ATM S 442/504: Atmospheric Motions II

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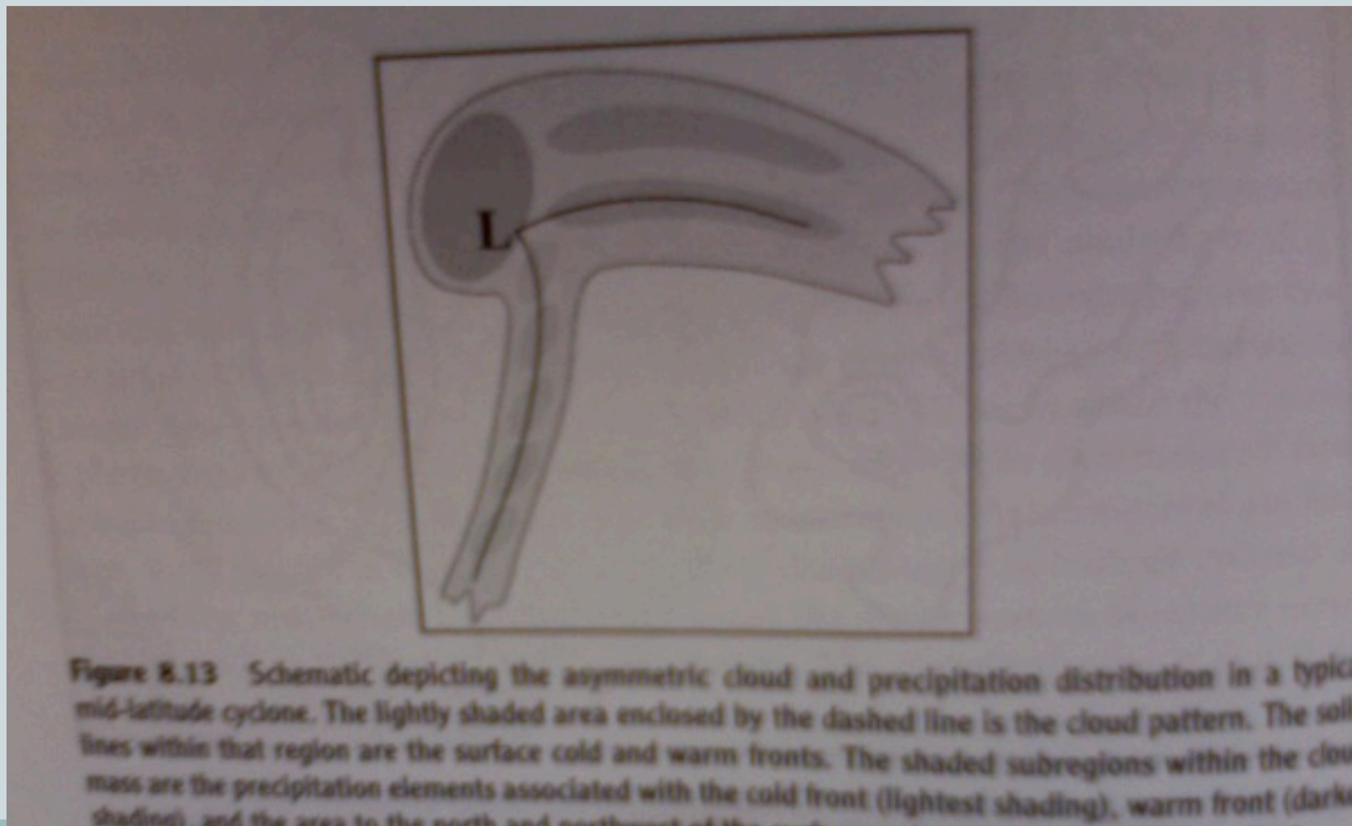
Convection/Latent Heating

