Department of Meteorology

Turbulent Scalar Transfer from Street Canyons

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ACTUAL

Introduction

Thermal modelling of urban surfaces and buildings is a very important concept for engineers, planners and meteorologists. Understanding the transfer of heat, pollution and other scalars from the surface layer to the air aloft is crucial to improve the quality of life, but still little is know about the influence of urban morphology on scalar transfers.

The aim of this research project is to quantify scalar transfer from one of the simplest units of urban morphology: a street canyon. A steeply pitched roof was added and parameterised in a simple numerical model. Also, a new technique for quantifying fluxes is currently being developed.

The Resistance Network Model

The resistance network model, developed by Harman et al. (2004), based on the bulk aerodynamic formulation for fluxes by Garratt (2002), was modified in order to parameterise the effect of a change in roof shape on the flow. Key flow features compared to flow over a flat roof are:

- The dynamics of the flow departs from the single vortex within the canyon to a double vortex within the recirculation region;
- This change in flow dynamics means that air travels a longer distance before impinging on the street surface, slowing it down;
- The resistance to transport increases at the street and, therefore, the flux decreases.

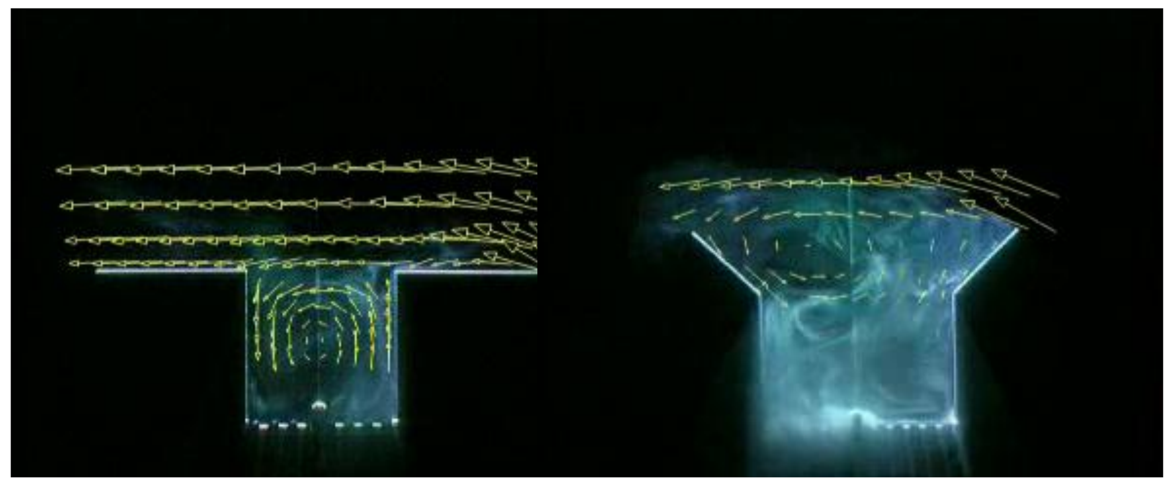
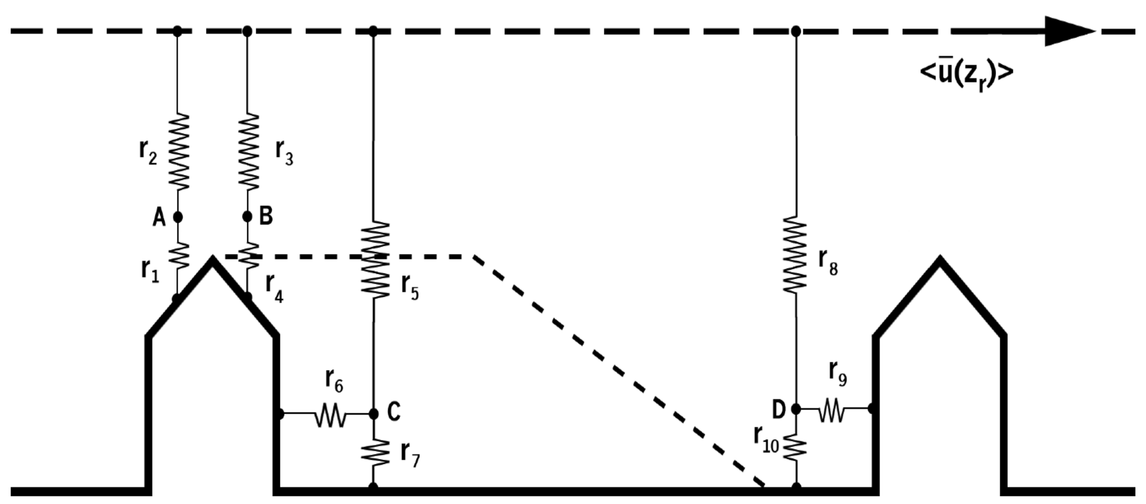


