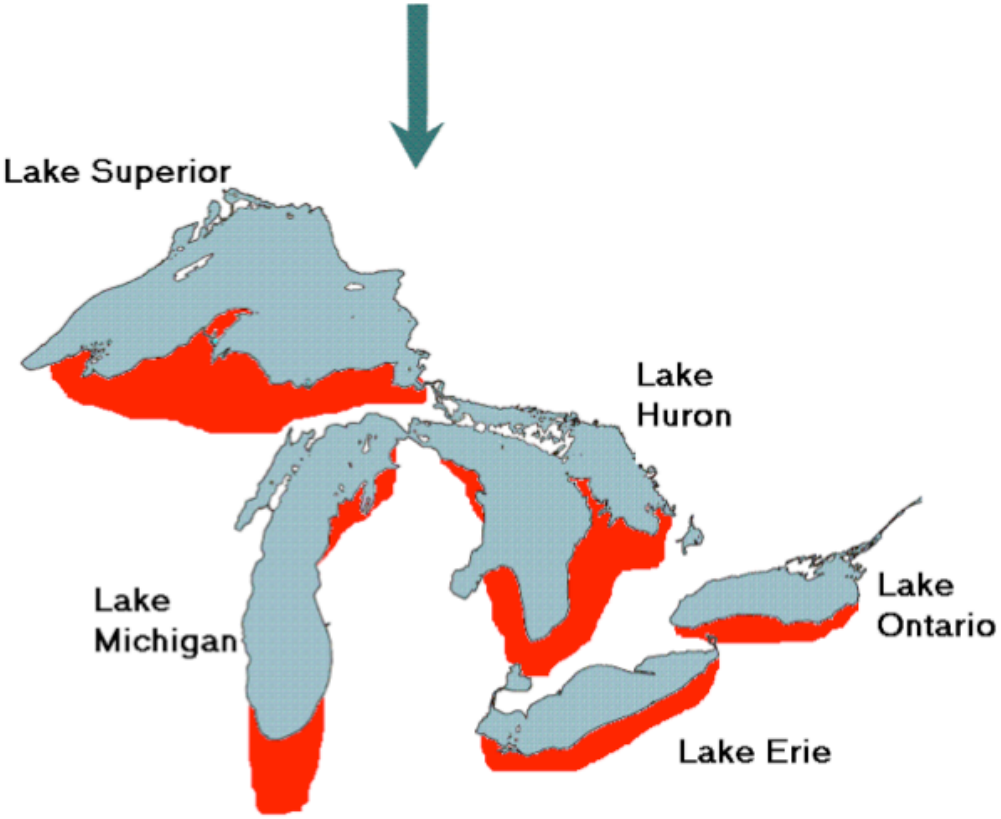
Homework #4

Diagram Extravaganza
Due: 12 August 2011

I. Lake-effect snow

The following map shows the Great Lakes with the direction of the wind on a particular winter day, when frigid air is blowing from the Arctic and Canada and sweeping over the lakes.



1. Label the lakes with their respective name. *(You might need to consult an atlas.)*

2. Color or shade (with another color than blue) the areas where you might observe snow on that particular day. *(Note: There is no midlatitude cyclone in the area.)*

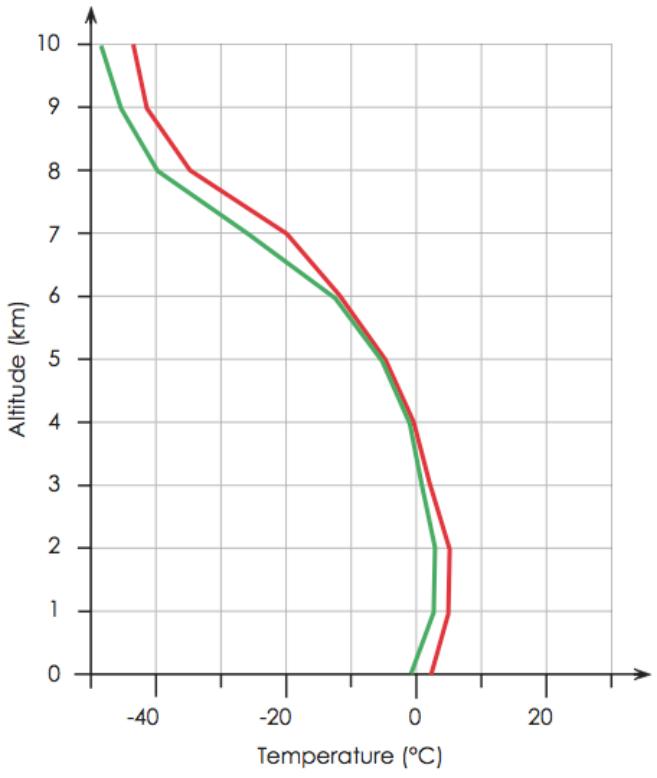
3. Which lake(s) will cause the heaviest snow bands? Explain why.

