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Interactive Comment

Interactive comment on "Dominance of brown carbon in aerosol emissions from burning of boreal peatlands" *by* R. K. Chakrabarty et al.

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This paper reports the absorption properties of laboratory combusted peat samples in order to address the accelerated warming of the Artic as it relates to absorbing aerosol particles. It specifically address the smoldering phase of peat, which is known to produce brown carbon compounds very efficiently. These compounds have appreciable visible absorption and plausibly pose a threat to the Artic in terms of positive radiative forcing.

The paper is clear and well-written, with minor exceptions outlined below. Figures are easy to follow. The inclusion of the direct radiative forcing calculation strengthens the impact of this paper, as it provides a means to compare other brown carbon measure-

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ments.

The main shortcoming of the manuscript as written is the absence of a sensitivity study on the surface albedo underlying the aerosol plume. Clearly that has a significant impact on the calculated forcing but it has not been done, or has not been included. The main result of the paper is hidden before the Conclusion section and should be brought explicitly into the abstract and introduction sections. I recommend this paper for publication with these revisions. I consider them minor.

Specific Comments

The abstract would benefit from additional quantitative results, especially with respect to radiative forcing and photochemistry.

Response: The abstract has now been revised and elaborated in scope. It highlights the major finding regarding the sensitivity of forcing as a function of surface albedo. For sake of clarity to the readers, the statement on photochemistry has been omitted. This manuscript doesn't report any quantitative measurement of the impact of brown carbon aerosols on photochemistry.

pg 28796 - Are these fires burned intentionally? The statement that the burn area will increase "in response to climate change" indicates that there is some natural connection between temperature and burn area but that is not obvious to me as a reader.

Response: No, these fires are not intentional. What was implied by our statement is that drying as a result of climate change would lower the water table in peatlands and increase the frequency and extent of peat fires. A new sentence has been now added to the end of the introductory paragraph to further clarify this point: "Climate change would result in drying and lowering of the water table in peat lands, which in turn would increase the frequency and intensity of peat fires"

The end of the introduction would benefit from the inclusion of the authors approach (in more detail) and findings, to help guide the reader as they follow the methods section.

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Specifically, what kinds of measurements were conduction (briefly) and what were the key findings?

Response: This suggestion is well taken. The end of the introduction section now bears a few sentences on the instruments used to carry out the specific measurements of aerosol properties. We have not introduced the key findings in the introduction section as we feel it might interfere with the linear flow of the manuscript contents.

It would be helpful for the authors to include an explanation of the atmsopheric transmission (0.79), beta (0.17), and cloud fraction (0.6) chosen for their estimation. If other studies wish to compare their results with these findings, they will need to understand the justification for those choices.

Response: The values adopted for atmospheric transmission, backscatter fraction (beta), and cloud fraction are for clear-sky conditions. The choice of these values originates from the IPCC 2001 report (https://www.ipcc.ch/ipccreports/tar/wg1/197.htm). Several researchers have adopted these values to calculate clear-sky radiative forcing estimates in the recent years. Appropriate citations of these studies have now been included in the revised manuscript.

What kind of landscape has an albedo of 0.19?

Response: 0.19 is the average earth albedo, as suggested by Chen and Bond (2010, Atmospheric Chemistry and Physics). This citation is now included in the revised manuscript for the purpose of clarity.

The authors show that by including the observed absorption from these peat smoke aerosol particles, the net forcing over snow and low level clouds shifts from small, but negative, to significantly positive. This seems like a major result, but is hiding buried in the paper. It should be in the abstract and in the end of the introduction.

Response: Thank you for this suggestion. In the revised manuscript, we have now added this finding in the abstract. In addition, we have added a new figure 5 showing

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the plots of integrated (net) forcing efficiency as a function of surface albedo for both fuel types. A paragraph to explain this plot has also been added to the manuscript.

Further, the title of the article does not describe the new and important findings of this work. It is doubtful that readers will be surprised that brown carbon dominates (predominates is the correct term) peatland smoke. However, readers may be surprised to find out the degree to which brown carbon compounds in the smoldering peat impact the radiative forcing of the aerosol in the Arctic region. I suggest the authors consider finding a higher profile title to represent their work.

Response: This suggestion is well taken. Accordingly, the title of the revised manuscript has been revised.

The integrated forcing appears to be incredibly sensitive to the albedo of the surface below it. It would be incredibly useful to know the albedo at which the forcing goes from positive (as over ice and cloud) to negative (as over darker land surfaces). Further, it would be useful to know what fraction of the Arctic includes surfaces above which the smoke has a positive forcing (more than half?).

Response: This is a very good suggestion. We have now added a new figure 5 to the revised manuscript. This figure shows the plots of integrated (net) forcing efficiency as a function of surface albedo for both fuel types. The forcing changes from negative to positive between a surface albedo of 0.55 - 0.6 for both fuel types. Hence, it would be safe to say that for a surface albedo greater than $\sim$0.6, brown carbon aerosols from peat fires would give rise to a warming effect. Speculating the fraction of arctic with surface albedo greater than 0.6 is beyond the the scope of this manuscript.

In addition to a new figure, a new paragraph has been added at the end of section 4: “Figure 5 a,b show net forcing efficiencies, integrated over the tropospheric solar spectrum, as a function of surface albedo (as) for aerosols emitted from both fuel types. For Siberian peat samples, the forcing efficiency crosses over from negative (cooling) to positive (warming) values at as $\approx$ 0.5. The cross-over points are nearly identical for

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varying fuel moisture content. However, for Alaskan peat with 50% moisture content, the cross-over takes place at a lower value (as $\approx$ 0.57) compared to as $\approx$ 0.61 for 25% moisture content. Overall, it could be said that brown carbon aerosols from boreal peat fires would result in a net warming effect under clear-sky conditions over surfaces with albedo greater than 0.6."

What is SFE of soot over those same surfaces? Comparing these numbers to soot particles would help readers put the particles into perspective.

Response: Dr. Tami Bond's group calculated fresh BC SFE by using the backscattering fraction = 0.17, MAE = 7.5 m2 /g at 550nm, and MAC at other wavelengths are calculated by assuming it is depending inversely on wavelength, i.e., AAE = 1. MSC is calculated from MAC with single scattering albedo of 0.25. They estimated BC SFE is 210 W/g over land surface (albedo = 0.19). They also speculated that with increasing surface albedo, the SFE would keep on increasing. In the revised manuscript, we have added the following sentence "It is interesting to contrast and compare the extremely high integrated forcing value for BC over land, which is around 210 W/g (Chen, 2011)".

Technical Comments What was the fuel moisture content of the particles in Figure 1?

Response: The relative humidity (RH) of the particles were below 40%. This is because photoacoustic spectrometers work best and most reliably below a threshold particle RH of 40%. If increased beyond this RH threshold, then there could be interference from water mass transfer in the signal.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 28793, 2015.