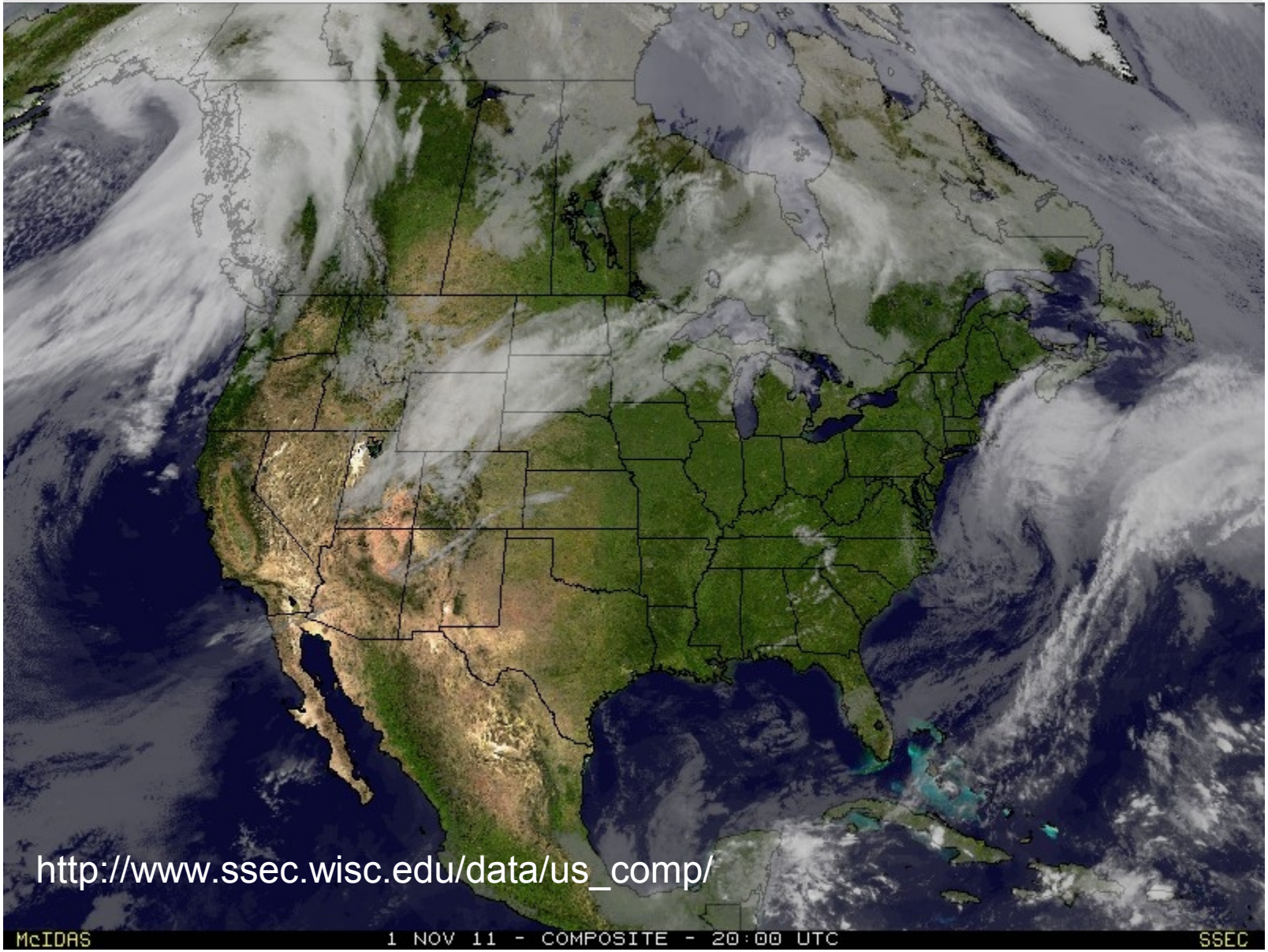
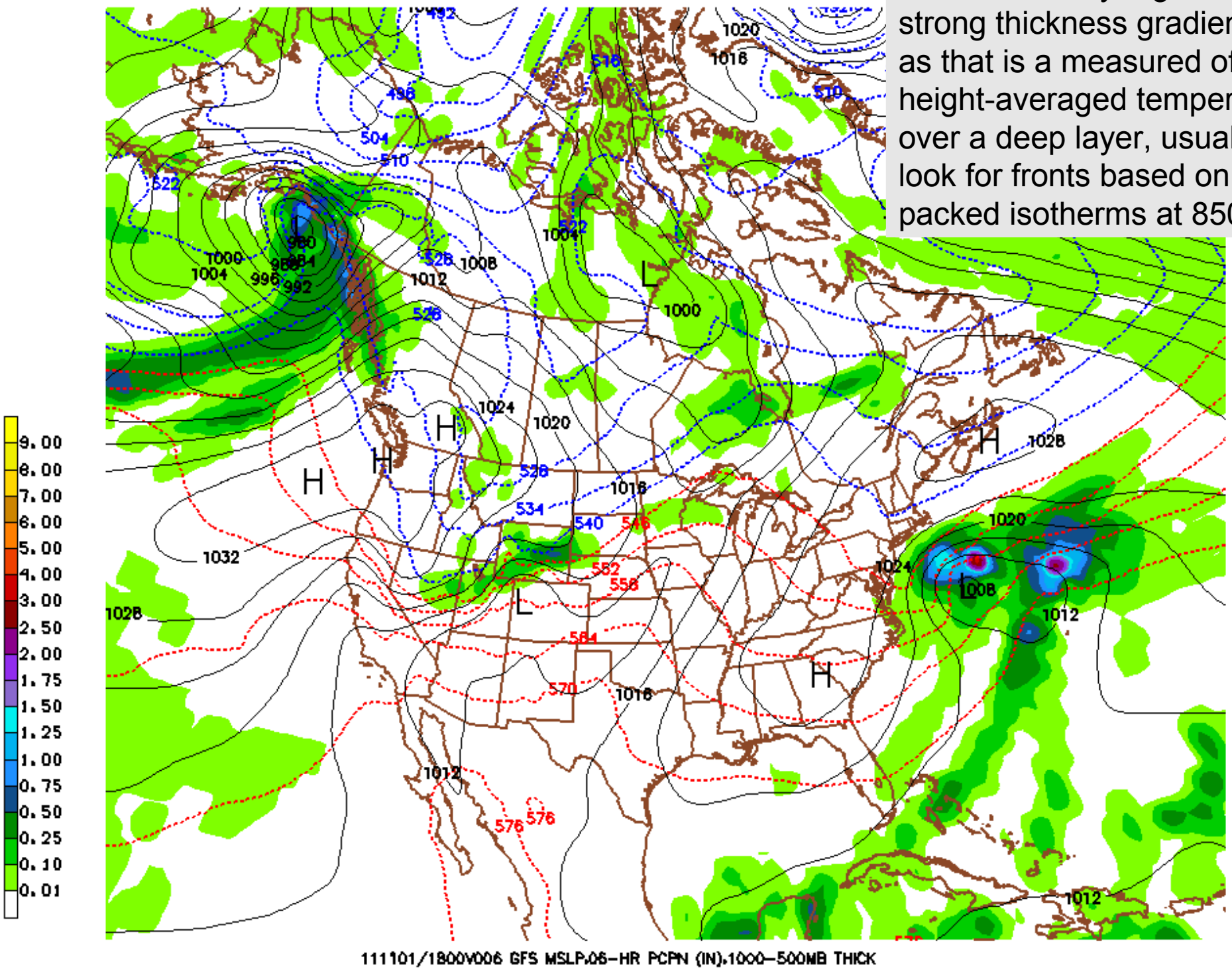
Goals for today:

