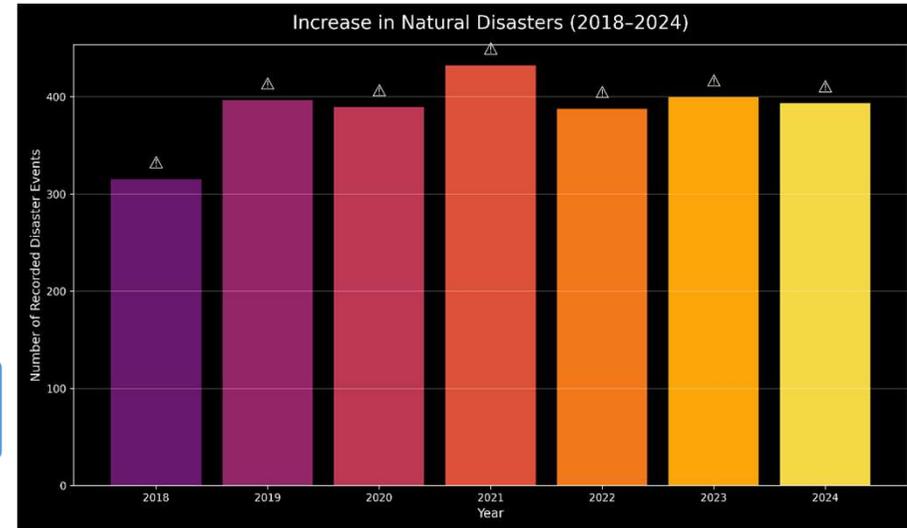Dr. Surya Deb Chakraborty

Flood Analysis Using SAR Images

1

Disasters are increasing in frequency, intensity, and impact. Earth Observation is no longer optional — it is essential

🌍 **167 million people affected by natural disasters in 2024**

In 2024, **393 natural hazard events** were recorded worldwide.

These disasters affected **about 167.2 million people** and caused **over US$240 billion in economic losses**.

16,753 people lost their lives due to these events globally

Increase in Natural Disasters (2018–2024)

# Why Flood Mapping is Critical

- Floods are among the **most frequent and destructive natural disasters**

- **Cause:**
    - Loss of life
    - Damage to infrastructure
    - Crop loss
    - Long-term socio-economic impact

- **Accurate and timely flood maps are essential for:**
    - Disaster response
    - Relief planning
    - Damage assessment

Challenges in Flood Mapping Using Optical Data

Limitations of Optical Satellite Data During Floods :

- Flood events usually occur with:
  - Heavy rainfall
  - Thick cloud cover

- Optical sensors:
  - Cannot see through clouds
  - Fail during night-time

- Result: **No usable data exactly when we need it most**
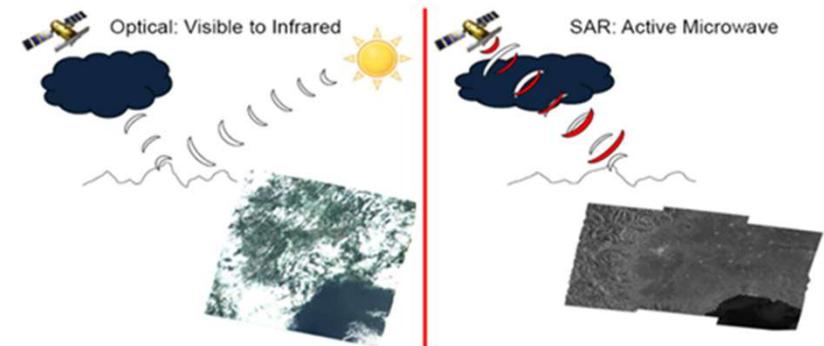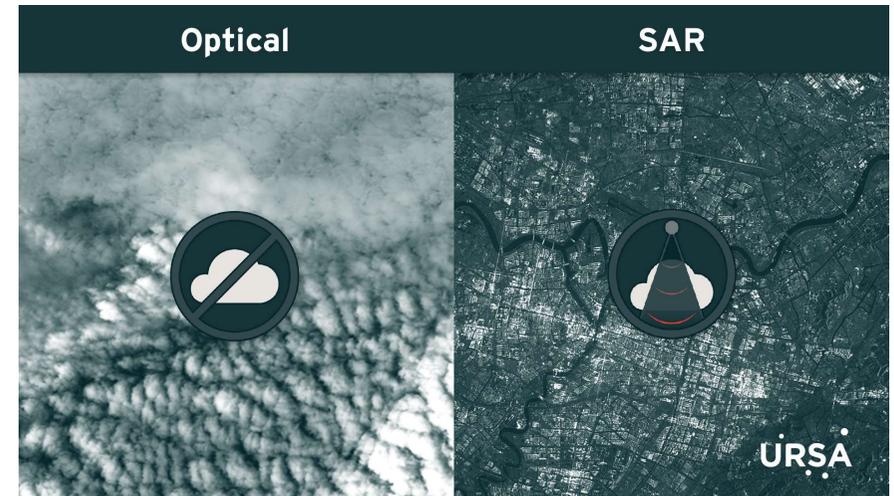
Why Synthetic Aperture Radar (SAR)?

Visible to infrared

Active Microwave(SAR)

SAR Advantages

- It sends its own energy and records the backscatter

- Key advantages:

  ○ Works **day & night**

  ○ All weather capabilities (clouds, rain, and haze)

