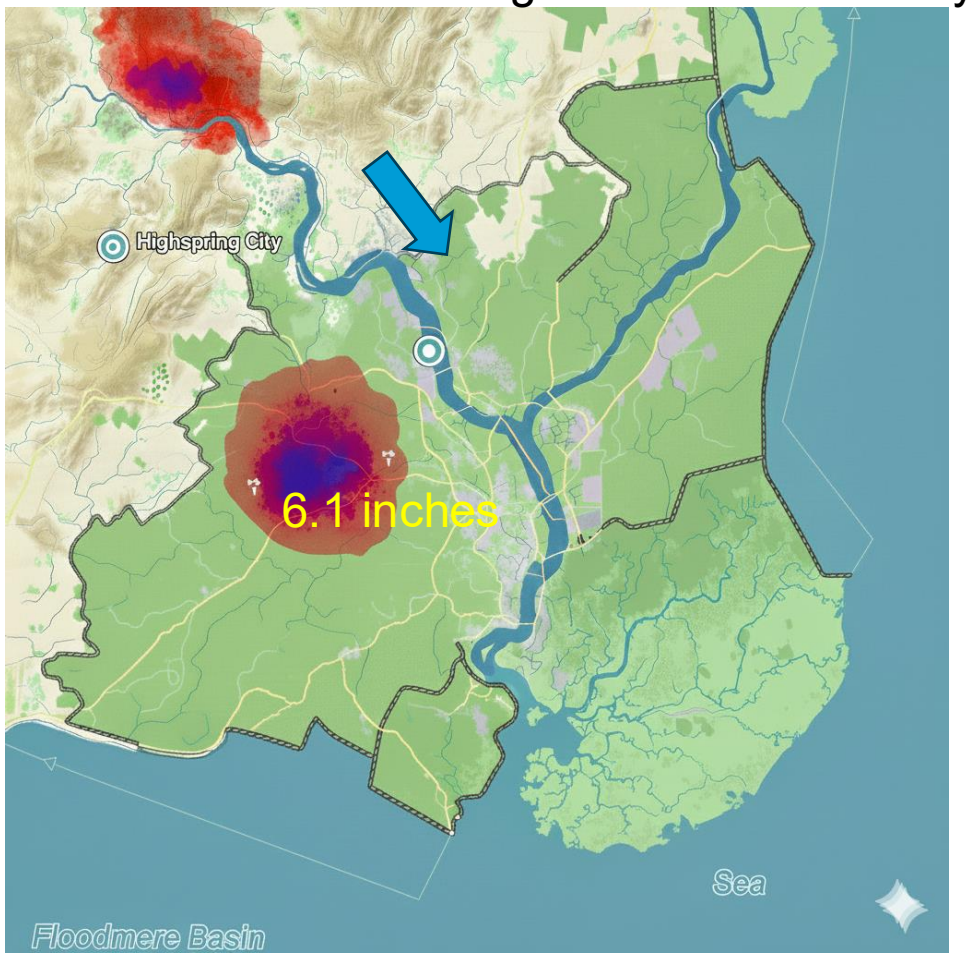
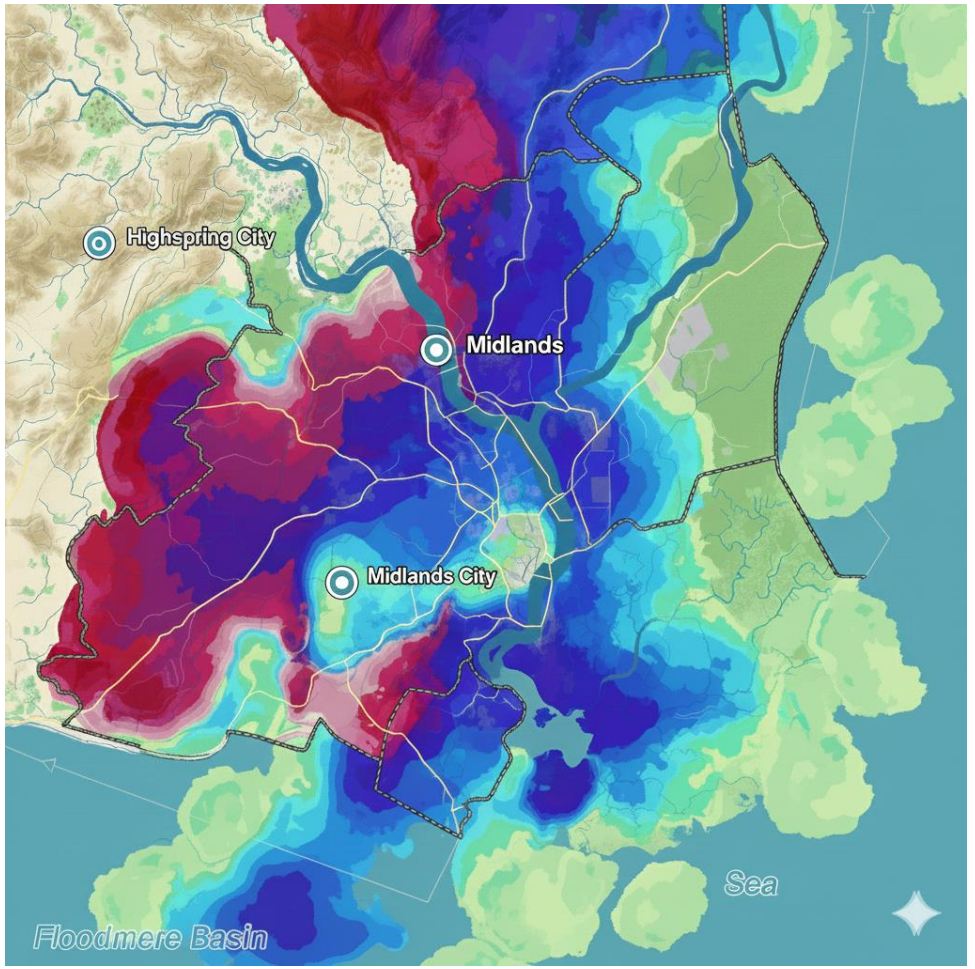
Example: Floodmere Basin Floods

First rain bands moving into area with heavy rains



Second and 3rd days heavy rain. 2 to 8 inch in matter



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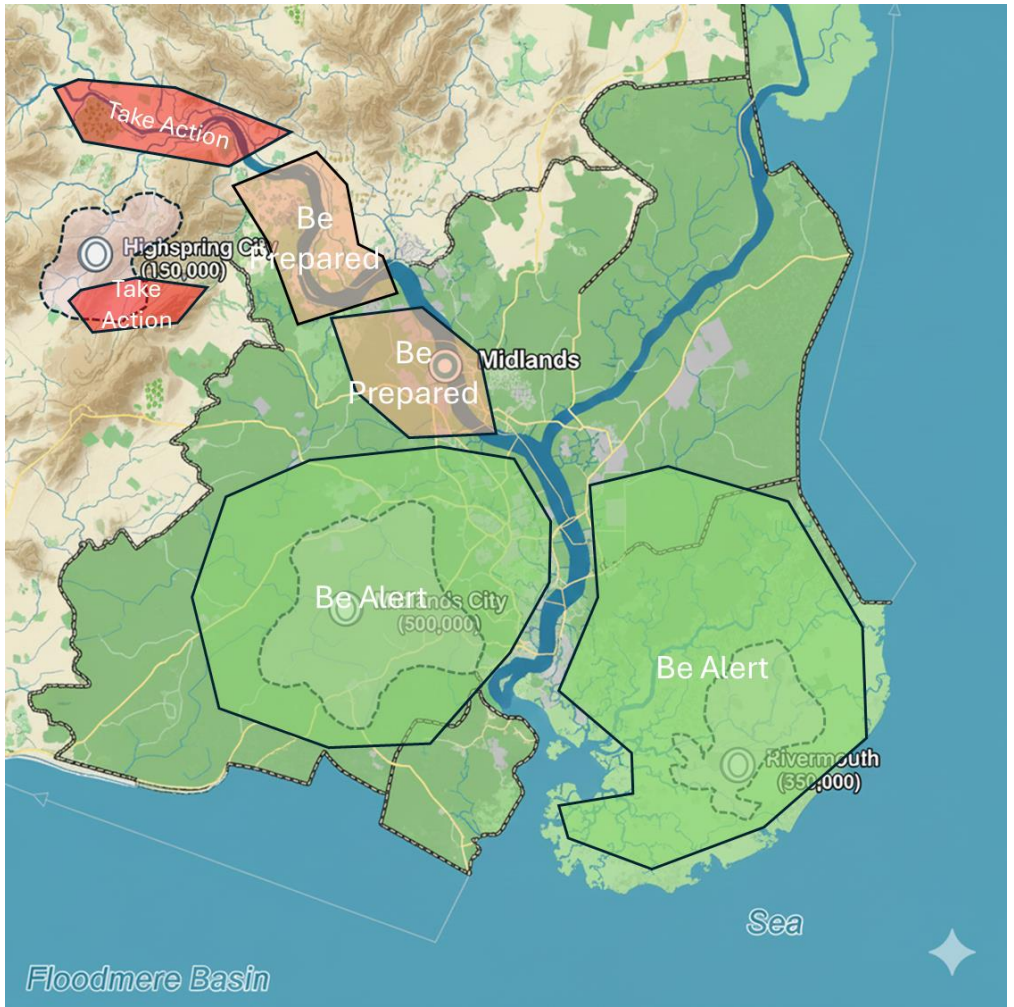
Example: Floodmere Basin Floods

