Winter Temperature Trends Across India

Faster warming in February makes spring feel shorter

INTRODUCTION

Global mean temperatures have risen by more than 1.3° since 1850, and set a new record in 2023. The primary cause of this warming is rising levels of carbon dioxide in the atmosphere from burning coal, oil, and natural gas. The purpose of this analysis is to place India in the context of these global trends, with a focus on winter (December-February).

We calculated the monthly average temperature for 33 states and union territories. We focused on the period 1970-present as this is the period when most global warming has occurred and for which consistent data exists. For each state or territory, we found the rate of warming for each month and each three-month meteorological season. Warming rates are expressed as change in the state-average temperature since 1970.

Additionally, many Indians report that spring has disappeared–temperatures transition quickly from winter to summer-like conditions. We consider whether warming trends in the winter can explain this observation and where it is most likely to apply.

RESULTS

1. Winter is warming across India

Every region considered had net warming during winter (Figure 1). Manipur had the largest change since 1970 (2.3°C), while Delhi had the smallest (0.2°C). Winter is the fastest warming season for 12 out of the 34 states and territories considered. This is second only to autumn, which was the fastest warming season in 13 regions.

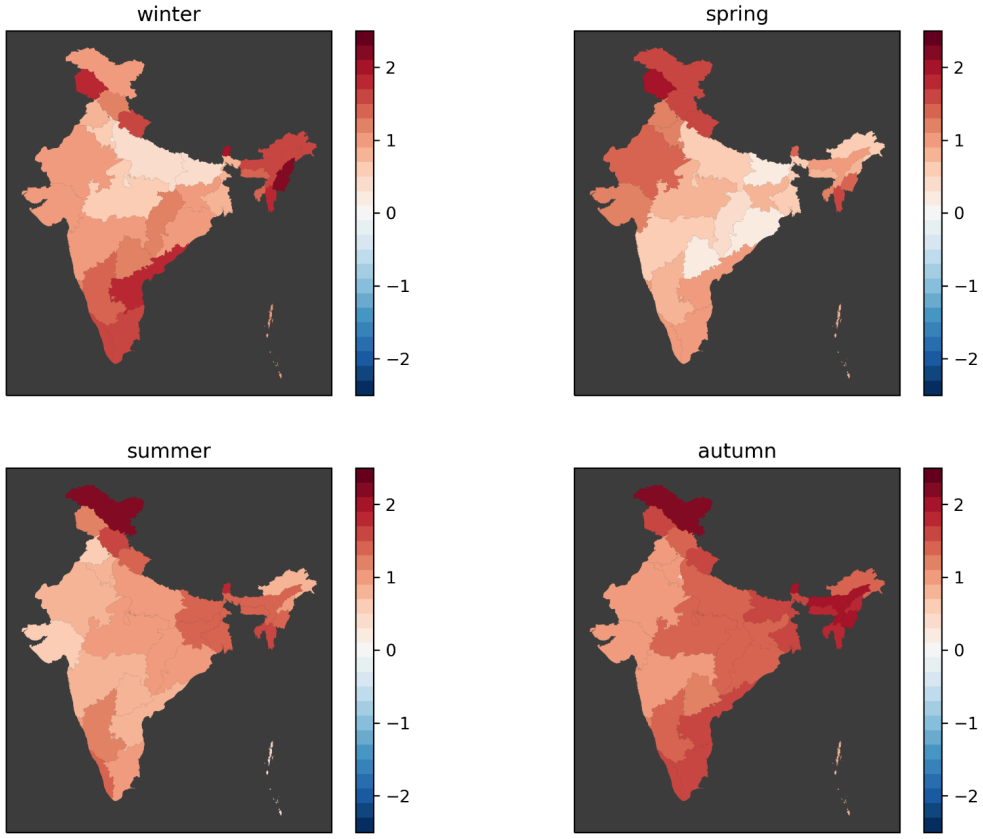

Figure 1. Seasonal warming trends in India. The warming rate is expressed as the change in temperature since 1970.

2. The pattern of warming changes during the winter

There are notable differences in the pattern of temperature changes during the winter season. The southern part of the country has strong warming in December and January (Figure 2). Sikkim (2.4°) and Manipur (2.1°) had the largest changes in temperature in December and January, respectively. The northern part of the country had weaker warming and even cooling during December and January. Delhi had the lowest rates during this period (-0.2° in December, -0.8° in January), and among the states Ladakh (0.1° in December) and Uttar Pradesh (-0.8° in January) had the lowest warming rates.

