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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Physical properties of High Arctic tropospheric particles during winter" *by* L. Bourdages et al.

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Dear Reader,

We are disappointed with the conclusions of both reviewers, and contend that their specific criticisms of our manuscript can be addressed. Our work examines particle properties in a region with no previous information: the High Arctic troposphere during winter. We continue to believe that publication of these results, which have implications for radiative transfer and climate, are of considerable interest to the ACP readership.

Our paper presents data that we obtained with a High Spectral Resolution Lidar (AHSRL) and Millimeter-wave Cloud Radar (MMCR) in the High Arctic at Eureka. The measurements explore the optical properties, including effective radius, of particles in

four main categories: tropospheric ice clouds, mixed-phase clouds, boundary-layer ice crystals, and aerosols. Significant new results include:

a) The vertical distribution of liquid water in mixed-phase clouds b) Particle sizes for ice clouds, mixed-phase clouds and boundary-layer ice crystals c) Additional indications that boundary-layer ice crystals are not "diamond dust" d) Small particles in ice clouds have high depolarization, against expectations

This is the first data set that provides such information on cloud phenomenology in the High Arctic during winter.

There is apparently some confusion as to how we sorted features observed in the measurements into categories, and if we have the opportunity to revise our manuscript for ACP we would make clarifications. Our study of high-resolution measurement images from the AHSRL and MMCR revealed that aerosols and clouds have different characteristic optical properties and physical structure. Figure 3 in our manuscript provides an instructive example. Pattern recognition is difficult to program into a computer, but the different cases are readily identified "by eye" using structural features in time and height, as the figure reveals. We hand-selected as many clear cases as possible, and discounted those that were ambiguous or of mixed type. Cases were chosen using a 1 km deep "mask", and any "cross-talk" into the 1 km deep mask was strictly forbidden in the selection process. The statistics of the optical properties in each category were then derived, and show clear differences. We did not want to presuppose specific optical properties, and indeed the results show that there is overlap between some of the categories.

The revisions will emphasize more the uniqueness and importance of what we have achieved. The results we present are the first on the optical properties of clouds and aerosols during the High Arctic winter. There is a dearth of data in this region despite its importance to climate. Particle sizes and their vertical distribution are of special importance to radiative forcing and climate modeling, and we have provided a summary of our observations in a table that should be of great use in future studies. For example, that the size of boundary-layer ice crystals should be so large was a surprise, and is more evidence that they cannot be due to “diamond dust” as has been the traditional interpretation. The vertical distribution of mixed-phase clouds is also a key result which will have considerable implications for radiative transfer computations. Before this point the vertical distribution was not known. Models of the Arctic climate will need to account for the new understanding of the Arctic winter environment seen in our measurements. We would expect to draw more attention to this table, which will be of considerable interest to the user community, by highlighting it in the Abstract and Introduction,.

Furthermore, we would point out that the combination of the AHSRL and MMCR in the dry Arctic environment during winter provides an unusual opportunity. The AHSRL measures backscatter cross-section using the pressure-broadened spectrum, which is much more direct than for other lidar types. The dryness of the Arctic atmosphere removes an important source of attenuation from the MMCR signal that exists at mid-latitudes and complicates the retrieval. The combined sensitivity of these instruments has allowed us to retrieve the effective radius at high spatial and temporal resolution. This specific combination of instruments and conditions have allowed us to show that ice cloud particle sizes decrease steadily with altitude, and that the small-particle population has high depolarization. This last result was a considerable surprise. It is quite possible that the same thing happens at mid-latitudes, but the measurement is complicated by the moist atmosphere there. The result points toward the need for an aircraft campaign for in-situ of wintertime clouds in the Arctic.

Please also see our responses in the reply to each reviewer’s comments.

Sincerely,

Thomas J. Duck,

On behalf of the Authors

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 7781, 2009.