

SIO 217B Atmospheric and Climate Sciences II

Exercise #6

1. Meteorological data are frequently provided on pressure surfaces (e.g., the spatial distribution of winds and temperature at the level in the atmosphere where pressure is 850 hPa). In situations where the pressure surface goes below sea level (such as 1000-hPa surface in Exercise #2), winds and temperature are extrapolated (similar to how surface pressure is converted to sea level pressure). Download the files containing T_{1000} , u_{1000} , and v_{1000} for 1993 March 14 00Z. Plot contours of temperature overlaid by wind vectors in the domain 20-50°N, 270-310°E using intervals of 4°C. Note that the distribution of 1000-hPa wind is (not surprisingly) similar to that for 10-m wind.
2.
 - a) Write down an equation for calculating horizontal temperature advection from zonal and meridional wind components and the temperature gradient in spherical coordinates.
 - b) Using a centered finite difference method, calculate horizontal temperature advection in units of °C day⁻¹. Plot contours of temperature advection in the domain 20-50°N, 270-310°E using intervals of 10 °C day⁻¹. If possible, add wind vectors and temperature contours to the plot using different colors. Make sure the sign of advection matches whether the wind vectors cross from warm to cold or from cold to warm.
 - c) Why is temperature advection strongest where winds are strong, where temperature contours are closely spaced, and where wind is most perpendicular to temperature contours?
3.
 - a) Download the files containing T_{1000} for 1993 March 13 18Z and March 14 06Z. Write down an equation for calculating the average local rate of temperature change (Eulerian frame of reference) between these two times.
 - b) Calculate the rate in units of °C day⁻¹, and plot the results in the domain 20-50°N, 270-310°E. Note that the regions with the greatest local rate of temperature change coincide with the regions where temperature advection is strongest.
4.
 - a) Write down an equation for calculating the rate of temperature change experienced by air parcels as they move around in the Lagrangian frame of reference, assuming that vertical temperature advection is zero.
 - b) Apply this equation to the data obtained above, and plot the results in the domain 20-50°N, 270-310°E. Each location in the plot will show the rate of temperature change experienced by the air parcel that happens to be at that location at 1993 March 14 00Z. The areas of large rate of temperature change along the east coast of the U.S. probably result from a mismatch between advection calculated at a single point in time and the local rate of temperature change calculated over a 12-hour period.
5.
 - a) Careful examination of the plots (it may be necessary to change contour intervals) indicates that the interior of the eastern U.S. experiences cooling in both the Eulerian and Lagrangian frames of reference. What do you think is causing this cooling, seeing that

advection is insufficient to explain it? (Hint: consider the local times of the beginning and end of the 12-hour period.)

b) It is also interesting to note that there is negligible local cooling over the Gulf of Mexico despite the occurrence of cold advection. What do you think is causing the warming of air parcels (in the Lagrangian frame of reference) over the Gulf of Mexico?