Dependence of Retrieved Cloud Properties on Environmental Conditions in Cold Air Outbreaks over the North Atlantic: Results from COMBLE

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Cold-air outbreaks (CAOs) occur from the equatorward advection of extremely cold polar air masses across the sea ice boundary to a relatively warmer ocean. These extreme events have a large impact on human health and the latitudinal redistribution of heat. The Cold-air Outbreaks in the Marine Boundary Layer Experiment (COMBLE) conducted between 1 Dec 2019 and 31 May 2020 out of Andenes, Norway utilized instruments from the Department of Energy Atmospheric Radiation Measurement Program's Mobile Facility to quantify the properties of boundary layer (BL) convection, retrieve cloud properties, and measure aerosols in-situ. In this study, COMBLE data are used to quantify how the vertical structure of the boundary layer clouds (i.e., cloud top, and base heights and temperatures, cloud thickness, cloud coverage, and cloud layer maximum radar reflectivity) and their microphysical properties (i.e., cloud liquid and ice water content, cloud liquid and ice effective radius) change depending on whether or not CAOs are present. An index M, which represents the difference in potential temperature between the surface and upper BL, is calculated to describe the intensity of a CAO event. The variation of probability distribution functions of BL cloud properties with M index, according to whether single-layer or multi-layer clouds occurred, and according to the presence of precipitation (no precipitation, virga, or rain) will be presented. Distributions of micropulse lidar linear depolarization ratios in terms of Ka-band radar reflectivity and cloud base temperature are examined to investigate the distribution of cloud phase. To compare the vertical structure of the cloud distributions as a function of height, the retrieved cloud microphysical properties are plotted as a function of normalized height Zn in cloud, where Zn=0 at cloud base and Zn=1 at cloud top, so that the comparison is not affected by different cloud bases or thicknesses. By investigating the vertical distributions of radar reflectivity, BL clouds are found fractionally more important in CAOs than in non-CAOs, with higher clouds occurring more frequently in non-CAOs. Implications for the role of CAOs in ultimately affecting the radiative budget of the Arctic region are discussed.