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Depletion of Black Carbon Mass in the Springtime Arctic Boundary Layer

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Understanding the processes controlling black carbon (BC) in the Arctic boundary layer (ABL) is crucial for evaluating the impact of anthropogenic and natural sources of BC aerosol on Arctic climate. Vertical profiles of BC mass loadings were performed in the ABL over the sea-ice in the Alaskan Arctic in April 2008 using a Single-Particle Soot Photometer (SP2) during flights on the NOAA WP-3D research aircraft. Positive vertical gradients in BC mass mixing ratios were observed in the ABL over the sea-ice, generally in the vicinity of open leads. BC mass loadings more than doubled with increasing altitude within the ABL and across the boundary layer transition while carbon monoxide (CO) remained constant in the aged Arctic air mass. This is evidence for depletion of BC mass in the ABL. BC mass loadings were positively correlated with ozone (O_3) in ozone depletion events for all the observations in the ABL. Since bromine catalytically destroys O_3 in the ABL after being released as molecular bromine in regions of new sea-ice formation at the surface, the BC–O_3 correlation suggests that BC particles were removed by a surface process such as dry deposition. We have developed a box model to estimate the dry deposition flux of BC mass to the snow constrained by the vertical profiles of BC mass in the ABL. Open leads in the sea-ice may increase vertical mixing and entrainment of pollution from the free troposphere possibly enhancing the deposition of BC aerosol to the snow.