  ○ Penetration capabilities

  ○ **Active and passive sensor**

Hence, SAR is **ideal for flood monitoring**

Optical	SAR

URSA
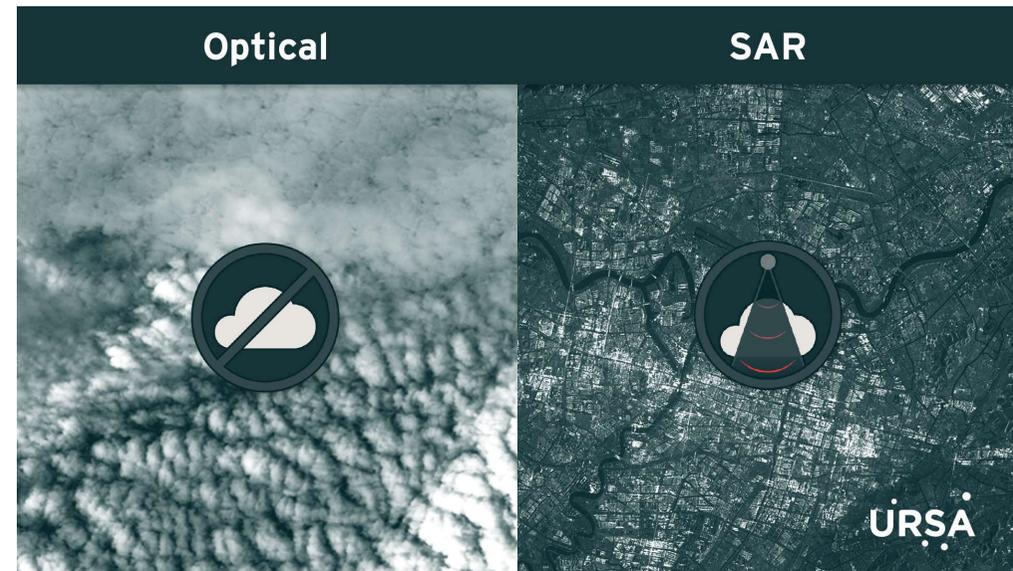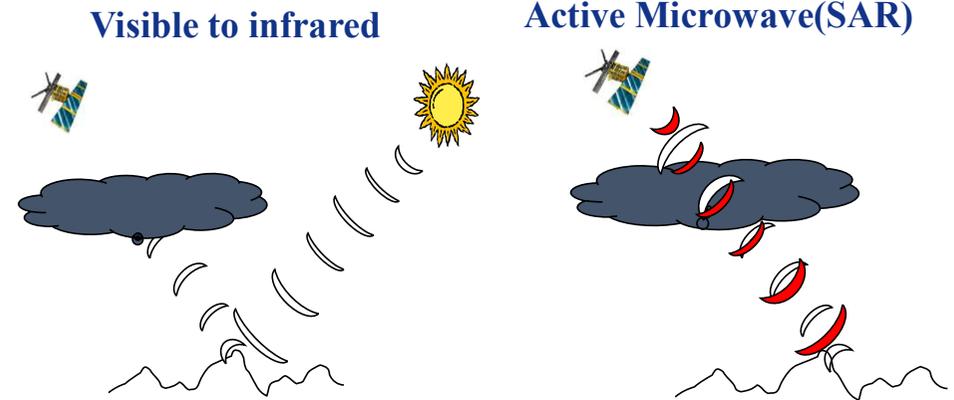
Microwave Radar Bands

Wavelength Range of Microwaves

Band	Wavelength range (cm)	Utility
Ka, K, Ku	0.8 – 2.4	Early airborne radar systems
X	2.4 – 3.8	Military reconnaissance, terrain mapping
C	3.8 – 7.5	Flood mapping, agriculture, forest, marine/oceanic research
S	7.5 – 15.0	medium-range meteorological applications (ex. rainfall measurement, airport surveillance and specialised tracking tasks)
L	15.0 – 30.0	Forestry, Oil spills, boat/ship identification, glacier/ice, geology
P	30.0 – 100.0	Geology, study of vegetation canopies, glacier/sea ice and soil

Interaction with Target

What are Microwaves?

- Electromagnetic radiation in microwave wavelength region

- Range - about 1 cm to 1 m

- Main advantages:
  - Can penetrate through cloud cover, haze, dust, and moderate rainfall
  - Data can be collected at any time
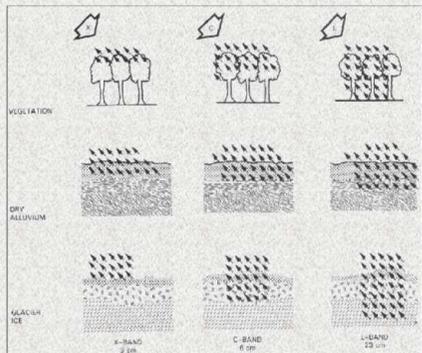
Properties of Microwaves

Characteristic that control Radar energy / Target interaction

1. System parameter

▪Wavelength
▪Polarization
▪Look angel
▪Resolution

2. Target parameter
Surface roughness
Moisture Content
Slope and orientation
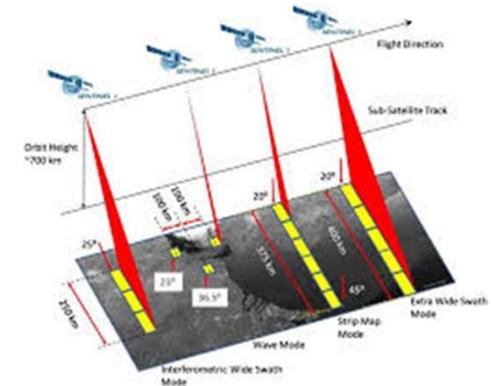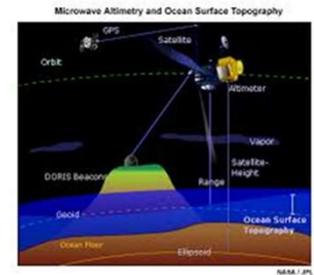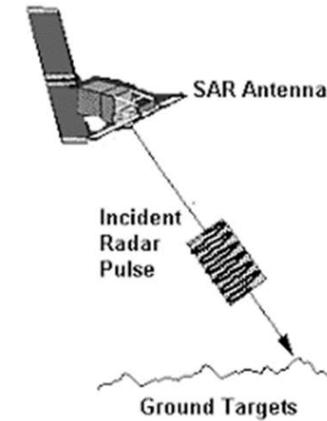
Polarisation

Properties of Microwaves - Polarisation

- Polarization refers to the orientation of the electric field

- Most radars transmit microwave radiation either horizontally polarized (H) or vertically polarized (V)

- Similarly, the antenna receives either the horizontally or vertically polarized backscattered energy; some radars can receive both

- There are four combinations of transmit and receive polarizations:
  - HH - for horizontal transmit and horizontal receive,
  - VV - for vertical transmit and vertical receive,
  - HV - for horizontal transmit and vertical receive, and
  - VH - for vertical transmit and horizontal receive
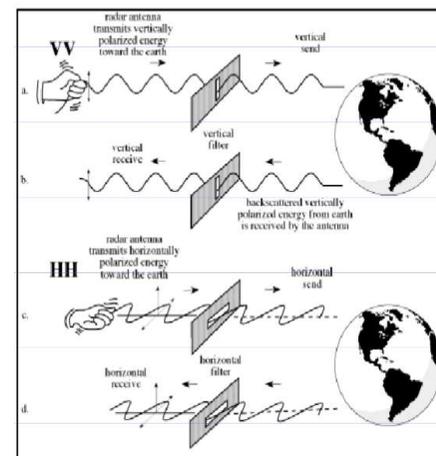
Polarization

