Geoscientific
Model Development
Discussions

Interactive comment on "Automated tracking of shallow cumulus clouds in large domain, long duration Large Eddy Simulations" *by* T. Heus and A. Seifert

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We thank the referee for the thorough review of our manuscript. Clarity is always a challenge in this kind of highly technical writing, and we believe that the comments of the reviewer greatly improve the readability of the manuscript. In general, we have followed the suggestions of the referee.

1   General issues

1. *Motivation: I miss a clear motivation in the introduction. You touch upon some of these points in your introduction, but it is somewhat scattered. The very last paragraph of the conclusion gives a few hints again, but this is obviously too late. What have others done with such a tool? What do you plan to do? Why did you develop your own tool instead of using established ones - which would ease the comparison/discussion? Can you please clarify that in the introduction. Description: In the introduction the description is sometimes jumping on too quickly. Make sure that you introduce the reader to your specific points and terminology.*
   We have revised the introduction. Although we feel that most of the points mentioned by the reviewer were already touched upon in the introduction, we agree that coherency was lacking. We believe that the revised manuscript fixes this.

2. *English Language: At several places throughout the manuscript the use of the English language sounds a bit odd to my (non-native) English speakers ear. It's no big problem, but sometimes not easy to read. Whenever I was confused, I made a point for the "specifics" list below.*
   We have revised all the points in the manuscript indicated by the reviewer, and then some more when we felt clarification was possible upon rereading the manuscript.

3. *The question of retaining "remnants" and their physical meaning is unclear to me: - page 2295, section 3.3: Why do you allow these remnants? Why do you treat single remnants with a single neighbor so different than the ones in between several cores (not considering distance to the core any more)? Why don't you split up the whole cloud area between the given cores (obeying some maximum distance from the core)? Can you please comment? The iterative methods sounds very tedious and time consum- ing. Why don't you derive the distance of each box (x,y,t) to all original cores (within the the maximum distance allowed)*

and then relate it to the core with the smallest distance. Your method sounds like a nearest neighbour approach, but more compli- cated. Could you please add a list with all the cloud type definitions "remnant", "pulse","multi-cell/pulse", and "passive" to the text and characterize them with a few words?

Large remnants are usually outflow regions of large multi-pulse systems. This type of cloud has very different characteristics from the convective pulses, something we aim to explore in an upcoming study. It would be impossible to distribute those areas over the pulses that are connected to them without imposing many assumptions on the system. Single remnants, on the other hand, can be uniquely assigned to a single pulse without imposing those assumptions. The iterative method is indeed some kind of nearest neighbor, but following the interface of the cloud. An earlier implementation that indeed was based on direct nearest neighbor connected remnant areas to cloud cores even when there was a cloud free region in between. After optimizations, we believe that our method is much more accurate, while the computational cost is very bearable.

2 Specific issues

1. *page 2288, abstract, line 14: dx not introduced.*
   Corrected.

2. *page 2289, line 1: "life stage of the cloud" does not sound like proper English. Google- testing this term provides only 5 hits and 2 are from the main author.*
   After discussions with native speakers, the consensus seems to be that the term is not wrong, but not a normal way of phrasing either. We've rephrased the sentence to clarify our meaning.

3. *page 2289, line 3, sentence "To develop ... as well ...": Do you refer to the Plant and Craig publication with the "as well"? It's not clear when reading it for the first*

time. This sentence contains the only motivation part in the introduction. Could you extend/explain this a bit more?
   We have extended the section a bit, included the expected range of applicability, and we hope that it now explains (or at least forshadows) why we opted to develop our own method instead of using anything that is already available.

4. *page 2289, line 8-13: I find these sentences quite difficult to read. Many commas don't make it easier. Can you try to clarify them?*
   We've rewritten the paragraph, with an emphasis on shorter sentences and believe it is more clear now.

5. *page 2289, line 19: How did DA12 do the tracking?*
   Together with the rewritten paragraph above, this should be more clear now.

6. *page 2289, line 22: At this point the reader does not have a clue what a "merging issue" could be. Please introduce the problem.*
   The rewritten paragraph aims to introduce the problem in a better way; the phrasing is changed as well to make it clear that we are still talking about the same problem here.

7. *page 2290, line 7: I don't understand how the "projected cloud cover" approach in- creases "the risk of splitting"? I only see the tendency to merge clouds from different levels.*
   The reviewer is correct on this point; we've adapted the manuscript accordingly.

8. *page 2290, line 13: You start the paragraph with a totally new concept. Is this "Splitting of connected..." the same as the splitting just above? I guess not. Please help the reader. The splitting of combined cells in the tracking process is a new concept here and the necessity is not instantanously clear. Please introduce this point, which is important in your further description, with one or two*

further sentences.
The manuscript has been clarified on this point.

