Ch14 (ctd). Mid-latitude cyclones (ctd.)

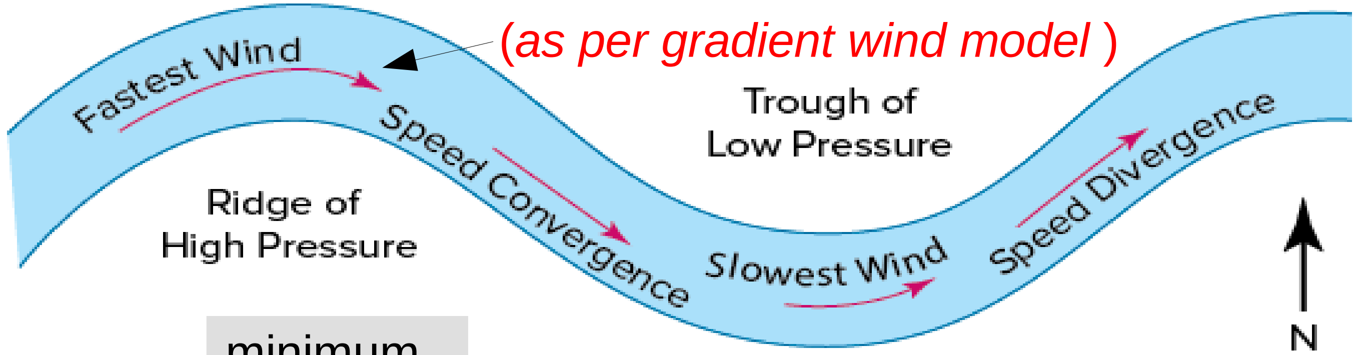
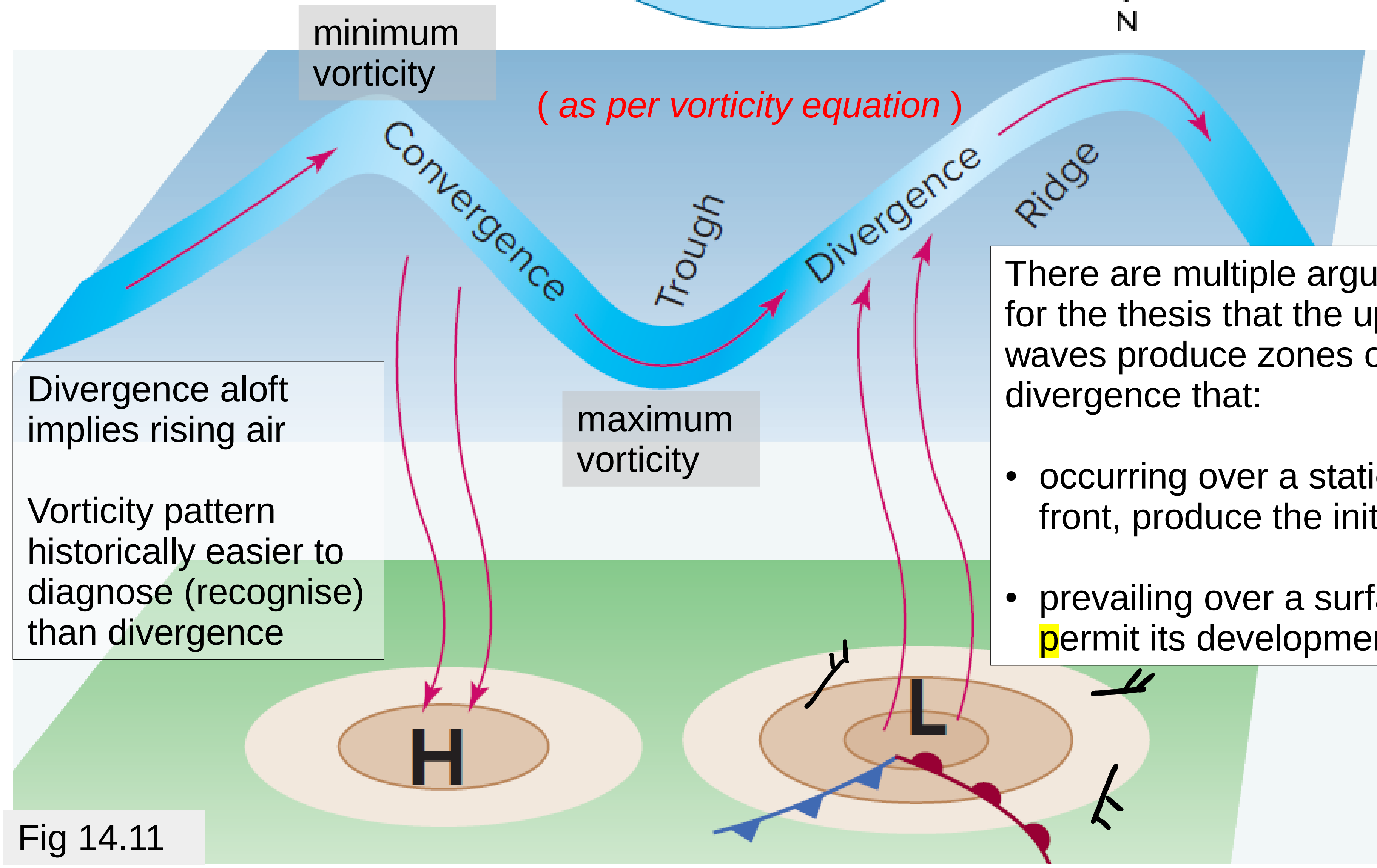


Fig 14.10



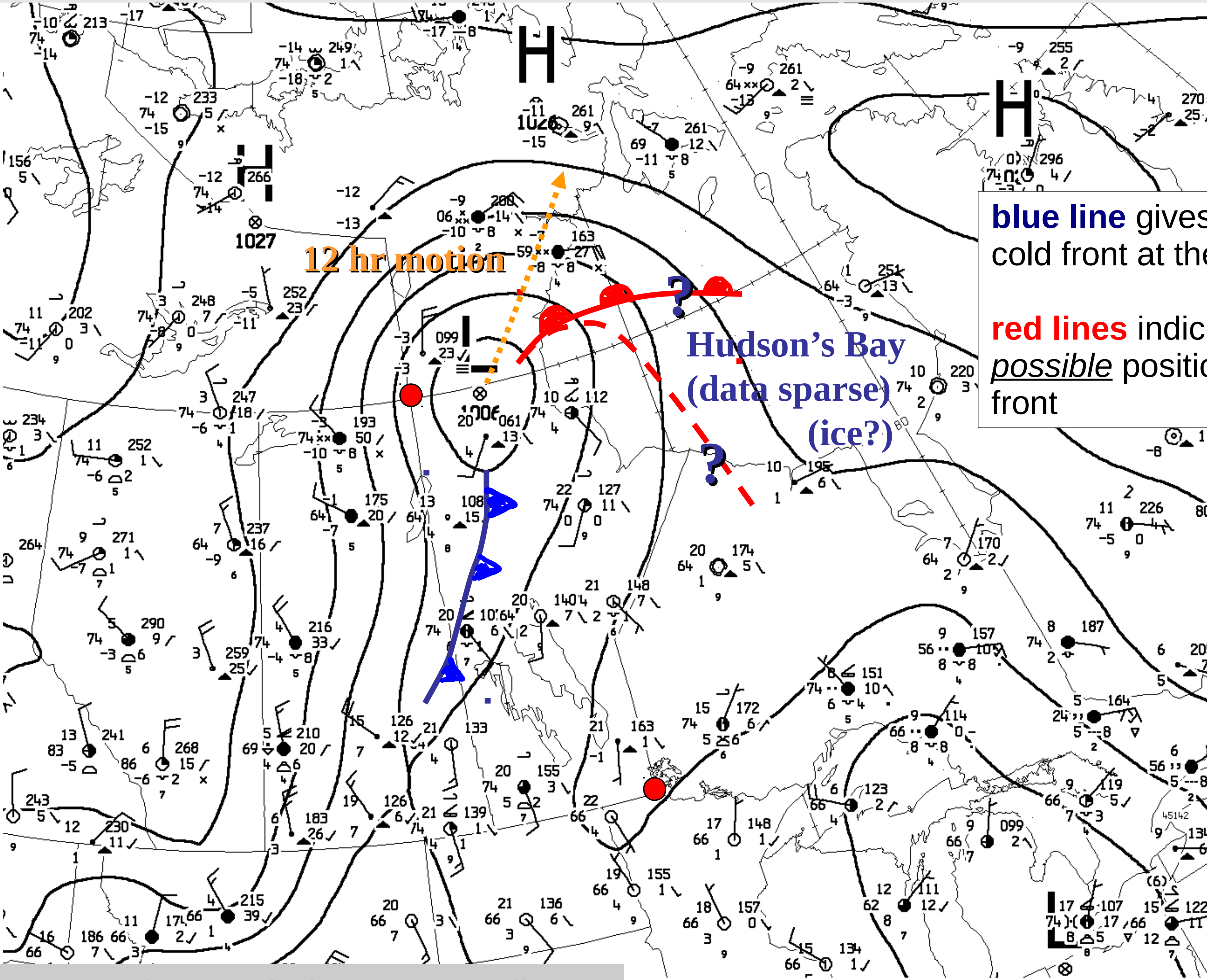
Divergence aloft implies rising air

Vorticity pattern historically easier to diagnose (recognise) than divergence

There are multiple arguments for the thesis that the upper waves produce zones of divergence that:

