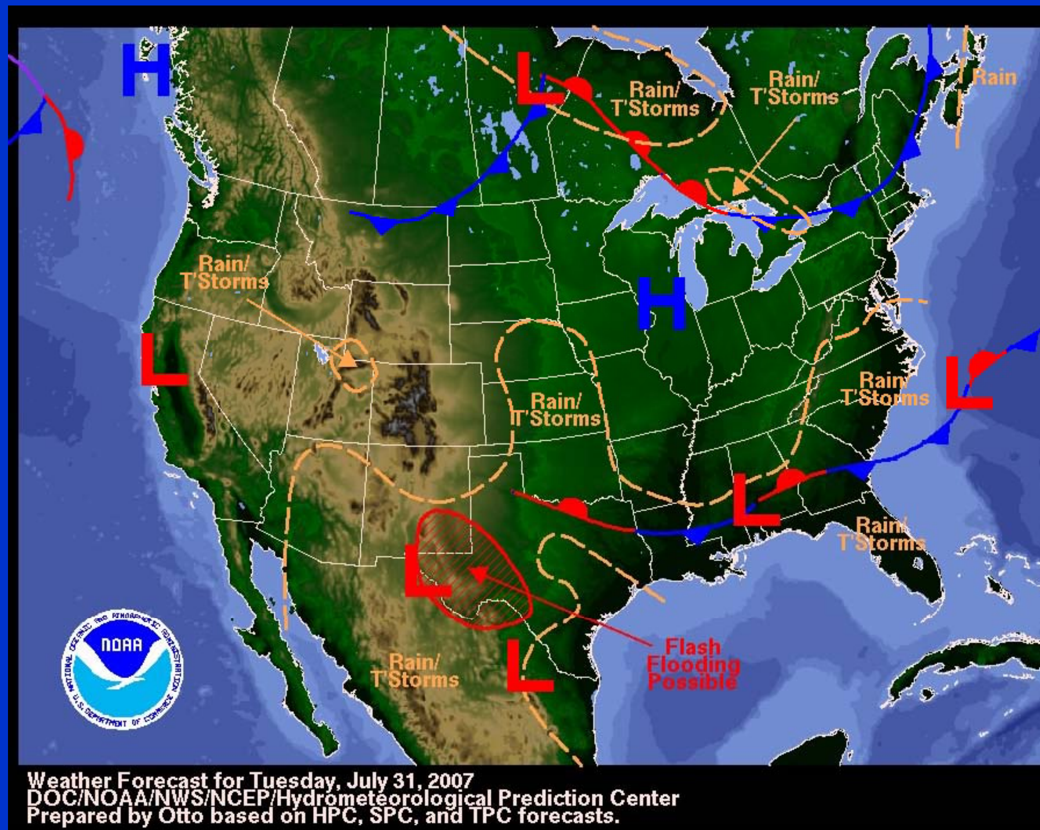
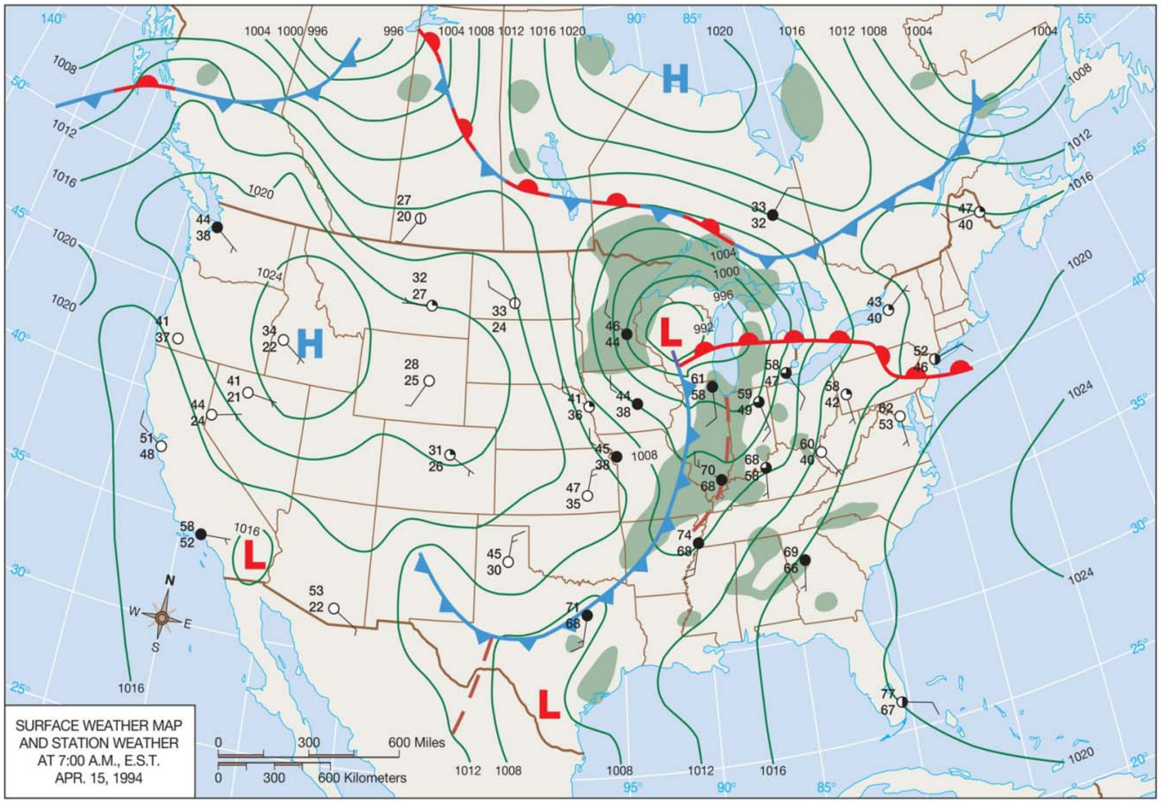
# Chapter 3: Weather Map




- Station Model and Weather Maps
- Pressure as a Vertical Coordinate
- Constant Pressure Maps
- Cross Sections

# Weather Maps





**(from *Understanding Weather & Climate*)**

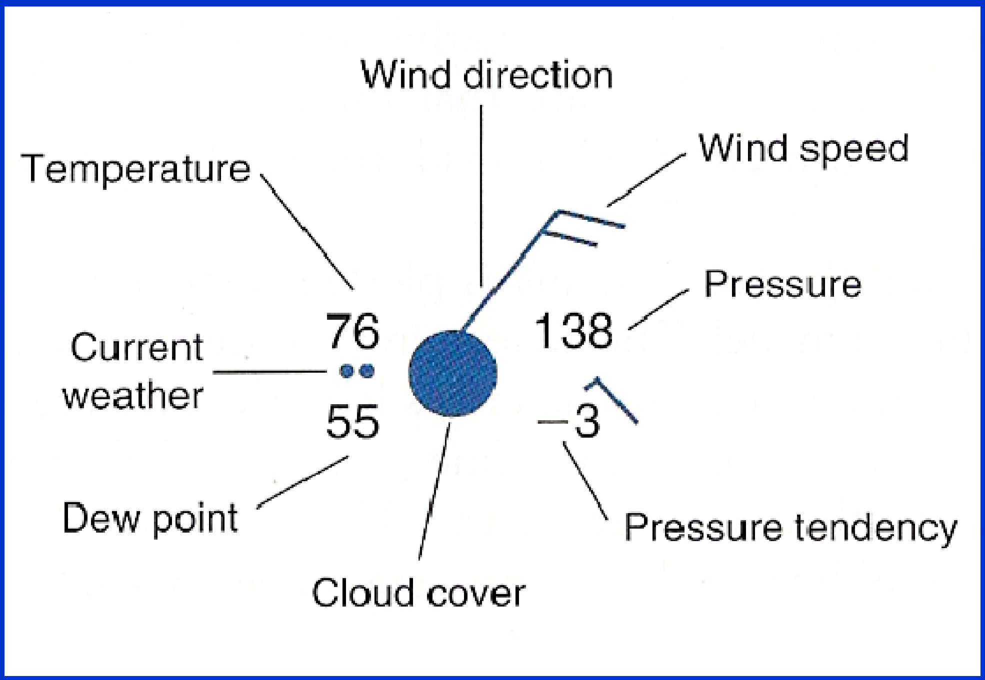
- Many variables are needed to described weather conditions.
- Local weathers are affected by weather pattern.

➔ We need to see all the numbers describing weathers at many locations.

➔ We need weather maps.

- “A picture is worth a thousand words”.

