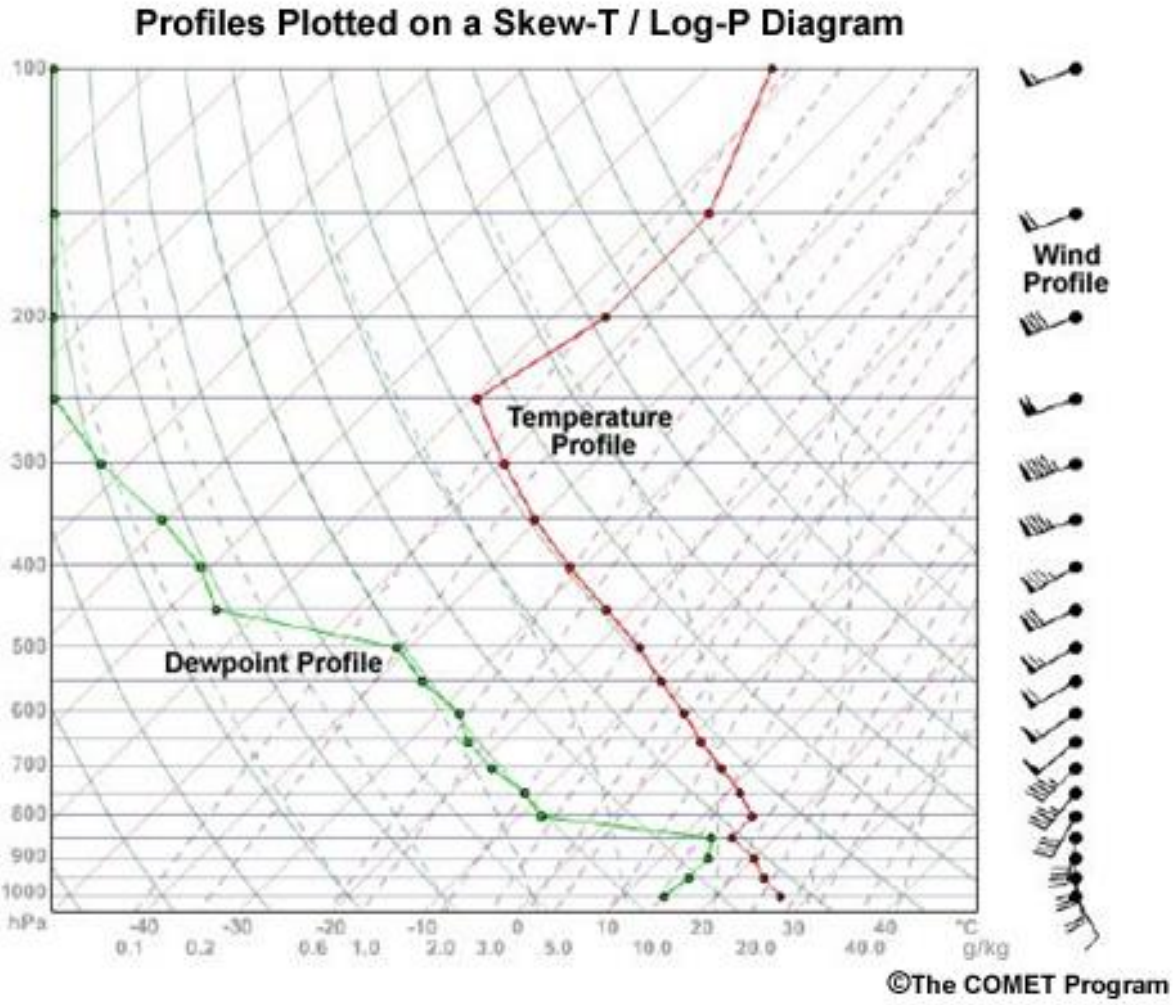
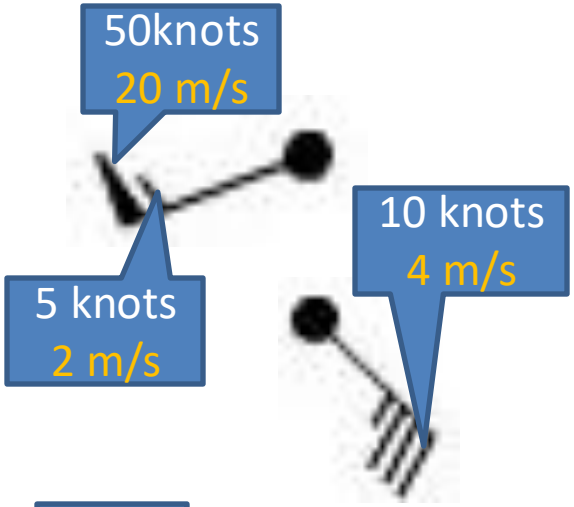
上节课回顾

探空曲线



露点： 气块在保持水汽不变的情况下等压降温到气块饱和时的温度.

风速风向表示



USA
China

1m/s=1.94 knots

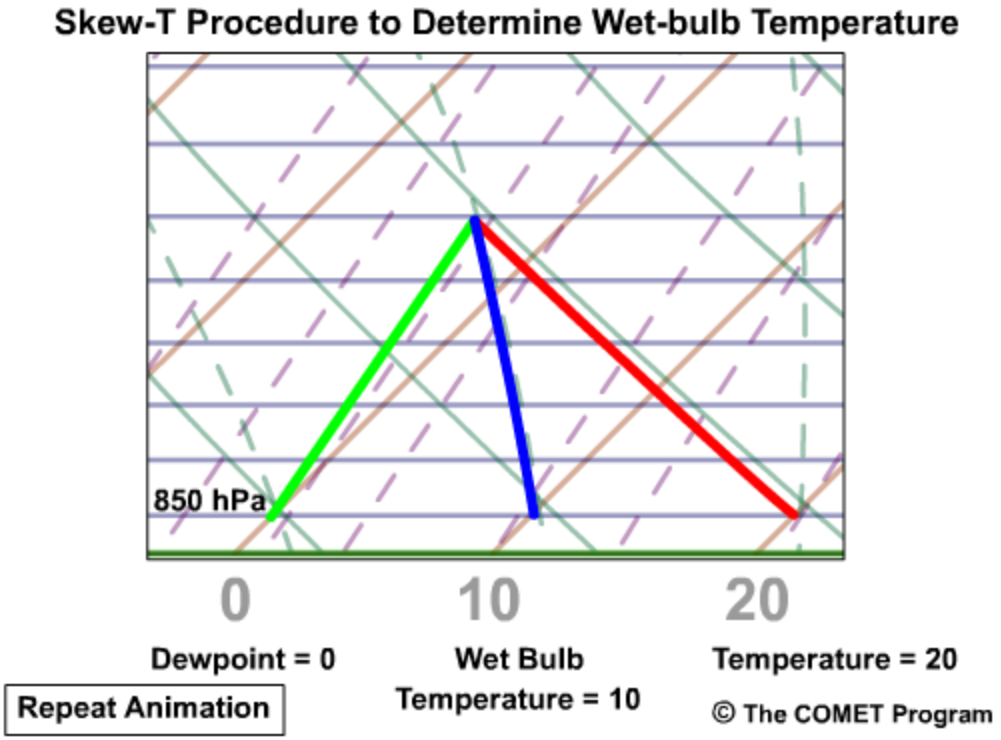
上节课回顾

Parameters: Temperatures

The wet-bulb temperature is the temperature to which a parcel of air at a constant pressure cools through the evaporation of water into it. At this temperature, the parcel becomes saturated.

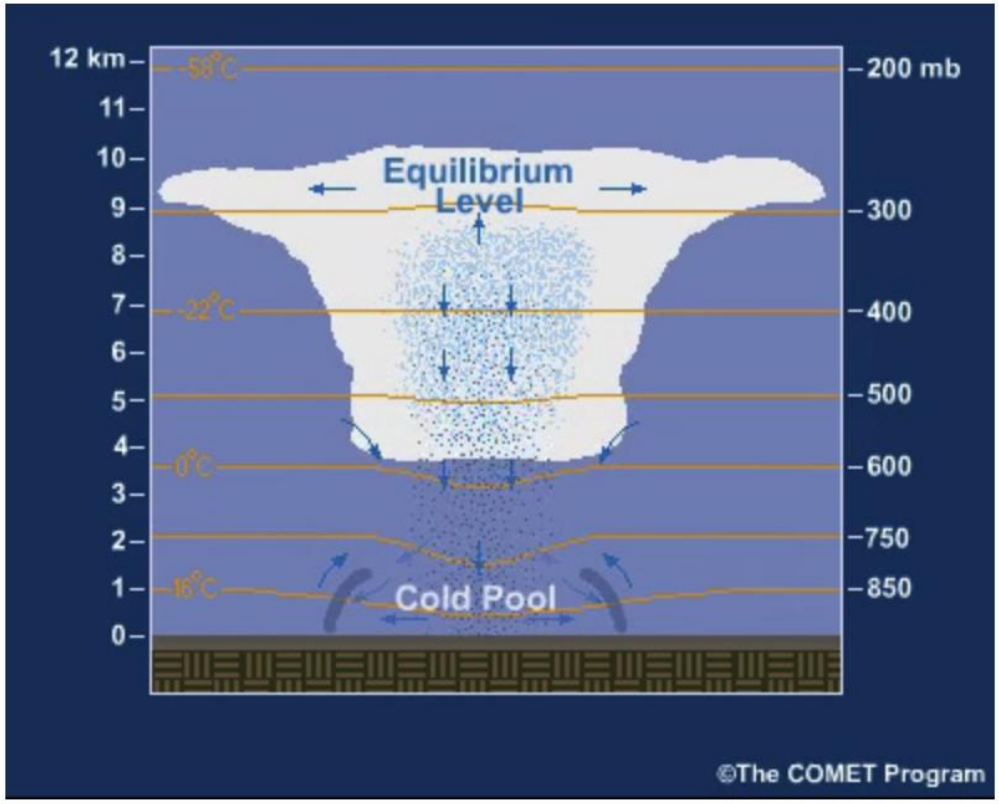
$$T_w = T - L\frac{w_s - w}{c_p}$$

From LCL, proceed down the saturation adiabat to the original level.

