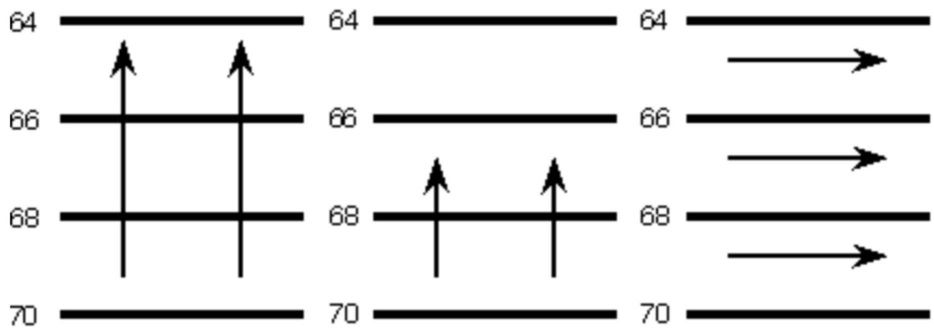
Department of Earth & Climate Sciences Name ______________________________
San Francisco State University Fall 2015

ERTH 465 Key
Quiz 2 – 50 pts

1. Examine the Figures A, B, and C below. The arrows represent horizontal wind vectors and the solid lines are isotherms.



(a) Which figure shows a case of zero temperature advection and why? (5 pts)

Temperature advection is the dot product of the wind with the temperature gradient. For there to be temperature advection, there must be a component of the wind at right angles to the temperature gradient. In Figure C, though there is a temperature gradient, the wind is flowing parallel to the gradient, and so there is no temperature advection.

(b) Which figure shows the maximum temperature advection of the three figures shown and why? (5 pts)

Since the wind vectors are at right angles to the isotherms in Figures A and B, there is temperature advection implied in both of them. But since the temperature gradient is the same in both, the magnitude of the advection would be controlled by the magnitude of the wind. Since the wind speed is greater in Figure A, the maximum temperature advection implied by the three figures would be that shown in Figure A.

(c) What is the nature of the temperature advection shown by Figure B and why? (warm or cold). (5 pts)

The air is flowing from higher valued (warmer) isotherms to lower valued (colder) isotherms. Hence, this is a case of warm advection.

2. Explain why there is no (or little) temperature advection associated with warm core lows (like hurricanes). (5 pts)

Warm core lows have the warmest temperatures at their centers, and the thickness contours are tangent to isobars. This means that the mean isotherms (and isotherms) are tangent to isobars as well. Assuming geostrophic flow, the wind is flowing parallel to isotherms. Also, advection is the product of a wind speed and a gradient along the streamline. There is no temperature gradient along a streamline in the case of warm core lows.

3. The simplified temperature tendency equation is:

$$\partial T/\partial t = dT/dt \; - \; u\, \partial T/\partial x - v\, \partial T/\partial y - w\, \partial T/\partial z$$

Say that (i) the air parcels themselves are experiencing no temperature changes, (ii) at the ground there is no vertical wind, and (iii) there is north-south component ot the wind.

(a) Simplify the equation above by considering the constraints of the problem. (5 pts)

Since the air parcels themselves are not experiencing temperature changes, the Lagrangian derivative is zero. Since there is neither a vertical wind component, w, nor a wind along the y-axis then there is no south wind component, or v=o. Hence, the equation is simplified as follows:

$$\partial T/\partial t = -\, u\, \partial T/\partial x$$

(b) Say that for the conditions described, the temperature on a weather map **increases** 5°C per 100 km (100 km = 1.0 X 10^5 m) distance towards the east. Say also that there is a purely **east*** wind of 20 m s^{-1}.

*Meaning the way a meteorologist indicates a wind direction—an east wind.

What is the local temperature change at the station due to this temperature advection? Your answer should be in ^{o}C/hr. Show all steps. (25 pts)

$\partial T/\partial x$ is 5^{o}C/100 km. The gradient will be positive since the temperatures are higher towards the east.

u = - 20 m s^{-1} since the wind is an east wind (moving from east to west, or in the negative direction on the x-axis).

Substitute all these in into the equation in (a) above.

$\partial T/\partial t = -(-20\ m\ s^{-1})\ (5^{o}C/1.0 \times 10^{5}\ m)$
$\partial T/\partial t = (0.001^{o}C\ s^{-1}) \times (3600\ sec\ h^{-1}) = 3.6^{o}C\ h^{-1}$

Conceptually, this answer is physically realistic since there are east winds blowing from warmer isotherms to cooler isotherms. So we should expect warm advection increasing the temperatures locally, given the constraints of the problem