2 Nov., 2011

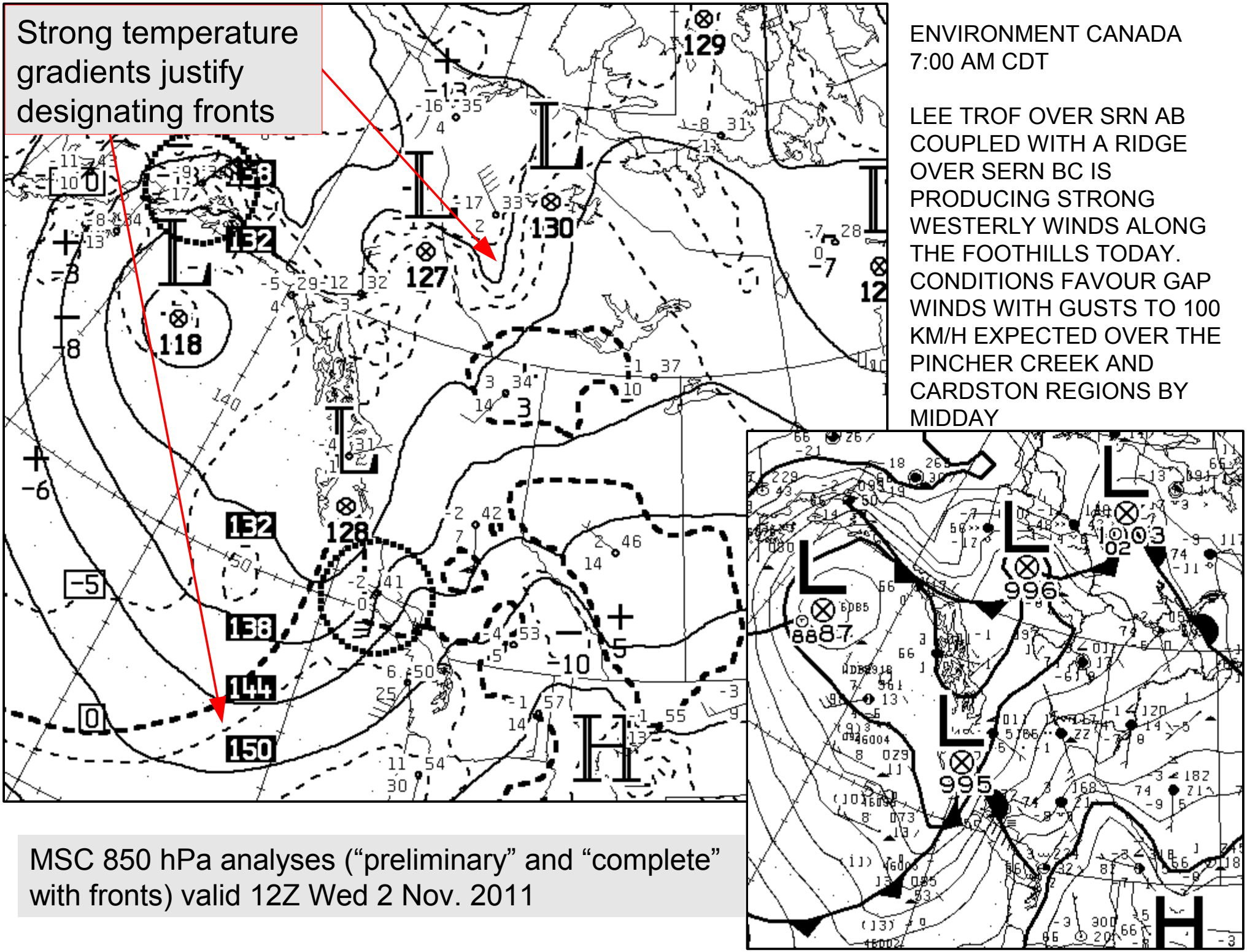
- Ch 9: Airmasses & Fronts



Note the strong correlation with the 6 hr forecast on the next page



We can identify regions with strong thickness gradient, but as that is a measured of height-averaged temperature over a deep layer, usually look for fronts based on packed isotherms at 850 hPa


Strong temperature gradients justify designating fronts
ENVIRONMENT CANADA
7:00 AM CDT
LEE TROF OVER SRN AB COUPLED WITH A RIDGE OVER SERN BC IS PRODUCING STRONG WESTERLY WINDS ALONG THE FOOTHILLS TODAY. CONDITIONS FAVOUR GAP WINDS WITH GUSTS TO 100 KM/H EXPECTED OVER THE PINCHER CREEK AND CARDSTON REGIONS BY MIDDAY
MSC 850 hPa analyses (“preliminary” and “complete” with fronts) valid 12Z Wed 2 Nov. 2011

Airmass

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

- originates by having *stagnated* (light winds, anticyclonic conditions) in a geographically uniform “source region,” where surface exchange of energy and moisture has conditioned this large, deep mass of air

Airmass

• in mid latitudes there is strong spatial variation in *T, p* (etc.) and (thus) 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 “airmass weather” – static, because one is in the interior of an airmass: diurnal changes only

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

Airmass Classification

Source Region	Polar (P)	Tropical (T)
Continental (c)	cP cold,dry, clear,stable	cT hot, dry, unstable near surface
Maritime (m)	mP cool,moist cloudy, cndtly unstable	mT warm, moist; usually cndtly unstable

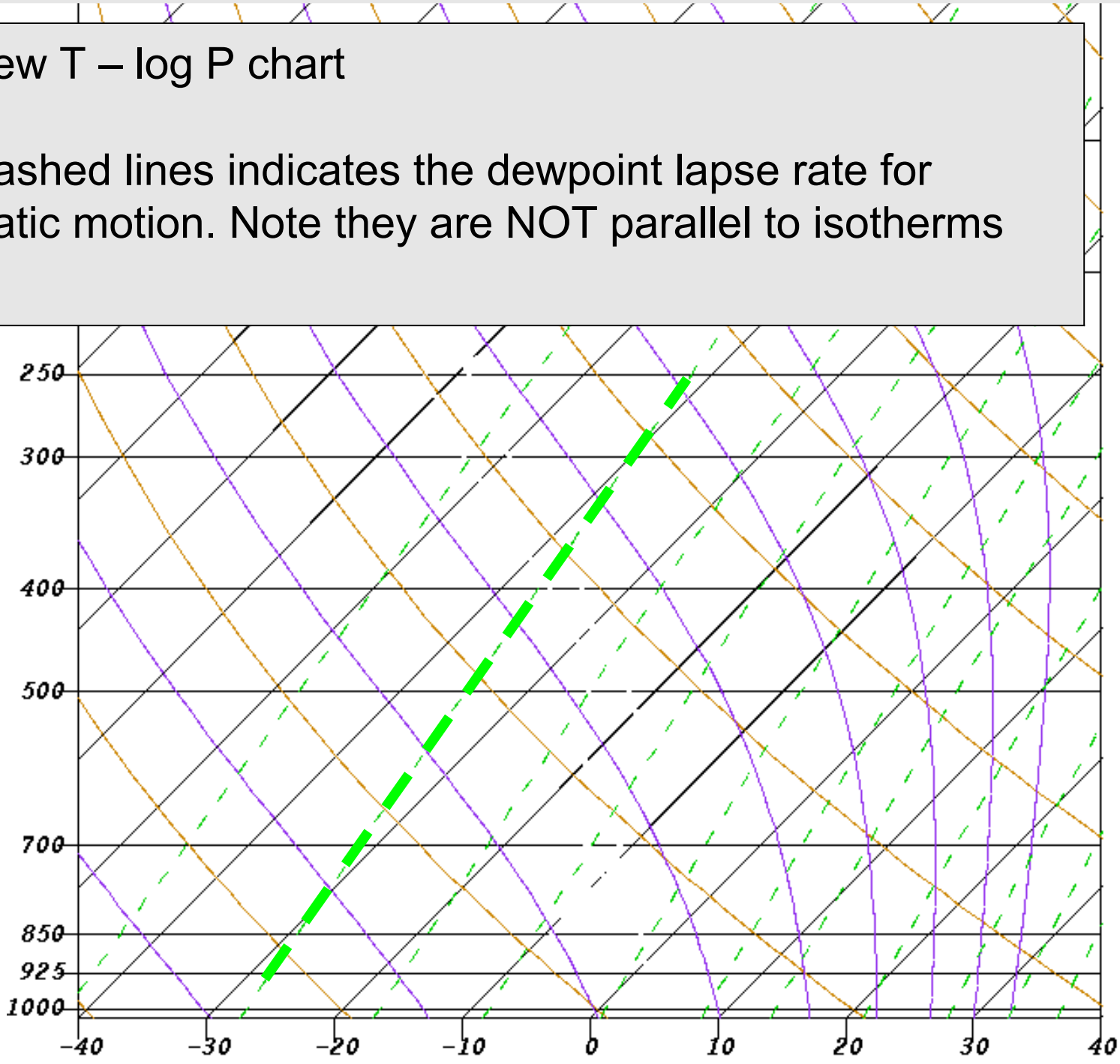
- extremely cold cP air is called continental arctic (cA)

