Explained | IMD is already sensing heat waves. What are they and why do they happen?

PREMIUM

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A traffic policeman drinks water to quench his thirst during a heat wave, at the Delhi-Gurugram expressway, May 15, 2022. | Photo Credit: PTI

than the long-term average.

On February 21 itself, the national capital recorded its third hottest February day (33.6° C) in more than five decades.

In the week before, the IMD had warned of heat waves in the Kutch and Konkan regions, only to withdraw them after a sea breeze came to the rescue.

If the heat waves had played out, they would have been the earliest these regions would have experienced this deadly phenomenon.

El Niño + heat waves

Irrespective of whether these are freak occurrences, heat waves are expected to become more intense, longer, and more frequent over the Indian subcontinent. According to the IMD, a region has a heat wave if its ambient temperature deviates by at least 4.5-6.4° C from the long-term average. There is also a heat wave if the maximum temperature crosses 45° C (or 37° C at a hill-station).

Spring (March-April) in 2022 in India was already a sign of things to come: the heat wave 'season' started early, was more intense than the long-term average, and had more waves.

The 2022 heatwave season was also unusual because the heat waves extended much further south into peninsular India thanks to a north-south pressure pattern set up by the La Niña, a world-affecting weather phenomenon in which a band of cool water spreads east-west across the equatorial Pacific Ocean.

The last three years have been La Niña years, which has served as a precursor to 2023 likely being an El Niño year. (The El Niño is a complementary phenomenon in which warmer water spreads west-east across the equatorial Pacific Ocean.)

As we eagerly await the likely birth of an El Niño this year, we have already had a heat wave occur over northwest India. Heat waves tend to be confined to north and northwest India

Why do heat waves occur in the first place?

Origin of heat waves

Heat waves are formed for one of two reasons: because warmer air is flowing in from elsewhere or because something is producing it locally. Air is warmed locally when the air is warmed by higher land surface temperature or because the air sinking down from above is compressed along the way, producing hot air near the surface.

A study published on February 20, 2023, in *Nature Geoscience* offers some clues as to how different processes contribute to the formation of a heat wave. (The following explanation adapts the study's findings to the Indian context.)

1. In spring, India typically has air flowing in from the west-northwest. This direction is bad news for India for several reasons. In the context of climate change, the Middle East is warming faster than other regions in latitudes similarly close to the equator, and serves as a source of the warm air that blows into India.

2. Likewise, air flowing in from the northwest rolls in over the mountains of Afghanistan and Pakistan, so some of the compression also happens on the leeward side of these mountains, entering India with a bristling warmth.

3. The air flowing in over the oceans is expected to bring cooler air, since land warms faster than the oceans (because the heat capacity of land is much lower). Alas, the Arabian Sea is warming faster than most other ocean regions.

4. Next, the strong upper atmospheric westerly winds that come in from the Atlantic Ocean over to India during spring control the near-surface winds. Any time winds flow from the west to the east, we need to remember that the winds are blowing faster than the planet itself, which is also rotating from west to east. The energy to run past the earth near the surface, against the surface friction, can only come from above. This descending air compresses and warms up to generate some heat waves.

tends to warm the upper atmosphere faster than the air near the surface. This in turn means that the sinking air is warmer due to global warming, and thus produces heat waves as it sinks and compresses.

Given these are the processes that contribute to the formation of a heat wave, and the ways in which global warming affects them, it must be clear why once-a-decade heat wave events have started to occur once every few years, and are also more intense. The area covered by these heat waves is also influenced by the background pressure patterns set up by El Niño and La Niña events, and of late it has been expanding.

Sophisticated anatomy

The other factors that affect the formation of heat waves are the age of the air mass and how far it has travelled. The north-northwestern heatwaves are typically formed with air masses that come from 800-1,600 km away and are around two days old. Heat waves over peninsular India on the other hand arrive from the oceans, which are closer (around 200-400 km) and are barely a day old. As a result, they are on average less intense.

In sum, heat waves have a sophisticated anatomy with important implications for how well we can predict them. Nonetheless, early-warning systems can take advantage of the processes, modes of formation, location, and age of the air mass to improve the quality of warnings and also increase how soon they can be issued. Sizeable investments in human and computational resources have already increased India's forecast skills in the last decade.

For reasons that we are yet to fully understand, mortality over India due to heat waves are substantially lower than those in other mid-latitude regions (including potentially significant underreporting).

We should also not become complacent, and further improve forecast warnings, issue them as soon as possible, and couple them with city-wide graded heat action plans to protect the vulnerable.