Chapter 13. Air masses and fronts

TABLE 13.1 | Air-mass classification.

Air-Mass Name	Air-Mass Symbol	Characteristics	Source Region
Continental Arctic (Continental Antarctic)	cA (cAA)	very cold and dry very stable	Arctic and Antarctic (winter only)
Continental Polar	cP	cold and dry stable in winter slightly unstable in summer	high-latitude continents and ice-covered oceans
Maritime Polar	mP	cool and moist unstable	high-latitude oceans
Maritime Tropical	mT	warm and moist unstable on west side of oceans stable on east side of oceans	subtropical oceans
Continental Tropical	cT	hot and dry very unstable	subtropical deserts (summer only in North America)

- body of air with rather uniform T, T_d over large horizontal distance; air-masses are separated by narrow boundary zones, ie. “fronts”

- originate by having stagnated (light winds, anticyclonic conditions) in a geographically uniform “source region,” where surface exchange of energy and moisture conditions the character and stability of this mass of air

- in mid latitudes strong spatial variation in *T, P* (etc.) results in strong winds. In mid-latitudes therefore we have a transition zone: air masses invade, confront each other across fronts, are modified… producing “weather”

- concept of “air-mass weather” – static – because one is in the interior of an air-mass: diurnal changes persist, driven by the surface energy budget

- passage of a front is a significant weather event – large sudden change

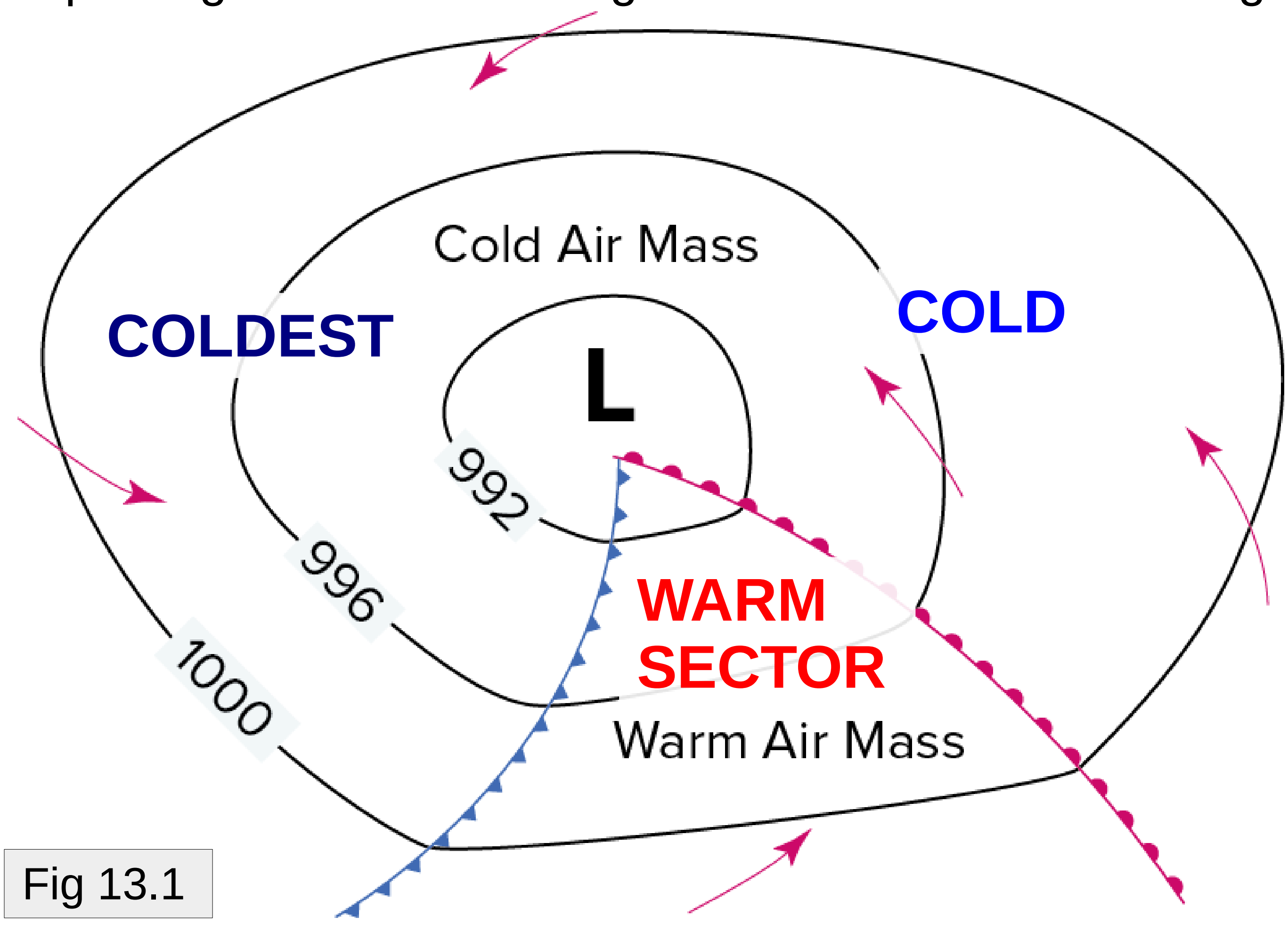


Fig 13.1

Thermal contrast across cold front typically stronger than across cold front

Temperature contrast between two air masses implies gravitational potential energy to fuel a midlatitude storm

