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Interactive Comment

Interactive comment on "Modeling of biomass smoke injection into the lower stratosphere by a large forest fire (Part II): Sensitivity studies" *by* G. Luderer et al.

G. Luderer et al.

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Reply to referee #3 (The Reviewers comments are contained in brackets):

[This paper is a sequel of the accompanying paper (Part-I), Trentmann et al. (2006) on the modeling study of the Chisholm fire. This paper discusses the results of a series of sensitivity studies to understand the relative importance of the general meteorological conditions, the heat flux from the fire, the moisture from the combustion and the CCN. The paper is very well written and only the following suggested minor revisions are necessary.]

We would like to thank the referee for her/his review and the constructive comments. Replies to the specific comments are given below.

EGU

[1. The paper discussed the role of CCN extensively and the conclusion is that CCN is of minor importance to the evolution. But certainly IN should also be present in the pyro-Cb and the model has IN as well. Normally IN have much lower concentration than CCN and hence probably play even a smaller role. But it should help readers to state clearly that it is the case.]

It must be noted that heterogeneous freezing in the current microphysics scheme of ATHAM is parameterized using the stochastic hypothesis proposed by Bigg (1953), hence (as in almost all other 3D cloud resolving models) there is no explicit treatment of IN.

It has been known for a long time that forest fire smoke contains particles that are quite efficient ice nuclei (Hobbs and Locatelli, 1969), however there is great uncertainty about their abundance and properties. Despite occurring at much lower concentrations than CCN, IN might have an impact on the transition from liquid to ice phase in the pyroCb. Due to the limitations in the microphysics scheme, however, this was not taken into account here.

The description of the cloud microphysics was extended in Section 2 of this paper and also in the companion paper by Trentmann et al. In Section 4 and the summary it was noted, that the model does not account for the possible effect of the ice nucleating ability of smoke.

[2. The authors have stated that the there are uncertainties about radiative dissipation of the combustion energy. One additional possibility that may exist and I am not clear from reading the manuscript is that the CCN may absorb and hence trap some radiated heat (a sort of greenhouse effect). This effect may act to increase or decrease the stability of the pyro-Cb depending on whether this absorption occurs at high or low level. It may be worthwhile to say something about this possibility.]

In the thermal IR where the fire radiation is emitted, aerosols are rather inefficient absorbers. It is likely that most of the radiative energy from the fire is absorbed by cloud

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droplets or gaseous absorption at cloud base or in air masses that are entrained into convection. Since this energy also adds to the convection dynamics this effect provides additional support for the assumption that all the fire energy becomes available for the convection.

In addressing this comment, the discussion of the influence of the radiative dissipation on convection has been extended in the companion paper by Trentmann et al.

[3. P. 6105: it is indicated that the present results contradict that of Andreae et al. (2004) and Koren et al. (2005) on the role of CCN and that there are no invigorating effects of CCN on the dynamics of this mid-latitude pyro-Cb. Is this specifically due to the nature of the mid-latitude convection or you are actually saying that there is a disagreement between the reasoning?]

Cloud microphysics in general and aerosol-microphysics interactions as well as mixed phase processes in particular are very complex issues and associated with great uncertainties. The mechanism proposed by Andreae et al. (2004) and Koren et al. (2005), i.e. suppression of precipitation resulting in invigoration due to shutoff of downdrafts and additional latent heat of freezing, is different from the mechanism that leads to slightly decreased stratospheric injection due to the large abundance of smoke CCN in the present modeling study. The effect described in this modeling study is due to the shift of the glaciation to the level of homogeneous freezing that results in delayed release of the latent heat of freezing.

In the case of extremely strong mid-latitude pyroCb convection studied here precipitation formation is rather inefficient even in the case study without CCN from the fire due to the fast ascent of air parcels within the convection column that does not leave sufficient time for droplet growth to precipitable sizes during the ascent. Hence in both the REF and the loCCN cases the glaciation level is reached and, for this particular situation, the mechanism proposed by Andreae et al. (2004) and Koren et al. (2005) is not relevant and cannot be transferred to the case studied here.

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Interactive comment on Atmos. Chem. Phys. Discuss., 6, 6081, 2006.

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