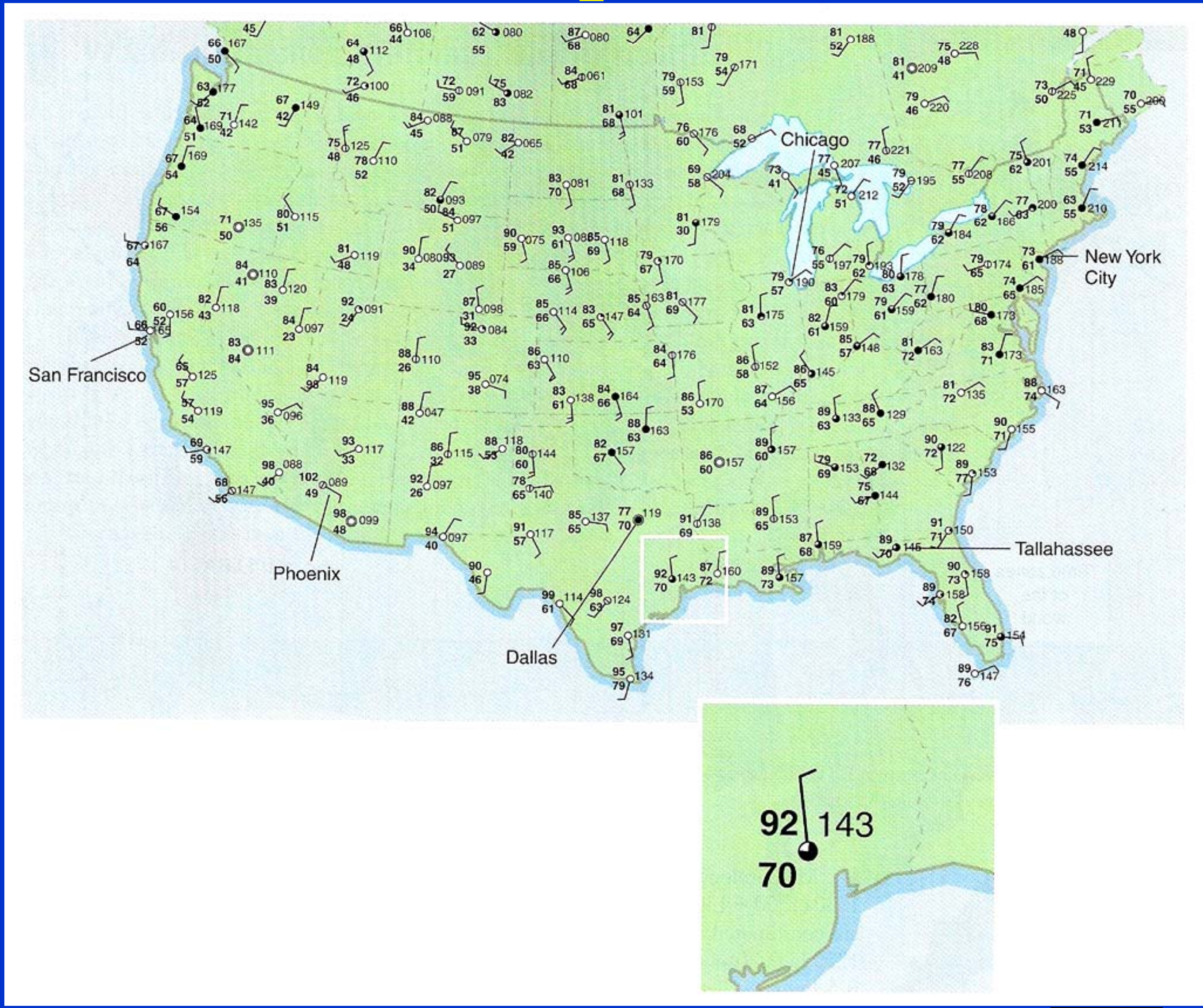
# The Station Model




(from *Meteorology: Understanding the Atmosphere*)

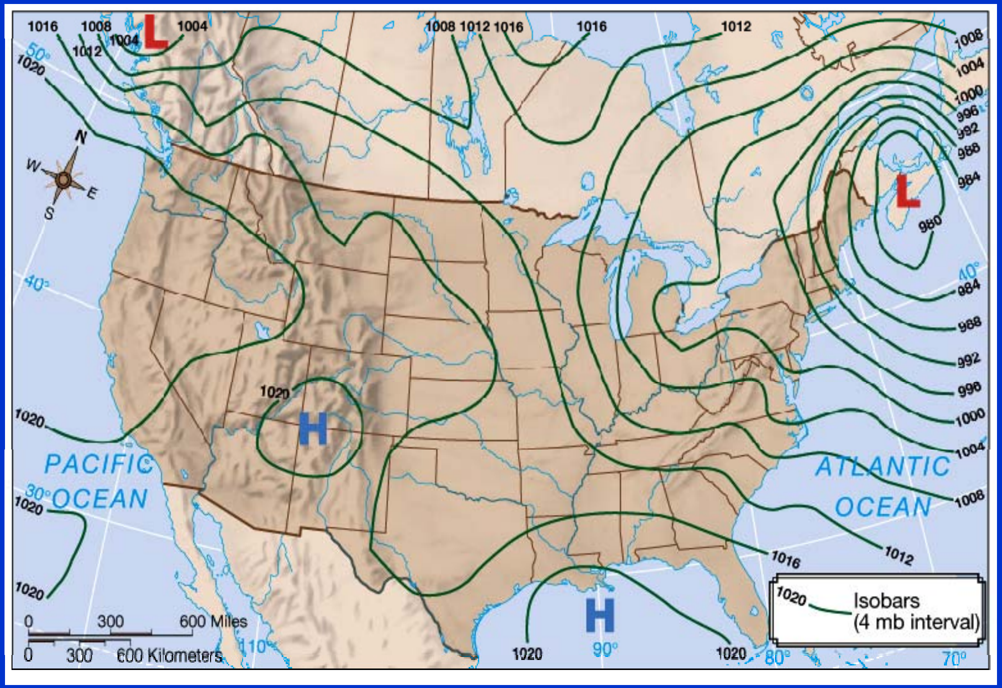
- Meteorologists need a way to condense all the numbers describing the current weather at a location into a compact diagram that takes up as little space as possible on a weather map.
- This compressed geographical weather report is called a ***station model***.

# Weather Map on 7/7/2005



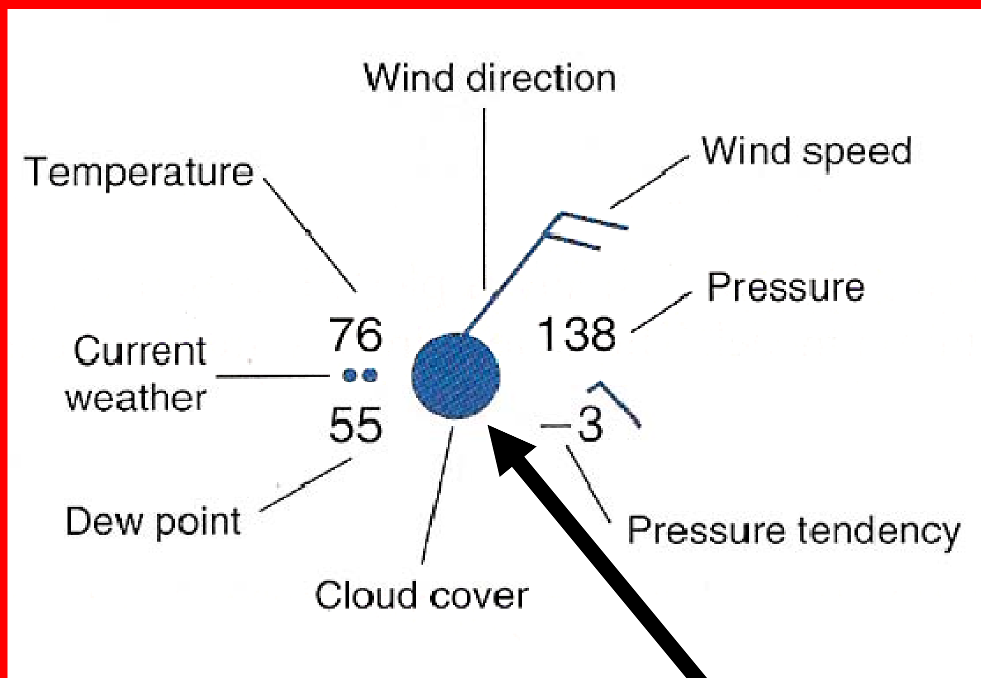

(from *Meteorology: Understanding the Atmosphere*)

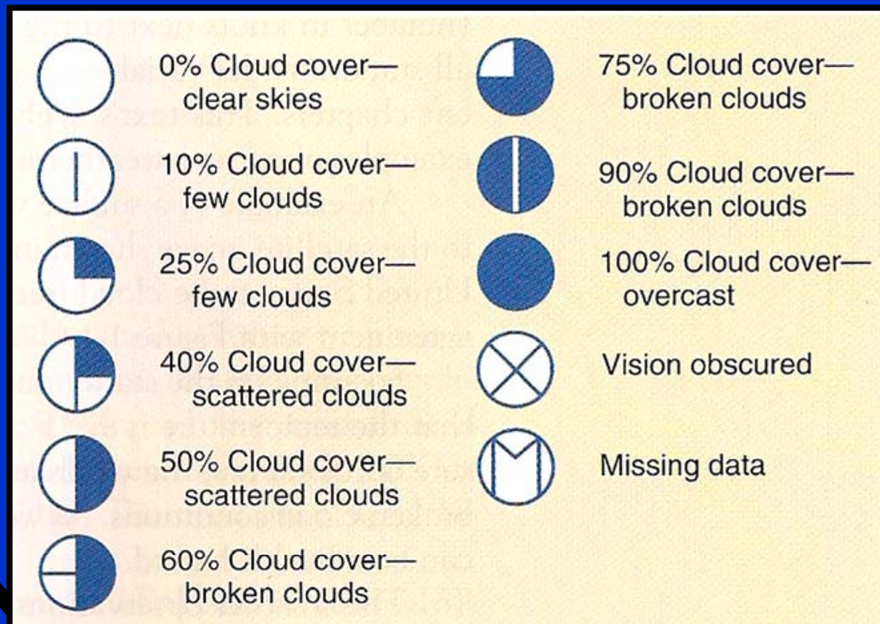
# Isobar




- It is useful to examine horizontal pressure differences across space.
- Pressure maps depict ***isobars***, lines of equal pressure.
- Through analysis of ***isobaric charts***, pressure gradients are apparent.
- Steep (weak) pressure gradients are indicated by closely (widely) spaced isobars.

