

# Development of Medium- to Long-Range Hydrologic Forecasting System for Ganges-Brahmaputra-Meghna River Basins

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24<sup>th</sup> Jul 2024

Jonghun Kam

Pohang University of Science and Technology  
(POSTECH)

# Introduction of POSTECH



City of Pohang

Population: ~493,102

270 km Southeast of Seoul

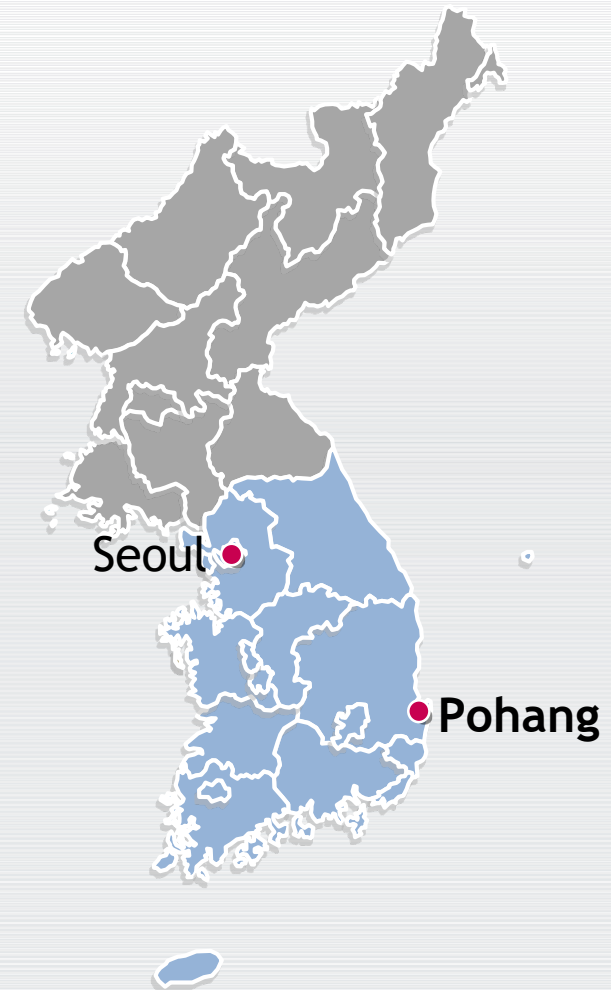
North Gyeongsang Province

1968 - Rural Fishing Village

1986 - Industrial City

2017 - Science and Technology Hub

Home to **POSTECH**



# Introduction of POSTECH



Established in 1986 by  
Founding Chairman  
Tae-Joon Park  
with  
First President  
Hogil Kim

School Motto  
Integrity  
Creativity  
Aspiration

**Students: 3,788**

Undergraduate: 1,302

Graduate: 2,486

- International Graduate Students: 5.5%

320 Incoming Freshmen per year  
from the top 1% of high school graduates

Faculty: 474

**Undergraduate Student to Faculty Ratio: 4.5:1**

Researchers: 875

Staff: 292

Alumni: 23,042

Campus: 1.6M m<sup>2</sup>

# Introduction of POSTECH



2023



Value Creating  
University

# Introduction of POSTECH



**Human  
Value**



**Knowledge  
Value**



**Socio-Economic  
Value**

First Founding Tenet:

**Nurture future global leaders through outstanding education**

12 Undergraduate Departments

20 Graduate Programs

Scholarships for all students

Innovative Educational Methods

Massive Open Online Course

Flipped Learning

**37 Years of Excellence**

1st in the university-Industry Collaboration by THE (2017)

2nd in the THE World's Best small Universities Rankings (2023)

28th in the THE World University Rankings (2010)

Human  
Value

Devoted  
Education



Knowledge  
Value

Outstanding  
Research



Second Founding Tenet:

**Conduct pioneering research and development in science and engineering**

Strategic promotion of research in the fields of **Convergence, Energy, Materials, Basic Science, ICT, and Health**

Science Citation Index: 7.15 per faculty

Paper Citation Counts: 23.1 per paper

**26th in the world for Citations Per Faculty (QS, 2023)**

118 Research Institutes

PBC (POSTECH Biotech Center)

NINT (National Institute for Nanomaterials Technology)

KIRO (Korea Institute of Robot and Convergence)

GIFT (Graduate Institute of Ferrous & Energy Materials Technology)

MPK (Korea Foundation for Max Planck POSTECH/Korea Research Initiative)

PIRL (POSTECH Information Research Laboratories)

POSTECH-Apple Developer Academy and Apple Manufacturing R&D Accelerator(PAA<sup>2</sup>)



# Introduction of POSTECH



The Pohang Accelerator Laboratory is home to the only 3<sup>rd</sup> and 4<sup>th</sup> generation light sources in Korea.

Constructed in 1994, the 3<sup>rd</sup> generation PLS has been visited by over 3,000 scientists for their experiments.

The 4<sup>th</sup> generation PAL-XFEL (3<sup>rd</sup> in the world) opened in 2016 after 5 years of construction.

The mission of PAL is to develop and perform state-of-the-art experiment techniques using synchrotron radiation.

# Introduction of POSTECH



Socio-Economic  
Value

Job  
Creation



Third Founding Tenet:  
**Serve the nation and humanity through education, research, and industry-academia collaboration**

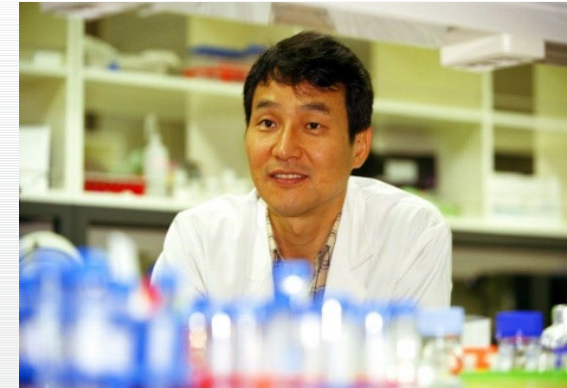
**1<sup>st</sup> in the world for Industry-Academia Collaboration**  
(Times Higher Education 2017)

**Genexine** - Founded by Prof. Young Chul Sung. Clinical stage biotechnology company with a focus on innovative immunotherapeutics

**Geekble** - Founded by POSTECH undergraduates Chanhoo Park and Hyunsung Kim. A media startup that produces branded content on science and technology to bridge the gap between geeks and the world



**Univer+City** - Collaborative initiative for mutual development of university and city



# Introduction of POSTECH



## International Student and Scholar Services (ISSS)

Full range of services for international members

## International Student Exchange Programs

Semester exchange, visiting, and short-term programs  
138 Partner Institutions in 33 Nations



## Residential College

Holistic on-campus housing for all students  
DICE (Dormitory for International Cultural Exchange)



## Summer Experience in Society (SES)

3-month summer vacation to promote student participation  
in various activities in society



## Student Mentoring Program

In-house program that connects and supports students

## POSTECH-KAIST Science War

Annual festival for friendly competition between the two  
premier science and engineering universities in Korea

## Global Partnerships

140 Partner Institutions in 32 Countries Across the World

**Australia (3)**  
Monash University  
U of Melbourne  
U of Wollongong

**Austria (3)**  
Graz U of Technology  
Montanuniversität Leoben  
TU Wien

**Belgium (1)**  
KU Leuven – Faculty of Science

**Canada (2)**  
U of Waterloo  
Polytechnique Montreal

**China (15)**  
Harbin Institute of Technology  
Institute of Nanjing Advanced Biomaterials & Processing Equipment  
Nanjing U  
Nanjing Tech U  
Nanjing Nanotech Institute  
Peking U  
Shanghai Advanced Research in Physics Sciences  
Shanghai Jiao Tong U  
Southern U of Science and Technology  
The Chinese U of Hong Kong, Shenzhen  
U of Electronic Science & Technology of China  
U of Science & Technology Beijing  
U of Science & Technology of China  
Xi'an Jiaotong U  
Zhejiang U

