Flood Forecasting in a data-scarce region based on GRACE and SMAP data

Alvee Bin Hannan[1], Siam Maksud[1], and Nasreen Jahan[1]

[1]Bangladesh University of Engineering and Technology

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Abstract

Bangladesh is an extremely flood-prone country due to its geographical location at the downstream end of the Ganges, Brahmaputra and Meghna (GBM) river basin. Flood destroys agricultural products of large areas and causes loss of lives and damage to infrastructures. Heavy rainfall during the monsoon season is the major cause of flooding in this region which occurs almost every year. However, the lack of observations of rainfall in the upper catchment areas outside Bangladesh makes flood forecasting challenging in this region. In addition, errors in rainfall forecasts and lack of high-resolution bathymetry and topographic data put major constraints to flood forecasting in Bangladesh through hydrologic and hydrodynamic models. Currently Flood Forecasting and Warning Centre (FFWC) of Bangladesh Water Development Board (BWDB) is producing short-range flood forecasts with a lead time of up to three days. However, medium-range (3 to 5 days) forecasts are crucial for reducing flood-related losses as they provide more time for decision making and preparation compared to short-range forecasts. In this study, a flood forecast model based on Artificial Neural Network (ANN) has been developed for the Kushiyara river which is one of the major rivers of the northeastern region of Bangladesh. Rainfall data from the fifth generation European Centre for Medium-Range Weather Forecasts Reanalysis (ERA5), daily Terrestrial Water Storage (TWS) from the Global Land Data Assimilation System with the Gravity Recovery and Climate Experiment Data Assimilation (GRACE-DA) and daily Surface Soil Moisture data from Soil Moisture Active Passive (SMAP) have been used as input to the model. The model shows reasonable accuracy in forecasting the water level of the Kushiyara river at Sheola station with a lead time of up to seven days. For 1-day lead time, the correlation coefficient (R) between the observed and simulated water levels is 0.97. The performance of the model is also promising for a medium-range forecast (R=0.93 for 7-day lead time). This study indicates that the release of daily GRACE gravity field solutions in near-real-time may enable us to forecast and monitor high volume flood events in this region.

FLOOD FORECASTING IN A DATA-SCARCE REGION BASED ON GRACE AND SMAP DATA

ALVEE BIN HANNAN

SIAM MAKSUD

NASREEN JAHAN

DEPARTMENT OF WATER RESOURCES ENGINEERING

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

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December 17, 2021

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THIS PRESENTATION WILL FOCUS ON

Necessity of Flood Forecasting in Bangladesh

Generating Water level Forecast using ANN

Evaluation of forecasts

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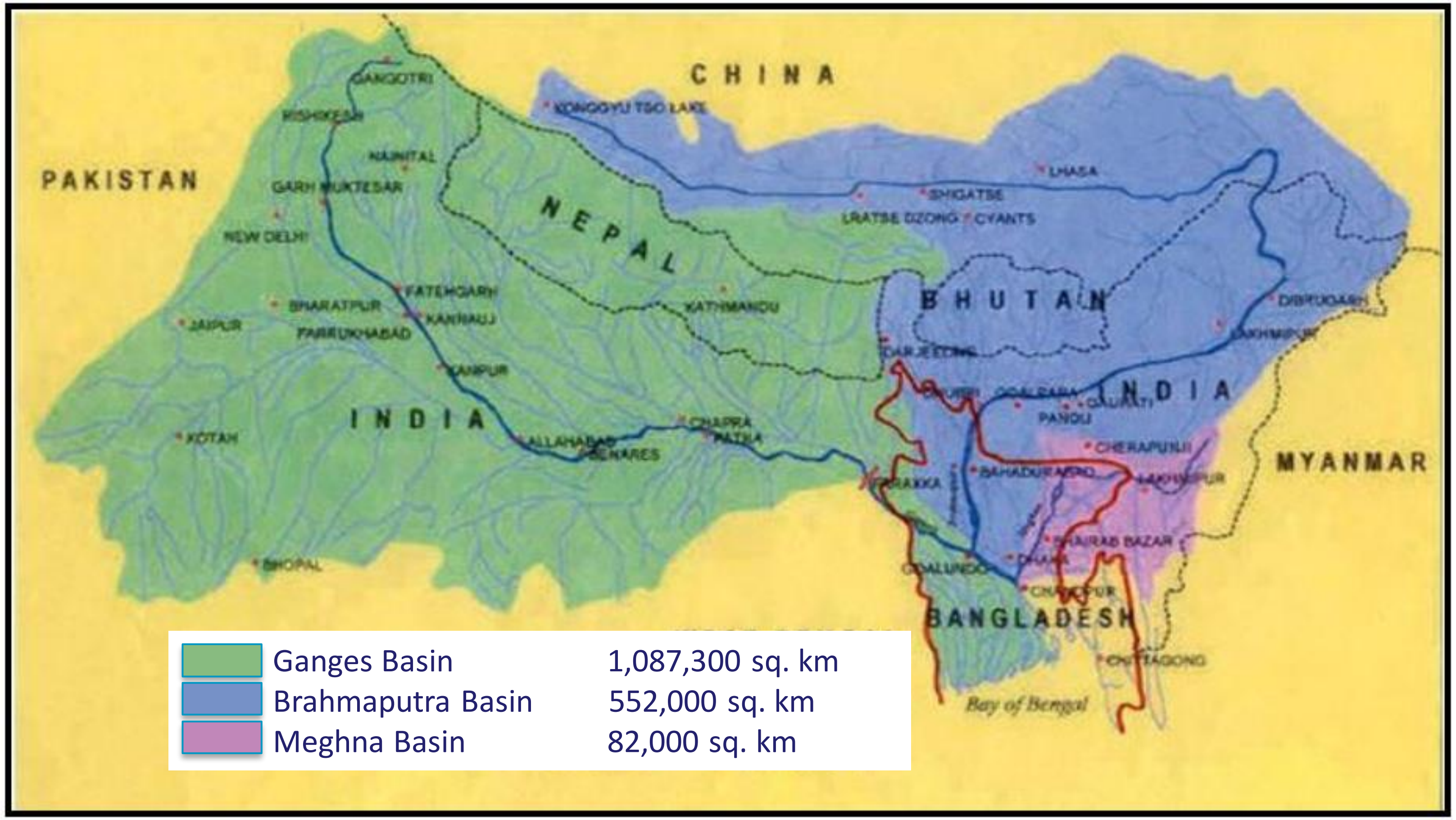
WHAT CAUSES FLOOD IN BANGLADESH?