Warnings issued after the first day



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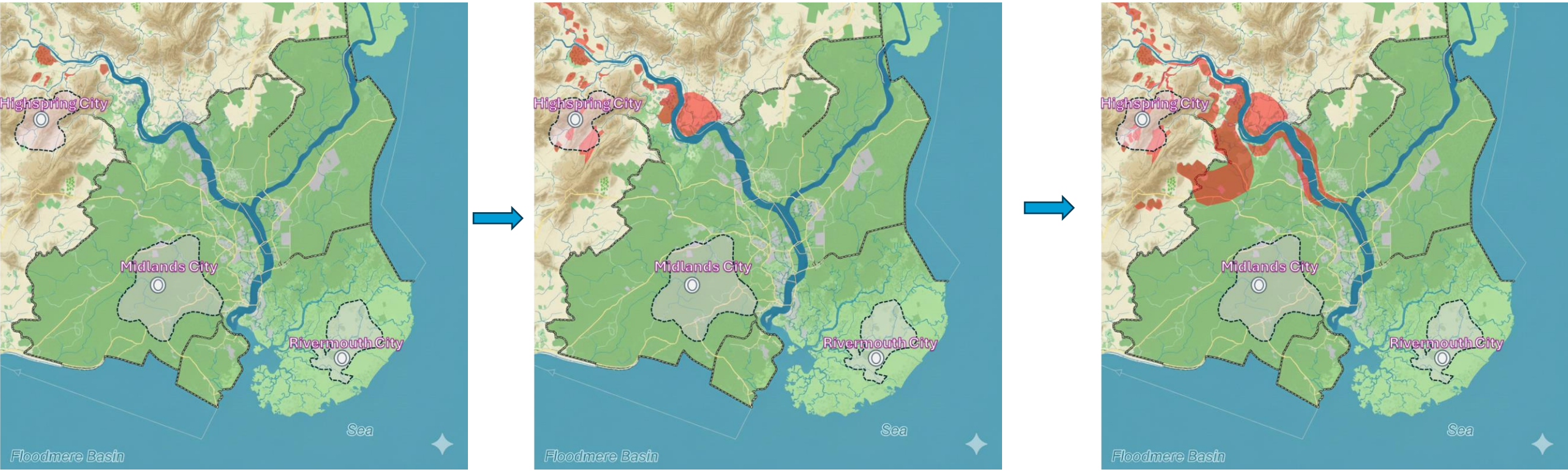
Example: Floodmere Basin Floods

Evolvement of floods around Highspring city
After the first rain bands moving from Northwest
To Southeast



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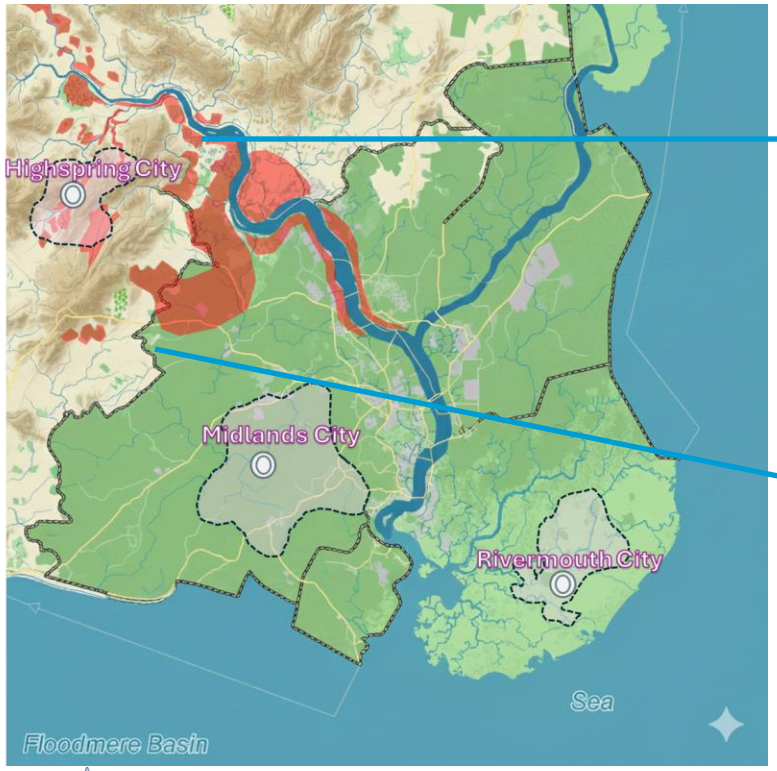
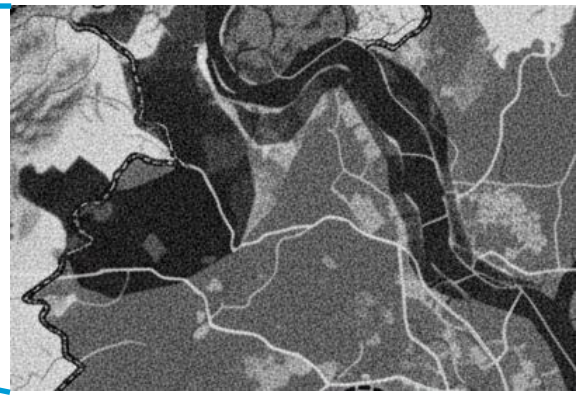
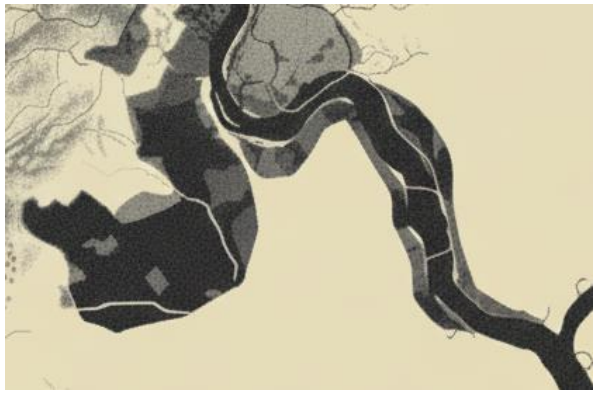
Example: Floodmere Basin Floods



Fake SAR image



Water versus no water



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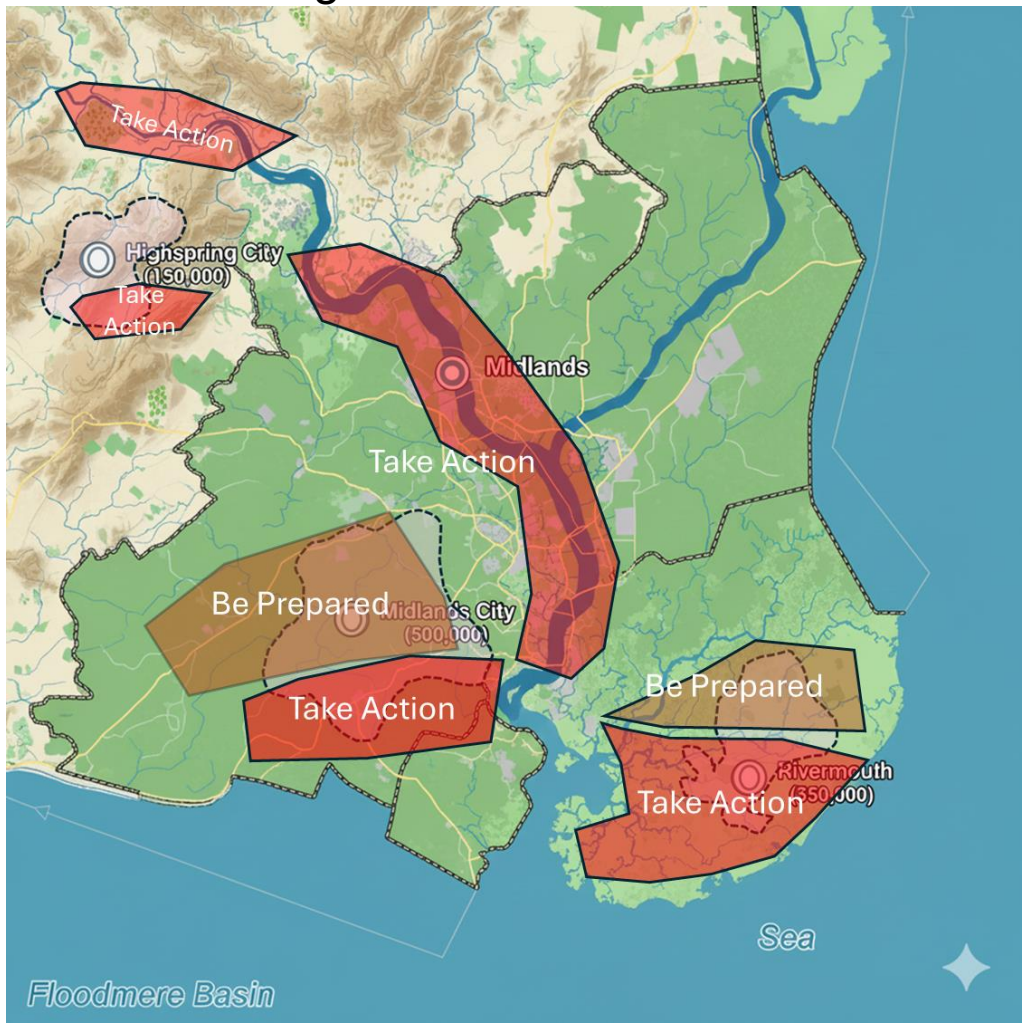
Example: Floodmere Basin Floods

