

Dear Professor Kang,

Both reviewers have significant concerns regarding the description of your methods (both observations and modeling) and the analysis of your results. Unfortunately they have not been willing to review your responses to their comments or your revised manuscript. I have carefully read through your responses and your revised manuscript and have provided my comments below. There are a couple of referee comments that I don't feel were adequately addressed. Consider my comments and submit your revisions after you've had a native English speaker read through any new text. Please respond point by point, and be sure to highlight all new changes in your revised manuscript.

Regards,

Becky

General comments:

- It is unclear what "footprint analysis" means. Please replace with "back trajectory analysis" in all instances or define what you mean by footprint if they are not the same.
- Data available upon request does not meet TC policy. You need to provide your BC and LAP data here as supplementary information or provide a DOI containing the data per TC policy:
http://www.the-cryosphere.net/about/data_policy.html#data_availability

Referee comments:

- Referee #1's comment on page18 (page 10 line 13) seems not to have been addressed. You need to address this on page 13.
- Referee #2 comment #1: Please mention this as a source of uncertainty in your analysis (section 3.4) in the main text.
- Page 5 lines 10-12: You describe grain size, but not snow depth or density measurements. Please describe methods for all measurements, as requested by the reviewers.
- Page 7 lines 24-28: The lines in blue do not answer the reviewer's question. Did you assume uniform BC throughout the snow depth? It looks like that is the only option in the inputs. If so, what sort of error does this represent?
- Page 9 line 19: "kind of biomass burning" Can you be more explicit here? I'm still not sure what you mean by "open".
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Unclear wording or missing information. Much of this is in the methods section, which has improved somewhat, but I think still will not satisfy the reviewers concerns on this point. Specific comments are below.

- Page 2 line 12: insert "a wavelength (λ) of" before 440 nm. Elsewhere, insert " $\lambda =$ " before any number representing a wavelength.
- Page 2 line 25: 142 – 271 mm of what? Snow or ice mass?
- Page 2 line 27: "days during ablation through" doesn't make sense. Please check this and reword.
- Page 2 line 31: It doesn't make sense that the presence of dust suggests a relative role for BC. Dust and BC have different sources.

- Page 4 lines 28-29: You characterize region I and II, but not region III. What characterizes region III and differentiates it from I and II? What do you mean by “intensified sampling”? What is “LHG”?
- Page 4 line 30: Is “LHG” the same as region III?
- Page 5 line 6: Is there a region you mention (c) but don’t use it in the equations below?
- Page 5 line 17: This is too qualitative. What is the mass fraction of dust compared to BC and OC?
- Page 5 line 24: which is it, 550 or 850? Why one or the other?
- Page 5 line 27: How was the carbon converted to methane?
- Page 5 line 31: Is this the range for the detection limit? 750 seems high.
- Page 6 line 17: need units for the numbers 0 and 75
- Page 7 line 9: What is “standard solar irradiance”? Does this mean you don’t have observations of surface irradiance? Remove “to get the albedos”.
- Page 7 line 22-23: provide units for all variables.
- Page 7 line 31: Is incoming shortwave radiation the same as surface irradiance?
- Page 8 line 1: How is “solar shortwave insolation” different from “incoming shortwave radiation”?
- Page 8 line 8: Is the observed snow depth based on previous studies? If so reference them here.
- Page 8 lines 6-9: Include units in parentheses for all variables in the text where they are described.
- Page 8 line 32: Have higher OC/EC ratios than what? Fossil fuels?
- Page 9 line 20: “for half of the BC deposition” How was “half” determined, quantitatively? Same with 30% on line 22 and 70% on line 26.
- Page 10 line 11: What is the upper boundary and how does it compare to your grain size measurements?
- Page 10 line 7: insert λ to be more explicit what these numbers are referring to.
- Page 10 line 22: What do you mean by “radiative flux”? Can you express in terms of previously used variables, such as RF or albedo?
- Page 11 line 15: What is shortwave radiation “input data”? Is it surface irradiance? You need to be consistent in your defined terms throughout the manuscript.
- Page 12 line 18: What are Koch snowflakes?
- Page 13 line 11: “Snow cover durations were shortened during the melt season from X-Y days...” Insert numbers for X and Y.
- Page 13 line 13: “annual mass budget” Is this a loss of mass? “mass budget” does not necessarily imply a loss.
- Page 14 line 2: Wasn’t this study a survey of LAP, and not snow cover?
- Page 14 line 13: What is radiation input data? Is this observed surface irradiance?

