Previous Work (Till Review I)

Extreme Weather Prediction using Deep Learning

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DATASET DESCRIPTION

Standard Products (L1B)

Sr. No.	Dataset Channel Name	Resolution (pixel distance)	Description
1	IMG_VIS	1km	Gray Counts for Visible Channel
2	IMG_SWIR	1km	Gray Counts for Shortwave Infrared Channel
3	IMG_TIR1	4km	Gray Counts for Thermal Infrared Channel 1
4	IMG_TIR2	4km	Gray Counts for Thermal Infrared Channel 2
5	IMG_MIR	4km	Gray Counts for Middlewave Channel
6	IMG_WV	8km	Gray Counts for Water Vapor Channel

- Temporal interval: 30mins
- Spatial area covered: Indian Subcontinent (60° N to 60° S, 30° E to 130° E)

Derived Products

- L2B: Per Pixel Products
  - Per-pixel lat-long as viewed by satellite
  - Resolution – 8km
  - HEM: Hydro Estimator Precipitation
  - LST/SST: Land/Sea Surface Temperature

- L2C: Sector Products
  - Map projected values
  - Resolution – 4km
  - Fog, Snow

- Extreme weather events occur in monsoon months

  June – September

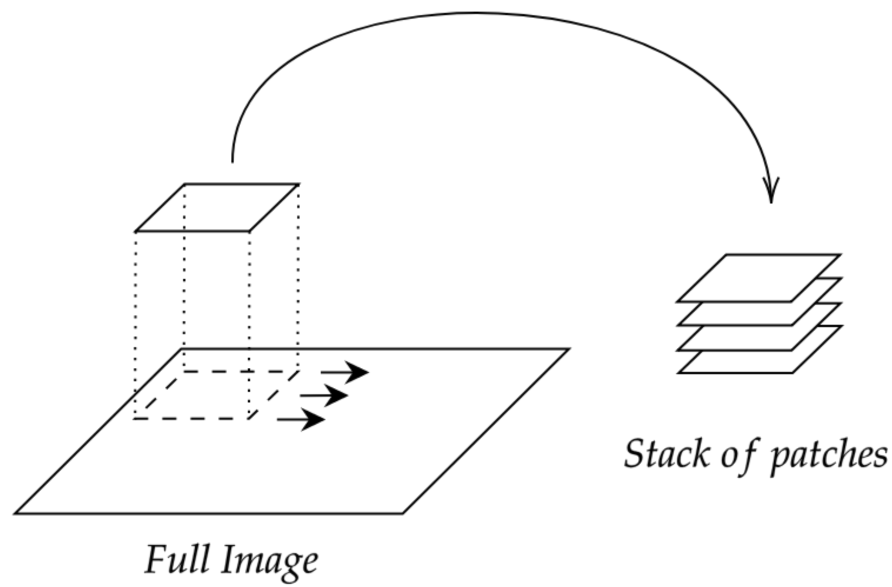
DATA PROCESSING

Hardware bottlenecks

- Data
  - 5 images input, 1 image output; size 1800x1800
  - ~ 19.4GB
- Model
  - ConvLSTM: 335137 parameters ~ 1.34GB
  - Modified U-Net: 330209 parameters ~ 1.32GB
- Machine configuration
  - GPU: NVIDIA Quadro P6000 (2GB VRAM)
  - Impossible to backpropagate even for 1 data point (~20.78GB)
  - Maximum possible image size 128x128 (1 batch size)

Solution

- ○ Patch generation using data augmentation
  - Split 1800x1800 image into patches of 40x40
- ○ Problem with image reconstruction
  - Square grid noise
- ○ Solve it by generating overlapping patches
  - 40x40 patches with overlapping stride of 20



Data Preprocessing

- Normalization
  - Min-Max scaling
- Noisy images
  - ~5% data noisy/corrupted
  - Skip these images by selecting continuous sliding window (>= 6)

