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Climate Change AI

Flood mapping with optical and microwave satellite data: from indices to machine learning

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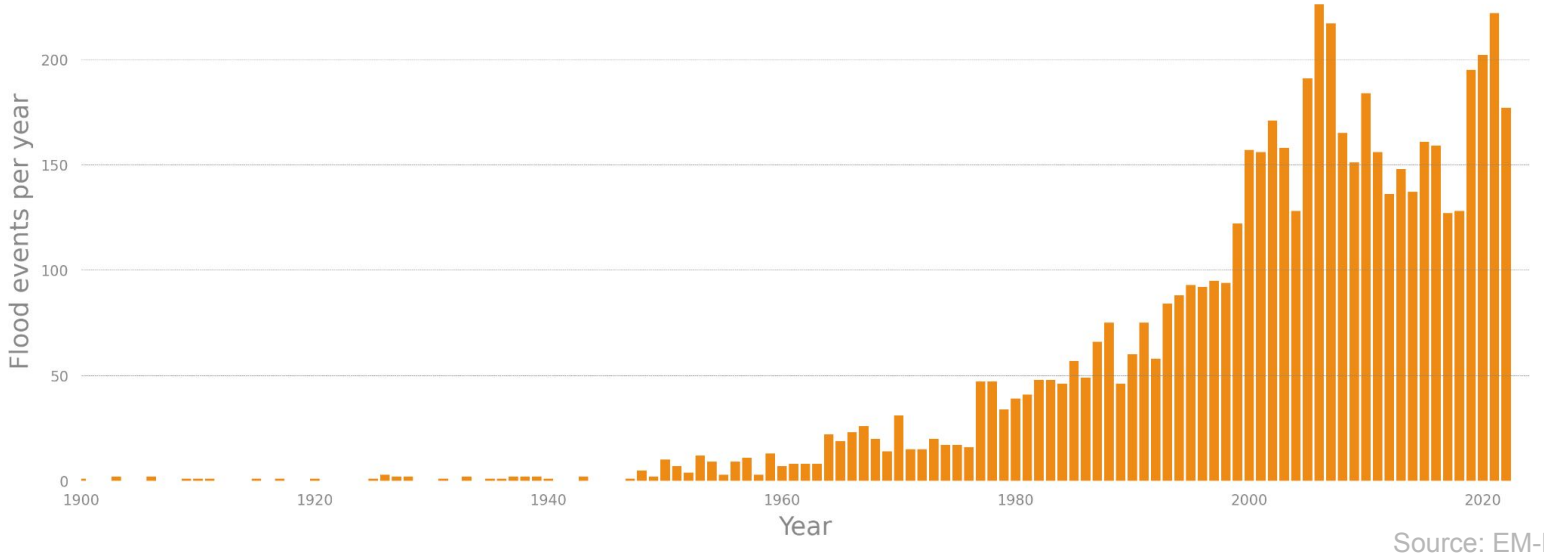
Global floods and need to map them