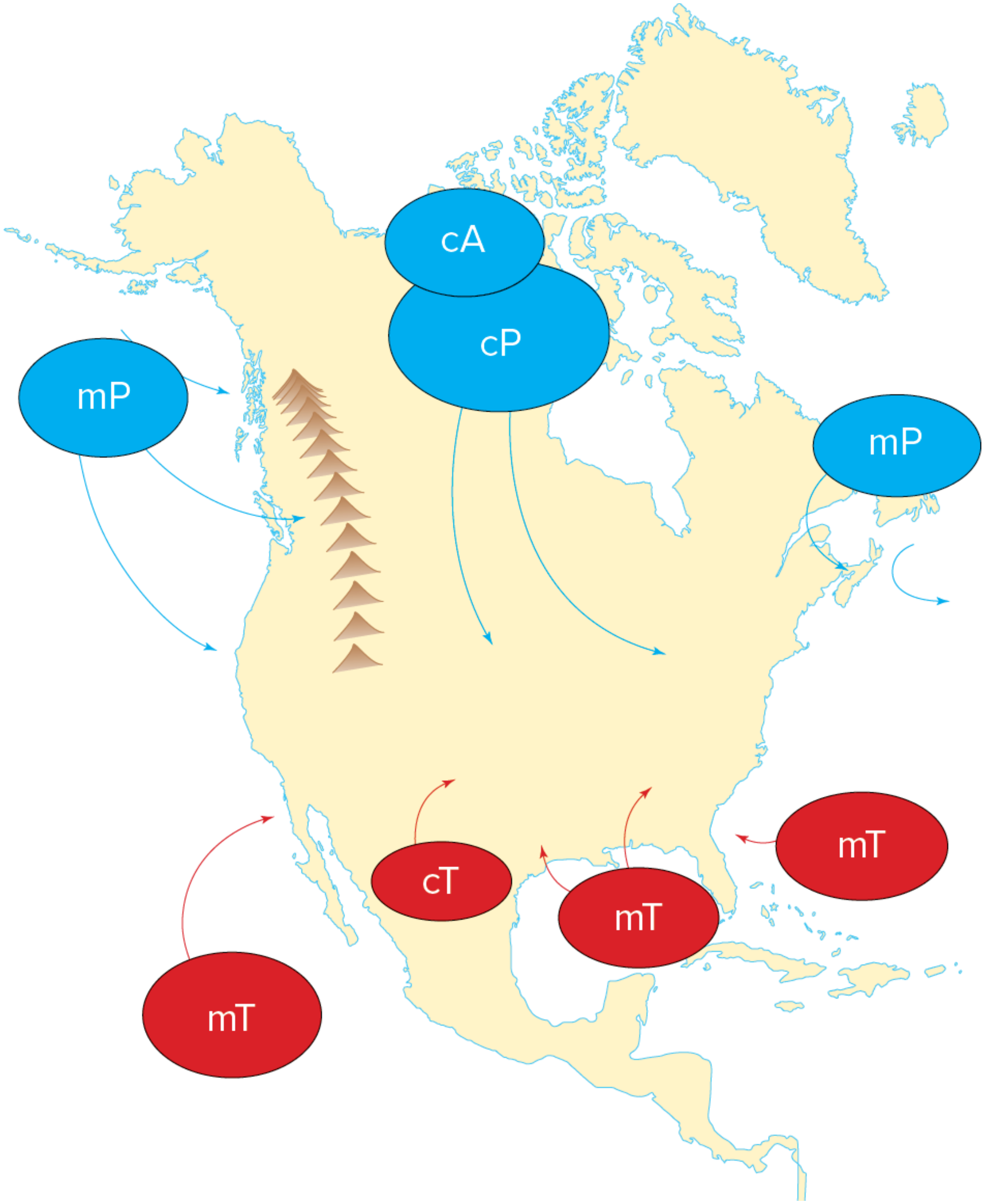


Fig 13.3

Winter weather in Cdn prairies dominated by cA and (modified) mP air masses... the Chinook is associated with incursion of mP air

Atlantic mP air masses affect east coast of N. America less often than Pacific mP affects the west coast (due to generally westerly mid. latitude wind)

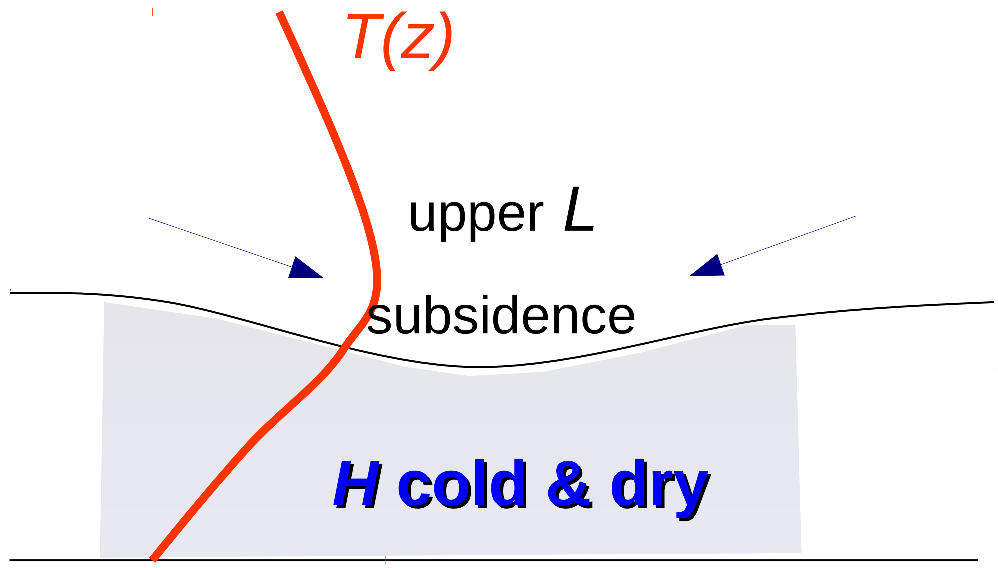
Advected onshore by NE winds (typically due to lows moving up the east coast), Atlantic mP air tends to be cold and moist

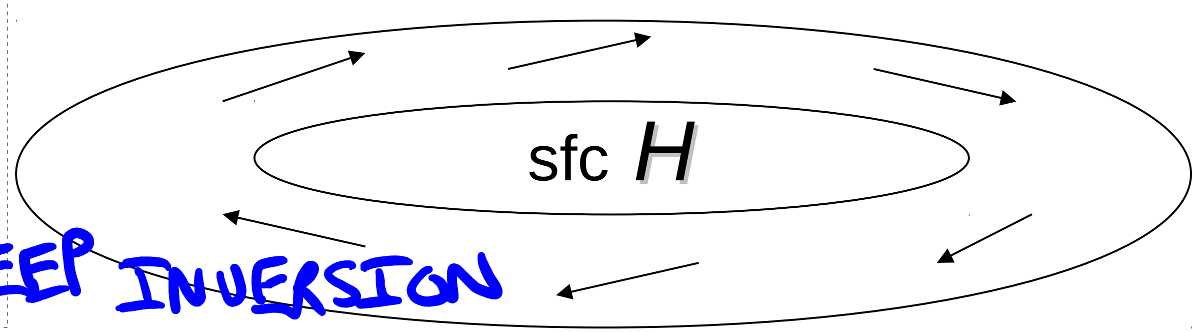
High latitude, winter :

