Wind around buildings with a two-way coupled Navier-Stokes (NS) and lattice Boltzmann solver (LB).

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ABSTRACT

Simulation of urban wind flow is still challenging in the engineering field due to complex geometry and the multiscale nature of the flow. Resolving all the scales of motion in the entire domain is often too computationally expensive and thus not feasible for industrial applications. Moreover, the region of interest usually represents a small percentage of the total volume of the domain.

We propose to split the simulation in two smaller sub-domains solved by two-way coupled models. The region of interest, where the medium-to-small scale turbulent motions are resolved, is modelled using a lattice Boltzmann (LB) method based on [1] and run on graphic processing units (GPUs). The remainder of the domain, where only the mean flow is relevant, is modelled using a finite volume Navier-Stokes (NS) model from OpenFOAM [2] run on CPU. Our NS/LB dual method combines the accuracy and computing speed of the GPU implementation of the LB model with the stability, low memory consumption and mesh flexibility of the NS solver. Moreover, the NS/LB dual model exploits the widespread availability of CPU / GPU hardware on consumer devices.

The boundary conditions at the NS boundary (marked A in Fig 1) are set to fix the velocity and pressure gradient received from the LB mesh; while the boundary conditions at the LB boundary (marked B in Fig 1) are set to fix the velocity received from the NS mesh and calculate the corresponding lattice Boltzmann pressure. Data transfer and time stepping is implemented using the parallel-explicit coupling scheme in the preCICE library [3].

Fig. 1 shows the results of applying the NS/LB dual model to flow around a 3D wall mounted cube at Re = 100. The difference between the NS and LB flow speed at the limits of the overlap region is approximately 1% of the reference velocity and the difference between the NS/LB dual method velocity and the single method NS velocity is less than 4% of the reference velocity. Next steps will focus on the influence of the size and position of the overlap zone and in modelling turbulent flows.

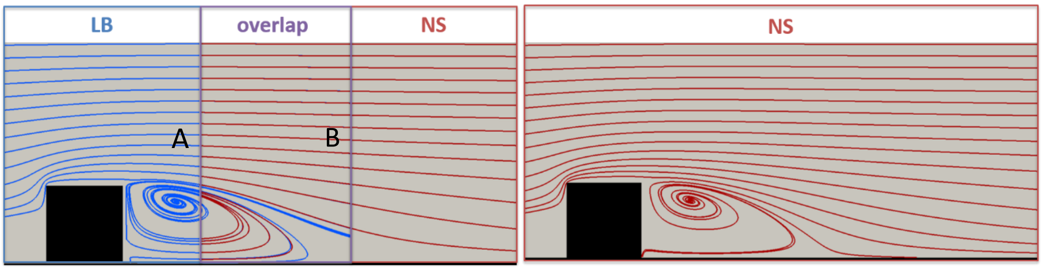

Figure 1 Comparison between NS/LB dual model (right) and single NS model. Streamlines around a 3D wall mounted cube on the central vertical plane. LB streamlines (blue), NS streamlines (red).

REFERENCES

[1] Harwood A., O'Connor J. Sanchez Muñoz J., Camps Santasmasas M. and Revell A. "LUMA: A Many-Core, Fluid-Structure Interaction Solver based on theLattice-Boltzmann Method". In: SoftwareX (Feb. 2018).

[2] H. Bungartz, F. Linder, B. Gatzhammer, Mehl M., Scheufele K., Shukaev A. and Uekermann B. "preCICE - A fully parallel library for multi-physics surface coupling".

[3] OpenFOAM (2016). OpenFOAM 4.1. [online] Available at: https//openfoam.org/version/4-1/ [Accessed 18 Dec. 2018].