San Francisco State University Spring 2017
Department of Earth & Climate Sciences

ERTH 260: Physical Processes in the Atmosphere

Inclass Exercise 10 Key: **Estimating the Temperature Change Due to Advection (100 pts)** Due Friday 26 March 2017

For this exercise, you will need to estimate the contribution to the local change in temperature that advection would make. In this exercise you will learn how to do that, but also will make a 1 hour "forecast" of the temperature at San Francisco in which advection was the only factor.

The simplified temperature tendency equation is

$$(\Delta T/\Delta t)_{local} = (\Delta T/\Delta t)_{all\ air\ parcels} - V\,\Delta T/\Delta s \qquad (1)$$

Term 1	Term 2	Term 3
Local Temperature Change	Individual Temperature Change	Horizontal Temperature Advection (Change)

Term 3, the temperature change due to advection, is simply called "temperature advection." A term of that form, namely, the product of a wind speed with the gradient of something such as temperature, or density, or pressure, or dew point temperature etc., is always called the "advection term".

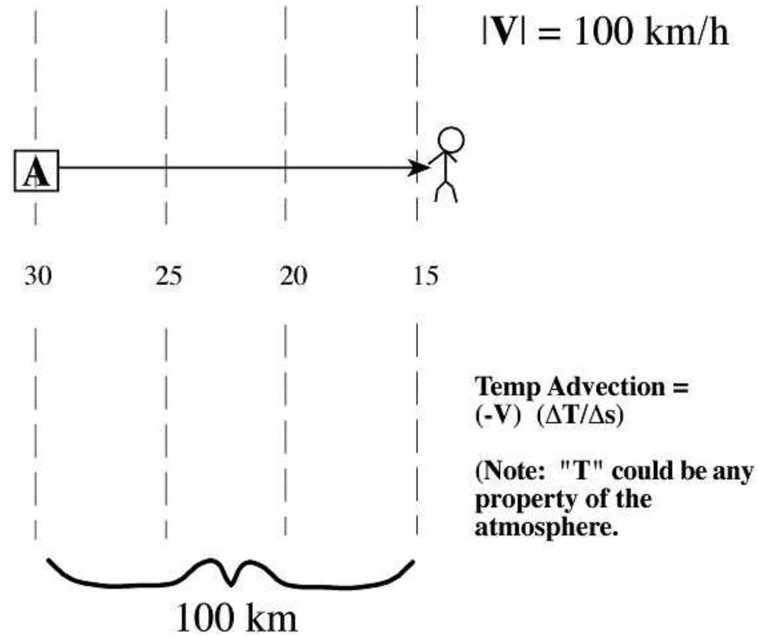
The property or variable being advected modifies the term "advection", as in "density advection", etc. Temperature advection alone can account for warming temperatures (warm temperature advection) or chilling temperatures (cold advection) at a weather station.

1. For short time frames of an hour or so or less the temperature changes experienced by individual parcels is very small or negligible. Rewrite Equation (1) with this simplification. (10 pts)

$$(\Delta T/\Delta t)_{local} = -V\,\Delta T/\Delta s \qquad (2)$$

2. The term $\Delta T/\Delta s$ can be approximated by a finite difference expression (discussed earlier in the semester).

$$\frac{\Delta T}{\Delta s} = \frac{T_2 - T_1}{Distance} \qquad (3)$$



Air Parcel is at Location 1 and the weather station observer is at Location 2.

Fig. 1*: Chart showing the portion of a streamline segment that is used to calculate the contribution of the temperature advection to the temperature change at the observer's location. Dashed lines are isotherms labeled in Centigrade.*

Assume the observer is at San Francisco. The wind is shown as a vector, with the air parcel at A shown moving towards the observer. The distance is 100 km between Location 1 (location of air parcel) and Location 2 (San Francisco) and the wind speed is 100 km/h. Using Equations (2) and (3) for the situation shown in Fig 1, compute the temperature change due to advection at the end of the hour period considered, assuming a (ridiculous) wind speed of 100 km/h. Show all work and steps. (40 pts)

First, evaluate Equation (3) for the case shown in Fig. 1.

