

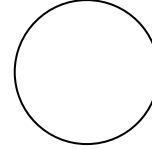
Name: _____

MEA 214
Midterm Exam, Spring 2008 – Tuesday 26 February

As usual, feel free to ask me if you are confused about the meaning of any question. Good luck, and have a great spring break! Don't forget that we **do** have lab this week, and that we will **forecast both today and Thursday** (but not during spring break).

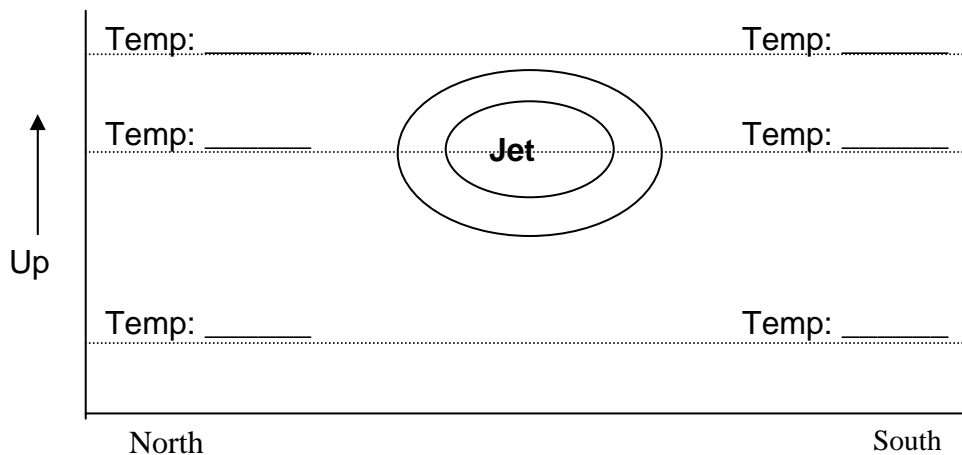
- ___ 1.) CCN are to **condensation** what _____ is/are to **freezing**.
- a.) cloud condensation nuclei
 - b.) latent heat release
 - c.) the Bergeron process
 - d.) ice nuclei
- ___ 2.) Which of the following is **not** relevant to the Bergeron process?
- a.) The vertical pressure gradient force and gravity
 - b.) Lower saturation vapor pressure over ice than liquid water
 - c.) The occurrence of mixed-phase clouds
 - d.) Supercooled liquid water
- ___ 3.) Which of the following is the best definition of the term *jet stream*?
- a.) A warm ocean current that flows northward offshore of the eastern U.S., eventually extending towards northern Europe.
 - b.) A low-latitude convection cell that operates within about 30 degrees latitude of the equator in either hemisphere.
 - c.) The altitude at which commercial jet airplanes tend to fly, which is about 30,000 feet above sea level.
 - d.) A narrow band of strong westerly winds that is greatest in strength at about 10 km altitude.
- ___ 4.) Which of the following explains why westerly winds *decrease* in strength above the core of the jet stream?
- a.) Winds above the jet are slowed by an increase in stability in the stratosphere, which is located immediately above the jet stream.
 - b.) The winds slow due to the decrease in gravitational acceleration with increasing altitude. Gravity is one of the 2 forces involved in hydrostatic balance; as gravity weakens, so does the pressure gradient force, which leads to weaker winds.
 - c.) Due to increased friction as air in contact with the stratosphere slows the jet.
 - d.) None of the above.
- ___ 5.) The hypothetical maps below show several different possible orientations between fronts and upper-level jet streams. Which of these do you think is most realistic?
- a.)
 - b.)
 - c.)

6.) Rapidly rotating weather systems such as tornadoes can be treated as “balanced vortices”. Which of the forces or apparent forces that we discussed in class are likely to be largest, and in balance, in a strong tornado? The diagram below shows an idealized tornado circulation. For the air parcel located at “A”, draw force vectors for the two forces you expect to be largest, and label each.



- ___ 7.) The frictional force is important near the Earth’s surface. Which of the following describes the relation of friction to patterns of cloud and precipitation?
- a.) Friction in the near-surface force balance leads to converging and rising air in low pressure systems.
 - b.) The reduction of friction with height gives rise to strengthening winds with height, and this is ultimately responsible for the jet stream.
 - c.) Friction causes divergence aloft in the left exit and right entrance region of jet streaks, as air accelerates and decelerates.
 - d.) Friction is the cause of orographic lifting, which can be very important to precipitation along the windward slopes of mountain ranges.

