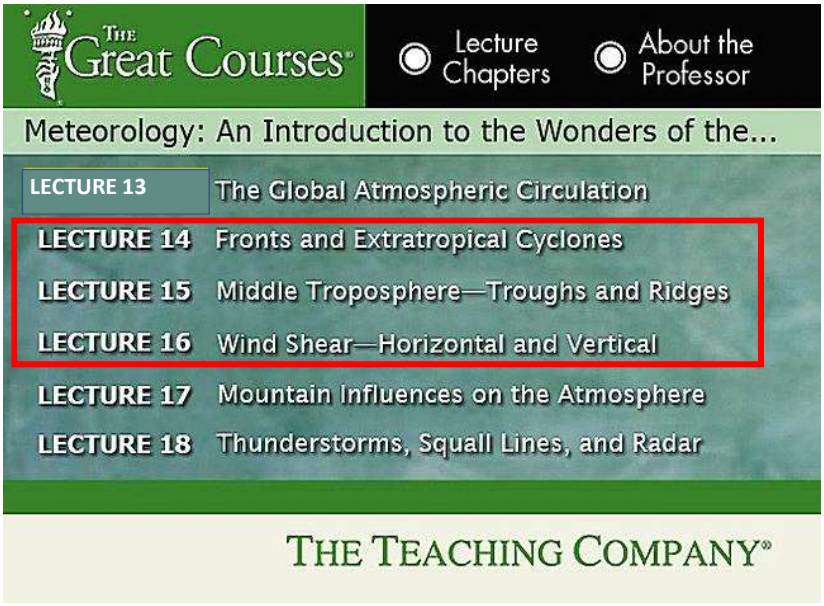
Week 5 – Lectures 14, 15, 16



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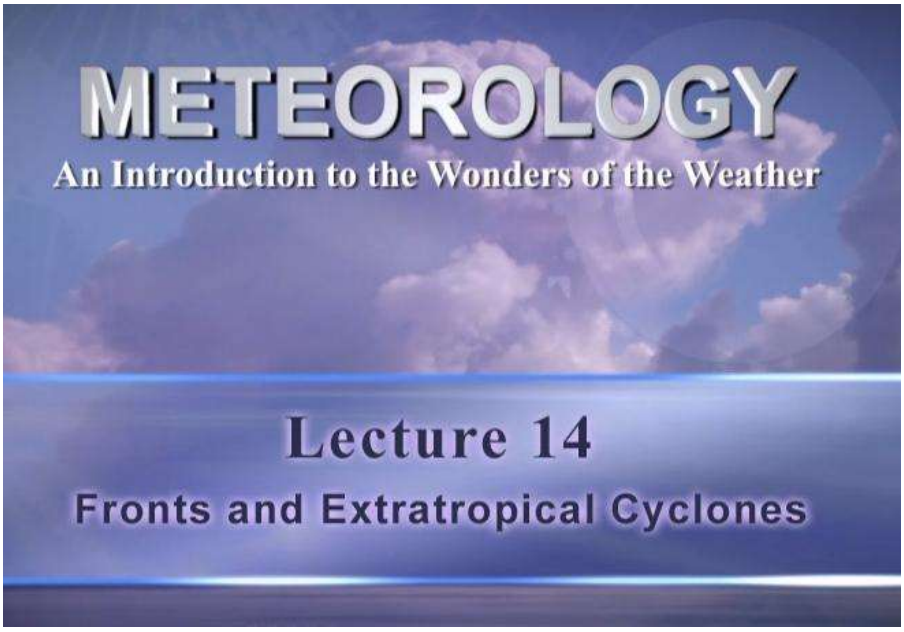


2

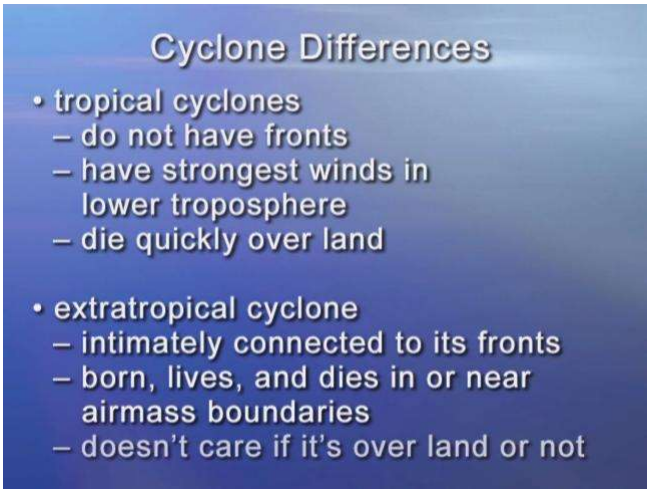
Review

- Hemispheric circulation with a complex 3 cells system:
  - ascent at 60 degrees and at the equator,
  - descent 30 degrees latitude and the poles;
  - Hadley, Ferrel and polar
- Prevailing Winds
  - Westerlies mid-latitudes
  - Easterlies at the poles
  - And NE or SE at the equator/tropics
- Air Masses
  - Maritime/Oceanic or continental in type
  - Polar or tropical in Origin
  - 4 Air Mass types:
    - cP = continental Polar
    - cT = continental Tropical
    - mP = maritime Polar
    - mT = maritime Tropical
- Fronts – where air masses of different densities meet

3

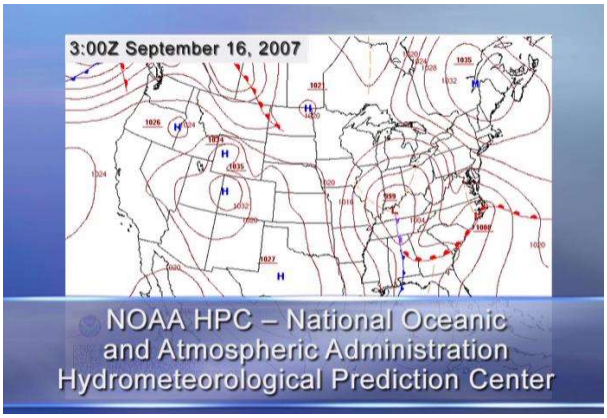
This lecture – Surface Weather maps & Extratropical Cyclone

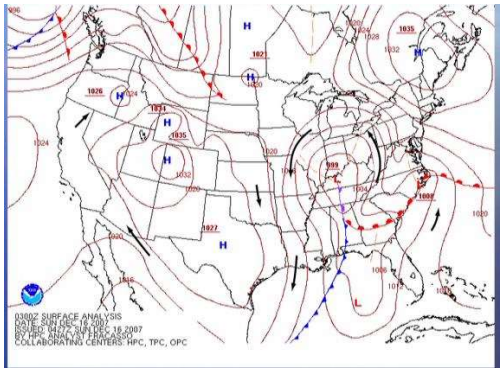
- 2 types of cyclones - sources
  - Tropical – strong ones = hurricanes with counter-clockwise flow (later)
  - Extratropical – we'll use surface wx maps



4

- Length implies wind speed
- Isobars that are closer mean stronger winds (mostly around lows)
- Clockwise flow (generally faster) than counterclockwise (i.e. high pressure – let's listen and see if I got it correctly (saying right would be a pun





5

Influences on Winds & Weather

NOAA HPC – National Oceanic
and Atmospheric Administration
Hydrometeorological Prediction Center

- Lakes, hills, mountains, valleys, cities, forests, passes etc.

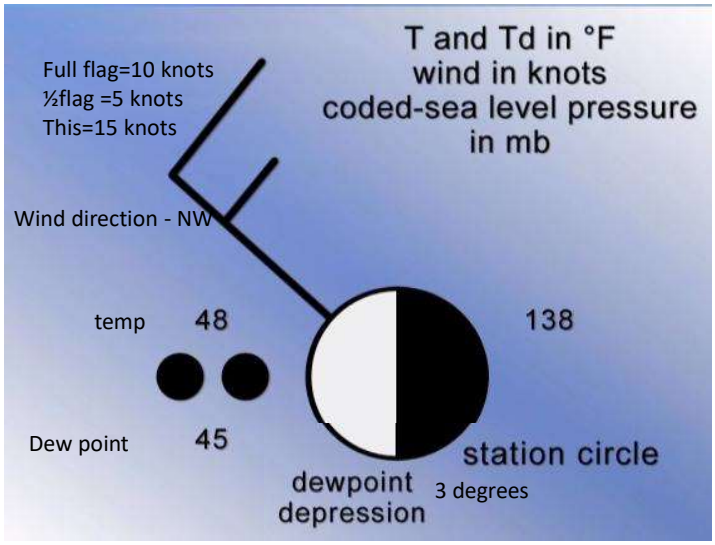
6

Flags and pennants

What the symbols mean:

T = temperature

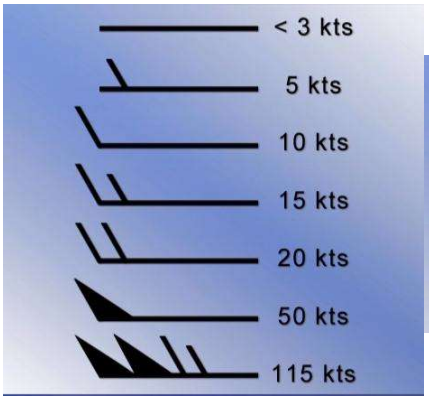
Td = dew point temperature

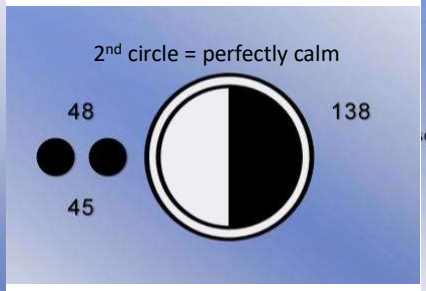


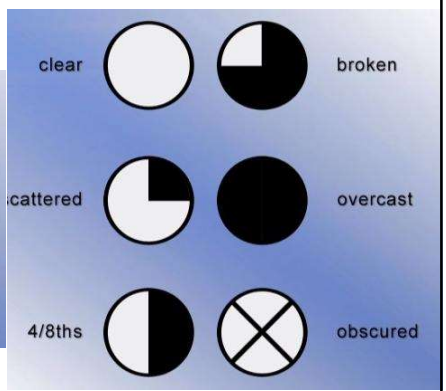
7

Knots

- 1 knot = nautical mph; knot = 1.15 statute miles or 1.15 mph (aka m/hr) and ~ 2 km/hr (aka kmph)
- 60 knots = 1 degree latitude



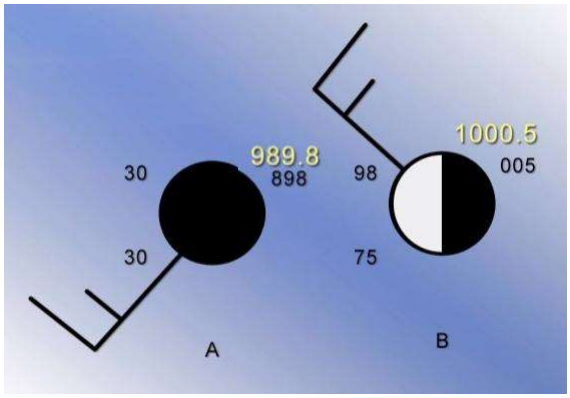




8

- If 1st digit a 0, 1, or 2 add 10 in front and move decimal to left by 1 space

Coded pressure in mb



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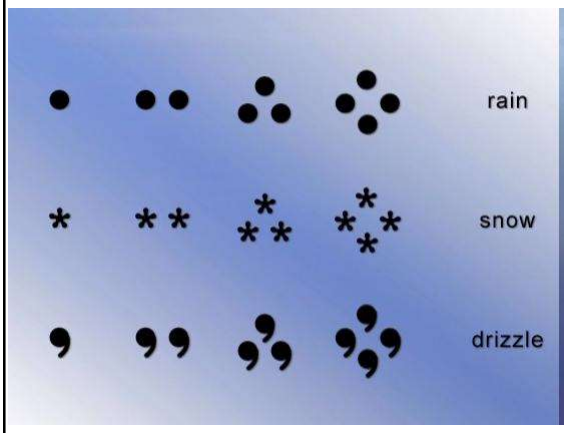
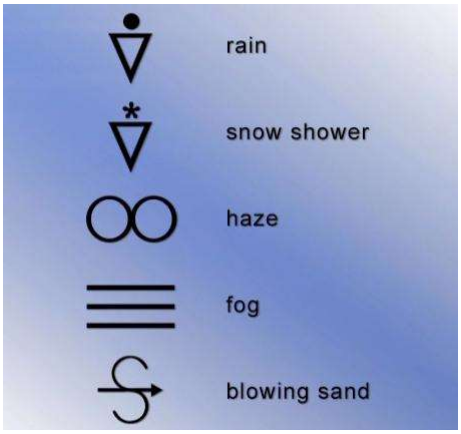
Precipitation





