Reconstruction of the great famine of western India using historical rainfall and global reanalysis datasets: challenges and uncertainties

THA2019 International
Conference on Water Management and
Climate Change towards Asia's Water-Energy-Food Nexus and SDGs
23rd January 2019

東京大学 THE UNIVERSITY OF TOKYO

Seemanta Sharma Bhagabati

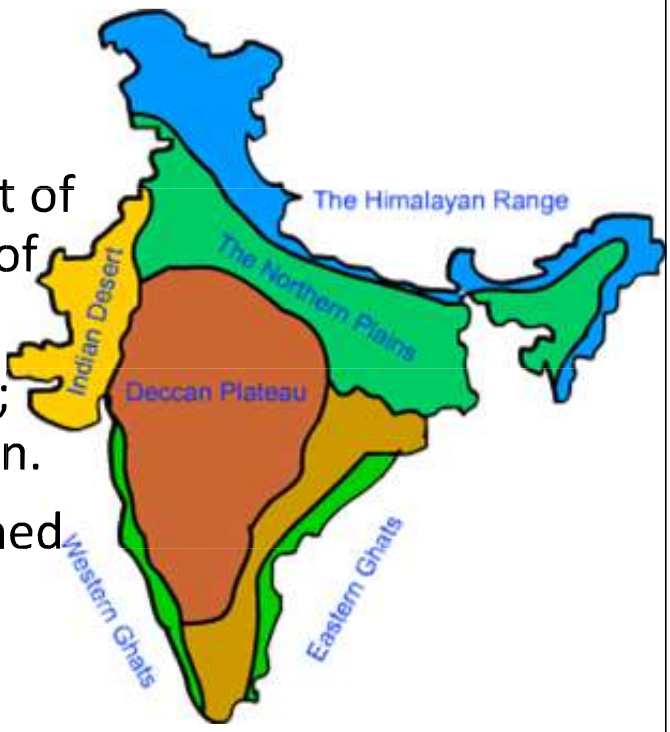
Department of Civil Engineering, The University of Tokyo

Outline

1. Introduction
2. Study area
3. Research strategy
4. Model setup and results
5. Conclusion and future work

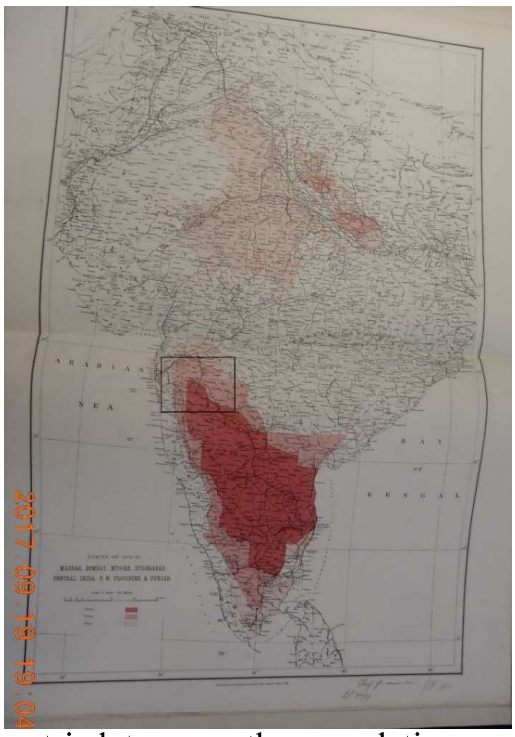
Introduction

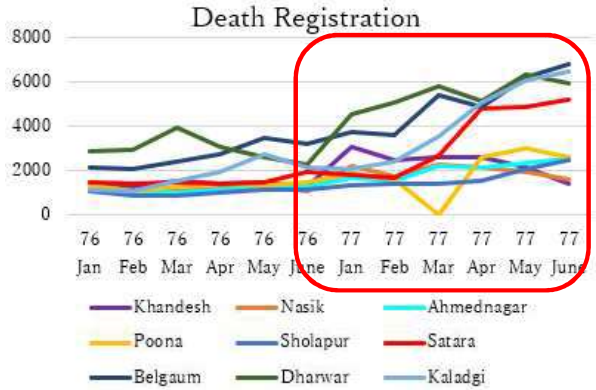
- The **Deccan Plateau** is a large **plateau** which covers most of the western and southern part of India.
- Agriculture is the main industry; hence heavily relies on Monsoon.
- In 1870s, 2 big disasters happened
  - The Deccan Riot (1875): Peasants revolted against their absentee landlords
  - The Great Famine (1876-78): Resulting from the lack of rainfall (droughts in 1876 led to famine)



Introduction (contd.)

- Droughts in the Deccan plateau (1876) caused the Great Famine in 1876-78 : The famine ranged over a large part of India.
- The pandemic of malaria hit the damaged areas around Northern India in 1879.
- The total number of deaths amounted to 5 million.





- Several studies tried to map the population change due to the Great Famine but were unable to provide any clear statistics and only provided decadal statistics.
- Although death records exist, the correlation between deaths and drought is unclear.

Introduction (contd.)

