Mapping of gradients of indoor temperature, CO_2 and PM_{10} through a multisensors observational campaign

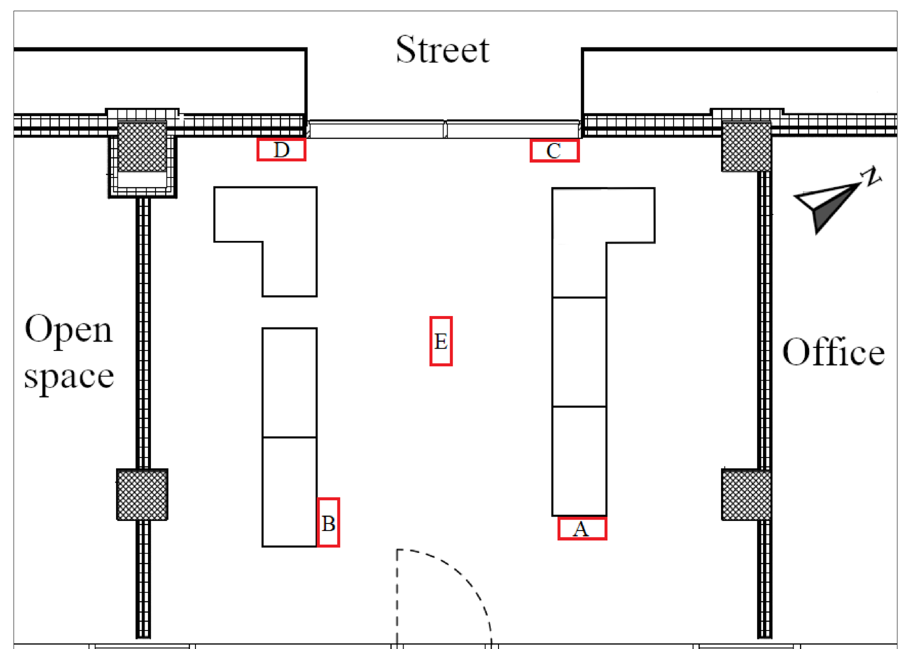
Eleonora Racca [1], Massimo Amerio [2], Paolo Gambino [1]
[1]Department of Physics, University of Turin, Turin, Italy
[2]EURIX S.r.l., Turin, Italy

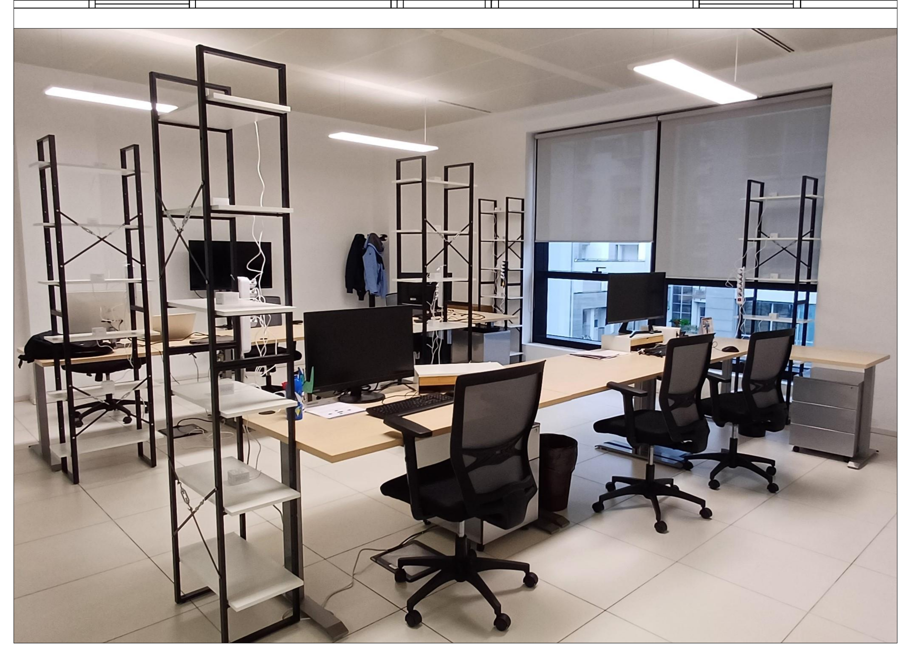
Introduction

Measurements of indoor air pollution play a crucial role for keeping under control the indoor microclimate to avoid diffusion of airborne diseases and provide healthy environment for the daily life. This aspect gained great attention especially since the Covid19 pandemic.