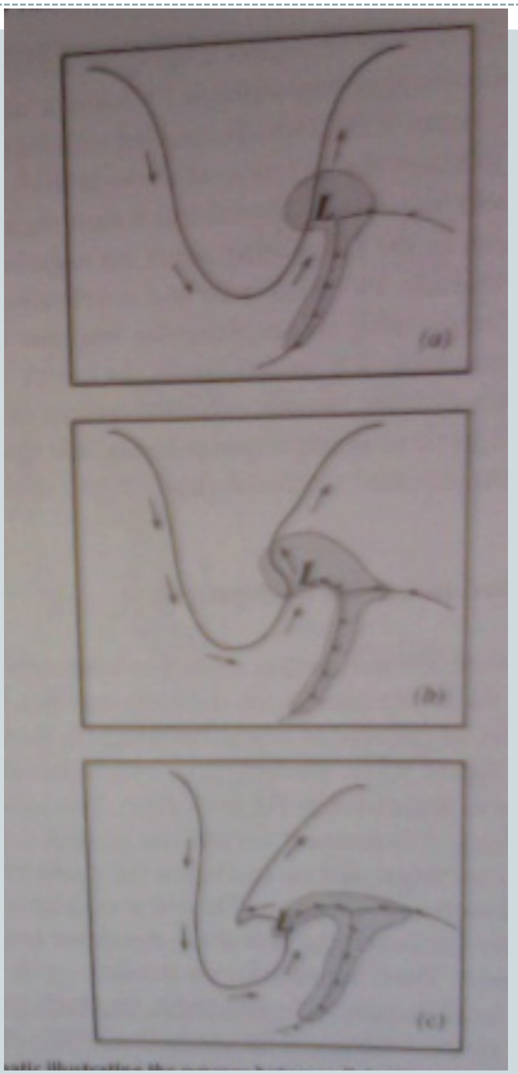
- Typical pattern of latent heating in a baroclinic eddy:



Effect of Latent Heating on Occlusion

- Remember *heating* causes *negative PV* anomalies in *upper troposphere* (and positive in lower troposphere)
- Consider cyclogenesis from PV perspective:
  - Positive PV anomaly in upper troposphere interacting w/ surface baroclinic zone
  - Let's look at effect of latent heating on a system that's already developed a bit

Latent heating leading to occlusion



- Initially: Upper level high PV anomaly shifted westward relative to surface low
- Assume latent heating as shown

