The Effect of Urban Influences on Storms and Storm Relative Motion

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1. Introduction

I want to research cities and the intensity of their heat island effect (how much heat is produced due to cement, buildings, cars, etc. and less green spaces like grass, trees, etc.) and how this change in temperature effects mesoscale storms (storms roughly 5KM to 500KM in size), such as their tracking, through and around 3 urban areas (Omaha NE, Des Moines IA, and Dallas TX).

I feel that research on how the heat island’s intensity affects the tracking of a storm is crucial for adequately warning people who could be in danger if the storm is altered by the heat from the city and it now is headed in their direction and is intensifying as it approaches. I feel that not only that but showing how our human activity plays a role in altering the dynamics of the atmosphere, the more we build/change things and take away the green spaces the more the heat there will be, leading to more issues dynamics of the atmosphere above the city.

With a hypothesis along the lines of: If there is a urban heat gradient large enough to overcome a capped atmosphere, then the resulting storms, intensification and storm relative motion changes will result.

2. Literature review

Although UHIs have been heavily researched in the past 30 years (Bornstein et al. 2000) the research has been focused on precipitation and temperatures or as Ashley et al. (2012) say, "the secondary Phenomena". These phenomena have been frequently studied. Due to their effects, they are linked to many implications. First, economically, by heat caused by the consumption of fuel in the cars of the city, to the heat caused by the air conditioners being used in the summer (Grimmond et al. 2010). Second, heat leads to many health risks such as dehydration, heat exhaustion, and heatstroke cases every year (Goggins et al. 2012). UHIs still have the potential to go beyond these bounds and alter the air above and thus altering the CCN concentrations in the atmosphere as discussed in Shem and Shepherd (2009). The bigger question and the one that needs to be found is do UHI’s alter the storm tracks while these storms are going over a city.

In the 1970's Stanly Changnon and Huff (1973) researched UHIs and over eight metropolitan areas, and found that severe weather is a threat for metropolitan areas due to this increased surface precipitation. This would later show that convection had to have taken place (Ashley et al. 2012). Huff and Changnon also found the UHIs caused these increased precipitation amounts in the summer, also in (Imhoff et. al. 2010, Shem and Shepherd 2009, Bornstein et al. 2000, and Ashley et al. 2012). In fact Imhoff et. al. (2010) found that for all metropolitan areas in the U.S. the UHI is the greatest in the summer time, and the severity of UHIs are also influenced by the type of climate the city is in. For example the Southeastern U.S. is moist and warm, but the Great Plains are cooler and not as moist.

Changnon researched UHIs again in (1979) and found that St. Louis’s UHI formed precipitation downwind of the city. With this data and previous research, including Huff and Changnon (1973), Changnon concluded that the city of St. Louis caused this rainfall increase. It is clear much research has been done on UHIs effects on temperature and definitely on precipitation events around urban areas. This is evident in Changnon (1979), Huff and Changnon (1973), Imhoff et. al. (2010), Shem and Shepherd (2009), and Bornstein et al. (2000), but in order to have a better understanding of urban environments temperature and precipitation, convection must be discussed, since the previous research does not analyze the UHI’s convection. In these cases the findings assume that the UHI causes the initiation, but they do not focus on the cause in each case which is, in most cases, going to be convection.

Shem and Shepherd (2009) as discussed before had major findings in modeling the effects of UHI on precipitation in and around Atlanta on of the biggest discoveries they found was the increase in rainfall around an urban area and the logic of why initiation/ intensification occurs around a UHI. The biggest find for my research is the possible "urban-rural pressure gradient discussed in their paper that is caused by heating of the cities and vertical mixing during the heat of the day. Leading to a possible explanation of why my hypothesis may be true.
In 2011 a case study (Niyogi et al.) looks at these downwind effects versus the upwind effects in and around the urban areas of Indianapolis. In this study Niyogi et al. used four rural counties for a control and compared it to the urban regions using Radar imagery primarily. In their study they characterized the storm types and how they changed between the two locations. Then statistically analyzed the storm tracks and totals from upwind and downwind from the regions. The biggest findings in this study show that urban influences do in fact have an impact on thunderstorms especially in the upwind versus the downwind side of the urban area versus the rural area. This leads to good evidence to back my hypothesis and research.

Through the years little research on how UHI’s effect thunderstorms or convection (Ashley et al. 2012). Although in recent years the shift of focus has began to shift from the temperature and precipitation some studies such as Ashley et al. (2012), and Niyogi et al. (2011) do exactly that and helped me to better develop my hypothesis. There are also sources such as Changnon (1979), Huff and Changnon (1973), Imhoff et. al. (2010), Niyogi et al. (2011), Shem and Shepherd (2009), and Bornstein et al. (2000), that all help me develop my methods, hypothesis, and have helped with the overall development of my research.

3. Experimental methods

First, the researcher will use NWS, MesoWest, and IEM surface station and weather archives to identify the intensity of the heat island in three cities (Omaha, NE; Des Moines, IA; and Dallas, TX) using a FORTRAN code to Grid the data in a few cities and plot the data on a horizontal field. Next, the researcher will gather NWS/NCDC radar data to identify initiation, storm motion, and/or intensification as the storms pass over a metropolitan area by analyzing the storms reflectivity as they pass through the cities (Ashley et al. 2012) using radar software such as Gibson Ridge. Finally, the researcher will gather this data compare the plots before the storm and see if the hypothesis is valid and test it for its statistical significance.

References

Ashley W.S., M. L. Bentley, and A.J. Stallins; 2012: Urban-induced thunderstorm modification in the Southeast United States (author abstract) (report), Climate Ch., 113(2), 481.


Goggins, W.B., E.Y.Y. Chan, E. Ng, C. Ren, and L. Chen; 2012: Effect modification of the association between short-term meteorological factors and mortality by urban heat islands in Hong Kong, PLoS ONE, 7(6).