- though uniform horizontally, an airmass cannot be uniform in the vertical… necessarily there are vertical gradients, affecting airmass stability

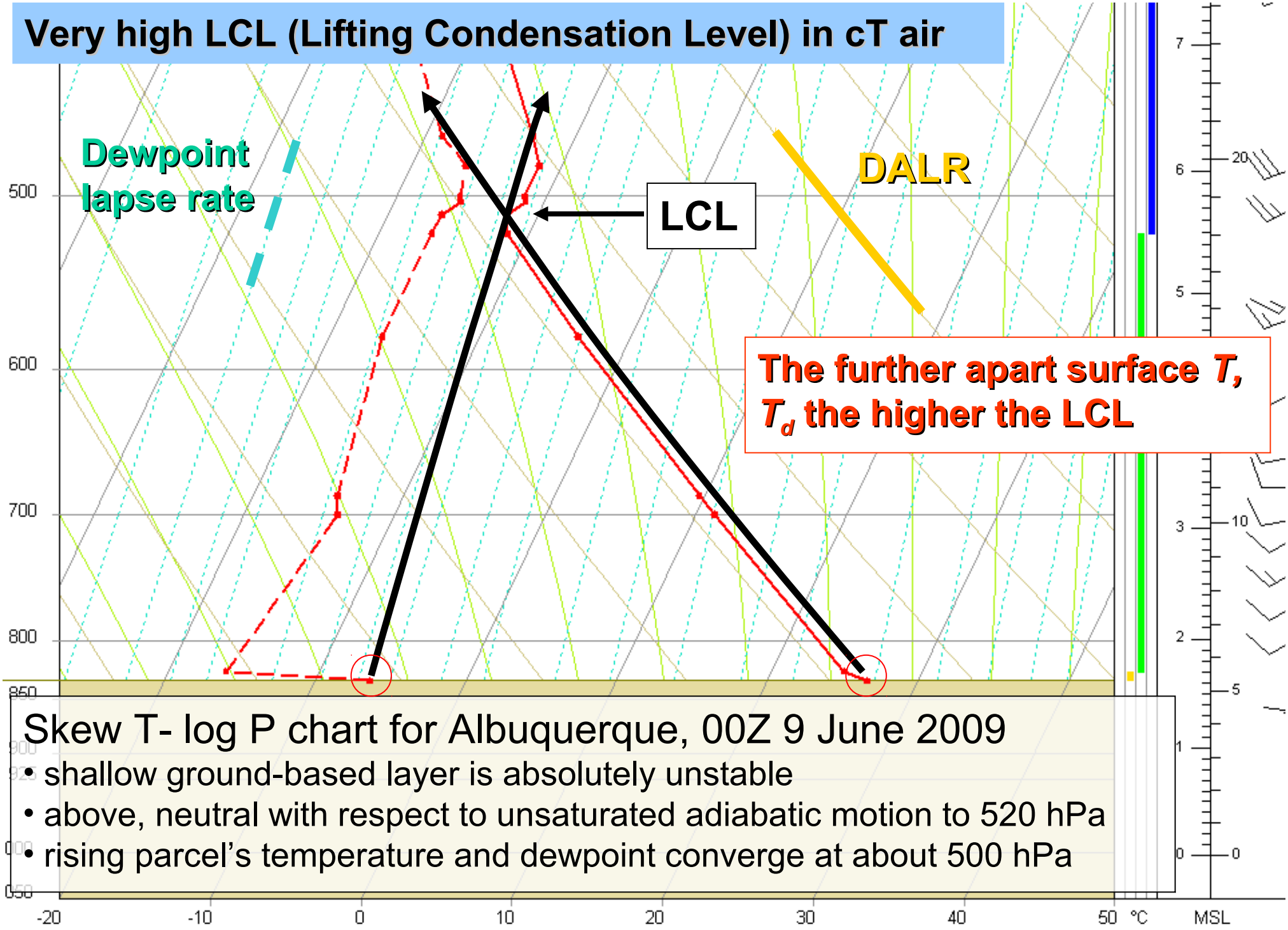
Lifting Condensation Level in relation to the Thermodynamic Chart

- this is a blank skew T – log P chart
- family of green dashed lines indicates the dewpoint lapse rate for unsaturated adiabatic motion. Note they are NOT parallel to isotherms

- dewpoint T_d of rising unsaturated parcel falls at 0.2°C/100 m
- whereas temp. T of parcel falls at 1°C/100 m
- so T approaches T_d at 0.8°C/100 m (p277)



