Atmos. Chem. Phys. Discuss., 12, C2936–C2942, 2012
www.atmos-chem-phys-discuss.net/12/C2936/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The distribution of snow black carbon observed in the Arctic and compared to the GISS-PUCCINI model" *by* T. Dou et al.

Anonymous Referee #3

Received and published: 25 May 2012

The distribution of snow black carbon observed in the Arctic and compared to the GISS-PUCCINI model

The manuscript provides a good overview of the recent observations of spring time black carbon in the Arctic snow pack (sBC). These values are mostly from Doherty et al (2010), but new data from several field campaigns is also added. sBC concentrations at the end of the Arctic summer are also reported and used as the initial BC concentrations in model runs. Again, these values are mostly from Doherty et al (2010), but a significant amount of new data is added here from the 3rd Chinese Arctic Expedition and from the 1st Korean Arctic Expedition. The springtime observations are compared to the GISS-PUCCINI model with two sets of meteorological fields, and a reasonable agreement is found. The model is reported to perform better in estimating sBC con-

centrations than other models known to the authors. The modeled concentrations of blac carbon in aerosol phase (aBC) are also compared to observed ones, and while the model catches the annual cycle of aBC, the modeled spring maxima of aBC are much lower than the observed ones. In the conclusions the model used in this study is suggested as a good tool for estimating sBC in Arctic snow. The agreement between the modeled and observed sBC concentrations is presented as the main outcome of the study.

I have several points in which the paper needs to be (or can be) clarified or improved. Some of the changes are small, some need more work. The page and row numbers below refer to those in the ACPD printer firendly version. The tables and figures are adressed separately. Also please check the English language, specificly the use of present and past tense. After any changes in the actual manuscript, please make the corresponding changes to the abstract.

Major issues:

P11250 L 4-5 (Concentrations ... data analysis)

A reference or explanation for the bias is needed before changing other people's resuls.

P 11250 L 22 – P 11251 L 1 (In this study ... bottom by turns.)

The reference (Sturm et al, 2002) gives the snow pack structure averaged over all sampling locations within 16.4 km radius from the station floating with the ice at the peak of accumulation period 1998. In the perspective of the large scale modeling this should be seen as one measurement point at one spring 14 years ago. The generalization of the snow layer structure over the whole Arctic and densities with 3 meaningful numbers based on this data simply can not be done. For estimatinmg the density of the snow pack I suggest the following approach: Sturm et al, 1995 give a rough generalization of what kind of snow is expected to be found in diffferent terrain types on land. The snow found at tundra is the closest substitute for what would be estimated to be found

over floating ice (layers of wind slab and possibly new snow and depth hoar in varying order). The measured density values in different layers (Sturm et al, 2002) can then be used to give the range in which the snow density (and mass based BC concentrations) vary. (Sturm, M., Holmgren, J. And Liston, G. E.: A seasonal snow cover classification system for local to global applications, J. Geophys. Res., 1261-1283, 1995.)

P 11253 L 24 – P 11254 L 1 (The correlation ... in the Arctic.)

Correlation is not very good estimate for the performance of a model. Two sets of values can correlate perfectly even if all values in one set are larger than maximum value in the other set. Also the number of observation points is statistically low, the correlation coefficients between the models and observations are very close to each other with both models, and in both cases the fitted (least mean square) line is heavily affected by the six points in the Russian Arctic (Fig.4.). I wouldn't make the conclusion that one meteorological reanalysis is better than the other, but rather that they are roughly equal and the discrepancy between model results and observations comes from some other source.

P 11257 L 27 – P11258 L 2 (,we suggest that ... and sea ice.)

If there is significant underestimation of aBC in this model (similarly to other current models), how does this model get the sBC right when other models do not. Please explain.

P 11257 L 11-12 (The overall ratio of observed to modeled sBC is 1.1.)

If this ratio was produced by simply taking the average of the ratios at each grid point where there were measurements, the ratio is heavily biased towards the Canadian Arctic where the number of measurements points is largest (and measured values increased by 11%). In this case the ratio does not represent the Arctic as a whole, and should not be given this way. I suggest giving these values separately for each area with both model runs (See comments to figuer 4.)

Minor issues

P 11248 L 4 (The average radiative forcing...)

I assume this refers to the global average. If so, please include the word global.

P 11248 L 13-17 (The comparison ... winter and spring.)

This sentence remains unclear to me. What is the meaning with "some points os sBC" in the middle?