IMPLEMENTATION

Architecture

1. Convolutional LSTM
   – Proposed for precipitation nowcasting

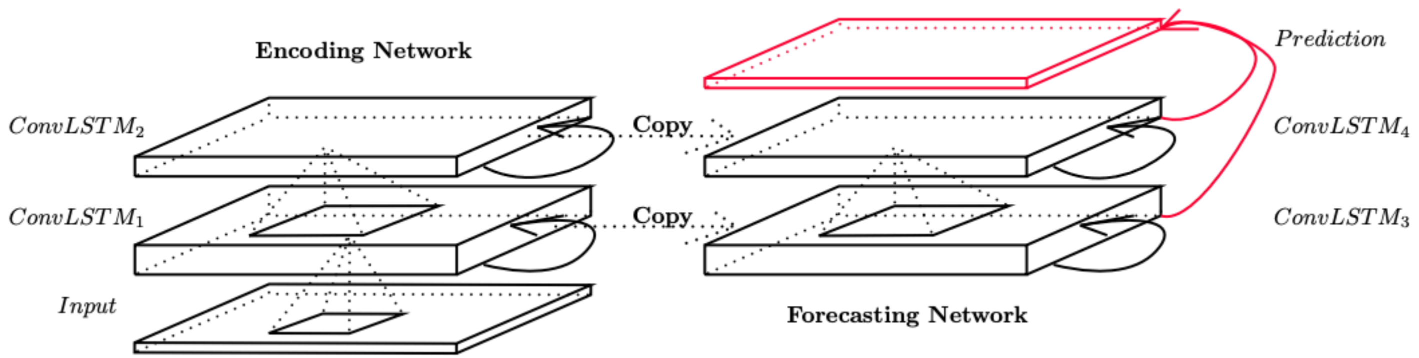
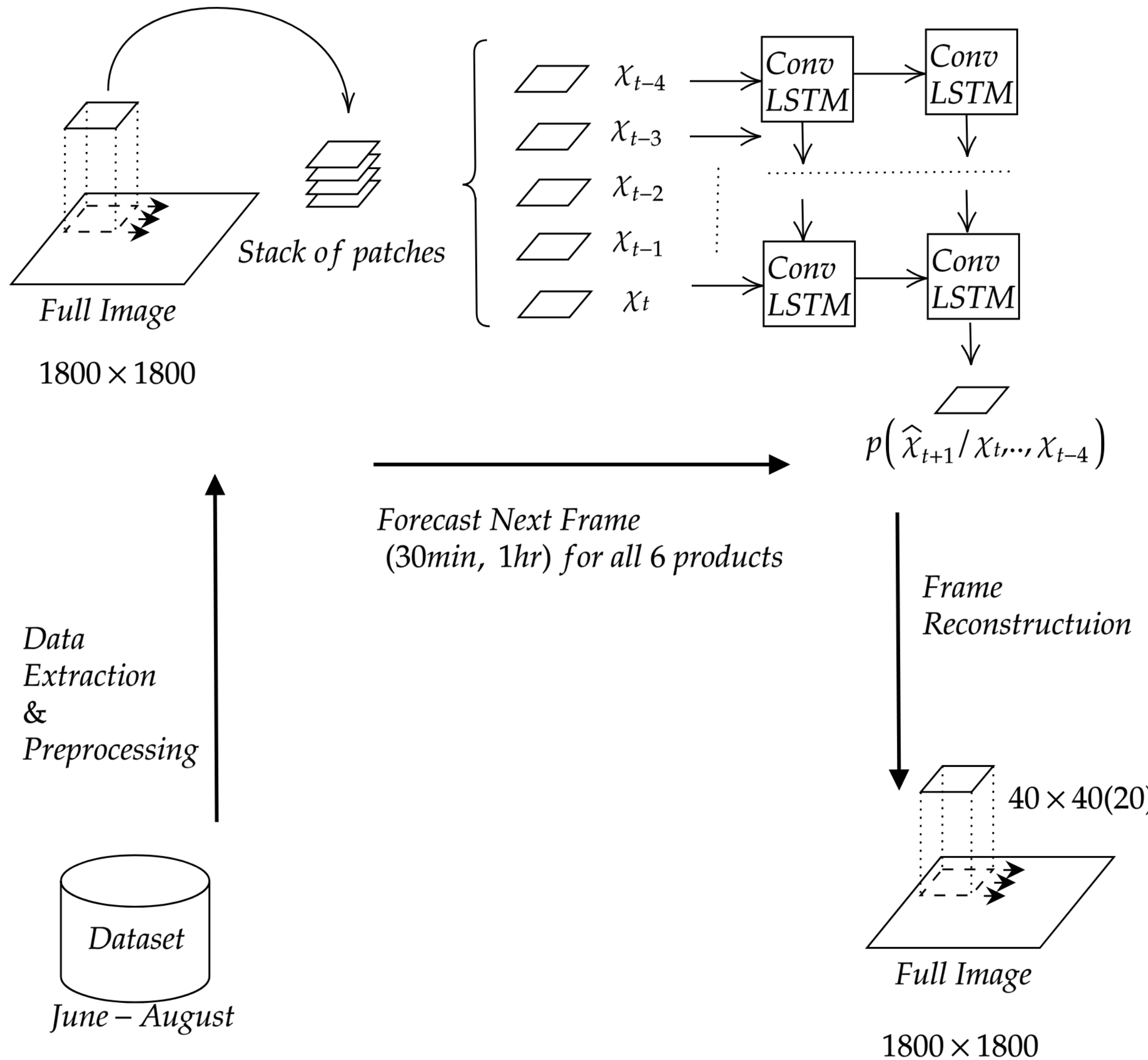


