LES simulations of forced convective heat transfer at the surfaces of an isolated building using non-conformal grid

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Abstract: The knowledge of external convective heat transfer coefficients (CHTC) is of great importance for many engineering applications. This is the case for building applications where, for example, an accurate evaluation of CHTC is needed to calculate convective heat gains and losses from building facades and roofs. It is also important to evaluate the thermal performance of double-skin facades, solar collectors and greenhouses. Assessment of the CHTC can be performed by full-scale measurements, wind-tunnel experiments or Computational Fluid Dynamics (CFD) simulations. When CFD is considered, it can be a useful tool to determine CHTC in urban areas. In these cases, Large Eddy Simulation (LES) should be used because it can capture the complexity of the flow pattern much more accurately than Reynolds-Averaged Navier-Stokes (RANS) simulations. However, generating high-resolution high-quality computational grids for LES simulations of the CHTC is not straightforward. Ideally, LES grids, where the grid size is used as a filter, should consist of cubical cells. In addition, grids for assessing CHTC should have very high resolution near the building surface in order to fully resolve the thin laminar sublayer (often only a few mm in thickness) which represents the largest resistance to convective heat transfer. In order to avoid a prohibitively high total number of cells and the need for excessive computational resources, we can resort to the development of a grid, consisting of cubical cells, that is refined gradually in all directions, i.e. a non-conformal grid. Nevertheless, the accuracy of this type of grid for the case of buildings in the highly turbulent atmospheric boundary layer still needs to be verified. Therefore, in this paper, the performance of non-conformal grids is evaluated. The evaluation is based on verification by a comparison between conformal and non-conformal grids and on validation with wind-tunnel measurements of surface temperature of a reduced-scale wall-mounted cube. The resulting number of cells for the conformal and non-conformal grid is 9,710,472 and 1,431,789 respectively, where both grids have the same near-wall resolution. The results obtained by the non-conformal grid are in a very good agreement with the results by the conformal grid. In this case, the average difference between simulated surface temperatures on all surfaces of the cube is about 0.9% Moreover, the general agreement between the experimental results and CFD results using non-conformal grid is very good. In this case, the average and maximum absolute deviation of surface temperature are 2.0 % and 5.5%, respectively. The verification and validation studies verify the accuracy of non-conformal grid for the investigation of CHTC for a wall-mounted obstacle. It can be concluded that the use of the non-conformal grid reduces the total number of cells by a factor 6.7, without compromising accuracy. To the best of our knowledge, LES CFD simulations of CHTC using non-conformal grid for a full-scale building have not been performed. In the second part of the paper, an application of non-conformal meshing around a full-scale building is presented.

Keywords: *Computational Fluid Dynamics (CFD); Large Eddy Simulation (LES); Heat conduction; Turbulence modeling; Validation; Conjugate heat transfer; non-conformal grid.*