

Chapter 8 – Part 1

Extratropical Synoptic-Scale disturbances

Spring 2024

General Synoptic Motions

- Weather can be thought of as a succession of disturbances in the atmospheric circulation.
- Use case studies (usually a series of maps) to learn about general behavior.

500 mb Charts

- Middle of the atmosphere (5520m ~ 18000 MSL).
- Far away from the influence of the surface.
- Typically produced every 12 hours.
- Rawinsondes (radiosondes)
- Flown at standard times by international agreement (00Z and 12Z)

Meteorological Time

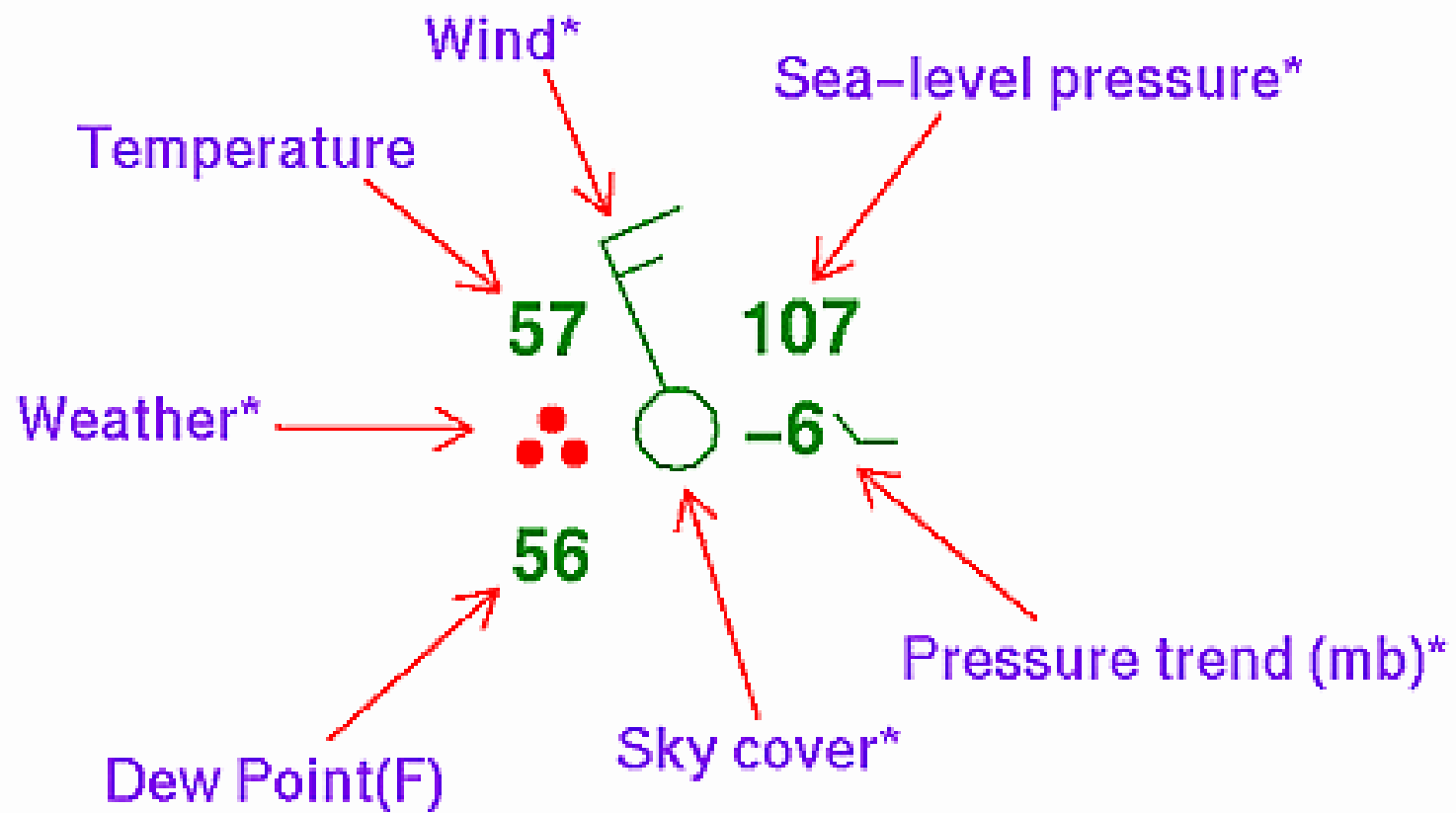
- UTC = Universal Time Coordinates
- UTC = GMT (Greenwich Mean Time) = Z
- Daylight saving: Central Time = GMT – 5
- Standard time: Central Time = GMT - 6

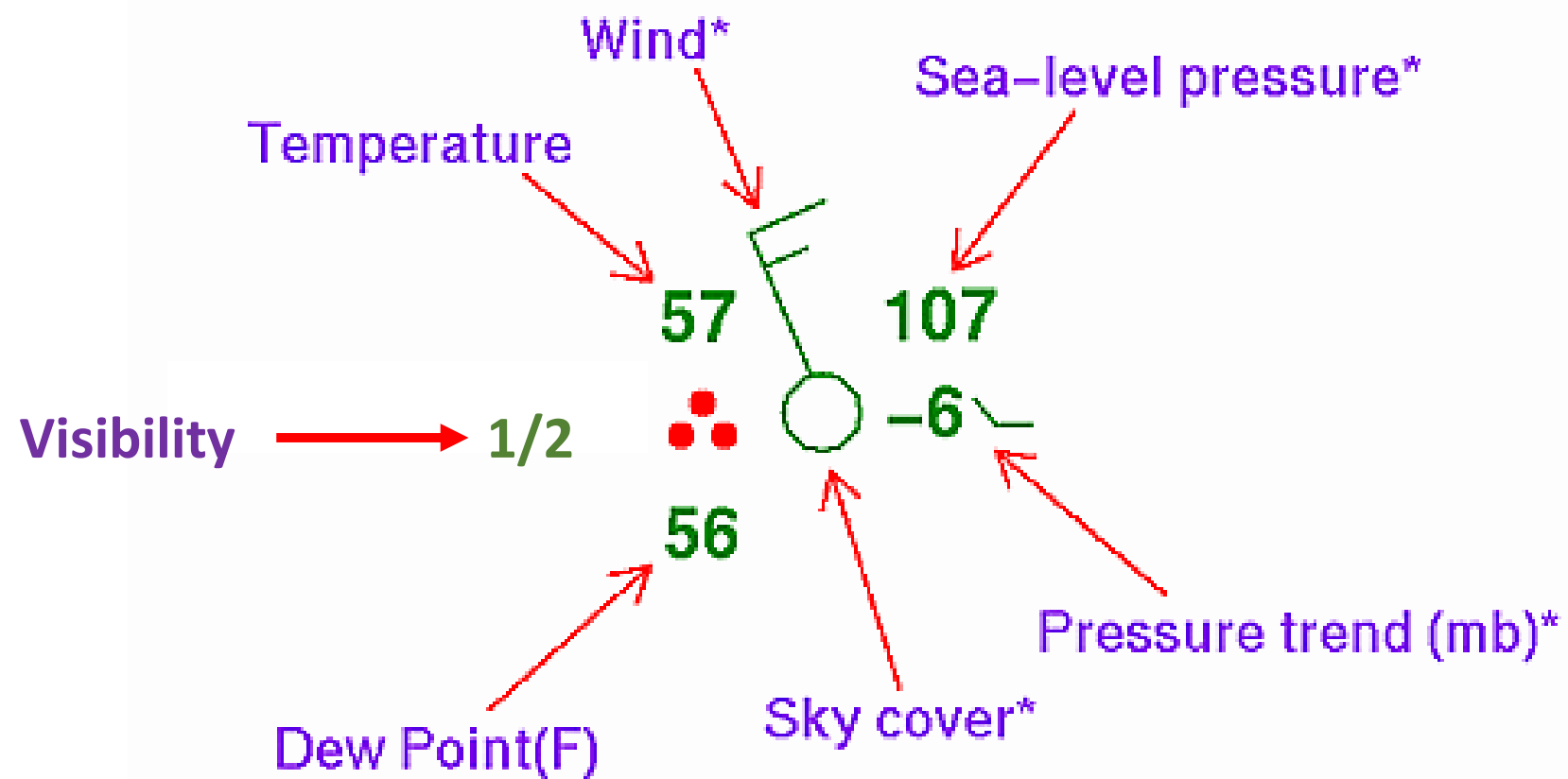
500 mb Heights

- Horizontal wind blows parallel to contours.
- Low pressure to left in NH.
- Speed $\propto 1 / \text{spacing}$.
- Low heights \rightarrow Cold air mass, High heights \rightarrow Warm air mass.
- Movement of troughs (W \rightarrow E) same as general direction of wind.
- Longwaves: 3-7 around the earth.
- Shortwaves: Small scale troughs and ridges superimposed on longwaves.

Surface Plots

- From regular surface observations (IEM – Iowa Environmental Mesonet)
- Station models
- Winds – Barbs point in direction wind is coming from.