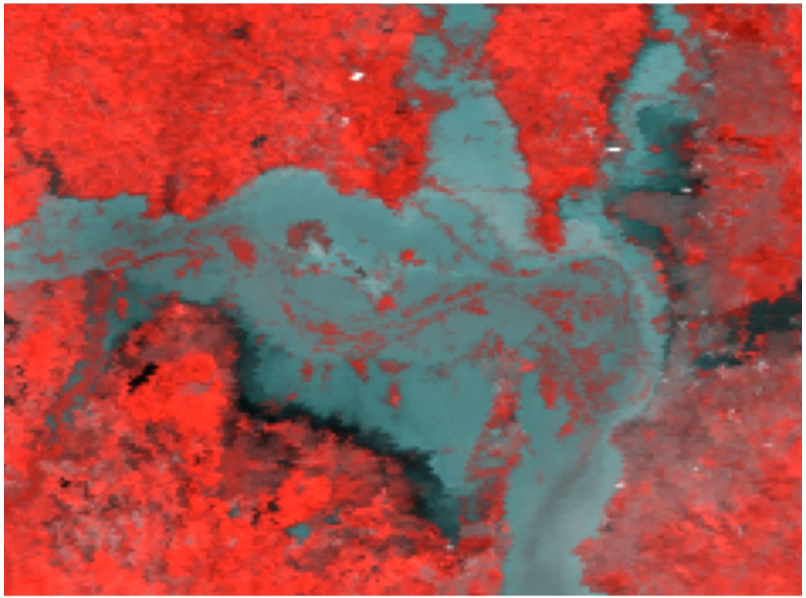
Source: EM-DAT

- A quarter of world's population is exposed to floods (Rentschler, et al., 2022)
  - 89% of flood-exposed population in Low and Middle Income Countries
  - Affected 1.6 billion people and $651 billion USD damage between 2000-2019 (UNDRR, 2020)
- We need near real-time flood maps for disaster response and up-to-date maps for risk reduction

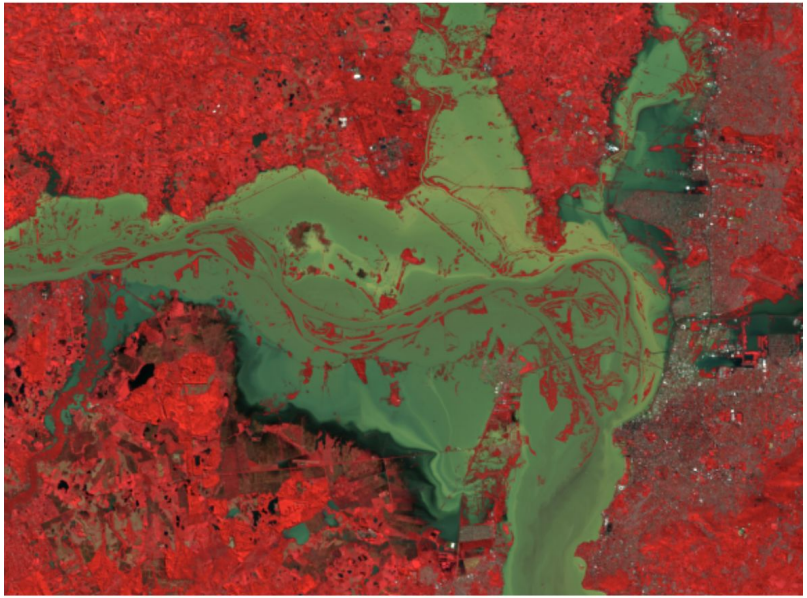
Coarse to fine resolutions: MODIS vs Sentinel-2

- Get familiar with spatial resolution of satellites
- Use MODIS (250 m) and Sentinel-2 MSI (10 m) datasets
- Flood event: Southern Brazil, near Porto Alegre city, May, 2024