1.72 million sq. km of the Ganges, Brahmaputra and the Meghna basin drains out through Bangladesh

Precipitation in this large GBM basin causes extreme flood in Bangladesh



Md. Monowar Hossain et. al., Climate change impact on the discharge of Ganges-Brahmaputra-Meghna (GBM) basin and Bangladesh , 2015

WHY FLOOD FORECASTING IS IMPORTANT

https://www.tribuneindia.com/news/world/over-700-000-marooned-as-flash-floods-wreak-havoc-in-bangladesh-112858

Frequent floods in north-eastern region of Bangladesh causes damages to lives and property

A reliable forecast with a significant lead time can help minimize these losses

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https:// www.dhakatribune.com/bangladesh/nation/2017/08/28/rice-production-fall-floods-deluge-farmland

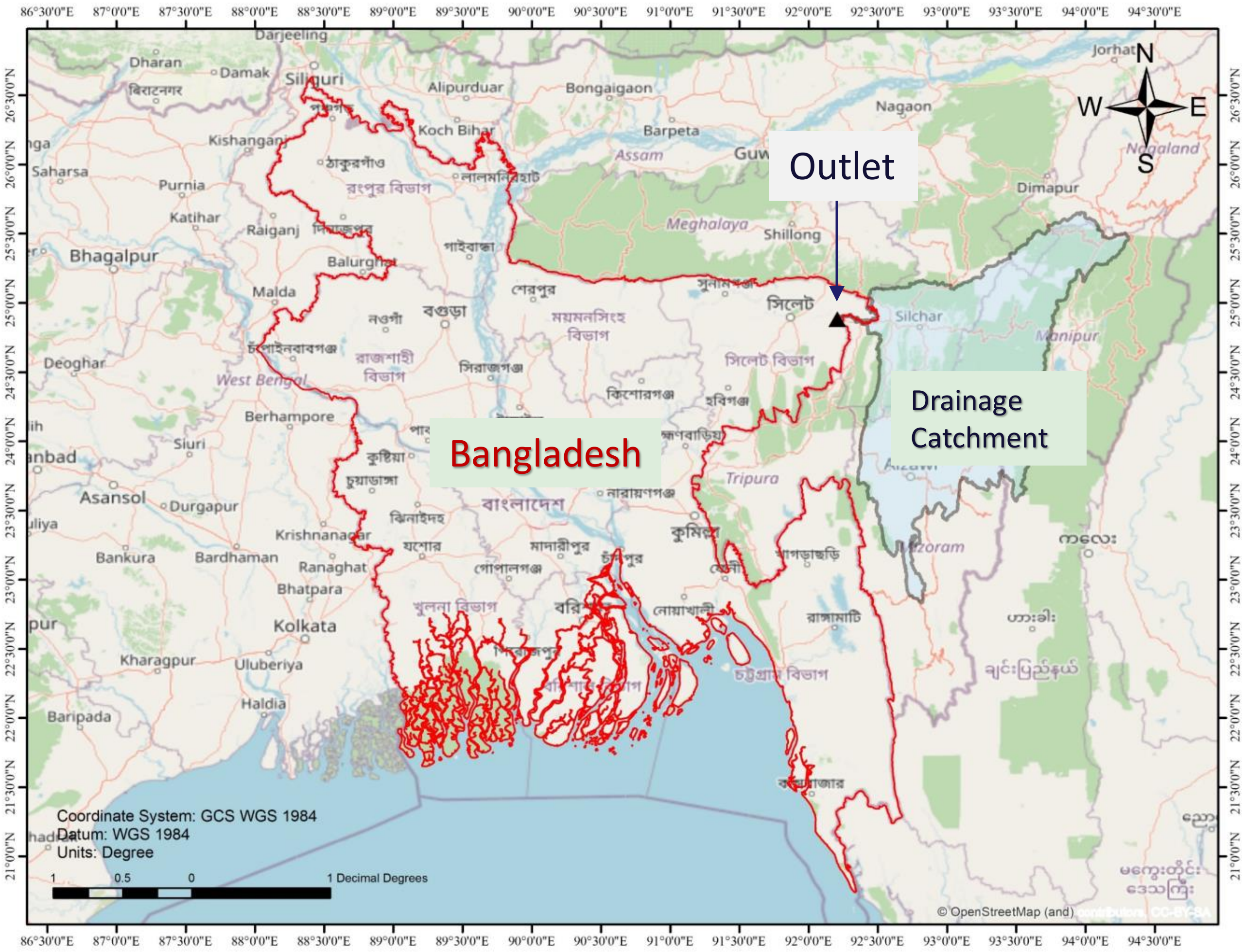
In 2020 alone, Floods caused a damage worth around 155 million USD in crops, destroying crops in 392,440 acres of land

In 2020, flood affected around 4 million people

https://give2asia.org/2020-bangladesh-flood-response/

OUR STUDY AREA

We want to forecast the water levels at an outlet for the Kushiyara River located in the North-East region of Bangladesh



LIMITATION OF EXISTING FLOOD FORECAST SYSTEM

Lack of Rainfall Data

Long Term data unavailable for suited Hydrologic model

Use of Inaccurate forecast data

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SO HOW DID WE MANAGE TO GET DATA?