**Hong Kong SAR, China (6)**  
City U of Hong Kong  
Hong Kong U of Science & Technology  
Hong Kong Baptist U  
Hong Kong Polytechnic U  
The Chinese U of Hong Kong  
The U of Hong Kong

**Czech Republic (2)**  
Charles U  
Czech Technical U in Prague

**Democratic People's Republic of Korea (1)**  
Pyongyang U of Science and Technology

**Denmark (2)**  
Technical U of Denmark  
U of Southern Denmark – Faculty of Engineering

**Ethiopia (1)**  
Adama Science and Technology U

**Finland (1)**  
Aalto U

**France (19)**  
Bordeaux INP  
CNAM  
E-Artsup Toulouse  
Clermont Auvergne INP  
Ecole Polytechnique  
INSA Centre Val de Loire  
INSA Lyon  
INSA Rennes  
INSA Rouen  
INSA Strasbourg  
INSA Toulouse  
Institut polytechnique de Grenoble  
MINES ParisTech  
MINES Saint-Etienne  
Paris-Saclay University  
Université de Grenoble Alpes  
Université de Technologie de Belfort-Montbéliard  
Université de Technologie de Compiègne  
Université de Technologie de Troyes

**Germany (8)**  
Freie Universität Berlin  
Max Planck Gesellschaft  
RWTH Aachen  
Technische Universität Berlin  
Technische Universität Dresden  
Technische Universität München  
University of Münster – SBE  
Universität Stuttgart

**India (4)**  
Indian Institute of Technology, Delhi  
Indian Institute of Technology, Madras  
Council of Science and Industrial Research-National Chemical Lab  
Vellore Institute of Technology

**Indonesia (3)**  
Institut Teknologi Bandung  
Institut Teknologi Sepuluh Nopember (ITS)  
Universitas Indonesia

**Iran (1)**  
Sharif University of Technology

**Israel (3)**  
Hebrew U of Jerusalem  
Technion – Israel Institute of Technology  
Tel Aviv University

**Japan (13)**  
Hokkaido U  
Kyoto U  
Kyushu U  
Nagoya U  
Niigata U  
Ritsumeikan Asia Pacific U  
Ritsumeikan U  
RIKEN  
Shinshu U  
Tohoku U  
Tokyo Institute of Technology  
Toyota Technological Institute  
The U of Tokyo

**Malaysia (2)**  
Universiti Kebangsaan Malaysia  
University of Malaya

**Mexico (1)**  
Tecnológico de Monterrey

**Netherlands (2)**  
U of Twente  
TU Delft – Faculty of TPM

**Norway (1)**  
Norwegian U of Science & Technology

**Portugal (1)**  
Instituto Superior Tecnico Lisboa

**Russia (6)**  
Far Eastern Federal University  
Moscow State U  
St. Petersburg Electrotechnical U  
St. Petersburg State U  
St. Petersburg State Polytechnical U  
The Joint Institute of Nuclear Research

**Singapore (3)**  
Nanyang Technological U  
National U of Singapore  
Singapore U of Technology and Design

**Spain (1)**  
U of Barcelona

**Sweden (2)**  
Chalmers U of Technology  
Linköping U

**Switzerland (2)**  
Eidgenössische Technische Hochschule Zürich  
École polytechnique fédérale de Lausanne


**Taiwan (4)**  
National Yang Ming Chiao Tung U  
National Tsing Hua U  
National Taiwan U  
National Taipei U of Technology

**Thailand (5)**  
Chulalongkorn U  
Mahidol U  
Suranaree U of Technology  
VISTEC  
Asian Institute of Technology

**United Kingdom (3)**  
Imperial College of Science, Technology & Medicine  
U of Birmingham  
U of Liverpool

**United States (13)**  
Carnegie Mellon U  
Colorado School of Mines  
Rutgers, The State U of New Jersey  
Stony Brook University  
Stanford U  
U of California, Berkeley  
U of California, Davis  
U of Delaware  
U of Illinois at Urbana-Champaign  
U of Maryland, College Park  
U of Minnesota, Twin Cities  
U of Missouri System  
U of Oregon

**Vietnam (6)**  
VNU – Hanoi U of Science  
Hanoi U of Science & Technology  
VNUHCM – U of Science  
Ho Chi Minh City U of Technology  
VNU – U of Engineering and Technology  
VinAcademy

Host research institution	Participating researchers	Activity
 <p><b>POSTECH</b></p>	<ul style="list-style-type: none"> <li>• POSTECH : 9 researchers (except for PI)</li> <li>• Weathepia : 5 researcher</li> </ul>	<ul style="list-style-type: none"> <li>• Development of a medium- to long-range hydrological forecast system platform</li> <li>• Strengthening disaster management stakeholder capacities</li> </ul>



Principal Investigator (PI)

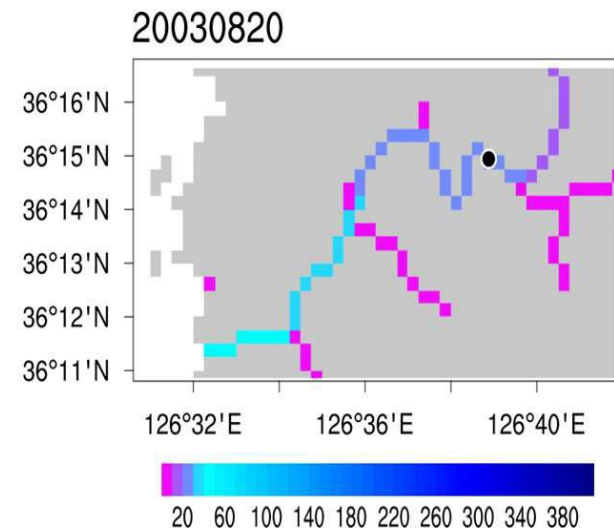
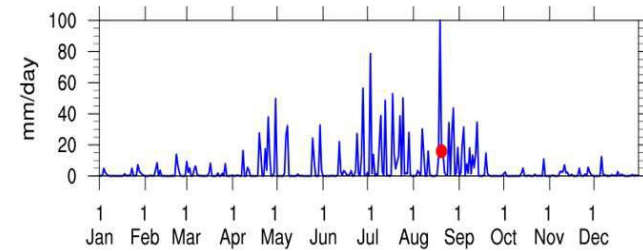
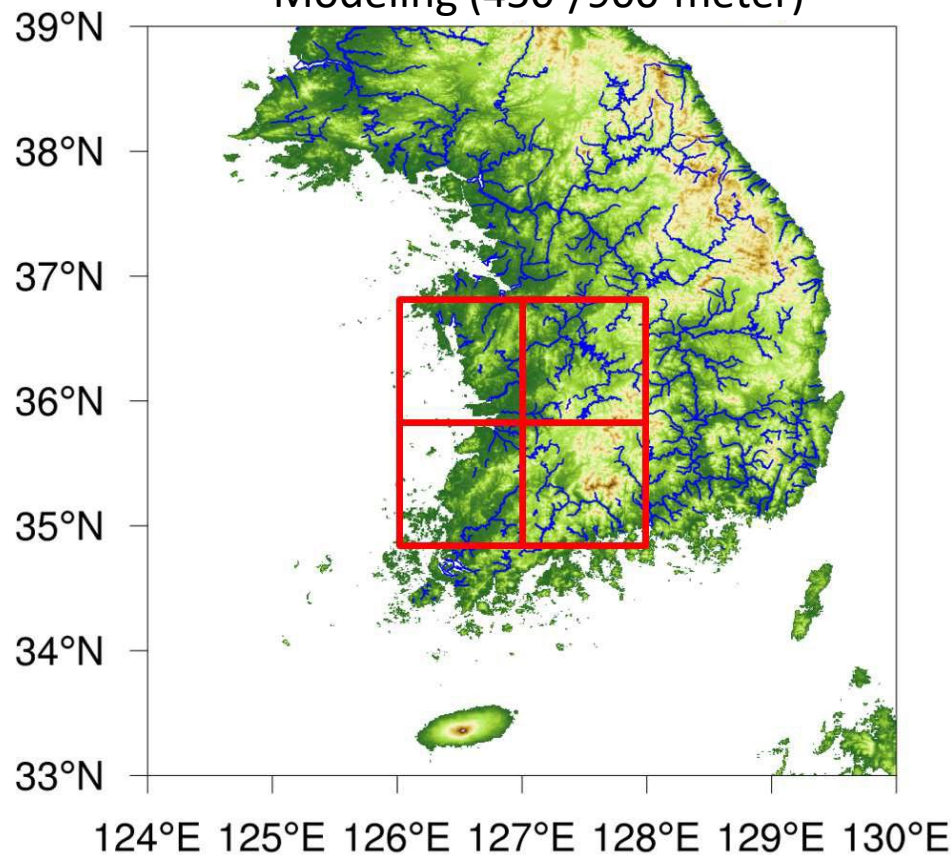
## Prof. Jonghun Kam

