**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Parameterization of homogeneous ice nucleation for cloud and climate models based on classical nucleation theory" *by* V. I. Khvorostyanov and J. A. Curry

V. I. Khvorostyanov and J. A. Curry

vitalykh@tdn.ru

Received and published: 2 September 2012

Reply to reviewer's remarks on the manuscript by Khvorostyanov and Curry "Parameterization of homogeneous ice nucleation...", acp-2012-97

Since our reply contains many mathematical symbols as was required by reply to review, our reply is presented in 2 forms: as a plain text here (the symbols are spoiled) and as pdf file in supplement, where all the symbols are correct.

****

The authors are very grateful to reviewer for careful reading the manuscript, his huge

work with verification of all equations and corrections of misprints, and several useful remarks that allowed to improve the paper and clarify the text.

The authors are grateful for recommendation of the manuscript for publication. All the reviewer's remarks are accounted for exactly as reviewer recommended and the corresponding corrections are made in the paper. Our point-by-point response to all remarks follows.

Specific (inclusive technical) comments.

1) p. 6747. Units of $J_{hom,0}$ are added. Temperature in Celsius is introduced.

2) Typo after eq. (23) is corrected.

3) p. 6752. Notations are corrected, units are added.

4) p. 6753. Notations for ïĄšv, ïĄšis, ïĄšws are corrected.

5) p. 6753. The reference to KC05 is added, along with the phrase: "Formation of drops is not considered in this work and the term Icon is absent in eqs. (8a,b). However, both sw and si are required for further consideration since ice nucleation is governed by sw, and crystal growth is governed by si." This clarifies the situation considered. The expressions for ïĄĞ2 and ïĄĞ12 are given in eq. (8c).

7) p. 6754, eqs. (12), (13). References to Fuchs (1959) and Sedunov (1974) are added.

8) eqs. (14)-(16). Is added "with constant ïĄši, ïĄšis during the relatively short time of integration,"

9) p. 6755, eq. (17), (18a). Yes, it is possible to introduce two activity spectra, by T and sw, the method described by the authors allows to do that since these dependencies are separated. This is done now after eq. (52a), the equations for the activity spectra by sw and T are added in eqs. (52b), (52c). For derivation of the general expressions, we use a simpler equation for activation spectrum in (18a).

10) p. 6755. Dependencies of Rf,hom on T and sw are considered later. Here, we give just general expressions.

11) p. 6755. Reference to section 3.2 for definition of Jf,hom is given after eq. (18b). Eq. for Jf,hom is given not here but in section 3.2 because several transformations of this equation are considered there. If to move eq. for Jf,hom here, reading section 3.2 would be difficult.

12) Subscript is added in eq. (18d).

13) "as employed. . ." is added.

14) The effective radius is introduced in eq. (20) as suggested by reviewer.

15) OK.

16) Yes, spare dt0 is deleted.

17) Yes, there was a typo in eq. (25) while the correct source ïĄźfc was given 4 lines later. Reviewer made a correct remark here, but suggested the expression for ïĄźfc that is different from ours. Following reviewer's remark, we added a notation for the source term ïĄźfc directly in eq. (17), corrected (25) and slightly shortened the text after.

18) Ordinate in Fig. 1a is corrected.

19) p. 6759. Yes, the definition of the critical supersaturation is important here. It is added now on this page.

20) The notations are changed as "ïĄĎMv, and the relative amount, or percentage of condensed ice, Frcon,". The term "mass of ice supersaturation" is deleted.

21) OK

22) The following clarification is made before eq. (30): "The crystal nucleation rate Rf,hom (Eq. 18d) in a polydisperse aerosol can be simplified and is obtained by differ-

entiating of Eq. (29) by t:" Thus, no long derivations or new assumptions are needed, just differentiation by t of the preceding equation. The differential in (30) is replaced with dra. Subscript of Nc,hom is corrected.

23) Notations are added as requested.

24) OK

25) OK

26) Notations are corrected around (37a), spare notations deleted (were moved to after (31)).

27) OK

28) OK

29) Yes, it is better to write as / . This is done now in caption for Fig. 8 and on page 6768.

30) u is replaced with us.

31) A comment on the initial time t0 = tcr = 0 is added after Eq. (45).

32) p. 6769, line 12. Yes, typo. The eqs. numbers are corrected, (8a), (8b).

33) Eq. (47c) is slightly refined, so that it is valid for any t0 = tcr, not only for t0 = 0, since it includes the difference of sw and sw,cr.

34) OK

35) G is replaced with Gn in (49).

36) OK

37) OK

38) Nc(si) is replaced in (55) with Nc(sw).

39) Typo in Eqs. (59), (60c) is corrected, superscript is "3".

40) a) superscript in eq. (A1) is corrected. Equation for Bi with ref. to (58) is added in the 1st line. Equation numbers from Gradshteyn and Ryzhik (1994) are added in all references. b) Typo in eq. (A9) is corrected. c) Reference to ïĄŹ1 after (A.19) deleted. d) Misprint in eq. (29) is corrected. e) subscript "I" at ïĄć is deleted.

41) OK.

42) Typo on p. 6775, line 1 is corrected.

43) and 44) OK

45) Reference to Ghan et al. (1993) is included, somehow it has been missed in the refs. list by the authors and editors.

46) OK

47) Eq. (77) is corrected as suggested by reviewer, with ïĄšis and yïĆći instead of si,cr. As reviewer noticed, this removes typos but does not change the next eq. (78).

48) Subscript "s" is added in (78).

49) Typos in eq. (79) are corrected.

50) Derivation of Eq. (80) is slightly extended and a comment is added after (80) "that $(tm − tcr,1) » ïĄć-1$ and $ïĄć(tm − tcr,1) »1$ according to Eq. (54).", which explains this approximation.

51) A comment is added before (81), "using the approximate equality si,max $\approx$ si,cr due to small variations of si,max discussed above,". Subscript "s" is added at u in (82).

52) The employed times on this page are tmax, tcr,1, and tcr,2. They are different for all runs and we do not consider here their analytical expression, not needed. The references to Figs. 2,4,6,7 explain what is meant here. We slightly refines description to make it clearer.

C6498

53) OK.

54) Subscript "i" is added in (86) for B.

55) Some more comments are added in derivation of (88). Subscript "i" is added for B.

56) Typos are corrected in (86), but note that we write this eq. as $\sim$ (c1iw)3/2, and not as reviewer assumed, $\sim$(c1ww)3/2, therefore the final equation contains the factor (c1w/c1i)1/2, different from what reviewer derived. Besides, the factor (1+si,cr)si,cr is moved from Ki,dif to Nc, which is more physical.

57) OK

58) We carefully checked again derivation of eq. (91). Typo in the first line of (91) is corrected, the final equation is correct.

59) OK

60) ïĄÿd is replaced with ïĄÿdep.

61) Subscript "i" is added at B.

62) OK. The factor with si,cr is moved from the coefficient to Nc.

63) OK.

64) Misprint in (96) is corrected.

65) Ref. to MacKenzie is corrected. Correct spelling is MacKenzie, not McKenzie.

66) Reference to Jensen et al. (1994) was added along with references to all other models participated in CPMCP.

67) The reference list was checked as reviewer recommends. Several references were added related to the equation of state, numerical models, general review papers on water and ice properties.

C6499

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/12/C6494/2012/acpd-12-C6494-2012-supplement.pdf

C6500