5th Generation ECMWF Reanalysis (ERA5) → Precipitation

Terrestrial Water Storage (tws) ← Global Land Data Assimilation System with the Gravity Recovery and Climate Experiment Data Assimilation (GRACE-DA)

Soil Moisture Active Passive (SMAP) → Surface Soil Moisture

Water Level and Discharge ← Bangladesh Water Development Board (BWDB)

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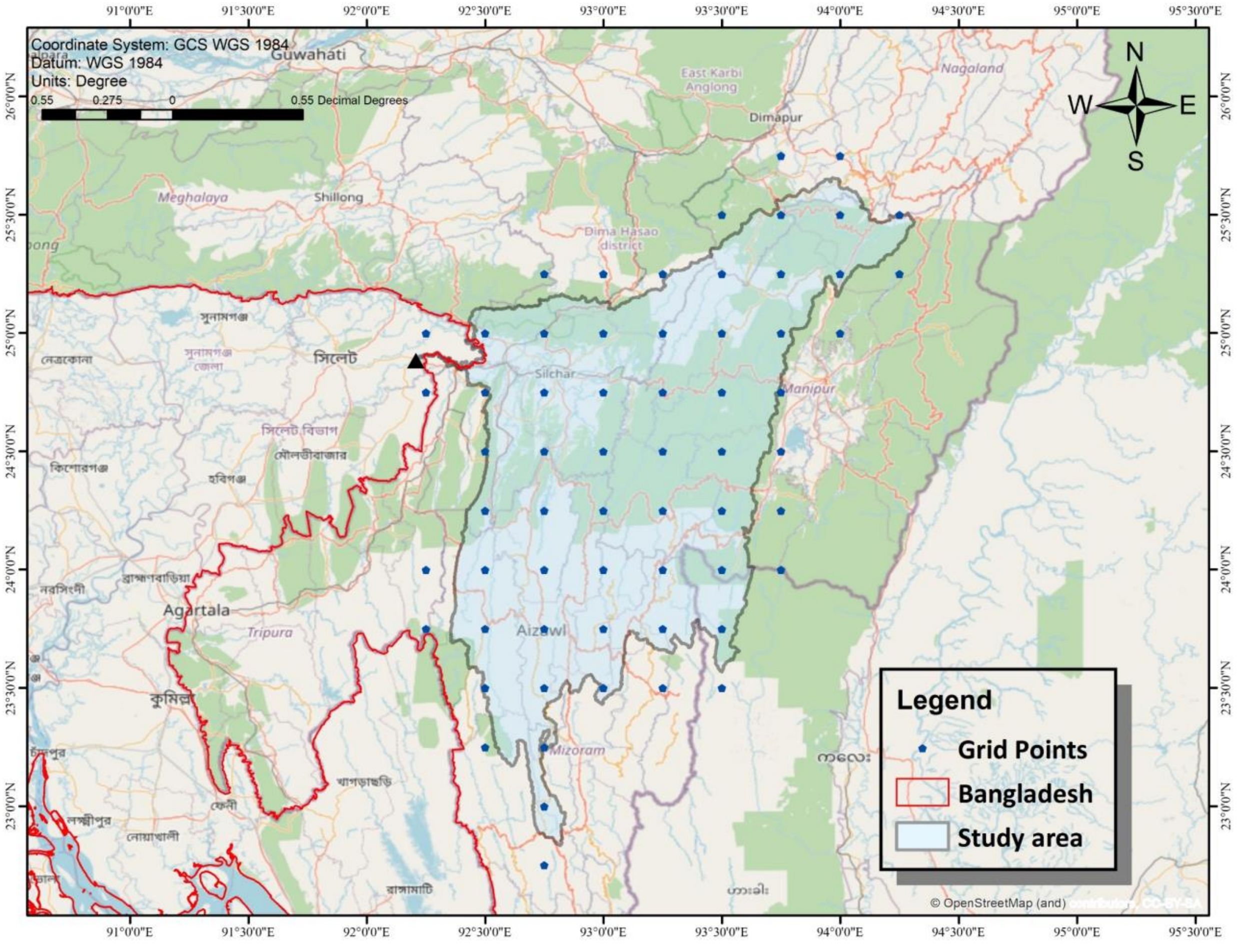
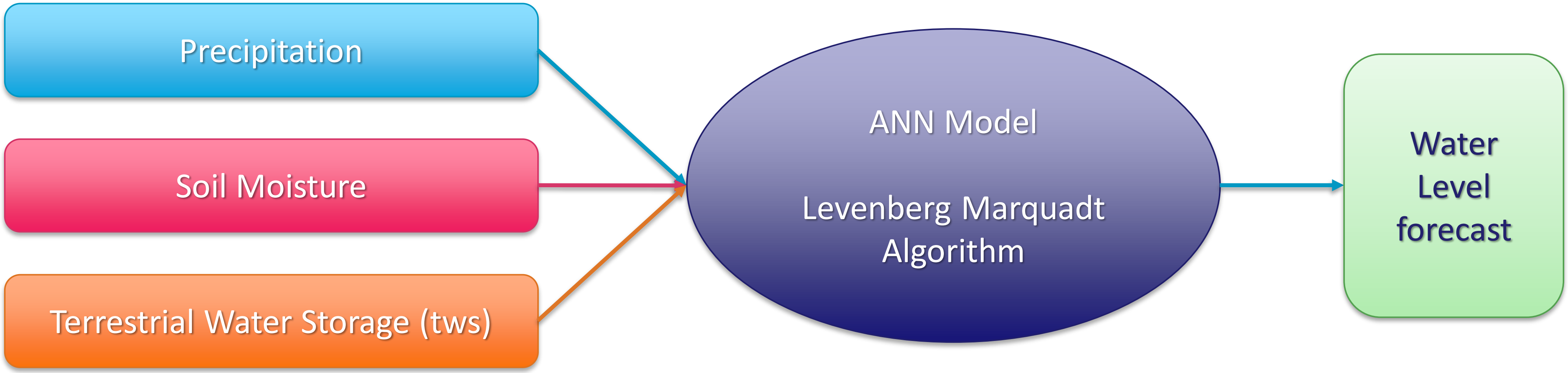
MORE INFORMATION ON OUR DATA

