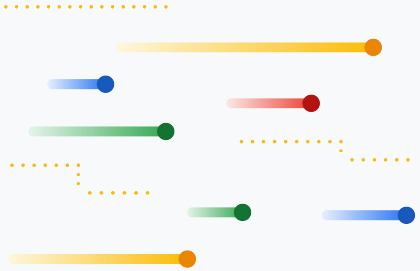
Google Research

# HydroNets: Leveraging River Structure for Hydrologic Modeling

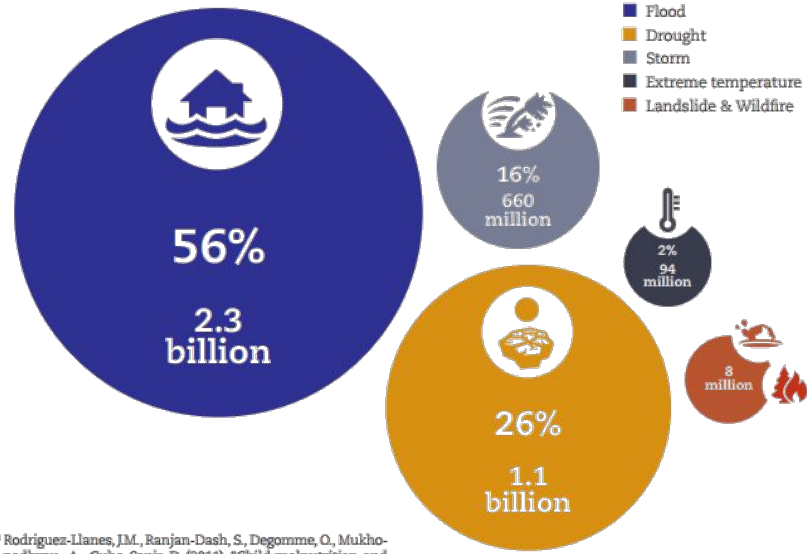


Google Research

# Flood Forecasting Initiative

# Flooding impact

**Numbers of people affected by weather-related disasters (1995-2015)**
(NB: deaths are excluded from the total affected.)

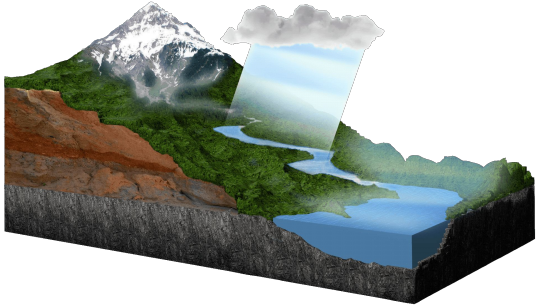



[2] Rodriguez-Llanes, J.M., Ranjan-Dash, S., Degomme, O., Mukhopadhyay, A., Guha-Sapir, D. (2011). "Child malnutrition and recurrent flooding in rural eastern India: a community-based survey". BMJ Open 2001;1: e000109.