Warnings issued after the first wave of rains



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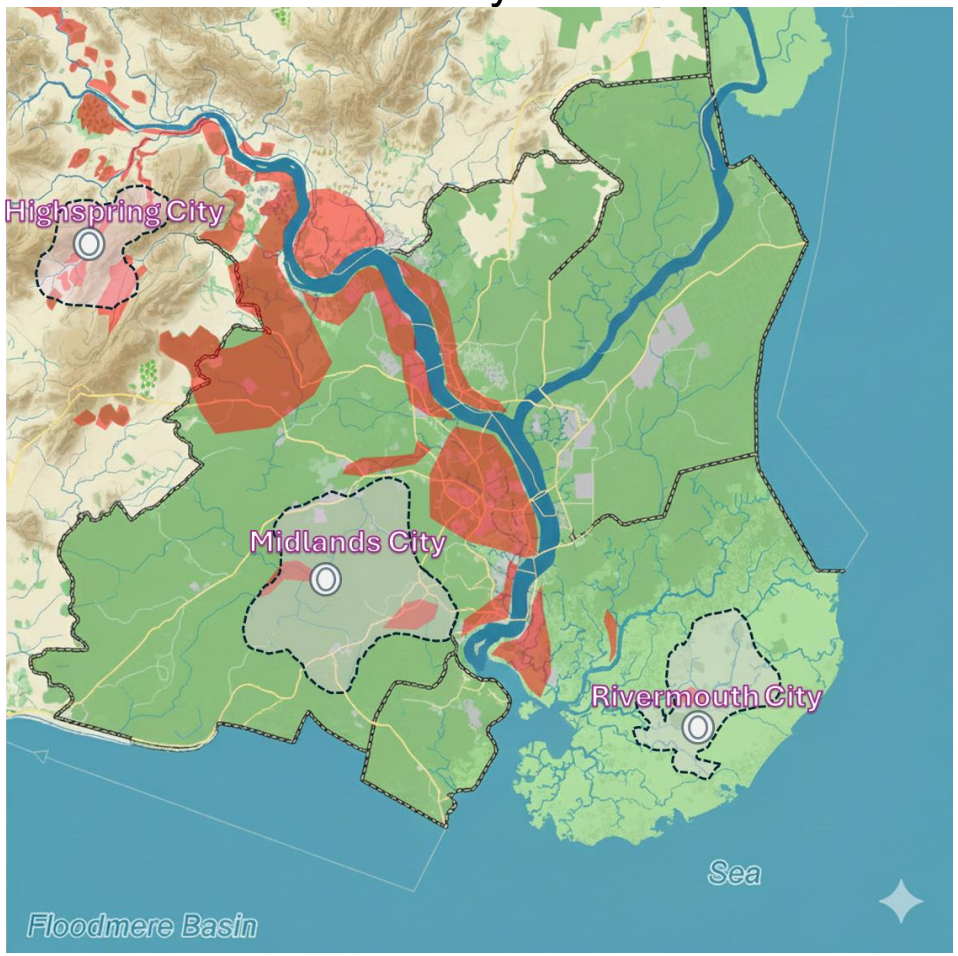
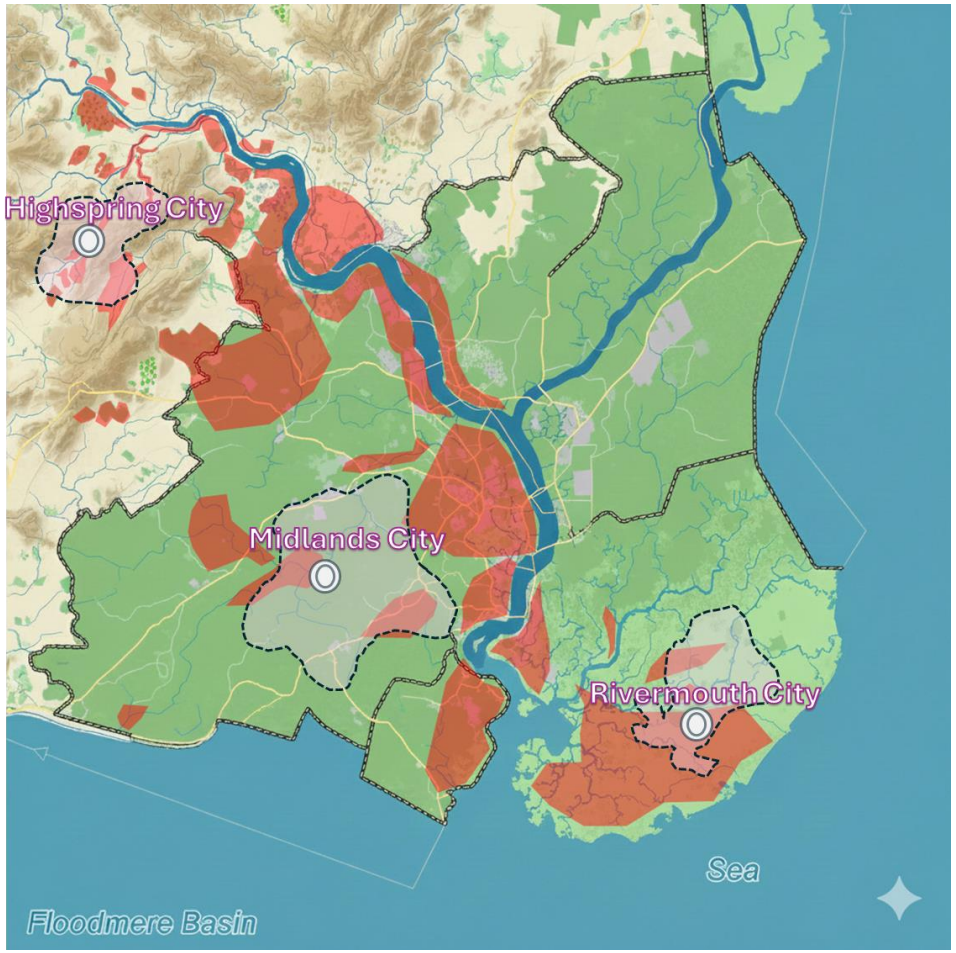
Example: Floodmere Basin Floods

Second- and third-day water extend





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Guiding questions for each group

Which of the provided information will be used by you?

What are the immediate steps or actions taken based on information that is available?

What message will be sent to your users/stakeholders?

Who do you coordinate with?

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Plenary

Summary report from each group

Open discussion and key takeaway message on using AI for flood management and disaster risk reduction in general

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Session -3 Demonstration of AI post-processing for flood management

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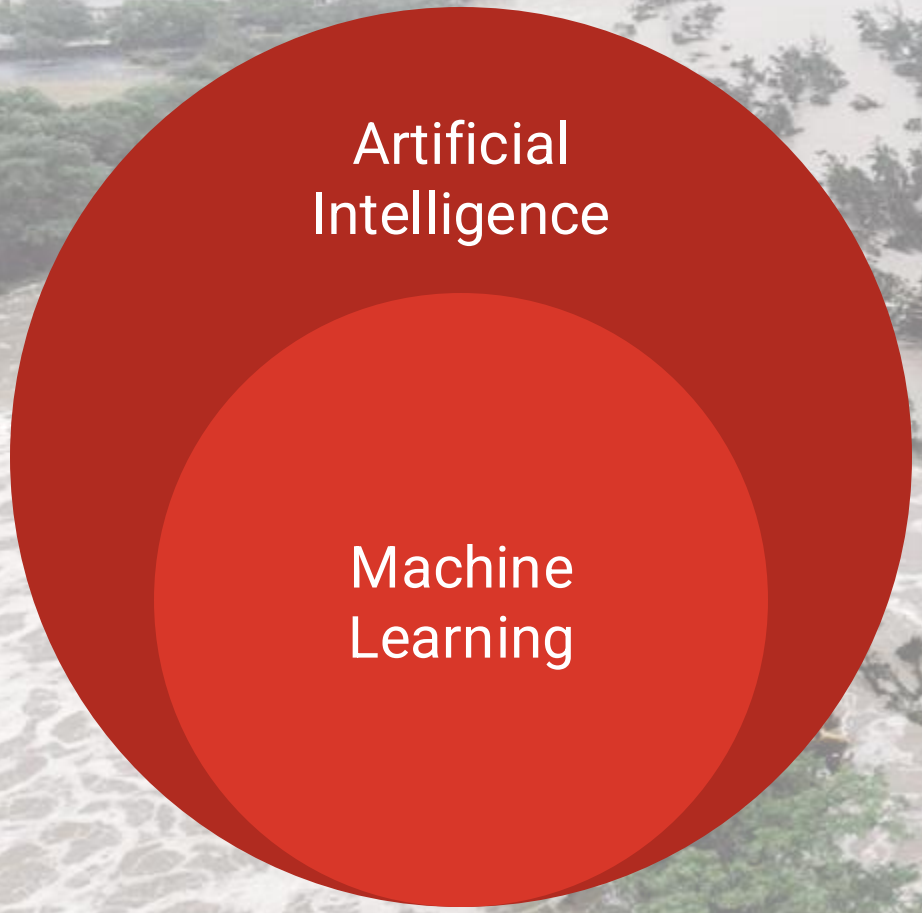
AI-Enhanced Mapping of Floodwater Extent from Satellite Images



UMBC

Example Area for Water Extent Calculation

- The analysis specifically covers a portion of the Colorado River Basin, which was one of the key area of focus during the Texas flood response efforts (2025, July).

