Lab 6: Weather Maps and Analysis

Part A Answers: *See the 2 completed versions of Figure 6.3: See below for the contoured isobars and fronts. See the second Figure 6.3 (next page) for the correct representation of: areas of continuous precipitation; high (H) and low (L) pressure centers; and the mostly likely air mass types and their locations.*

The most common errors are these omissions:

- *Not smoothing the isobars but still representing a correct pressure pattern. Intuitively isobars are smooth lines because air flows. But, each isobar must still technically be correctly positioned according to the pressure at each station on the map. So, you might have to re-draw some isobars or parts of them. [Correct process: Use the needed contour interval and starting value. Interpolate between station pressures to locate the correct isobar position. Then smooth contours that are too jagged.* ***See your instructor if you aren't sure you are doing this correctly.]***
- *not identifying each isobar with its pressure value (i.e. the isobar value that the line represents)*
- *not kinking the isobars at the fronts*
- *not positioning the point where the warm and cold front connect within the low pressure center (note this doesn't have to be in the center of the low)*

Figure 6.3: Contoured Surface Map <u>without</u> indicating precipitation, H or L pressure centers, and air masses.

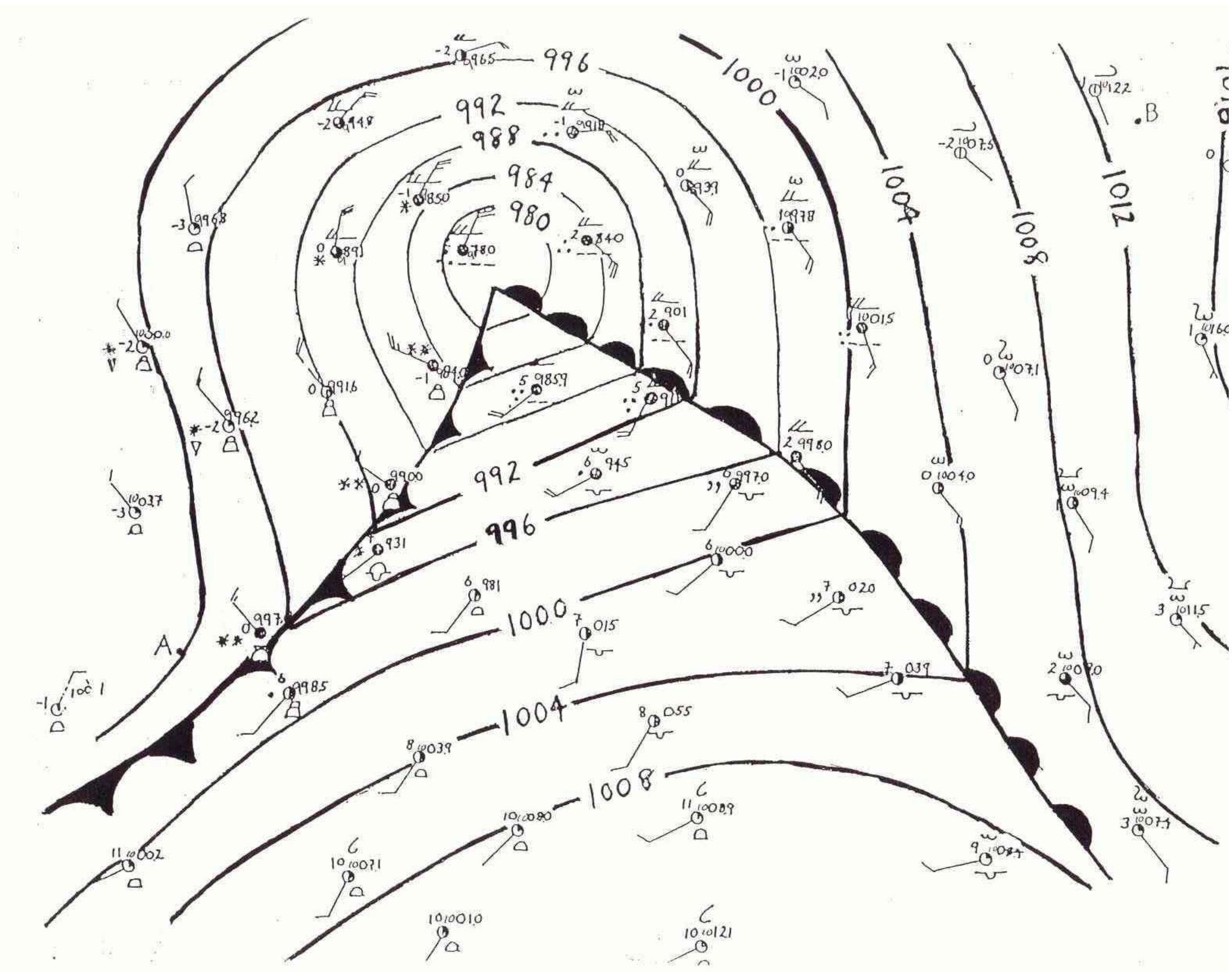
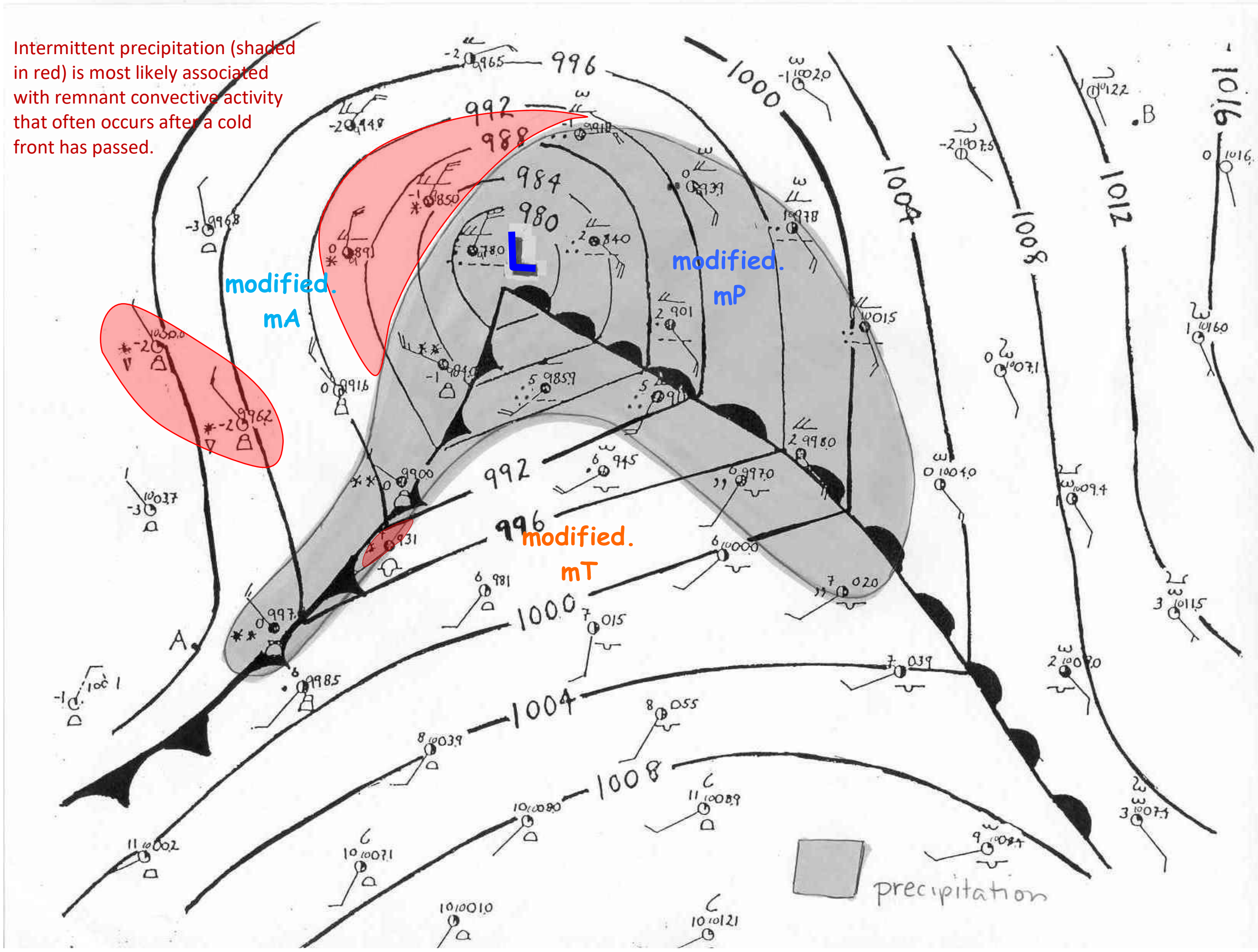