# The Google Flood Forecasting Initiative

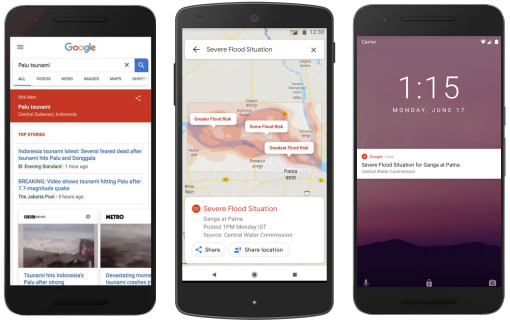
# Flood Forecasting Overview

Hydrologic model



Hydraulic model

Warning Distribution



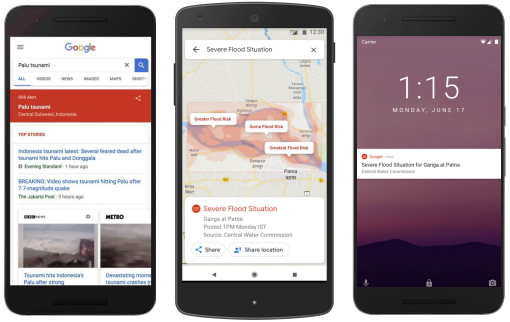
# Flood Forecasting Overview

Hydrologic model



Hydraulic model

Warning Distribution



Google Research

**550K+**

Emergency alerts to date

**2B+**

Alert deliveries to individuals

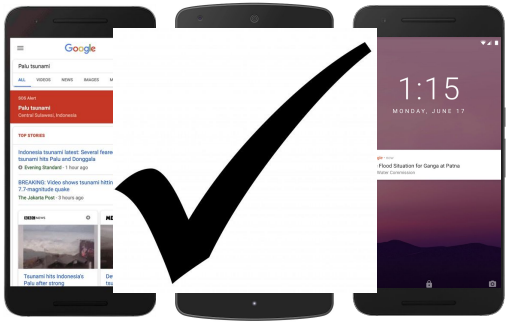
# Flood Forecasting Overview

Hydrologic model



Hydraulic model

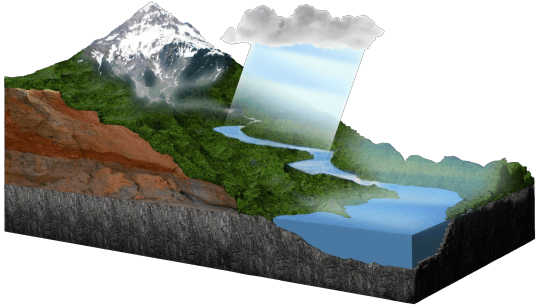
Warning Distribution



# Real-World Accuracy

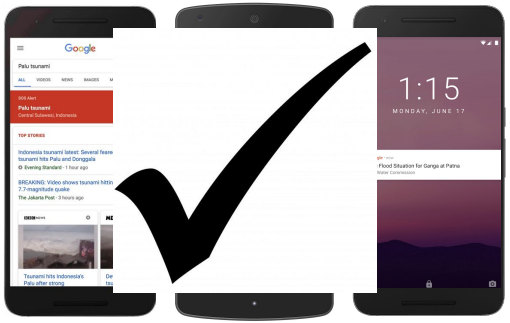
# Flood Forecasting Overview

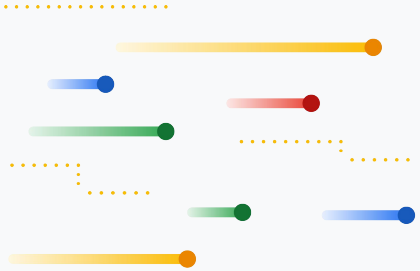
Hydrologic model



Hydraulic model

Warning Distribution





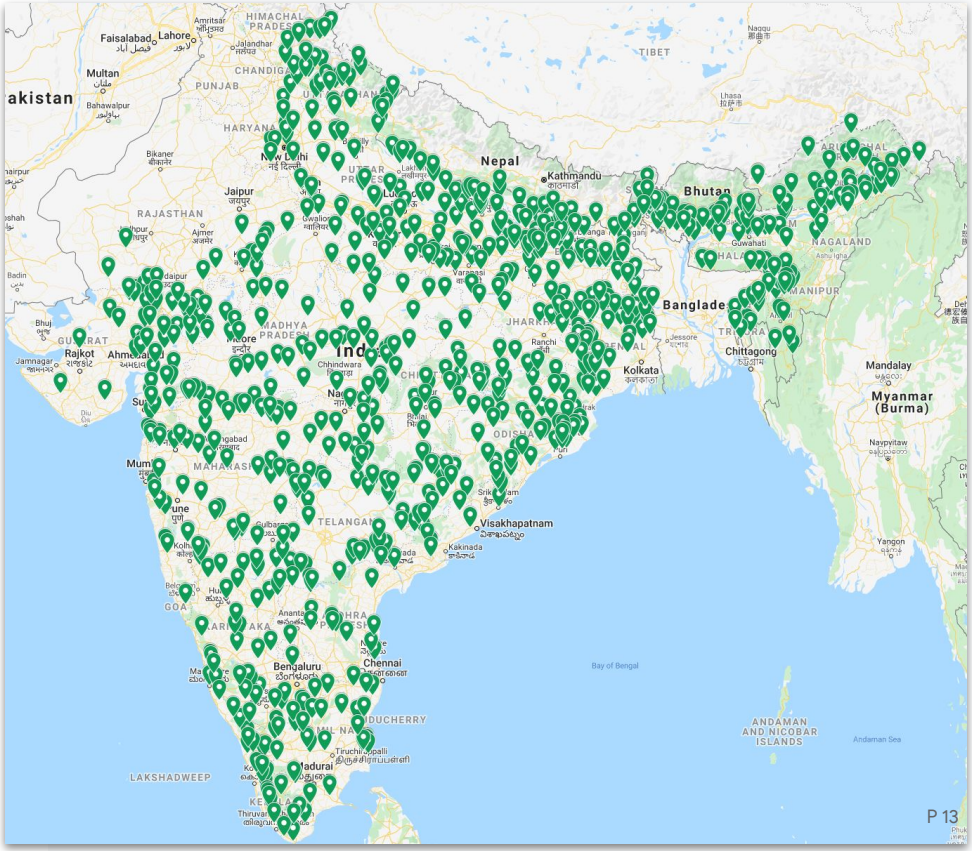
Google Research

# Modeling in India

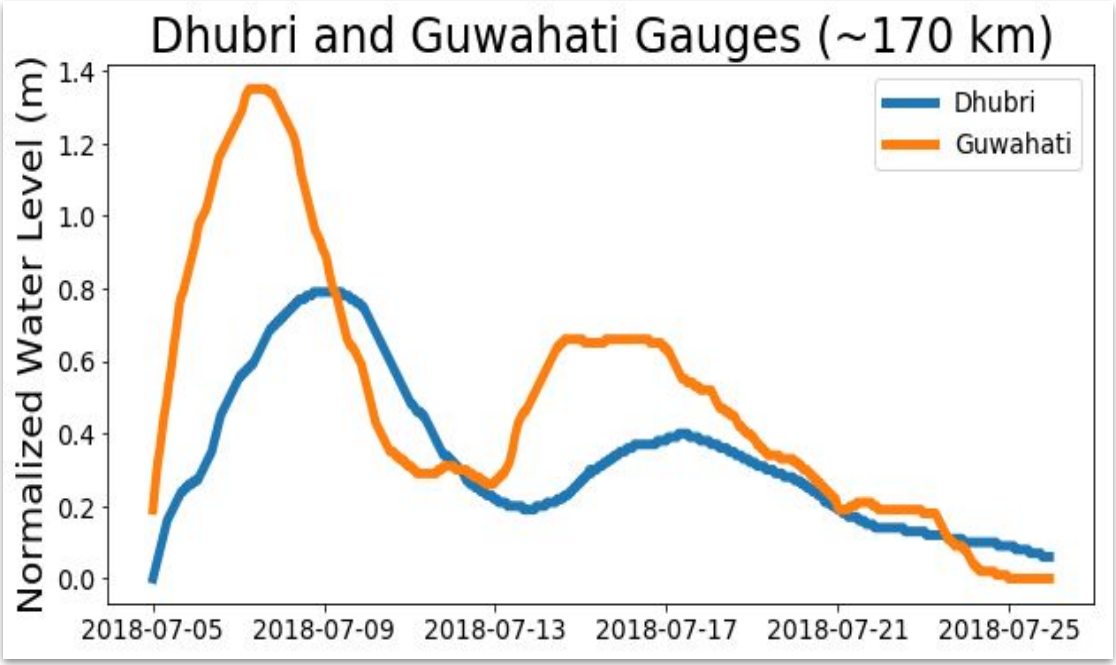
# Hydrologic Modeling in India

- We would like to improve accuracy and forecast horizon of our operational warning systems

