General Meteorology

Lecture 12

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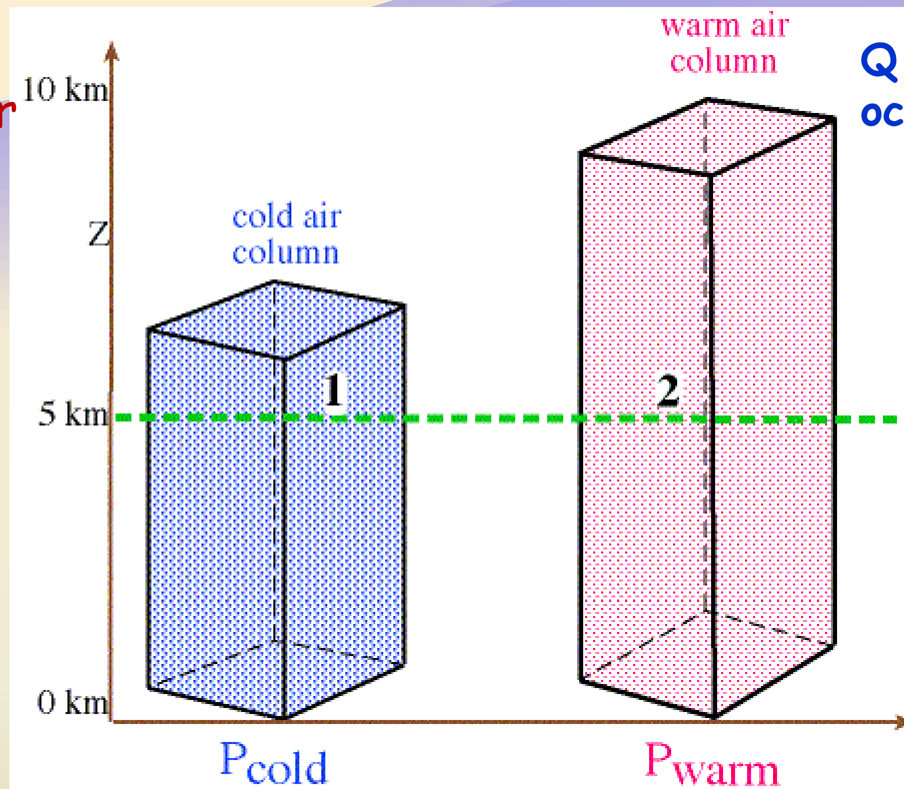
Q: which will be larger, the surface pressure for the cold air column or the surface pressure for the warm air column?

Q: which column of air has a larger density?

dP = g *p* Z

cold air, *p* increases, Z must decrease

warm air, *p* decreases, Z must increase



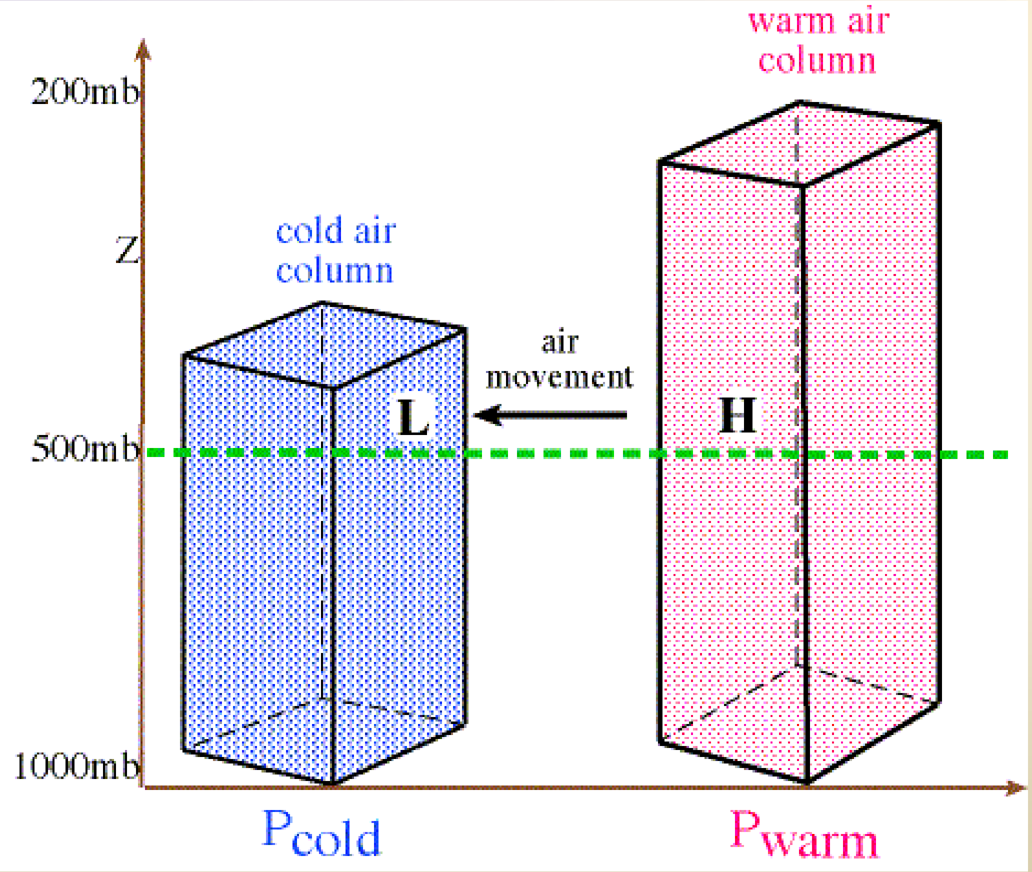
Q: which column of air occupies a larger volume?

