Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-94-RC2, 2018

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Open fires in Greenland: an unusual event and its impact on the albedo of the Greenland Ice Sheet" *by* Nikolaos Evangeliou et al.

Anonymous Referee #2

Received and published: 25 April 2018

General comments :

This work investigates the quantification of emissions of black carbon (BC) from intense fires on peat lands in Western Greenland during summer 2017 and their impacts on albedo reduction and radiative forcing. The authors conclude that those impacts of BC deposition of the Greenland Ice Sheet are almost negligible, which turns out to be a scientific result for the community. This study is interesting and sound for ACP. I have nevertheless several criticisms requiring a careful and revision and in-depth improvements both in the methodology, often unclear, and in the discussion of the results before the paper is suitable for publication in ACP.

Specific comments :

L1-2 : The title seems to indicate that the main focus of the paper is the quantification of the reduction in albedo due to open fires in Greenland. Only ten lines in the paper really focus on the modification of the albedo due to BC deposition. The title should reflect the main findings of the paper : quantification of BC emissions of this unusual event, transport of the plume, deposition.

L41-44 and L496-500 : I find a bit strange to conclude both abstract and conclusion by something purely speculative and that does not match the main results of the paper.

L83-84 : "the largest fires". Give maybe statistics or cite a climatological study to support this assertion.

L111 : The authors should give more details about the procedure applied on the data. "Additional classification" is too vague.

L130 : "assuming a 6h persistence". How is this hypothesis justified ? Is it confirmed b observations or by other studies ?

L161 : Say clearly that the only variable computed in this study from measurements is the burned area A. The other factors are based on assumptions or provided by previous studies.

L181 : Those values suggest that aerosols are not only composed of BC (which is a reasonable assumption). How do the authors justify this size distribution ? It has indeed a huge influence on the deposition efficiencies (both sedimentation and wet removal) and on the calculation of aerosol optical properties. Both the radiative forcings and reduction of albedo on snow surfaces will be sensitive to this assumption on the size distribution. I suggest that the authors perform a sensitivity study on the influence of those parameters.

L200 : "a simple emission scheme". What does it mean ? Why don't the authors use the same methodology for all fires ?

L200-201 : Those emission factors should depend on the type of soil and vegetation. Which maps have been used here ? Which values for emission factors have been finally chosen ? The reader should be able to reproduce the results of this study ; without such assumptions, it is impossible.

Sect. 2.4 : Do the authors calculate radiative forcing assuming refractive index of BC only ? The choice of the refractive index should be done in accordance with the size distribution (L181), which probably reflects an internal mixture of aerosols.

L226 : "we display" : where ?

L292 : "a small portion of the emitted BC". Please quantify it.

L334 : "due to the generally dry weather when the fires were burning". It can be also ascribed to the fact that dry deposition mostly occurs in the quasi-laminar sublayer close to the surface. Aerosols are quickly deposited close to the sources before being injected at higher altitudes and being transported away from sources.

L365 : "the anthropogenic contribution is larger". For the sake of clarity, the authors might write that the anthropogenic is relatively larger in Southern Greenland in contrast to Northern Greenland but remains lower than the biomass burning contribution.

L367 : "the BC concentrations that are calculated here for the studied fire period are relatively high compared to those reported previously". I am not sure this is always true. The authors should also quote more recent studies, e.g. Polashenski et al. (2015), Legrand et al. (2016) or Thomas et al. (2017), who have reported higher events of biomass burning BC deposition over Greenland. If the BC deposited on snow/ice surfaces is much larger in those studies, it also suggests higher surface BC concentrations.

L378 and L389 : "dosages". Do you mean concentrations / mixing ratios ?

L397-398 : BC particles are probably not the main contributors to AOD in this region for two reasons : the BC loadings are rather low in comparison to other aerosol com-

pounds and the diameter of BC-containing particles is much smaller than the wavelength (0.5 um). A better proxy of the temporal evolution of the integrated BC would be the absorbing AOD (AAOD), which is also often provided at AERONET stations. The AAOD/AOD would be also a good indicator of the contribution of BC to the total AOD (even if BC is not the only absorbing component). This should be shown on Fig. 5.

L401-407 : How do the authors explain the significant AOD enhancement at the beginning of September observed at Narsarsuaq station ?

L422 : "was not studied". Does it mean that the transport of those North American fire plumes was not correctly captured by FLEXPART ? It is indeed impossible to see on Fig. 6d as the vertical scale is not appropriate.

Sect. 4.2 : The authors should remind that they calculated only the forcing due to the Greenland fires, which is itself small compared to the North American or Eurasian fires. It should also be said explicitly that the calculated radiative forcing values does not include semi-direct nor indirect effects, which may be dominant here.

