COMPUTATIONAL ANALYSIS OF TORNADO DYNAMICS USING A NEW IMMERSED BOUNDARY LATTICE BOLTZMANN FRAMEWORK

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ABSTRACT

Computer-aided simulation of tornadoes on buildings is considered an efficient and economical approach to study tornado dynamics. One of the main challenges of this topic is to establish a set of physically-rational and mathematically-efficient boundary conditions for the tornado scenario. Inspired by the success of immersed-boundary (IB) lattice Boltzmann method (LBM) in studying fluid-structure interaction problems, this talk presents a new IB-LBM framework for investigation of tornadic wind effects. Using the "*relative motion*" principle, a tornado approaching a building is now re-interpreted as a "*virtual*" translation of the building, with a velocity that is equal to the original tornado translation magnitude but opposite to the real tornado translation direction, towards a "*purely rotational*" airflow about its "*virtually pinned*" center. Thus, the outer boundary velocity description of the tornado domain can simply take the rotating part of the tornado, which is independent of time provided that the boundary is kept a sufficient distance from the building, and the computational resources required for the tedious boundary velocity update process can be successfully saved. Then, the IB method is employed to simulate the "*virtually moving*" building. The present LBM-based method was benchmarked in this study through simulation of a rotational airflow; then, with the aid of the IB strategy and the large eddy simulation (LES) model, a computational analysis of tornadic wind loadings on a multi-building configuration was performed [1],[2]. The conducted case studies resulted in a number of general numerical suggestions that can benefit future tornadic wind simulations.

References

[1] X. Guo, J. Cao. *A two-dimensional IB-LBM framework combined with retailored RCVM for assessing the rotation intensity of a tornadic wind over a building configuration*, Engineering Structures, 131 (2017), 57-68.

[2] X. Guo, J. Cao. *An IB-LBM investigation into the aerodynamic coefficients in relation to the rotation intensity of a tornado-like wind*, Computers and Mathematics with Applications, 78(4) (2019), 1206-1226.

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