



Urban Heat Stress in major cities of India: Kolkata (East & Northeast India)

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The Urban Lab of Centre for Science and Environment (CSE) has analyzed the temperature trends for India from Jan 2015 till May 2022. This is an effort to understand the warming trend in a comprehensive way by covering all three dimensions of heat stress—Surface air temperature, Land surface temperature, and relative humidity (heat index). This city report is part of the larger study that has analyzed heat stress trends at global, national, regional, and local level. The city level analysis of this study covers metropolises of Delhi, Mumbai, Kolkata and Hyderabad (each located in different IMD's homogenous region). Objective of the city analysis is to understand the combined effect of climate change induced unseasonal heatwaves and urbanisation induced heat Island effect on the thermal comfort and heat stress among these topographically and climatically diverse in cities.

This is part of the larger report on heat stress in India. For the main report please follow this [link](https://www.cseindia.org/heatwave-paper-National.pdf) (<https://www.cseindia.org/heatwave-paper-National.pdf>).

Data and method

Freely accessible data is available on United States Geological survey (USGS) Earth Explorer website. Landsat 8 operational land imager/thermal infrared sensor (OLI/TIRS) satellite imagery were downloaded and used to analyze the land surface temperature.

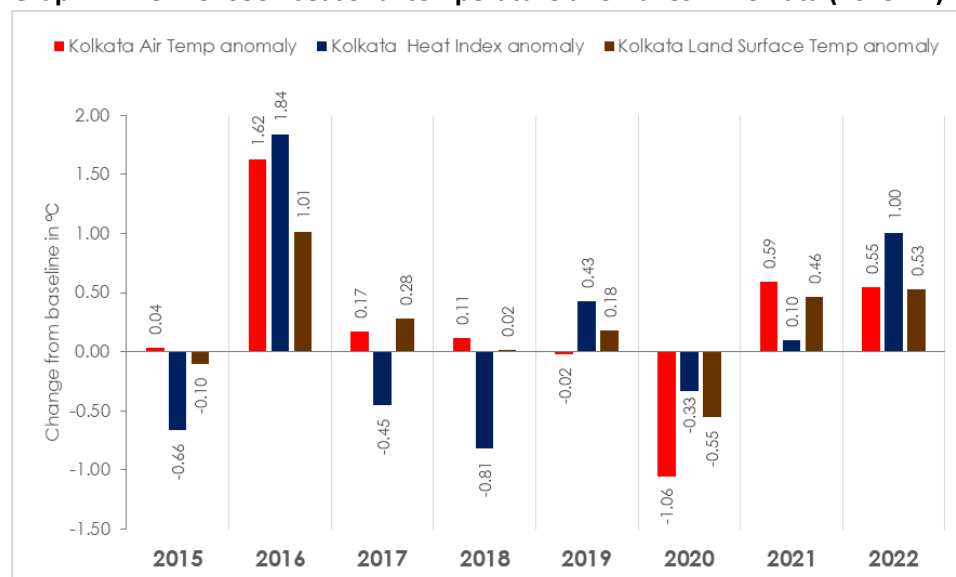
This city level assessment is focused on two things: Change in heat patterns over years for pre-monsoon season; and the land surface temperature variation on days with high air temperature during the pre-monsoon season of 2014, 2016, 2018, 2020 and 2022. For Kolkata the later analysis is based on 22 April 2014, 11 April 2016, 17 April 2018, 6 April 2020 and 28 April 2022.

Please refer the main report for further details on data and methodology employed in this study.

Findings-Heat patterns during pre-monsoon season

All heat parameter up this season in Kolkata but still not as hot as 2016 pre-monsoon: Kolkata recorded significant positive anomaly on all three temperature parameters. Air temperature has been 0.55°C hotter than 1981-2010 baseline, while land surface temperature has been 0.53°C hotter. Heat Index is up by 1.00°C compared to 2010-19 baseline. This year pre-monsoon season has not been as hot as recorded in 2016 and 2021. Unlike the trend noted at the India level, Kolkata has reported minimal departure from normal for pre-monsoon season in 2015, 2017 and 2018. In 2020, which was the hottest year for the planet so far Kolkata was cooler than normal by over 1°C (See *Graph 1: Pre-monsoon seasonal temperature anomalies in Kolkata (2015-22)*).

