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On the vertical Bowen ratio profile in the PBL

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We discuss convection in the planetary boundary layer (PBL) in terms of the *convective flux* c=$c_p\overline{\vartheta'\omega'}/g$. This is the vertical sub-gridscale flux of equivalent temperature ϑ=T+Lq/c_p. Latent and sensible heat flux across the earth's surface are assumed known. The profile $c(p)$ in the PBL is gained from the *convection equation* (i.e., the pertinent energy equation); it is driven by the *gridscale budget* with boundary condition $c(p_s)$. Unknown parameter is β, the *Bowen ratio*. To look for an objective specification of the profile $\beta(p)$ in the PBL is the purpose of this paper.

The Bowen ratio adopts the value -1 somewhat below the top of the PBL in those cases in which the sensible heat flux changes sign at the top while the latent heat flux remains upward throughout the PBL. For this realistic setting there must be a *critical pressure level* where both turbulent fluxes become opposite equal so that the convective flux vanishes. The idea is to consider the Bowen ratio at p_{crit} as "measured" and to interpolate between $\beta(p_{crit}) = -1$ and $\beta(p_s)$. There is much freedom in specifying the interpolation; we consider the linear as well as several logarithmic profiles $\beta(p)$. Yet a naive choice of $\beta(p)$ makes the buoyancy flux (the third term in the convection equation) infinite close to p_{crit} because it is proportional to 1/(1+β); this generates a pole of the convection equation. We demonstrate that the pole can be removed by a minute shift of p_{crit}.

The result of this exercise is that any profile $\beta(p)$ through $\beta(p_{crit}) = -1$ and $\beta(p_s)$ can be made consistent with the convection equation. Further, the corresponding $c(p)$ is practically independent upon the specific $\beta(p)$. Thus our simple method is a robust and flexible fit for the Bowen ratio profile across the entire PBL with the available data (gridscale budget plus surface flux plus advance knowledge of how the $\beta(p)$-profile is bended). Implications of the results are discussed.