- Associate Professor Division of Environmental Science and Engineering, POSTECH, Republic of Korea
- M.A.&Ph.D. 2015, Princeton University, Princeton, NJ USA
- B.S.E. 2010, Purdue University, West Lafayette, IN USA



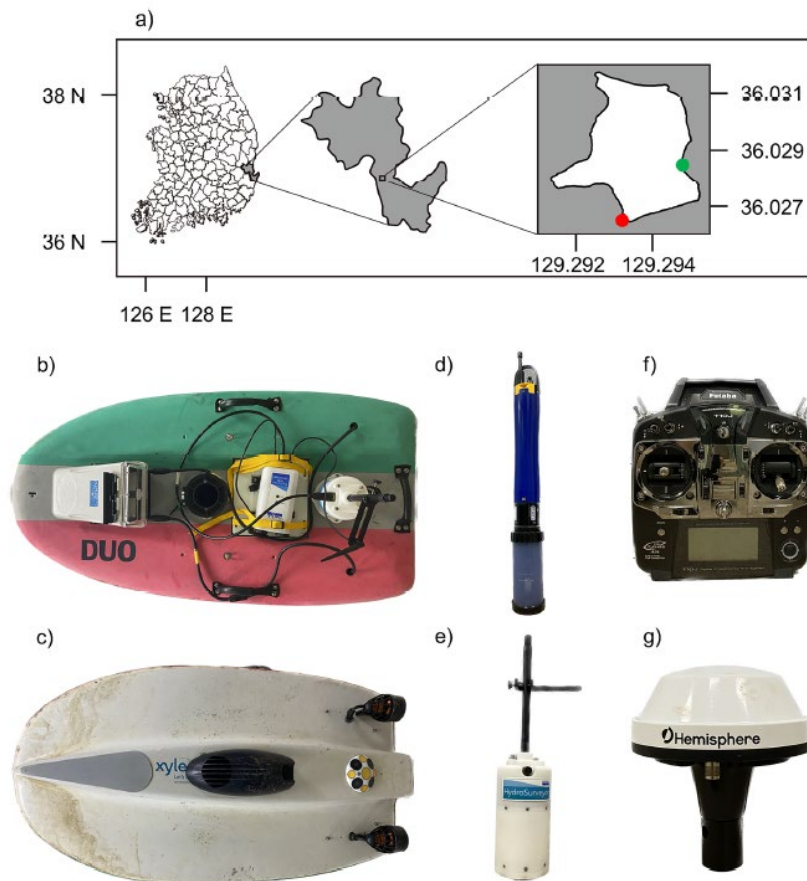
## I. Hydrological modeling technology (Korean Peninsular-scale case)

### Hyper-resolution Hydrologic Modeling (450-/900-meter)



## II. Uncrewed water quantity and quality monitoring technology (reservoir-scale case)

Uncrewed Vehicle with water depth and water quality sensors



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  - 05-4. Verification of predicted daily streamflow using the S2S weather forecast
6. Summary of the medium- to long-term hydrologic forecasting system



## Bangladesh floods in May 2022

BANGLADESH | VIDEO

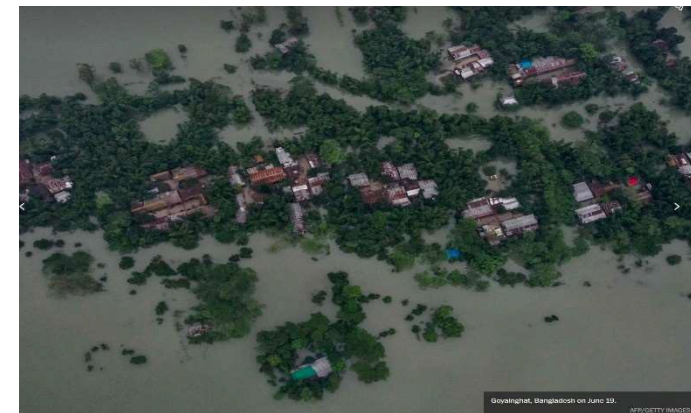
### Managing floods in Bangladesh

Why cooperation across borders is vital for better flood management.

THE EDITORS | Aug 19, 2022



Bangladesh floods 2022. Video screengrab / courtesy: Zakir Hossain Chowdhury.



Govainhat, Bangladesh on June 19, 2022. AFP/GETTY IMAGES



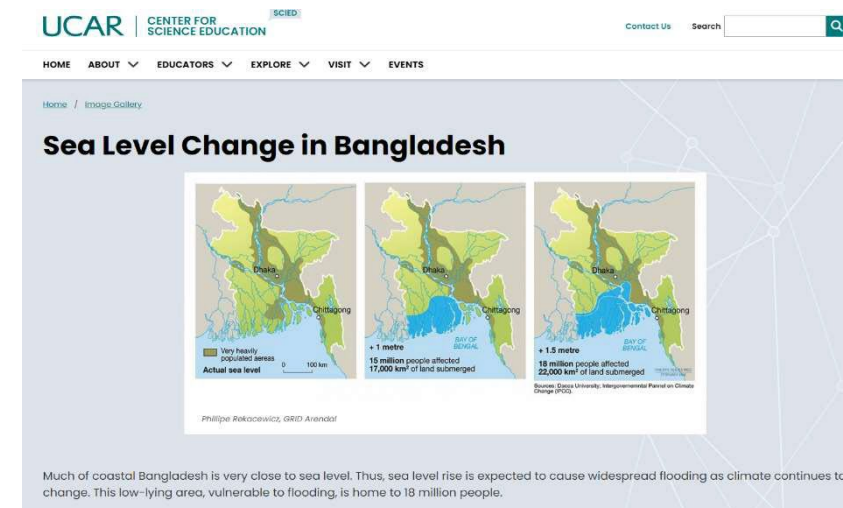
People gather to collect food aid in Dombeyganj, Bangladesh on June 20, 2022.



## Climate Crisis



- The floods in Bangladesh in 2022 resulted in not only socio-economic losses but also inflicted psychological damage on the public.

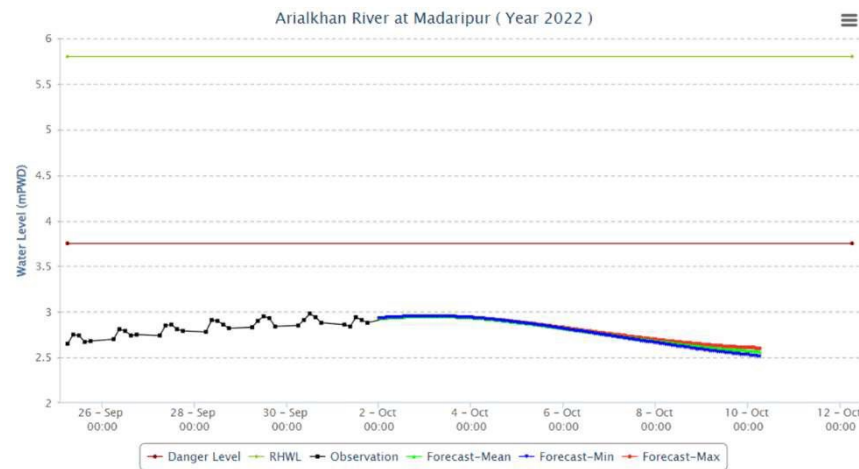


- Bangladesh anticipates that the damages from floods will increase due to rising sea levels caused by global warming.