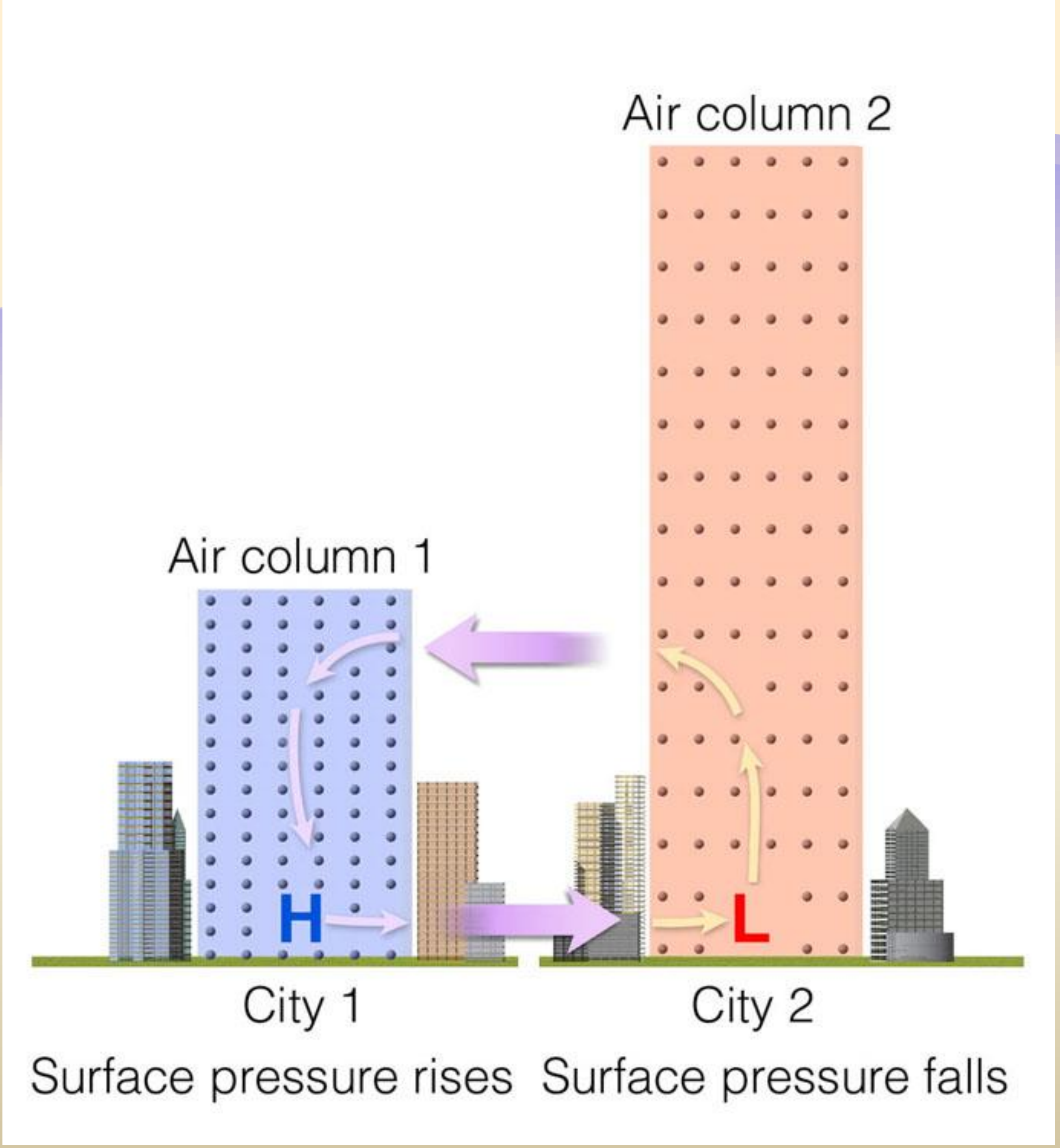
Q: At which location (1 or 2) will the pressure be higher?

A: At location 2, since there is more air molecule over location 2 than location 1.

Q: what will happen at 500 mb?

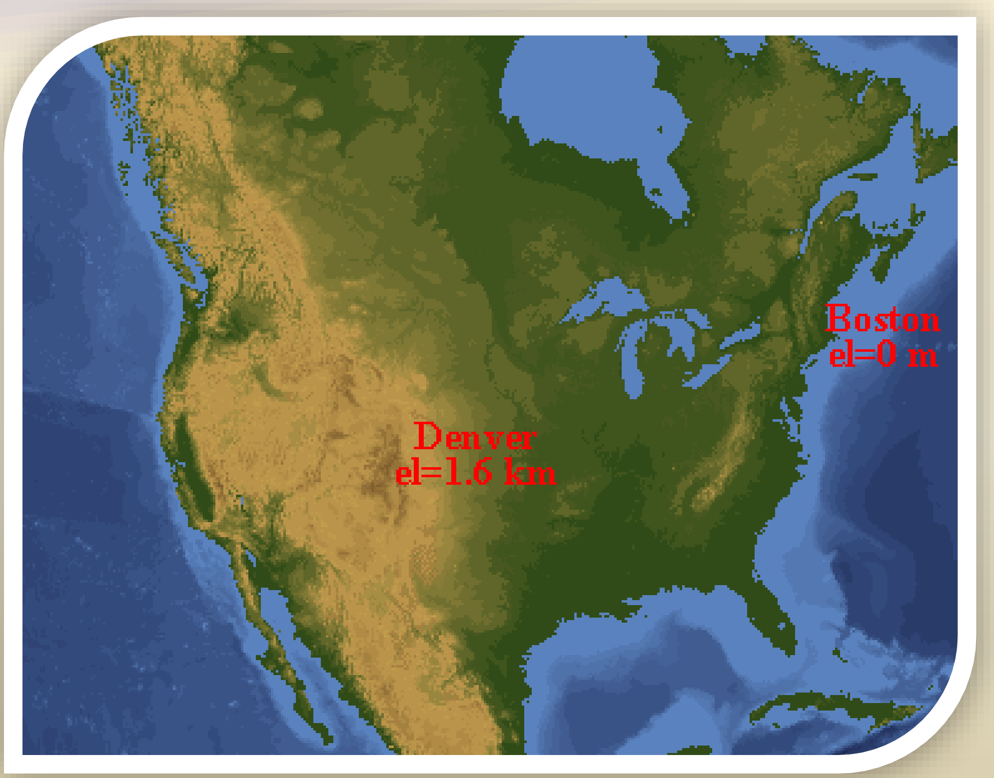
A: Air will move from the warm column to the colder column at 500 mb due to the *pressure gradient force*.




Air column 2
Air column 1
H
L
City 1
City 2
Surface pressure rises
Surface pressure falls

Measuring Pressure at the surface - elevation differences

One very important source of error when generating a surface pressure chart is that not all stations are at sea level....