HH - for horizontal transmit and horizontal receive
VV - for vertical transmit and vertical receive
HV - for horizontal transmit and vertical receive
VH - for vertical transmit and horizontal receive

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➤ **Roughness – The higher the object's roughness, the larger the fraction of the energy reflected back to the radar.**
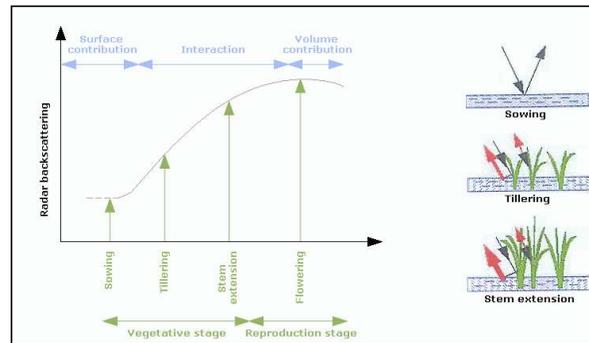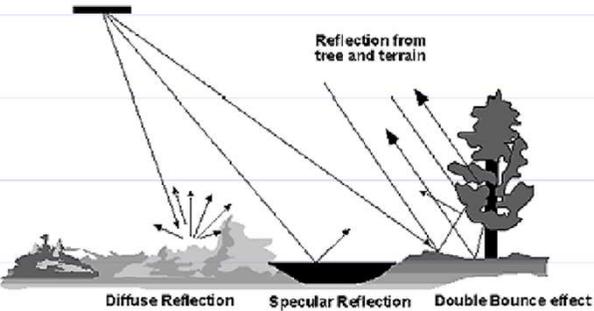
Increase of plant height does correspond to an increase in roughness, hence reflected energy.
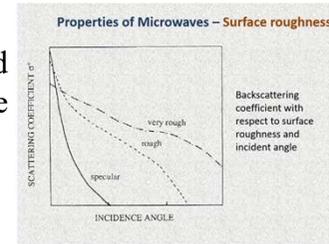
➤ **Moisture – The moisture content in the plant translates into relevant variations of the backscattered energy.**

plant growth

moisture changes

plant drying
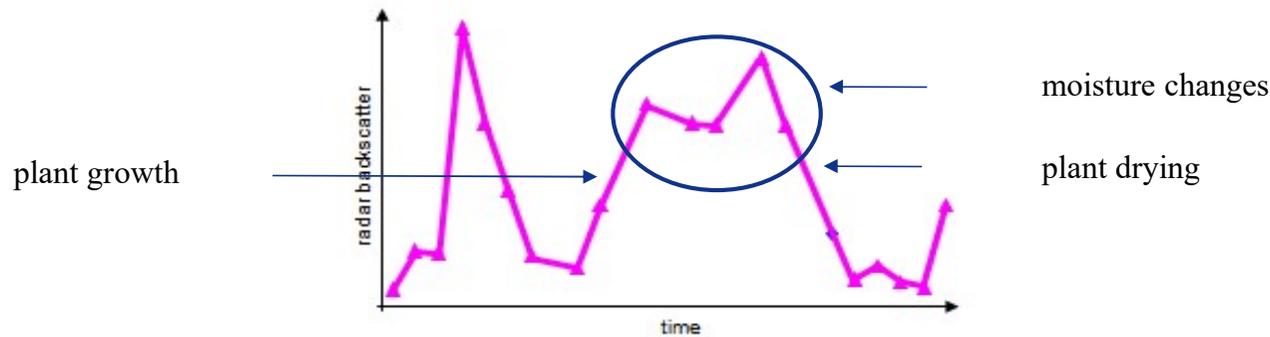
How SAR Sees Flooded Areas

SAR Backscatter Behaviour During Floods

- Smooth water surface → **low backscatter**

- Appears **dark** in SAR images

- Flooded areas show:

  ○ Sudden change in backscatter compared to pre-flood condition

- This change is the **key to flood detection**

No return: Smooth surface, specular reflection

Moderate return: Intermediate roughness

Strong return: Rough surface, diffuse scattering
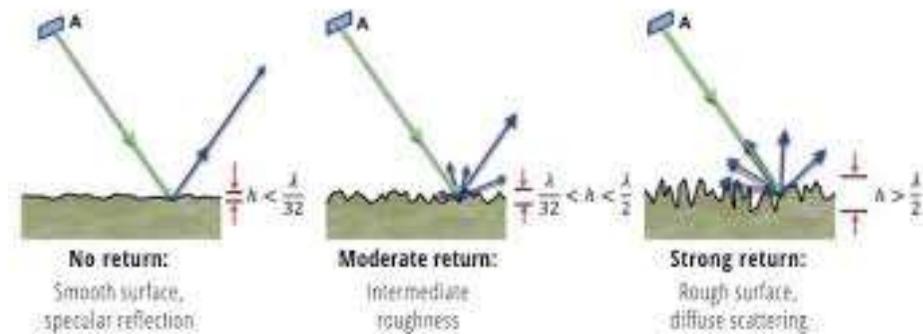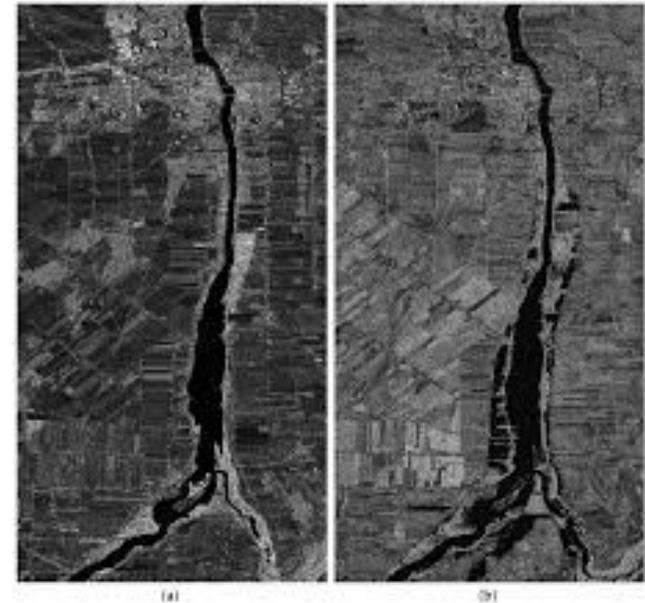
Why Sentinel-1 for Flood Analysis