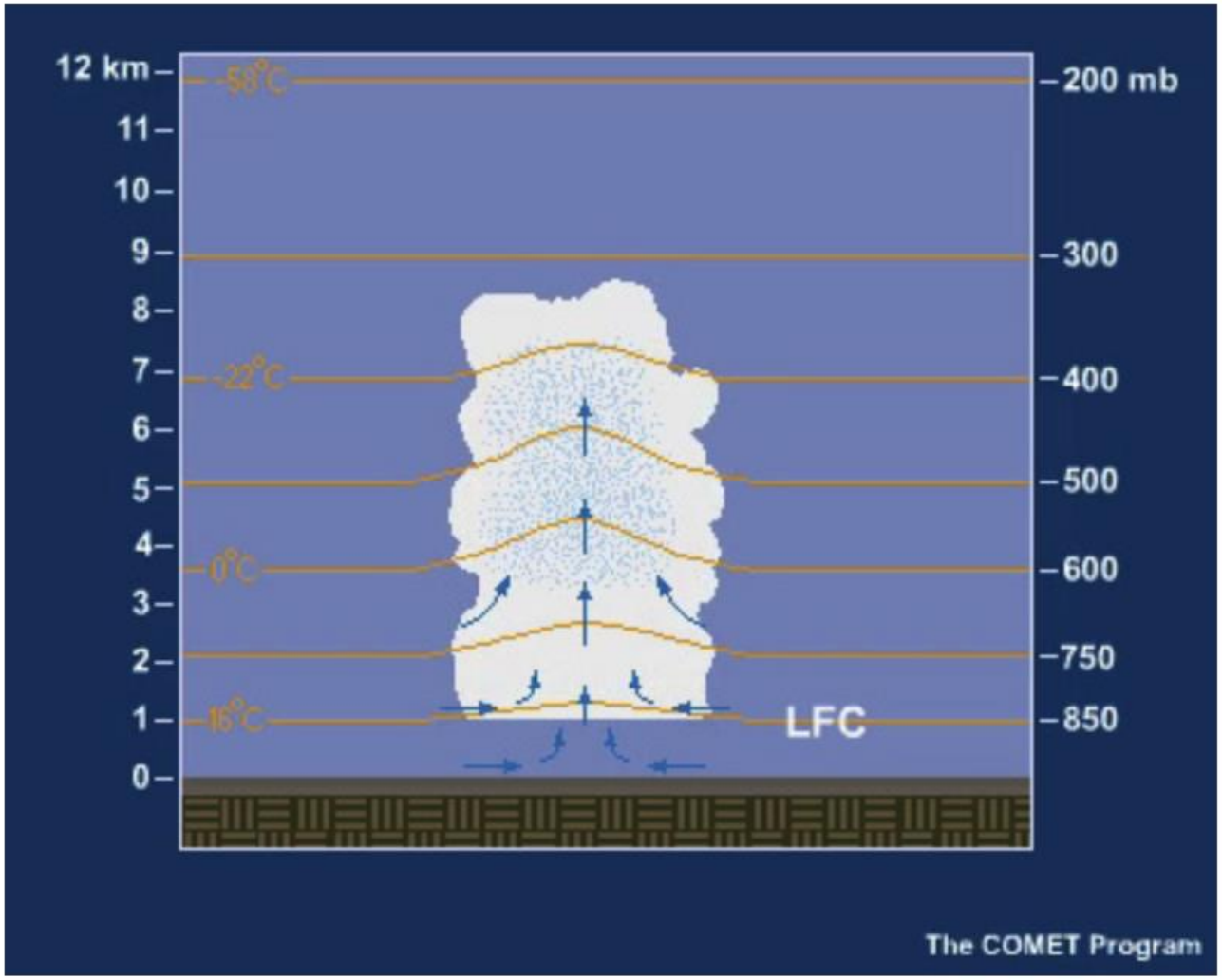


All stages

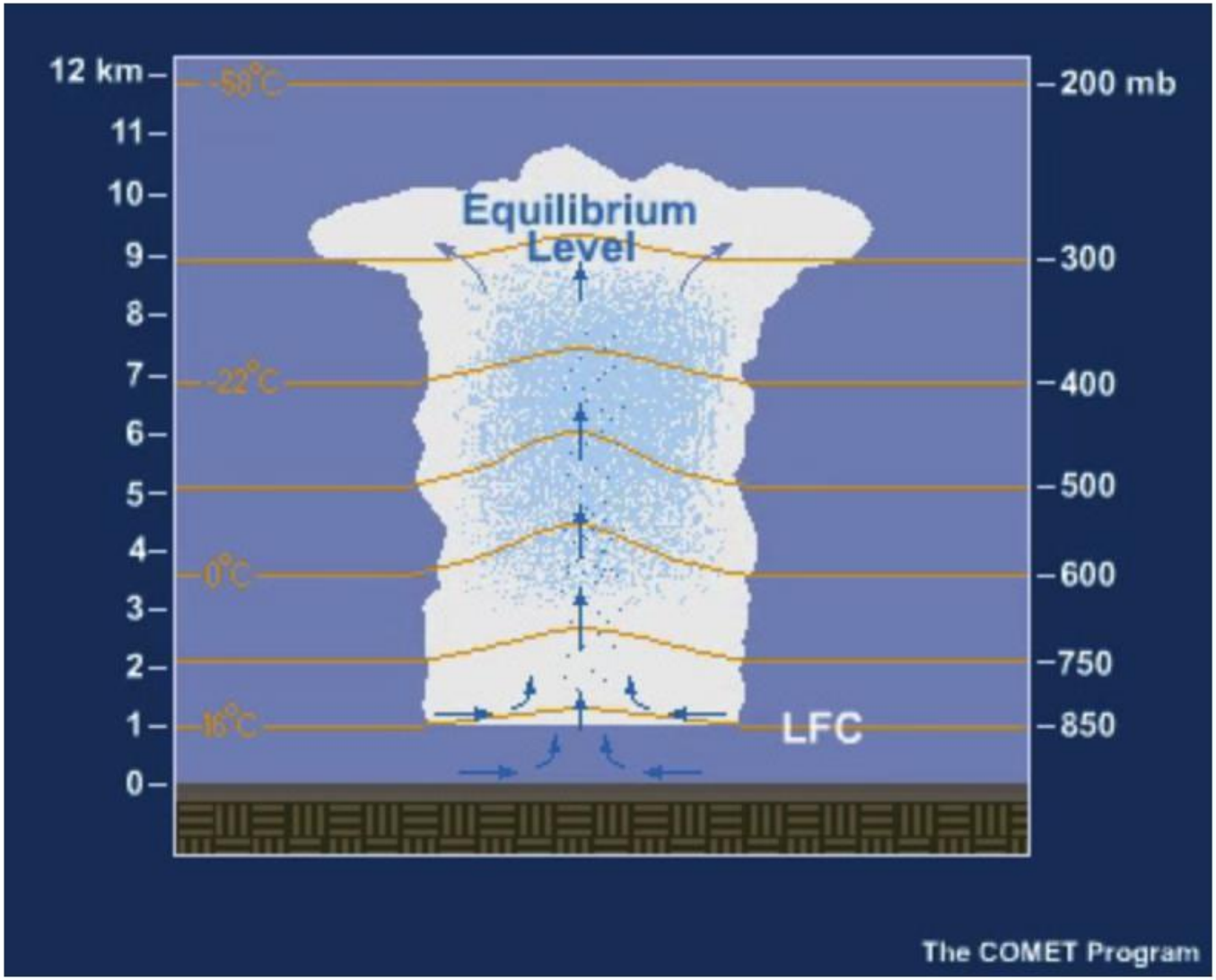
If no vertical wind shear!



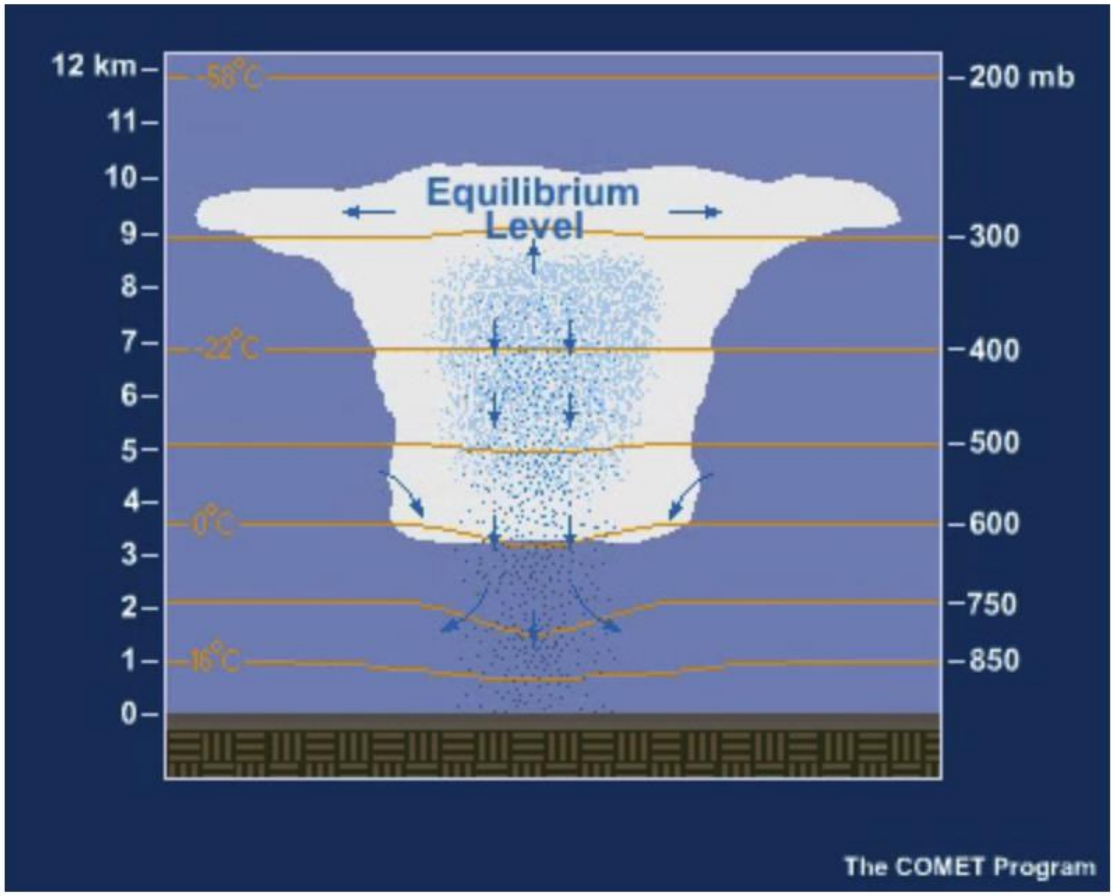
Stage 2


12 km
11
10
9
8
7
6
5
4
3
2
1
0
-58°C
-22°C
0°C
16°C
LFC
200 mb
300
400
500
600
750
850
The COMET Program

Stage 2

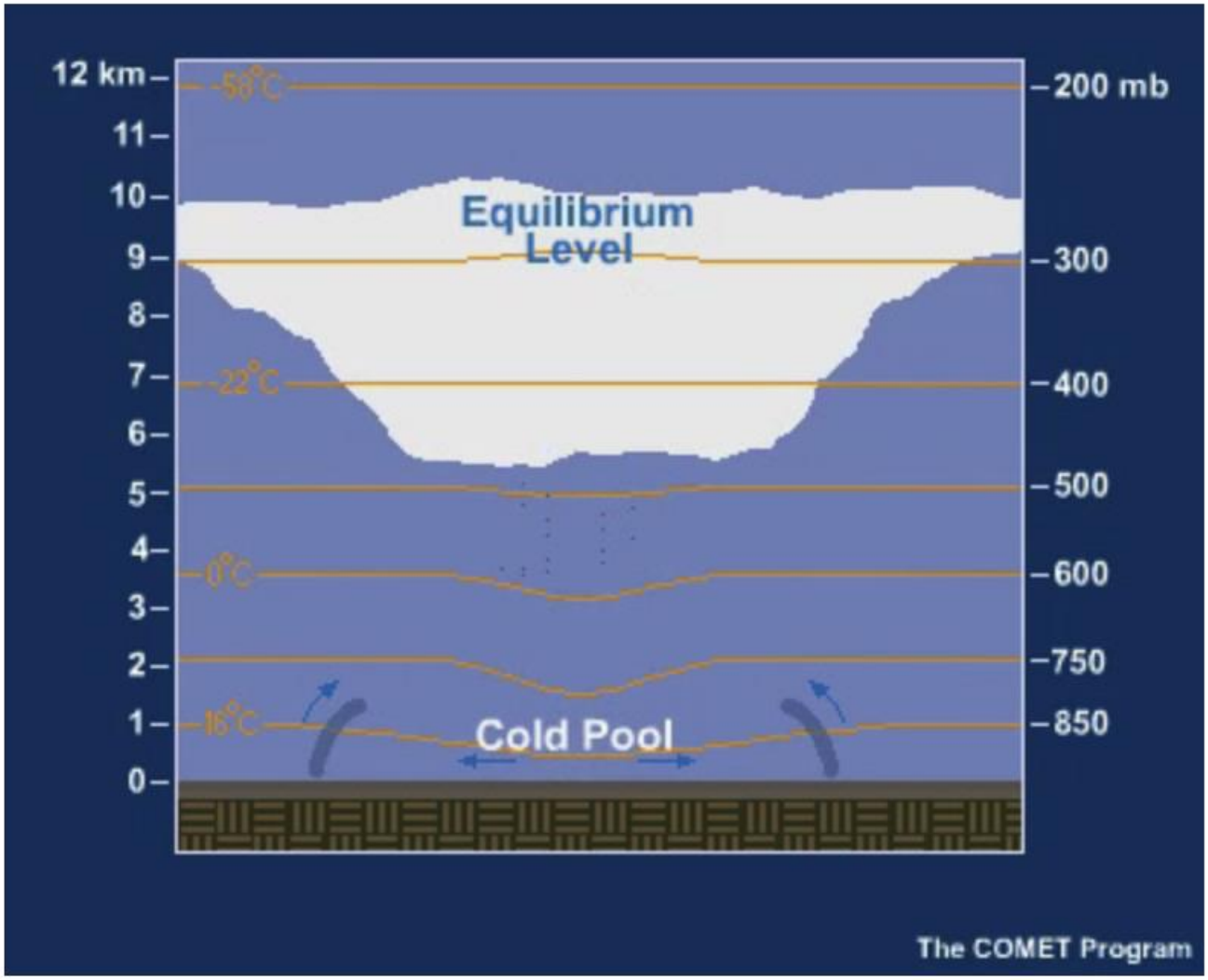

12 km
11
10
9
8
7
6
5
4
3
2
1
0
-58°C
-22°C
0°C
16°C
Equilibrium Level
LFC
200 mb
300
400
500
600
750
850
The COMET Program