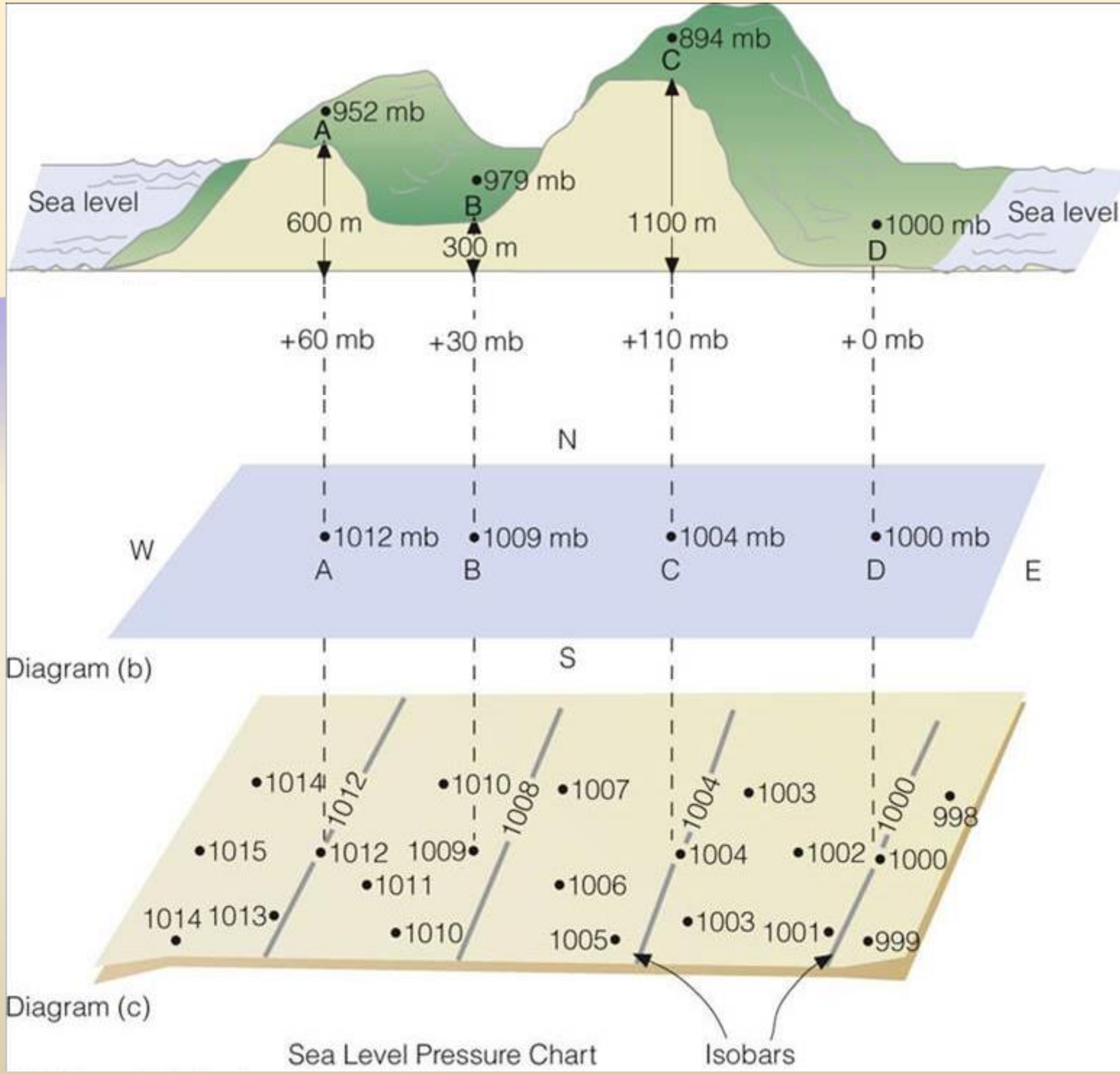
Measuring Pressure at the surface

reducing pressure to sea level

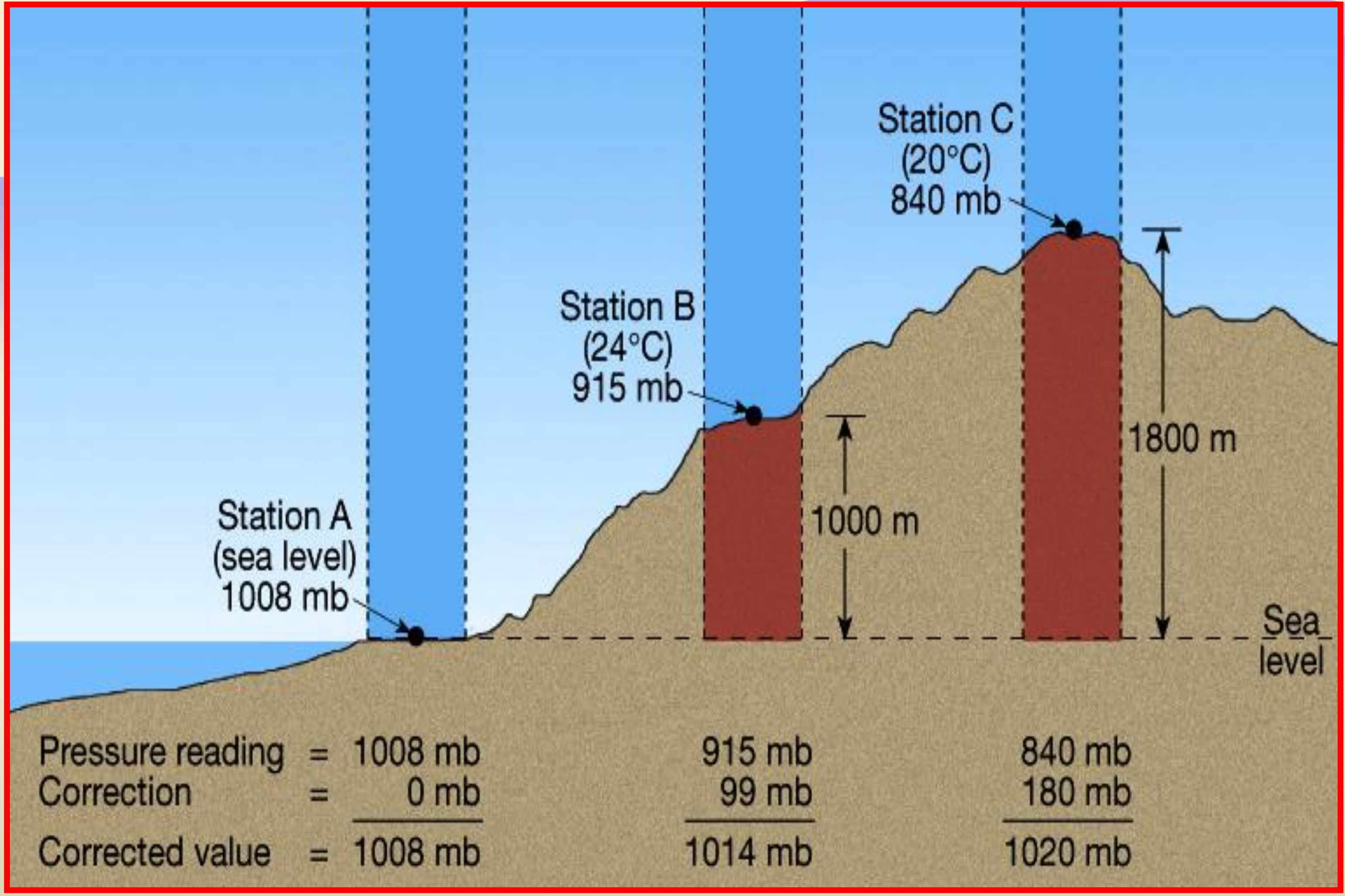
We can reduce the pressure measurements to sea level using the following rule:

in the lower part of the atmosphere, pressure changes by about 10 mb for every 100 meters of elevation change....

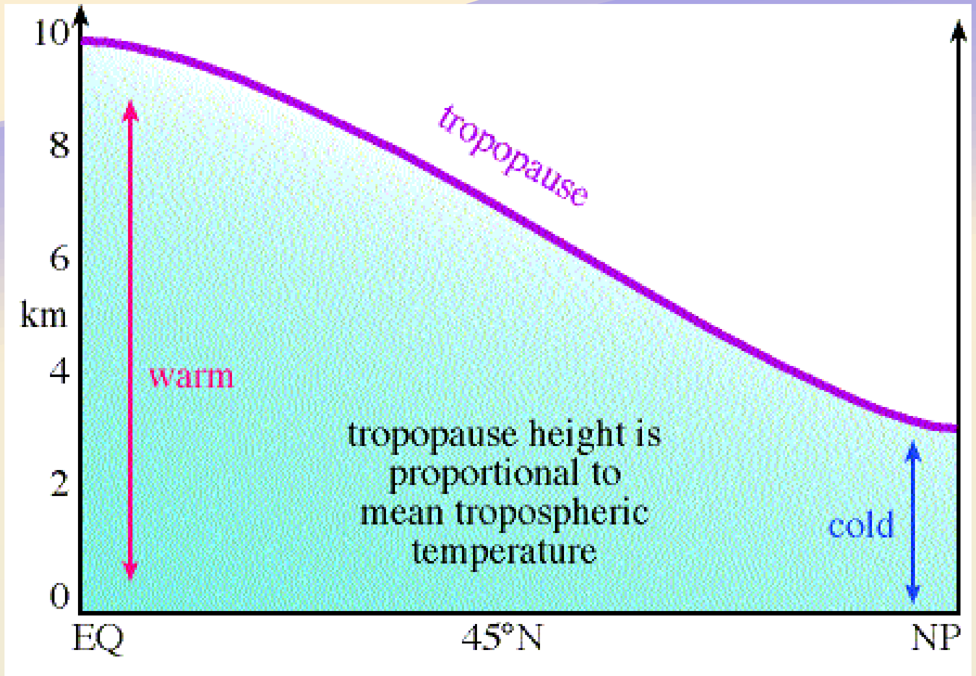
Using this rule, we reduce all pressure measurements to sea level, producing a *constant elevation* sea level pressure (SLP) chart ..., commonly referred to as a surface weather map.



