acp-2014-301
Doherty et al., Biases in modeled surface snow BC mixing ratios in prescribed aerosol climate model runs.

Replies to comments are shown in *italics.*

Reviewer #1 comments on revised manuscript:

Corrections
1. Line 106/116/119/156/178/may be more: Does these "CESM" differ from "CESM1"? I wasn't sure if this is intentional or mistake.
No, this is the same. All instances of "CESM" have been changed to "CESM1".

2. Line 169-170 ("Aerosol emissions were very similar to those used by~): Can you make it more clear what you mean by "very similar"?
In fact for the year used, it is the same. This now reads:
"Aerosol and aerosol precursor emissions for year 2000 of these runs were the same as those used by Lamarque et al. (2010) to generate the aerosol deposition fields used in our prescribed-aerosol runs."

3. Line 181: "data base"-->database
Done.

4. Line 183-184: I think "by the addition of snow in new snowfall" sounds confusing. Perhaps " by addition of new snowfallin the surface snow layer"?
Or can you please rephrase that?
Now reads: "…and by the addition of new snowfall to the surface snow layer…"

5. Line 184-185 ("wet-deposited BC is ~ only with new snow,"): I guess that "new snow" means new snowfall? If you meant new snow in the surface snow layer, it will be also affected by dry-deposited BC. I would suggest changing to "new snowfall".
Now reads: "…wet-deposited BC is added only with new snowfall,…"

6. Line 220 and Line 231: There is a dot in subscription of the denominator. Can you remove them?
The "dots" are periods, because the equation marks the end of the sentence. I leave it to the ACP editors/type-setters to decide whether the period belongs in these two locations.

7. Line 280 ("…the relative timing of BC versus snow deposition to the surface"): I understand what the authors tried to say, but this phrase seems too vague. Can you please write that more descriptively?
This now reads: "…so the only difference in how they affect surface snow BC mixing ratios is through changes in the relative timing of when BC is deposited to the surface versus when snow is deposited to the surface."

8. Line 283 ("…Equation [5] and [MR..") – I think "and" should be replaced with

"comma". Otherwise, the sentence is not correct.
The sentence as written was correct. However, we have modified so it is perhaps more clear: "Surface snow BC mixing ratios $[MR_{BC}]_d$ for each gridbox/day are then calculated using Equation [4], and corresponding values of $[MR_{BC}]_m$ and $[MR_{BC}]_y$ are calculated using Equation [5] with $[MR_{BC,snowfall}]_m$ and $[MR_{BC,snowfall}]_y$, respectively (Table 1)."

9. Line 289 ("have been increasingly time-averaged") – this sounds strange to me. Perhaps "have been averaged over a longer temporal scale"? Please rephrase it.
Now reads: "…values that have been time-averaged over increasing temporal scales…"

10. Line 291: "across multiple prognostic model run years" may be written to "across multiple years of the prognostic model run"?
Now reads: "… which is the product of averaging across multiple years of prognostic model runs using the same BC emissions"

11. Line 385: please place a comma in between "climatology" and "the mixing ratios".
Done.

12. Line 401: "Figure 3-5". Do you need to include Figure 2? Fig2 also show that.
Yes Figure 2 should be included, because Fig 2 shows overall statistics of the different offline calculations. This same quantitative sense is difficult to see in Fig3-5, which give a temporal comparison of modeled vs offline calculations of snow mixing ratios.

13. Line 456: Lee et al. used year 1996–2000, not 2004-2009.
Apologies; 2004-2009 was used by Jiao et al. This section now reads:
"Coupling these model-derived BC mass deposition rates with observed precipitation rates can therefore produce unrealistic values of MRBC both 1) where there are systematic biases in the prognostic model's snowfall and 2) where the inter-annual variability in the model is decoupled from the observed snowfall rates used in the prescribed-aerosol run or offline calculation (i.e., here, year 2000 of a prognostic aerosol model vs. 2004-2009 of CRU/NCEP used in Jiao et al., 2014). Thus, using reanalysis data for snowfall rates in offline estimates of BC albedo forcing such may introduce an additional source of bias in MRBC."

14. Line 503-506 ("As our offline … snow BC mixing ratios (MRbc}") : Can you cute "this anti-correlation .. not mean that"? So it will be like this: As our offline calculation have shown, low and high baised in MRbc,snowfall do not offset each other on surface snow BC mixing ratios(MRbc).
This now reads:
"As our offline calculations have shown, low and high biases in $MR_{BC,snowfall}$ do not have offsetting effects on surface snow BC mixing ratios (MR_{BC})."

15. Line 523-526: That sentence has a flaw. I think you need to put a comma in between "on albedo" and "most absorption" instead of "and".
This now reads:
"However, since the amount of sunlight drops off rapidly with snow depth, MR_{BC} in the

top few cm of the snowpack has the strongest influence on albedo. Most absorption of sunlight by BC will occur in the top few cm of the snowpack, i.e. the surface snow layer in SNICAR."

16. Line 553-554: I can't agree on this with the author. A reason for biased BC concentrations or mixing ratios in Tibetan Plateau could be biases in transport or neighboring emissions. So positive biases in precipitation may not necessarily result in positive biases in surface snow BC mixing ratio. Note that Lee et al. shows (rather implicitly) a systematically different transport of BC between the models and observation for the ice core data.
The reviewer is correct that mixing ratios are necessarily biased high -- since as the reviewer notes, other processes may be contributing other biases. However, the specific source of bias being discussed will lead to a high bias (which may or may not be offset by other biases). The wording has been changed to: "In addition, if modeled snowfall in this region is systematically biased high, as appears likely to be the case in CESM1 for the Tibetan Plateau, prescribed BC wet deposition mass fluxes based on prognostic runs of this model may also be biased high" (i.e. "will be biased high --> "may be biased high"

17. Line 567– 575: I don't understand why there is inconsistency in the mass balance of BC within the prescribed model runs. Can you explain more? The explanation provided inside the parentheses is not sufficient for me to understand. Because I don't understand the "mass balance" issue, I also don't understand Line 572-575.
This now reads:
"This approach will produce an inconsistency in the mass balance of BC within the prescribed-aerosol model runs, in that the change in the mass of BC in the atmosphere between time-steps will not equal the mass of BC deposited to the surface. However, both the atmospheric BC concentrations and surface snow BC mixing ratios in the model calculation will be physically more consistent."

18. Unit in Figure 1 needs to be fixed: "/m2-day" to "m^{-2} day^{-1}"
Done.

19. Y-axis unit in Figure 4 and Figure 5: I suggest "Number of gridbox per season"
Changed to "Number of gridboxes per season"

Reviewer #2 comments on revised manuscript:

Technical correction: Table 3 on page 16. This is now table 4.
Thanks for noticing this. Corrected.