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# Midterm Examination Feb 25, 2014

## COURSE: ATOC 184
## TITLE: Science of Storms

Examiner: Dr. Eyad Atallah

STUDENT NAME _____

McGill ID NUMBER _____

INSTRUCTIONS:

Instructions: Answer all of the questions in the space provided. The value of each question is provided after the question along with a **suggested length**. No notes or texts outside of translation dictionaries are permitted. Standard calculators are also allowed. Please place your name and student number on each page of this exam.

This exam comprises 8 pages, including the cover page.

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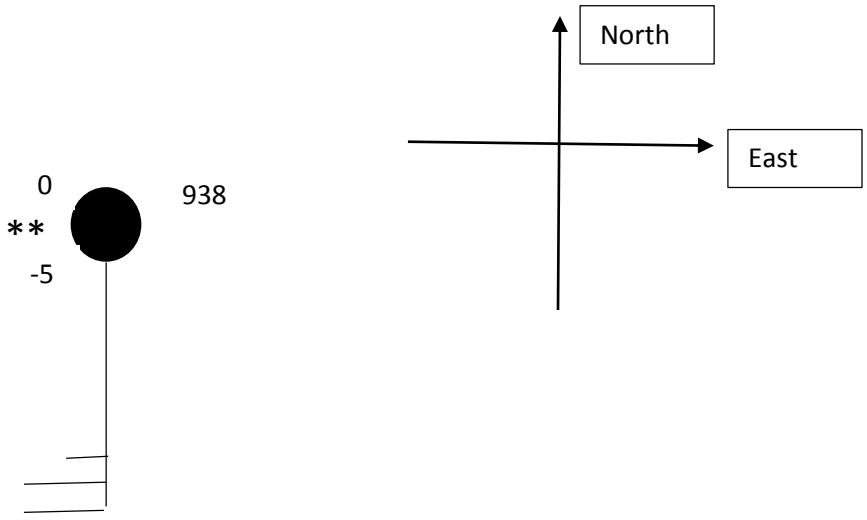
1) Consider the following weather observation where the temperatures are in degrees Celsius. (6 points)




a) What is the temperature at the station? ____0C___

b) What is the dewpoint at the station? ___-5C____

c) What is the wind direction (degrees)? ___180____

d) What is the wind speed in knots? ____25___

e) What is the weather? _____light snow_____

f) What is the pressure at the station? __993.8 hPa_____

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2) Given the wind direction in problem "1", would you expect the pressure at a station to the WEST to have a higher or lower pressure. Be sure to briefly explain your answer. (5 points – 2 or 3 sentences).

Ok, this answer depends on the direction of the wind in question 1. For the correct wind direction (southerly) the pressure to the west would be lower. This is because of the wind generally being in geostrophic balance in which case lower pressure is always located to the left of the wind in the Northern Hemisphere. (Note to grader—make sure that the answer is consistent with the answer for wind direction in question 1).

3) I often say that the concept of relative humidity is misleading and I want you to prove it. Show that there is more water vapour in the atmosphere when the temperature is 25 C and the relative humidity is 40% than there is in the atmosphere when the temperature is 0 C and the relative humidity is 100 %. You will have to consult the following chart. Note that temperatures are in degrees C and the vapour pressures are in hPa.