The investigation of indoor spatial gradients of temperature and air pollutants is mainly assessed numerically through Computational Fluid Dynamics models (CFD, e.g. Gao, 2007) and experimentally with measurements in strictly controlled environments (e.g. Zhang, 2006). In recent years, with the development of new low cost multisensors, it is possible to monitor the space-time evolution of indoor ambient physical quantities, mapping their gradients in a room.

In this work, we studied the space-time gradients of temperature, PMs and CO_2 in the office of EURIX S.r.l., located in Turin (Northern Italy) by distributing 30 multisensors at different heights in different places within the room.





Setup

The monitoring campaign lasted from the 12th of April to the 17th of May 2024 in an office at the second floor of a newly constructed building in Turin. The office faces a street located North-West and it is separated from the corridor by a glass wall. A HVAC system controls the ventilation and the temperature of the room through supply and recovery air vents placed on the ceiling of the room.

The 30 multisensors were placed on different shelves in the room (red rectangles): two close to the window, one at the centre of the room and two close to desks, nearby the door. The multisensors provided measurements of temperature, relative humidity, PMs, CO_2, VOC, atmospheric pressure each 5 minutes.

We analysed the vertical and temporal profile of different quantities by computing the average for sensors placed at the same height. As a first step, we studied their behaviour during nights, when HVAC system was switched off and the room was empty.

PM_{10}

We considered the night between the 15th and 16th of April, due to a spike of PMs during the day. The vertical profile for the $\mathbf{PM_{10}}$ shows a higher concentration of PMs at the lowest monitored height, while the averages at different heights result mixed. After an initial phase during which the profiles show an irregular behaviour, starting from 21:30 CEST (UTC+2) PMs start to increase at the lower heights.

After the office becomes empty, around 17:30 CEST, the main perturbation left in the room is represented by the HVAC. It is switched off at 19 CEST, leaving the system unperturbed from 19 CEST to 7 CEST. Looking at the data, it seems like that the life-time spend by PMs within the room before starting to deposit at the lower heights is around 2 hours.

CO_2

The behaviour for the CO_2 during the nights shows a constant decrease of the average concentration for all the heights. This decrease can be related to the absence of human activities within the room, the primary source of carbon dioxide during the day.

As for the PMs, also the CO_2 presents greater average concentrations measured on the bottom shelves, while a more mixed behaviour is reported at different heights.

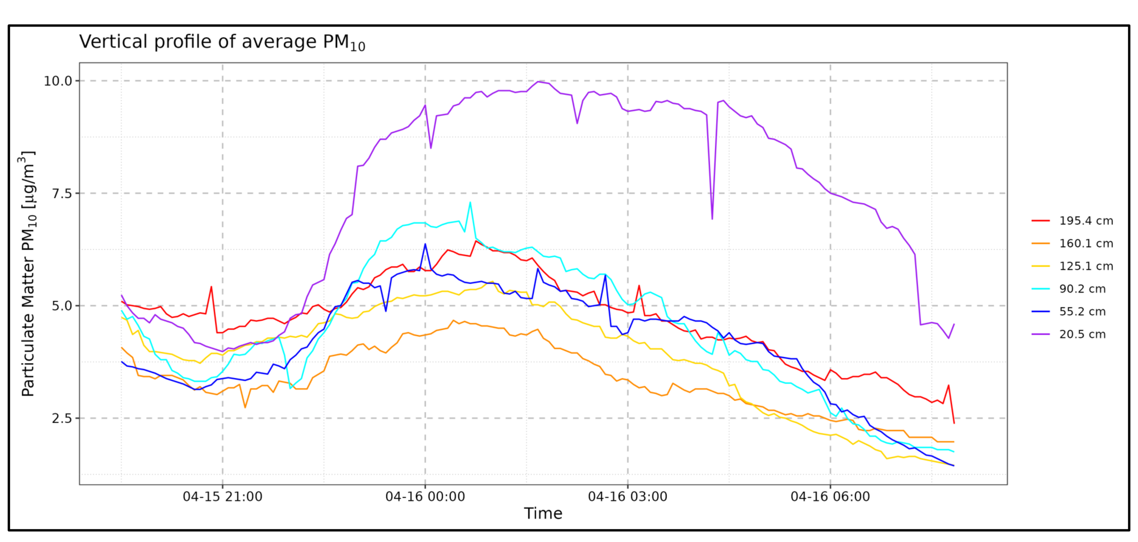
The monthly averages for the CO_2 concentrations present a regular behaviour, with peaks during the working hours. During the day, the major CO_2 concentrations were observed between 90 and 160 cm above the floor, corresponding to the heights of the seated occupants.