All data are available from:
https://appliedsciences.nasa.gov/what-we-do/disasters

UMBC

Synthetic Aperture Radar (SAR) and Segmentation

Why SAR and The Challenge with Traditional Methods:

- Accurately and rapidly mapping flood events is crucial for effective disaster response and mitigation.
- Traditional methods that rely on optical satellite imagery (like from Sentinel-2) are severely limited by weather conditions, particularly cloud cover, which is often present during and after major storms.
- SAR sees through clouds

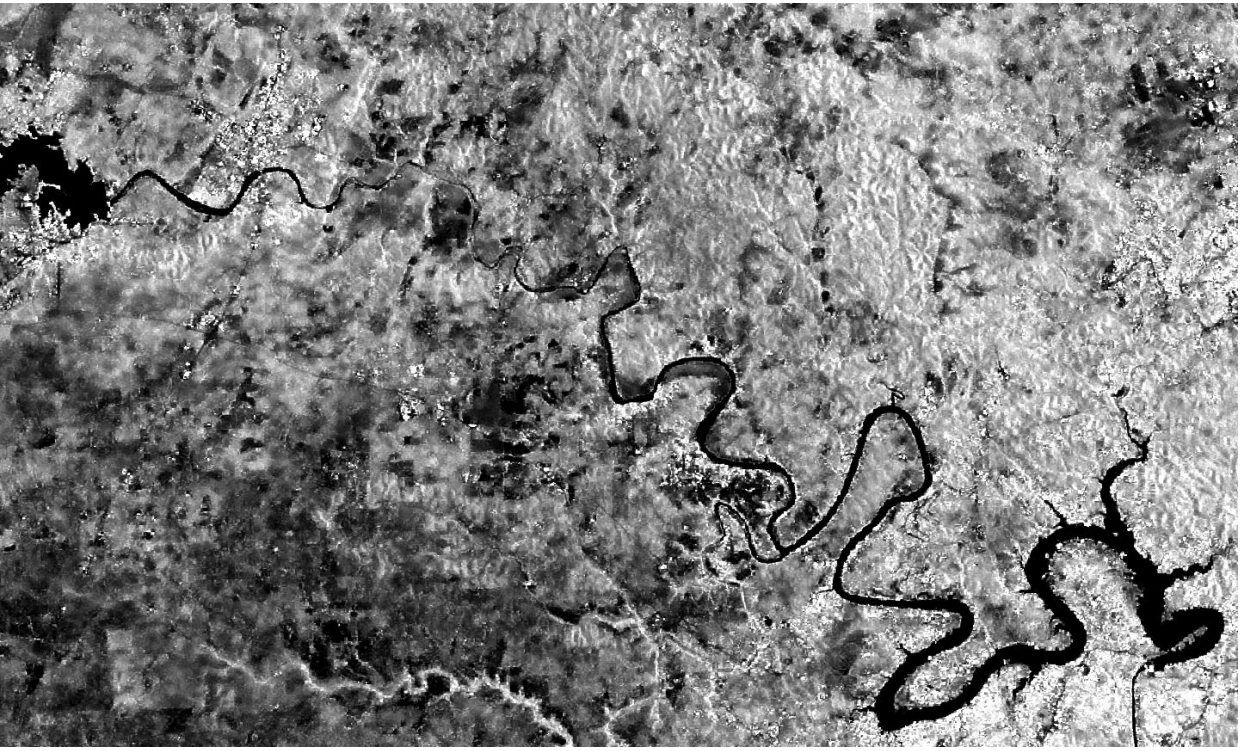
Why Segmentation (SAR images look very complex)**:**

- Segmentation is a process where the algorithms examines the SAR image and automatically marks which parts are water and which are land.
- It enables fast decision-making during emergencies. Segmentation turns complicated radar images into easy-to-read flood maps.
- It makes the flood extent visible, measurable, and actionable.
- It allows measurement — not just visualization.

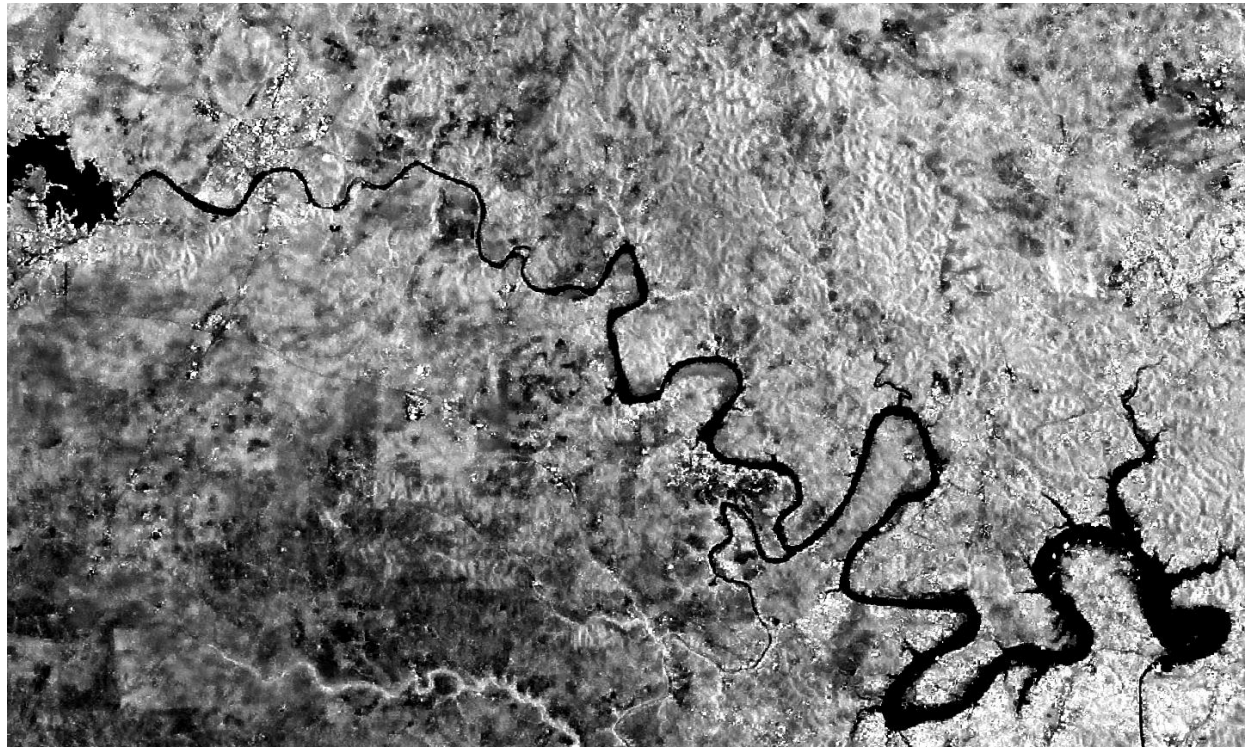
Collected SAR Images (Sentinel 1)

NASA Earth Sciences
Applied Sciences : https://appliedsciences.nasa.gov/what-we-do/disasters/disasters-activations/texas-flooding-july-2025

