Numerical computation of a turbulent wind flow over buildings and estimation of its effect on drone's model

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The nonlinear dynamics of turbulence formed by the wind flowing near solid objects can be studied with a variety of different physical models, more or less numerically demanding. An application is the study of the formation of turbulence past buildings, with the goal of determining the no-fly zones for drones in smart cities.

In this paper, we examine the Unsteady Reynolds-averaged Navier-Stokes (URANS, specifically k-Omega Shear Stress Transport) model, which provides accurate prediction of flow separation than other RANS models. We compare the results with those of the Delayed Detached Eddy Simulation (DDES, specifically Spalart-Allmaras DDES) model, more physically comprehensive, but more numerically demanding. Both successfully predicted the average velocity distribution and the average Reynolds stress distribution behind the obstacle [2,3]. However, the predicted loads for simplified geometry for the drone modeled in this study as a cube at certain locations differed by a factor of 4 depending on the turbulence model employed. The analysis of the effect of different turbulence models on a group of simplified drone models with fixed positions close to buildings allows us to check and develop the no-fly zones. In this work, the difference between the DDES and URANS models is investigated for the estimation of the turbulence intensity and the total forces acting on the bluff bodies.

Despite certain limitations in the URANS model, it is still a practical alternative considering the cost advantages and the great demand for meshes in urban simulation. Subsequent studies could develop upon this to correct the results, such as adding a safety factor in predicting the level of turbulence, to ensure the accurate use of drones in urban environments. Additionally, the complexity of urban models could be simplified by using Reduced Order Modelling to allow for the possibility of urban simulation by DDES.

References

1. M. Z. G. Yousif, & H. Lim,, On the characteristics of the turbulent wake behind a wall-mounted square cylinder. arXiv:2012.11263 *Physics.flu-dyn*, (2020).
2. M. Saeedi, P.P. LePoudre, & B.-C. Wang, Direct numerical simulation of turbulent wake behind a surface-mounted square cylinder. *J. Fluids Struct*, **51**, 20–39 (2014).
3. J.A. Bourgeois, P. Sattari, & R.J. Martinuzzi, Alternating half-loop shedding in the turbulent wake of a finite surface-mounted square cylinder with a thin boundary layer. *Phys. Fluids*, **23(9)** , 095101 (2011).