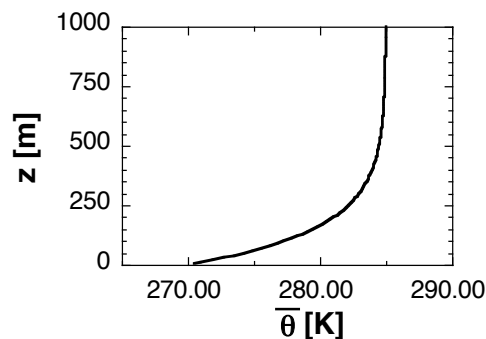


Returning to this problem:



In the apple orchards of central Washington, some farmers have large fans (actually propellers) deployed in their fields to inhibit frost formation. Frost is typically a threat on clear nights with little or no wind, and the surface and air just above it cool due to radiation to space. The figure shows a profile of potential temperature  $\bar{\theta}(z)$  for such a situation.



When turned on, the fans create turbulence, which affects the mixing coefficients  $K_m$  and  $K_h$ . Suppose the average eddy size (or mixing length) with the fans off is 10 cm, but with the fans on it is larger.

**Challenge:** How big should we make the propeller so that enough warm (high potential temperature) air is pulled downward by PBL turbulence to counterbalance the radiative cooling?

**Further Assumptions:**

- (1) Radiative cooling is 1 K/hour at every level in the lowest 100 m.
- (2) Vertical turbulent heat flux  $\overline{(w'\theta')}$  = 0 at surface.
- (3) Horizontal wind speed is 1 m/s at 100 m and 0 m/s at the surface.
- (4) Mixing length is essentially the diameter of the spinning propeller.

(a) Using your  $\overline{(w'\theta')}$  from the previous problem set, and estimating  $d\bar{\theta}/dz$  from the figure, what must be the value of  $K_h$  to give the needed  $\overline{(w'\theta')}$ ?

(b) Using the vertical shear of the wind speed in assumption (3), the mixing length hypothesis, and assumption (4), what is the diameter of the propeller?