Development and applications of an urban meteorological
Numerical model in Cartesian coordinate

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We intend to make the development and applications of a new urban-canopy-resolving meteorological numerical model coded in the Cartesian coordinate, which is expected to treat any complex object (buildings, etc.) explicitly in urban street with a finer resolution.

With the continuing increase in computational resources, the mesoscale models are being run at successively higher resolutions. Running a mesoscale model at a huge fine horizontal resolution may be attainable in the near future, and the topography (e.g., steep mountains, buildings and any complex object on the surface) could then be more accurately represented. In this numerical model development, the Finite Volume Method (FVM) in conjunction with the SIMPLER (Semi-Implicit Method for Pressure-Linked Equation Revised) algorithms is used for calculations of the unsteady, three-dimensional, compressible equations on a staggered grid. Abandoning the customary terrain-following normalization, we choose the Cartesian coordinate in which the height is used as the vertical one. A Cartesian-grid system approach, which consists of the variable regular cells and a special treatment of the boundary cells, is proposed for expression of the arbitrarily complex geometries. The blocking-off method is introduced to handle any complex objects, then resulting in a stable, robust, and efficient numerical scheme that allows for applications to airflows over the complicated topography. The spatial discretization is obtained by a finite volume technique on the staggered grid, and higher-order upwind convection scheme is employed to relate the flux at each control volume face. For the temporal integration of the equation, the fully time implicit scheme is utilized.

As applications, the numerical model has been run on calculating flows over cube/steep mountains by Direct Numerical Simulation (DNS), and turbulent flow in urban city by Large Eddy Simulation (LES), respectively. In this work, numerical simulation is conducted and compared with wind-tunnel experiment on the thermal and turbulent structures of the flow over a low-rise building residential area in street canyon. Details will be given in the meeting.