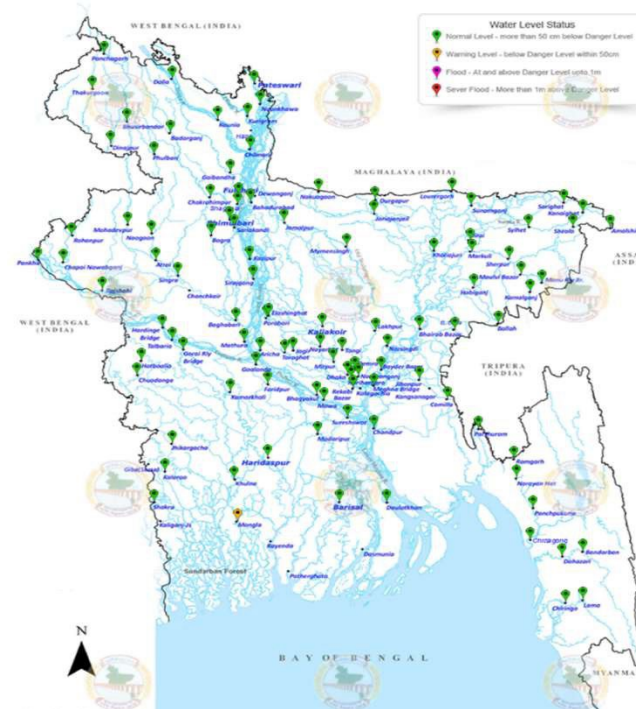
## Climate Forecast Application for Bangladesh (CFAB)

Medium-term (10-day) hydrological forecast system in FFWC



- There is difficult to utilize 10-day weather forecast data using a statistical hydrological model.

Flood Forecasting & Warning Center (FFWC) Operational System



**Final goal****Development of Medium- to Long-Range  
Hydrologic Forecasting System for  
Ganges-Brahmaputra-Meghna River Basins****First Year**  
(Sep 2023-Feb 2024)

Reproduction of long-term hydrological data using the VIC-river routing model (2015-2022)

Construction of S2S historical weather forecast data

**Second Year**  
(Mar 2024-Aug 2024)

Evaluation of hydrological reanalysis data and S2S historical forecast performance

Development of a medium- to long-range hydrological forecast system platform

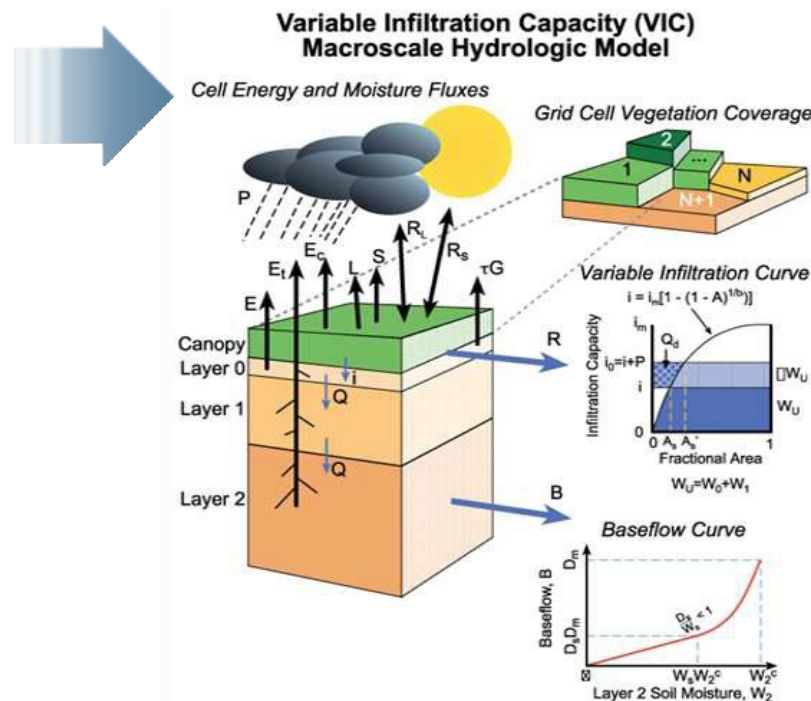


## Reproduction of hydrological data using the VIC-river routing model

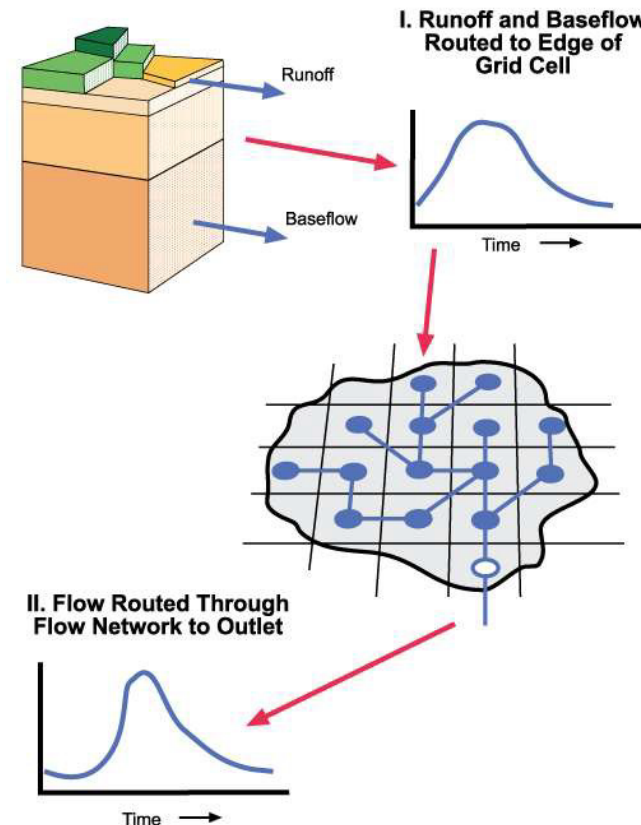
ERA5L & S2S data

Surface runoff

Base runoff



### VIC River Network Routing Model





## Generated reproduced hydrological data from reanalysis and forecast data

### Limitations of observational data

- Spatial discontinuity
- Data quality issue
- Limited temporal resolution
- Environmental and climate change effects
- High installation and maintenance costs
- Difficulty in data interpretation

