Seventh HRLM Symposium, 17-19 September 2018, Berlin, Germany

Session:

Hybrid RANS-LES simulation of a tall building in a complex urban area

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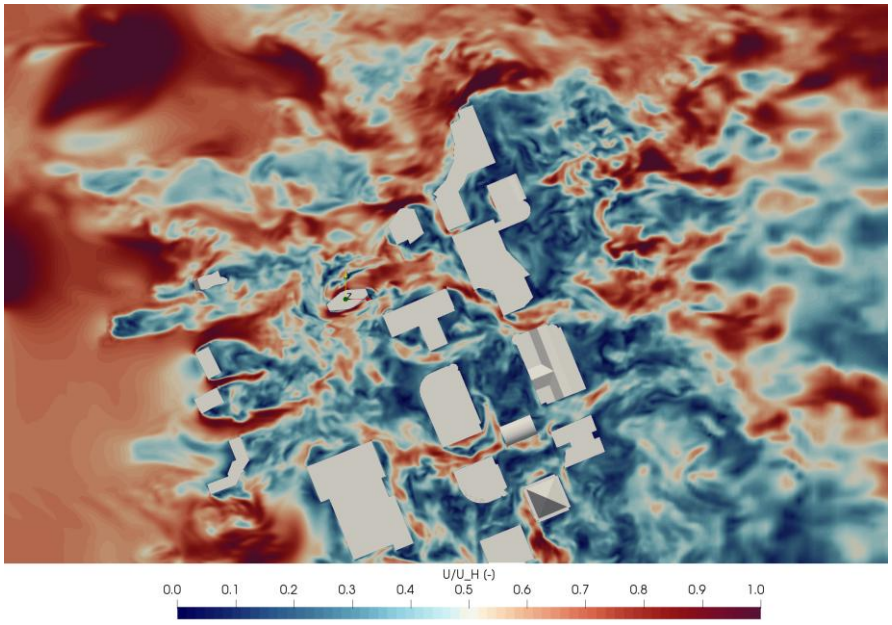
Abstract

The aerodynamic performance of a building becomes increasingly important as its height protrudes further into the atmospheric boundary layer. For tall buildings, a thorough understanding of the aerodynamics is essential to make informed structural design decisions. However, this is a challenging case for numerical simulation, as it involves accurate representation of both the bluff body aerodynamics and the incoming flow field over a large range of scales. Representation of the turbulent conditions surrounding the building is of practical importance as the turbulent boundary layer and interference from nearby buildings can have a significant effect on the aerodynamic response. Hybrid RANS-LES methods provide an attractive option for such flows and in this study Detached Eddy Simulation [1] has been used to simulate the flow around a building in a complex urban environment.

A Divergence-Free Synthetic Eddy Method by Poletto [2] was used at the inlet, which produced turbulence at the building location in good agreement with target spectra. The pressure time histories were sampled over the building's surface and integrated to provide overturning and torsional moments. The effect of the highly-turbulent velocity field (Figure 1) is apparent in the relatively low span-wise coherency of forces. Comparison to values collected in rigid-model wind tunnel tests shows good agreement of mean and standard deviations of moments. Spectral densities of the moments, which is the key quantity of interest, are in good agreement with experiment for practical frequency ranges.

Due to the efficiency of wind tunnel methods for testing multiple wind directions, it is unlikely that numerical simulation will replace physical testing for building aerodynamics in the foreseeable future. However, results provide a promising step towards the use of CFD as a complementary and diagnostic tool in the analysis of wind loading for tall buildings.

Session:



…Fig. 1 Contours of relative velocity on a plane 40m above the ground (full scale)

References

[1] Spalart, Philippe R. "Comments on the feasibility of LES for wings, and on a hybrid RANS/LES approach." Proceedings of first AFOSR international conference on DNS/LES. Greyden Press, 1997.

[2] Poletto, R., T. Craft, and A. Revell. "A new divergence free synthetic eddy method for the reproduction of inlet flow conditions for LES." Flow, turbulence and combustion 91.3 (2013): 519-539.