Figure 1. Flow patttern for flat and pitched roof (Thanks to B. Leidt at University of Hamburg for use of wind tunnel facilities).



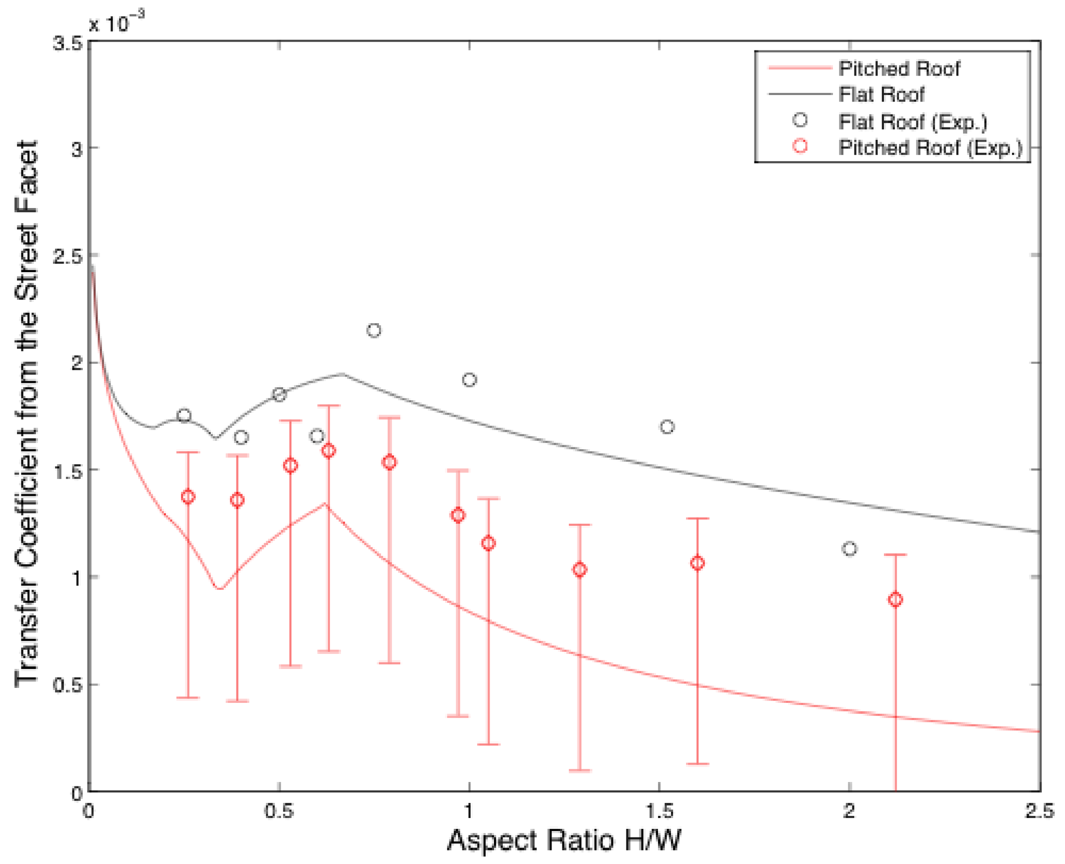
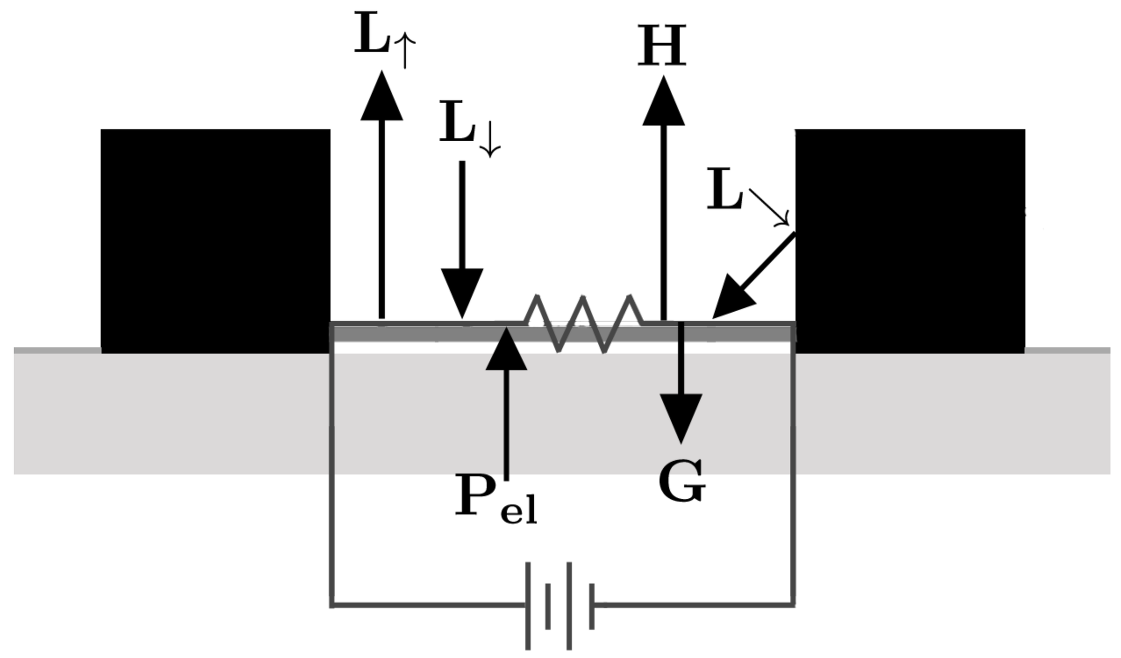