### Target performance of evaluation index

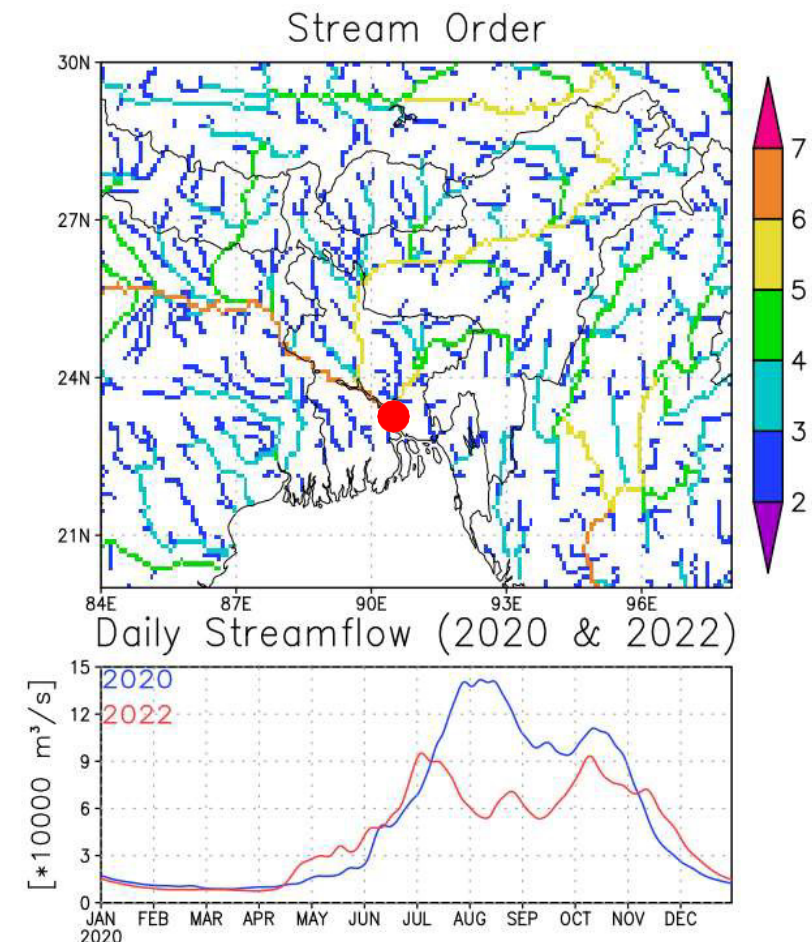
Nash-Sutcliffe Efficiency (NSE) > 0.8

Kling-Gupta Efficiency (KGE) > 0.6

### Hydrological forecast performance evaluation methods

Receiver of Curve (ROC)

Continuous Ranked Probability Score



List	Goals	Month (Sep 2023 ~ Aug 2024)											
		9	10	11	12	1	2	3	4	5	6	7	8
Data construction	Construction of daily reanalysis data from ECMWF												
	Construction of daily forecast data from S2S												
	Reproduction of hydrological data using the VIC-river routing model												
Evaluation of historical hydrological data performance	Comparison and verification of monthly observation and reanalysis streamflow												
Evaluation of historical S2S weather forecast performance	Verification of predicted streamflow using the S2S weather forecast (2015-2022)												
Technology development and transfer	Development of a medium- to long-range hydrological forecast system platform												
Workshop	Technology transfer												

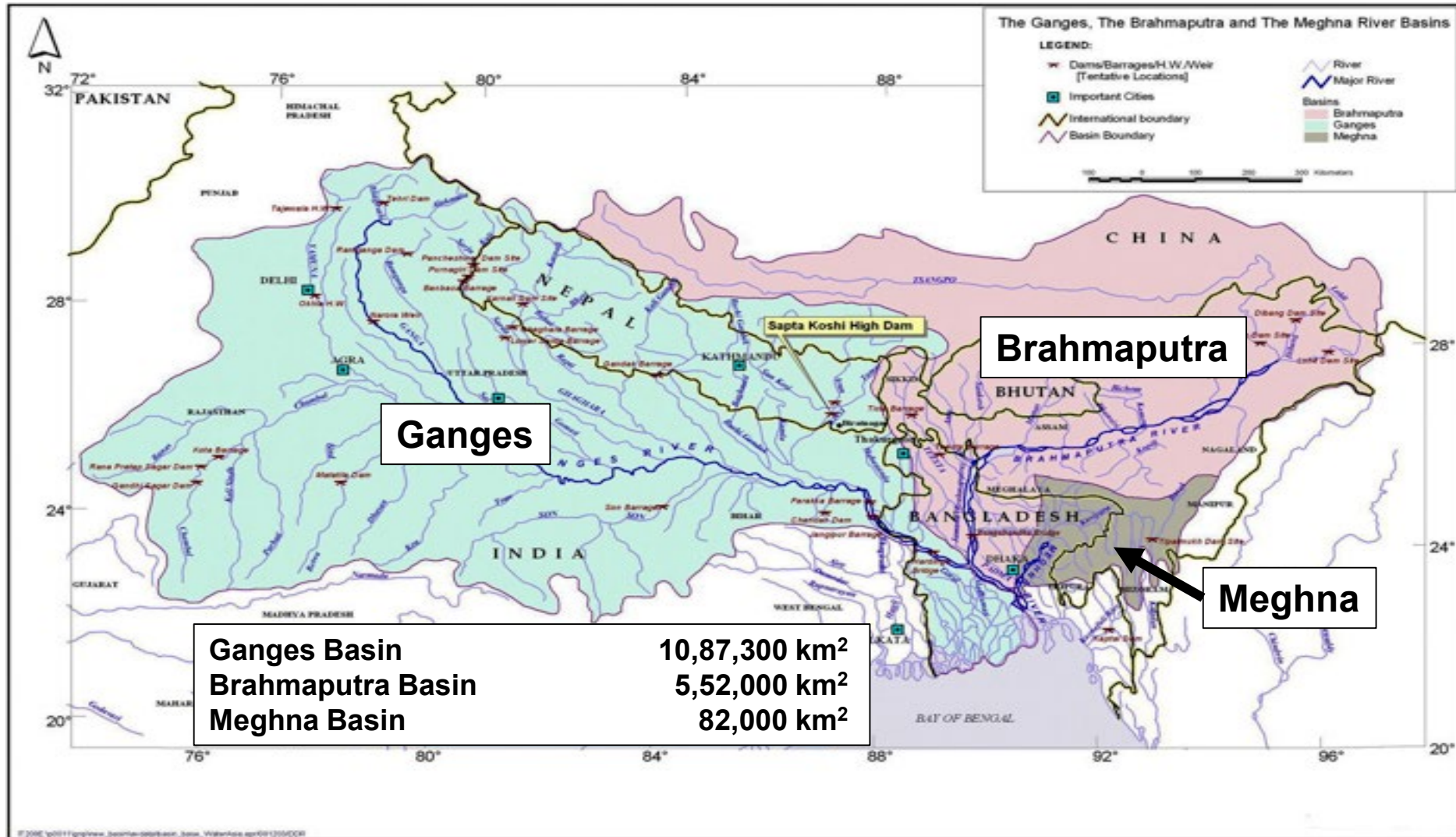
	ERA5L (reanalysis data)	ECMWF S2S (forecast data)
Period	1951 - Present	2015 - Present
Resolution	10 km x 10 km	100 km x 100 km (0.1° x 0.1°)
Data format	NetCDF	Grib
Forecast period range	-	32 days
Ensemble member	-	50
Benefit of this data in this project	<ul style="list-style-type: none"> <li>Historical river discharge of Bangladesh can be estimated including areas where observation is impossible.</li> </ul>	<ul style="list-style-type: none"> <li>Utilizing numerical forecasting data enables the production of medium- to long-term river discharge forecasts for Bangladesh rivers.</li> </ul>

- Why we used only the ECMWF S2S forecast in this project?

Institution	Total runoff Surface runoff Sub-surface runoff	Forecast period	Forecast interval	Ensemble number	Forecast data release date
CMA	0	2015.01-Present	3 or 4 days	3	After 1 month
CNRM	0	2015.05-Present	7 days	24	After 1 month
ECMWF	0	2015.01-Present	daily	50	Within 3 days

- The total runoff and surface runoff (sub-surface runoff) data are required to produce daily streamflow using the VIC-River Routing Model.
- In the S2S forecast datasets, only 3 institutions (CMA, CNRM, and ECMWF) release the forecasted them.
- The ECMWF, only, produces the medium- to long-term forecast (~30 days) every day and publishes them within 3 days. This continues to be helpful not only for short-term forecasting but also for medium- to long-term forecasting.