Very high LCL (Lifting Condensation Level) in cT air



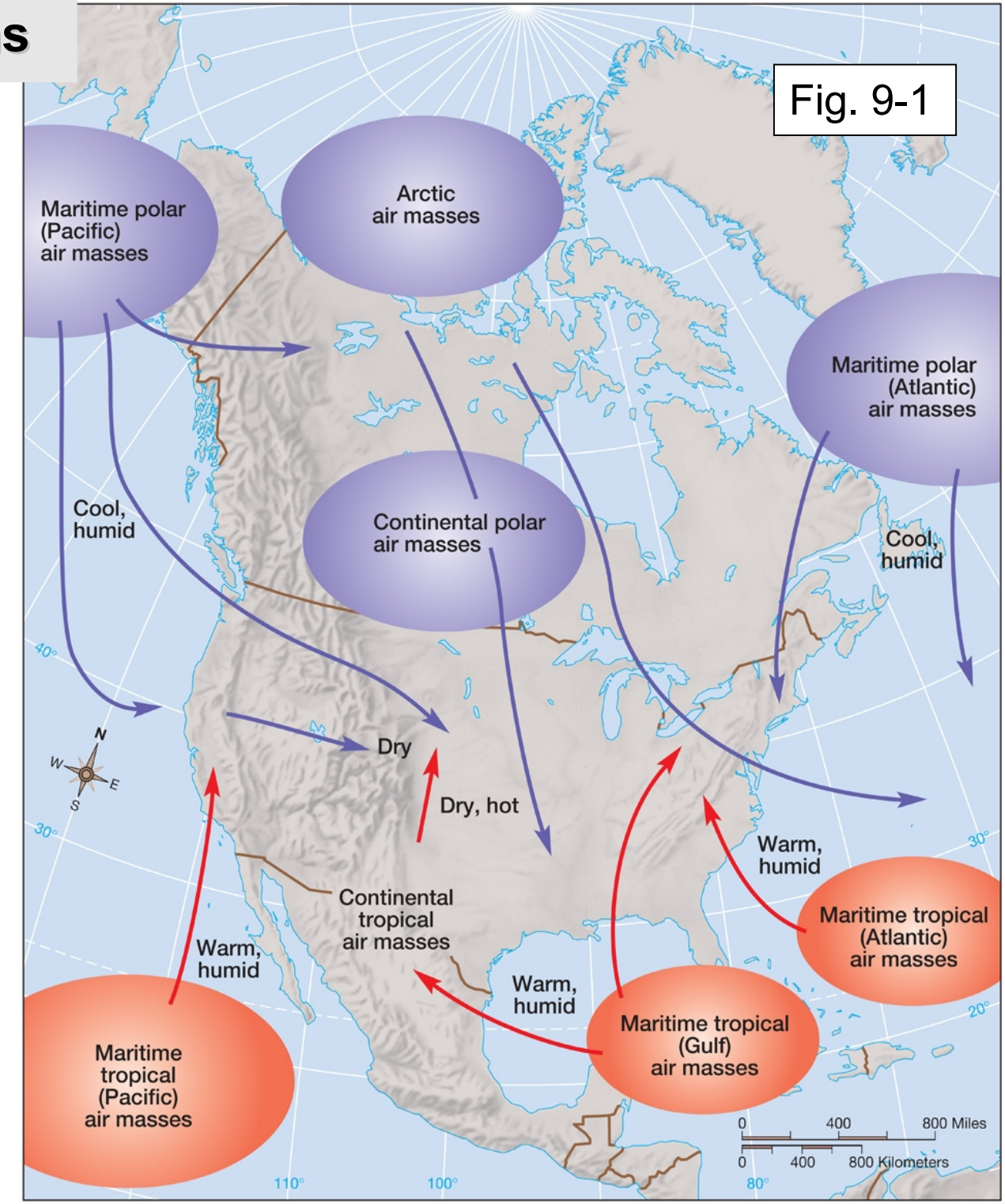
Skew T- log P chart for Albuquerque, 00Z 9 June 2009

- shallow ground-based layer is absolutely unstable
- above, neutral with respect to unsaturated adiabatic motion to 520 hPa
- rising parcel's temperature and dewpoint converge at about 500 hPa

Airmass Source Regions

- cP by far our most common airmass in Alberta

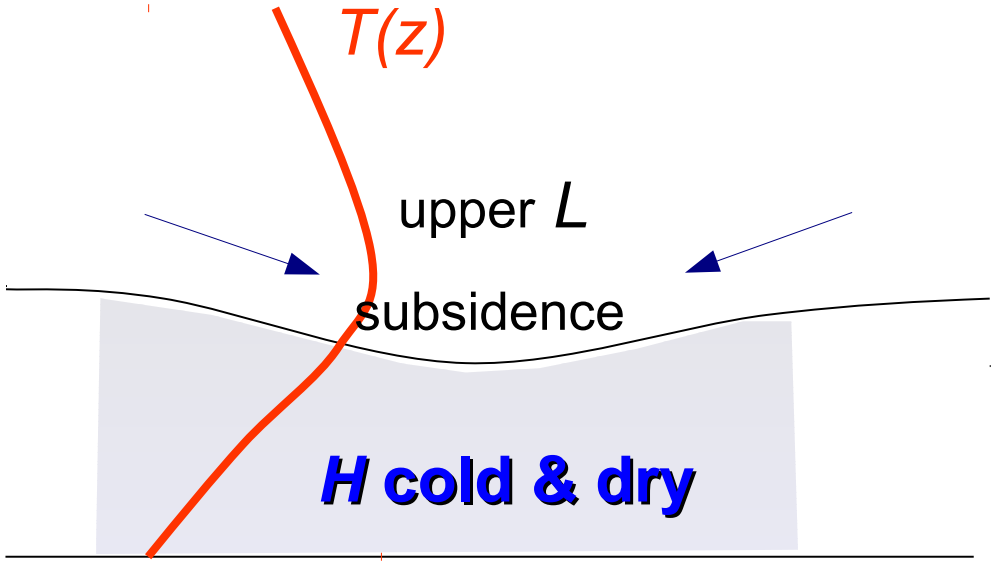
- eg. classic Alberta summer day – dry, cool, light Cu

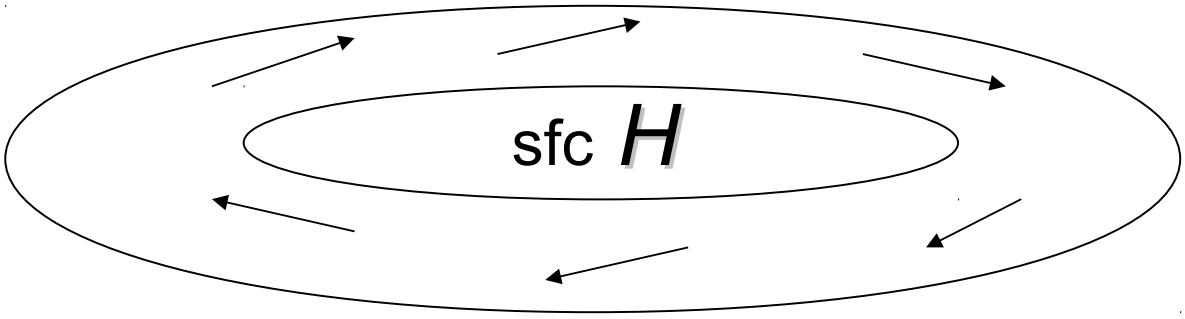


Formation of winter cP air mass

- hi latitude winter
- long night, low (or no) sun
- snow cover? – high albedo
- daily totalized Q* negative
- airmass cooled from base – inversion – poor mixing – bad air quality – no convection
- may deepen day after day
- cold, dry air + subsidence, few clouds

- in summer, less extreme
- not so dry
- daytime heating erases inversion, permits Cu



