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570: Intra-urban variability of climatological indices in Florence (Italy)

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Abstract

Intra-urban thermal range can reach similar values of the urban-rural difference. In this paper 5-years of thermal measurements carried out in Florence (Italy) by 25 air temperature sensors are presented. To evaluate the thermal difference within the urban environment of Florence, daily and hourly indices were applied to hourly data. Daily extreme indices were calculated on pre-defined arbitrary threshold according to the European Climate Assessment (ECA) indices definitions. Data were analyzed by season and significant differences were observed. A mean difference of almost 3 ℃ between the hottest and the coolest station was found in all seasons in maximum, minimum and average daily temperature. Significant intra-urban differences were also found in all climatological indices, such as frost and summer days. The difference in tropical nights was even more evident. The results of this study contribute to quantify the thermal intra-urban temperature range in the city of Florence, suggesting important application in phenology, aerobiology, human health and urban planning.

Keywords: extreme indices; frost days; summer days; degree days indices

1. Introduction

The difference between urban and rural temperature (Urban Heat Island Effect – UHI) has been investigated all over the world [1,2,3,4]. But inside the urban environment it is possible to find a large intra-urban air temperature difference [5,6]. Even if the intra-urban air temperature difference is less studied than the UHI itself [3,7,8], it can reach values similar to those of the urban-rural difference, and can have important applications in several fields of study, such as biometeorology and phenology [9].
The aim of this study is to quantify the intra-urban thermal variability of the city of Florence by using a 5-yaers database of a network of air temperature sensors.

2. Materials and methods

2.1 The network of air temperature sensors

In this paper, data collected by a network of air temperature sensors (HOBO® PRO series Temp/RH Data Logger, Onset Computer Corporation, Pocassette, MA, USA; operating range T, −30°C to 50°C; RH, 0–100%; resolution, 0.2℃ between 0℃ and 40℃) with naturally ventilated solar radiation shields (RS1-HOBO® PRO accessories) were used. The network consisted of 25 loggers randomly located in the urban area of Florence. Data were collected at fifteen minute intervals since December 2005.

2.2 Indices of climate extremes

Daily Temperature indices (℃) and extreme indices (number of days) were calculated on pre-defined arbitrary threshold according to the European Climate Assessment (ECA) indices definition (http://eca.knmi.nl/) [10].

Daily temperature indices
1. TG: mean of average daily temperature (℃)
2. TN: mean of minimum daily temperature (℃)
3. TX: mean of maximum daily temperature (℃)

Daily extreme indices
1. FD: frost days (TN<0℃; days)
2. SU: summer days (TX>25℃; days)
3. TR: tropical nights (TN>20℃; days)

All indices were also calculated on a hourly basis:

Hourly extreme indices
1. FH: frost hours (T<0℃; hours)
2. SUH: summer hours (T>25℃; hours)
4. TRH: number of tropical hours during the night (T> 20℃; hours; night=from 10 p.m. to 5 a.m.)

All indices were calculated in order to analyse the intra-urban thermal variability in each season.

3. Results

Intra urban thermal difference were evident in all season (Tab. 1). The higher difference between the stations was found during summer for each index (TN, TG and TX).

Table 1: Differences among the stations in each season in Minimum (TN), Average (TG) and Maximum air temperature (TX) (expressed as mean ± standard deviation; winter=DJF; spring=MAM; summer=JJA; Autumn=SON)

Season	TX (℃)±sd	TG (℃)±sd	TN (℃) ±sd
DJF	11,4±0,7	7,5±0,6	4,2±0,9
MAM	20,1±0,6	14,8±0,7	9,8±1,0
JJA	30,4±0,9	24,1±0,8	18,0±1,1
SON	20,9±0,8	15,8±0,7	11,4±1,0

The mean TN value during summer was 18 ℃, and the mean TX values varied between 16 and 19.4 ℃ among the stations. As regard TX, the mean value was 30.4 ℃ and the mean values varied between 29.1 an 32.6 ℃ (Tab. 2).

Table 2: Minimum (TN), Average (TG) and Maximum air temperature (TX) collected during Summer in each station (expressed as mean ± standard deviation)

Station	TN (℃)±sd	TG (℃)±sd	TX (℃) ±sd
1	19.0±2.7	25.1±3.1	31.8±4.1
2	16.7±2.6	23.5±3.0.	31.0±4.8
3	18.5±2.7	25.2±3.2	32.6±4.2
4	17.3±2.6	23.4±3.1	30.0±4.2
5	19.4±2.7	24.5±3.1	29.4±3.6
6	18.1±2.7	23.6±3.0	29.1±3.8
7	16.0±2.7	22.6±3.0	29.6±4.1
8	18.2±2.7	24.4±3.1	31.2±4.1
9	17.3±2.7	23.7±3.0	31.2±4.3
10	16.2±2.8	23.5±2.9	30.7±4.1
11	17.7±2.7	23.6±3.0	30.0±4.0
12	18.1±2.7	23.7±3.0	29.7±3.8
13	19.4±2.7	25.3±3.2	31.1±4.0
14	19.4±2.7	24.7±3.1	30.6±4.0
15	19.0±2.7	25.3±3.1	32.4±4.2
16	18.4±2.7	24.6±3.1	31.2±4.1
17	17.0±2.6	23.9±2.9	30.5±4.1
18	16.6±2.7	23.6±3.0	30.4±4.0
19	16.3±2.6	23.2±3.0	30.8±4.0
20	19.3±2.7	25.2±3.2	31.7±4.2
21	19.4±2.7	24.8±3.1	30.7±4.1
22	16.3±2.7	23.0±2.9	30.1±4.0
23	17.0±2.6	23.4±3.1	30.4±4.3
24	18.4±2.7	23.8±3.0	29.6±3.9
25	17.9±2.7	24.0±3.1	30.5±4.1

