Baroclinic Development

In other words, how do cyclones/anticyclones form and/or change intensity

Meteorology 411 – Iowa State University – Week 10

Bill Gallus

How do we get surface pressure falls?

- We could try to come up with an equation to predict surface pressure, but this can be complicated
- Instead, realize that a cyclone's strength is also reflected by its amount of spin, or vorticity. This can be seen in the defnition of ζ_g which is equal to $\nabla^2\Phi$ (thus the deeper a low, the higher the vorticity).

How do we get surface pressure falls (cont)?

- Think about what has to happen to get increased vorticity. Air has to converge so that Coriolis force can turn it into cyclonic motion. Converging air rises. Thus, we know the same processes that give us rising motion will give us surface pressure falls.

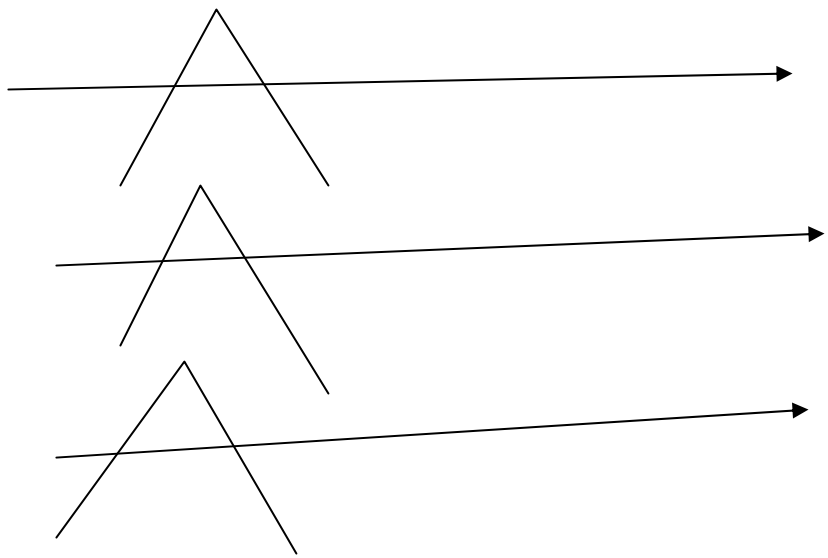
Surface pressure falls due to:

- 1) PVA “Type B Cyclone”
- 2) WAA “Type A Cyclone”
- 3) Friction (only happens inside highs)
- 4) Local diabatic heating maximum
- 5) Adiabatic warming (downslope)

Remember again that σ was in denominator of all terms, and thus a more unstable atmosphere generates a cyclone easier

Also, f_0 is in numerator, so cyclones form easier in higher latitudes

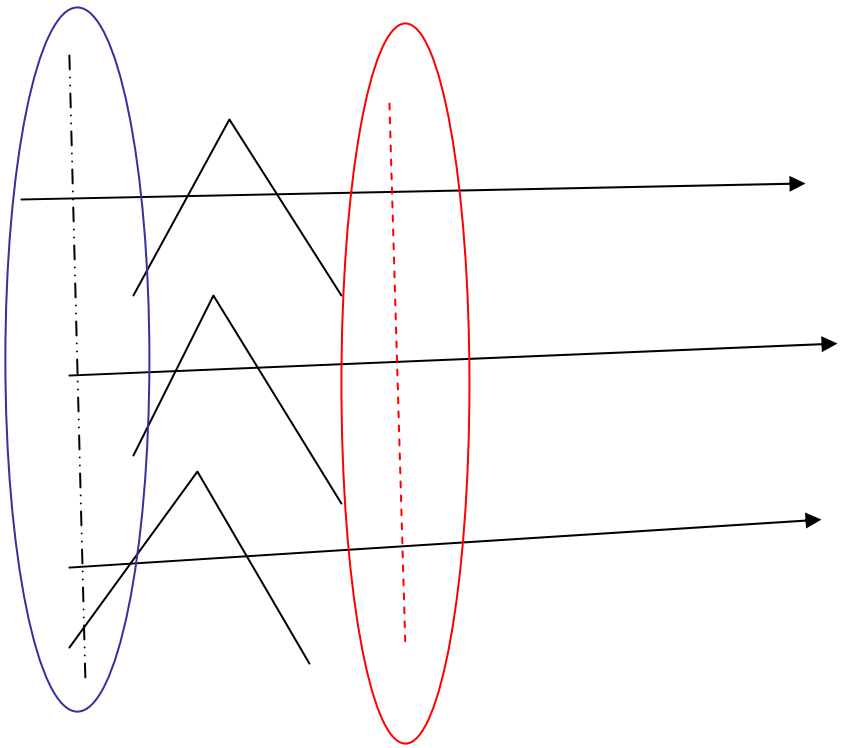
Some scenarios to think about – what will happen to surface pressure if:



