Why cloudburst forecast in India still remains elusive

Monitoring stations on the ground can hardly capture cloudburst characteristics due to their highly localised and short occurrence.

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Cloudbursts — violent and voluminous amounts of rain pouring down in a short duration over a small area — have been reported since the mid-20th century. Yet, the characteristics of these events remain elusive, and our efforts in monitoring and forecasting them is at an embryonic stage. However, their disastrous impact that cause loss of lives and property is seemingly increasing in a changing climate and have led to close observations in the recent decade, advancing our understanding of these events.

Clouds blanket 70% of the Earth’s surface at any given time. They are like a thin layer of the floating ocean, with enough water to cover the entire surface of Earth with about one inch of rain. A modest-sized cloud (1 cubic km) may contain more than 5,000,000 litres of water — equivalent to the mass of hundred elephants.

Cloudburst events are often associated with cumulonimbus clouds that cause thunderstorms and occasionally due to monsoon winds surges and other weather phenomena. Cumulonimbus clouds can grow up to 12–15 km in height through the entire troposphere (occasionally up to 21 km) and can hold huge amounts of water.

**Characteristics**

However, cloudbursts are not defined based on cloud characteristics and do not indicate clouds exploding. Cloudbursts are defined by the amount of rainfall. According to the India Meteorological Department (IMD), 100 mm of rain in an hour is called a cloudburst. Usually, cloudbursts occur over a small geographical region of 20 to 30 sq. km.

In India, cloudbursts often occur during the monsoon season, when the southwest monsoon winds bring copious amounts of moisture inland. The moist air that converges over land gets lifted as they encounter the hills. The moist air reaches an altitude and gets saturated, and the water starts condensing out of the air forming clouds. This is how cloudbursts usually form, but such an orographic lifting together with a strong moisture convergence can lead to intense cumulonimbus clouds taking in huge volumes of moisture that is dumped during cloudbursts. Tall cumulonimbus clouds can develop in about half an hour as the moisture updraft happens rapidly, at a pace of 60 to 120 km/hr. A single-cell cloud may last for an hour and dump all the rain in the last 20 to 30 minutes, while some of these clouds merge to form multi-cell storms and last for several hours.

More prone areas

Cloudbursts, hence, occur mostly over the rugged terrains over the Himalayas, the Western Ghats, and northeastern hill States of India. The heavy spells of rain on the sloping topography trigger landslides, debris flows, and flash floods, causing large-scale destruction and loss of people and property. Recent cloudbursts that caused significant devastation occurred over the Himalayan foothills in Himachal Pradesh (in the year 2003), Ladakh (2010), and Uttarakhand (2013). Cloudbursts were reported from the northeastern States and Western Ghats States during the current monsoon season (2022).

On July 8, 2022, flash floods occurred in the Ladder Valley en route to Amarnath Temple in Jammu and Kashmir, taking the lives of several pilgrims. While the media linked this event to cloudbursts that occurred upstream of the temple, there is no meteorological record in the surrounding regions to validate this. Weather forecasters indicated scattered light rains for the region, and the IMD recorded moderate rainfall at the temple station. Monitoring stations on the ground can hardly capture the cloudburst characteristics due to their highly localised and short occurrence. Hence, most of these events go unreported due to the lack of monitoring mechanisms in the region, weakening our ability to understand these events in complete perspective.

Heavy rains and waterlogging brought Bengaluru to a standstill during the first week of September 2022. Social media was abuzz, passing off a two-year-old video of cloudbursts in Perth, Australia, as Bangalore cloudbursts. None of the city’s weather stations recorded a cloudburst but indicated heavy rains during the week as the monsoon winds gained strength due to a low-pressure area developing in the Arabian Sea.

Strong monsoon winds surged along the coast and also result in cloudbursts, as in the case of Mumbai (2005) and Chennai (2015). Coastal cities are particularly vulnerable to cloudbursts since the flash floods make the conventional stormwater and flood management policies in these cities dysfunctional.

**Why forecasting cloudbursts is a challenge**

Efforts to monitor and forecast cloudbursts are still at a nascent stage.

1. As per the IMD definition, over 100 mm of rainfall in one hour is called a cloudburst. It usually occurs over a small geographical region (20-30 sq. km).
2. Rainfall of 100 mm per hour translates to 100 litres per square metre where a cloudburst occurs. For a small region of 20 sq. km, it is about two billion litres of water in an hour.
3. Tall cumulonimbus clouds causing cloudbursts can develop quickly (in about 30 minutes) as the moisture updraft happens rapidly — 60-120 km/hr.
4. Cloudbursts occur mostly over the rugged terrains over the Himalayas, Western Ghats, and northeastern hill States of India.
5. In India, cloudbursts often occur during the monsoon season, when the SW monsoon winds bring copious amounts of moisture inland.
6. Satellites fail to detect cloudburst systems as the resolution of the precipitation radars are much smaller than the area of individual cloudburst events.
7. Multiple doppler weather radars can monitor moving cloud droplets and help to provide forecast for the next three hours. But radars are expensive and installing them widely may not be feasible.
8. The change in monsoon extremes and cloudbursts are in response to the 1-degree Celsius rise in global surface temperature.

**Frequent occurrences**

Cloudbursts are reported frequently from across the country. The climate change signal is conspicuous, but we do not have long-term (20 years or more) hourly data to attest it. With IMD enhancing its automatic weather stations, we may have hourly data that can help map cloudburst-prone regions.

The change in monsoon extremes and cloudbursts we see now are in response to the 1-degree Celsius rise in global surface temperature. As emissions continue to increase and global commitment to reduce emissions proves insufficient, these temperatures are set to hit 1.5°C during 2020-2040 and 2°C during 2040-2060. We will need urgent action and policies to protect lives and property from extreme events that will amplify the effects of global temperature changes.

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