*Saturation vapor pressure over pure liquid as a function of temperature*

| T(C) | e(w) | T(C) | e(w) | T(C) | e(w) | T(C) | e(w) |
|---|---|---|---|---|---|---|---|
| -35 | 0.3148 | -16 | 1.7639 | 3 | 7.5784 | 22 | 26.4283 |
| -34 | 0.3473 | -15 | 1.9161 | 4 | 8.1322 | 23 | 28.0853 |
| -33 | 0.3829 | -14 | 2.0800 | 5 | 8.7215 | 24 | 29.8325 |
| -32 | 0.4218 | -13 | 2.2562 | 6 | 9.3482 | 25 | 31.6743 |
| -31 | 0.4642 | -12 | 2.4457 | 7 | 10.0144 | 26 | 33.6148 |
| -30 | 0.5104 | -11 | 2.6492 | 8 | 10.7223 | 27 | 35.6585 |
| -29 | 0.5606 | -10 | 2.8677 | 9 | 11.4739 | 28 | 37.8100 |
| -28 | 0.6153 | -9 | 3.1021 | 10 | 12.2717 | 29 | 40.0741 |
| -27 | 0.6748 | -8 | 3.3535 | 11 | 13.1180 | 30 | 42.4558 |
| -26 | 0.7393 | -7 | 3.6228 | 12 | 14.0154 | 31 | 44.9600 |
| -25 | 0.8094 | -6 | 3.9112 | 13 | 14.9664 | 32 | 47.5922 |
| -24 | 0.8853 | -5 | 4.2199 | 14 | 15.9739 | 33 | 50.3577 |
| -23 | 0.9677 | -4 | 4.5501 | 15 | 17.0405 | 34 | 53.2622 |
| -22 | 1.0568 | -3 | 4.9030 | 16 | 18.1693 | 35 | 56.3116 |
| -21 | 1.1532 | -2 | 5.2800 | 17 | 19.3634 | 36 | 59.5118 |
| -20 | 1.2574 | -1 | 5.6825 | 18 | 20.6258 | 37 | 62.8692 |
| -19 | 1.3700 | 0 | 6.1120 | 19 | 21.9601 | 38 | 66.3900 |
| -18 | 1.4915 | 1 | 6.5701 | 20 | 23.3695 | 39 | 70.0810 |
| -17 | 1.6226 | 2 | 7.0583 | 21 | 24.8576 | 40 | 73.9490 |

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Please show all you work (10 points)

Ok, so at 0C with a relative humidity of 100%, the saturation vapour pressure=actual vapour pressure. From the chart we see that the value is 6.11 hPa. Now for a temperature of 25 C and a relative humidity of 40% we have .4 = AVP/SVP. From the chart SVP = 31.7 hPa so now 0.4 x 31.7 = AVP. So in this case the actual vapour pressure = 12.7 hPa. So there is about twice as much water vapour at a temperature of 25C and a RH of 40% then there is at 0C and a RH of 100%

4) Explain how it's possible for winds to have different speeds even if the strength of pressure gradient force is the same everywhere. (10 points – 3-4 sentences)

This question is unfortunately a little ambiguous so there are two possible answers.

1) A difference in the strength or degree of friction can cause the wind speeds to have different values for the same pressure gradient. This can be because the winds are at two different levels or because on wind is over water while the other is over land.
2) The other answer has to do with the centrifugal accelerations associated with curved flow. For flow around a high pressure system, the centrifugal force is directed in the same direction as the pressure gradient force. This causes an increase in the necessary Coriolis force which means that the wind speed has to increase. In a low pressure system, the centrifugal force is directed agains the pressure gradient force resulting in a reduction in the wind speed.

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5) Why are jet streams associated with strong changes in temperature? (10 points 3-4 sentences)

   This essentially has to do with the difference in volume or thickness between warm and cold air masses. Since warm air is less dense than cold air, pressure changes more quickly with respect to height in cold air than warm air. This causes the pressure surfaces to slope leading to a pressure gradient force which in turn produces wind. Large changes in temperature lead to a large pressure gradient force and consequently stronger winds.

6) In general, we need to have air which is rising, in order to get clouds and precipitation. Explain why this is the case. (10 points 2-4 sentences)

In order to get clouds, we first have to get a parcel of air to saturate…or in other words we have to cool a parcel of air until it reaches its dewpoint temperature, at which point we have 100% relative humidity. When air rises, it cools adiabatically since it is doing work to displace the surrounding atmosphere as it expands. Eventually, provided there is sufficient moisture, the air will cool to its dewpoint.

7) List 4 tools that meteorologists use to keep track of the weather (4 points)

Radar

Satellites

Airplane

Rawinsondes or weather balloons

Surface observations (ASOS)