Straight flow, uniform speeds, crossing mountain range of equal height

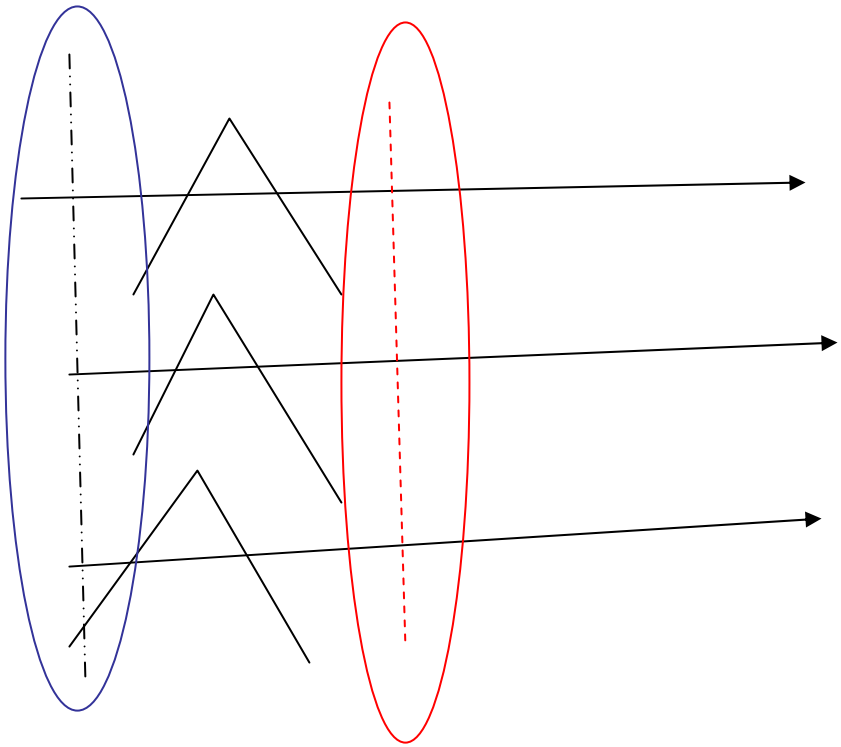
No temperature gradient

Answer:



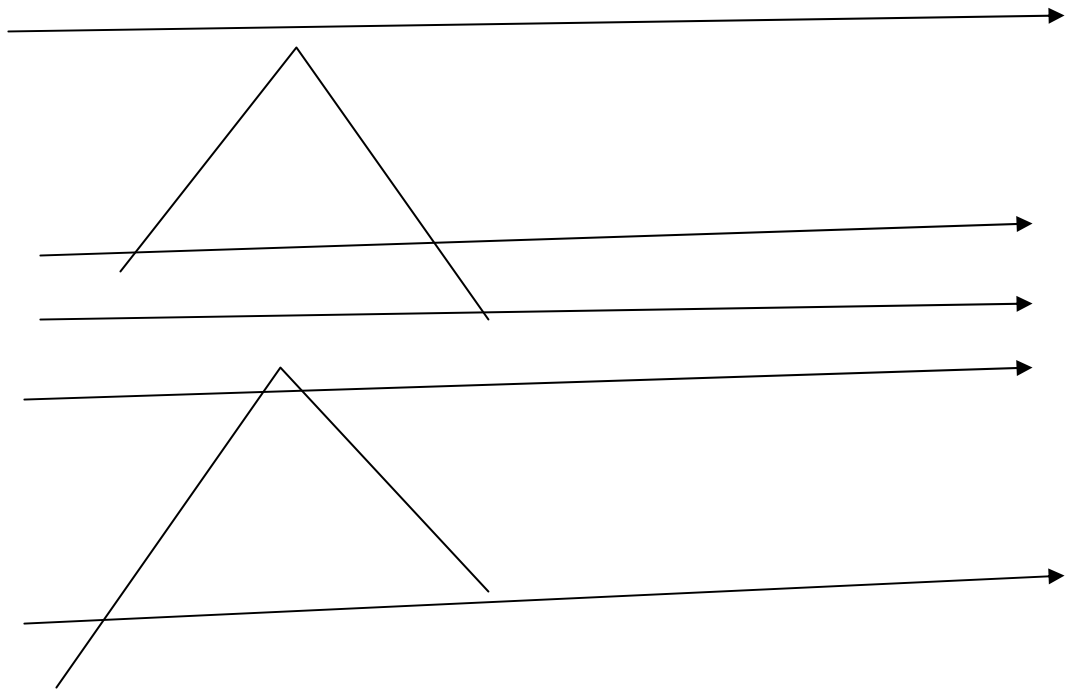
Low pressure trof on lee side of mountains, high pressure ridge on windward side