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Thunderstorm legend

11

At s.l. 1013 mb

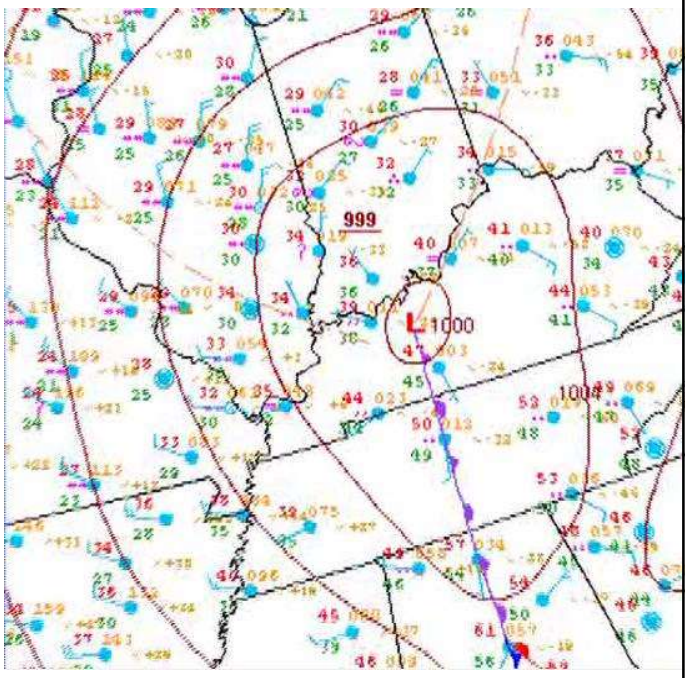
- Nominal sea level barometer – 1013 mb

Barometric pressures @ other elevations "corrected" to sea level barometer:

http://www.csgnetwork.com/barcorrecthcalc.html

https://airdensityonline.com/2016/11/corrected-and-uncorrected-barometer/

https://en.wikipedia.org/wiki/Barometer#Mercury_barometers

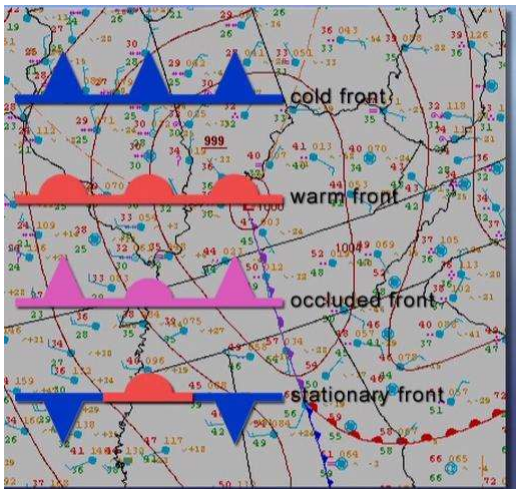


12

Fronts – represent density differences = difference discontinuities

FRONTS:

- COLD
- WARM
- OCCLUDED
- STATIONARY



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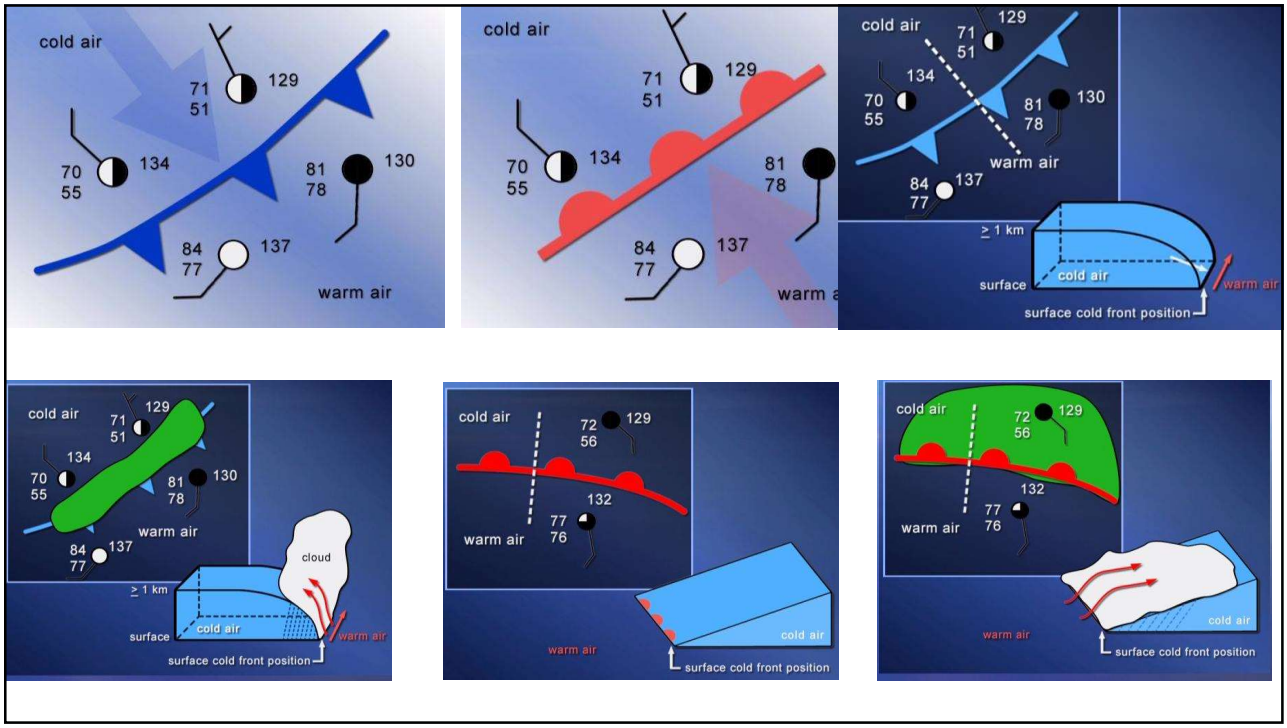

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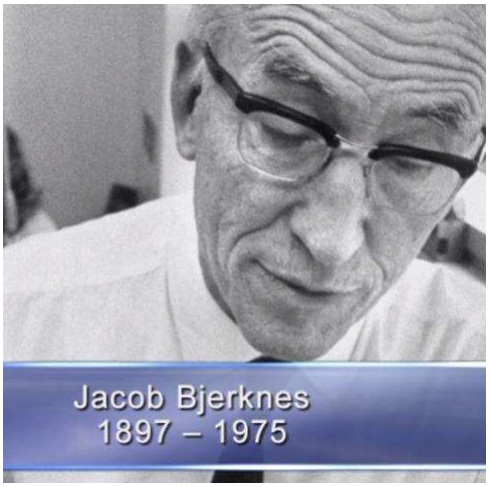
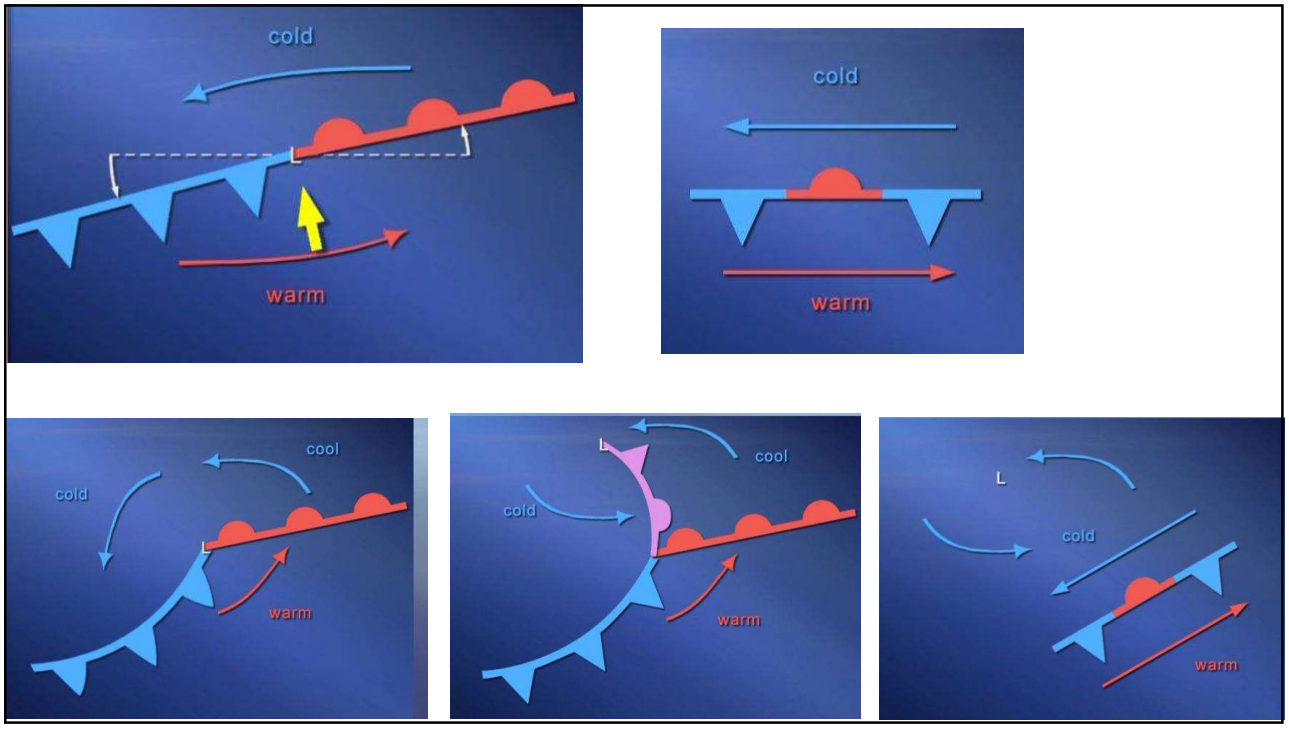
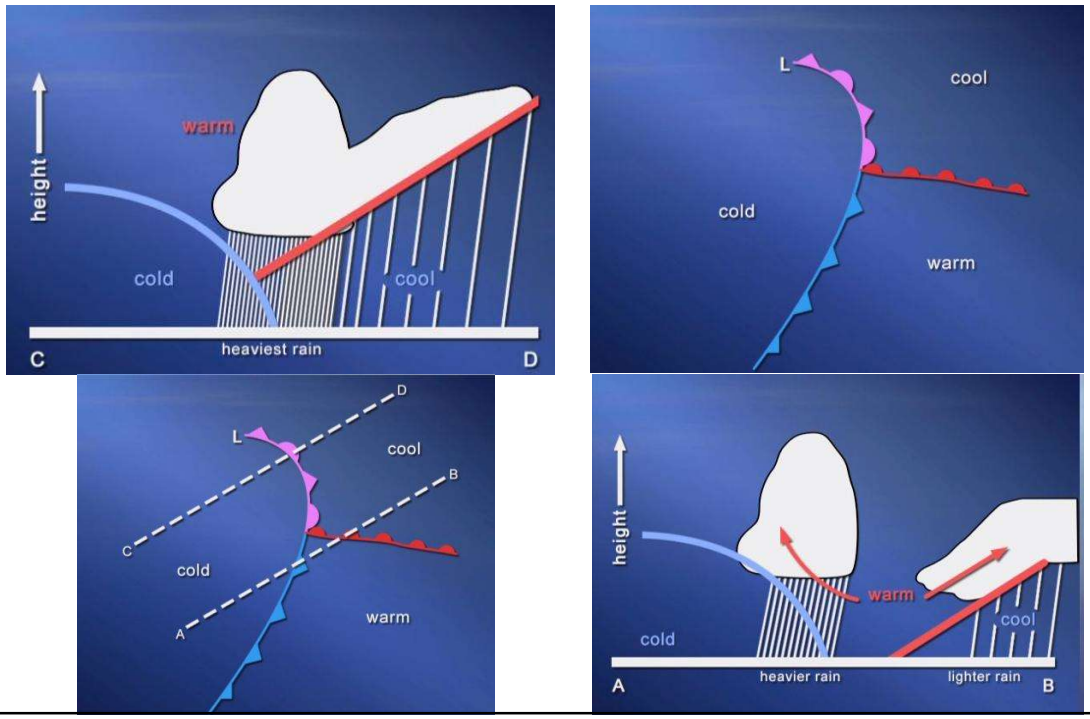
Norwegian cyclone model



