

## Urban impact on the daily cycle of air temperature

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Understanding and preventing urban warming is vital in urban climate research, but the main anthropogenic factors behind the phenomenon are very complex. Previous studies mostly focused on the urban heat island and larger warming trend of mean temperature, neglected the basic periodic variations of the climate. The daily and annual cycles of the surface air temperature are the two fundamental climate variations. A typical temperature cycle has three characteristics; mean, amplitude and phase. We hypothesize that an analysis of the changes in the characteristics of the whole daily and annual temperature cycles, including not only the mean temperature and temperature ranges (amplitudes), but also the maximum, minimum temperatures and the phases, can provide more information concerning the urban warming. Through a detailed analysis of long-term observations in Hong Kong, we found that the daily phase has shifted a total of 1.77 hours later over the last 130 years (1.36 hours per century) in the urban area of Hong Kong as represented by the Hong Kong Observatory (HKO) data. The annual phase change in HKO reflects the phenomenon that globally observed annual phase advances or seasons onset earlier. Similar results are revealed by studying 670 long-term stations worldwide. The average daily phase delay in the identified large city stations is 3 times larger than that observed in the rural stations. Such a daily phase delay phenomenon can be explained by the increase in effective daily thermal storage in cities due to human-made structures; the change in annual thermal storage is much smaller. The results can help determine the extent of the urban impact on different temperature cycles, and provide more information on how human activities impact on the climate.