Response to Anonymous Referee # 2

(Note: Reviewer comments are listed in grey, and responses to reviewer comments are in black. Pasted text from the new version of the paper is in italics.)

The manuscript is a useful contribution to the scientific progress and the modeling methods employed are valid and clearly described. The manuscript is well written and is appropriate for publication in ACP. Some minor revisions are suggested as follows:

We greatly appreciate the reviewer for the detailed, valuable and constructive comments. The suggestions are extremely helpful to improving our manuscript.

Some minor revisions are suggested as follows:

1. Page 1, Line 29. Change "Aerosol activation" to "Suppressing BC droplet activation in clouds".

   Thanks for this suggestion. We have changed the sentence according to the reviewer's comment:

   "*Suppressing BC droplet activation in clouds mainly decreases the fraction of column BC below 5 km whereas suppressing BC ice nucleation increase that above 10 km.*"

2. Page 3, Line 27. Change "precipitated" to "settling".

   Thanks. We have changed the word:

   "*In mixed-phase clouds, observations have found that riming increase BC scavenging efficiency because settling ice crystals collect BC in the supercooled droplets of clouds at lower altitudes (Hegg et al., 2011).*"

3. Page 4, Line 2. Change to "...and water vapor condenses".

   Thanks. We have changed the sentence:

   "In addition to the riming, ice crystals can also grow through the Bergeron process—when water vapour pressure is supersaturated with respect to ice and undersaturated to liquid water, cloud droplets evaporate and water vapour condense onto ice crystals/snow."

4. Page 4, Line 6. Cite Liu et al. (2011) and Wang et al. (2014) which are already listed in the References.

   Thanks for this comment. We have Cited Liu et al. (2011) and Wang et al. (2014):

"*Modelling studies suggest that the Bergeron process is important to the simulation of BC in the Arctic (Fan et al., 2012;Liu et al., 2011;Wang et al., 2014).*"

5. Page 4, Line 21. Change "in an incomplete way" to "without considering all relevant microphysical processes".

Thanks. We have revised the sentence according to the reviewer's comment:

"*Thus, most global models treat BC wet scavenging without considering all relevant microphysical processes (Textor et al., 2006;Wang et al., 2011;Croft et al., 2010;Qi et al., 2017).*"

6. Page 5, Line 20. Change to "...and mass mixing ratios".

Thanks for pointing this out. We have revised the sentence:

"*The stratiform cloud microphysics scheme used in CAM5 is double moment (Morrison and Gettelman, 2008), predicting number concentrations and mass mixing ratios of cloud particles as well as diagnosing number concentrations and mass of precipitation.*"

7. Page 7, Line 10. Change to "BC aerosols are emitted".

Thanks for pointing this out. We have changed the sentence:

"*BC aerosols are emitted in combination of 80% hydrophobic* BC_{phobic} *and 20% hydrophilic* BC_{philic}*.*"

8. Page 7, Line 11-12. Add at the end of the sentence "although the aging time has been estimated in the range of .... (references)."

Thanks for this comment. We have added references at the end of the sentence:

"*Although the aging time has been estimated in the range of one hour to two weeks (Zhang et al., 2015;Fierce et al., 2015;Matsui, 2016)* "

9. Page 13, Figure 2. The arrow for evaporation of BC_snow is pointed toward "BC_phobic". Shouldn't is be extended (over BC_phobic) toward "BC_phlic"?

Thanks for correcting this. We have modified Figure 2, as shown below:

