EAS270_Ch14_Storms_A.odp
JDW, EAS U.Alberta, last mod. 29 Nov. 2016

Mid-latitude cyclone (storm)

- is associated with low surface pressure
- synoptic scale
- initiated & supported by upper divergence
- deep, tilted system
- baroclinic
- energy derived from temperature contrast across polar front

Sec. 14.1 and Table 14.1 give an *idealized* classification of atmospheric circulation systems (on the meso- and synoptic- scales: shallow vs. deep, barotropic vs. baroclinic, tilted vs. vertically-stacked, cold vs. warm core

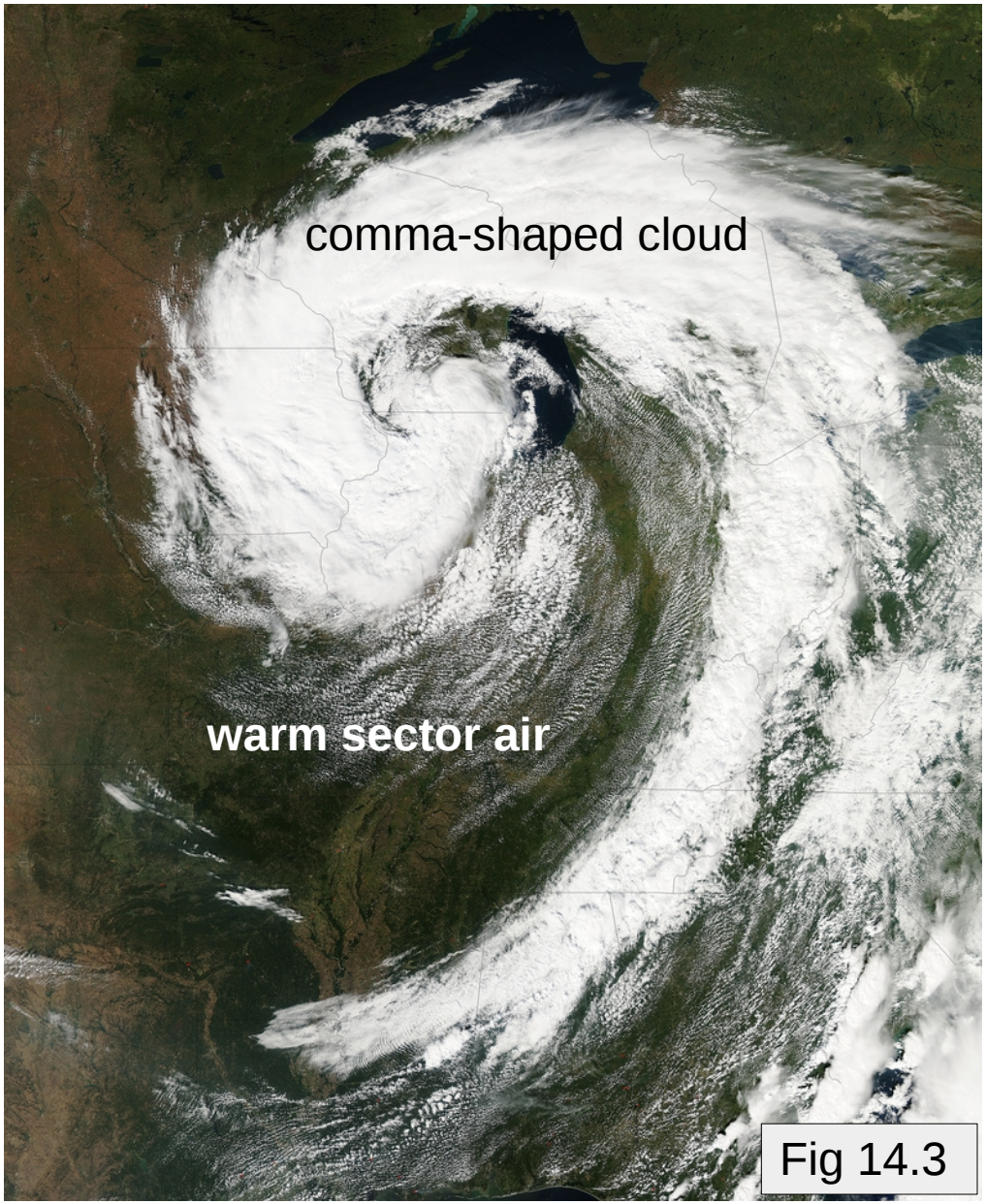
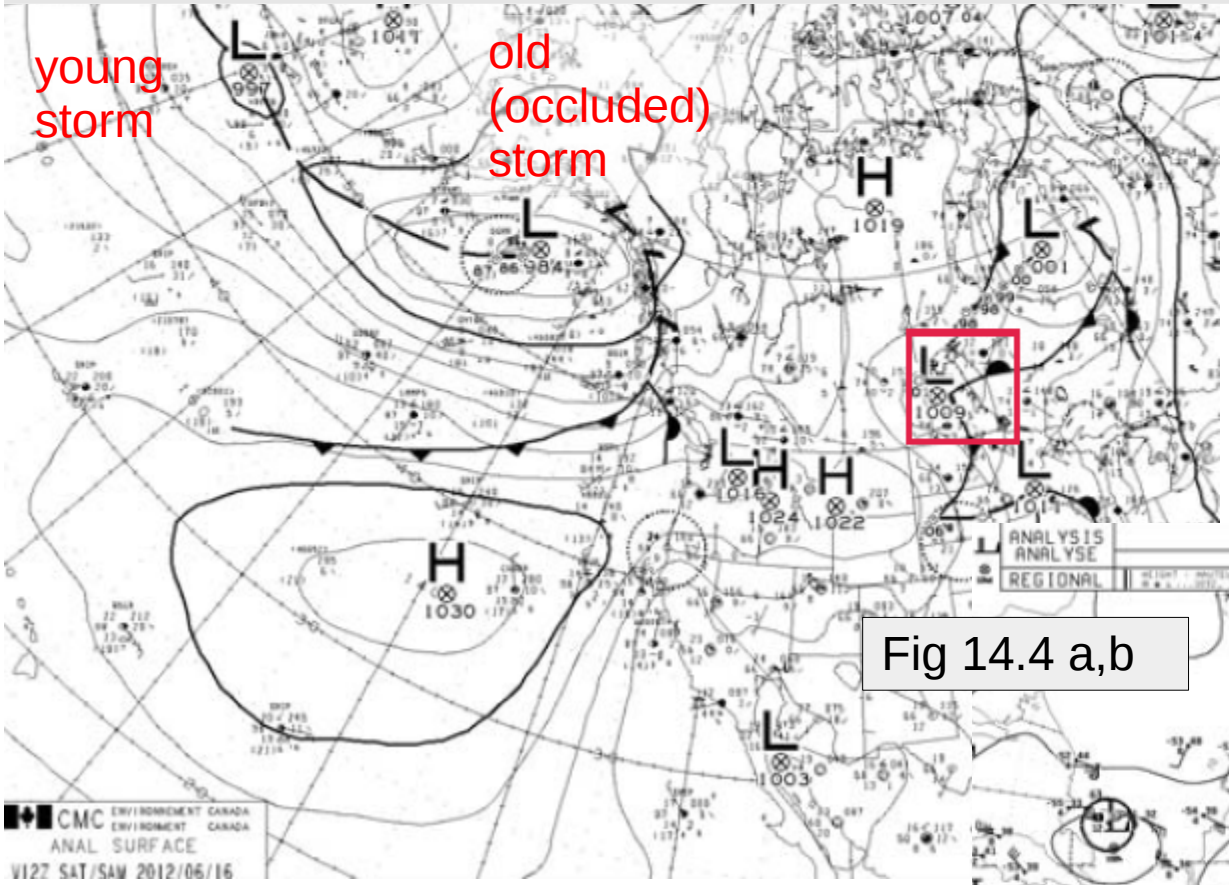
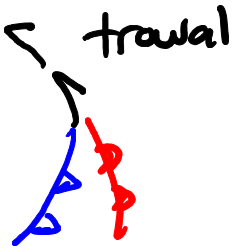


Fig 14.3



- can sometimes identify "families" of storms along the polar front, in different stages of the storm life cycle