Advantages of Sentinel-1 SAR Data

- Free & open-access (Copernicus Program)

- C-band SAR, ideal for water detection

- Revisit time:

  - 6–12 days

- Widely used by:

  - Disaster agencies

  - Researchers

  - Operational flood services

SAR Acquisition Modes
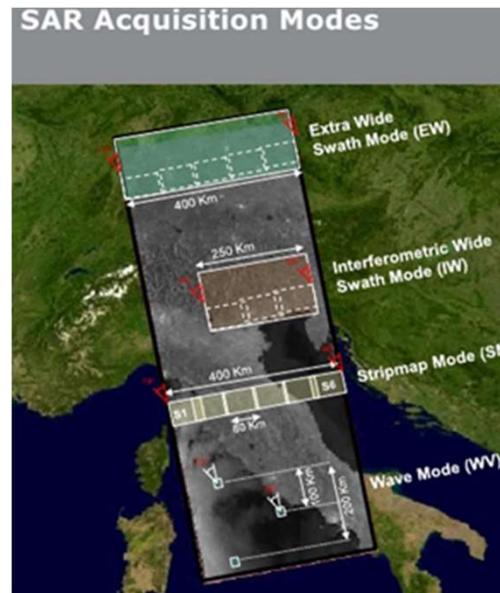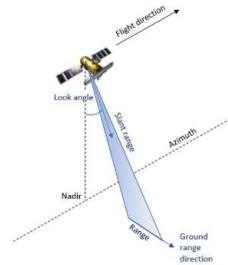
Flood Disaster monitoring

Different types of Flood

Cyclonic flood in LAOS

Flash flood in Nepal
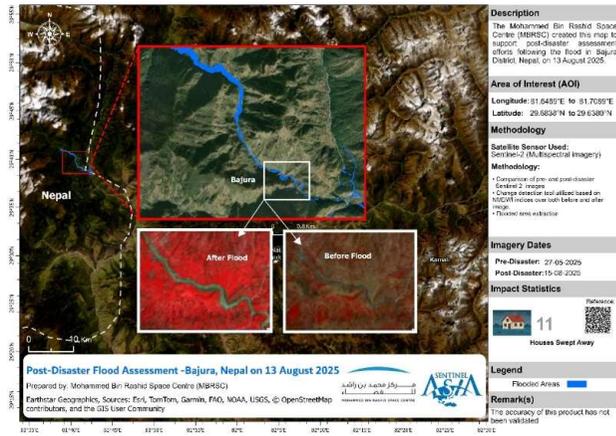
Landslide due to Flood in Sudan
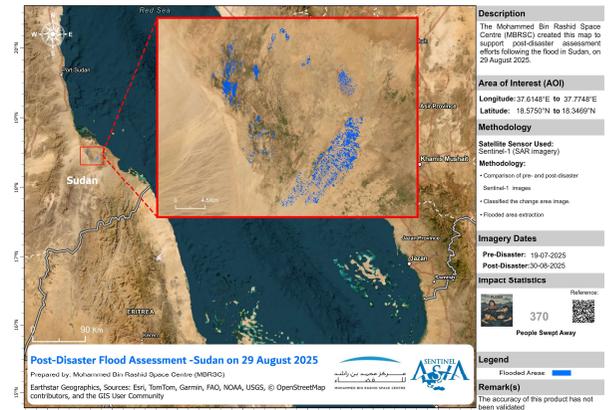
Mud flow due to Flood in Turkmenistan
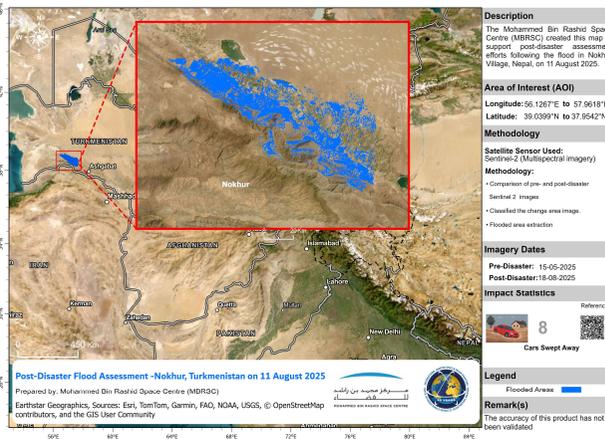
Cloud Blust flood in India
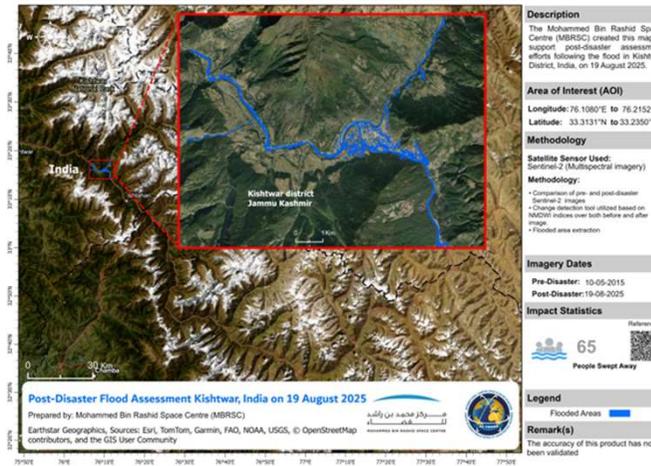
Flood in Mozambique

