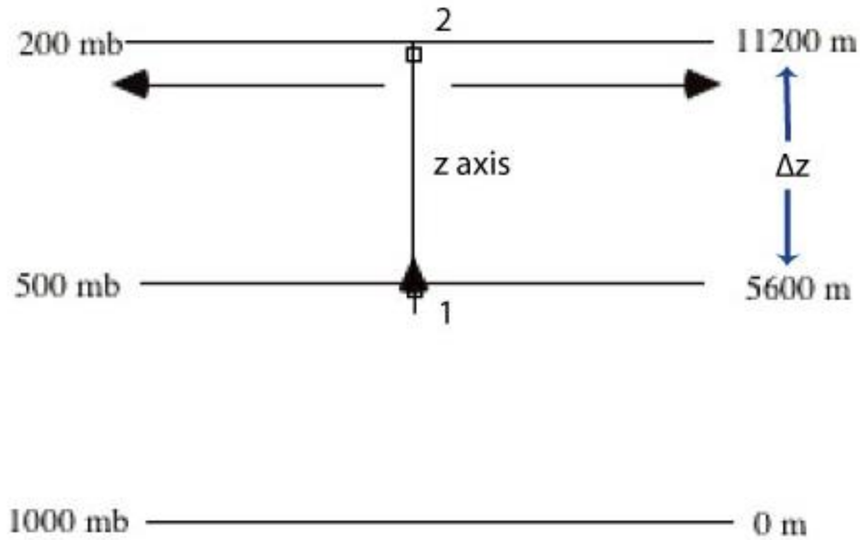
San Francisco State University Name ________________________
Department of Earth & Climate Sciences Spring 2018

# ERTH 260--Inclass Exercise #13: Dine's Compensation and Forced Lofting (100 points)

On a given day, the horizontal divergence in the layer from 500 mb to the Tropopause at 200 mb is calculated to be $1.5 \times 10^{-5}$ $sec^{-1}$ You are asked to compute the vertical motion that would occur at 500 mb (in cm $s^{-1}$) in "compensation" to this divergence. An important (helpful) constraint is that vertical motion is always zero at the tropopause and at the ground.




Drawing to help you conceptualize what is going on.

$$(DIV_h)_{UpperTrop} = -\left( {w_2 - w_1}/{\Delta z} \right) \qquad (1)$$

Master Equation expressing Dine's Compensation

1. Multiply both sides of equation (1) by Δz to get Equation (2).

$$-(w_2 - w_1) = DIV_h \; \Delta z \qquad (2)$$

2. Solve Equation (2) for the vertical motion at level 1, $w_1$ to get Equation (3)

$$w_1 = DIV_h \Delta z + w_2 \qquad (3)$$

3. Substitute the finite difference equivalent $\Delta z = z_2 - z_1$ to get Equation (4).

$$w_1 = DIV_h (z_2 - z_1) + w_2 \qquad (4)$$

4. Insert the constraints of the problem:

   $w_2 = 0$, $z_2 = 11200$ m, $z_1 = 5600$ m, and $DIV_h = 1.5 \times 10^{-5}\ sec^{-1}$ to obtain $w_1$, which is really w at the 500 mb level, the Level of Non-Divergence

5. $\Delta z = 11200$ m - 5600 m = 5600 m

   so

   $w_1 = 1.5 \times 10^{-5}\ s^{-1} \times 5600\ m = 8.4\ cm\ s^{-1}$

Check conceivability of answer: The answer says that the upper tropospheric divergence in this case is associated with forced lofting at the 500 mb level, which makes conceptual sense.