Although the grammar and wording are somewhat improved, there are still some issues. Some specific suggestions on word changes are below which should help to clarify the manuscript.

- Page 1 line 20: insert “relative” before “biomass burning”
- Page 1 line 21: insert “relative” before “contribution”
- Page 1 line 23: delete “changes of”

- Page 2 line 10: change “by” to “of”
- Page 2 line 16: replace “the simulation showed” with “suggested”
- Page 2 line 17: deposited **to** land snow, not in Page 2 line 17: put a comma after $W \text{ m}^{-2}$
- Page 2 line 17: replace “or as large as” with “contributing as much as”
- Page 2 line 19: replace “in” with “for the”
- Page 2 line 20: insert “also” between “can” and “change”
- Page 2 line 23: replace “in particular, from” with “especially $\lambda =$ “
- Page 2 line 24: replace “on Claridenfirn of” with “in”
- Page 2 line 26: remove comma after “region”
- Page 2 line 27: what is “disturbed” desert dust?
- Page 2 line 29: remove “even”
- Page 3 line 22: replace “seldom” with “sparse”
- Page 3 line 26: remove “cover” after “snow”
- Page 3 line 27: change first comma to a period to end the sentence. Then start the next sentence with “We further...”
- Page 3 line 28: insert “observed” before LAPs.
- Page 3 line 28-29: should read “We use back trajectory analysis coupled with BC fire emission inventories to approximate natural/anthropogenic contributions”
- Page 3 line 29: increase *our* understanding
- Page 3 line 30: insert comma after TP and remove the next word “and”
- Page 3 line 30: replace “this is also helpful for” with “inform”
- Page 4 line 5: remove “in the earth system”
- Page 4 line 17: remove “on”
- Page 4 line 27: replace “contains” with “includes”
- Page 5 line 23: remove “special”
- Page 5 line 25: Should read “The sample is reheated further in a stepwise fashion to near 900...”
- Page 5 line 26: Should read “burn out all remaining BC”
- Page 5 lines 27-30: Move this sentence up to after “...of the OC in the sample.” Change “modified .. arranged” to “limited the initial temperature plateau”
- Page 6 line 6: Should read: “...used approach for determining source regions of various atmospheric species.”
- Page 6 line 7: remove “that”
- Page 6 line 7: can be *qualitatively* attributed
- Page 6 line 19: Remove “Then,”
- Page 6 line 23: Should read “FINN used satellite” (remove “the”)
- Page 6 line 25: Remove “Then,”
- Page 6 lines 29-30: Should read: “Note that this analysis is qualitative and does not take into account loss from wet and dry deposition”
- Page 6 lines 31-32: Remove sentence beginning “Thus,”
- Page 6 line 32: Should read “Despite these uncertainties, the relative differences between the BC contributions are used to...”
- Page 7 line 2: remove second comma
- Page 7 line 25: Should read “will lead to discrepancies between”

- Page 8 line 6: insert “and” before “for”
- Page 8 line 7: should read “clean snow due to changing snow grain sizes with snow age”
- Page 8 line 28: replace “values” with “concentrations”
- Page 8 line 29: replace “by the soil” with “from the soil”
- Page 8 line 30: replace “represent” with “examine”
- Page 9 line 3: replace “little” with “slightly”
- Page 9 line 13: remove “arrived at”
- Page 10 line 2: replace “simulate” with “estimate the”
- Page 10 line 13: Should read “albedo differences between measurements and simulations is less”
- Page 10 line 20: remove “when testing regional to global scale models”
- Page 11 line 5: Replace “validation” with “assessment”. It is impossible to “validate” a model (although I realize this term is frequently used in the literature)
- Page 11 line 11: Should read “Thus, this does doesn’t include the effect of OC on estimates of”
- Page 11 line 14: Changes *in* snow cover
- Page 11 line 24: low *SD* scenarios
- Page 12 line 19: A lack of OC *consideration* due to
- Page 12 line 25: Remove “We also have to pay attention to the fact that”. Replace “their” with “dust”
- Page 12 line 26: replace designed with “assumed”.
- Page 12 line 27: efficient *at* light scattering
- Page 12 line 28: replace “materials that” with “and”
- Page 13 line 8: replace “the estimation” with “estimates”
- Page 13 line 30-31: “would have been marginal” depends on assumed concentrations. Maybe say “uncertain” instead of “marginal”
- Page 14 line 14: reduced *snow cover* from several
- Page 14 line 19-20: “total mass balance” should read “mass lost” if I’m understanding this correctly