Stage 3

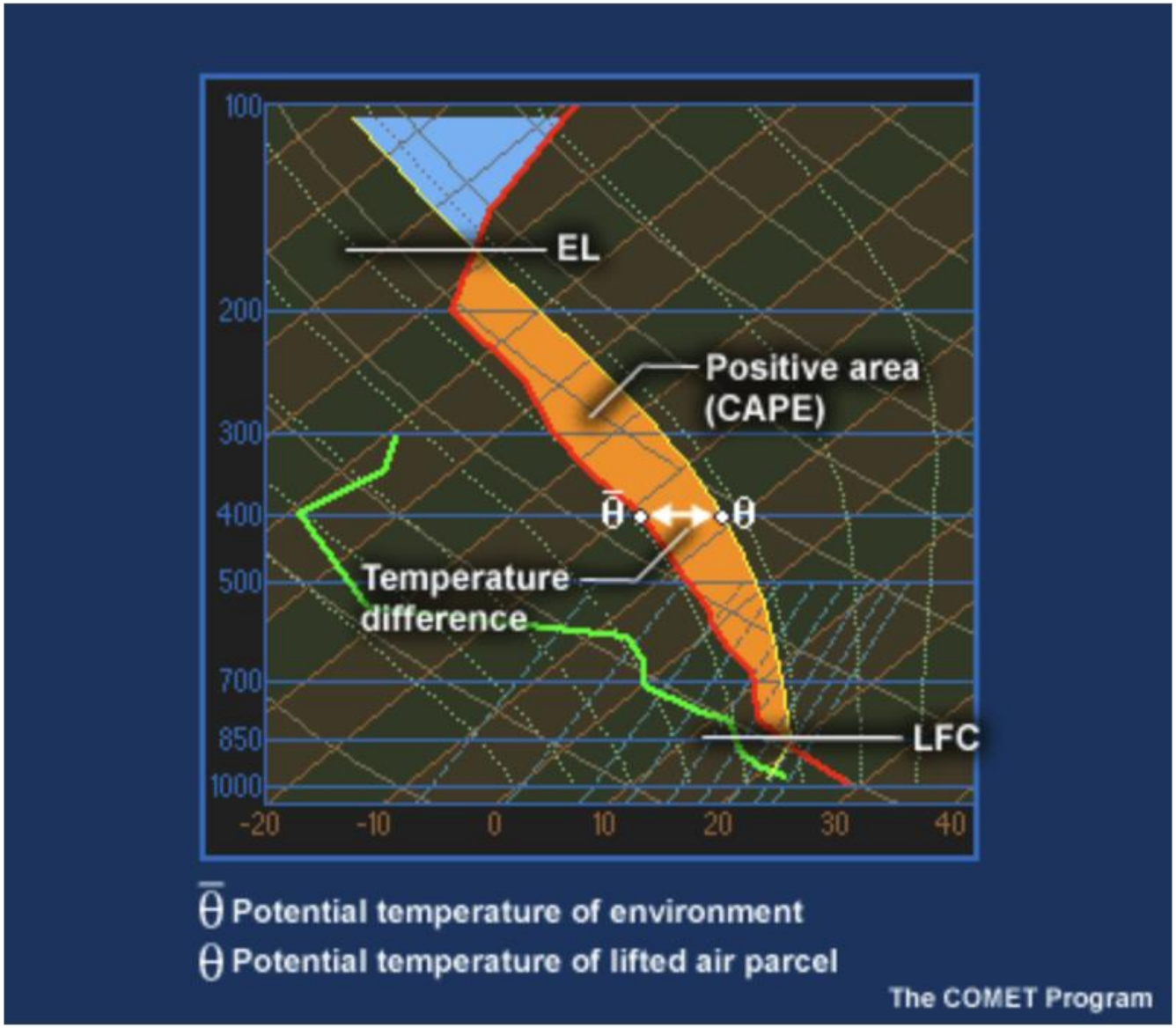


1) precipitation to drag air down
2) entrainment of drier air at mid-levels
3) rain evaporation

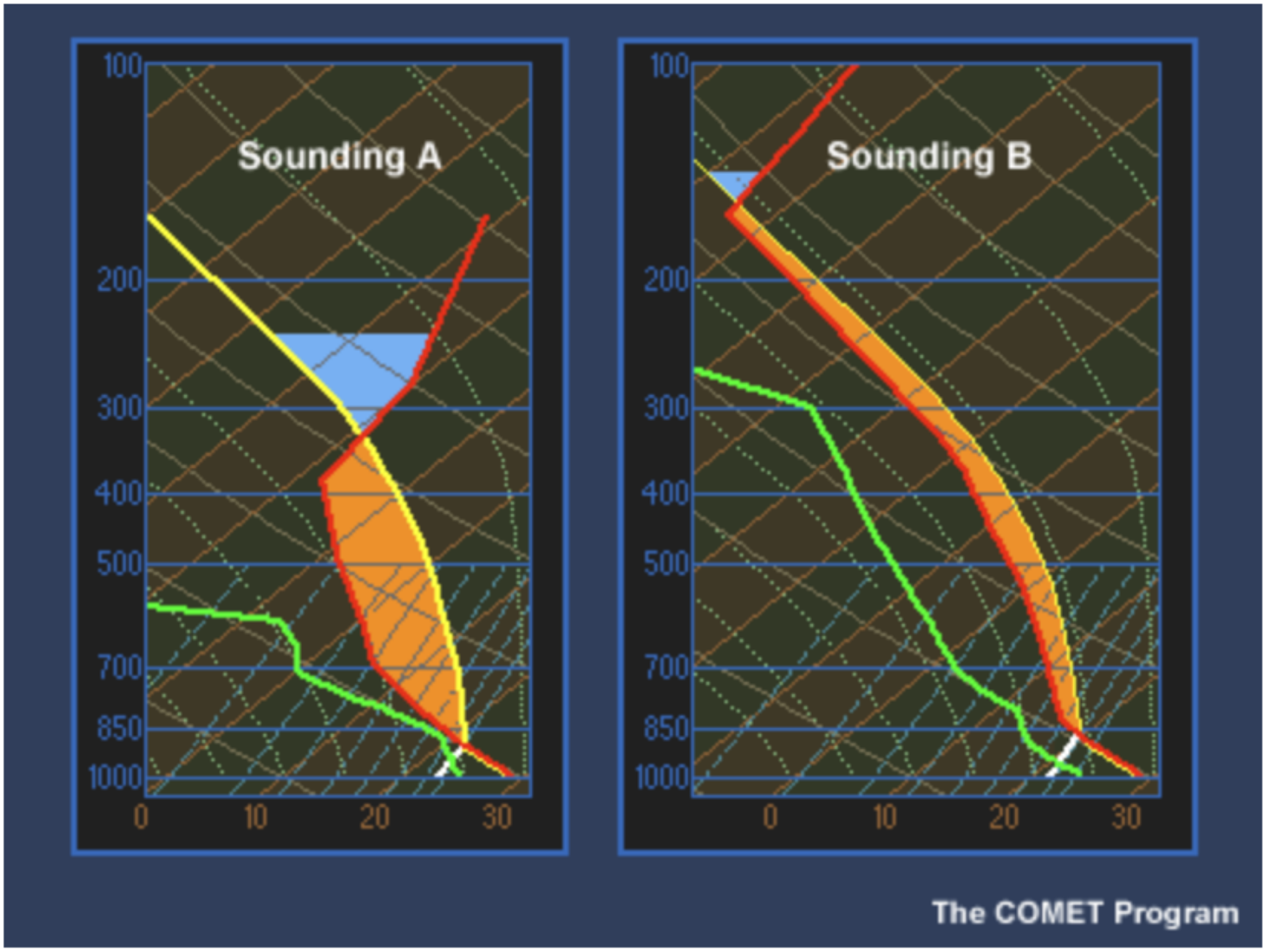
Stage 4


12 km
11
10
9
8
7
6
5
4
3
2
1
0
-58°C
-22°C
0°C
16°C
Equilibrium Level
Cold Pool
200 mb
300
400
500
600
750
850
The COMET Program

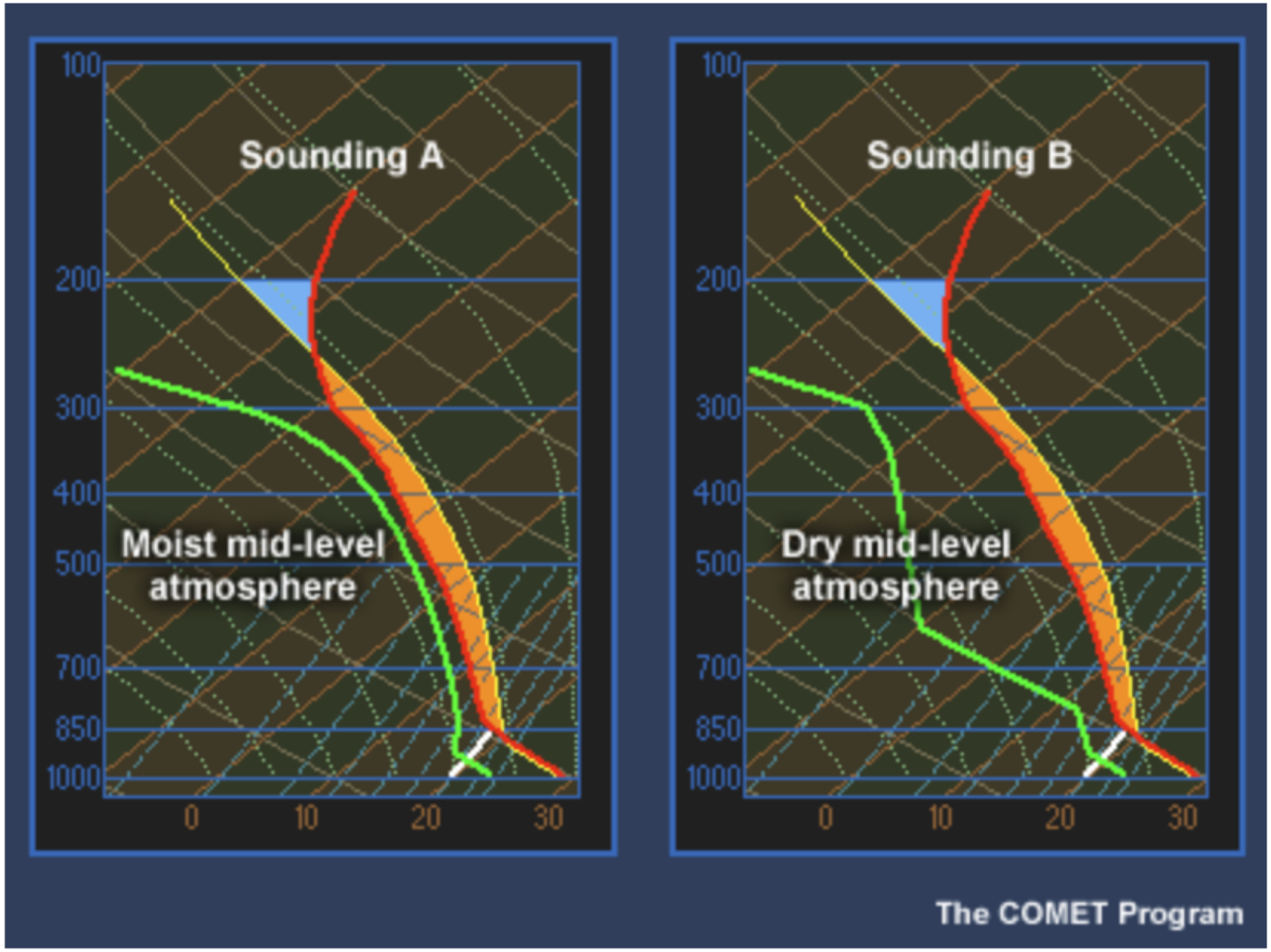
CAPE


100
200
300
400
500
700
850
1000
-20
-10
0
10
20
30
40
EL
Positive area
(CAPE)
θ̄
θ
Temperature
difference
LFC
θ̄ Potential temperature of environment
θ Potential temperature of lifted air parcel
The COMET Program

