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TEMPERATURE PERTURBATIONS IN A LED LIGHTED MUSEUM SHOWCASE

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In scientific museums, showcases are necessary for the exposition of ancient and breakable scientific instruments. Due to their thermal capacity, the museum building and the showcase act as filters to the abrupt variations of temperature in external environment. It is a system box in box [1], [2]. Besides, the exposed objects in a showcase are lighted using lighting systems that could be installed inside or outside the showcase. Recently, the LED (Light Emitting Diode) lights are used inside museum showcases because they favor the view and do not heat the environment in the showcase.

But is it true that the microclimate is not perturbed inside the showcase? In order to answer to this question the temporal trend of the temperature has been measured inside and outside a lighted showcase with LED lights. The showcase is part of the museum of the Physics Department of the University of Torino and exposes scientific instruments (figure 1). The museum was established in 2009 to preserve and enhance the scientific instruments which were used for research and teaching from the late XVII century in the physics laboratories of the University (www.museodifisica.unito.it).

Four one-week periods were selected: a) 21-25 June 2012, b) 22 July–2 August 2013, c) 16-23 October 2012, d) 27 February-6 March 2013. The first and the second periods were representative of summer conditions: the heating was off and there were convective meteorological conditions. The third period was in autumn, the heating was on, but favorable weather conditions allowed to keep heating intensity low. The fourth period was in winter with heating on. All periods included a Saturday and Sunday (non-perturbed days), when the building was closed, the heating and lighting systems were off, and the working activity was reduced: no people in the building and only few computers on. The temperature measurements outside the building is provided by the meteorological station on the top of the building (http://www.meteo.dfg.unito.it).

The analysis includes the temperature daily averages and their standard deviations, the maximum daily fluctuations, that can be compared with the national standards required by the normative, and the cross-correlation useful to compute the time lags between the temperature series. In the following, the summer (case b) and winter (case d) temperature data are presented and discussed.

Fig. 1. The showcase with the location of the inside (green circle) and outside (red circle) thermometers.

Summer period from 22 July to 2 August 2013.
The meteorological station on the building top measured 7 daily temperature cycles from 22 to 28 July with typical summer values. In the morning of 29 July, an intense thunderstorm with heavy rain decreased the temperature of about 6 °C in 10 minutes, and the daily mean temperatures of about 4.5 °C. In the following days, the previous week temperature values have been restored (figure 2a).
In the building, the heat capacity of the thick walls smoothed the temperature fluctuations. During Saturday 27 and Sunday 28 July, when the building was closed and the working activity was reduced, the daily variation for inner temperature decreased (figure 2a).
In the showcase, the temperature is always higher than outside, with a sensible reduction during non-perturbed days. During perturbed days, the modulation of the temperature in the showcase follows an exponential law as consequence of the LED system and the voltage transformer switching on and off, whereas during non-perturbed days the modulation of the temperature was driven by the natural daily variation (figure 2a).
Figure 2b shows the amplitudes of daily cycles inside and outside the showcase, and on the building top. The Italian Normative UNI 10829 [3] suggests the interval 0–1.5 °C in the amplitude of temperature daily cycles for the conservation of wood and paper.
Although the inner daily temperature amplitude is always lower than the outer one, because of showcase thermal capacity (figure 2b), there are only 5 on 12 values under the 1.5 °C threshold.

