

Review of the manuscript 'Combining atmospheric and snow layer radiative transfer models to assess the solar radiative effects of black carbon in the Arctic' by Donth et al.

The manuscript describes the use of BC measurements in the atmosphere and the snow, to calculate the radiative effect of BC applying an iterative procedure to couple the radiative transfer in the atmosphere and snow.

The manuscript is well-organised and include detailed description of the results. It has, however, some points to be clarified before publication.

Comments

- **Page 3, caption table 1:** There are various ways of defining BC. Please include a reference to for example Petzold et al. (2013) to clearly define your use of BC. Also please mention how EC values compare with BC values.
- **Page 4, lines 17-19:** Sentence is unclear. Please reformulate.
- **Page 5, line 15:** The reference to Evans (1998) and the SHDOM code appears to be out of place. Should it be Stamnes et al. (1988) instead?
- **Page 5, lines 12-18:**
 1. How many streams was used for DISORT?
 2. The solar zenith angle is large for all regions considered. Did you make any spherical corrections? If not, why not, and how do you expect this to affect your results?
 3. What was the vertical resolution of your model atmosphere?
- **Page 6, Fig 1:** The profiles shown are averages. Please also include the standard deviation (or other measure of variability) of the profiles to give an idea of how the profiles varied for the different campaigns.
- **Page 7, line 2:** In the snow a two-stream model is used. Presumably more streams were used for the atmospheric radiative transfer. Why is it sufficient to use only two streams in the snow pack?
- **Page 7, line 6:** Stamnes et al. (1988) is not a reference for the delta-Eddington approximation. Maybe rather cite Joseph et al. (1976)?
- **Page 7, line 14:** In the snow the BC optical properties are from Bond et al. (2013) while in the atmosphere they are from Hess et al. (1998). Hence, the BC particles are different in the atmosphere and the snow. What is the rationale behind this choice other than what is available in the models used?
- **Page 8, Table 3:** Should the first row in the table be named "Thickness" instead of "Depth"?
- **Page 8, lines 20-21:** The sentence "This procedure is repeated until the deviation between previous (step n) and revised surface albedo decrease below 1 %" is unclear. Please reformulate.

- **Page 10, Fig. 3:** May it be concluded from the plot that the iteration procedure has no impact on the surface albedo in the wavelength region where BC absorbs?
- **Page 11, lines 1-2:** The upward and downward irradiances were averaged and from these the averaged heating rates were calculated. This appears as a rather unusual and unphysical approach. Would it not be more appropriate to calculate the instantaneous heating rates and then average these?
- **Page 11, line 15:** The enlargement of Fig 4. seems to be missing. As Fig. 4 is, it does not make sense to have many overlapping lines. Please provide a zoom in of the visible wavelength region ($\lambda < 700$ nm).
- **Page 11-12, line 31-1:** In the introduction it is stated that “the radiative effects of atmospheric BC particles and BC suspended in snow shows an opposite behavior” and “these two effects balance each other”. Here it says “the impact of BC particles suspended in the snow pack is assumed to be of minor importance for Arctic conditions”. These statements appear to be contradicting each other. Please clarify.
- **Page 12, lines 1-2:** The paper by Warren (2013) discussed remote sensing of BC in the snowpack. I can not see how it justifies the claims made here?
- **Page 14, line 2:** Is the factor of about 3 mostly due to differences in solar zenith angle?
- **Page 16, line 32:** Sentence starting with “Absorption in the ...” is unclear. Please reformulate.
- **Pages 19-21:** In the conclusions please discuss how the results from this study compare with previous studies mentioned in the introduction.

Language corrections

- **Page 2, line 7:** change ‘of suspended’ to ‘suspended’.
- **Page 2, line 34:** change ‘will warming’ to ‘will warm’.
- **Page 3, line 16:** remove ‘.’ after ‘quantified.’.
- **Page 9, line 1:** Should it be “converge” instead of “conversion”?
- **Page 11, line 6:** Remove “(SSA respectively)”.

References

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