Would Iowa have to care about this low pressure trof?



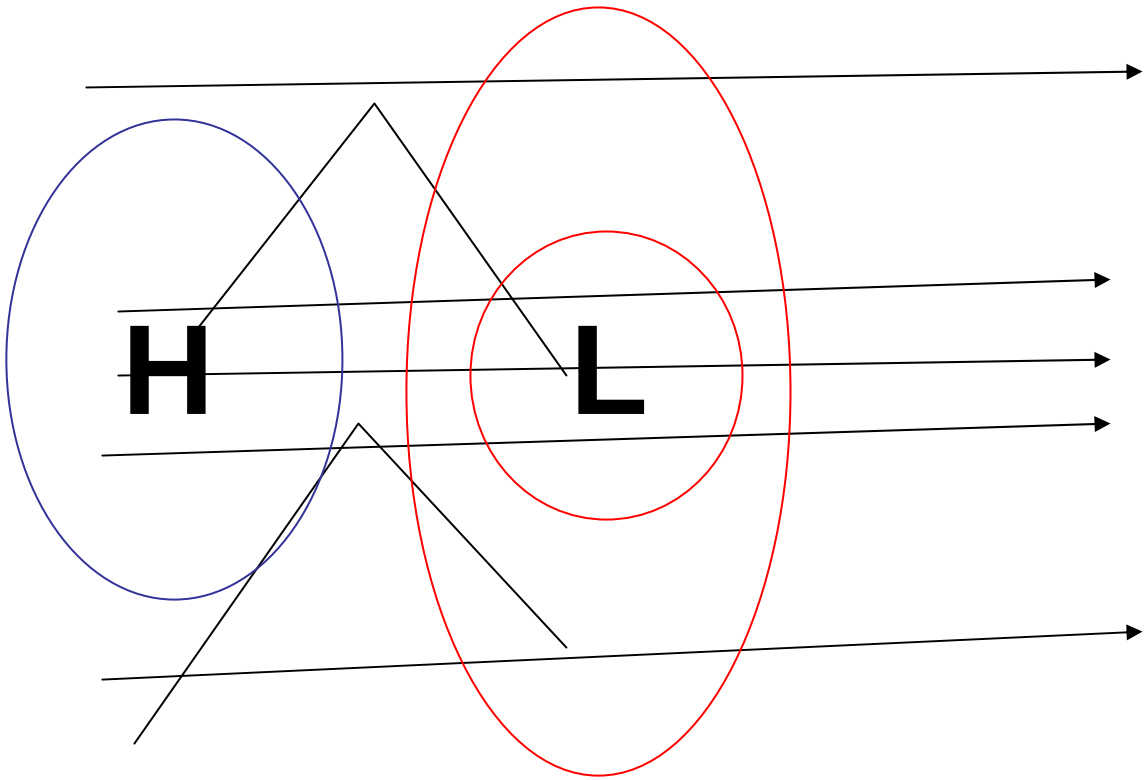
NO – it is being created entirely by downslope warming and will stay anchored to the lee of the mountains.

New scenario:



Notice now a jet streak of faster winds over one part of mountain. What would be different in surface pressure field?

