Contents

1. Convection Scaling

We know that turbulence is generated by buoyant convection (thermals) and by mechanical processes (wind shear).

- Free convection: when buoyant processes dominate.
- Forced covection: when mechanical processes dominate.

1a. *Forced Convection Scaling*

When talking about stress in previous lectures, we defined the total Reynolds stress as:

$$|\tau_{Reynolds}| = (\tau_{xz}^2 + \tau_{yz}^2)^{1/2} \tag{1}$$

We define a velocity scale called the *friction velocity* u_*:

$$u_*^2 = |\tau_{Reynolds}|/\bar{\rho} = (\overline{u'w'_s}^2 + \overline{v'w'_s}^2)^{1/2} \tag{2}$$

We will also introduce the surface layer temperature scale

$$\theta_*^{SL} = \frac{-\overline{w'\theta'_s}}{u_*} \tag{3}$$

And the surface layer humidity scale

$$q_*^{SL} = \frac{-\overline{w'q'_s}}{u_*} \tag{4}$$

1b. *Free Convection Scaling*

- Length Scale: Because thermals rise until they reach the top of the ML, the thermal size scales to z_i.

- Velocity Scales: We first define the buoyance flux as: $(g/\overline{\theta_v})\overline{w'\theta'_v}$. Although we could use this flux directly, we generally use a velocity scale istead:

$$w_* = \left[\frac{g z_i}{\overline{\theta_v}} (\overline{w'\theta'_v})_s \right]^{1/3} \tag{5}$$

  This velocity scale works well and the magnitude of the vertical velocity is on the same order of magnitude.

- Time scale

$$t_* = \frac{z_i}{w_*} \tag{6}$$

- Temperature scale

$$\theta_*^{ML} = \frac{(\overline{w'\theta'})_s}{w_*} \tag{7}$$

  This scale is on the order of how much warmer thermals are than their environment.

- Humidity scale

$$q_*^{ML} = \frac{(\overline{w'q'})_s}{w_*} \tag{8}$$

  This scale is on the order of how much moister thermals are than their environment.