Past studies (Global)

- Multiple studies have been conducted, focusing on droughts in multiple regions/countries

	Studies	Target area	Time scale	Type of analysis	Remarks
1	Ahmadalipour & Moradkhani, 2018	Africa	1960-2100	Drought vulnerability	Drought vulnerability Index (DVI)
2	Asong et al, 2018	Canada	1950-2013	Precipitation analysis	Standardized Precipitation Evapotranspiration Index (SPEI)
3	Barella-Oritz & Quintana-Segui, 2018	Spain	1989-2008	Precipitation analysis	Regional Climate Models, ERA-Interim
4	Kim et al, 2011	Korea	1777-2008	Precipitation analysis	Effective Drought Index (EDI)
5	Mendoza & Velasco, 2005	Mexico	1502-1899	Drought frequency analysis	Agricultural and hydrometeorological events
6	Yao et al, 2018	China	1961-2013	Drought severity and trends	Precipitation based analysis: Precipitation anomaly (Pa), standard precipitation index (SPI), etc.
7	Zhang et al, 2019	Global (32 river basins)	1948-2010	Precipitation and Evapotranspiration	Standardized Moisture Anomaly Index (SZI), Potential Evapotranspiration (PET)

Statistical and historical studies are not shown

Introduction (contd.)

Past studies (India)

- Multiple event based and long-term studies in the mid to late 20th century and 21st century respectively.
- Many datasets on droughts and floods are also released for the 20th century.
- Very limited studies in the 19th century, especially event-based study.
- No study on the Great Famine from a hydrological point of view.

	Studies	Target area	Time scale	Type of analysis	Remarks
1	Dhorde & Patel, 2016	Western India	2002-2010	Satellite data products (MODIS)	Leaf area index (LAI)-based temperature vegetation dryness index (TVDI)
2	Jha & Srivastava, 2018	Western India	2001-2013	Meteorological	Standardized Precipitation Evapotranspiration Index (SPEI)
3	Kumar et al, 2013	Entire India	1901-2010	Meteorological	Standardized Precipitation Evapotranspiration Index (SPEI)
4	Singh et al, 2017	North-west Himalaya	1740 – 2014	Isotope analysis	Tree ring drought records
5	Swetalina & Thomas, 2016	Central India	1974-2009	Hydrological/statistical	Flow Duration Curve (FDC)
6	Yan et al, 2016	Northern & Eastern India	1901-2010	Drought frequency analysis	Palmer Drought Severity Index (PDSI)

Statistical and historical studies are not shown

Introduction (contd.)

- Goal & uniqueness
  - Understanding the Great Famine from the hydrological perspective
- Objective
  - Reconstruction of historical meteorological events (the Great Famine) in the Indian sub-continent
- Outputs
  - Drought maps, water availability in the basin, time-scale analysis of meteorological parameters
- Expected outcomes
  - Link and understand the disorders in the Deccan Plateau in the late 1870s which resulted from a series of events (the Deccan riots in 1875, droughts in 1776, the Great famine in 1776-78).

Study area

Rainfall observation stations (district names)

- Poona
- Satara
- Sholapur

Bhima River

River length: 861 km

Catchment area: 70,614 km^2

Tributary of Krishna River

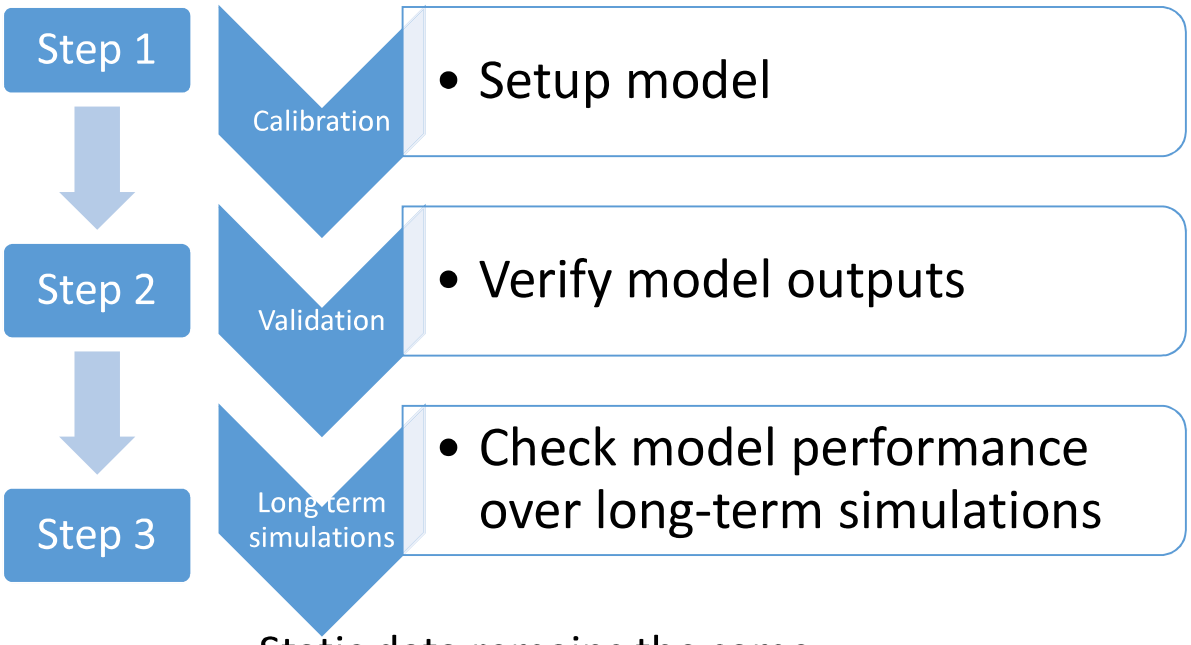
Elevation:

