Atmos. Chem. Phys. Discuss., 15, C4806–C4810, 2015
www.atmos-chem-phys-discuss.net/15/C4806/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The importance of Asia as a source of black carbon to the European Arctic during springtime 2013" *by* D. Liu et al.

Anonymous Referee #3

Received and published: 13 July 2015

GENERAL REMARKS

The manuscript presents observation data from a flight campaign in the year 2013, focusing on black carbon (BC) transport into the Arctic, which is a topic of high relevance. Presented data cover BC mass concentrations, properties of BC-containing particles such as coating thickness, and ratios of BC to excess CO which are relevant for the determination of BC scavenging during atmospheric long-range transport. Observation data are combined with FLEXPART studies on source regions and HYSPLIT back trajectory analyses for the determination of meteorological conditions during transport. Both pieces of information are used to determine a scavenging fraction of BC for the long-rang transport into the Arctic air. The topic is well suited for publication in ACP and the study is well conducted whereas the data analysis requires major revisions,

in particular the section on the scavenged BC fraction; see comments below. Furthermore, the presentation of the material may benefit from restructuring and focusing. In summary the manuscript is acceptable for publication in ACP after major revisions have been considered.

SPECIFIC COMMENTS

Concerns raised by referees #1 and #2, mainly related to the representativeness of 2013 observations for long-term considerations, to missing of flaring as another BC source in the Arctic, and to the use of inventories for anthropogenic emissions and OBB emissions from different years, are not discussed here; please refer to reviews #1 and #2.

1| Source regions: The classification of source regions uses geographical terms for all cases, except for the "Clean Air" source –region. This nomenclature is strongly confusing since the manuscript's focus is on the point that the Arctic air is not clean. Following Fig. 3 it is recommended to use the term "Arctic air" or Arctic Background" or something similar. Then the terminology of source regions is consistent.

2| Scavenging of BC particles: One core part of the data analysis is focusing on the determination of the fraction of BC which is scavenged during atmospheric transport. The analysis of the scavenged fraction builds on the determination of the ratio of BC to excess CO and its differences between source characteristics and observations in the far field of atmospheric transport. Here the authors use the ratio of BC mass concentration (reported in ng m-3) divided by the volume mixing ratio of excess CO (reported in ppbv). This data product is also used to build vertical profiles; see Fig. 10. Referenced literature data refer to observations in the boundary layer over Europe, south-east Asia and an urban environment like Mexico City. Similar observations from elevated plumes of anthropogenic pollution (Park et al.,2005) and boreal fires (Petzold et al., 2007) are not considered, but should be discussed. Constructing vertical profiles of BC/deltaCO, however, requires the analysis of mass ratios of BC to CO (reported in g

BC / g deltaCO) instead of combining volume concentrations and mixing ratios. Values of mass ratios are independent of the reporting altitude, while mass concentrations change with altitude, as long as they are not reported for STP conditions; see Park et al. (2005) and Petzold et al. (2007) for details. Because of this inconsistency, the analysis of BC/deltaCO needs to be repeated, using mass mixing ratios. Referring to Andreae and Merlet (2001), this parameter can be compared to emission characteristics for specific types of biomass burning. It is therefore strongly recommended to repeat the analysis of BC/deltaCO and the related data interpretation.

Another point of discussion arises from the applied methodology in the determination of BC scavenging. Data shown in Fig. 11 show the scavenging factor as a function of the total precipitation, determined from the integrated precipitation along the back trajectories. The analysis does not show any dependence between the two parameters. Looking at Fig. 9, a large amount of precipitation is associated to trajectory altitudes above 7 km (pressure below 450 hPa) at mid-latitudes higher than 40 deg. north. It would be of interest to see the air temperatures at the considered altitudes. Which information on precipitation was used here?

In general, the link of BC scavenging to total precipitation neglects potential scavenging pathways by aerosol-cloud interactions (both liquid and ice clouds). A detailed discussion of this topic is recommended.

3| Applying mean and standard deviation to 12 days back-trajectories should at least be checked against median and 25- and 75-percentiles (which is more robust) to justify the application of the averaging procedure. Furthermore, it should be discussed whether 12 days back-trajectories can be interpreted in case air mases have crossed convective systems (which are often associated to precipitation).

4| Restructuring of chapters: Large parts of sections 4.1 and 4.2 might be shifted into a new section on methodologies of air mass origin determination and plume source determination. Actually, the description of these methods in the results section causes

some duplication which might be avoided when inserting a new section on methods in chapter 3. Furthermore, chapters 5 and 6 may be merged into a single chapter on Discussion and Conclusions. Actually there is some redundancy in both chapters.

MINOR ISSUES

1| The last paragraph of the abstract contains some information already given above, it can be removed.

2| Page 14846, line 11: replace the term “soot” by “black carbon”.

3| Page 14846, line 23: the reference to Polissar et al. (1999) may be replaced by another more general reference to the radiative impact of BC, e.g. by the reference Bond et al. (2013) which is already cited in the manuscript.

4| In the manuscript OBB is sometimes referred to as open biomass burning, sometimes as open-fire biomass burning. Consistent terminology is recommended.

5| Page 14847, line 4-7: The sentence is confusing and should be rephrased.

6| Page 14850, line 3: typo, it should read Aerodyne C-TOF.

7| Section 3.1: Figure 2 contains similar information as Fig. 5 and might be removed.

8| Page 14856, lin e9 ff: Differences of the BC coating thickness are insignificant in a statistical sense, this should be stated clearly.

9| Fig. 9b, lower panel: pressure line should be coloured in red.

REFERENCES

Andreae, M. O., and Merlet, P.: Emission of trace gases and aerosols from biomass burning, Global Biogeochem. Cy., 15, 955-966, 2001.

Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Berntsen, T., DeAngelo, B. J., Flanner, M. G., Ghan, S., Kärcher, B., Koch, D., Kinne, S., Kondo, Y., Quinn, P. K., Sarofim, M. C., Schultz, M. G., Schulz, M., Venkataraman, C., Zhang, H., Zhang, S.,

Bellouin, N., Guttikunda, S. K., Hopke, P. K., Jacobson, M. Z., Kaiser, J. W., Klimont, Z., Lohmann, U., Schwarz, J. P., Shindell, D., Storelvmo, T., Warren, S. G., and Zender, C. S.: Bounding the role of black carbon in the climate system: A scientific assessment, J. Geophys. Res., 118, 5380–5552, doi: 10.1002/jgrd.50171, 2013.

Park, R. J., Jacob, D. J., Palmer, P. I., Clarke, A. D., Weber, R. J., Zondlo, M. A., Eisele, F. L., Bandy, A. R., Thornton, D. C., Sachse, G. W., and Bond, T. C.: Export efficiency of black carbon aerosol in continental outflow: Global implications, J. Geophys. Res., 110, doi: 10.1029/2004jd005432, 2005.

Petzold, A., Weinzierl, B., Huntrieser, H., Stohl, A., Real, E., Cozic, J., Fiebig, M., Hendricks, J., Lauer, A., Law, K., Roiger, A., Schlager, H., and Weingartner, E.: Perturbation of the European free troposphere aerosol by North American forest fire plumes during the ICARTT-ITOP Experiment in summer 2004, Atmos. Chem. Phys., 7, 5105-5127, doi: SRef-ID: 1680-7375/acpd/2007-7-4925, 2007.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 14843, 2015.