- occurring over a stationary front, produce the initial low
- prevailing over a surface low, permit its development

Fig 14.11

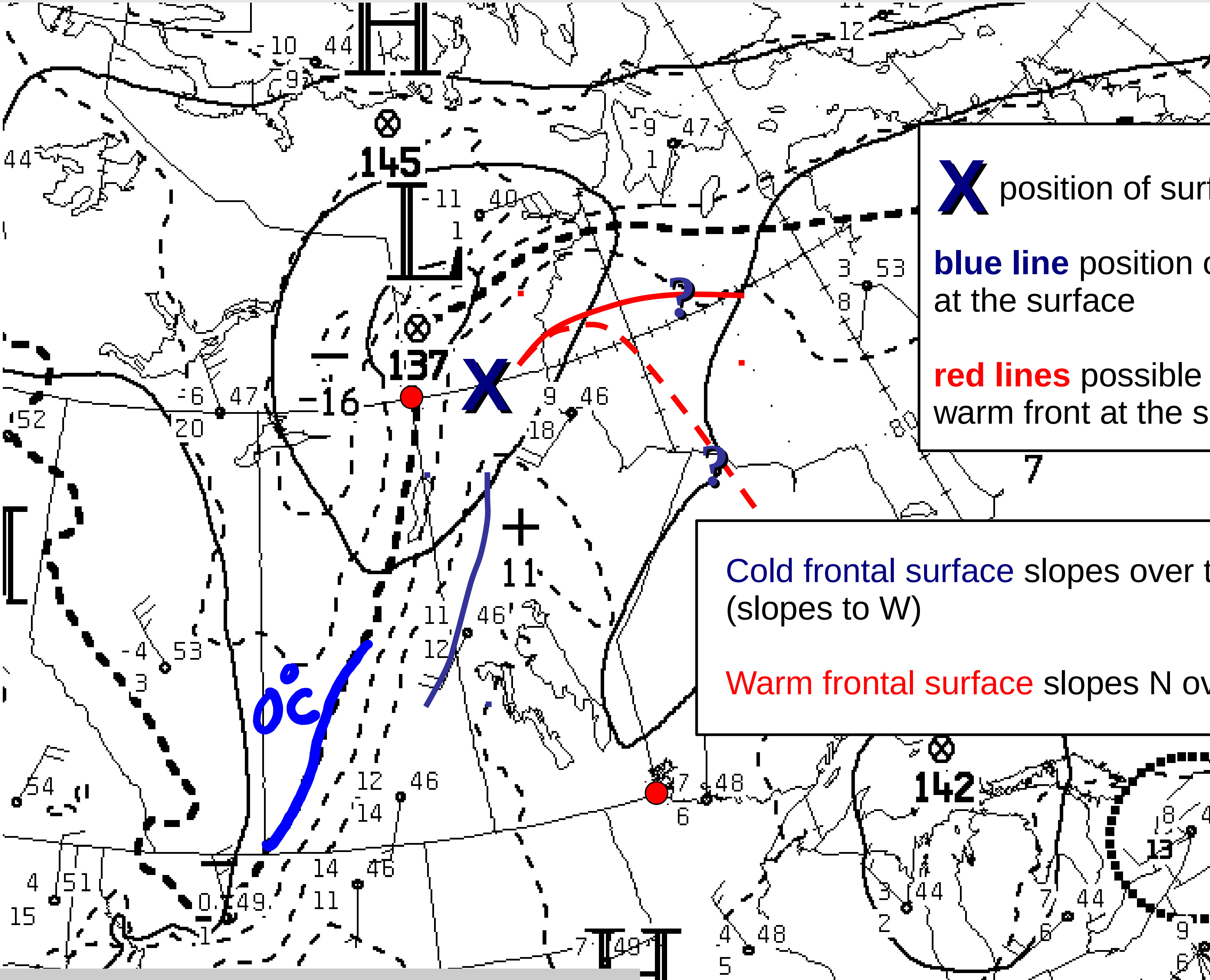


blue line gives position of cold front at the surface

red lines indicate *possible* position of warm front

CMC surface analysis 00Z, 23 April 2006

Example of fronts associated with a mid-latitude cyclone



X position of surface low

blue line position of cold front at the surface

red lines possible position of warm front at the surface

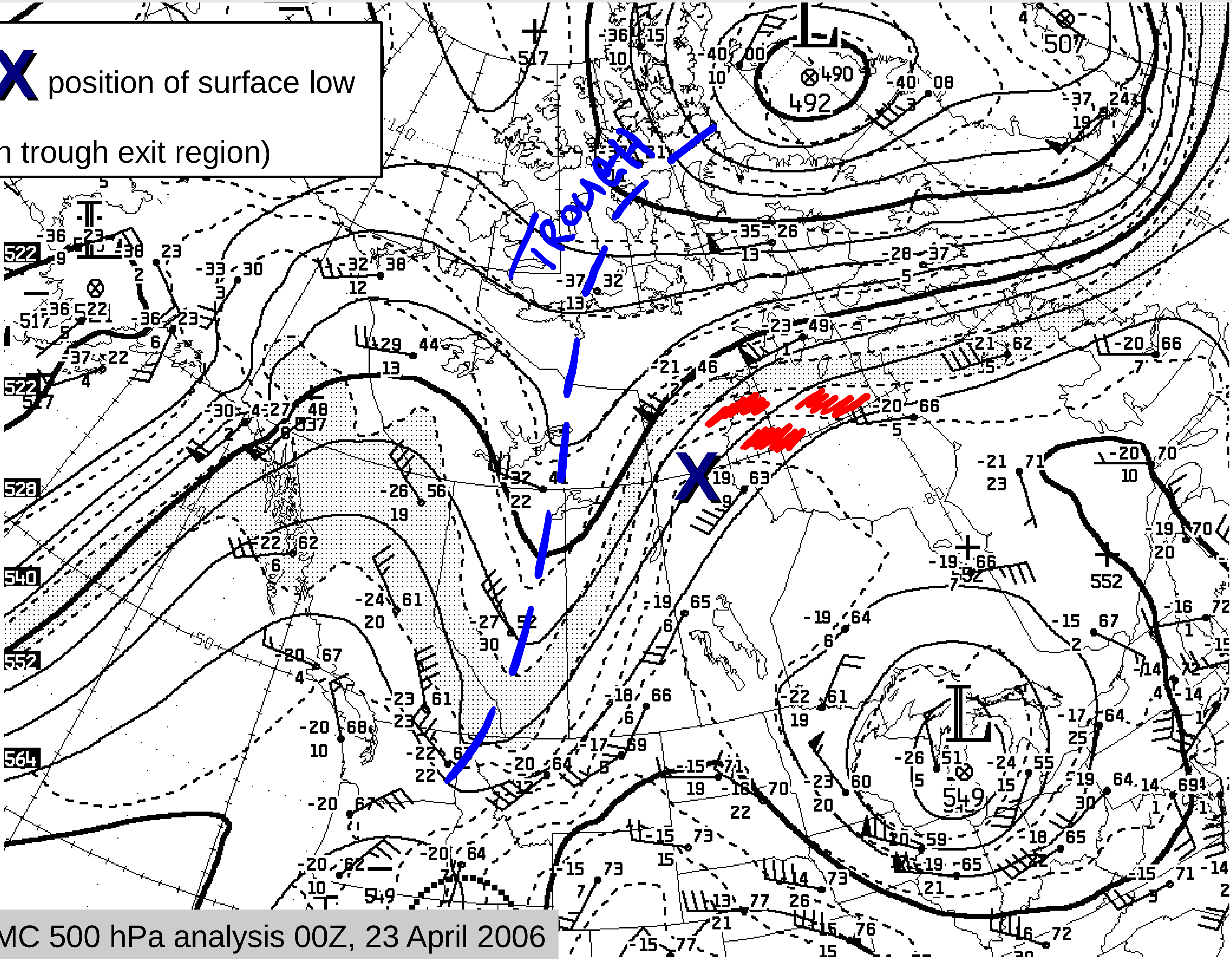
Cold frontal surface slopes over the cold air (slopes to W)

