



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

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SHORT ABSTRACT

Urban forcing on the overlying atmosphere varies over a wide range of scales, developing intense urban-atmosphere interactions resulting in the generation of small-scale, intense, and highly unpredictable climatic systems. The advantages of numerical weather prediction (NWP) models to understand the land-atmosphere interactions and their ability to dynamically downscale coarser resolution global climate products integrated with higher resolution surface parameters has been a widely accepted approach in studying this process. However, the accurate representation of urban morphology is critical in improving the potential of mesoscale NWP models like WRF (Weather Research and Forecasting) to simulate the micro-climatic conditions over the cities more precisely. This study adopted a two-city approach to analyse the urban-atmosphere interactions in the case of the complex tropical region by selecting two dimensionally different cities, i.e., Kolkata and Guwahati, which also differed in terms of urban intensity. Both cities are situated on the most active monsoon belt of the Indian sub-continent, which also has significant influence on their regional climatology.

A high-resolution uWRF model was configured considering the general climatology of the region and incorporating improved urban surface characteristics using Local Climate Zone (LCZ) maps. Advanced deep learning-based image classification techniques were applied to derive the LCZ products from high resolution satellite images for both cities. This high-resolution model was further used in analysing different scenarios to understand the nature of micro-scale interaction between urban surfaces and the overlying climate, with the purpose of enhancing the understanding of urban micrometeorology under varying natural and

anthropogenic conditions. The modelled results for important climate variables like T_2 (2m air temperature), T_s (surface/skin temperature), WS (10m wind speed), RF (cumulative rainfall), RH (2m relative humidity), etc. were analysed in detail. The climatic variations from most complex urban areas (overlapping with the city core) towards the outskirts of the city were most prominent during the pre-monsoon season for both cities. The core city with the highest and most compact built-up configuration was observed to be almost 2.5 °C to 3°C warmer than the surrounding vegetated areas during the day and about 1.8°C to 2.5°C at night in case of Kolkata and upto 5 °C during the day and 3.5 °C at night in case of Guwahati revealing the distinct UHI effect for both cities. A gradual decline in T_2 values in a range of 0.2 – 0.5 °C and an increase in WS values in a range of 0.5 – 1 ms⁻¹ with each consecutive urban LCZ class was observed, implying the direct impact of compact urban geometry on local climate. Although the other variables like T_s and RF also followed a declining trend in this direction, the transformation did not exactly follow a gradual trend.

The analysis further revealed that the dimensions and intensity of urbanization has a definite impact on the synoptic scale weather event such as monsoons, as a gradual increase (3 – 5 mm) in the RF magnitude was visible from LCZ 2 to LCZ 6 which further increased (upto 15 mm) in the non-urban surroundings. However, these variations in RF were more vividly observed in case of the larger and denser Kolkata region whereas, it seemed to be influenced more by the local topography in case of the relatively smaller and less dense Guwahati. Moreover, evaluation of the urban-climate conditions according to the changing urban landscape over 20 years also revealed a similar trend. Analysis of these parameters with much reduced anthropogenic functions during the COVID-19 lockdown phase in 2020 showed a considerable improvement in the meteorological conditions compared to the usual trend in 2019. Thus, an optimal urban micro-climate index (UMCI) was developed to evaluate the combined effects of the different climate variables on the intra-urban climatic conditions. This index can be a helpful tool in assessing the urban meteorological health identifying the most liveable as well as the vulnerable pockets within the cities during different phases of the day. Further, modifications in the existing urban morphology by implementing suitable heat mitigation measures proved to be an important strategy to address the adverse climatic effects on densely populated developing cities by reducing the magnitude of the sensible heat fluxes and latent heat capacity.