15

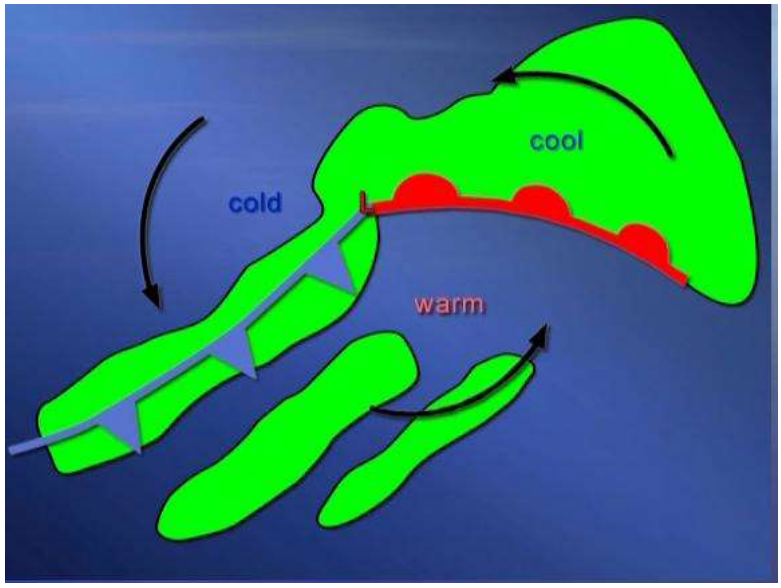


16


warm
height
cold
cool
heaviest rain
C
D
L
cool
cold
warm
D
L
cool
B
C
cold
A
warm
height
warm
cool
cold
A
heavier rain
lighter rain
B

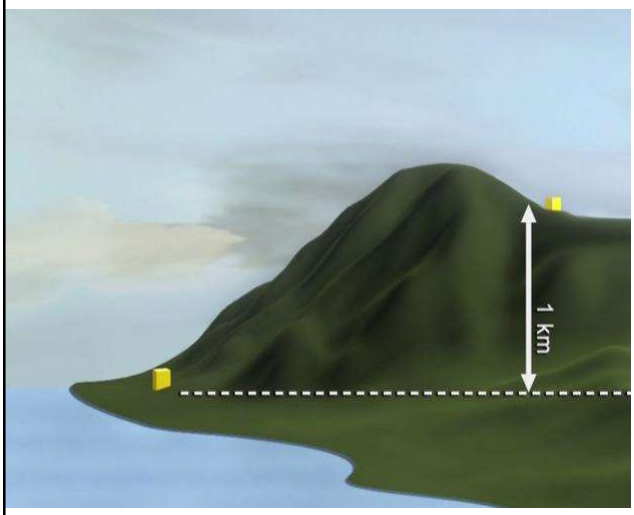
17

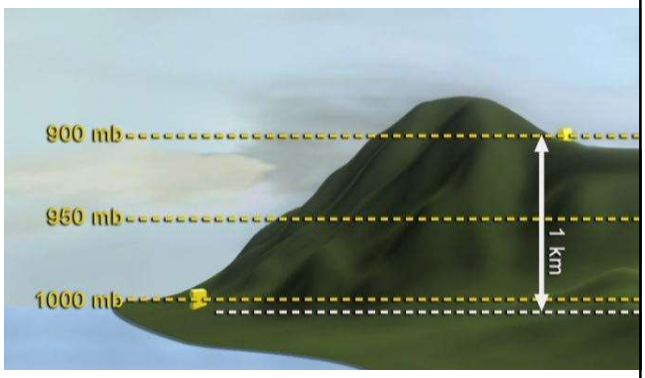
FRONTS


cool
cold
warm

18

Need to adjust pressures due to elevation





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How's that adjustment made

- As if each station were at sea level – add altitude correction from lookup table

http://www.csgnetwork.com/barcorrecthcalc.html

https://airdensityonline.com/2016/11/corrected-and-uncorrected-barometer/

https://en.wikipedia.org/wiki/Barometer#Mercury_barometers

20

Pa = 0.03937 In Hg

Next looking up above (middle Troposphere)

P_{atm}	Altitude	millibars	P_{atm}	Altitude
101.325 kPa	Sea Level (0m)	1013	29.92 In Hg	Sea Level (0 ft)
97.71 kPa	305 m	977	28.86 In Hg	**1,000 ft**
94.21 kPa	610 m	942	27.82 In Hg	**2,000 ft**
89.88 kPa	**1,000 m**	899	26.55 In Hg	3,281 ft
84.31 kPa	1,524 m	843	24.90 In Hg	**5,000 ft**
79.50 kPa	**2,000 m**	795	23.48 In Hg	6,562 ft
69.68 kPa	3,048 m	697	20.58 In Hg	**10,000 ft**
54.05 kPa	**5,000 m**	540	15.96 In Hg	16,404 ft
46.56 kPa	6,096 m	466	13.75 In Hg	**20,000 ft**
37.65 kPa	7,620 m	376	11.12 In Hg	**25,000 ft**
32.77 kPa	8,848 m*	328	9.68 In Hg	29,029 ft*
26.44 kPa	**10,000 m**	264	7.81 In Hg	32,808 ft
11.65 kPa	15,240 m	116	3.44 In Hg	**50,000 ft**
5.53 kPa	**20,000 m**	55	1.63 In Hg	65,617 ft

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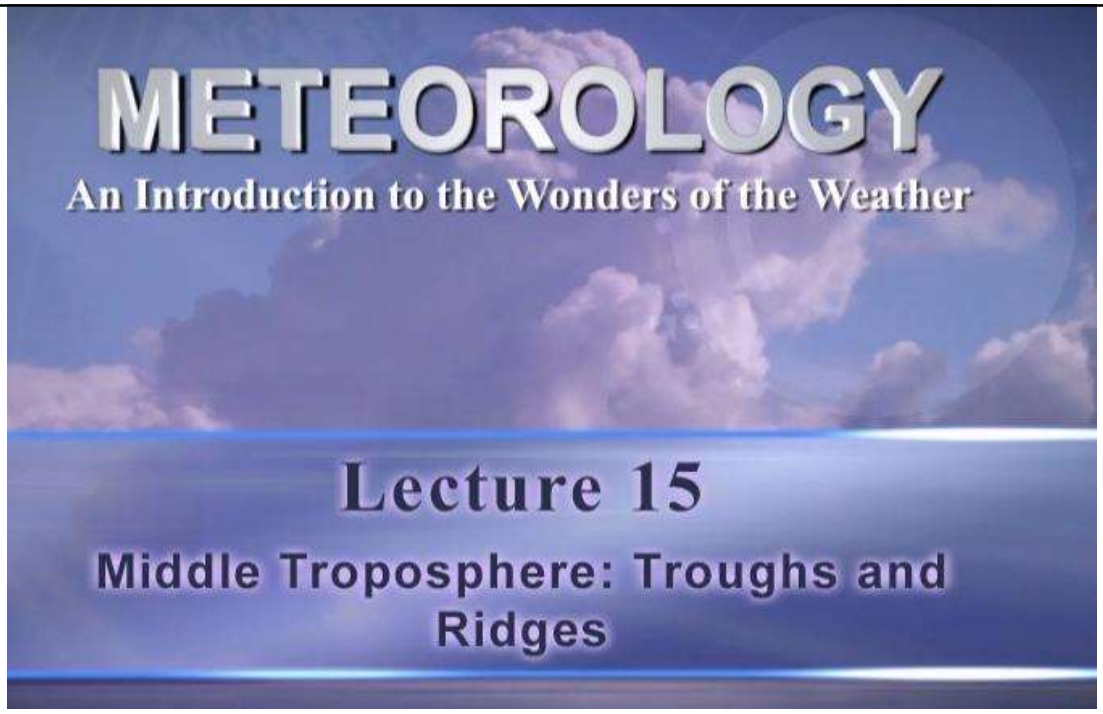

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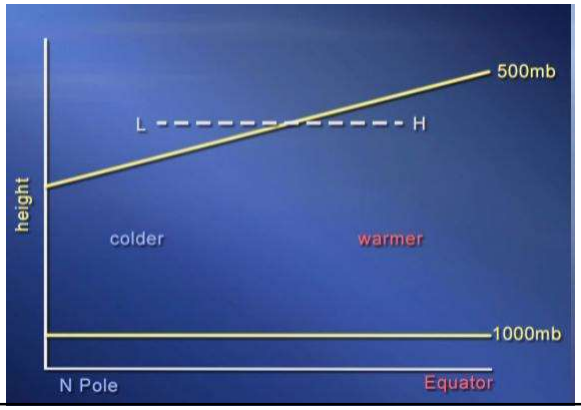
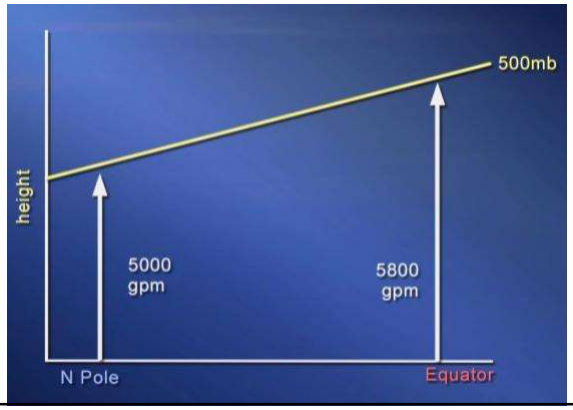
Middle Troposphere

- Troughs and ridges
- Thickness mainly a difference in temperature/density. Troposphere thicker at equator; high level wind flows to pole. It's harder to climb mountains near the poles





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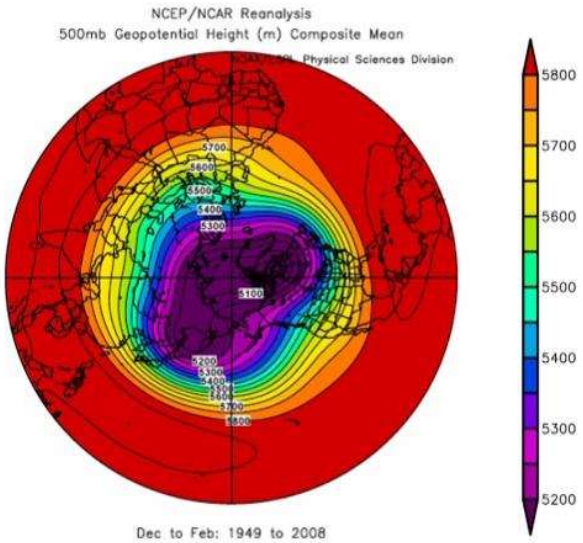
Everywhere = 500 mb

- Atmosphere thin near pole



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geopotential meter (gpm)

- Vertical distance adjusted for small variation in the earth's gravity with height
- Gravity changes with distance = inverse square law decrease with the square of that distance. But air is not very dense
- Gpm ~~ standard meter
- With the wind to your back the low pressure is to your left

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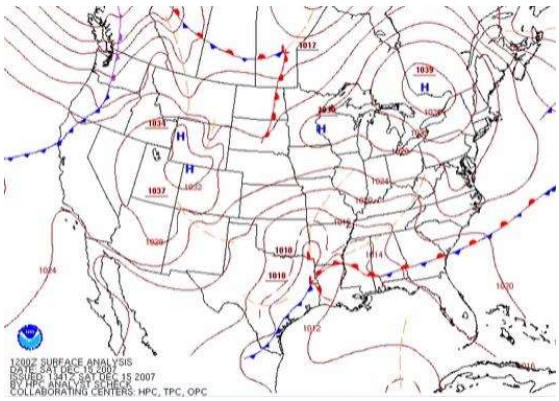
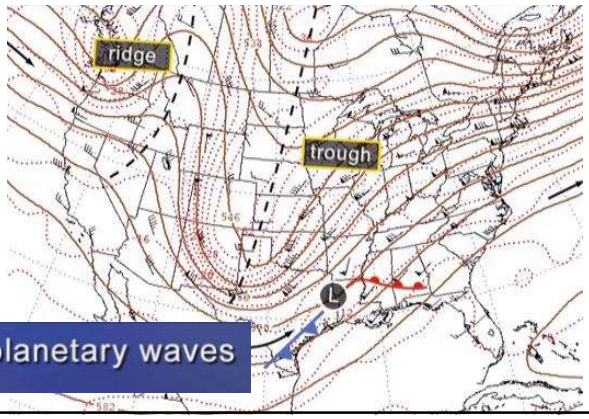
Surface vs. 500 mb charts for 12/15/2007 extra-tropical cyclone storm