During-Flood (07 May, 2024) MODIS Satellite image

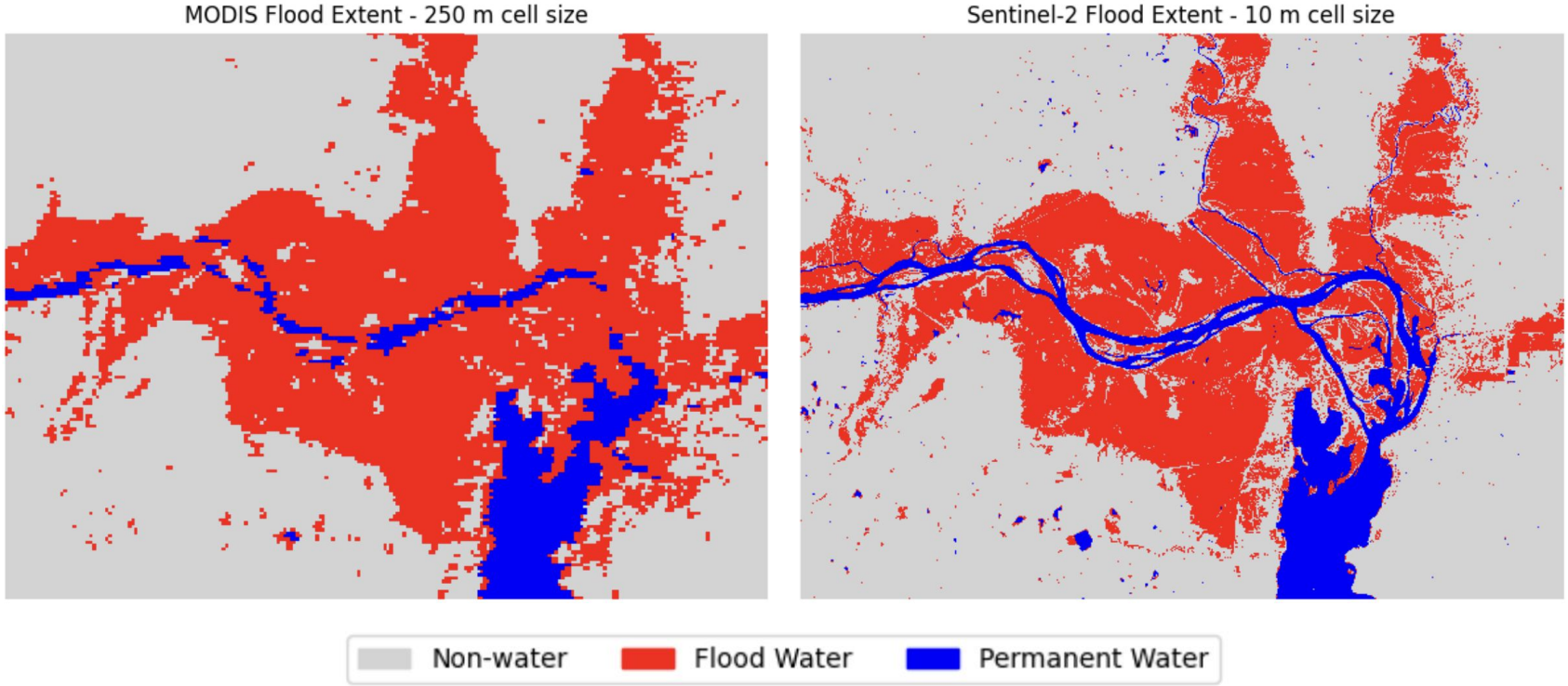


During-Flood (06 May, 2024) Sentinel-2 Satellite image



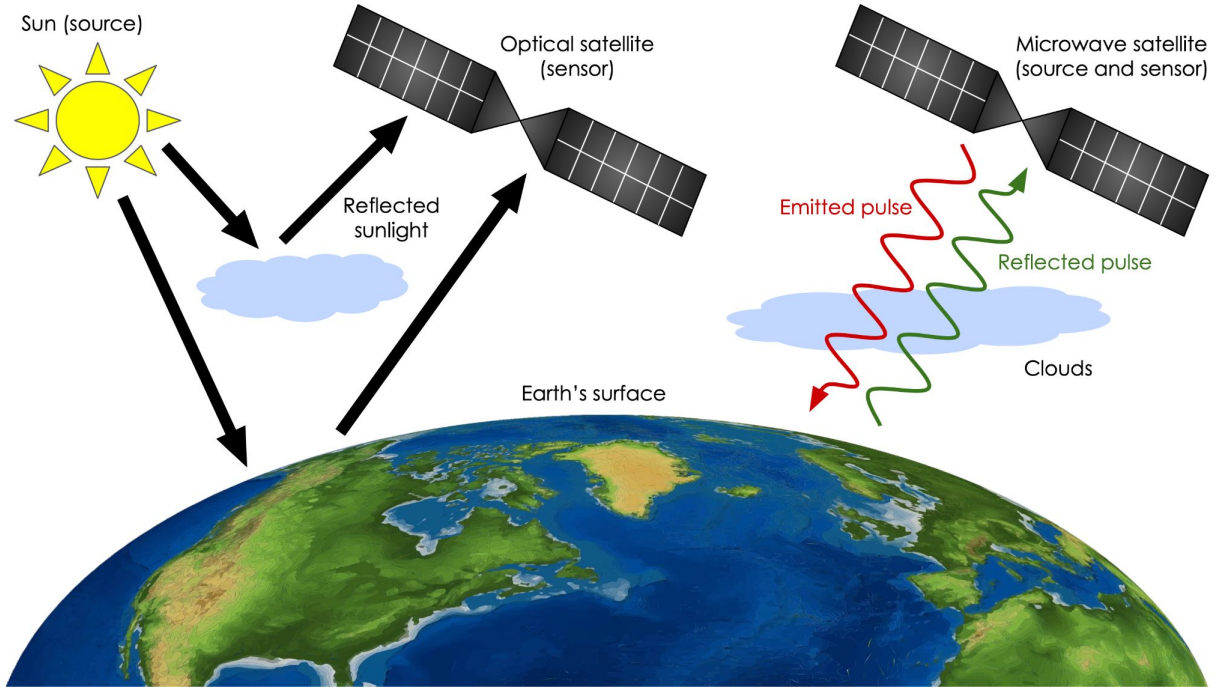
Flood mapping using optical data

- Using spectral indices like Modified Normalized Difference Water Index to map floods