- long (or perpetual) night, low (or no) sun
- snow cover – high albedo
- K^* small or zero
- dry, little or no cloud
  $L\downarrow < L\uparrow$ $(L^* < 0)$
- Therefore $Q^* < 0$ on 24 hour avg
- $Q_H \approx Q^* < 0$
- air mass cools from base
- very stable – poor mixing
- continues for days → DEEP INVERSION

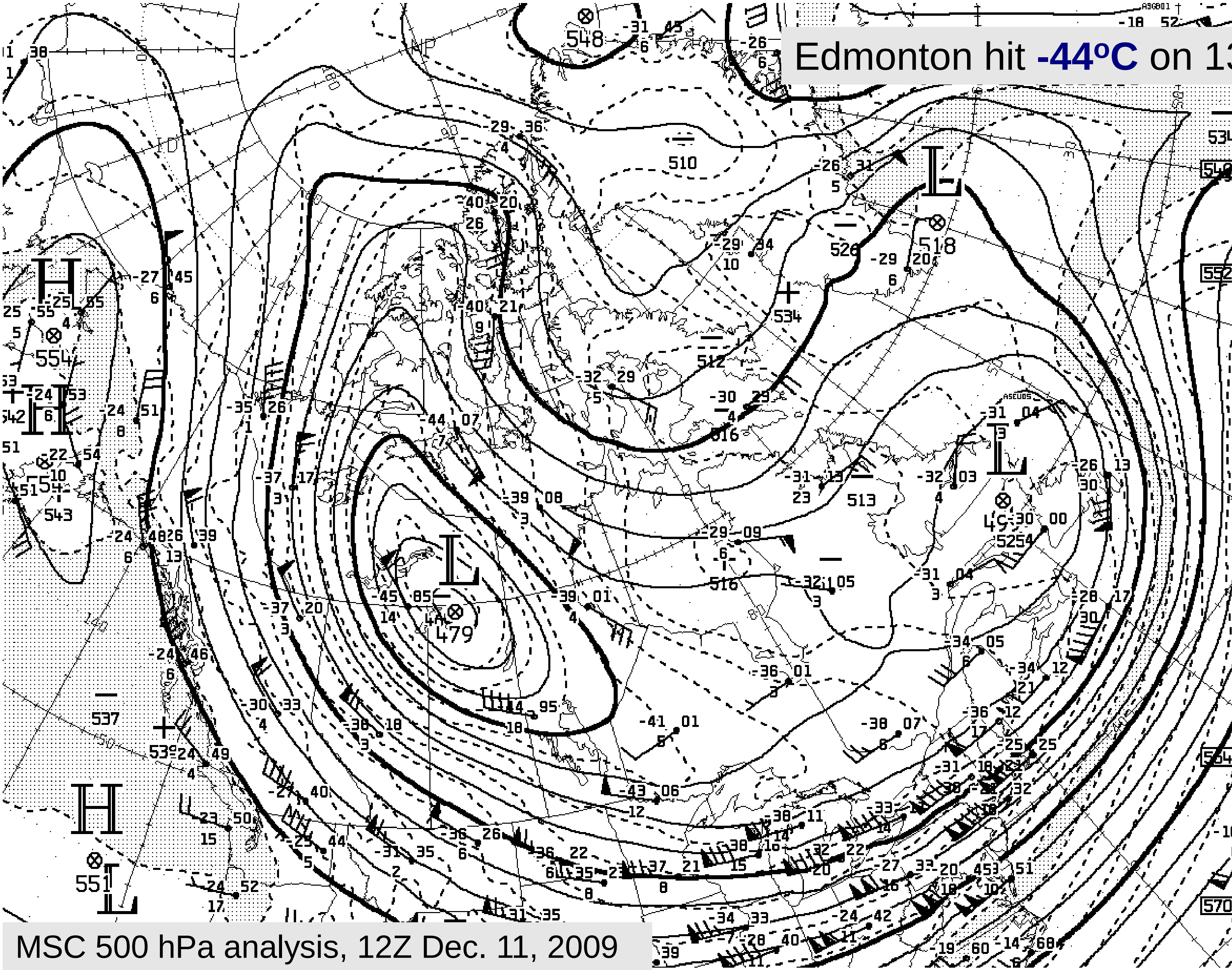
In summer: same source areas produce cP... less extreme, not so dry

