IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Understanding water-energy interactions and hydrologic partitioning in natural river basins	
Project Number	**IMURA0769** *(will be inserted by The Academy)*	
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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

Rainwater and solar-energy undergo complex interactions with each other in a natural river basin resulting in partitioning of rainwater into evapotranspiration and streamflow, which is also known as hydrologic partitioning. At a large timescale, river basins follow some striking patterns in the way they mediate hydrological partitioning. In particular, it is well known that long-term hydrologic partitioning across geographical regions can be delineated by the "Budyko curve." A few hydrologists have argued that long-term hydrologic partitioning tends to follow the "principle of maximum entropy production." However, they have not explained how hydrologic partitioning occurs at a short timescale despite the fact that long-term hydrologic partitioning is merely an integration of short-term hydrological partitioning. Traditional rainfall-runoff models simulate short-term hydrological partitioning by employing a large number of free-parameters. Unfortunately, no study so far has been able to assign clear physical meanings to the parameters of a hydrological model mainly due to equifinality of model parameters. On the other hand, a recent study has argued that short-term hydrological partitioning can be simulated by developing a model without any free-parameter, supporting again the notion hydrologic partitioning across river basins tend to follow certain governing laws. We thus need to focus on acquiring an in-depth understanding on how water and energy interact in a river basin at small timescales. We plan to use a "large eddy simulation" (LES) model to quantify flow of water and energy in river basins across geographical regions and identify the "dominating forces" governing hydrologic partitioning at different timescales. Such an effort will not only improve our scientific knowledge on hydrological processes but also it will help us in developing hydrological models for predicting disasters like floods and droughts in data-scarce regions.

Project aims

The main aims of this proposed research are:

- To use a LES model to understand interactions between rainwater and solar energy in natural river basins.
- To analyse the results from the LES model to understand how climate and different basin characteristics influence water-energy interactions and hydrologic partitioning.
- To utilize the information from the above two steps to develop a simple conceptual model for explaining hydrological partitioning at different timescales more accurately.

Expected outcomes

The following outcomes are expected from the proposed research:

- Better scientific understanding of water-energy interactions in river basins.
- A more efficient model for predicting hydrological phenomena like floods and droughts.

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

The proposed research will address the concerns raised by the IITB-Monash academy (theme 4: Water) by developing modelling tools that can help in sustainable management of water resources, particularly in data-scarce regions.

Capabilities and Degrees Required

The proposed research project needs a highly motivated PhD student with strong fundamental knowledge and quantitative skills. Knowledge in computer programming is essential. The candidate should have a master's degree in any subject area related to hydrology or water resources engineering. We also encourage applications from exceptional candidates holding a master's degree in any of the following subject areas: physics, mathematics, mechanical engineering, and chemical Engineering.

Potential Collaborators

Prof. Marco Giometto (Columbia University), Prof. Edoardo Daly (Monash University), Prof. Subimal Ghosh (IIT Bombay), and Prof. Arpita Mondal (IIT Bombay).

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 (Carbon Capture and Sequestration) (9); Modelling and Simulation (37); Computer Simulation (25); Maths (8).