952 mb
A
979 mb
B
894 mb
C
Sea level
600 m
300 m
1100 m
1000 mb
D
Sea level
+60 mb
+30 mb
+110 mb
+0 mb
N
W
1012 mb
1009 mb
1004 mb
1000 mb
A
B
C
D
E
S
Diagram (b)
1014
1012
1010
1008
1007
1004
1003
1000
998
1015
1012
1009
1004
1002
1000
1011
1006
1014
1013
1010
1005
1003
1001
999
Diagram (c)
Sea Level Pressure Chart
Isobars


Station A
(sea level)
1008 mb
Station B
(24°C)
915 mb
Station C
(20°C)
840 mb
1000 m
1800 m
Sea
level
Pressure reading = 1008 mb
Correction = 0 mb
Corrected value = 1008 mb
915 mb
99 mb
1014 mb
840 mb
180 mb
1020 mb

Representing pressure above the surface

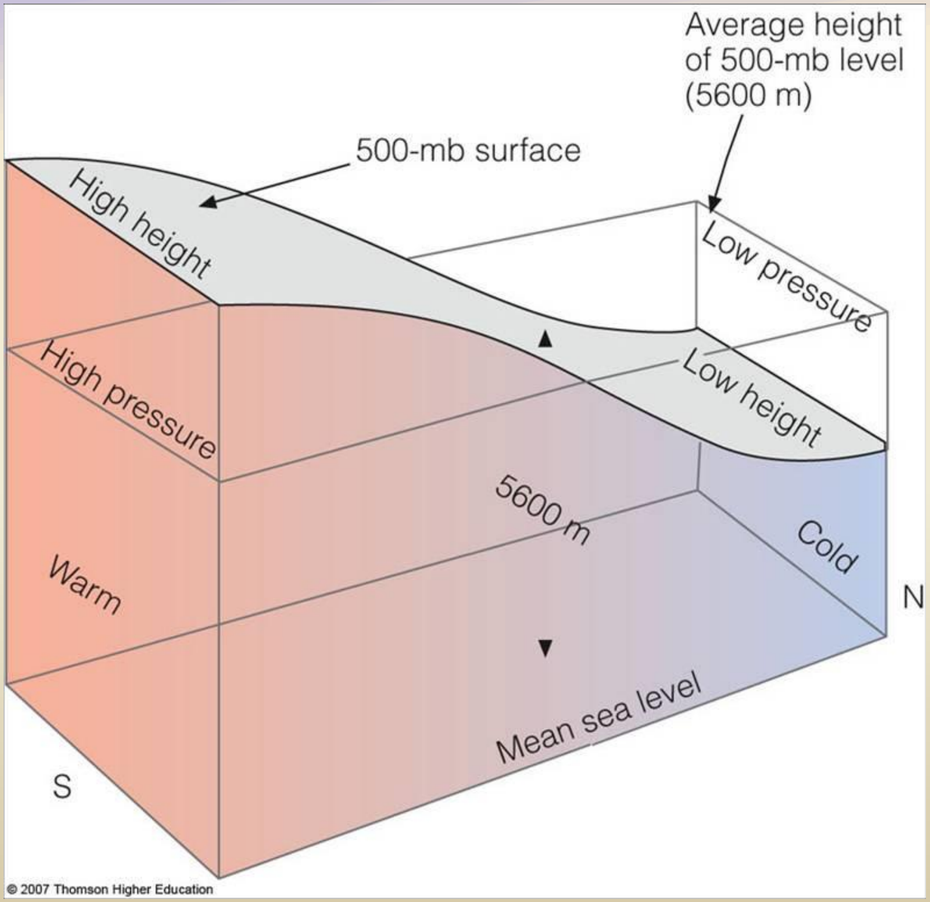


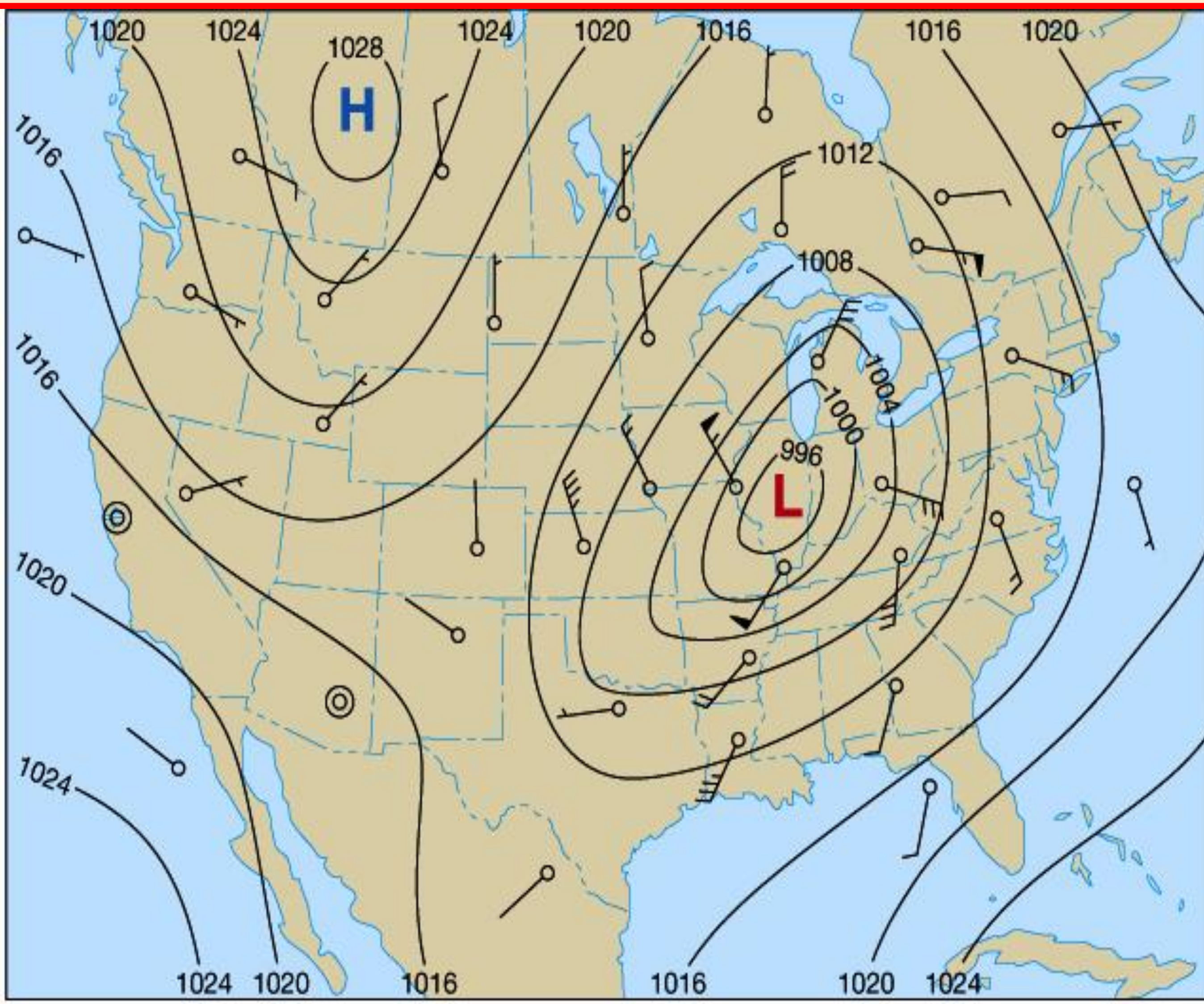
tropopause height is proportional to the mean tropospheric temperature.