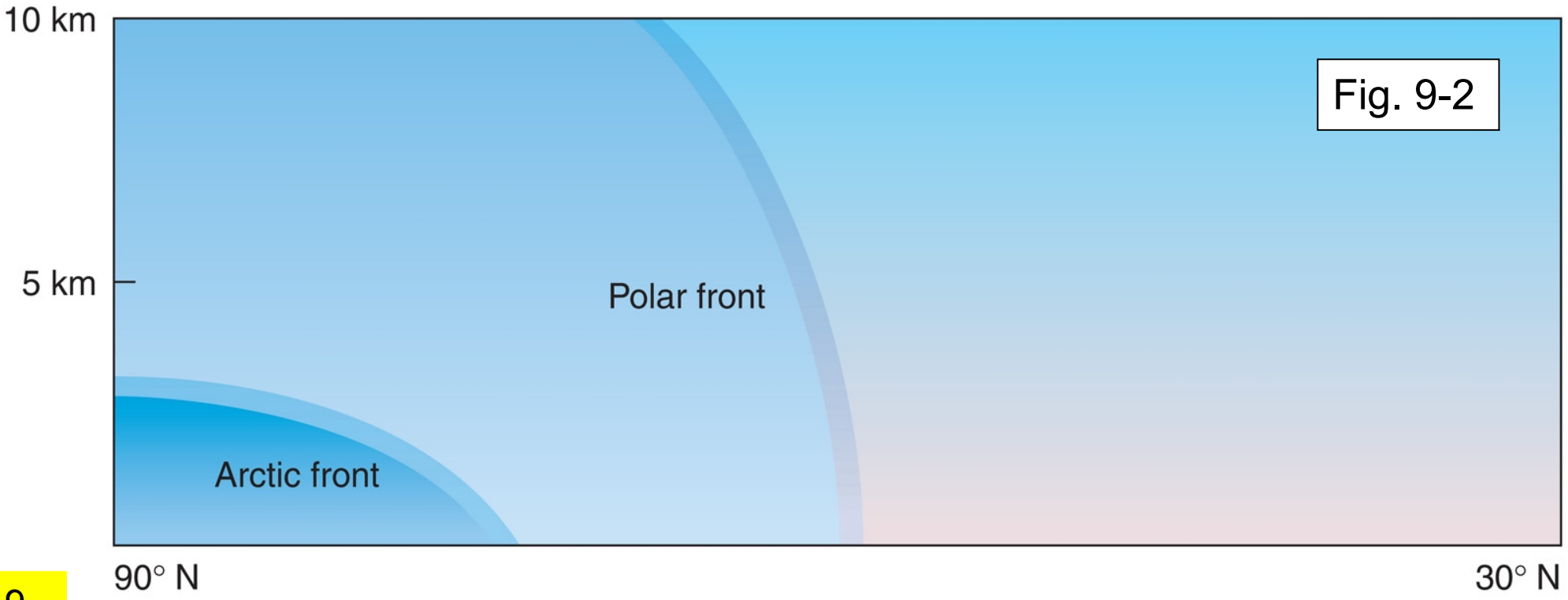


cA airmasses and the arctic front

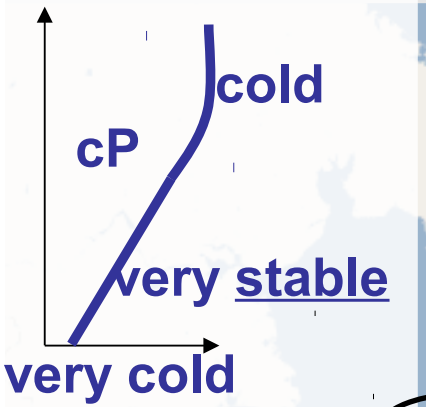
• extremely cold airmasses (cA) are usually shallow (order 1 km or less)

• sometimes one may distinguish a sharp boundary between a dome of extremely cold dry air, and a less extremely cold airmass – boundary is the "arctic front"

• little or no "weather" associated with such fronts (too dry)



Airmass modification/transformation



transformed back to cP

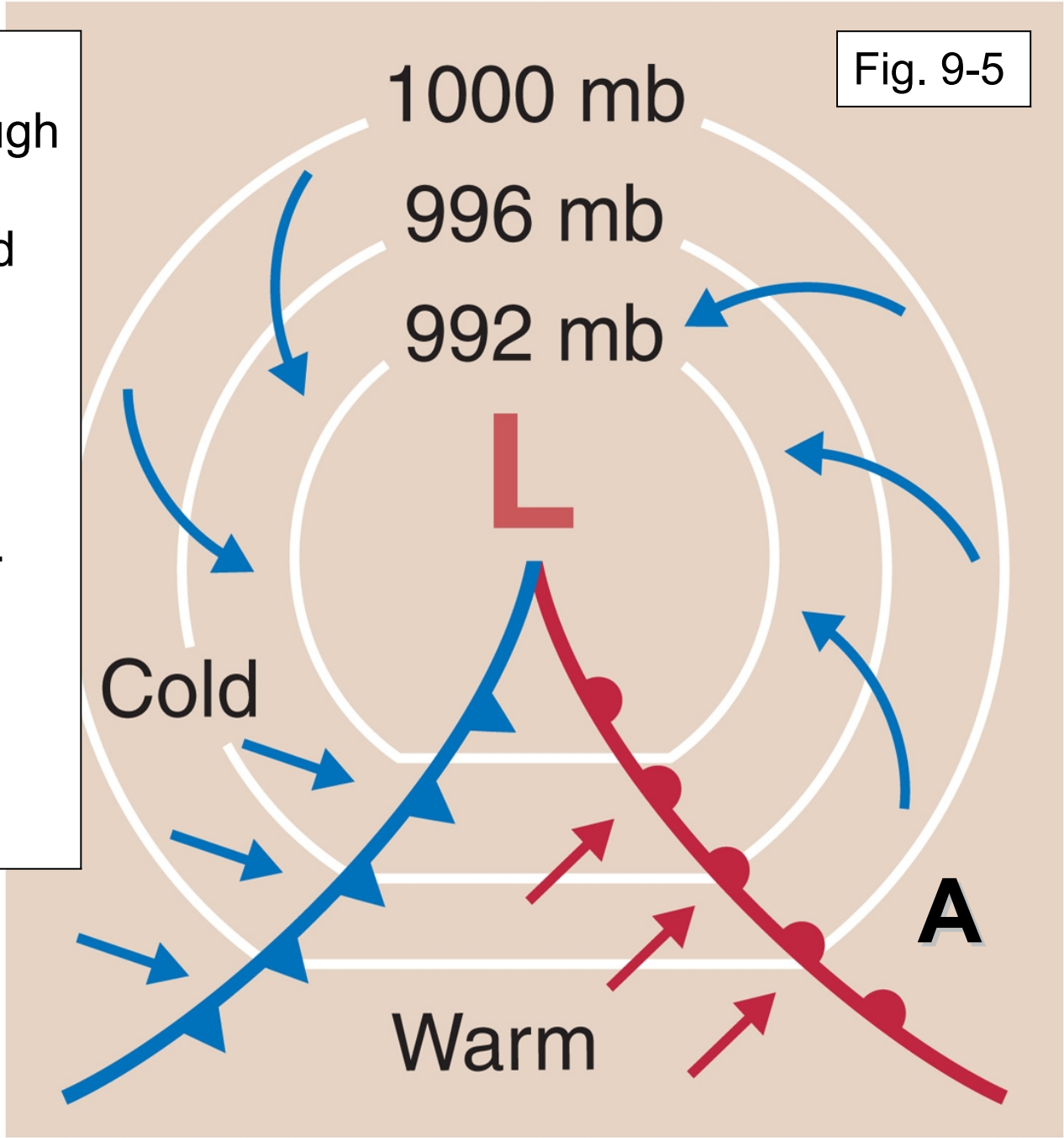
heat & vapour added over sea (Q_H, Q_E)

vapour loss - precip crossing Rockies

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

Fronts & the ideal structure of a mid-latitude cyclone

- front lies along or near isobar kinks, i.e. lies in trough
- low level cross-isobar wind
- wind direction changes across front
- system moves eastward… observer at **A** sees initially falling, then steady, then rising pressure



Criteria to locate fronts (ie. airmass boundaries)

- large ΔT over short distance (packed isotherms)
- large ΔT_d over short distance
- sudden change in wind direction

