Correlation between Land Surface Temperature and Urban Heat Island with COVID-19 in New Delhi, India

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Abstract

This study aims to analyse the correlation between Urban Heat Island (UHI), Land Surface Temperature (LST) with COVID-19 (Coronavirus disease) pandemic in New Delhi, India. This study engaged a secondary data analysis of surveillance data of COVID-19 from Ministry of Health and Family Welfare Government of India and temperature data from MODIS (MOD11A1 & MOD11A2). The significant relation in between COVID-19 confirmed cases and LST in day time postulate a positive significance (p value <0.05) with $R^2=81\%$ and for night time this is $R^2= 86\%$.

Highlights

1. Covid-19 is a pandemic disease which now widely spreading all over world.
2. The weather-temperature factor: LST is one of the most important prompt factors which shows its weather-related impact on Covid-19.
3. The spread of covid-19 and temperature in India is very fast, so this result of this study will be useful in efforts to thwart the spread of covid-19 disease

1. Introduction

A pneumonia case in Wuhan city, Hubei Province China has been reported by World Health Organization (WHO) whose reason of origin was unknown (WHO, 2020). The case was rapidly developing until on January 2020, when Chinese Government declared that the pneumonia represents a new type of Coronavirus or COVID-19. COVID-19 is an extremely transmissible disease which was first recognized in December 2019 in Wuhan, Central China. Globally till 23rd of March, more than 14,000 people have died and greater than 334,000 have been infected by COVID-19 (WHO, 2020). Over the world as on 26th of April the statistics of the death rate have been stated 200,000. Due to the transmittal of COVID-19, a nationwide lockdown was imposed in India from 24th of March for three weeks up to 14th of April and later extended up to 3rd of May (Chen B et al., 2020). Due to this implementation of nationwide lockdown most of the industrial activities and mass transportation have been restricted. This resulted in the drastic dropping of pollution level only after the initiation of lockdown procedure in 88 cities across the country according to the data provided by CPCB (Central Pollution Control Board, India, 2020). Thus, it can be concluded that lockdown has been an alternative measure for controlling air pollution and temperature. This present work has been intended to prove the relation among the urban heat island and the temperature over the study region (Li, Q et al., 2020).

Urban heat island (UHI), a phenomenon first described in 1818, refers to the occurrence of higher atmospheric and surface temperatures in urban areas than in the surrounding rural areas (Ma Y et al., 2020). There are two types of UHIs: surface UHI and atmospheric UHI. Surface UHIs are measured based on Land Surface Temperature (LST), while atmospheric UHIs are measured based on air temperature. These are calculated based on air temperature and are often classified into canopy layer UHIs and boundary layer UHIs. This study is focused on the surface UHI which are typically presented in both the

cases of day and night. They are tended to be strongest during day due to the radiation from the sun. UHI demonstrate themselves in various forms in a city and its suburban areas (Chakraborty, Surya Deb et al., 2015). They impact air temperatures in the canopy layer (micro-scale; roughly from the ground to tree or building height) along e.g. precipitation in the boundary layer (meso -scale; in the layer of the atmosphere that is still affected by the city, but above the canopy layer). Additionally, UHI are recognized for surface temperatures along with subsurface temperatures. The researches that evolved for the quantification of UHI states that determination of canopy layer of UHI is measured by the air temperature (usually 2m) above the ground (Chakraborty, T., and X. Lee, 2019). There are two main strands of research that has been evolved for quantifying the UHI, the first of which is that, this measurement has been enacted transversely through a city or through a comparative analysis of temperatures, like to illustrate the city center and it surrounding rural areas. Secondly, the surface UHI is derived from remote sensing data. Whereas measurements of air temperatures above the ground is directly connected with the UHI in the canopy layer, and the thermal emissivity of land surfaces and the derived Land Surface Temperatures (LST) can be extracted using remote sensing data. Remotely sensed data and above ground air temperatures are related and unique. However, the term “surface UHI” is often used to precisely distinguish UHI measured using LSTs from air temperature patterns.

One of the significant beneficial impacts of lockdown due to COVID-19 is the global restoration of elements of weather like air quality, temperature (Anderson, R.M. et al., 2020). This present study thus signifies the direction how a relationship could be established between UHI, its corresponding temperature and the rate of spreading of COVID-19 in New Delhi India. Focusing on the NCT (National Capital Territory) of Delhi the study is thought to be a conceivable addition to the scientific community providing a nudge towards the sustainable urban planning and an easy alternative planning for the upgraded resilient capital city in the upcoming years (Cucinotta, D., Vanelli, M., 2020).

