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Biogeosciences Discussions

Interactive comment on "Black (pyrogenic) carbon in boreal forests: a synthesis of current knowledge and uncertainties" *by* C. M. Preston and M. W. I. Schmidt

C. M. Preston and M. W. I. Schmidt

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We look forward to submitting a revised version, taking the reviewers' comments into consideration. Please also look at our general response in Author Comment.

Anonymous Referee #1 Received and published: 15 March 2006 Comments on the paper 'Black (pyrogenic) carbon in boreal forests: a synthesis of current knowledge and uncertainties' by C. Preston and M.W.I. Schmidt

General comments The paper spans a wide range of topics and reviews quantification, production, characteristics/stocks, mechanisms of loss of black carbon, and the cycle of black (pyrogenic) carbon in boreal forest regions. It is thus of interest for a broader scientific audience. Each particular chapter is well-written and worthwhile reading, but

the overall impression is that the paper is not focused. The missing focus is most obvious when the title is compared to the text: Only chapters #5.3.1 ('Qualitative characterization of PyC in forest soils') and #7 ('The PyC cycle in boreal forest regions') are specifically designated to boreal PyC, while others (#5.1 'General effects of fire on SOM properties') reiterate recent reviews on BC or miss a direct relation to the topic (#5.2 on agricultural and grassland soils, #5.4 'BC in marine sediments'). To give another example: Chapter #6 on 'Mechanisms of PyC loss' does not address PyC in boreal forests, but includes 'Degradation of geological and sedimentary substrates'. Though important mechanisms are discussed here, this section would better be published as a stand-alone paper rather than being part of the review. Suggestions to make the paper acceptable for publication in Biogeosciences mainly include partitioning into at least two papers of which one should specifically address the topic as quoted in the title, while the other could deal with general mechanisms of PyC production and loss in different environments. A paper on BC in boreal forests could, for example, synthesise the findings on annual rates on BC production, loss, stocks, and their uncertainties. I am unfortunately forced to decline the paper in its current form.

R = Response to specific comments. Since the reviewers were working from documents with different setups (but identical contents) we provide correlation to the on-line version for Rev. #3.

Abstract: How does the figure on boreal BC compare to global estimates?

R The global estimates are still based on Kuhlbusch and Crutzen (1995), and Kuhlbusch et al. (1996), around 50-270 Tg BC/y, of which 40-240 is solid residues and the remainder (10-30) is emitted to the atmosphere. We estimate boreal production at 7-17 Tg y-1 as solid residues and 2-2.5 Tg BC y-1 as aerosols. The global estimate will be added to the Abstract.

Chapter #3 'Quantitative analysis of PyC': Methods are listed at the beginning and should be referenced.

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R The paragraph will be rearranged so that the references listed at the end of the paragraph (reviews and methodological comparisions, with addition of Hammes et al. 2006b) will appear with the list of methods. Other references may be found with the discussion of specific methods.

P. 218, l. 26. What is the time horizon of that rate (within 100 years, 500 t BC ha-1 would accumulate)?

R The sediment cores cover at least several hundred years pre-settlement and some over 1000y. Certainly, the corresponding accumulations in the forest would seem quite high and Clark and Royall (1994) discuss at length errors, uncertainties and the need for more research. They used an average density of 0.5 g cm-3, so accumulation of 500 t charcoal/ha within 100 y would correspond to a 10 cm layer. Assuming that the sediments reasonably represent the inputs in nearby forest stands (still a bit of a big "if" factor), present-day measurements of charcoal in nearby forest floor and soil (unfortunately not available) should give an idea of overall losses due to some unspecified combination of decomposition (microbial, chemical, photochemical) including losses as DOC, and oxidation by another fire. This would be another good idea for an interdisciplinary project; we'll add it to the research recommendations.

P. 219, l. 24. How was BC measured in the study of Muri et al. (2002)?

R BC was measured by a thermal oxidation method (375 C for 24h in air) followed by HCl treatment to remove inorganic C. "By thermal oxidation" has been added to the text.

Chapter 4.2. A table summarizing aerosol emissions and emission factors would be helpful. The first sentence is redundant and contradicts the length of the chapter. Most of the text on page 220 can be omitted. A clear definition of 'volatile' and 'aerosol' in the context of BC would be helpful for non-atmospheric scientists.

R This section will be rewritten and slimmed down, with possible use of a table.

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P. 221, l. 14. Is this a global estimate?

R Yes, “global” will be added to the sentence.

P. 222, l. 9. What is meant by ’climatological mean’ (in the context of four years!)?

R This is confusing and will be reworded.

Chapter #5.1. The authors cite two recent reviews dealing with fire effects on SOM. Is this chapter really necessary?

R These two pages very briefly summarize two large review papers, as well as dealing with topics not included in them, such as novel approaches to characterization of BC and changes in 13C. Also see our general arguments at the beginnning, that these are topics that that should be brought to the awareness of researchers proposing to work in the boreal.