___ 8.) Consider the idealized “slice diagram” pictured below. This is a north-south vertical cross section in the Northern Hemisphere. *Fill in the blanks with “cold”, “warm” or “similar” to indicate the temperature relative to the value on the other side of the jet (at the same level).*



- 9.) True/False questions. Lake-effect snow (LES):
- ___ a.) is primarily a *springtime* phenomenon, when the atmosphere is least stable.
 - ___ b.) can be highly localized due to the convective nature of the storms.
 - ___ c.) is an entirely different mechanism compared to what happens when cold air flows over a warmer *ocean*.

___ 10.) Consider a strong lake-effect band extending down the



long axis of Lake Ontario, as sketched at right. Which one of the following describes a mechanism that is likely to contribute to the intensity of snowfall at point A (*over the lake*) during this event? Assume a west-southwesterly wind flow.

A

- a.) Warm air moves over colder water, which results in destabilization of the air mass and convective showers.
- b.) The warmer water surrounded by cold land can lead to the development of a *land breeze circulation* that can converge over the lake, contributing to lift.
- c.) Friction is stronger over land than over the water, leading to “frictional convergence” along the shore as wind encounters rougher terrain.
- d.) Orographic lift can also add to the lift, further enhancing lake-effect snow.

___ 11.) Which of the following best explains why fully developed cumulonimbus clouds often have an “anvil” shape?

- a.) The updraft in cumulonimbus clouds gets so strong that the upper portions of the cloud fan out as the air rises.
- b.) As air rises it expands due to lowering pressure with height, and so the top part of the cloud will be bigger (and take on the shape of an anvil).
- c.) The upper parts of the cloud are composed of ice particles, which tend to spread out laterally more than the lower, liquid water portions of the cloud.
- d.) The tropopause marks the base of the stratosphere, which is very stable; when a storm’s updraft hits the tropopause it spreads out like smoke hitting a ceiling.

___ 12.) Which of the following is consistent with the charge distribution and separation mechanism in cumulonimbus clouds?

- a.) Collisions between hail, supercooled droplets, and ice crystals lead to the development of primarily *positive charge in the lower portion of the cloud*, with *negative charge higher up in the colder anvil*.
- b.) Collisions between hail, supercooled droplets, and ice crystals lead to the development of *primarily negative charge in the lower portion of the cloud*, with *positive charge higher up*.
- c.) Collisions between warm and cold air masses produce a sharp density contrast that separates charge, analogous to shuffling your feet on a carpet and getting a shock when you touch a doorknob.

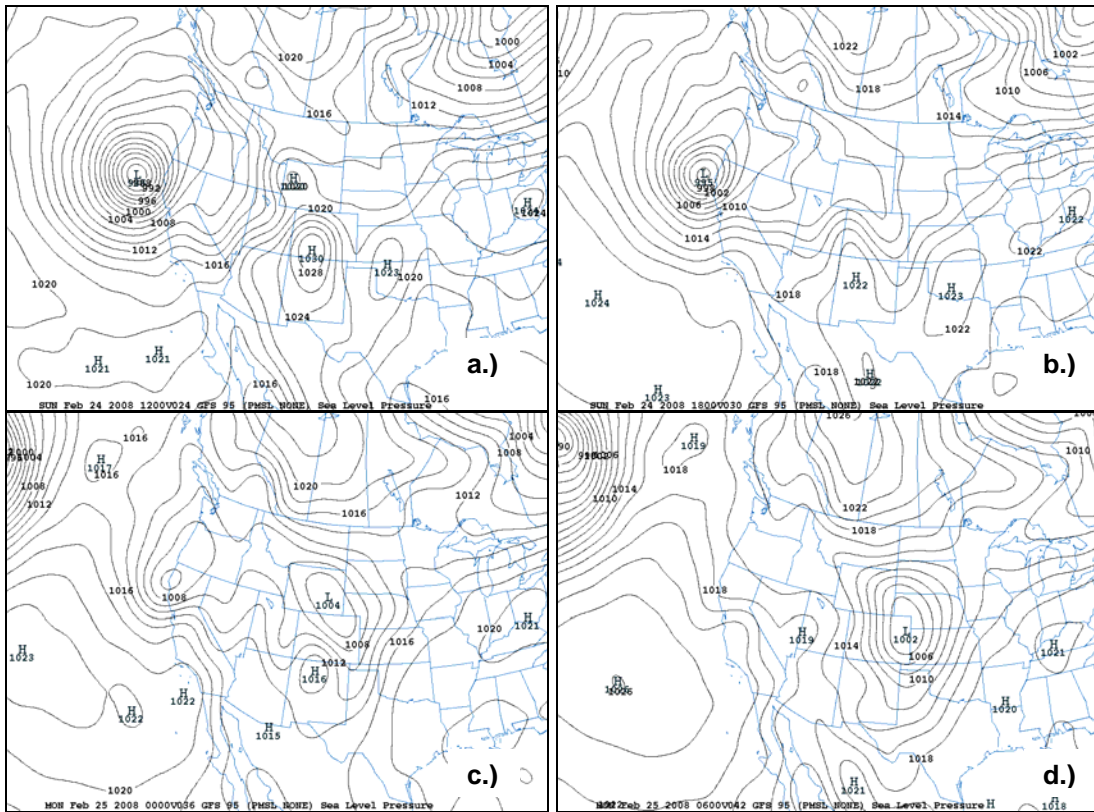
___ 13.) Which of the following best describes the “thermoelectric effect” in ice?