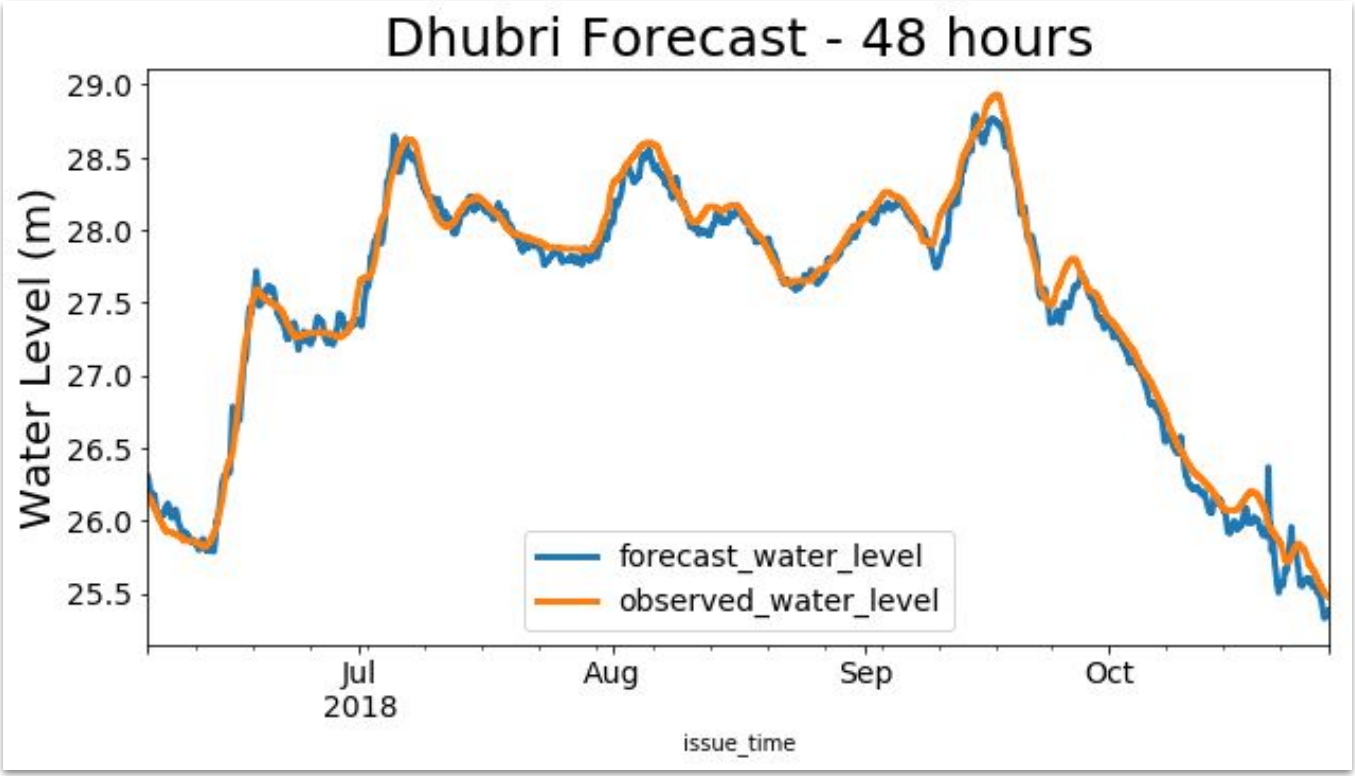
- Expected launch - June 2020



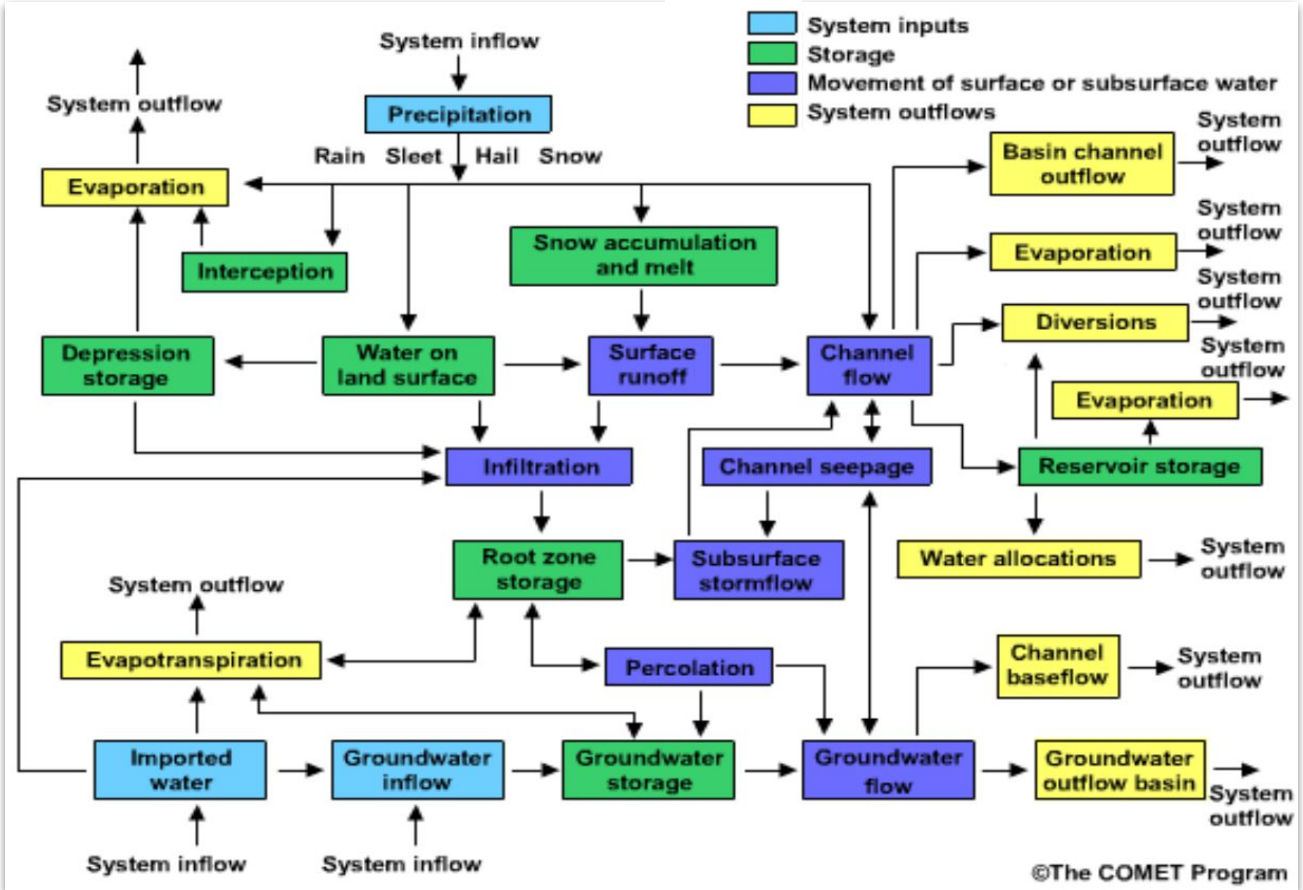
# Gauge to Gauge Correlation



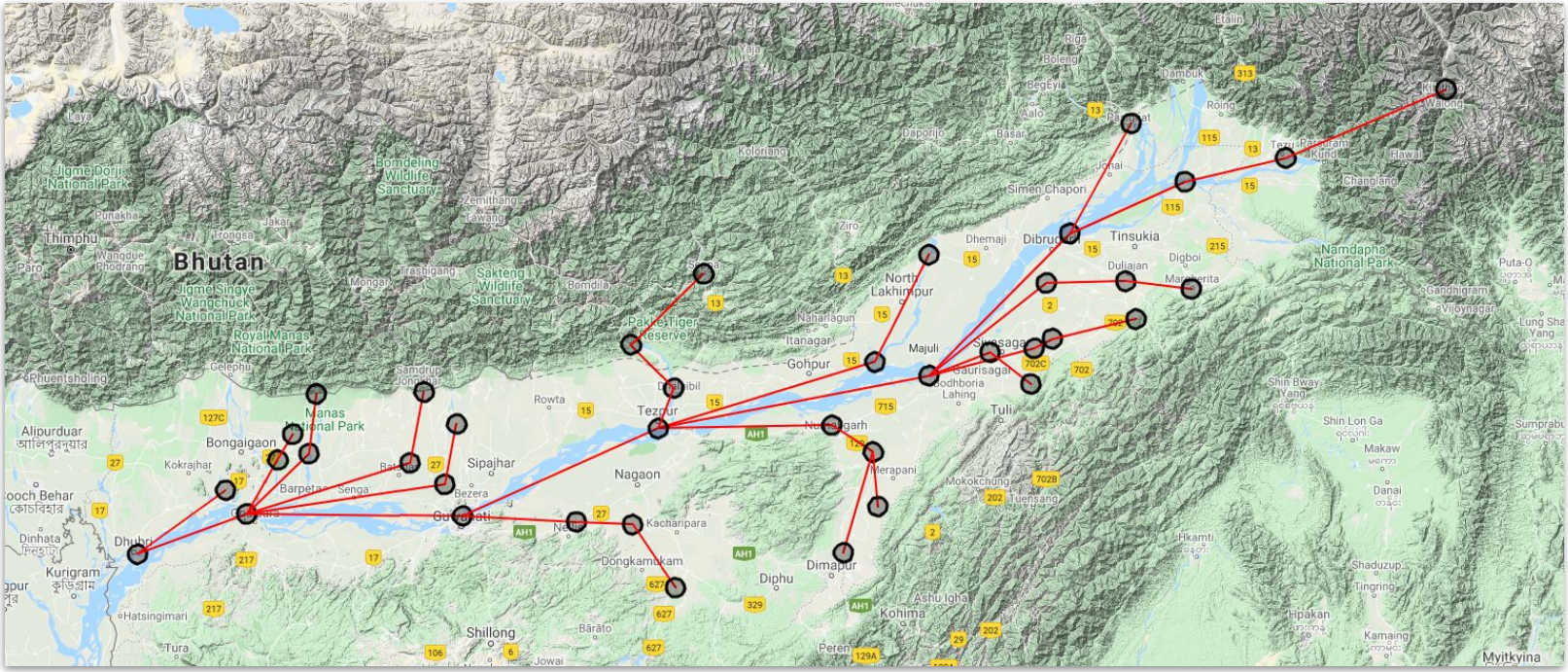