Answer:



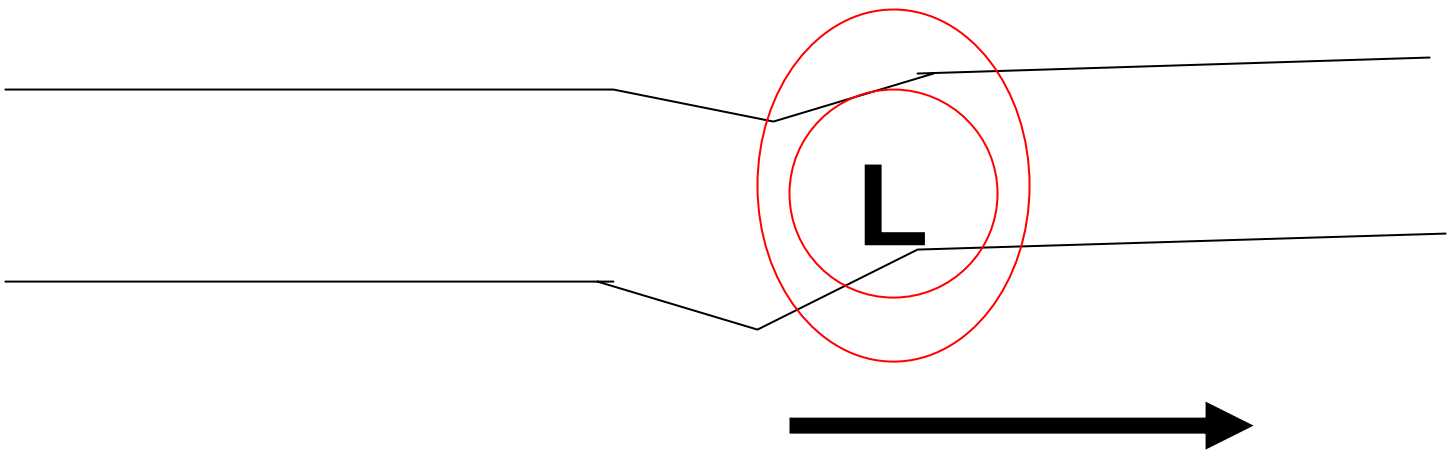
We'd now have a closed low on the lee side, closed high on the windward side.

Would Iowa have to worry?

NO – it would still be anchored.

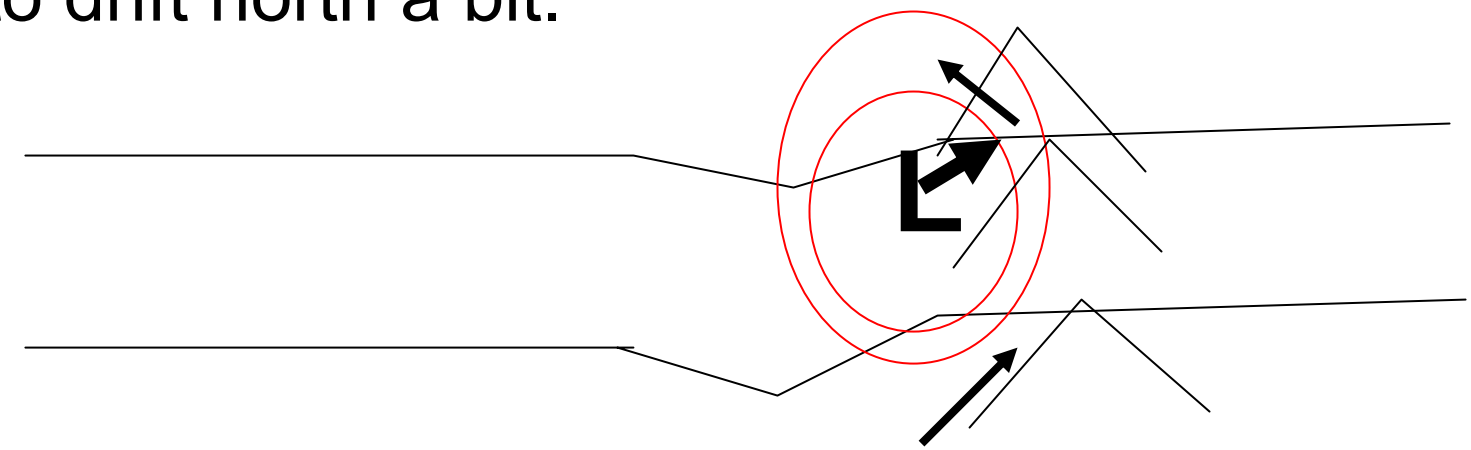
New scenario

Without mountains, or a temperature gradient, a surface low would exist just downstream from an upper-level vorticity maximum (shortwave trough) and would move along as the shortwave moved