Spatial resolution 0.25^0

March 2015 – June 2017

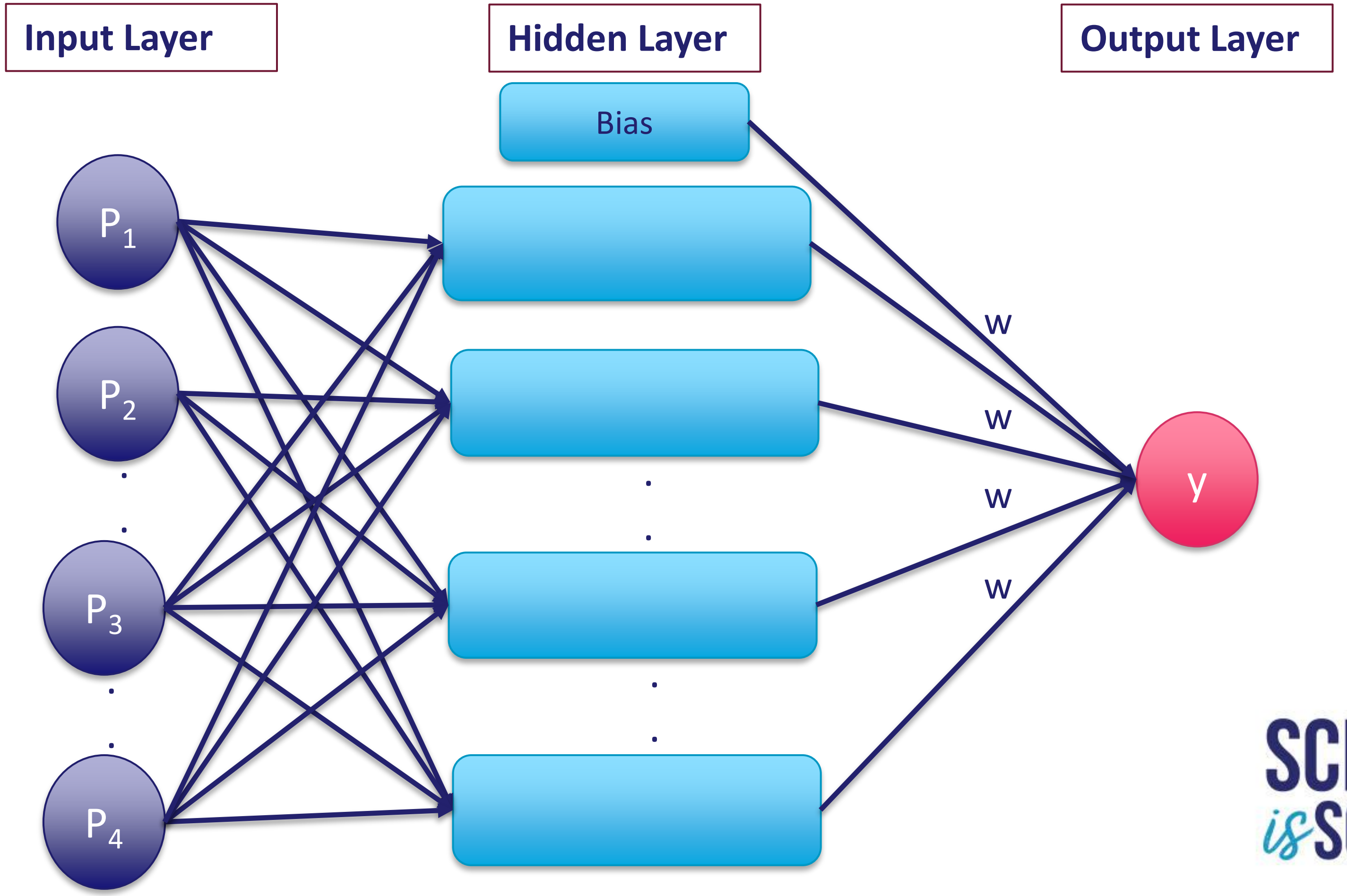


SO WHAT DID WE DO WITH ALL THESE DATA?