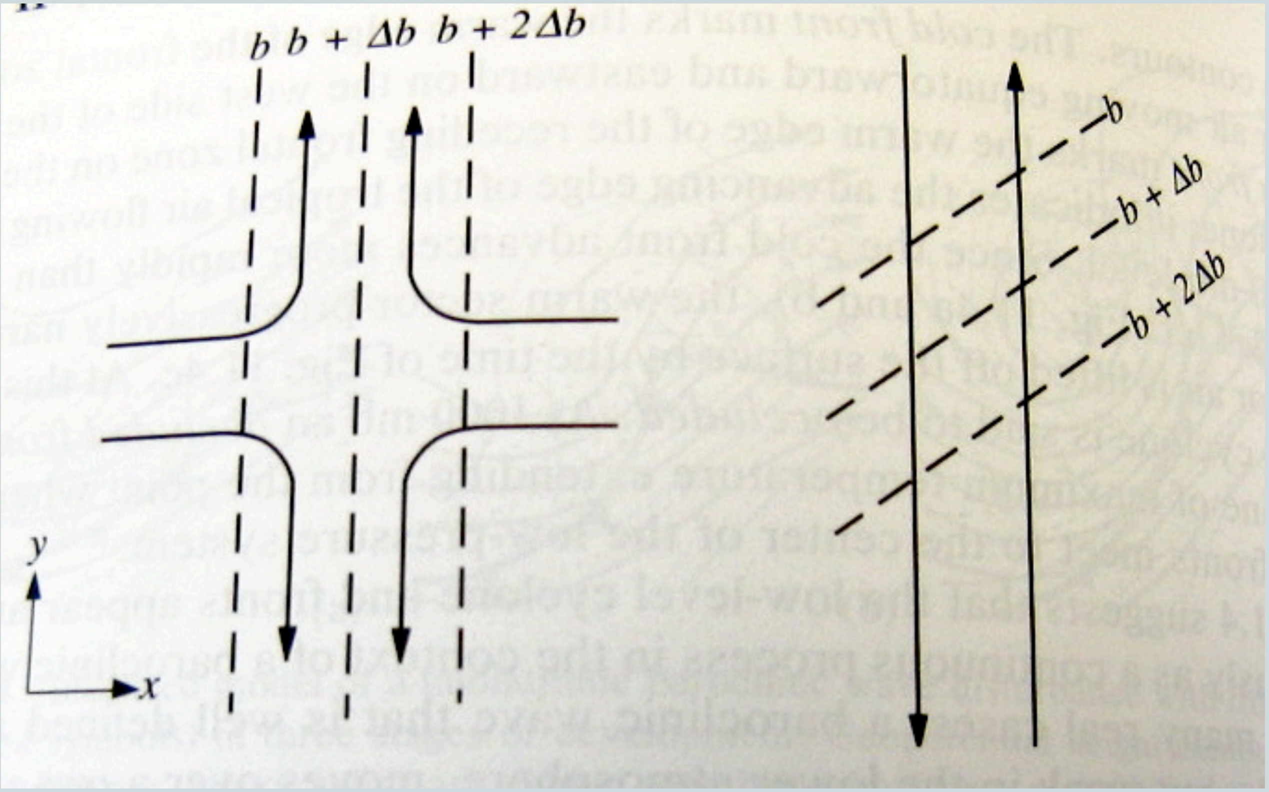
- Latent heating causes erosion of the upper level PV as shown
- Induced flow therefore is no longer symmetric (it now shifts easterly)

- This then affects the latent heating below, which further erodes and concentrates PV aloft
- Occlusion!