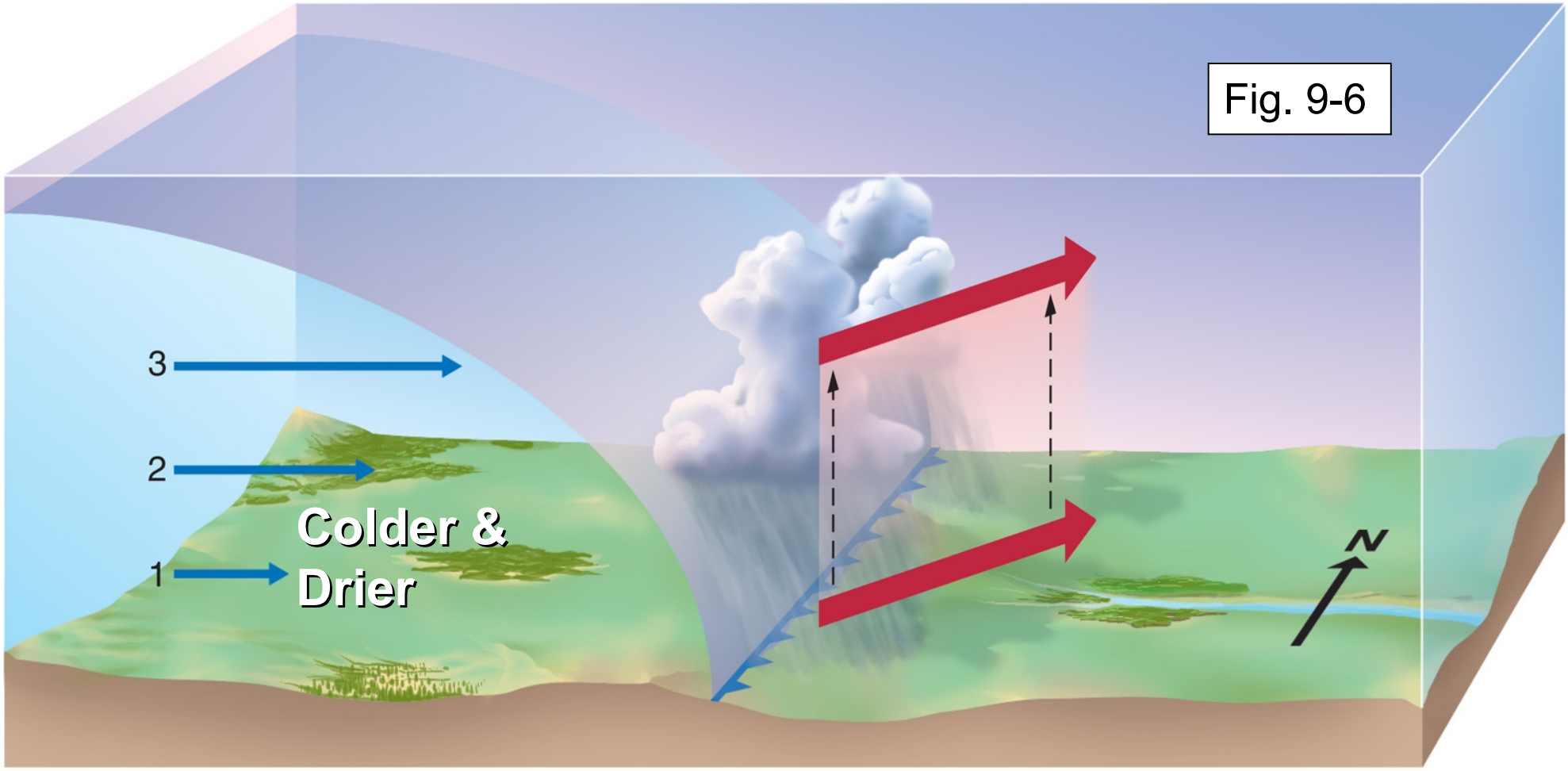
- ***rare to see <u>all</u> of these signs***
- ***somewhat subjective***

- sudden change in sign or magnitude of pressure trend $\Delta p / \Delta t$
- band of cloud and precipitation
- 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

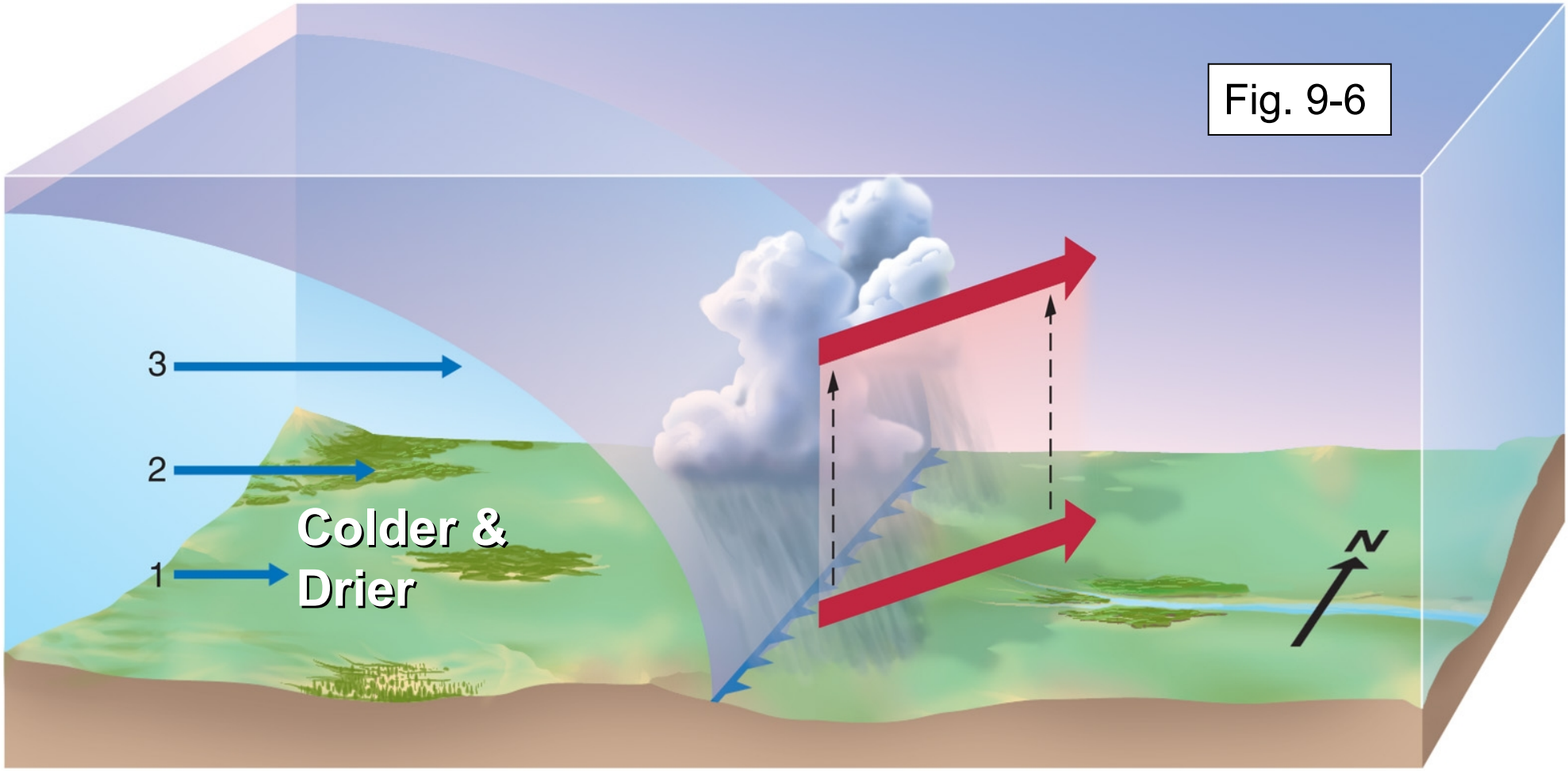
Ideal configuration of a cold front



- note that at upper levels the front is located upstream of its surface position

- shift in wind direction across front – implies “convergence”