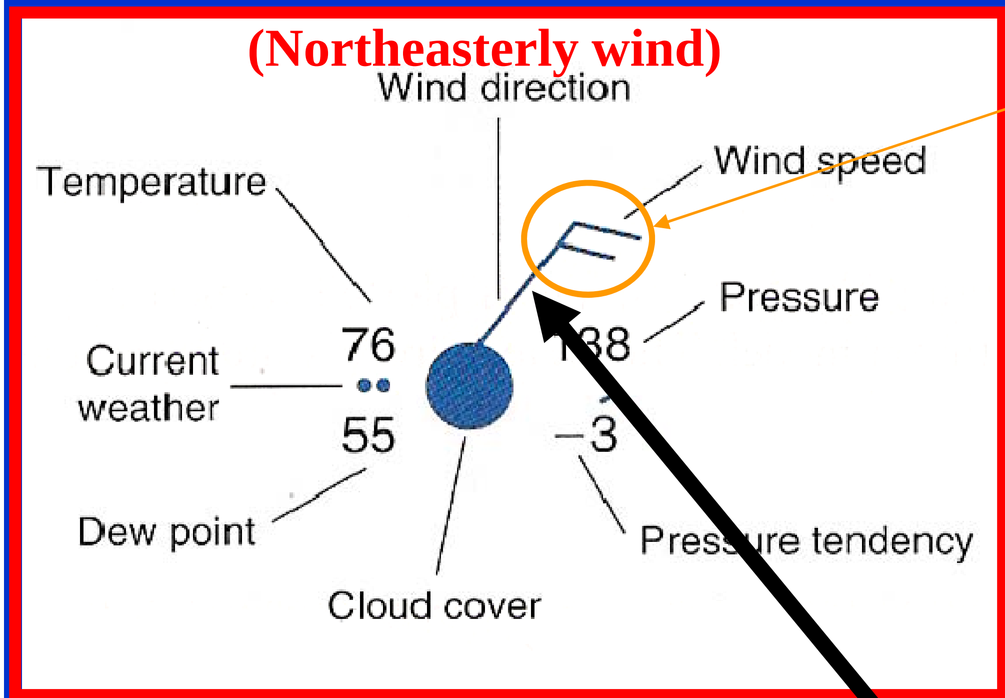
# The Station Model: Cloudiness



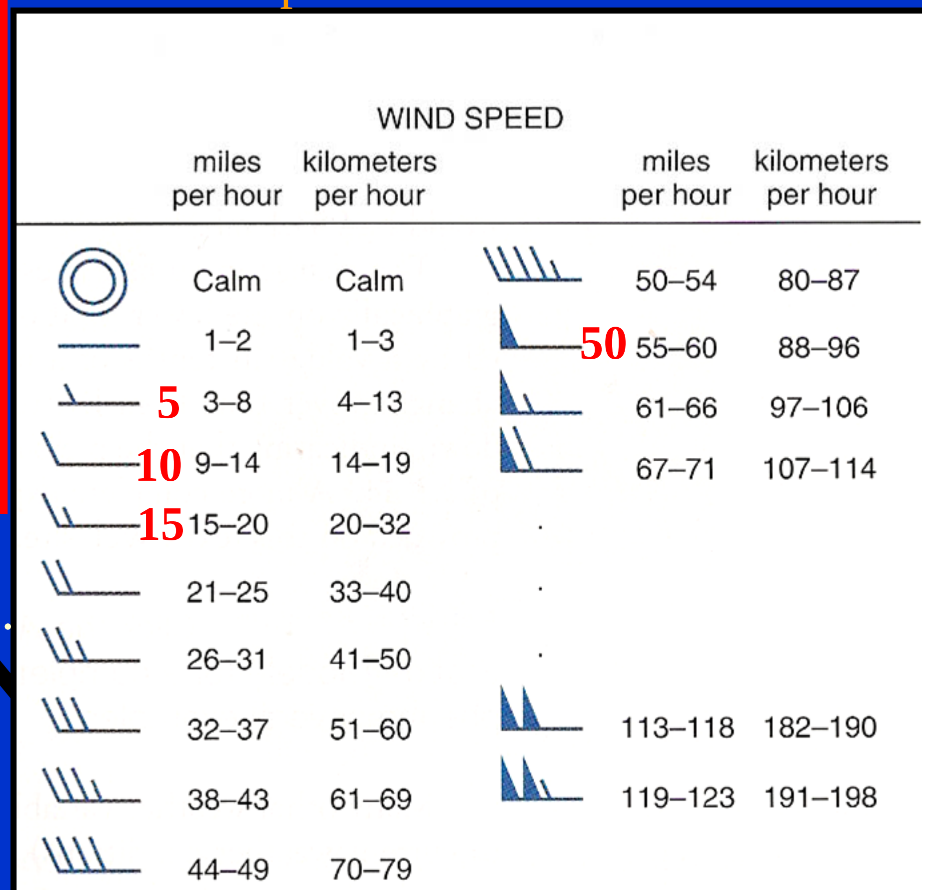




(from *Meteorology: Understanding the Atmosphere*)

# The Station Model: Wind




Wind speed is indicated to the right (left) side of the coming wind vector in the Northern (Southern) Hemisphere

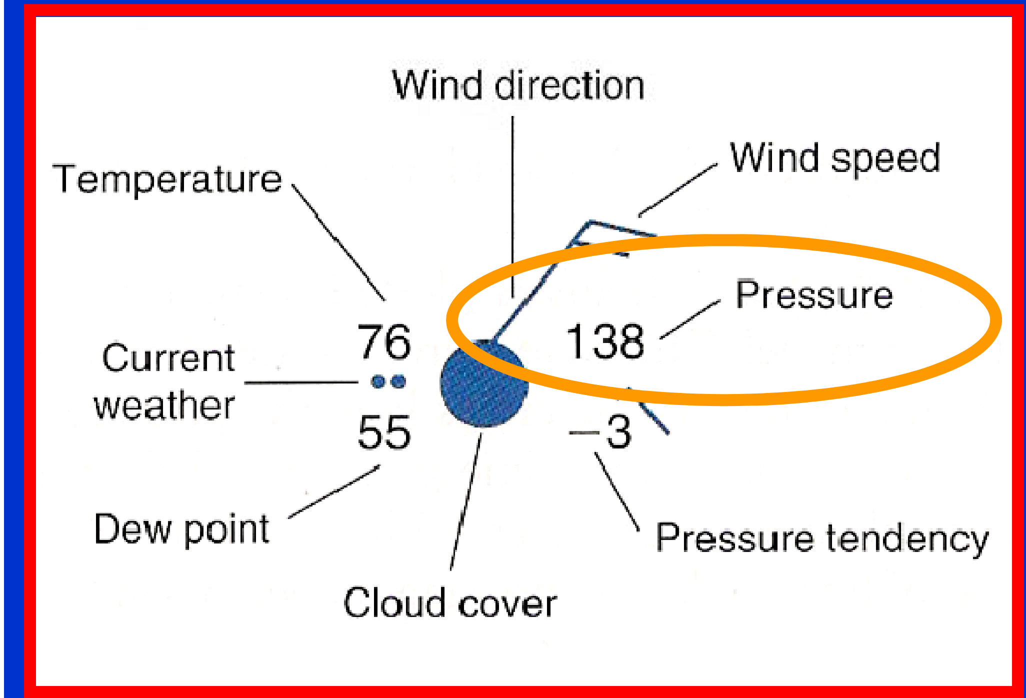


WIND SPEED

| | miles per hour | kilometers per hour | | miles per hour | kilometers per hour |
|---|---|---|---|---|---|
| | Calm | Calm | | 50–54 | 80–87 |
| | 1–2 | 1–3 | 50 | 55–60 | 88–96 |
| 5 | 3–8 | 4–13 | | 61–66 | 97–106 |
| 10 | 9–14 | 14–19 | | 67–71 | 107–114 |
| 15 | 15–20 | 20–32 | | . | |
| | 21–25 | 33–40 | | . | |
| | 26–31 | 41–50 | | . | |
| | 32–37 | 51–60 | | 113–118 | 182–190 |
| | 38–43 | 61–69 | | 119–123 | 191–198 |
| | 44–49 | 70–79 | | | |

- Wind speeds are indicated in units of “knot”.
- 1 international knot
  = 1 nautical mile per hour (exactly),
  = 1.852 kilometer per hour (exactly),
  = 0.514 meters per second,
  = 1.15077945 miles per hour (approximately)

# The Station Model: Pressure

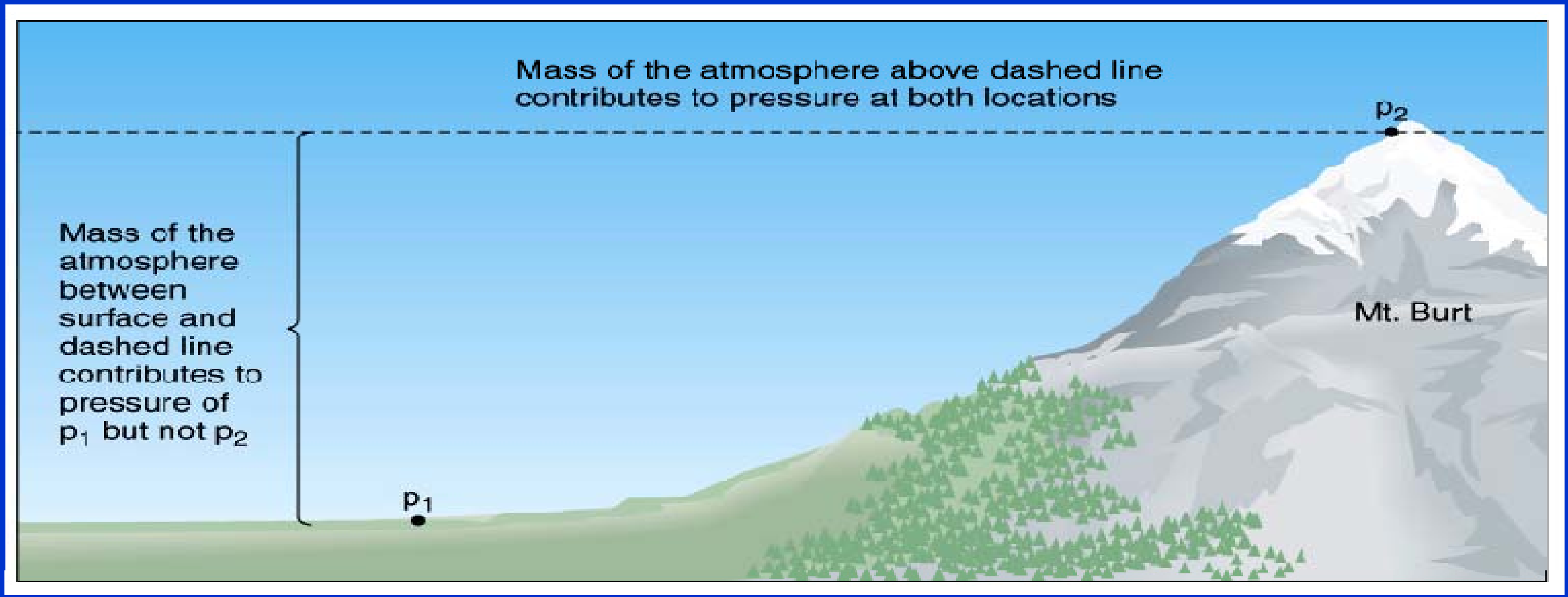



- The pressure value shown is the measured atmospheric pressure adjusted to sea level.
- The units used are "mb".
- To save space, the "thousand" and the "hundred" values, and the decimal point are dropped.