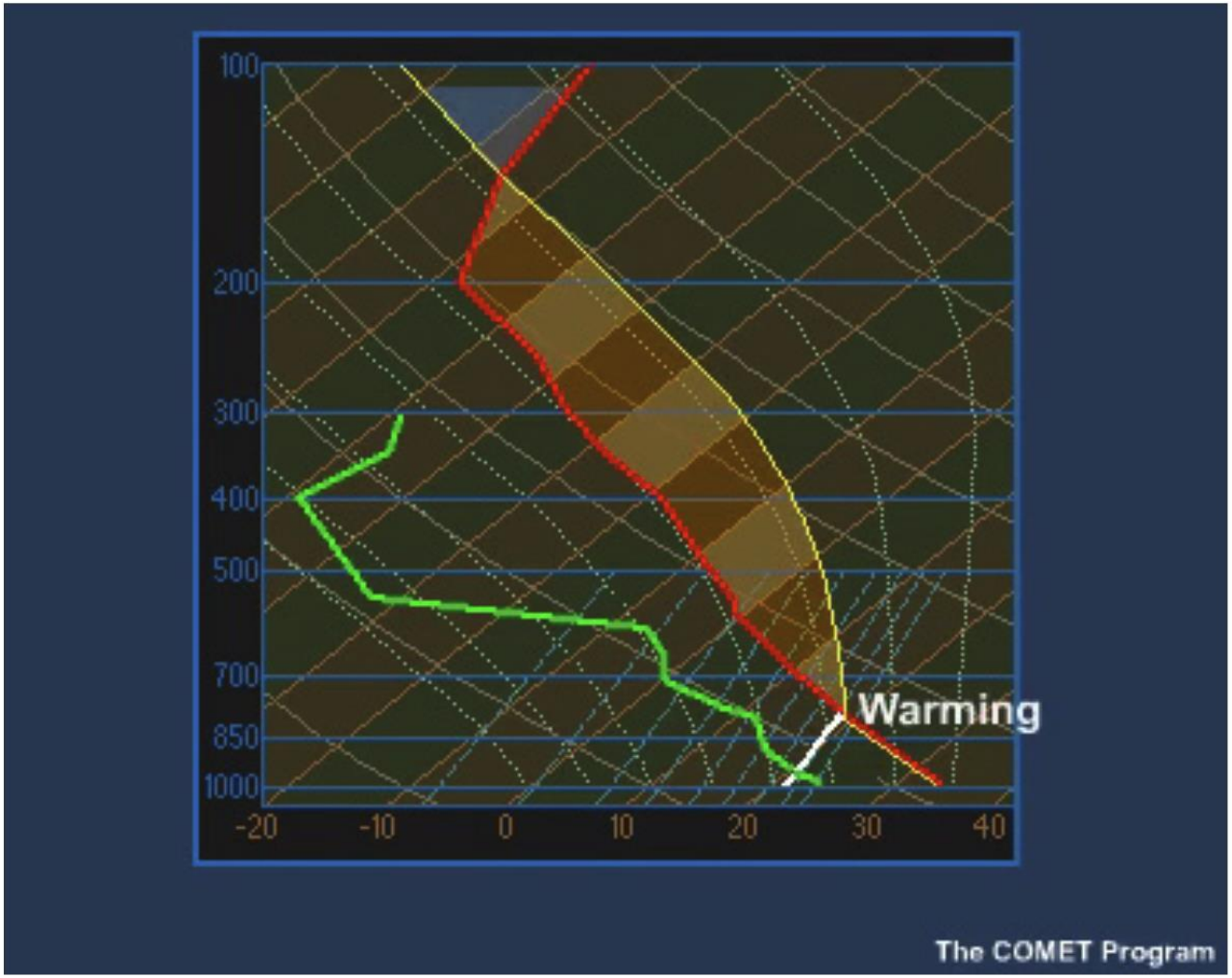
Effects of Entrainment and Water loading 1



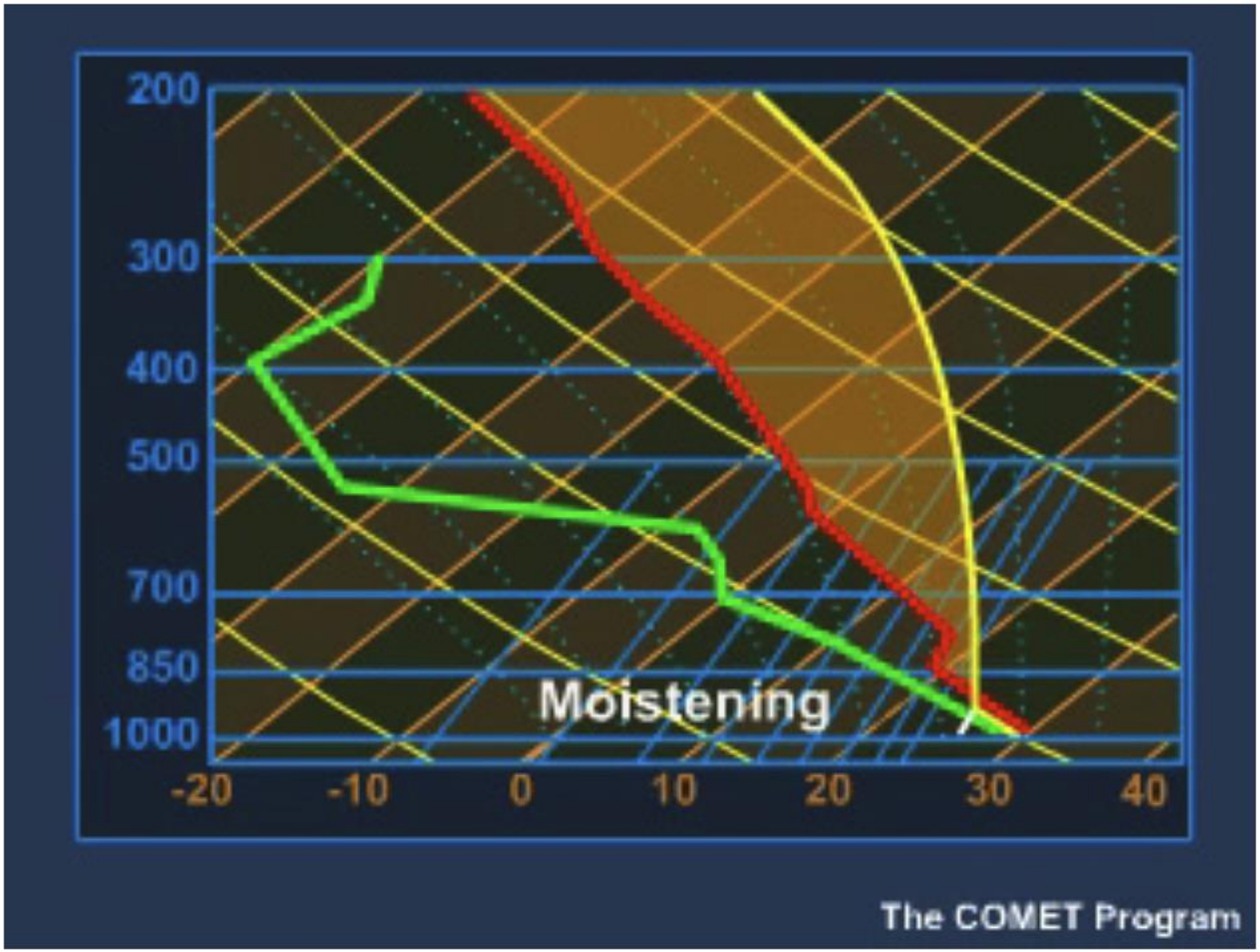
Effects of Entrainment and Water loading 2