Figure 6.3: Surface map showing continuous precipitation (grey), the ***L*** *pressure center, and most likely air mass types (****mA****,* ***mP****,* ***mT****). Red areas indicate intermittent precipitation and should not be shaded. Note: There are no high pressure centers (H) on this map, but they may exist beyond the map margins.*



1) **If this storm was over the Canadian prairies in the fall, modified versions of maritime Arctic (modified mA), maritime Polar (modified mP), maritime Tropical (modified mT) are most likely.**

Answer Question 1 by eliminating the least likely air masses and picking the most likely ones using their typical source region characteristics and seasonal locations. Use the Surface map's station data (temperature, wind, etc.) and Figure 11.2 (from the course textbook → Ahrens et al. (2nd Ed), 2016, p. 312; also available via the cyclone website Lab 6 links, and table from the Lab 6 instructions). In your analysis, realize that air masses modify as they move from their source regions, and can adopt temperature and humidity characteristics from the regions that they move or sit over (slower movement usually means more change).

Why is the summer air mass diagram a more appropriate model for locating the storm above?

The Surface map temperatures aren't that cold, and summer conditions usually lag into the fall. Usually, the Canadian prairies won't see colder cA air masses until late fall/ winter.

Air Mass	Characteristics	Temperature in Source Region (^{0}C)	Specific Humidity (g/kg)
cA & cAA	very cold very dry (winter)	- 46	0.1
mA	cold moist (winter)	- 11	1.4
mP	cool moist (winter)	4	4.4
cT	warm, dry	24	11.0
mT	warm moist	24	17.0
mE	warm, very moist	27	19.0

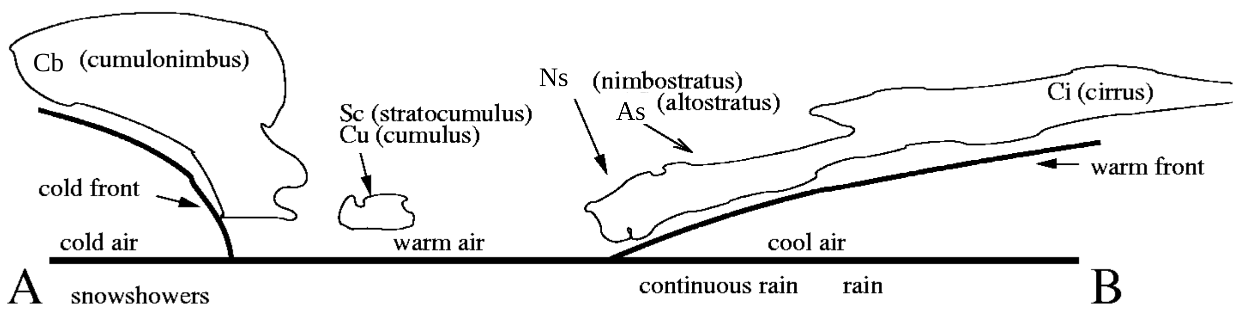
By reasoning, and the process of elimination, the air masses most likely involved in the weather system shown in Figure 6.3 if it were in the Canadian prairies (if having a specific location helps, think southern Alberta / Saskatchewan, i.e. Regina Saskatchewan) during the fall are:

- **modified mT** (maritime tropical; from the south) is the warm air mass (behind the warm front – i.e. between the cold and warm fronts). Reasons, the air mass:
    - matches modified mT source region characteristics;
    - is moving (as determined by Surface map wind flow data) from the south
    - temperatures indicate warmer temperatures in the southern-most part of the system and these are warmer than modified mP but not warm enough and too far away from the source region to be considered modified mE or cT.
- **modified mP** (maritime polar) is the cool air mass (ahead of the warm front, most likely coming from the eastern mP source region). Reasons, the air mass:
    - temperature characteristic's match mP best and they are not that modified
    - comes from the east (see Surface map wind data) and this best matches mP air masses.
- **modified mA (maritime Arctic)** from the north is the cold air mass (behind the cold front). Reasons, the:
    - air mass is modified but the mA source region characteristics matches best even though the air temperatures are not cold enough for cA; and
    - the presence of snow indicates the airmass originated from a colder mA area rather than warmer mP source region (even though the typical location patterns don't follow those shown in text Figure 11.2.)