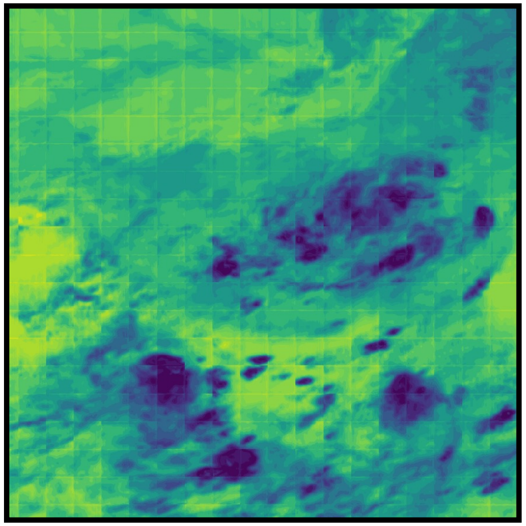
Figure 3: Encoding-forecasting ConvLSTM network for precipitation nowcasting

$$
\begin{aligned}
i_t &= \sigma(W_{xi} * \mathcal{X}_t + W_{hi} * \mathcal{H}_{t-1} + W_{ci} \circ \mathcal{C}_{t-1} + b_i) \\
f_t &= \sigma(W_{xf} * \mathcal{X}_t + W_{hf} * \mathcal{H}_{t-1} + W_{cf} \circ \mathcal{C}_{t-1} + b_f) \\
\mathcal{C}_t &= f_t \circ \mathcal{C}_{t-1} + i_t \circ \tanh(W_{xc} * \mathcal{X}_t + W_{hc} * \mathcal{H}_{t-1} + b_c) \\
o_t &= \sigma(W_{xo} * \mathcal{X}_t + W_{ho} * \mathcal{H}_{t-1} + W_{co} \circ \mathcal{C}_t + b_o) \\
\mathcal{H}_t &= o_t \circ \tanh(\mathcal{C}_t)
\end{aligned}
$$

