Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
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Comment 2 on gmd-2021-387

Anonymous Referee #2

Referee comment on "University of Warsaw Lagrangian Cloud Model (UWLCM) 2.0: adaptation of a mixed Eulerian–Lagrangian numerical model for heterogeneous computing clusters" by Piotr Dziekan and Piotr Zmijewski, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-387-RC2, 2022

The authors have presented results from experiments performed to evaluate the performance of a Eulerian-Langragian numerical model adapted to heterogeneous computer systems. Since the original model is not new, I find the description of scientific and numerical methods used in the model satisfying and well referenced.

A consideration is made for the fact that the authors used hardwares and softwares which are readily available to them to conduct the experiments whose results are presented. I however find some of their assumptions and technical arguments used to arrive at their conclusions misleading and confusing. For example, in line 155 the authors write "We conclude that GPUs provide substantial benefits in equipment cost and power usage" while there are no results shown in the manuscript to support this conclusion. Until the authors clearly show data on the cost and power consumption of the GPUs and CPUs used in the experiments, the statement should be removed. Furthermore, I find the following terms used ambiguously throughout the manuscript, parallelization, system memory, server, and complexity. The terms are in some cases used in a non-standard way making it difficult for the reader to interpret the results presented. My comments in this regard are as follows:

- **Parallelization**: the authors have used the term "parallelisation" multiple times in the manuscript, e.g. in lines 4, 187, 195, 212, 222 as well as figures 2 and 4. The UML sequence diagram in figure A2 however shows concurrency which is not necessarily a parallelization. The fact that the original model also contain some aspect s of parallel programming may cause confusion to readers when the authors refer to the sequence shown in figure 2 as a "CPU and GPU parallelization". Perhaps "Concurrent CPU-GPU operations" will fit well.
- **System memory:** the authors have used the term "system memory" in a way that leaves the reader with no clear picture of the memory model applied. In lines, 88, 192, and 211 they use "system memory" to refer to the memory only accessed by CPU. Then in line 88 to 89 the authors write "Since the CPU and GPU data attributed to a

task are colocated in the modeled space, all CPU-to-GPU and GPU-to-CPU communications happen via PCI-Express…", and in line 135 they write "….all Eulerian fields are stored in shared memory". These statements considered together with the previously mentioned lines and put into context with "GPU memory" mentioned in lines 71, 84, 134, 162, 173, 181, and table 1, is confusing. To avoid this confusion the authors should adopt the standard heterogeneous memory model where "host memory" and "device memory" refers to CPU and GPU memory spaces respectively.

- **Server**: the authors have used the term "server" to refer to a single computational unit defined by a memory configuration in lines 37, 129, 135, 144, 153, 211, 217, figure 2, and tables 1 and 2. At the same time the authors use the same argument to introduce "single-node" in section 4.3 and "multi-node" in section 4.4. It will be clear for the reader if the authors consistently used single-node and multi-node systems as the standard definitions for shared and distributed memory units as opposed to using the term "server".
- **Complexity**: the authors have used "complexity" to loosely refer to time complexity in lines 139 and 140, but they seem to acknowledge the role of space complexity in lines 144 and 145. The two should be clearly separated and if possible shown using well defined or derived mathematical functions or presented graphically.

Additionally, the following lines should be corrected, rewritten or removed due to ambiguity and misspellings:

88: The term "system memory" is ambiguous here considering the standard heterogeneous computing memory model. "Host memory will be appropriate. Table 1 should also show the amount of memory available to the hosts in the systems described. See above the comment on system memory.
92 - 93: "An MPI task will typically control more than one CPU thread, because usually cluster nodes have more CPU cores than GPUs" This statement is misleading if you consider the current and future GPU clusters.
94 - 95: The statement should start with "The maximum number..." and end with "... in the x direction.
123 - 124: The performance need some comparison to be labeled "lower".
126 - 127: What threads do the authors refer to here? GPU or CPU threads? This should be clarified.
129: Perhaps a "single-node system" instead a "server" is more fitting. See the comment on "server" above.
132: The authors write "…grid is 128x128x128". Are these grid cells? Proper definition is necessary.
134 - 135: It is not clear which shared memory the authors refer to here, whether in the host or device. Also consider the comment on "server" above.
136: Figure reference is missing and "where" should be replaced with "were".
136 - 137: The authors should clarify whether there is any overhead in the timing function(s). If there is how does it affect the numbers shown?
136 - 138: The authors should show the analyses which were done with ARM MAP and VTune, and indicate how the numbers compare to the results from the UWLCM function. Otherwise the sentence should be removed.
137: Replace "where" with "were".
138: Replace "vTune" with "VTune"
139 - 141: Usage of the term "complexity" is ambiguous here, the authors should clarify whether they are talking about time or space complexity. See the comment on complexity above.
140 - 141: The authors should support the statement on complexity of GPU computations

with a well defined or derived mathematical relation or graphically. See comment on complexity above.
147 - 148: It is not clear what the authors refer to as parallelization of CPU and GPU computations (also in line 187). Should be rewritten for clarity. See comment on parallelization above.
150: The sentence should read "how much speedup is achieved by employing GPU resources".
153: The authors should reconsider the usage of the term "server". See the comment on server above.
154: There is no clear mathematical relationship between what the authors have defined as the "GPU speedup" and N_{SD} making the interpretation of figure 3 difficult. Should be revised accordingly.
155: This conclusion is not supported by any result. Without data on the cost and power consumption of the used hardware, the sentence should be removed.
161 - 171: Reference to table 3 should come earlier in line 160 to make the description of the mentioned configurations more under stable.
2019 - 2020: 'higher factor' should be substantiated with a comparison.
223: The authors write "A simulation with 20 million grid cells and 2 billion particles can be done in real time" without any evidence. The sentence should be removed unless it is substantiated with clear evidence or references.
227 - 229: This paragraph should be revised to include clear meaning of parallelization. See the comment on parallelization above.

Appendix B: The authors use "processes" and "tasks" ambiguously. The paragraph should be revised to remove the ambiguity.

Appendix C: Should be removed and the paragraph included in section 4.

Table 3:

- Definition of N_{nodes} is missing.
- Is there any relationship between n_x, n_y, n_z and "Eulerian cells in domain [10^3]; and N_{SD} and "super droplets in domain [10^6]? If there is, it should be described otherwise the table is confusing.