Answer to reviewer 3

The first major comment from Reviewer 3 is the use of a Klett inversion to derive aerosol backscatter properties.

This kind of inversion is more easily used for an upward looking lidar as an upper clear air reference can be used and it is much more difficult for a downward looking instrument where the aerosol free region is at generally at near ranges (i. e. an unstable inversion in this case, see the paper of J. Klett in Applied Optics,1985). But the more important reason for not doing this is that the aerosol optical depths are generally small enough to assume that the attenuated backscatter is a good proxy of the total backscatter coefficient. The reason for using a pseudo color ratio and a pseudo depolarization ratio is explained in more detail in the answer to reviewers 1 and 2. Notice also that there is a new figure (Figure 5) with the aerosol color ratio values in addition to the values already given in Table 2, and now also included in Tables 3 and 4. As explained in the text, the error bar makes this parameter less stable for the relative comparison of our layers. Also the main goal is to have a parameter comparable with the CALIOP version 2.2 layer operational color ratio. Since the comparison between these pseudo ratios with ratios based on the aerosol backscatter is rather lengthy, we feel it is better to have a specific Appendix on this topic. In the main text section 2.2 we have provided more detail about why we use the pseudo ratios.

The second major comment of reviewer 3 is that the depolarization ratio includes the molecular contribution. This was on purpose to make our estimate comparable with the CALIOP data. This is probably not clear enough in the text and has been added in section 2.3.1. The corresponding aerosol depolarization ratio is also given in text and was added in Table 2 in the new version for comparison with the Gobbi mid-latitude values, but again this is not the goal of this paper to emphasize such a comparison considering the large differences in the origin of the layer between other studies and our specific work. Our goal is really to be comparable with CALIOP to make a coherent study of the Arctic layers transported from Asia/Siberia to Scandinavia.

The third comment is similar to other comments of the other reviewers requesting more information on the airborne lidar. This has been added in section 2.3.1.

The fourth comment is very specific to this reviewer, who finds Table 3 difficult to read in the first version. We fully agree with this and apologize for not improving this in the first version. We added now a color code to distinguish the layers according to their positions: Siberian fires (light brown), mixed Asian sources south of 52N (gold and red to indicate when dust are expected to influence the mixture), layers in the area where the aircraft flew (green). We believe that this code helps to follow the discussion of section 4, where we discuss the aerosol layer optical properties measured by CALIOP. The Cloud Aerosol Discrimination (CAD) score was examined and typical values are reported in section 4. They are always larger than 50% and even 75% of the layers have a CAD larger than 75%. The table includes also new CALIOP parameters (aerosol color ratio and aerosol classification) allowing also a discussion of our results in comparison with these operational parameters of version 2.. We believe that such independent assessment of the CALIOP aerosol classification is worth to be reported. Table 3 is now presented in two parts, before and after April 8th, to make it more readable.

Minor remarks

Fig 1 and 2 have been combined as suggested and a color scale was added for the wind intensity.

The subsidence assumption is based on the inclination of the isentropic surfaces between 70N and 75N which matches the aerosol layer inclination in the vertical cross section. It is a well known result that we may assume isentropic motions on short time scales (1-2 days), especially in this area where diabatic effects are not very large in the free troposphere (away from large cloudiness). We have changed the sentence by saying that the aerosol inclination matches the isentropic surface inclination.

The correlation of CO with aerosol is a good way to distinguish pure dust from layers influenced by pollution sources or biomass burning. Many references are available especially from work in tropical regions. We added two references.

Lower troposphere for the source regions considered in the FLEXPART work means the 0-3 km altitude range. This is explained in section 3.1. This is a good proxy for the PBL sources because small scale PBL venting not resolved by FLEXPART still can be accounted for. There are many examples that the small scale venting easily influences a 1-km layer above the PBL.

Other technical corrections have been made and we apologize for not seeing them in the first version.