Graph 1: Pre-monsoon seasonal temperature anomalies in Kolkata (2015-22)



Note: Daily heat index was computed using the U.S. National Oceanic and Atmospheric Administration's (NOAA) formula. Air temperature and land surface temperature anomalies are computed with respect to 1981-2010 baseline. Heat Index anomaly is computed with respect to 2010-19 baseline.

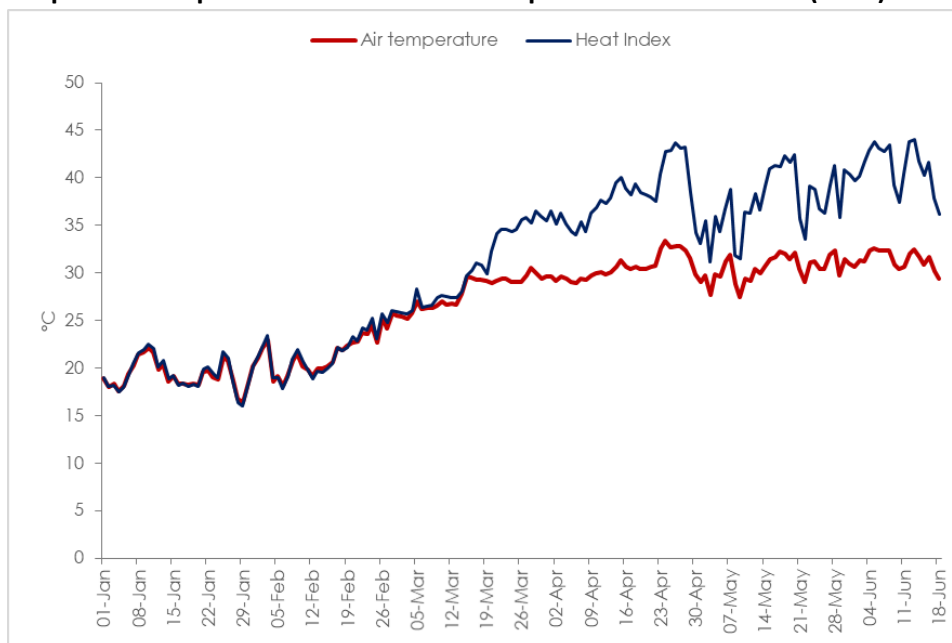
Source: CSE analysis of IMD ground observation data and NASA satellite based remote sensing data

Heat Index is better measure of thermal discomfort in Kolkata, as it continues to climb up despite stabilization of air temperatures: Daily average air temperature in Kolkata tends to stabilize around 30°C from April onwards. But heat index continue to rise due to increase in humidity. Daily average heat index is usually 6-12°C higher than daily average air temperature. Since IMD doesn't account for humidity in its consideration for heatwaves, dangers of humid heat that is known to be more lethal to humans don't get reported. The daily average heat index crossed 41°C mid-April itself (See *Graph 2: Buildup of heat in Kolkata air temperature vs heat index (2022)*). Heat Index higher than 41°C is considered dangerous for human health while heat index of 54°C or higher is considered extremely dangerous.

Belur Math and Ballygunge surroundings were on average hottest neighborhoods based on heat index: There is variation of over 1.2°C in the observed seasonal air temperature among neighborhoods that have official air quality monitoring. Fort William recorded highest seasonal air temperature average of 29.9°C in the city while Victoria with 28.7°C was the coolest. From heat index perspective Belur Math in Howrah with an average seasonal heat index of 38.5°C has been the hottest part of the city. Rabindra Bharti

University had lowest average seasonal heat index in the city (See *Graph 3: Distribution of pre-monsoon heat within Kolkata air temperature vs heat index*)

