IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Water availability and climate change: attribution and impacts**	
Project Number	**IMURA0934**	
Monash Main Supervisor (Name, Email, Phone)	Julie Arblaster	*Full name, Email*
Monash Co-supervisor(s) (Name, Email, Phone)	Ben Henley	
Monash Head of Dept/Centre (Name, Email)	Andrew Mackintosh	*Full name, email*
Monash Department:	School of Earth, Atmosphere and Environment	
Monash ADGR (Name, Email)	Peter Betts, peter.betts@monash.edu	*Full name, email*
IITB Main Supervisor (Name, Email, Phone)	Arpita Mondal	*Full name, Email*
IITB Co-supervisor(s) (Name, Email, Phone)		*Full name, Email*
IITB Head of Dept (Name, Email, Phone)	D Parthasarathy	*Full name, email*
IITB Department:	Interdisciplinary Program in Climate Studies	

Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1	*Advanced computational engineering, simulation and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*
7	*Humanities and social sciences*
8	Design

The research problem

Define the problem

Freshwater availability in terms of streamflow is critical in sustaining water security. Global studies show coherent drying in some of the world's regions and wetting in others, both for the historical past and under future warming projections. Regional scale assessment of streamflow changes is imperative for effective management of water resources. However, formal detection and attribution of climate change impacts on water availability and streamflow changes are limited. Further, attribution analyses are rarely linked with impacts in terms of the affected population, irrigated areas or crop yield, or loss of industrial productivity or ecological sustainability.

This study proposes to address these gaps by undertaking detection and attribution (D&A) analysis of observed changes in freshwater availability and associated impacts. The goal of this analysis is to investigate whether signals of anthropogenic climate change are discernible in historical changes in freshwater resources. Such an analysis would aid also in understanding the roles of other external forcings such as changes in land-use/land-cover characteristics, human regulation of flows, irrigation, or direct effects of carbon-dioxide. Further, this study also wishes to assess the risk of changes in freshwater resources under future warming conditions, such as the 1.5 °C and 2 °C targets or other socioeconomic reference pathways. This will be achieved through the use of statistical analysis of observed data as well as simulations from physics-based and conceptual models. While focus will be on India and Australia as case studies, the methods developed in this study are expected to be applicable globally.

A D&A analysis involves simulation of runoff and streamflow and associated impacts in a world with (Actual) or without (Counter-factual) climate change, obtained from climate model simulations in conjunction with hydrological models, that may range from multi-parameter grid-based modules including routing components, to simple water balance models. Alternately, runoff from climate models can be directly used to obtain corresponding streamflows. A comparative analysis between the two approaches would shed light on their strengths and weaknesses in hydrological impact assessment studies. Further, cascading uncertainties in D&A studies need to quantified. To this end, this study proposes uncertainty assessment techniques relevant to D&A studies on water resources and associated impacts. In addition, this study would also explore and possibly implement D&A studies for other components of the hydrological cycle such as soil moisture and evapotranspiration.

Project aims

Define the aims of the project

The following are some of the broad aims of this project:

1) To quantify changes in freshwater availability in India and in Australia, and associated impacts based on statistical analysis of observed data. This step would include analysis of changes in mean as well as extreme streamflows, and other hydrological variables such as evapotranspiration or soil moisture at varying spatio-temporal scales.
2) To assess the observed links between freshwater availability and population impacts population, irrigated areas or crop yield, loss of industrial productivity and/or ecological sustainability.
3) To utilise and/or develop hydrological models or land-surface models to obtain runoff and streamflow simulations under varying levels of climate change. This aim may include developing statistical and/or dynamical downscaling models and bias correction for climate model simulations.
4) To carry out fingerprint-based D&A analysis to delineate drivers of changes in freshwater resources at regional scale. In addition, this step may also include calculation of fraction of attributable risk to understand how the likelihood of individual events (such as the 1 in 100-year drought) has changed due to altering environmental conditions.
5) To quantify future hydrological change, such as to streamflow, under specific warming targets or future socioeconomic reference pathways.
6) To understand the sensitivity of D&A conclusions to the choice of regions (wet vs dry, small vs large catchments), variables (streamflow vs soil moisture), temporal scale of analysis (annual vs seasonal), and spatial scale of analysis (short vs long records, regional vs at-site).

7) To quantify the uncertainty in the D&A framework as relevant to freshwater availability.
8) To link D&A conclusions to impacts in terms of the affected population, irrigated areas or crop yield, or loss of industrial productivity or ecological sustainability.

Expected outcomes

Highlight the expected outcomes of the project including likelihood of patents

Three to four high-impact international journal papers are expected as outcome of this project. An improved understanding of observed and projected hydrological changes attributable to climate change would be a substantial contribution to science, and would likely contribute to assessments by the Intergovernmental Panel on Climate Change (IPCC).

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Freshwater availability is of paramount importance for ensuring water security of a society. A comprehensive understanding of water availability and changes in them is necessary for long term planning and management of water resources, and for disaster preparedness. India is a largely agriculture-dependent country with links between water shortage and the socio-economic health and prosperity. A major contributor to the Australian gross domestic product (GDP) is also agriculture, which depends on water availability. Moreover, these two countries also witness large climate variability that can be amplified in the hydrologic cycle and can complicate water availability. In the light of global warming and climate change, therefore, it is imperative to understand the drivers of changes in streamflow and the associated impacts. The role of other factors such as land-use/land-cover changes, or local human interventions also need to be accurately quantified.
The proposed study aims at understanding historical as well as future changes in water resources that are relevant for water supply. Thus, it suits the IITB-Monash Research Academy's goals related to both the themes of 'Water' and 'Infrastructure Engineering'.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

The candidate should have an exceptional academic background and a strong interest in research. Candidates with BTech/MSc./MTech degrees related to the fields of Civil Engineering and/or Hydrology, or Environmental Science and/or Engineering, or Atmospheric Science, or Earth Science, or Applied Mathematical/Physical Sciences are encouraged to apply. A background in hydrometeorological processes, programming and statistics is necessary. Any prior experience using climate and/or land-surface/hydrologic models or handling large hydroclimatic datasets will be considered an advantage.

Candidates are strongly encouraged to write to supervisors during the application process, before attending the interviews.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

IITB: Prof. Riddhi Singh, Prof. Subimal Ghosh, Prof. Subhankar Karmakar.
Monash: Dr Tim Petersen, Dr Ailie Gallant, A/Professor Edoardo Daly, Prof Andrew Mackintosh, Prof Nigel Tapper, Dr Carolyn Poulsen.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Water, Climate Change
Modelling and Simulation