

An Indian-Australian research partnership

**Project Title:**

**Project Number**

**Monash Main Supervisor**

(Name, Email Id, Phone)

Dr Grace Rumantir  
[Grace.Rumantir@monash.edu](mailto:Grace.Rumantir@monash.edu)

*Full name, Email*

**Monash Co-supervisor(s)**

(Name, Email Id, Phone)

**Monash Department:**

**IITB Main Supervisor**

(Name, Email Id, Phone)

Prof. Kumar Hemant Singh  
[Kumar.h.singh@iitb.ac.in](mailto:Kumar.h.singh@iitb.ac.in)

*Full name, Email*

**IITB Co-supervisor(s)**

(Name, Email Id, Phone)

Prof. Trilok Nath Singh  
[tnsingh@iitb.ac.in](mailto:tnsingh@iitb.ac.in)

**IITB Department:**

## Research Academy 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](http://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

## The research problem

The Earth-systems consists of large sets of both spatial and temporal data. This large amount of data makes analyses difficult. These amounts are often not sampled evenly. The need to model on a large population, based on the learning from a smaller sample is what is done mostly in this field. Therefore the learning machine, which maps the predictors to the response variables, must be intelligent enough to treat this data diligently. Still more, the machine should be able to incorporate past observations to make better predictions. As many predictive variables like sea levels and atmospheric temperature have been spanning from the geological past, data like these must be included wherever possible to enhance the model.

Gaussian Process (GP) described as distribution over functions and can be completely characterized by

their mean and covariance functions. The predictive capability of these processes entirely relies on the kernel function. Modelling in Earth-Systems generally deliver complex structural models often spanning in many dimensions. The design of multidimensional kernel requires learning relevant features from observed data. Tools commonly used in machine learning (ML) help extract these features. And finally these features help identify various sub-structures within data. Literature has been sparse with regard to serious application of these in Earth-systems. GPs can naturally adapt to data size and environments in the Bayesian sense. A process involving Gaussian variables is easy for learning and inference purposes. So, the supervised learning problems which can be thought of as learning a function from examples can be cast directly into a GP framework.

### **Project aims**

The research will majorly deal with supervised learning using GPs to make better models. The following objectives have been identified for this research proposal:

1. Design and development of intelligent predictive models/ensembles in various Earth-Systems.
2. Understanding and handling of multivariate and heterogeneous data types taking care of sparsity.

### **Expected outcomes**

1. Intelligent algorithms to identify sub-structures of the Earth using geoscience data.
2. Geological Models to quantify and thus help reduce uncertainties.

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

Novel and practical prediction models require advanced computational and modelling techniques. The key is to have a thorough understanding of the interaction among predictor and response variables using ML tools like clustering, classification, importance sampling and regression can help achieve the identified outcomes. The above mentioned project involves design of the same which will especially be applicable to Earth-systems. Good predictions will help quantify uncertainty and make crucial decisions.

### **Capabilities and Degrees Required**

This research would likely be an extensive and exhaustive one that would involve two aspects. First, this would require the in-depth knowledge of Earth type systems and associated phenomena. Second, coding experience involving statistical distributions, optimization and various machine learning tools is also required. Each of these aspects would require extensive scholarly support for which involvement of a student with the knowledge of numerical methods popularly used in earth sciences with computing skills. Acquaintance to GPs and multidisciplinary approach to coding are desired.

### **Potential Collaborators**

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

None

Please provide a few key words relating to this project to make it easier for the students to apply.