Seeing through clouds: optical vs radar data

- Develop an understanding of optical and radar satellite data
- Radar data can penetrate clouds and can operate at night

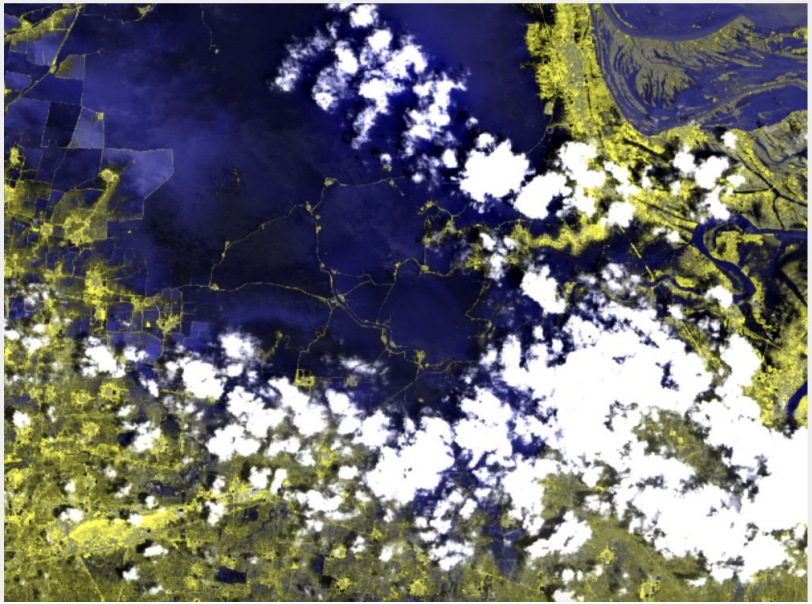


Source: Tripathy, et al. (2025)

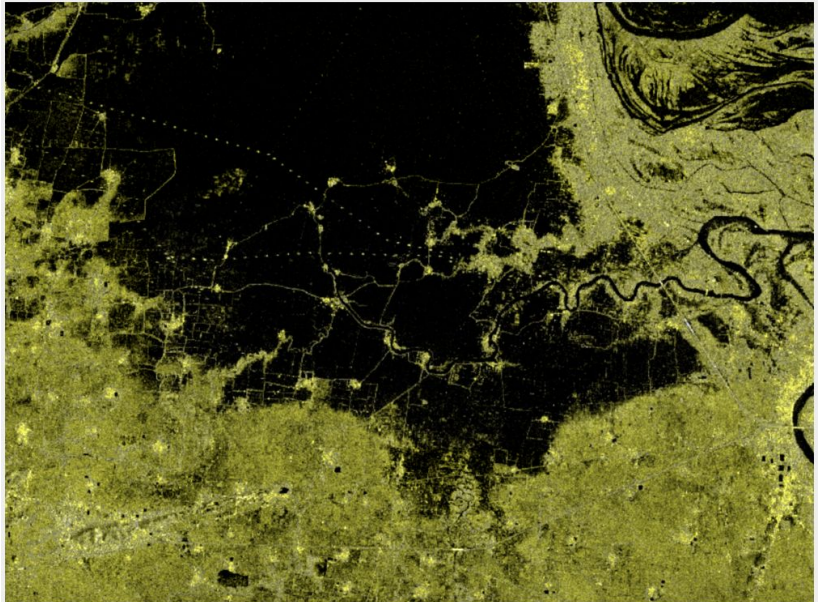
Seeing through clouds: optical vs SAR data

