1/28/21

→ turbulent heat transport in vertical only

$$(\;) = (\overline{\;}) + (\;)'$$

actual measurement used - avg over min?

correlation

$$\underbrace{(kg\,m^{-3})(m^2 s^{-2} K^{-1})}\,K \qquad \frac{\partial}{\partial t}\Big(\underbrace{\rho\, c_p \overline{T}}_{\text{energy/vol.}}\Big) = -\frac{\partial}{\partial z}\Big(\rho\, c_p \overbrace{\overline{T'w'}}^{\text{correlation}}\Big)$$

$$(\underbrace{kg\, m^2 s^{-2}}_{\text{energy}})\, m^{-3}$$

parameterization - difficult to calculate $\overline{T'w'}$

bulk aerodynamic method

surface T

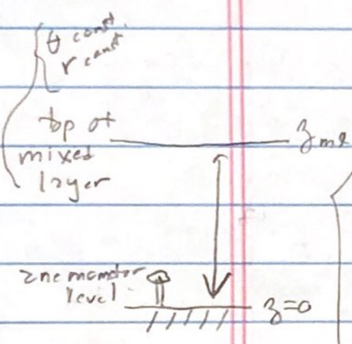
T at anemometer level

$$\rho\, c_p \overline{T'w'}\Big|_{\text{"anemometer level" } \sim 10m} = \rho\, c_p \left[C_H\, U_0 \left(T_s - T_0 \right) \right]$$

empirical drag coefficient

wind speed at anemometer level

$$\rho\, c_p \overline{T'w'}\Big|_{\text{top of mixed layer}} = 0$$



flux convergence in layer $\quad \frac{\partial}{\partial t}\left(\rho\, c_p \overline{T}\right) = \frac{\rho\, c_p \left[C_H U_0 (T_s - T_0)\right] - 0}{z_{me} - 0}$

hydrostatic eqn. $\quad z_{me} = \Delta z = \frac{-\Delta p}{\rho g} = \frac{-\overbrace{(p_{me} - p_s)}^{<0}}{\overline{\rho}\, g}$

$$\Rightarrow \frac{\partial \overline{T}}{\partial t} = \frac{\rho g\, C_H\, U_0 \left(T_s - T_0\right)}{|\Delta p|}$$

$C_H = 1.25 \times 10^{-3}$ experimentally determined

actually is ~~not~~ a constant

varies w/ $|\vec{V}|$

"back of envelope"

estimate!

→ suppose $-2°C$ air flows over $18°C$ water

cold continental air over Gulf Stream

in lowest 200 hPa (mixed-layer depth)

$$\frac{\partial T}{\partial t} = \frac{\overbrace{(1\,\cancel{kg}\,m^{-3})}^{\text{density of air}}\overbrace{(10\,\cancel{m}\,s^{-2})}^{g}\overbrace{(1.25\times10^{-3})}^{C_H}\overbrace{(10\,m\,s^{-1})}^{U_0}\overbrace{(20\,K)}^{\Delta T}}{(20\,k\cancel{Pa})(10^3\,\cancel{kg}\,m\,\cancel{s^{-2}}\,m^{-2})(k\cancel{Pa}^{-1})}$$

$p = \rho RT$

$$\rho = \frac{p}{RT} \sim \frac{100\,k\cancel{Pa} \times (10^3\,kg\,m\,s^{-2}\,m^{-2})\,k\cancel{Pa}^{-1}}{(300\,m^2 s^{-2}\,\cancel{K^{-1}})(300\,\cancel{K})}$$

$$\frac{10^5}{9\times10^4} \sim \frac{10^5}{10^5} = 1\ kg\,m^{-3}$$

$$\frac{\partial T}{\partial t} \sim \frac{10 \times 10^{-3} \times 10 \times \cancel{20}}{\cancel{20} \times 10^3}\ K\,s^{-1}$$

$$= 10^{-4}\ K\,s^{-1}$$

$1\ day = 86400\,s \sim 10^5\,s$

$$= (10^{-4}\,K\,s^{-1})\frac{10^5\,s}{1\ day} = \boxed{10\,K\ day^{-1}}$$