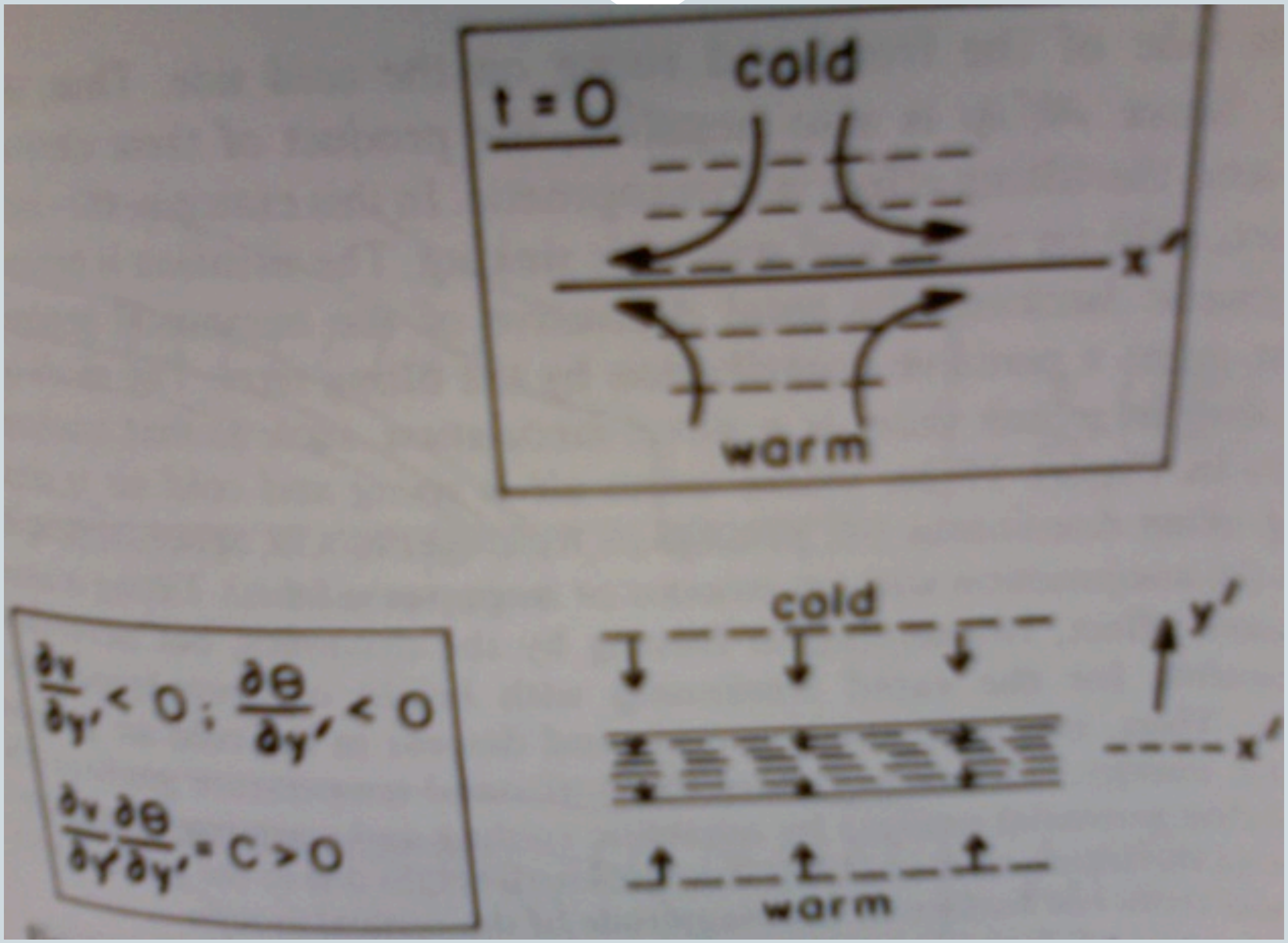
Solid line: upper level PV contour (higher PV to N) **L**: surface low **shading**: precip

