Geography 304
Midterm
Questions and Answers

1. Identify five factors that must be considered when preparing a surface temperature forecast. Explain why each of these factors is important.
    - Refer to the handout on forecasting temperatures for the answers to this question

2. Atmospheric data from vertical profiles can be analyzed at different levels in the atmosphere. Choose three levels and describe the atmospheric properties commonly analyzed at these levels. Discuss why these atmospheric properties are important in the analysis of the weather events.
    - 250 hPa – height of the 250 hPa pressure surface, winds, jet stream, jet streak, convergence and divergence areas, position of long-wave patterns, large-scale storm tracks, streamlines; description of the overall large scale flow highlighting the longwave pattern that ultimately dictates the movement of weather systems, identification of jet streaks and associated convergence and divergence areas that will assist with the analysis and development of surface weather systems; position of jet streaks suggests the future development of troughs and ridges
    - 500 hPa – height of the 500 hPa pressure surface, winds, vorticity, thickness; identify short-wave troughs and ridges that are directly related to surface weather systems; analysis of vorticity and thickness advection that describe vertical motion and hence potential development on atmospheric circulations; steering storm tracks; level of non-divergence
    - 700 hPa – height of the 700 hPa pressure surface, winds, temperature, moisture; identify upper level frontal structure; identify availability of mid-level moisture; temperature advection
    - 850 hPa – height of the 850 hPa pressure surface, winds, temperature; freezing level; upper level frontal structure; temperature advection
    - surface – sea level pressure field, winds, temperatures, clouds and weather; identification of surface cyclones and anticyclones, fronts; analysis of cyclonic development, tracking of weather system motion; identification of associated clouds and weather with system;

3. Identify and explain two circulation patterns that would lead to the development of a surface high pressure system in the Northern Hemisphere.
    - The descending motion in the area where the Hadley Cell and Ferrel Cell meet at approximately 30 degrees creates high pressure systems at the surface.
    - An area of diffluent flow at the surface supported by convergence aloft will create a high pressure system at the surface. Cold air advection would enhance this process.

4. Explain the importance of each term in the equation given below. Explain the relationship that the equation describes. Explain where you expect to find a jet stream based on this equation.

$$\frac{\Delta U_g}{\Delta z} = \frac{-|g|}{T_v f_c} \cdot \frac{\Delta T_v}{\Delta y} \quad \frac{\Delta V_g}{\Delta z} = \frac{|g|}{T_v f_c} \cdot \frac{\Delta T_v}{\Delta x}$$

- Term 1 is the vertical wind shear that describes the change in geostrophic wind speed with height
- Term 2 is a constant for any given location describing the influence of the average temperature and Coriolis force versus gravity
- Term 3 is the horizontal temperature gradient in the "y-direction"
- This equation describes the relationship between the vertical wind shear and the horizontal temperature gradient
- The jet stream will be associated with a baroclinic zone or an area where there is a well defined temperature gradient

5. Identify the three different types of jet streams. Describe how these three jet streams are different. Why is one of these jet streams more important than the other two in the dynamics of mid-latitude weather systems?
   - Subtropical jet, Polar jet, and low level jet
   - The Polar jet meanders significantly N/S over mid-latitudes whereas the subtropical jet is fairly constant in direction; the subtropical jet moves N/S with the seasons; the Polar jet forms the storm track for mid-latitude weather patterns thus transporting energy and moisture through this system of ridges and troughs; the subtropical jet and related circulation is solely responsible for the transport of energy and moisture N/S from the equator
   - The low level jet is of course the only one that is not an upper air feature; develops as a result of boundary-layer dynamics; responsible transporting energy and moisture into developing cyclones in the mid-latitudes
   - The Polar jet is the most important of the three for mid-latitude weather systems since it is the storm track with associated jet streaks, short-wave troughs and ridges. The meandering nature of the this jet stream with its associated jet streaks will provide the necessary upper level divergence and/or convergence to support the development of surface weather systems.

6. Explain why short waves move through the long wave atmospheric flow pattern.

$$C_0 = U - C = -\frac{\beta L^2}{4\pi^2} \quad L = 2\pi\sqrt{\frac{(U-C)}{\beta}}$$

In these equations *C, U,* and *L* are the wave speed, wind speed and wavelength respectively.