source: 945 m

Mouth: 336 m

Research Strategy

Typical flowchart



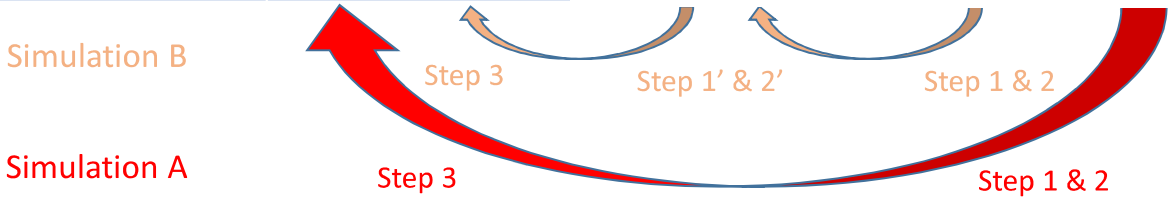
Static data remains the same

But not applicable for simulating events which are over a century old

Research Strategy

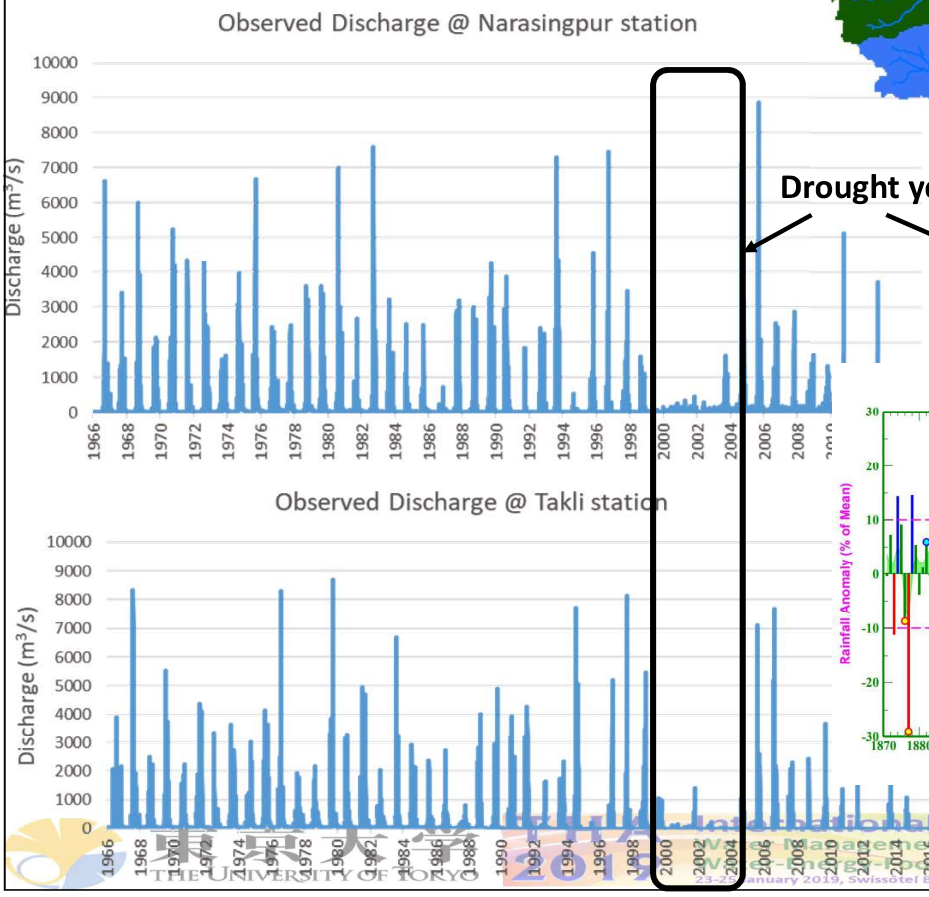
Model setup strategy

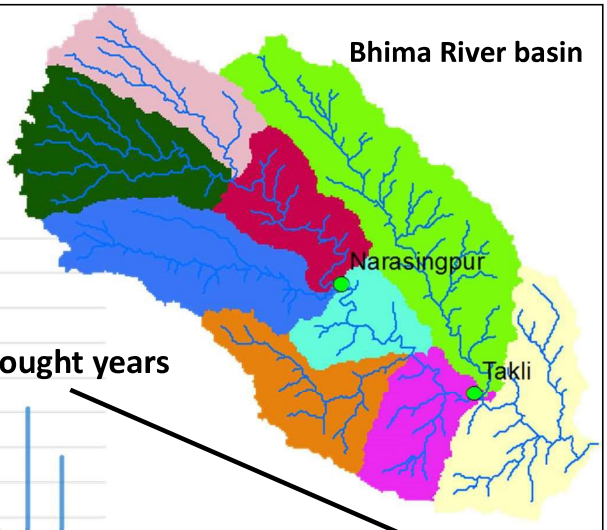
	1876
Meteorological data	Global reanalysis data (meteorological data only)
Static data	Partially available
Missing data	No observed data (rainfall/discharge) available
Hydraulic structures	Very few
Drought year	1876



