Regional Climate Modeling

Understanding hydroclimatic extremes over Bangladesh with new gridded products and daily bias correction of CMIP5 regional climate projections

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Global Climate Change will alter precipitation and temperature patterns.
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Greenland Is Melting Away
By CORAL DAVENPORT, JOSH HANER, LARRY BUCHANAN and DEREK WATKINS

This river is one of a network of thousands at the front line of climate change.

Northern India’s groundwater loss can be seen from space

54% of India Faces High to Extremely High Water Stress

www.indiawatertool.in

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The Himalayan “Water Tower”
Impacts 10 major rivers and over 2 billion people

Immerzeel et al, Science, 2010
The GBM Basin Region
(Ganges-Brahmaputra-Meghna River System)
Spring Droughts / Fall Floods
Salinity Intrusion during dry season

Has distinct spatial and temporal signature

Based on monthly average of 1988-2007 simulation results
Flood inundation
In monsoon months

Has distinct spatial and temporal signature

Based on monthly average of 1988-2007 simulation results
Large Scale Population Vulnerability

- Seasonal drivers
- Large scale signature
- Impact on water and sanitation
- Climate change
World is rapidly urbanizing

- By 2050, 75% of the population will be living in cities
- Most of this growth will be in China, Vietnam, India, Pakistan, Nigeria, Brazil, Bangladesh, Indonesia, etc.
- Emerging Megacities (> 10 m) in Asia already under enormous pressure of water scarcity and sourcing
The World's Megacities Are Set for Major Growth

Population growth of the world's top 15 megacities (millions, 2011-2025)

- Mexico City: 20m in 2011, 25m (+25%) in 2025
- New York: 20m in 2011, 24m (+20%) in 2025
- New Delhi: 23m in 2011, 33m (+43%) in 2025
- Beijing: 16m in 2011, 23m (+44%) in 2025
- Tokyo: 37m in 2011, 39m (+5%) in 2025
- Shanghai: 20m in 2011, 28m (+40%) in 2025
- Manila: 12m in 2011, 16m (+33%) in 2025
- Sao Paulo: 20m in 2011, 23m (+15%) in 2025
- Buenos Aires: 14m in 2011, 16m (+14%) in 2025
- Rio de Janeiro: 12m in 2011, 14m (+17%) in 2025
- Karachi: 14m in 2011, 20m (+43%) in 2025
- Calcutta: 14m in 2011, 19m (+36%) in 2025
- Mumbai: 20m in 2011, 27m (+35%) in 2025
- Dhaka: 15m in 2011, 23m (+53%) in 2025

*including metropolitan areas
Source: UN Population Division, World Economic Forum
Dhaka, Bangladesh: from Mughal Outpost to Fastest Growing Megacity
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500,000 PEOPLE

move to DHAKA, BANGLADESH from COASTAL and RURAL areas every year

85% ...of the total urban population now lives in SUBSTANDARD, SLUM HOUSING
Rapid growth of informal settlements in Dhaka BD

Some grim statistics

- 90% live below the poverty line
- 70% lack safe sanitation facilities
- 90% lack sufficient drainage and thus are exposed to pathogens
- 2,639 people per square miles
- 400,000 moving to cities / year
Urban water and sanitation:
Huge problems in Dhaka and other cities in Bangladesh
Urban water and sanitation: Huge problems in Dhaka and other cities in Bangladesh
Regional Climate Change & Impacts in the Bengal Delta Region

- Large Scale Changes
  - Hydroclimatology
  - Water availability
  - GBM streamflow
  - Coastal salinity
  - Flood Inundation
  - Ocean climate

- Regional Scale Changes
  - Precipitation & Temp
  - Rainfall patterns
  - Temperature shift
  - Diurnal variability
  - Rainfall extremes
  - Temp extremes

- Local Scale Changes
  - Population, Water Access
  - Urban Population
  - Slum area growth
  - Water/Sanitation
  - Water pollution
  - Land-use change

Multi-scale Geospatial Modeling of Climate Impacts in Bengal Delta
Climate Change Impacts in Bengal Delta

Large Scale Changes Hydroclimatology
- Water availability
- GBM streamflow
- Coastal salinity
- Flood Inundation
- Ocean climate

Dynamic Downscaling CMIP5 RCM outputs CORDEX Bangladesh

New daily bias correction Validation with observed Extraction of Extremes

Temperature Extremes TX10, TX35GE, TX90, TR Precipitation Extremes RX1, RX5, R20, CR10

Seasonal Climate Change Dry and Wet Trends Future Projections

Local Scale Changes Population, Water Access
- Urban Population
- Slum area growth
- Water/Sanitation
- Water pollution
- Land-use change

Multi-scale Geospatial Modeling of Climate Impacts in Bengal Delta
Climate Change Impacts in Bengal Delta

Dynamic Downscaling
CMIP5 RCM outputs
CORDEX Bangladesh

Source: WMO, UCAR, NOAA
Climate Change Impacts in Bengal Delta

Dynamic Downscaling CMIP5 RCM outputs
CORDEX Bangladesh
Climate Change Impacts on Dhaka Cholera

New daily bias correction Validation with observed Extraction of Extremes

Model without Correction.

Figure: Monthly climatology of rainfall (left), maximum temperature (middle) and minimum temperature (right) of different CIMP5 regional models and observed climate over Bangladesh.

Taylor diagram of model with respect to observed data sets (left) precipitation and (right) temperature.

Multi-stage Bias Correction (60 days window)

60 days window for 30y

Gamma
Fitted probability

ECDF
For Observed

Future Correction

After Bias correction Correlation has been improved significantly both in terms of magnitude and spread of data.

Blue dot shows the corrected precipitation and temperature, green dot shows uncorrected precipitation in base line period and red dot shows uncorrected temperature in the base line.
Climate Change Impacts in Bengal Delta

Temperature Extremes
TX10, TX35GE, TX90, TR

Precipitation Extremes
RX1, RX50, R20, CR10
Climate Change Impacts in Bengal Delta

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Temperature Extremes
TX10, TX90, TX35GE, TR
Precipitation Extremes
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The graphs show the probability distributions of maximum and minimum temperatures per year under different climate change scenarios (RCP 4.5 and RCP 8.5) for the years 2020s, 2050s, and 2080s compared to the baseline.
Climate Change Impacts in Bengal Delta

Seasonal Climate Change
Dry and Wet Trends
Future Projections
Summary of findings

- Regional scale climate change is distinct for the Dhaka region
- New dataset and bias-correction allows use of CMIP5 models
- Significant trends are seen in key Hydroclimatic Extremes
  - *The spring (March-May) period is becoming increasingly warmer and drier, affected by water scarcity in Dhaka and southwestern regions of Bangladesh (and impacts)*
  - *During monsoon rainfall, intense events and frequency of extreme events are on the rise, although average rainfall volume rise is modest, and even decreasing in the east*
Thank you

☐ Questions / Comments / Suggestions ?!

Please Contact

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