- daytime heating erases inversion
- conditionally unstable

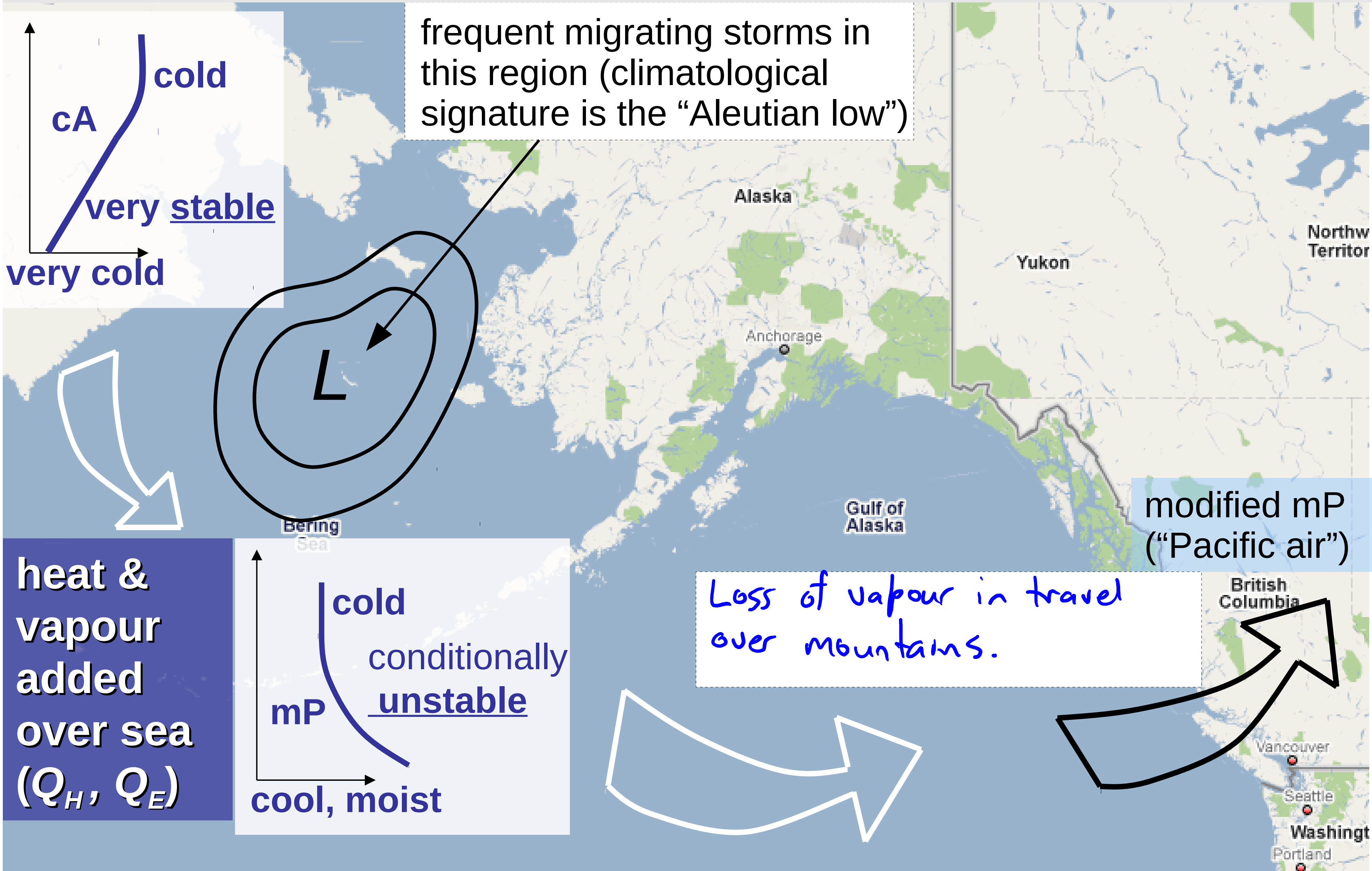




Edmonton hit **-44ºC** on 13 Dec.



MSC 500 hPa analysis, 12Z Dec. 11, 2009



Air masses are constantly being modified/moderated by surface exchange, as well as by internal mixing, phase changes & precip,…

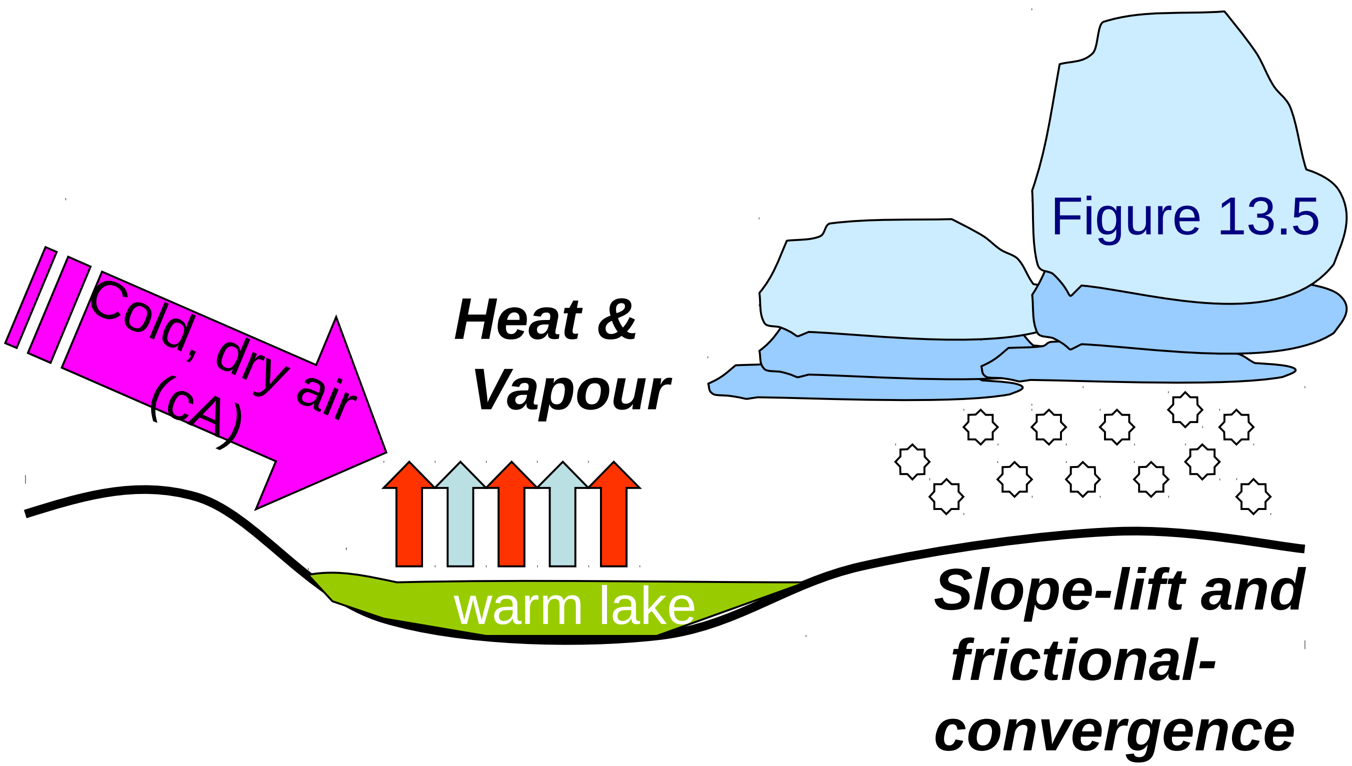
- ice-free lake
- maximal $T_{\text{water}} - T_{\text{air}}$
- long overwater fetch

} accentuate possibility for lake effect snowfall

Youtube link – Lake Effect clouds at Buffalo Nov. 2014...

www.youtube.com/watch?v=KA9XNRHxKbg

(Thanks to Max Lorsignol)



(a similar effect occurs when a continental winter airmass flows offshore onto the ocean & resulting in convection)