# Gauge to Gauge Prediction



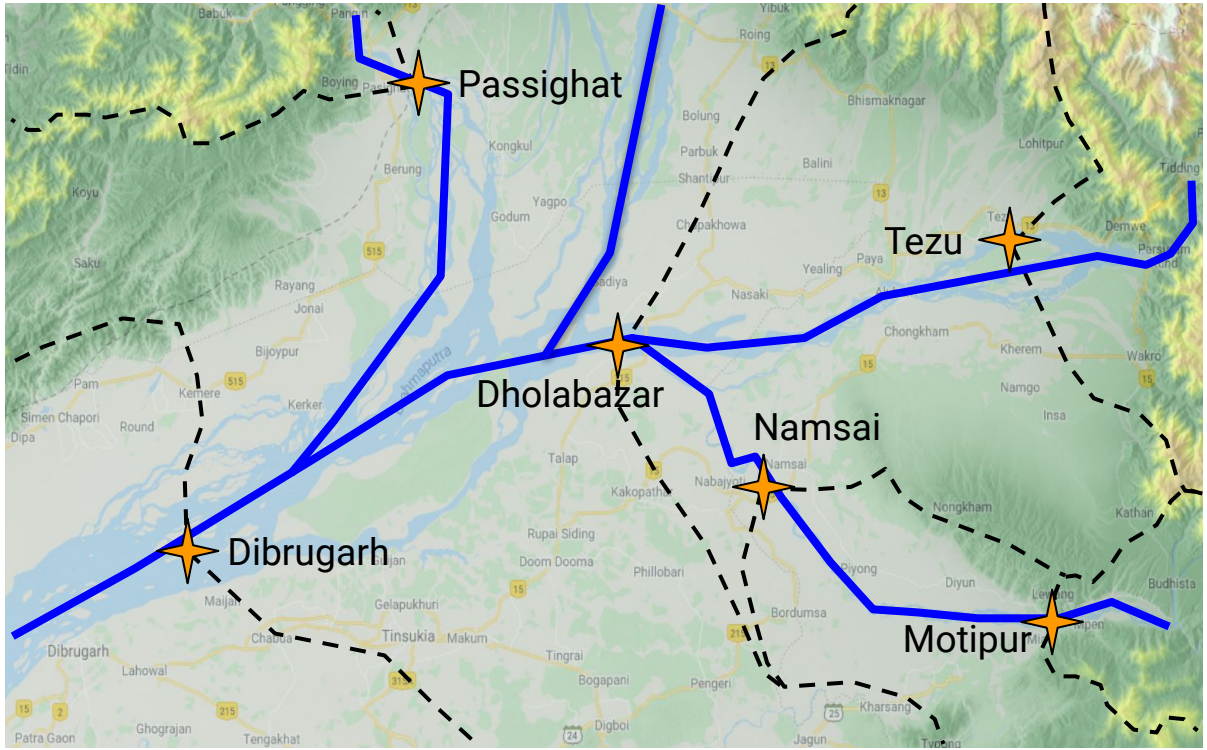
# A Traditional Hydrologic Model

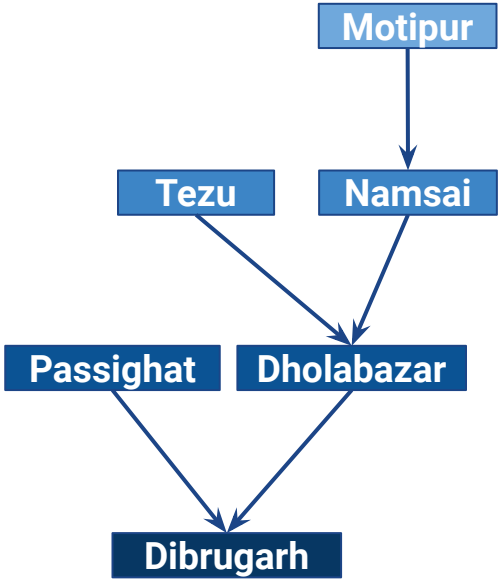


# River Structure Prior Knowledge



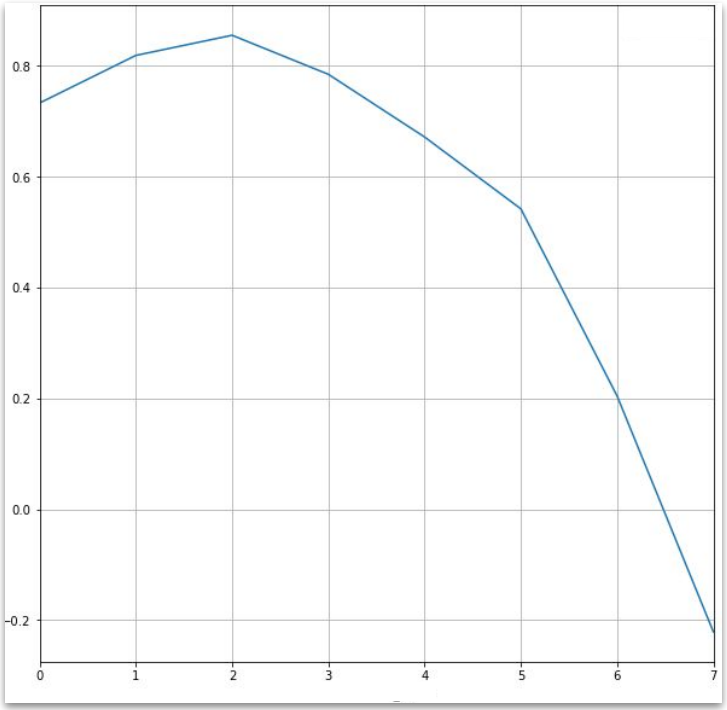