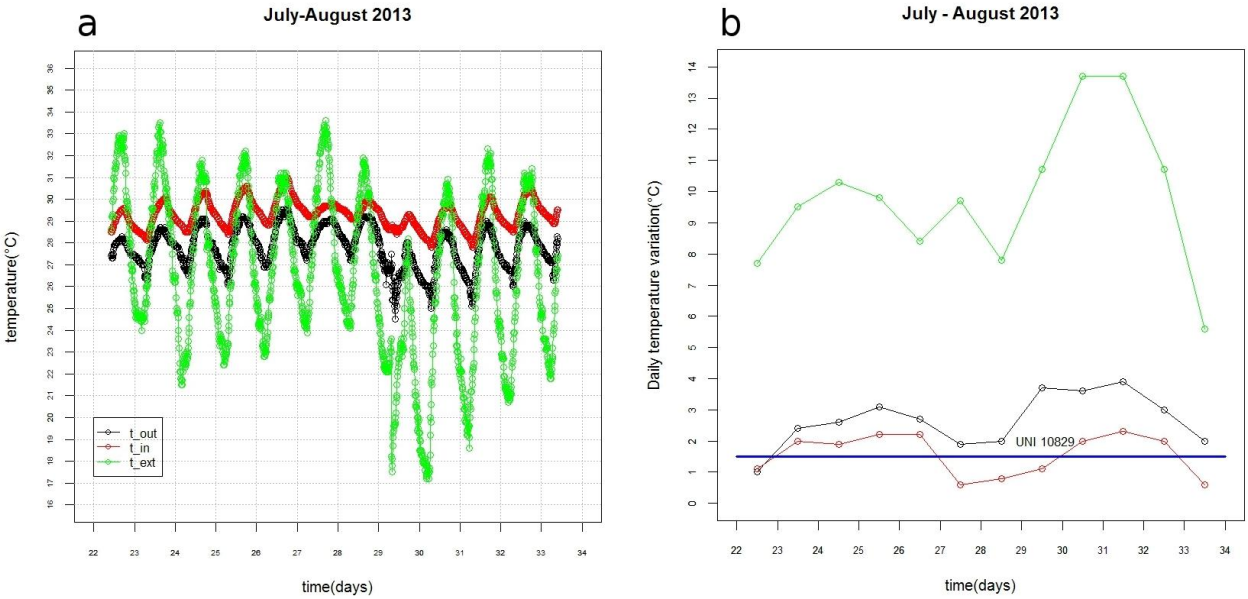

Fig. 2. In summer: a) Temperature time series inside the showcase (t_in in red), outside the showcase in the building (t_out in black) and at the building top (t_ext in green), b) maximum daily temperature variation inside the showcase (red), outside the showcase in the building (black), at the meteorological station on the building top (green), and the UNI 10829 threshold (blue).

Winter period from 27 February to 6 March 2013.

In winter, the heating was on, and in consequence, the temperature measures inside the building are independent from the external ones (figure 3a). The temperature inside and outside the showcase are similar during the not-perturbed days (Saturday 2 and Sunday 3 March) and differ of about 0.5°C when the lighting system is on.

During this winter period the maximum daily temperature fluctuations are always under the threshold that is recommended by the normative [3]. The comparison between the maximum daily temperature fluctuations inside and outside the showcase (figure 3b) show that, in this case, the showcase did not reduce the daily fluctuations.

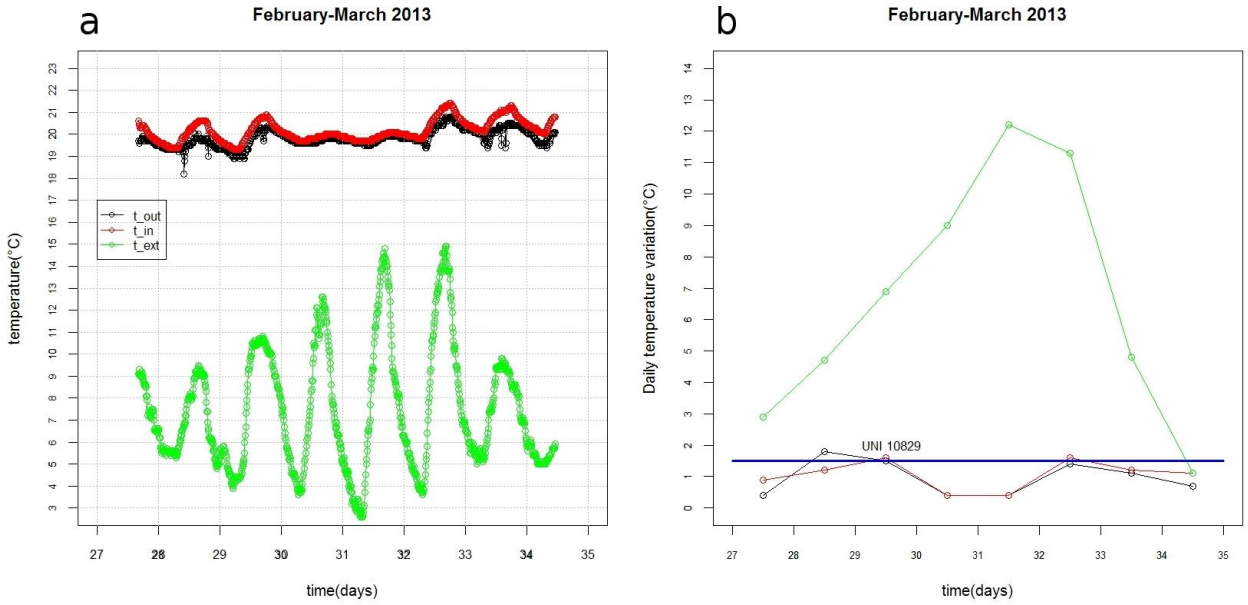

Fig. 3. As in figure 2, but in winter.

References/Bibliografia

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