Surface Plot Features

- Winds and isobars
- Winds not quite parallel to the isobars.
- Highs and Lows pressure centers
- Wave-like structure
- Boundaries are evident
 - Temperature and dew point difference across the boundary
 - Strong gradient near the line.
 - Wind and pressure pattern shifts
- Boundaries = “fronts”

Fronts

- Separate different air mass types.
- Thickness gradient defines the approximate location of the front.
- Front is placed near the warm side of the gradient.
- Type of front depends on the movement of the colder air.
- Active front: the warmer air has a wind component with respect to the frontal motion in a significant depth of the atmosphere toward the front.
 - Inactive: no warm air component toward the front.

Front Locations

- Wind shift line
- Temperature discontinuity
- Pressure trough (region of low pressures)
- Dew point temperature discontinuity
- Pressure tendency pattern
- Horizontal visibility variations
- Horizontal variations in precipitation type

Front Types

- Cold front
- Warm front
- Stationary front
- Cold occlusion
- Warm occlusion

Front Types

Cold Front



Warm Front



Stationary Front



Occluded Front



Dry Line



Upper Level Front



Cold Front Forming



Cold Front Dissipating

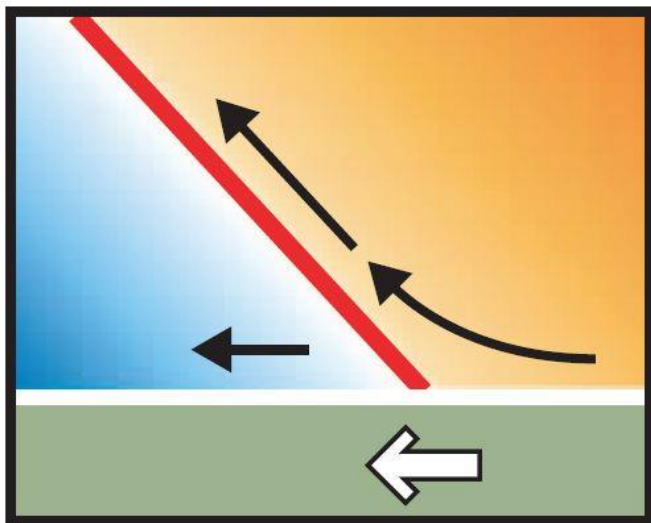


Warm Front Forming

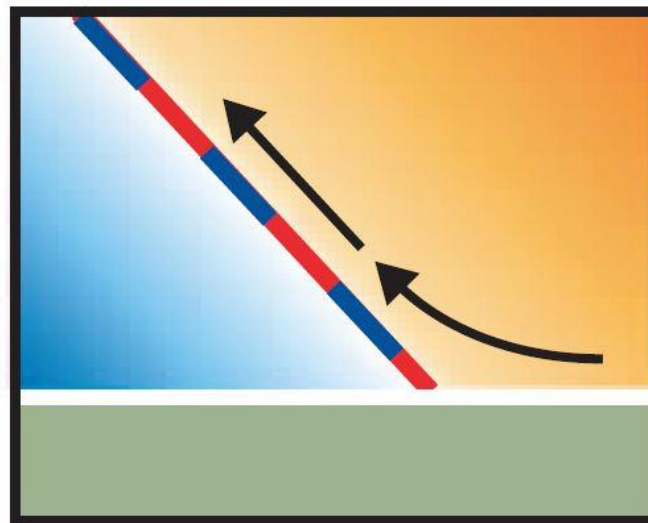


Warm Front Dissipating

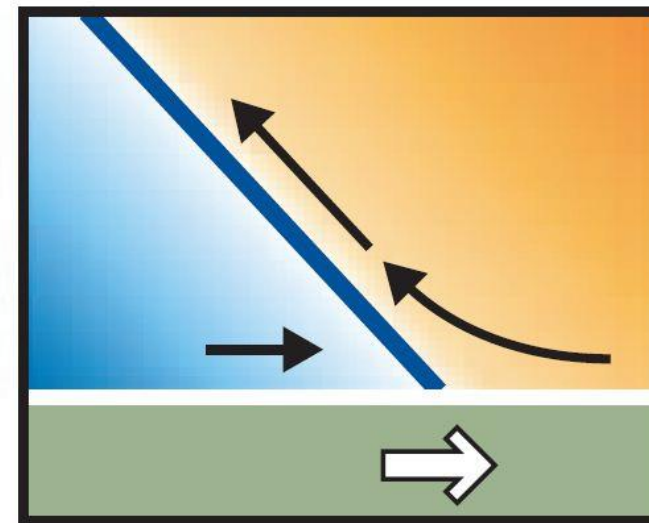




Warm front

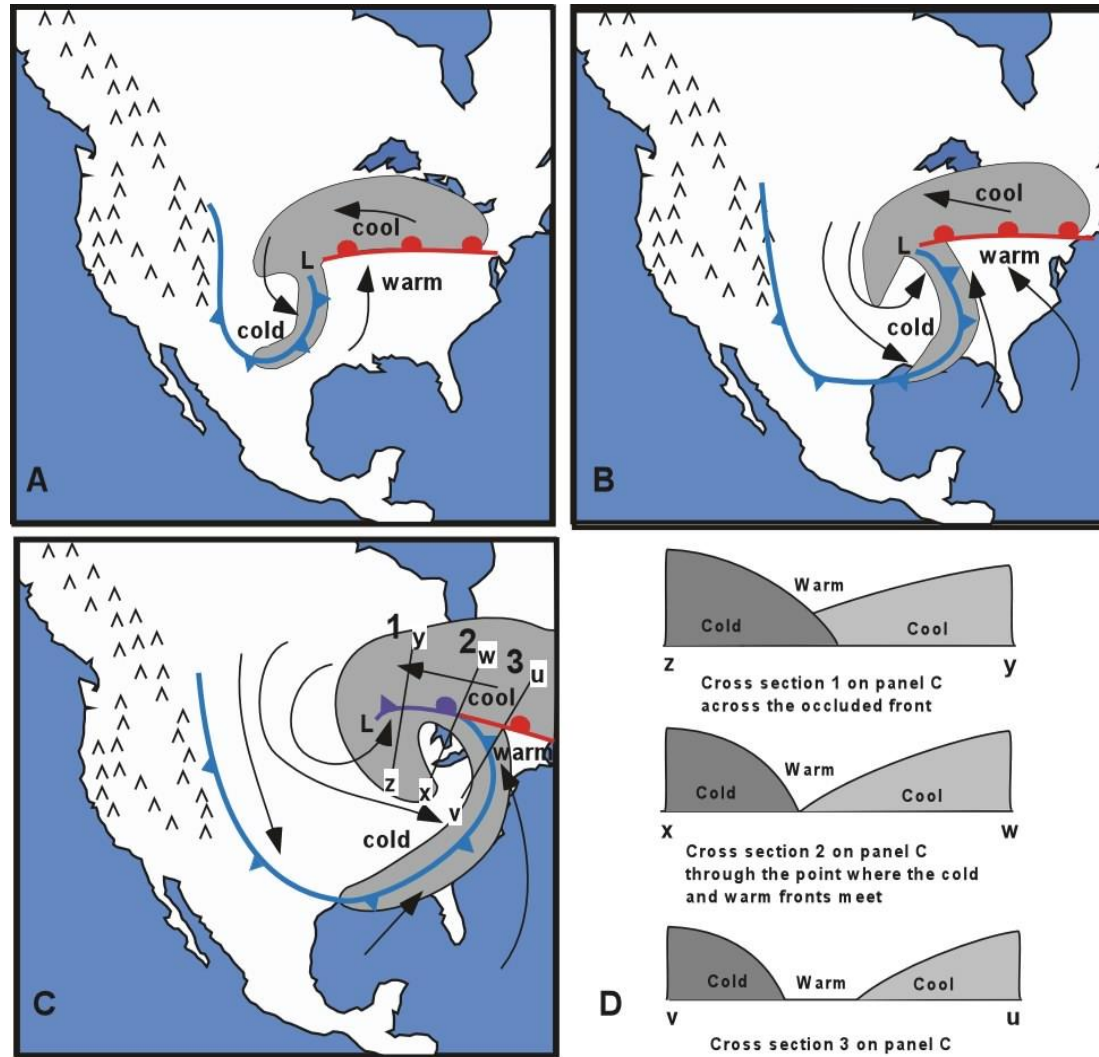


Stationary front

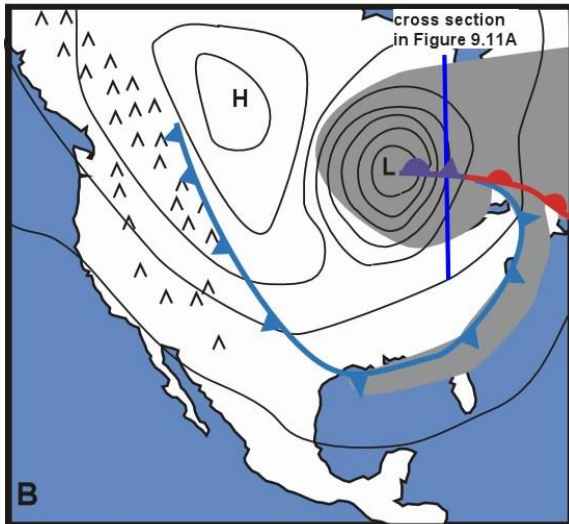
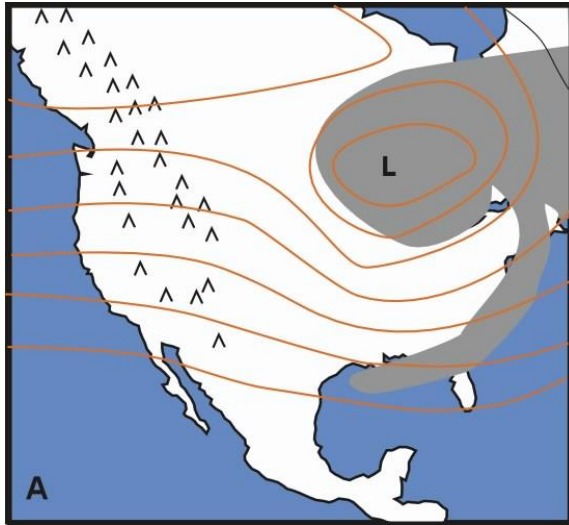