Snow will be heaviest at the south end of Lake Michigan due to the long fetch. A northerly wind travels down the long axis of the lake, allowing more time for the air to warm and moisten and then produce more precipitation over land. Lakes Huron and Superior also have long fetches with a north wind.

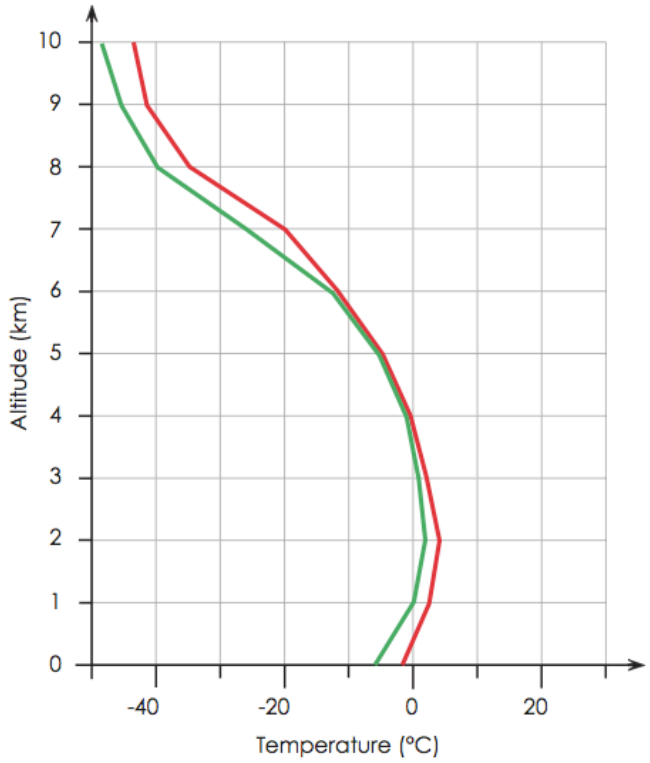
4. Lake Erie is very shallow and therefore often freezes during the winter. Explain how that might change your answer to question 2.

If Lake Erie freezes, lake effect snow will be significantly diminished for two reasons. One is that a frozen lake will be less effective at warming the air above it, so there will be less convection over the lake. Secondly, water will be unable to evaporate from the lake if it is frozen, so any air that is able to convect will be quite dry.