Lightning Detection Network

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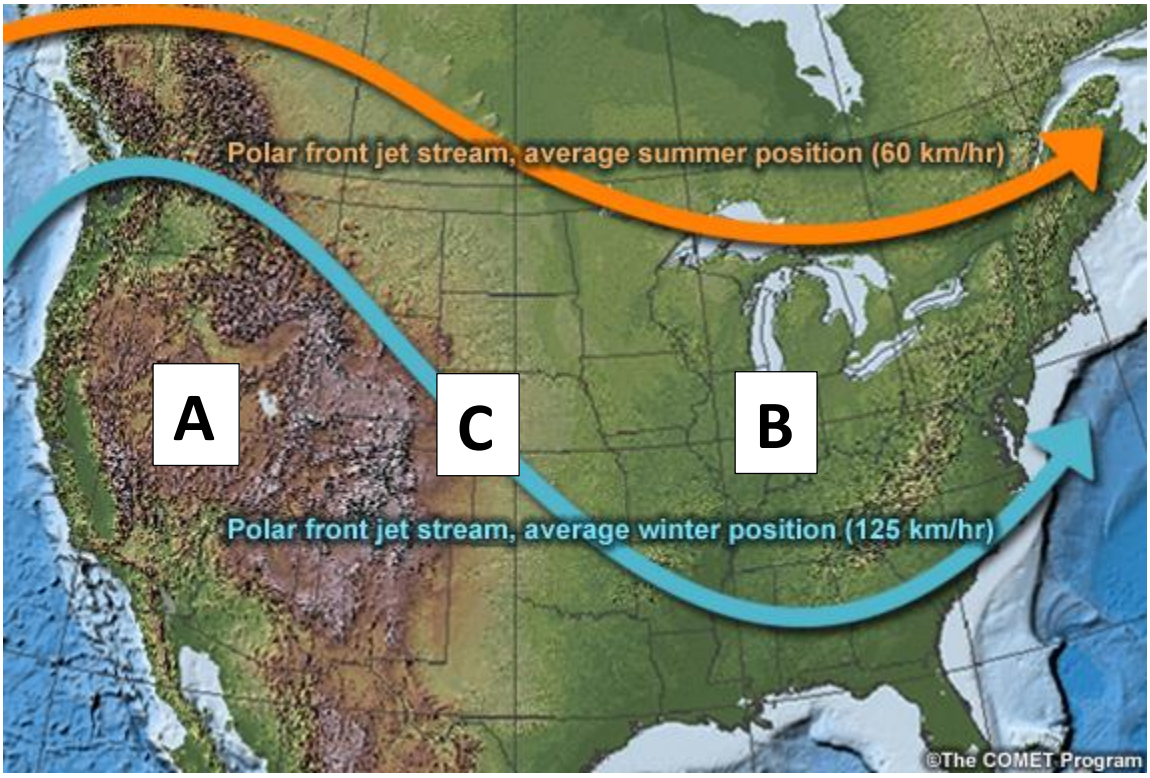
8) Consider the following map which shows the usual position of the jet stream for both, the summer (northern curve) and winter season (southern curve). The wind direction is indicated by the arrow at the end of the curve. For the questions below, only worry about the winter jet stream.




a) Would you say that temperatures at location "A" or location "B" would in general be warmer? Give a brief explanation of your answer. (10 points 1-3 sentences)

Location A is warmer than location B. Possible explanations include…

1) At jet level, warm air is associated with high pressure while cold air is associated with low pressure and A must be a region of high pressure as indicated by the clockwise flow.
2) Cold air-low pressure is always to the left of the jet stream in the northern hemisphere as indicated by geostrophic or gradient balance.
3) Location A is equatorward of the jet and location B is poleward of the jet

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b) Would you expect a high pressure or a low pressure system to develop at the surface at point “C”? Be sure to explain your answer. (10 points 2-4 sentences)

Location C is marked by CONVERGENCE at jet level. We can arrive at this conclusion because air must flow faster around high pressure systems than around low pressure systems because of the centrifugal force associated with curved flow. This convergence at jet level results in an increase in the total number of air molecules in the column above C which results in an increase in the surface pressure or the creation of a high pressure system at the surface.

9) Why is the wind more likely to be in geostrophic balance at 200 hPa than at 900 hPa? (5points – 1 sentence).

Since 900 hPa is closer to the surface than 200 hPa, friction is more likely to be important at 900 hPa than it is at 200 hPa which disrupts geostropic balance.

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10) List three kinds of satellite imagery used in meteorology with a short (one sentence or less) description of each. (10 points)

Infrared – measures the infrared radiation or temperature of the surfaces and or clouds

Visible – Measures the visible reflectance or albedo of objects

Water Vapour – measures the actual water vapour content of the atmosphere

11) What is the difference between an absolutely stable atmosphere and a conditionally unstable one? (10 points 2-4 sentences)

In an absolutely stable atmosphere, are vertical displacements of air result in a return of the air parcel to its original position. This occurs whether or not the sir parcel in question is saturated. However, in a conditionally unstable atmosphere, parcels that achieve saturation become unstable or accelerate away from their original position once displaced.