AN ARTIFICIAL NEURAL NETWORK MODEL WAS TRAINED TO PREDICT WATER LEVELS

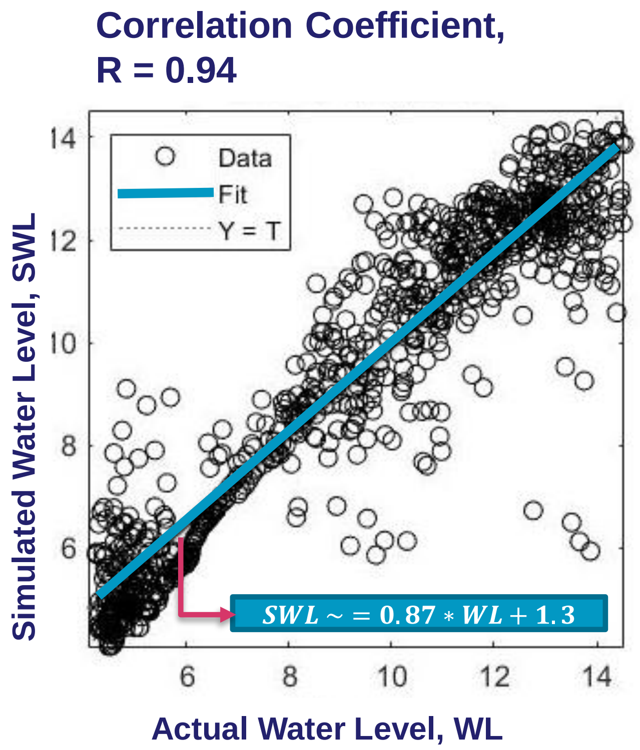
The Levenberg Marquadt Algorithm was chosen to find a correlation between our input data and target water levels to help predict water levels at 1-day, 3-day, 5-day and 7-day lead times

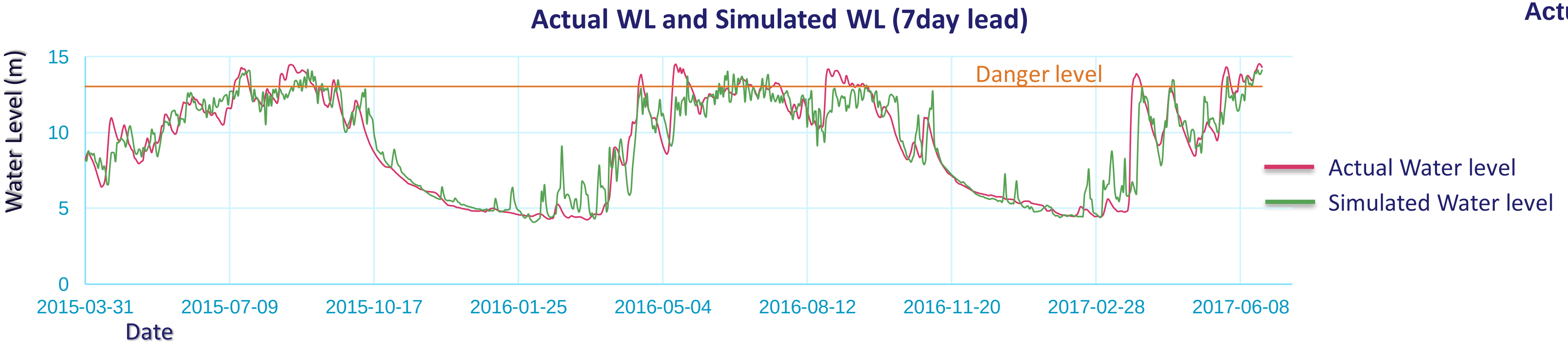


FINALLY, WE HAVE SOME RESULTS

For a Lead Time of 7-days, we observed a Correlation of 0.94 between the input parameters and water level 7 days later

This is what the generated time series looks like:





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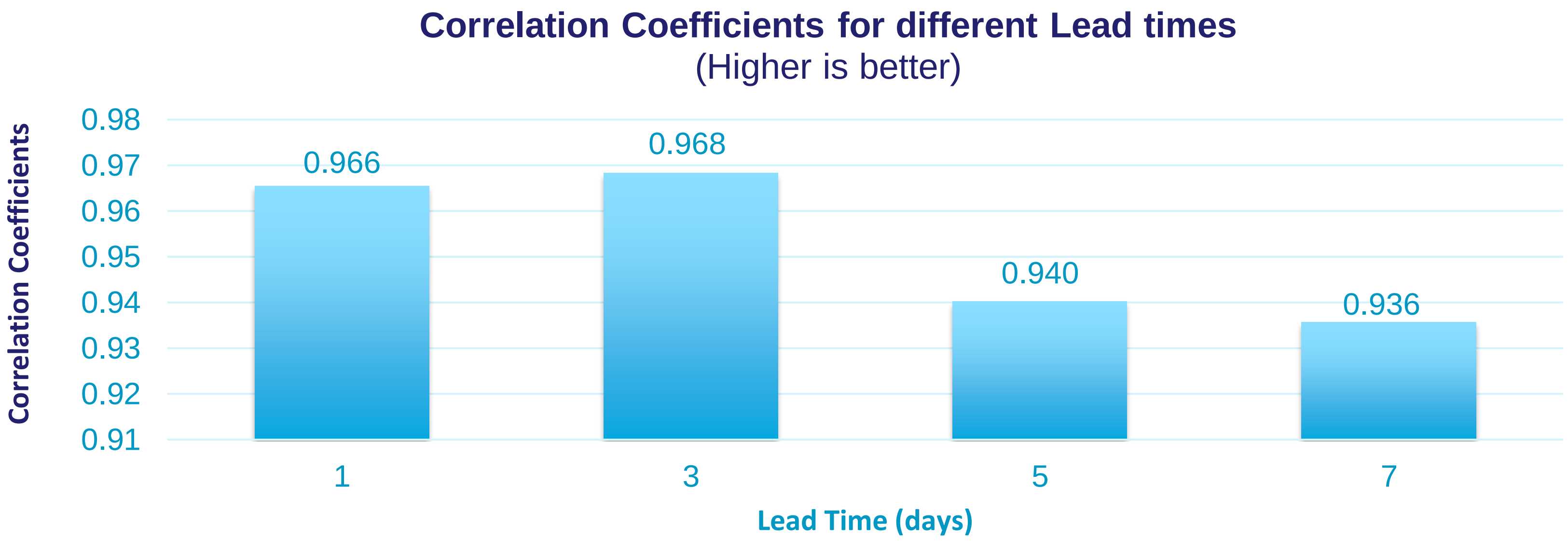
EVALUATION OF FORECAST MODEL FOR DIFFERENT LEAD TIMES