The pattern changes dramatically between January and February. All regions have warmed in February, but the warming is especially pronounced in many of the regions that showed cooling or low warming in the previous months. Jammu and Kashmir had the highest warming (3.1°C) and Telangana had the lowest (0.4°C).

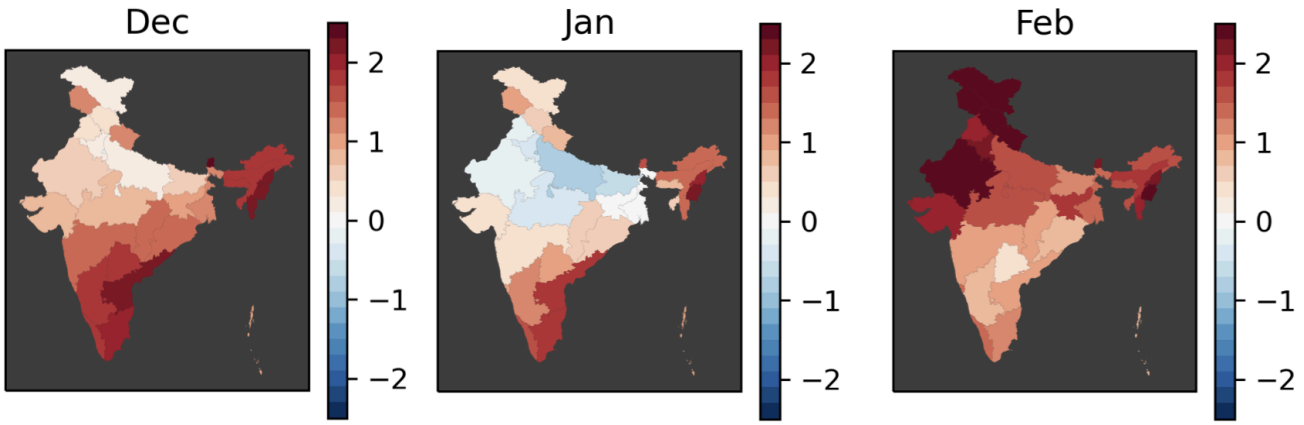

Figure 2. Monthly warming trends in India during winter. The warming rate is expressed as the change in temperature since 1970.

3. Sudden changes in temperature now occur in late winter

In the northern part of India, the contrast between January trends (cooling or slight warming) and February (strong warming) means that these regions now have the potential for abrupt transitions from cool winter-like temperatures to the much warmer conditions that traditionally occurred in March.