Model developed for SAR data preprocessing
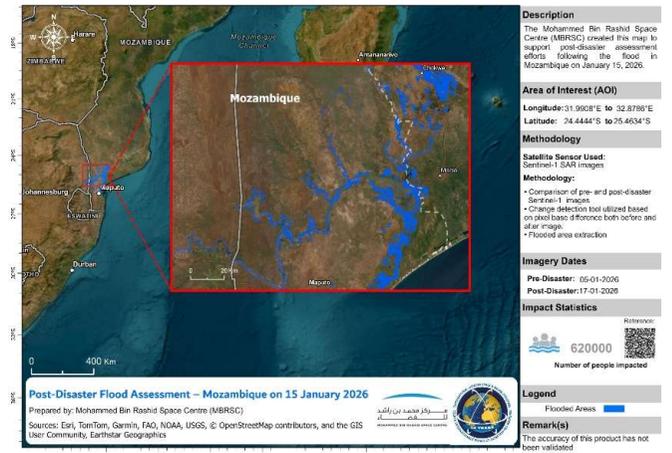
End-to-End Flood Mapping Workflow Using SAR
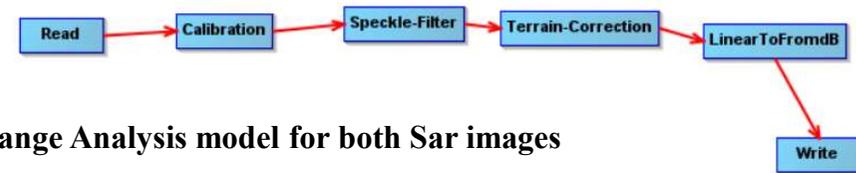
Flood Change Analysis model for both Sar images

1. SAR data download

2. SAR preprocessing

3. Change detection

4. Classification

5. Flood extraction

6. Final flood map

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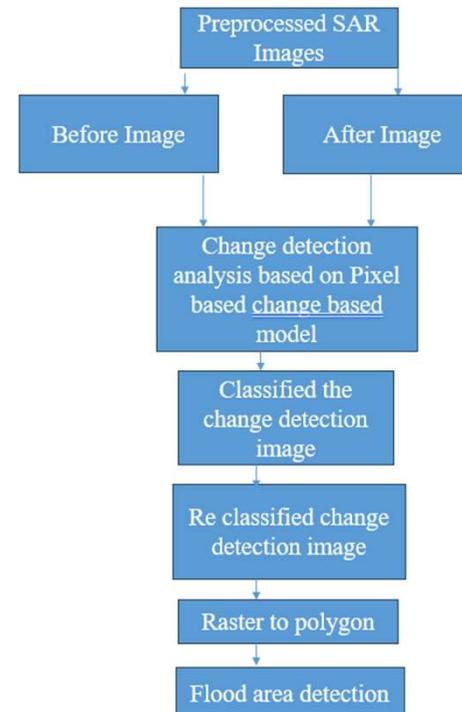
SAR data processing in SNAP

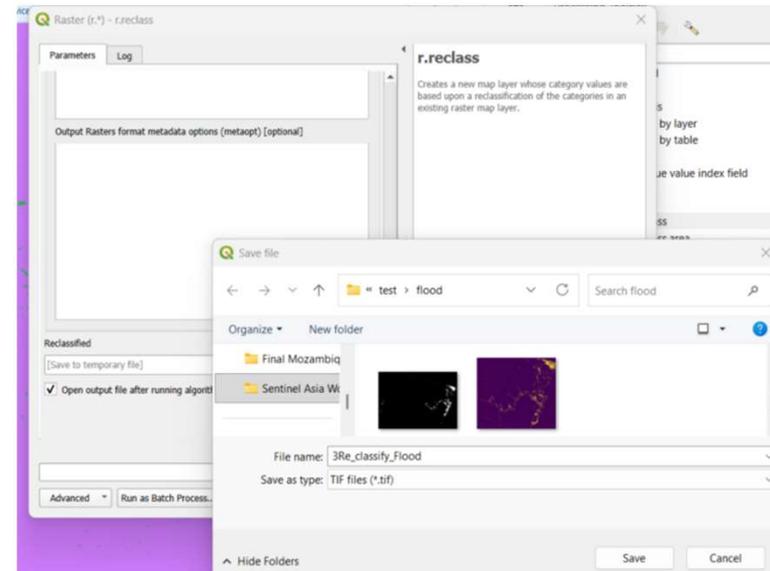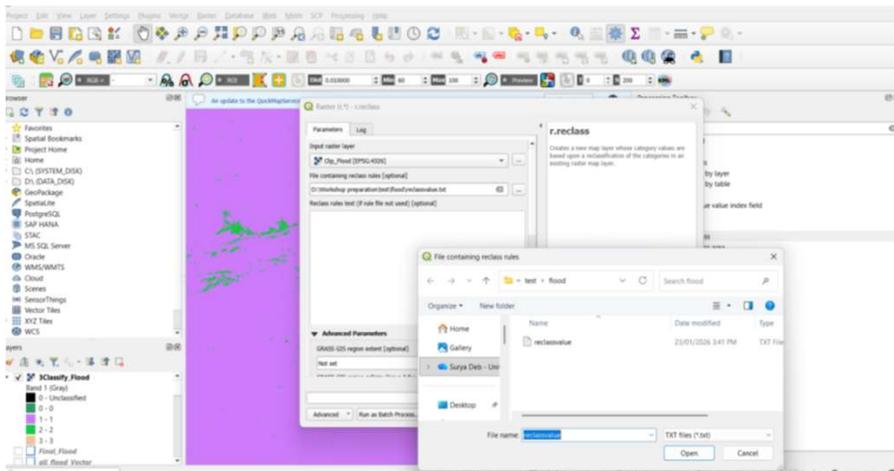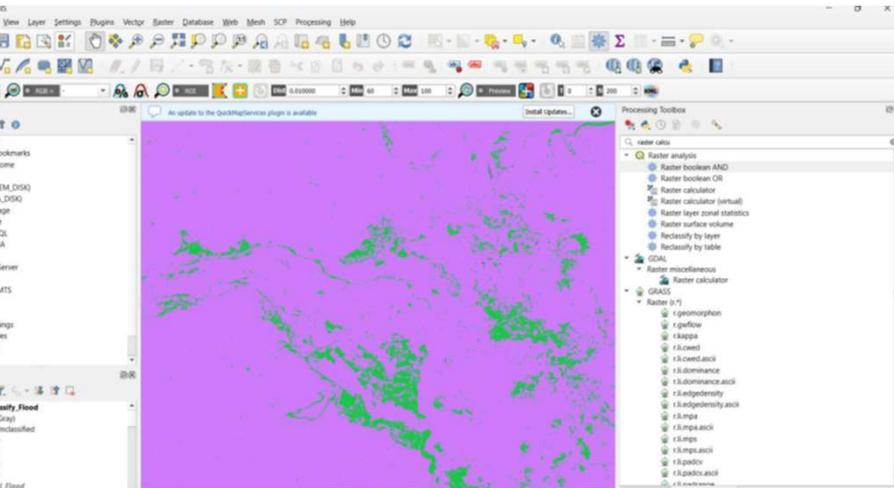# Flood analysis in QGIS