- Ganges-Brahmaputra-Meghna River Basins



## • Historical of floods in Bangladesh from 1948-2013

Year	Duration	Causes	AI (sq.km)	CD (million TK)	PA (million)	Deaths
1948-1953	**	**	**	**	**	**
1954	June and July	Flash Floods	36,920	1,200.00	30	112
1955	**	**	50,700	1,290.00	**	129
1956	**	**	35,620	900.00	**	**
1962	**	**	37,440	560.00	**	117
1963	**	**	43,180	580.00	**	**
1968	**	**	37,300	1,160.00	**	126
1970	August	Monsoon Rain	42,640	1,100.00	30	87
1971	April and July	Heavy Rain	36,475	**	**	120
1974	**	Monsoon Rain	52,720	28,490.00	30	1,987
1984	May	Heavy Rain	28,314	4,500.00	20	553
1987	July and Aug.	Monsoon Rain	57,491	35,000.00	30	1,657
1988	Aug. and Sep.	Monsoon Rain	89,970	100,000.00	47	2,379
1998	Aug. and Sep.	Monsoon Rain	100,000	120,000.00	55	1,050
1999	July and Sep.	Monsoon Rain	100,000	70400.00	30	918
2004	Aug. and Sep.	Monsoon Rain	58,000	200,000.00	36	750
2007	July and Sep.	Heavy Rain	32,000	72,535.00	16	3363
2008	September	**	3,394.13	**	1	7
2010	June	Floods and Landslides	**	**	**	56
2012	23 June	Floods and Landslides	230,000	**	5	139

The most damaging flood in history before recorded observations

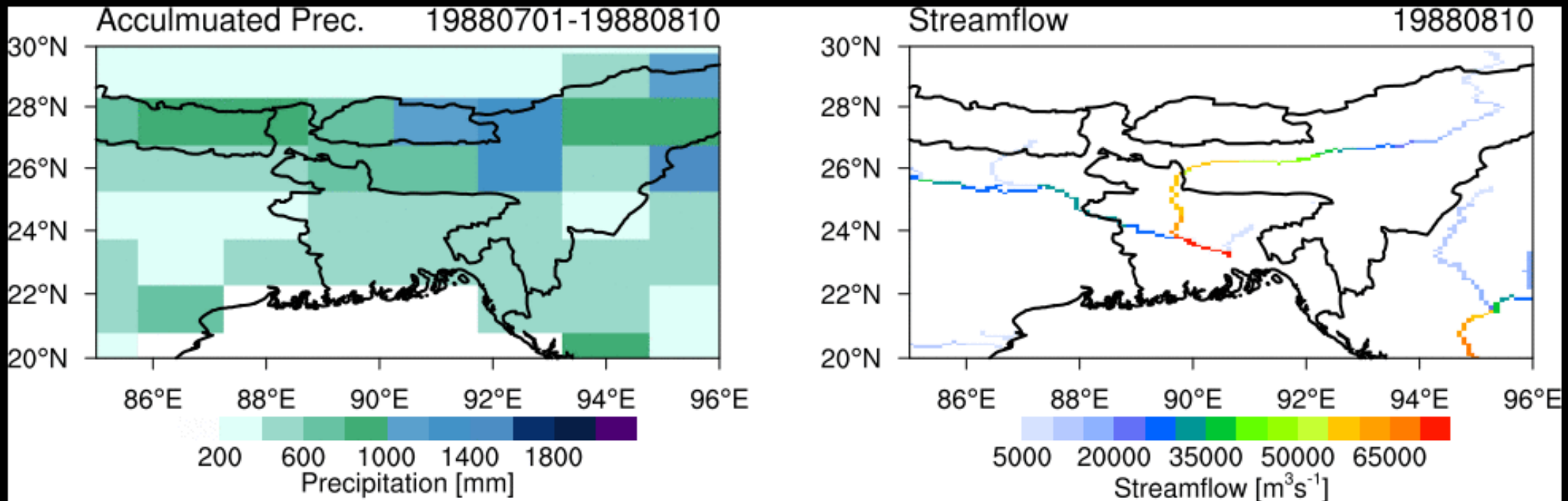
**Source:** Choudhury *et al.*, 2003; available at: [reliefweb.int/.../bangladesh/bangladeshs-worst-floods-1954-are-now-affect; on: 11.10.2014](http://reliefweb.int/.../bangladesh/bangladeshs-worst-floods-1954-are-now-affect; on: 11.10.2014); AI = Area Inundated, CD = Cost of Damage, PA = Population Affected; \*\* Indicates that data were not available.

(Shaibur *et al.* 2027)

# 05-3

## Reproduction of hydrological data using the VIC-River Routing Model

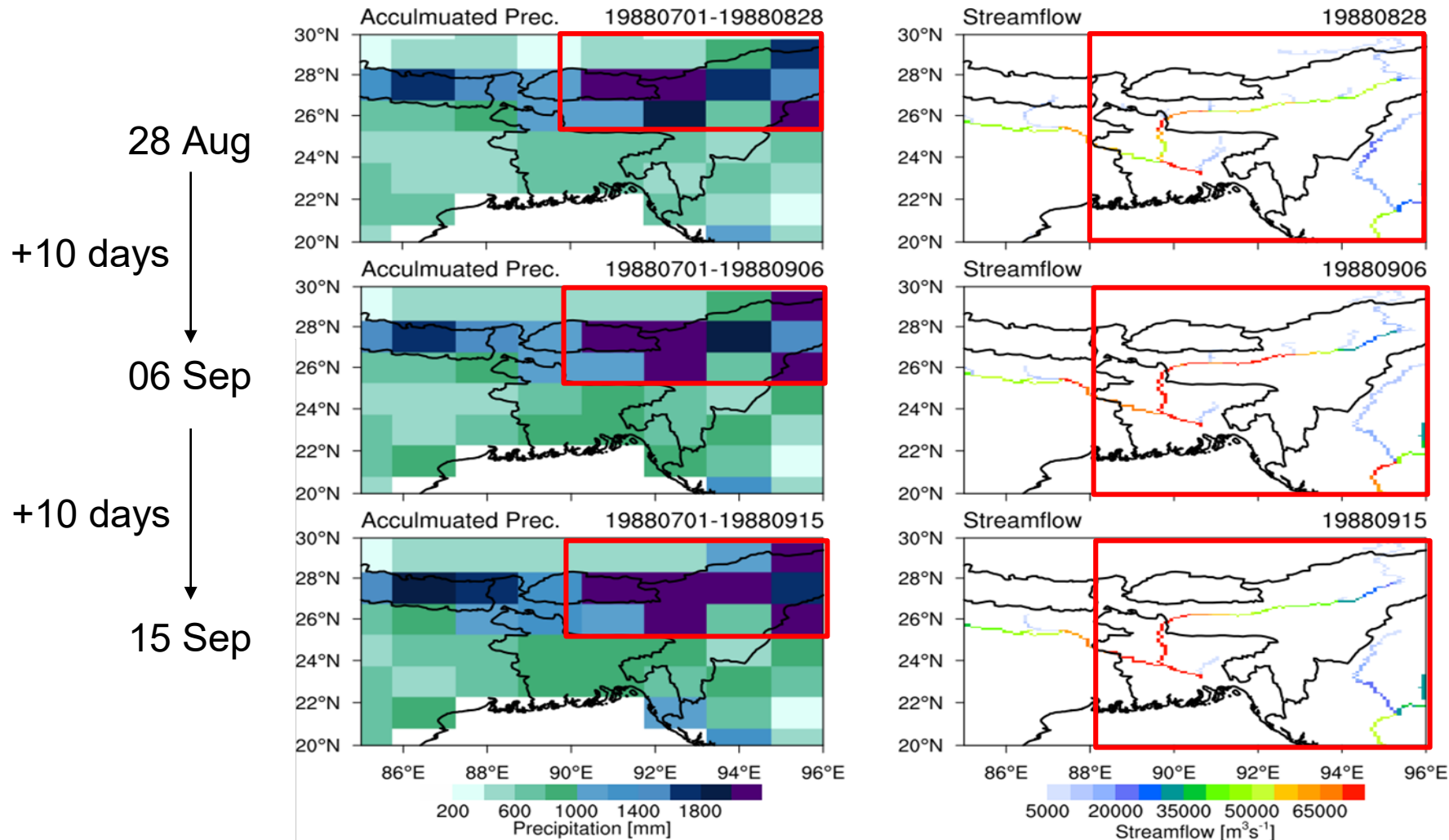
- Re-enactment of the 1988 flood (1988.07.01-1988.09.30)