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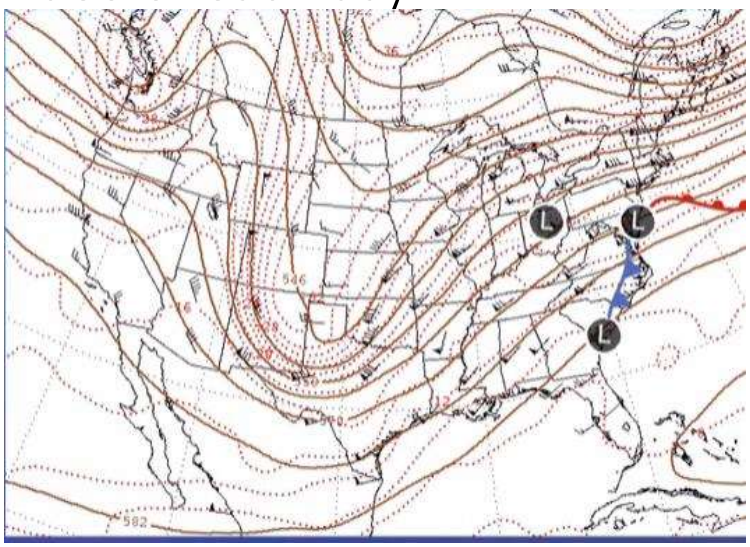
24 hours later of the 500 mb chart – later a video of each day



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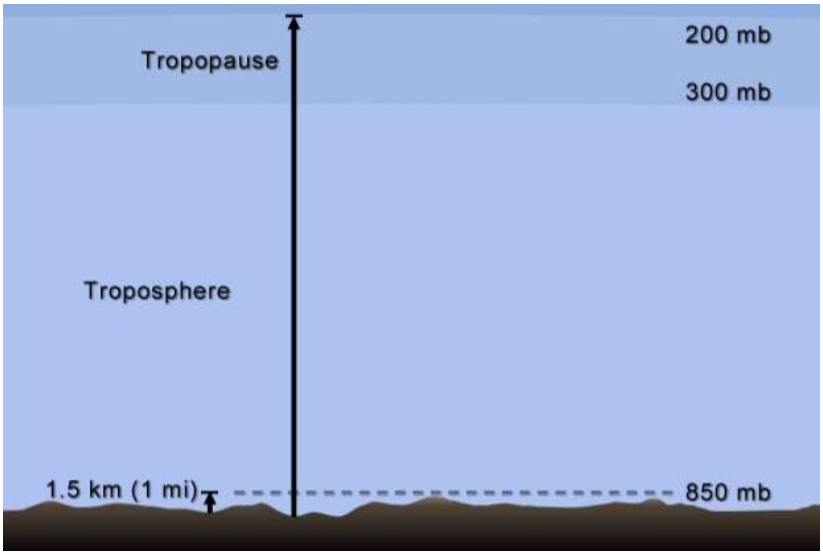
Troposphere Pressures



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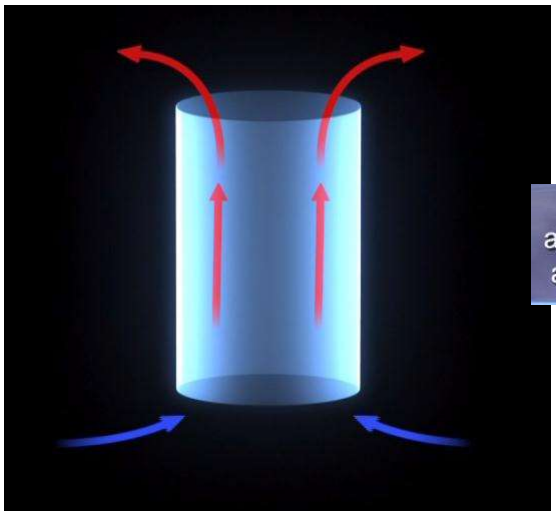
Advection



Rising motion helps create, develop, and maintain surface lows and when the ascent goes away so does the cyclone.

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Vorticity

- PVA

positive vorticity advection
warm advection

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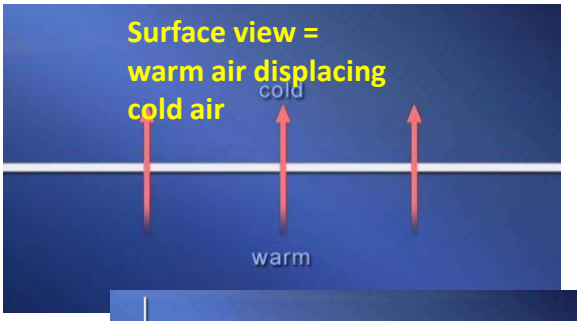
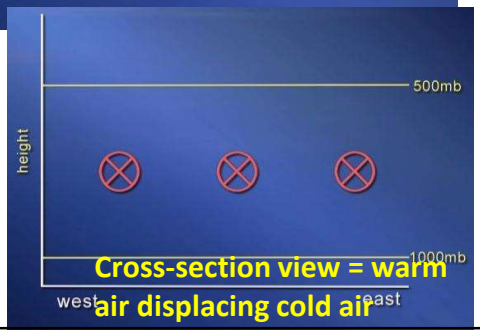
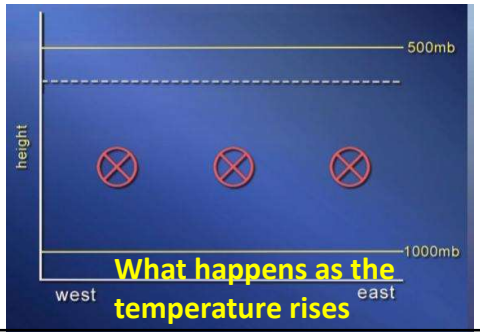
Warm advection – air rises / thickening atmosphere



The "X" – implies going INTO the paper – in this case wind coming from the south





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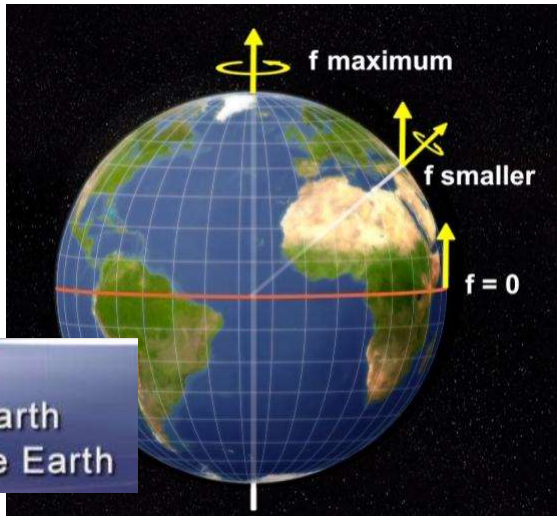
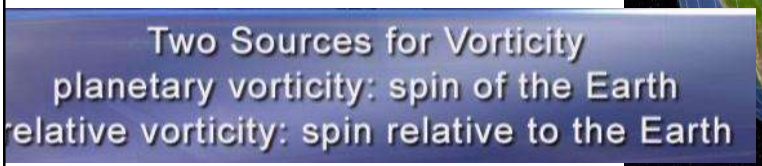
Vorticity – vertical or horizontal by right hand rule

- Curl counterclockwise – up (positive)
- Curl clockwise - negative
- 2 sources
  - Spin of earth
  - Spin relative to the earth





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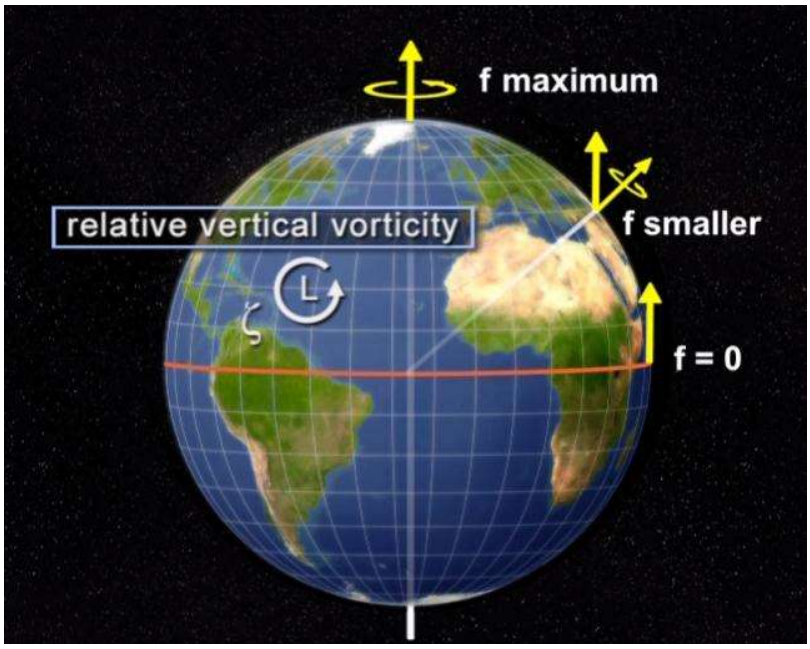

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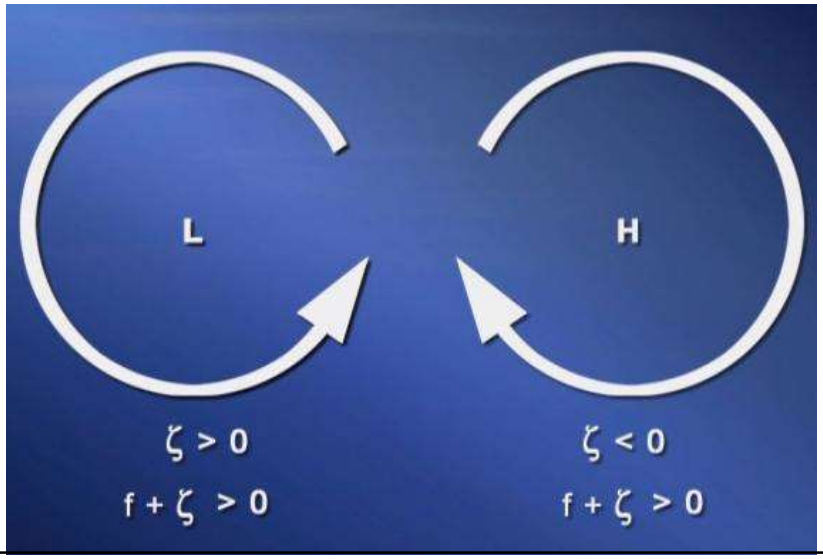
Counterclockwise in lows; clockwise for highs



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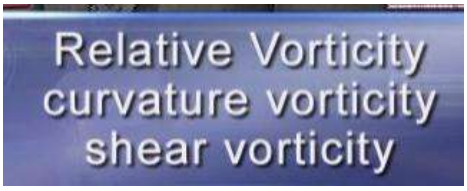
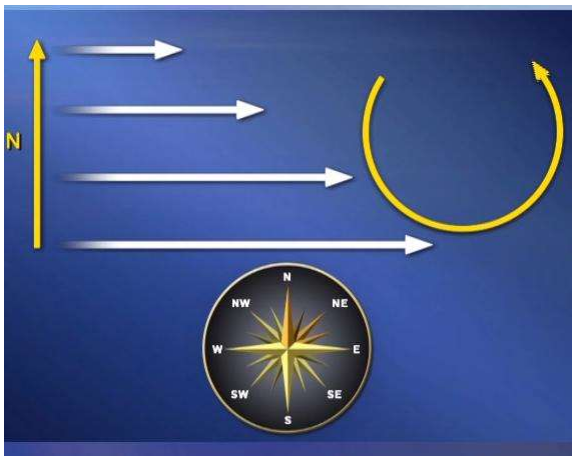
Relative Vorticity, Curvature Vorticity and Shear Vorticity = north to south (winds decreasing)