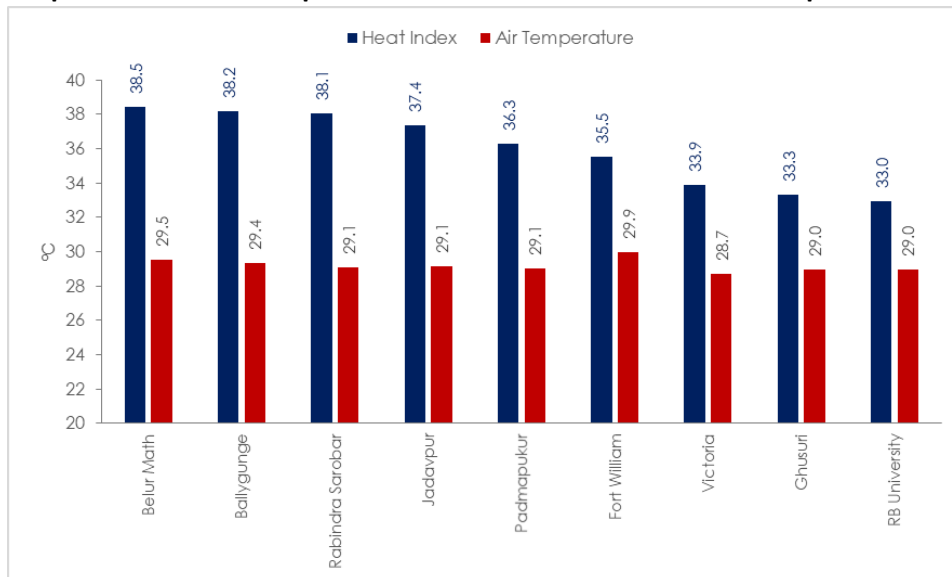
Graph 2: Buildup of heat in Kolkata air temperature vs heat index (2022)



Note: Daily heat index was computed using the U.S. National Oceanic and Atmospheric Administration's (NOAA) formula.

Source: CSE analysis of IMD ground observation data

Graph 3: Distribution of pre-monsoon heat within Kolkata air temperature vs heat index



Note: Daily heat index was computed using the U.S. National Oceanic and Atmospheric Administration's (NOAA) formula.

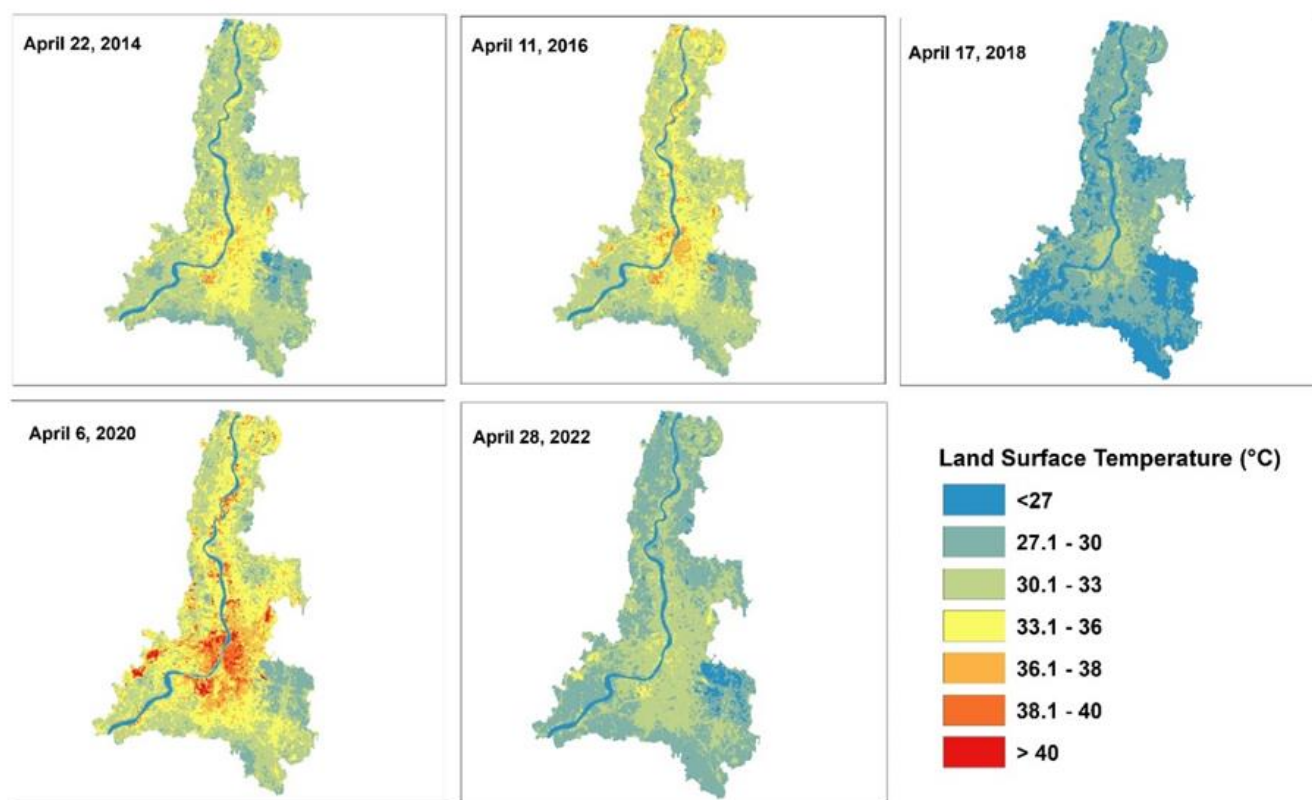
Source: CSE analysis of temperature and humidity data from CAAQMS network of CPCB

