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New features of turbulent heat transfer in stable and very stable stratification

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Traditionally the turbulent heat transfer in the atmosphere is estimated by analogy with the molecular transfer using the Boussinesq's eddy-conductivity concept. It is assumed that the vertical turbulent flux of potential temperature is proportional to its vertical gradient through the turbulent exchange coefficient for heat. This analogy implies a linear, or at least a direct relationship between the flux and the gradient in question. In the present study we discuss the stability dependence of the vertical potential temperature flux in terms of the Richardson number Ri and the stability parameter z/L, where z is the height and L is the Obukhov length, which follows from the energy- and flux-budget turbulence closure[1]. The latter, based on budget equations for the turbulent kinetic and potential energies and the vertical turbulent fluxes of momentum and buoyancy, allows demonstrate an incomplete adequacy of the eddy-conductivity concept. Particularly, at large Ri or z/L, corresponding to strongly stable stratification, the vertical turbulent flux of potential temperature becomes independent of the vertical temperature gradient, thus making the eddy-conductivity concept inapplicable. The theory is in good agreement with the Surface Heat Budget of the Arctic Ocean (SHEBA) data.

[1]Zilitinkevich S., Elperin T., Kleeorin N., Rogachevskii I., and Esau I., 2011: A hierarchy of energy- and flux-budget (EFB) turbulence closure models for stably stratified geophysical flows, arXiv:1110.4994v1.