Cold front

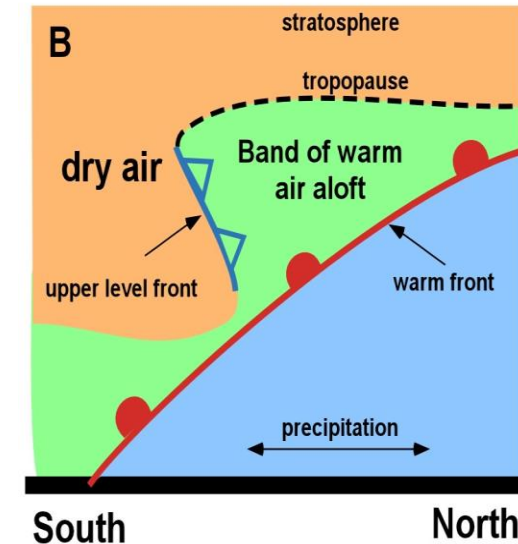
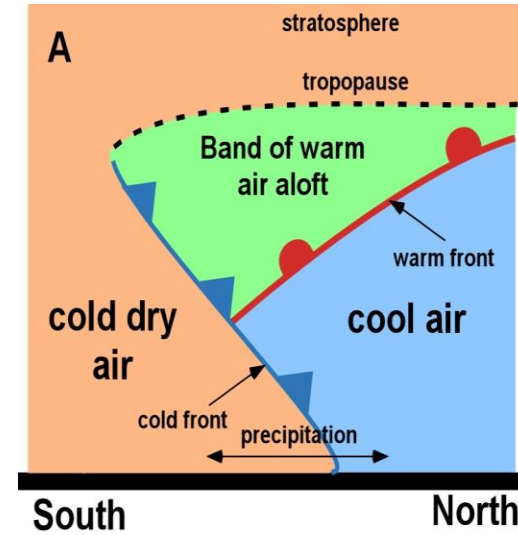
Occlusion



Another look at Occlusions



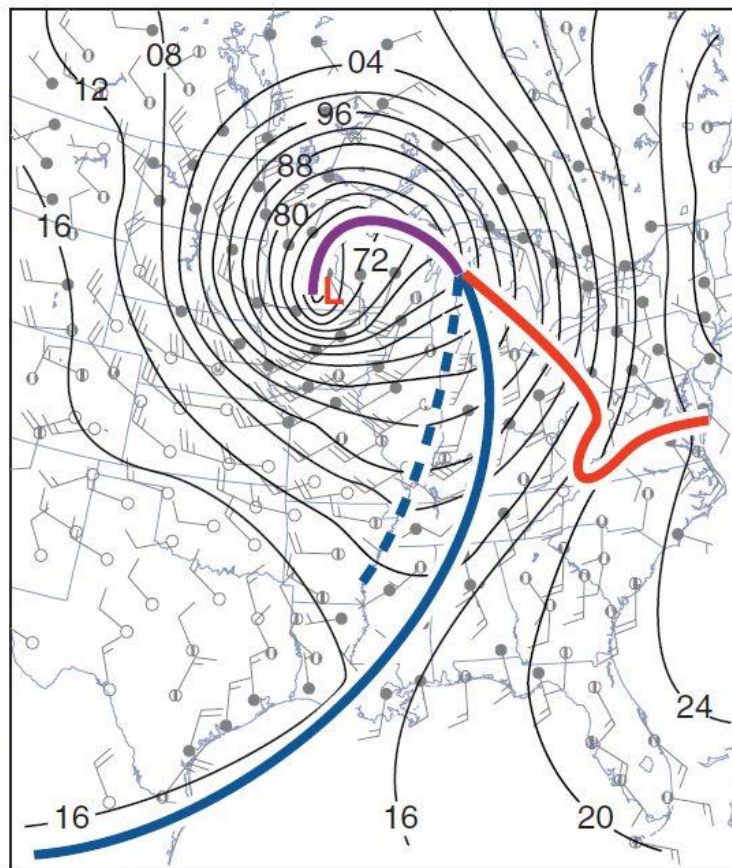
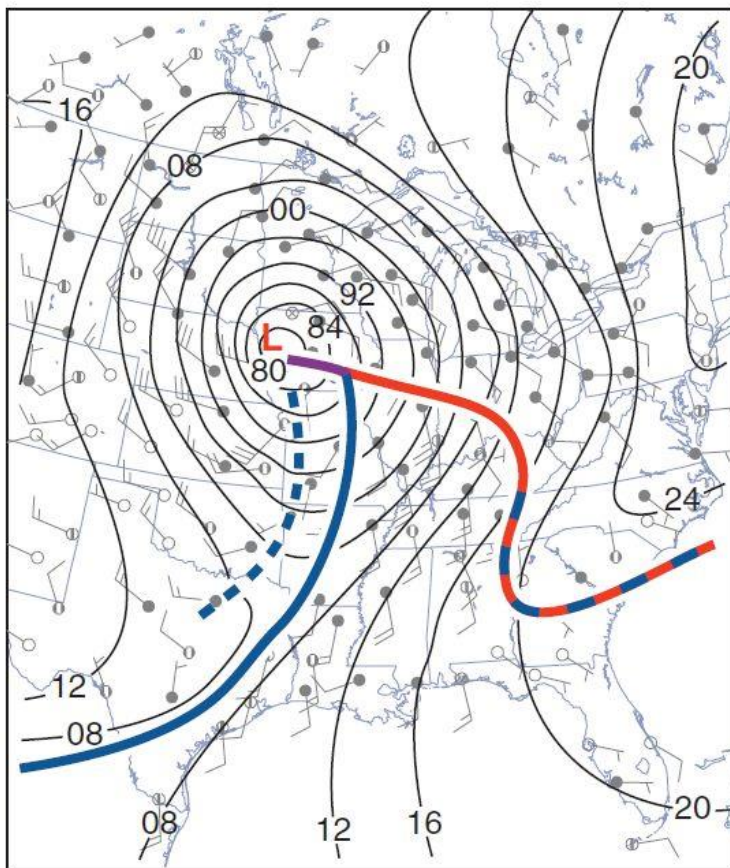
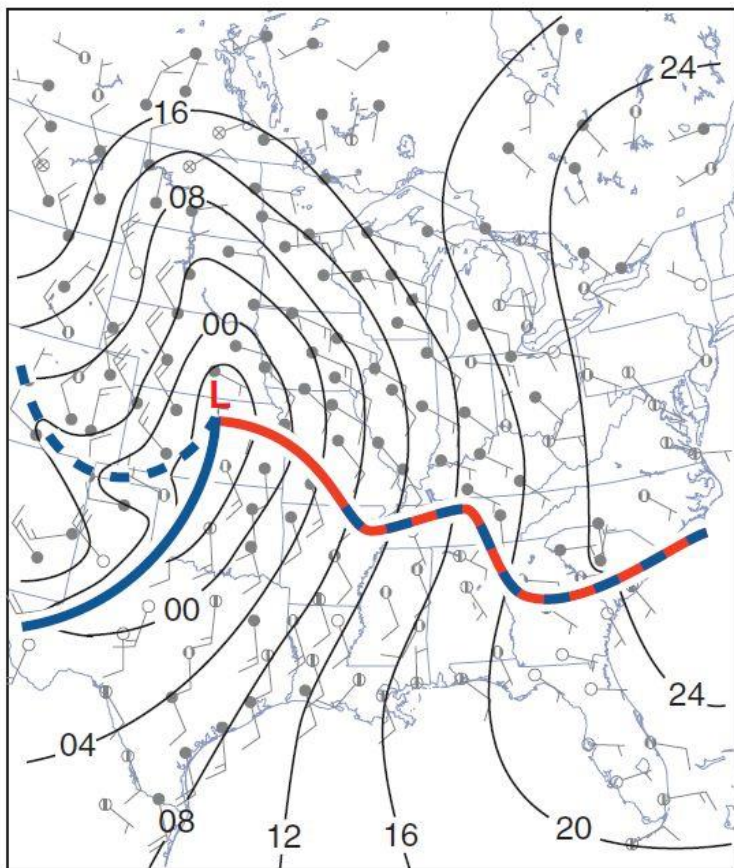
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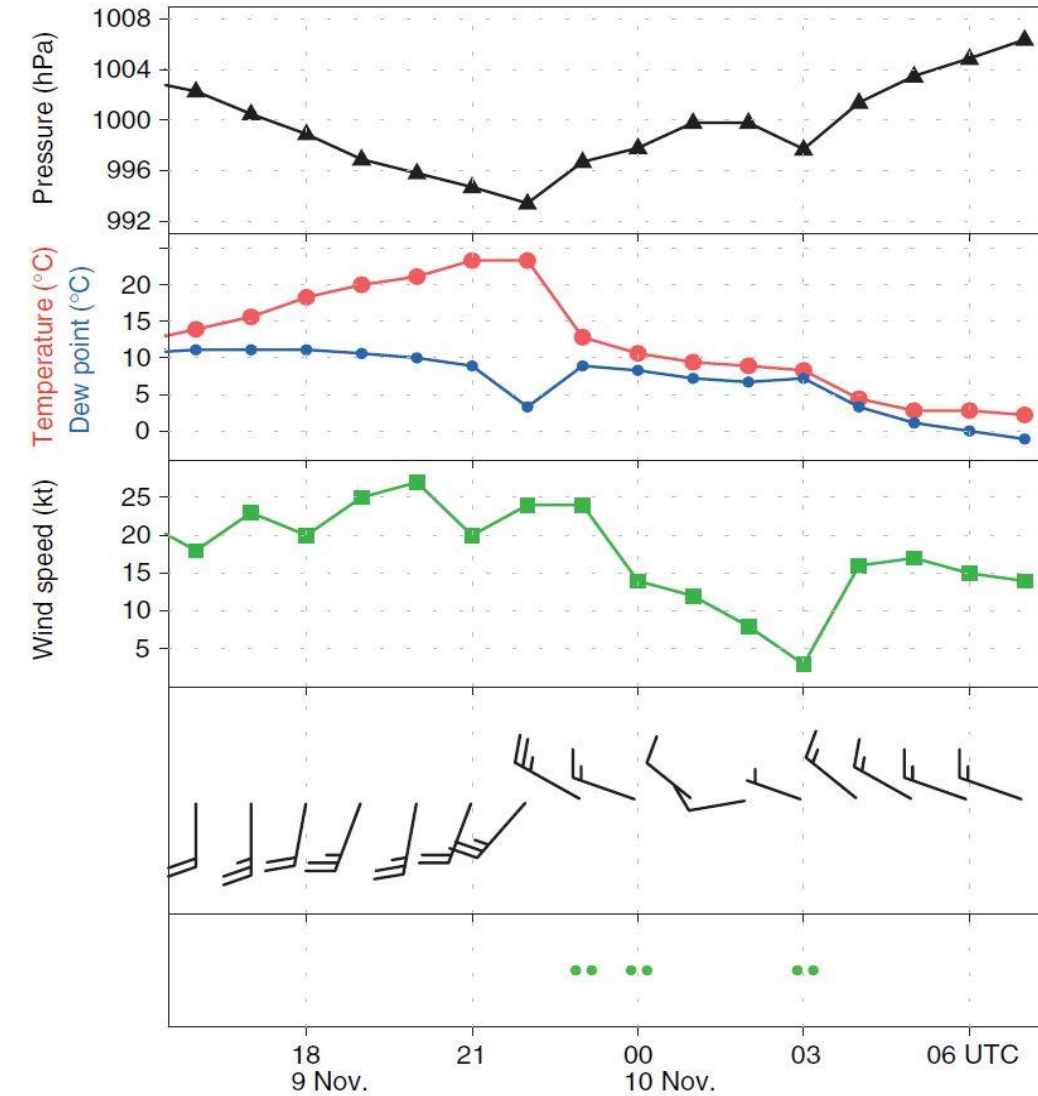
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Occlusion Types