2025/06/29 – Before flood

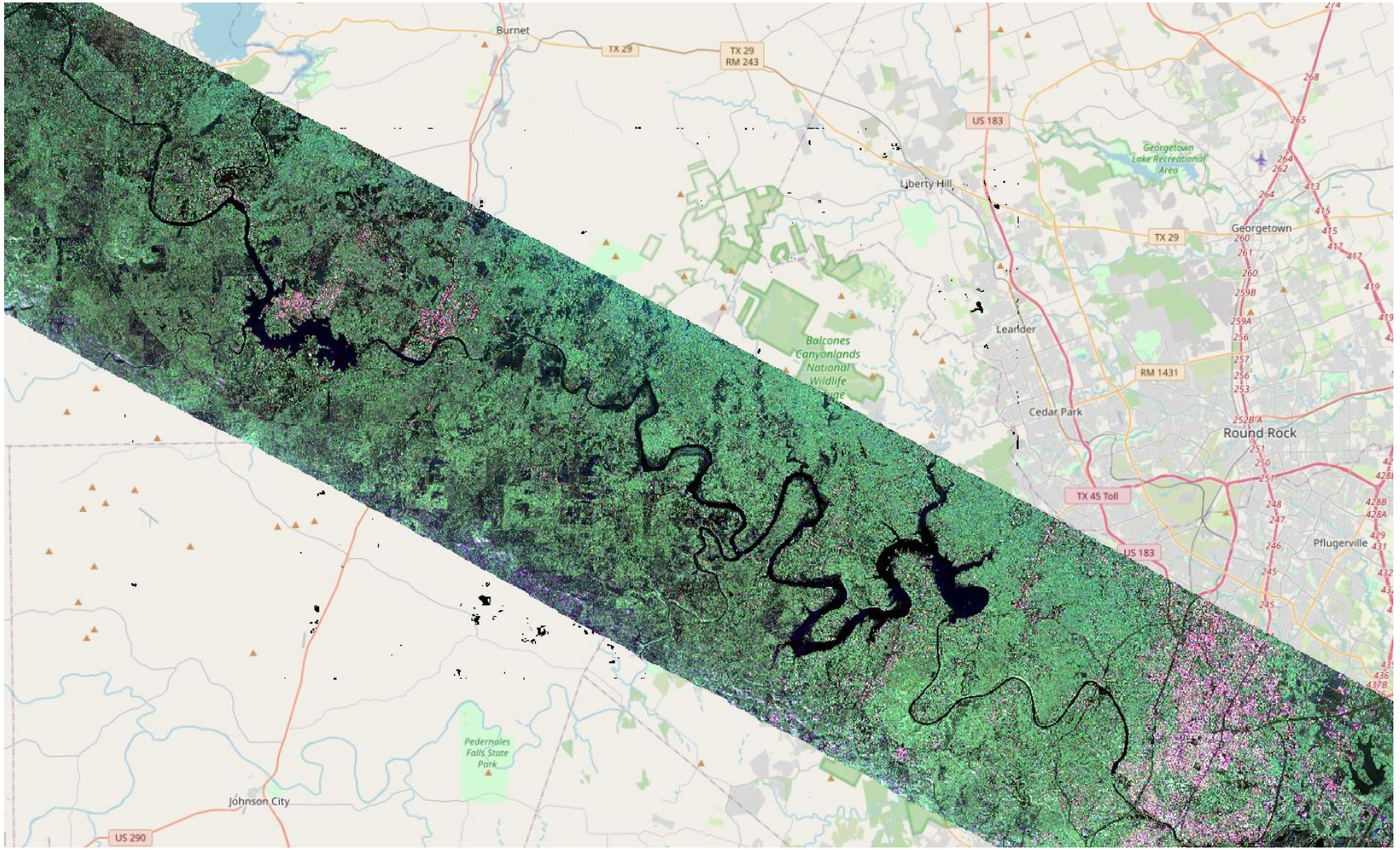


2025/07/11-After flood



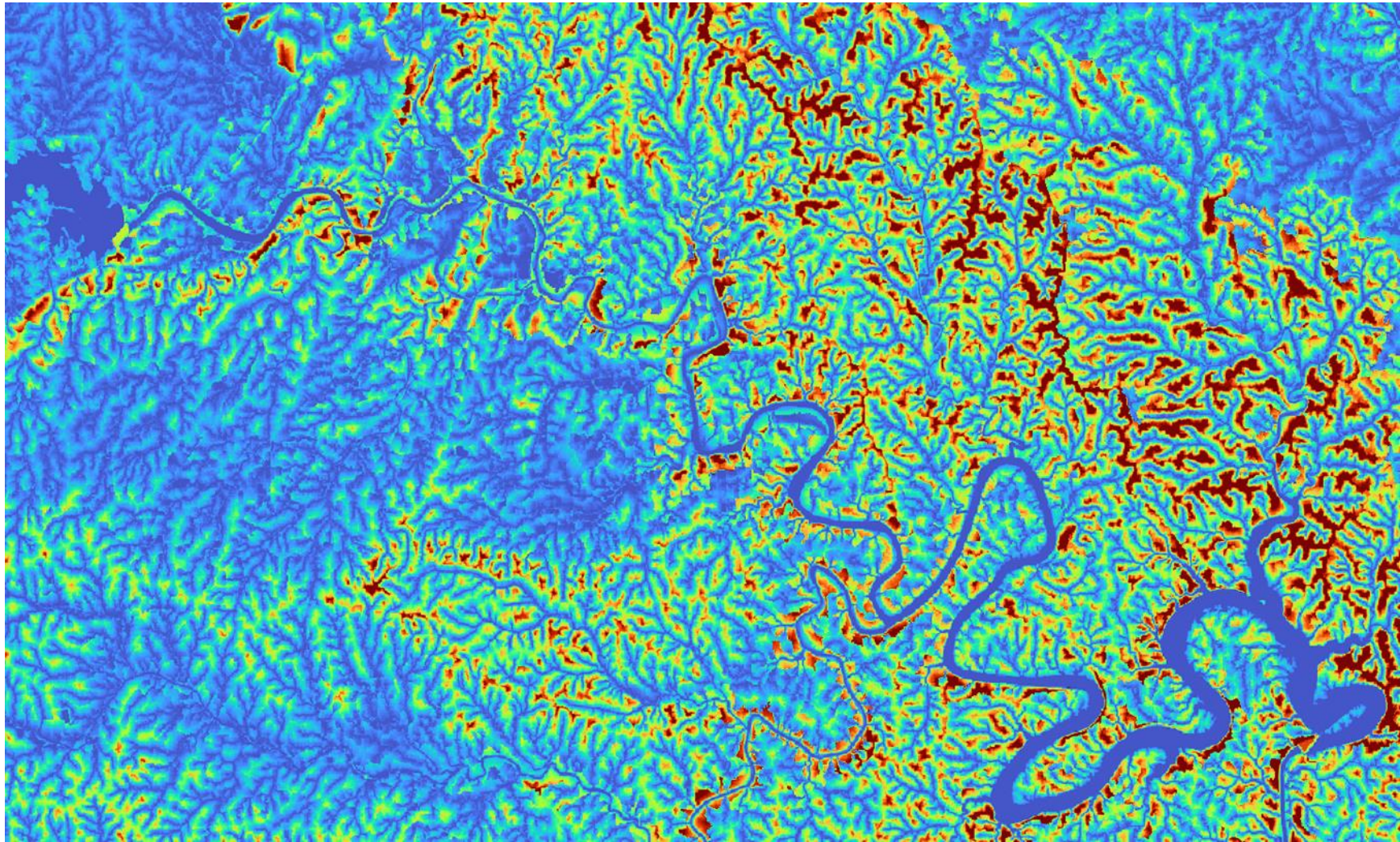
Collected SAR Images (UAVSAR JPL-NASA)

2025/07/09 – After flood



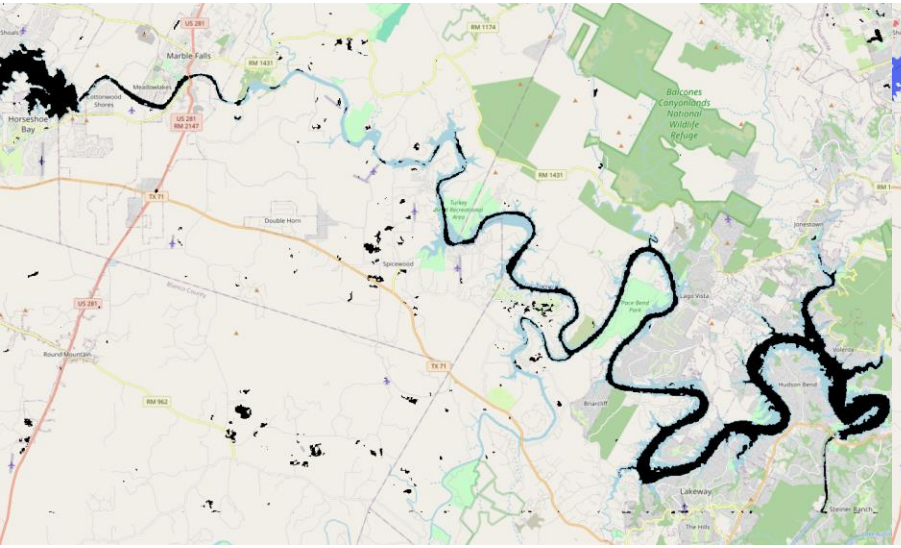
Example of Supporting Data

HAND (Height Above Nearest Drainage) is a terrain-derived index that measures how high each pixel is above the closest river or stream channel. It transforms a DEM into a hydrologic surface showing how water naturally flows and where it pools. Low HAND values (0–2 m) indicate flat, flood-prone areas, while high values show safe, elevated terrain. Because it depends only on topography, HAND is **static** and does not change from one flood event to another.