Flood area highlighting in QGIS
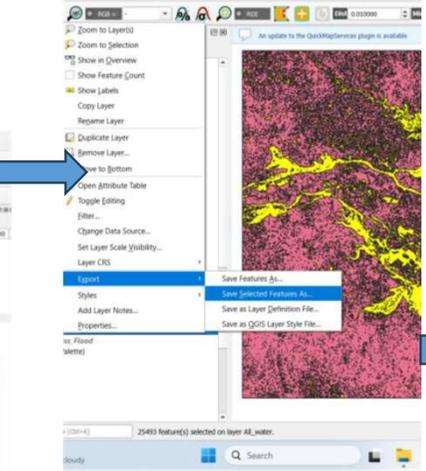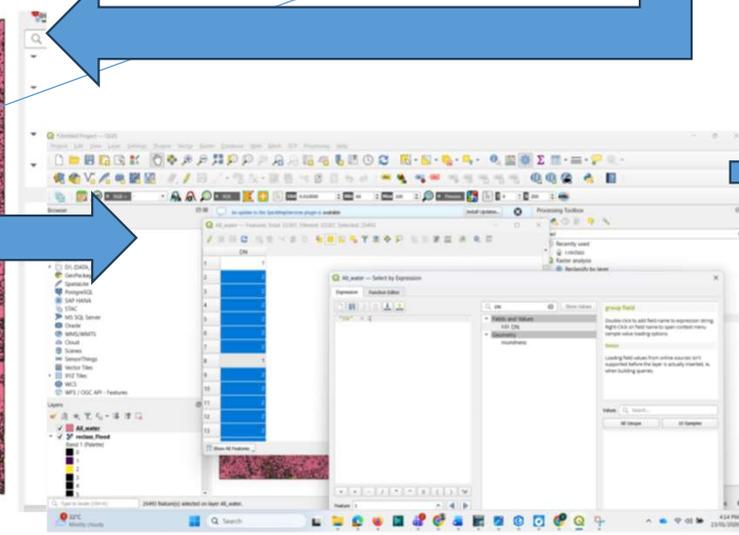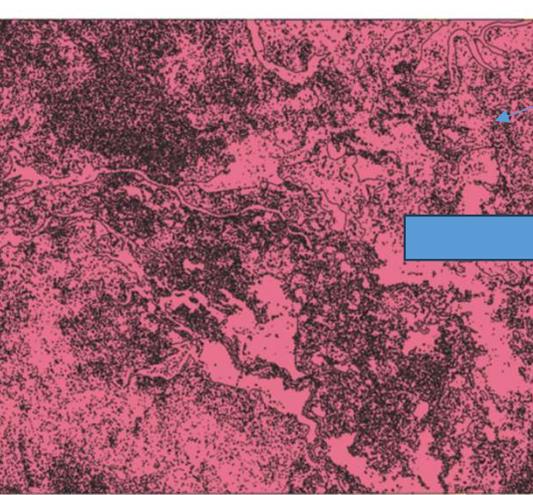
Flood area clipping in QGIS
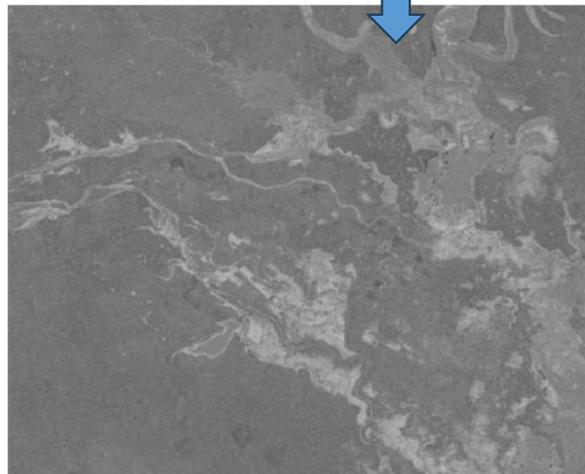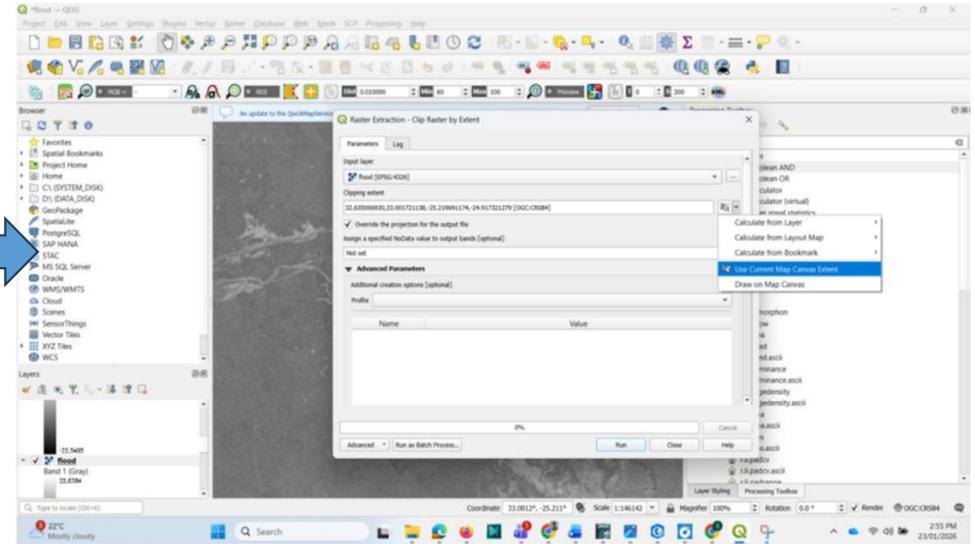