- Occlusion type depends on air temperature differences between air behind cold front and air ahead of warm front (“cool air region”).
- Cold Occlusion: Air behind the cold front is colder than air ahead of warm front.
- Warm Occlusion: Air ahead of warm front is colder than air behind cold front.

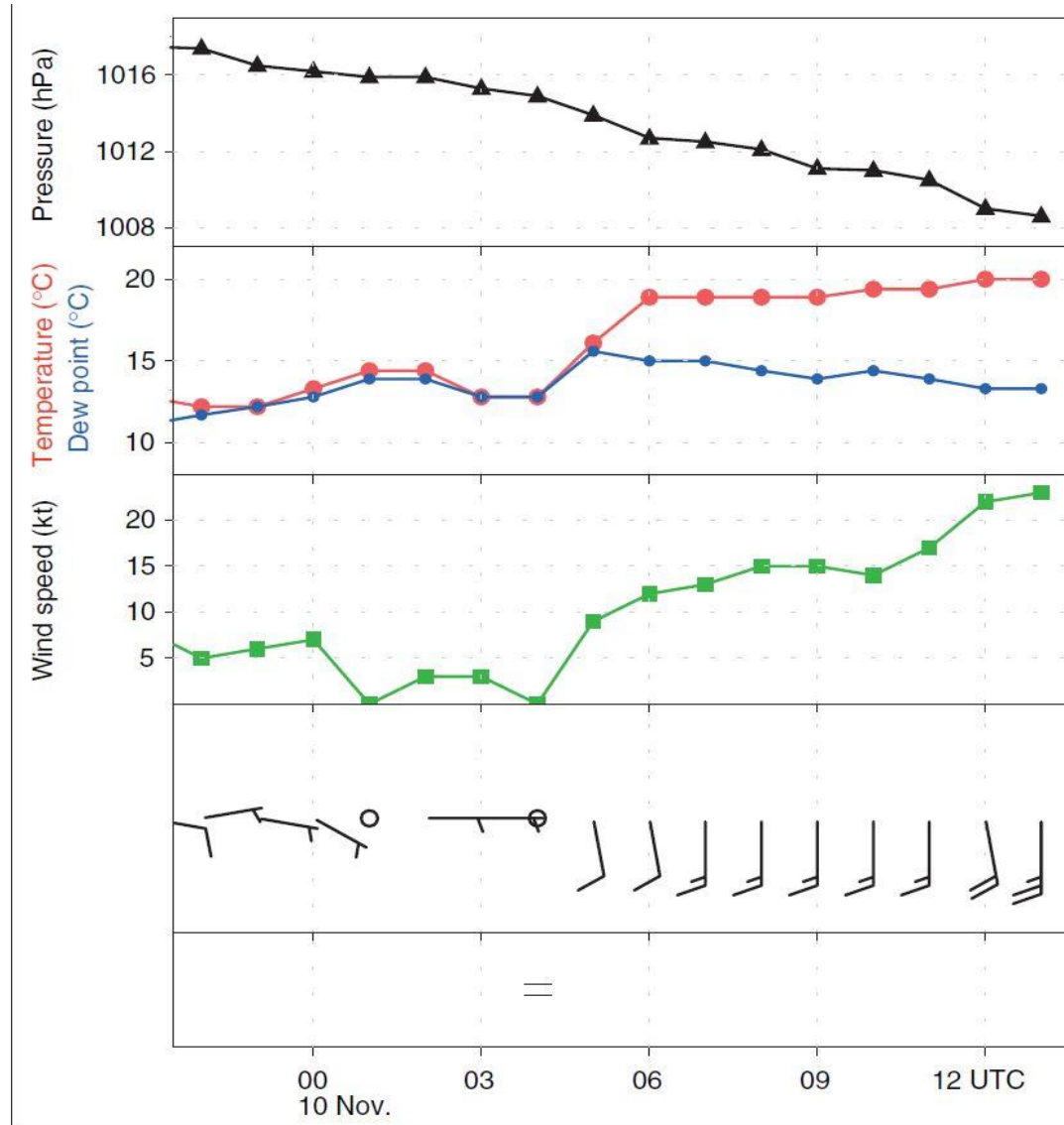


What type of front is this?