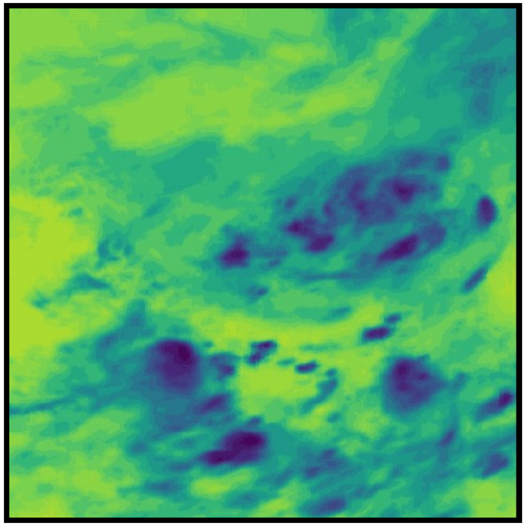
Implementation Details



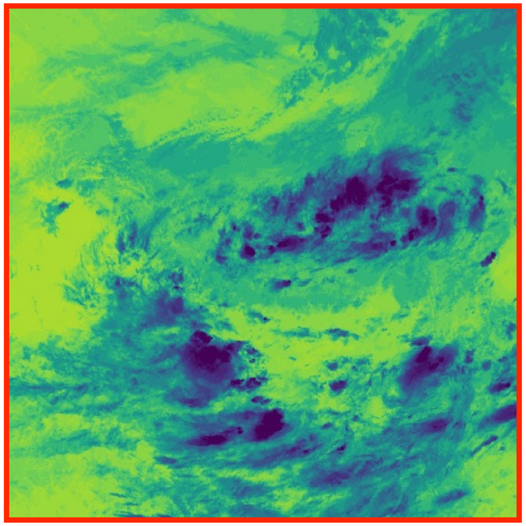
Square grid and blurring problem



None Overlapping frame



Overlapping frame



Denoised frame

Denoising Model

2. Modified U-Net

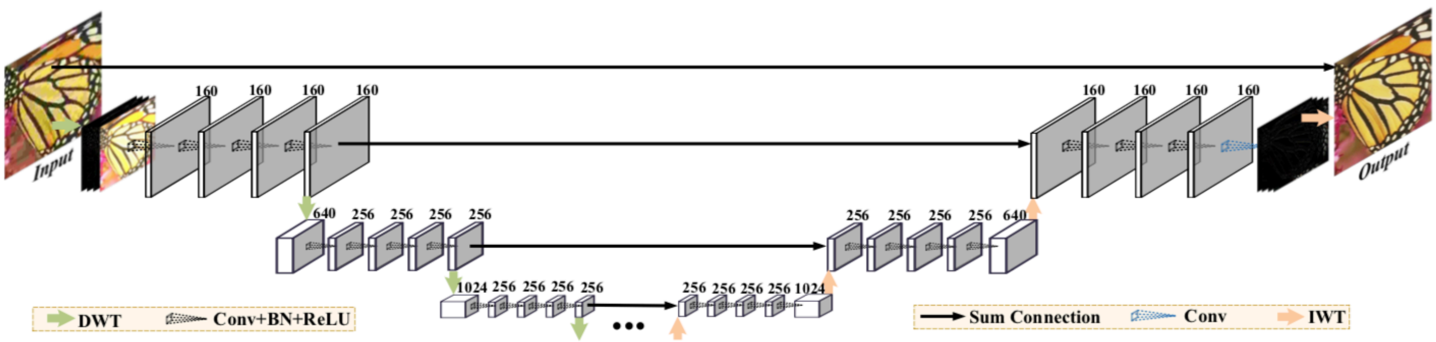


Figure 3. Multi-level wavelet-CNN architecture. It consists two parts: the contracting and expanding subnetworks. Each solid box corresponds to a multi-channel feature map. And the number of channels is annotated on the top of the box. The network depth is 24. Moreover, our MWCNN can be further extended to higher level (e.g., ≥ 4) by duplicating the configuration of the 3rd level subnetwork.

Results

Sr. No.	Dataset Channel Name	SSIM	PSNR
1	IMG_VIS		
2	IMG_SWIR		
3	IMG_TIR1		
4	IMG_TIR2		
5	IMG_MIR		
6	IMG_WV		