2. Study Area

Delhi, one of the largest megacities of South Asia and the capital of India, is located at 28.5° N latitude and 77° E longitude and 216 m above mean sea level (Mahato, Susanta et al., 2020) which is visually summarized in Figure 1. Delhi lies almost entirely on the Gangetic plains with the Thar Desert in the West, central hot plains in the South, and hills in the North and East. The river Yamuna forms the eastern boundary passing through the city. The city lies in a semi-arid climate zone. In the last two decades, the city grew from being Delhi to National Capital Region (NCR) of Delhi, covering an area of ~1,500 km² (Amann, M. et al., 2017).

3. Materials And Methodology

3.1. DATA

In this paper we used day and night time 8-day composite LST data from MODIS with spatial resolution of 1 km derived from Land Processes Distributed Active Archive Centre (LPDAAC) of the United States

Geological Survey (USGS) (Ramachandran, S, 2007), captured in a clear sky condition. The MOD11A1 LST are retrieved from the Terra MODIS band 31 (11 μm) and band 32 (12 μm) thermal infrared radiances using a Generalized Split-window (GSW) algorithm (Peel M C et al., 2006). Each MOD11A1 (1 day) and MOD11A2 (8 days) data product is delivered in a gridded. HDF format, which contains two LST datasets (a daytime at $\sim 10:30$ local solar time and a night time at $\sim 22:30$ local solar time; $+5:30$ GMT). The COVID-19 cases number has been obtained from Ministry of Health and Family Welfare Government of India (<https://www.mohfw.gov.in/>).

3.2. METHODOLOGY

We considered the dates from 29-03-2020 up to 30-04-2020, these dates have been taken amidst the lockdown period with 8 days interval MOD11A1 LST data. The difference in Land surface temperature between core urban (Tu) and Non-urban (Tr) area i.e.; Rural area ($\Delta T = T_u - T_r$) ΔT represents UHI else UCI (Urban Cool Island) (Kumar Rahul et al., 2017). Urban area was assigned with a 10 km width strip of non – urban area depending of the size of the area. The rural area has been demarcated with a buffer zone of 10 km surrounding the urban area. Finally, we analyzed the correlation between LST data, along with the COVID-19 cases (Drosten C. et al., 2003).

4. Result

4.1. Urban Heat Island and Land Surface Temperature analysis

In this paper we have selected dates from the end of March and April which is a transition period between winters to summer season in India. Due to this reason the LST (Land Surface Temperature) has been found relatively higher in day than night. The day time maximum and minimum temperature of urban and rural area has been recorded simultaneously as 45.89°C , 31.19°C and 48.87°C , 26.15°C whereas the night time has been recorded as 27.06°C , 14.79°C and 26.70°C , 13.77°C which is graphically represented in Figure 2. The UHI and UCI phenomena found in Delhi indicate the role of land surface temperature variability between core urban (Tu) and the surrounding non-urban area (Tr). During this time (April ends) when air temperature is at the peak in India, LST became much hotter than that of the end of March (Zhao, L et al., 2014). Delhi faced UCI (Urban Cool Island) during day time that means the rural area experiencing more temperature than core urban area; vice-versa situation has been seen in night time. This summary is visualized in statistical manner in following graphs (Figure 2).

4.2. Correlation among LST, UHI and COVID-19 Cases

On the present pandemic situation of COVID-19, present cases in forecasting the confirmed cases are already directed by many researchers (Shi, P et al., 2019). Figure shows that how urban and rural places are appreciably contributing with temperature and COVID-19 confirmed cases. Here we assume the significant p-value is <0.05 and this is significantly satisfying the null value. Apparently, the logarithmic regression we used here signifies that how Land Surface Temperature (LST) in day time aids with positive significance with $R^2=81\%$ (p-value is 0.02) and for night time this is 86% (p-value is 0.08). This

determines that the cluster of datasets for LST with relation to COVID-19 cases represents a positive relation that inferably apparent to both the parameters (Wang, Y et al., 2020) is shown statistically on graphical representation on Figure 3. On the other hand, UHI (Urban Heat Island) which signifies the proceedings of heat difference between rural and its urban neighbor does not signify any combatant relation to COVID-19 cases. The significance of this combatant is showing R² value 37% for daytime UHI and 17% approximately in night time UHI. Hence this algorithmic based regression system simply implies the negative correlation with epidemic cases while LST is significantly approaching higher as the COVID-19 cases are getting increase day wise. Hence proving UHI is not significant with COVID-19.