Warm frontal surface slopes N over cold air

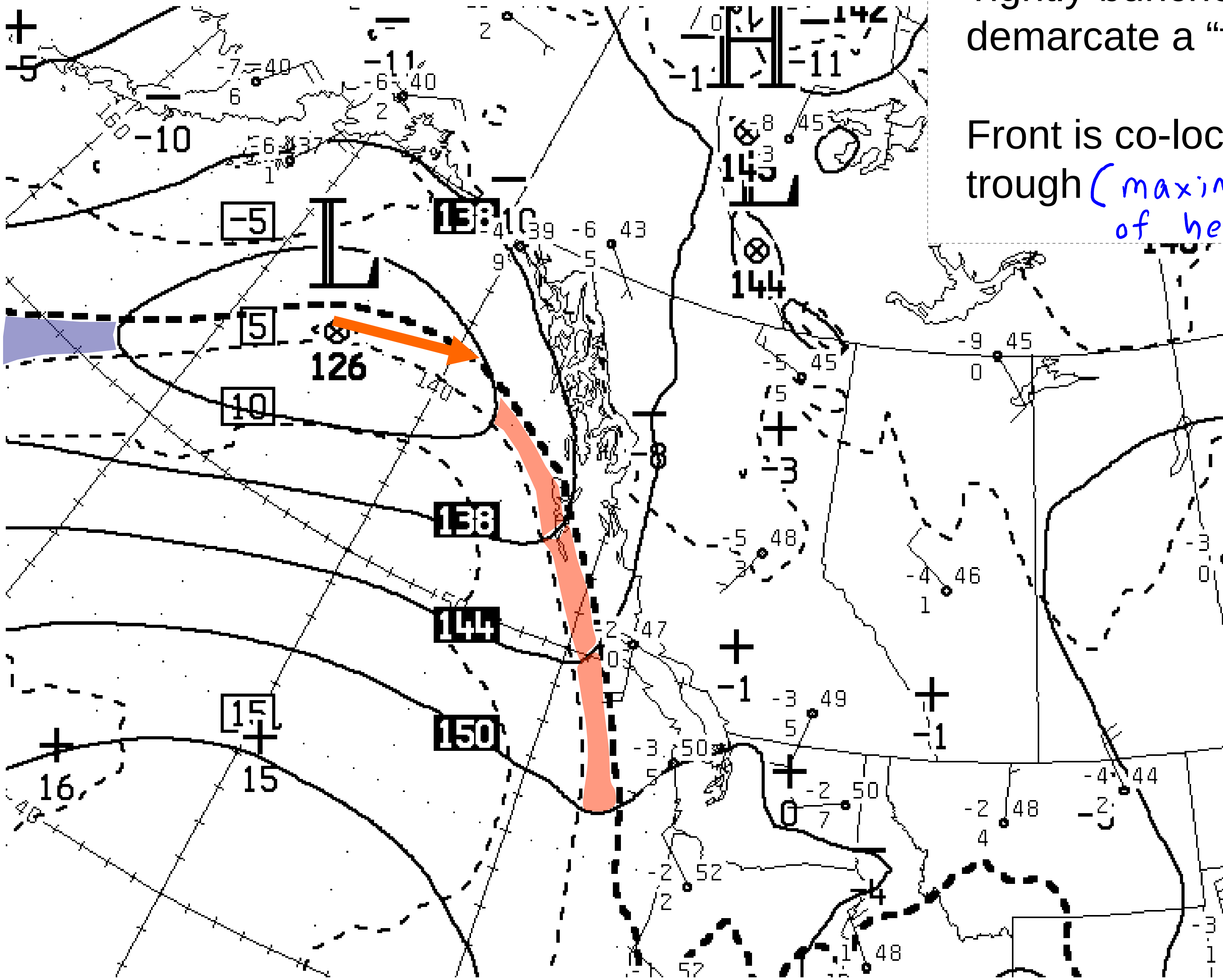
CMC 850 hPa analysis 00Z, 23 April 2006

X position of surface low

(in trough exit region)



CMC 500 hPa analysis 00Z, 23 April 2006



Tightly-bunched isotherms demarcate a “front”

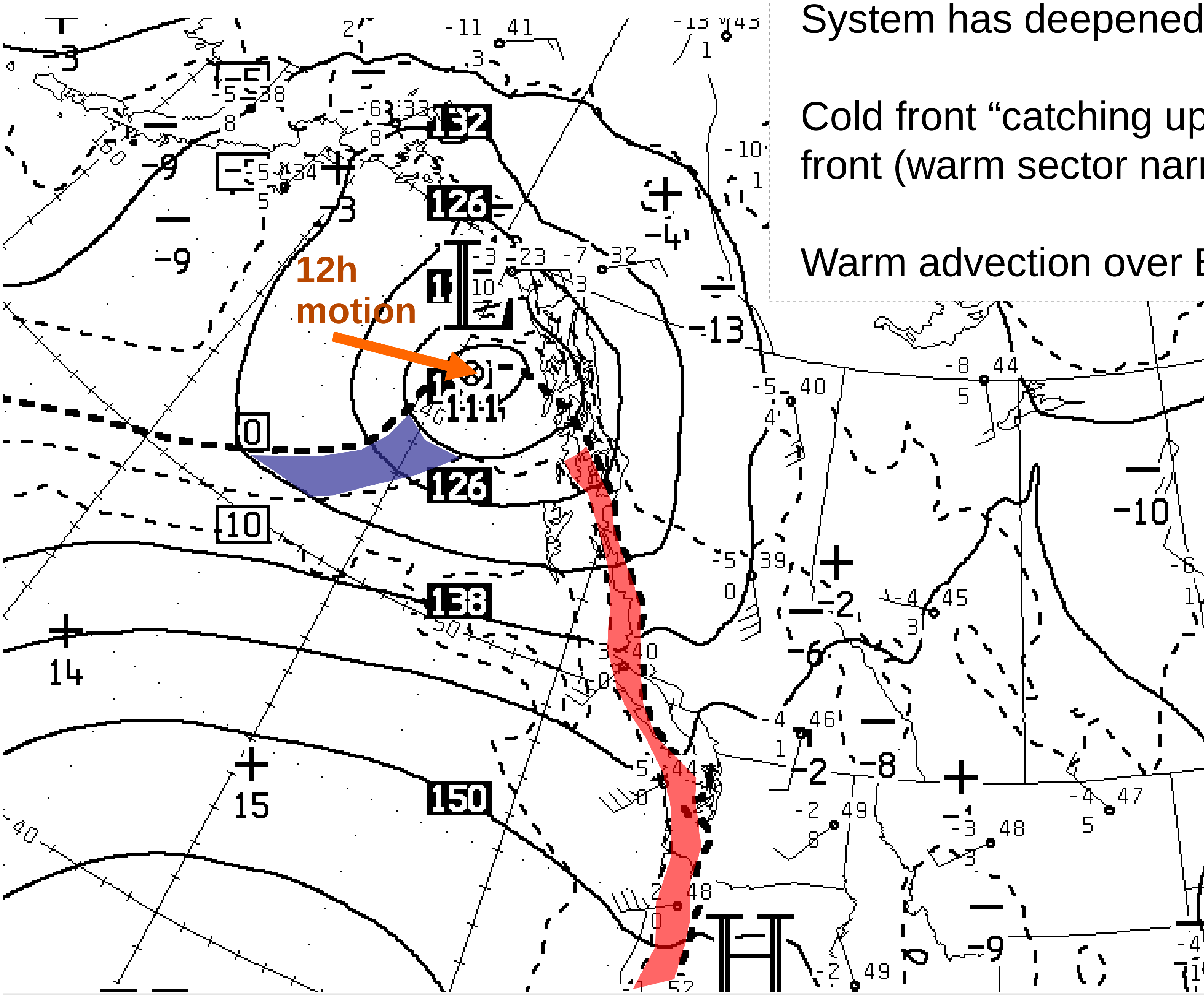
Front is co-located with a trough (maximum in curvature of height contours)

CMC 850 hPa analysis 00Z Thurs 29 Oct. 2009

System has deepened (intensified)

Cold front “catching up” with the warm front (warm sector narrowing)

Warm advection over BC



CMC 850 hPa analysis 12Z Thurs 29 Oct. 2009

- wavelength ~ 1000 km or less (much shorter than the longwaves)
- essentially related with thermal advection aloft (isotherms not parallel to height contours)
- whereas longwaves occur even on a rotating globe *without* latitudinal temperature gradient
- move faster than the longwaves