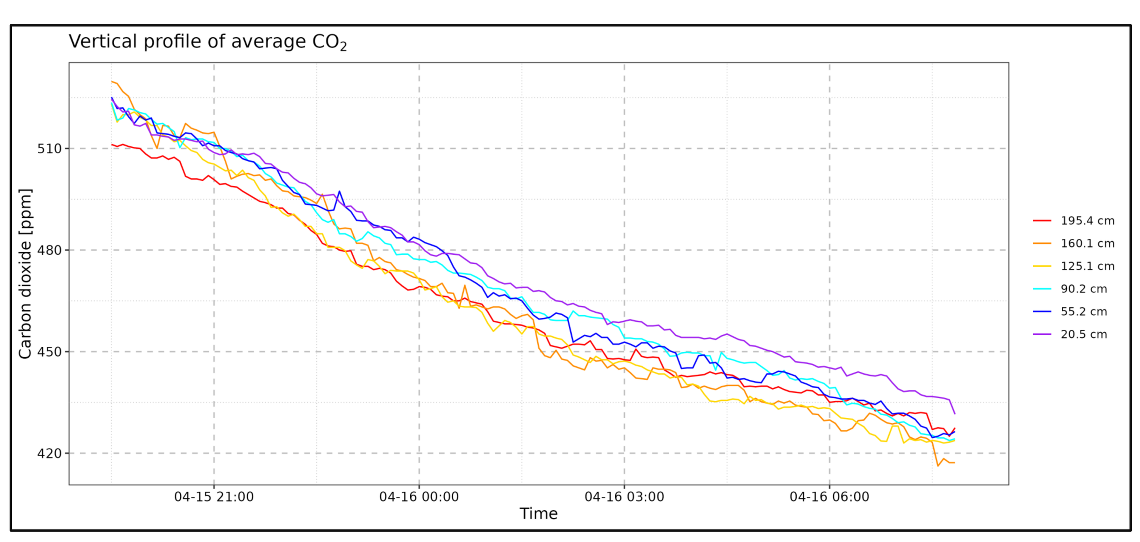
Temperature

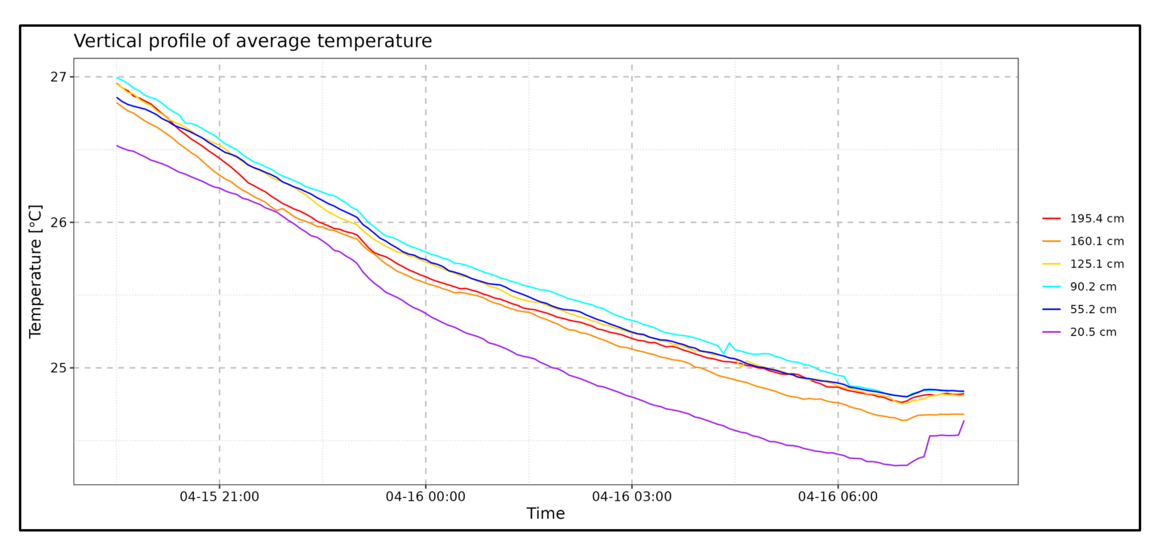
The vertical profiles for the temperature during the nights shows that the lowest temperature was recorded at the lowest height, while above 55 cm the temperature seems to have similar values.