➔ So "**138**" means 10**13.8** mb

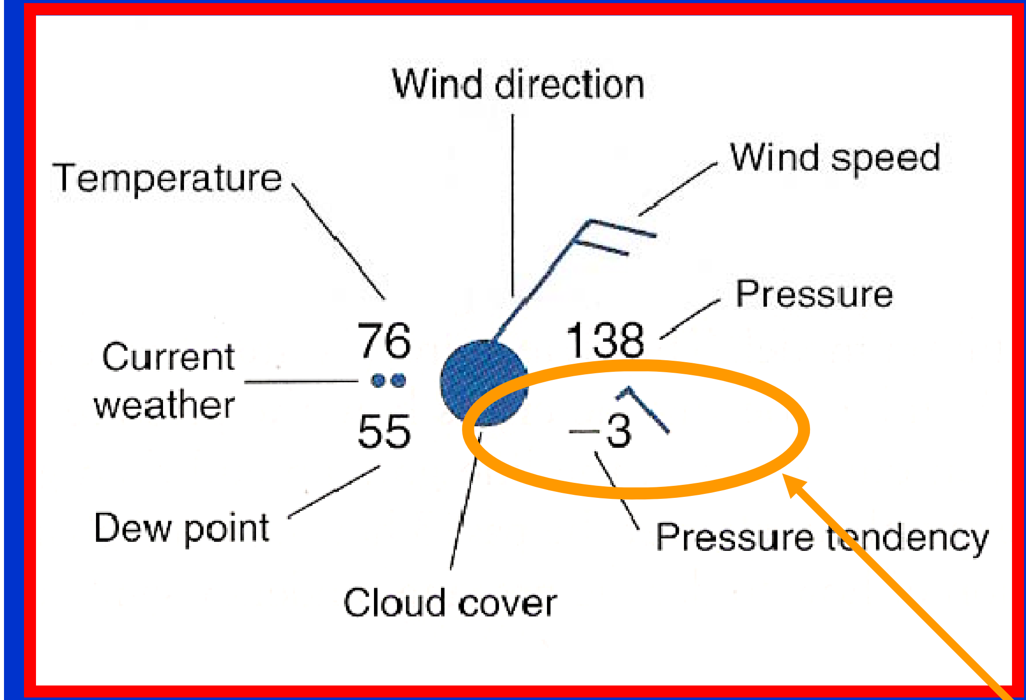
To decode the value of pressure on the station model, add a 9 if the first number is 6, 7, 8, or 9; otherwise add a 10.

# Pressure Correction for Elevation




- Pressure decreases with height.
- Recording actual pressures may be misleading as a result.
- All recording stations are reduced to sea level pressure equivalents to facilitate horizontal comparisons.
- Near the surface, the pressure decreases about 100mb by moving 1km higher in elevation.

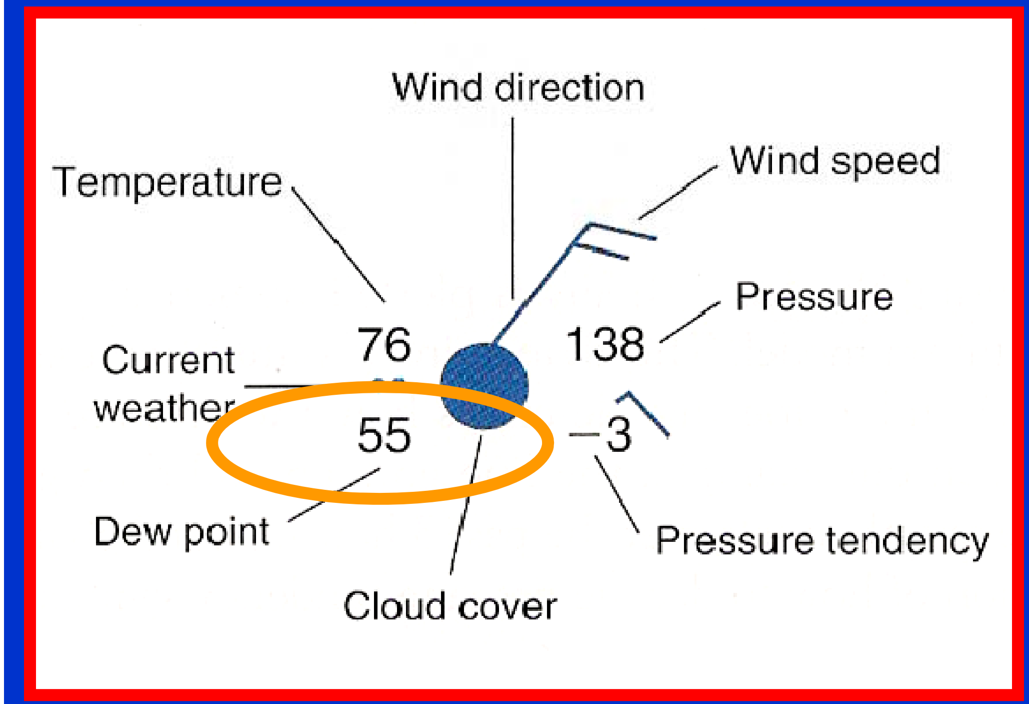
# The Station Model: Pressure Tendency




- The change in surface pressure in the past three hours is plotted numerically and graphically on the lower right of the station model.

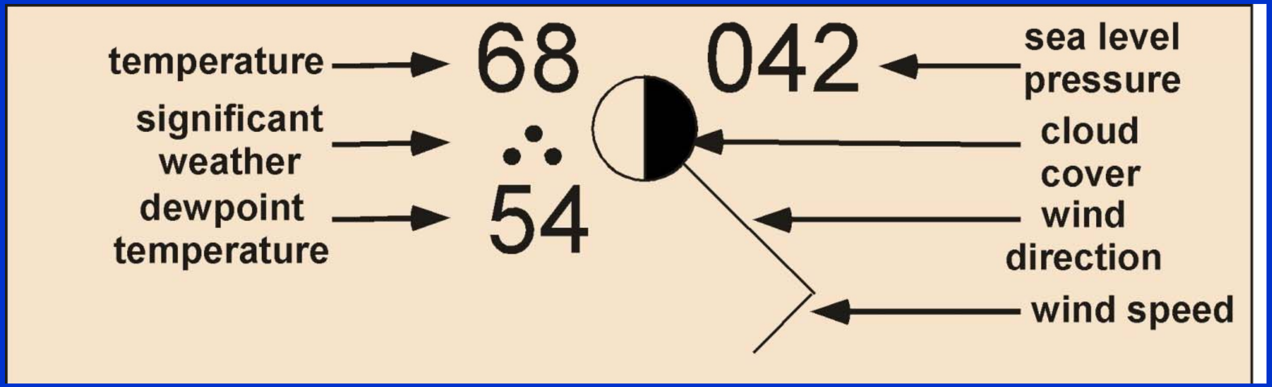
The pressure rose and then fell over the past three hours, a total change of ***0.3*** mb.

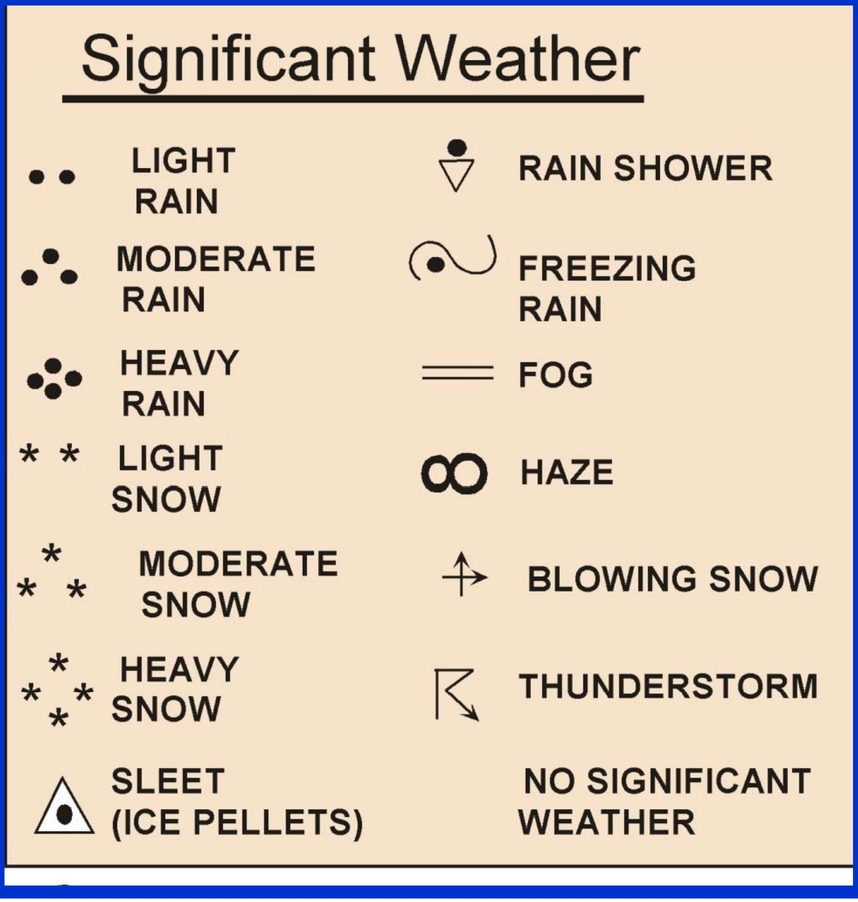
# The Station Model: Dew Point Temperature




- ❑ Dew point temperature (in united of ºF if reported in the US) indicates the moisture content.
- ❑ A higher value indicates a larger amount of moisture.