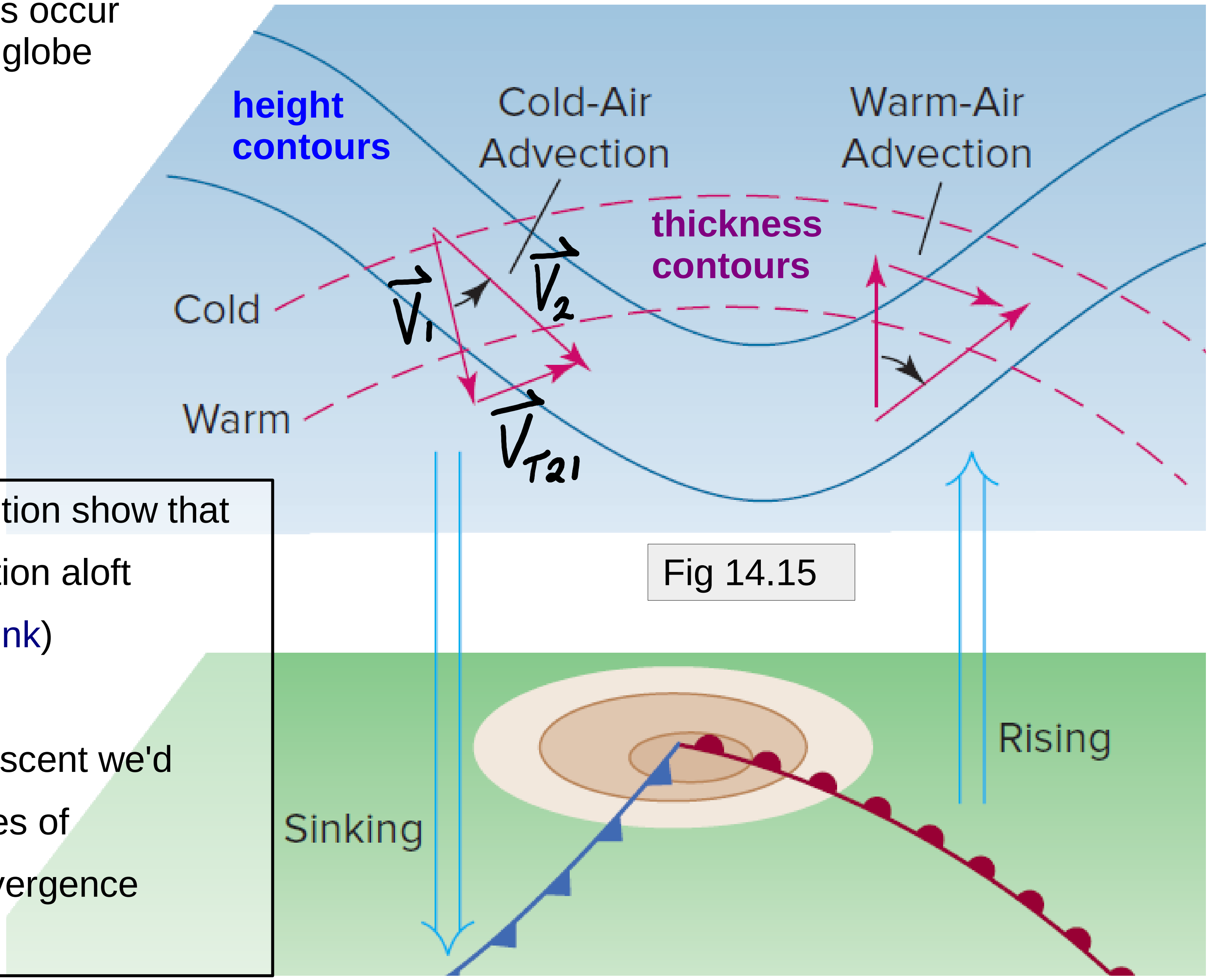
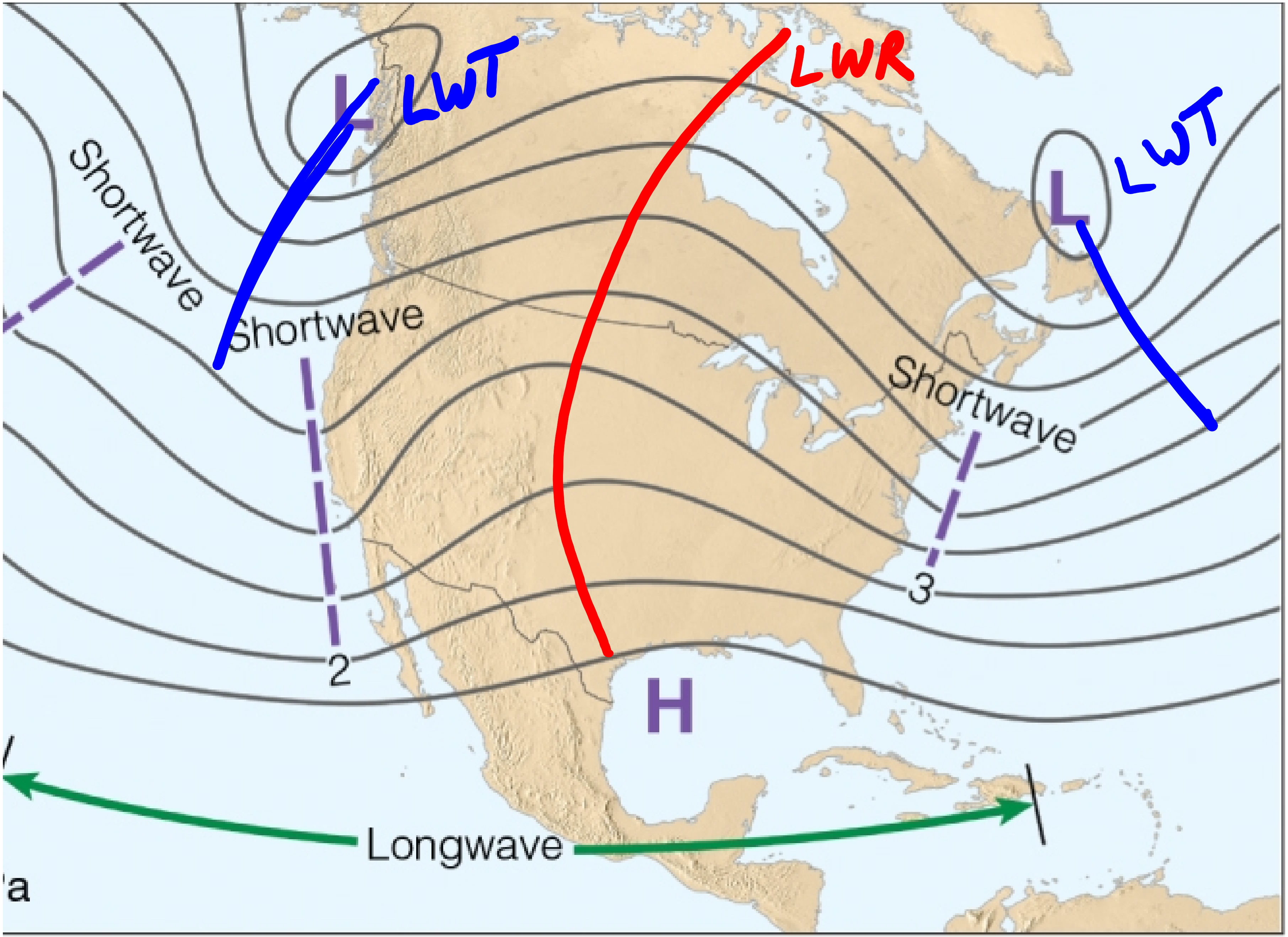


Fig 14.15

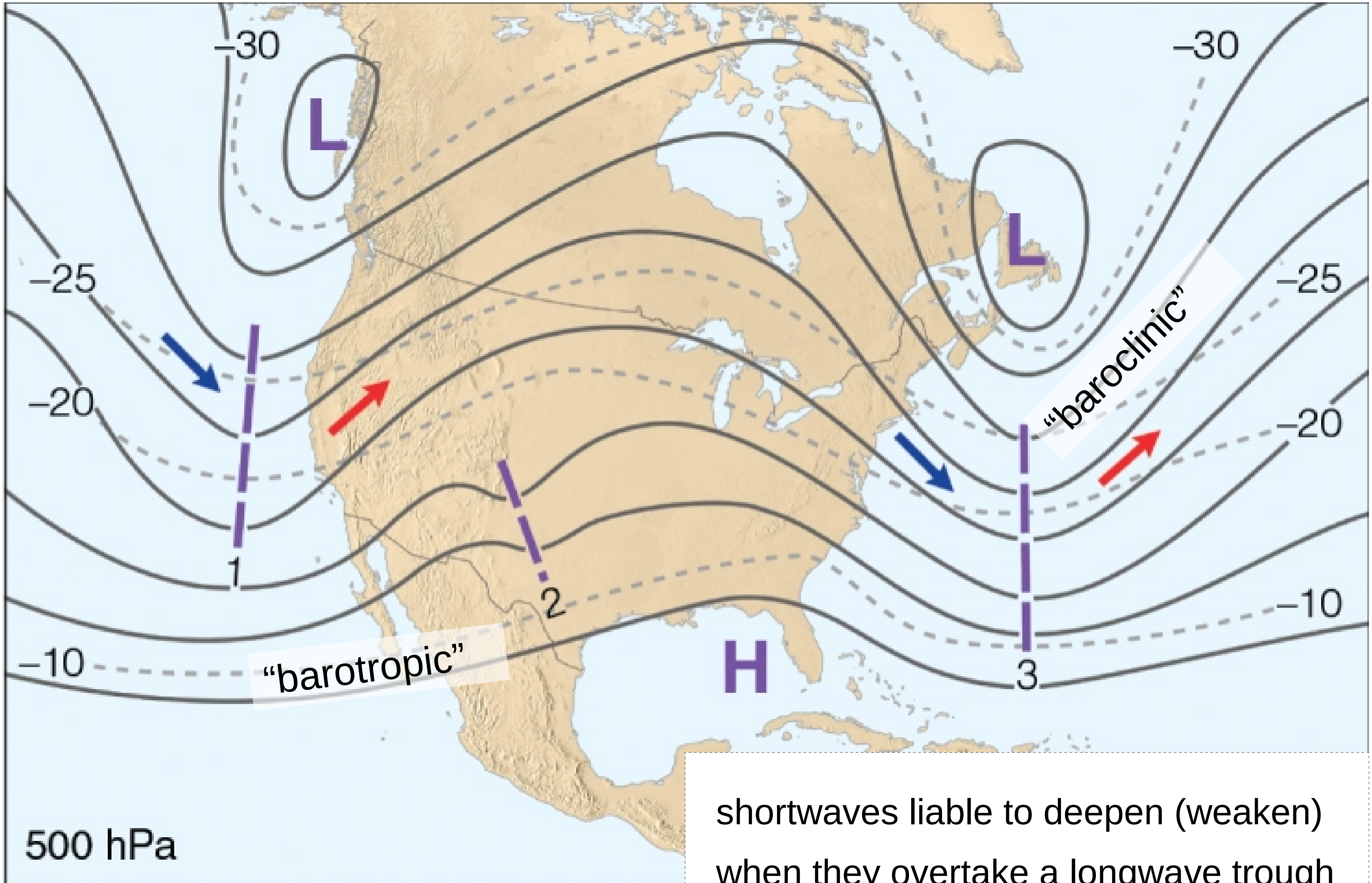
The equations of motion show that WARM (cold) advection aloft induces ASCENT (sink)

