Abstract
Theoretical predictions about urban boundary-layer flows are difficult to obtain. As an alternative to three-dimensional CFD simulations, vortex interactions can be analysed with the numerical Green’s function. The Green’s function characterises the strength and scale of vortex interactions and reflects the influence of the boundaries. Using the numerical Green’s function, the regime transitions from isolated roughness to wake interference and wake interference to skimming flow are determined as a function of the aspect ratio. There is good agreement with LES and the accepted transition values. For further details see [1].

1. Urban flow regimes
The existence of distinct urban flow regimes is well-established [2]:

For AR=H/W, transitions occur around AR=0.3 and AR=0.7 in the street-canym limit (L→m).

Despite the importance of this classification schema, there has been little work explaining why the transitions occur where they do. Most of the work is fairly old, e.g., physical explanations are limited. Nevertheless theoretical understanding is limited. Obviously useful predictions can be based on the presence of a double-eddy structure [3].

The absence of theoretical understanding is surprising. Obviously useful predictions can be made for many turbulent flows. But urban turbulence is neither homogeneous nor isotropic...

3. Numerical Green’s function
The Green’s function corresponds to the induced streamfunction. For brevity we only show Gx, i.e., the induced vertical velocity.

For simplicity we restrict ourselves to 2-D. In vortex dynamics the Green’s function describes the solution induced by a point vortex determining their strength and scale. Hence knowledge of how the Green’s function changes with the aspect ratio should provide insight into the regime transitions.

In vortex dynamics the Green’s function describes the solution induced by a point vortex [5]. For simplicity we restrict ourselves to 2-D:

In an unbounded domain the Green’s function G(x) = G(x) but this is not true in general.

Calculating the Green’s function at every point is impractical. Hence we model the canyon flow using a pair of vortex sheets — one at the bottom and one at the roof level — and examine how G(x) changes with AR.

4. Comparison with LES
Using the LES model PALM [6], turbulent flow in a single street canyon was simulated. The configuration followed [7].

5. Future work
Application to uneven street canyons is being investigated. The Green’s function approach may be useful for parameterisation.

References