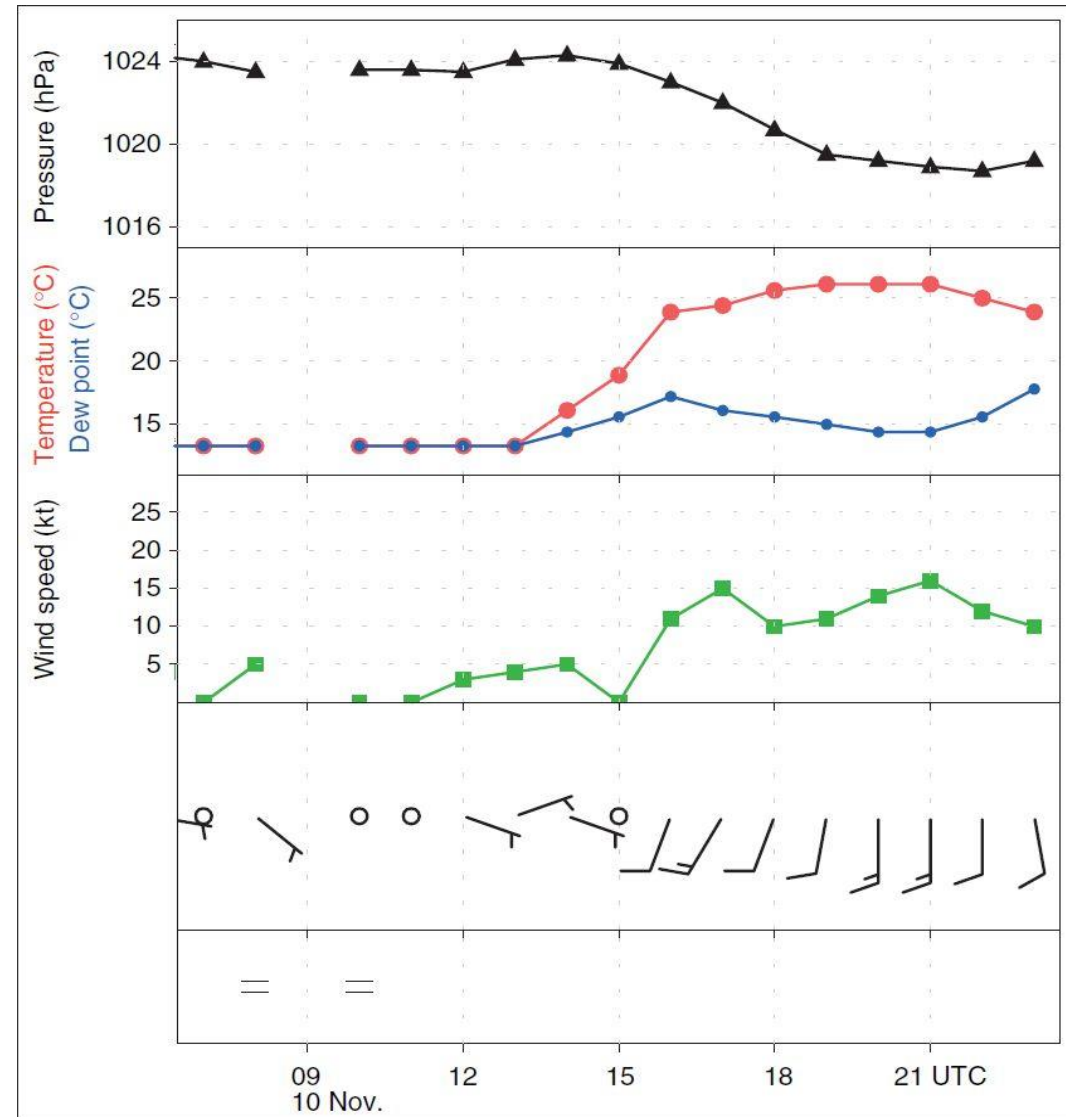


*These are called meteograms

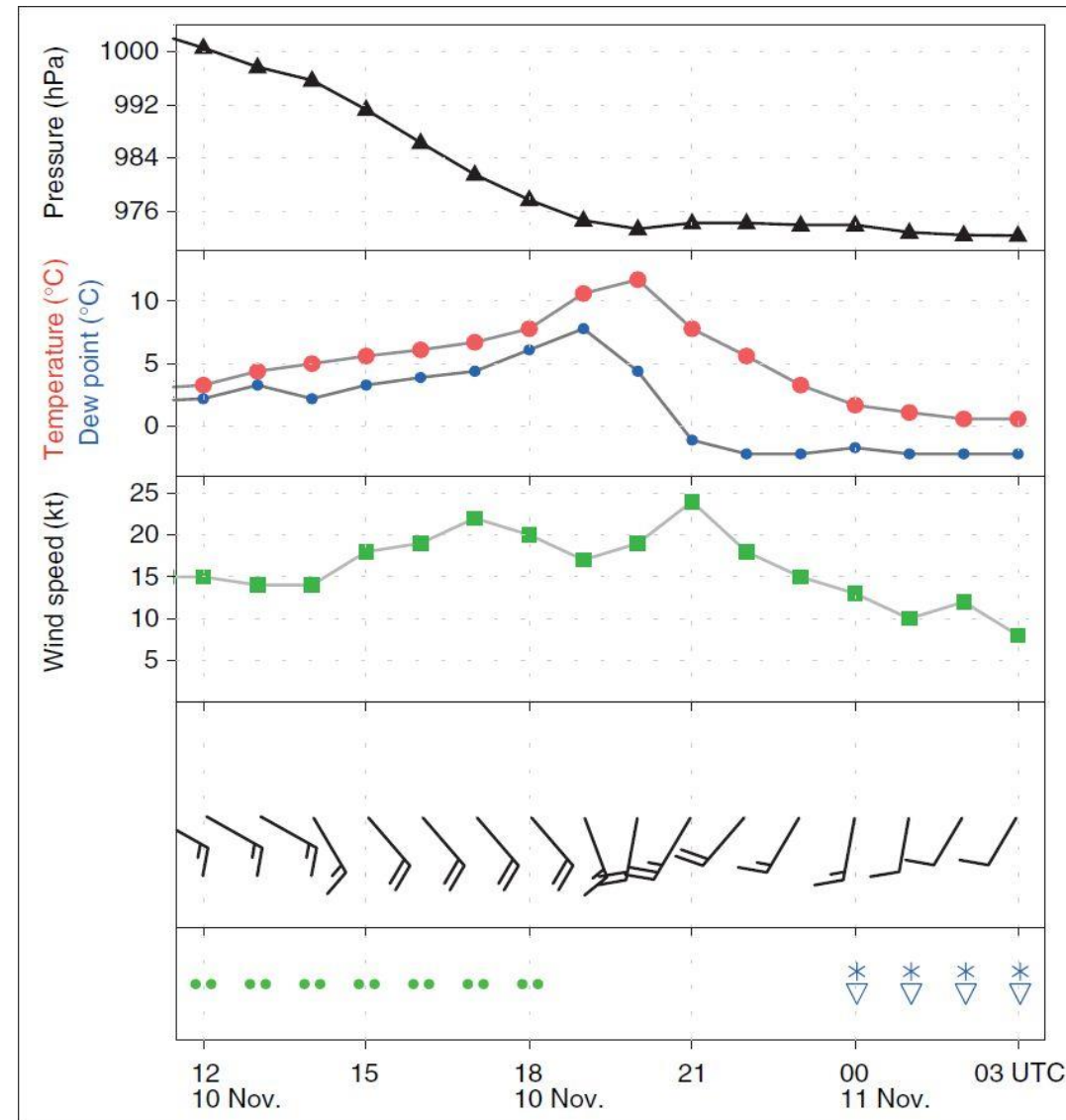
What type of front is this?



What type of front is this?



What type of front is this?



Other Features

- Other features can also:
- Cause strong temperature gradients
- Obscure temperature gradients
- Mountain regions
- Land-water interfaces
- Ocean surface