- a.) This physical effect describes the positive charge *induced on the ground* below an electrified thundercloud.
- b.) This term applies to the *propagation of lightning* from cold to warm parts of a cumulonimbus cloud.
- c.) This effect accounts for the *migration of positive ions to colder parts of a piece of ice*.
- d.) This effect describes the *decreased chance of thunderstorms during cold weather*, such as during the winter.

For problems 14 and 15, consider the sequence of maps below, which show the sea-level pressure forecast from the GFS model at 6-hour intervals from a.) through d.). Note the strong cyclone that is initially located just west of California in panel a.).

___ 14.) Track the center of the strong cyclone west of California during this sequence of maps. Which of the following best describes what most likely happened to this system?

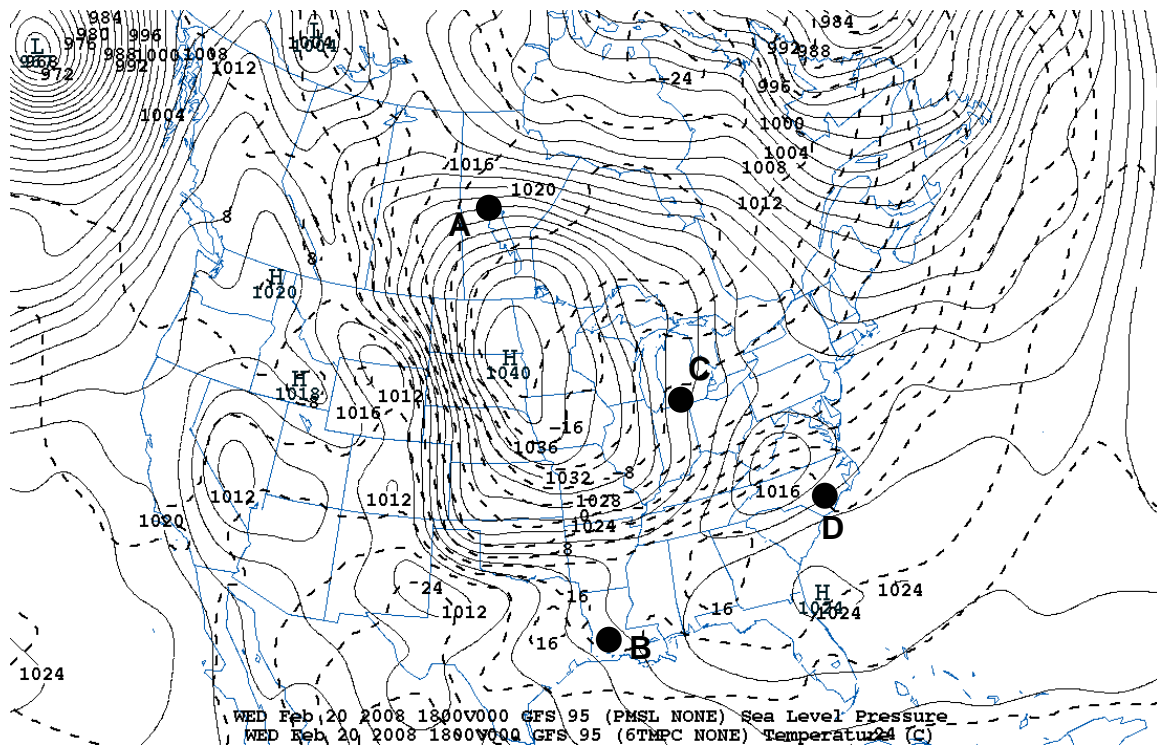
- a.) The upper trough associated with this system must have drastically weakened.
- b.) The air column compressed as the westerly flow went up and over the Rocky Mountains, reducing vorticity and eliminating the circulation of the system.
- c.) The dry air of the southwestern U.S. choked off precipitation with this storm, resulting in weakening.
- d.) Much like a hurricane, mid-latitude cyclones are strong over water, but die quickly once moving inland.