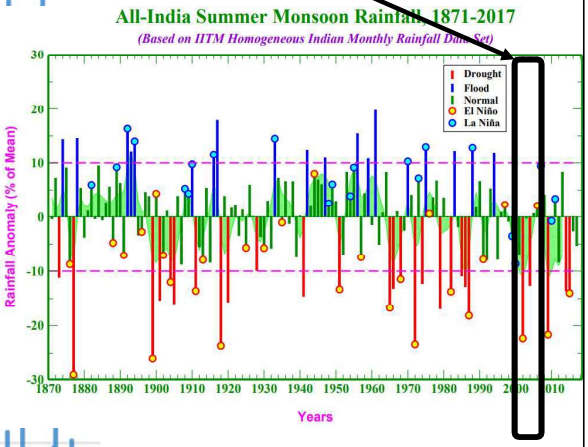
Model setup and results

Observed Discharge



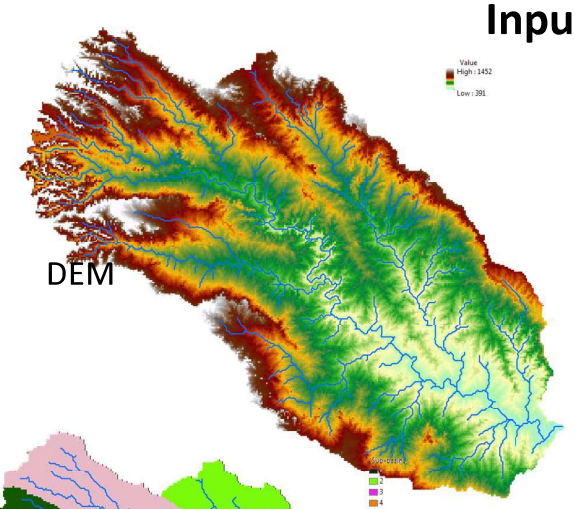


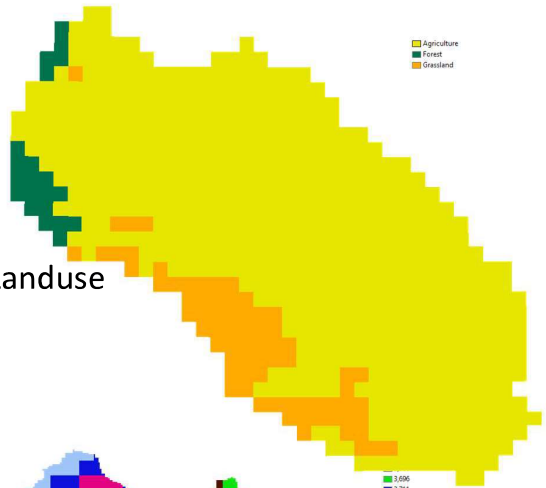
Drought years

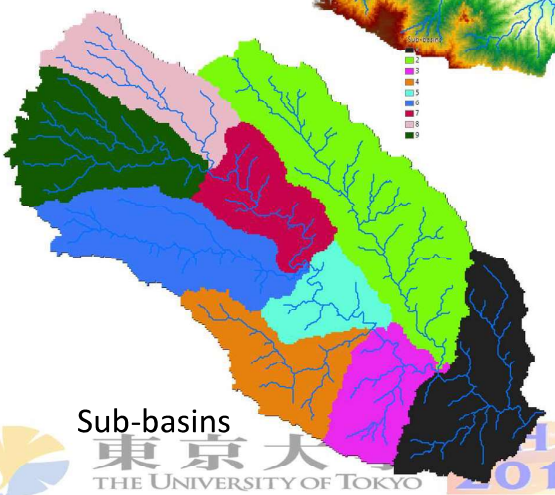


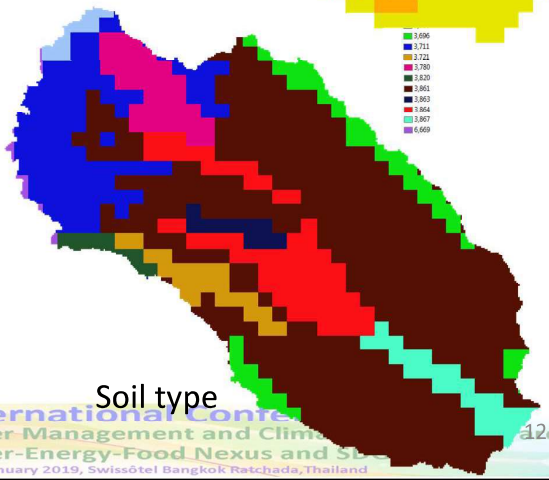
