## Response to the comments of Referee #1:

First of all, we thank the referee for spending time and effort to perform a thorough review of our manuscript. Most of the comments were really helpful to improve the quality of our paper.

**Major Comments:**

**Reg. 1:** In the current version, the Introduction follows the suggestion of the reviewer: after a short overview why mesoscale meteorological information is necessary to interpret observed aerosol distributions, we give an overview of the conditions of the observations and define the goal of the paper.

**Reg. 2:** We added references to the associated figures at all places where they were needed.

**Reg. 3**: The suggestion is taken for the horizontal cross-sections; however, for the vertical profiles we keep both simulation runs as they document the differences more clearly that many additional words in the text.

**Reg. 4:** In the simulations presented in the paper, a uniform thermal velocity of -1 cm/s was assigned to the scalar fields representing the three different aerosol classes. This is now mentioned in Section 3.1. Test simulations with zero thermal velocity for the scalars do not show significant differences to the results shown in the paper.

**Reg. 5:** The Discussion and Conclusion Section have been rewritten and are, hopefully, better structured in the current version.

**Detailed Comments:**

- p16442: Abstract has been rewritten.

- p16443, L3: OK

- p16443, L5: “favorable” removed and reference to Skeie/Grönas included.

- p16443, L11,14: We rewrote the paragraph aaccording to the suggestions of the referee. However, we believe for the introduction it is enough to state that we observed large aerosol backscatter values by remote-sensing instruments and the observed profiles featured certain mesoscale patterns. The conclusion what kind of particles we most likely observed can only be drawn by combining our observations and our numerical simulations. And this will be done in Sect. 4.

- p16443, L19: right; replaced by “Additionally, “

- p16443, L28: OK, phrase removed.

- p16444, L 5: done

- p16444, L10: done

- p16444, L14: Information added to the Figure Captions of Fig. 1 and 2. The images are unprojected and taken from the MODIS web page.

- p16444, L15: OK

- p16644, L22: OK, done

- p16445, L1: done, figure reference introduced

- p16445, L17: We decided to leave the online reference to the satellite site of Dundee in the text. As it really only supplementary information, the effort is too large to create a separate image depository at ACP.

- p16445, L20: done

- p16446, Fig. 3: Information added. Please use lat/lon grid to orientate.

- p16466, Figs. 4 and 5: done

- p16466, L5: done, figure reference introduced

- p16446, L9: forward reference removed.

- p16446, L14: corrected as suggested

- p16446, L17: done, figure reference introduced

- p 16446, L20: see comment to p16445, L17.

- p 16447, L11: explanation about backscatter and depolarization added.

- p 16447, L16: changed as suggested

- p16448, L5-9: Unfortunately, there is no additional background profile further east in the Isfjorden that could be taken to support our hypothesis. Additionally, vertical profiles of the meteorological quantities necessary to calculate the Richardson number do not exist. Based alone on flight level data, we cannot calculate the vertical derivatives of wind speed and potential temperature. In this respect, the payload onboard the POLAR2 was not really suited to tackle problems as turbulent mixing and estimates of the static stability in this particular mission.

- p16448, L17: We wished we could provide such a figure. However, for the preparation of this paper we averaged the lidar signals over several instances when the aircraft was flying in the same area to improve the signal to noise ratio. Naturally, the error increases with decreasing aerosol load and due to the speed of the aircraft we would have mixed temporal and spatial variations in the aerosol load. Hence, we restrict ourselves to selected profiles in the Isfjord area.

-p16448, L27: Done.

-p16449, L5: This is right: Two sentences are introduced at the end of Sec 2.2 and at the beginning of Sec. 2.3 which now relate both parts of the paper, i.e. the part investigating the dust plume and the one investigating the sea salt emissions observed at the northern tip of Svalbard. Regarding the lidar curtain, see remarks to p16448, L17. We don't think that we have observed sea salt at this point (directly at the end of Adventdalen downwind of Svalbard). However, we cannot exclude it as well.

