

## SIO 217B Atmospheric and Climate Sciences II

### Exercise #14

1. Download the files containing  $T_{700}$ ,  $u_{700}$ , and  $v_{700}$  for 1993 March 14 00Z. Calculate horizontal temperature advection in units of  $^{\circ}\text{C day}^{-1}$  (as in Exercise #6). Plot contours of temperature overlaid by wind vectors in the domain  $20\text{-}50^{\circ}\text{N}$ ,  $270\text{-}310^{\circ}\text{E}$  using intervals of  $4^{\circ}\text{C}$ . Add contours of horizontal temperature advection using intervals of  $25^{\circ}\text{C day}^{-1}$ .
2. a) Write down an equation for calculating vertical temperature advection from pressure vertical velocity, temperature, and any other relevant parameters (hint: thermodynamic equation in pressure coordinates with zero diabatic heating).  
b) Download the files containing  $T_{775}$ ,  $T_{600}$ , and  $\omega_{700}$  for 1993 March 14 00Z. Calculate vertical temperature advection assuming that temperature varies linearly with pressure between the 775 hPa and 600 hPa levels and that pressure vertical velocity and density between 775 hPa and 600 hPa are the same as  $\omega_{700}$  and  $\rho_{700}$ . Plot contours of pressure vertical velocity overlaid by wind vectors in the domain  $20\text{-}50^{\circ}\text{N}$ ,  $270\text{-}310^{\circ}\text{E}$  using intervals of  $25\text{ hPa hr}^{-1}$ . Add contours of vertical temperature advection using intervals of  $25^{\circ}\text{C day}^{-1}$ .  
c) Note that vertical temperature advection is negative where the air is moving upward ( $\omega < 0$ ). Why does upward moving air produce cold advection even though the air is warmer near the surface than it is higher up?
3. a) Write down an equation for calculating vertical temperature advection from potential temperature and vertical velocity in height coordinates.  
b) Calculate the average temperature and thickness between the 775 hPa and 600 hPa levels (as in Exercise #11), the potential temperature at the 775 hPa and 600 hPa levels, and vertical velocity in height coordinates at the 700 hPa level (as in Exercise #13). Assuming that potential temperature varies linearly with height between the 775 hPa and 600 hPa levels and that vertical velocity between 775 hPa and 600 hPa is the same as  $w_{700}$ , calculate vertical temperature advection. Plot contours of vertical velocity overlaid by wind vectors in the domain  $20\text{-}50^{\circ}\text{N}$ ,  $270\text{-}310^{\circ}\text{E}$  using intervals of  $5\text{ cm s}^{-1}$ . Add contours of vertical temperature advection using intervals of  $25^{\circ}\text{C day}^{-1}$ . The two methods of calculating vertical temperature advection should produce very similar results.
4. Add horizontal temperature advection to vertical temperature advection to obtain total temperature advection. Plot contours of total temperature advection in the domain  $20\text{-}50^{\circ}\text{N}$ ,  $270\text{-}310^{\circ}\text{E}$  using intervals of  $25^{\circ}\text{C day}^{-1}$ . Note how there is a large degree of cancelation between horizontal temperature advection and vertical temperature advection.
5. Download the files containing  $T_{700}$  for 1993 March 13 18Z and March 14 06Z. Calculate the average local rate of temperature change (Eulerian frame of reference) between these two times (as in Exercise #6). Plot the results in the domain  $20\text{-}50^{\circ}\text{N}$ ,  $270\text{-}310^{\circ}\text{E}$  using intervals

of  $10\text{ }^{\circ}\text{C day}^{-1}$ . Note that the regions with the greatest local rate of temperature change generally coincide with the regions where total temperature advection is strongest.