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The effect of the sea-ice zone on the development of boundary layer roll clouds during cold air outbreaks

A. Liu (1), G.W.K. Moore (1), K. Tsuboki (2), I.A. Renfrew (3)

(1) Department of Physics, University of Toronto, Toronto, Canada, (2) Hydrospheric Atmospheric Research Center, Nagoya University, Nagoya, Japan, (3) School of Environmental Sciences, University of East Anglia, Norwich, U.K.
(moore@atmosp.physics.utoronto.ca / Fax: 416 978 8905 Phone: 416 978 4686)

High latitude air-sea interaction is an important component of the earth's climate system and the exchanges of mass and energy over the sea-ice zone are complicated processes that, at present, are not well understood. In this paper, we perform a series of experiments to examine the effect of sea-ice concentration on the development of high latitude boundary-layer roll clouds. The experiments are performed at sufficiently high spatial resolution to be able to resolve the individual convective roll clouds, and over a large enough domain to be able to examine the rolls downstream development. Therefore allowing for a more realistic representation of the dynamic and thermodynamic processes that are important. Furthermore the high spatial resolution of the experiments allows for an explicit representation of heterogeneity within the sea-ice zone. The results show that the sea-ice zone has a significant impact on the atmospheric boundary layer development, which can be seen in both the evolution of the atmospheric structure and the development of heat and moisture transfer patterns. In particular, we find the air-sea exchange of momentum, moisture and heat fluxes are modified by the presence of the roll vortices (typically a 10% difference in surface heat fluxes between updrafts and downdrafts) and by the concentration and spatial distribution of the sea-ice. This suggests that a more realistic representation of processes over the sea-ice zone is needed to properly calculate the air-sea energy and mass exchange budgets.