# River Structure Prior Knowledge



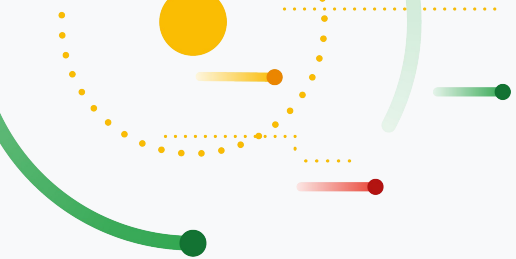



# The value of Depth

R2
Persist




Depth

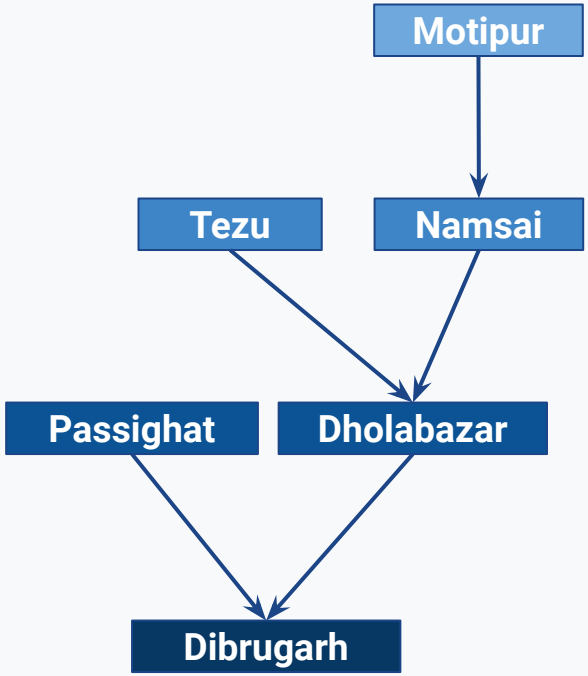


Google Research

