Atmos. Chem. Phys. Discuss., 13, C7780–C7785, 2013
www.atmos-chem-phys-discuss.net/13/C7780/2013/

Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #1

Received and published: 7 October 2013

Overview

This paper considers the activation of cloud droplets in pyro-convective clouds. It is important that these results are published as they confirm results from other similar studies in deep convective clouds, an area where the level of understanding is still not very mature. Some of the results, in my opinion, are not particularly new findings; mainly that for 'low' aerosol concentrations ($N_{cn} = 1000$ /cc) rain formation occurs more rapidly than for 'high' ($N_{cn} = 10^4$ /cc) aerosol concentrations, in which the ice phase leads to a delayed precipitation mechanism. The 1000/cc simulation, as stated by the

authors, is not realistic. In my opinion it is interesting to see what the effect of such low concentrations are, but more important to investigate the sensitivity within more realistic bounds.

Some of the explanations are not clear enough for me to understand the points being made. I also think it would be useful to show what the number concentrations of hydrometeors are in the cloud, rather than solely rely on mass concentrations.

I have to recommend major revision as I am recommending that some sections are re-written (Abstract and a conclusions section are needed) and that some graphs are added to show the number concentrations of droplets and ice crystals.

Specific comments

- Abstract: the first two paragraphs do not really read like an abstract, but more of an introduction. I would suggest that it be re-written to contain the essence of the paper and the main findings.
- Introduction, line 9: "air parcels to rise". You just mean convective instability. Air parcels rising is not really what is happening. The air parcel description is continued on line 11 and is an over simplification for essentially the movement / dynamics of a fluid.
- Same page "this aerosol plume was observed for several months well within the stratosphere". Please provide a reference for this point.
- Same page "continental microphysical structure was documented" what does this mean? Please elaborate.

- Page 3 onto page 4: “sensible heat release by the fire was the most important parameter”. I’d prefer to have some clearer explanation of what the context is here. What else was investigated, why was it so important, etc.
- “is reaching higher altitudes” should be “reached higher altitudes”, i.e. past tense not present tense. There are several examples of this kind of language in the text.
- Next sentence talks about a “positive feedback”, but no details are given as to what you mean. Do you mean radiative effects? But you don’t consider radiation in these calculations.
- Line 17: “Thus, pyro-convective cloud are a unique form of atmospheric. . .an ideal test bed” I am not sure I follow exactly what makes them an ideal test bed. Does this really follow from what you said? I think you need to say why they are an ideal test bed.
- Page 5, line 5: “within a pyro-convective clouds” should remove “a” or use “cloud” instead of “clouds”
- Line 17: “supersonic flow around the vent of a volcano” can you provide a reference that this is the case?
- Page 6, line 8: “indirect aerosol effects”. I note that in the new IPCC report the authors are not referring to indirect effects anymore and have a new definition. Should this be adopted here?
- Line 11: “nucleation of cloud drops”. It is not nucleation as nucleation implies a new phase. It is activation as liquid water exists in the aerosol below water saturation.

- Line 14: “It was found that, depending on the ratio. . .” I suggest either removing this sentence or explaining it in more detail. It doesn’t give the reader much at present.
- Page 6, last para. It does seem odd that your definition of cloud base is an updraft velocity of 0.1 m/s, but that the look up table only has the smallest updraft equal to 1 m/s. How does this affect the calculations? Do you thus interpolate between 0 (i.e. no activated drops) and 1 m/s? Is there any potential to mis-represent the number of activated drops?
- Section 3.1: number of cloudy grid points. I presume there is a threshold above which a grid point is counted as “cloudy”. It is important to state what this criterion is so that people can repeat your analysis. Also does “cloud” include ice cloud? Does “cloud” include rain water?
- Rainrate in figure 1. Is this rainfall at the surface or the precipitation through the atmosphere?
- Figure 2: I am not clear what the point of aerosol mass is since you say previously that you use the same N_{cn} everywhere. Can you be explicit about how the aerosol mass is used? It makes a difference to the interpretation of the results. Is it just a passive tracer emitted by the fire?
- Figure 4: on page 11, line 6 you compare the maximum liquid water content altitude. But clearly the fields are time-dependent, so I feel this should be noted. The point is that it may be that the situation looks a little different later or earlier in time.
- Similar argument applies for figure 5: you are comparing y-z profiles at 60 minutes, whereas the fields are time dependent (see Figure 1) and the clouds are at different stages of development. You could perhaps just note this and say you are saying that the more polluted cloud takes longer to glaciate?

- Page 12, line 5: you talk about ice forming by freezing of cloud droplets AND by nucleation AND deposition freezing. Surely all of these are ice nucleation processes? A minor point is that deposition nucleation isn't really freezing as liquid water isn't involved at all in deposition ice nucleation.
- I think what is happening is that homogeneous nucleation of ice in the supercooled droplets is leading to high concentrations in the polluted case. You don't actually mention this but I think it is crucial to say whether or not this is the process responsible for the high concentrations (you do mention the freezing temperature of water, do you mean the temperature for homogeneous nucleation?). Otherwise why would increasing the number of biomass burning aerosol (organic aerosol, which current literature would suggest are not ice nuclei) result in an increase in the number of ice crystals in the cloud?
- Page 14, line 16: radiative effects: obviously the question of the spatial coverage of pyro-convective clouds is raised when the discussion turns to radiative effects and some discussion on this point would be welcomed.
- I would expect to see a conclusions section which states the main findings of the study succinctly. If there are no definite conclusions then it throws into question whether the paper is of worthy scientific merit to be published in ACP. I do believe it is of high enough scientific merit, but still feel the authors should make the effort of writing down the conclusions.
- Fig A1, A2 and A3 are only referred to in the appendix and not described at all.
- It would be really useful to know what the droplet number and ice number concentrations were in the clouds. I did not see any of this information but is it relevant to assess whether the microphysical schemes are producing realistic cloud fields. For instance with 60,000 /cc of aerosol particles it is somewhat surprising that

warm rain formation happens at all. However, more knowledge of the cloud fields would enable a better assessment.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 19527, 2013.