The Correlation values for different lead times look like this:



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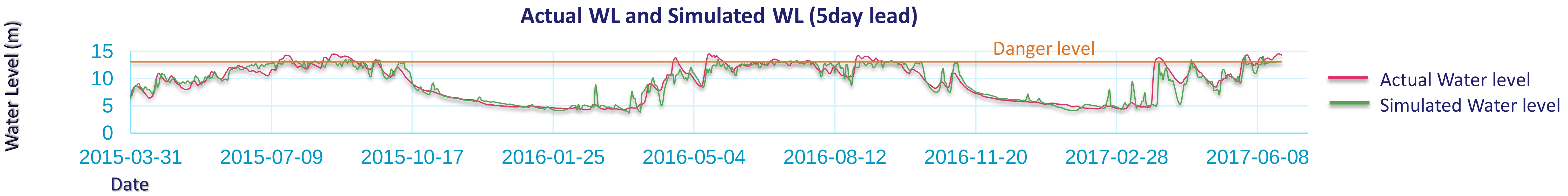
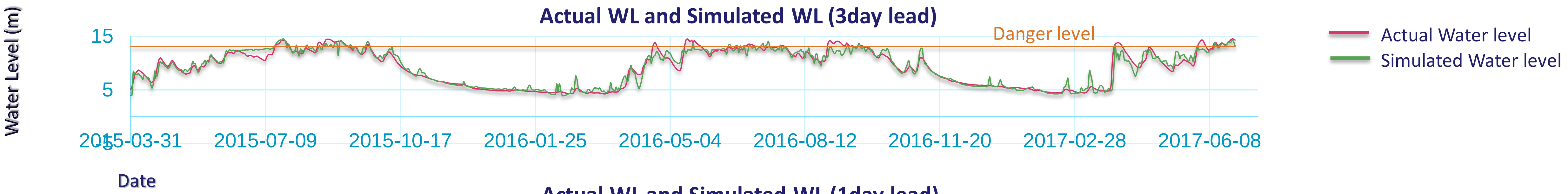
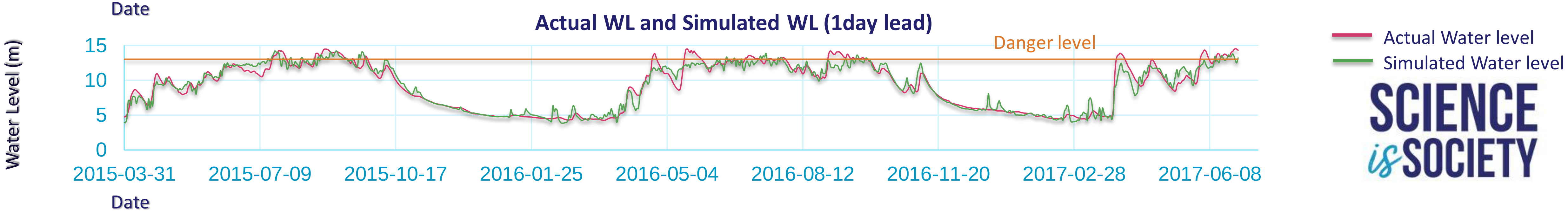
EVALUATION OF FORECAST MODEL FOR DIFFERENT LEAD TIMES







