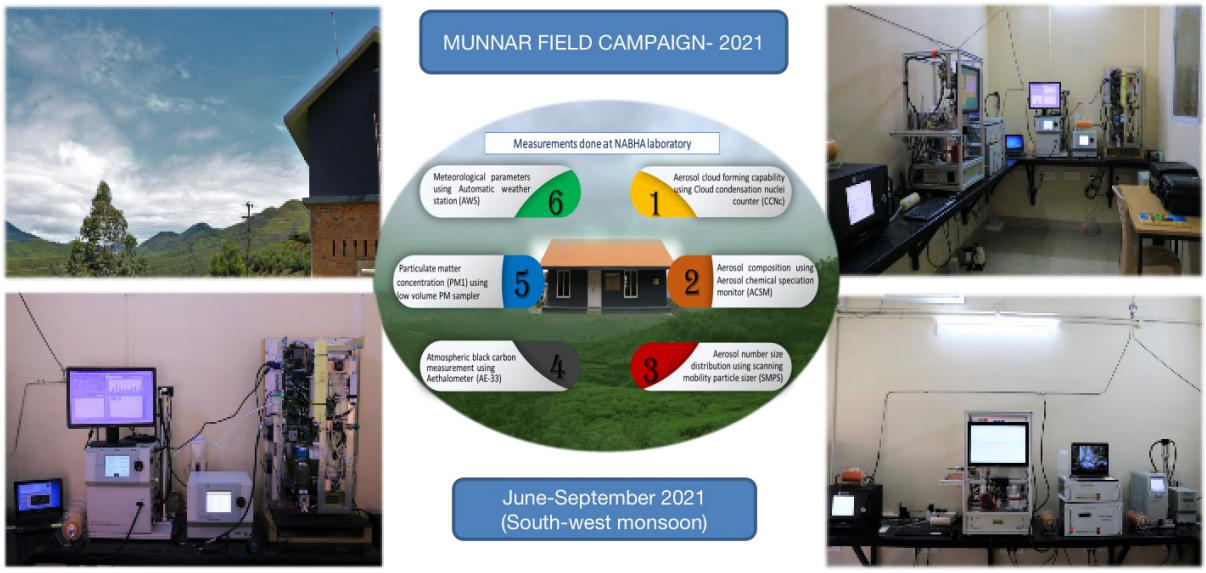
NABHA Laboratory, Munnar

The relationship between clouds and aerosol has been the subject of various research campaign efforts worldwide and in India. Different groups working in atmospheric and climate sciences are actively involved in deciphering the aerosol-cloud-precipitation-climate interaction. Nearly eight significant high-altitude atmospheric research laboratories are available in India, primarily working in this area, with significantly different research objectives and instrumental setups. The NABHA *(Natural Aerosol and Bio-aerosol High Altitude*) laboratory, set up by IIT Madras with financial support from Shark Industries, is a first-of-its-kind addition to this list of high-altitude atmospheric labs. The state-of-the-art laboratory is set up on the College of Engineering, Munnar (CEM) premises in the hill station Munnar, Kerala, with the primary research objective of studying the climate change scenario in south India.

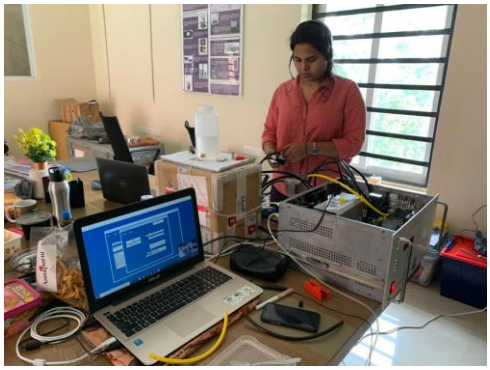
With its unique geo-strategic location of being on an elevation of approximately 1600m above mean sea level (AMSL) in the Western Ghats, away from dense urban agglomeration, the NABHA laboratory is engaged in atmospheric aerosol and bioaerosol measurements, critical in understanding the impact of pollution on climate change or vice-versa, by providing background aerosol measurements that can be compared to measurements from urban areas. Also, in high-altitude mountainous terrains, the low-level monsoon clouds pass very close to the surface, allowing close monitoring of clouds. The geographical position of the Western Ghats Mountains in Munnar provides a unique opportunity to study the formation of cloud condensation nuclei (CCN) and their variability with seasonal changes. The laboratory receives almost unobstructed marine winds from the Arabian Sea during the southwest monsoon season, enabling us to study long-range transported aerosols and various types of bioaerosols in the area.