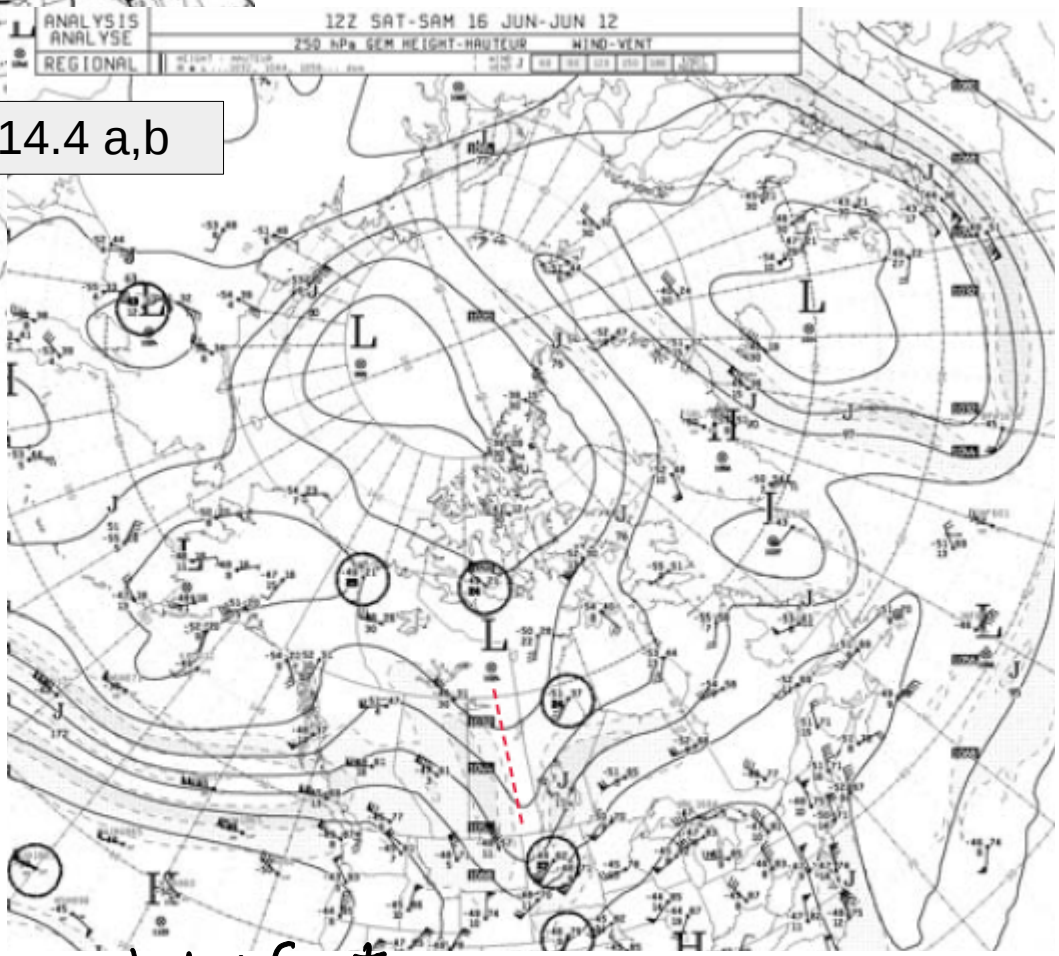
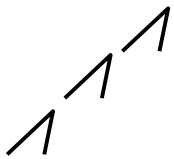


Fig 14.4 a,b

- surface low in Manitoba is positioned beneath the exit region of the upper trough upwind (which runs through Saskatchewan)



symbol on Cdn charts for a TROWAL (Trough of Warm air Aloft) i.e. an occluded front

Cutoff low; synoptic scale cold pool of air trapped on equator-ward side of the polar jetstream; vertically stacked; slow-moving; persistent cloud & precip.

Cutoff **high** – warm air on polar side of front; prevailing fine weather

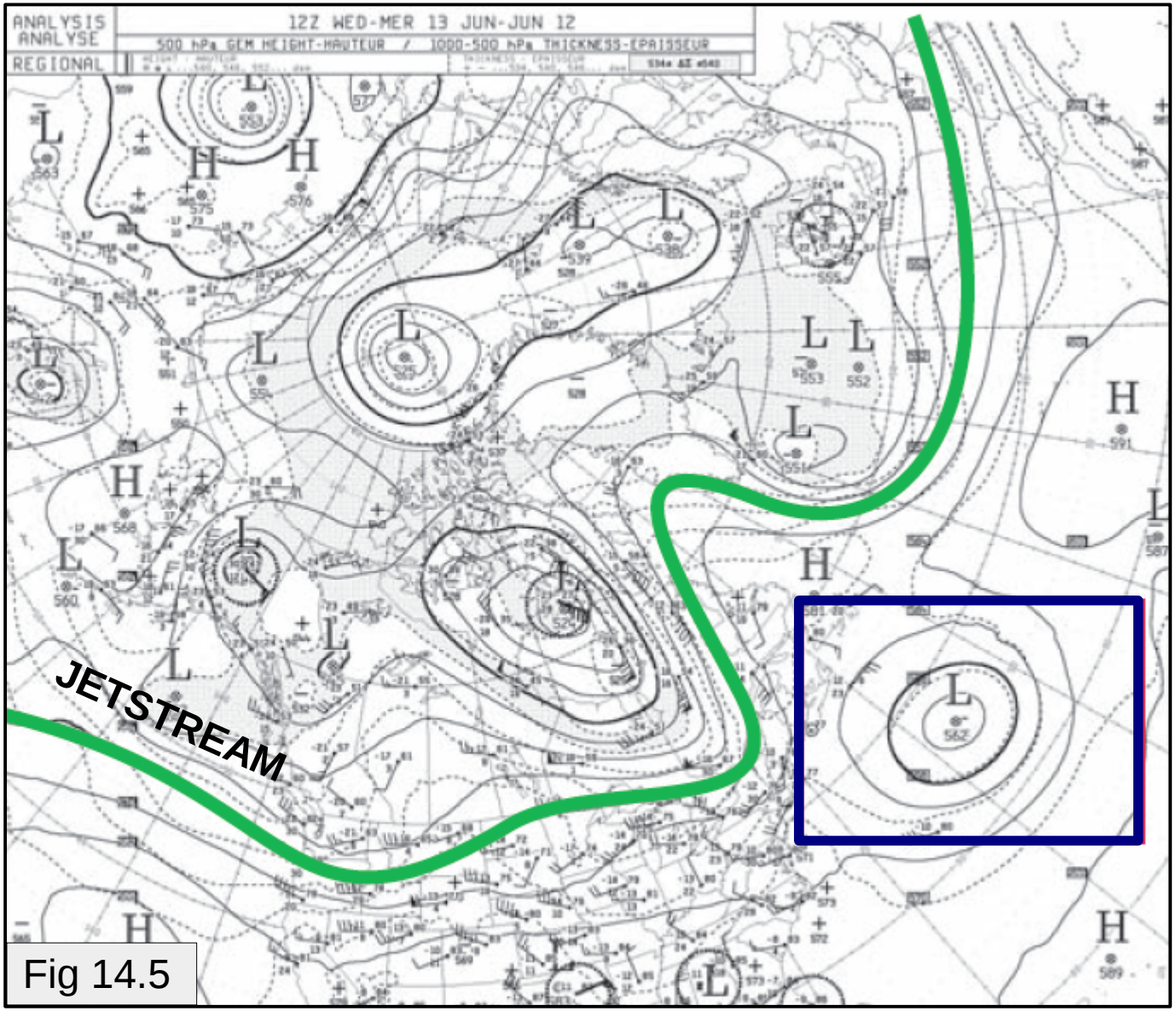
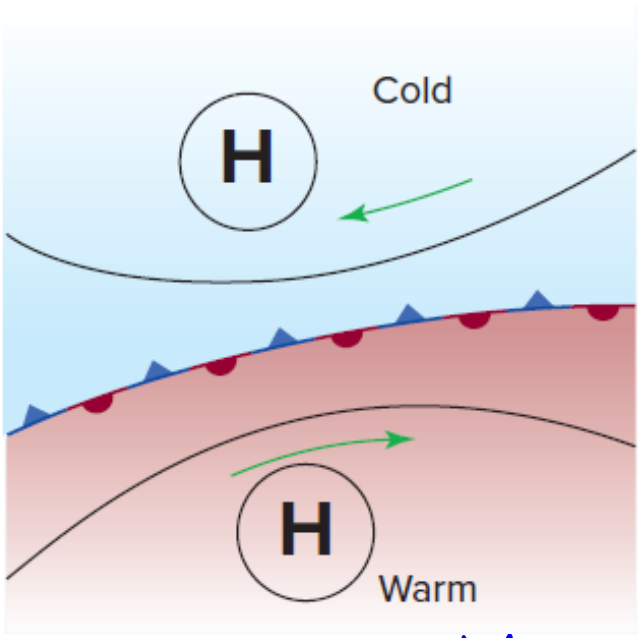


Fig 14.5

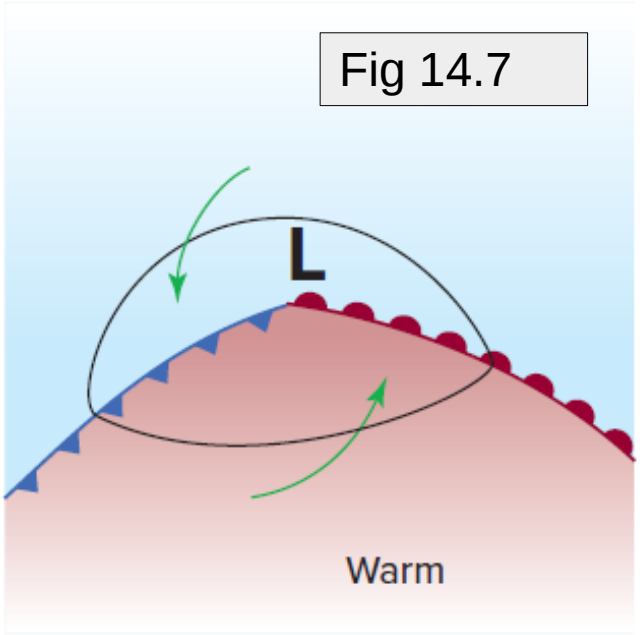
Fig 14.7



a)

