Indian Academy of Sciences, Bengaluru
Indian National Science Academy, New Delhi
The National Academy of Sciences India, Prayagraj

SUMMER RESEARCH FELLOWSHIPS — 2025

Format for the four-week Report*,^,@

Name of the candidate	: Sudhan R
Application Registration no.	: ENGS1672
Date of joining	: 07/04/2025
Name of the guide	: Dr. Y. Bhavani Kumar
Guide's institution	: National Atmospheric Research Laboratory, Tirupati
Place of stay during the tenure of the fellowship	: Hostel provided by Guide Own arrangement Ranipet, Tamil Nadu Other (Specify)

Sudhan. R
Signature of the candidate
Date: 07/05/2025

7/5/2025
Signature of the guide
Date:

INSPIRE/KVPY FELLOWSHIP (please fill this box)#			
1.	I am currently a recipient of	INSPIRE FELLOWSHIP	□ Yes / ✓ No
		KVPY FELLOWSHIP	□ Yes / ✓ No
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3.	I receive a monthly fellowship of Rs. __________ from INSPIRE/KVPY towards my living expenses		
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	I affirm that the information given above is correct.	Sudhan. R Signature of the candidate	

IMPORTANT NOTES:

* **The four-week report could be between 300 and 350 words.**

^ **This format should be the first page of the report and should be stapled with the main report.**

Mandatory to fill this section, this should be filled and signed by you even if you are not an INSPIRE/KVPY Fellow. Otherwise release of fellowship amount will be withheld.

@ **The hard copy of the duly signed report should reach the Academy office within 10 days of completing the first month fellowship. If delayed the fellowship amount will not be paid.**

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Candidate's name:		Fellowship amount:
Student:	Teacher:	Deduction:
Guide's name:		Amount to be paid:
KVPY Fellow:	INSPIRE Fellow:	A/c holder's name:
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SUMMER RESEARCH FELLOWSHIP PROGRAMME

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Title	Investigating Convection – Driven Wave Signatures in the Atmospheric Boundary Layer Using LiDAR
Name	Mr. Sudhan R
Application Number	ENGS1672
Candidate's Institute	Sri Eshwar College of Engineering, Affiliated to Anna University
Name of the Guide	Dr. Y. Bhavani Kumar
Name of the Institute	National Atmospheric Research Laboratory (NARL)
Report	4 – Week Report

ABSTRACT

This report summarizes the work carried out during the initial phase of the Summer Research Fellowship at the National Atmospheric Research Laboratory (NARL), under the mentorship of Dr. Y. Bhavani Kumar. The project focuses on exploring the presence of wave signatures within the Atmospheric Boundary Layer (ABL) induced by surface convection, using LiDAR backscatter data. While conventional studies have extensively addressed ABL height detection, the identification and analysis of convection-triggered atmospheric wave structures remain relatively underexplored in LiDAR remote sensing.

This work aims to investigate whether such wave features can be extracted from high-resolution backscatter profiles, contributing to a deeper understanding of boundary-layer instability, wave propagation, and potential turbulence onset.

07/5/2025

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1. INTRODUCTION

The Atmospheric Boundary Layer (ABL) is the dynamic lower part of the troposphere that responds rapidly to surface processes such as heating, friction, and orographic effects. Its structure influences critical atmospheric phenomena including weather, cloud formation, and pollutant transport.

LiDAR (Light Detection and Ranging) systems provide high-resolution vertical profiles of backscattered signals from aerosols and particulates, offering rich insights into ABL dynamics. While standard analysis focuses on identifying the ABL height through gradients in aerosol concentration, this study proposes a novel direction — investigating fine-scale wave-like fluctuations in the LiDAR signal that may be signatures of **convection-triggered ground waves** within the ABL.

These waves can reveal subtle instability patterns, offering a new remote sensing approach to detecting **early-stage turbulence** and **energy transport mechanisms** in the lower atmosphere.

2. OBJECTIVES OF THE STUDY

- To study the formation of convection-induced wave activity in the ABL
- To understand how such waves manifest in LiDAR backscatter signals
- To identify regions of signal oscillation and variability that may indicate wave propagation or wave breaking
- To explore signal processing techniques for isolating these signatures
- To propose a methodology for analysing wave and potential turbulence indicators in ABL remote sensing data

3. WORK COMPLETED DURING THE FIRST FOUR WEEKS

3.1 Literature Review

- Studied the physical processes of wave generation by convective activity in the ABL
- Reviewed previous studies on gravity wave and turbulence detection in the lower troposphere
- Analysed methodologies used in LiDAR-based boundary layer height detection and their limitations
- Identified a research gap in the detection of **fine-scale wave structures** via aerosol backscatter data