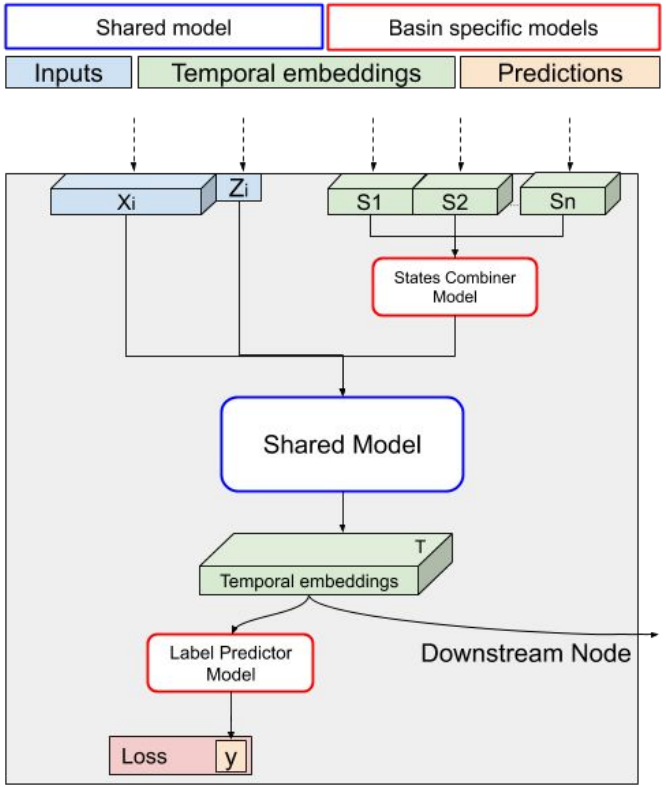
# The HydroNets Architecture

# Guiding principles

- Causality between basins
- General modeling vs. basin specific
- Data flow should reflect water flow