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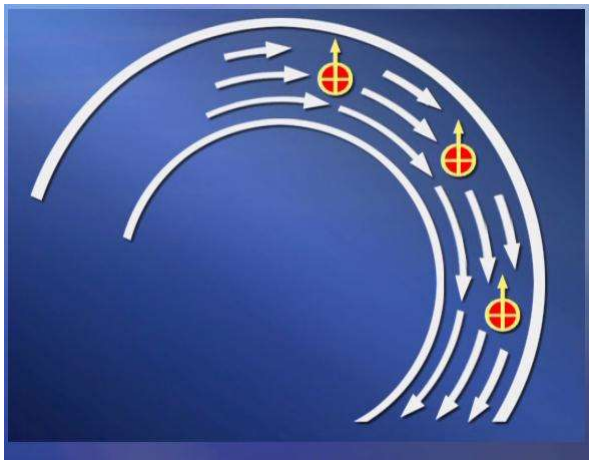
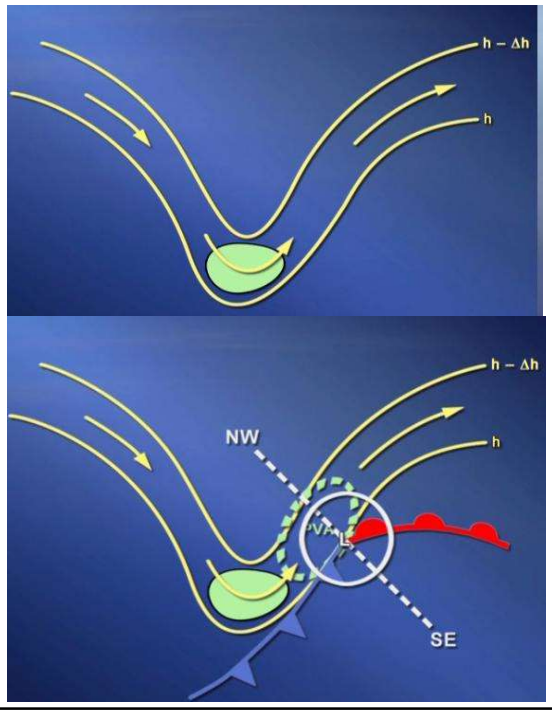
Flow is clockwise





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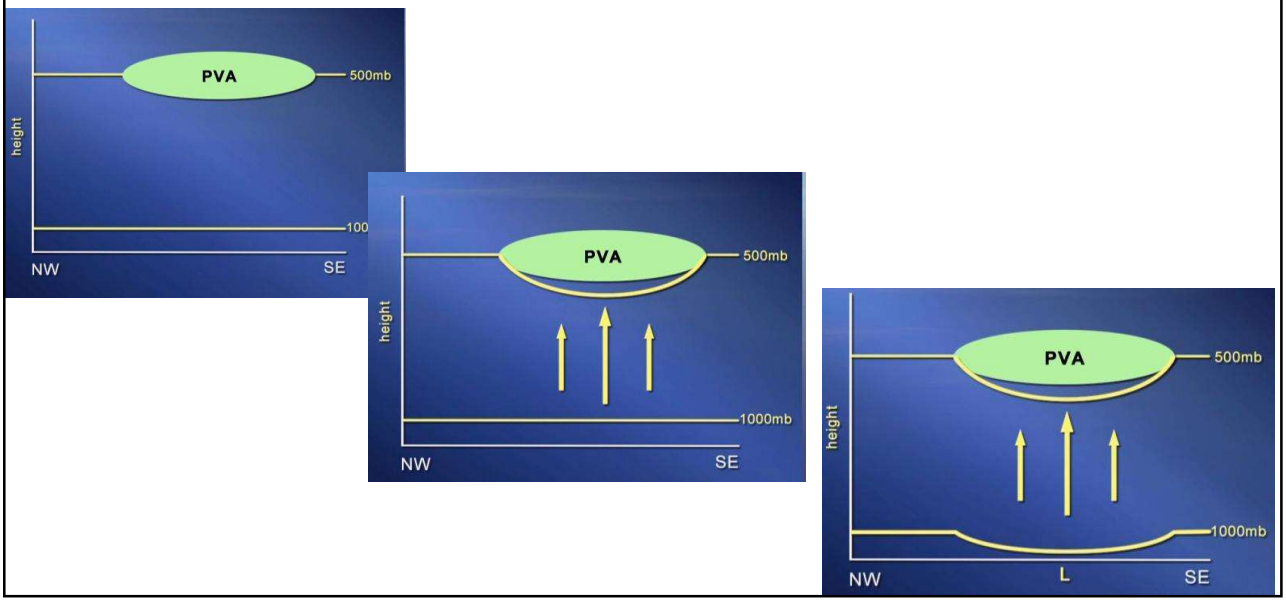
Spin creates lower pressure lowers mb heights
PVA – POSITIVE VORTICITY ADVECTION



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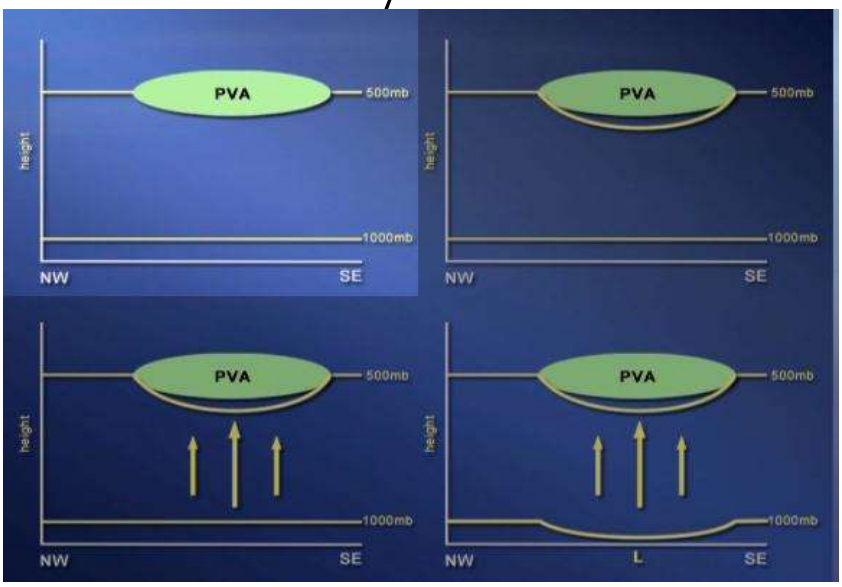
Positive Vorticity Advection = PVA



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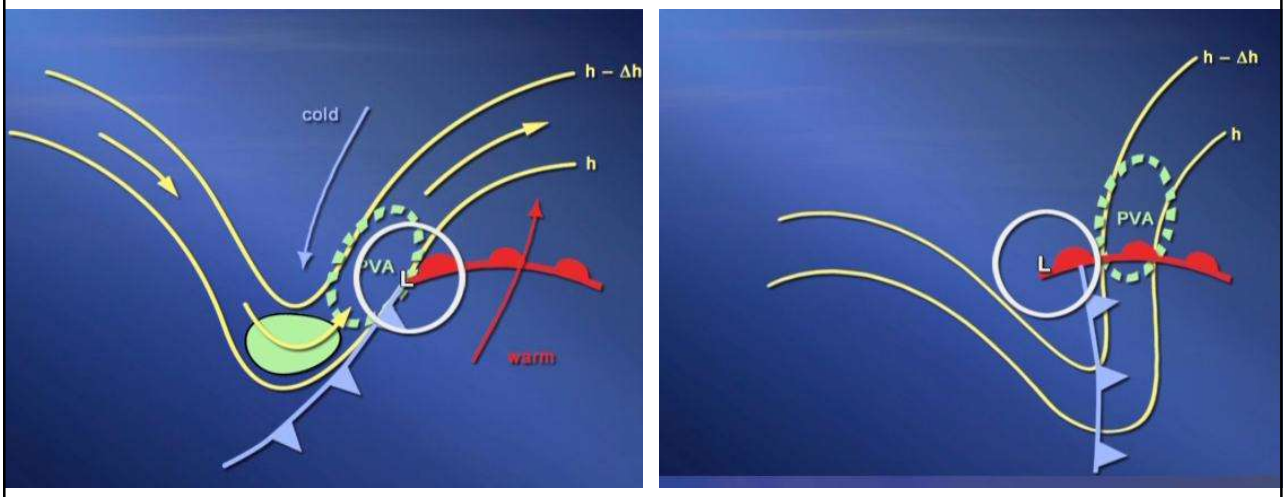
Note the difference of where the low is with respect to the PVA



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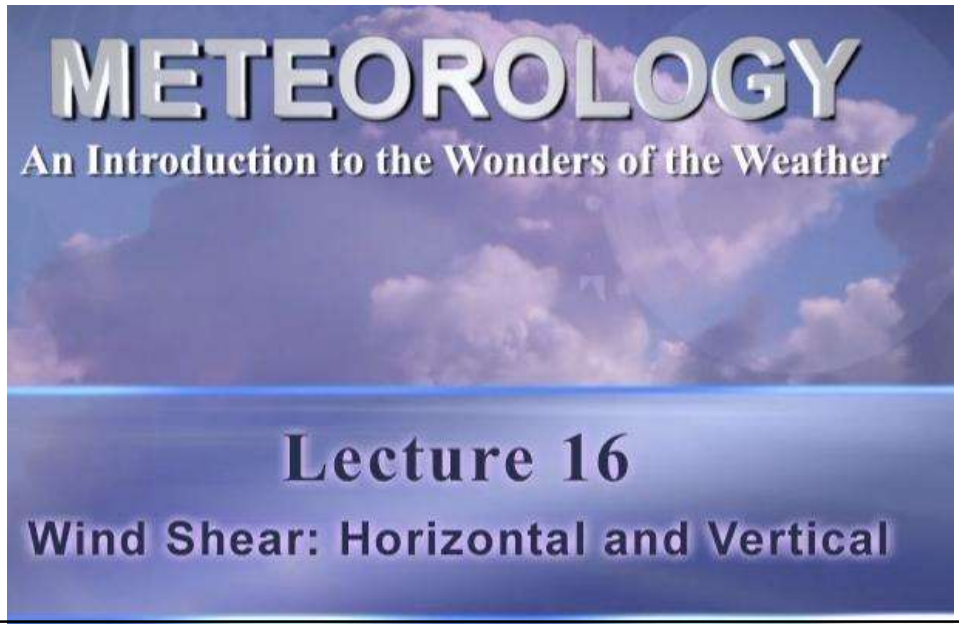
Wind Shear – Horizontal and Vertical



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Divergence

Upper Troposphere

- Using the 200mb level, near the tropopause in mid-latitudes

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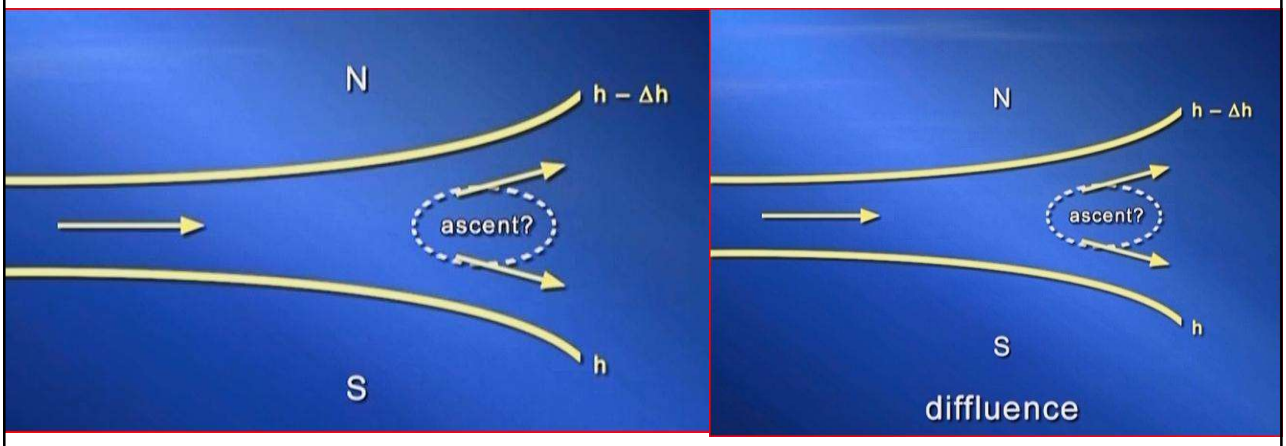
Divergence or Diffluence