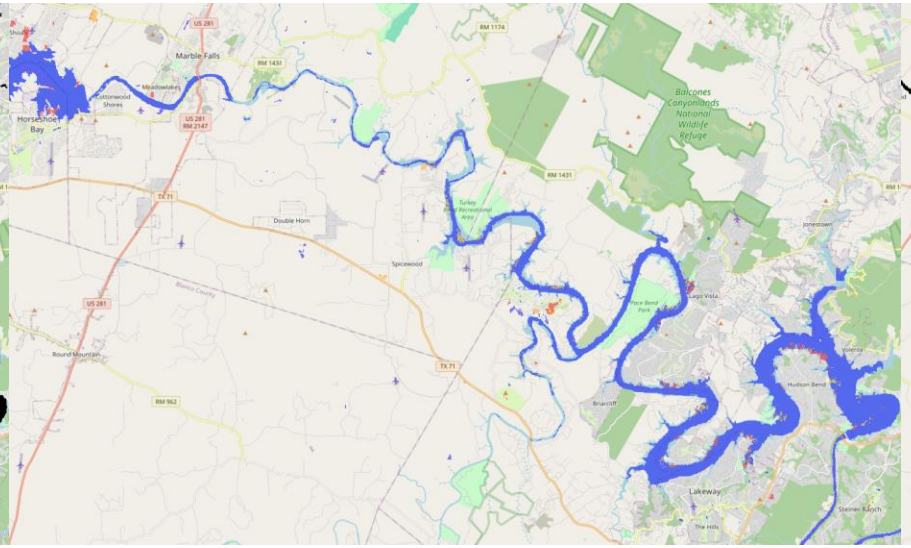
ML Segmented Images

2025/06/29 – Before flood (Sentinel 1)



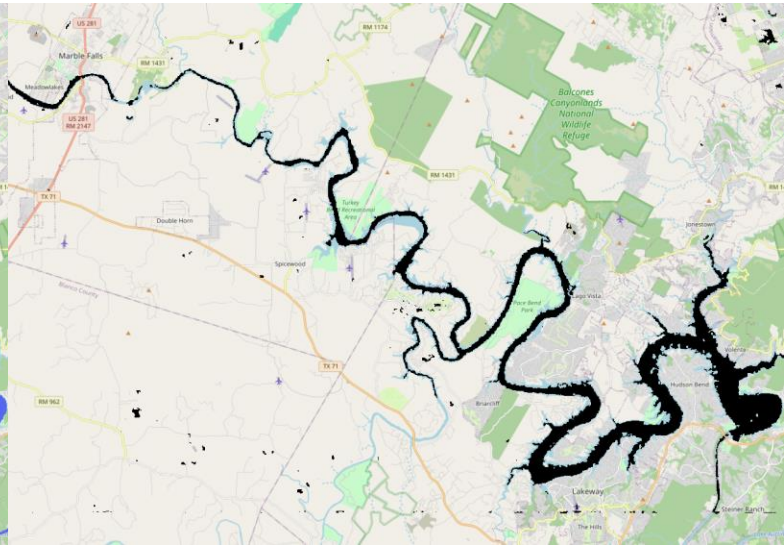
Random Forest Algorithm

2025/07/09 – After flood (UAV)



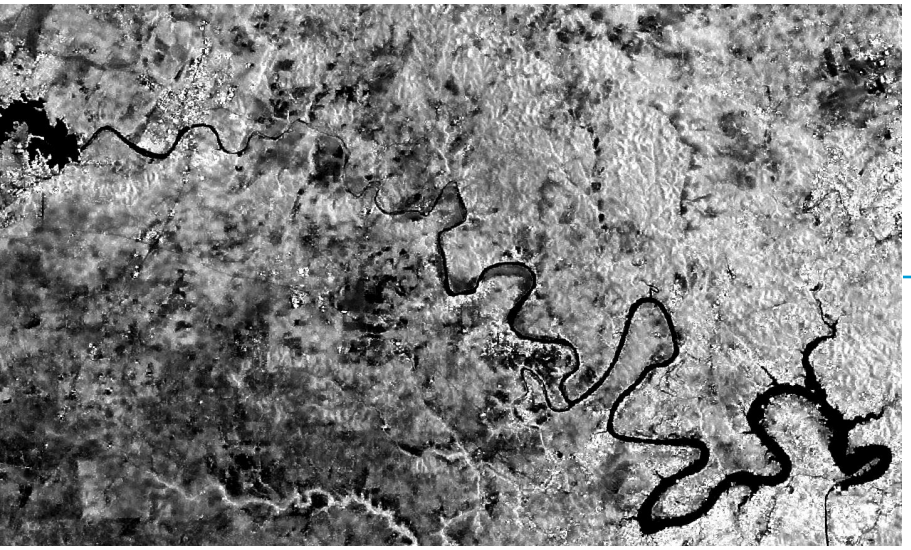
UNET Algorithm

2025/07/11 - After flood (Sentinel 1)

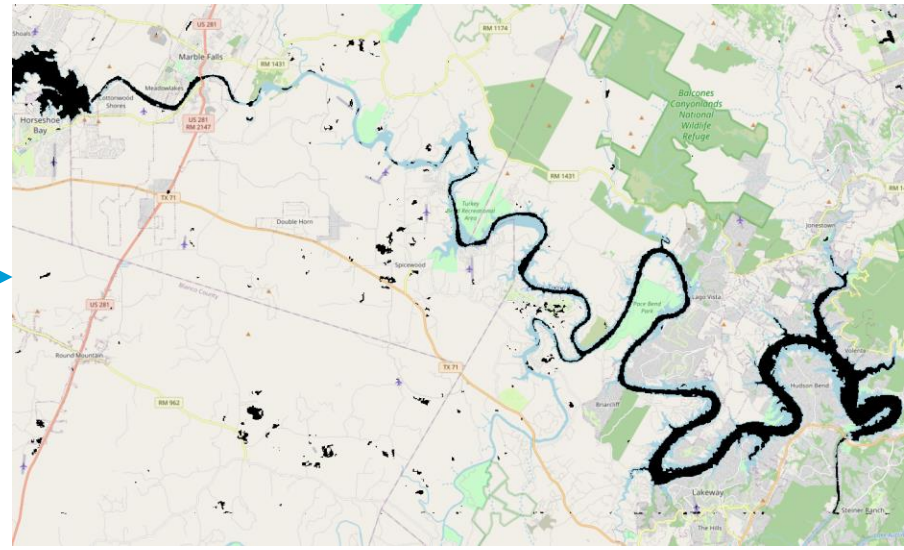


Random Forest Algorithm

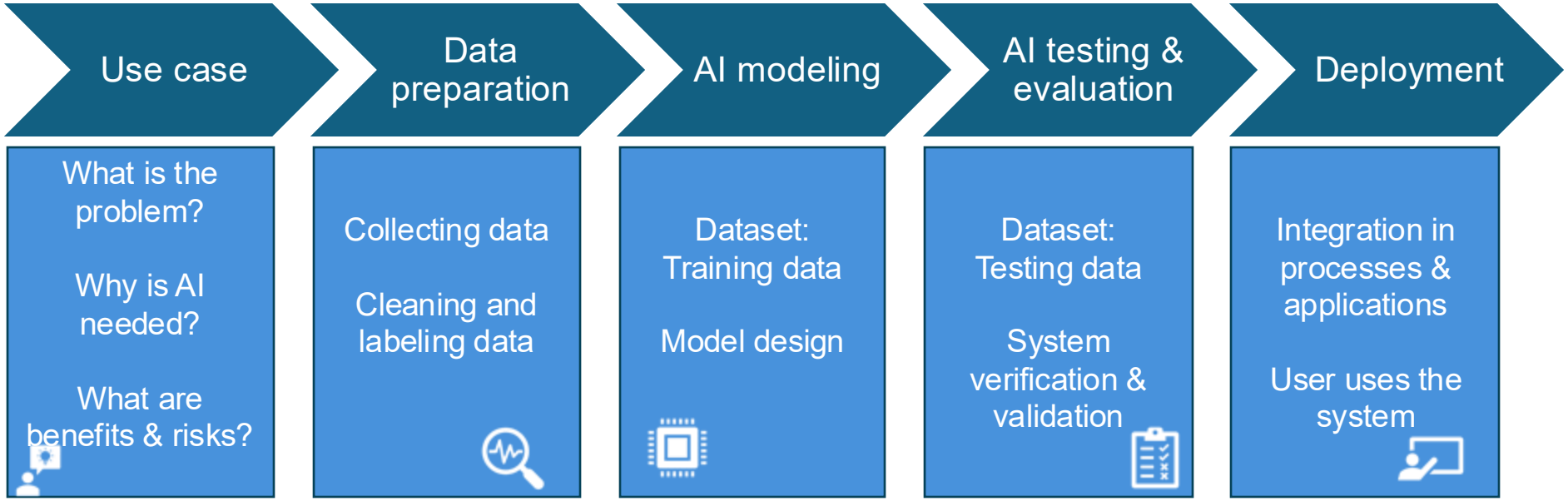
How Segmentation Works?