NABHA laboratory is dedicated to conducting high-altitude field measurements of CCN, bioaerosols, aerosol number size distribution and chemical composition to understand aerosol-cloud-precipitation-climate interactions better. Further, the lab provides an ideal site for studying New Particle Formations from biogenic precursors contributed by the dense forests and tea plantations surrounding the lab. Also, aerosol and bioaerosol chemical speciation can be performed within a wide range of basic and applied scientific disciplines, each with its own objectives, scientific goals and outcomes.

The lab contains excellent instruments for quantifying atmospheric aerosols and bioaerosols, studying CCN activation and cloud formation, and for chemical characterisation of aerosols, making it unique in exploring these diverse interests, emphasising perspectives from climate change and human health. We conducted a four-month-long field measurement campaign at the NABHA lab during the southwest monsoon season in 2021 with the objective of studying the background aerosol properties and climate implications.



In this campaign, we precisely measured aerosol particle size, chemical composition and the water vapour supersaturation at which CCN activation occurs (calculated using Kohler theory). The aerosol size distribution was measured using a scanning mobility particle sizer (SMPS), and CCN concentrations were measured using a cloud condensation nuclei counter (CCNc). An aethalometer was used to quantify the absorbing aerosols and understand the radiative implications of black carbon. The chemical composition of non-refractory aerosols was studied using an Aerosol chemical speciation monitor (ACSM).



This facility at Munnar has been used to concisely review bioaerosol type, diversity, and impacts in the Western Ghats. Also, the measurements here can help understand the properties distinguishing bioaerosols from non-biological aerosols. We can focus extra on regions of specific interest, such as forests and marine and coastal environments, and summarise key considerations related to bioaerosol and non-biological aerosol measurements, such as fluxes, long-range transport, and sampling from high-altitude areas. Our lab is only one of its kind and has more precise scientific objectives, instruments, and measurements than other labs available in India.

For reference, the objectives of the NABHA lab are summarised as follows:

Name, Location of High-altitude Laboratory	Primary Scientific Objectives
Natural Aerosol and Bioaerosl High-Altitude (NABHA) Laboratory, Munnar	➢ Aerosol-Cloud-Precipitation interaction. ➢ Chemical Characterization of aerosols. ➢ Quantification and impact of Bioaerosol on climate, cloud formation, precipitation, human health. ➢ To understand the role of aerosol (bioaerosol) size, chemical speciation and hygroscopicity in cloud activation processes. ➢ Pollution and climate change-related studies

Research outcomes:

Research findings from the measurements carried out at this site are being reported to the scientific community through publications, such as the ones listed below:

1. Singh, Aishwarya, Kavyashree Kalkura, Rameshchand KA, Ravikrishna Raghunathan, Ulrich Poschl, Hang Su, James Allan et al. "Cloud Condensation Nuclei (CCN) activity of sub-micron aerosols during the Southwest Monsoon over a pristine site in the Western Ghats, India." In *EGU General Assembly Abstracts*, vol. 2024, (2024).
2. Jose, Christi, Aishwarya Singh, Kavyashree N. Kalkura, George V. Jose, Shailina Srivastava, K. A. Rameshchand, Shweta Yadav et al. "Complex hygroscopic behaviour of ambient aerosol particles revealed by a piezoelectric technique." *Authorea Preprints* (2023).
3. Kalkura, Kavyashree N., Aishwarya Singh, Snehitha M. Kommula, Upasana Panda, Ramesh Chand K A, Ernesto Villegas, James D. Allan et al. "Characteristic Aerosol Properties during Monsoon and COVID Lockdown under Cleaner Conditions: Source Apportionment and Chemical Properties from a High-Altitude site in India." In *AGU Fall Meeting Abstracts*, vol. 2022, pp. A42B-04. (2022).