___ 15.) Note the cyclone that forms over Wyoming and Colorado at the time of panel c.), and moves to eastern Colorado by d.). Which of the following is true of this low-pressure system?

- a.) It is forming in an area that is rare, climatologically, for cyclone formation.
- b.) It may be associated with the same upper trough that had been associated with the California system.
- c.) This appears to be an example of a *lee cyclone*, and it is forming in a favored location for such systems, east of the Rockies.
- d.) Both b.) and c.) are true.

16.) Consider the sea-level pressure and 1000-mb temperature map shown below. How would you best categorize the air mass over Minnesota and the surrounding vicinity? Use the proper name and 2-letter air mass designation: _____



17.) Sketch the location of fronts on the diagram above, using your best estimate of type and proper symbols.

18.) For the location of each of the dark circles in the figure above, sketch a plausible station model on the corresponding location below, including most likely wind speed and direction, temperature, dew point, pressure, sky cover, and weather conditions. You can provide temperatures and dew points either in °C or °F.

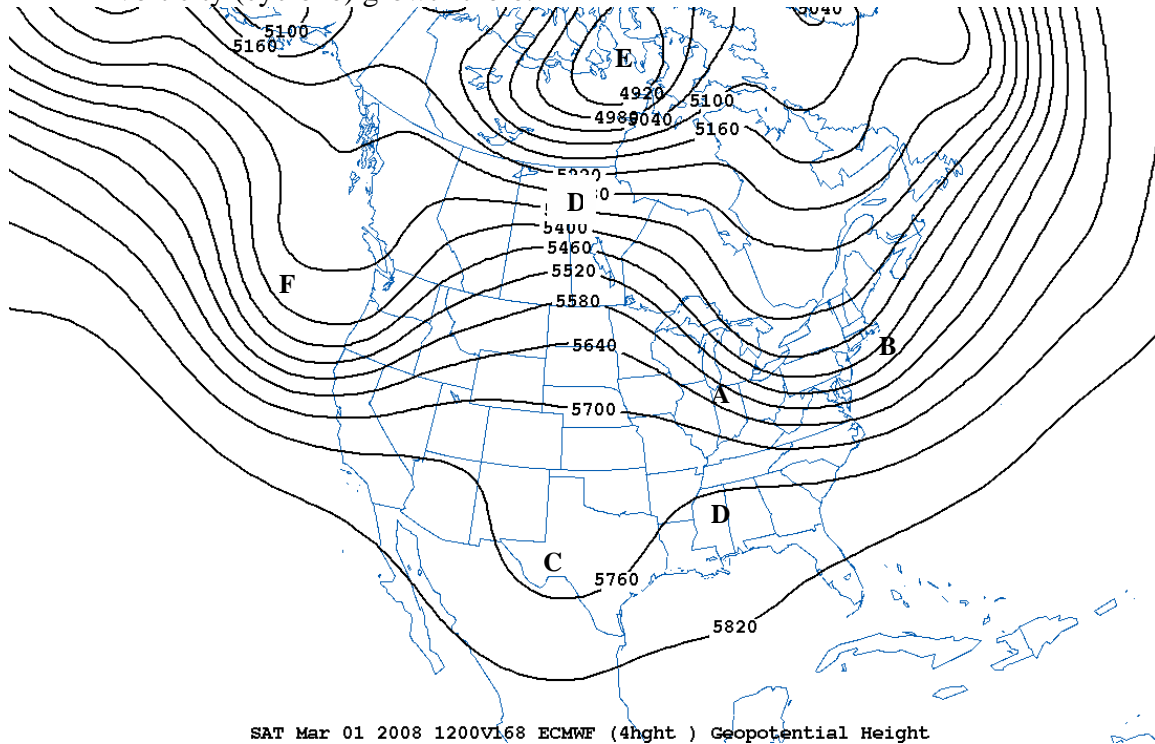
A: ○ B: ○ C: ○ D: ○

19.) Match the following short-term forecasts, *for the next 12 hour period* from the time of the map above, to the *best location* on the diagram. The analysis above is valid at 18 UTC.

- ___ i.) Warm and humid with a chance of showers or thunderstorms.
- ___ ii.) Warm and breezy, with a slight chance of showers by midnight.
