Secrets of influence of Himalayan air movements on monsoons can improve predictions

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A team of Indian scientists have uncovered mysteries of how vertical air motion over the Himalaya have shaped the Indian monsoons, the lifeline of South Asia for centuries.

Scientists are constantly looking towards ways for improved prediction of the Indian monsoon needed for agriculture, water management, and disaster preparedness across South Asia, where millions of people rely on monsoon rainfall for their livelihoods. It will also help better assessment of air quality over South Asia.

New insights into the hidden patterns of airflow over the Himalayas are now making this possible. However, the limited studies of vertical air movement in this region so far have relied on indirect balloon or satellite-based measurements, which cannot capture the long-term fine-scale variability of vertical air motion in the complex Himalayan terrain.

Scientists from Aryabhatta Research Institute of Observational Sciences (ARIES), an autonomous research institute under the Department of Science & Technology (DST) at Nainital along with Space Physics Laboratory (SPL) of the Indian Space Research Organisation (ISRO), at Thiruvananthapuram carried out the first direct and high-resolution measurements of vertical air motion during the Asian Summer Monsoon (ASM) months over the central Himalayas within the Asian Summer Monsoon Anticyclone (ASMA) region.

For this they utilized long-term observation data from the indigenously developed Stratosphere-Troposphere (ST) radar located at ARIES, Nainital, in the central Himalayas. This radar helped them ‘see’ the wind sensing the faintest vertical motions of air.

For two years the scientists pointed this radar upward, collecting thousands of hours of

data as the radar-based measurements from this study filled a critical gap, providing the first continuous, precise, and high-resolution measurements of mean vertical air velocity as low as 5 cm s-1 over the Himalayas in all-weather conditions.

They were hunting for the vertical push and pull of wind inside the Asian Summer Monsoon Anticyclone, a giant swirling system that sits over the region every monsoon.

They identified a persistent downward- moving air between 10 and 11 km above Earth’s surface, a new feature that reveals a distinct region of descending motion in the upper troposphere during the monsoon months, indicating that vertical circulation within the Asian Summer Monsoon Anticyclone is more complex than previously understood, with alternating regions of rising and sinking air. The study also shows clear variations in vertical air movement in the lower and middle troposphere, while the steady upward air flow above 12 km stayed mostly unchanged.

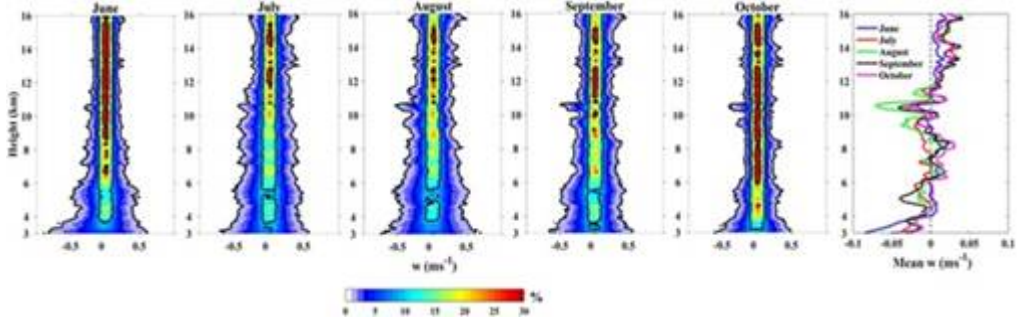

Fig. *Contour Frequency Altitude Diagrams showing how often different values of vertical velocity occur at each height for each month during clear-air conditions, based on the 2-year composite. The solid black lines indicate the 1%, 10%, and 25% occurrence levels. The panel on the far right displays the monthly mean vertical velocity profiles for June, July, August, September, and October.*

These results provide new insights into how air moves vertically within the anticyclone, especially the slow, steady rise above 12 km and the "two-step" process that carries air from the lower troposphere to the stratosphere.

The research, published in, "*Earth and Space Science", by* American Geophysical Union (AGU), hold immense potential for developing more accurate weather forecasts, strengthening early warning systems, and improving climate models that can protect agriculture, water resources, and human health.

Understanding the vertical motion within the Asian Summer Monsoon Anticyclone will also enhance assessments of pollutant and greenhouse gas transport, thereby contributing to improved air quality management and more effective climate change mitigation strategies.

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