Satellite Fusion Based Historical Inundation Estimates in Bangladesh

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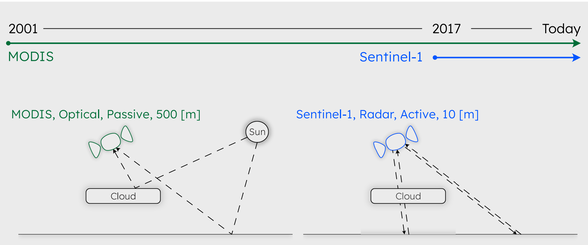
Why Historical Inundation Estimates?

- In Asia: 68 billion in losses in agricultural production, 60% due to floods (FAO 2015)
- Insurance can support farmers' sustainable development (Benami et al 2021)
- Payout based on **measurable proxy** for losses
- Payout issued when **pre-defined threshold** is reached
- **For Floods**: based on **Return Period vs Fractional Flooded Area** estimates
- Requires accurate historical estimate of **yearly maximum flood extent** (capture peaks)
- Requires long time series (**at least 20 years**)

Mapping Floods over 20 Years

- Best Satellites for Flood detection (Radar, Sentinel-1, 10 m resolution) only available recently
- MODIS provides long time-series but only Optical, 500 m resolution

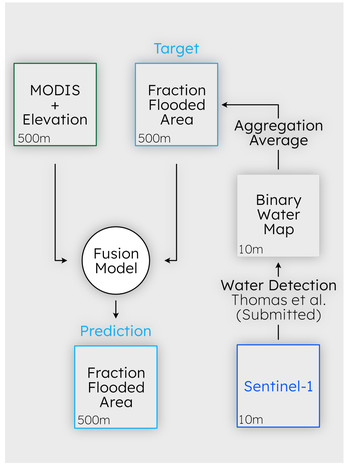


Goal Create historical (20+ years) time series of flooded areas over Bangladesh for return period estimates

➜ Reproduce Sentinel-1 observed fraction of flooded area with MODIS data

➜ Fusion algorithm

A Fusion Framework to Combine Data Sources

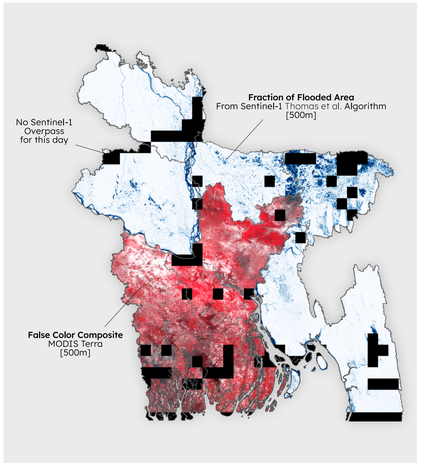


Target: Fraction Flooded Area at 500 meter resolution

- Based on Sentinel-1
- Dynamic thresholding binary map at 10 [m] resolution Thomas et al., submitted
- Fraction inundated area (∈ [0,1]) for each MODIS pixel at 500 [m] resolution

Features:

- 8-Days MODIS Terra composite image at 500 [m] resolution
- Elevation (FABDEM)



Combine CNNs and LSTM for Spatial and Temporal Context

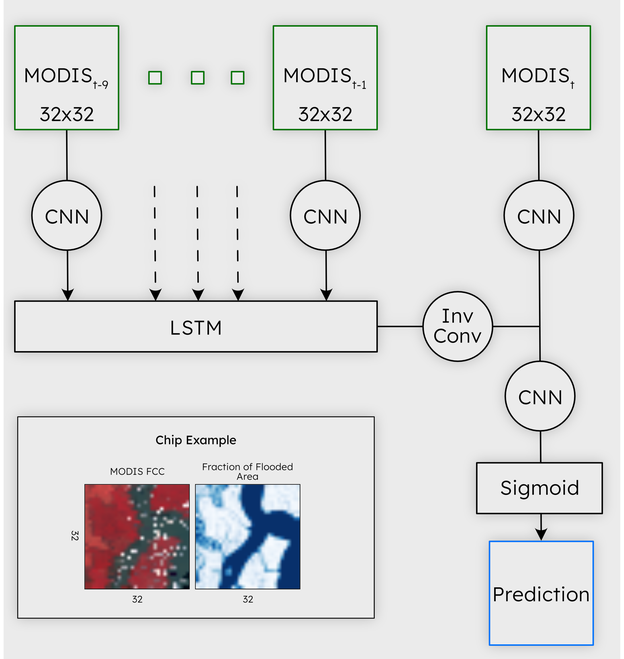
Long-Short-Term-Memory (LSTM) coupled with Convolutional Neural Networks (CNNs):

For each day:

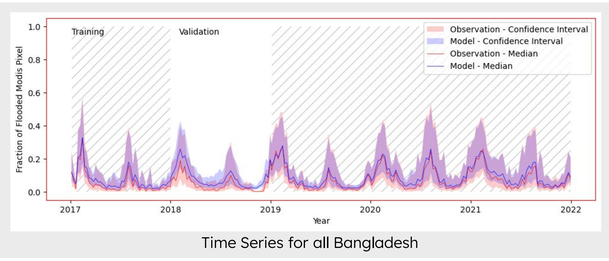
- The 10 MODIS images up to the event are run through a CNN (one network, same parameters)
  ➜ This provides the spatial context
- The 9 previous CNN outputs are run through an LSTM
  ➜ This provides the temporal context
- The LSTM output is combined with the CNN at time t and run through the last CNN to provide a prediction

Training and Testing:

- Each Chip is 32x32 pixels at 500 [m]
- The total dataset contains 150'946 chips
- Year 2018 is removed from the dataset for testing (21'487 chips)

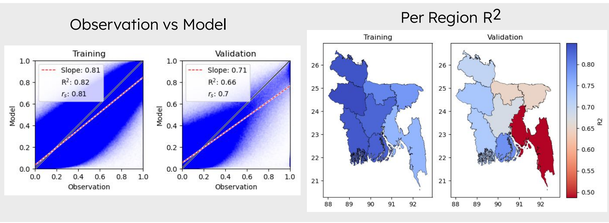


Trained Model



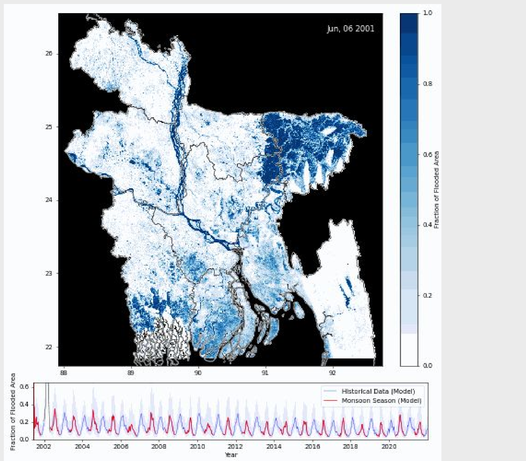
Time Series for all Bangladesh

Overall R^2 of **.66** for the validation



Inferred Time Series

Animated!



Future work:

- Per-year cross-validation
- Improve Mountain regions
- Longer LSTM to capture annual trends

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