Response to referee 1

July 31, 2024

Paper entitled "Buoyancy driven motion of non-coalescing inertial drops: microstructure modeling with nearest particle statistics. Acta Mechanica"

In this work, the authors employ the open-source code basilisk to study three different particle arrangements of droplets. The simulations are based on a geometric volume-of-fluid method where a specific algorithm is used to prevent the coalescence between droplets and thus to keep the system mono-dispersed. In particular, the authors employ an optimized multi-marker method where multiple marker functions are used to avoid numerical coalescence. The authors perform simulations at different volume fractions, up to 20%. Overall, the paper is well written and the results presented are of interest to the multiphase flow community. I think that after revision the paper can be accepted for publication.

We thank the Referee for his/her positive appreciation of the paper. Before providing a point-by-point response to the Referee's comments, we just wish to mention the main changes introduced in the paper to address the concerns raised by the other referee.

- In figure 9 (old figure 8) we plot the ratio $P_{(r-nst)}/P_{nst}^{th}$ instead of $P_{(r-nst)}/P_{nst}^{\phi \ll 1}$, the following discussion have been changed in consequences.
- Additionally, we have included a plot of P_{nst}^{th} for various ϕ to assist readers who may not be familiar with nearest neighbor distributions.

Additionally, as discussed before submission with the editor, we updated our DNS results for a more refined set of DNS (from $d/\Delta \approx 20$ to $d/\Delta \approx 25$) as the other set of results exhibited some doubtful results due to meshing problems. The main changes arising from this new set of DNS are the followings,

- The bond number is now fixed to $Bo = 0.5$.
- The maximum *Galileo* number is 80 instead of 100.
- The appendix (B.3) have been updated yielding better converged results.

As expected, the results and conclusions made in this study remain unchanged.

The following points should be improved:

1. What is the rationale for studying these three different configurations? How did the authors define these three configurations?

These configurations were selected because they represent distinct and fundamental types of microstructures observed in particle-laden flows.

2. Compared to the standard VoF (single-marker), what is the computational overhead?

It is said in the text that: "In particular, it is observed that the no-coalesce.h algorithm accounts for approximately 4% of the total computational time of a simulation in the densest scenario " Do the referee needs more details ?

3. It would be good to show some qualitative visualizations of the system behavior before moving to the discussion of the results.

The authors appreciate the referee's suggestion for including qualitative visualizations of the system behavior. In our opinion, *Figure 7* serves as a visualization of the system behavior, showcasing the distinct particle structures for each configuration (homogeneous, and layers). This figure provides a clear qualitative comparison of the microstructures, thereby aligning with the referee's suggestion.

4. In Figure 4, it would be useful to add a legend also in the figure (and only in the caption). Also, it is difficult to read this figure. Will it be possible to see the results in different sub-panels? One for lambda=1 and one for lambda=10?

The authors agree, the legend have been added, and the figure is now split into one for each viscosity ratio λ.

5. The deformation of the drops is limited (as shown in Figure 12). Did the authors perform simulations with more deformable drops?

Unfortunately due to the high computational cost of these simulations additional DNS could not be performed

6. Is turbulence forced in the triple-periodic box? Or the induced flow motion is just induced by the motion of the bubbles?

As mentioned in the text, we consider only the buoyancy forces in this problem.