- ___ iii.) Becoming slightly warmer with gusty westerly winds.
- ___ iv.) Periods of locally heavy snow, with gusty northwesterly winds.

___ 20.) Which of the following best explains the tendency for cyclones to form to the east of the Rocky Mountains?
 a.) The air column tends to *compress* there as air descends the east slopes.

- b.) The *temperature contrast there is generally large*, favoring cyclone formation.
- c.) *Upper waves* are usually located immediately to the west of the Rockies; these waves are responsible for cyclone formation.
- d.) The air column tends to *stretch* after passing over the mountains, favoring vorticity (cyclone) growth there.



21.) Consider the 500-mb map pictured above. For each of the features listed, identify the lettered location where you would **most** expect to observe the following. You can use the same letter more than once if needed, and you don't have to use all of the letters, but list just one letter for each feature.

- a.) rising air, clouds, and precipitation
- b.) a surface anticyclone (high-pressure system)
- c.) a jet streak
- d.) the warmest air column
- e.) the coldest air column
- f.) a developing cyclone (low pressure area) at the surface

22.) For point "D" on the 500-mb map shown above, which horizontal forces would you expect to be important (meaning that they would play a significant role in the horizontal force balance there):

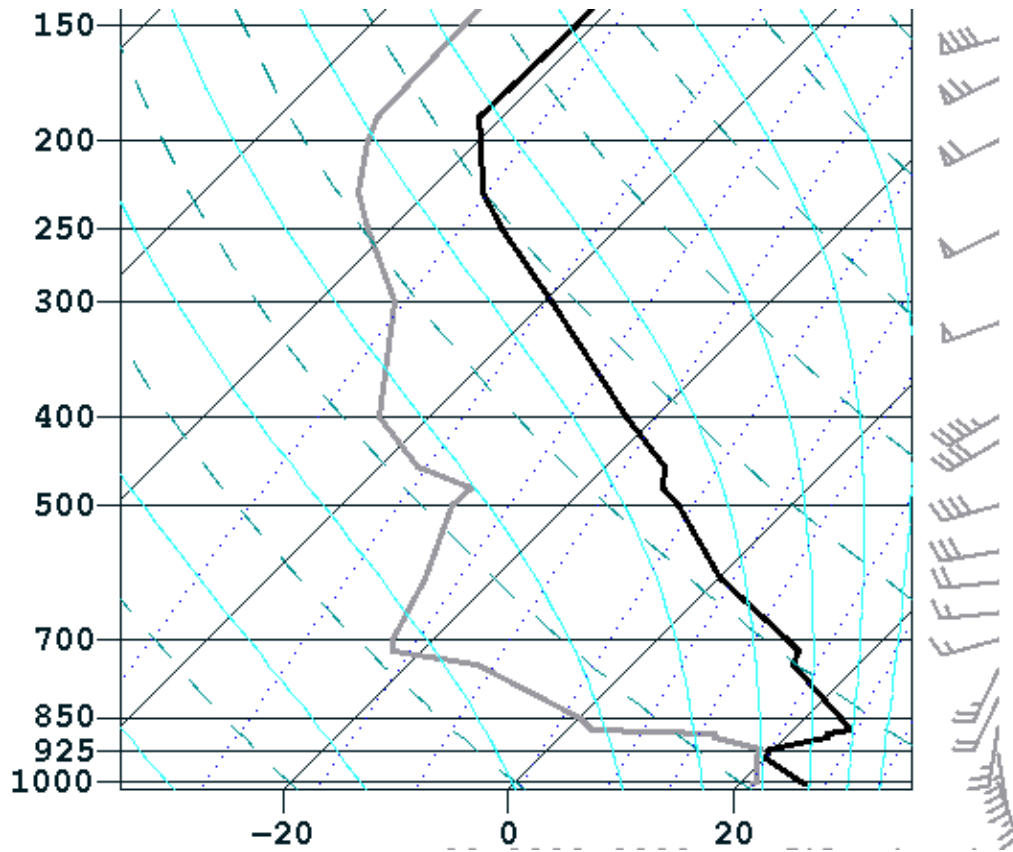
- a.) Coriolis, pressure gradient force, centrifugal, friction
- b.) Coriolis, pressure gradient force
- c.) Coriolis, centrifugal
- d.) Coriolis, pressure gradient force, centrifugal