- 2 height contours; lower heights to the north and higher heights to the south



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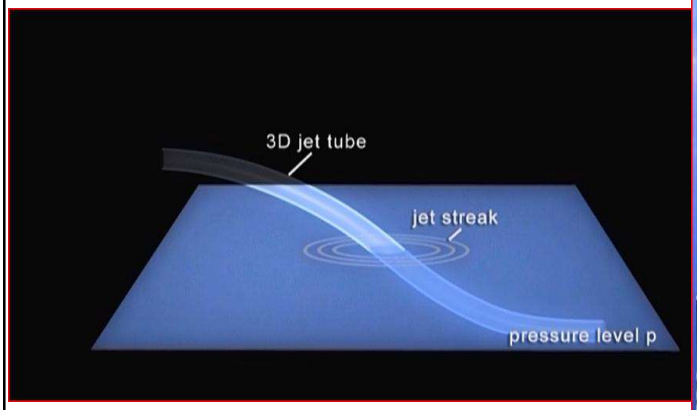
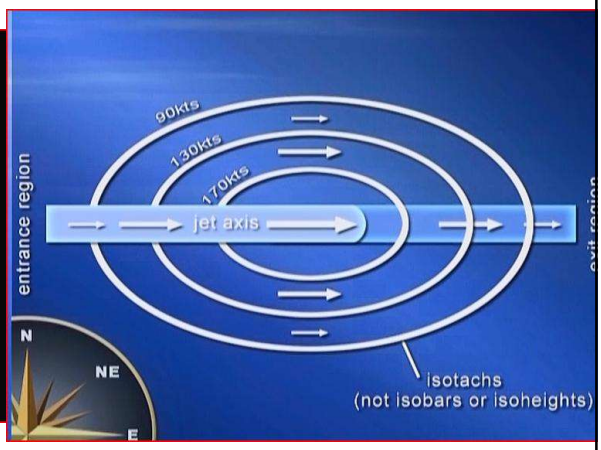
Jets

- Jet streaks or jet tubes





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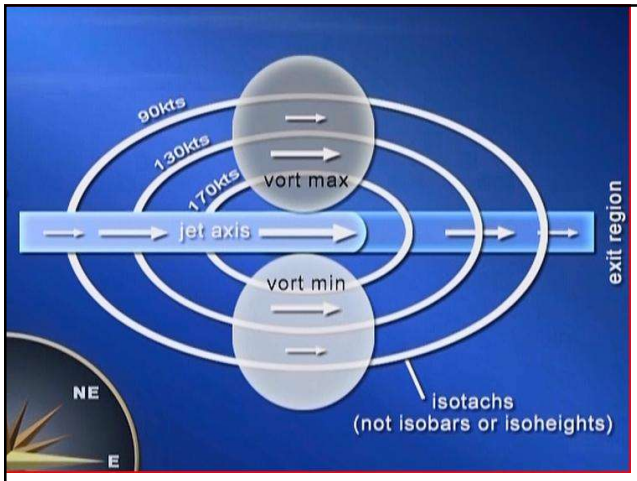

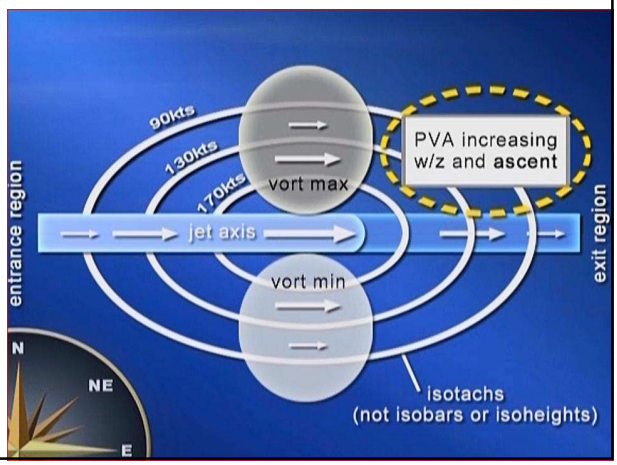

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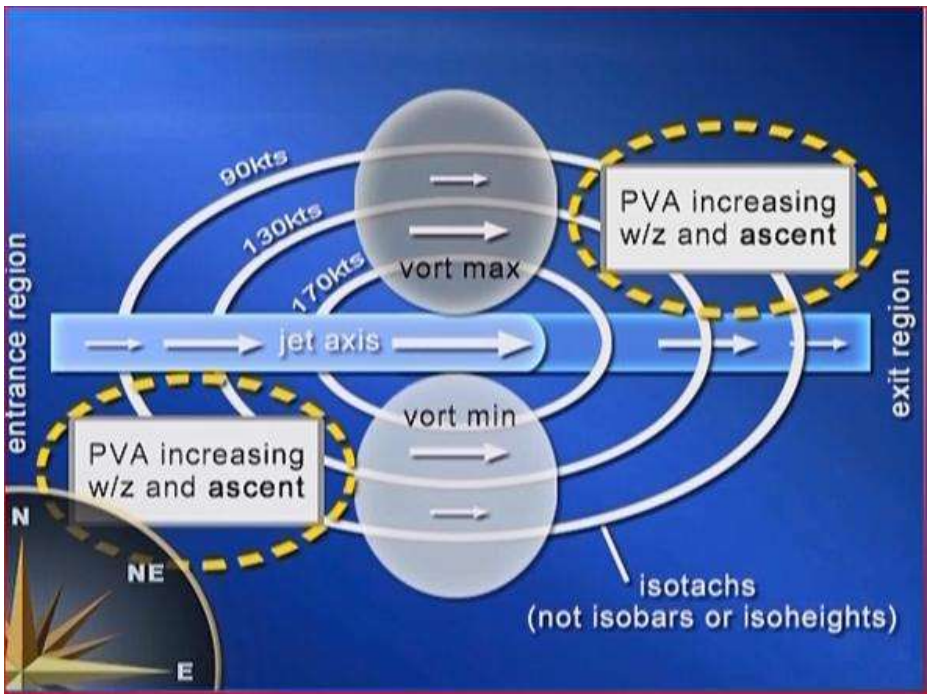

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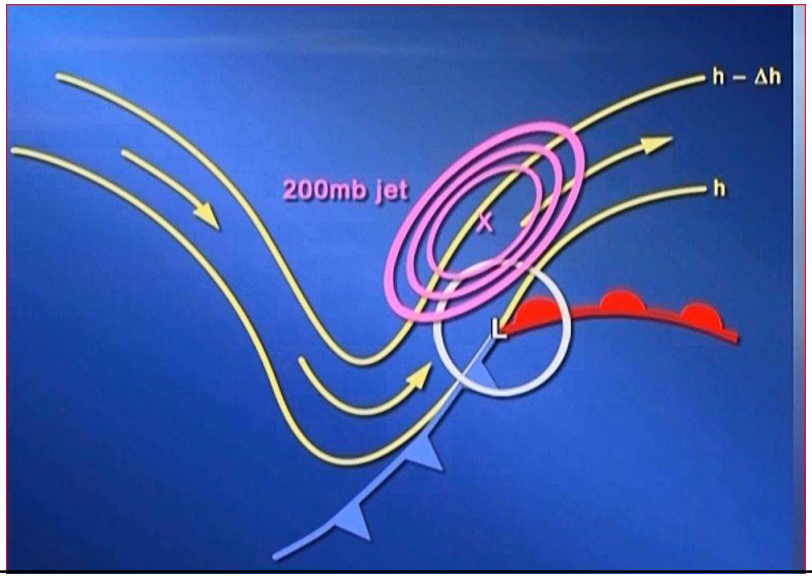
12/2007 snowstorm/cyclone

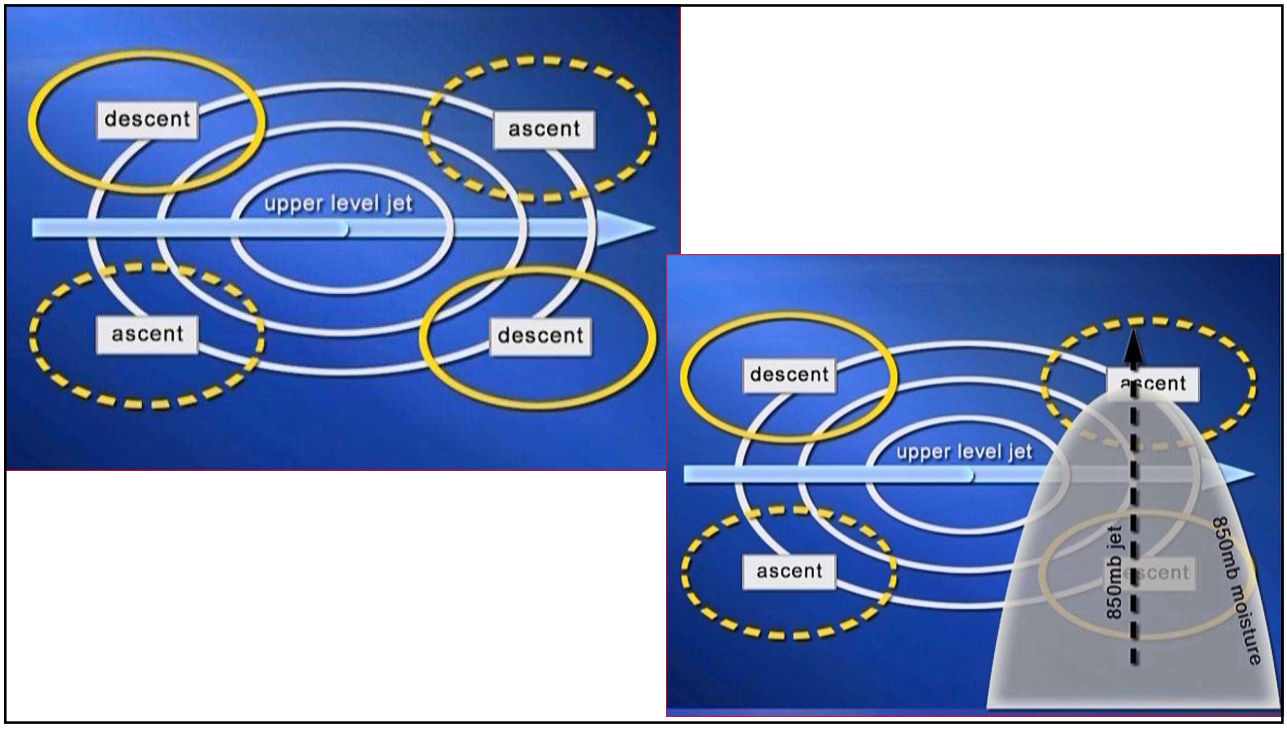


46

4 quadrants of the jet again

- Positive Vorticity Advection will induce ascent in left exit and right entrance; this in turn induces a secondary circulation
- Focusing on exit:

47



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Why does wind increase in speed with height

40 m/sec = 90 mph

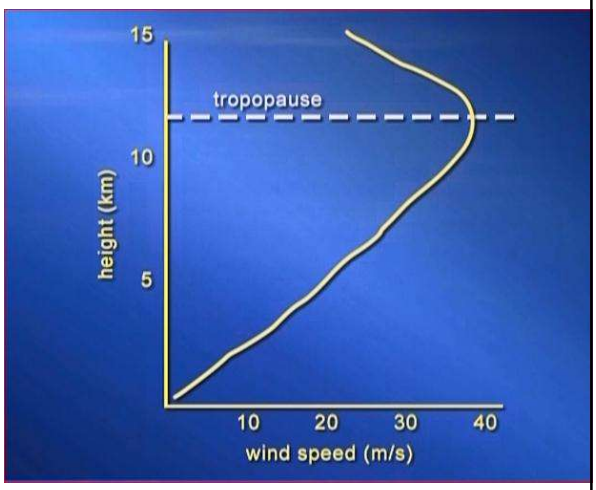
Friction at bottom – but also only at the bottom