L436 : "cloudless conditions". I do not understand the purpose of this. It is only an ideal simulation, which is not commented in the paper afterwards. What does it bring to the discussion ?

L440-442 : It is not clear if the given values refer to the total radiative forcing of BC. What are the relative contributions of the direct radiative forcing of BC and of the radiative forcing of BC deposited on snow surfaces ? The authors also give the values without any uncertainty, but a lot of assumptions have been done to retrieve the BC emissions, the BC size distribution, the BC optical properties. Each of those hypothesis would lead to a range of values of IRF.

L 442: "Fig 7c depicts the temporal behaviour..." Does it represent calculations in cloudy conditions ?

L443-444 : I don't see how this information (blue line) can be useful. The location of

the pixel where the maximum IRF is found likely varies with time. Besides the analysis of this figure is not done in text. I recommend to remove it.

L448-455 : If the authors want to be able to compare their results to global studies, as it is done here, they need to multiply the value of RF by the area of the simulation domain to obtain a forcing value in watts, and then divide it by the surface area of the Earth to obtain an equivalent global radiative effect in mW/m2 that could be compared to results for global studies.

L453-455 : What about the impact of North American and Eurasian fires, whose plumes reach Greenland during the studied period ?

L456-457 : What is the albedo reduction due to BC deposition that can be ascribed to Greenland fires / to fires outside Greenland / to anthropogenic sources ? If the goal of the paper is indeed to focus on the impact of the Greenland fires, quantifying this effect and comparing it to the relative contribution of the different sources would be really valuable for the paper. The authors should also compare their albedo reduction values to previous studies, e.g. Polashenski et al. (2015).

Sect. 5 : The conclusions may be more quantitative. For example : L478-479 : the ratio of BC deposition from the different sources can be given L481-483 : the AOD enhancement can be precised L488 : “albedo change due to the BC deposition”. Which sources have been considered ?

L496-500 : Remove this purely speculative sentence. The opposite could also be said, given the findings of the paper.

The choice of the figures kept in the manuscript is rather strange. Most useful figures relevant for the discussion have been displaced to the Supplementary Material. I recommend to move them to the main paper.

Fig. 2a: Are those values averaged over the simulation domain ? over Greenland ? I had hard time to figure out how those values could be realistic. I think there is either

a issue with the unit or a mistake in the calculation. Shouldn’t it be ng/m3 or ng/kg instead of ug/m3 ? The total concentrations of BC in the domain should be calculated as the volume average of the grid cell concentrations, not the sum over all grid cells in the domain...

Fig 2b : Here again, there is an issue with the unit. The color bar indicates ug/m2 (which is probably right), but the caption says ng/m2. Which one is correct ?

Fig. 4 : It is extremely difficult to see the colored grid cells an read their values. Please improve the quality of this figure.

Fig. 5 : Does the altitude represent agl or amsl ? The orography in Greenland is not flat.

Fig 5 : Why do you keep the contribution of fires burning outside Greenland but exclude the BC contribution of anthropogenic sources ? According to Fig. 4, their contribution is absolutely not negligible and they might modify the time series of column-integrated BC in Greenland.

Fig. 6 : it would be better to use the same scale for longitude and altitude on panels (b) and (d).

Fig. 7c : Is the snow albedo reduction plotted for 31 August or for the full period ?

Table 1 : This table is not commented nor anlyzed in text. We can notice changes in the sources of RS data at different periods, which should be detailed in the methodology section.

Legrand, M., et al. (2016), Boreal ïňĄre records in Northern Hemisphere ice cores: A review, Clim. Past, 12(10), 2033–2059.

Polashenski, C. M., J. E. Dibb, M. G. Flanner, J. Y. Chen, Z. R. Courville, A. M. Lai, J. J. Schauer, M. M. Shafer, and M. Bergin (2015), Neither dust nor black carbon causing apparent albedo decline in Greenland’s dry snow zone: Implications for MODIS C5 sur-

face reïňĆectance, Geophys. Res. Lett., 42, 9319–9327, doi:10.1002/2015GL065912.

Thomas, J. L., et al. (2017), Quantifying black carbon deposition over the Greenland ice sheet from forest fires in Canada, Geophys. Res. Lett., 44, 7965–7974, doi:10.1002/2017GL073701.

Technical comments :

L350 : “adopted”. Do you mean “adapted” ?

L394 : Replace “for validating” by “to validate”.

L485 : Replace “attenuation” by “attenuated”

L512 : Please write “Brent Holben” in two words.

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