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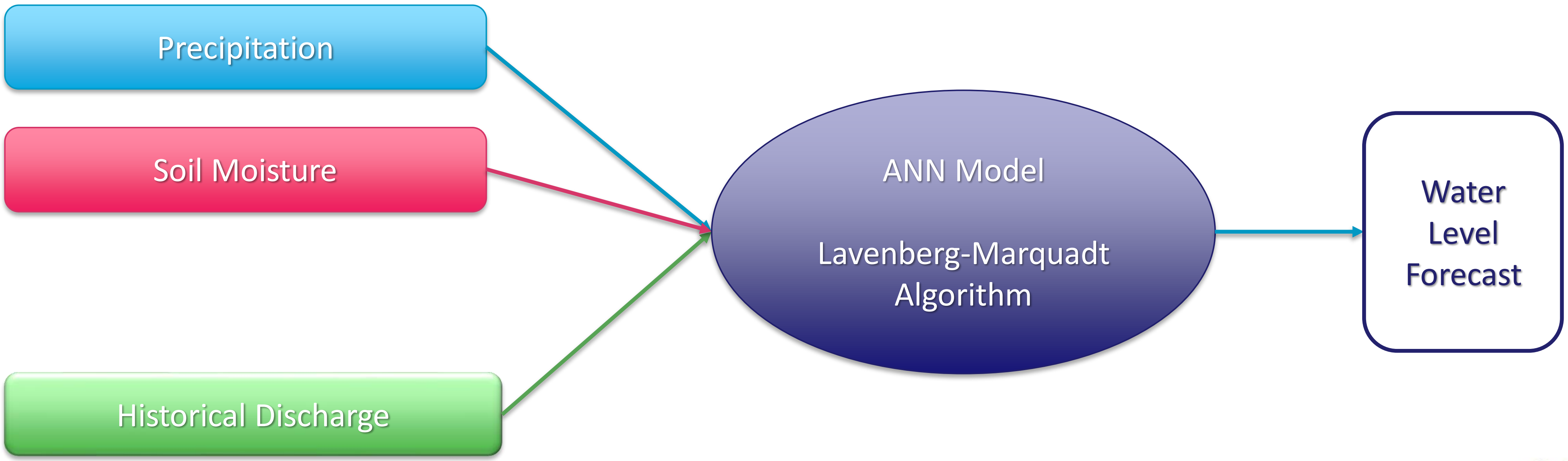
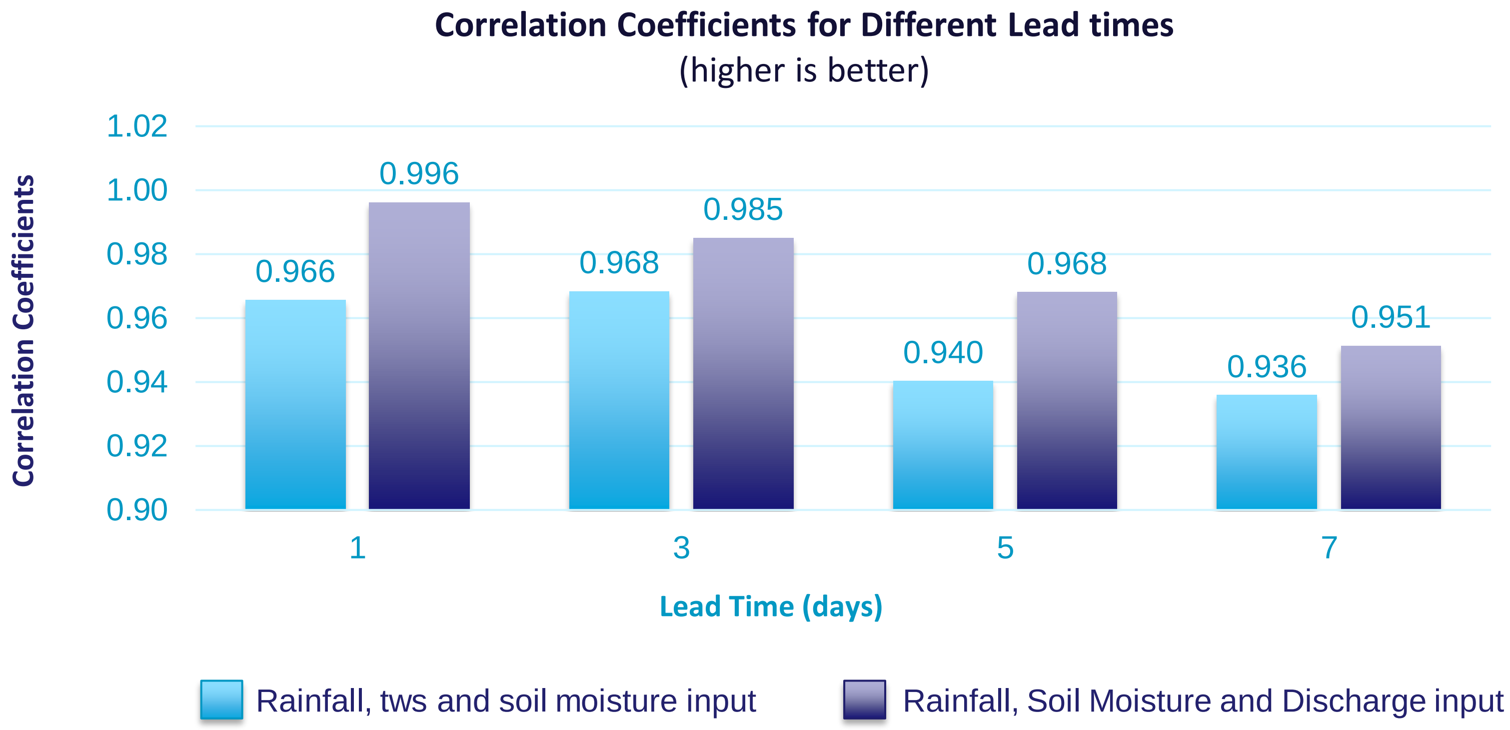
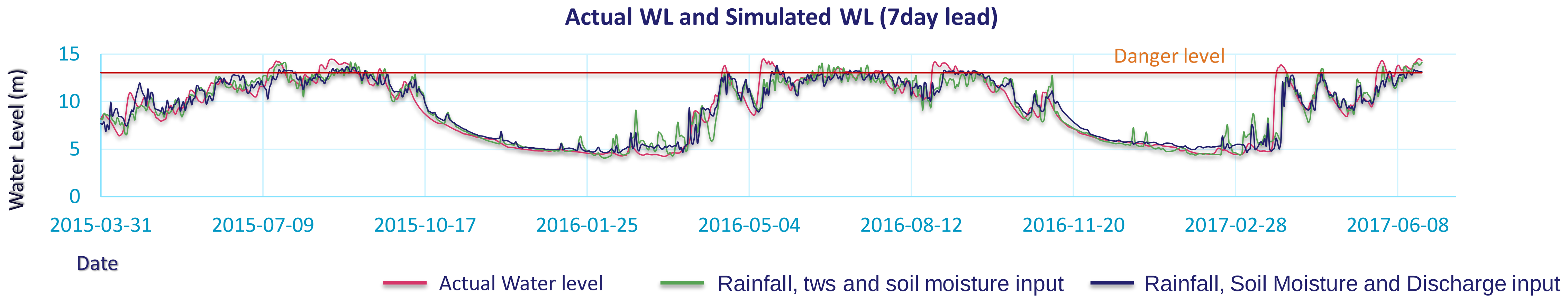
THEN WE USED ANOTHER INPUT PARAMETER TO OUR MODEL