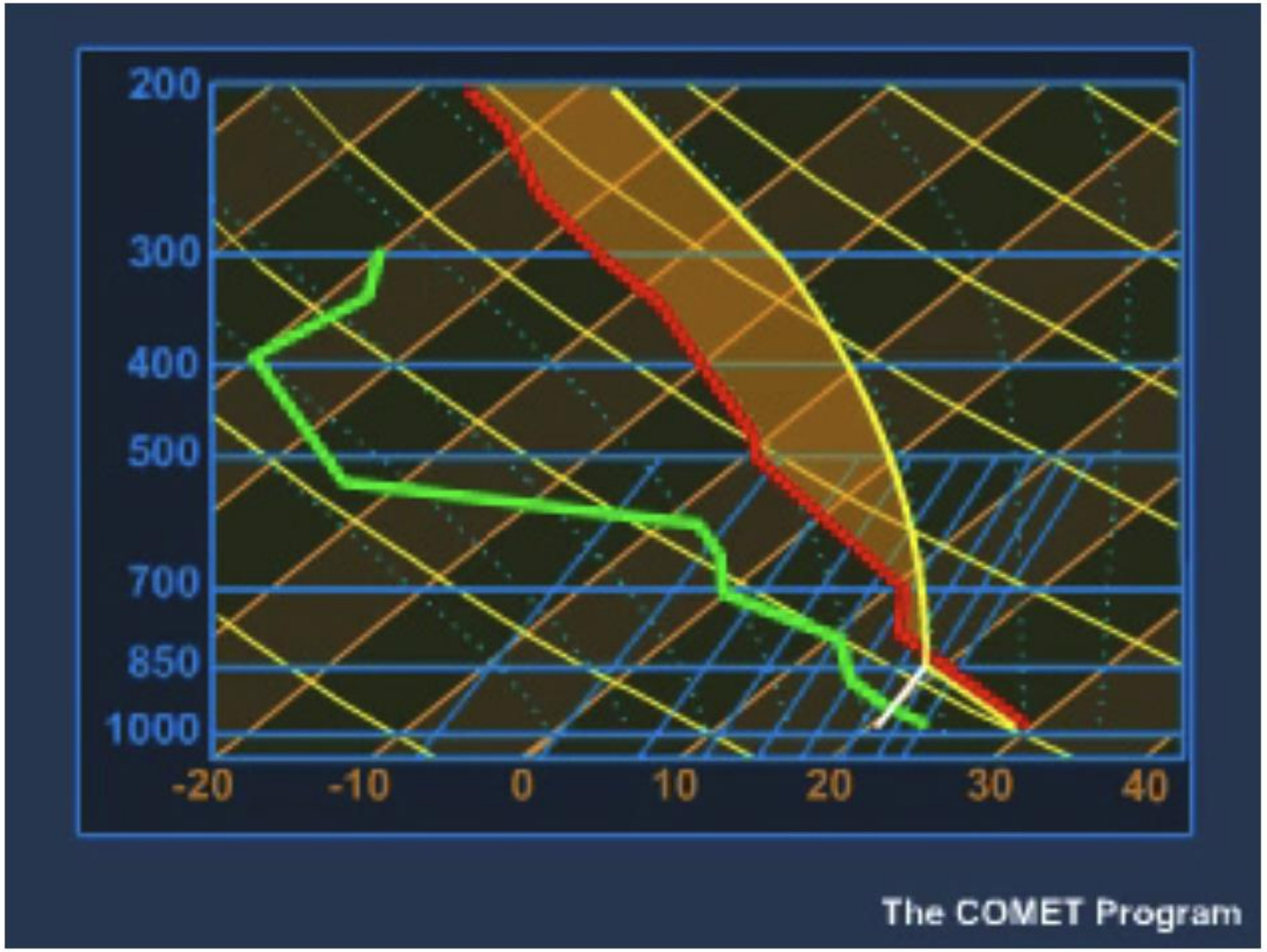
Overcoming CIN 1: warming



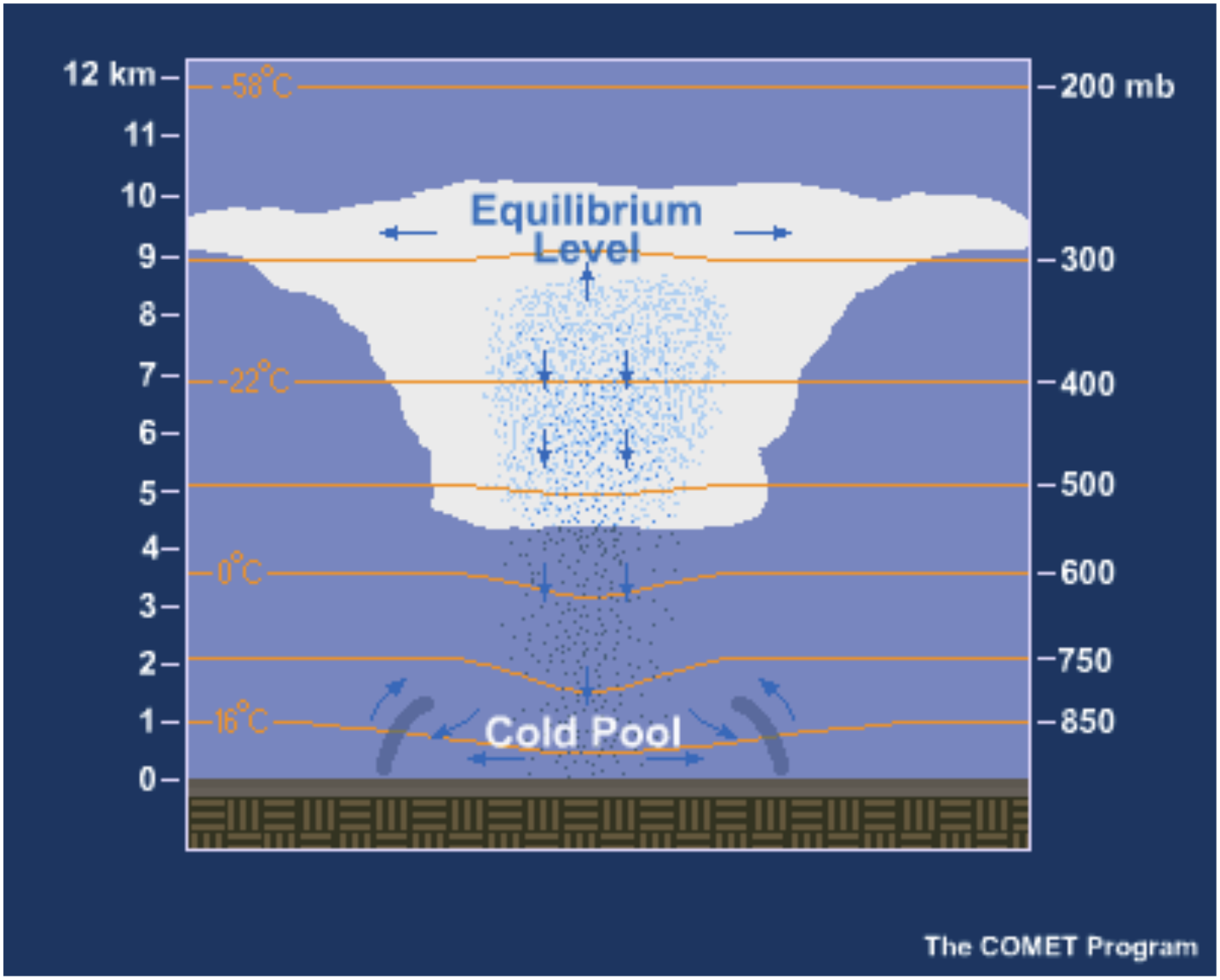
Overcoming CIN 2: moistening

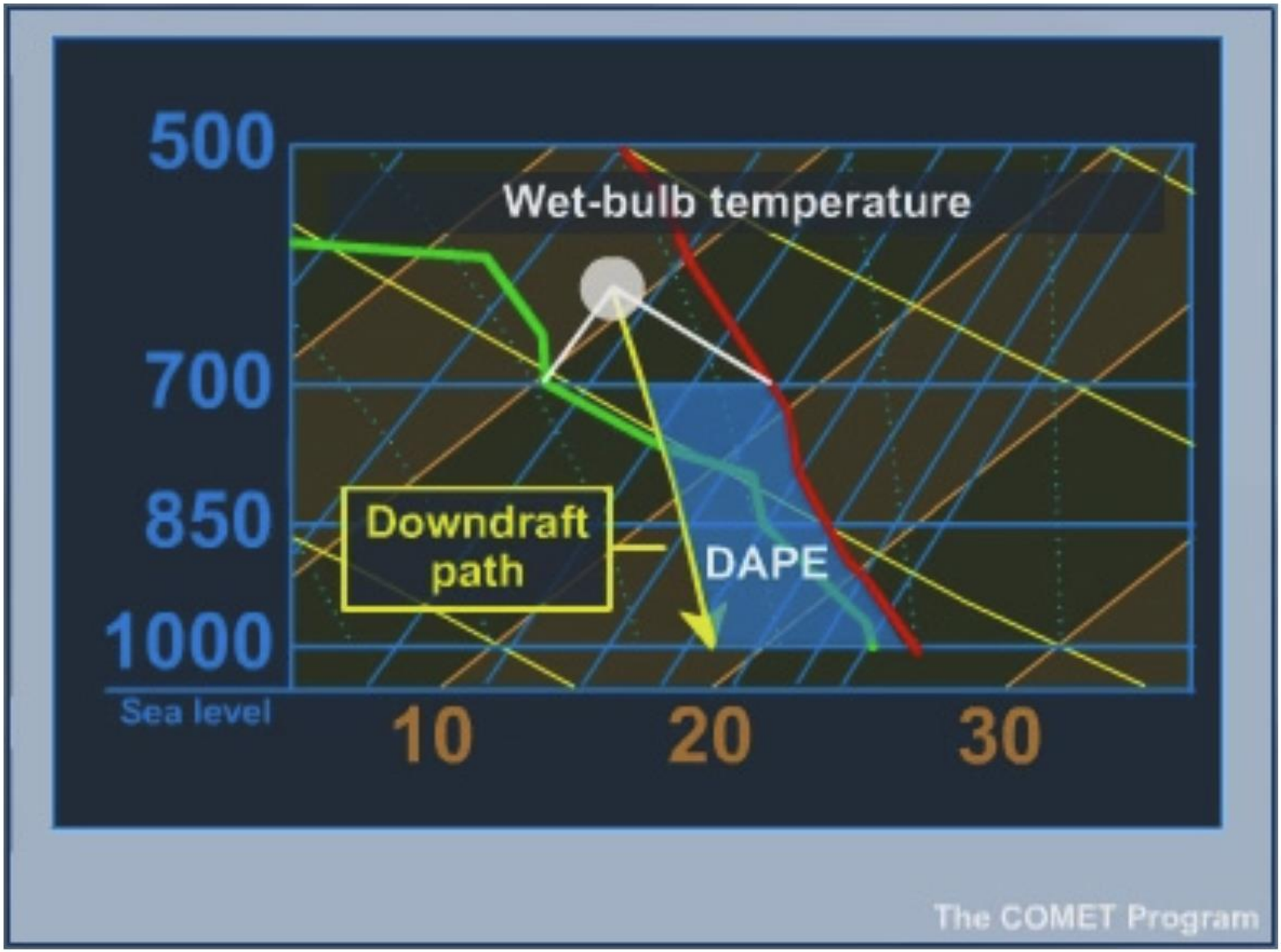


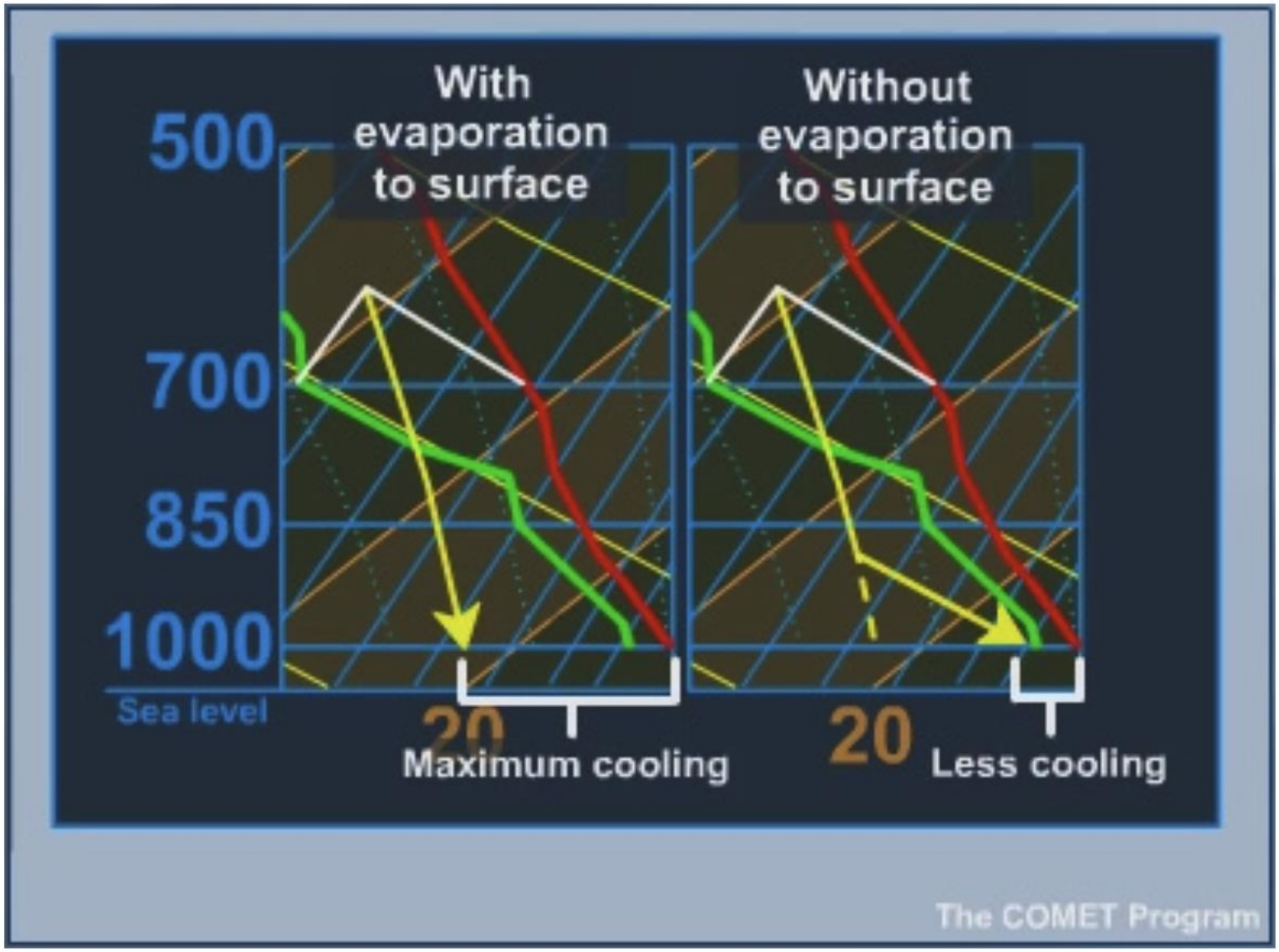
Overcoming CIN 3: synoptic lifting

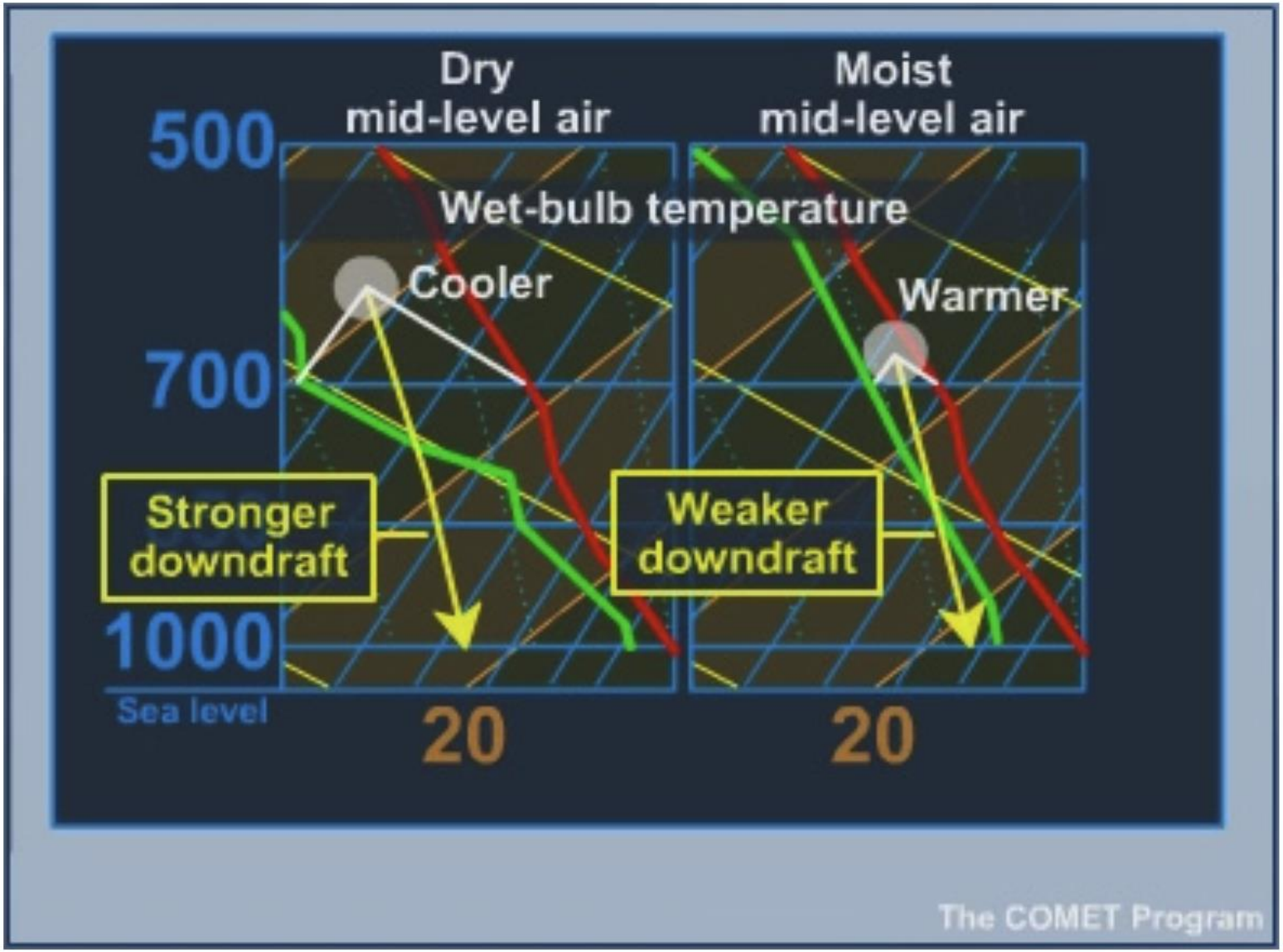


Downdraft Strength

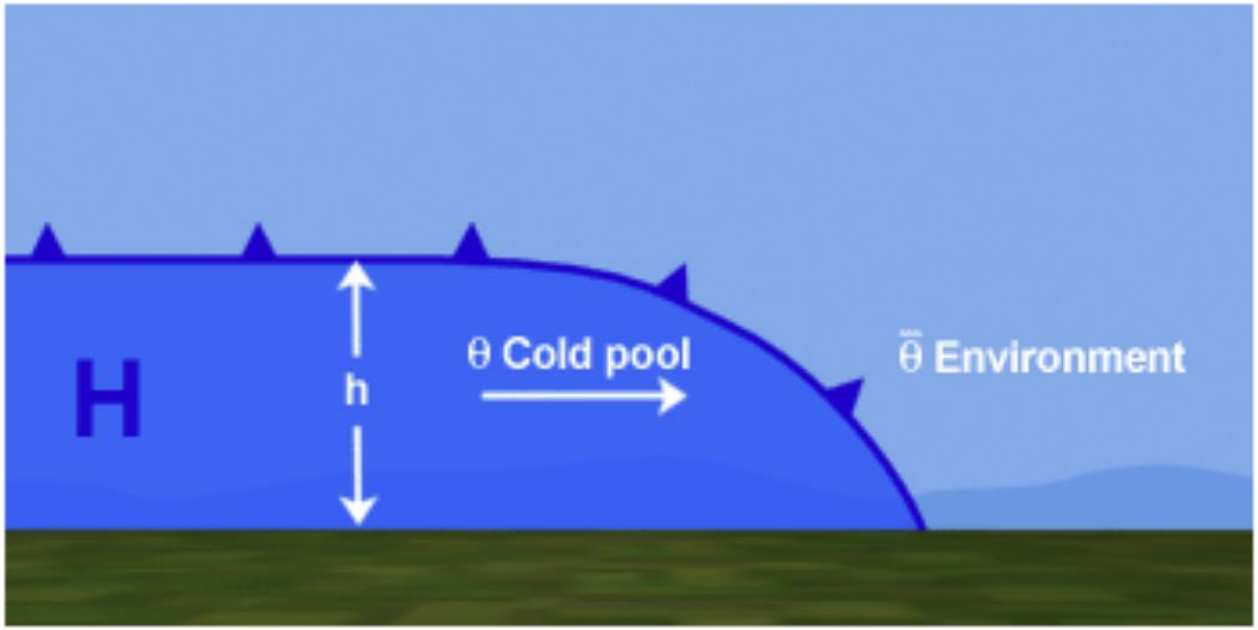



500
700
850
1000
Sea level
10
20
30
Wet-bulb temperature
Downdraft path
DAPE
The COMET Program


With evaporation to surface
Without evaporation to surface
500
700
850
1000
Sea level
20
Maximum cooling
20
Less cooling
The COMET Program


Dry
mid-level air
Moist
mid-level air
500
Wet-bulb temperature
Cooler
Warmer
700
Stronger
downdraft
Weaker
downdraft
1000
Sea level
20
20
The COMET Program

