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UCRL-CONF-218272

Consequences of the Large-Scale Subsidence Rate on the Stably Stratified Atmospheric Boundary Layer Over the Arctic Ocean, as seen in Large-Eddy Simulations

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January 19, 2006

American Meteorological Society's 17th Symposium on Boundary Layers and Turbulence
San Diego, CA, United States
May 22, 2006 through May 26, 2006

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Abstract for the American Meteorological Society's
17th Symposium on Boundary Layers and Turbulence
Monday, 22 May 2006 - Friday, 26 May 2006
San Diego, CA

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Abstract

The analysis of surface heat fluxes and sounding profiles from SHEBA indicated possible significant effects of subsidence on the structure of stably-stratified ABLs (Mirocha et al. 2005). In this study the influence of the large-scale subsidence rate on the stably stratified atmospheric boundary layer (ABL) over the Arctic Ocean during clear-sky, winter conditions is investigated using a large-eddy simulation model. Simulations are conducted while varying the subsidence rate between 0, 0.001 and 0.002 ms^{-1}, and the resulting quasi-equilibrium ABL structure and evolution are examined. Simulations conducted without subsidence yield ABLs that are deeper, more strongly mixed, and cool much more rapidly than were observed. The addition of a small subsidence rate significantly improves agreement between the simulations and observations regarding the ABL height, potential temperature profiles and bulk heating rates. Subsidence likewise alters the shapes of the surface-layer flux, stress and shear profiles, resulting in increased vertical transport of heat while decreasing vertical momentum transport. A brief discussion of the relevance of these results to parameterization of the stable ABL under subsiding conditions in large-scale numerical weather and climate prediction models is presented.

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.