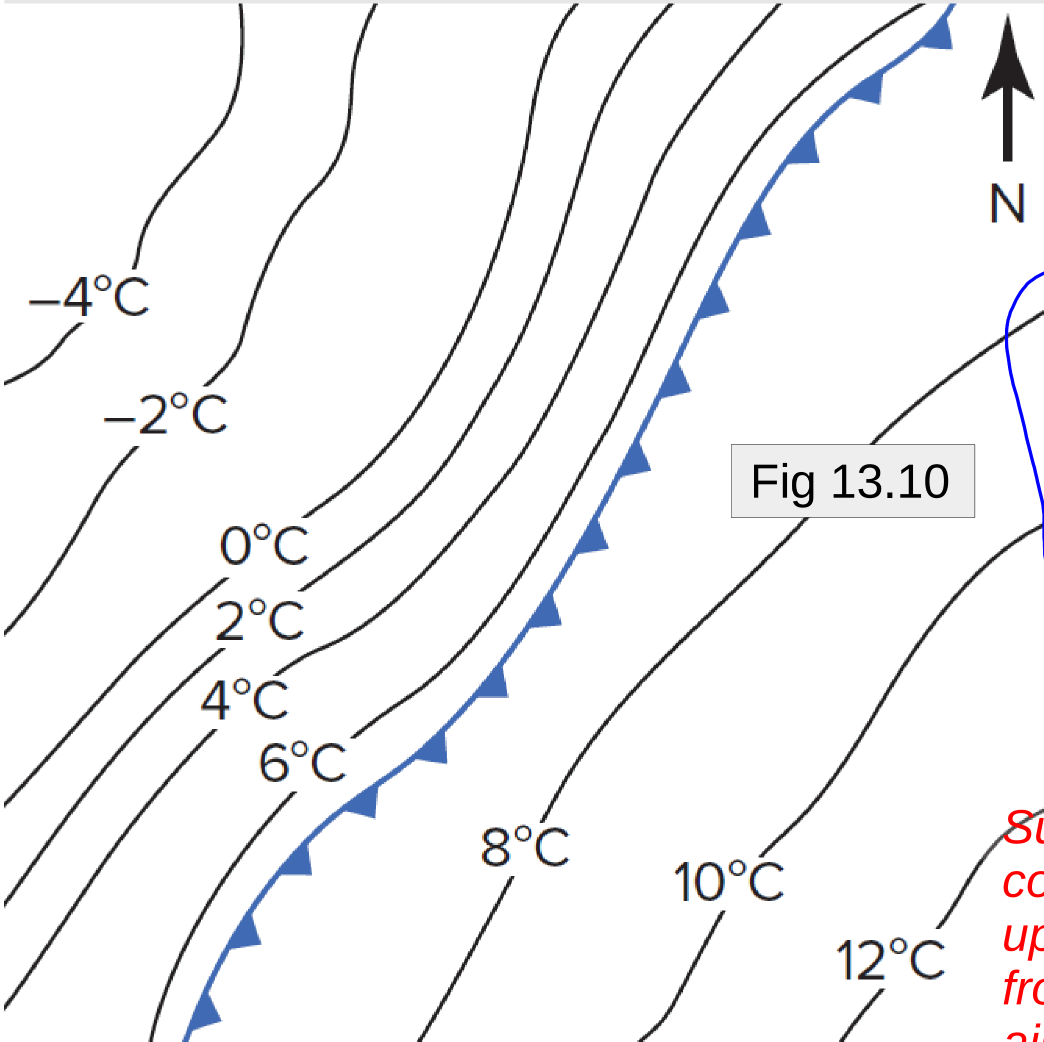
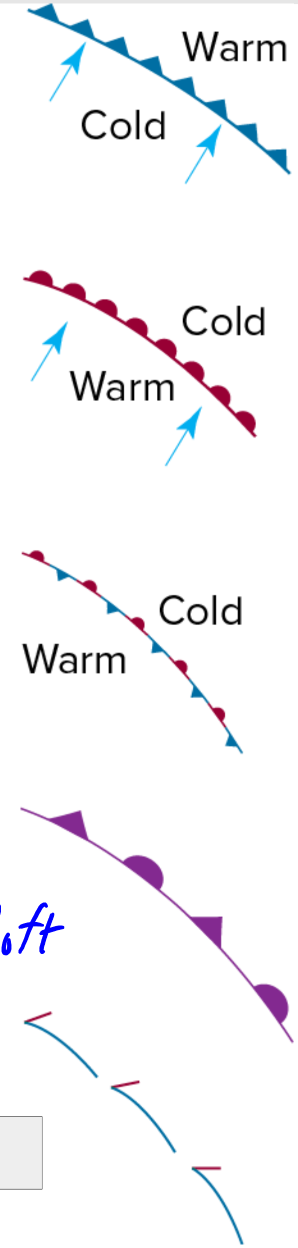


Fig 13.10

Front is a zone, ~ 100 km wide, not a discontinuity

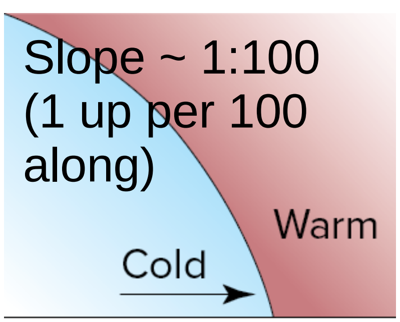
Gravity would "like" the frontal surface to lie horizontal



Sufficient detail: cold front catches up with warm front, warm sector air squeezed aloft

Trough of warm air aloft
=
TROWAL

Fig 13.9



a)