Model setup and results

Input data

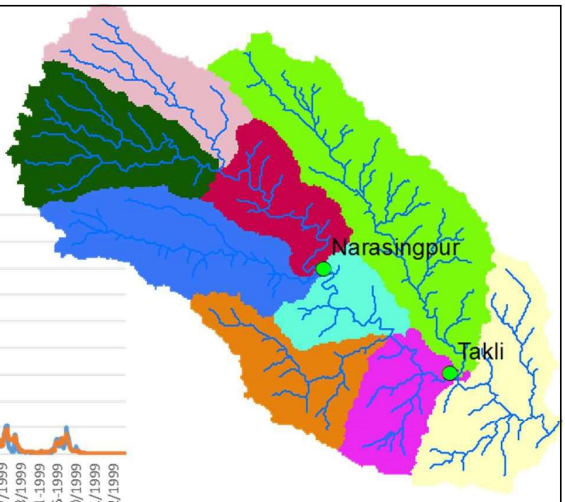


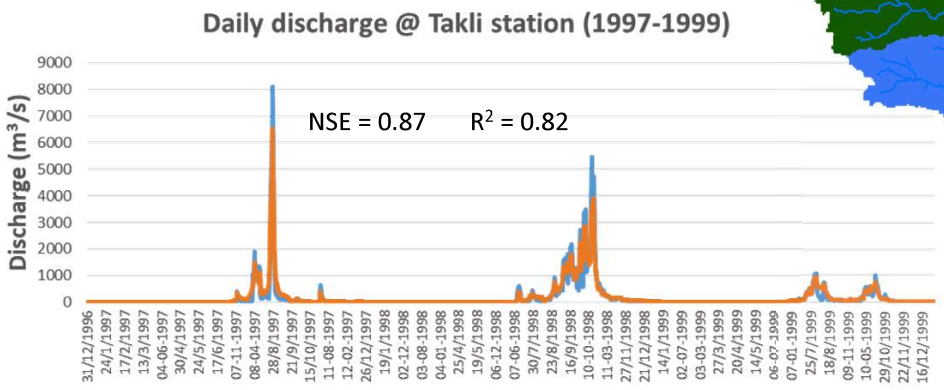


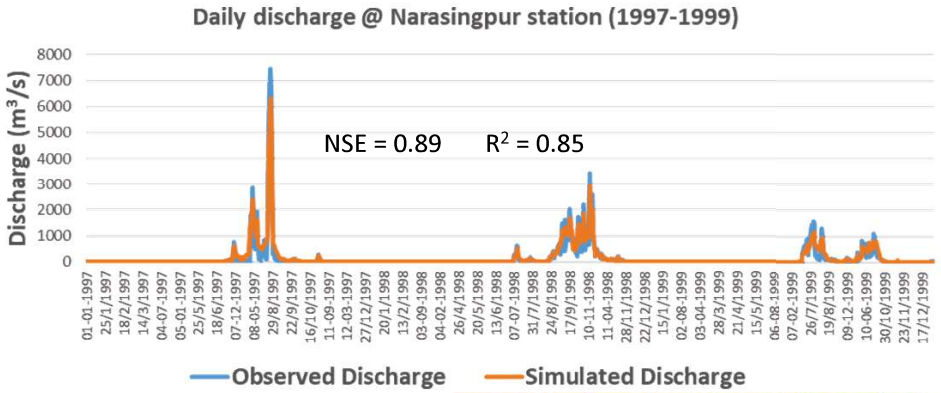




Model setup and results







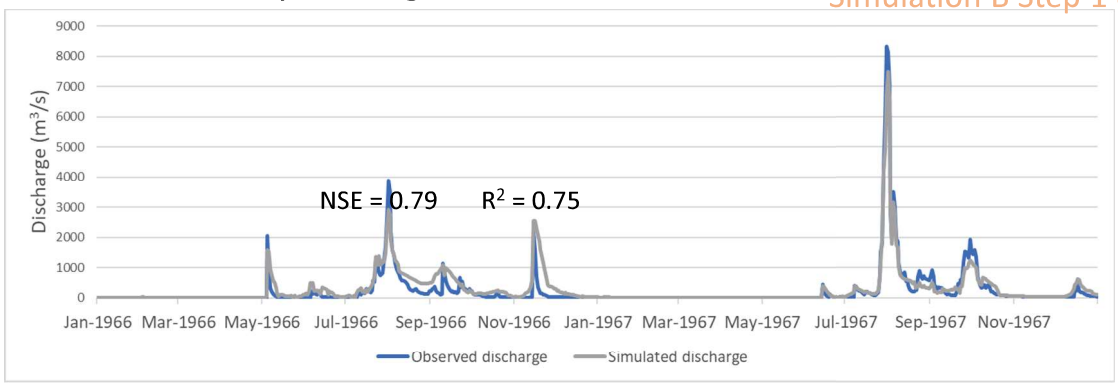
Calibration year – 1997
Validation years – 1998-1999

