Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2018-7-RC1, 2018

Geoscientific Model Development Discussions

Interactive comment on "Implementation of an Immersed Boundary Method in the Meso-NH model: Applications to an idealized urban-like environment" *by* Franck Auguste et al.

Anonymous Referee #1

Received and published: 29 May 2018

[10pt,a4paper]article [utf8]inputenc amsmath amsfonts amssymb [lmargin=2.5cm, rmargin=2.5cm]geometry

Comments : Auguste et al. 2018

May 29, 2018

1 General comments

This manuscript presents an Immersed Boundary Method implemented in the Meso-NH model. The authors first focus on the implementation of the boundary technique. Following this, the authors turn to a detailed validation of the code.

I would like to compliment the authors for presenting such an extensive work. Implement a ghost-cell / cut-cell technique is not an easy task and the authors are doing good. Moreover the implementation of IB techniques in forecast weather code seems to be very promising according to the obtained results.

That's said, some additional things absolutely need to be added/modified to make this presentation clearer from a numerical point of view. As it will be mention in the following paragraphs some variables are not defined distinctly. Numerical details are lacking (test of Level Set function, needs of a second mirror points in the ghost cell technique, ...). When reading the numerical part the reader get frustrated from this lack of details. Moreover, despite it's interest for fluid mechanics purpose, and especially for validating the mass conservation, the potential flow around a cylinder does not seems to be

Printer-friendly version

Discussion paper

adapted to the present journal. For reasons which will be explain in the paragraphs below I recommend the author to rewrite the numerical parts and the test cases 4,5,6 with much more details in a supplementary materials or in the journal dedicated to numerical fluid mechanics. The newly paper submitted to GMD should contain a short presentation of the numerical method with a reference to the supplementary materials (or paper) and the cases of section 7.

2 Specific comments

2.0.1 Abstract

Nothing to report

2.0.2 1 Introduction

Excepts the minor few points reported below the introduction is well written.

- *This study describes the numerical implementation, verification and validation of an Immersed Boundary Method (IBM) in the atmospheric solver Meso-NH for applications to urban flow modelling.* needs some reference
- *Covering all possible cases is obviously impossible but from a fluid mechanics standpoint one can invoke the principle of similarity which permits, for example, to observe von Kármán streets in the wake of a centimeter-scale cylinder as well as in the cloud layout behind an island.* I understand the thought of the authors, but in both cases the Reynolds number (which characterize the "principle of similarity") is much different.

- *Even if the physical application in our mind is the atmospheric mesoscale reaction to perturbations induced by urban cities, the more the obstacles are considered as a part of the scales numerically resolved the more the results accuracy is.* Is this sentence is useful ?

- *This approach and its variant developed by Goldstein et al. (1993) for a rigid interface can suffer from the lack of stiffness (fluid-solid interface is generally spread over few cells) which can be problematic to recover 5 the boundary layer.* The main issue with Goldstein et al. (1983) approach comes from the fact that the time step should be very low if we want to enforce a rigid boundary condition.

2.0.3 5 Potential flows

- *Depending on how to resolve the partial differential equations, Cartesian grid methods (Ye et al., 1999) are written for finite-volume discretizations (Cut-Cell Technique, CCT) and for finite-difference discretizations (Ghost-Cell Technique, GCT) as in Tseng and Ferziger (2003).* This sentence could be clarified.

- *Another argument in favor of discrete forcing is that it does not introduce source terms in the conservation equations.* Source terms are introduced but in a discrete way rather than in a continuous way.

2.0.4 2 The Meso-NH code at a glance

The overall section is understandable but some definitions are missing : $\mathbf{u}$, s,... The additional term such as $\mathbf{f}_\theta$ should be explicitly given or not mentioned. Indeed for a significant part of the paper (potential flow, DNS, ...) Coriolis forces, molecular diffusion does not play any role. Moreover more details about the LES technique could be given, for instance what is the filter size ?

Finally, it is interesting to know that the advective term can be solved using 4 different schemes to understand section 5. But the paper will gain in clarity if those details were mentioned in another paper / report.

2.0.5 3 The IBM forcing in the Meso-NH code

This part is the less understandable. We distinguishably see the large amount of work done by the authors to implement the methods but too few details are given and some paragraph are misunderstanding.

- *An intensive study had been done (not shown here) to verify the ability of the LSF spatial derivatives to recover the vector normal to the interface* this is really interesting and those results should be given. Indeed other authors (Kempe & Froelich JCP 2012) are using LS method to follow the shape of moving immersed bodies.
- *l3-l8* this paragraph should be clarified. Is it necessary to mention the Heaviside function as function of the LS function ? The authors could say that there are only looking at point closed to the interface.
- *A problematic case regularly met in the mirror interpolation is the vicinity of ghosts with the interface.* Why ?
- *The definition of several images per ghost permits the access to a building of the normal profile of the fluid information by an 1D quadratic interpolation* This point could be clarified.
- *Note the $\frac{l\phi}{2}$ -approximation on the location of the derivative term.*This point could be clarified.

- *First looking at the RHS of (5), the ... law coming from the resolution of the explicit-in-time schemes near the interface and in the solid regions badly affects the ... computation (note that the GCT operates after the step projection).* To be clarified.
- the meaning of the symbol $\widetilde{u}$ could be clarified
- Why the disk radius is split in 8. Why not 4 or 16 ? Figure 4 (b) is misunderstanding since the arbitrary surface is a square !
- *This number is limited by a convergence criterion (compromise between incompressibility satisfaction and CPU cost).* What is the CPU cost of this step ?
- The subsection 3.3 could be clarified. The referee is not fully accustomed to wall turbulence modelling. Nevertheless the discussion is quite hard to follow.

Since the proposed methods are closed to the ones proposed by Kim, Kim & Choi (JCP 2001) the authors could mention it in the introduction.

2.0.6 4 Potential flows

I found this section really interesting. I just mention a few minor points to clarified :

- *With a change of Galilean reference frame, this study corresponds to an uniform body acceleration ab in a fluid initially at rest* The steady uniform flow past a sphere is not equivalent to the accelerated flow past a sphere. How the added mass is computed ?
- *Unsurprisingly Acyl increases with the confinement*. Reference ?

- Taylor-Green vortices are solutions of the full 2D Navier-Stokes equations. I don't understand their location in the potential flow section.

- *To conclude, this section validates the modification to the pressure solver. IBM appears less accurate than BFM when the ground presents low curvature in regard of the space resolution. It seems more pertinent than BFM to model high interfaces such as sharp edges or corners.* More details should be given to explain this behaviour.

2.0.7 5 Potential flows

- *The adopted strategy with IBM is to model the advection term with a low order scheme near the interface (Sect. 3).* To avoid numerical diffusion, why a low order scheme is used ?

- *The vorticity equation for a 2D inviscid flow reveals no production in time.* To be clarified.

- *To fit as well the potential solution, a non-trivial condition is employed on the tangent velocity ...* Why such a complicated boundary condition is used ?

2.0.8 6 DNS

Nothing to report except give more details on how the viscous term added in momentum equation is computed.

2.0.9 7 8 9

Nothing to report.