This reinforces the ascent we'd expect from the zones of convergence and divergence (vorticity equation)



(a) DAY 1

- Shortwaves generally move faster than the longwaves



(b) DAY 2 (24 hours later)

shortwaves liable to deepen (weaken) when they overtake a longwave trough (ridge)

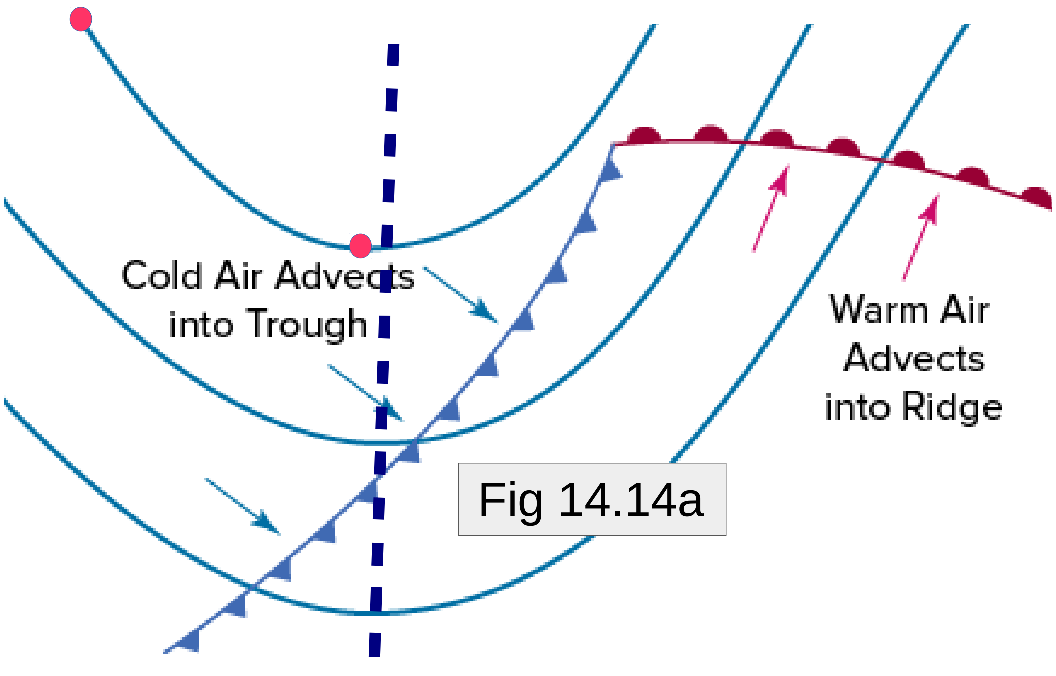


Fig 14.14a

upper trough axis

- shortwaves may be accentuated by thermal advection at the surface associated with the fronts

- thermal advection at the surface has resulted in this trough "digging" (developing sharper curvature and increased amplitude)
- i.e. cold advection at low level has lowered height in the trough
- consequence: stronger zones of convergence and divergence aloft

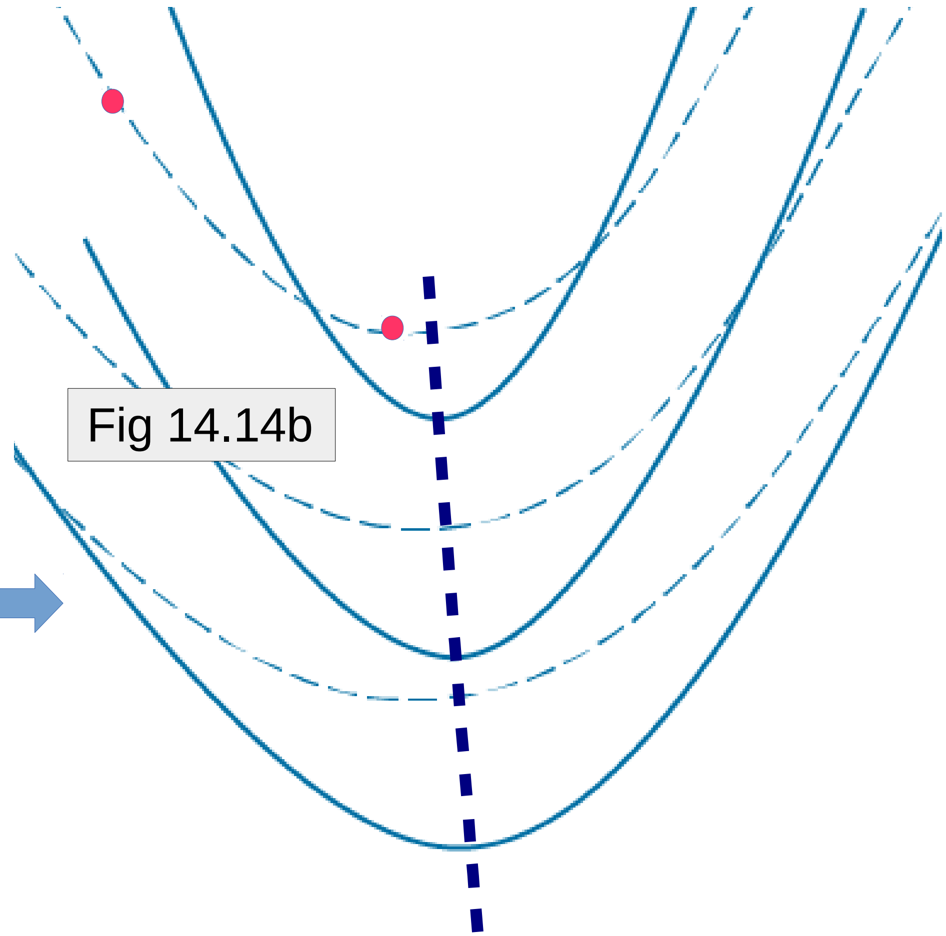
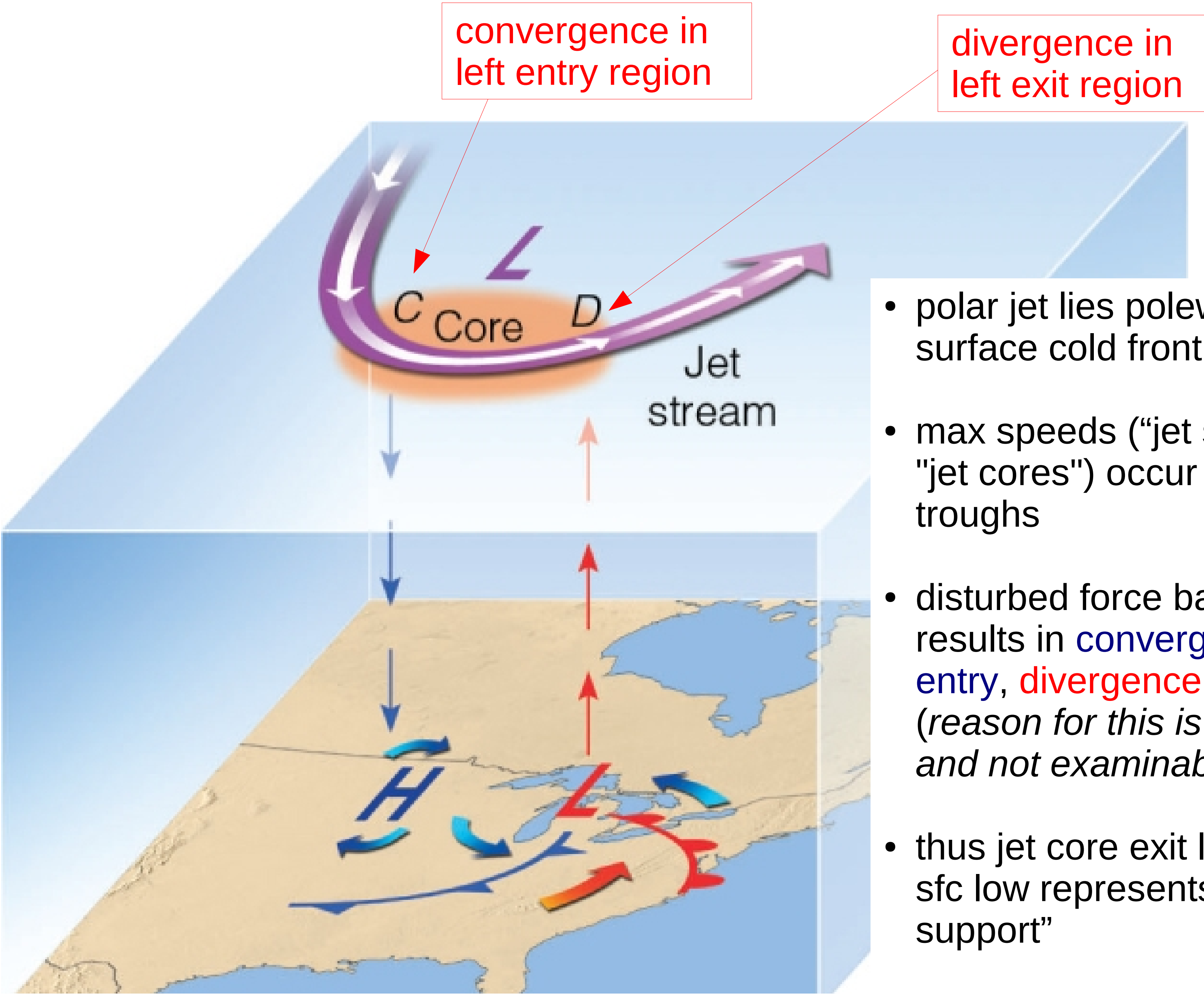
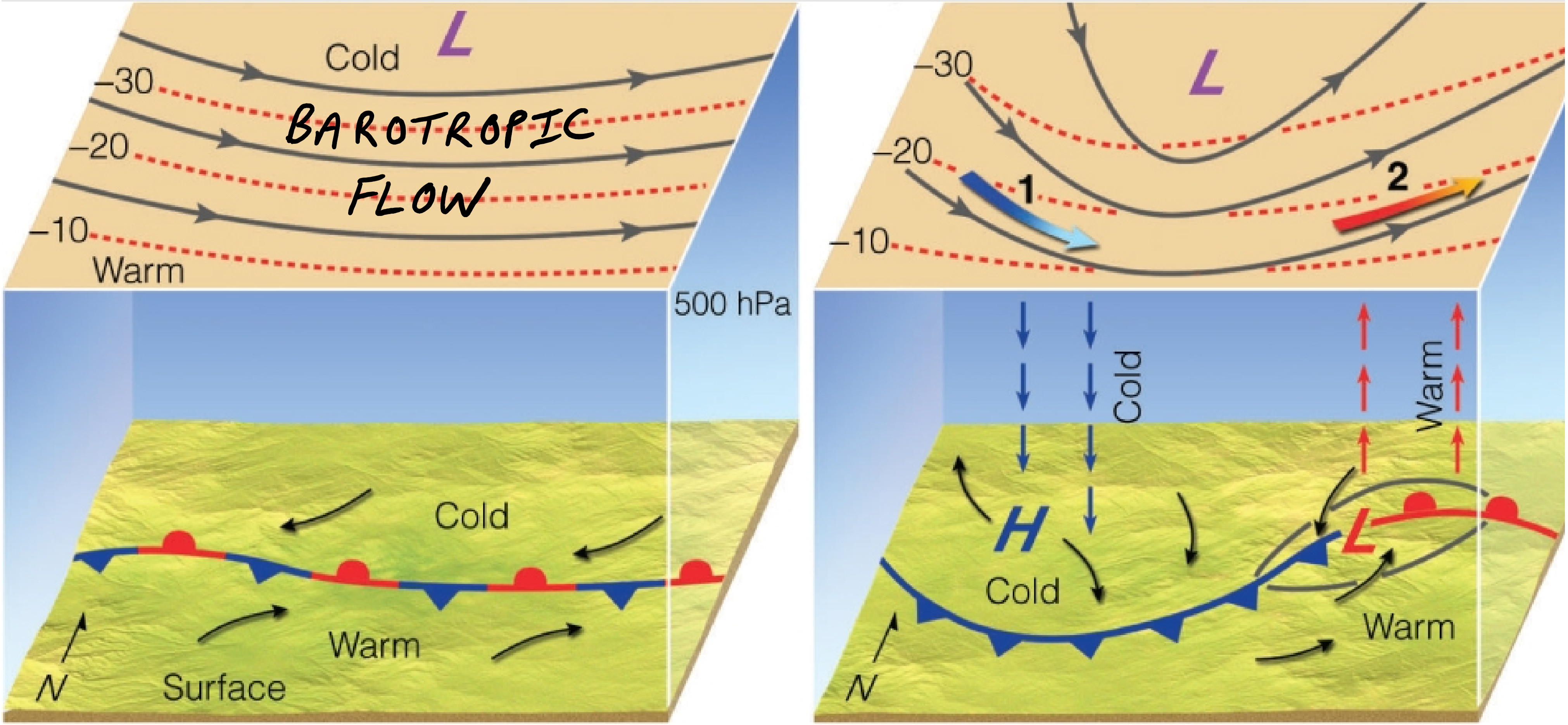