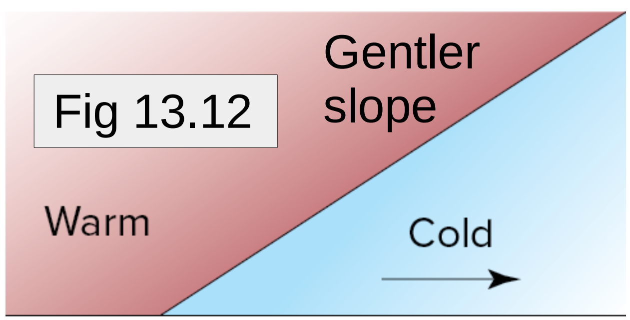


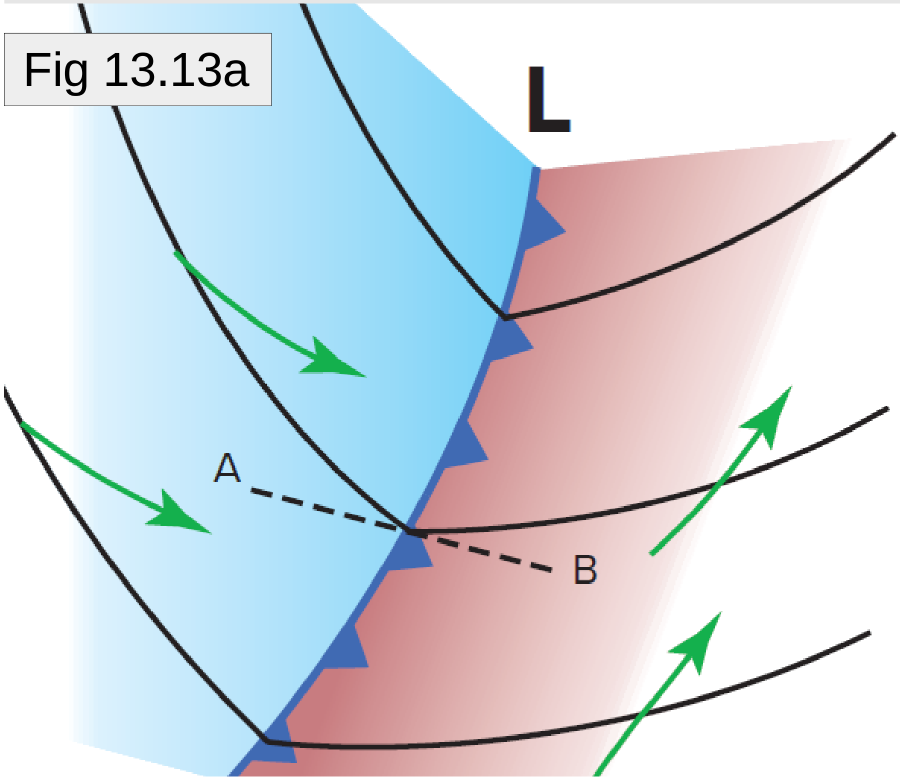
Fig 13.12

b)

Cold front – cold air advancing at front

Warm front – warm air advancing at front

Fig 13.13a



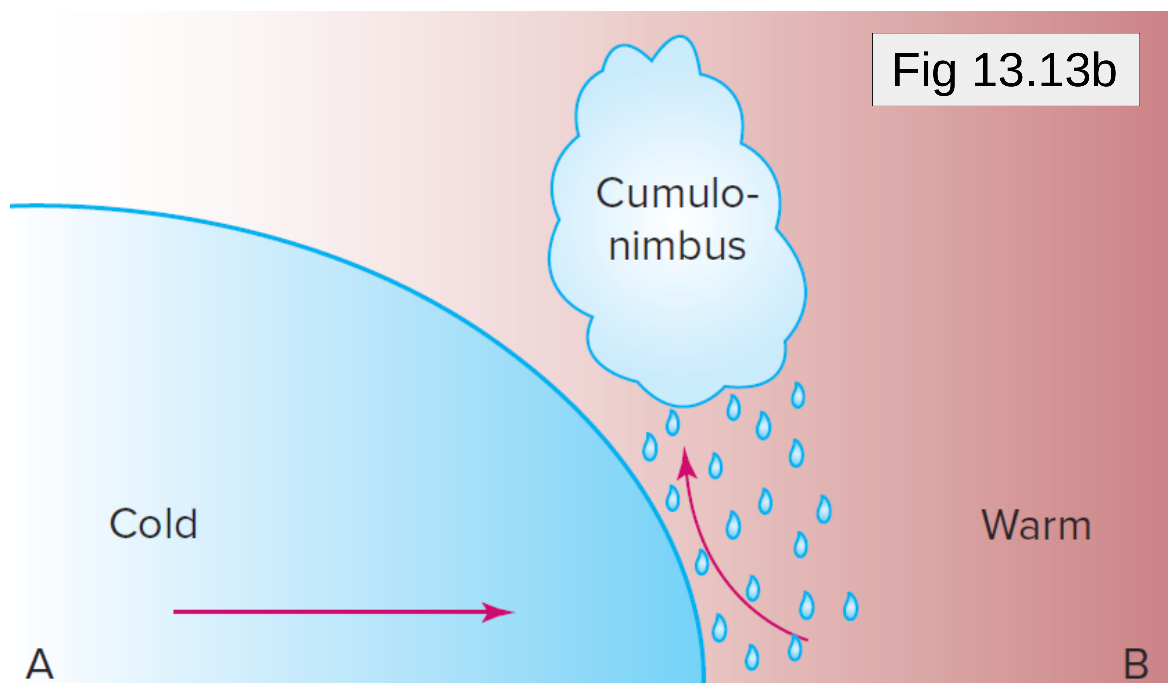
indicative of nature of the changes

	A	B
Temperature (°C)	1°C	7°C
Dew Point Temperature (°C)	−5°C	5°C
Wind Direction *	WNW	SSW
Pressure	Rising	Falling
	Clear Skies	Clouds and Rain

FRONT LIES IN KINK OF ISOBARS

On transect from A to B, lowest pressure occurs at the front.

Fig 13.13b



indicative only

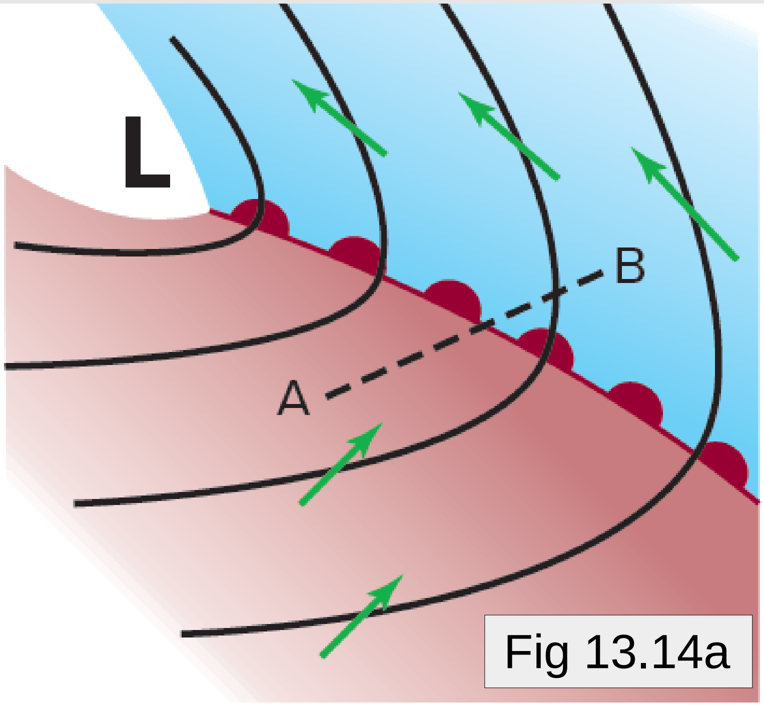


Fig 13.14a

	A	B
Temperature (°C)	20°C	18°C
Dew Point Temperature (°C)	17°C	9°C
Wind Direction (N. hemisp.)	SSW	ESE
Pressure	Slight Increase	Falling
	Scattered Cloud	Clouds and Rain

