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## ***Interactive comment on “Boreal snow cover variations induced by aerosol emissions in the middle of the 21st century” by M. Ménégoz et al.***

### **Anonymous Referee #1**

Received and published: 3 January 2013

General comments: The paper is valuable, as it presents detailed spatial information on how BC emissions affect the annual snow cover. There is a rather large literature on the climate impact of BC on snow. While the overall picture is known, a paper that investigates the details of the boreal snow cover is warranted. The title reflects the content of the paper; however, “aerosol emissions” could potentially be replaced with “black carbon emissions” since black carbon is in focus. My biggest concern is if the snow pack model is adequate with only two snow layer. See specific comment.

I would recommend publication with minor changes, possibly major changes depending on how the specific comment on the two layer snow pack model is treated.

Specific comments and technical corrections:

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P4733/L1 The term “boreal snow cover variations” should be defined somewhere in the paper. What is boreal defined as in this paper, and what areas are in focus in this article?

P4736/L25-27 You could potentially refer to more recent papers on the spatial relationship between radiative forcing and temperature.

Shindell, D. T.: Evaluation of the absolute regional temperature potential, *Atmos. Chem. Phys.*, 12, 7955-7960, doi:10.5194/acp-12-7955-2012, 2012.

P4737/L17-22 Have you considered that petroleum activities within the Arctic may be an important local source of BC in 2050?

See for instance: Peters, G. P., Nilssen, T. B., Lindholt, L., Eide, M. S., Glomsrød, S., Eide, L. I., and Fuglestvedt, J. S.: Future emissions from shipping and petroleum activities in the Arctic, *Atmos. Chem. Phys.*, 11, 5305-5320, doi:10.5194/acp-11-5305-2011, 2011.

P4737/L28 Could you please define “continental pan-Arctic,” or at least be more specific? There are many different definitions of what is the Arctic, and I would like to know what definition the authors use.

P4739/L6-9 Potentially major. I am a bit skeptical with a snow pack consisting of only two layers. Since this article is going to be published in a snow physics related journal, I want to make sure that the BC-snow model is adequate. Flanner et al. (2007) had five layers, while Rypdal et al. (2009) had ten models in their modeling of BC in snow. Could you assess if a multi-layer snow model would help your analysis? If you decide to keep the current two-layer model, you will need to present a convincing comment of why (not necessarily in the article text, but at least in the response to this comment).

One challenge is that the BC content can potentially vary significant from snow layer to snow layer. My understanding is that you sum up all the snow in the lowest snow layer with an average BC content, which is a simplification that potentially could be problem-

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atic. I understand that you investigate future scenarios, in which large differences in BC deposition due to varying weather conditions might be disregarded and, thus, explain a simplification of the snow pack.

Flanner, M. G., C. S. Zender, J. T. Randerson, and P. J. Rasch (2007), Present-day climate forcing and response from black carbon in snow, *J. Geophys. Res.*, 112, D11202, doi:10.1029/2006JD008003.

Rypdal et al. (2009), Costs and global impacts of black carbon abatement strategies, *Tellus B*, 61(4), 625-641.

P4739/L21-P4740/L5 What happens during melt? As the top layer is melted away, is this replaced in the model with 8 mm of snow from the layer below with an average BC concentration? You could potentially add one sentence describing the melting process in the model.

P4742/L8-12 Just a clarification. Are the total aerosols emissions through the summer increased by 50%, but distributed over a longer period? Or are the emissions 50% larger every single day of the fire season, a season that is prolonged by a month?

P4742/L23-25 Could you please add a reference to support 2878 Gg/yr of BC? Where did this number come from?

P4743/L4 Change Sovde et al. with Søvde et al.

P4743/L20-27 Here you compare the observed snow cover duration including BC with modeled snow cover without BC. You state in the abstract that BC reduces the snow cover by 0-10 days. Could this BC effect alter the RMSE numbers in Fig. 2c?

Perhaps you have miswritten the caption for Fig. 2b? Is that figure based on S1 or S1B?

P4744/L27 Please add Mote et al. (2005) to the reference list.

P4745/L14 I'm not sure about the wording "present day aerosol emissions." As you

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compare the effects of different emissions in the future, not present emissions, you could rephrase. Potentially replace with “all other aerosol emissions.”

P4750/L26 Move the reference Fig. 7e, perhaps to after North-east Asia.

P4764/Fig 2 ”b) present-day simulation in absence of BC effects on snow albedo (S1).” Have you mixed S1 and S1B here?

You could also use different color maps to clarify that the color scaling is different between a and b as a group and c.

P4767/Fig 5 Why is the change in deposition slightly negative (“S3-S2, difference = -0.8 Gg/month”), while the change in emissions are slightly positive (+3.9 Gg/yr, P4743/L10 or Fig 1). I realize that the values are small and a change in sign could occur, but I would nevertheless have an explanation of this deviation. Is it because Fig 5 only looks at continental deposition?

P4769/Fig 7 Change the caption, since (c) is given twice.

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Interactive comment on The Cryosphere Discuss., 6, 4733, 2012.

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