3.2 Data Familiarization

- Gained access to historical LiDAR backscatter datasets containing vertical aerosol profiles
- Understood the typical waveform structures and the expected resolution of fluctuations
- Observed regions with apparent oscillatory behaviour that could be linked to convective events

3.3 Methodology Development

- Identified suitable tools such as wavelet analysis and moving standard deviation techniques to detect localized signal anomalies
- Proposed using **signal variability metrics** and **multi-scale transforms** to extract wave and turbulence patterns
- Developed an initial workflow for visualizing backscatter variability with respect to height and time

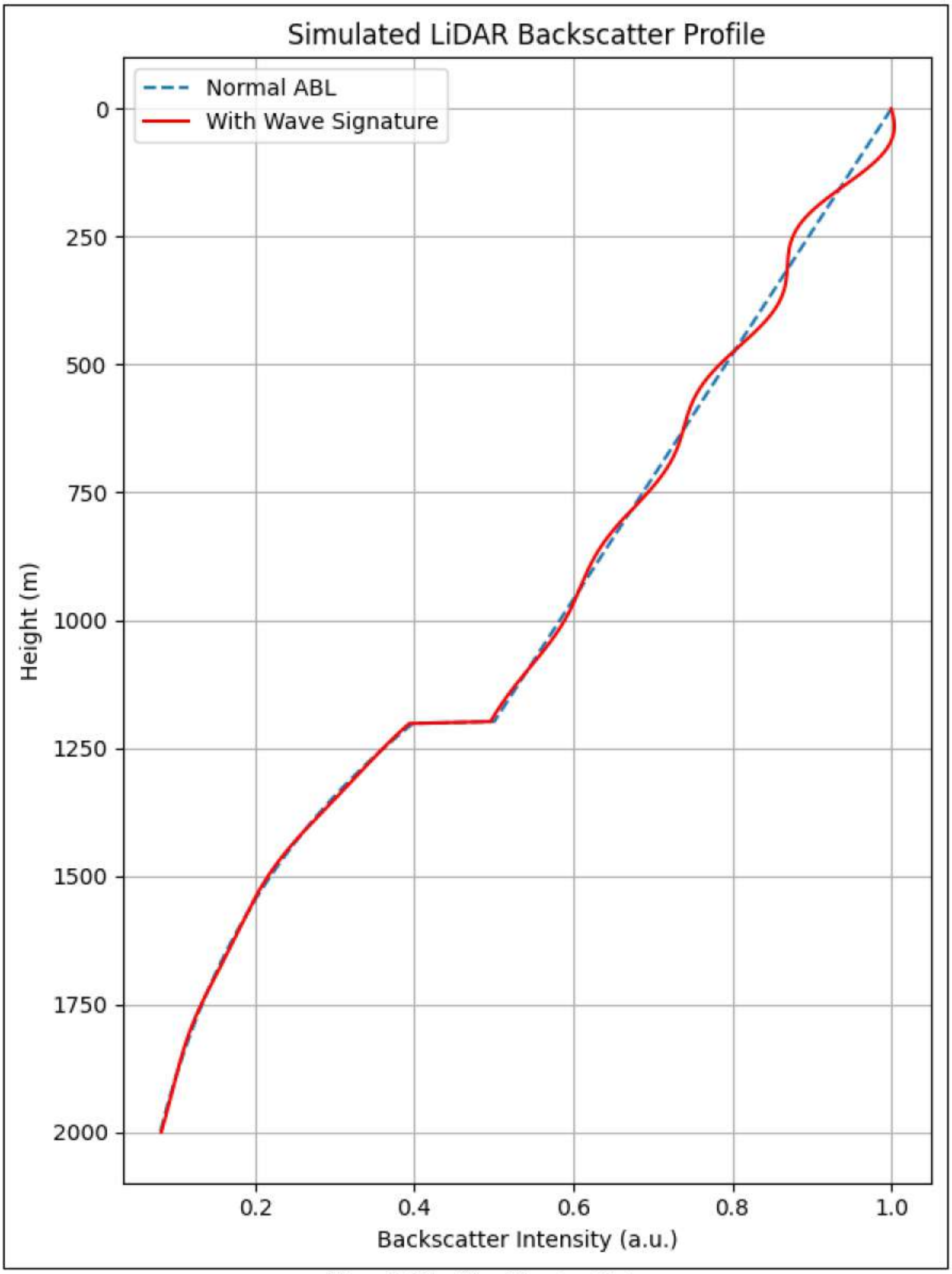

Figure 1: Lidar Wave Signature Plot

4. FUTURE WORK PLAN

- Select case study days with strong surface heating or convective potential
- Apply wavelet and spectral analysis techniques to isolate wave regions in the LiDAR signal
- Quantify signal fluctuations and correlate with meteorological conditions (if available)
- Visualize vertical and temporal evolution of wave features and turbulence zones
- Validate observed patterns with established theoretical models on convective instability