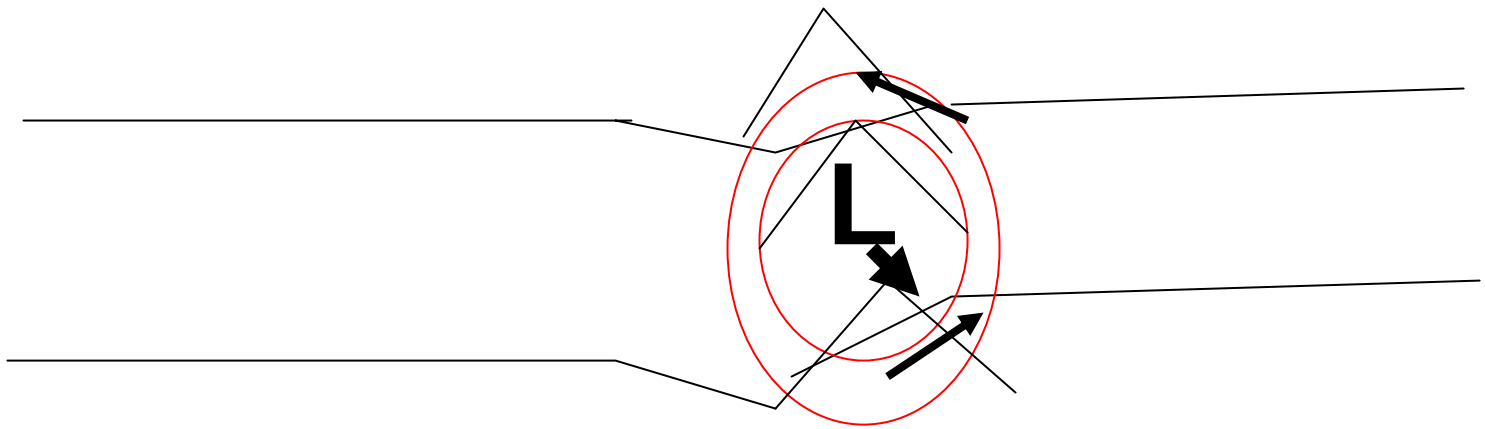
But, what happens if a mountain range like the Rockies is present..

As the low approaches the mountains, upslope would happen to its south, inducing pressure rises, while downslope happens to its north, causing pressure falls – so the LOW will appear to drift north a bit.