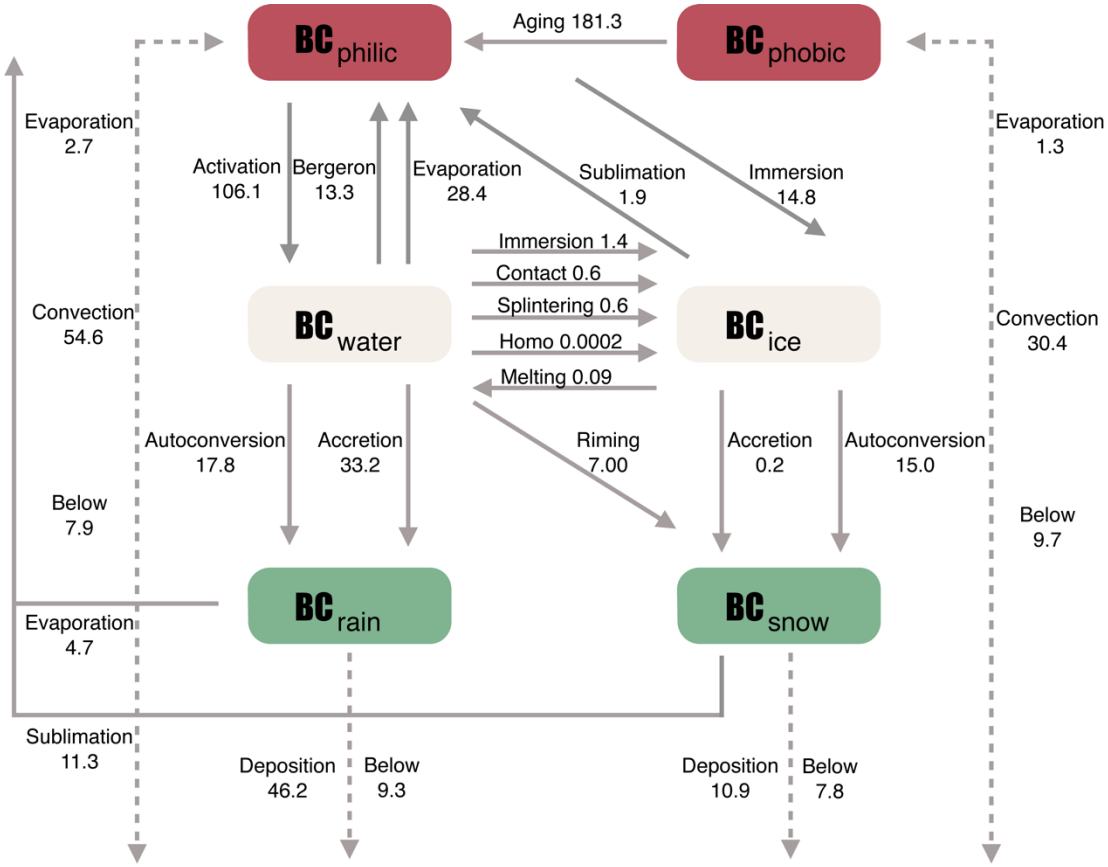

Figure 2. Global budget of BC conversion (kg/s) among interstitial hydrophobic BC (BC_{phobic}), interstitial hydrophilic BC (BC_{philic}), BC in cloud water (BC_{water}), BC in cloud ice (BC_{ice}), BC in rain (BC_{rain}), and BC in snow (BC_{snow}) due to different cloud processes and aging. The conversion rates shown in the figure represent global total values averaged for year 2009.

10. Figure S1. Use "Cloud water conversion rate" or "Rate" to label the y-axis. The unit should be either "g/(m2 s)"(column integrated) or "(g/g)/s" (column averaged).

Thanks for pointing this out. We have modified the Figure S1 according to the reviewer's comment. Please see the Figure below:

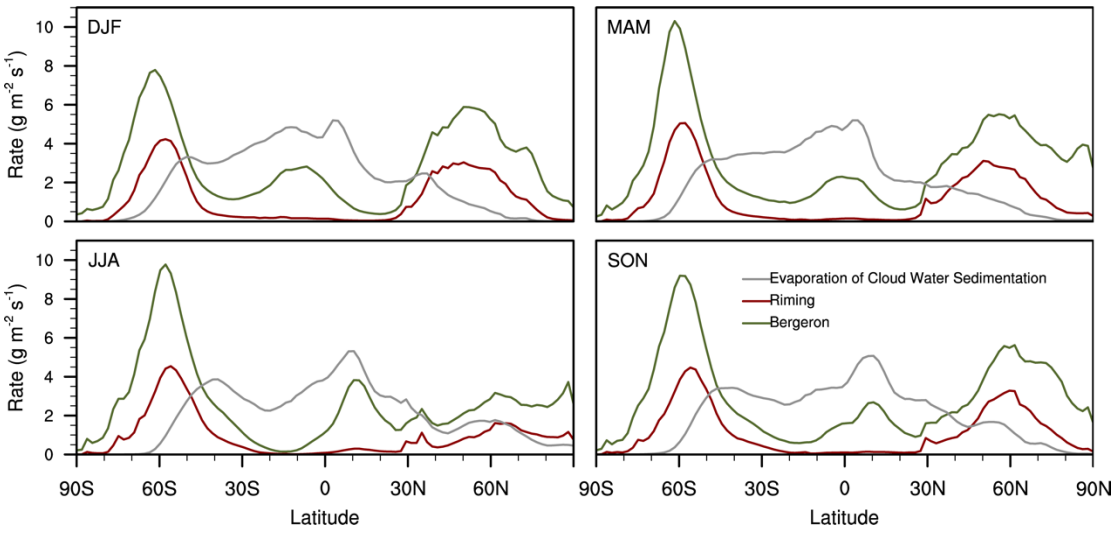

Figure S1. Cloud water column mean conversion rate due to Bergeron, riming, evaporation of cloud water and ice sedimentation, evaporation of cloud process, over four seasons (DJF, MAM, JJA, and SON).

References:

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