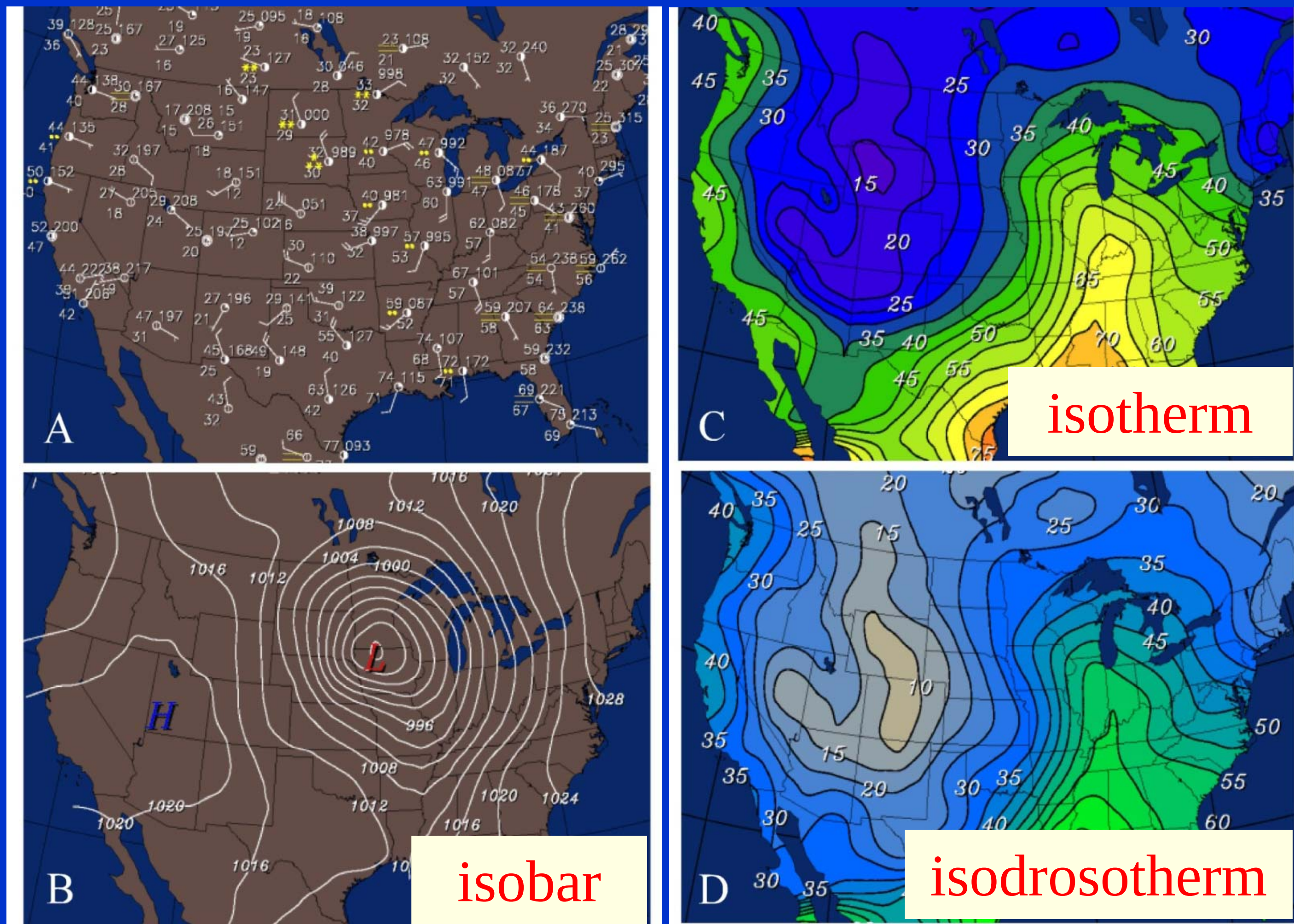
# The Station Model: Significant Weather




- There are over a hundred symbols for various weather conditions.
- If no symbol is plotted, no significant weather condition is occurring at the station.

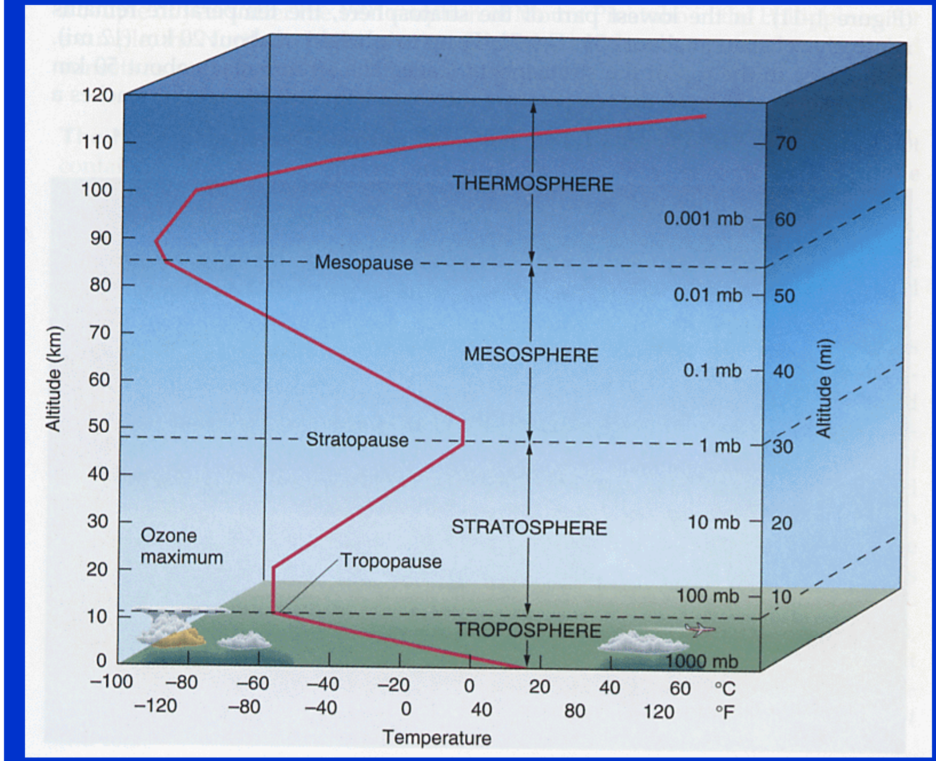
# Contour Lines on Weather Maps




Courtesy of the Department of Atmospheric Science, University of Illinois at Urbana-Champaign Courtesy of the Department of Atmospheric Science, University of Illinois at Urbana-Champai

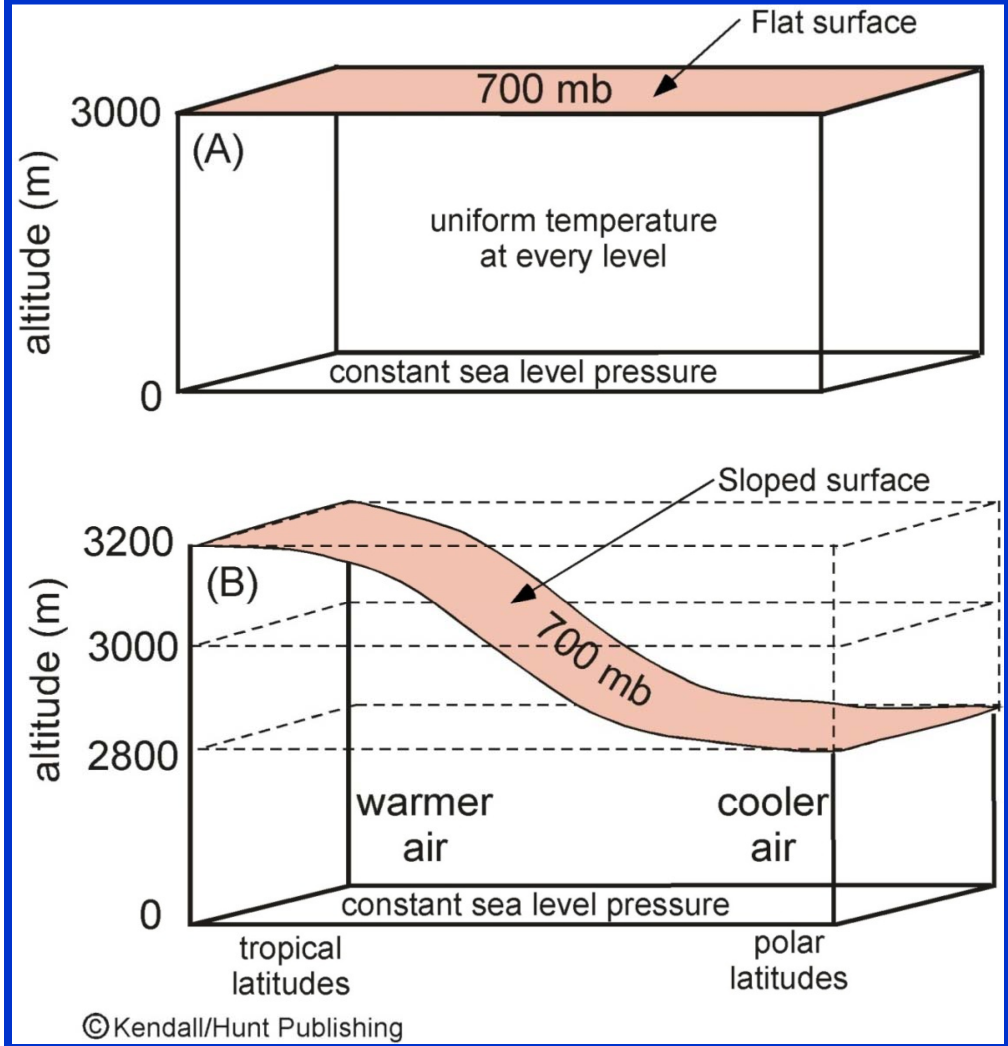
• Meteorologists draw lines connecting points on weather maps with the same values of temperature (isotherm), pressure (isobar), dewpoint temperature (isodrosotherm), or other quantities to simply interpretation of data on the maps.