Density decrease with height and less resistance

Not the whole story: most speeds in stratosphere decreasing

…because colder to the north (or south in s. hemisphere

Causes vertical wind shear



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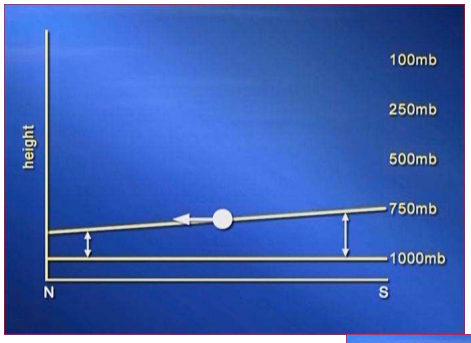
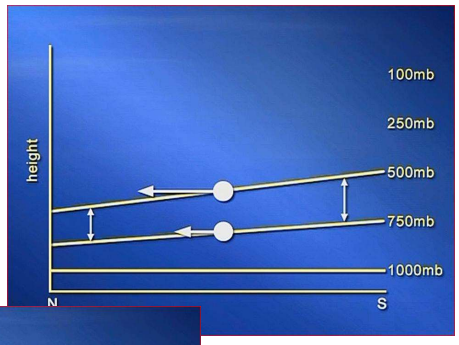
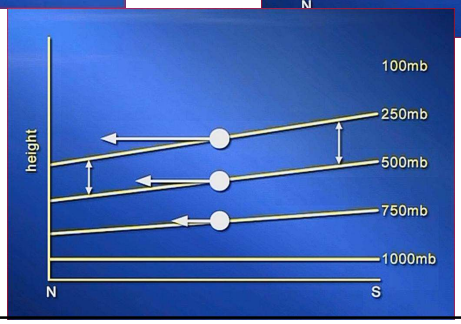
- Wind increases due to colder north/denser, lower atmosphere







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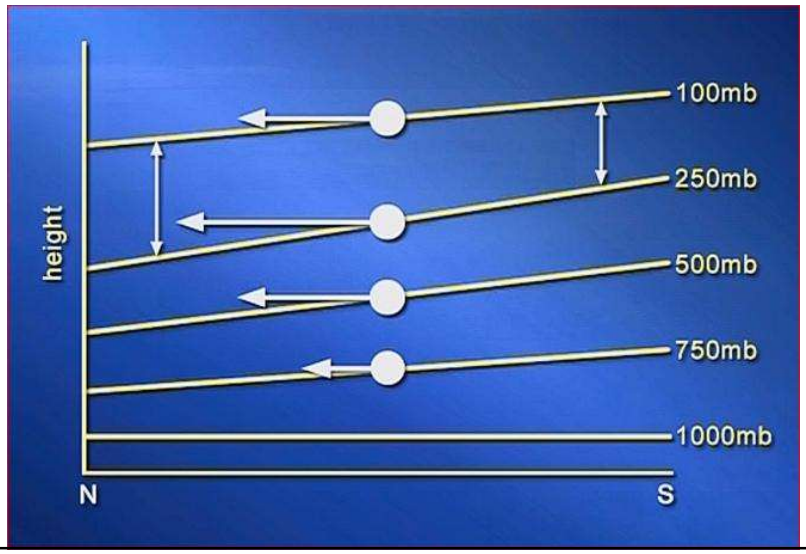
- Finally it gets warmer – and where at high altitude it's warmer at the north pole than the equator – even in winter



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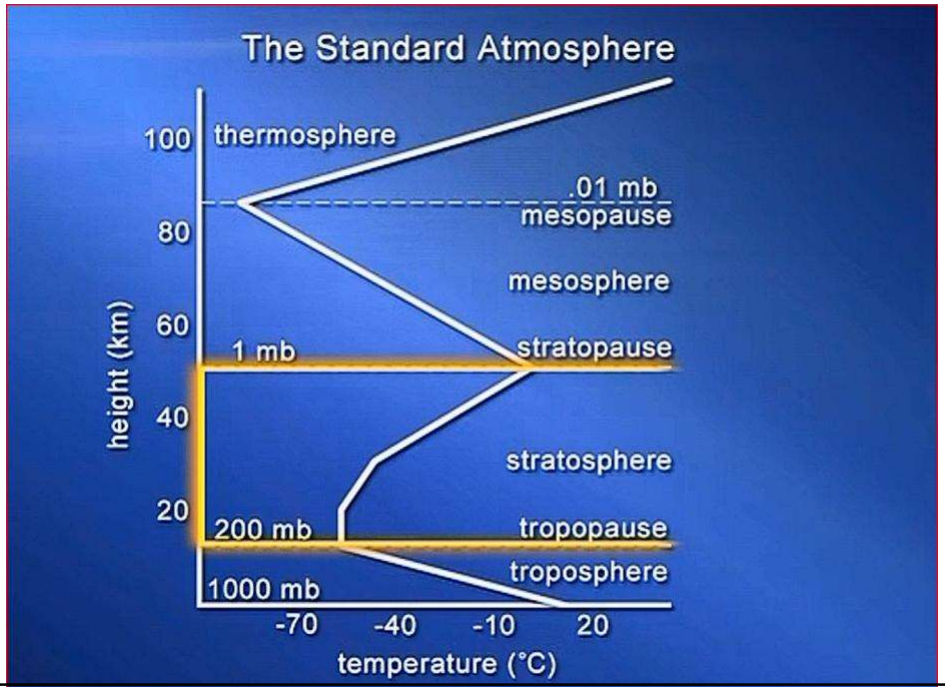

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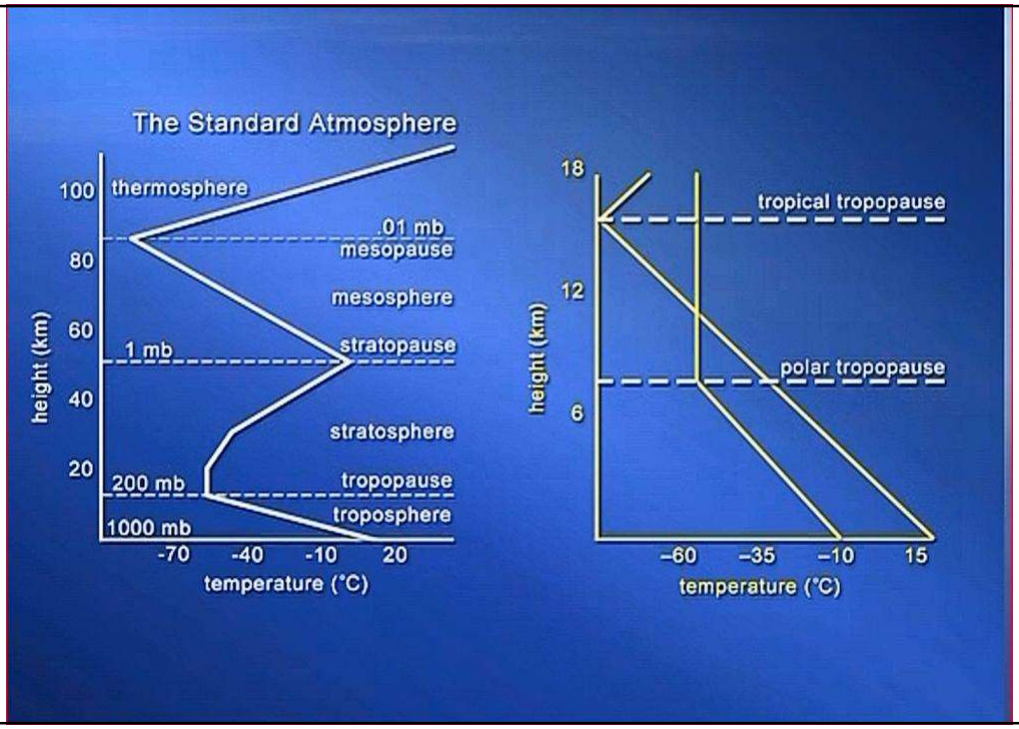
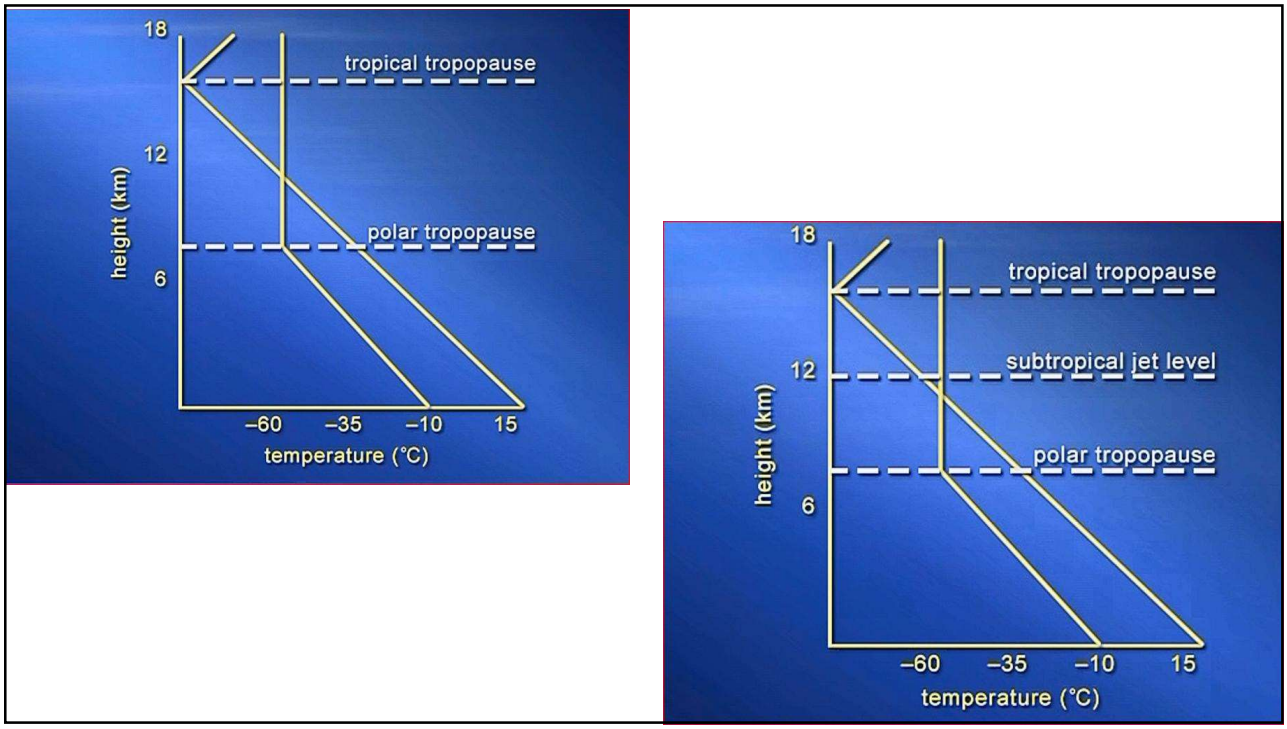
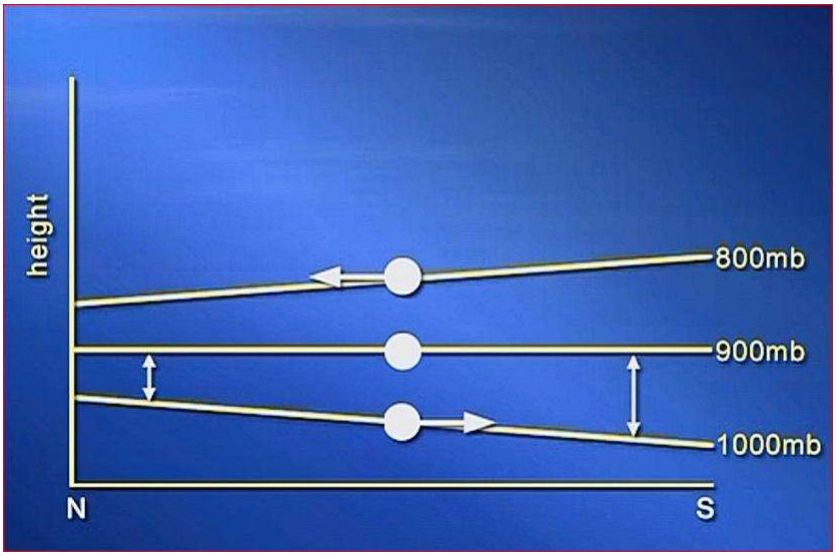