higher near the equator - warm troposphere
lower at the poles - cold troposphere

Isobaric Charts

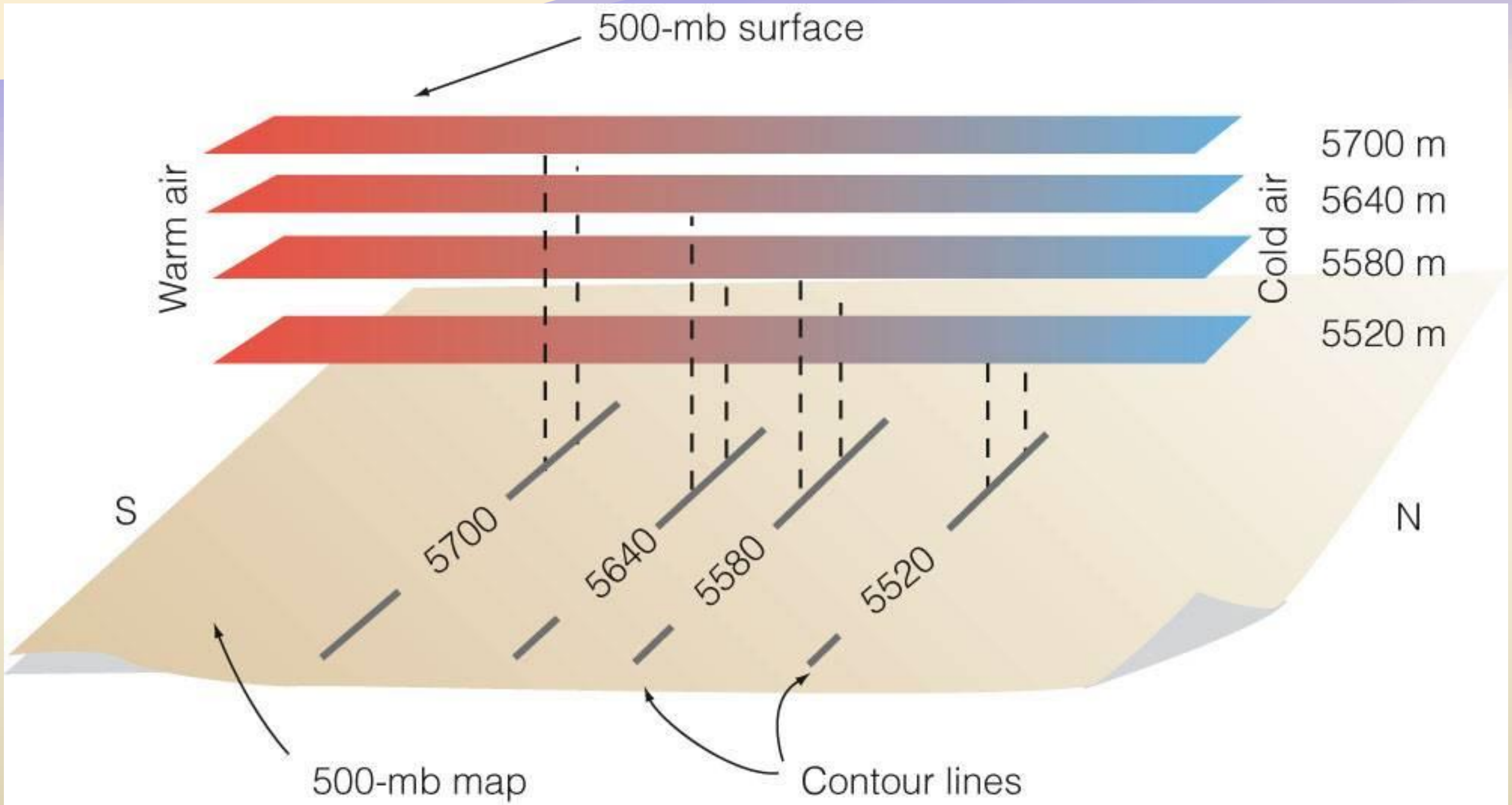
the tropospheric depth is proportional to the mean tropospheric temperature





ff	Miles per hour
	Calm
	1–2
	3–8
	9–14
	15–20
	21–25
	26–31
	32–37
	38–43
	44–49
	50–54
	55–60
	61–66
	67–71
	72–77
	78–83
	84–89
	119–123

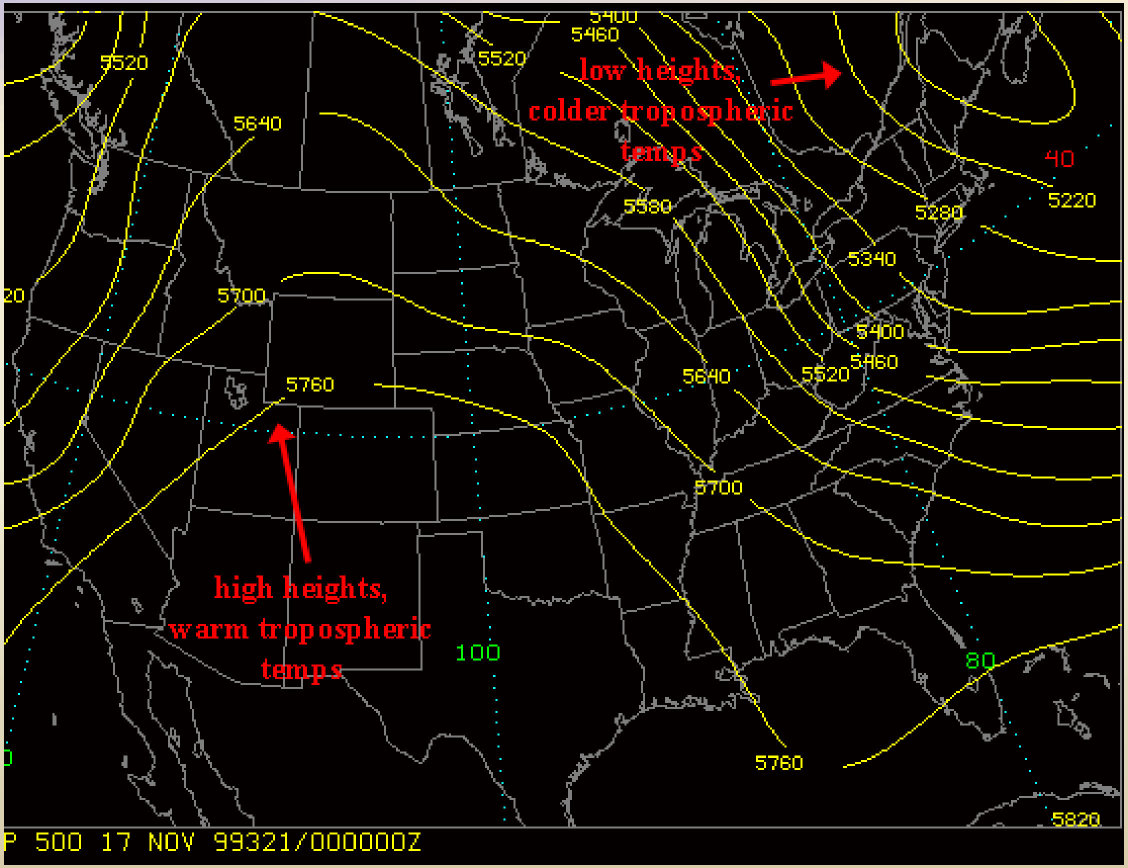
Hence, on an isobaric chart (e.g., 500 mb) we plot isopleths of the height of the surface.