5. Conclusion

A significant correlation has been established between temperature and COVID-19 cases proving an important factor for the cause of rapid increase in incident rate in New Delhi.

Declarations

Declaration of Conflict of Interest

The Authors declare that they have no conflict of interest.

References

- Amann, M., Purohit, P., Bhanarkar, A.D., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Kiesewetter, G., Klimont, Z., Liu, J. and Majumdar, D., 2017. Managing future air quality in megacities: A case study for Delhi. *Atmospheric Environment*, 161, pp.99-111.
- Anderson, R.M., Heesterbeek, H., Klinkenberg, D., Hollingsworth, T.D., 2020. How will country-based mitigation measures influence the course of the COVID-19 epidemic? *Lancet* 395, 931–934.
- Chakraborty, Surya Deb, Yogesh Kant, and Debashis Mitra. "Assessment of land surface temperature and heat fluxes over Delhi using remote sensing data." *Journal of environmental management* 148 (2015): 143-152.
- Chakraborty, T., and X. Lee. "A simplified urban-extent algorithm to characterize surface urban heat islands on a global scale and examine vegetation control on their spatiotemporal variability." *International Journal of Applied Earth Observation and Geoinformation* 74 (2019): 269-280.
- Chen B, Liang H, Yuan X, Hu Y, Xu M, Zhao Y, et al. Roles of meteorological conditions in COVID-19 transmission on a worldwide scale. medRxiv 2020.
- Cucinotta, D., Vanelli, M., 2020. WHO declares COVID-19 a pandemic. *Acta bio-medica: Atenei Parmensis* 91, 157.

Drosten C, Gunther S, Preiser W, et al. Identification of a novel coronavirus in patients with severe acute respiratory syndrome. *N Engl J Med* 2003;348:1967–76.

Kumar, Rahul, Vimal Mishra, Jonathan Buzan, Rohini Kumar, Drew Shindell, and Matthew Huber. "Dominant control of agriculture and irrigation on urban heat island in India." *Scientific reports* 7, no. 1 (2017): 1-10.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., et al., 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. *N. Engl. J. Med.*

Ma Y, Zhao Y, Liu J, He X, Wang B, Fu S, et al. Effects of temperature variation and humidity on the mortality of COVID-19 in Wuhan. *medRxiv* 2020.

Mahato, Susanta, Swades Pal, and Krishna Gopal Ghosh. "Effect of lockdown amid COVID- 19 pandemic on air quality of the megacity Delhi, India." *Science of The Total Environment* 2020): 139086.

Peel, M. C., Finlayson, B. L. & McMahon, T. A. Updated world map of the Kppen-Geiger climate classification. *Meteorol. Zeitschrift* **15**, 259–263 (2006).

Ramachandran, S. Aerosol optical depth and fine mode fraction variations deduced from Moderate Resolution Imaging Spectroradiometer (MODIS) over four urban areas in India. *J. Geophys. Res. Atmos.* **112**, 1–11 (2007).

Shi, P., Dong, Y., Yan, H., Li, X., Zhao, C., Liu, W., et al., 2020. The Impact of Temperature and Absolute Humidity on the Coronavirus Disease 2019 (COVID-19) Outbreak-Evidence from China. *medRxiv*.

Wang, Y., Wang, Y., Chen, Y., Qin, Q., 2020b. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. *J. Med. Virol.*
Widiarso T. *Rekayasa Gaya Hidup Menuju Kota Masa Depan Yang Berkelanjutan Di Indonesia*.

World Health Organisation. Summary table of SARS cases by country. 1 Nov 2002–2020. [country2003_08_15.pdf](#).

Zhao, L., Lee, X., Smith, R. B. & Oleson, K. Strong contributions of local background climate to urban heat islands. *Nature* **511**, 216–219 (2014).

Figures

Figure 1

Day time Land Surface Temperature (LST) study map of research site showing with 10 km buffer

Figure 2

Graphical representation showing Day (a) and Night (b) time disperse and scatter of LST and UHI varying date wise in Urban and Non-Urban Land Surface Temperature

Figure 3

Showing algometric distribution and regression relation with COVID-19 cases in date wise through Day (a) and Night (b) time LST values