9. *page 2291, line 6: "... a little intermittent precipitation ...". Is the precipitation some- what intermittent or is it "some intermittent precipitation"?*
Corrected

10. *page 2291, line 16: "results quickly" $\Rightarrow$ "quickly results".*
Corrected

11. *page 2291, line 17: The wording of "structures cannot miss a connection in time" is a bit sloppy. I understand what you mean, but this hardly is a sensible sentence.*
Clarified

12. *page 2291, eq 1: This way I derive a Umax of 0.4 m/s. This sounds like a very slow motion. Is this correct? Can you comment?*
This is correct; the motion is slow because of two reasons: 1 is the 2D integration as was already mentioned in the manuscript, and 2 is the use of a Galilean transform that subtracts the mean velocity from the field. The remaining fluctuations then become fairly small. The manuscript has been update to reflect point 2.

13. *page 2291, line 25: "To alleviate the limiting of cloud size ...". I find your frequent use of "ing"-forms a bit hard to read. In this case: Why not "limitation"?*
Fixed.

14. *page 2292, line 7: "To perform the full tracking, 10 fields (as a function of (x, y, t)) are necessary on output from the LES simulation." $\Rightarrow$ "To perform the full tracking, 10 LES output fields are necessary (all as a function of (x, y, t))."?*
Adapted the referee's suggestion.

15. *page 2292, line 12: "For every cloud that is tracked ... ". Please split the sentence in two. E.g. with a second sentence "In addition, the vertical position have to*

match in both columns, i.e., the cloud base of each column needs to be below the cloud top of the other column in order to be connected."
We've rewritten the sentence.

16. *page 2292, line 19: "directions" $\Rightarrow$ "direction"*
Fixed.

17. *page 2292, line 19: "For these neighboring ...". Another confusing sentence. Please simplify and split.*
Rephrased.

18. *page 2292, line 25: "Like for clouds," $\Rightarrow$ "As for clouds, "*
Fixed.

19. *page 2293, section 3.2: This section should be clarified. At the moment I would have to read the given literature to understand something. What is a "decaying scalar"? The parameters of Eq. 3 are not introduced. What is w', C', cst? Can you maybe give an illustrative example? Should in Eq. 4 "C(x) <C(z)>" not be "C(x,z) <C(z)>"?*
We've rewritten parts of this paragraph, and hope it should be more clear now. We also changed from vector to scalar notation in equation 4 (now eq. 3) to avoid confusion, and to emphasize that this part of the thermal assignment occurs in 3 spatial dimensions (and therefore during the simulation).

20. *page 2294, line 26: "Since the larger ...". I understand that the region becomes larger for a larger original circumference, but in Fig. 2, I have the impression that the left core grows much quicker (covers areas further away from the core). The reason could be a contact at another time step, couldn't it? Please say that.*
This is true, and this is a desired quality of the algorithm. Of course, the cartoon is somewhat exaggerating this to get the point across. We've modified the text to clarify.

21. *page 2295, line 2: "increase in cloud base" ⇒ "vertical distance between cloud bases" ?*
Clarified.

22. *page 2295, line 3, "The amount ...": I don't understand "is rarely a limiting factor"? In Figure 5 many remnants are visible. How does that correspond to "rarely"?*
Perhaps 'limiting factor' is not the right term here. We have changed it to 'shows little sensitivity'. The point being that even without an iteration limit many areas would still be seen as remnants, since the height criterion inhibits the cloud cores to reach those areas. However, sometimes a single thread is (just) able to overcome the height criterion, and then slowly acquires all of this remnant. This behavior is mitigated with this iteration limiter.

23. *page 2295, section 3.4, first sentence: The last commas in this sentence does not seem to be necessary.*
Fixed.

24. *page 2296, line 4: Comma after "including" has to be removed.*
Fixed.

25. *page 2296, line 10: What is "larger resolution"? Should be "coarser".*
Fixed.

26. *page 2296, line 11: "... there is some room for these kind of tactics." :) Very very colloquial.*
Formalized.

27. *page 2296, line 25: " Part of this is deceptive and due to the mean wind ..." ⇒ "Part of this is deceptive because of the mean wind ..."*
Fixed.

28. *page 2297, line 18: "active multi-cell clouds". Are these the "multi-pulse" clouds? Please stick to your own terminology.*
Corrected (plus one other occasion of cell where pulse is meant).

29. *page 2297, line 18: "From this figure, and from the accompanying movie ...". The comma is not necessary.*
Fixed.

30. *page 2298, line 16: "the cover of the precipitation" ⇒ "the area covered by precipita- tion"*
Fixed.