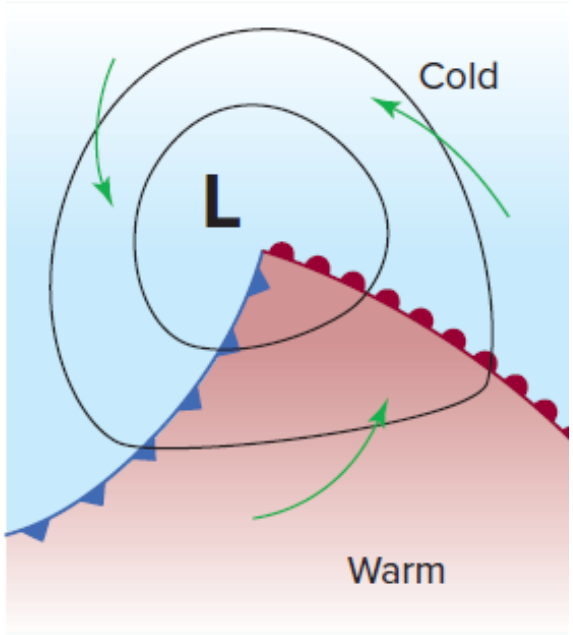
quasi-stationary

- Wind shear across QS front
- Store of gravitational potential energy (PE)



b)

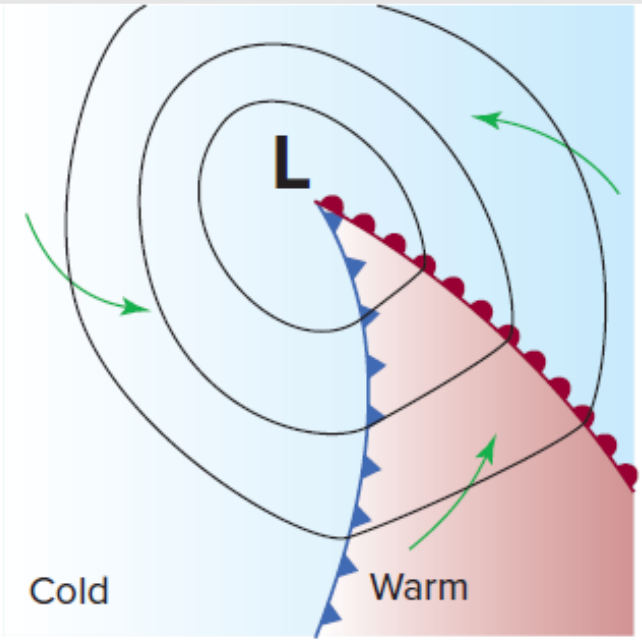
- Divergence aloft lowers P_{sfc}
- cyclonic wind initiated
- distinct cold and warm fronts result, joining at a "kink" or "wave"
- ascent of the warm air over cold liberates PE
- frontal cloud & precip



c)

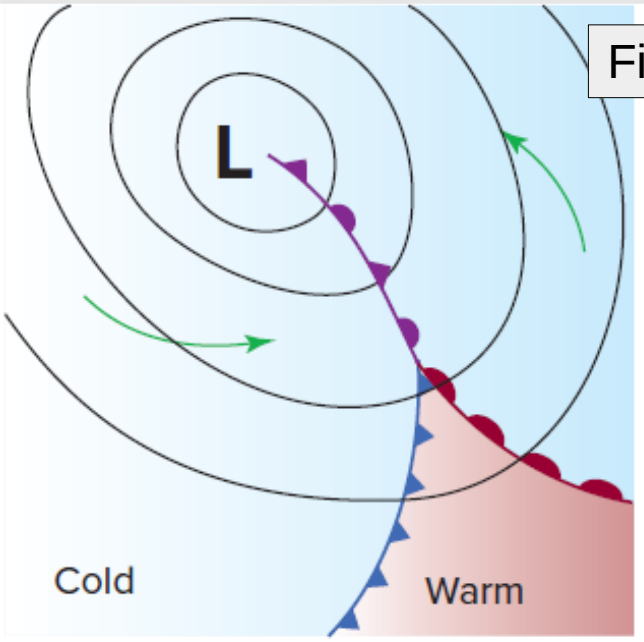
- Mature "open wave stage"
- lower central pressure, stronger winds
- well defined warm sector
- vigorous convection on the cold front

Fig 14.7



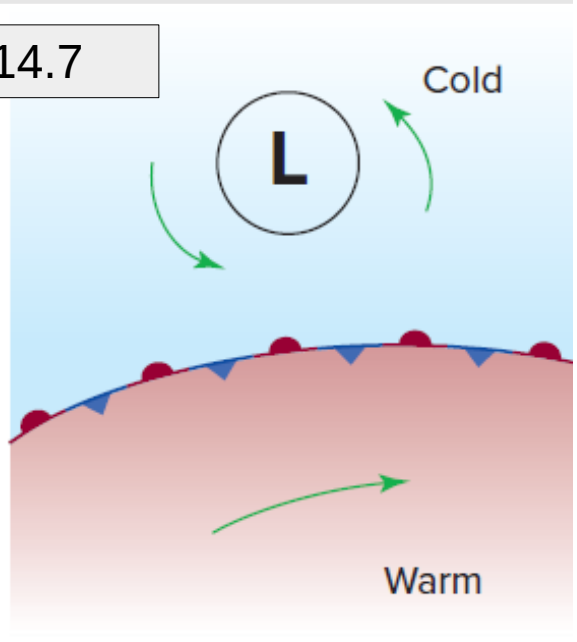
d)

- Mature storm, even lower central pressure
- Stronger winds
- Cold front converging on warm front narrows the warm sector



e)

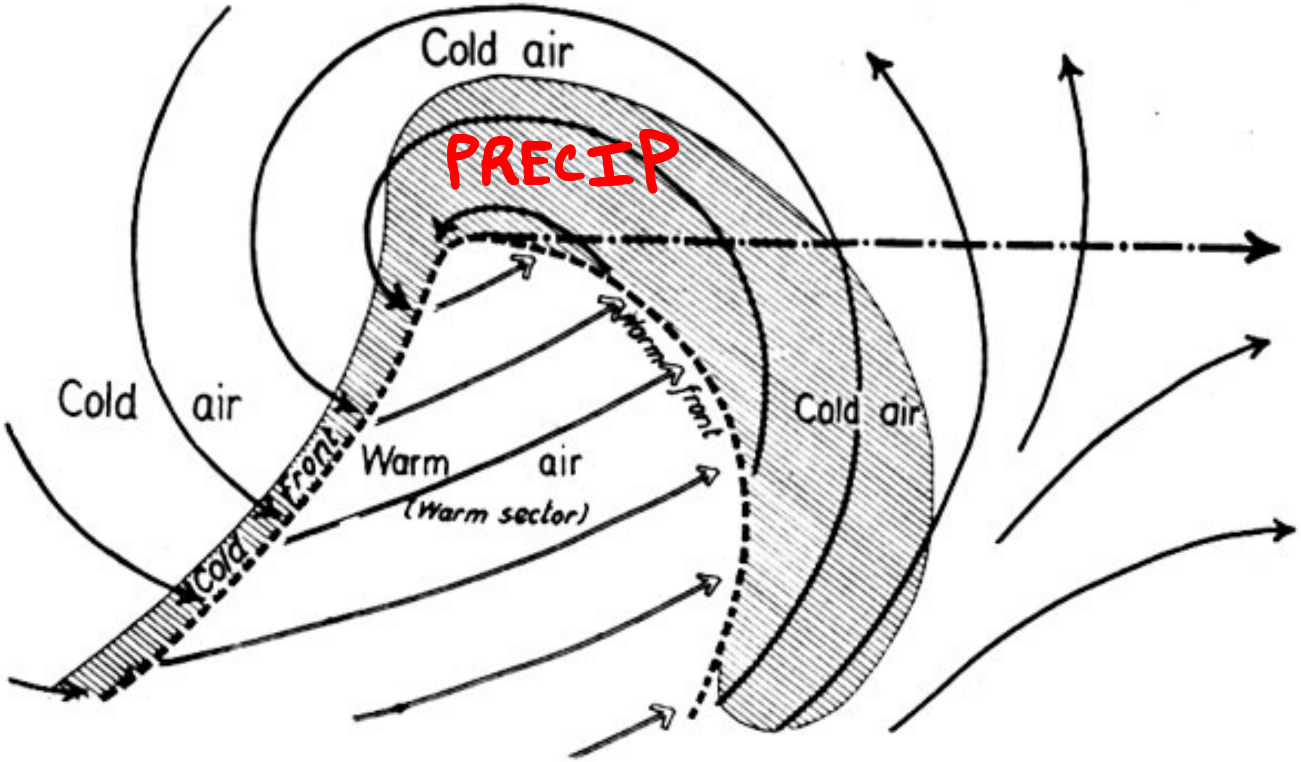
- Occlusion begins – cold front converging on warm front forces warm sector air aloft (Trough of warm air aloft – "TROWAL")
- Reduced airmass contrast at the surface towards centre of low
- Surface warm sector air now remote from the storm core



f)

