IITB-Monash Research Academy

An Indian-Australian research partnership

Indian Institute of Technology Bombay | MONASH University

Project Title:	**Severe thunderstorms in the tropics and subtropics**	
Project Number	**IMURA1089**	
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Monash Co-supervisor(s) (Name, Email Id, Phone)	None	
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IITB Head of Dept (Name, Email, Phone)	Prof. Subimal Ghosh, head.climate@iitb.ac.in	*Full name, email*
IITB Department:	IDP in Climate Studies	

Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**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***	***Artificial Intelligence and Advanced Computational Modelling***
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Circular Economy*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Health Sciences*
5	***Earth Sciences and Civil Engineering (Geo, Water, Climate)***	5	*Smart Materials*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Sustainable Societies*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Infrastructure*
	HSS, Design, Management		

The research problem

Statement:

Thunderstorms are among nature's most spectacular phenomena. The most intense storms contain powerful updrafts that can produce hundreds of lightning strikes and may be accompanied by strong winds, hail, or flooding, posing considerable risks to life and property. Such severe thunderstorms are known to require two main ingredients in their large-scale environment in order to form; sufficient available energy to fuel the storm, and sufficient wind shear (changes in the wind with height) to provide an organisation mechanism (e.g., Brooks, 2013).

A large literature exists on developing climatologies of favourable environments based on the occurrence of these ingredients and evaluating how the frequency of such favourable environments may change in a warmer climate (e.g., Allen & Karoly, 2014; Diffenbaugh et al., 2013; Singh et al. 2017). To date however, this literature has largely focussed on mid-latitude regions, primarily in North America, Europe and Australia. But a large fraction of the most intense thunderstorms (Zipser et al. 2006) and some of the most impactful severe thunderstorms occur in tropical and subtropical regions such as South Asia, Equatorial Africa, and parts of subtropical and tropical Australia. This project seeks to develop an understanding of the physical mechanisms that produce severe thunderstorms in these regions, the environmental conditions that promote them, and to project how these dangerous storms may be affected by climate change.

References:

1. J. T. and D. J. Karoly, "A climatology of Australian severe thunderstorm environments 1979–2011: inter-annual variability and ENSO influence," *Int. J. Climatol.*, vol. 34, pp. 81–97, 2014.
2. H. E. Brooks, "Severe thunderstorms and climate change," *Atmos. Res.*, vol. 123, pp. 129–138, 2013.
3. N. S. , M. Scherer, and R. J. Trapp, "Robust increases in severe thunderstorm environments in response to greenhouse forcing," *Proc. Nat. Acad. Sci.*, vol. 110, pp. 16361–16366, 2013.
4. M. S. , Z. Kuang, E. D. Maloney, W. M. Hannah, and B. O. Wolding, "Increasing potential for intense tropical and subtropical thunderstorms under global warming," *Proc. Nat. Acad. Sci. U.S.A.*, vol. 114, pp. 11657–11662, 2017, doi: 10.1073/pnas.1707603114.

Project aims

1. Develop a climatology of different types of severe thunderstorms in tropical and subtropical regions including South Asia and Equatorial Africa

2) Evaluate the relationship between such storms and environmental proxies commonly used in midlatitudes. Apply Machine learning techniques to develop new proxies that work for tropical regions.

3) Evaluate the future changes of such severe storm environments based on model projections and physical theory.

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the students stay at IITB and at Monash

While in IITB the student will develop a background in Climate Sciences as well as get an exposure to the wider questions of Climate Mitigation, Adaptation and Policy. The student will phrase the science question and will identify its impacts. At Monash University, he will work on the theoretical aspects of the problem and will undergo training specific to understanding the nuances of the problem. The numerical modelling will be carried out both at IITB and Monash.

Expected outcomes

Highlight the expected outcomes of the project

The outcomes of this project will be an improved understanding of the relationships between large-scale environments and thunderstorms in particularly vulnerable tropical regions. At present severe storm potential is often assessed using relationships that have only been properly evaluated in midlatitude regions. Further the project will assess how such storm environments may change in a warmer climate,

which, again, has generally only been done previously based on relationships that are not well validated in tropical and monsoonal climates.

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.

1. The parallel data processing toolkit used and developed to process Big Data will also involve use of high-end computational methods.

2. This project will explore possibilities of using high-resolution climate data to develop models for the relationships between large-scale parameters and severe thunderstorms using modern AI / ML techniques.

3. High resolution cloud resolving model employs state of the art developments in computational modeling

How well the IITB and the Monash supervisor(s) know each other

Provide details of previous collaborations (if any). For new collaborators, have you had a chance to meet each other in person or through VC or Skype?

The supervisors have known each other for over 5 years since Dr. Dixit's postdoctoral stint in UNSW Sydney. While they do not yet have joint papers, they have had many scientific discussions, both in-person and online, and their research is well aligned. For example, in Bao et al. (2022), Dr Dixit used a prior theory of the tropical thermodynamic structure introduced in Singh & O'Gorman (2013) to help explain results of idealised simulations of tropical circulations.

Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project

Monash:
Prof. Michael Reeder – expert on atmospheric dynamics and influence of midlatitude processes on monsoons
Prof. Steve Siems – expert on atmospheric modelling, including high-resolution cloud resolving modelling. Prof Siems has also participated in the IITB-Monash program as a supervisor.

IITB:
Prof. Subimal Ghosh – Expert in Hydro-Climatology of Global monsoons. He was involved in adding "Earth Sciences and Civil Engineering" research cluster in IITB-Monash academy.
Prof. Karthikeyan Lanka – Expert in Land-Atmosphere interactions during Indian Monsoon

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to 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.

An ideal student would have a strong background in physics, mathematics or related disciplines. Previous coding experience and background in meteorology or atmospheric science is beneficial but not necessary.

Necessary Courses

Name three tentative courses relevant to the project that the student should complete during his/her coursework at IITB (the student will require to secure 8 point in these courses)

Introduction to Climate Science
Atmospheric and Oceanic Dynamics
Atmospheric Thermodynamics
Monsoons and Tropical Climate

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.

Monash:
Prof. Christian Jakob – expert in atmospheric convection and convection parameterisation in models. Prof Jakob's expertise on use of satellite and other observations of clouds and preciptiation may be useful in developing the climatology of severe thunderstorm environments.

IITB:
Prof. Karthikeyan Lanka – An expert in Remote Sensing and hydrology. His expertise will be useful in understanding the role of land-atmosphere interactions in storm dynamics.

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.

1. **Modelling and Simulation,**
2. **water, climate change**
3. **Computational fluid dynamics**