P11249 L 17-19 (references)

Do all the given references refer to the earlies observations in mid-1980s? If not, please rephrase the sentence or remove unnecessary references.

P11249 L 19-21 (Camp Century ... Arctic Ocean sites.)

Camp Century and Dye 3 are clarified be located in Greenland, whereas no clarification is given for Alert or Barrow. Please be consistent.

P11250 L 13-14 (... derive an empirical formula ...)

How was this formula derived?

P 11250 L 19-20 (...and h1 and h2 are as given in Fig.1.)

This would be better if written here. Eg: ...and h1 is the top 25% of the snow pack depth and h2 the bottom 75%.

P 11251 L 10-13 (The vertically ... great uncertainties.)

Leaving out values simply because they are too large is not a good practice. Please include those values in the analysis or find a real reason to exclude them. (Possible local contamination?).

P 11252 L 8 (Repaeting year 2000 monthly-varying...)

Are the year 2000 emissions representative for the modeled period 2007-2009? How much uncertainty does this bring?

P 11253 L 3-5 (The entire ... located with it.)

Why was the Arctic divided to latitude bands? Why was no longitudal separation appleid?

P 11254 L 12-13 (Most observations ... Arctic Ocean.)

If the sBC values observed in the center of Arctic Ocean were assumed to be too low because only surface snow was measured, that would require the subsurface sBC to be significantly higher. This is not the case in the Canadian or Russian Arctic where sBC profiles were measured. Please explain or give a reference why the sBC would be concentrated in subsurface snow on the Arctic Ocean.

P 11255 L 11-13 (Result shows ... and 2009.)

Besides temporal variation, it would be nice to give some numbers for the spatial variation (Fig.5.) in the text.

P 11255 L 19-21 (Rahn et al ... pollution products.)

The structure of this sentence is unclear.

P 11258 L 26-29 (It also needs ... Arctic regions.)

I don't see this line being enough for adressing the snow density issue.

Tables

The two large tables fill a major fraction of this manuscript. They give information on the spring and late summer sBC concentrations at sites around the Arctic. The respective sBC values from the GISS-PUCCINI model are not included in the tables. In both tables the columns labeled "surface", "subsurface" and "whole layer" need better labels so that the reader can understand what they are and what are the units. Also column

"uncertainty of estimation" needs units. Many references in the tables are given as field campaign names or other acronyms (NPEO, APLIS/SEDNA, U.Vic, HOTRAX). Has this data been published elsewhere? If yes, please give appropriate reference. If the data is first published in this study, please mark it so. The tables (especially table 2) do not bring out much of the results, but mostly values reported elsewhere. Therefore I suggest the authors to concider whether they would be better given as Appendix or supplementary material (if the journal format allows this).

Figures

Figure 1

What are the vertical lines in the figures and what is the horizontal line at right panel at 90% snow depth? Those are not in the original figure (Doherty et al., 2010). Since the 25% / 75% division is made to all sites, it would be good to have the h1 and h2 in both figures. Also, please correct the unit format on the vertical axis of the left panel.

Figure 2

The observation site numbers in the X-axis do not match the ones in table 1. (I assume the values are spring-time sBC concentrations.) Therefore the only real information on X-axis is the separation between the Canadian and Russian Arctic, which can easily be seen also in figure 1. I recommend removing this figure, because it does not give any new information.

Figure 3

This is a good and informative figure. It could, however, be further improved by putting the measurement locations from each year in the same panel with the modeled sBC values and by removing the top left panel (obs). The three panels would be good to present as in figure 5.

Figure 4

This figure consits of two separate figures. Both of them have some significant issues. In the top figure the X-axis is a major problem. The bars can not be connected to individual grid boxes and thereafter to individual measurement points since only the region is given in the axis, and even that to only every second group of bars. Averaging the values over each region would produce a more clear figure and would tell the model's ability to produce the measured values in each region. In the bottom figure the fitted line is governed by the six (Russian) grid boxes with high sBC concentrations. Also units are missing. Since the discrepancy between modeled and observed high sBC concentrations is not caused by the fact that the sBC values are high (discussed in the text), the lower figure does not give much useful information. I recomment removing the lower figure.

Figure 5

A good figure, where I only suggest to change the word "decrease" to "change" in the caption.

Figure 6

The time axis would be much more clear if only the years (or January 1st for each year) were given.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 11245, 2012.