Frontogenetic Configurations

- Deformation and shear



Frontogenesis due to Confluence



Frontogenesis due to Shear

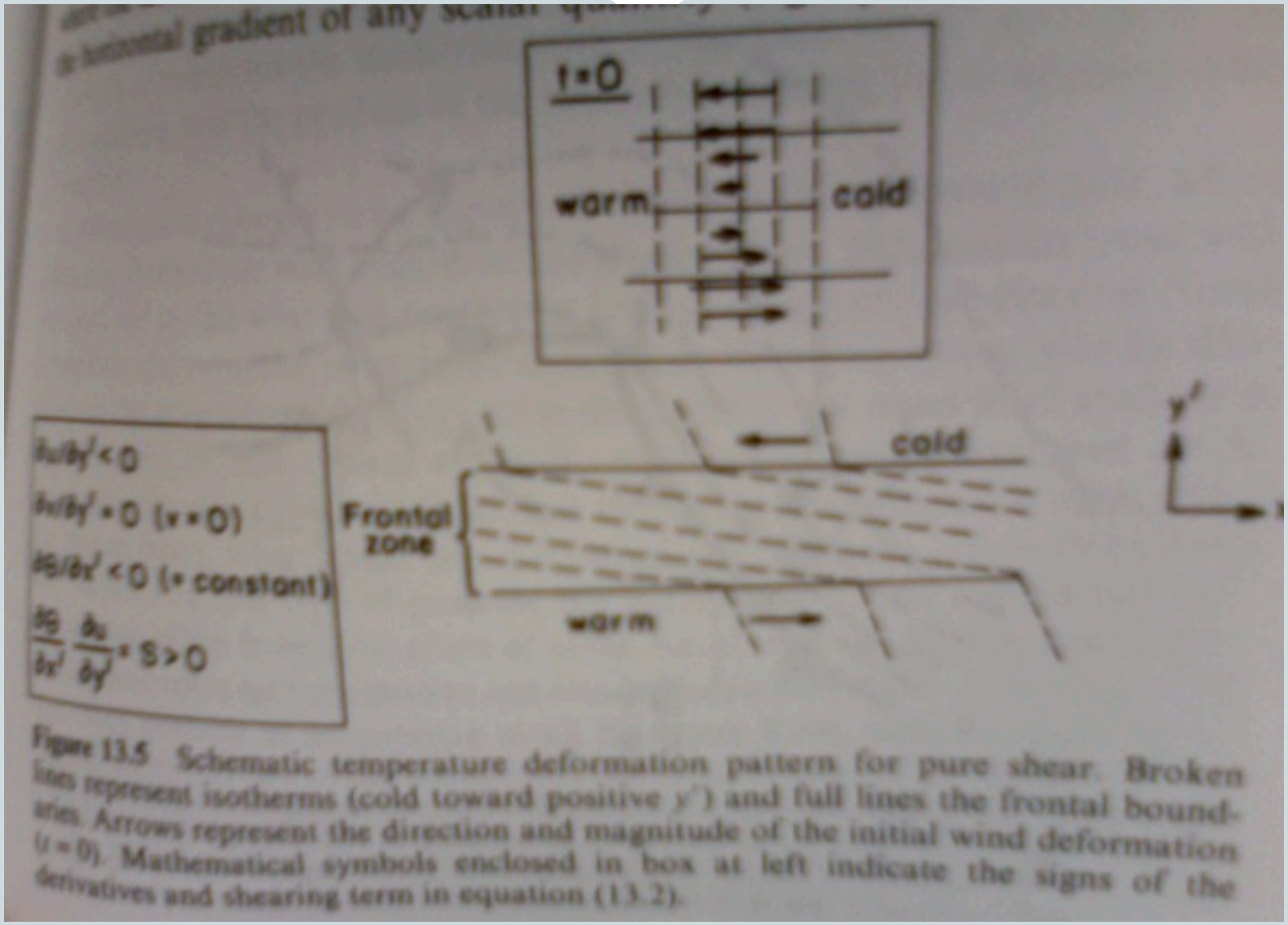
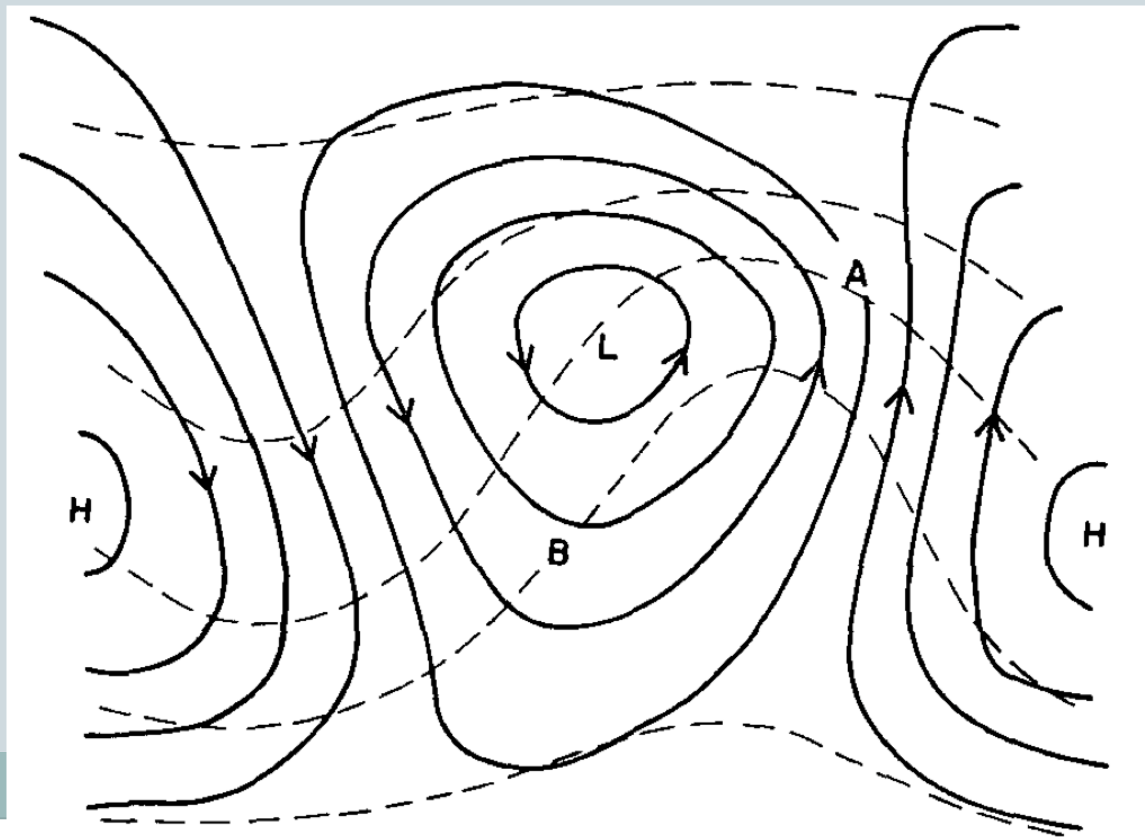