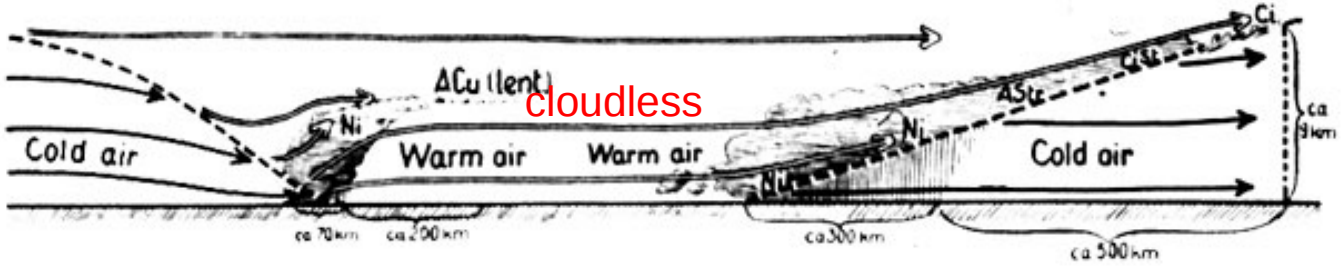
- Occluded low (located N of front & jetstream)

Cross section north of the storm centre (not crossing the fronts)



nominal direction of travel

Fig 14.6a



Cross section south of the storm centre (crossing both fronts)

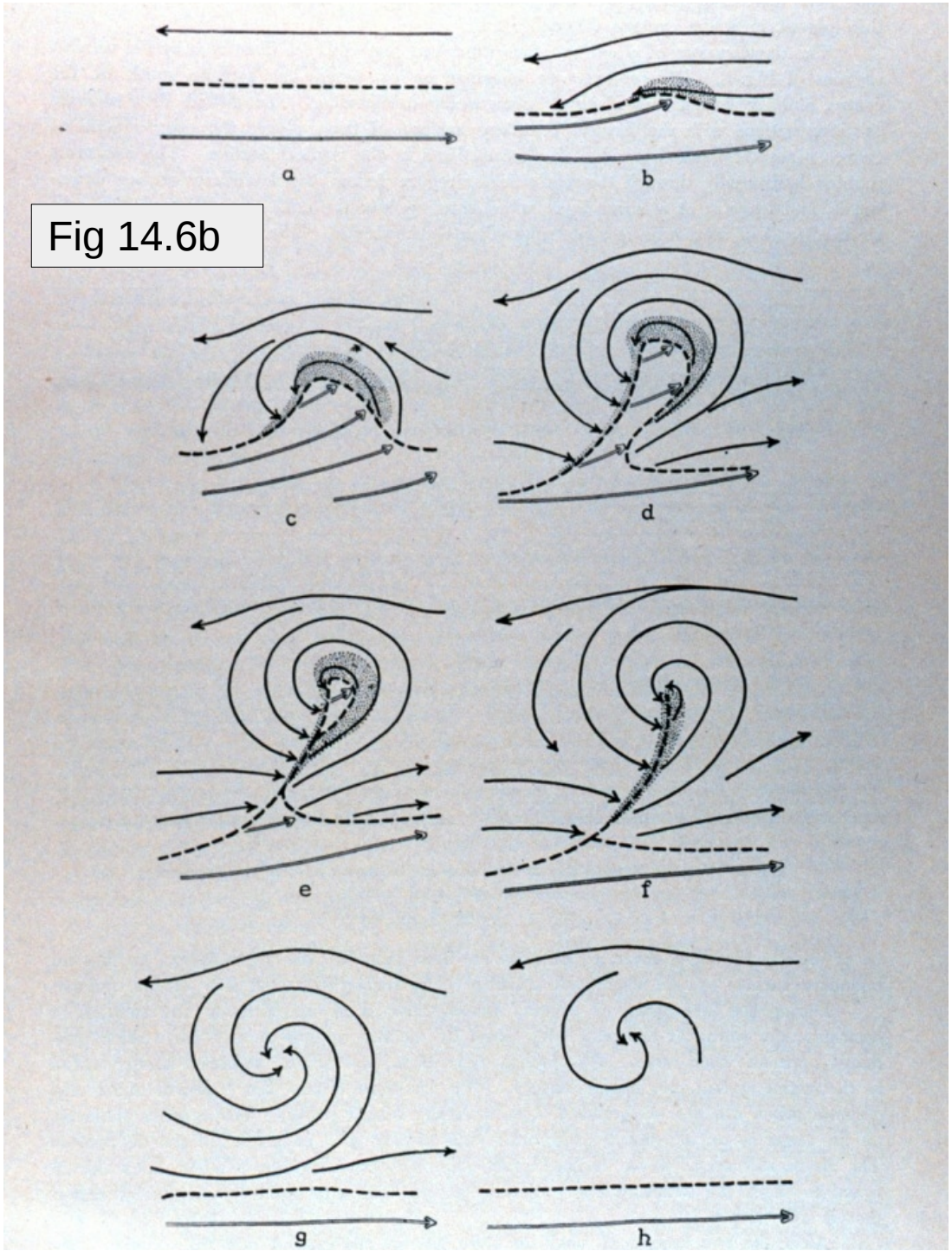
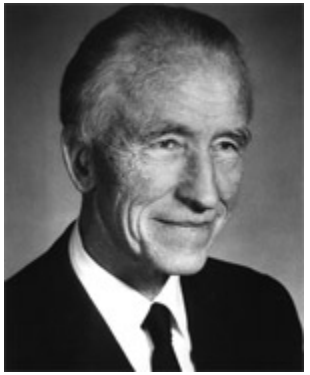


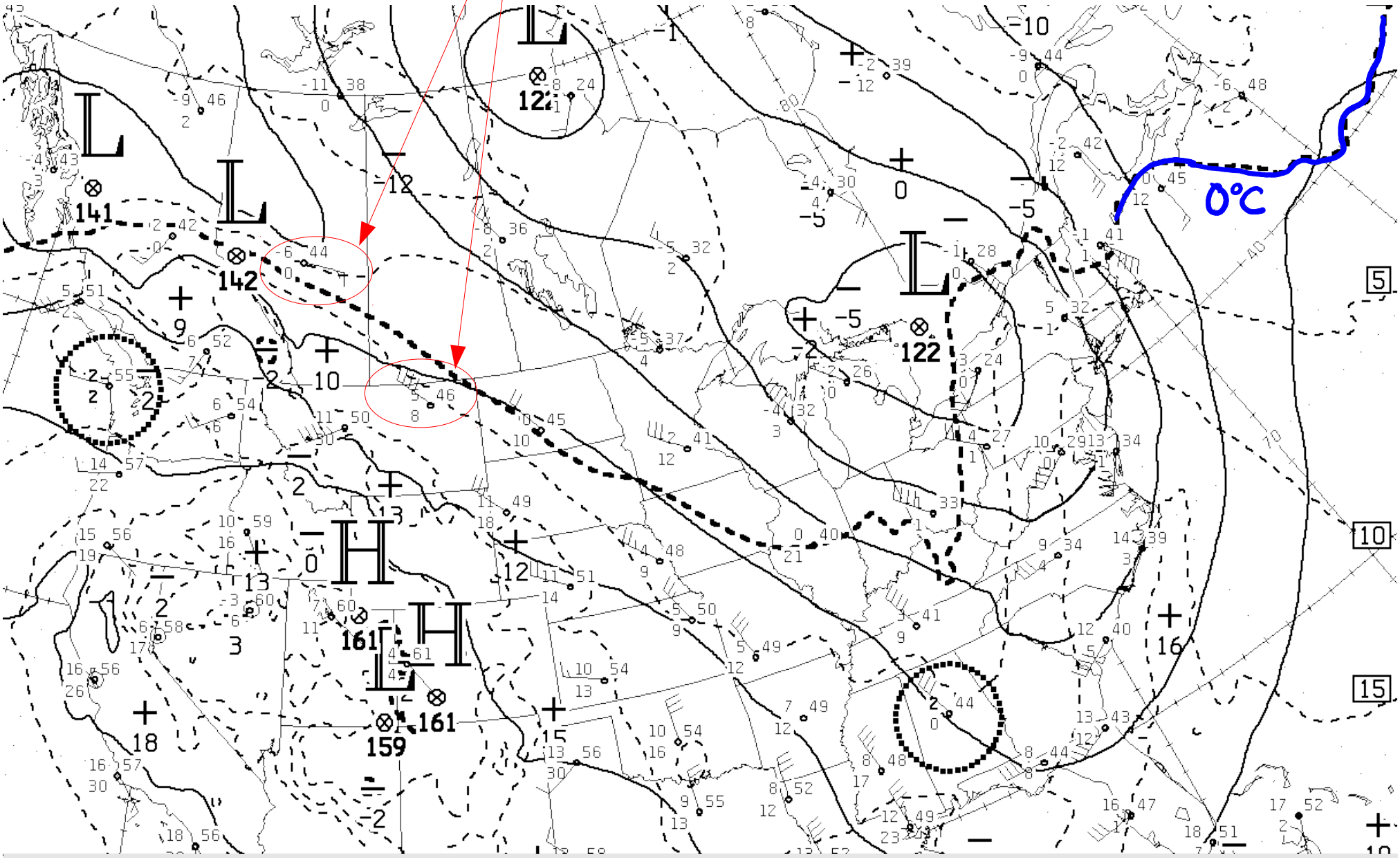
Fig 14.6b

- cyclone lifetime a few days to over a week

Bjerknes developed this paradigm for the storm's life cycle on the basis of (mostly) *surface* observations