- Become familiar with Sentinel-1 SAR and Sentinel-2 MSI optical data

During (16 Aug 2025)

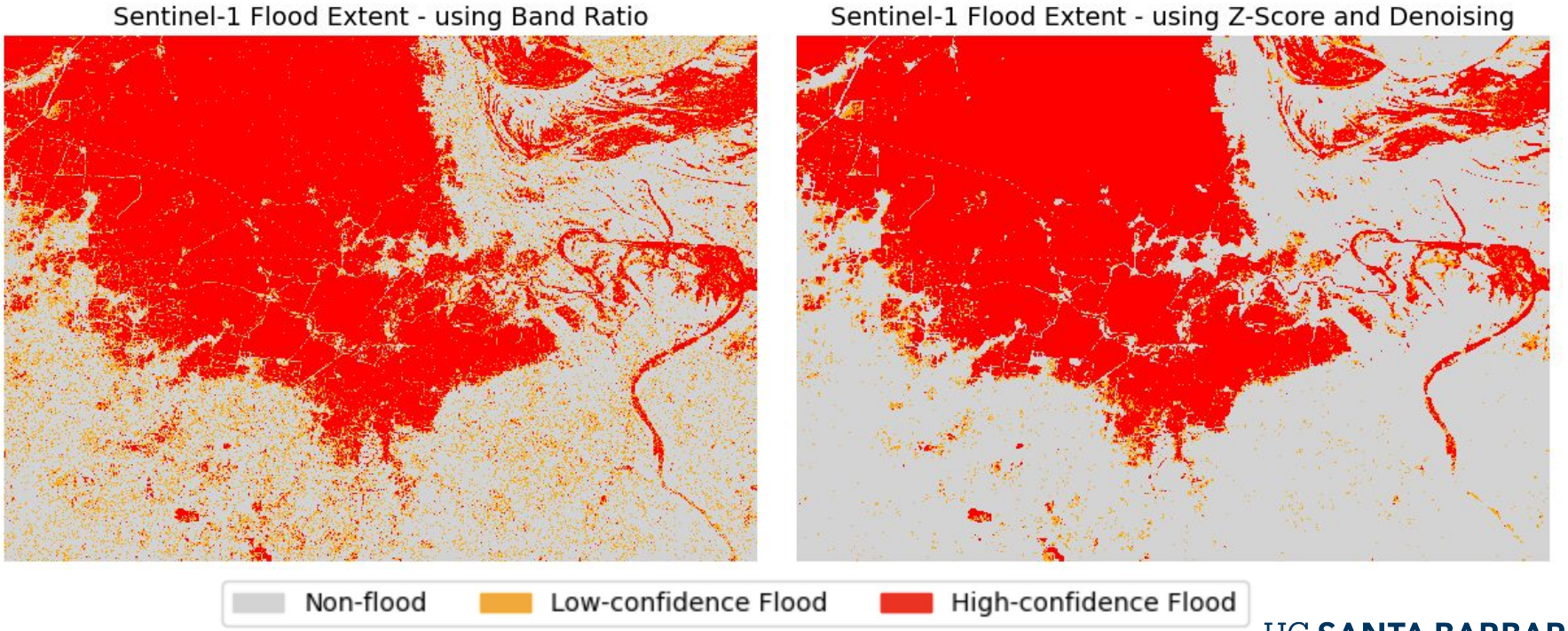


During (17 Aug 2025)



