Atmos. Chem. Phys. Discuss., 10, C5342–C5345, 2010
www.atmos-chem-phys-discuss.net/10/C5342/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Long-term trends of black carbon and sulphate aerosol in the Arctic: changes in atmospheric transport and source region emissions" *by* D. Hirdman et al.

Anonymous Referee #2

Received and published: 15 July 2010

The purpose of this paper is to discuss the influence of transport variability on trends of Equivalent Black Carbon (EBC) and sulphate observed at Alert (1985-2008), Barrow (1988-2008) and Zeppelin (1990-2009). It is an important question which has been already addressed in Sharma's work and in Hirdman 2010. What is new in this paper is on one hand the use of the full record of these 3 stations (only 7 years is considered in Hirdman 2010) and on the other hand to consider 3 sites and the Flexpart model with different source regions (only two sites are studied in Sharma 2006 and trajectory analysis is used for the transport characterization). The methodology based on a cluster analysis is one of the major achievement and this is explained in section 2.3. It is however the most difficult part to read mainly because a lack of some examples to illus-

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

trate the meaning of the 4 clusters which are identified in section 3.2. I am wondering if a (I,n) plot for a given example would help to clarify how the cluster analysis works, I being the geographical region of fig.1 and n a set of measurement times.

The paper is well written and provides convincing evidence that the BC trends at the 3 arctic stations cannot be explained by the variability of the transport from mid-latitudes sources, although there is some variability of this parameter as shown in section 3.1. Another important result is the dominant role of the Northern Eurasia (NE) to explain the large variability of the EBC , but not necessarily the long term trend. My main concern would be the lack of interannual analysis for individual season (mainly summer and winter). Indeed often in the text and also in fig. 10, one can notice that the influence of a given cluster at a given station is very dependent of the season. For example Fig.11 or 13 for winter or summer data individually may provide another picture of the link between transport variability and trends. Another missing part in the discussion is a more detailed discussion of sulphate data and EBC stressing both their expected differences (sulphate being more sensitive to aerosol removal and transformation, different sources ?) and the expected similarities (role of transport). Trends for both species are given separately but such a discussion could also provide information about the respective role of sources and transport variability.

I believe this paper is very good and deserves publication in ACP, however I suggest minor changes to make it even better and I would like to see more information about seasonal trends.

Detailed analysis and minor questions

The introduction provide a good summary of the state of knowledge and relevant questions are : what are the sources influencing the summer data ? what do we learn by using sulphate and EBC ? What are the respective roles of emissions and transport pathways ? It is mentioned that Zeppelin has two EBC stations with contradictory results about recent trends. It is not really clear which one is chosen and why are results

ACPD

10, C5342–C5345, 2010

different ?

Section 2 is very complete except may be a better readability of section 2.3 by using examples as explained before. The bias in the Barrow record due to data filtering is mentioned, but how will this change the results ? The instrumentation change is pointed out in the difficulty to identify trends but not the influence of this data filtering. In section 3.2 line 6 better define what you mean by “number of cases” (measurement times) ?

Section 3.1. This a very interesting section. The large number of cases for AO means that local processes (removal, aerosol transformation, local sources) are very important and that measured BC aerosol could be quite old since their emission from mid-latitudes. This could be somewhat more recognized. Information about season dependent processes are given but not derived from given figures (line 24 p. 12146, line 4-6 p. 12147, line 23 p. 12147,. . .)

Section 3.2 From this section it is clear that the season is an important parameter.

Section 3.3 The trend of the cluster frequency is indeed a good way to discuss the long term transport variability. It is surprising that the Barrow and Alert trends are not more similar considering their common sensitivity to the NAO. Influence of the data filtering ? The fact that no trend in Zeppelin is related to the shorter period is not so clear because it is only shorter by 5 years compared to the longest Alert record. Is there a trend for the summer period considering the correlation with NAO in summer ?

Section 3.4 and 3.5 In these sections, yearly trends of EBC and sulphate are recalculated using the cluster analysis to compute an annual mean. The aim is I believe to identify regional source changes responsible of the observed yearly trends. In fact some information about the expected results of this methodology should be given at the beginning of section 3.4 (see for example the introduction of section 3.6 which nicely explains the methodology used in this section). Fig. 12 is very illustrative of the importance of the NE sources in the EBC variability in Alert and ENE in Zeppelin.

ACPD

10, C5342–C5345, 2010

Sulphate variability at these stations (Fig. 14) exhibits the same kind of results. But the trends are quite different for both species in table 3. In fact I am confused by the differences between table 3 trends and trend lines shown in fig. 13 and 15. I do not see positive sulphate trends in fig. 13 and 15 for Alert. Eventhough there is a short record for EBC in Zepplin, sulphate and EBC interannual variability are quite different for this time period, could it be related to differences in the ENE cluster frequency ? As explained in my general comments information about the winter and summer trends might also be valuable at least for Alert where there are the longest and more robust records.

Section 3.6 In this section the cluster frequency interannual variability and the cluster annual means are combined to derive more meaningful calculated trends which can be compared with the observed trends. The most important result is the large influence of the AO cluster because of its high frequency. It again indicates the importance of the local source and sink trends. I am confused by the author's statement (line 13 p. 12155) that circulation do not drive the trend. In fact trends could be quite different if there were not the compensation between the AO and NA frequency for Alert. So the measured trend in this station is not just a mirror of the source trend. It may be also interesting to show the Zeppelin sulphate trend for the shorter time period corresponding to the EBC record for the purpose of comparison. In the same way, the Zeppelin cluster frequency for the EBC shorter record might be also useful to show (Fig. 11).

Technical details. Say that trend lines are calculated with geometrical mean in legend of fig. 13 an 15.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 12133, 2010.