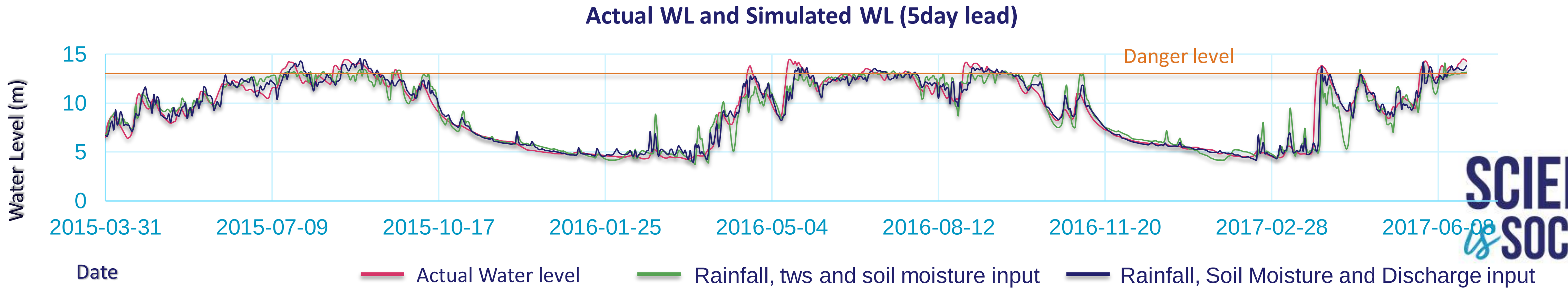


WE NOTICED A SIGNIFICANT IMPROVEMENT IN THE RESULTS IF WE INCLUDE HISTORICAL DISCHARGE DATA INSTEAD OF TWS IN THE MODEL



COMPARISON OF FORECAST FROM THE TWO MODELS WITH DIFFERENT INPUT PARAMETERS





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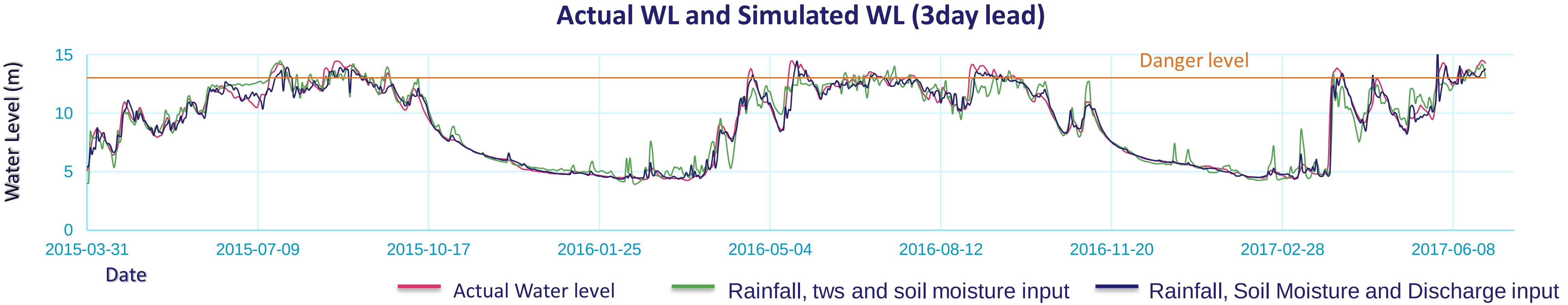

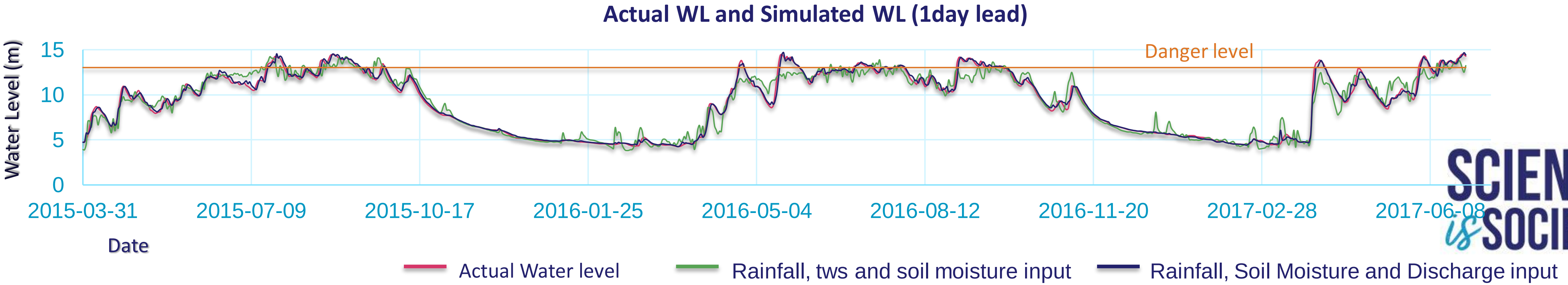

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IN CONCLUSION,

A somewhat reliable medium range (5-7 days) forecast is possible using SMAP retrieved Soil moisture data and tws data retrieved from GRACE-DA datasets.

Use of GRACE data is unsuitable for flood forecast due to its latency

Incorporating Discharge data as input can help improve the results even further.

THANK YOU

Find us at:

alveehannan@gmail.com

siam.maksud@gmail.com

jahan@ualberta.ca

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