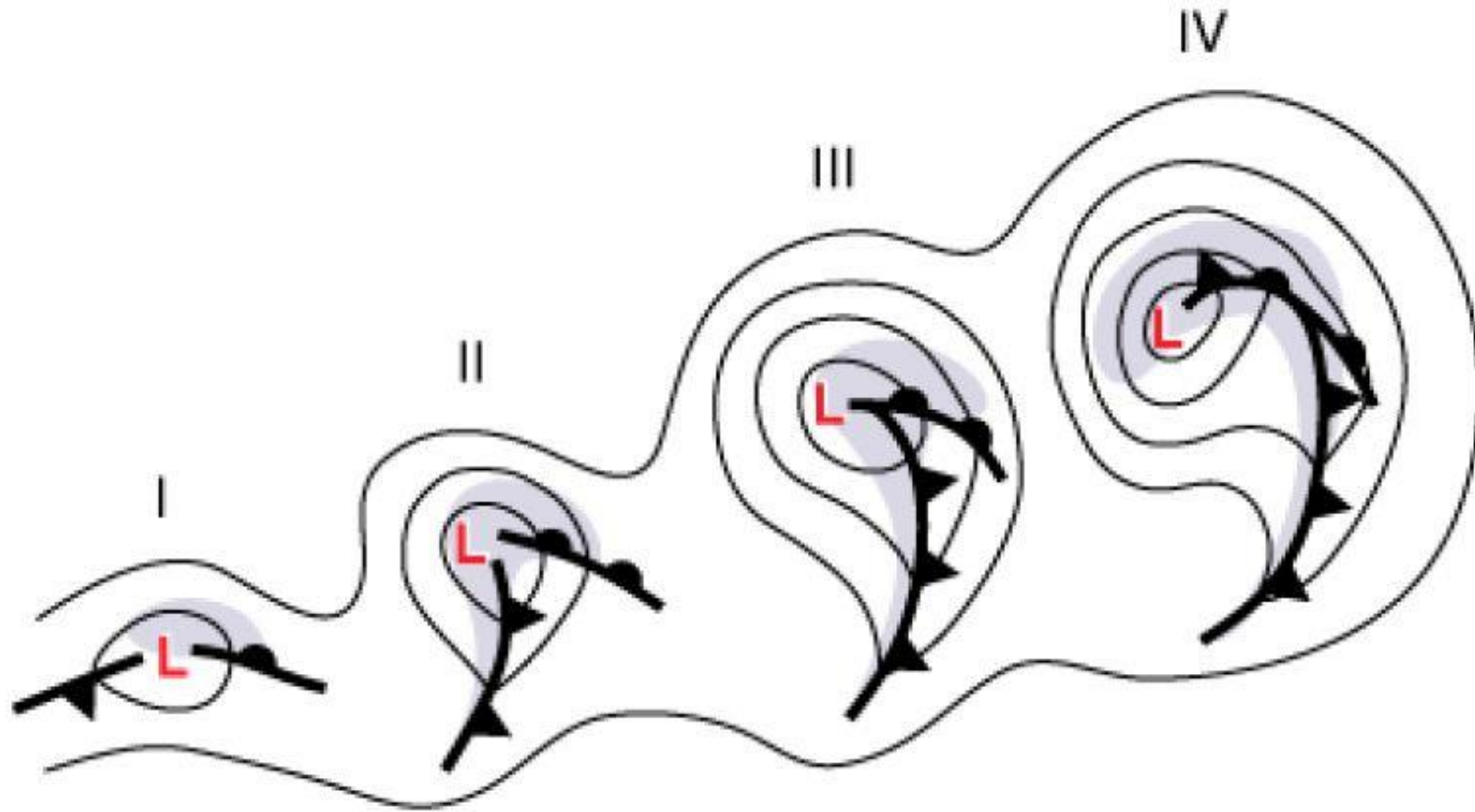
Key Terms

- Frontogenesis: The formation of a frontal zone.
- Frontolysis: The dissipation of a frontal zone.
- Baroclinic: $\nabla T \neq 0$ on constant pressure surfaces.
 - Temperature advections do exist.
 - Lift across baroclinic zones.
- Barotropic: $\nabla T = 0$ on constant pressure surfaces.
 - Temperature advections do not exist.

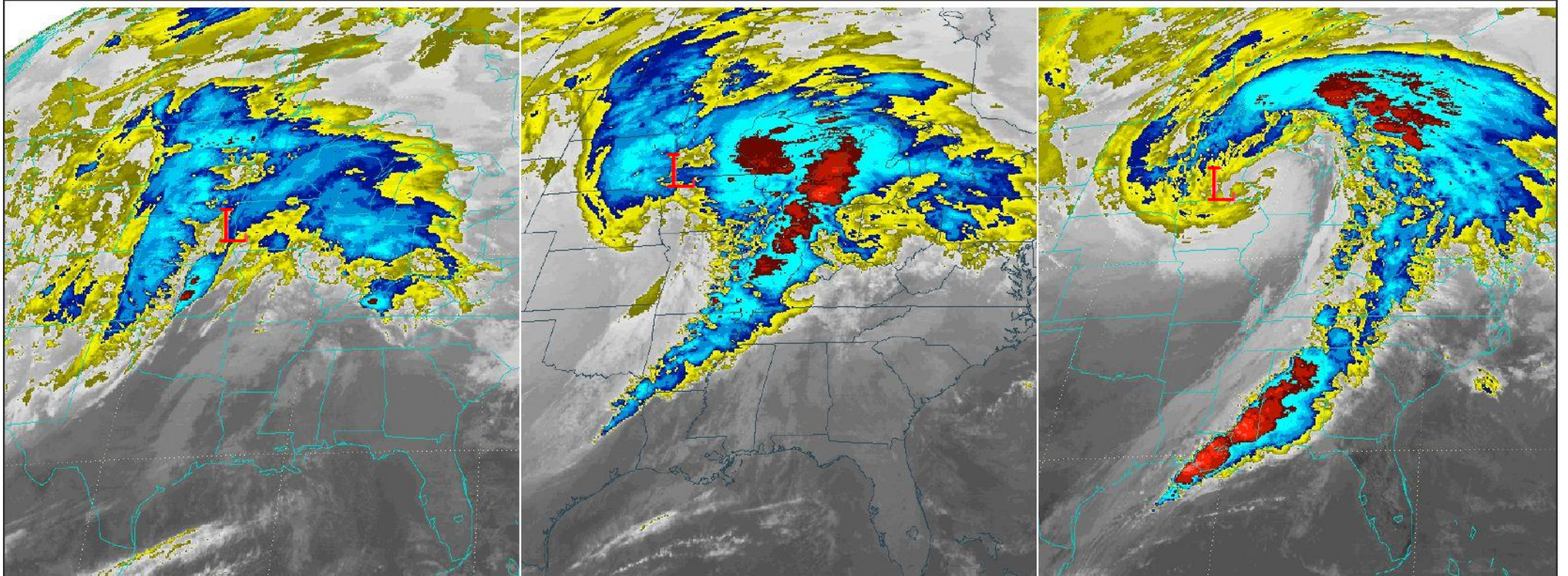
Norwegian Cyclone Model

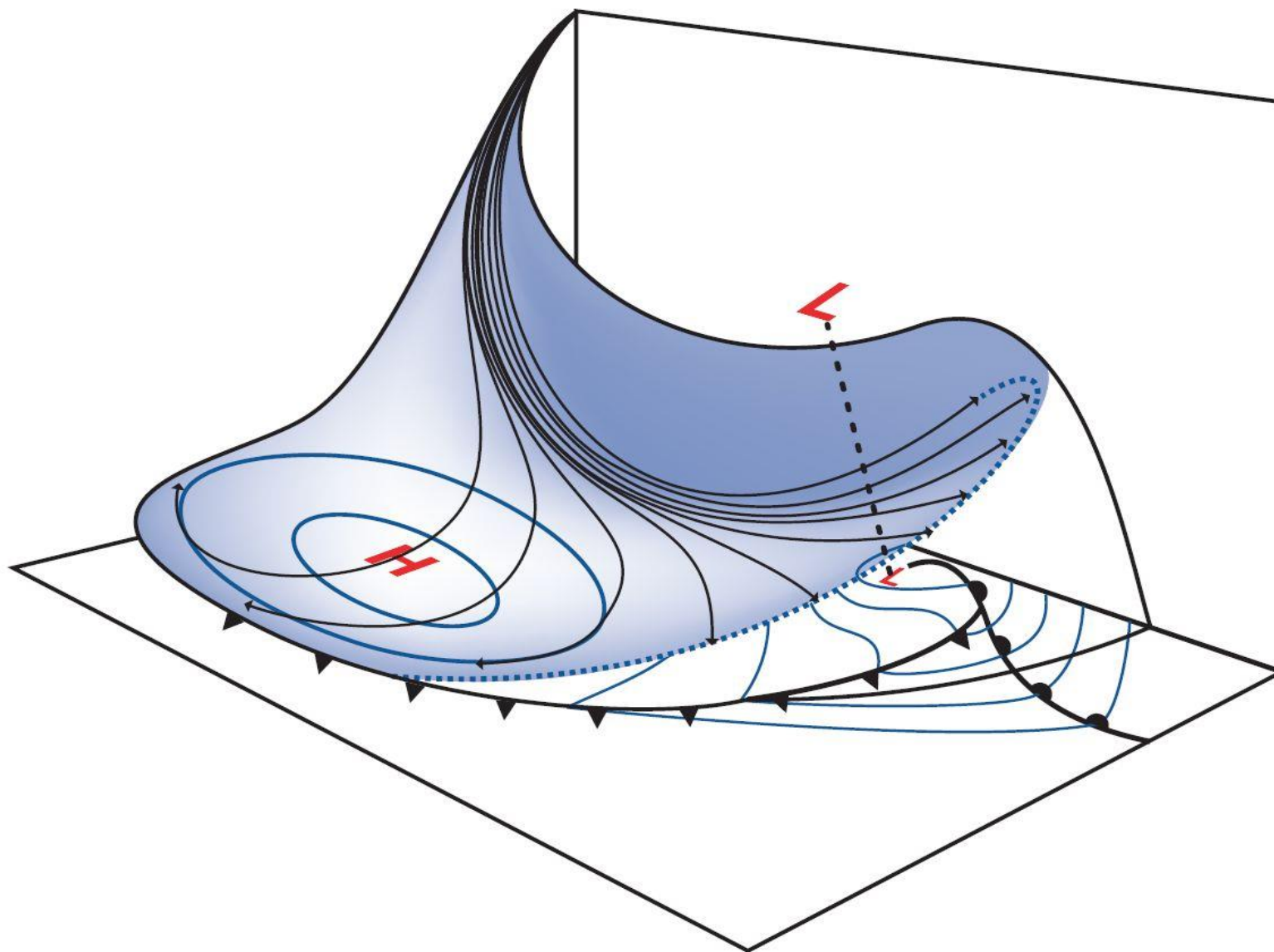
- “Norwegian” - Bergen school (1918) - Idealized
 - V. Bjerknes, J. Bjerknes, K. Solberg, T. Bergeron.
- L develops at “kink” in stationary front.
 - Upper level forcing
- Fronts develop around low
 - Warm and cold advection begin and deepen low.
- L moves into cold air
 - Occluded front forms.
 - L is cut-off from warm sector
 - DEVELOPMENT CEASES
 - New low may develop at triple point.