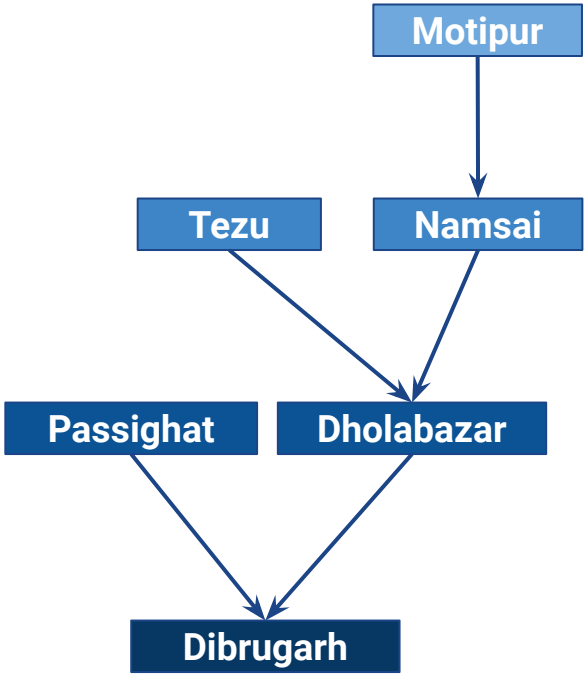
# A Single Node

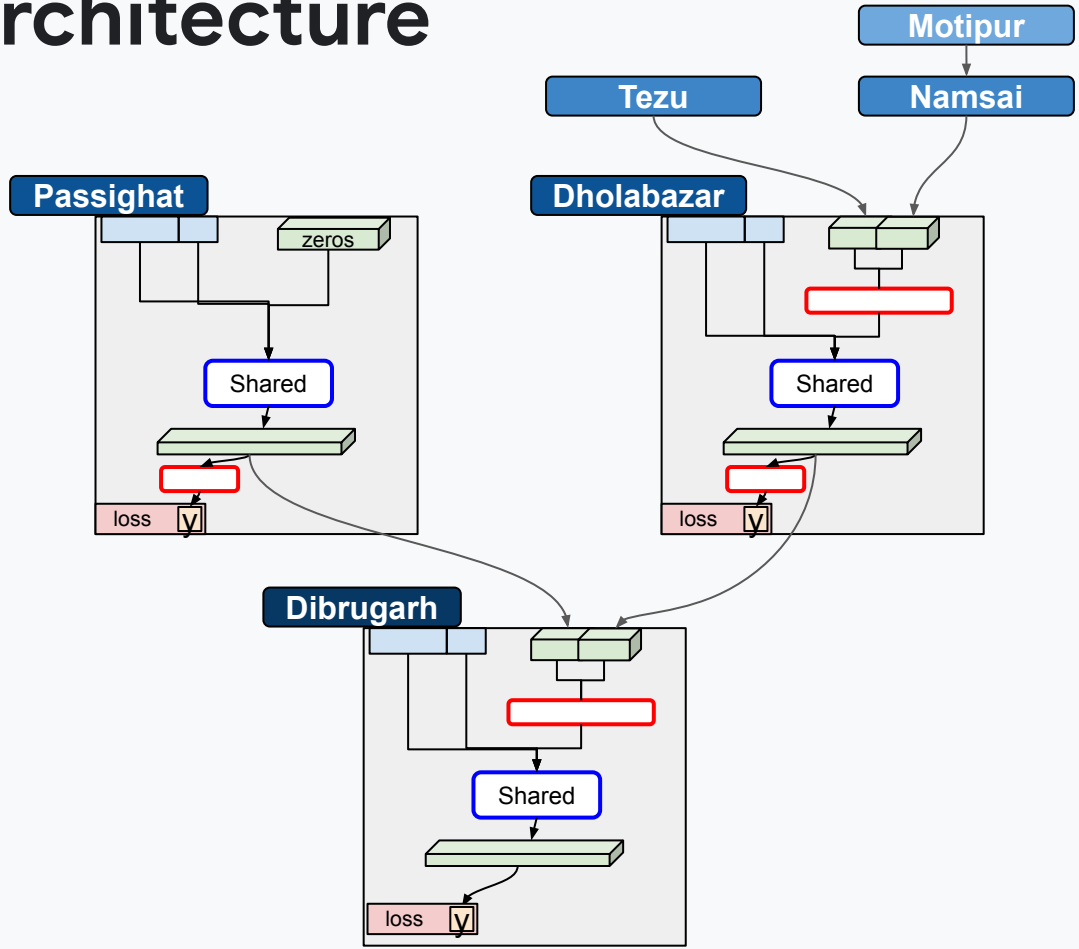



The three sub-models:

- **Combiner**: Accounts for the relative importance of sources to their drain.
- **Shared**: Classical rainfall-runoff hydrological modeling.
- **Predictor**: Accounts for basin-specific properties.