Cold Pool Strength

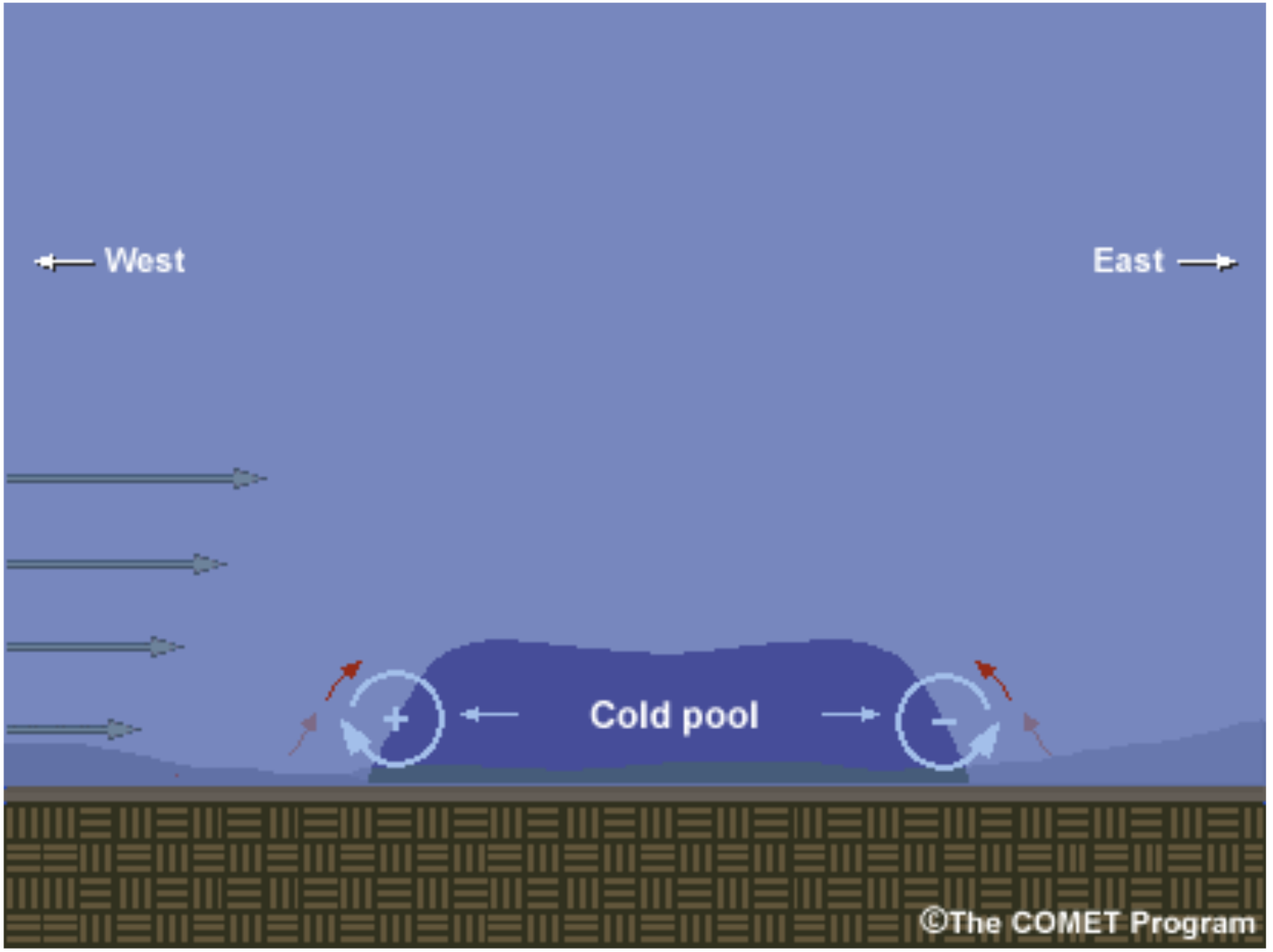


The COMET Program

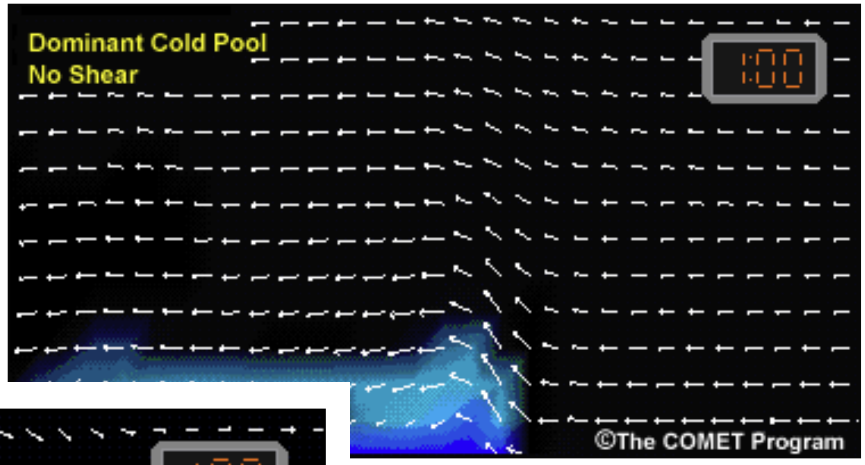
Cold pool propagation speed depends on

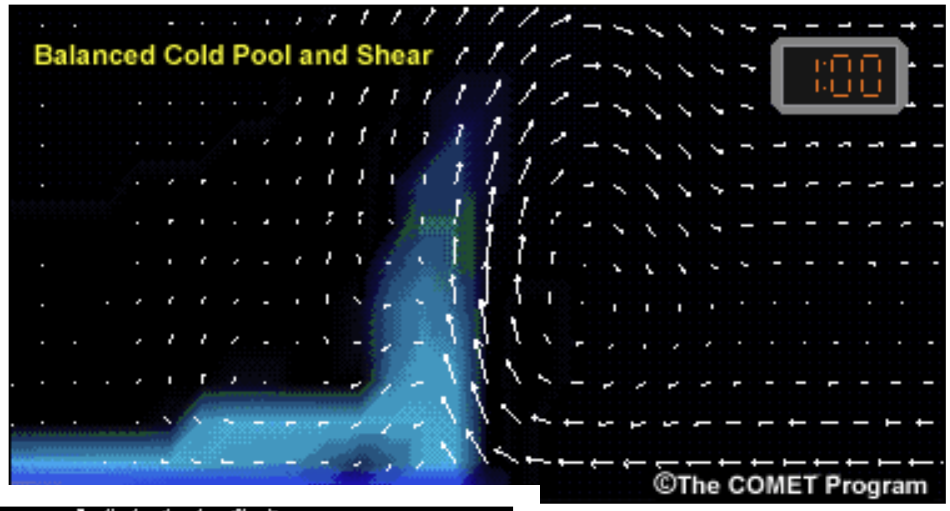
1) depth
2) temperature difference

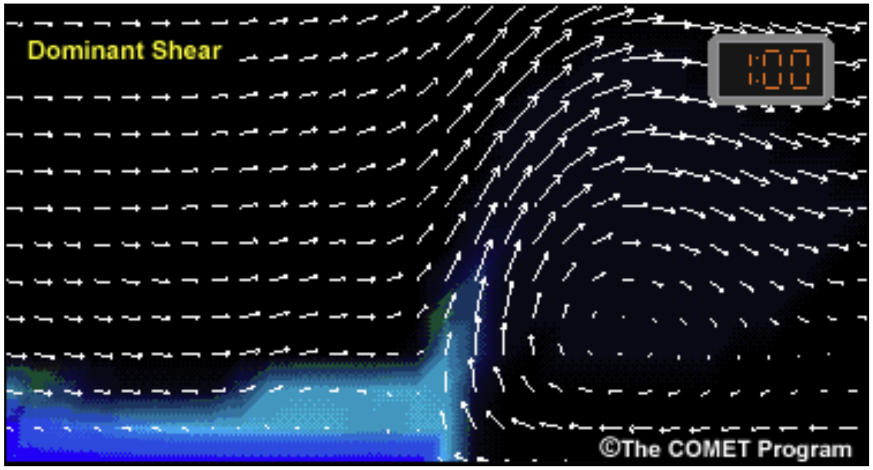
What if there exists vertical wind shear?