Isobaric Charts - example of 500 mb chart

Notice that the higher heights are towards the south where it is warmer

lower heights are found further north where it is colder.....



Isobaric Charts

Isobaric Charts - heights of the commonly used surfaces

The table to the left gives "approximate" altitudes of the common isobaric charts used in meteorology.

Isobaric Charts

Isobaric Surface (mb) Charts	Approximate Elevation (m)	Approximate Elevation (ft)
1000	120	400
850	1,460	4,800
700	3,000	9,800
500	5,600	18,400
300	9,180	30,100
200	11,800	38,700
100	16,200	53,200

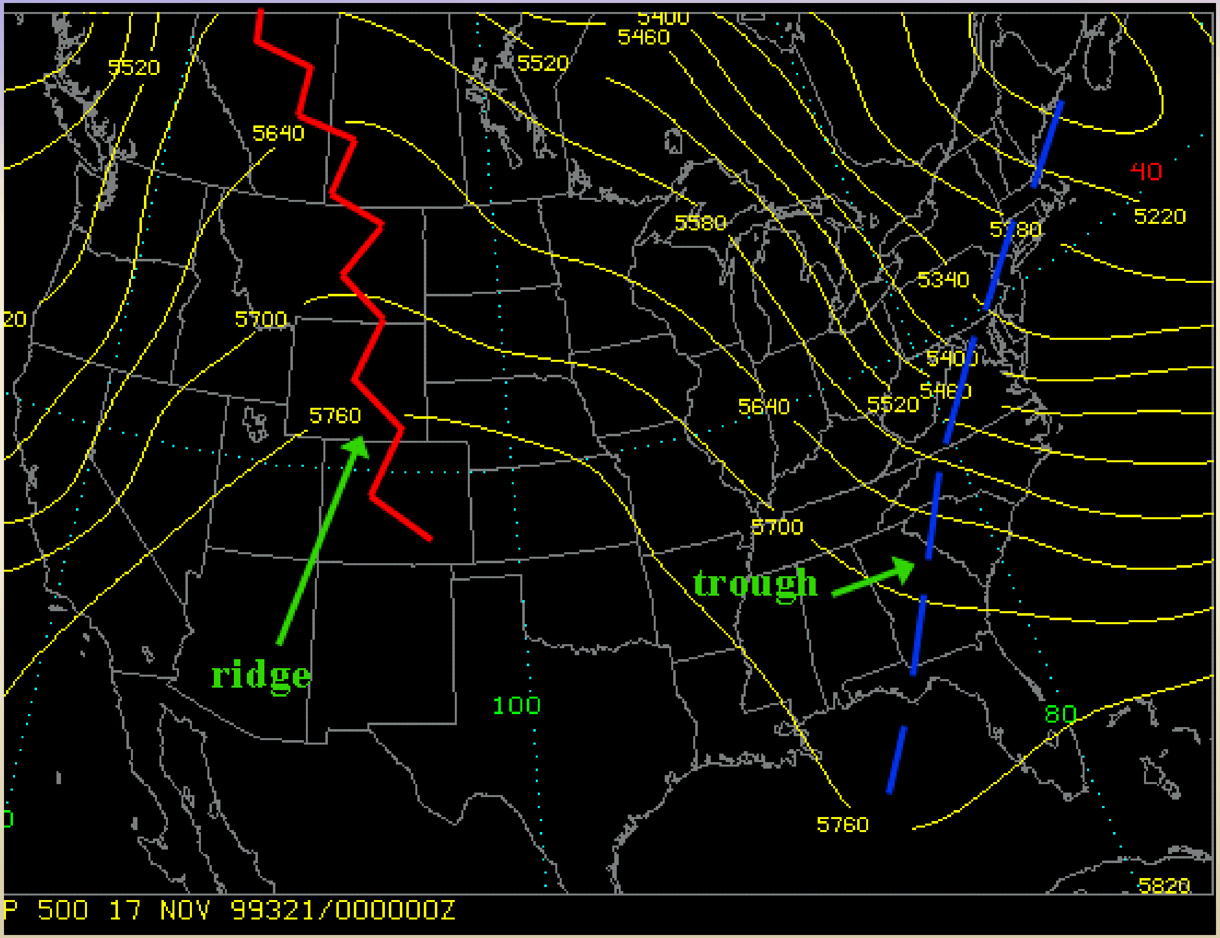
Isobaric Charts - Ridges and Troughs

Notice that the height lines are NOT oriented E-W

In fact, one can see a wave-type pattern in the height lines with:

Is there warm or cold air aloft associated with a ridge?

warm air

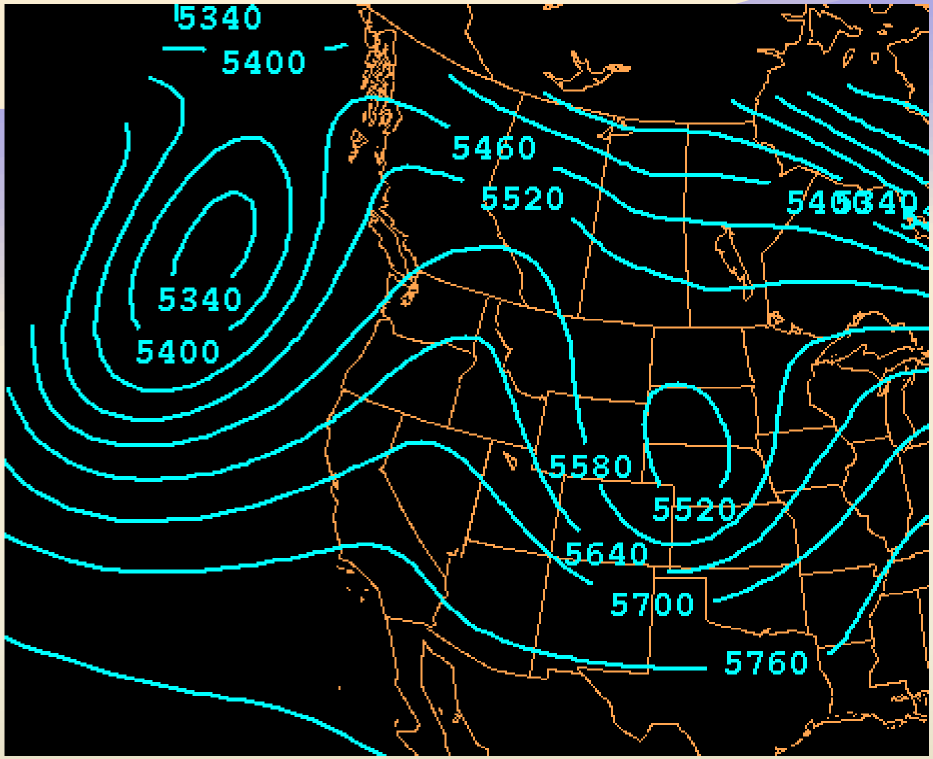


Is there warm or cold air aloft associated with a trough?

