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Interactive comment on "3-D model simulations of dynamical and microphysical interactions in pyro-convective clouds under idealized conditions" *by* P. Reutter et al.

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Reutter et al. (hereafter "auth") perform simulations of pyrocumulus convection using the ATHAM model, which was also used in three previous studies of a specific, actual pyroCb. This work involves a more sophisticated aerosol and microphysical component to ATHAM than was previously used. This work also adopts/augments the cloud condensation nucleus (CN) approach that Reutter et al. (2009) used in a simpler parcel-model experiment. Here auth simulate a 1-hour fire and three aerosol number concentrations to assess impact on pyroconvective cloud dynamics and microphysics, using the results to infer aerosol indirect effects.

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Interactive Discussion
Discussion Paper

Auth's experimental setup is clearly idealized (E.g. there is no wind in the simulations; the atmospheric profile is generic mid-latitude.) but for the most part is defendable in its construction (with exceptions mentioned below). The paper is well written. The results, which are generally consistent with prior studies of aerosol/convective-cloud interactions, will be of value and should motivate future studies. However, this report in its present form raised several questions/concerns that I hope will be addressed in a revision. I believe that if these concerns are addressed, the revised work can be recommended for publication.

I first list the more substantive concerns, followed by Minor/technical ones.

Substantive Questions/Concerns

The simulations presented differ in one respect: 3 loadings of aerosol number concentration, a "clean case" (1000/cm3), "intermediate case" (20000/cm3), and a "polluted case" (60000/cm3). All three are fed by a sensible heat source representative of an intense boreal forest fire. The "clean case" then becomes the apparent control experiment. However, it is not clear how this setup compares to a non-fire control setup, either in terms of the heat/buoyancy source or environmental aerosol loading. Have auth done a simulation of a "natural" thermal trigger and environmental CN loading? I would be interested to see a comparison of this convection as another control, with which to compare the "clean case."

Auth show a time series of cloud volume (number of cloud grid points) and rain rate for the 60 minutes of the fire and 30 minutes thereafter. Figure 1 shows that the pyrocloud is still growing (and precipitation increasing) at the end of the 90-minutes. To the extent that cloud lifetime indirect effect is a topic of this paper, it would be very informative to see the relative times of maximum cloud area and precipitation rate, both of which presumably occur after the 90-minute simulation shown. Would auth consider extending the time analysis to include the reduction of these quantities for all three simulations? Referring back to the prior question about a non-fire control scenario, the Figure 1

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analysis would be even more informative with a comparison to this suggested control case.

A provocative finding in this paper is that the pyrocloud continues to expand, and rain-rate increase, after the fire is turned off. This seems curious to me because there is no thermal forcing other than the fire, yet convective development apparently continues for at least 30 minutes in this state. However, auth do not explore the post-fire cloud dynamics or microphysics in sufficient detail. The suggestions above, to extend the simulation in the post-fire state and run a non-fire control case, also apply to this concern. And it would be valuable to see vertical views of the post-fire state and a discussion thereof.

Auth show an isoline of interstitial aerosol concentration on the vertical slices through the cloud, but there is no discussion of this. It seems like a valuable element of discussion, as to how the interstitial aerosol is affected by the simulations. On page 19537, lines 20-23, auth conclude that precipitation onset in the clean case is via liquid-phase microphysics. However, I don't see how that can be determined by the figures they show.

On page 19540, line 19-20, auth make a conjecture as to the radiative effects with respect to cloud evolution. They present no basis for this. I would suggest they consider dropping this sentence.

These simulations and the presented metrics in the figures are informative, but they made me wonder how updraft strength varied in the experiments. I suggest including an analysis of maximum updraft velocity (as function of time and altitude within the cloud).

Minor/Technical

P19529, L 24. Fromm et al. (2010) should be Fromm et al. (2008) (Part I or II, dealing with the Chisholm pyroCb)

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P19529, L26. Change “which lead to” to “which led to.”

P19529, L25-27. Sentence beginning “Also, for this case. . .” requires a citation.

P19530, L5. The statement “The sensitivity simulations. . .weakly affected by the aerosol loading” needs a citation.

P19532, L9. What is auth’s modification to the Seifert and Beheng scheme mentioned here?

P19533, L23-25. Does this last sentence of the paragraph need a citation?

P19533, L4-5. “This rapid evolution is triggered by the latent heat release. . .form ice crystals, snow, and hail.” Is this evident in the figures presented? If so, please point out.

P19537, L20-23. “Nevertheless, in order to form graupel and especially hail, a sufficient amount of rain droplets is crucial. Therefore, the onset of precipitation in the clean case occurs via the liquid phase.” I do not see where this is shown in Figure 5. Please clarify.

P19543, L3. “actiation” should be “activation”

Figure 1 and 2. To me the colors of the 1000 and 60000 cases are too similar. Please consider more distinctive coloring.

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