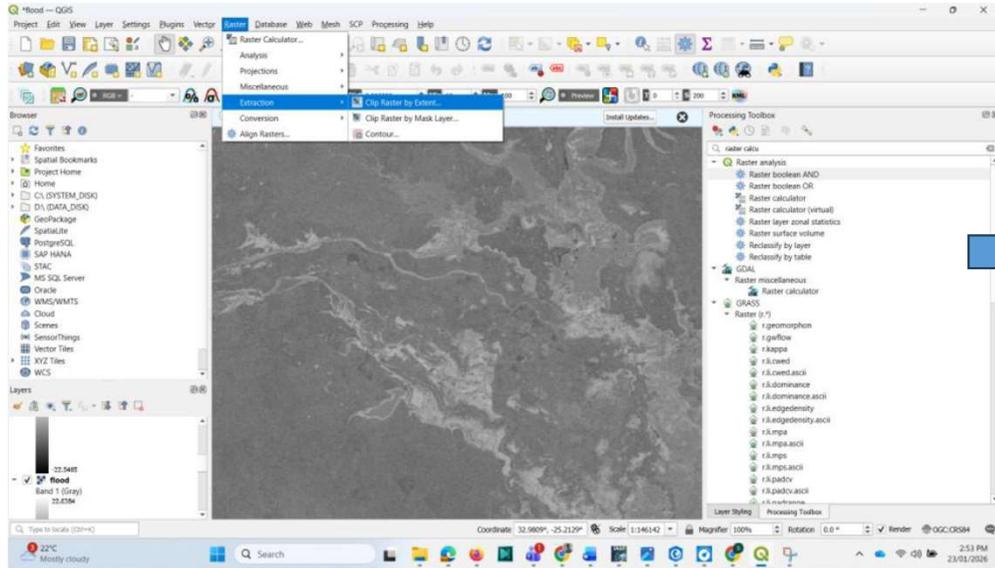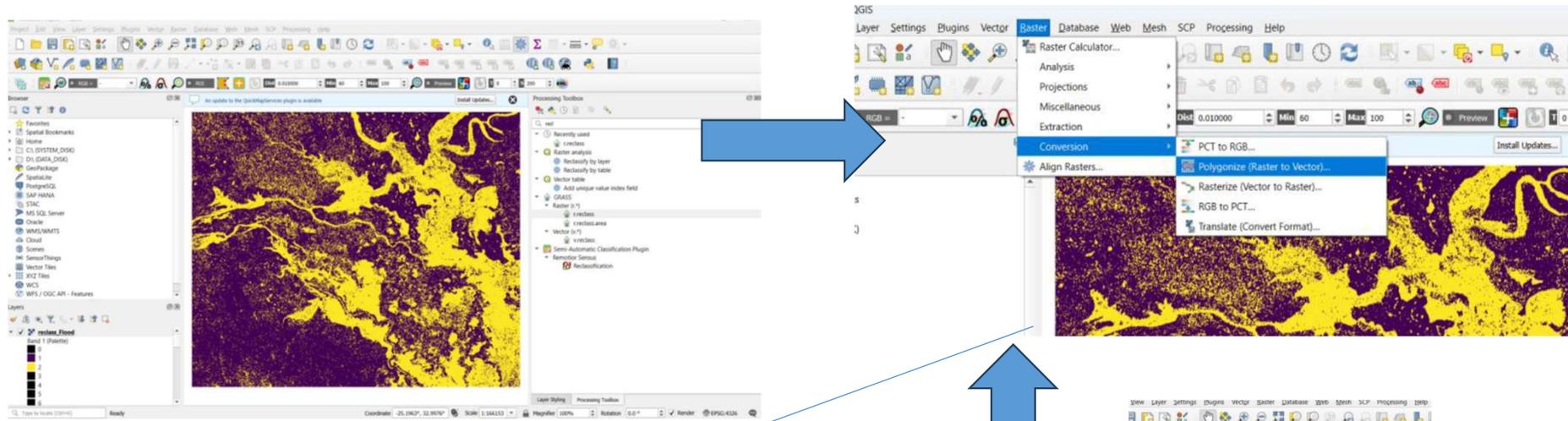
Classification of Flood Area
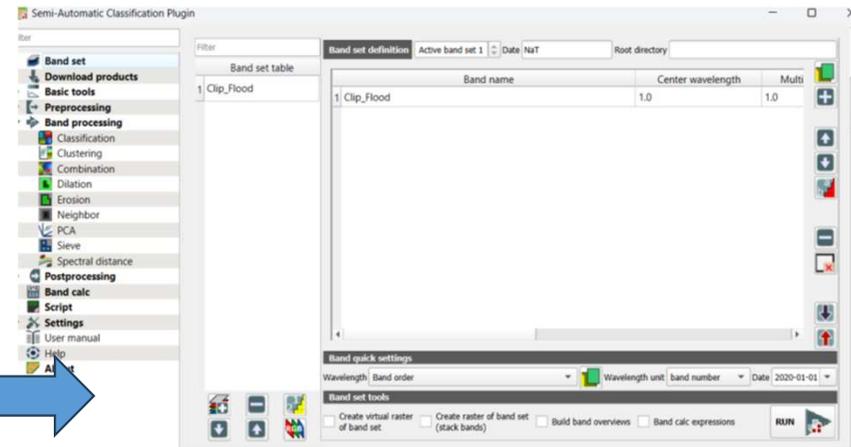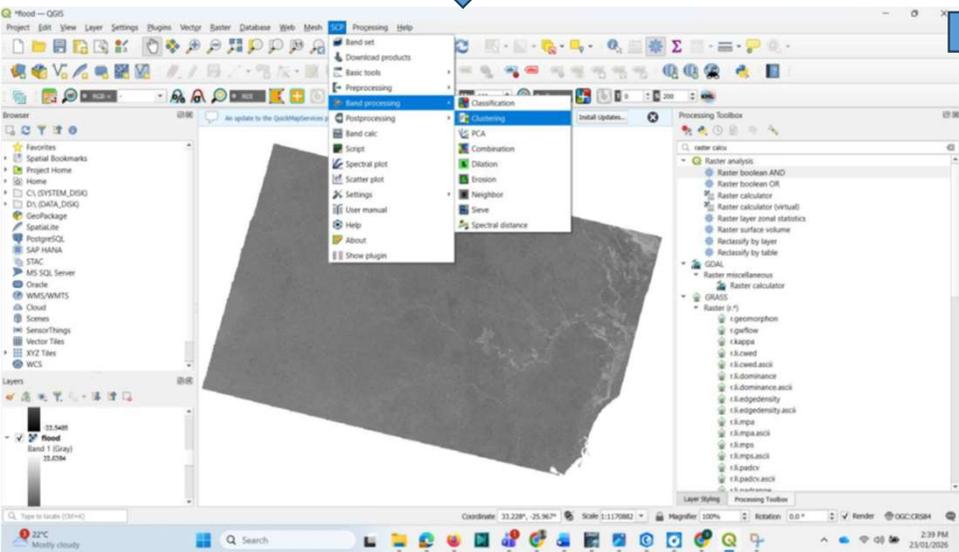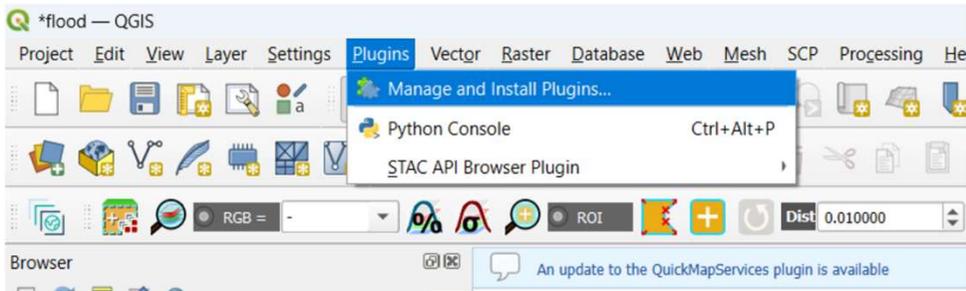
Mozambique Flood Monitoring