Findings-Heat patterns on hot days

Land surface temperature (LST) variation on hot days over years: Bright red tone in the map represents region with high temperature and as the tone shifts towards blue, the temperature reduces. Highest LST was observed on April 6, 2020 when 47.4°C was recorded within city limits. It is followed by April 11, 2016 (42.3°C) and April 22, 2014 (41.4°C). This year, maximum LST was observed to be just 36.6°C (See *Figure 1: Variation in land surface temperature over Kolkata for 2014, 2016, 2018, 2020 and 2022*).

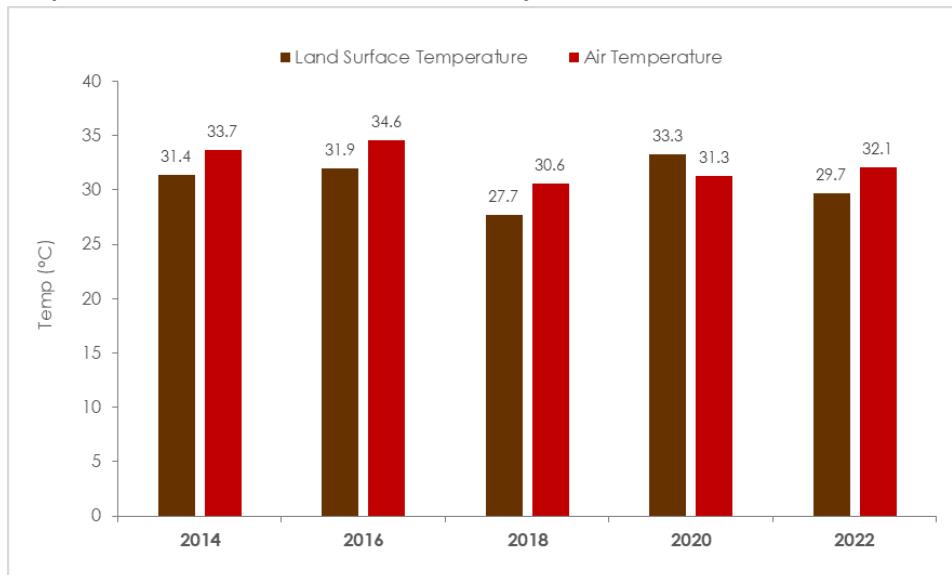
Maximum LST is recorded in the city center, around Netaji Shubash Chandra Bose International Airport and the areas alongside the Hooghly River. All these areas recorded LST values above 37°C. In general, minimum LST is observed minimum was observed in the areas in and around the wetlands in the eastern part of the city.

Figure 1: Variation in land surface temperature over Kolkata for 2014, 2016, 2018, 2020 and 2022