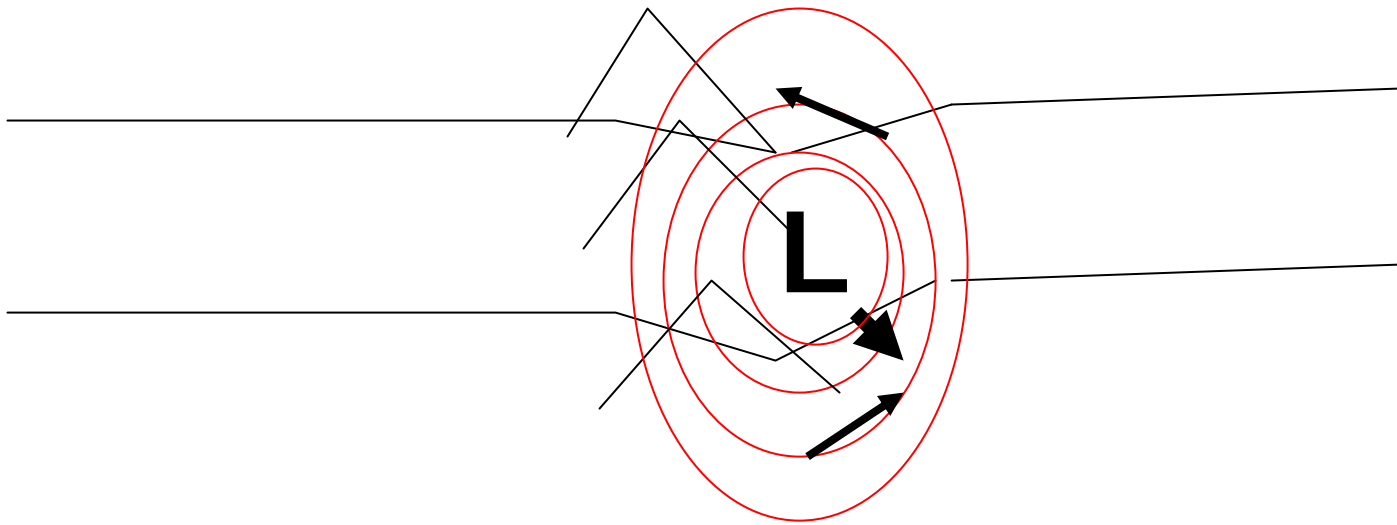
And when it crosses the mountain…

As it nears the top of the mountain range, suddenly the downslope is now on the south side, with upslope on the north side, so the LOW will dramatically shift southward on lee side of mountain, and can deepen greatly if the mountains are not symmetric – like the Rockies



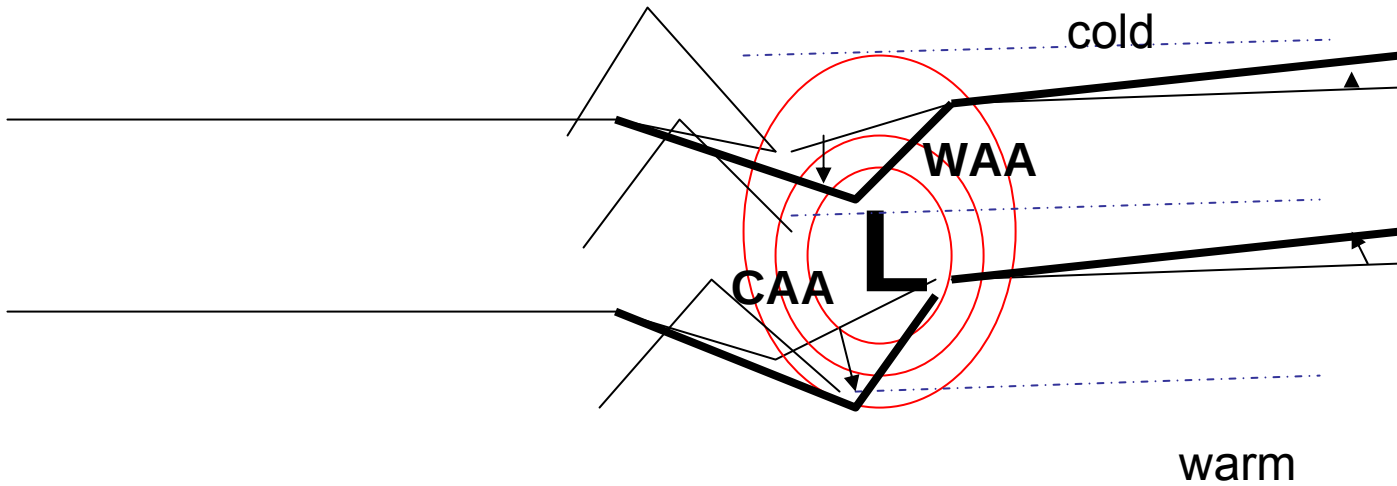
Lee side LOW

If there is still no temperature gradient, the low would weaken as it moved further east from the propagation of the shortwave trough, since it would get farther away from the mountains and stop feeling the downslope. It would also turn back to the east in its movement.