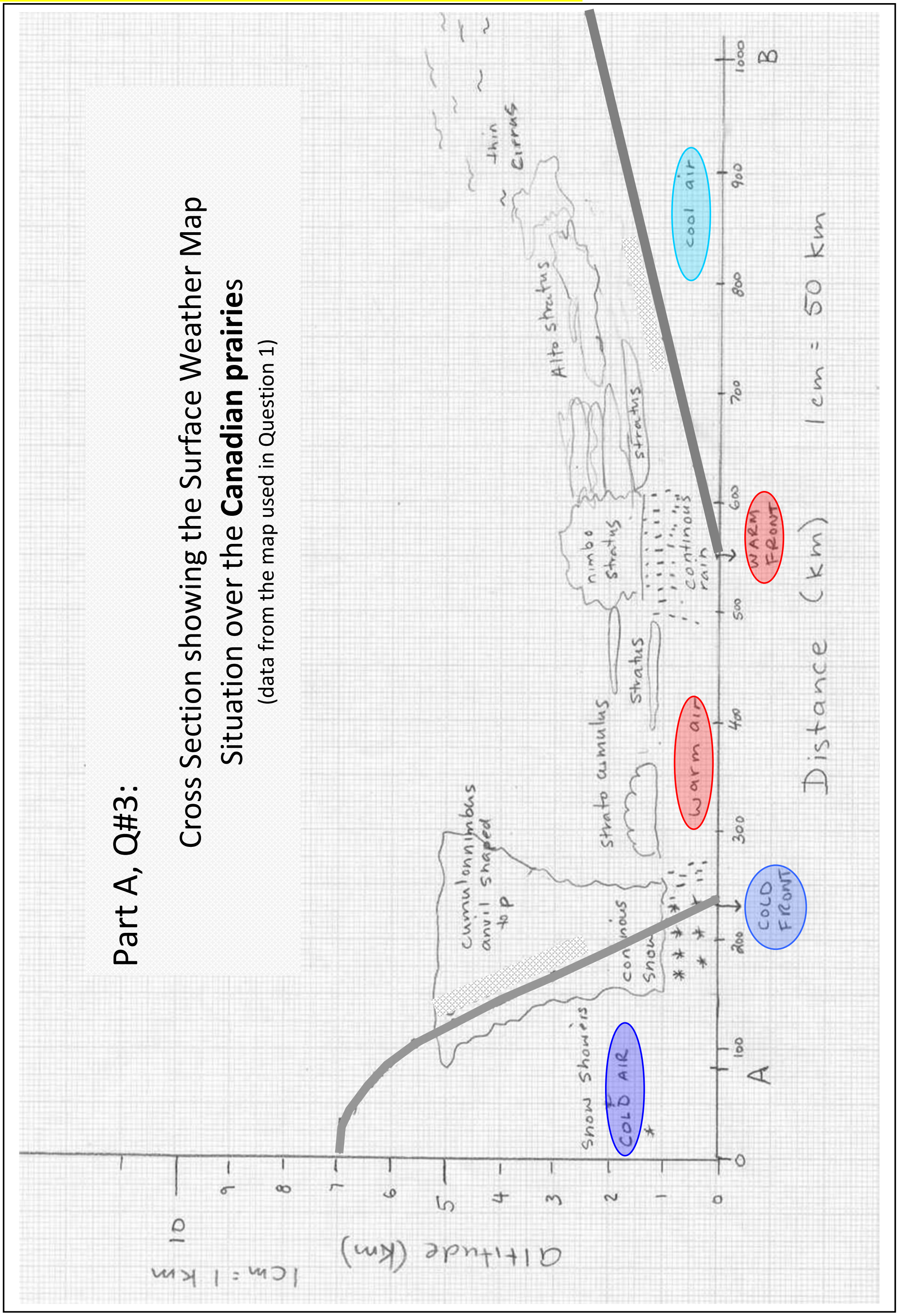
2) *Answer Question 2 by interpreting the Surface map station symbol data. The weather along the cold front occurs because the faster moving, denser cold air forces the warm air it moves into, to rise and condense.* This causes convective clouds - cumulus, (Cu), towering cumulus (TCu), and cumulonimbus (Cb) at the front; a shift in wind direction; a change from warmer to cooler temperatures; and variable, short lived but intense snow shower (precipitation) at the cold front. *If standing on the surface, an observer would experience: winds changing from weaker southwesterly flows to stronger northwesterly flows, showery snowfall of varying intensity that occurs over a short period of time, and then clearing skies with winds decreasing and cooler temperatures as the cold front passes.*

