CHARACTERIZATION OF TURBULENCE SPECTRUM OF INDOOR AND OUTDOOR WIND COMPONENTS

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INTRODUCTION

- It is well known that dispersion of pollutants depends on characteristics of air turbulence. In fact the turbulence spectrum is relevant for air pollution dispersion particularly for outdoor in complex areas in urban cases.
- In **indoor** environment, the turbulence fluctuations are strictly linked with the air change rate (AER) variable that is directly connected with the relationships between outdoor air pollution and indoor concentrations
- For outdoor measurements, the velocity spectrum is dominated by the Kolmogorov exponent calculated by wavelength by the equation:

$$E(k) = C_k \cdot \varepsilon^{-2/3} \cdot k^{-p}$$

- By this equation is possible to derive the equation in the frequency domain (the Kolomogorov exponent p is identical to that one derived by spectrum calculated by wavelength) :

$$E(w) = C(U, V) \cdot C_k \cdot \varepsilon^{-2/3} \cdot |w|^{-p}$$

- Generally, the relationship of outdoor turbulence on indoor environment might be affected by different indoor ventilation systems.

EXPERIMENTAL SETUP AND CHARACTERIZATION OF INDOOR SITE

The Inail is interested in health of worker, and, within this subject, a project for the evaluation of indoor air quality (project *VIEPI-Valutazione Integrata dell'Esposizione al Particolato Indoor*) was supported by Inail. In this context, a field campaign has been conducted inside and outside a laboratory located at the INAIL research center of Monteporzio Catone, Italy (Figure 1a). As indoor environment, a meeting room has been selected, named R49 (Figure1b), with dimensions 6mx8m.
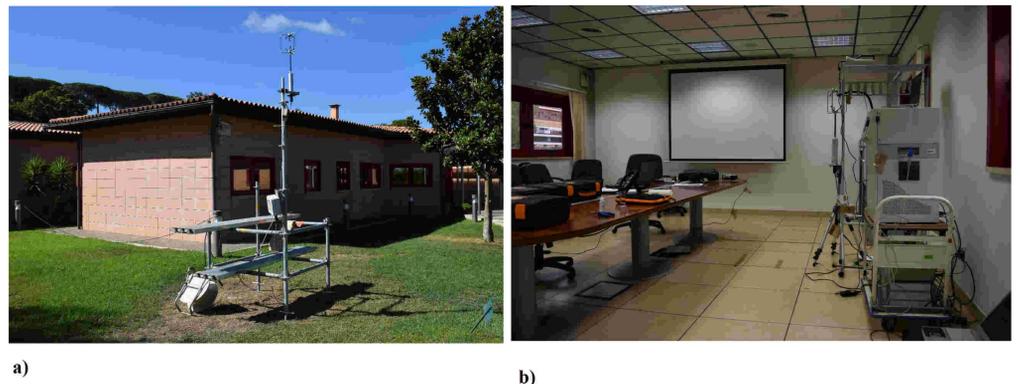

a)   b)

Figure 1. Wiev of Inail Research outdoor laboratory at Monteporzio Catone (a), Building for indoor turbulence investigation (b).

Five different indoor ventilation regimes were investigated, better described below:

-Windows and door closed (**RoomClsd**): All windows and the entrance door are closed
-Windows closed and door opened (**RoomOpn**): Windows are closed and the entrance door of room is open
-Two windows opened and door closed (**2WinOpn**): Entrance door closed and two windows opened at opposite position
-Windows and door closed, local HVAC on with cooling off (**HVAC-NotCool**): windows and entrance door are closed with the local HVAC system switched on without air cooling.
-Windows and door closed, local HVAC on with cooling on (**HVAC-Cool**): windows and entrance door are closed with the local HVAC system switched on with air cooling at 22°C.

RESULTS

In our spectrum analysis we have considered the U-component of wind. The **outdoor spectrum** decreases continuosly with frequency, which is coherent with the processes of dissipation in atmosphere.

The **indoor spectrum** shows two different behaviours.

- the decreasing rate of power spectra with frequency between 0.001Hz and 0.01Hz is reduced with respect to outdoor. This anomalous turbulence production can be probably explained by the limitation of room volume. This effect is particular evident in the power spectrum during HVAC-Cool conditions..
- At the higher frequencies (f>1Hz) the indoor is more relevant with respect the outdoor spectrum (if a normalisation criterion is used to compare data).

TEST ID	Indoor		Outdoor		pNRE (%)	
	p-Kolmogorov	TKE	p-Kolmogorov	TKE	Indoor	Outdoor
RoomClsd	0.56	0.0002	1.61	1.95	-66.2	-3.3
RoomOpn	1.46	0.0007	1.62	1.77	-12.2	-2.9
2WinOpn	1.65	0.0013	1.59	1.83	-1.1	-4.5
HVAC-NotCool	2.03	0.0118	1.65	1.19	21.9	-0.8
HVAC-Cool	1.95	0.0196	1.66	1.14	17.2	-0.5

Values of the indoor and outdoor Kolmogorov exponent (p), turbulence kinetic energy (m^2/s^2) and p errors for different indoor ventilation regimes.

CONCLUSIONS

- We have calculated the power spectrum of U-component in indoor and outdoor sites for five different ventilation regimes.

- <u>**The more important result concerns the values of the p-Kolmogorov exponent for indoor is found linked with the ventilation conditions which are quite different by the typical values of -5/3 as for outdoor**</u>

- The observed power spectrum at frequencies higher than 1Hz implies a slower dissipation of turbulence in indoor environment with respect to the outdoor one.

<u>The results could indicate possible linkages between indoor and outdoor ventilations which should be better investigated.</u>