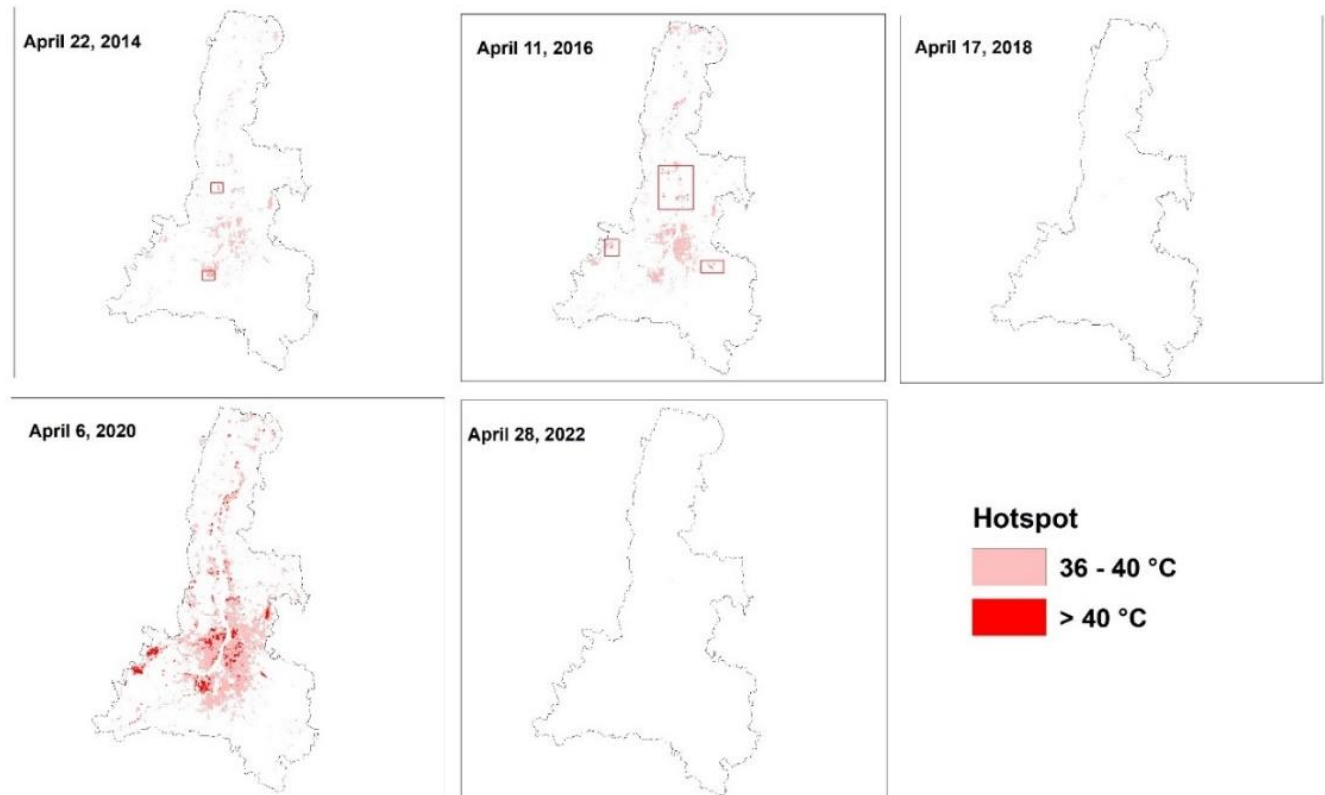
Source: CSE analysis of Landsat 8 satellite image from USGS Earth Explorer website

Decreased Land Surface Temperature this summer: The average LST in Kolkata on April 28, 2022 was 29.7°C. Compared to April 6, 2022 the average LST has decreased by 3.6°C (see *Graph 4: LST Trend over Kolkata during heatwave spells in 2014, 2016, 2018, 2020 and 2022*). This is despite the daily average air temperature on April 28, 2022 being higher compared to April 6, 2022. In general the average LST has been lower than the daily average air temperature recorded at city's primary weather station at Dumdum. 2020 summer has been an exception probably due to massive reduction in PM pollution in the city due to Covid lockdowns. PM pollution partly blocks solar radiation from reaching the ground. In absence of it land is exposed to higher load of solar radiation which leads to high LST.

Graph 4: LST Trend over Kolkata on hot days in 2014, 2016, 2018, 2020 and 2022

Note: Average land surface temperature is based on mean of all values recorded over the city and ambient temperature is based on mean of daily values recorded at 2 stations in the city.

