Inferring the past: a combined CNN-LSTM deep learning framework to fuse satellites for historical inundation mapping

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Why Historical Inundation Estimates?

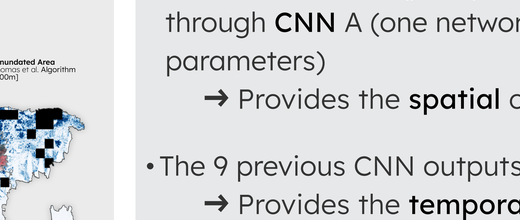
Mapping floods using satellite data is crucial for managing and mitigating flood risks

Historical flood data derived from satellite imagery can inform long-term planning, risk management strategies, and insurance-related decisions

Mapping Inundations over 20 Years

Radar Satellite: best for inundations but short time series

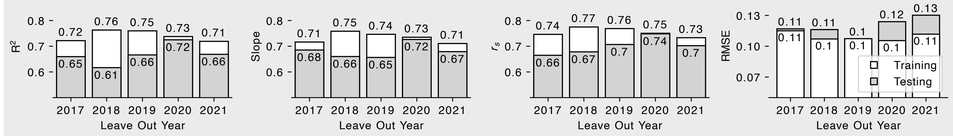
MODIS: Long time series, but optical



Goal Create historical (20+ years) time series of inundated areas over Bangladesh

➜ Reproduce Sentinel-1 observed **Fractional Inundated Area (FIA)** with MODIS data ➜ **Fusion Model**

Temporal Cross-Validation



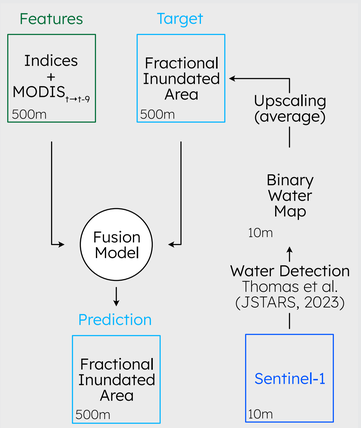
Dataset:

- 150,946 chips
- 5 years
- every 2-10 days

Cross-Validation:

- Iterate years
- Ensemble for Inference

A Fusion Framework to Combine Data Sources



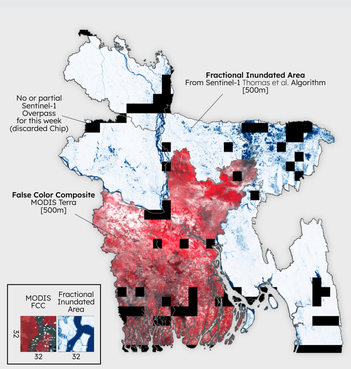
Fractional Inundated Area (FIA) at 500 meters, 32x32 chips

- Based on Sentinel-1 dynamic thresholding binary map (10 meters)
- Upscale to 500 [m]

Features:

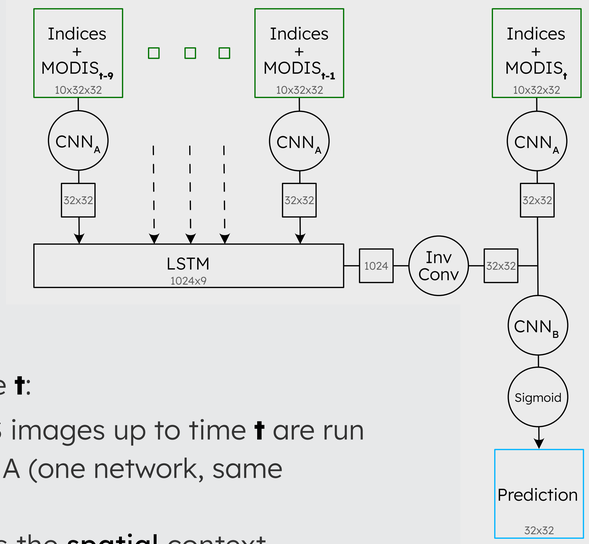
1) 8-Days MODIS Terra composite image at 500 [m] resolution (10 images)

2) Elevation **3)** Slope **4)** Height Above Nearest Drainage (HAND)



Combine CNNs and LSTM for Spatial and Temporal Context

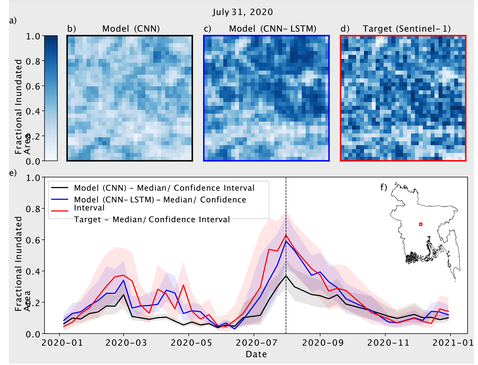
Long-Short-Term-Memory (**LSTM**) Network coupled with Convolutional Neural Networks (**CNNs**)



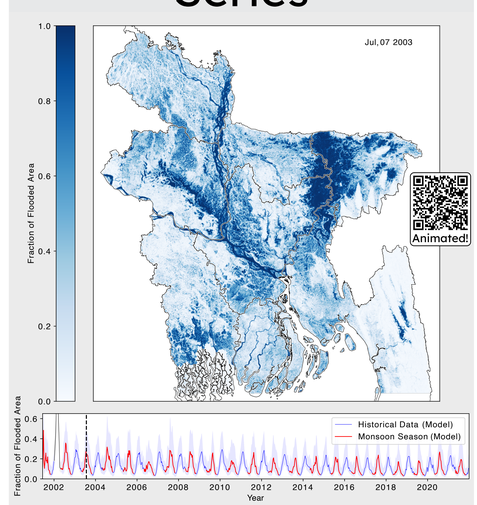
For each image **t**:

- The 10 MODIS images up to time **t** are run through **CNN** A (one network, same parameters)
  ➜ Provides the **spatial** context
- The 9 previous CNN outputs are run through a **LSTM**
  ➜ 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

CNN Baseline



Historical Time Series



A promising way to combine space and time

Spatio-Temporal Features:

- Improve inundation identification
- Filling in gaps under clouds
- CNN-LSTM captures **trend** in **rising** and **falling inundation level**

Struggles:

- Rapid and unpredictable inundation dynamics (mountainous areas, coastal)

Future Work:

- Improve CNN for spatial context
- Bridge gap to VIIRS

Giezendanner et al. (2023), CVRP EARTHVISION: Inferring the past: a combined CNN-LSTM deep learning framework to fuse satellites for historical inundation mapping

Saunders, Giezendanner et al. (2023), IGARSS: A Comparison Of Remote Sensing Approaches To Assess The Devastating May-June 2022 Flooding In Sylhet, Bangladesh

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Github Repo

Paper

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