- Front runs along the trough (kink in isobars)

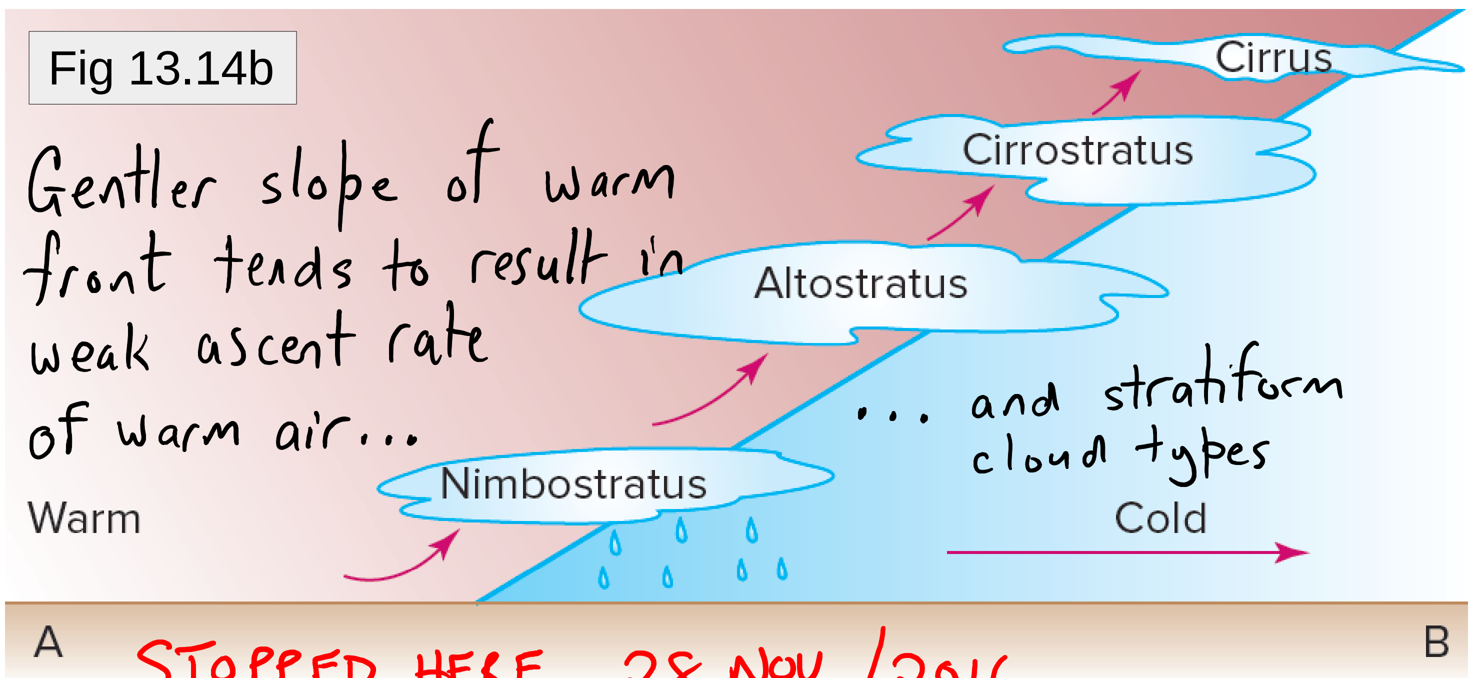
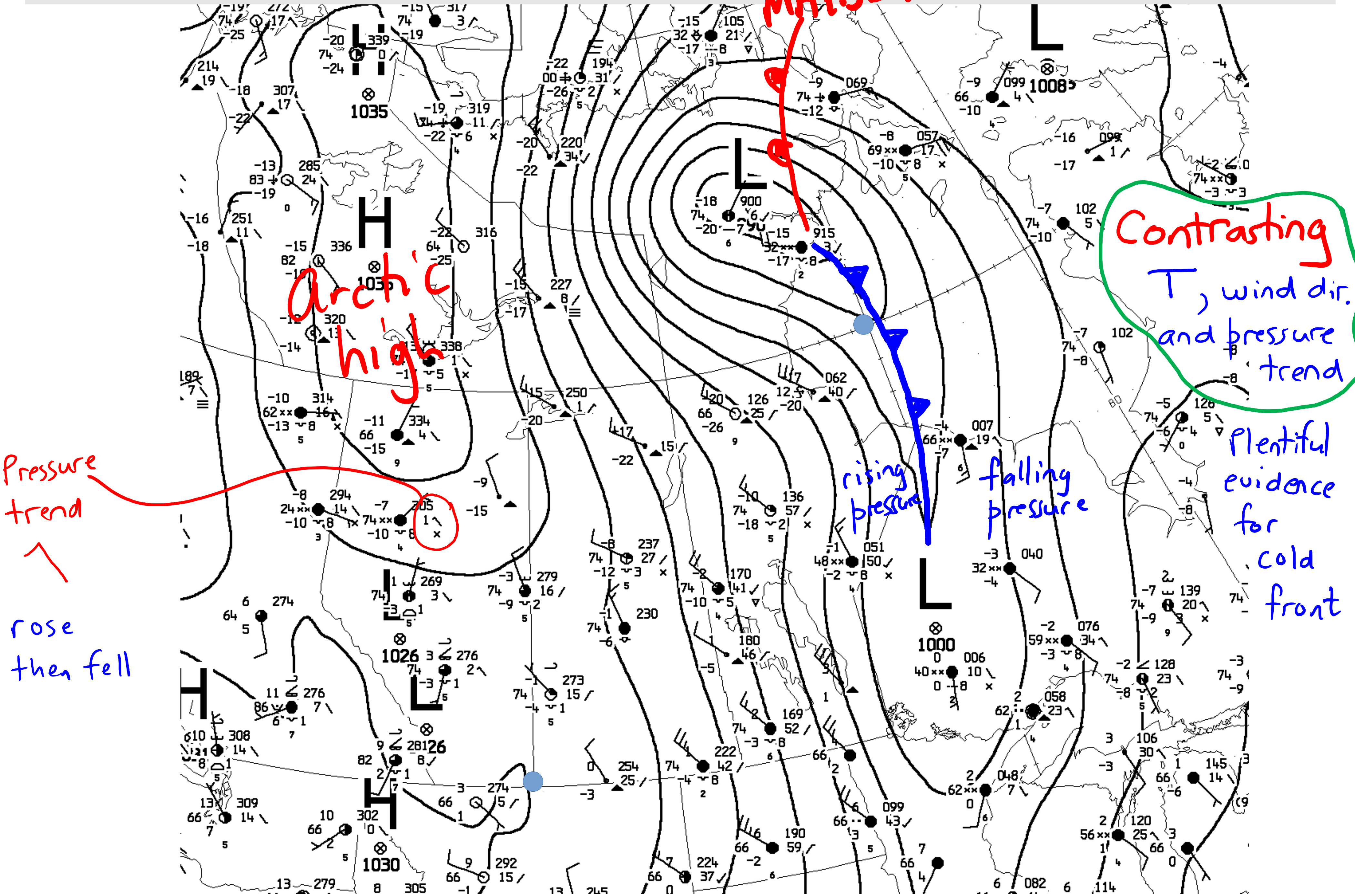
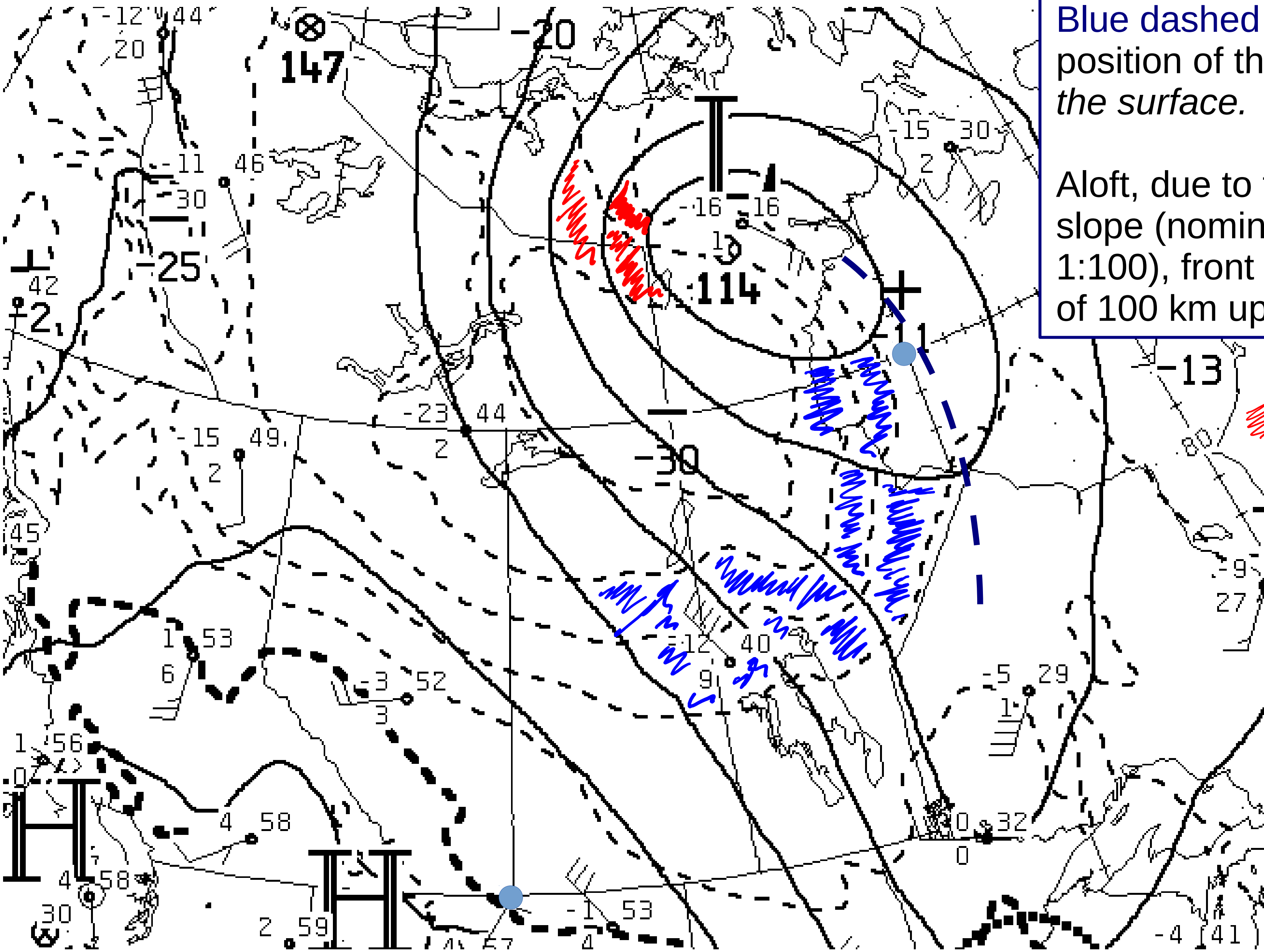