Figure 2 and 3. The resistance network model (r_i represents the resistance to scalar transport and the dotted line depicts the wake generated by the downstream building.) and a comparison between experimental data and the model for the flat and pitched roof configuration. Barlow et al. (2004) and Pascheke (2005). The transfer coefficient is defined as 1/(rU), where U is the freestream wind speed.

The Copper Circuit Board Technique for Measuring Scalar Fluxes

The copper circuit board technique for measuring scalar fluxes is current being developed in order to quantify fluxes from street canyons using heat as a passive scalar. The technique is based on the work of Bohm (2000), using an etched copper circuit board with a current passing through it. The transfer velocity is quantified using a surface energy balance which is being developed.



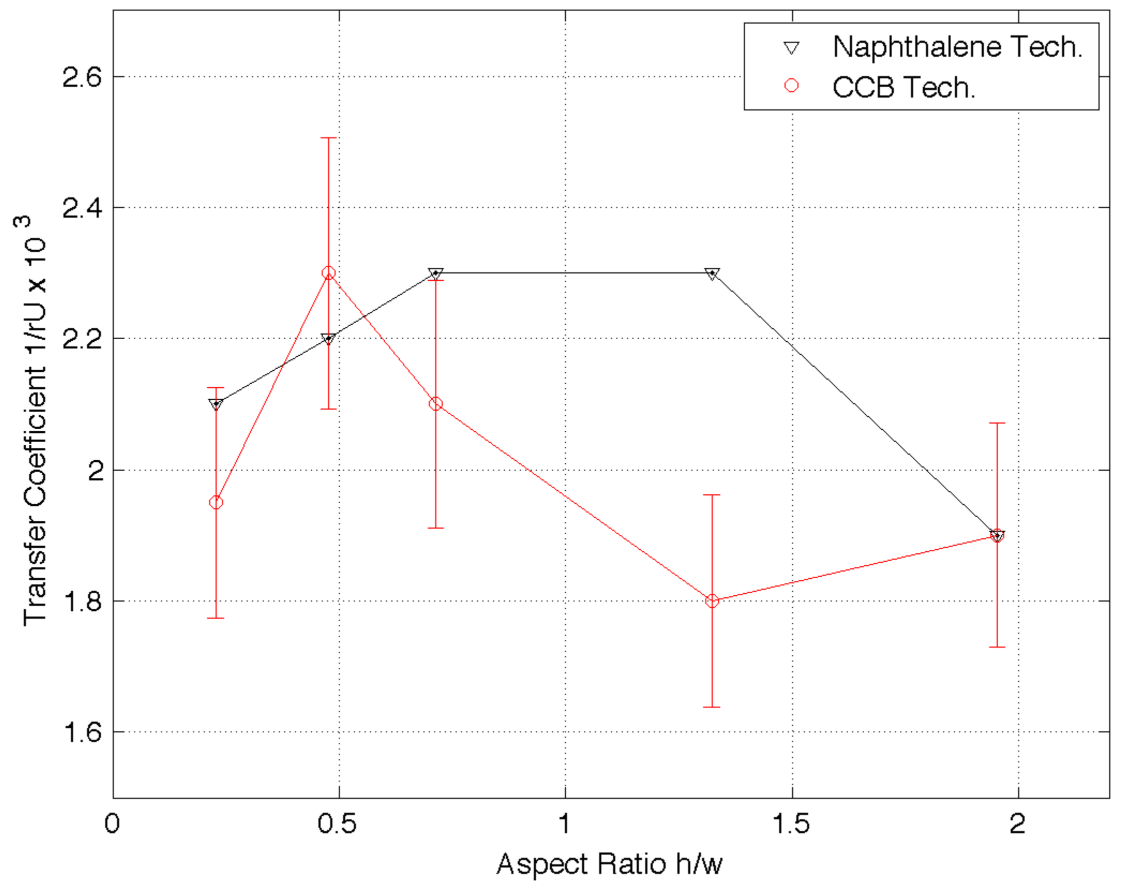


Figure 4 and 5. Cross section of the experimental set-up, carried out in the wind tunnel in Reading. Comparison between techniques and measurement of transfer coefficients, as previously explained.

The experiments are being carried out in the wind tunnel of the Meteorology Department in the University of Reading. The surface temperature is measured with a thermal imager mounted on the top of the tunnel and other temperatures are measured by high precision thermocouples. Figure 4 shows the cross-section of the experimental set-up and current terms being directly measured instrumentally. Figure 5 shows a comparative result between the naphthalene sublimation (Barlow and Belcher, 2002) and the CCB technique.

Conclusions

- There is a fundamental change in street canyon flow dynamics due to a pitched roof. It is possible to modify a simple numerical model to capture the impact on scalar fluxes;
- A novel wind tunnel technique using heat as a passive scalar is being developed to simulate scalar fluxes from street canyons and the current results show agreement with techniques already developed;
- Future plans include to test the effect of wind direction and fetch on fluxes (i.e. differences between fluxes from a sudden change and downstream of a change in roughness)

References

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