P. 231, l. 11. A reference must be given for the Australian study.

R Hopmans et al. (2005) was inadvertantly missed in the text, which will be corrected. However, it was clearly provided in Table 1 to which the reader’s attention was directed at this point.

Rates of BC production upon forest fires are listed in Table 1 and include not only boreal, but also (sub)tropical sites. This is interesting, but outside the scope of the study. The comparison shows that ’mean’ rates in the tropics exceed those in colder regions. Is there any explanation for this?

R As discussed earlier, it is important to include non-boreal data because boreal data are inadequate. In particular, they are probably too low. For example, three key studies measured only charcoal captured in traps and thus previously airborne, and no studies measured char formation on standing or fallen/falling trees. These issues were discussed, but will be further clarified. We will also split up the tables into “boreal” and “other” subsections.

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Chapter #6.1. The first two sentences are a reiteration of previous sections and thus redundant.

R This is a long article, and we chose to sometimes briefly reiterate main points at the beginning of major section. This was done for two reasons: to help reorient the reader who may have got a bit lost in a long article, or to orient those who might well choose to focus on certain certain sections. In the revision, we will reduce redundancy as far as possible, but will try remain (interdisciplinary)reader-friendly.

P. 233, l. 23-26. This sentence on graphite incubation can be moved to chapter#6.2.

R We will look at reorganizing this section, although we thought that it was more effective where it was. Other incubations deal with fire-derived char.

Chapter #6.4. The first part of this chapter would better be part of #6.1.

R We will look at rearranging or combining these sections and part of the general revision.

P. 237. This section is not related to PyC in boreal forests at all. Could be part of a general review.

R It uses circumstantial or surrogate data as a basis to estimate residence times for the most recalcitrant PyC produced in boreal fires. The longevity of PyC or BC is one of the key questions for incorporating into into boreal forest C budget modeling. There is a common perception that PyC will be very long-lasting and contribute to stable soil C pools. As there is essentially no information on loss of BC in boreal regions by any mechanism, one useful approach is to use information on decomposition of recalcitrant geochemical substrates (with oxygen exposure) to develop estimates of maximum residence times. That this exercise has more general applicability does not disqualify it from boreal relevance. Wengel et al. (2006) has directly compared degradation of black shale with laboratory-produced char.

Chapter #7.1, first paragraph. It would be worthwhile comparing the calculated char-

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coal production rates, charcoal consumption rates, and current BC stocks in soil to check whether the various assumptions/measurements are consistent (budgeting).

R We previously noted (p. 233, l. 13-17) two studies that found charcoal and black carbon stocks in boreal forest were lower than would be expected from production rates, and therefore may have been affected by consumption by subsequent fires. Based on the very limited and inadequate data for boreal PyC, we feel that such calculations would be premature, and all aspects - production rates, consumption/loss rates and soil stocks all need much more research. However, this point could be emphasized more in discussion and research needs, including implications from the Clarkand Royall (1994) paper.

Pages 238-239. The many estimates on annual emission rates could be presented in tabular form.

R There are not “many estimates” in this section. Quite different from the other two tables that report published experimental data, in this section we develop our best estimate of boreal BC production based on two two studies of boreal C fire emissions, and data from Kuhlbusch and Crutzen (1995) on ratios of CO2/C and BC/CO2 production. It would be inappropriate and probably misleading to have a table. The reader needs to read through this section to understand how our estimates were produced.

Chapter #7.3. The text on page 241 is more on ’Does vegetation fire influence boreal forest soil function’ rather than on ’Does charcoal influence’. Probably, the title could be adopted accordingly.

R It is certainly true that vegetation, fire and PyC interact to influence soil function in boreal forests. Perhaps a more suitable title would be: How do charcoal, fire and vegetation influence boreal soil function?

P. 242, l. 17. The difference between charcoal from wildfire and activated charcoal should be specified.

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R The text will modified to include information about their different properties (mainly surface area), and a recent reference (Brown et al. 2006) will be added.

Figure 3 looks convincing, but the authors should provide references for the atomic ratios of the compound classes. It is not sufficient to state that these ratios are 'typically measured in geochemical studies' (page 216, l. 12).

R This will be modified to "meet the criteria of van Krevelen O/C and H/C ratios around 0.4" (Schmidt and Noack 2000). A new reference will be added (Hammes et al. 2006a). Also, the sentence was written for those in other fields who are not familiar with van Krevelen ratios.

Figure 7 does not show some of the data discussed with respect to it at the beginning of chapter 8 (fuel conversion rate 1-3%, conversion to volatile soot 0.1-0.4%) and is thus incomplete. Also pool sizes are not given. I suggest skipping it because it provides no additional information.

R This figure will be improved.

Interactive comment on Biogeosciences Discuss., 3, 211, 2006.