# Pressure As a Vertical Coordinate



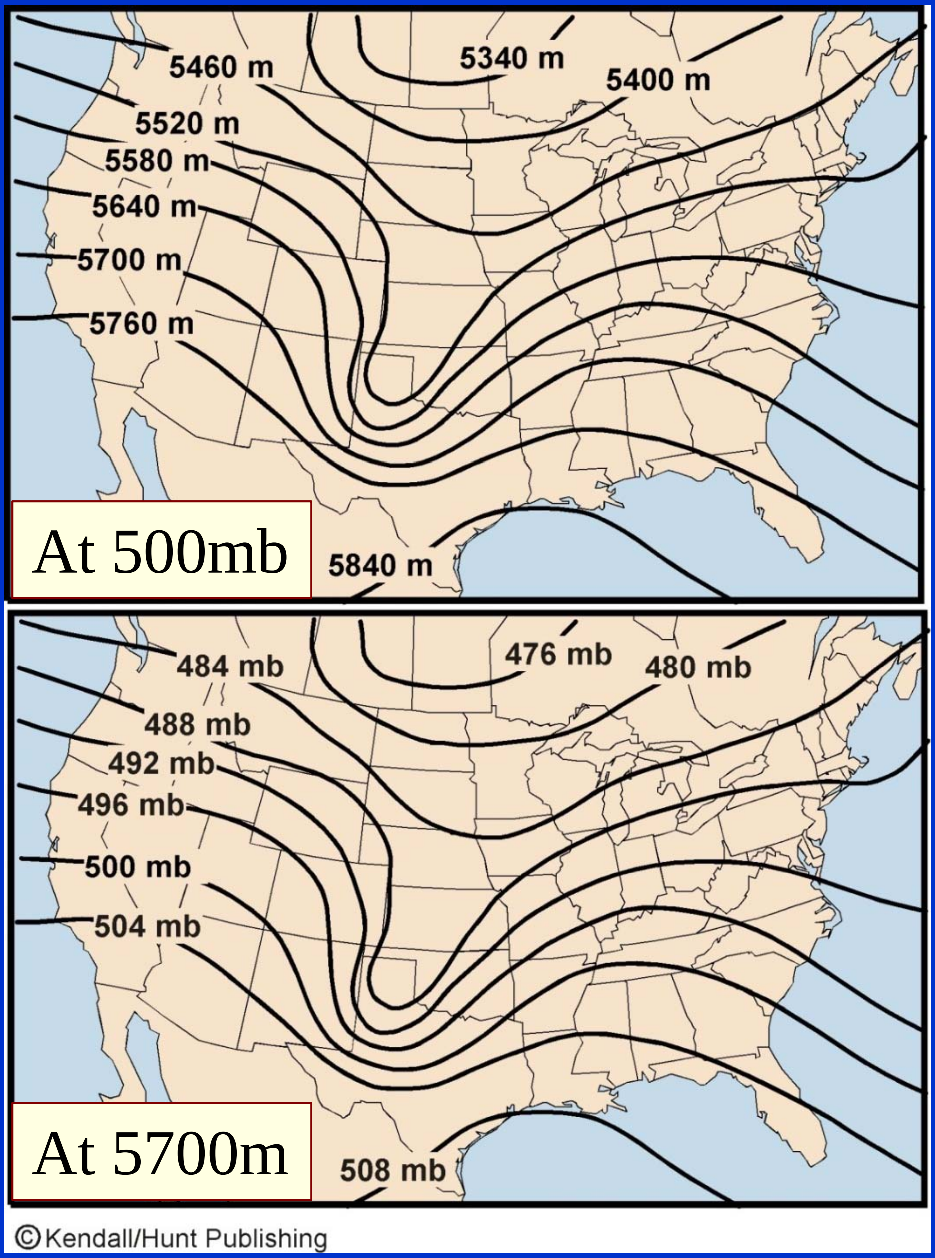

- Each altitude above a point on the Earth's surface has a unique value of pressure.
- Pressure can be easily substituted for altitude as a coordinate to specify locations in the vertical.
- Rawinsondes determine the height of the instrument above Earth's surface by measuring pressure.
- Because aircraft fly on constant pressure surfaces, upper air weather maps, first used extensively during World War II, traditionally have been plotted on constant pressure surface.
- Fluid dynamics theories and equations that explain atmospheric motions are often in a more concise forms when they use pressure as a vertical coordinate.

# Pressure Surface




- A pressure surface is a surface above the ground where the pressure has a specific value, such as 700mb.
- Constant pressure surfaces slope downward from the warm to the cold side.
- Since the atmosphere in the polar regions is cold and the tropical atmosphere is cold, all pressure surfaces in the troposphere slope downward from the tropics to the polar regions.

# Height (Pressure) Map at a Constant Pressure (Height)




- Since the atmosphere in the polar regions is cold and the tropical atmosphere is warm, all pressure surfaces in the troposphere slope downward from the tropics to the polar regions.
- The pressure information on a constant altitude allow us to visualize where high- and low-pressure centers are located.
- The height information on a constant pressure surface convey the same information.
- The intensity of the pressure (or height) gradients allow us to infer the strength of the winds.

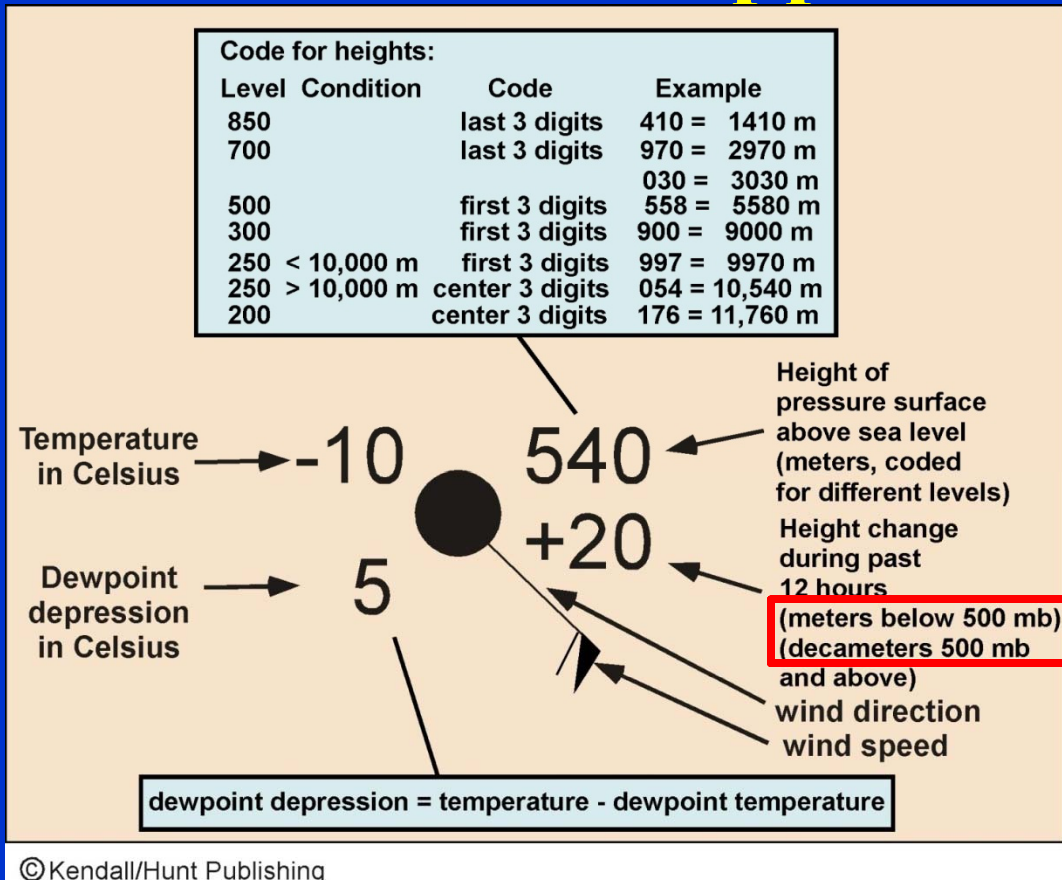
# Upper-Level Weather Maps

**TABLE 3.1 Commonly Available Constant-Pressure Maps**

| Pressure Level | Approximate Altitude (feet) | Approximate Altitude (km) |
|---|---|---|
| 850 mb | 5,000 ft | 1.5 km |
| 700 mb | 10,000 ft | 3.0 km |
| 500 mb | 18,000 ft | 5.5 km |
| 300 mb | 30,000 ft | 9.0 km |
| 250 mb | 35,000 ft | 10.5 km |
| 200 mb | 40,000 ft | 12.0 km |

- Meteorologists use height maps at constant pressure levels to describe weather conditions in the upper atmosphere.
- On constant pressure maps, we can infer a strong pressure gradient exists where a strong height gradient exists.
- Height maximum → high pressure.
- Height minimum → low pressure.

# Station Model in Upper-Level Weather Maps



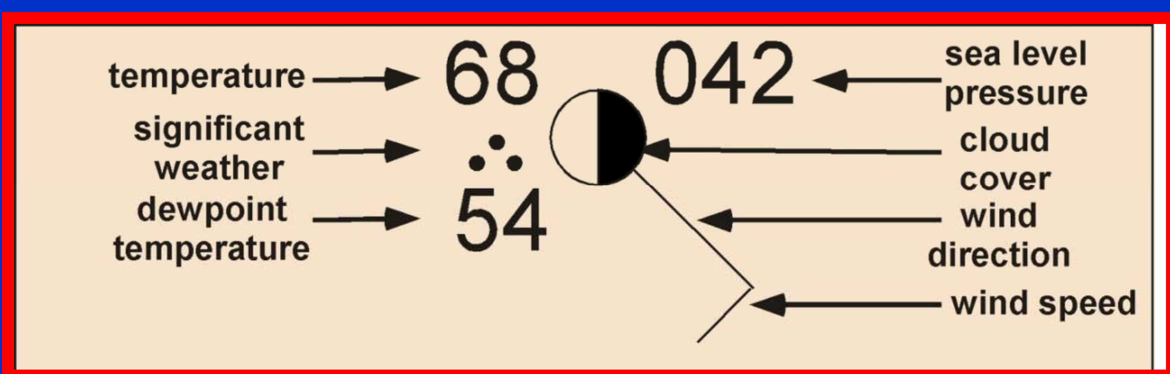
Code for heights:

| Level | Condition | Code | Example |
|---|---|---|---|
| 850 | | last 3 digits | 410 = 1410 m |
| 700 | | last 3 digits | 970 = 2970 m |
| | | | 030 = 3030 m |
| 500 | | first 3 digits | 558 = 5580 m |
| 300 | | first 3 digits | 900 = 9000 m |
| 250 | < 10,000 m | first 3 digits | 997 = 9970 m |
| 250 | > 10,000 m | center 3 digits | 054 = 10,540 m |
| 200 | | center 3 digits | 176 = 11,760 m |



Upper-Level Station Model

Decameter = a metric unit of length equal to 10 meters.