3) *Answer Question 3 by producing a cross section like that in the figure below but scaled to represent the Surface map's weather features and their locations (see the example answer on the next page). Your cross section's distance scale should be the same as that given on Lab 6, Figure 6.3 (1 cm = 50 km). See your instructor if you don't know how to transfer map data to a cross section and preserve the original map scale and feature locations). The vertical axis (altitude) scale is given in the question as 1 cm of the graph = 1 km of altitude in the sky (vertical scales are usually exaggerated). Note: a cold front is often represented as a curved line because the denser cold air tends to hug the surface more than warm air (associated with warm fronts). Text figures of warm and cold fronts can also help visualize this situation.*

These key features should be included on your cross section but they should match the weather station information as seen on the cyclone in Figure 6.3. See the next image for an example Lab 6 answer.



Example Question 3 answer showing the Fig. 6.3. A to B profile (or cross section). Note: 1) The slopes of the warm and cold fronts are numerically correct (however, your cold front is most likely a straight line). 2) Front symbols (barbs and teeth) should not be shown along the sloped lines. (This is because fronts are only defined where they touch the ground, not in the sky.) 3) Cloud and current weather information matches Fig. 6.3 weather symbol locations. 4) Relative air mass temperatures are correctly labeled.



Part B Answers:

These answers are based on linking and interpreting the stacked time series graph (Lab 6, Figure 6.5) and features on the synoptic map (Lab 6, Figure 6.4). The annotated stacked time series graph below will aid you in identifying the weather features. When answering these questions remember the following:

- *Figure 6.5: Many of the time series 1observations are continuously recorded, but precipitation is not. Each precipitation point only represents the previous 6-hour period. The wind direction symbol is best thought of as a wind sock, filling from the large end to the small point, and the North arrow* (N↑) *symbol on the axis label indicates that North is at the top of the page. Wind direction always is "the direction the wind is coming from". For example: If the sock points to the top of the page, the wind is coming from the south; it is a southerly flow.*
- *Figure 6.4: The map shows the situation in Vancouver at a specific local time, Pacific Standard Time (PST). Knowing the map's time, you can connect the stacked time series data with the map and see the synoptic weather situation that is captured by the data in Figure 6.5 at the same time.*

1) To the nearest hour the….

a) **warm front passed through Vancouver on:** Dec. 20 @ 20:00 hours (~8 p.m.).

Reasons /evidence, the:

- Synoptic surface map for 4 PM shows an advancing warm front should hit Vancouver before a cold front, and that neither fronts have reached Vancouver by 4 PM.
- Winds shift from an easterly to a southerly flow which is characteristic of the passage of a warm front; these winds agree with what is shown by the isobars on the Figure 6.4 synoptic map. [Note that you also saw the same pattern of surface wind direction and isobar shape when contouring your Surface map (Figure 6.3) in Part A. Seeing a similar storm in Figure 6.4 and the stacked time series graph (Figure 6.5) indicates how surface winds and isobars are related.
- Pressure drops
- Temperatures increase and these increases are not connected to solar radiation inputs as in December, sundown in Vancouver occurs at ~ 4 p.m.
- Continuous cloud cover pattern occurs at the same time as very low incoming solar (K↓) values
- Precipitation occurs in advance of, and connected with the front's passage. The precipitation is continuous, occurs over a longer time period, and is fairly heavy; this is consistent with the passage of a warm front. This aligns with passing warm front models.
- Sharp increase in RH is not matched by as strong a temperature drop, (when RH and temperature are not inversely related, real changes in moisture can be interpreted).