Figure 13.5 Schematic temperature deformation pattern for pure shear. Broken lines represent isotherms (cold toward positive y') and full lines the frontal boundaries. Arrows represent the direction and magnitude of the initial wind deformation ($t = 0$). Mathematical symbols enclosed in box at left indicate the signs of the derivatives and shearing term in equation (13.2).

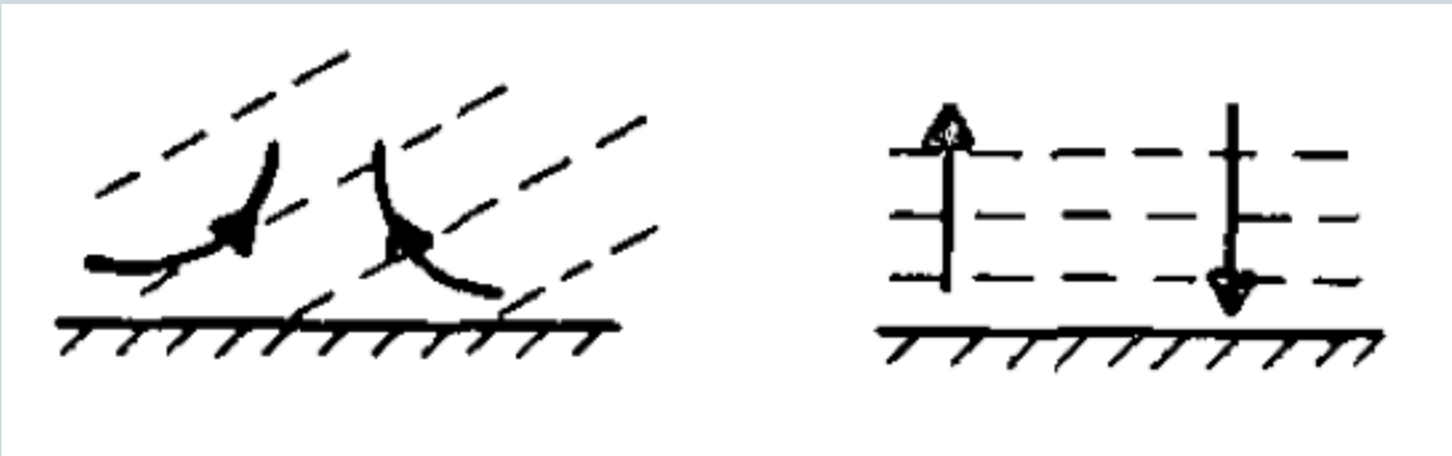
Frontogenesis in Cyclones

- A has deformation across temp grads, B has shear (strong cold advection to the NW of B, weak thermal advection to the SE)