Surface Station Model

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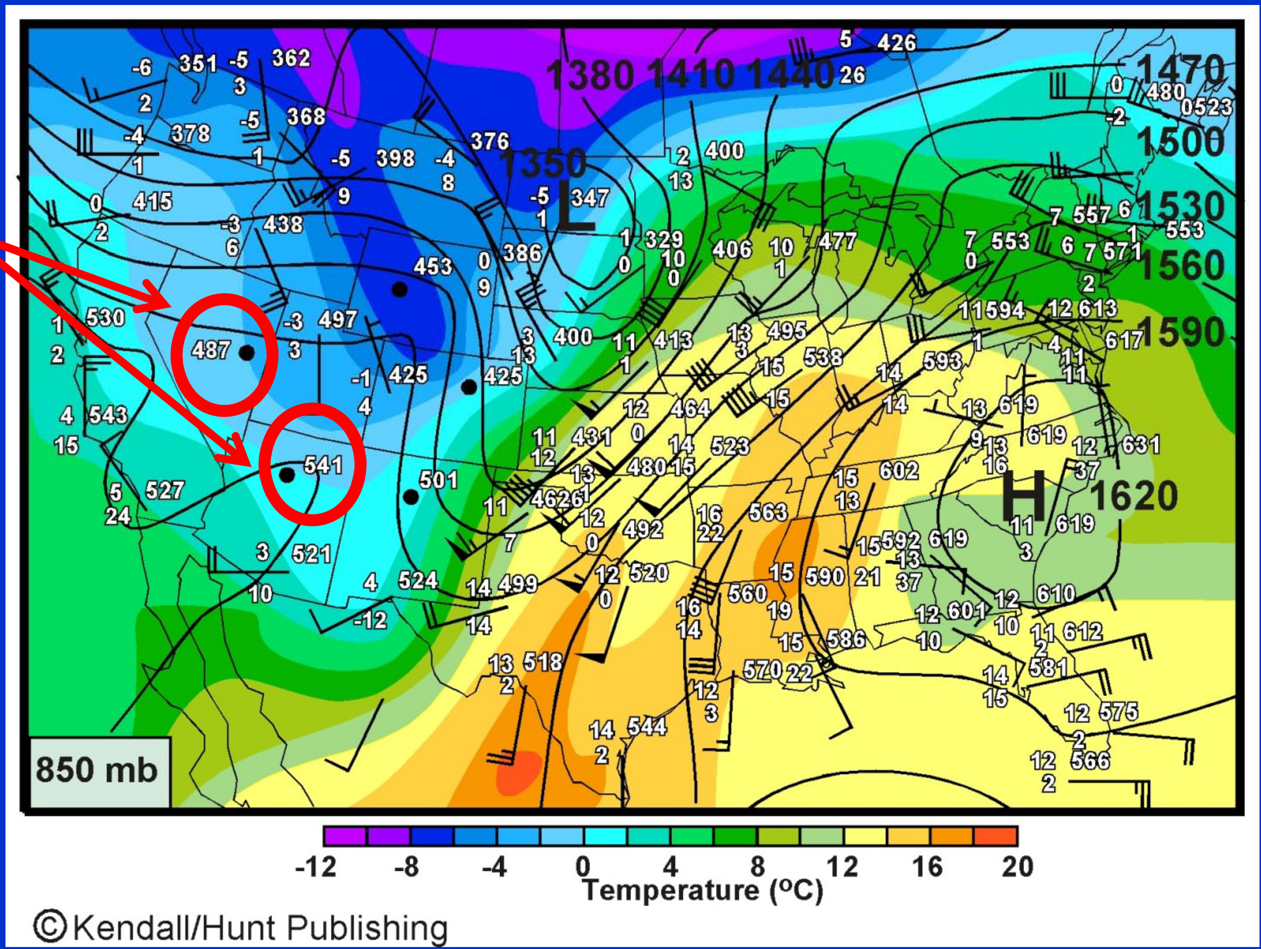
# Other Upper-Level Weather Maps

- **850mb**: to identify fronts
- **700mb**: intersects many clouds; moisture information is important
- **500mb**: used to determine the location of short waves and long waves associated with the ridges and troughs in the flow pattern. Meteorologists examine “vorticity” (i.e. rotation of air) on this pressure level.
- **300, 250, and 200mb**: near the top of the troposphere or the lower stratosphere; these maps are used to identify the location of jetsreams that steer the movements of mid-latitude storms.

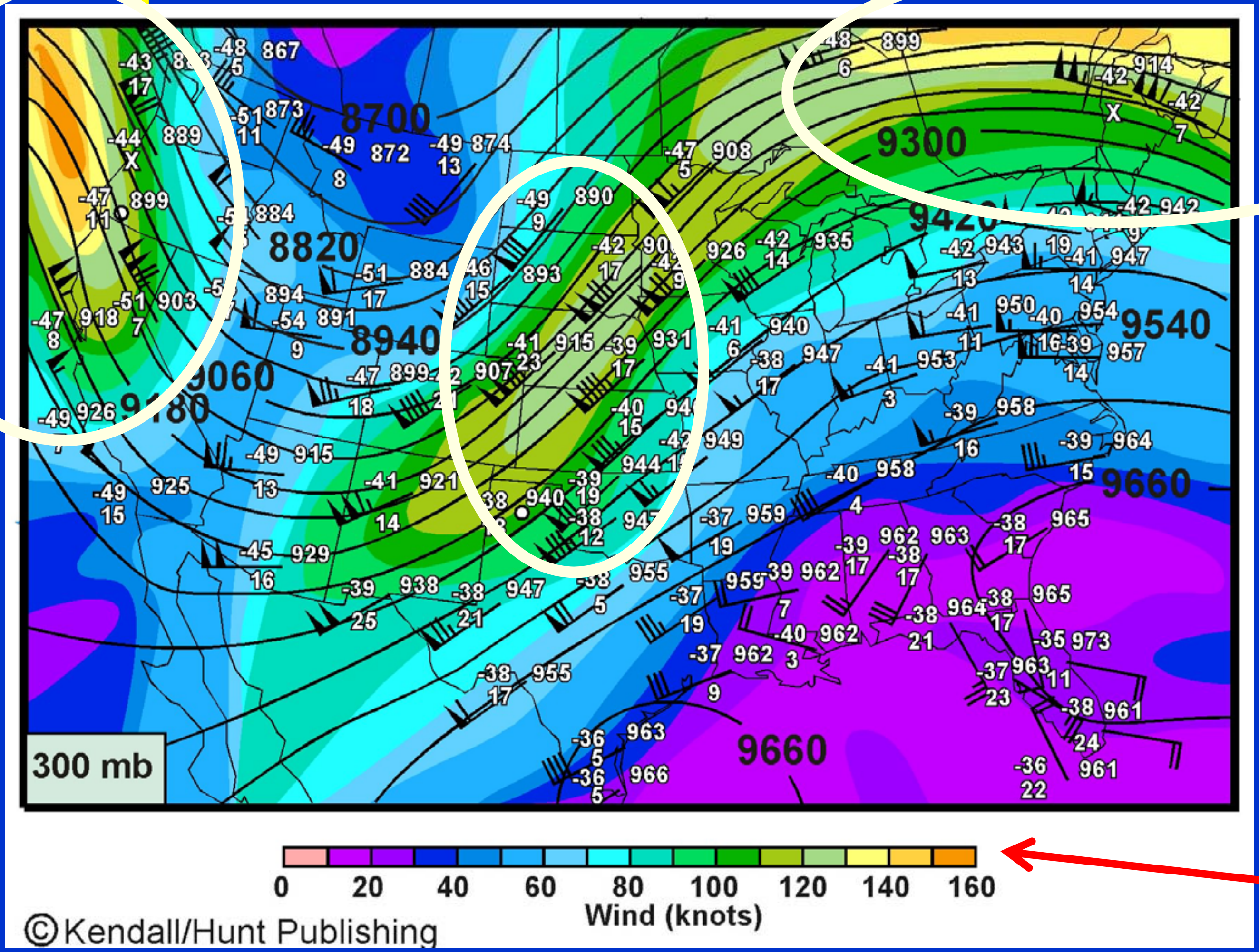
# Example: A 850mb Weather Map

Stations whose pressure are less than (i.e. above) 850mb




- The 850mb map is particularly useful to identify the location of fronts.
- In this example, a low-level jet is seen flowing parallel to the cold front extending from New Mexico to Wisconsin.