Classifier



Components of AI Pipeline

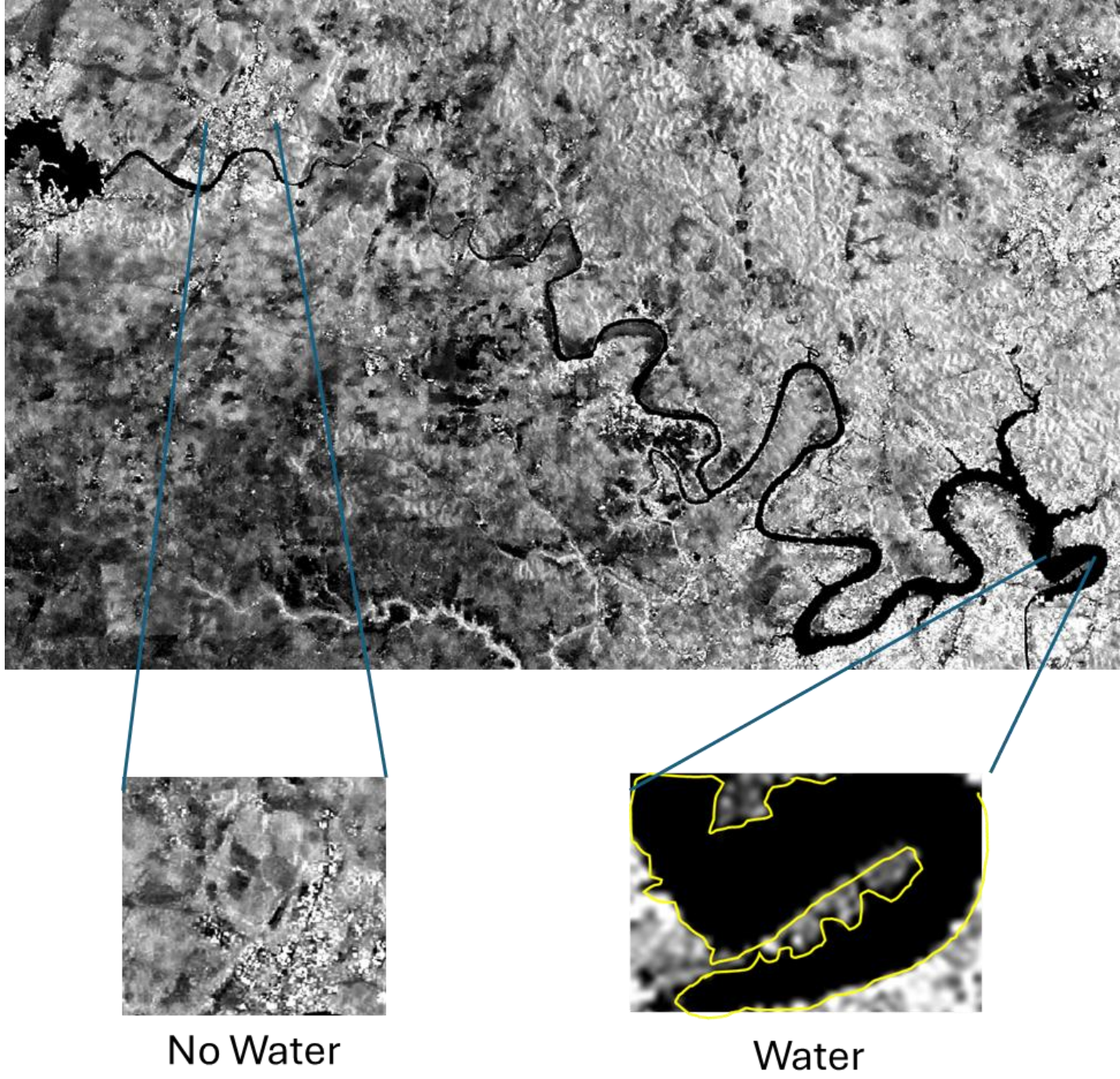


(*adapted from* Vincenzi et al., 2024)

How ML Works

patch → filters → feature maps → feature vector → tree

- A small set of example pixels is marked for each category.
  - User marks a few pixels that represent each class (e.g., water, land).
- The algorithm learns the visual patterns behind those examples.
- It then applies this knowledge across the entire image to generate a full segmentation.



Data preparation

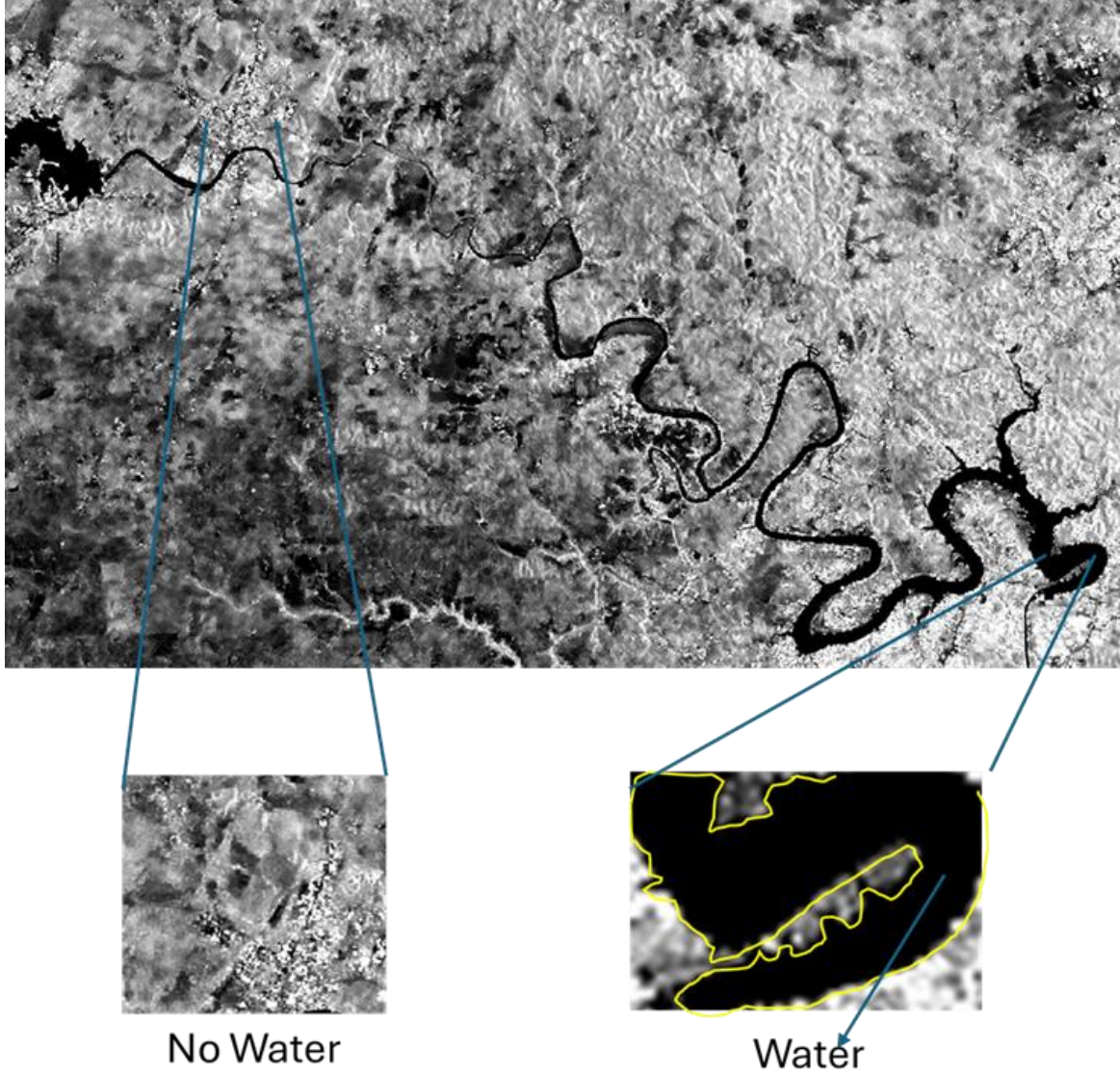
Collecting data

Cleaning and labeling data

How ML Works

patch → filters → feature maps → feature vector → tree

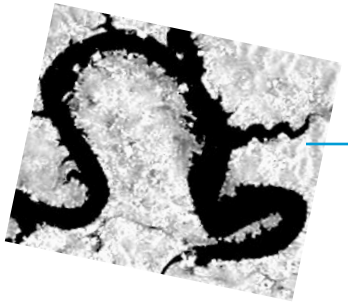
- It analyzes more than pixel brightness.
  - Local details such as edges, smoothness, and textures.
  - For example, texture describes how rough, smooth, or patterned an area is.
- These cues help separate regions that look similar at first glance.
- Interior areas often appear smoother, while backgrounds show more variation.