As regard daily and hourly extreme indices, statistical differences between the stations were found in all seasons. In winter, the maximum difference between the hottest and the coolest station was 18 days (6 vs. 24 days) (figure 1). FD were also recorded in spring and autumn, but the difference between the stations was negligible (only 3 days). No SU was recorded in winter (Fig. 1); in summer, the main difference between the stations was 9 days (78 vs. 87 days). The highest difference between the stations was recorded in spring and autumn: in spring, the coolest station recorded meanly 11 days and the hottest 30, with a difference of 19 days; in autumn the difference between the stations was 22 days (36 vs. 14 days).
Finally, as regard TR, the highest difference between the stations was found in summer with 36 days (42 vs. 6 days).

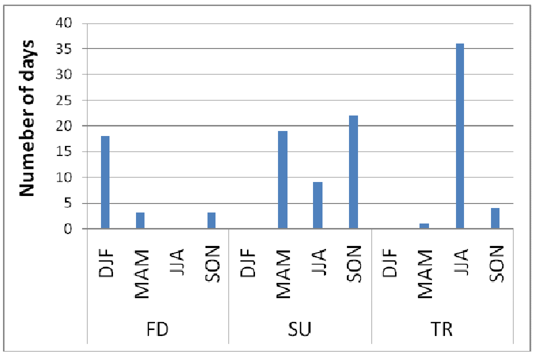

Fig 1. Maximum difference in Frost Days (FD), Summer Days (SU) and Tropical Nights (TR) between the hottest and the coolest station.

As regard hourly extreme indices (FH, SUH, and TRH), the differences between the stations have a similar trend than daily indices (Fig. 2). Only SUH during summer had a different trend than the corresponding daily index. SU showed a very low difference between the stations (9 days in the whole summer period), while SUH showed a difference of 335 hours (a mean of 4 hour per day), with a maximum mean value of 1101 (a mean of 12 hour per day) and a minimum mean value of 746 (a mean of 8 hour per day).

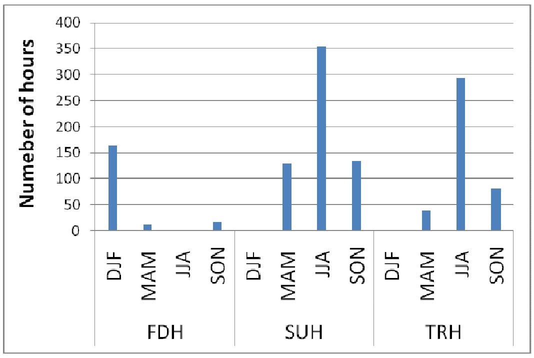

Fig 1. Maximum difference in Frost Hours (FH), Summer Hours (SU) and Tropical Nights Hours (TR) between the hottest and the coolest station.

4. Discussion

The thermal intra urban variability of Florence was evident in all seasons, and especially during the summer period, showing a strong influence of solar radiation exposure on air temperature values. The mean difference in maximum, minimum and average air temperature among the stations was mainly of 3 ℃ in each season. Similar results were found in the Mediterranean city of Tel Aviv analyzing the cooling effect of the trees in summer: during the summer period a reduction of 3 – 4 ℃ was found according to the canopy coverage level and planting density of trees in the urban environment [11].
As regard daily and hourly extreme indices, the results of this study show some important consequences on plant phenology and human health.
In particular, the results of FD and FH evidence that inside the urban environment, according to urban morphology, some areas of the city can be

more vulnerable during cold spells. On the other hand, the results of SU and SUH show that in the same city, there can be areas were plant and people can have a higher risk to be exposed to higher temperatures. Furthermore, the different result between the trend of SU and SUH shows that some areas of the city can be characterized by persistent higher temperatures than other areas. Persistent extremely high temperature are associated to the increasing risk of death [12].

Finally, as regard TR and TRH, the intra-urban differences are even more evident. These results can have some important application on human health. It is known that oppressive night-time conditions after a very hot day might be more stressful than the maximum temperature itself during the night [13]. In Florence, a clear relationship between ambulance response calls and hot nights was found, especially for calls for alcoholic diseases [14]. All those results show that people living in different areas of the city may have higher or lower risks of heat-related illnesses during heat waves [9]: future work should analyse the relationship between thermal condition in the area near the health event, in order to create a map of the city with the risk associated to the health event.

5. Conclusion

The results of this study help quantify the intra-urban thermal variability of Florence. Further studies are needed in order to analyze the relationship between air temperature and some urban characteristics, such as instrument exposure, number and height of buildings. and the presence of trees and green areas near the station. These results can have important application in several field of study, such as phenology, aerobiology, human health and urban planning.

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