1. Open the **Processing Toolbox**.
2. Search for the **Reclassify** tool.
3. Use a predefined reclassification table:
   o Original values **0 and 1** → **Class 1 (Non-water)**
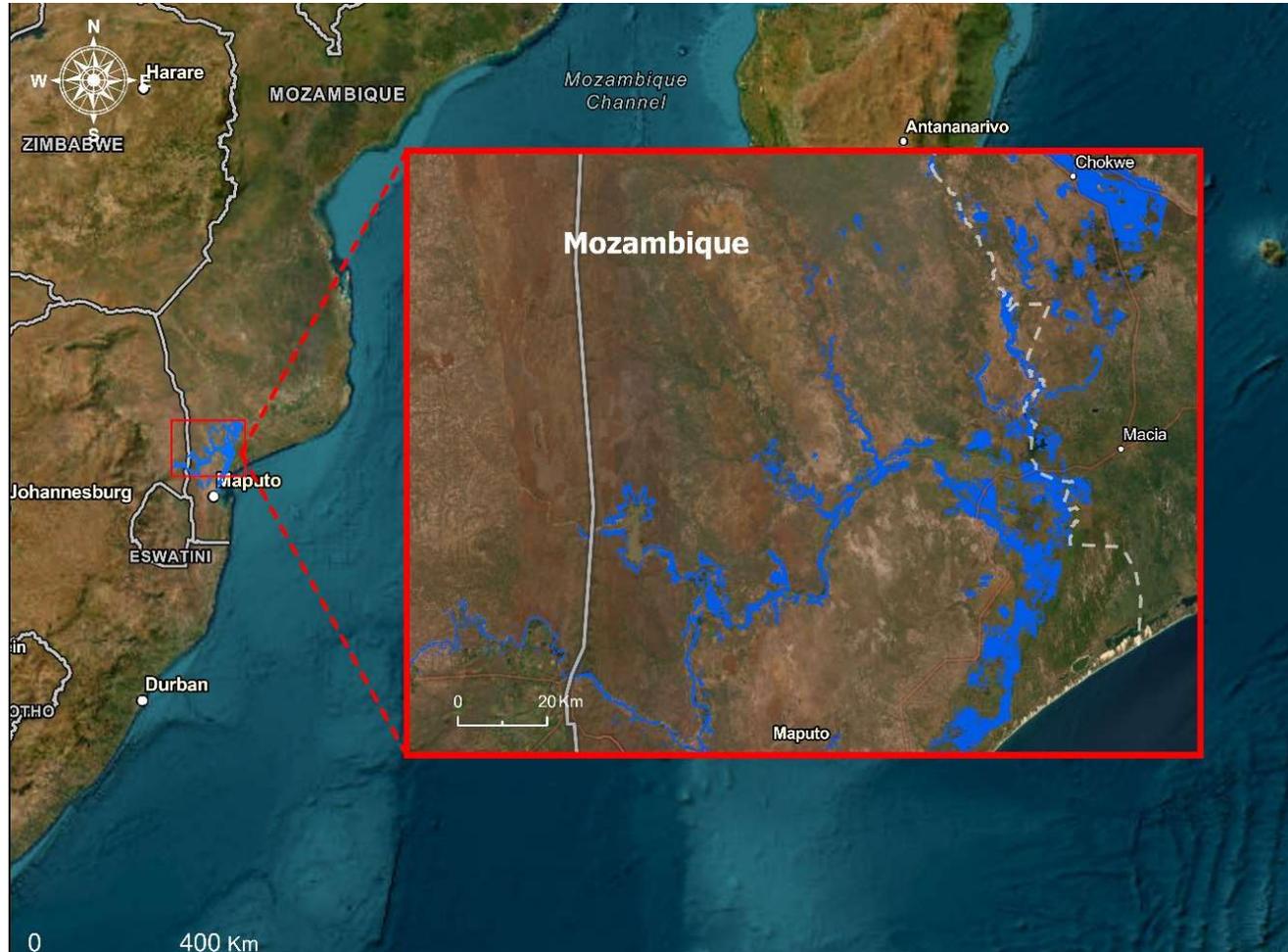   o Original values **2 and 3** → **Class 2 (Water)**

```
0 thru 1 = 1
2 thru 3 = 2
```

Re classification and Final Flood area extraction
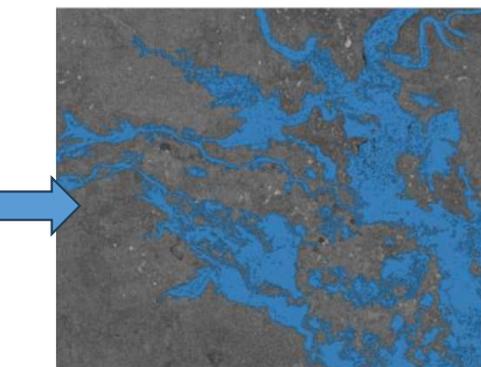
Mozambique Flood Monitoring

Thank You