Fig 13.14b


MAYBE! a warm front too?
arctic high
Pressure trend
rose then fell
rising pressure
falling pressure
Contrasting T, wind dir. and pressure trend
Plentiful evidence for cold front
1035
1035
1026
1030
1000
1008



Blue dashed line is the position of the front *at the surface.*

Aloft, due to frontal slope (nominally 1:100), front is of order of 100 km upstream

CMC 850 hPa analysis 00Z 8 Saturday November 2014

- large ΔT over short distance (packed isotherms)

- large ΔT_d over short distance

- sudden change in wind direction

> - *rare to see <u>all</u> of these signs*
> - *somewhat subjective*
> - *no two fronts are exactly alike*

- sudden change in sign or magnitude of pressure trend $\Delta P / \Delta t$

- cloud and precipitation pattern

- front located along troughline (ie. along kink or bend in isobars)

As a front sweeps by, these spatial changes are experienced as a rapid temporal change.

Signs of cold frontal passage in Alberta: suddenly gusting wind turns from SE or S or SW towards W or NW; rapid cooling; clearing follows; pressure begins to rise

Topics/concepts covered

- the five named air masses
- concept of "air-mass weather"
- mechanism to produce a cA air-mass
- the arctic vortex & arctic outbreak (shallow dome of cA air)
- generalities of air-mass modification; examples (Chinook; lake effect snow)
- types of fronts and their symbols
- identifying features and weather characteristic of cold & warm fronts