23.) What is the typical number of return strokes in a negative cloud-to-ground lightning discharge ?

- a.) 1 b.) 5 c.) 25 d.) 50 e.) 100 f.) 500

24.) For each of the characteristics listed below, list the type of front to which the statement best applies. Options include *warm*, *cold*, *occluded*, and *stationary* fronts.

- a.) Often accompanied by thunderstorms, especially in spring: _____
 b.) Fastest-moving front: _____
 c.) Generally accompanied by weakest temperature contrast: _____
 d.) Accompanied by the largest precipitation area: _____
 e.) Signifies mature stage of parent cyclone: _____
 f.) Most likely to be accompanied by freezing rain in winter: _____



25.) On the skew-T diagram above, use a *lifted surface air parcel* to indicate:

- a.) the LFC (label on diagram) b.) the CIN (label and shade)
 c.) the CAPE (label & shade) d.) the EL (label on diagram)

26.) True or False (answer T or F):

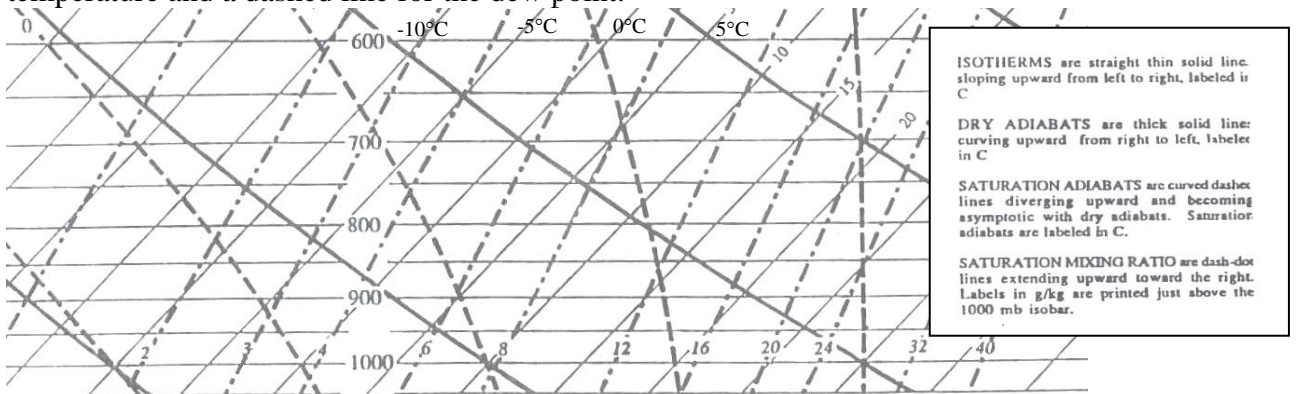
- ____ a.) Lightning “flickers” because of the heat generated by the lightning; this effect is similar to the mirage over a road on a hot summer day.

- ___ b.) The visible channel (return stroke) for negative cloud-to-ground lightning progresses *upward from the ground towards the cloud*.
- ___ c.) “Heat lightning” is different from ordinary lightning because it is produced by the heat of the day, and does **not** have a true lightning channel.
- ___ d.) Lightning *has never* been observed where mixed phase clouds are not present.
- ___ e.) Positive cloud-to-ground lightning originating in a thunderstorm anvil is generally stronger than cloud-to-ground lightning of negative polarity.
- ___ f.) Lightning can strike the same place twice, contrary to folklore.