Simulation A Step 1 & 2

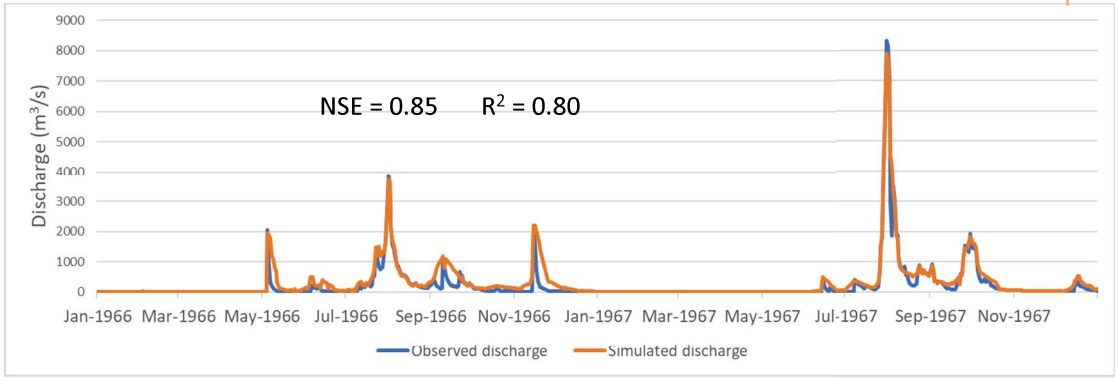
Model setup and results

Daily discharge at Takli station

Simulation B Step 1 & 2

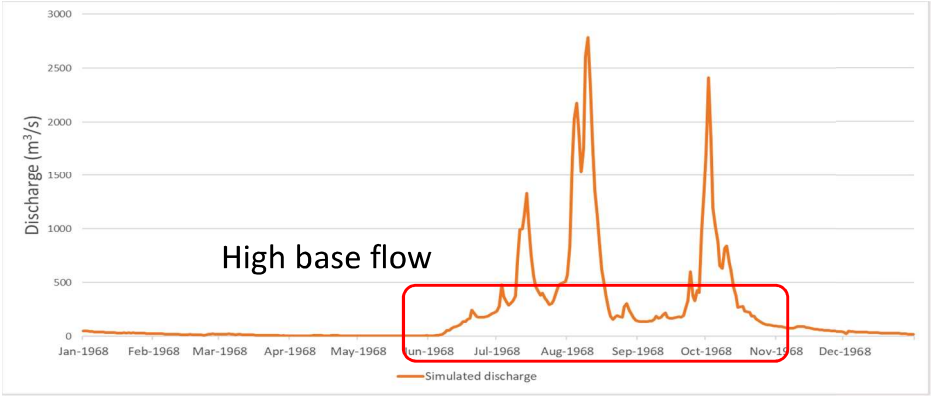


Simulation B Step 1' & 2'

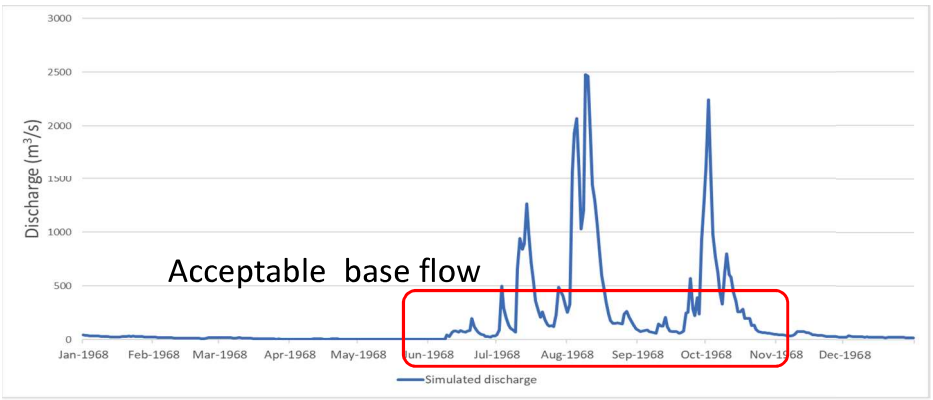


Model setup and results

Daily discharge at Takli station



Simulation A Step 3

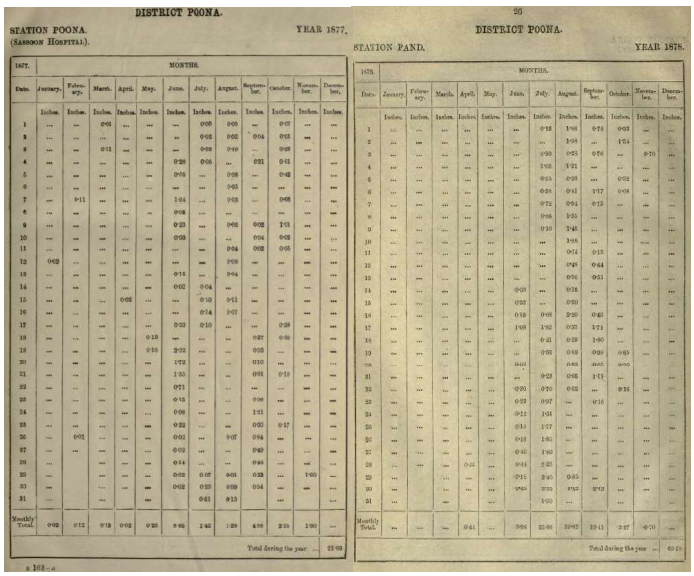


Simulation B Step 3

Precipitation data availability

- Rainfall data is available ~1878 onwards
  47 stations
- Hand-written data ~ 1870 – 1878 (limited)

Rainfall of the Bombay Presidency (LSE, London)


DISTRICT POONA.

STATION POONA. (SASSOON HOSPITAL). YEAR 1877.

MONTHS.

DISTRICT POONA.

STATION PAND. YEAR 1878.