Other configurations

- Vertical motion can also cause frontogenesis



Vertical motion requires ageostrophic flow though

Left plot is like deformation, right is like shear

Ageostrophic Circulation

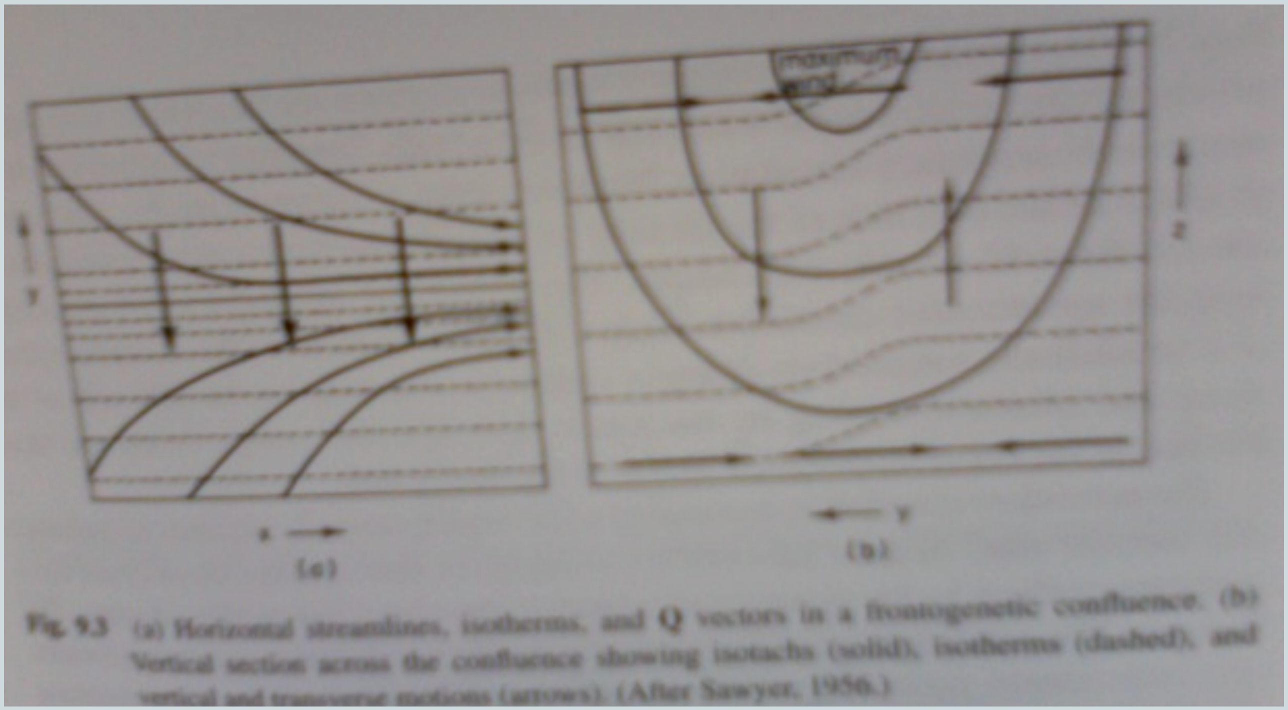


Fig. 9.3 (a) Horizontal streamlines, isotherms, and Q vectors in a frontogenetic confluence. (b) Vertical section across the confluence showing isotachs (solid), isotherms (dashed), and vertical and transverse motions (arrows). (After Sawyer, 1956.)