27.) Suppose that you are forecasting for Raleigh today, with the forecast valid tomorrow (Wednesday). The GFS model is forecasting the following conditions:

Pressure	Temperature	Dew Point	Height (m)
1000.0	-2.0	-8.0	200.0
850.0	-9.0	-12.0	1400.0

a.) Plot the data listed above on the skew-T diagram below, using a solid line for the temperature and a dashed line for the dew point.



- ___ b.) What is the numerical “*lapse-rate*” of this layer, in degrees C per kilometer?
- ___ c.) What is the corresponding “*lapse-rate*” *stability* of this layer?
 - i.) absolutely stable ii.) conditionally unstable iii.) absolutely unstable
- d.) Estimate the maximum temperature for Raleigh assuming strong adiabatic mixing to the 850-mb level and a surface pressure of ~1005 mb. _____ °C

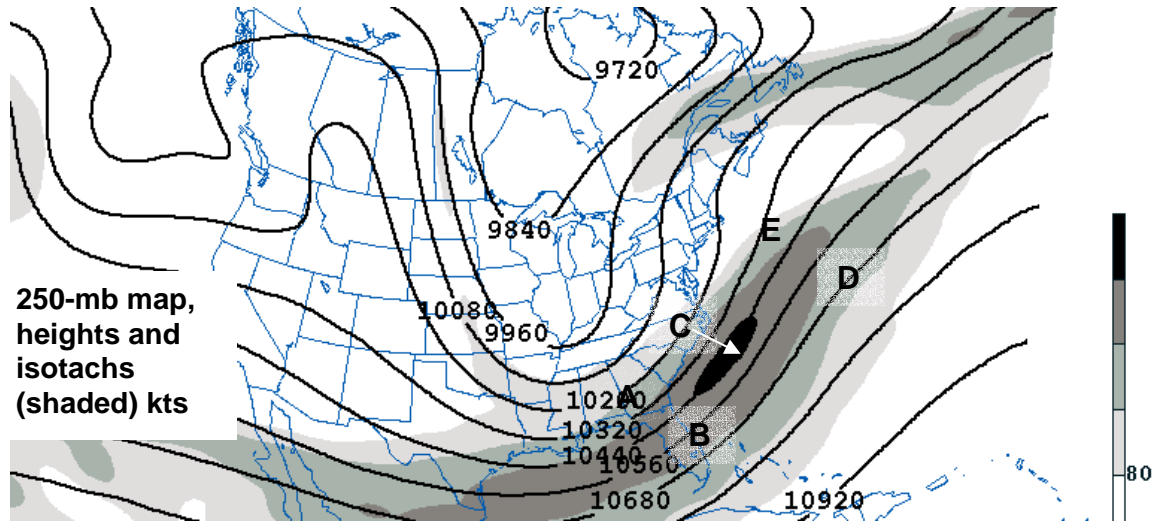
28.) NWP True/False

- ___ a.) Weather forecast models generally make forecasts for many very small “time steps” of a minute or so each, thus it requires very fast computers to run them.
- ___ b.) Model analyses are based entirely on observations and are thus independent of any biases or forecast errors that the model might have.
- ___ c.) Model errors are due almost entirely to shortcuts in the way models represent physics; there is almost no error in the model initial condition analysis.

___ 29.) What are ACARS?

- a.) A new type of automobile with reduced emissions.
- b.) The next generation of NWS geostationary satellites.

