Conference Agenda

15th ROOMVENT Conference

Session

UV: Urban ventilation and pollution

Session Chair: **Gian Vincenzo Fracastoro**

Presentations

Line source estimation of environmental pollutants using Bayesian inference coupled with Super-Gaussian geometry model

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In the urban environment, the dispersion of pollutions from unknown sources like terrorism attack, automobile emission and industrial production may cause significant danger or health risk anytime. In order to manage this risk, it is necessary to estimate the source information using limited measurements from the sensor network. Accurate and rapid source term estimation is beneficial to arrange the countermeasures and control the dispersion. In this case, the source estimation of environmental pollutants has been the concern of many researches. However, in most of them, the source was assumed to be an ideal point without any geometrical information. This assumption is not consistent with the real situations where sources always own some shapes or volumes. The inconsistency may result in serious errors and information-losses during the source estimation. Thereby, the current method needs to be improved further for the identification of geometric sources. Meanwhile, some sources can be regarded as lines such as traffic pollution in street canyon, outlets of ventilation and partitions of rivers.

Focusing on these sources with most elementary geometry, this research proposed a new method for the line source identification by combining the Bayesian inference with the Super-Gaussian function. The applicability of the new method was tested by a numerical experiment. A simple outdoor boundary layer flow was simulated to obtain the measurements and adjoint concentration field, which caused by hypothetical tracers released from each sensor in the reversed flow field. The difference between the measurements and the modeled concentrations was formulated according to Bayesian theorem to estimate the source parameters stochastically. The Super-Gaussian function was employed to approximate the line source with several tractable coefficients. Markov Chain Monte Carlo method was employed to obtain the probability distribution function of each parameter through sampling. The results (**Fig. 1**) showed that this method is capable of identifying all the parameters without any prior geometric information about the line source as long as enough information is provided by sensors.

Air pollution and health effects: review of indicators and evaluation methods

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Nowadays, the concept of outdoor air quality (OAQ) is gaining interest, especially considering the impacts that air pollutants have on people's health. The cruciality of the theme is also recognized by the international attention, as detailed by the Sustainable Development Goals, which identify the assurance of people health and wellbeing as an objective for all countries. The concern on health consequences caused by air pollution effects is a felt theme especially in the urban environment, where, according to United Nations projections, will live almost 6.5 billion people by 2050. In the view of providing sustainable cities, policy decision-maker should integrate in urban planning processes also proper solutions to safeguard people health from air pollution, making the built environment healthier and safer. For this reason, there is the need to provide suitable tools to guide the decision-making process in this direction. In line with this, the research aims to better investigate the relation between air pollutants and people in urban environment, in order to explore possible evaluation methods able to provide a solid scientific basis to the planning process and thus to respond to decision-makers' needs.

Specifically, the paper presents a literature review, aiming to identify the most used indicators able to link urban air pollutants and health effects, and the appropriate evaluation methods to be potentially used as decision-making support tools. The review process started from epidemiological studies, which mostly agree on the fact that the damage created by the presence of pollutants is dependent on the intensity of the phenomenon, based on a dose/response approach, which is able to express the static relationship among the concentration of pollutants and the occurrence of a damage to health. The literature review allowed to identify a set of indicators, mostly used in epidemiological studies, among which mortality, morbility and the number of Years of Lost Life (YLL). Moreover, little research is also interested in defining indexes using an alternative and innovative approach, in order not to focus on the negative effects, but on disease prevention, as in the case of the Life Quality Index.

Attention was focused also on the review of existing evaluation methods, which could be used in order to quantify in monetary terms the effects that pollutants have on health and society. The main methods reviewed are either objective, as the Cost of Illness (COI), or subjective, as the Willingness to Pay (WTP). The former, which allows to calculate the direct and indirect costs associated to health effects, appeared to be the most diffused method in literature; the latter instead is recently spreading in the field, allowing to take into consideration also social and intangible costs that people can experience during the period of illness. The main objective of the analysis was to investigate strengths and weaknesses of the different methods, as well as their applicability into the urban planning process, in order to provide possible scientific outcomes to the decision-maker, to support a new form of urban planning, able to better include also health and wellbeing aspects.

Drag force rose representing the interaction between arrays of cubical buildings and wind

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The drag force generated by aligned arrays of cubes of different packing density and exposed to different wind directions in a wind tunnel is discussed. Results allowed to build a drag force rose which shows that the drag force increases with increasing packing density till $\lambda_p = 0.25$ for any wind direction. It is also shown that, independent of the packing density, the drag force increases with increases deviation of WD from the perpendicularity.

The impact of urban vertical air temperature variation on natural ventilation performance in a high-rise residential building

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Urban microclimate environment has a crucial impact on building energy consumption and natural ventilation performance. However, there are few studies to demonstrate the impact of urban microclimate vertical variations taking into account urban boundary layer meteorology especially in a high-rise residential building. Therefore, this study conducted an experiment to measure the vertical air temperature around high-rise residential buildings using an unmanned aerial vehicle installed with a light and wireless sensor. A range of vertical air gradients (-0.0068K/m to -0.0333K/m) during day time was obtained and used as the temperature profile of boundary condition in the CFD simulation. The indoor thermal comfort using PMV and SET indices for single-side ventilation and cross ventilation were compared in a high-rise residential building at 3rd, 13th and 23rd floors. Results showed that for vertical air temperature gradient (0.0K/m and -0.01K/m), cross ventilation presented more remarkable differences with a maximum PMV of 0.13 and SET of 0.4ºC at 23rd floor.

