IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Optimization of groundwater planning and management under predictive uncertainties using computationally efficient data assimilation**	
Project Number	**IMURA0923**	
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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)*

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

The research problem

Groundwater abstraction in India accounts for about 25% of the global groundwater abstraction and contributes to about 65% of irrigated agriculture. More than 50% of the total number of districts in India show declining groundwater trends and this is expected to be aggravated by climate change (World Bank, 2016). Policy development for optimal and sustainable groundwater management should be underpinned by assessments for the future, accounting for changes in the hydrological cycle, recharge and evapotranspiration regimes induced by climate change.

Such assessments warrant the use of numerical models simulating surface and groundwater models in computationally complex uncertainty and optimization frameworks to develop reliable solutions for groundwater management. Land surface models can simulate a suite of spatial and temporal variables (patterns) that can be used for groundwater resource assessments. However, assimilating such spatially and temporally varying patterns into a computationally complex groundwater model presents a significant challenge. Recent studies have demonstrated the applicability of a range of techniques including deep neural networks and other (e.g. empirical orthogonal functions in the attached paper) for computationally efficient prediction of spatial and temporal patterns of variables like rainfall, temperature, deep drainage and evapotranspiration enabling assimilation of this information into numerical groundwater models to be used in optimization and uncertainty analysis frameworks.

We propose the PhD project to develop and test a simulation-optimization methodology for decision making under uncertainty where the predictive simulations of a model chain comprising land surface and groundwater models are used in an optimization model to inform sustainable groundwater planning decisions. The methodology development will focus on computationally efficient propagation of predictive uncertainties through the model chain and the optimizer to inform decision making under uncertainty.

Project aims

The research hypotheses that this project aims to address are the following:

Optimization of groundwater planning and management decisions under predictive uncertainties can be improved by propagating the predictive uncertainties through a model chain and integrating it with a mathematical optimization scheme to derive optimal solutions. In achieving this the study will:

- test the effect of data assimilation approach on groundwater modelling
- develop a python-based toolkit for univariate data assimilation
- integrate the assimilated data into a regional groundwater model
- and develop the simulation-optimization tool for optimal decision making under uncertainty

Expected outcomes

Highlight the expected outcomes of the project including likelihood of patents

High quality publications in reputed international journals
Conference presentations.
Development of practically useful software utilities

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

The project will sit under the Water Theme of IITB-Monash Research Academy and belong to the cluster of earth sciences and civil engineering under the research theme of water. This project addresses the challenging problem of quantifying data and predictive uncertainties in a chain of models comprising land surface and groundwater models and integrating this knowledge for optimal decision making. India and Australia are experiencing the challenges of climate change and its impact on sustainable use of groundwater resources. Many groundwater basins are overexploited and the effect of climate change is expected to aggravate the impacts. Addressing these challenges by developing necessary skill sets that can be readily deployed for sustainable management of resources is at the core of the Water Theme at IITB-Monash Research Academy. The proposed PhD project is directly relevant to meet this objective.

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.

M.Tech/MS/MSc in Engineering (Civil, Remote sensing, Environmental Engineering, Geoinformatics, Water resources engineering)
Strong mathematical and analytical skills are required, strong programming skills in python is essential

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.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

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.

Optimization under prediction uncertainty, groundwater modelling, data assimilation,