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Velocity-defect laws, log law and logarithmic friction law in the convective atmospheric boundary layer[1] MENGJIE DING, CHENNING TONG, Clemson University — The mean velocity profile (MVP) in the convective atmospheric boundary layer (CBL) is derived analytically employing the shear-stress budget equations and the mean momentum equations. The multi-point Monin–Obukhov similarity (MMO) recently proposed provides the scaling properties of the one-point statistics in these equations. Our previous studies have shown that the CBL is mathematically a singular perturbation problem. Thus, we obtain the MVP using the method of matched asymptotic expansions. Three scaling layers are identified: the outer layer, the inner-outer layer and the inner-inner layer. Two new velocity–defect laws are discovered: the mixed-layer velocity–defect law and the surface-layer velocity–defect law. The local-free-convection MVP is obtained by asymptotically matching the expansions in the first two layers. The log law is obtained by matching in the last two layers. The von Karman constant is obtained using velocity and length scales, and therefore has a physical interpretation. A new friction law, the convective logarithmic friction law, is obtained. The present work provides an analytical derivation of the MVP hypothesized in the Monin–Obukhov similarity theory, and is part of a comprehensive derivation of the MMO scaling from first principles.

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