Abstract View

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Bulk Transfer Coefficients for Heat and Momentum over Leads and Polynyas

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ABSTRACT

Leads and polynyas are areas of open water surrounded by pack ice. In winter, when the polar oceans have extensive ice covers and the water-air temperature difference is typically 20°–40°C, they allow enormous amounts of sensible and latent heat to escaoe from the ocean to the atmosphere. Parameterizing these fluxes accurately is thus an important part of modeling the growth and decay of sea ice.

To develop a unified method for parameterizing the turbulent transfer from open water surrounded by pack ice, we have reanalyzed data reported in the literature on momentum and heat transfer over Arctic leads and polynyas. The neutral stability value of the 10-m drag coefficient, $C_{DN10} = 1.49\times10^{-1}$, is independent of wind speed and open-water fetch for winds from 1 to 10 m s^{-1} and fetches from 7 to 500 m. That value is slightly higher than values typical of the open ocean at these wind speed probably because of the form drag over the upwind ice or at the ice edges and because the wave field is still actively growing. We parameterize the neutral stability value of the 10-m transfer coefficient for sensible heat, C_{HN10}, with the nondimensional fetch X/L, where X is the over-water fetch and L is the Obukhov length. The C_{HN10} has a maximum value of 1.8×10^{-3} at very small -X/L but decreases rapidly with increasing -X/L to 1.0×10^{-3} -essentially the open ocean value. We find no compelling reason to believe that the bulk transfer coefficient for latent heat is different from C_{HN10}. The approach of C_{HN10} to its open ocean value at relatively short fetches (roughly 200 m) implies that horizontal homogeneity may not be as severe a constraint for evaluating scalar transfer coefficients as it is for some other applications of the flux-gradient relations.

The bulk transfer coeficients actually used in modeling turbulent transfer over leads and polynyas are derivable from our reported C_{DN10} and C_{HN10} values if the atmospheric stability is known. Lastly, we therefore develop a simple formula for estimating L from an easily obtainable bulk Richardson number.

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