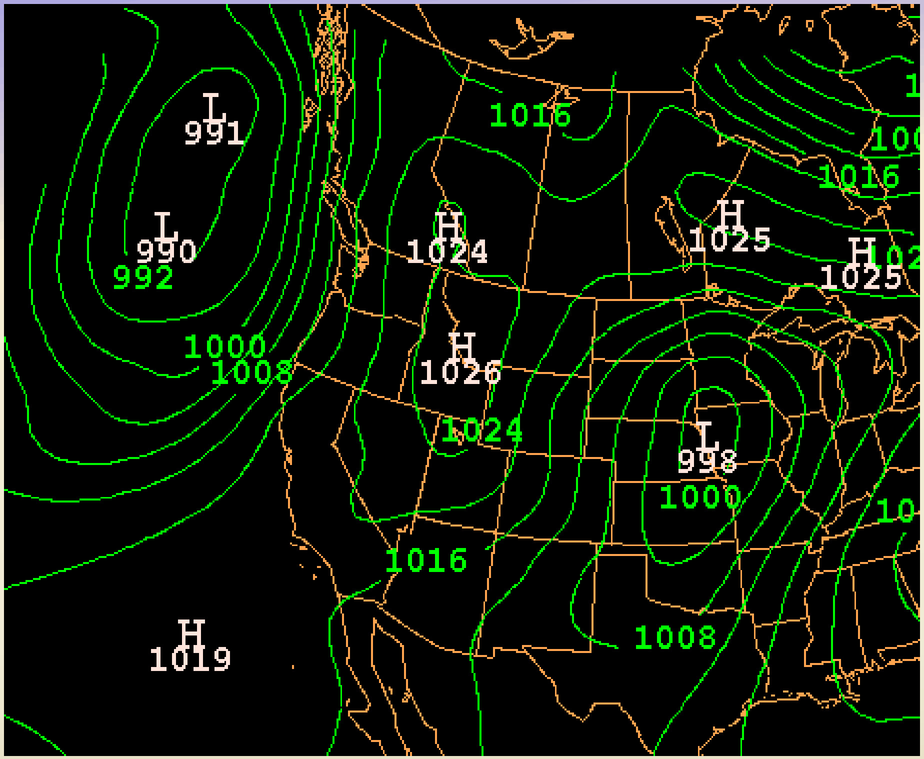
cold air

Ridges and Trough aloft - Highs and Lows at the Surface

500 mb Chart



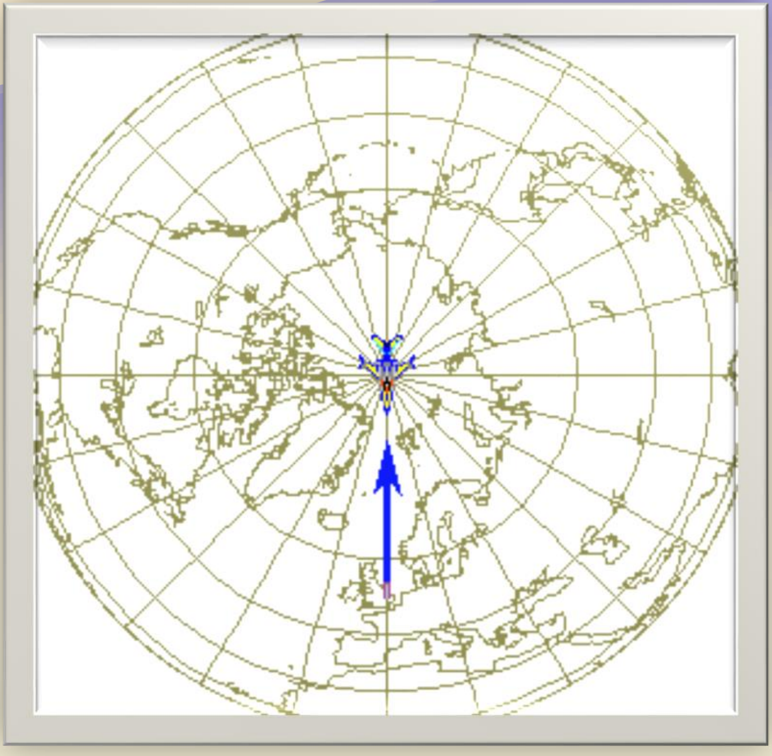
Surface Pressure



Notice that ridges aloft are associated with Highs at the surface *(anticyclon)*
Troughs aloft are associated with Lows at the surface *(cyclones)*.

This association of ridges/troughs with Highs/Lows occurs most of the time, BUT NOT ALWAYS

The Coriolis Force



Apparent Coriolis Force

The *coriolis force* arises due to the fact that the earth is rotating

Properties of the coriolis force:

acts on objects not rigidly attached to the earth

always acts to deflect an object to the right (left) of its direction of motion in the northern (southern) hemisphere

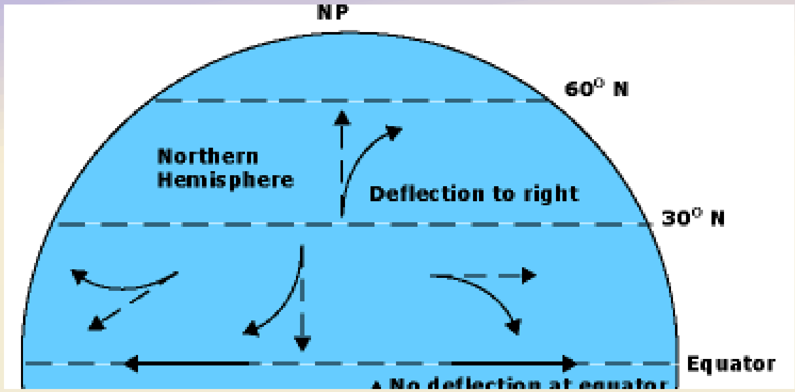
magnitude is zero at the equator, maximum at the poles

magnitude depends on the rotation rate of the earth - the magnitude would increase if the earths rotation rate increased

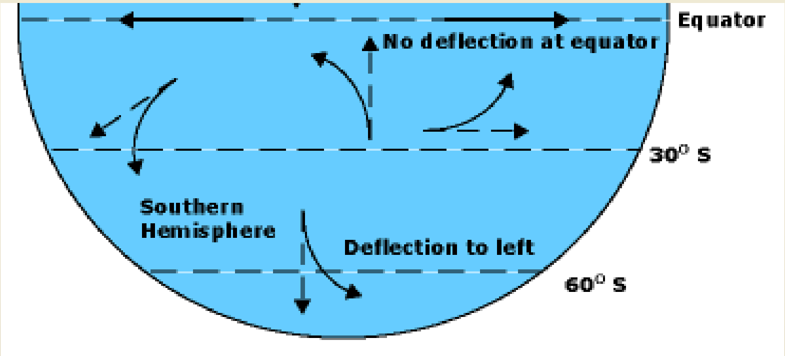
if the earth were not rotating, the coriolis force would be zero