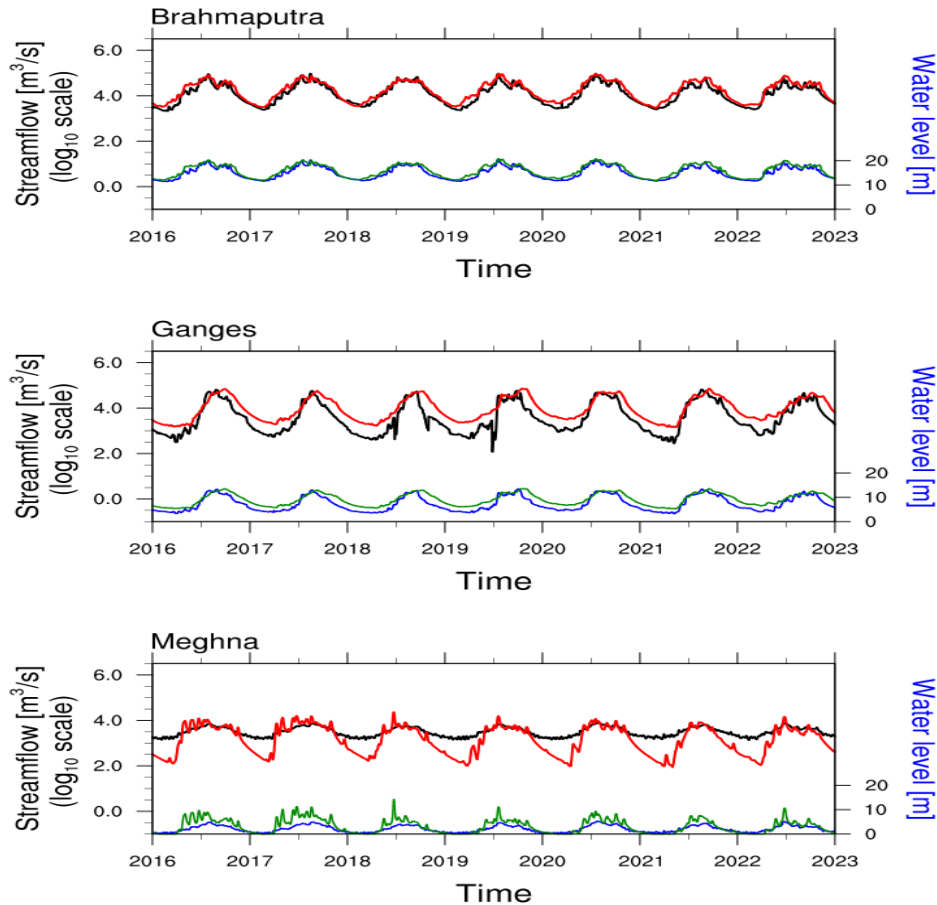
- Re-enactment of the 1988 flood (1988.07.01-1988.09.30)

### Precipitation

### Streamflow



- Comparison of observation and reproduction data (2016-2022)

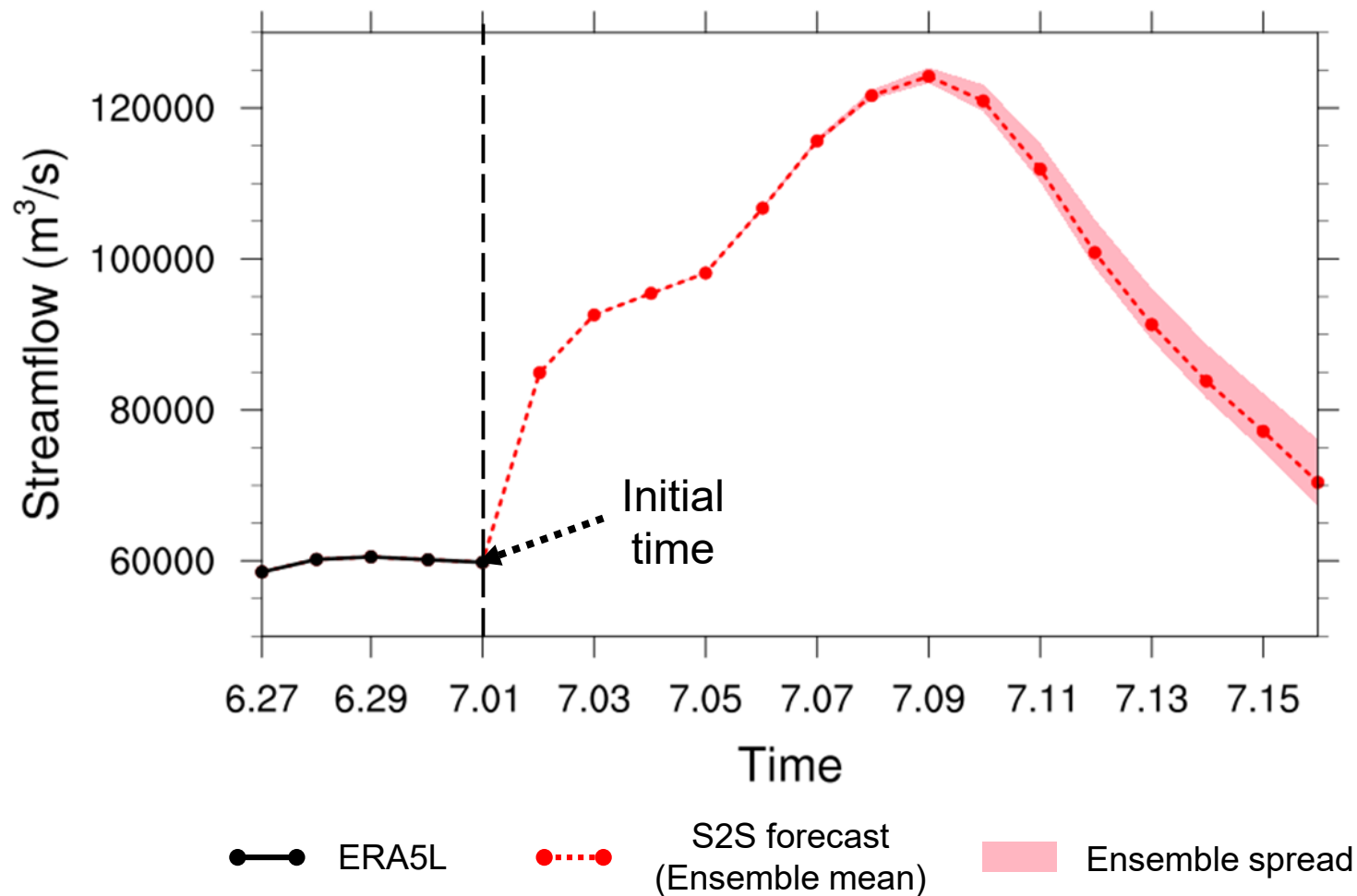


- **Streamflow** : — OBS — ERA5L
- **Water level** : — OBS — ERA5L

Streamflow	TCC	NSE	KGE
Barhmaputra	0.91	0.65	0.64
Ganges	0.76	0.17	0.31
Meghna	0.83	-0.73	-0.01

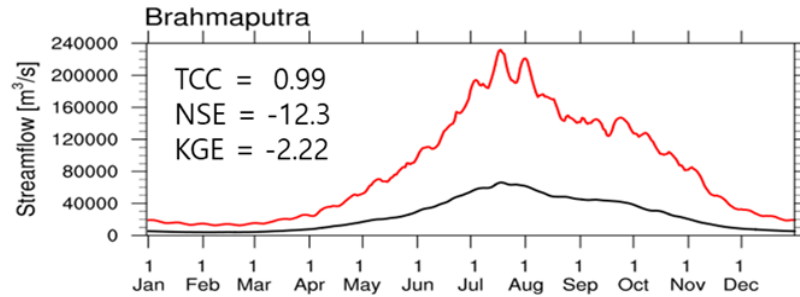
Water level	TCC	NSE	KGE
Barhmaputra	0.96	0.80	0.92
Ganges	0.93	0.52	0.69
Meghna	0.89	-1.25	-0.21