Fig 14.14b



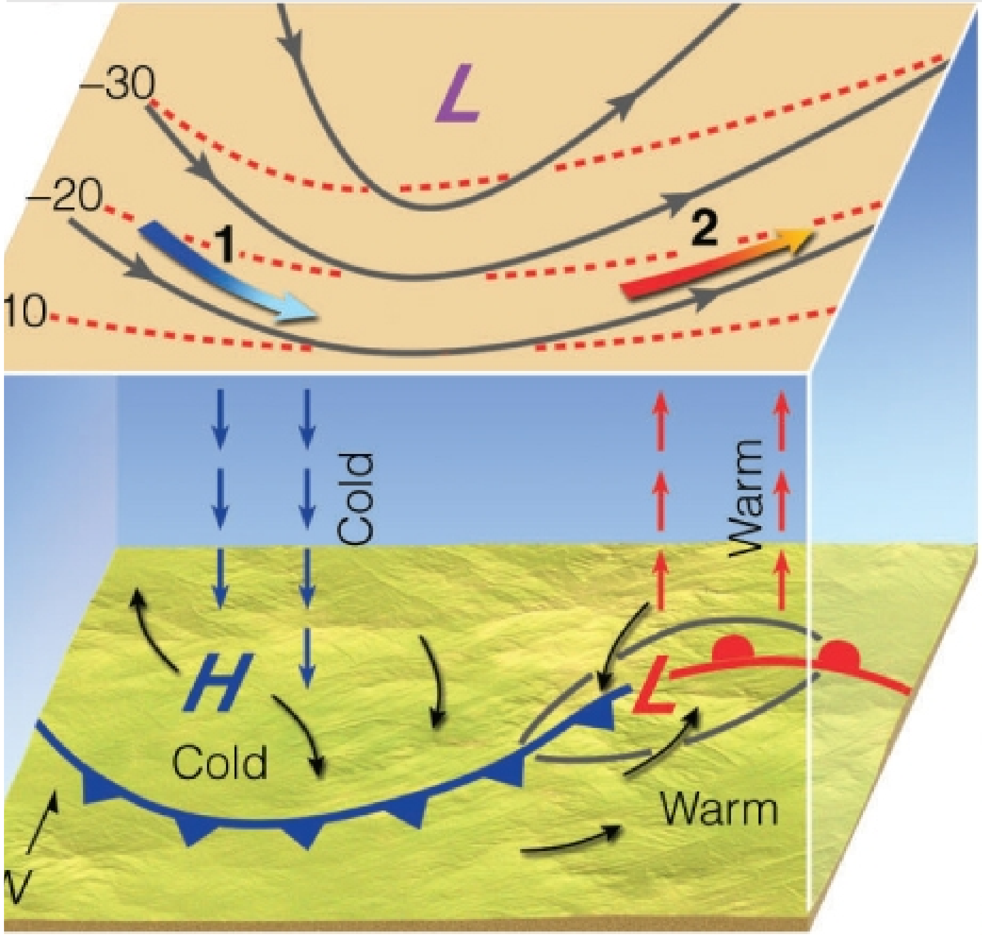
- polar jet lies poleward of surface cold front
- max speeds (“jet streaks” or "jet cores") occur in the troughs
- disturbed force balance results in convergence at left entry, divergence at left exit (*reason for this is complex, and not examinable*)
- thus jet core exit lying over sfc low represents “upper support”