Norwegian Cyclone Model



Norwegian Cyclone Model

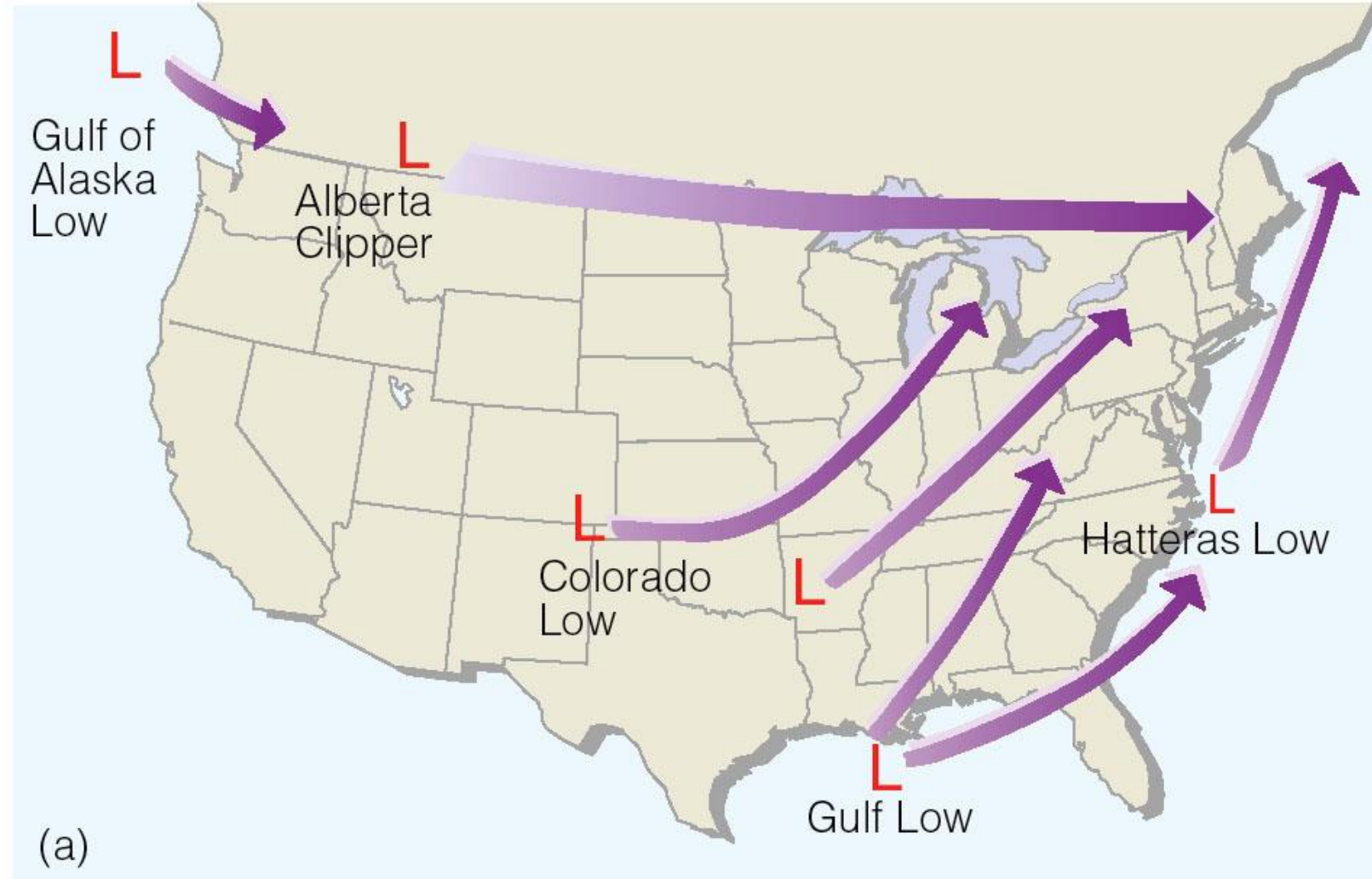




Five preferred locations
for low pressure
development



Low Tracks



Upper Level Flow

- Winds parallel to isobars (heights)
- “Standard” levels
- 850mb, 700mb, 500mb, 200mb, 100mb.

850 mb

- ~5000ft MSL
- Three locations
 - Underground
 - PBL (Planetary Boundary Layer)
 - Free Atmosphere
- Temperature advections
- Height Contours drawn every 30m using 1500m line as a base value
- Moisture for cloud cover.
- 0 °C line.

700 mb

- ~10,000ft MSL
- Clouds typically form between 5000ft and 15000ft
 - Humidity a good prognostic and diagnostic variable
 - >70% Clouds
 - >90% Precipitation
- Height Contours every 30m, 3000m as a base contour
- Isotherms dashed every 5 degrees C

500 mb

- Middle of troposphere ~18,000ft MSL
- Significantly removed from the surface (no friction)
- Longwaves and shortwaves
- Vorticity
- Surface low move about 50% of 500mb wind speed above low
- Height contours drawn every 60m with 5700m or 5400m contours as base contour
- 540 line (510 and 570)

300/250/200 mb

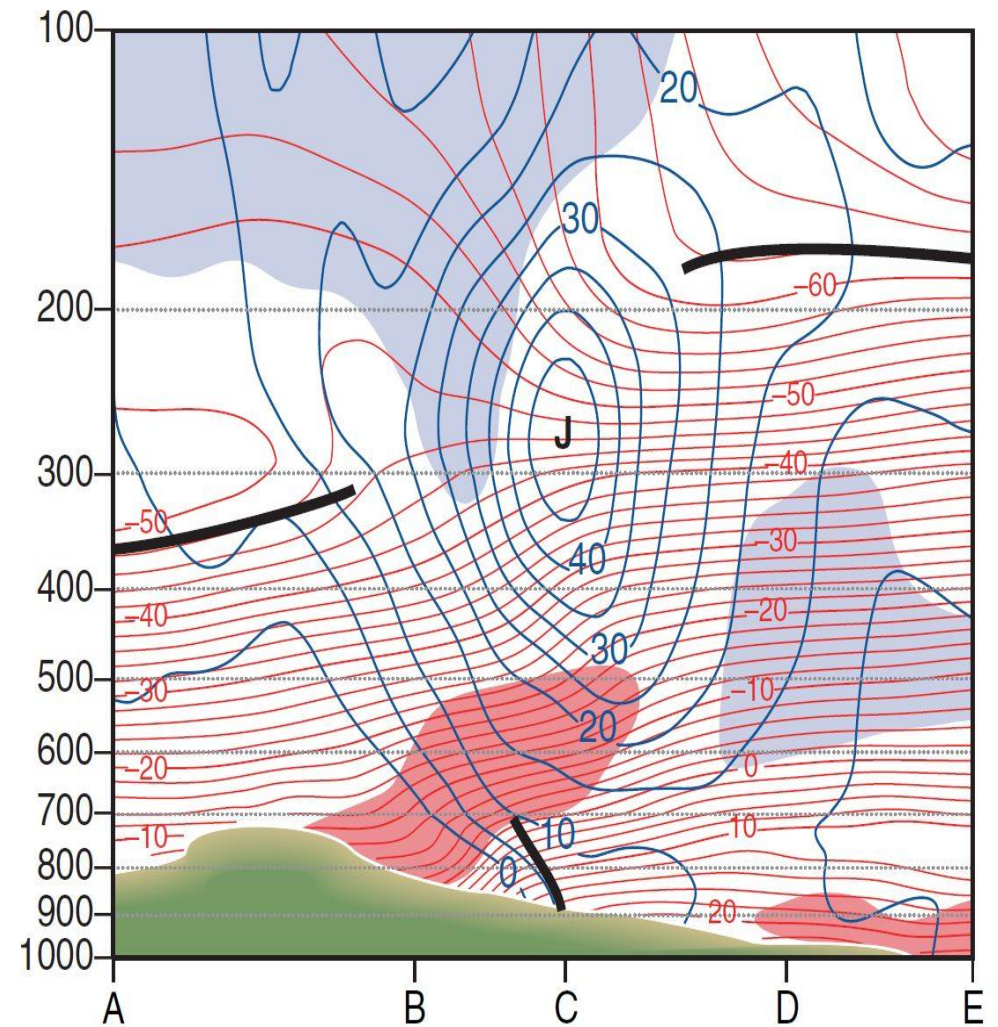
- Locations of jet streams and jet streaks
 - winter: 300mb
 - summer: 200mb
 - transition seasons: 250mb
- Height contours every 120m (12 dm).
- Dew point depressions listed, not dew points.

