Effects of Urbanization on Climate of Istanbul: Re-evaluation

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Statistical and numerical modeling tools are used to investigate the climate effects of urbanization in Istanbul, the largest Turkish city whose population was nearly doubled in 20 years between 1980 and 2000. Mann Kendall trend test was applied to minimum temperature data from stations located at urban, suburban and rural areas in Istanbul to determine the existence and significance of trends, and the approximate years abrupt changes started. In addition, using a mesoscale atmospheric model, a sensitivity experiment was carried out to explore the atmospheric effects of urbanization in the city. Both statistical and modeling analysis indicated significant warming in the atmosphere over the urbanized areas. Seasonal analysis showed that the urbanization effect on climate was most pronounced in summer season. In most cases, the changes in the trends occurred in the 1970s and 1980s when the population growth rate in Istanbul increased dramatically. The model results exhibited significant expansion of the urban heat island in Istanbul from 1951 to 2004, fairly consistent with the expansion of the city in this period. A two-cell structure for the urban heat island emerged at the reference level from the difference of the July simulations with current and past landscapes: one at the European side and the other at the Asian side of the city. The maximum reference-level temperature difference between past and present simulations was found to be around 1 ^{o}C. The modeling experiment also indicated that the velocity of the prevailing northeasterly wind and the water vapor mixing ratio were both reduced over the city. The heating effect due to urbanization was found to penetrate about 600-800m heights in the atmosphere over the city, and the two surface urban heat island cells were found to combine aloft.

The results from both statistical analysis and modeling experiment are summarized as follows:

1. When the temperature differences between urban stations and suburban/rural stations for a 24-year period after 1980 are compared with those for a 24-year period before 1980, notable monthly differences are observed which clearly indicate how the urbanization after 1980 increased the surface temperature in Istanbul.

2. The modeling experiment, which is performed for July, yields two surface heat island cells located at the Europian and Asian sides of Istanbul. Both of these cells correspond well with the expansion of the city in these areas after 1951. Maximum temperature difference for 6 am is found to be around 1 ^{o}C between 2004 and 1951. The two cells combine and spread southward at higher atmospheric levels. The effect of the urban heat island could be observed up to 600-800m heights over the city. The model results also indicate that the humidity and the prevailing northeasterly wind velocity are also reduced over the city in July as a result of the urbanization.