

An Indian-Australian research partnership

Project Title:	Stochastic Resonance Using Data Science Technology to Enhance Weak Ocean Magnetic Signals	
Project Number	IMURA0676 (5)	
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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)

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

Many phenomena that occur in earth systems are mostly nonlinear and are driven by a number of internal processes. As a result, given the number of observed processes and their data, models explaining these phenomena rely entirely on sophisticated error reducing mathematical techniques, to achieve an acceptable level of accuracy. Stochastic Resonance (SR) is a phenomenon in nonlinear systems whereby

weak input signal can be amplified by the addition of noise. Given i) the energetic activation barrier (the threshold), ii) a weak coherent input (such as periodic signal) and iii) a source of a noise that adds to the coherent signal, a resonance like behaviour can be detected as a function of noise level, leading to an enhancement of the previously below-threshold signal. This kind of signal enhancements have a number of important applications in various fields of science, such as detection of weak geomagnetic signals induced by non-tidal ocean currents in the nearby magnetic observatory data. Models in earth systems can be improved with the increase in the number of fundamental guiding variables, some of which are too weak to be useful verbatim.

Project aims

The aim of the project is to propose a stochastic algorithm for the detection of weak signals through simulation experiments. The experiments start with the generation of synthetic signals, the attenuation of the desired weak signal and the detection of real weak ocean magnetic signals in the final stage. These involve the use of appropriate design and application of wavelet and signal analysis algorithms and various filtering techniques. Insights into how weak signals can be enhanced can be useful in various applications to earth systems. The project can be summarized into three points:

1. Simulation experiments using synthetic signals with frequencies relevant to ocean systems
2. Development of a weak signal detection algorithm which can process, filter and reproduce the desired signals
3. Application of the proposed algorithm on the identification of temporal and spatial variation of weak magnetic signals induced by non-tidal ocean currents in the observatory and if possible satellite data.

Expected outcomes

1. Algorithms to detect weak signals in noisy nonlinear data through synthetic modelling
2. Identification of weak temporal and spatial variation of ocean magnetic signals

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

The research findings of the project will be technologically significant in a wide range of ocean, atmospheric and earth processes involving signal analysis. Enhancement of weak signals using noise can help identify previously undetected processes, and in turn also help modify earth systems modelling process by adding more input variables, newly detected through the enhancement of their weak signals.

Capabilities and Degrees Required

This PhD candidate for this research project would need to satisfy the following requirements: First, in-depth knowledge of earth systems and associated phenomena. Second, modelling experience involving optimization, advanced signal processing and various Data Science tools is also required. Each of these aspects requires involvement of student with computing and intelligent systems modelling skills with specific knowledge of signal processing commonly used in earth sciences. Acquaintance to Stochastic Resonance and multidisciplinary approach to modelling are desired.

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.

None

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

Stochastic Resonance, Data Science, Simulation of ocean-induced magnetic signals