Location 2: T = 15 C
Location 1: T = 30C
Δs = 100 km

$$\frac{\Delta T}{\Delta s} = \frac{T_2 - T_1}{Distance} = \frac{15C - 30C}{100\ km} = \frac{-15C}{100\ km}$$

Second, insert all values into equation (2)

$-V\ \Delta T/\Delta s = -\ (100\ km/h)([-15\ ^oC]/100\ km)$
$-V\ \Delta T/\Delta s = 15\ ^oC/hr$

3. Using Fig 1, write a simple "rule" for visualizing the impact of the temperature advection on the temperature change at a weather station on a weather map. (Example: if air moves across the isotherms from lowered value isotherms to higher value isotherms, I expect there to be (cold/warm) (choose one based upon the example here) temperature advection. (10 pts)

When air flows from areas of warm temperature to lower temperature, there is warm advection. When air flows from areas of cold temperature to warm temperature, there is cold advection.

Or

When streamlines extend from higher valued isotherms to lower valued isotherms there is warm advection and vice versa.

4. A common chart used by meteorologists assessing the synoptic situation is the a map of surface isobars overlain with 1000-500 mb thickness contours. Since the hypsometric relation proves that the thickness contours mimic the mean temperature of the air column between 1000 mb and 500 mb, the thickness contours really can be regarded as isotherms, even if they are not labeled as such. (10 pts)

   Here's an example of such a chart.