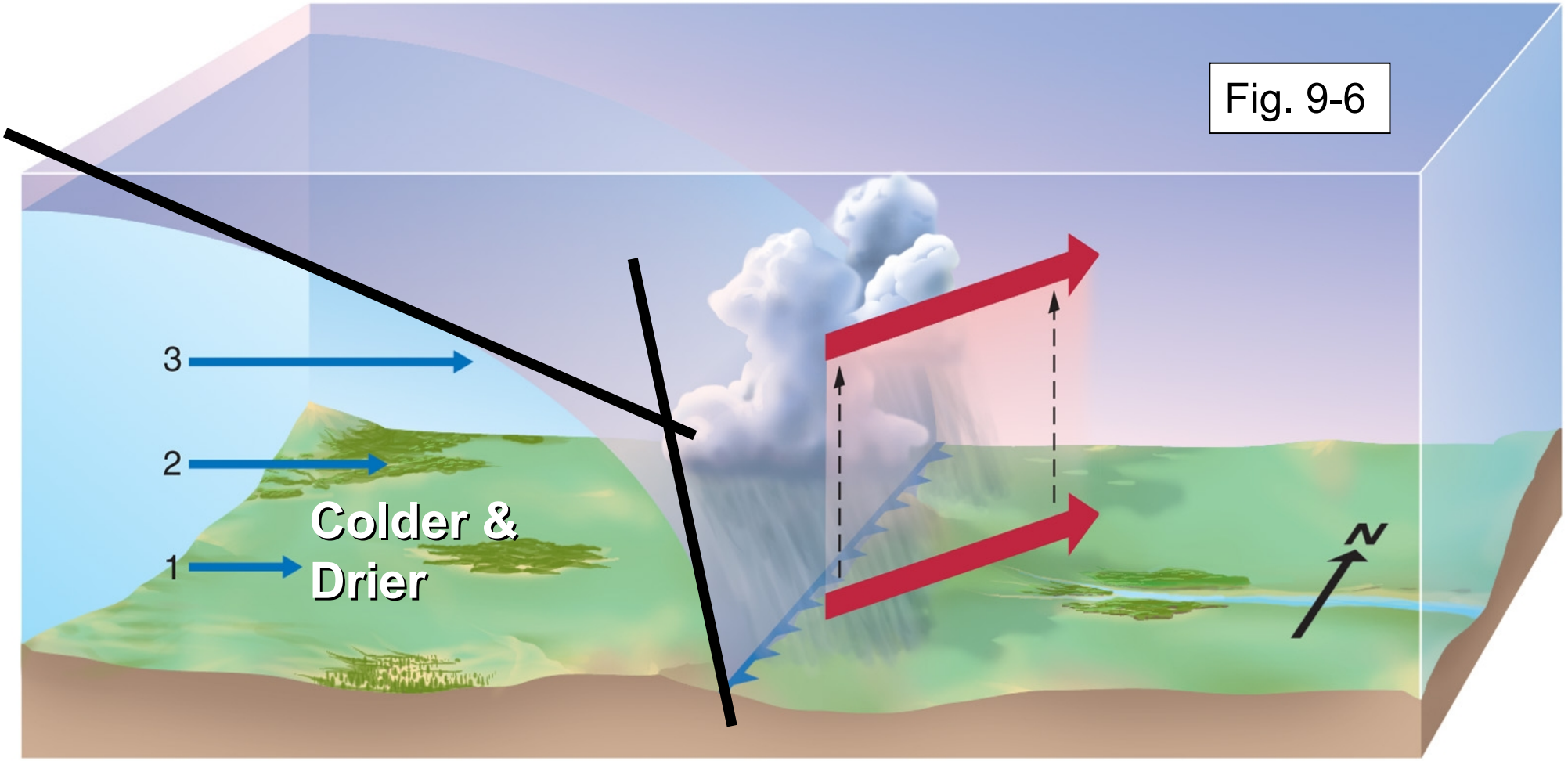
Ideal configuration of a cold front



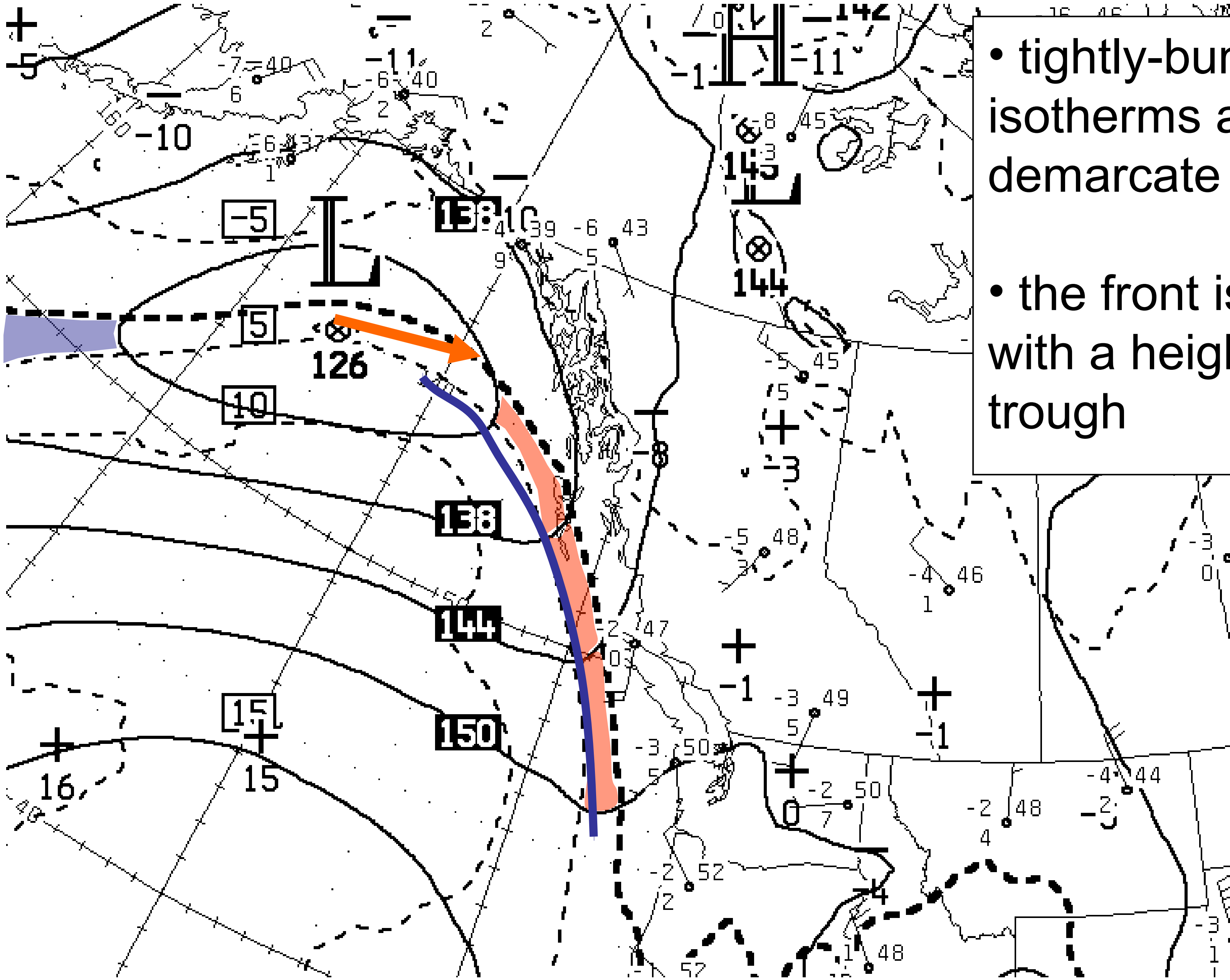
- denser air intrudes under the milder air, forcing ascent

- in Alberta, cold front typically separates distinct cP airmasses (i.e. rarely tropical from polar, as it may in U.S.)