$$l(x,y) = \frac{2\mu_x\mu_y + c_1}{\mu_x^2 + \mu_y^2 + c_1}$$

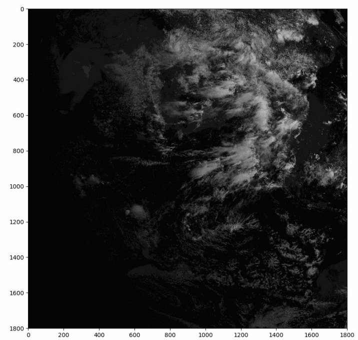
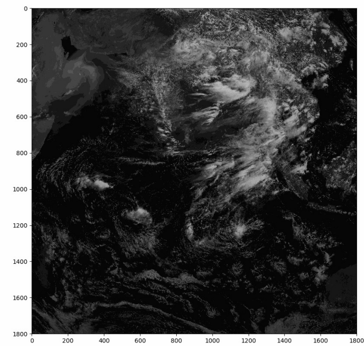
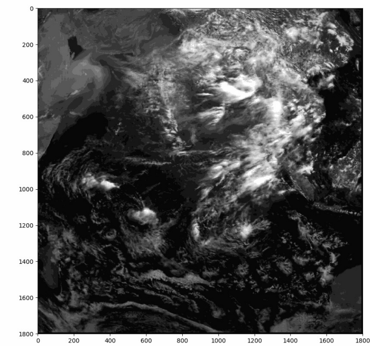
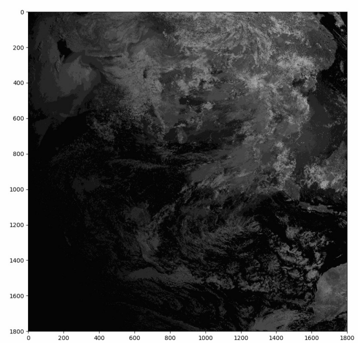
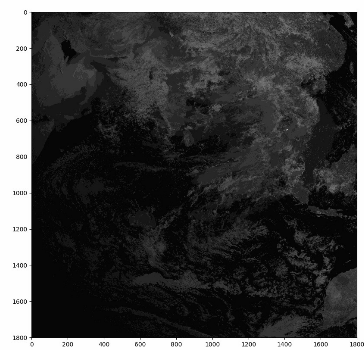
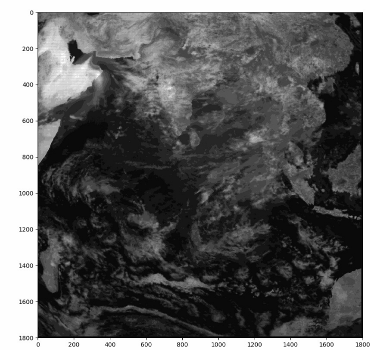
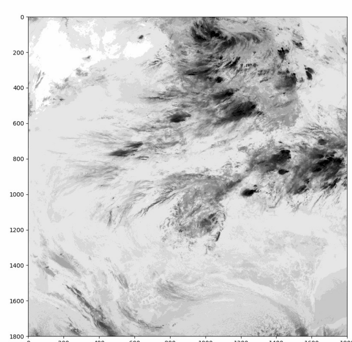
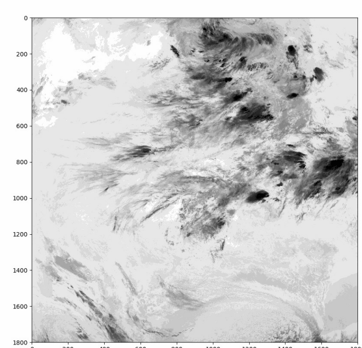
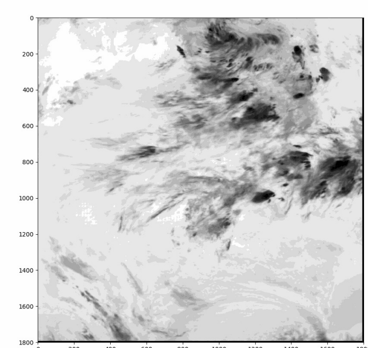
$$c(x,y) = \frac{2\sigma_x\sigma_y + c_2}{\sigma_x^2 + \sigma_y^2 + c_2}$$

