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SIMULATION OF TORNADIC WIND OVER BUILDING USING IMMERSED BOUNDARY LATTICE BOLTZMANN METHOD

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Numerical investigations on the impact of a tornado towards buildings are considered both effective and economical, but have been seldom reported due to many numerical difficulties. The major challenge in this respect lies in the establishment of a set of physically-rational and yet mathematically-executable boundary conditions for the tornado scenario. To open a new outlet for the tornado simulation, this paper presents an immersed-boundary (IB) lattice Boltzmann method (LBM) with the "relative motion" principle properly embedded and, thus, the tornado-building interaction handily modeled. That is, the Rankine-Combined Vortex Model (RCVM) -based tornado-building interaction is in this study conceptually interpreted by the superposition of a rotational airflow and a virtual translation of the building, since a tornado is essentially considered as an airflow that simultaneously translates and rotates, and the translation of the tornado center towards the building can be reversely interpreted as well. Using this novel type of interpretation, the boundary condition for the outer boundary of the entire LBM-simulation domain can be simply prescribed by using the rotational part of the tornado and, meanwhile, the building is virtually allowed for translation in a direction opposite to the actual translational part of the tornado, and mathematically modeled by the IB approach that inherently ensures the satisfaction of the no-slip boundary condition for the building. After validation of the present LBM-based method through simulation of a rotational airflow, the retailored-RCVM-based IB-LBM framework enriched by the large eddy simulation (LES) model targets at the case of a tornadic wind over a cylinder at a higher Reynolds number, and the effect of the tornado on the building is investigated. The outcome of numerical experiments performed in this study can provide a number of general suggestions that would benefit the tornado investigators in their future tornadic wind simulation endeavors.