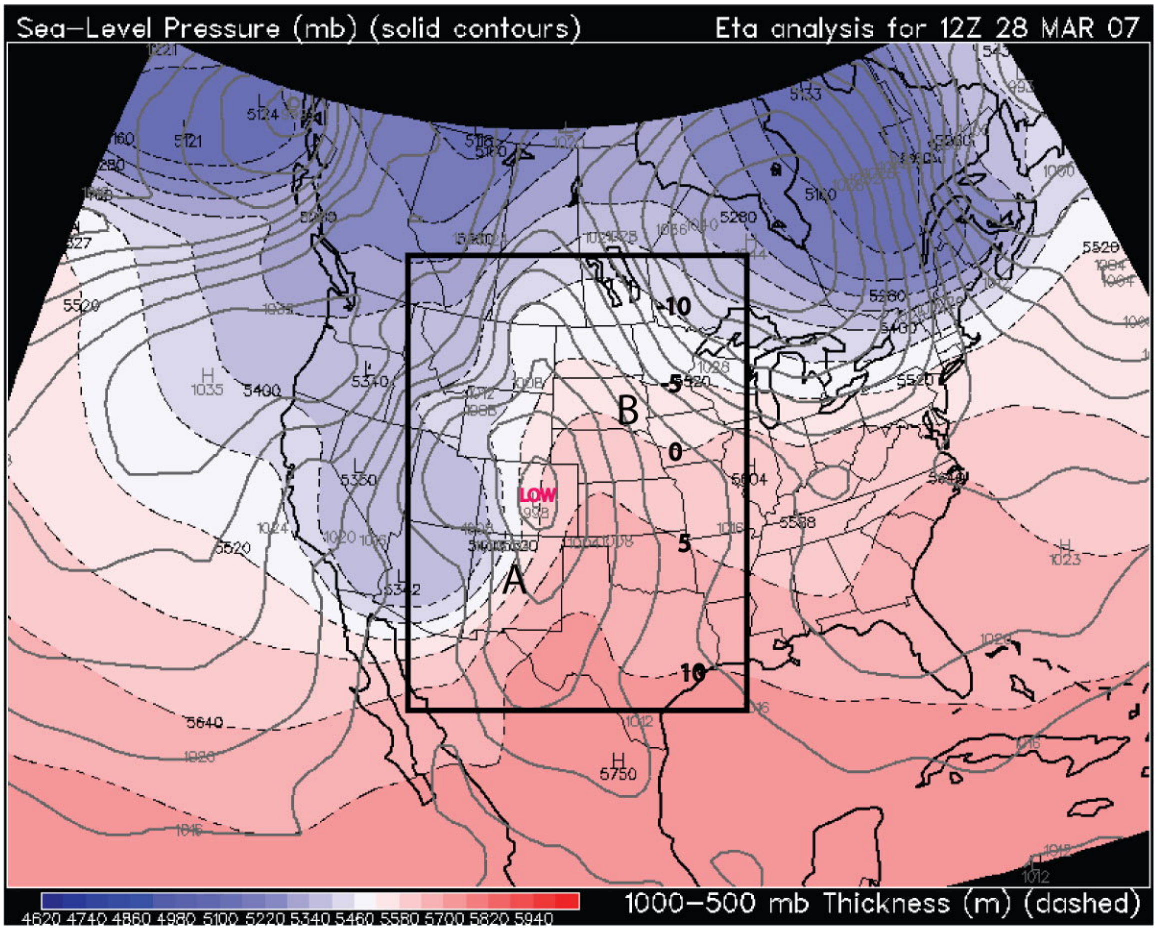
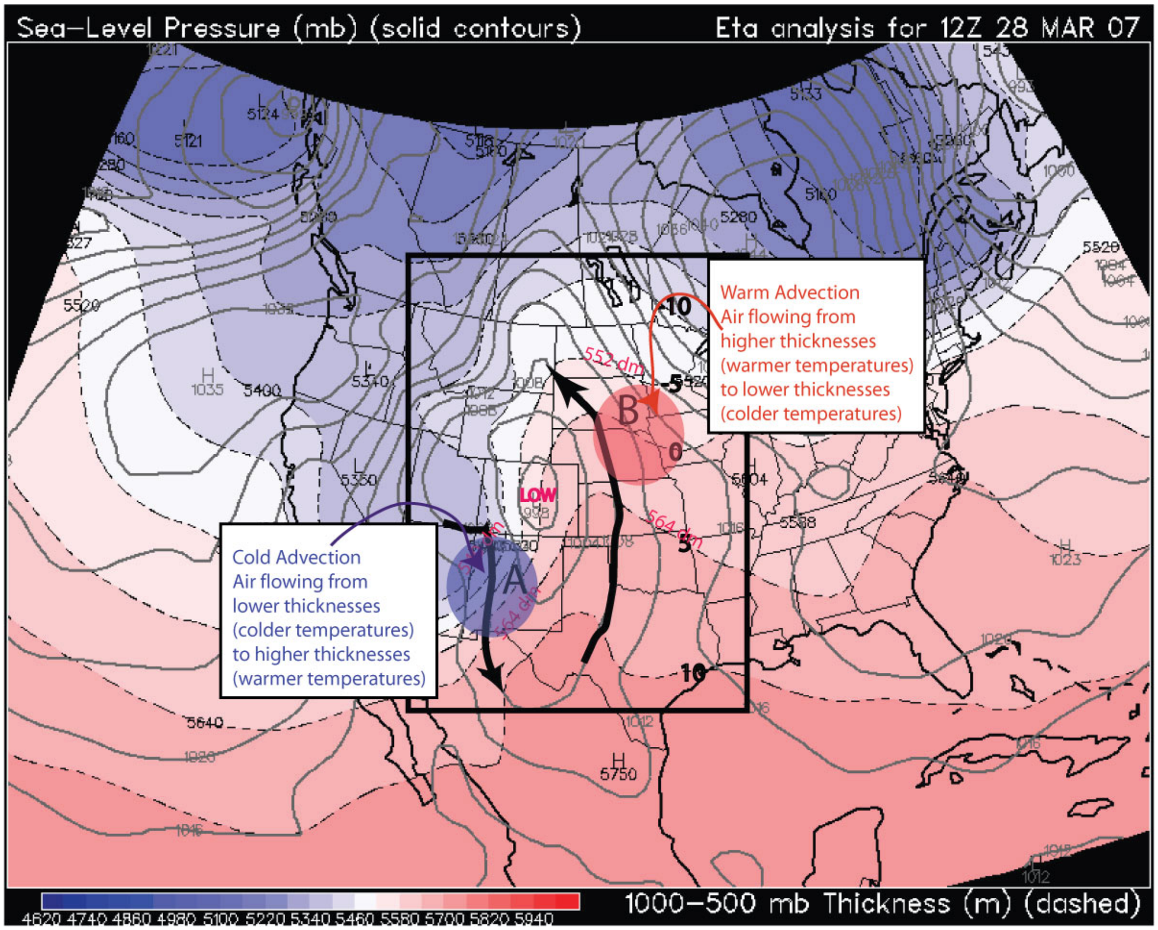


Figure 2: Surface weather map with 1000-500 mb thickness contours in dashed (decameters). In the domain highlighted (the box), the hysometric relation was solved and the contours relabled with the obtained mean virtual temperature.

