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An Analysis of Turbulent and Radiative Flux Gradient Relationships in the Highly Stable Polar Surface Layer

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Flux-profile relationships in the turbulent surface layer are conventionally scaled with Monin-Obukhov similarity theory where, for example, the vertical gradient of potential temperature is proportional to the *surface value* of the turbulent heat flux, Hf, divided by the friction velocity, u*. In stable conditions an additional factor is applied to account for the effects of buoyancy using the dimensionless gradient function Phi_h(z/L) where z is the height above the surface and L is the Obukhov length:

dT/dz=-Hf/(rho cp kappa u* z)*Phi_h(z/L)

Here kappa is 0.4 and (rho*cp) the heat capacity of air. The gradient function has been determined by direct observations in numerous field campaigns. However, for extreme stability limits (z/L>1) the near-surface air temperature gradient is substantial and IR-radiative flux gradients may confuse the interpretation of Hf from observations at typical tower heights. Furthermore, the IR-flux divergence may lead to distortions of the temperature profile very near the surface. In this paper we will present a formulation of the problem derived from the basic heat conservation equation. The importance of the radiative effects will be evaluated with a simple band-integrated transfer model using data from the Surface Heat Budget of the Arctic (SHEBA) program. Radiative flux divergence may explain different behavior of Phi_m and Phi_h observed in the SHEBA data for very stable conditioins.