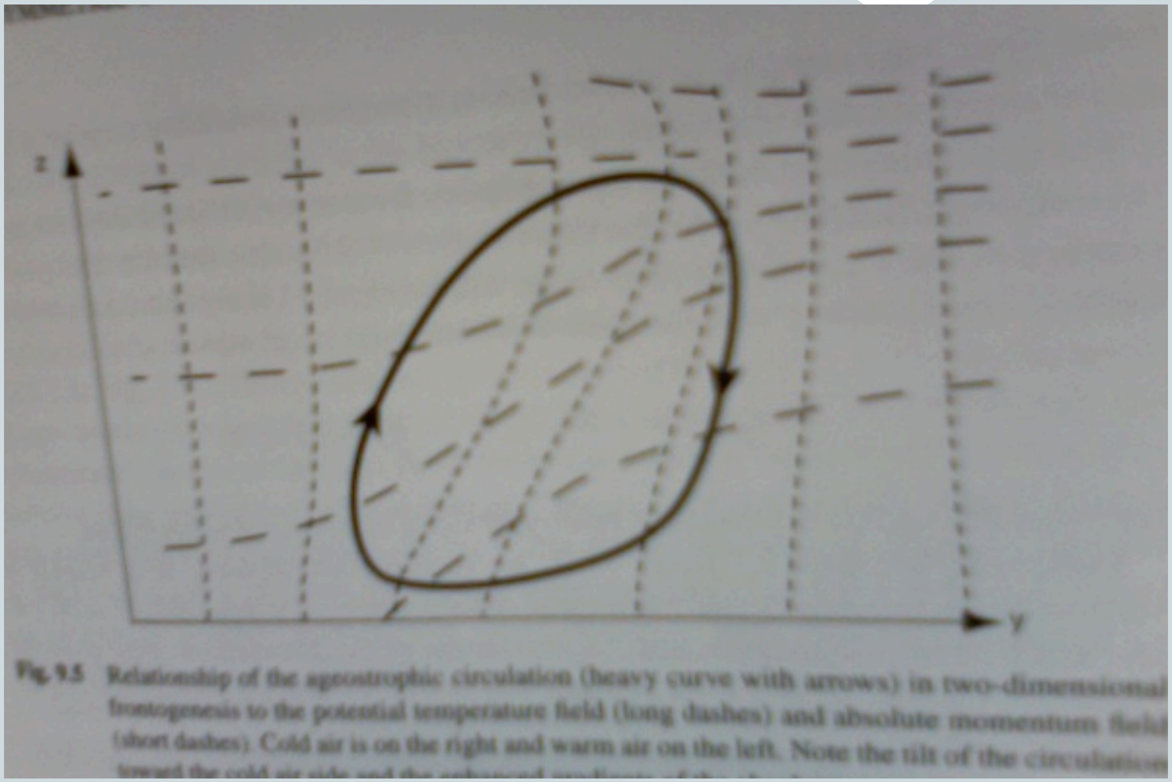
Left: **x-y** cross section showing confluence & Q vectors
Right: **y-z** cross section showing ageostrophic circulation

Also keep in mind that the strength of the **Q-vectors are proportional to temperature gradien**t: this provides the essential positive feedback eventually

Semigeostrophic Theory

- Our scaling arguments in class show that du/dz stays in thermal wind balance with d(theta)/dy…
  - So even as large temperature gradients develop in y, they still have to be balanced with shear
- However the meridional wind has a non-negligible ageostrophic component
  - So v in our y-z cross section (plot on right of previous slide) starts to advect temperature too!

Semi-geostrophic Frontogenesis



y-z cross section

Isentropes are dashed

Ageostrophic circulation is in black (what's required to preserve geostrophy for zonal winds)

- Including ageostrophic effects on temperature advection, fronts are made especially strong near the surface on the equatorward side, and at the tropopause on the poleward side.
- This then strengthens the ageostrophic terms at those locations (Q-vector positive feedback)! Note tilt of cell.