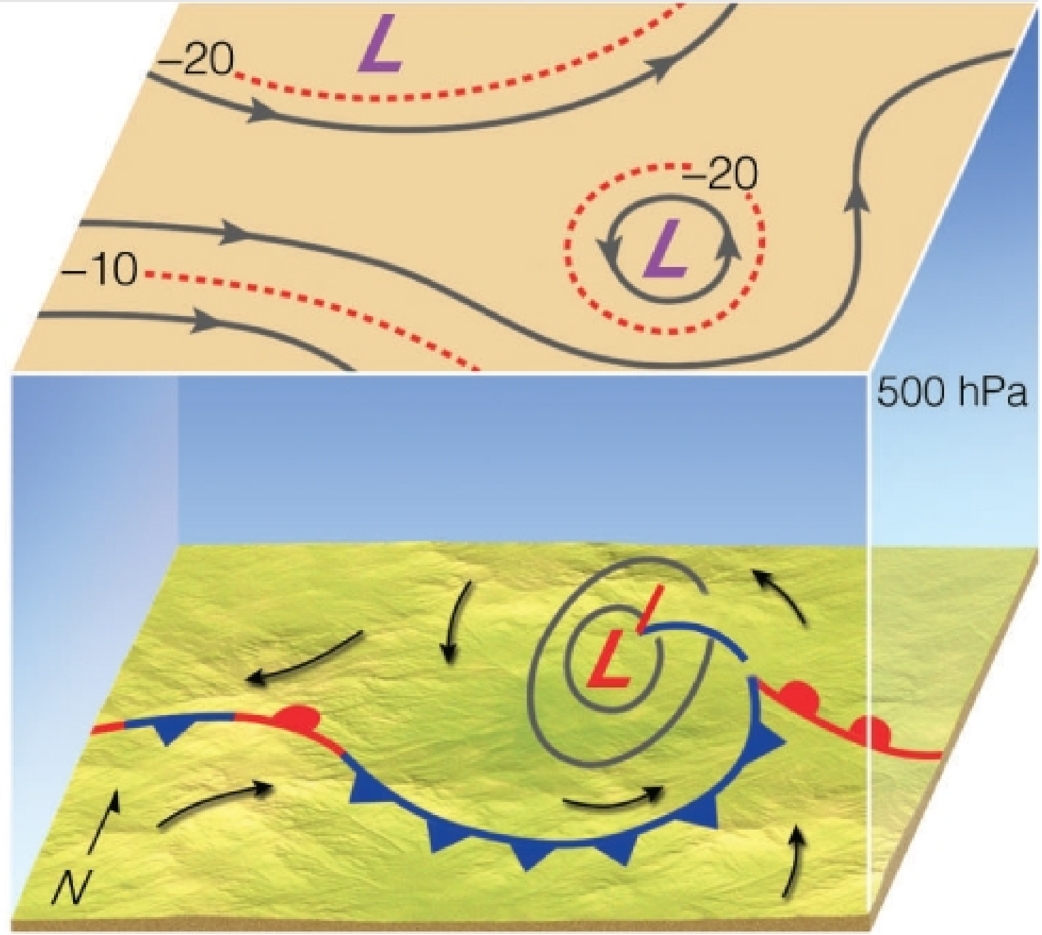


A. longwave trough above and parallel to quasi-stationary front – no advection aloft – grav. pot'l energy – wind shear

B. shortwave arrives

- cold advection in trough entry (1) raises sfc pressure and causes sink
- warm advection in trough exit (2) drops sfc pressure and causes lift
- closed sfc low is formed → winds, fronts





C. pattern of thermal adv. amplifies the upper level wave (deepens the upper trough, increases the winds)

D. storm has occluded, warm sector air is far away, cold dry air wrapping around sfc low is drawn in

The polar front model and the conveyor belt model are qualitative conceptual paradigms. The actuality of a storm is a complex 3-D, time-dependent flow, a particular solution to a large set of equations whose exact form is unknown to us but whose approximate form we do solve numerically – Numerical Weather Prediction