31. *page 2299, line 6: "pronounced in time" ⇒ "pronounced with time"*
Fixed.

32. *page 2299, line 11: Shouldn't "steepening" not be "leveling"? More large clouds for the same number of smaller would make a distribution less steep? Do I miss something?*
The manuscript is correct, but unclear: The number of mid-sized clouds decreases, in favor of the number of clouds beyond the scale break. The number of smallest clouds stays similar. Therefore, a steeper but more extended power law behavior can be seen. Clarified in the revised manuscript.

33. *page 2299, line 13: Again I'm lost. What does "As for the smaller scales " refer to? Also, what is meant by "some of these effects"?*
We pointed back to the "Finally....smaller scales" earlier in the paragraph. The sentences have been regrouped and clarified in the new version.

34. *page 2299, line 18: Skip the "is shown" at the end of the sentence.*
Fixed.

35. *page 2299, line 22: No comma "... for broken of chunks and splits up ...".*
Fixed.

36. *page 2300, line 16: "including above the " ⇒ "including heights above the " ?!*
Rephrased.

37. *page 2301, line 4-7: The 2nd and 3rd sentence sound wrong. It is the other way round, isn't it? The parameters impact the analysis. It is not the sensitivity of the parameters to something else. Replace "sensitivity" ⇒ "impact".*
Fixed.

38. *page 2302, line 17-21: I do not understand the statement about an "effective reso- lution". Could you please clarify. In addition, I can not find any corroboration for this statement in Figure 14. The point where the small size distribution deviates from the power law is 20 * dx, 15 * dx, 10 * dx in this figure, isn't it?*
We are not sure that the assumption of power-law behavior down to the smallest scales should really hold in this case. If anything, the scale break that is visible between 200m and 300m seems resolution independent, and may be physical, although the uncertainty in the current power law coefficients is likely to large to say anything of significance about it. What we meant to say was that the 25m resolution simulations start to deviate from the 5m resolution simulations in their cloud size distribution at a cloud size of around 150m ($6\Delta x$), and that the 10m resolution simulations start to deviate from the 5m simulations around 60m cloud size. We revised the manuscript to better emphasize our point.

39. *page 2303, line 9: It is "a" not "the methodology", as there have been other compara- ble methods out there before yours.*
Corrected.

40. *page 2303, line 11: "vastly reduced computational resources required" sounds very complicated and still incomplete. Maybe ⇒ "clear reduction of required com-*

putational resources".
Rephrased.

41. *page 2303, line 13-14: " and allows us to more fine grained conditional sampling" again sounds complicated and maybe wrong. What about "and allows for a finer con- ditional sampling"?*
Rephrased.

42. *page 2303, line 15: "the large side" ⇒ "the large scale end"*
Rephrased as part of the previous point.

43. *page 2303, line 21: What do you refer to with "these"? Can you skip it?*
Clarified.

44. *table 1: What is the category "of which pulse"? It is not "of which single pulse". Is it multi-cell or multi-pulse from the text?*
It is indeed the multi-pulse from the text. Clarified that, trying to convey the notion that we are talking about a part of such a mult-pulse system.

45. *figure 1: I do not find this flowchart very helpful. I think I understood in the end,the description in the text was more helpful to me. I hardly understand the right boxes "regiongrowing" and "split". What is "nr", "n1", "n2", "%loc"? In addition, in a printed version of your manuscript the tiny pseudo-code will hardly be readable. If you wantkeep this chart: Did you really summarize all aspects of this diagram in the text? Did you use all "routine names" correctly in the text?*
We believe that the flowchart might help more graphically oriented people to understand our algorithm a bit better, always in combination with the text. Given the novelty of some of the concepts we use, the text of the manuscript is probably always necessary to fully understand what is happening, but we have seen during seminars on our work that the flowchart can help. Therefore, we would like to keep it. We have revised some of the wording, and will be sure to print it as large

as possible in the final version. If we compile the manuscript in final mode, the graph does seem to be readable to us.

46. *figure 2, caption: The brackets "(", ")" go wild in the caption. "by letting the regions grow" ⇒ "by use of the regiongrowing process"*
The bracket issue acted up in the technical editing process and was unnoticed by us. Fixed in the new version. The region growing part is rephrased.

47. *figure 4, caption: "Every patch of the same color depicts a cloud that, after application of the splitting algorithm, belongs together" sounds strange. ⇒ "Every patch of the same color depicts a core, after application of the splitting algorithm."*
Rephrased, with "single cloud" instead of the suggested "core"

48. *figure 6, 7, 8: The y-axes are labeled differently. Why?*
Because of an out of sync script, the labels are now made consistent.