Buoyancy driven slope flows – An asymptotic analysis of the Prandtl model

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Steady, buoyancy induced flows on an infinitely extended slope are considered within the conceptual framework of the Prandtl model. For an eddy viscosity increasing linearly near the ground to become constant further up and a unity Prandtl number, a solution is sought as a function of the imposed surface buoyancy b_s, the (constant) Brunt Väisälä frequency N, the roughness height z_s and the parameters of the eddy viscosity model. A small parameter, essentially N^2/b_s times the wall distance where the eddy viscosity changes from linear in z to constant, is identified and analytic asymptotic expansions are developed for both near-wall and outer regions. Matching across an overlap region allows to construct a composite expansion which reveals the structure of the wall jet and the associated buoyancy perturbation. The present asymptotic solution will be compared to data as well as numerical and alternative solutions.