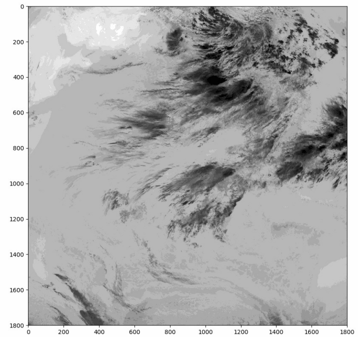
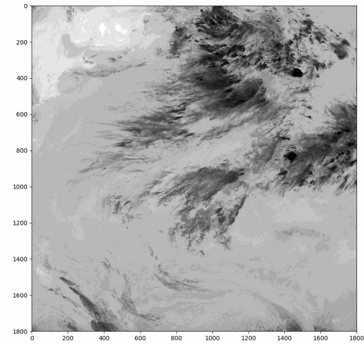
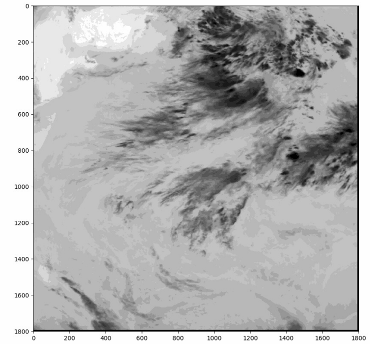
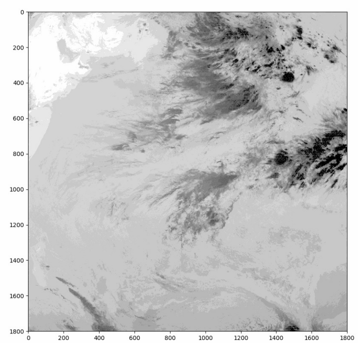
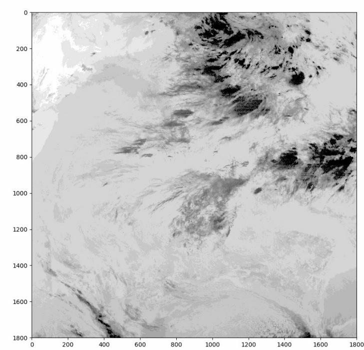
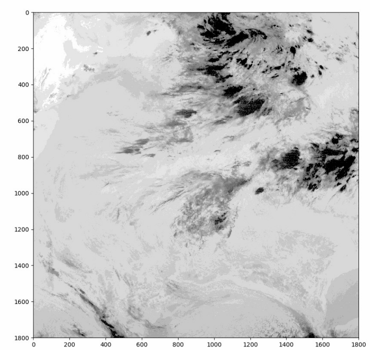
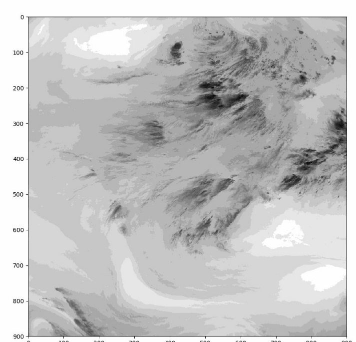
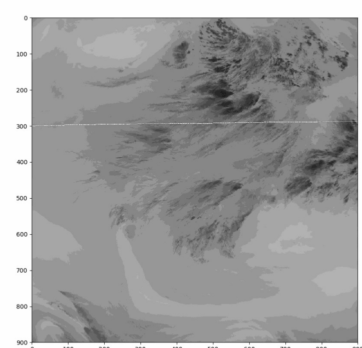
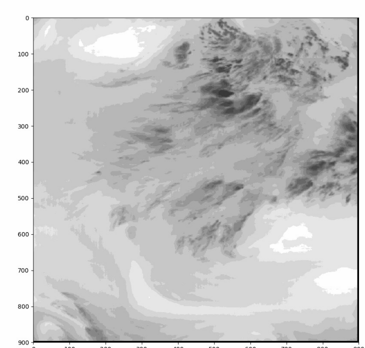
$$s(x,y) = \frac{\sigma_{xy} + c_3}{\sigma_x\sigma_y + c_3}$$

$$SSIM(x,y) = \left[l(x,y)^\alpha \cdot c(x,y)^\beta \cdot s(x,y)^\gamma\right]$$

