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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Time-dependent freezing rate parcel model" *by* G. Vali and J. R. Snider

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We appreciate the reviewer's support and the very appropriate suggestions for improvements. Responses are given for each item after the long arrow.

We agree with the reviewer's summary of the main point of the paper (impact of parcel cooling rate) with the slight extension that the treatment includes the limiting case of zero cooling rate as well, i.e. that of the parcel remaining at a stationary level for a period of time following rise in an updraft.

Page 29306: Line 4: Suggest rewriting "...includes a period of time when the parcel remains stationary at ..." ⟶ Thanks, that's better.

Line 22: "...due to lack of tools to study ice nucleation processes on a molecular scale." As far as I understand, there is research being conducted to study ice nucleation on the molecular scale. Perhaps the sentence can be rephrased ".... due to difficulties in studying ice nucleation processes on a molecular scale". ⟶ Thanks for the references. We meant to say that "there are no tools to observe processes on the scale of embryo formation," and changed the text to say that.

Page 29307: Line 5: Please add citations for the statement that immersion freezing is the dominant mode. ⟶ Added references: Lohmann and Diehl, 2006; Murray et al. 2010; deBoer et al. 2011; Eidhammer et al. 2010; IPCC Climate Change 2013 pg. 604.

Line 27: suggest rephrasing: "... as additional parameters in newer parameterizations (Li and Penner....." ⟶ Added the suggested wording.

Page 29308: Line 21: I suggest using capital D in Time-Dependent Freezing Rate (TDFR) ⟶ Yes.

Page 29309: Line 10: "or" instead of "of" ⟶ Yes.

Line 12: "Initial conditions" ⟶ Yes.

Page 29310 Line 16: "indicates" instead of "indicated". ⟶ Yes.

Page 29311 Line 19: I suggest that Eq 5 is described before making references to this equation in this and the next paragraph. ⟶ While this jumping ahead is not desirable in general, here it refers only to a numerical correction and Eq. (5) wouldn't be easy to introduce detached from the extensive discussion that is given in the next section. So, we prefer to leave the text as is, and trust in the readers' forebearance.

Page 29312: Line 9: Suggest rephrasing: "...are considered when located at considerable heights ....." $\longrightarrow$ Changed as ".. are considered when located well above cloud base ... ".

Line 10: "above", instead of "about". $\longrightarrow$ Corrected.

Line 18: I suggest including a reference to Knopf and Alpert 2013 (A water activity based model of heterogeneous ice nucleation kinetics for freezing of water and aqueous solution droplets, Faraday Discussions, 165, 513), who also show the effect of cooling-rate on freezing. $\longrightarrow$ Good point. In fact the values of ξ indicated by Knopf and Alpert 2013 are comparable to the value adopted in this paper. Added text accordingly.

Page 29313: Line 20: I suggest defining T_s here (as isothermal level) instead of at line 2 on page 29314. $\longrightarrow$ Changed accordingly.

Page 29314: Line 3:. $N(s - dt)$: number of what? $\longrightarrow$ As given in the first part of the sentence.

Line 5: What does 1 stand for for p1 and q1? $\longrightarrow$ Given in Table A1.

Line 6: is this notation correct: $-20\text{C} \geq T_s \leq -16\text{C}?$ $\longrightarrow$ Corrected the error.

Line24: Should $w = 1$ have units of C min-1 ?$\longrightarrow$ Added the units.

Page 29315: Line 2: not sure what is meant by: " and some other value" $\longrightarrow$ Rephrased as " ...either $w = 1\text{Cmin}^{-1}$ or some other value of w."

Line 8: Since q_w is sensitive to the updraft velocity, does that mean that q_w is also equally dependent on the cooling rate? $\longrightarrow$ Indeed, the dependence on updraft velocity

arises from its direct effect on the cooling rate of the parcel. Added a sentence to that effect.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 29305, 2014.