

# Uncertainty-Aware Deep Learning Framework for Forecasting Coastal Water Level in Virginia Beach

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## Motivation

Virginia Beach experiences frequent flooding. To better prepare for future flooding the City of Virginia Beach has installed several real-time sensors to monitor water levels at key locations. With these sensors and machine learning we explore the ability to forecast flooding events which can be used to mitigate their impacts to the community.

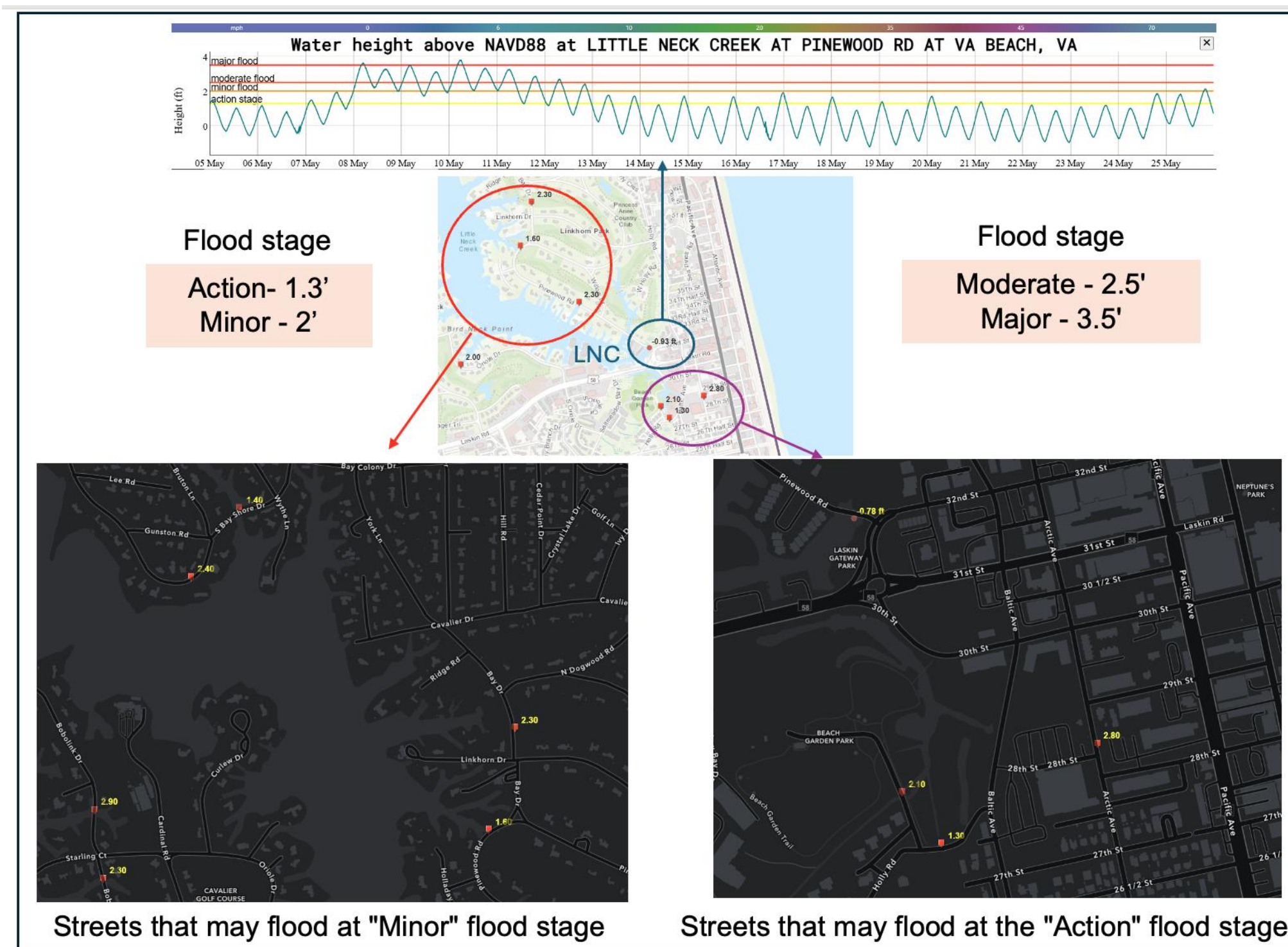


Fig 1: Schematic of the flood control system at the Little Neck Creek (LNC) gauge.

## Objectives

- Forecast water levels at Little Neck Creek location up to 72 hours ahead.
- Support early warnings and emergency planning and decision making.