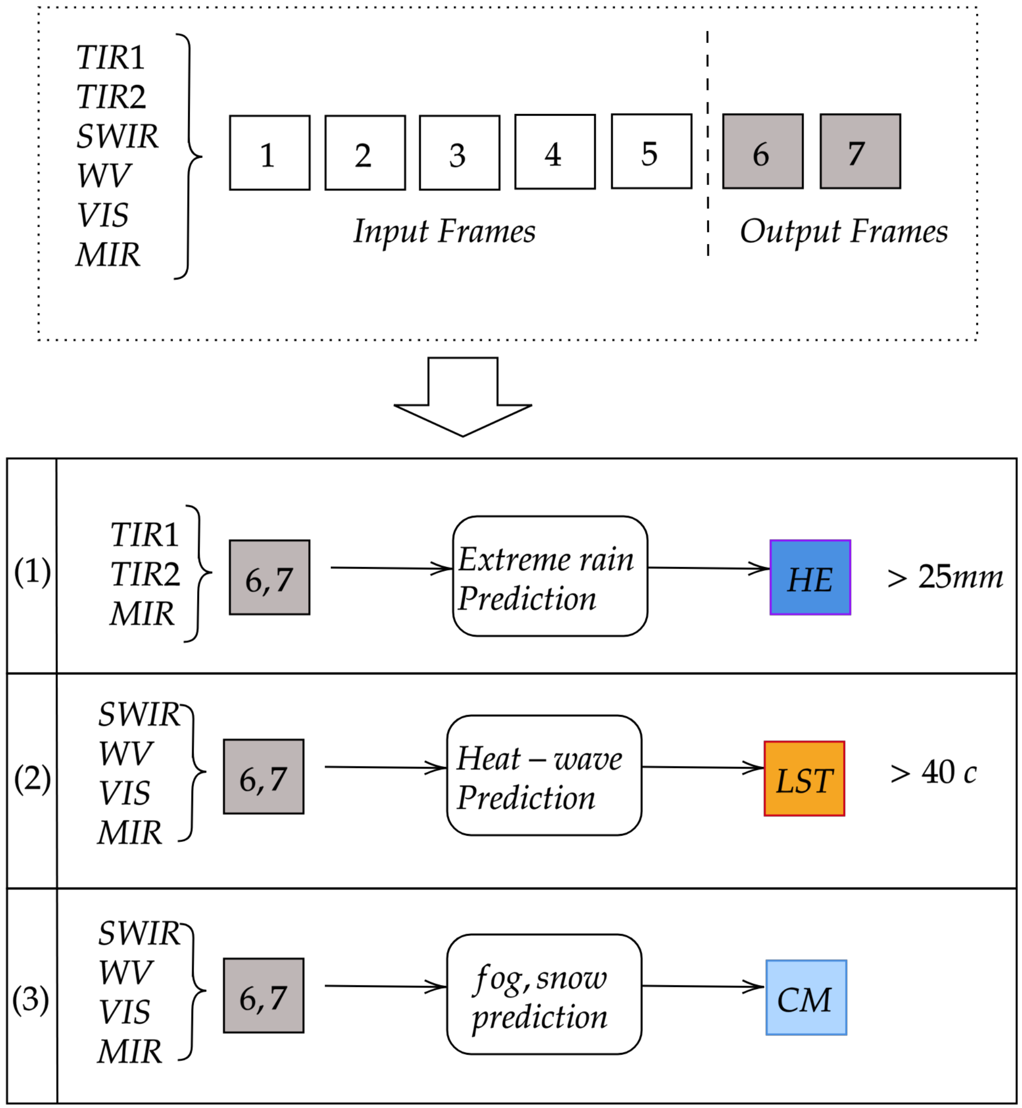
$$PSNR(x,y) = 10 * log\left(\frac{P_{max}^2}{\sigma(x,y)^2}\right)$$

samples of x and y: luminance (l), contrast (c) and structure (s)

Product	(t-4) th frame	t th frame	Predicted frame
VIS			
SWIR			
TIR1			

Product	(t-4) th frame	t th frame	Predicted frame
TIR2			
MIR			
WV			

Future Work


TIR1
TIR2
SWIR
WV
VIS
MIR
1
2
3
4
5
6
7
Input Frames
Output Frames
(1)
TIR1
TIR2
MIR
6,7
Extreme rain Prediction
HE
> 25mm
(2)
SWIR
WV
VIS
MIR
6,7
Heat – wave Prediction
LST
> 40 c
(3)
SWIR
WV
VIS
MIR
6,7
fog, snow prediction
CM

THANK YOU!

QUESTIONS?

Implementation problem

- GPU problem
- Dataset size
- Skipped images
- Missing values / Noise
- Different resolution of images
- Noise in output
  - Square grid noise
  - Blurry image