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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impacts of absorbing aerosol deposition on snowpack and hydrologic cycle in the Rocky Mountain region based on variable-resolution CESM (VR-CESM) simulations" *by* Chenglai Wu et al.

Anonymous Referee #1

Received and published: 26 September 2017

This study describes a novel use of a variable resolution configuration of the Community Earth System Model (VR-CESM) to explore impacts of light absorbing aerosols in snow of the Rocky Mountains. Previously, these and other mountain ranges could not be adequately resolved in coarse resolution GCM studies to quantify impacts of aerosols on mountain snow. The configuration applied here represents the Rocky Mountains with 0.125 degree horizontal resolution, constituting a substantial improvement over previous global and even regional model simulations. This is a very thorough end-to-end study including evaluation of simulated atmospheric and in-snow aerosol

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concentrations against observations followed by analysis of radiative forcings, temperature response, and hydrological response to the presence of black carbon and dust. Overall, I find this to be an excellent, logically-organized, and well-written study. I have only minor comments.

General comments:

The authors point out that simulated dust-in-snow concentrations are 1-2 orders of magnitude lower in the San Juans than measured by Skiles and Painter (2016) and simulated radiative forcing from dust is about an order of magnitude smaller. These are substantial biases. The authors also mention that dust particles larger than 10um are not included in the simulations, but comprise a majority of dust mass in measurements from this region. Is there good reason to believe that these model biases persist (and are of similar magnitude) throughout the study area, or do the authors believe these biases are somewhat unique to the San Juan Mountain area? If the former, I would consider mentioning in the abstract the omission of particles larger than 10um as a potential source of systemic bias in dust-in-snow SRE throughout the study area.

The study acknowledges that use of a coarse resolution (1.9x2.5 degrees) BC emissions inventory could have biased the simulation, which was conducted at $\sim$16 times higher resolution. In fact, the native resolution of the emissions inventory produced by Lamarque et al (2010) was 0.5 degrees (see abstract of that paper), so in fact finer resolution emissions could have been applied in this study. I do not suggest that the runs be conducted again, but I mention it so the authors are aware that higher resolution versions of their emissions data exist.

Please describe in more detail which version of the modal aerosol model (MAM) is applied here. i.e., is MAM3, MAM4, or MAM7 used? How, briefly, are black carbon and dust treated in this version of MAM/CESM?

Specific comments:

line 91: "except that" -> perhaps "except when" (grammar issue)

line 113: "by comparing against" -> "in comparison with"

line 132: "for for"

line 216: "all aerosols except BC (dust) as Flanner et al." -> "all aerosols except BC (i.e., only dust in this case) as in Flanner et al."

line 217: "the five regions" -> "five regions"

line 293: "snow samples at a depth of 30cm" - Here, I suspect you mean "snow samples through a depth of 30 cm" (i.e. samples collected from 0 - 30cm depth).

line 301: "is mainly contributed from" -> "consists mainly of"

line 309: "cycles" and "cycle" -> "circles" and "circle"

line 324: "although it is much weaker" -> "although they are much weaker"

line 398: "Rockiest" -> "Rockies"

line 405-408: The description of how a monthly-mean BC-in-snow concentration differs between the model and reality in cases where there is no snow during part of the month is unclear to me. Please elaborate a bit on this description, and if necessary describe any associated implications more clearly.

lines 498-502: In the discussion of dust SRE I would acknowledge again that the results do not include particles larger than 10um, which may/probably constitute the majority of dust-in-snow mass.

line 525: "This suggests that snow on the high mountains is less susceptible to the aerosol SDE" - I would re-word this. A higher snow cover fraction does not necessarily imply lower aerosol SDE. Quite often it is the opposite.

line 543: "ratio of surface air temperature change to SRE" - I suggest emphasizing that the efficacy is defined here in terms of *local* delta T and SRE.

line 559: "... which corresponds to a fraction of ..." - The meaning of this fraction (apparently a fraction of snow cover fraction) is confusing. I suggest using the terms "absolute" and "relative" to differentiate the two, or maybe just removing the relative fractions because I don't really think they are necessary.

line 565: ".., the runoff includes the surface runoff and sub-surface runoff" - Is sub-surface runoff examined at all in this study? If not, I would brielfy mention that here.

Figure 3 caption: Please define "cold season"

Figure 5: There is a lot of white space in this figure. I think the axis ranges could be narrowed a bit.

Figure 8 caption: There are two references to "bottom row". The first should be "middle row"

Figure 14: Does this depict surface runoff only, or total runoff (including the sub-surface component)?

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