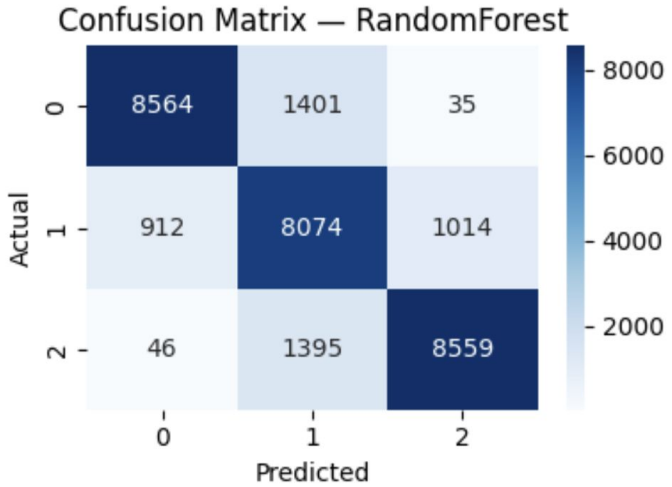
Flood mapping using SAR data

- Band ratio and Z-score anomaly detection based flood mapping
- Post-processing steps to clean derived flood maps



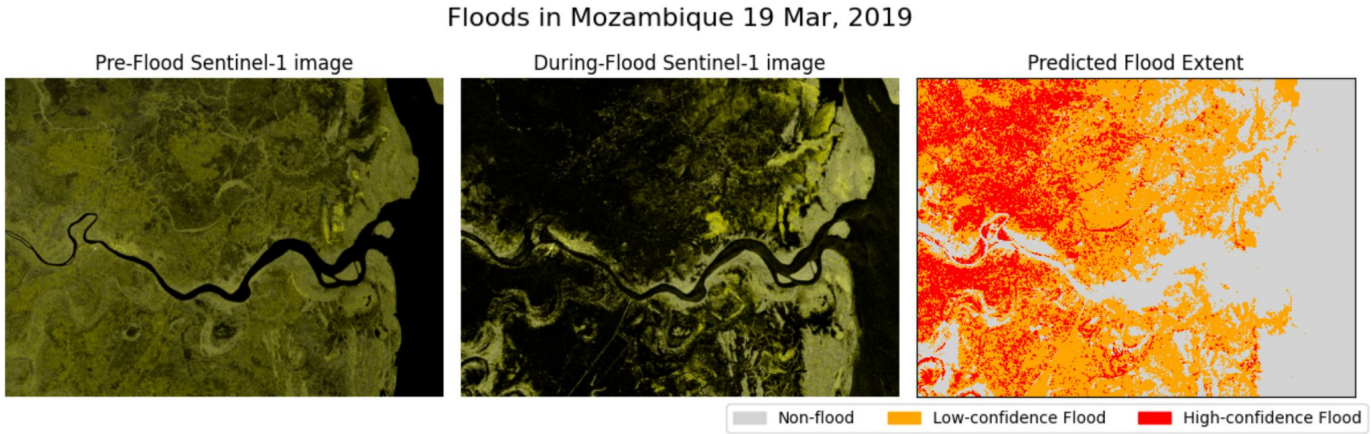
From manual methods to Machine Learning

- Machine learning methods are more automatable
- No need to decide arbitrary thresholds once the model is trained
- Trained model can be deployed on unseen geographies
- Comparing Logistic Regression and Random Forest
- Data splitting and dealing with class imbalance and overfitting



Deploying ML models for flood mapping

- Predicting floods using trained ML model
- Following flood extents are predicted:
  - Bangladesh - July, 2024
  - Houston, USA - Aug, 2017
  - Pakistan - Aug, 2022
  - Malaysia - Jan, 2021
  - Mozambique - Mar, 2019



Summary

- Rise in frequency and intensity of floods. Need to map floods during and after the event
- Satellite data offer great potential
- Many ways to map floods
  - Different satellites
    - Resolution - MODIS (250 m) vs Sentinel-2 MSI (10 m)
    - Sensor - optical (Sentinel-2 MSI) vs radar (Sentinel-1 SAR)
  - Different methods
    - Spectral indices like MNDWI
    - Band thresholding
    - Z-score based anomaly detection
    - Post-processing steps like denoising
    - Machine learning
      - Scalable solution
      - Data splitting, balancing and overfitting
      - Logistic regression and random forest

Thank you!

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