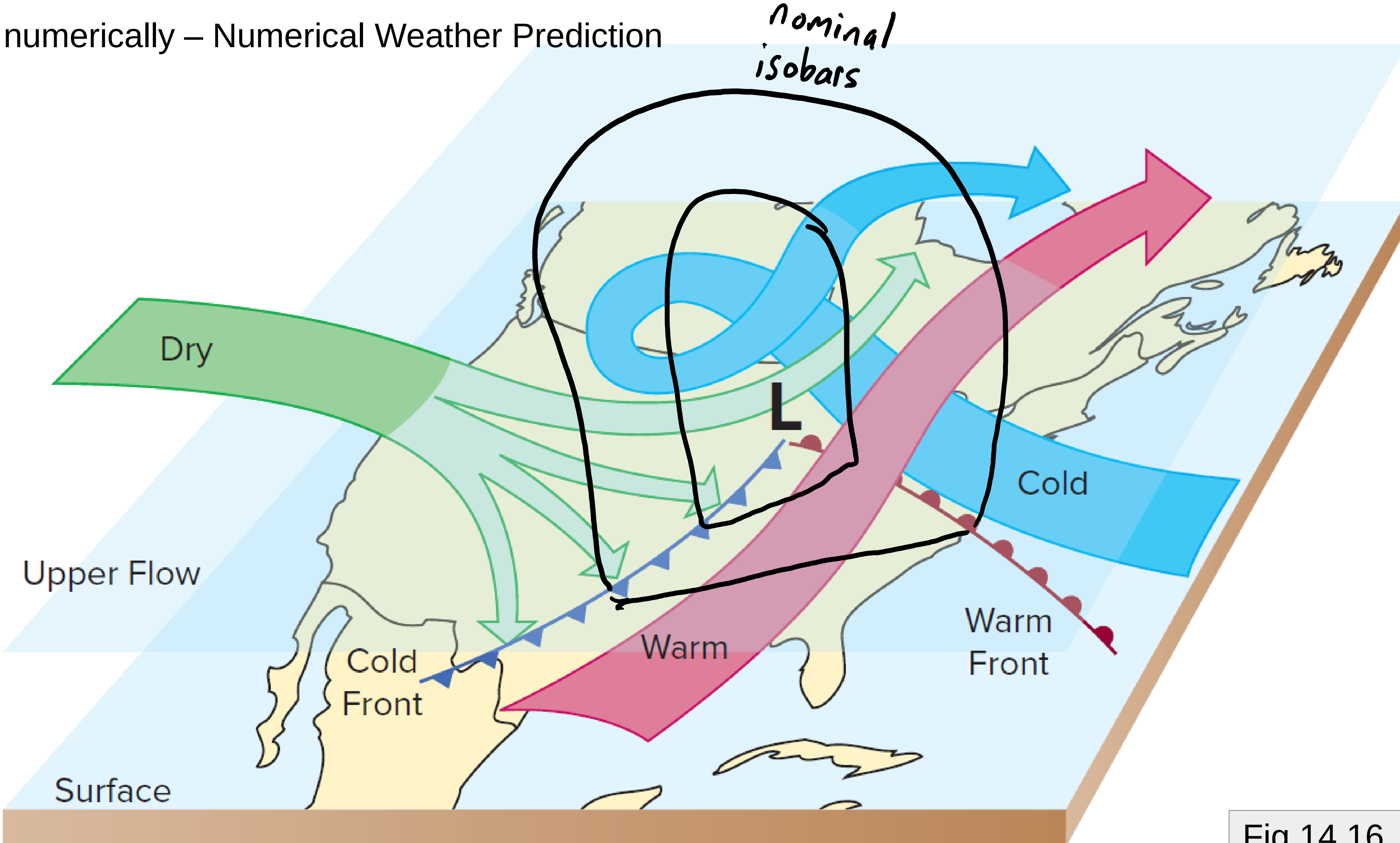


Fig 14.16

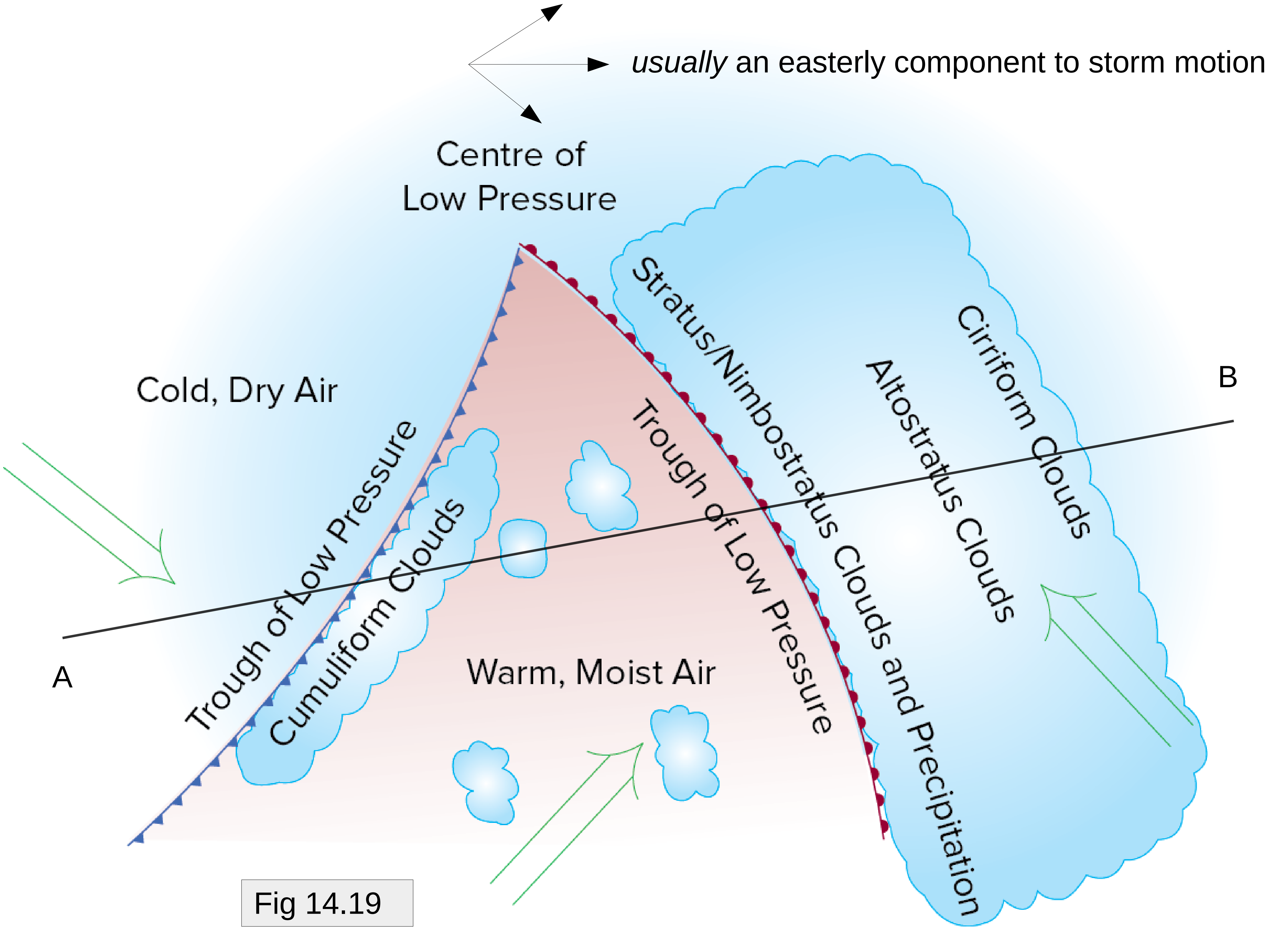

usually an easterly component to storm motion
Centre of
Low Pressure
Cold, Dry Air
Trough of Low Pressure
Cumuliform Clouds
Warm, Moist Air
Trough of Low Pressure
Stratus/Nimbostratus Clouds and Precipitation
Altostratus Clouds
Cirriform Clouds
A
B

Fig 14.19

- weak pressure gradient, light winds in/near the **H**
- subsidence, clear skies, fine weather – high temp (summer), low temp (winter)
- strong flow around the polar side of the omega high causes lows to skirt around the high (the "omega-block"). Pattern may persist for many days

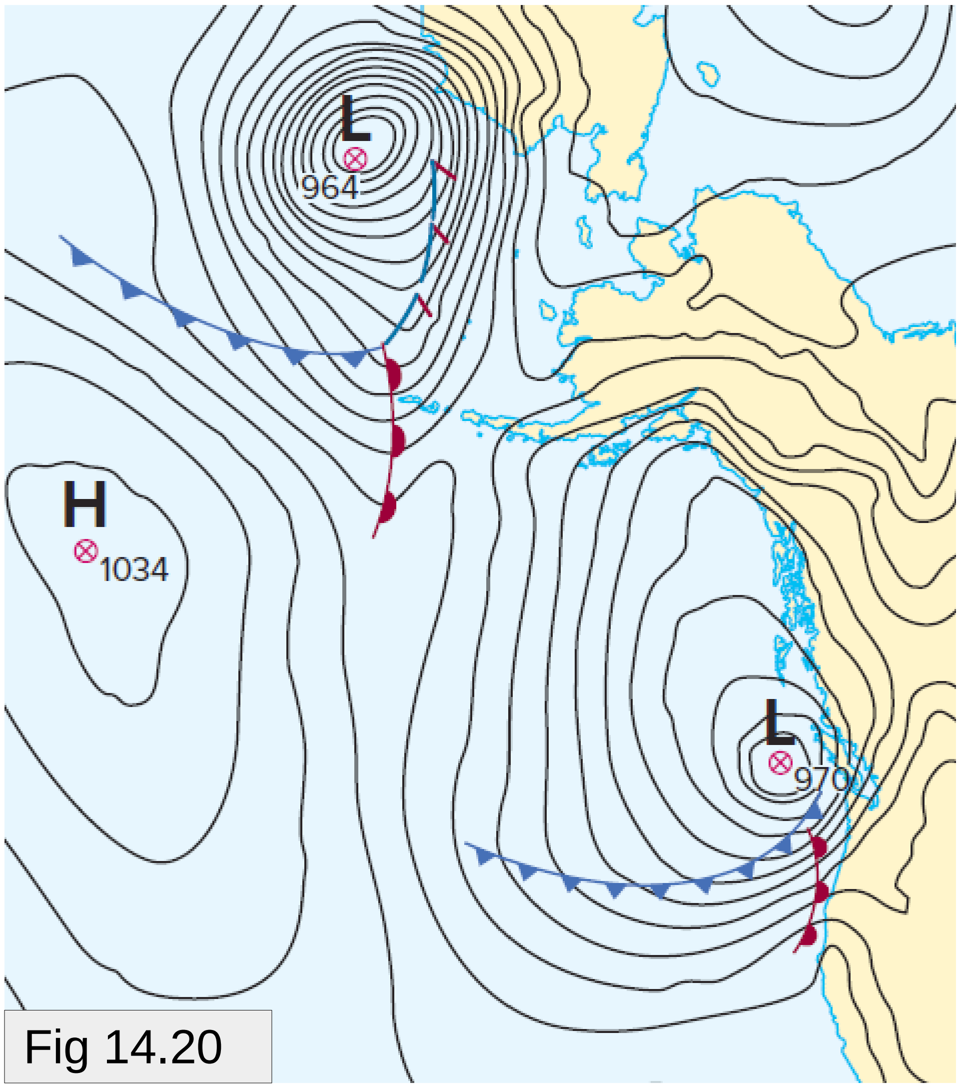


Fig 14.20

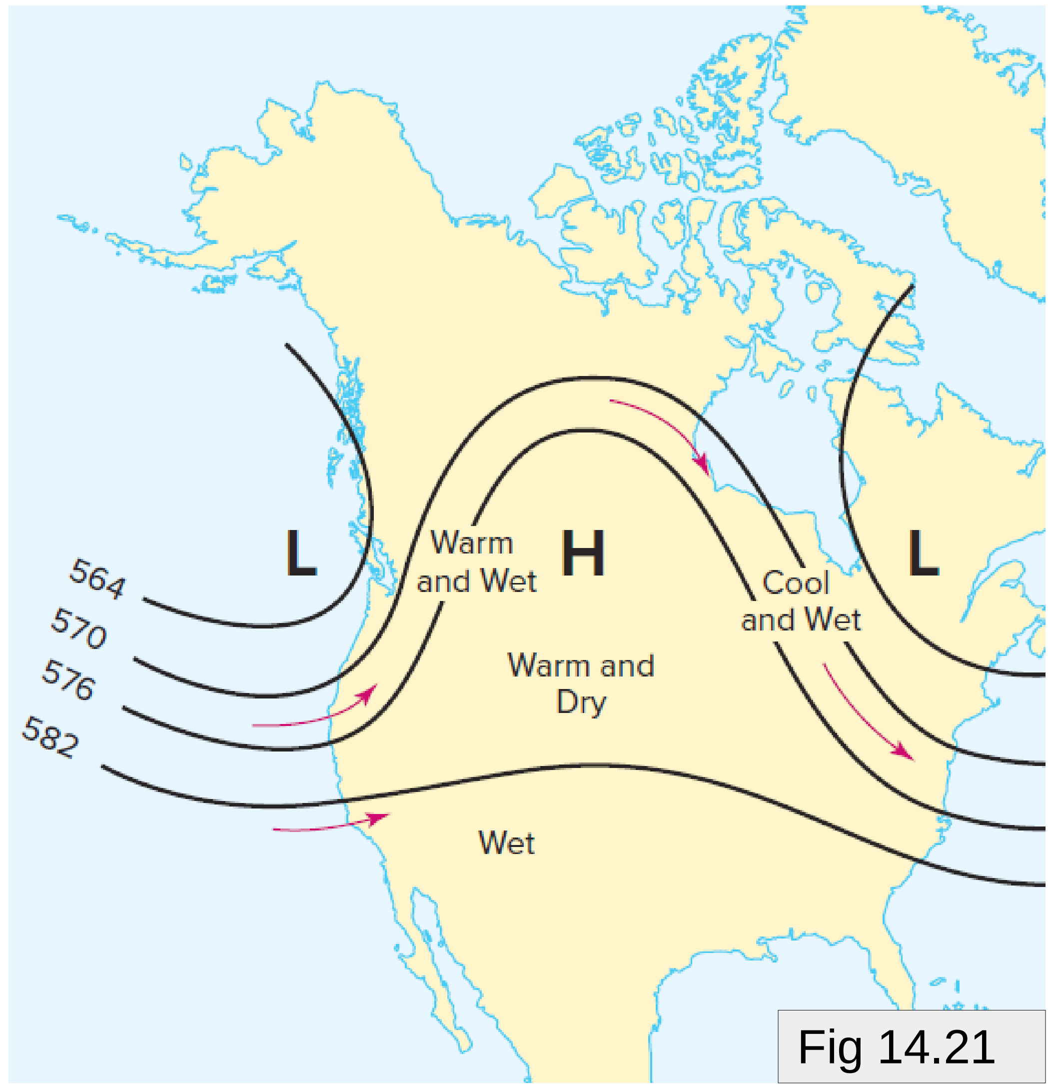


Fig 14.21

Topics/concepts covered (Ch 14)

- Bjerkes' Polar Front Theory for the life cycle of a midlatitude storm (previous file)
- existence of "shortwaves" superposed on the longwaves
- association between ascent and warm advection aloft (sink & cold advection)
- divergence aloft in the "left exit" region of a jet core