

Dear Dr. Sigl,

Thank you for your consideration of the 3rd reviewer's comments and for your revisions. I read through your replies and revisions carefully. I think that you mostly (but not entirely) have addressed the reviewers' comments. Your additions to the manuscript were a bit frustrating to read as they contained many overly long, run-on, grammatically incorrect sentences. I have noted this specifically below. I've also suggested some wording changes that I think will better respond to the reviewers' concerns and make the manuscript more clear. Please submit your revisions as tracked changes to me after carefully reading through and editing your writing. Page and line numbers refer to the tracked changes version of your revisions.

Regards,

Becky Alexander

Title:

The title is too long. It would be better to simply say "19th century retreat in the Alps preceded the emergence of industrial black carbon deposition on high-alpine glaciers" as that is what your paper clearly shows.

Abstract:

Page 1 Line 26: What does "well-replicated" mean? This is vague. Did you do replicate analysis of samples or is based on your stacked data set? I think it's the latter, but it would be better to choose more clear wording.

Page 1 lines 32 to end of abstract: I suggest ending the abstract as follows beginning on line 32: "...than 80% of their total 19th century length reduction, casting doubt on a leading role for anthropogenic BC emissions in terminating the Little Ice Age. Attribution of glacial retreat requires expansion of spatial network and sampling density of high alpine ice cores to balance potential biasing effects arising from transport, deposition and snow conservation in individual ice core records." I don't think the reviewers will be happy with the sentence beginning on line 32 ("Industrial BC emissions...") as you have not done any forcing calculations as the sentence may imply. The sentence beginning on line 33 ("BC records...") comes out of nowhere and doesn't make sense here.

Introduction:

Page 2 Line 11-12: Change to "...because it absorbs solar radiation even at very low concentrations..."

Page 3 lines 1-4: This is an example of a long run-on sentence that is difficult to make sense of. It needs to be split into two sentences. Perhaps "Together with mineral dust and other absorbing organic aerosols, BC deposited on snow and ice can lead to increased melt rates and changes in melt onset due to reductions in surface albedo. These effects are further enhanced by subsequent snow albedo feedbacks such as an increase in the water content and surface accumulation of impurities."

Page 3 line 5: Should read "...best estimate for industrial era global forcing of BC is..."

Page 4: This new section is difficult to read. The first sentence is long and grammatically incorrect. I cannot tell exactly what you are trying to say. I'll leave it up to you and your co-authors to split this up into two or more sentences and check it for grammar and correctness. The next section beginning with "The snow-albedo feedback" on line 18 also contains long, run-on sentences and is very disorganized making it difficult to read. You are casting doubt on the Painter et al study for three reasons: 1. A low resolution data set, 2. Measurements were performed using questionable analytical methods and 3. Large dating uncertainties. Perhaps you could start it like this: "The snow-albedo feedback hypothesis formulated by Painter et al was a first effort to attempt this but was limited by the available BC data at that time[here provide references for the data that was used in this study]. The available data were of relatively low time-resolution [reference specific data set(s)] and the dating was uncertain [reference specific data set(s)]." The phrase "compiled from very first applications using different analytical methods" doesn't really say anything. Just because they are the "first" measurements or "different" (different from what?) doesn't mean they aren't any good. You need to be specific on what you think is wrong with the analytical technique and provide appropriate references to support this. "Some of these methods" – which methods? Both Jenk et al and Thevenon et al or just one of them? At this point the reader doesn't know how many data sets you are referring to and if they all suffer from the same issues. How do you know that a method(s) did not deliver reproducible results? Is there a reference for this? Personal communication? You need to support such a claim. Perhaps you should follow this "The snow-albedo feedback hypothesis formulated by Painter et al was a first effort to attempt this but was limited by the available BC data at that time[here provide references for the data that was used in this study]. The available data were of relatively low time-resolution [reference specific data set(s)] and the dating was uncertain [reference specific data set(s)]." with "Here, we set out to re-evaluate the timing of industrial BC deposition in ice cores from the alps by using a new, more accurately dated record of light absorbing aerosols at much higher time resolution (sub-annual). In addition, we measure distinctive tracers of anthropogenic pollution (list them here) and compare all records with the most highly resolved history of glacier length changes of four glaciers in the Western Alps currently available." This removes some of the details (which are unclear for reasons stated above), and I suggest moving this more detailed discussion into section 3.2 I also suggest removing the last sentence of this section beginning with "We determine..."

Section 3.2:

Page 10 line 20: What do you mean by "non-equidistant samples"? "not-validated method" is not supported – see also my previous comment from the introduction.

Page 10 line 23: remove comma after "14 years"

Page 10 line 26: Should read "reach comparable levels during the peak"

Page 10 line 27: Replace "assume" with "speculate"

Discussion:

Page 13 lines 8 – 9: Should read “82% [52%] of the glacier length reductions had already occurred at the best [earliest] estimated time of emergence of industrial BC deposition.” I removed the end of this sentence because you can’t say it played no role later on.

Page 13 line 12: “1900 AD AND also by”

Page 13 line 14: remove comma after 1875 AD

Page 13 line 19: insert comma after Sun et al reference.

Page 13 lines 20-24: Should read: “However, these species are measured by the method applied for the EC record from FH02 which shows very good agreement with the rBC record from Colle Gnifetti (Section 3.2). This suggest that factors other than changes in surface snow albedo, such as temperature and seasonal precipitation distribution (Steiner, Zumbuhl), may have dominated mass balance and glacier length variability of these European glaciers until at least 1875 AD.”

Page 13 line 26: remove comma after variability

Page 14 line 10: change “can thus be understood as” to “may be”

Page 14 line 14: remove “to some extent”.

Page 14 line 19-21: Should read “...will require reconciliation of early instrumental and proxy climate data [references] and the use of models to decompose...”

Page 14 lines 25-29: Remove the last 3 sentences. This belongs in the conclusions.

Conclusions:

Page 15 line 28: replace “enhancing” with “reductions in”

Page 15 line 32-33: Should read “species co-analyzed enabled BC source attribution from industrial and biomass burning emissions.”

Page 16 line 7: Should read “We hypothesize that glacier length changes throughout the past 2,000 years have been...”

Page 16 line 15: Remove last sentence of this paragraph.

Page 16 line 16: Replace “computer” with “model”

Page 16 line 18: Should read “the past few decades”

Page 16 line 20: Should read “model evaluation” (remove the “s”)

Page 16 lines 21-22: Should read “Here we present the first continuous...”

Page 16 lines 24-27: Should read “Aerosol deposition at any single site also depends on factors such as atmospheric transport efficiency and the spatial distribution and conservation of snowfall.

Incorporating more BC records from multiple sites into a stacked composite is expected to enhance the

signal from the atmospheric burden over the noise caused by spatial variations in atmospheric transport and snow accumulation.”