II. Sleet and freezing rain

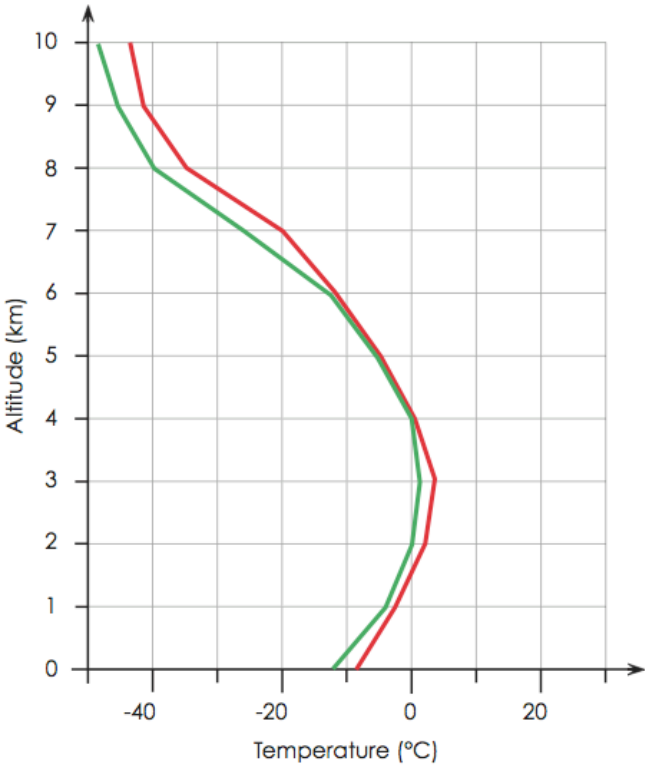


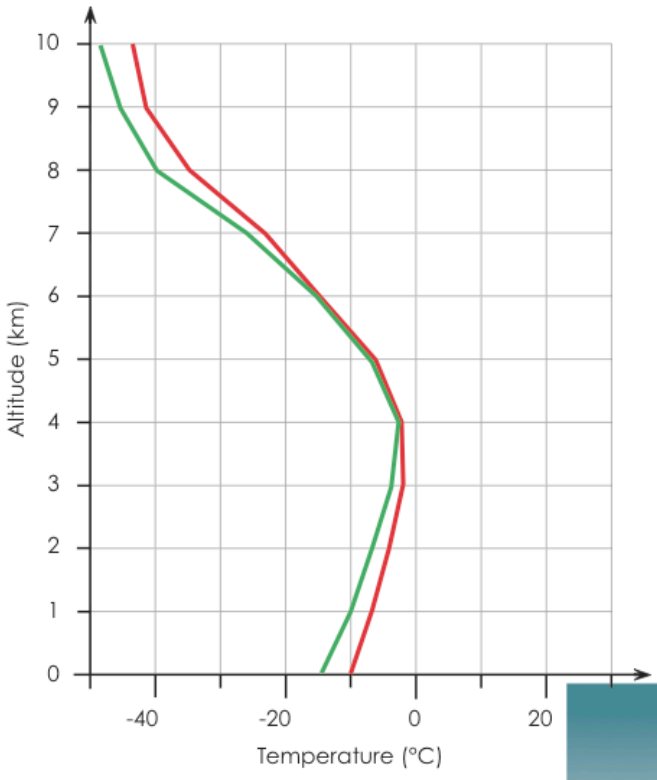
Profile A: Cloud from 4-6km. Since cloud temperature is below 0°C, there are likely ice crystals in the cloud. Below the cloud, the environmental temperature is above 0°C, so the falling snow would quickly melt. The temperature at the ground is +2°C, so precipitation at the ground would be rain.



Profile B: Cloud from 4-6km. Since cloud temperature is below 0°C, there are likely ice crystals in the cloud. Below the cloud, the environmental temperature is above 0°C, so the falling snow would quickly melt. The lowest 0.5km of the atmosphere is below freezing. Since this is a shallow cold layer, the falling rain likely did not re-freeze until it contacted the ground --> freezing rain at the ground.

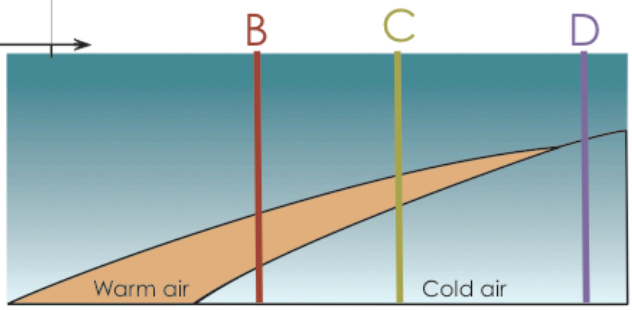
Profile C: Cloud from 4-6km. Since cloud temperature is below 0°C, there are likely ice crystals in the cloud. Below the cloud, the environmental temperature is above 0°C, so the falling snow would quickly melt. The lowest 1.5km of the atmosphere is below freezing. Since this a deeper layer (and the temperatures are further below zero, with -8°C near the ground), the falling rain will re-freeze in the air, forming ice pellets. (Note: rain does *not* re-freeze into snow.) Precipitation at the ground would be sleet/ice pellets.



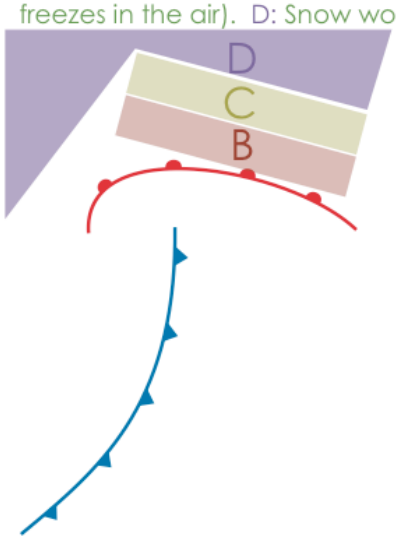


Profile D: Cloud from 4-6.5km. Since cloud temperature is below 0°C, there are ice crystals in the cloud. Below the cloud, the environmental temperature remains below 0°C all the way to the ground, so the falling snow would not melt. Precipitation at the ground would be snow.