Slope of a cold front

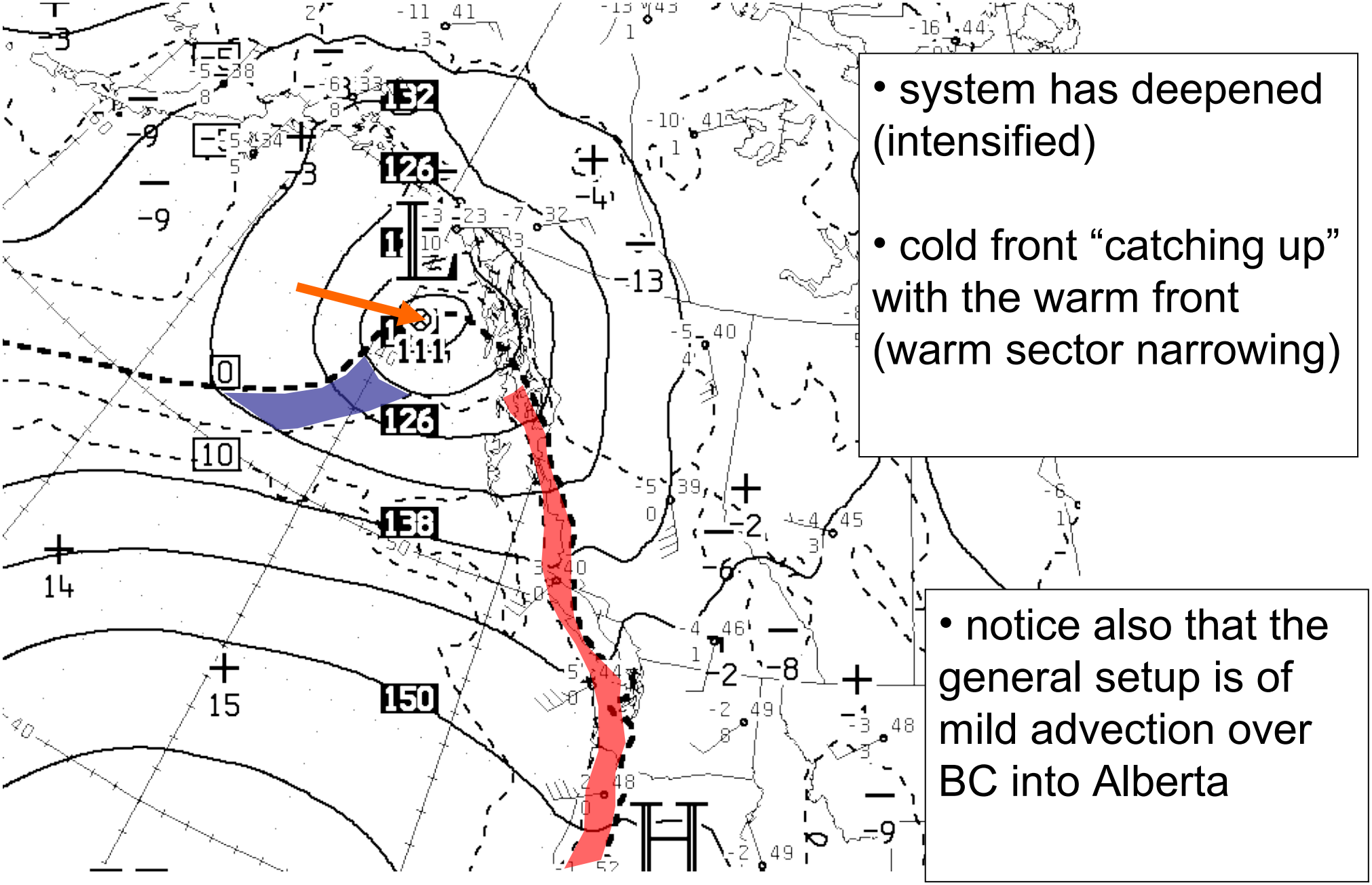


- in static air, front separating layers of different density would be horizontal
- thus frontal slope is related to motion, and is gentle: nominally 1:100 (but steeper near ground due to friction)
- **Thus if we ascend ~1 km the front is found ~100 km upwind**

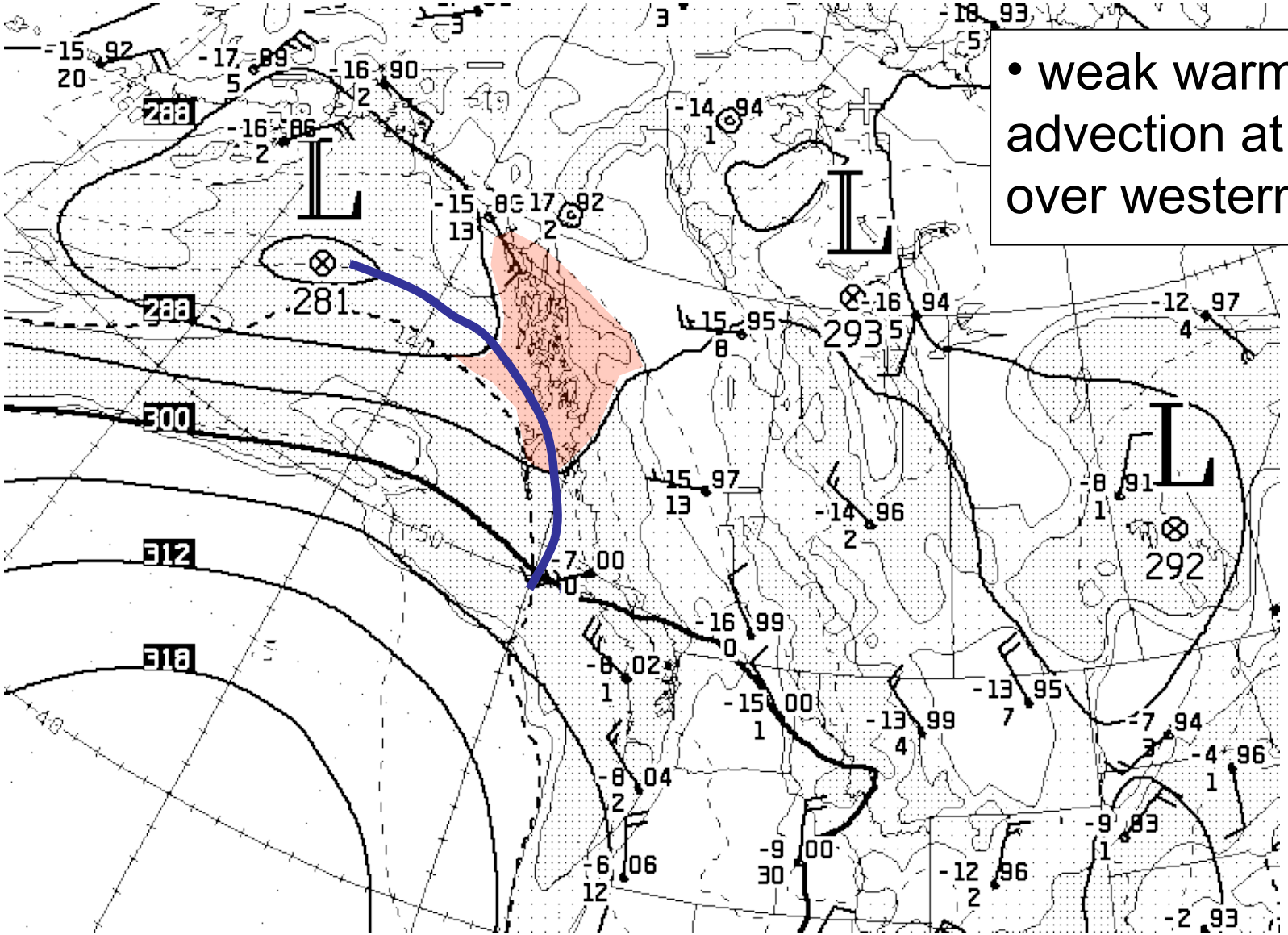


- tightly-bunched isotherms at 850 hPa demarcate a “front”
- the front is co-located with a height/pressure trough

CMC 850 hPa analysis 00Z Thurs 29 Oct. 2009



CMC 850 hPa analysis 12Z Thurs 29 Oct. 2009



• weak warm thermal advection at 700 hPa over western B.C.

CMC 700 hPa analysis 00Z Thurs 29 Oct. 2009