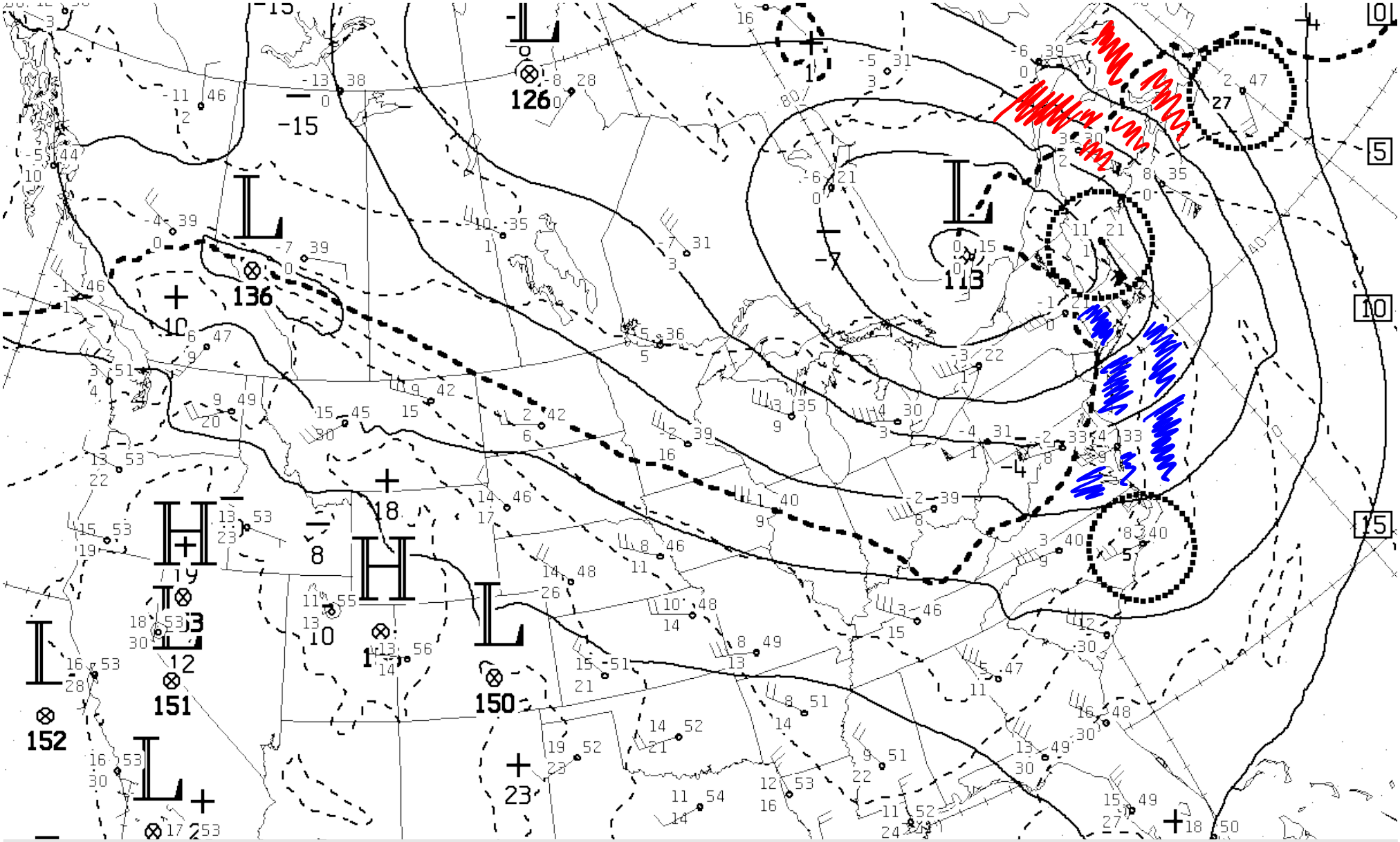
J. Bjerknes



CMC 850 hPa analysis 12Z Sat 28 Oct. 2006

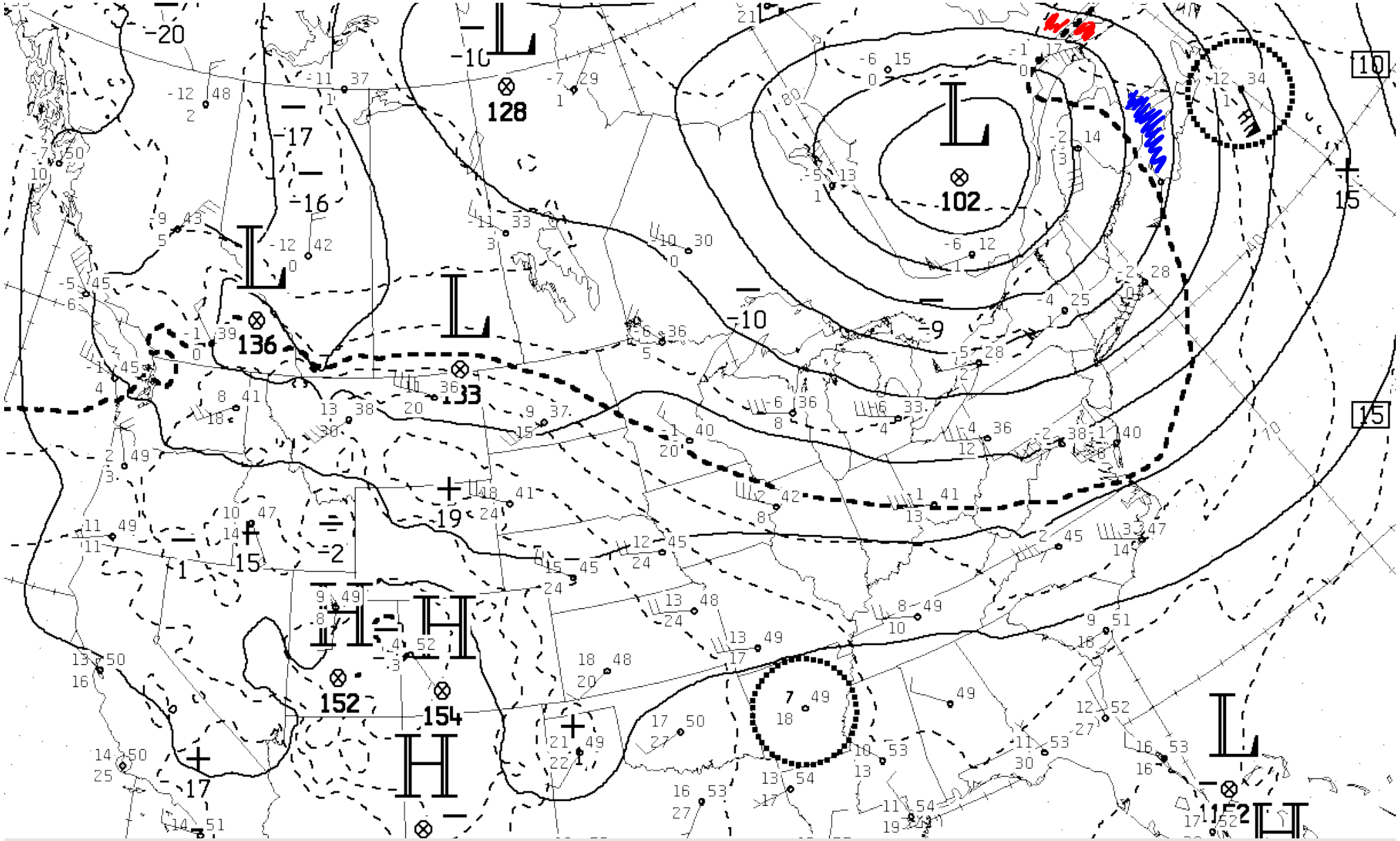
Strong temperature gradient over southern Canadian prairies; closed surface low first seen 9/17

The smaller and the more rectangular the quadrilaterals defined by isotherms crossing height contours, the STRONGER the warm or cold advection