- Edges
- Brightness
- Texture

General Flow of the Approach

patch → filters → feature maps → feature vector → tree



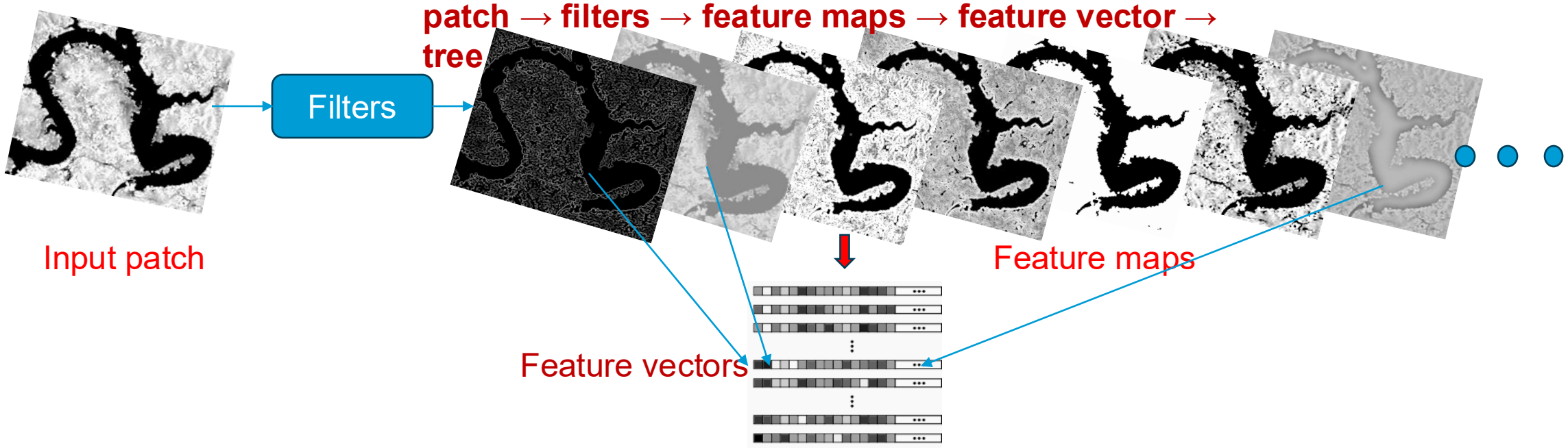
Filters

Edge
Texture
Intensity

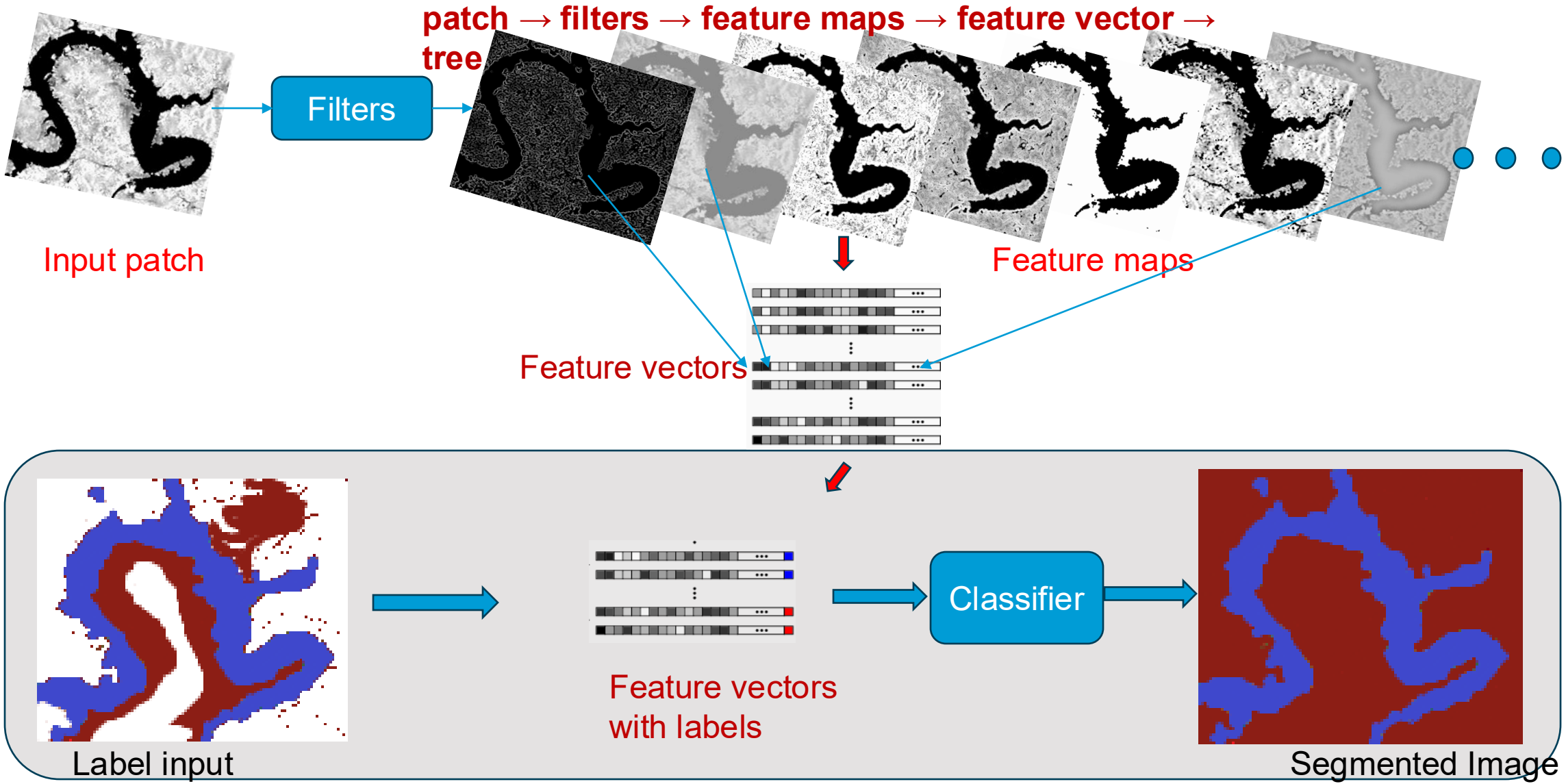
Input patch

Flow updated from https://academic.oup.com/bioinformatics/article/33/15/2424/3092362?login=false

General Flow of the Approach



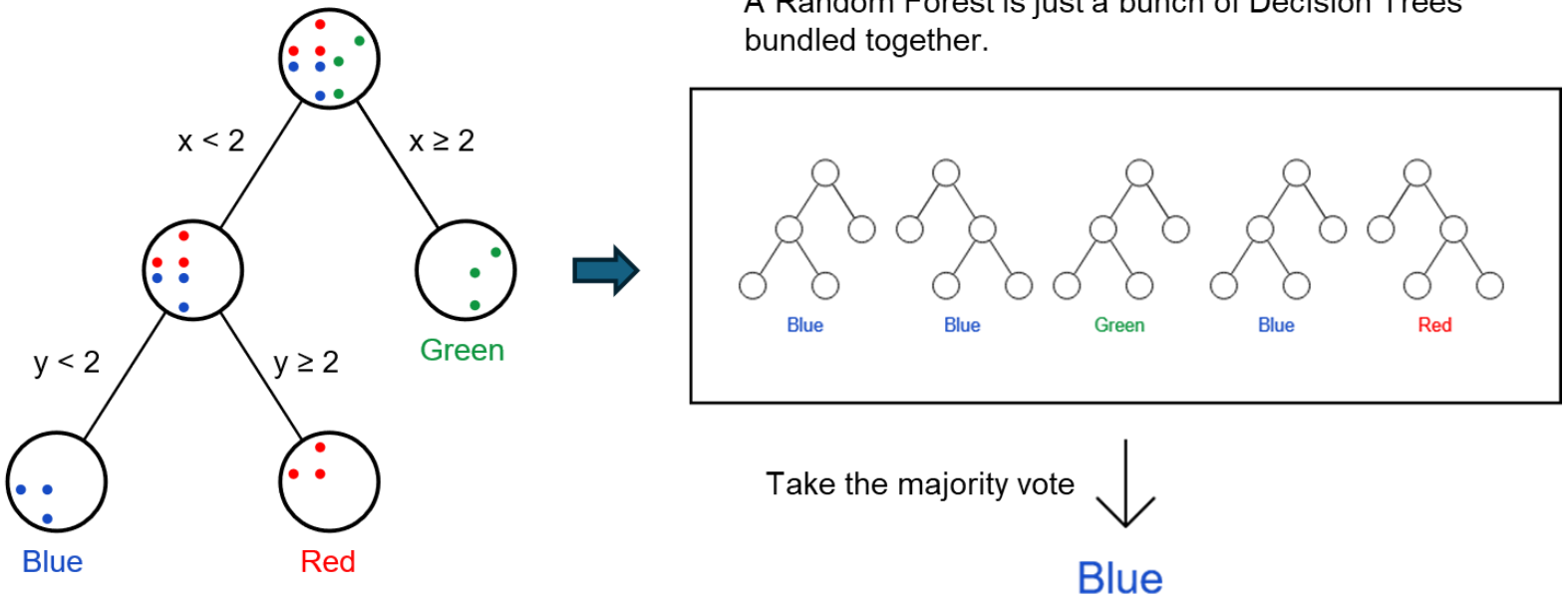
General Flow of the Approach



How ML Works (Classifier)

patch → filters → feature maps → feature vector → tree

- The model learns the patterns that separate one class from another.
- A Random Forest combines many simple decision rules.
- Each rule checks one feature (brightness, contrast, texture, etc.).
- Their combined votes produce a reliable classification for each pixel.



How ML Works

patch → filters → feature maps → feature vector → tree

- Learned patterns are applied to every pixel.
- Each pixel is assigned to its most likely class.
- A full segmentation is generated automatically.
- The same trained model can classify new images as well.

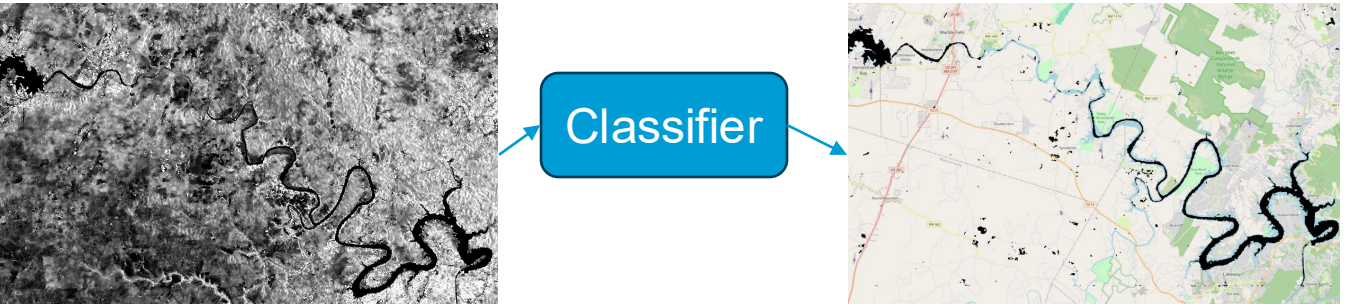


Image created by google Gemini