# The HydroNets Architecture

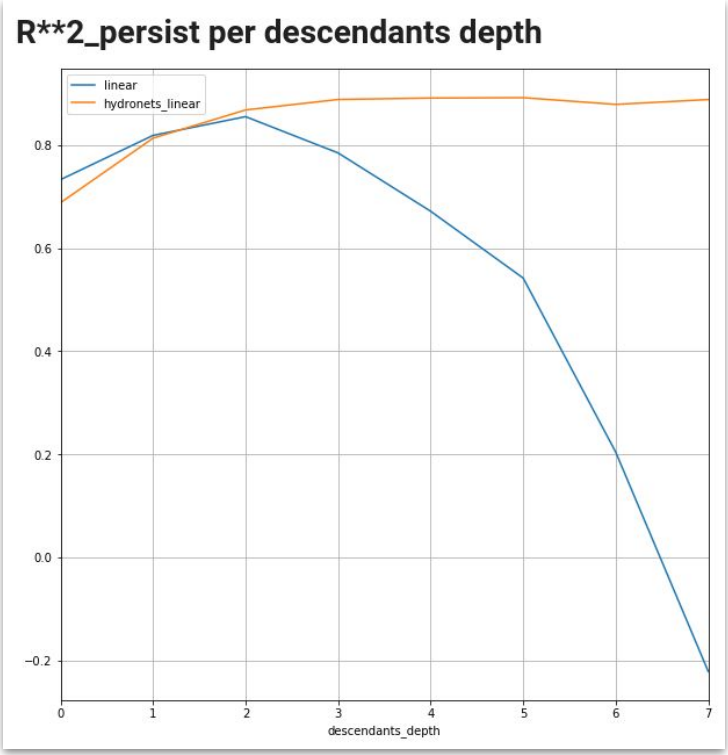


# Addressing Overfitting

**Legend**

- Linear baseline
- HydroNets

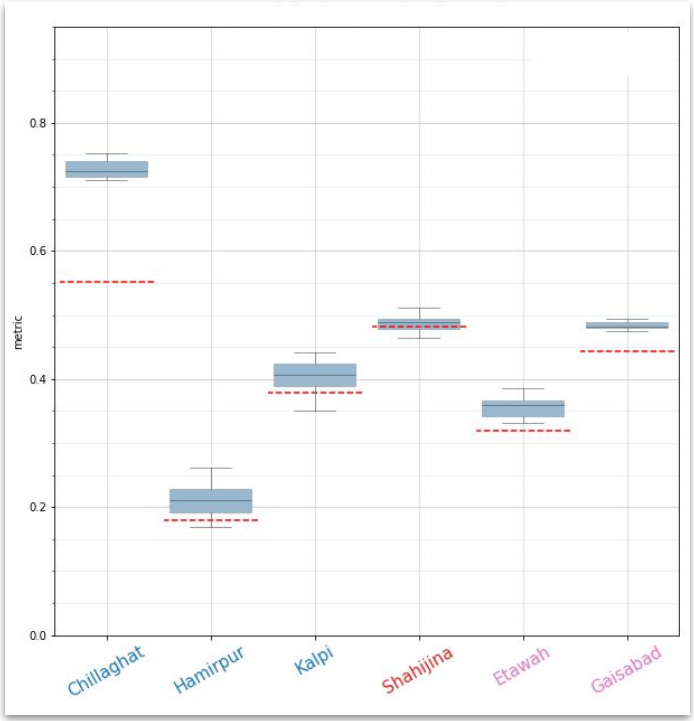


# Improved Performance

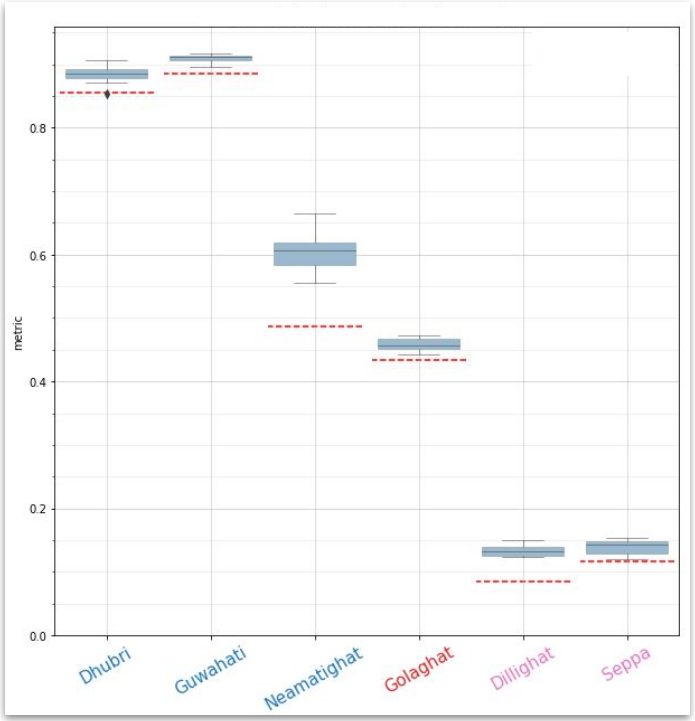
**Legend**

- Linear baseline
- HydroNets

## Ganges




## Brahmaputra



# Thank you!

- The flood forecasting warning system is already live, sending millions of alerts to users. Increased coverage and lead-time are planned for June 2020.
- HydroNets is a hydrologically-inspired architecture that allows us to leverage all basins for learning.
- Ideas for other domains?

go/floods-intro ashermetzger@ zmoshe@