Atmos. Chem. Phys. Discuss., 15, C2984–C2988, 2015
www.atmos-chem-phys-discuss.net/15/C2984/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying sources of black carbon in Western North America using observationally based analysis and an emission tagging technique in the Community Atmosphere Model" *by* R. Zhang et al.

Anonymous Referee #1

Received and published: 26 May 2015

General Comments

An analysis of model results for BC in snow in the Northwestern USA from simulations with CAM5 is presented. The focus of the paper is the validation of model results based on a combination of a large number of high-quality observational data sets. As a novelty, a Positive Matrix Factorization (PMF) analysis is performed to determine biomass and fossil fuel sources of BC in the snow.

Many models produce substantial biases in simulated BC concentrations in the atmo-

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

sphere in this region. An analysis of the relationship between BC in the atmosphere and deposition on snow is a very useful approach with regard to needed improvements of climate and air quality models. Unfortunately, there are several key aspects of the approach that seem problematic. In particular, the approach likely underestimates the influence of biofuel emissions in the model as explained in more detail in the following. Second, comparisons between BC concentrations in snow and air are based on unverified assumptions about correlations between these quantities.

Specific Comments

Page 12964, line 7 - 13: Please clarify whether sensible and latent heat fluxes are specified in calculations of atmospheric properties and land surface processes. How do amounts of snow and BC processes in snow in specified dynamics mode compare with results from the freely running model and how accurate are results? It seems that his approach has previously been used to study atmospheric processes but it is not obvious how well it works for snow and BCC.

Page 12964, line 26: The yet unpublished ECLIPSE data set is not properly acknowledged. See the ECLIPSE website for details.

Page 12965, line 5-8: It seems highly problematic to apply the ratio of biofuel to total emissions from the old AEROCOM/GFED emission data set by Dentener et al. (2006) to the new combined ECLIPSE/GFED3 data set that is used in CAM5. This will likely lead to incorrect estimates of fossil fuel and biofuel emissions. Different emission sectors are considered in these data sets (e.g. oil and gas flaring emissions are included in the ECLIPSE data set but are not included in the AEROCOM data set). There are also substantial differences in emissions from sources that are common to both data sets. For GFED3, there is a 43% increase in emissions for boreal North America compared to GFED2 (van der Werf et al., 2010). The latter implies that biofuel emissions and contributions to BC in snow in North America are substantially underestimated with this approach, which likely explains diagnosed underestimates in BB contributions to

ACPD
15, C2984–C2988, 2015

BC in snow in CAM5 in Fig. 6, a key conclusion.

Page 12968-12969: The presentation of equations and associated description of the analysis method seems somewhat lengthy and complicated. Maybe some of this could be moved to the supplement or otherwise be simplified?

Page 12971-12972, section 3.2: I found it difficult to understand this section. A table of concentrations and biases in different regions would be beneficial for a more concise summary of results.

Page 12973, lines 6-11: Comparisons between the snow column BC mixing ratio (BCC) and near-surface atmospheric concentrations of BC (BCS) are problematic for several reasons. First, at any given location, vertically integrated concentrations of BC in the snow are largely determined by the mean deposition fluxes of BC and snow during the time period since the snow pack started to form in the fall of the previous year. If data from permanent snow fields is considered then emissions of BC from previous years may also be important. Consequently, comparisons with mean BC concentrations in air in January-February-March (JFM) should be replaced by comparisons that are based on overlapping time periods for BCC and BCS. Second, as is also pointed out in the paper, spatial variability in BC concentrations is large and cannot be fully quantified based on the relatively small number of measurement sites. The sparse distribution and lack of co-location of measurements limits the statistical robustness of the comparisons, which is not quantified. Furthermore, estimates of LMNB and LMNE are biased low in the Northwest USA region for both BCC and BCS (see previous manuscript pages). This points at a common explanation for biases in these quantities (such as an underestimate in BC emissions), opposite to the explanation given here. It is not obvious how biases in the Northwest USA region can be explained by results for Canada since the impact of local emissions on regional concentrations is so high as the study shows?

Page 12974, lines 7-28: Potential emissions of BC particles from soils as source of

ACPD

15, C2984–C2988, 2015

missing BC in snow in the model is an interesting topic. Soils can indeed contain microscopic particles of charcoal from vegetation fires and particles from coal combustion (Schmidt and Noack, 2000). However, various processes such as soil erosion, BC decomposition, etc. need to be considered for potential emissions of BC from soils. What concrete observational evidence exists for a soil source of measured BC snow concentrations in this study? How can the fingerprint of a soil component in the PMF analysis be explained? Soil particles and BC are both often found in snow but this does not necessarily imply a common source. For instance, deposition of soil and BC to a snow field would be positively correlated if disturbed soils and fossil fuel sources of BC are both upwind of the snow field. Further, forest fires plumes may contain soil chemical elements and can therefore also produce a positive correlation. Hence it is not clear how a lack of BC in snow can be explained by missing (direct) emissions from soils in the model.

P. 12978, line 5-7: Please add more quantitative information about the differences. What are the mean values and standard deviations?

P. 12978, line 9: Define what combustion sources are considered. Does this refer to fossil fuel combustion emissions (P. 12974, line 9)?

P. 12980, line 4-5. A simple linear relationship in latitudinal variations in BC radiative forcing and BC deposition flux cannot necessarily be expected and the meaning of such a relationship is not clear. For instance, the radiative forcing depends on insolation and therefore latitude, which is not considered here. In addition, as explained above, JFM deposition fluxes and concentrations are not a good proxy of the BC loading in the snow pack. Furthermore, the discussion of radiative forcings does not seem to be logically connected to discussions in the rest of the paper.

References

Dentener, F., Kinne, S., Bond, T., Boucher, O., Cofala, J., Generoso, S., Ginoux, P., Gong, S., Hoelzemann, J. J., Ito, A., Marelli, L., Penner, J. E., Putaud, J.-P., Textor,

ACPD

15, C2984–C2988, 2015

C., Schulz, M., van der Werf, G. R., and Wilson, J.: Emissions of primary aerosol and precursor gases in the years 2000 and 1750 prescribed data-sets for AeroCom, Atmos. Chem. Phys., 6, 4321-4344, doi:10.5194/acp-6-4321-2006, 2006.

Schmidt, M. W. I., and Noack, A. G.: Black carbon in soils and sediments: Analysis, distribution, implications, and current challenges, Global Biogeochem. Cycles, 14, 777-793, 2000.

van der Werf, G. R., Randerson, J. T., Giglio, L., Collatz, G. J., Mu, M., Kasibhatla, P. S., Morton, D. C., DeFries, R. S., Jin, Y., and van Leeuwen, T. T.: Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997-2009), Atmos. Chem. Phys., 10, 11707-11735, doi:10.5194/acp-10-11707-2010, 2010.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 12957, 2015.