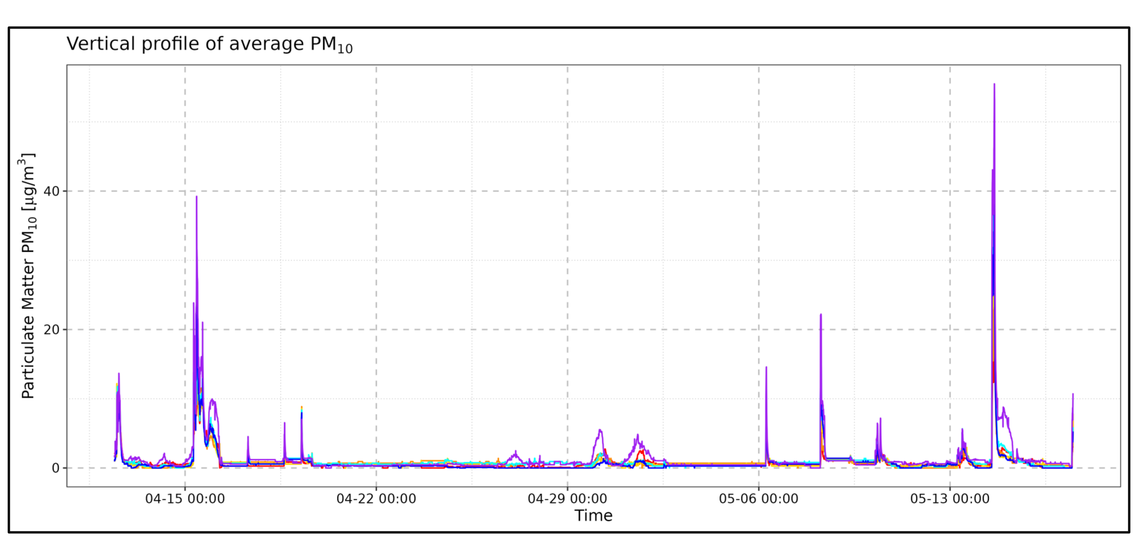
The presence of lower temperature closer to the floor may help the inhibition of the vertical motion of the pollutants, making them stagnate at lower heights. This can be a possible explanation to the behaviour of CO_2 and PMs.

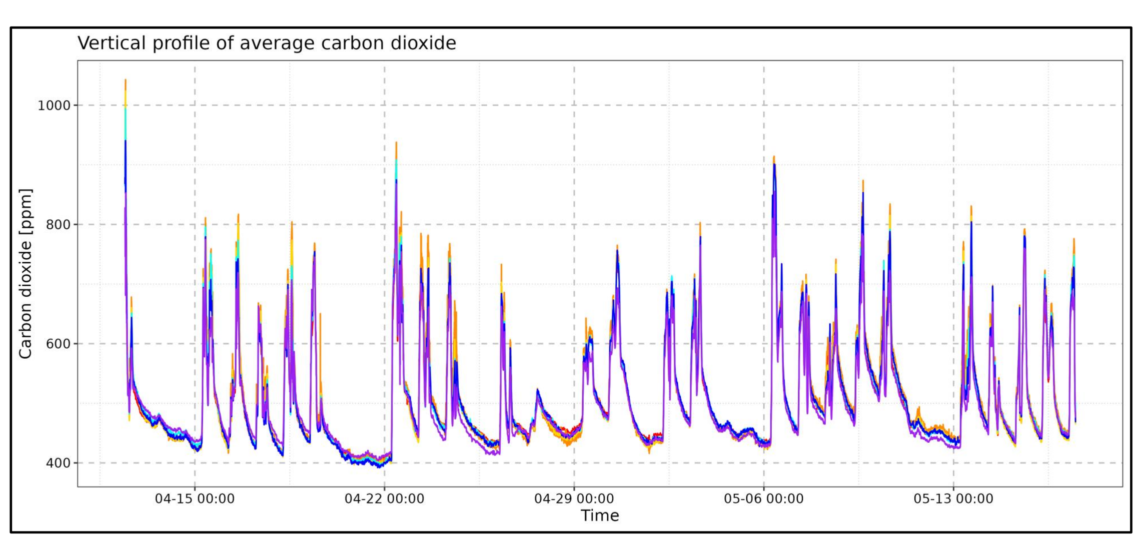
The monthly behaviour shows that, during the day, the higher temperatures were measured at higher heights, having a monotonically profile increasing from the floor to the ceiling of the room. This is in accordance with the expected behaviour due to the presence of HVAC system at the ceiling.