-p16450, L5: Well, we added the term “upward sloping aerosol and cloud layers”.

-p16450, L12: You are right. We changed this sentence.

-p16450, L27: The surface heat flux is proportional to the vertical gradient of the temperature. Assuming a constant sea surface temperature, warmer air masses results in weaker surface heat fluxes as the temperature difference becomes smaller. Therefore, the wind speed must be the driving factor of the boundary layer height. Furthermore, the vertical flux of sea salt aerosols is proportional to the third power of the wind speed. This means, there is no emission of sea salt without wind! This means a narrower aerosol layer height must imply a slower surface wind speed.

p16541, L8: We don’t agree. As we don’t measure the aerosol particles directly, we can only speculate about their constitution. It is just the combination of remote-sensing observations and numerical simulations that supports the hypothesis which is stated in this paragraph.

p16451, L15: Well. Sentence changed.

p16451, L21: Changed the order to a more logical sequence.

p16452: see remark to major point 4.

p16453, Fig.8: corrected

p16453, L11: The digital topographical model is interpolated to the 2 km x 2 km grid. The width of the Adventdalen varies and amounts to about 2 km. The steep mountains are certainly not fully resolved in the simulations!

p16453, L23: Done as suggested the respective figures are removed from the text.

p16453, L26: Sentence introduced at the end of the paragraph.

p16453, Fig 9: As we don’t use a realistic horizontal distribution of the temperature (we distribute the upstream profile to all horizontal grid points a direct comparison to the ECMWF fields doesn’t make any sense. Only the impacts of the ascending and descending motions on the wind and temperature fields are the important quantities which should be extracted from Fig. 9.

p16453, Fig. 10: The domain size for Fig 10 is chosen in such a way that just the most important dynamical features flow past the mountains can be identified. Due to fact that our simulations do not consider a realistic sea surface (incl. ice) parameterization, numerical results further north (e.g. a continuous increase of sea salt concentration over areas where the pack ice is located in reality) could lead to misleading conclusions.

p16454, L10-12, L13-25: done

p16455, L2: OK

p16455, L10: Specific remarks to actual dates of the observations are not made in the text.

p16455, L22: rewritten in the context of eliminating the results without heat flux.

p16456, L10: This conclusion is indeed based on arguments considering the stability of the boundary layer: we state that in the northern part the heat flux has no influence on the aerosol distribution because of the similarity of the simulated sloped isentropes with the observed aerosol features.

p1656, L11: We don't use the term "lee jet"; tip jet would be appropriate as well but coastal jet describes the origin much clearer.

p16456, L18: Coal: footnote added in the Introduction.

p16456, L20: Is now explained in the text: it is the next valley to the north of Adventdalen.

p16456, L25: With "total aerosol concentration" we simply mean the total increase in the backscatter above the molecular background ($R_{532}$ =1) regardless of the chemical composition or origin of these additional scatters.

p16456, L26: The origin of the particles producing the single peak of profile No 3 in Fig. 5c/d remains unclear. It was a spatially small-scale feature which was measured only twice and altogether not longer that 1 min, see Table 1. Taking into account the relatively coarse numerical resolution and the inadequate parameterization of the mobilization (i.e. we have no information about size and number density of the ice particles) and the only qualitative characteristics of the aerosols (represented by continuous scalar fields), one cannot expect a realistic treatment of the motion of ice particles in the model. Thus, the conclusion that ice particle movements are not simulated well is correct.

p16456, Fig 11: see comment to p16453, Fig. 10

p16457, L1-10: Elements have been moved to the Introduction.

p16457, L23: Soot removed, coal particles were meant!

p16457, L25: Because it occurred in spring. We removed the word "unique".

p16458, L5: Is now explicitly mentioned in the model description.

p16458, L13, 16: "contamination" removed and "triangular" replaced.

p16458, L16: This is correct. Sentence has been rewritten.

p16458, L18: The connection to the more large-scale view of climate model simulations is made clearer. This was actually meant by overall aerosol characteristics.

p16458, L27: right! Corrected.