## Data and Data Preparations

- High-resolution water level data provided by the City of Virginia Beach is collected every 6 minutes from 2016 to 2024.
- The dataset had 8 variables which were used to predict the water level
- We resampled to hourly intervals to address data gaps from sensor malfunctions
- We converted wind speed and wind direction into X and Y components
- We scaled the data (0-1) using MinMaxScaler

## Model

To estimate the model prediction uncertainty, we used a deep quantile regression model. This allows us to estimate multiple quantile predictions defined by using the following loss:

$$\mathcal{L}_\tau = \max(\tau \cdot (y_i - \hat{y}_i), (\tau - 1) \cdot (y_i - \hat{y}_i))$$

Here,  $y_i$  is the observed value and  $\hat{y}_i$  is the predicted value at  $\tau^{th}$  quantiles.

- Training Data: 2016-2021
- Test Data: 2022
- Look back: 24 hours
- We studied multiple architectures: multi-layer perceptron (MLP), 1D convolutional layers (Conv1D) and long short-term memory network (LSTM)

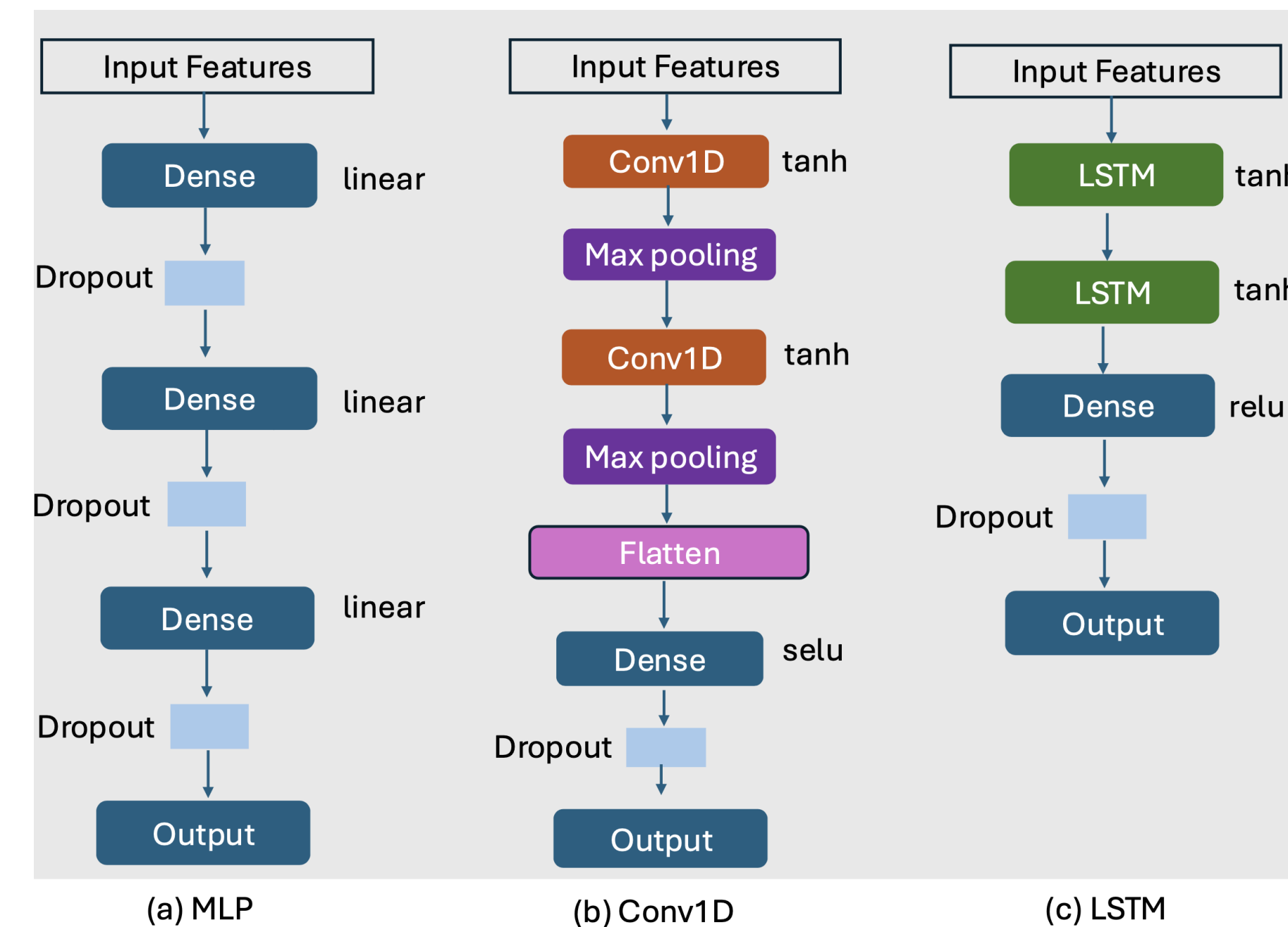


Fig 2: Deep Neural Network Architectures (a) MLP (b) Conv1D and (c) LSTM

## Results

- While all models performed similarly on average, the convolutional model outperformed others in most forecasting scenarios

### Comparison of the Accuracy Metrics of Different Models on the Test Data