- **Stationary waves**:
  set C = 0 giving and wavelength

in mid-latitudes $\beta \sim 10^{-11}$ and typical zonal wind speed U = 10 m/s the wavelength $L \sim$ 6000 km

- **Migratory waves**:

  If the wave is moving with speed C_0 then C (wave speed relative to the ground) is either positive or negative. When C is positive, the wave "progresses" from west to east. C_0 is small compared to U, hence L is small;

  If C is negative then C_0 is large compared with U and L is long. This implies that short waves are progressive and long waves are retrogressive

7. Does the thickness of a layer in the atmosphere change when the average temperature of that layer changes? Explain. What atmospheric process does the equation below refer to? How does the surface pressure change in response to this process?

$$z_2 - z_1 = \frac{R_d}{g}\overline{T}\ln\frac{p_1}{p_2}$$

   - Yes, the hypsometric equation describes that as the average temperature between the two pressure levels increases the actual distances between the two surfaces (the z's) increases to compensate for this temperature increase.
   - The process refers to temperature advection.
   - Warm air advection cause the atmospheric thickness to increase, density decreases hence surface pressure falls; reverse for cold advection

8. Two vertical columns of air are situated next to one another. One column is warmed. Explain the changes in thickness of the columns. What type of flow develops as a result of one column being warmer than the other?
   - The column being warming increases in thickness and causes pressures to decrease in the lower part of the atmosphere
   - The vertical pressure difference between columns causes the air to flow from the warmer column this moves mass away from the warmer column
   - Increase in mass of the original column causes pressures to rise in the lower levels
   - The pressure difference between columns in the lowest layers causes a flow to develop from the original column to the heated column.
   - A direct circulation results as air moves from cooler to warmer air at the lower levels and from the heated column to the original column aloft.

9. What do the two terms on the right of the equation given below represent? What terms are missing from this equation? Why are the two terms on the right side of the equation important? What is the relationship between these two components and vertical motion?

$$\left(\nabla_p^2 + \frac{f_0^2}{\sigma}\frac{\partial^2}{\partial p^2}\right)\omega = -\frac{f_0}{\sigma}\frac{\partial}{\partial p}\left[-v_g \bullet \nabla_p\left(\varsigma_r + f\right)\right] + \frac{R}{\sigma p}\left[-\nabla_p^2\left(-v_g \bullet \nabla_p T\right)\right]$$

- The first term on the right represents the change in vorticity advection with height
- The differential friction and diabatic heating terms are missing.
- The second term on the right represents the change in thickness (temperature) advection with height
- These two terms describe the affect of vorticity and thickness advection on vertical motion hence important in the development of weather systems. Use this equation with care since vorticity and thickness advection can work against one another hence no development occurs. Cold advection will cancel the effects of positive vorticity advection!

Forcing Function	Typical Cause	Vertical Motion
Term I – differential vorticity advection		
> 0	(downstream of) strong cyclonic geostrophic vorticity maximum aloft	$\omega < 0$, rising motion
< 0	(downstream of) strong anticyclonic geostrophic vorticity maximum aloft	$\omega > 0$, sinking motion
Term II – Temperature advection		
> 0	Warm advection (at low levels)	$\omega < 0$, rising motion
< 0	Cold advection (at low levels)	$\omega > 0$, sinking motion
Term III – Differential friction		
> 0	Cyclonic vorticity in the boundary layer; Ekman pumping	$\omega < 0$, rising motion
< 0	Anticyclonic vorticity in the boundary layer; Ekman suction	$\omega > 0$, sinking motion
Term IV – Diabatic heating		
> 0	Latent-heat release associated with condensation or fusion; heating of cold air by warm surface; radiative heating	$\omega < 0$, rising motion
< 0	Cooling associated with evaporation or sublimation; cooling of warm air by cold surface; radiative cooling	$\omega > 0$, sinking motion

10. What does frontogensis mean? Where in the atmosphere would you expect to find frontogensis occurring? Identify each term in the equation below. Describe the importance of each term.

$$F = \frac{d}{dt}\left|\nabla\theta\right| = \frac{1}{2}\left|\nabla\theta\right|\{Def_R \cos 2\beta - Div\}$$

- Frontogensis is the formation of a front that is the boundary between two different airmasses.
- Frontogensis occurs along a baroclinic zone, well-defined temperature gradient.
- The first term is the temperature (isentrope) gradient, the stronger the gradient the stronger the frontogensis
- The second term is the deformation term being composed of stretching and shearing deformation both very important to the intensification of the temperature gradient. This term includes the angle between the axis of deletation and the isopleths, this angle must be less than 45 degrees for frontogensis to proceed through deformation
- The last term is the divergence of the wind field necessary to enhance frontogensis. Ideally want convergence in the lower levels and divergence aloft to create and maintain ascending vertical motion.