To the nearest hour the….

b) **cold front passed through on:** Dec. 21 @ 02:00 hours (2 a.m.)

Reasons /evidence, the:

- Synoptic surface map for 4 p.m. shows that a cold front should hit Vancouver after the warm front has passed, and that neither of these have reached Vancouver by 4 p.m.
- Winds shift from a southerly to a westerly flow which is characteristic of the passage of a cold front; these winds concur with the pressure pattern shape shown on the synoptic map (see answer 1a above as the same explanation applies here)
- Pressures are increasing as the low pressure centre has moved over Vancouver
- Cloud cover is breaking up and scattered after the cold front passes (also note the greater incoming solar (K↓) values after sunrise later on Dec. 21st)
- Air is drier, seen by a drop in the RH values which does not inversely correspond to a temperature change at the same time (i.e. this indicates a real change in humidity)

- Precipitation is smaller in total amount, and occurs after the wind shift associated with the front's passage. It appears as 2 smaller precipitation amounts on Dec. 21, and because precipitation is only measured every 6, hours it is difficult to precisely time the precipitation inputs. For example, from the recorded data you can't tell if it rained just after 22:00 hours on Dec 20, just before 4 a.m. on Dec. 21, or sometime in between. Similarly, for the second precipitation input, it may have occurred any time between 4 a.m. and 10 a.m. on Dec. 21.

  Given the data collection method, you may also correctly imagine that all the precipitation fell at about the same time and it was measured over 2 observing times.

  Or alternatively, by looking at the minor wind veer at ~10 a.m. which is associated with a rise in wind speed, an increase followed by a decrease in cloud cover, and later the second input of precipitation, it is more likely that the second precipitation resulted from a large /deeper convective cloud passing over as the cold front continued to move past Vancouver. This is a common pattern of convective activity after a cold front passes an area.
- Temperatures decrease (continuously and gradually - frequently observed with cold fronts), though because this is occurring overnight it is hard to distinguish it from regular nighttime cooling patterns and clearing skies after a cold front; so it may not be a strong indicator of cold front passage in this example.

c) Detailed evidence for each front's passage is given in the answers above.

2) Weather activity explanations for:

a) Why did the maximum temperature for Dec. 20 occurred between 20:00 hours and 23:00 hours, when normally maximum temperatures occur in the afternoon?
Answer: Vancouver now lies in the warm air sector between the warm and cold fronts

b) What causes the relative humidity to become noticeably lower on Dec. 21?
Answer: A change in the air mass. The cold front air mass has lower moisture content. This is reflected in the drop in RH which is not associated with a rise in temperature as seen later in the RH and temperature time series data record.