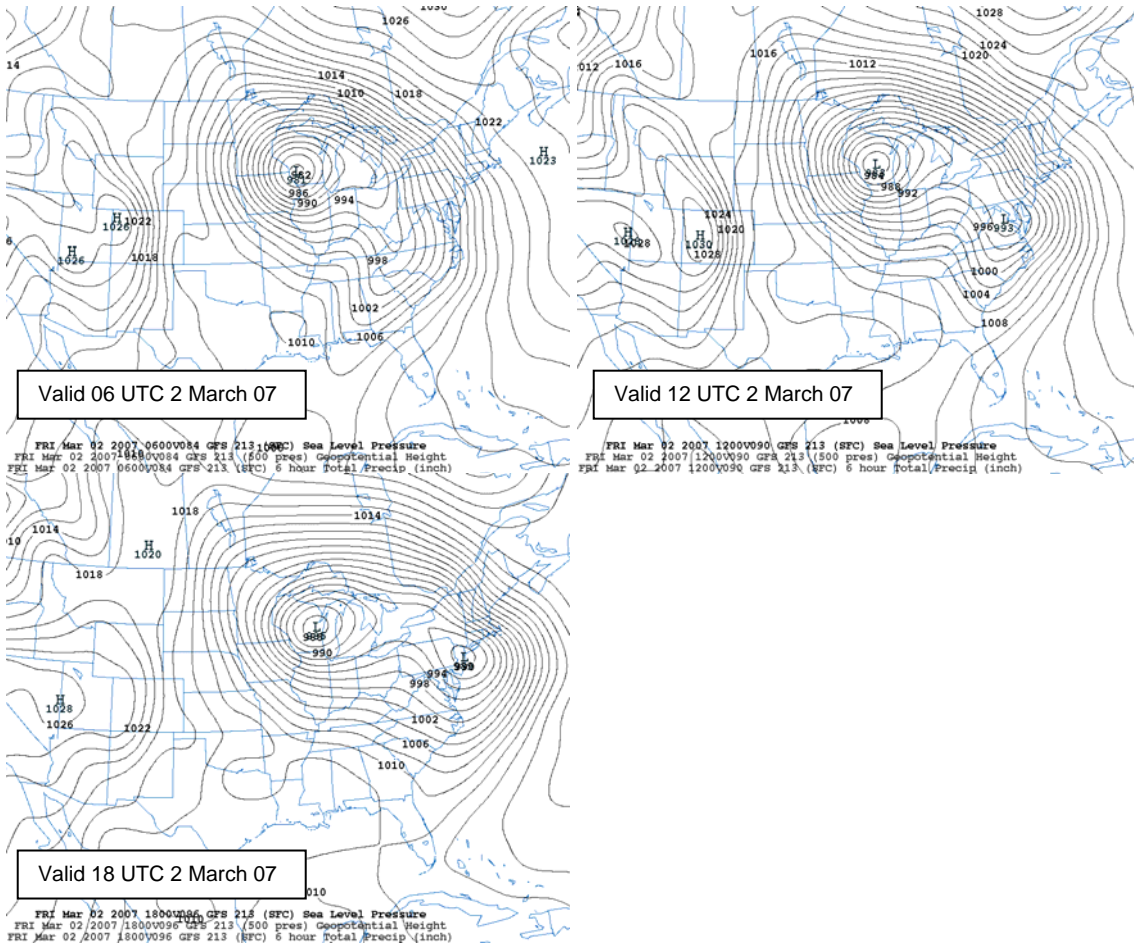
- c.) Weather reports from commercial aircraft.
- d.) The next generation of NWS radars, due to come online in 2006.
- e.) An important source of upper-air information for computer forecast models.
- f.) Both c. and e.



_____ 30.) Consider the 250-mb map shown above, with heights contoured and isotachs shaded. At which of the indicated point(s) would you expect to observe divergence aloft, rising air, clouds, and precipitation?

___ 31.) On the following page are three sea-level pressure forecasts from the GFS model, valid on Friday, 2 March, 2007. Based on these maps, and assuming that the model forecast will be accurate, which one of the following would be the most reasonable forecast for the period from 6 – 18 UTC on that Friday in 2007 for Raleigh, NC?

- a.) Increasing clouds and rain likely. Light northerly or northeasterly winds, and cool, with temperatures remaining in the 30's throughout the period.
- b.) Cloudy with periods of rain and windy early in the period; chance of thunderstorms or heavy rain. Rain ending during the morning, with clearing in the afternoon. Gusty south winds switching to westerly or northwesterly.
- c.) Overcast with steady light rain and light easterly winds. Turning warmer, with winds switching to southerly. Rain heavy at times during Friday afternoon.
- d.) Chance of sleet or freezing rain with northerly winds, switching to southeasterly. Warmer during the afternoon with rain. Gusty winds.



___ 32.) What score do you expect to earn on this exam?
 a.) 90-100 b.) 80-89 c.) 70-79 d.) 60-69 e.) < 60

___ 33.) Based on how hard you studied for this exam, what score do you think you deserve on the exam?
 a.) 90-100 b.) 80-89 c.) 70-79 d.) 60-69 e.) < 60

Don't forget to forecast for RDU today!

If I don't see you before, have a great spring break!