Other Views

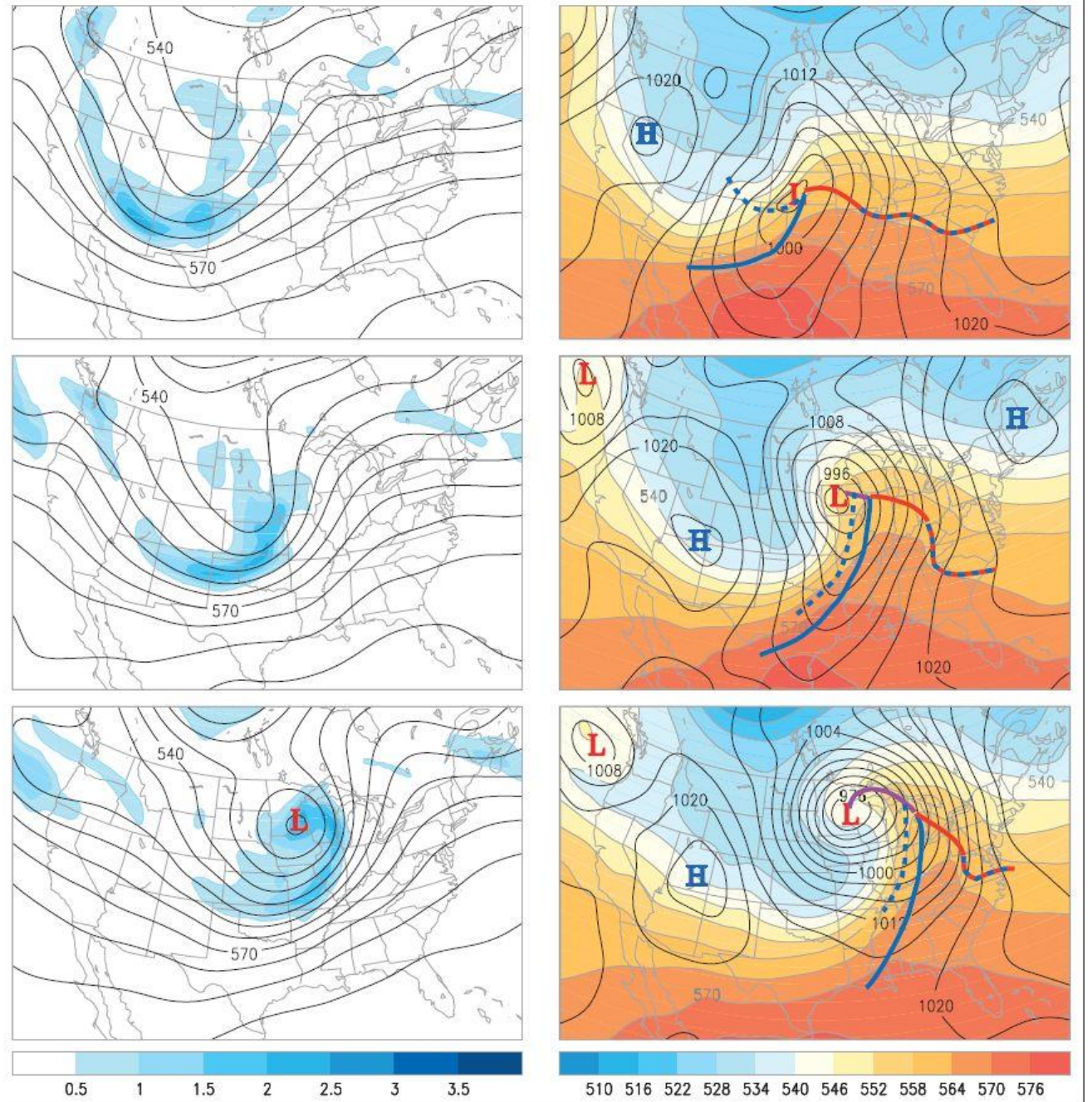
- Soundings.
 - Vertical profile of the atmosphere
 - Skew-T diagrams
- Vertical cross section.

Vertical Cross-section

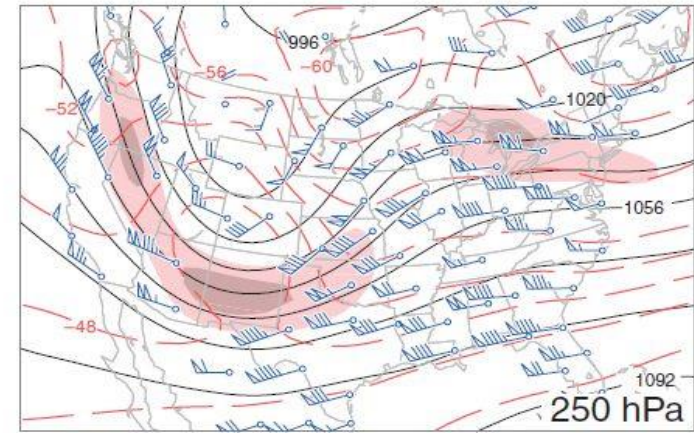
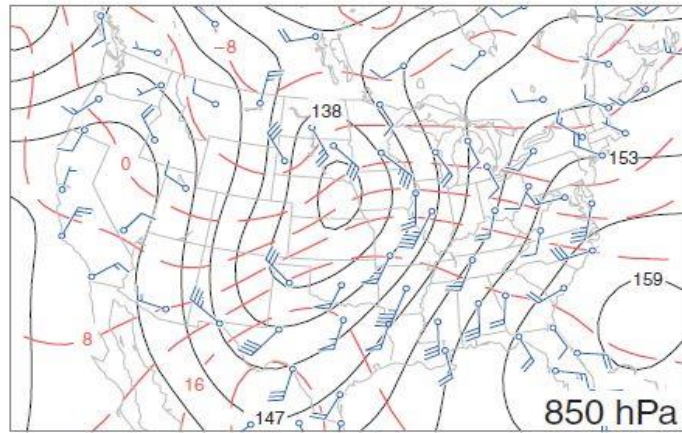
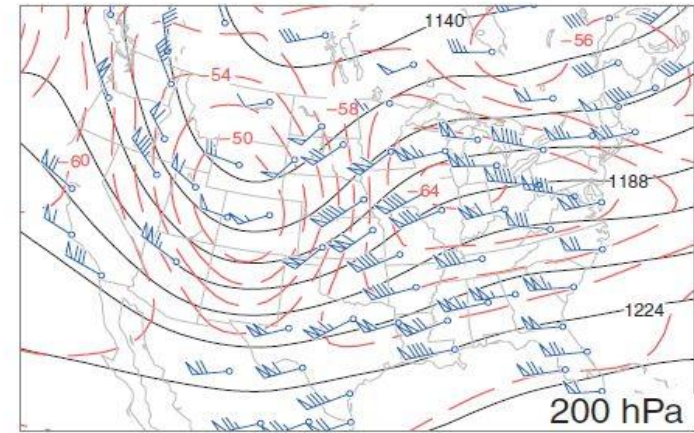
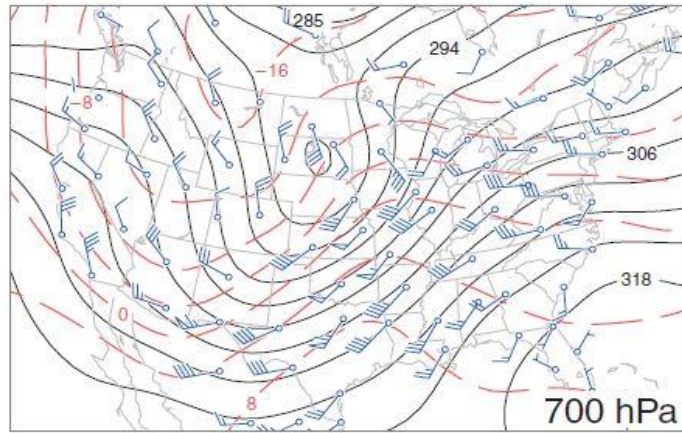
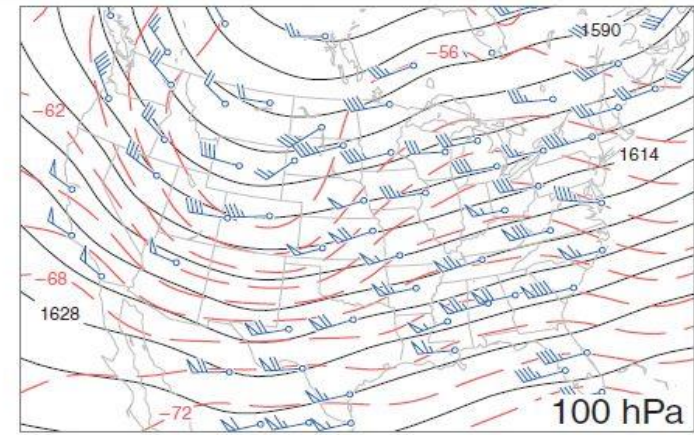
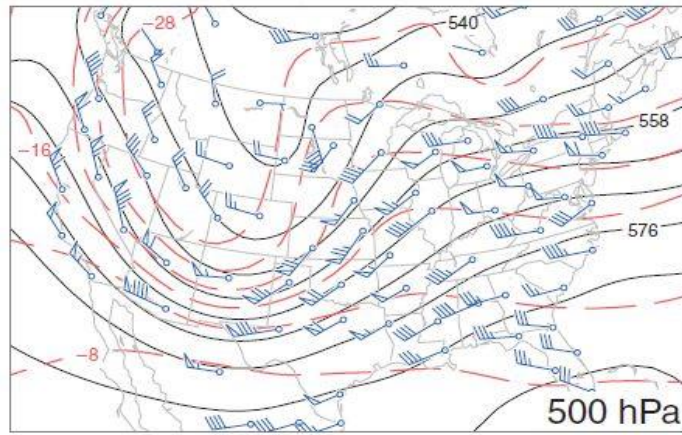
- Front in lower atmosphere
- Strong vertical wind shear.
- Gap in troposphere
 - Jet stream
- Reversal of T-gradient in stratosphere.



Putting it all together



Negative Tilt with height



Negative Tilt with height