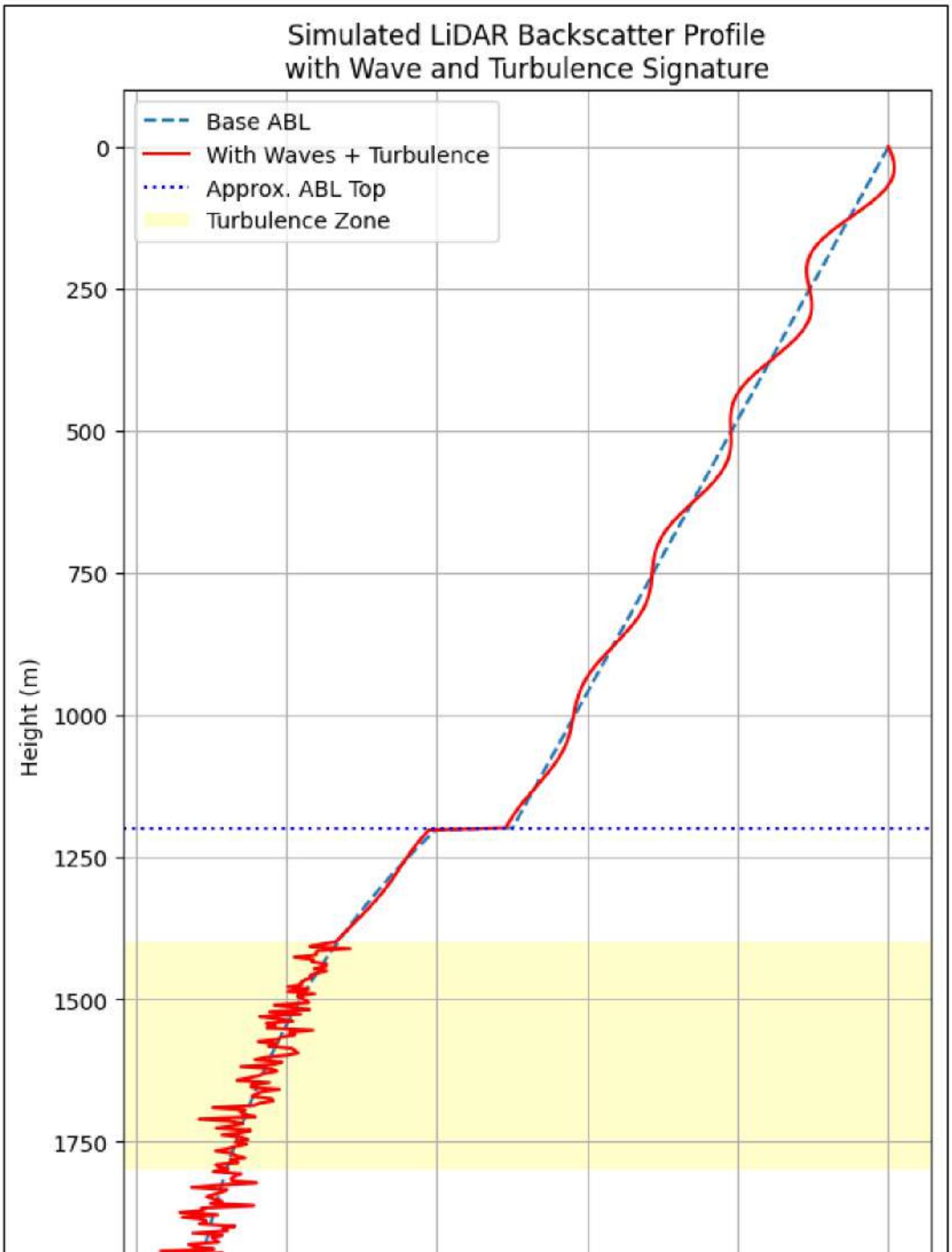

Figure 2: Lidar Wave Turbulence Signature

5. CONCLUSION

The project sets a novel direction in Atmospheric Boundary Layer research by shifting the focus from traditional height detection to the identification of convection-driven wave activity using LiDAR. The first month's efforts established a strong theoretical and observational foundation. The upcoming phase will involve deeper signal processing and extraction of scientifically significant wave structures, which may enhance our understanding of boundary-layer instability and early turbulence formation.

6. REFERENCES

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