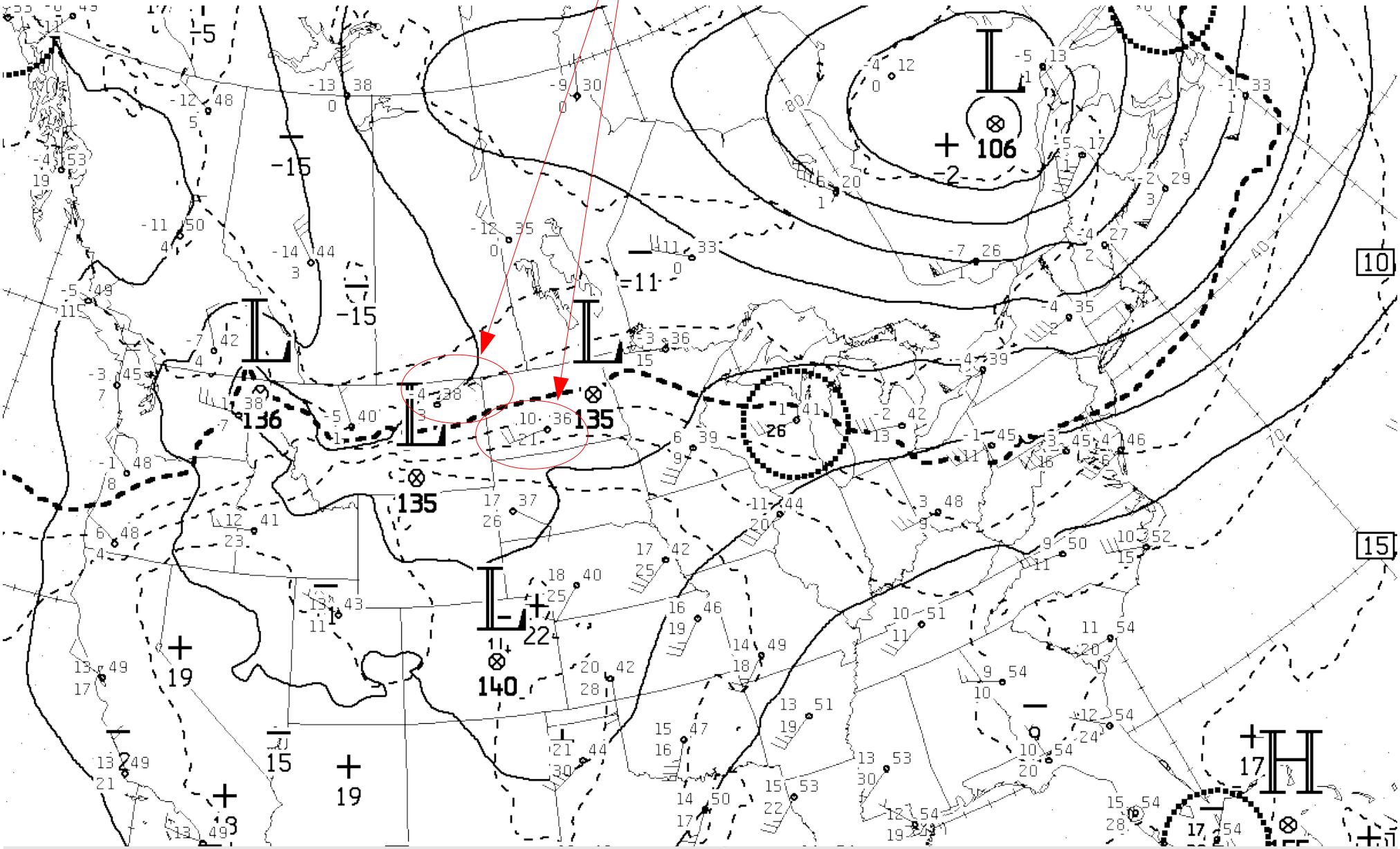
CMC 850 hPa analysis 00Z Sun 29 Oct. 2006

Strong temperature gradient over southern Canadian prairies; "kink" accentuating? 10/17



CMC 850 hPa analysis 12Z Sun 29 Oct. 2006

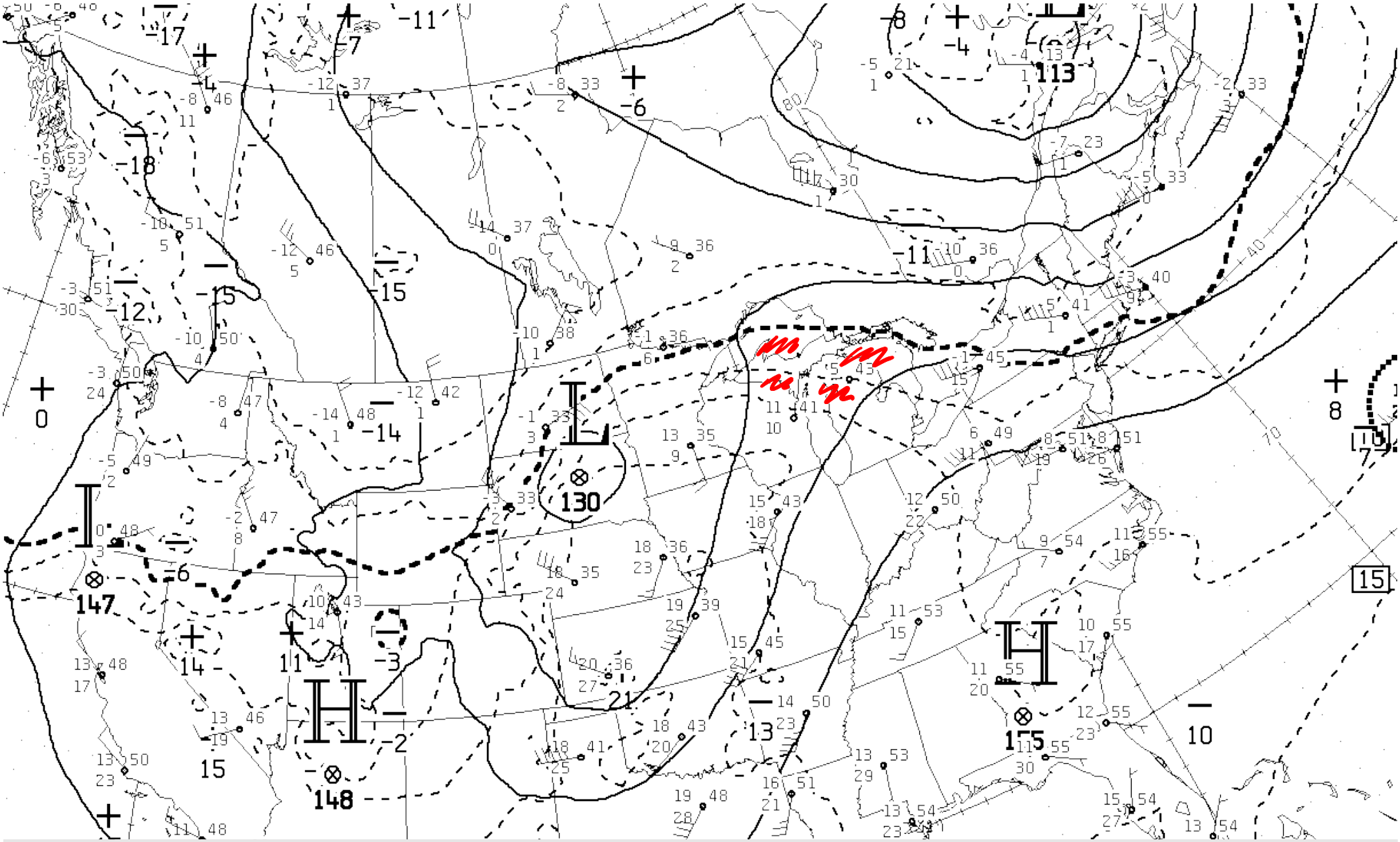
Central height 135 dam



CMC 850 hPa analysis 00Z Mon 30 Oct. 2006

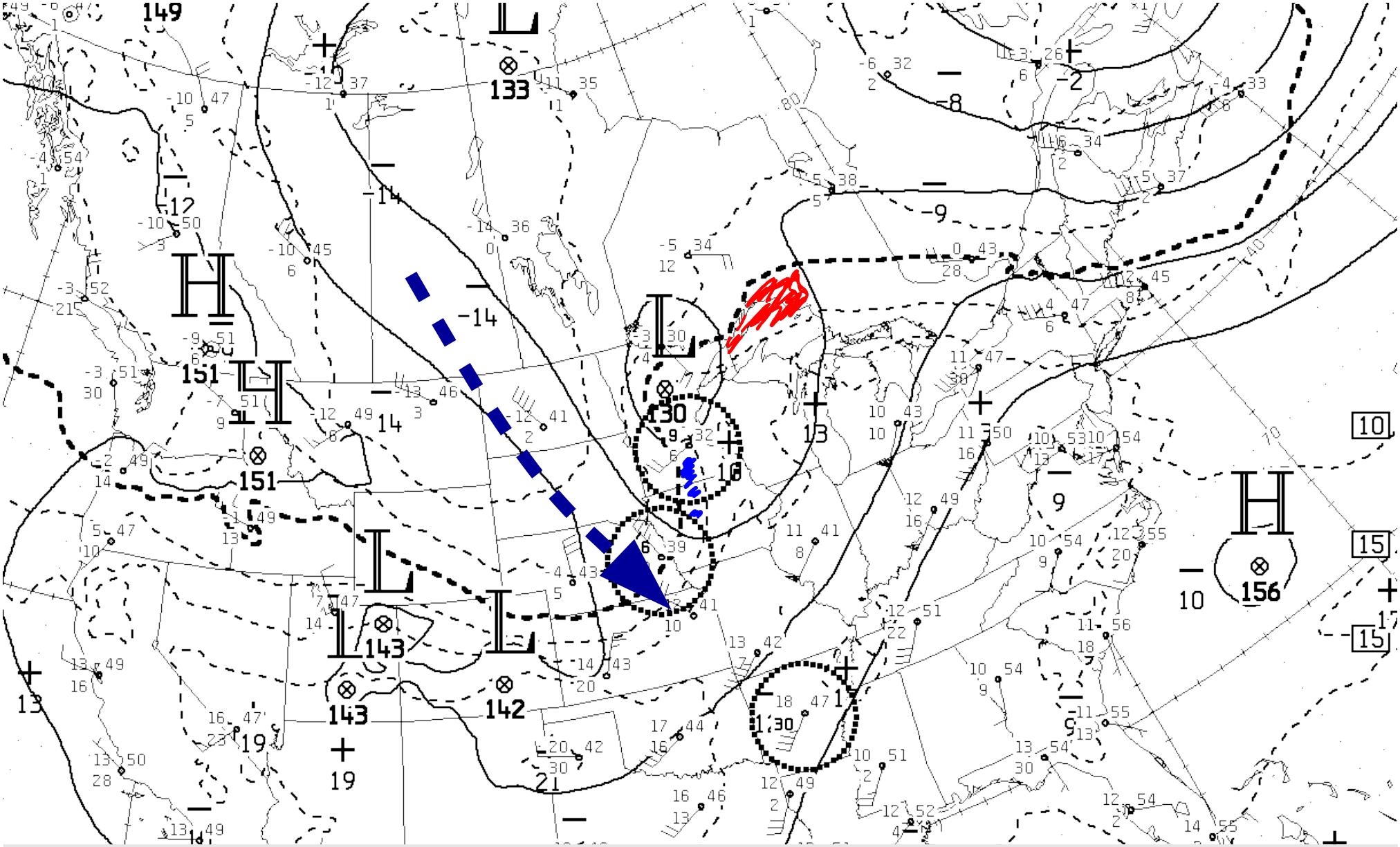
Storm deepened – open wave configuration – will run along & displace the frontal zone 12/17