Daily Rainfall of India (NOAA central Library)

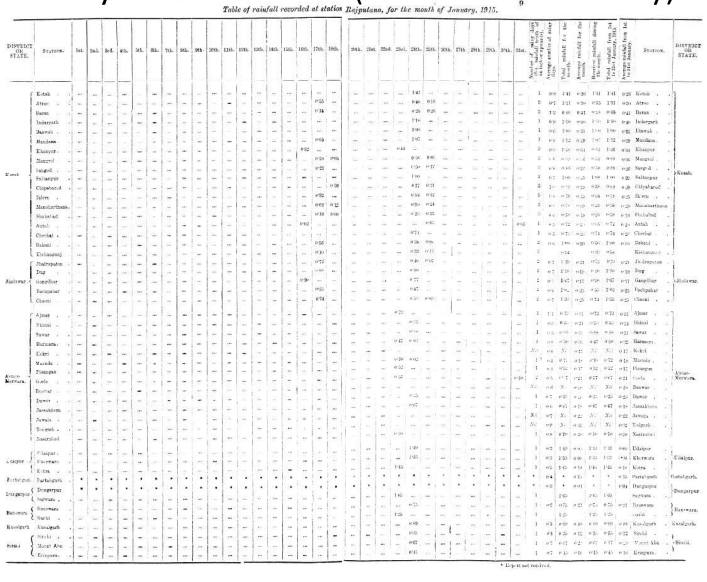
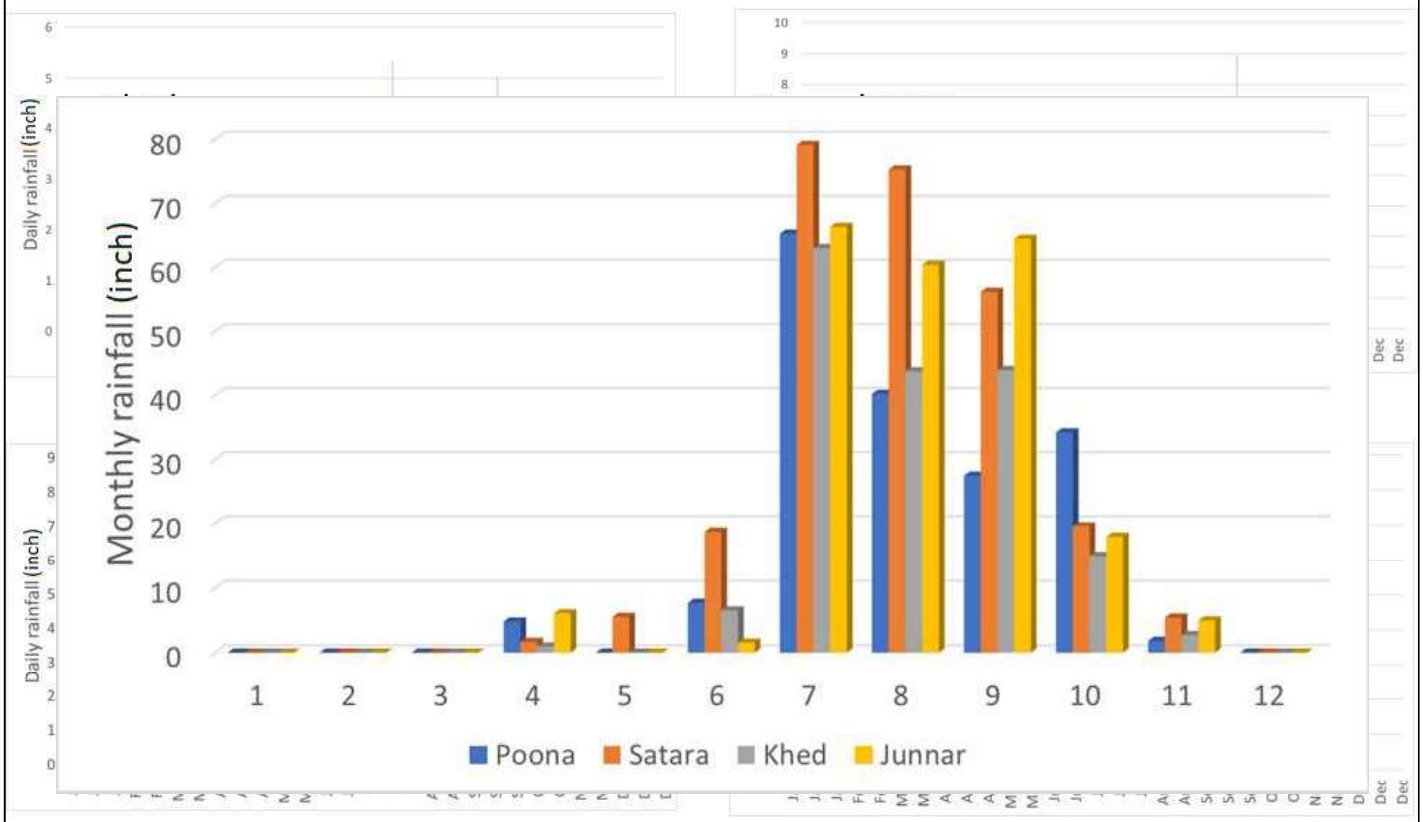