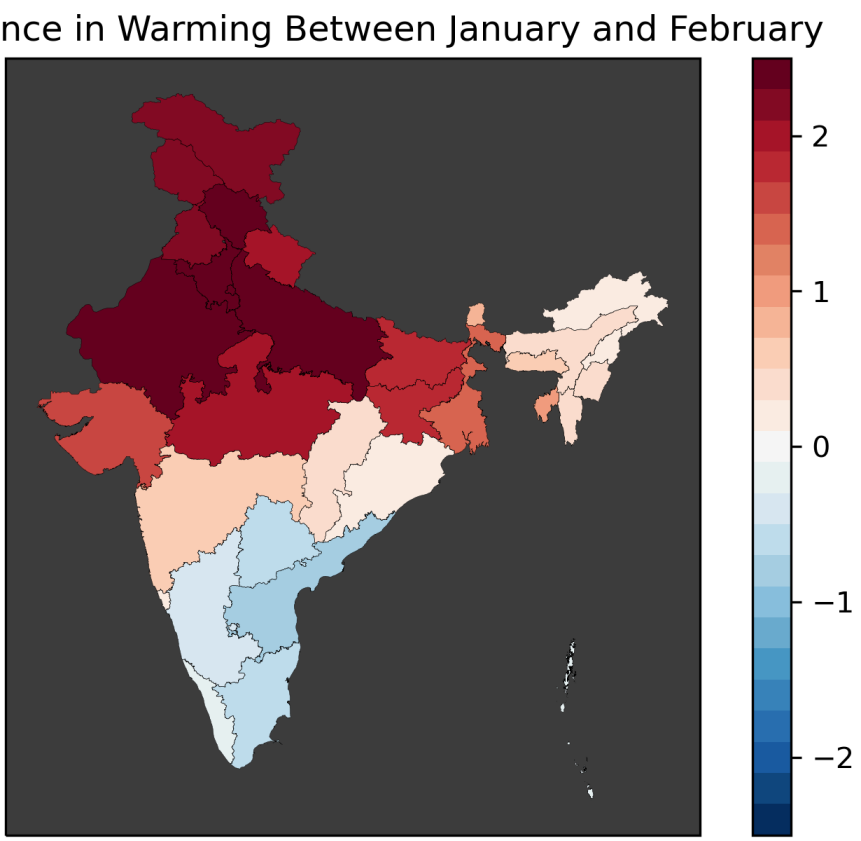

Figure 3. Change in warming rates between January and February. Values are changes in February temperatures since 1970 minus change in January.

To show this change, we took the difference between the January and February warming rates (Figure 3). The largest jump in warming rates occurred in Rajasthan (Figure 4. February warming=2.6° higher than January). A total of nine states and territories showed a January-February difference of more than 2°C: Rajasthan, Haryana, Delhi, Uttar Pradesh, Himachal Pradesh, Ladakh, Punjab, Jammu and Kashmir, and Uttarakhand. This supports the reports that it feels like spring has disappeared in many parts of India.

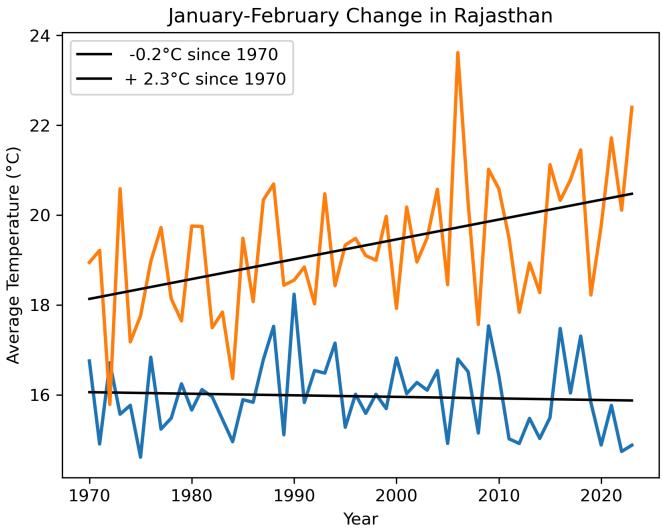

Figure 4. Temperature changes in Rajasthan in January (blue, -0.2°C since 1970) and February (orange, 2.3°C since 1970).

Methods

Calculating Monthly and Seasonal Average Temperatures

We extracted daily average temperatures from ERA5 from January 1, 1970 to December 31, 2023. ERA5 uses sophisticated computer models to blend meteorological observations from weather stations, balloons, and satellites. For each 0.25°-by-0.25° grid cell, we computed the mean over each month. The monthly data was then averaged across 34 states and union territories. Chandigarh and Lakshadweep were excluded from the analysis due to their small size.

Monthly averages were combined into averages for the meteorological seasons: winter = December-February, spring = March-May, summer = June-August, autumn = September-November.

Calculating Monthly and Seasonal Trends

For each region we used linear regression to fit a trend line for each month and season. The trend lines describe how the climate is changing. They are the best estimate of the most likely temperature in a given year. The actual observed temperature is then a combination of the long-term trend and variability from weather in that year.

The trend line captures the rate of warming (°C per year). These rates were multiplied by 53 to get the change in temperature since 1970. Note that this is not the difference in temperature between starting and ending years. This is the change in the long-term average conditions captured by the linear regression.

About Climate Central

Climate Central is an independent group of scientists and communicators who research and report the facts about our changing climate and how it affects people's lives. They collaborate widely with TV meteorologists, journalists, and other respected voices to reach audiences across diverse geographies and beliefs. Their work addresses climate science, sea level rise, extreme weather, energy, and related topics. Climate Central is a policy-neutral 501(c)(3) nonprofit.

Climate Central's Climate Shift Index (CSI) system, grounded in the latest peer-reviewed attribution science, quantifies the influence of climate change on daily temperatures around the world. CSI levels indicate how much human-caused climate change has altered the frequency of daily temperatures at a particular location.

Quotes

Dr. Andrew Pershing, VP for Science at Climate Central, said:

"The cooling in the central and northern Indian states during January followed by very strong warming in February creates the potential for a quick jump from winter to spring-like conditions."

"By burning coal and oil, humans have warmed the planet leading to warmer conditions in all seasons across India."