Source: CSE analysis of Landsat 8 land surface temperature and IMD weather data from Santa Cruz Meteorological Station

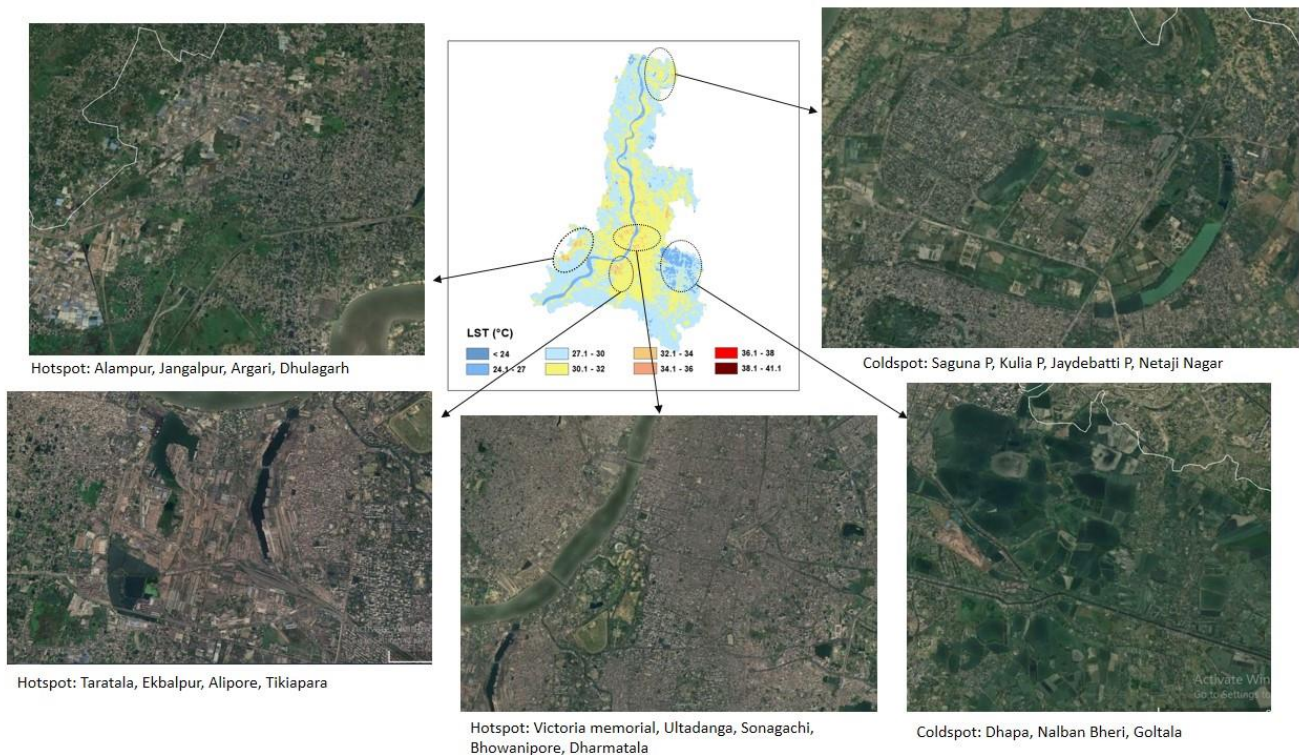
Figure 2: Hotspots identification over Kolkata on hot days in 2014, 2016, 2018, 2020 and 2022

Source: CSE analysis of Landsat 8 satellite image from USGS Earth Explorer website

Identification of heat hotspots over Kolkata: April 6, 2020 showed the most number of hotspot with LST exceeding 36°C followed by April 11, 2016 and April 22, 2014 (see *Figure 2: Hotspots identified over Kolkata during heatwave spell in 2014, 2016, 2018, 2020 and 2022*). The least number of hotspot were observed this year (April 28, 2022) and April 17, 2018. LST in the Kolkata Municipal Corporation and eastern Howrah are consistently high.

Denuded and densely built areas are the heat hotspots: Hotspot areas were observed in the eastern part of Howrah, Kolkata Municipal Corporation, western part of North 24 Paraganas and eastern part of Hooghly. Highly dense neighborhoods around Victoria and Alipore have consistently higher LST. Coldspots, areas with minimum LST, are observed in Dhapa and Netaji Nagar (See *Figure 3: Hotspots and Coldspots over Kolkata*).

Figure 3: Hotspots and Coldspots over Kolkata



Source: CSE analysis of Landsat 8 satellite image from USGS Earth Explorer website