Central height 130 dam



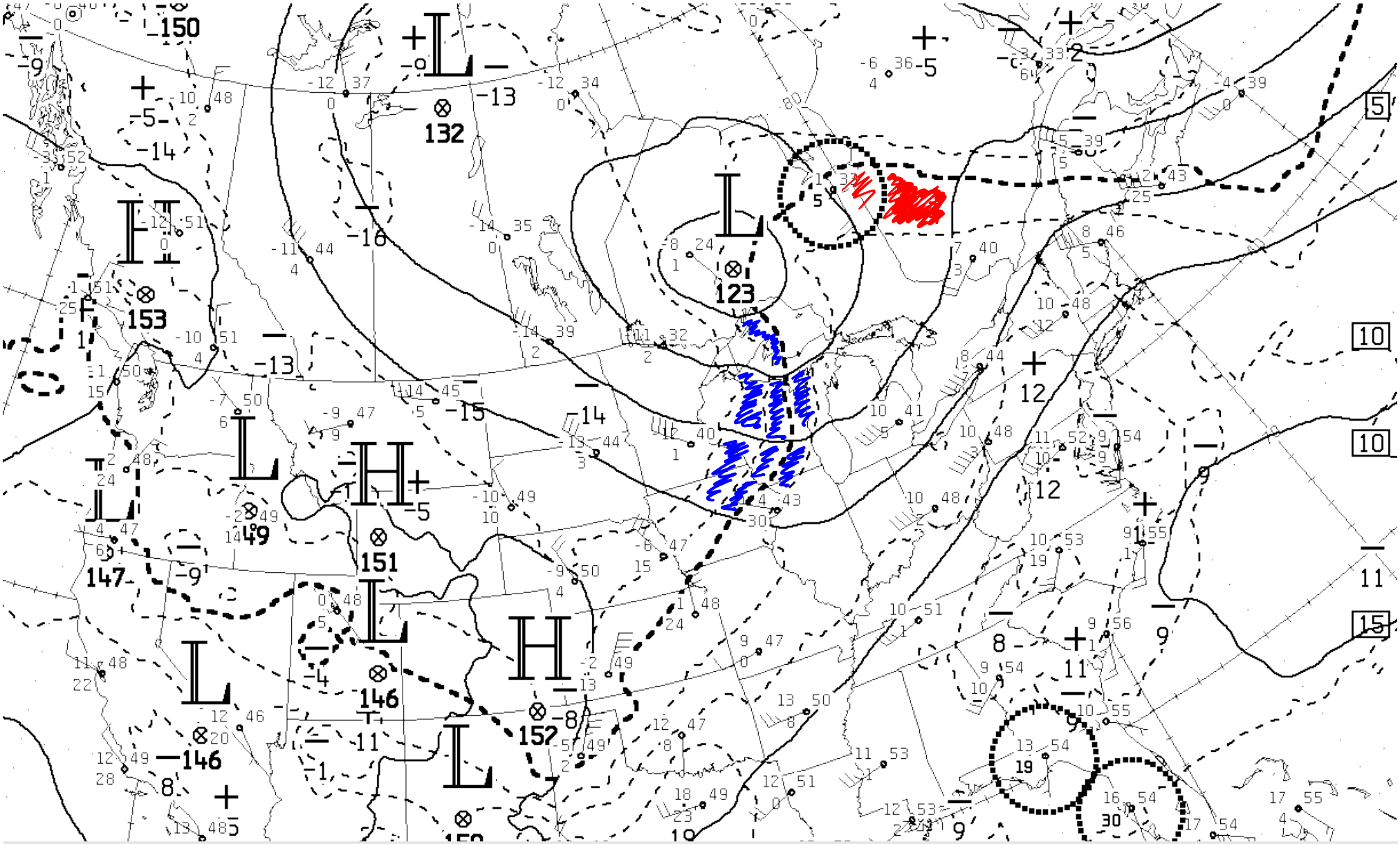
CMC 850 hPa analysis 12Z Mon 30 Oct. 2006

cold advection warm advection Central height 130 dam



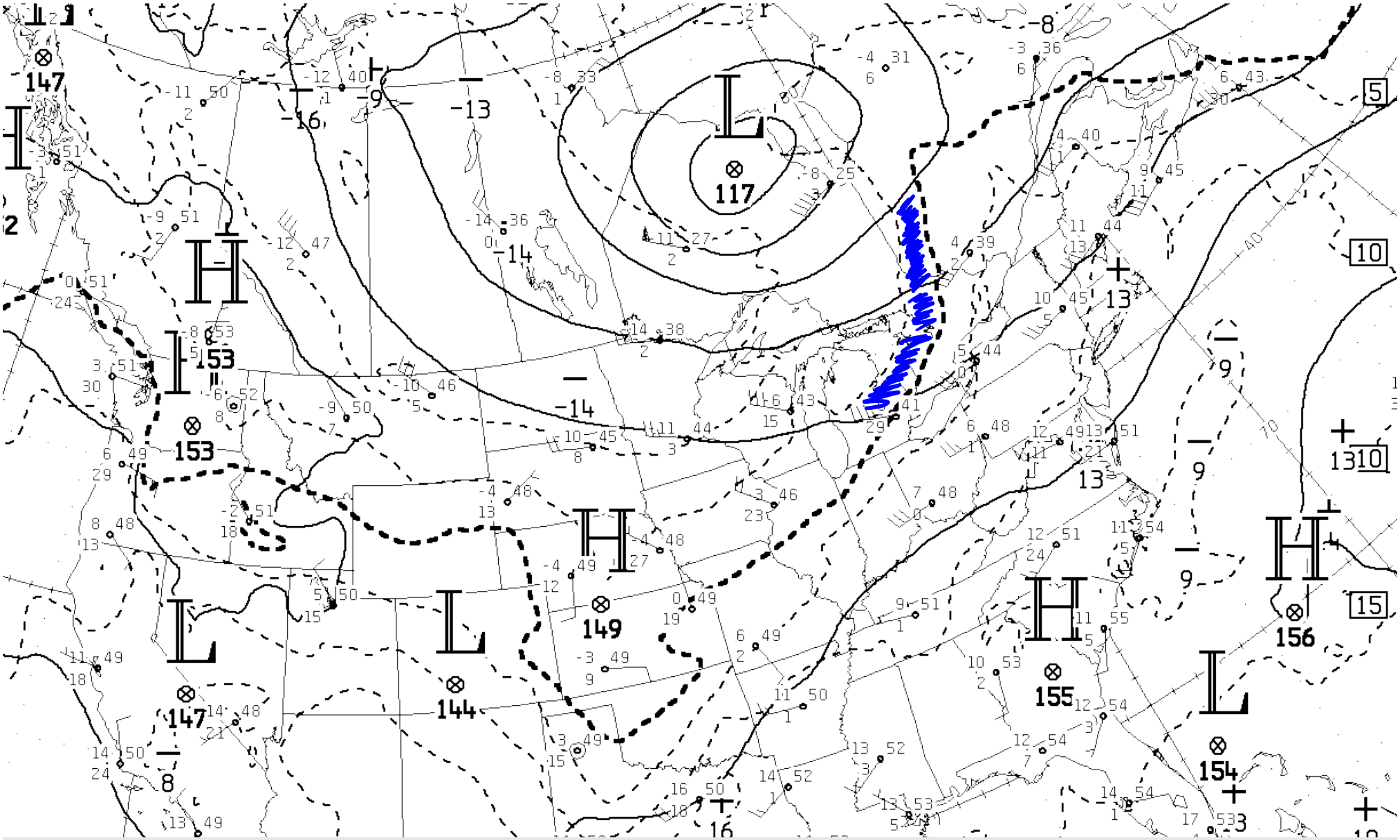
CMC 850 hPa analysis 00Z Tues 31 Oct. 2006