- Example of streamflow forecast data using the S2S forecast data

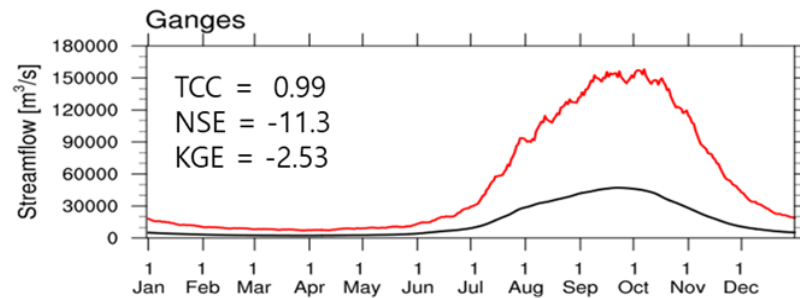


Climatological mean daily streamflow (1996-2015, Hindcast)

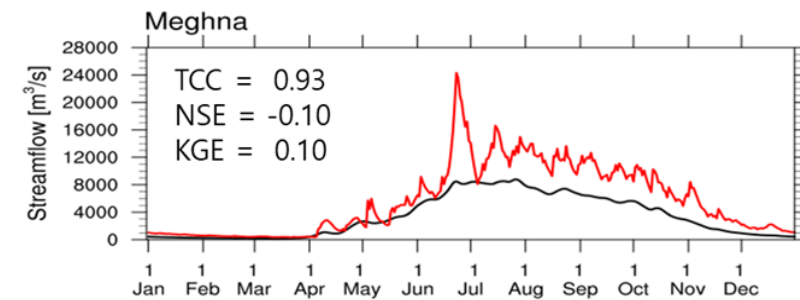
Brahmaputra



Ganges

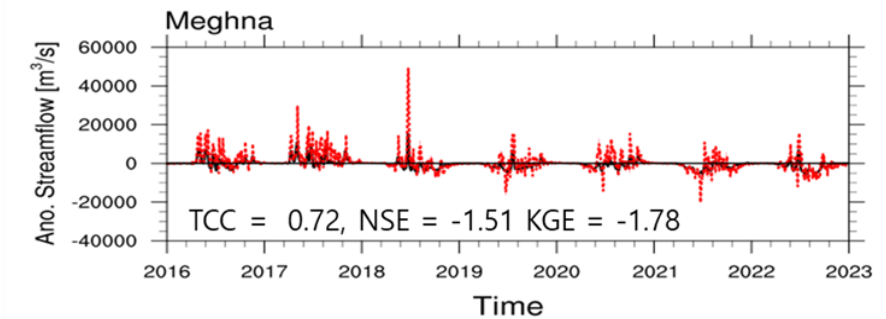
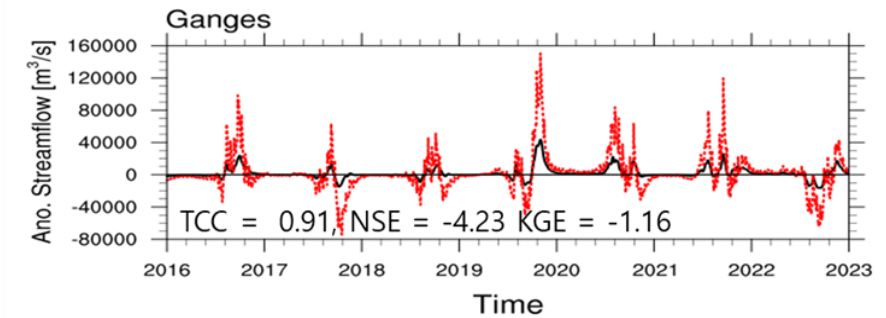
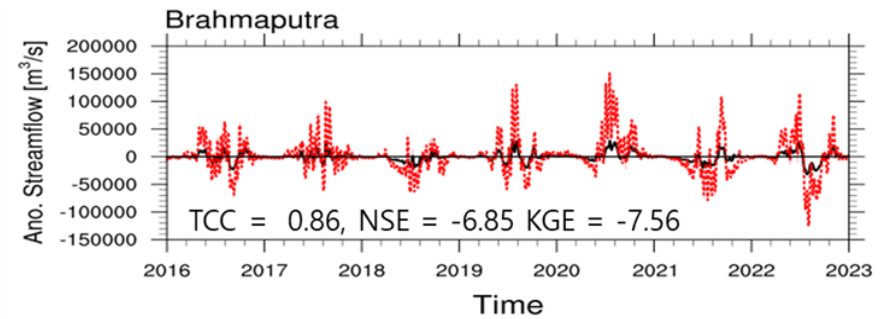


Meghna

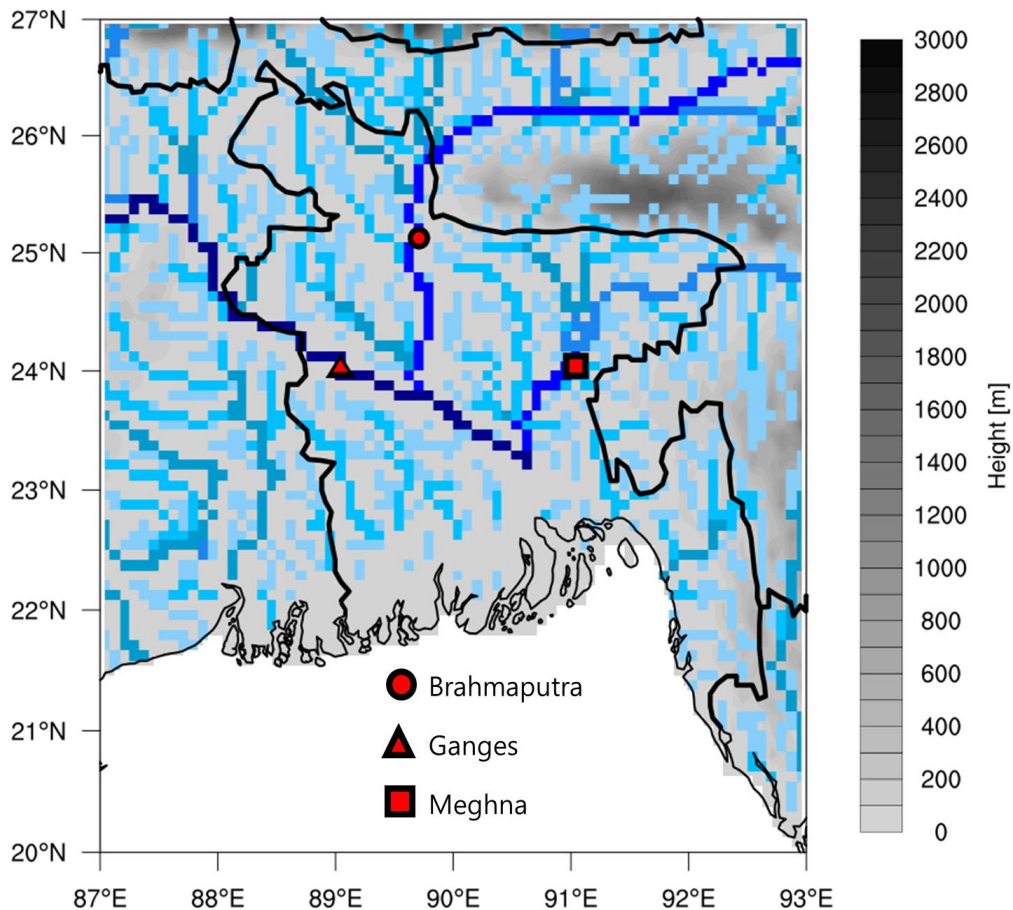


— ERA5L — S2S (Hindcast)

Anomalous daily streamflow (2016-2022, Forecast)



— ERA5L ..... S2S (Forecast)



- High temporal and spatial resolution data : Overcoming temporal and spatial limitations of observational data
- Predicted data generated based on the laws of physics : Utilization for medium- to long-term hydrologic forecasts
- Improved prevention and preparedness for hydrological disasters by enabling early detection and prediction of extreme weather events.
- Continuous updates on the latest hydrological information available.

**Thank you**