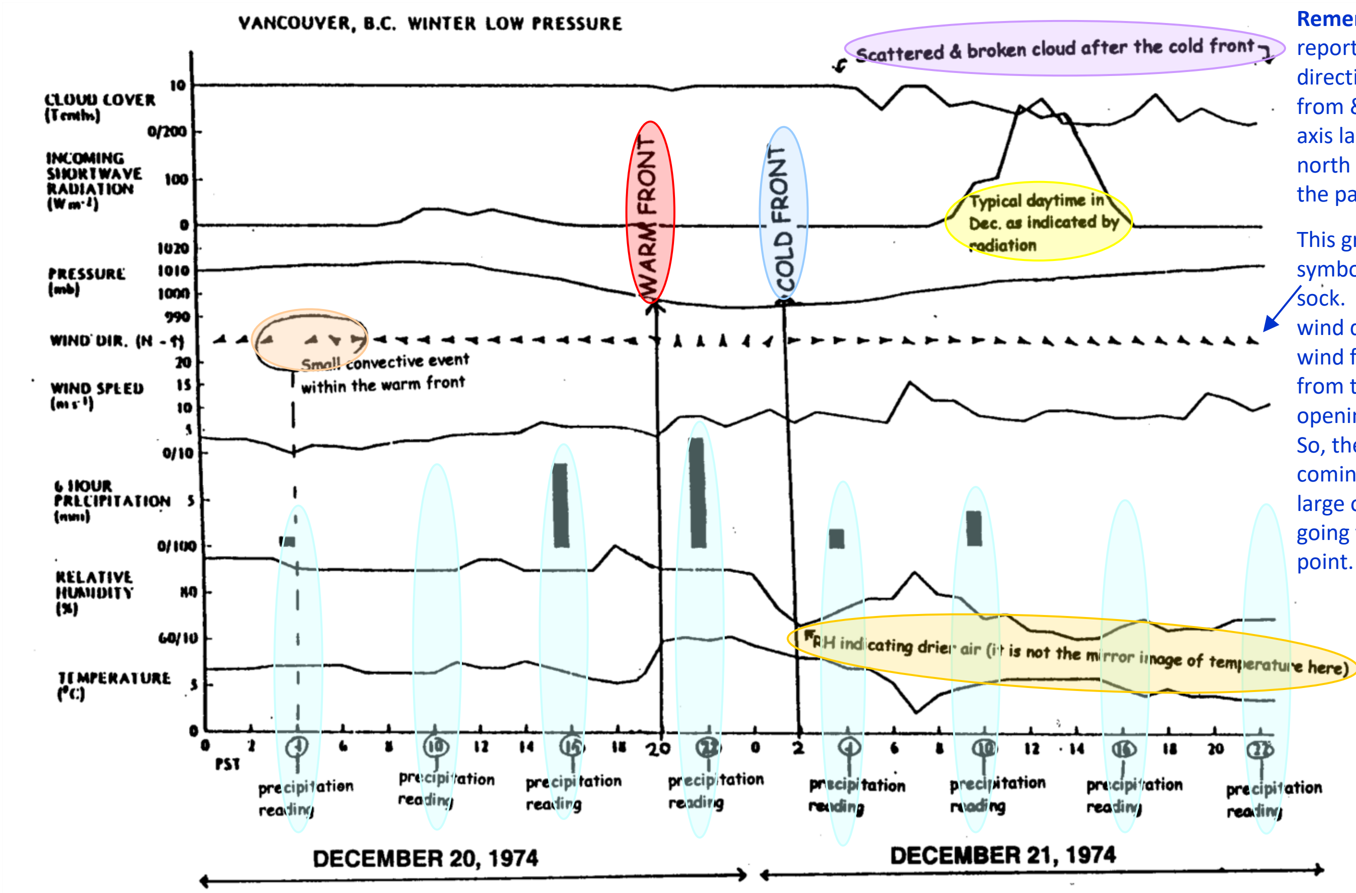
c) What causes the increase in radiation values and decrease in cloud cover on Dec. 21?
Answer : Clearing or cloud cover breaking up. The cold front is associated with cumulus clouds and not stratus /nimbostratus which are associated with the warm front. Cumulus (convective) clouds are scattered and have clear breaks so incoming solar can change rapidly from very low to very high values.

3) Does the following precipitation result from frontal or convective activity? Why?

a) **Precipitation late on Dec. 20:** Frontal, because the time series indicates weather patterns associated with warm front passage (precipitation in advance of the front, etc.. See Question 2b) above.)

b) **Precipitation early on Dec. 21** (between 2-4 a.m.)**:** Both frontal and convective, as cold fronts produce higher convective activity as they force air to rise. Inferred from the wind shift, briefer duration of precipitation, air mass moisture changes, etc.. See Question 2b) above. [As indicated above, the precipitation occurring near 10 a.m. on Dec. 21 is likely completely convective (inferred from the large wind speed increase just before the precipitation, decreasing but scattered cloud cover, and a very small wind shift (wobble) just before the precipitation.]

Figure 6.5 with annotations indicating the sequence of fronts passing Vancouver between Dec. 20 and 21



Remember: Wind is reported as the direction it comes from & the (N - ↑) axis label means north is the top of the page.

This graph's wind symbol is a wind sock. It shows the wind direction by the wind filling the sock from the large opening to the point. So, the wind is coming from the large opening and going toward the point.

Graph showing multiple time series plots which indicate the weather conditions observed at Vancouver during the passage of a winter low pressure system (December 20 to 21, 1974); the system is moving from the Pacific Ocean toward British Columbia. Source: Climate of Vancouver, J. Hay and T. Oke; reproduced with the authors permission.

Fig. 6.4: Surface synoptic map for 4 p.m. Dec. 20, 1974. Vancouver is the pink dot.