Notations

1. Bulk Richardson Number

The **Bulk Richardson Number** is defined as:

below R_T before KH waves can form. Laboratory and theoretical work have shown that the criterion for KH wave formation is $Ri < R_c$. This leads to the apparent hysteresis, because the Richardson number of nonturbulent flow must be lowered to R_c before turbulence will start, but once turbulent, the turbulence can continue until the Richardson number is raised above R_T.

5.6.3 Bulk Richardson Number

The theoretical work yielding $R_c \cong 0.25$ is based on local measurements of the wind shear and temperature gradient. Meteorologists rarely know the actual local gradients, but can approximate the gradients using observations made at a series of discrete height intervals. If we approximate $\partial\overline{\theta_v}/\partial z$ by $\Delta\overline{\theta_v}/\Delta z$, and approximate $\partial\overline{U}/\partial z$ and $\partial\overline{V}/\partial z$ by $\Delta\overline{U}/\Delta z$ and $\Delta\overline{V}/\Delta z$ respectively, then we can define a new ratio known as the ***bulk Richardson number***, R_B :

$$R_B = \frac{g\ \Delta\overline{\theta_v}\ \Delta z}{\overline{\theta_v}\left[(\Delta\overline{U})^2 + (\Delta\overline{V})^2\right]} \tag{5.6.3}$$

It is this form of the Richardson number that is used most frequently in meteorology, because rawinsonde data and numerical weather forecasts supply wind and temperature measurements at discrete points in space. The sign of the finite differences are defined, for example, by $\Delta\overline{U} = \overline{U}(z_{top}) - \overline{U}(z_{bottom})$.

Unfortunately, the critical value of 0.25 applies only for local gradients, not for finite differences across thick layers. In fact, the thicker the layer is, the more likely we are to average out large gradients that occur within small subregions of the layer of interest. The net result is (1) we introduce uncertainty into our prediction of the occurrence of

In the `.csv` files, it is noted as `R_bulk`.

2. Obukhov ength

The **Obukhov length** is calculated based on:

Each of these terms is now dimensionless. The last term, a dimensionless dissipation rate, will not be pursued further here.

The ***von Karman constant***, k, is a dimensionless number included by tradition. Its importance in the log wind profile in the surface layer is discussed in the next section. Investigators have yet to pin down its precise value, although preliminary experiments suggest that it is between about 0.35 and 0.42. We will use a value of 0.4 in most of this book, although some of the figures adopted from the literature are based on k=0.35.

Term III is usually assigned the symbol, ζ, and is further defined as $\zeta \equiv z/L$, where L is the ***Obukhov length***. Thus,

$$\zeta = \frac{z}{L} = \frac{-k\,z\,g\,(\overline{w'\theta_v'})_s}{\overline{\theta_v}\,u_*^3} \tag{5.7b}$$

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The Obukhov length is given by:

$$L = \frac{-\overline{\theta_v}\,u_*^3}{k\,g\,(\overline{w'\theta_v'})_s} \tag{5.7c}$$

And the L for lower surface of the layer is denoted as `L_low`, and the upper surface is denoted as `L_high`. Note that, the value for `z/L`, is calculated and noted as `Term_3` in the picture above. The lower surface value is denoted as `Term_3_low` and upper surface value is denoted as `Term_3_high`.