2. The schematic on the right represents a cross-section of a warm front. Indicate where, approximately, you would expect to observe profiles B, C, and D. *(Draw 3 vertical lines labeled B, C, and D.)*



B: Freezing rain must fall through an above-freezing layer (so it melts) and through only a shallow cold layer near the ground (otherwise it would re-freeze in the air). C: Sleet must fall through an above-freezing layer (so it melts) and through a deeper cold layer near the ground (so it re-freezes in the air). D: Snow would only fall through below-freezing air (otherwise it would melt).



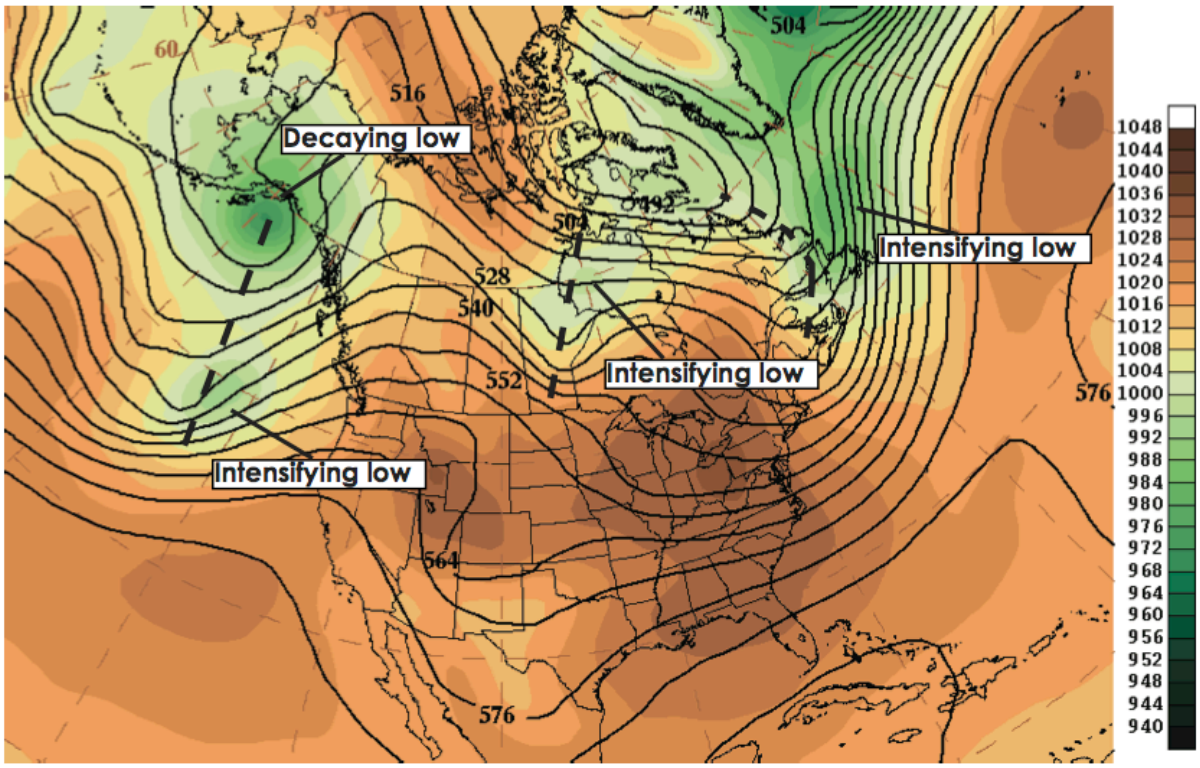
3. The schematic on the left represents a bird's eye view of a midlatitude cyclone. Indicate where, approximately, you would expect to observe profiles B, C, and D. *(Shade 3 areas and label them B, C, and D.)*

From the cross-section, it is clear that freezing rain (B) falls closest to the surface warm front; sleet (C) falls further into the cold air mass; and snow (D) falls furthest from the warm front. Thus, we expect to see these three types of frozen precipitation to the north of the surface warm front, in the region where the warm air mass is rising up and over colder air near the ground.