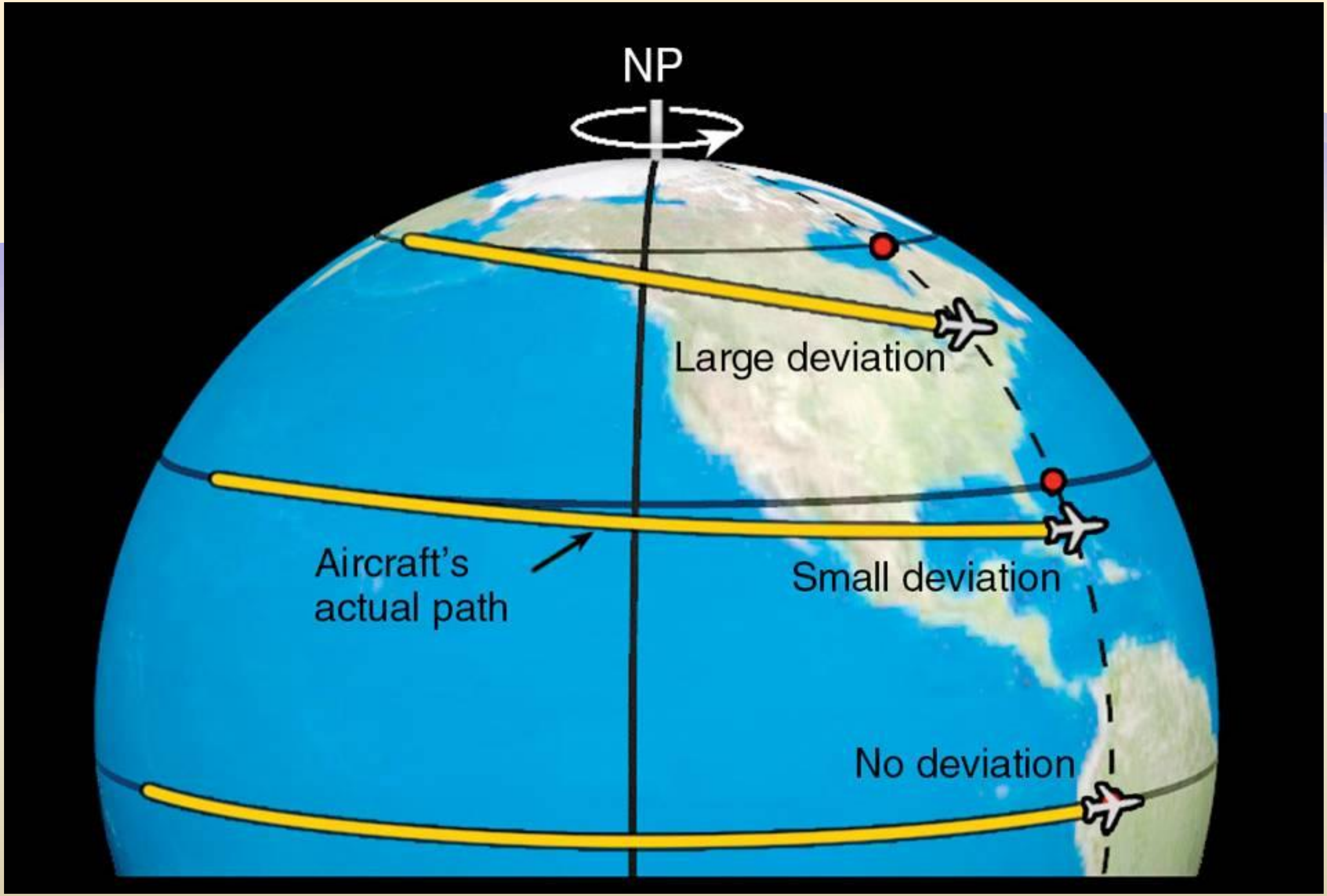
So the coriolis effect causes wind flowing from high pressure to low pressure to curve as the wind moves

In the Northern Hemisphere, the coriolis effect causes things to curve to the Right



In the Southern Hemisphere, the coriolis effect causes things to curve to the Left

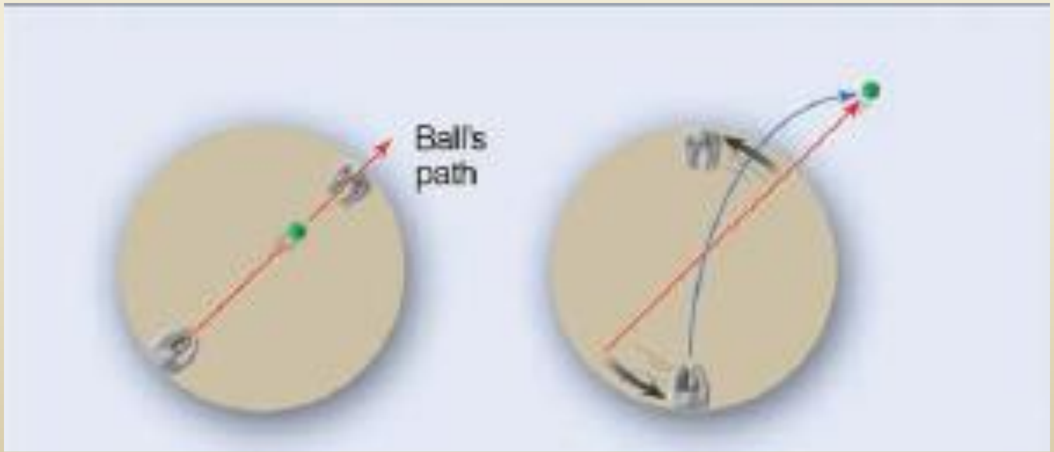



NP
Large deviation
Aircraft's
actual path
Small deviation
No deviation

$$\omega = \frac{2\pi}{1day} = \frac{2\pi}{86400s} = 7.292\times10^{-5} rad / s$$

$$\vec{F}_{co} = -2(\vec{\omega} \times \vec{V})$$

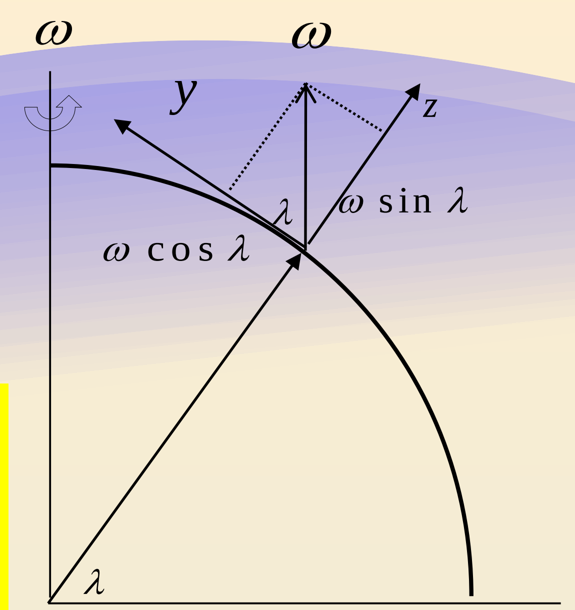
$$\vec{V} = u\hat{i} + v\hat{j} + w\hat{k}$$



$$\omega_x = 0$$

$$\omega_y = \omega \cos\lambda$$

$$\omega_z = \omega \sin\lambda$$



$$\vec{F}_{co} = -2\vec{\omega} \times \vec{V} = -2\omega \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & \cos\lambda & \sin\lambda \\ u & v & w \end{vmatrix}$$

$$F_{co\,x} = -2\omega\,(w\cos\lambda - v\sin\lambda)$$

$$F_{co\,y} = -2\omega\,u\sin\lambda$$

$$F_{co\,z} = 2\omega\,u\cos\lambda$$

The amount of deflection depends upon:

1. **the rotation of the earth**

2. **the latitude**

3. **the object's speed***

In addition, the *Coriolis force acts at right angles to the wind, only influencing wind direction and never wind speed*