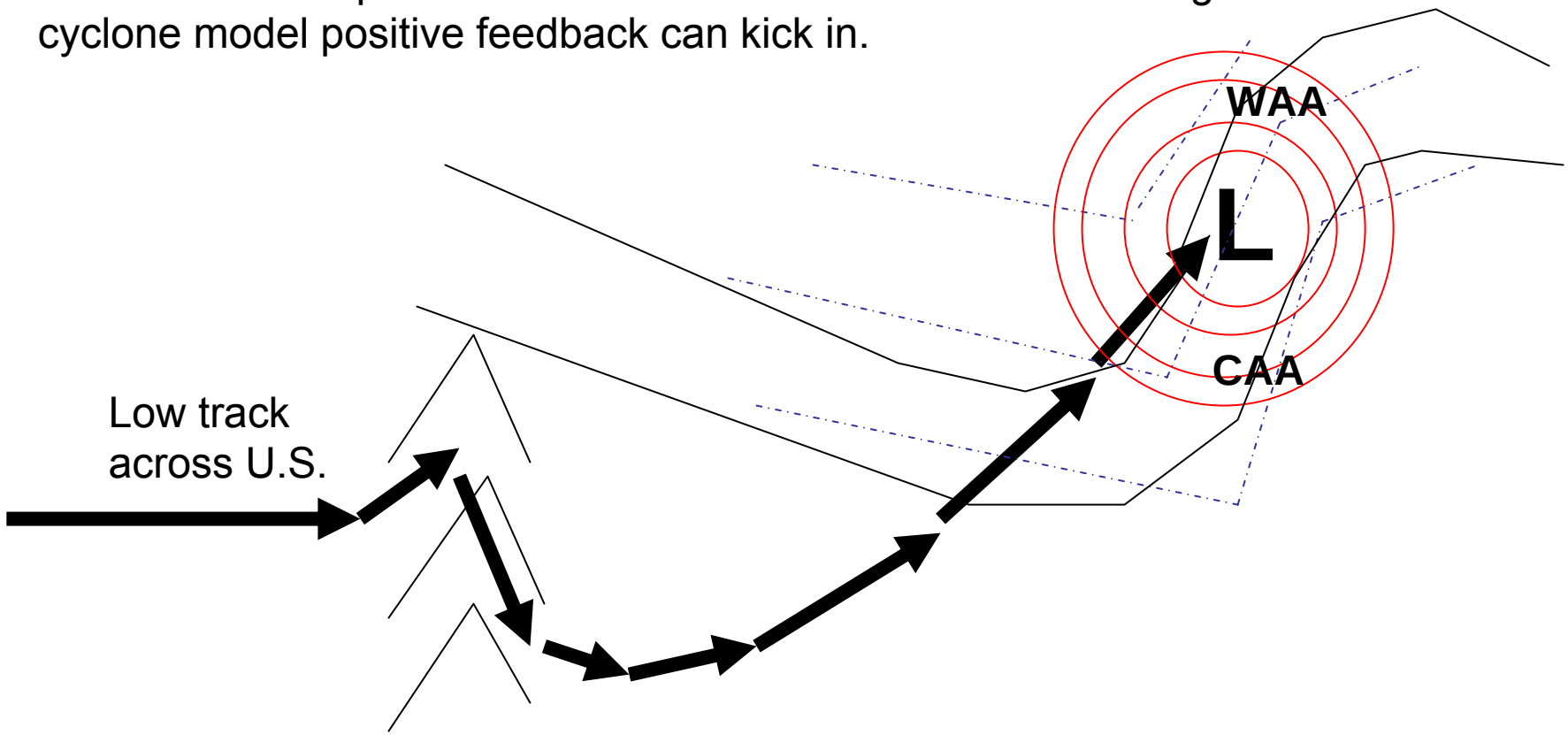
Effect of temperature gradient

BUT… if there is a temperature gradient east of the mountains (A fairly normal situation), then the Low's circulation will advect warm air north ahead of it, and cold air south behind it. The temperature advections will change the upper level height field, and build the ridge ahead of it and the trough behind it, so the PVA steering and WAA steering for low pressure would start to shift more to the ENE, then NE, and maybe even NNE.



Eventually, the lows swing NE toward Iowa or the Great Lakes

Plus, the temperature advections now are an extra ingredient with the WAA able to deepen the low even more. So the usual Norwegian cyclone model positive feedback can kick in.



What will the Great Lakes do?

- Remember diabatic heating can affect the surface pressures too.
- If it is fall, the Lakes are relatively warm, and tend to diabatically warm the air, lowering the pressure. So fall storms feel an extra pull to go north and over the Lakes
- In spring, the Lakes are cool, and tend to raise pressures nearby. This can try to force cyclones to stay to the south of the region – often frustrating storm chasers in Iowa who want to end up in the warm sector.

Other common trends in surface pressure…

- Arctic highs plunging down from Canada may accelerate down the east side of the Rockies and race faster toward Texas than toward Iowa, due to upslope on E. Side of Rockies.