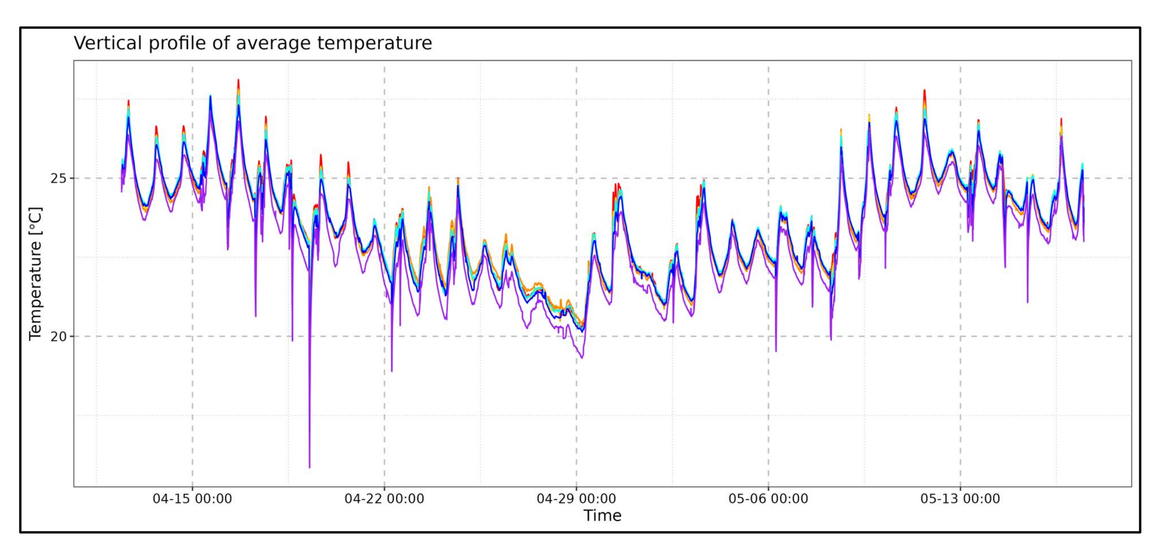












Conclusions

The data showed that the major concentrations of PM_{10} and CO_2 were observed at the lowest height of 20.5 cm above the floor, in correspondence to the lowest temperature. The monthly behaviour for CO_2 and temperature presents regular daily cycles. On the other hand, PM_{10} monthly concentrations are heavily affected by outdoor pollution, thus having a null indoor background and presenting some peaks, especially during May, when the window was opened more frequently.

This work shows that it is possible to observe the space-time gradients for concentrations of indoor air pollutants even using low cost multisensors. Therefore, the application of multisensors distributed at different locations and heights indoor may help understanding the dispersion of pollutants in closed environments.

References

- Gao, N. P., & Niu, J. L. (2007). Modeling particle dispersion and deposition in indoor environments. Atmospheric environment, 41(18), 3862-3876
- Zhang, Z., & Chen, Q. (2006). Experimental measurements and numerical simulations of particle transport and distribution in ventilated rooms. Atmospheric environment, 40(18), 3396-3408.

Contacts: e.racca@unito.it