III. Intensifying and decaying lows

The following figure shows sea level pressure in color and line contours of 500 mb heights. Identify the four surface lows. Label the surface lows as either intensifying or decaying. Label the upper-level trough axis with a dashed line in each case, to show the position of the surface low in relation to the upper-level trough.

Note that a .tiff version of the figure is posted on the website for reference, in case the printed version is too difficult to read. http://www.atmos.washington.edu/~feldl/courses/atms101/materials.html



IV. El Nino/Southern Oscillation

The following table shows the winter precipitation, rain and snow (in inches), measured at Mount Baker, Washington from 1966 to 2005. El Niño winters are shaded in orange while La Niña winters are shaded in blue.

Year	Rain	Snow	Year	Rain	Snow	Year	Rain	Snow	Year	Rain	Snow
1966	36.67	125.5	1976	53.98	65.8	1986	33.45	39.0	1996	44.88	31.5
1967	61.83	33.4	1977	24.27	9.8	1987	29.38	7.5	1997	54.85	100.2
1968	48.95	54.9	1978	35.31	29.1	1988	28.25	36.0	1998	37.28	20.4
1969	34.86	164.7	1979	30.73	45.2	1989	27.91	66.9	1999	57.23	45.9
1970	31.38	20.1	1980	52.24	36.1	1990	48.27	108.1	2000	38.58	36.5
1971	49.41	120.6	1981	35.28	17.0	1991	48.74	66.7	2001	19.72	20.0
1972	50.69	126.1	1982	57.28	88.6	1992	42.93	2.1	2002	48.78	83.8
1973	41.84	22.6	1983	42.41	3.5	1993	20.59	72.7	2003	34.67	4.8
1974	64.79	79.8	1984	37.94	8.5	1994	36.12	22.7	2004	28.89	41.3
1975	46.77	64.7	1985	20.94	77.8	1995	49.13	51.9	2005	28.74	23.5

5. Calculate the average amount of rain at Mount Baker over all El Niño winters (let's call it the "El Niño average").

6. Calculate the average amount of rain at Mount Baker over all La Niña winters (let's call it the "La Niña average").

7. Calculate the average amount of rain at Mount Baker over all remaining winters, namely, all winters that were neither El Niño nor La Niña (let's call it the "normal year average").

8. Repeat questions 2-3-4 for snow and summarize your results in this table:

	El Niño	"Normal" year	La Niña
Average rain	36.9"	40.4"	46.3"
Average snow	36.9"	50.9"	73.7"

9. What can you infer from your results about the El Niño teleconnection with the Pacific Northwest? Should you buy a Mt. Baker ski pass for an El Nino winter?

Winters appear to be wetter and snowier at Mount Baker during La Nina years.

1. Explain briefly which large-scale weather pattern is affected by El Niño that causes such a shift in precipitation in the Pacific Northwest.

During El Nino, the equatorial trade winds are weaker, which has an effect on the global circulation pattern. One result of this is ridging that develops over western North America, causing a split jet stream (or storm track), with one branch to the north into Alaska and another to our south, across southern California and into Florida. The Pacific Northwest is in between these tracks and is impacted by fewer midlatitude cyclones during El Nino years.

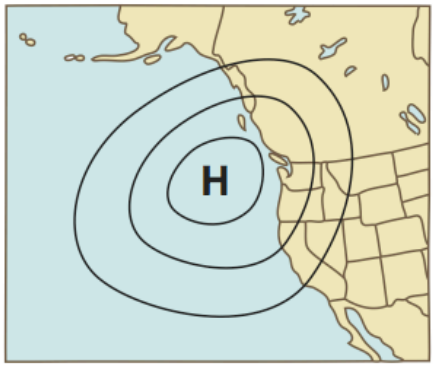
V. Flow around highs and lows

In practice, we do not draw all the forces each time we read a pressure map: we use a rule-of-thumb to find the wind direction and speed from the pressure pattern.

1. In the situation on the right, and using your favorite rule-of-thumb, what would you expect the wind direction to be in Seattle? ___ North/Northwesterly_____

In the Queen Charlotte Islands? __West/Southwesterly _

In Los Angeles? __North/Northeasterly_____



In the situation on the left, what would you expect the wind direction to be in Seattle? _South/Southeasterly_

In the Queen Charlotte Islands? _East/Northeasterly_

In Los Angeles? _South/Southwesterly__