Central height 123 dam



CMC 850 hPa analysis 12Z Tues 31 Oct. 2006

Central height 117 dam



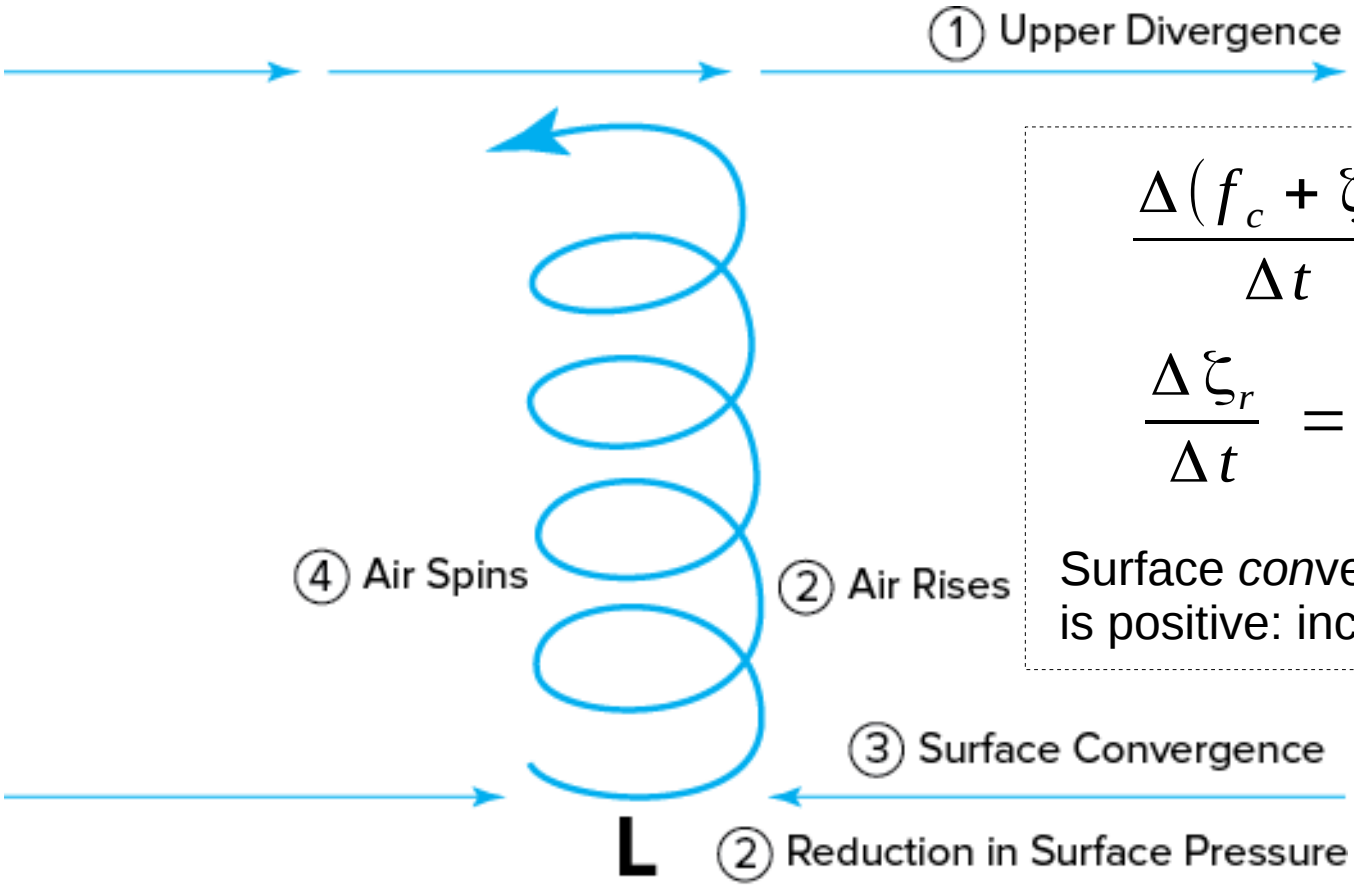
CMC 850 hPa analysis 00Z Wed 1 Nov. 2006

Favourable conditions for cyclogenesis where there is strong surface temperature contrast (e.g. at or near high latitude coastlines in winter). Strong latitudinal temperature gradient tends to result in large amplitude Rossby waves, i.e. strongly meridional flow, and vigorous storms: thus storms are stronger in winter

1) divergence aloft removes mass off the column 2) resulting in ascent and a surface low

3) and surface convergence, strengthening temperature gradients 4) rotating storm winds

(over a stationary front)



$$\frac{\Delta\left(f_c + \zeta_r\right)}{\Delta t} = -\mathrm{D}\left(f_c + \zeta_r\right)$$

$$\frac{\Delta \zeta_r}{\Delta t} = -\mathrm{D}\, f_c$$

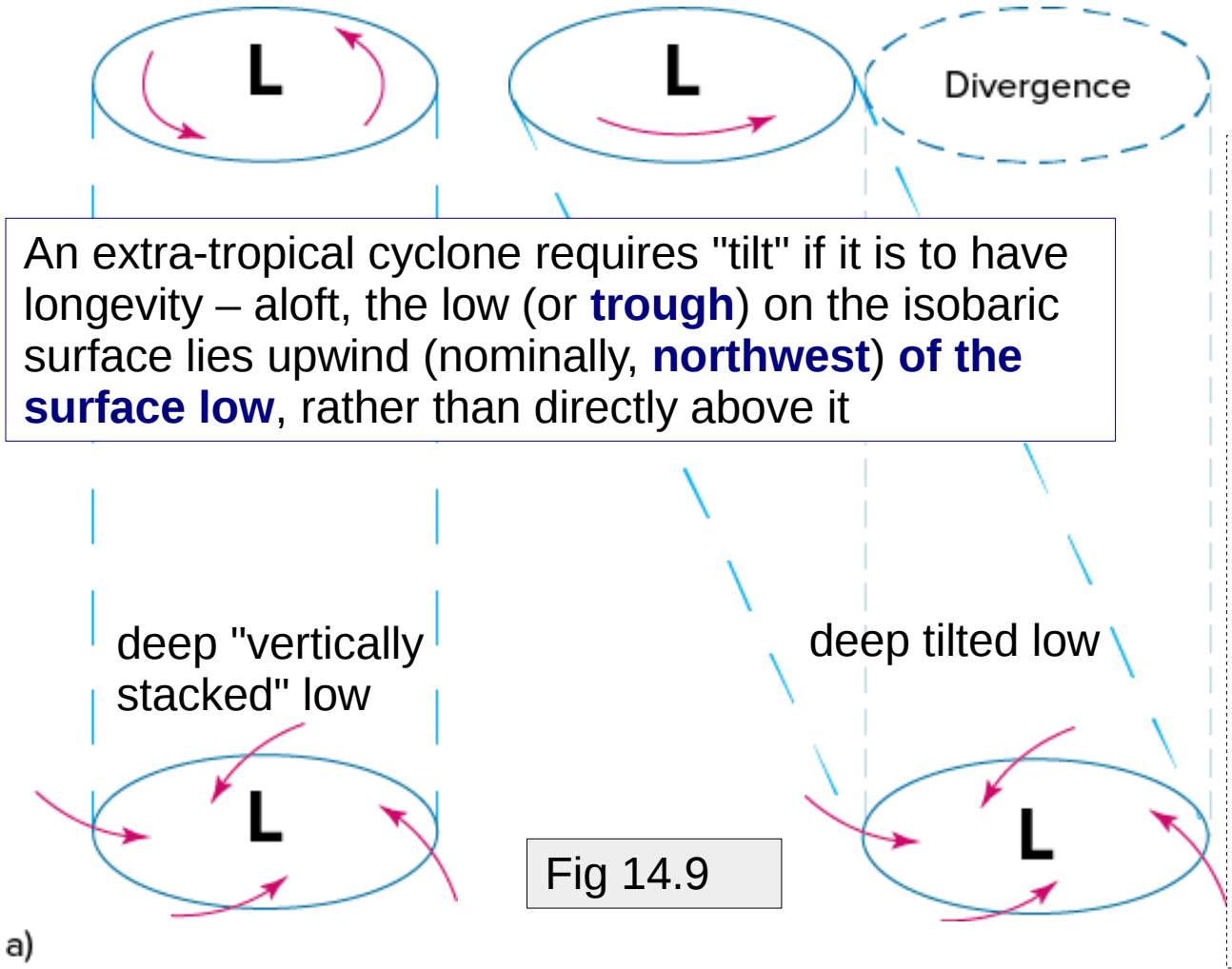
suppose initially no rotation

Surface *con*vergence implies D<0, so rhs is positive: increasing cyclonic vorticity

(cross-isobar flow)

Fig 14.8

Now known – an extra-tropical cyclone entails coordinated 3-dimensional pattern, i.e. surface manifestation of the storm links with a "wave" aloft. Feedbacks operate, e.g. div. aloft drops sfc *P,* increasing sfc winds, increasing sfc convergence, increasing vertical motion...



An extra-tropical cyclone requires "tilt" if it is to have longevity – aloft, the low (or **trough**) on the isobaric surface lies upwind (nominally, **northwest**) **of the surface low**, rather than directly above it

Fig 14.9

- We earlier encountered the Rossby wave" (longwave) – and gave it theoretical justification in terms of a simple paradigm – conservation of absolute vorticity along the wave

- Existence of planetary waves is verified by analysis of more complete equations of motion on a rotating planet

- Those equations of motion also indicate existence of a different type of wave, the "baroclinic" wave (short wave)