

# India's pioneering high-altitude atmospheric and climate research in the Himalayas

India is constantly upgrading its meteorological infrastructure and capabilities for making high-precision weather predictions and climate projections on regional and global scales. Advanced climate models powered by supercomputing facilities and large-scale observational data have significantly improved India's capabilities to forecast weather and climate events, including extreme weather events such as tropical cyclones and tsunamis, on different spatio-temporal scales. However, the predictive capabilities of climate models remain restrained due to the lack of adequate observational atmospheric data from high-altitude regions<sup>1</sup>, especially the Himalayas – the 'Third Pole' of the Earth<sup>2</sup>. Such underrepresentation of the Himalayas limits our understanding of the global weather and climate processes<sup>3</sup>.

Therefore, expanding the atmospheric observational network over the Himalayas and other high-altitude locations is crucial for improving weather and climate predictions<sup>4</sup>. India has already established a High-Altitude Cloud Physics Observatory in Munnar (Kerala) at an altitude of 1820 m above sea level (asl) managed by National Centre for Earth Science Studies, Thiruvananthapuram<sup>5</sup>, and a High-Altitude Cloud Physics Laboratory at Mahabaleshwar (Maharashtra) at an altitude of ~1400 m asl managed by the Indian Institute of Tropical Meteorology, Pune<sup>6</sup>. More such laboratories and observatories are needed in the Himalayas for better understanding high-altitude atmosphere and climate.

Marking a significant contribution in this direction, India's first-ever Himalayan High-Altitude Atmospheric and Climate Research

Centre at Nathatop (Village Mandlote in Chenani area) in the Shivalik hills in Jammu and Kashmir's Udhampur district was inaugurated by Jitendra Singh, Union Minister of State (Independent Charge) for Science and Technology and Earth Sciences on 8 April 2025 (ref. 7). The inaugural function was also attended by M. Ravichandran, Secretary, Ministry of Earth Sciences, Govt of India; Sanjeev Jain, Vice Chancellor, Central University of Jammu; Satish Sharma, Jammu and Kashmir State Minister for Science and Technology; Vasu Yadav, Chairman, Jammu and Kashmir Pollution Control Committee; the local public, and officials/researchers from the participating organisations.

Strategically located in the north-western Himalayas at 2250 m asl, this state-of-the-art facility established by the Central University of Jammu (CUJ) is designed to study the free troposphere, leveraging its minimal anthropogenic pollution to study aerosol dynamics, cloud microphysics and regional climate processes.

The Centre addresses a critical gap in global atmospheric observations, particularly in the Global East and South, where high-altitude monitoring stations are sparse. Its unique location enables the study of air masses from both eastern and western sources, providing insights into transboundary pollution and emission dynamics. Such high-altitude data from the Centre will contribute to reducing uncertainties in aerosol emission inventories, quantifying their impacts on ecosystems and enhancing global climate models by reducing biases in monsoon and precipitation forecasts.

During the inaugural function, Singh also flagged off the Indo-Swiss Joint Research Project

'ICE-CRUNCH' funded by the Swiss National Science Foundation and India's Ministry of Earth Sciences, executed by the researchers from the CUJ led by the Centre In-charge Shweta Yadav and ETH Zürich (Eidgenössische Technische Hochschule Zürich (Federal Institute of Technology Zurich), Switzerland) team led by Group Leader Zamin Kanji. The first measurements and observations at the Centre will be conducted under ICE-CRUNCH (Ice nucleating particles and cloud condensation nuclei properties in the North-Western Himalayas) aimed at exploring the properties of ice nucleating particles and cloud condensation nuclei and their role in cloud formation and precipitation in the Himalayas.

Two significant Memoranda of Understanding (MoUs) were also signed during the inaugural ceremony in the presence of Singh. The first MoU was signed between CUJ and the India Meteorological Department for real-time analysis of extreme weather events and establishing the site as a background observational station for environmental monitoring under the WMO-GAW (World Meteorological Organisation-Global Atmospheric Watch) programme. The second MoU was signed between CUJ, Jammu and Kashmir Forest Department, and Jammu and Kashmir Pollution Control Committee for facilitating coordinated measurements and long-term atmospheric monitoring at the Centre.

The Centre is expected to be a milestone in advancing atmospheric and climate research in the North-Western Himalayas while addressing pressing climate challenges in one of the world's most critical and vulnerable regions.

With international collaborations, more such centres should be setup to establish a denser observational network to study the Himalayan atmosphere. Such observational data would help ensure proper representation of the Himalayas – the ‘Third Pole’ – in the global climate models for better monsoon forecasts and climate projections.

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