# Example: A 300mb Weather Map

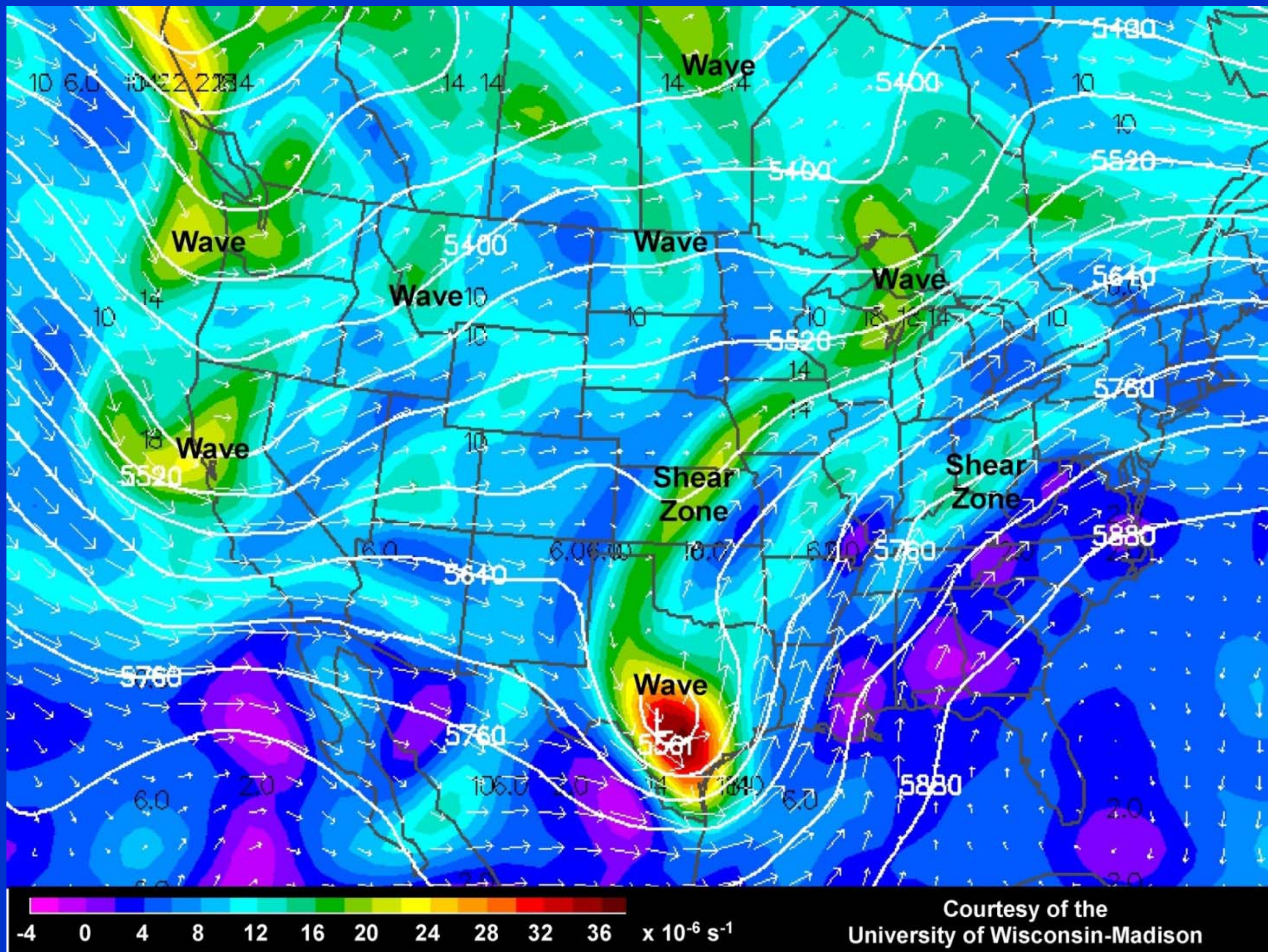



jetstreaks

isotachs

- The 850mb map is particularly useful to identify the location of jetsreams.
- In this example, a jetstream flows northeastward from the west cost of the US, into the Great Lakes, and to the Atlantic Coast of Canada.

# Example: 500mb Weather Map




- The 500mb surface, which is in the center of the troposphere, is typically the altitude meteorologists use to examine vorticity pattern.

# Vorticity

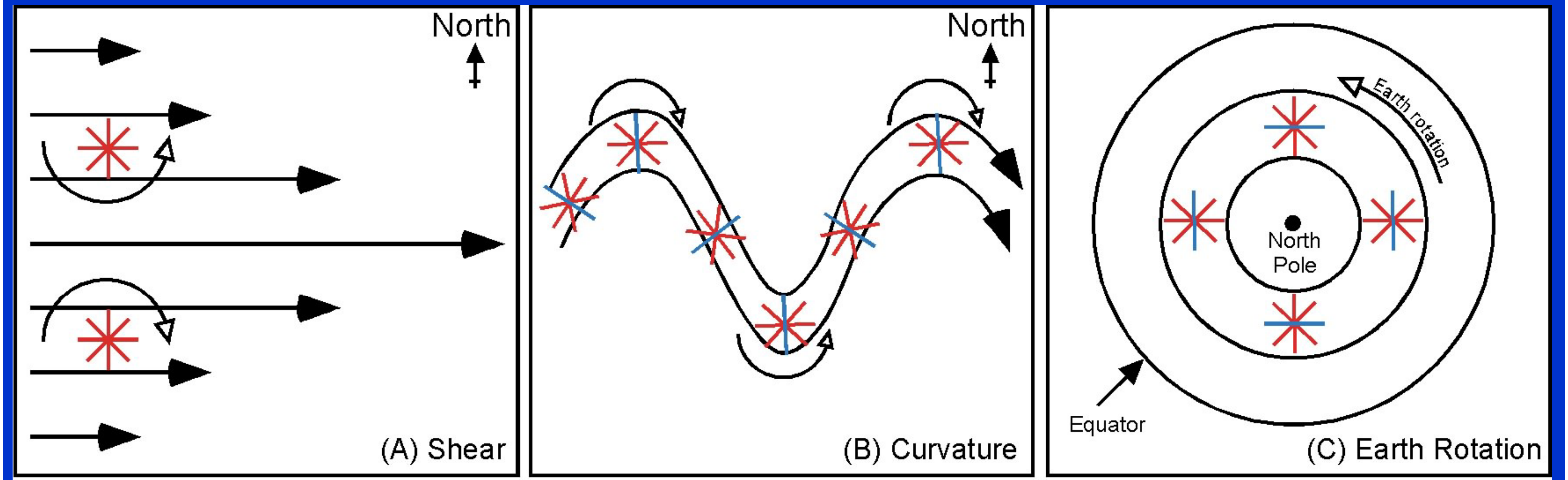
- Vorticity is the tendency for elements of the fluid to "spin.“.
- Vorticity can be related to the amount of “circulation” or "rotation" (or more strictly, the local angular rate of rotation) in a fluid.
- Definition:

Absolute Vorticity → $\boldsymbol{\omega}_a \equiv \boldsymbol{\nabla} \times \mathbf{U}_a$

Relative Vorticity → $\boldsymbol{\omega} \equiv \boldsymbol{\nabla} \times \mathbf{U}$

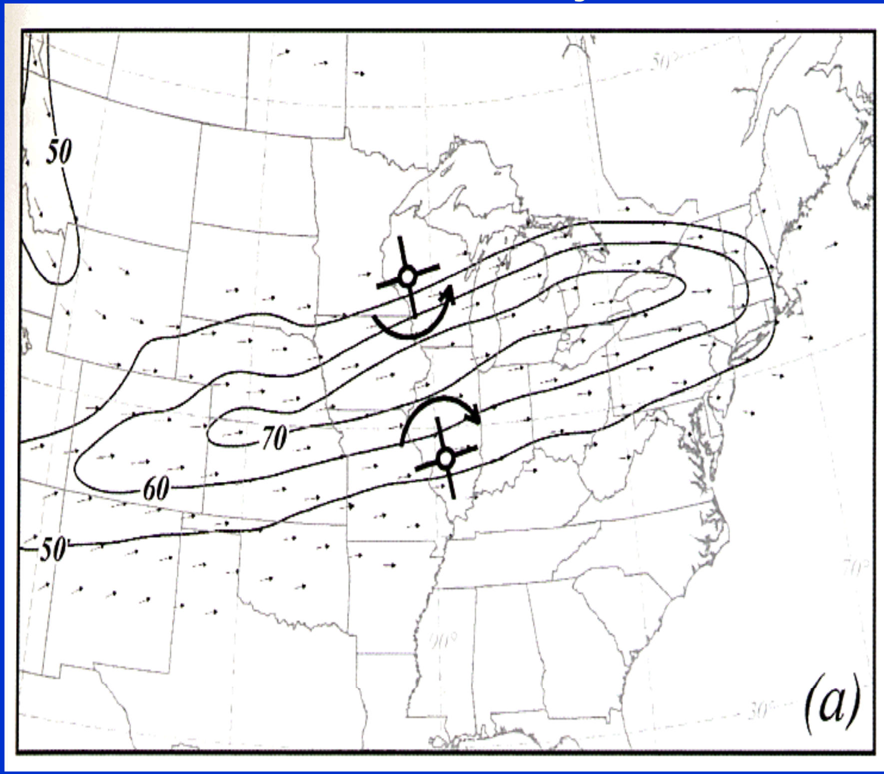
$$\omega = \left( \frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}, \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}, \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right)$$

# Three Sources of Vorticity



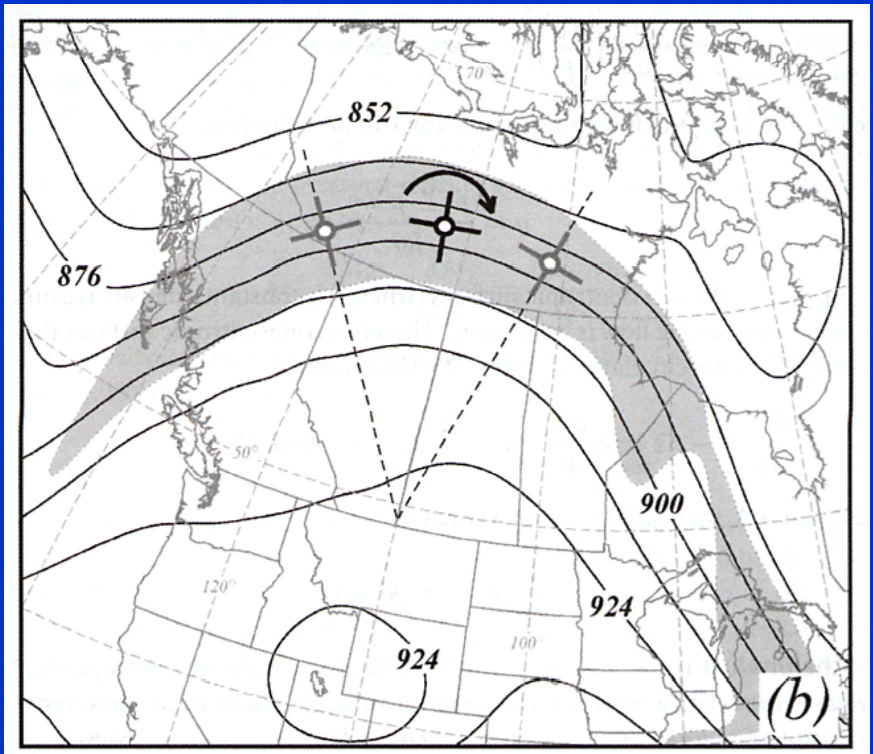
# Vorticity-Related Flow Patterns

Shear Vorticity




Even straight-line motion may have vorticity if the speed changes normal to the flow axis.

Curvature Vorticity




(a) 300mb isotachs; (b) 300mb geopotential hights

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