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Transport-Statistics and Energetics in Stable-Continuous Turbulence

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Continuous turbulence (CT) is the basic condition for relatively simple quantifications in stable stratification, e.g., Monin-Obukhov (MO) theory. From a statistical point of view, CT guarantees spatial and temporal randomness of variables, which is an important basis for quantitative considerations. Also, the entire concept of an exchange (diffusion) coefficient can only be applied under randomness conditions. Thus, there is equivalence of diffusion and random walk (RW), as demonstrated by Einstein in his annum mirabilis 1905.
In stable stratification, the limitation of vertical displacements by surface-distance is supplemented by buoyancy-effects. The latter can be quantified by the energy balance of vertical displacements: Vertical turbulent kinetic energy (VTKE) is transformed to potential energy (PE). This transformation happens in combination with deflection of vertical motion by the random interactions of fluid parcels that also happen in neutrality.
By application of the RW-definition of the diffusion coefficient it is possible to implement the buoyancy-related limitations (energy balance) to the determination of the exchange coefficient, most simply in the stable limit z » L. Determination of the exchange coefficient in its turn automatically yields the profile-constant.
Depending on a dimensionless turbulence parameter (ratio of average-square vertical velocity to squared friction velocity), the most probable approximate value of the profile-constant is 2.9. This value is within the traditional experimental range (2.0 to 12) but clearly below the 'community's' favourite range of 5 to 6. Due to an involved approximation, the value of 2.9 is systematically over-estimated, so that the RW result is not compatible with larger values.

The applied energy-balance formulation necessarily has to reflect the energetic processes. In the usual concept of energetics, shear-produced TKE is absorbed by the buoyancy flux (BF) and -BF acts as source of turbulent potential energy (TPE), which is dissipated by molecular heat-conduction: The BF vanishes from the energy balance (BF - BF = 0)!
This concept is based on volume/time-averages, whereas the RW concept is necessarily based on ensemble-averages. The concept applied in the present study is, therefore, necessarily different in regard to energetics: random-walking air parcels' energetics cannot be described that way. For the individual parcel nothing like the BF exists to deliver TKE to. The buoyancy-forces simply slow down the vertical motion, and VTKE is being transformed to PE due to increasing density-difference to the local average. As the random-walking parcel is a relatively close representation of the real turbulent process, the BF must have its place in the (subsequent) mixing process and cannot vanish from the balance. This distinction makes a significant difference in the energy-balance equation.
A decision on whether the BF vanishes from it requires analysis of the energetic effects of turbulent mixing in density-stratification. Heat-flux-caused BF is very complicated to analyse. The most-simple case of density-stratification is a volume-invariant fluid whose density is increased by a volume-invariant admixture of a dissolved substance. This simple case demonstrates that the BF cannot vanish because turbulent transport of admixture from bottom to top leads to an upward flux of PE whose source can only be $-BF = \partial JPE/\partial z$.
An experimental check of the energetics-concepts is done by comparison to observed TPE at close-to-critical Richardson number (equivalent z » L, limit of CT).
The RW-determined value agrees excellently with atmospheric observations, whereas a volume-concept-determined large-eddy-simulation value is more than double the observed TPE value.