The Standard Atmosphere
100
80
60
40
20
height (km)
thermosphere
.01 mb
mesopause
mesosphere
1 mb
stratopause
stratosphere
200 mb
tropopause
troposphere
1000 mb
-70
-40
-10
20
temperature (°C)
18
12
6
height (km)
tropical tropopause
polar tropopause
–60
–35
–10
15
temperature (°C)

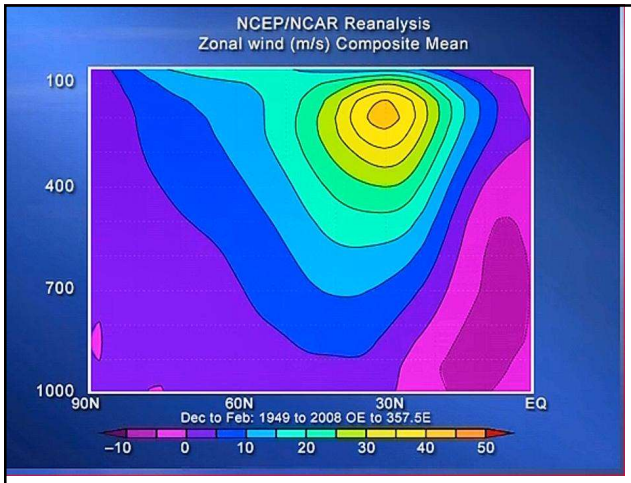
53

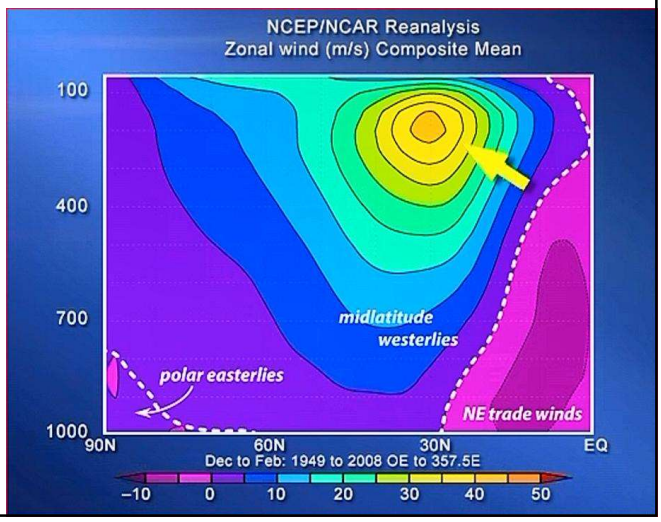

18
12
6
height (km)
tropical tropopause
polar tropopause
–60
–35
–10
15
temperature (°C)
18
12
6
height (km)
tropical tropopause
subtropical jet level
polar tropopause
–60
–35
–10
15
temperature (°C)

54

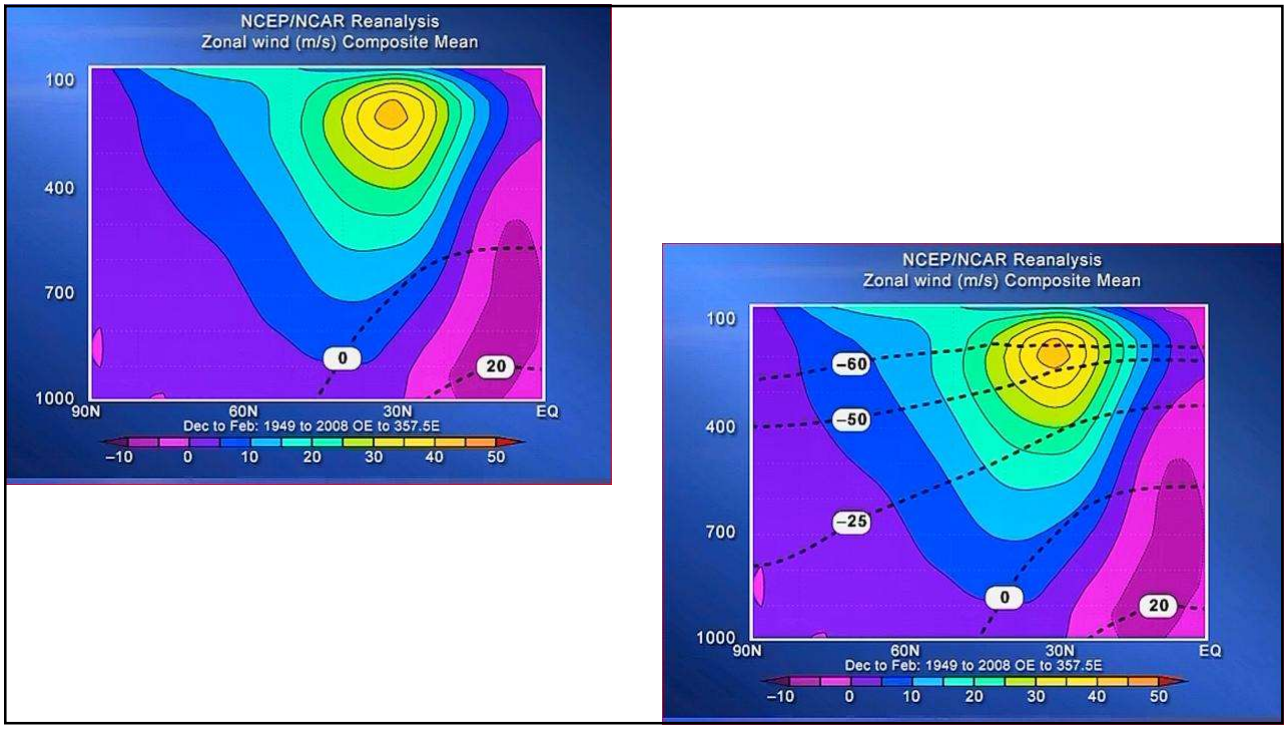

height
800mb
900mb
1000mb
N
S

55

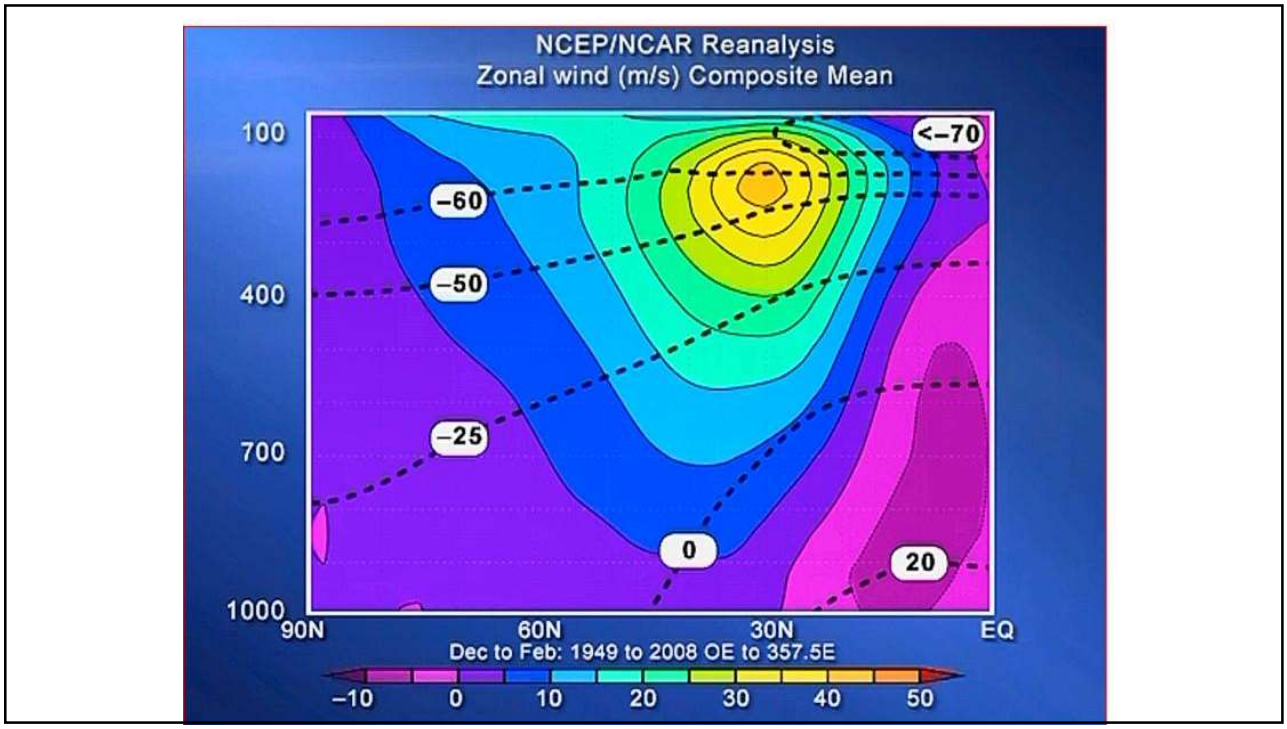

NCEP/NCAR Reanalysis
Zonal wind (m/s) Composite Mean
100
400
700
1000
90N
60N
30N
EQ
Dec to Feb: 1949 to 2008 OE to 357.5E
–10
0
10
20
30
40
50


NCEP/NCAR Reanalysis
Zonal wind (m/s) Composite Mean
100
400
700
1000
midlatitude
westerlies
polar easterlies
NE trade winds
90N
60N
30N
EQ
Dec to Feb: 1949 to 2008 OE to 357.5E
–10
0
10
20
30
40
50

56


NCEP/NCAR Reanalysis
Zonal wind (m/s) Composite Mean
100
400
700
1000
90N
60N
30N
EQ
0
20
Dec to Feb: 1949 to 2008 OE to 357.5E
−10 0 10 20 30 40 50
NCEP/NCAR Reanalysis
Zonal wind (m/s) Composite Mean
100
400
700
1000
−60
−50
−25
0
20
90N
60N
30N
EQ
Dec to Feb: 1949 to 2008 OE to 357.5E
−10 0 10 20 30 40 50

57


NCEP/NCAR Reanalysis
Zonal wind (m/s) Composite Mean
100
400
700
1000
<−70
−60
−50
−25
0
20
90N
60N
30N
EQ
Dec to Feb: 1949 to 2008 OE to 357.5E
−10 0 10 20 30 40 50

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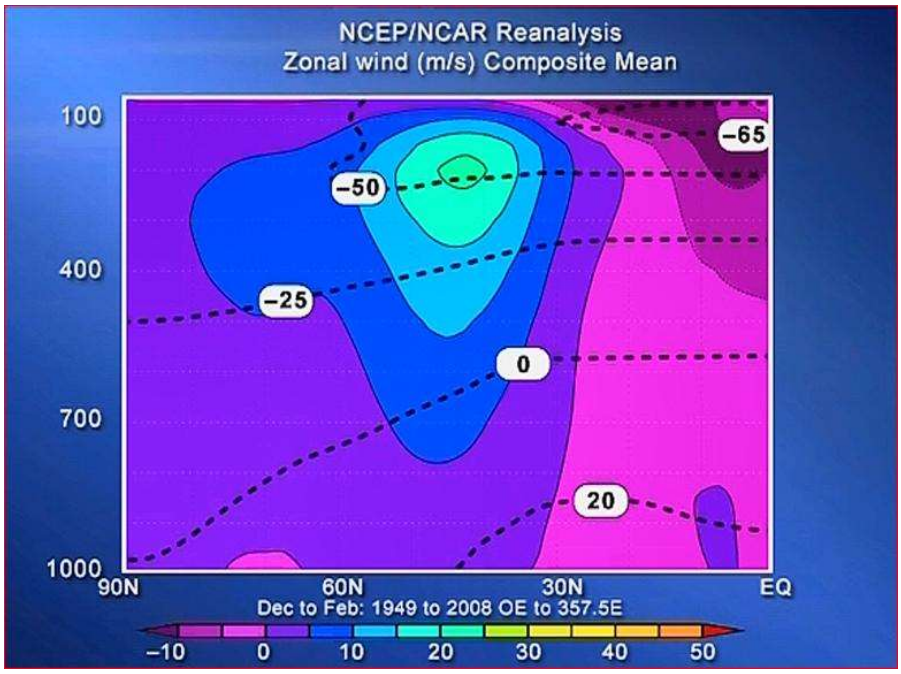
Summer



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- END OF WEEK 5

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