Comparison and performance of standard and high-performance filters in laboratory and school environments

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Filters in HVAC systems remove particulate pollutants, an important indoor air pollutant associated with a wide range of health outcomes, especially in vulnerable and susceptible populations like children. School classrooms represent particularly important environments for children, who typically spend over 1,300 hours in school buildings each year, making schools the second most important microenvironment after the home. Unfortunately, environmental conditions and ventilation in schools often are inadequate, often much worse than many other types of buildings. This study has the objective of evaluating whether high performance "drop-in" filters can improve indoor air quality in schools and other settings. In the laboratory, we tested new and used MERV 8 and MERV 13 filters, measuring pressure drop (following ASHRAE 52.2/ISO16890 series), $e\mathrm{PM}_1$, $e\mathrm{PM}_{2.5}$ and $e\mathrm{PM}_{10}$ removal efficiency (per ISO16890 at nominal air flow rate), size-specific particulate removal efficiency for particles from 0.3 to 10 µm, and nanoparticle removal efficiency (down to 10 nm) for a subset of filters. In addition, new filters were tested as received and after discharge by exposing the full filter to IPA vapor (ISO16890-4). The used filters were taken from after a season's use from two schools in the same school district in the US Midwest. These schools were selected, in part, on the suitability of indoor space and ventilation systems for this study. In several phases, using a case-crossover approach, we replaced filters in half of the building zones in these two schools with new MERV 8 filters, and the other half of the zones with MERV 13 filters. A number of air quality parameters, including CO_2, temperature, humidity, volatile organic compounds (VOCs), and $PM_{2.5}$, were measured periodically in four classrooms in each school. After three months, the MERV 8 and 13 filter assignments were reversed, and the air quality measurements were repeated. We also measured, periodically with repeated measures, the health and comfort perceptions of teachers, as well as a number of physical and learning outcomes in children in these two schools. We compare results of laboratory and field tests using the two types of filters, interpret the results in terms of pollutant levels, laboratory conditions, building features, and other factors. Lastly, we describe the opportunities and challenges in utilizing full-scale building tests to document filter performance in real-life settings.

ON THE ASSUMPTION OF QUASI-STATICITY IN VENTILLATION ENGINEERING

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Residential and industrial buildings equipped with a ventilation system are complex facilities. Many leakages and perturbations can occur according to the operating conditions.

Infiltration caused by wind is difficult to predict because it is a non-local phenomena. The wind can cause damages or accidents into the buildings, depending on the orientation and size of the inlet/outlet openings, pressure conditions and nominal airflow values. All this parameters can modify the propagation of the wind into the zone.

The presented study is part of a global project that aim to study aerodynamic effects induced by the external wind on global performance of ventilation systems (energy, air quality, humidity).

Ventilation network design and analysis are generally realized using nodal approaches (egg. 1 node for each zone) and quasi-static assumption. Thus, inertia effect of ducts are neglected as well as any possible acoustic resonance that could occur.

These effects might be not as negligible as one could thought while studying particular transient boundary conditions. Wind effect in urban environment up to storm impact, or internal pressure release from vessel bursting or other sudden changes could imply some internal pressure fluctuation not caught by quasi-static assumptions of nodal codes. Inertia effect is not automatically correlated to compressible assumptions and resonance can be identify even for incompressible conditions.

The present study aim into giving, for single zone up to multi-zone case the set of parameters (duct size, length, zone, volume, ..) that leads to resonance identification and thus to the importance of considering transient evolutions.

Mathis software, developed to analyses ventilation systems in dwellings and chosen as the standard tool in the French context is used for this study. After validating its behavior under transient condition with references on specific cases, parametric simulation is realized. Results for several boundary conditions are analyzed through the identification of a pressure overshot before reaching the established value; of the frequency if several oscillation where observed; of the time needed to reach the established regime and of the percentage of the over shot.

PUMPING FLOW VENTILATION OF HIGHRISE BUILDINGS: EFFECTS OF UPSTREAM BUILDING ARRANGEMENTS AND OPENING AREA RATIOS

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Periodic vortex shedding around a building could play an important role in wind-driven single-sided ventilation especially when two free openings are mounted on the leeward wall, in which case “pumping” flow dominates the natural ventilation. In this paper, we investigated the characteristics of vortex shedding and “pumping” flow affected by the arrangements of upstream buildings and opening area ratio of ports on the downstream target building. Computational fluid dynamics (CFD) simulations have been used to predict the instantaneous and mean flow fields. Numerical results indicate that the strength of “pumping” flow could be intensively weakened by two upstream buildings. The increase of upstream building length has a negative effect to the vortex shedding frequency at the wake of all buildings and ventilation rate of the downstream building. An increase of opening area ratio on the rear wall of the downstream building will raise the Strouhal number but have no positive correlation with ventilation rate. “Pumping” flow oscillating frequency does not have clear correlation with the ventilation rate. Our study on the wake vortex shedding flow across building clusters could benefit the future green design of urban buildings.