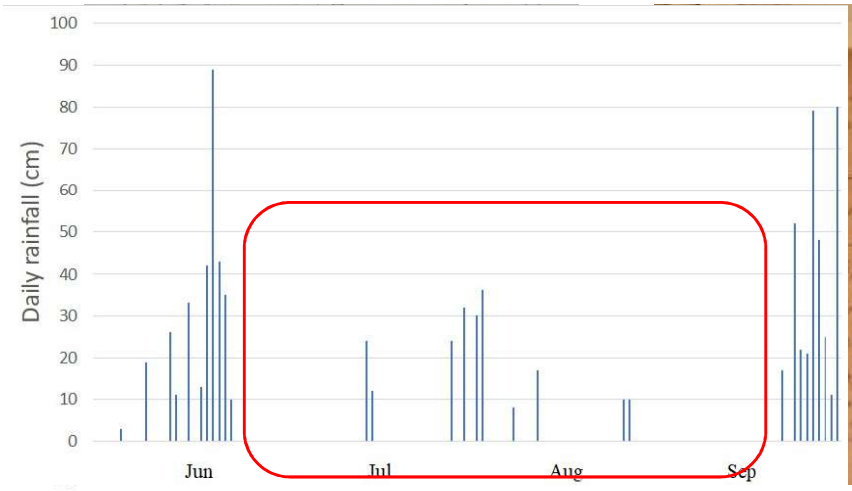
Table of rainfall recorded at station Rajputana, for the month of January, 1915.

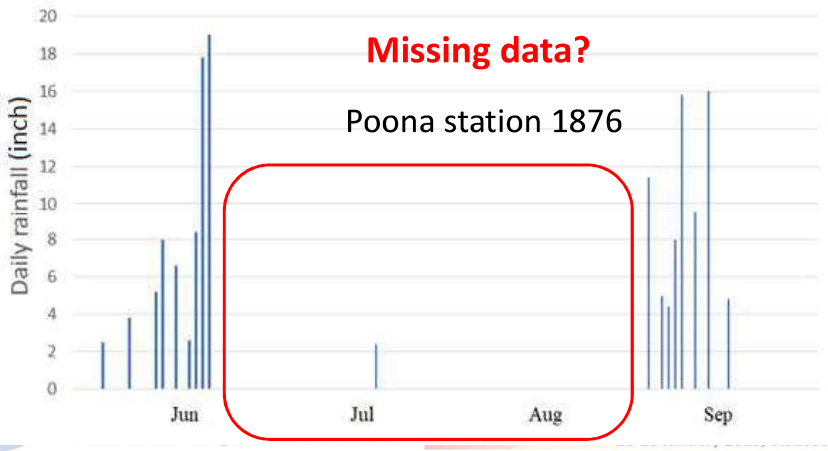
Rainfall in 1878

Wet moths: Jul-Aug-Sep



Handwritten rainfall data

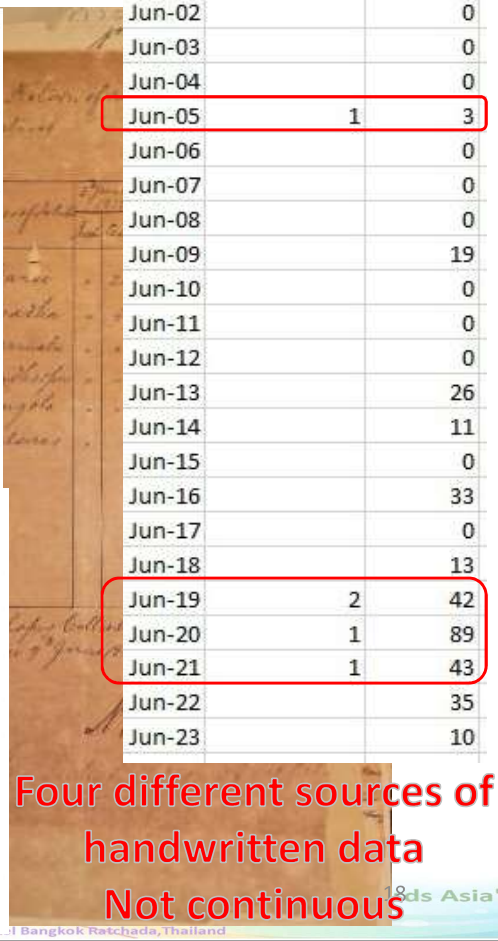




Missing data?

Poona station 1876

	Rainfall(inch)	Rainfall(cm
Jun-01		0
Jun-02		0
Jun-03		0
Jun-04		0
Jun-05	1	3
Jun-06		0
Jun-07		0
Jun-08		0
Jun-09		19
Jun-10		0
Jun-11		0
Jun-12		0
Jun-13		26
Jun-14		11
Jun-15		0
Jun-16		33
Jun-17		0
Jun-18		13
Jun-19	2	42
Jun-20	1	89
Jun-21	1	43
Jun-22		35
Jun-23		10



Four different sources of handwritten data

Not continuous

Conclusion and future work

- A hydrological model to simulate events of the 19th century in western India has been setup
- Observed rainfall during the famine period is limited

- Devise a way to use the sparse limited data before 1880s.
- Run model for 1870s
- Collect additional datasets for validation

Thank you for your attention