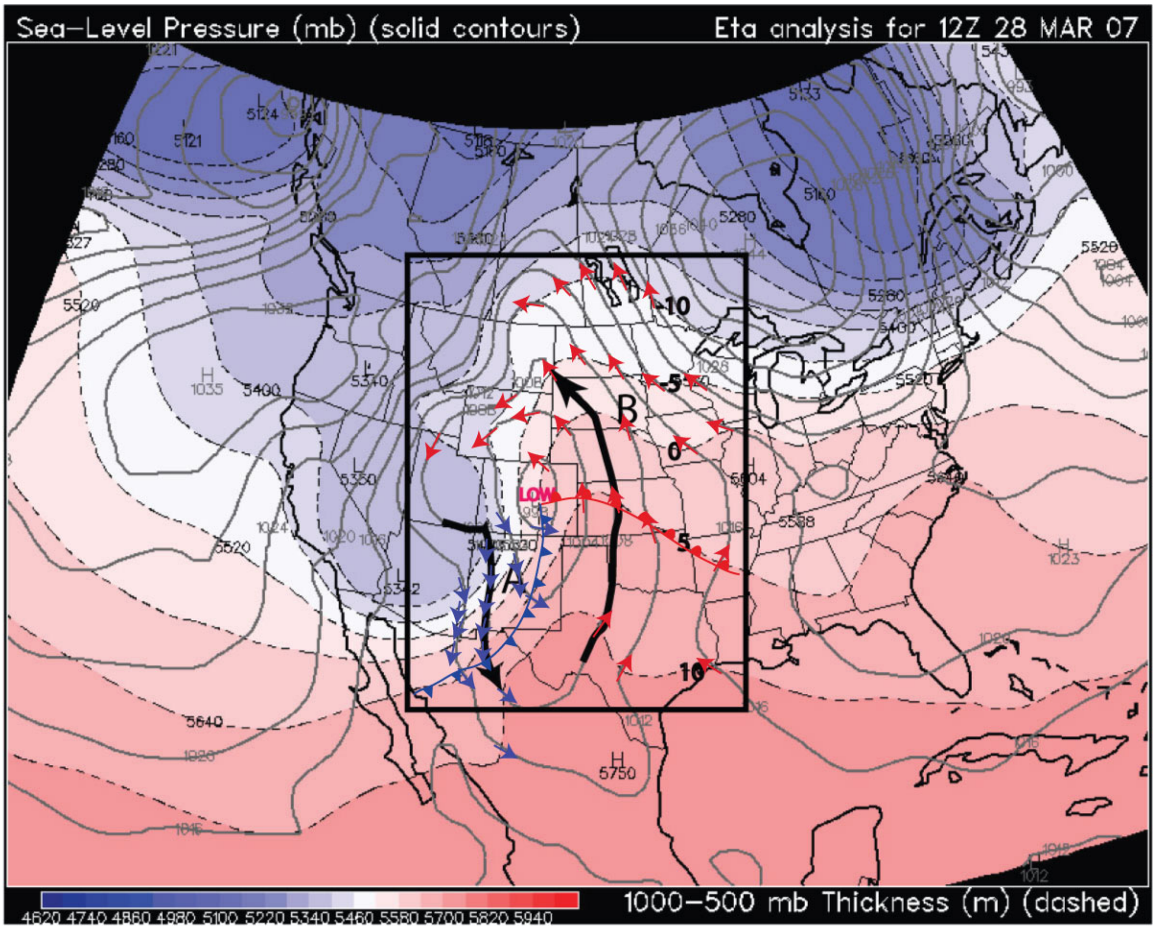
Assess the nature (sign) of the (thickness) temperature advection at A and B by stating warm or cold advection is occurring at the locations. To do this, make the assumption that the air is flowing PARALLEL to the isobars, counterclockwise around the (wave) cyclone in central Colorado on Fig. 2.

A ____Cold Advection

B ____Warm Advection



5. On the same map, plot a short blue arrow at every intersection of streamline and (thickness) temperature contour in cold advection areas tangent to the streamline and a red arrow for every intersection in warm advection areas tangent to the streamline. (30 pts)



Sea-Level Pressure (mb) (solid contours)
Eta analysis for 12Z 28 MAR 07
1000-500 mb Thickness (m) (dashed)
A
B
LOW
-10
-5
0
5
10