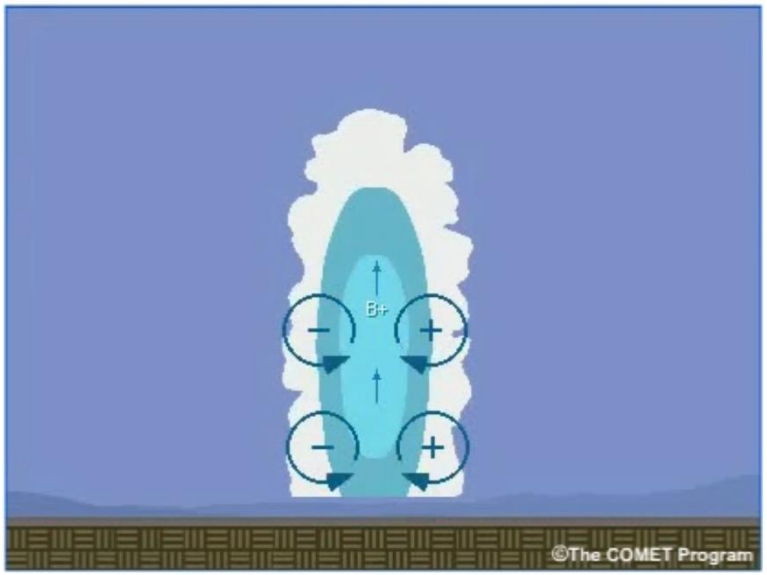
Modeling Cold Pool/Shear Interactions

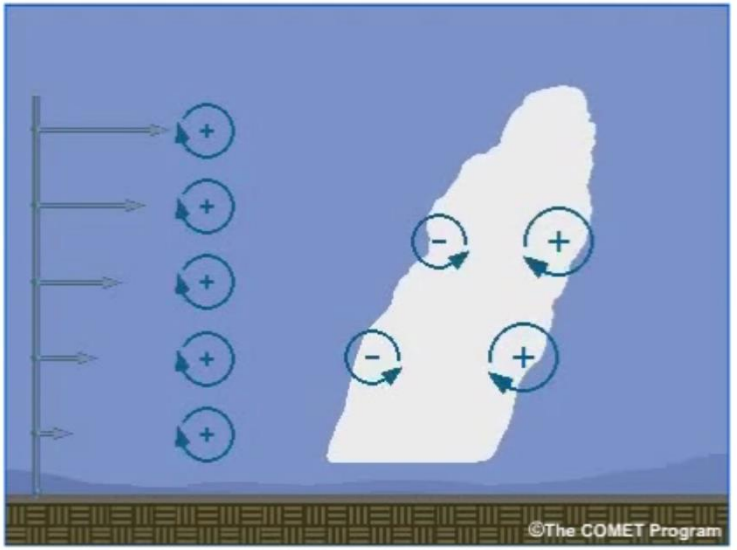




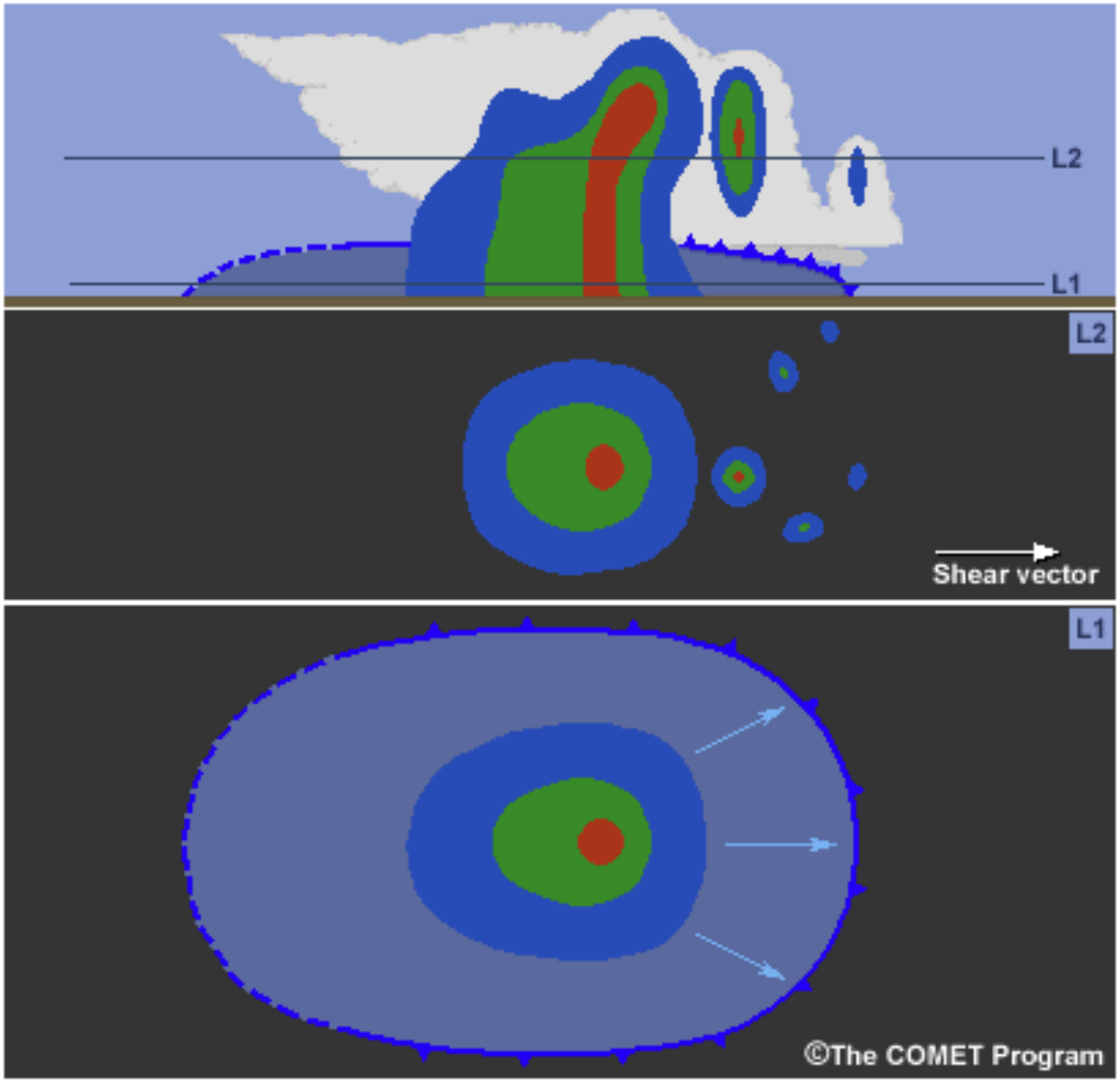


Horizontal Vorticity and Updraft Tilt





Shear and Multicell Structure

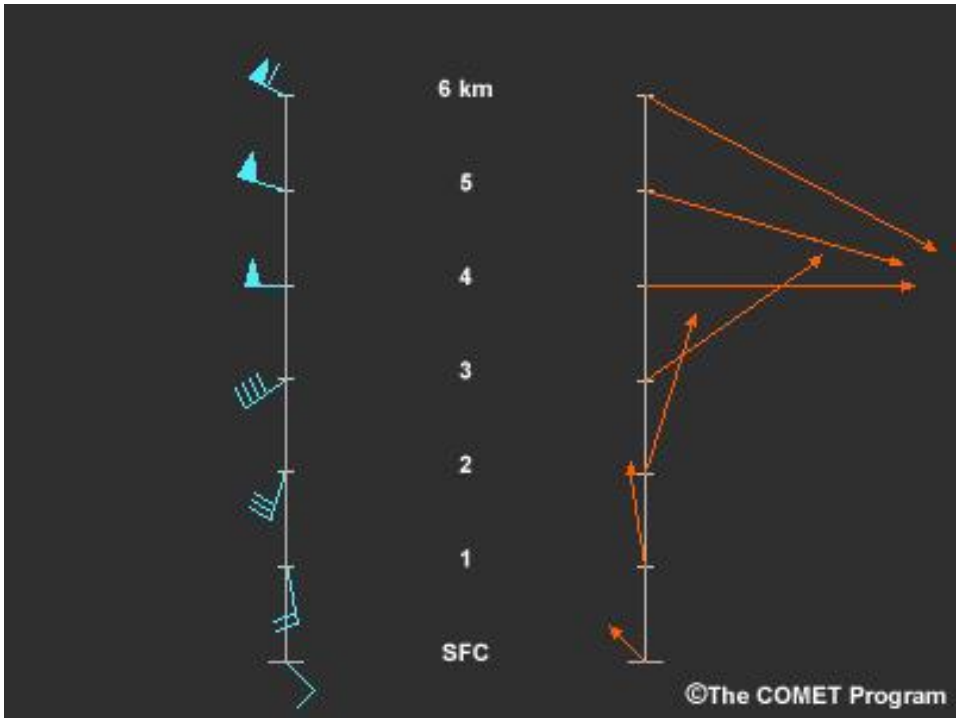


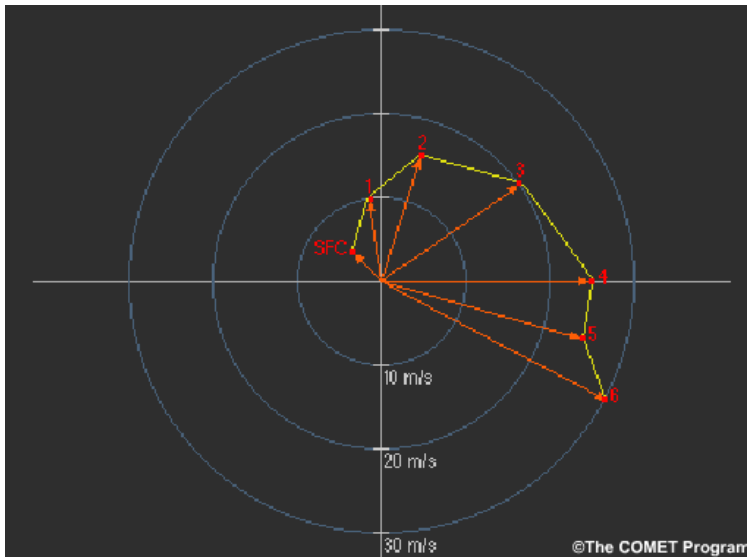
Hodograph

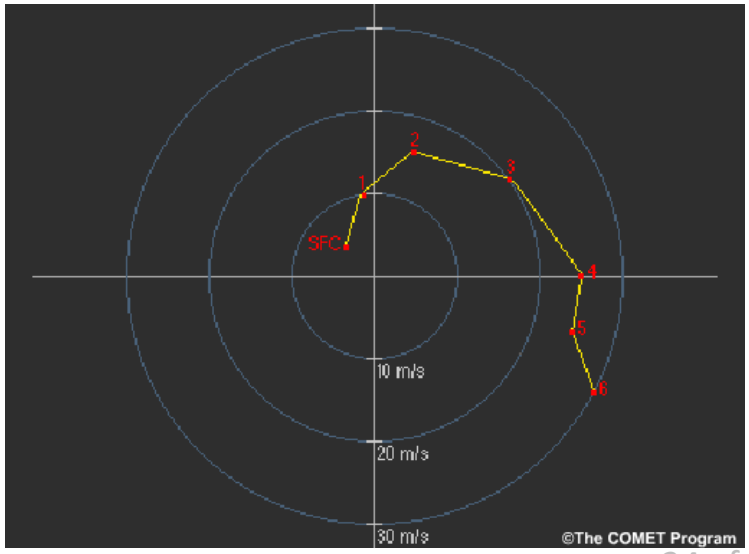
- A tool that helps to evaluate environmental vertical wind shear
- Vertical wind shear
  - Variation of horizontal wind vector with height
  - May determine
    - Where new storms may form
    - The likelihood of supercell storms
    - Storm motion
- Focus on estimation of
  - total shear, mean shear, and mean wind

How to produce a hodograph?

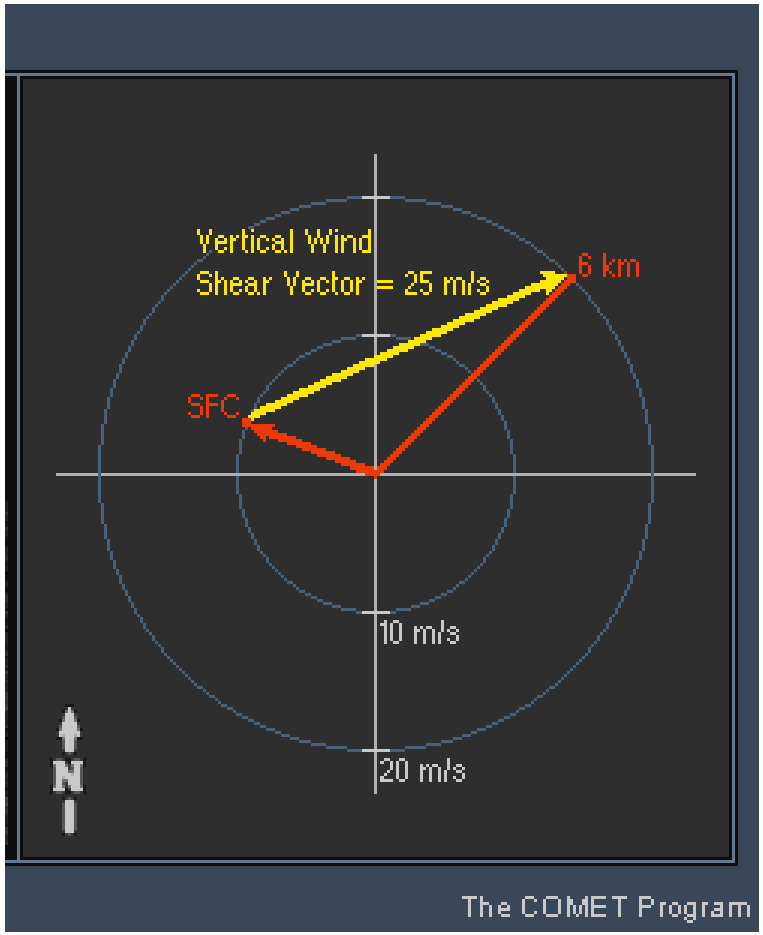
1. Convert wind barbs to wind vectors
2. Plot all wind vectors on a polar coordinate chart
3. Connect the end points of the wind vectors in sequence of increasing height







Vertical Wind Shear

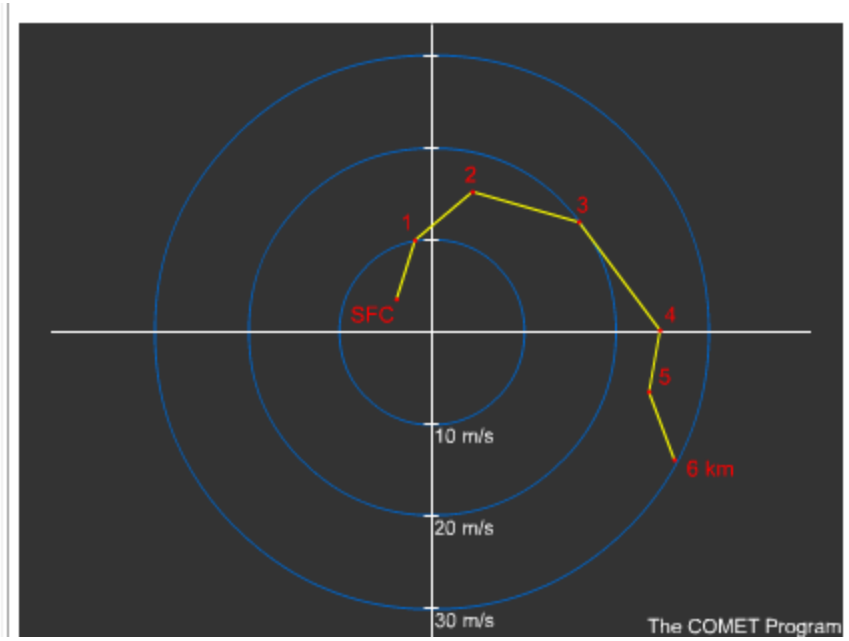


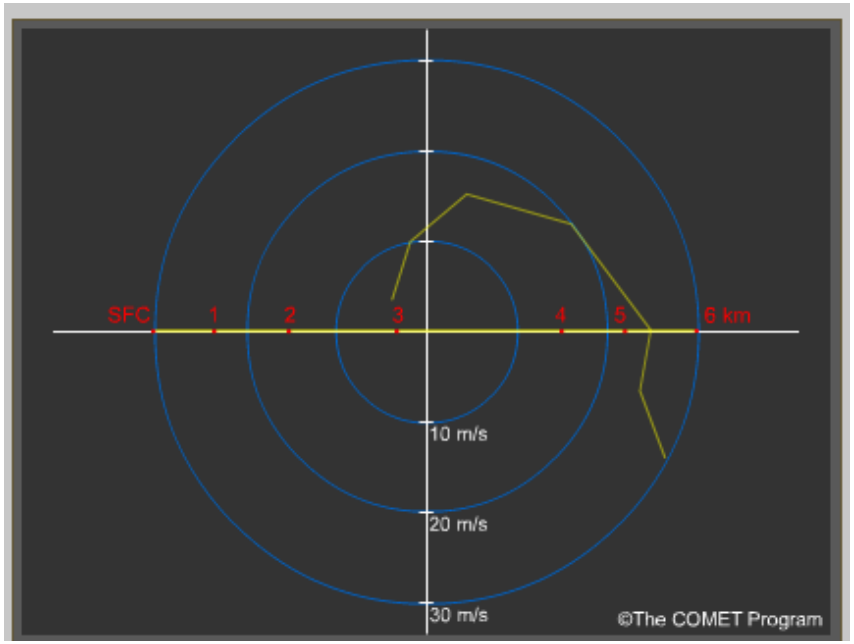
25 m/s over 6 km

0.004 s^{-1}

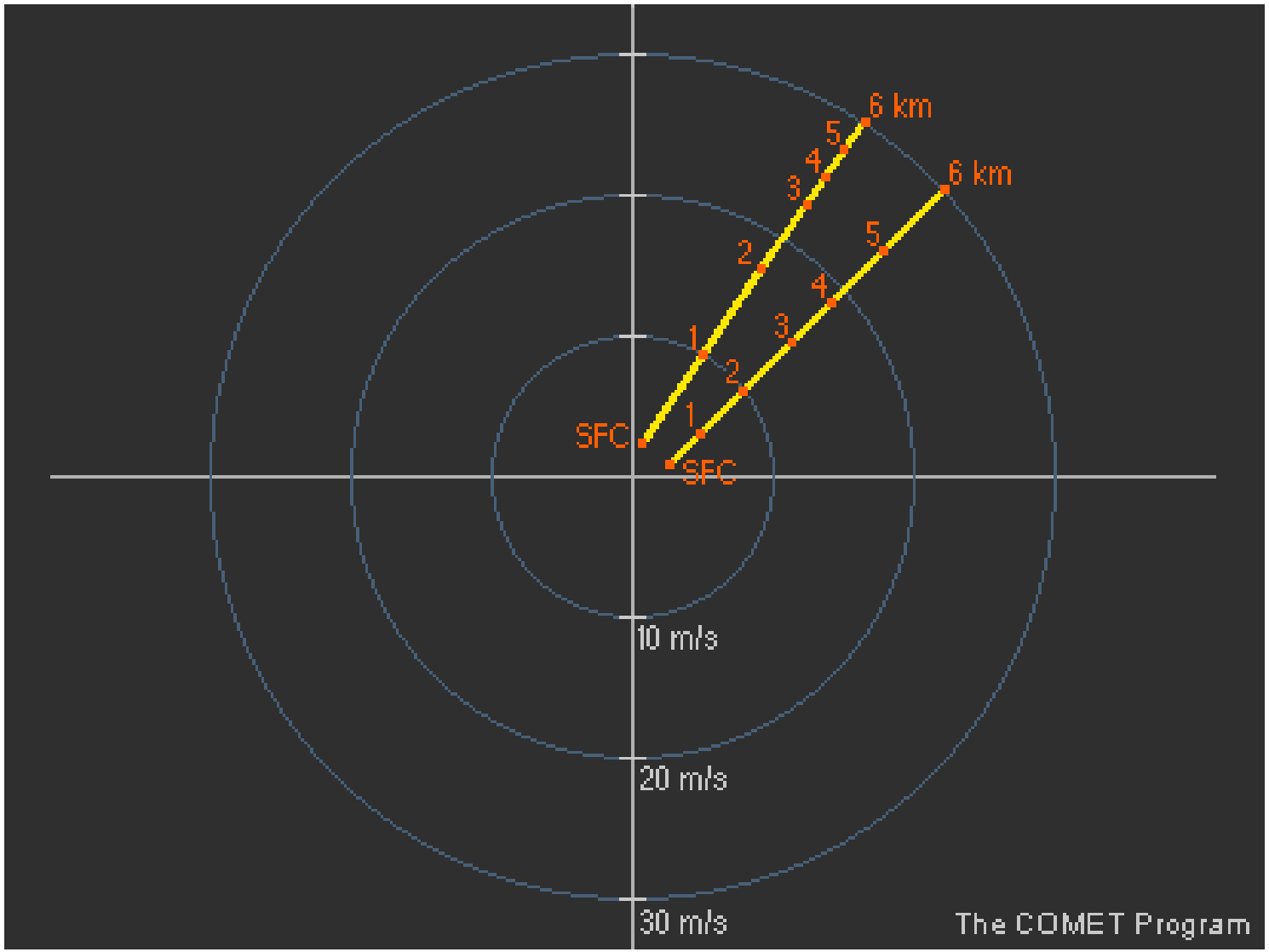
Total shear magnitude

- The net length of the hodograph

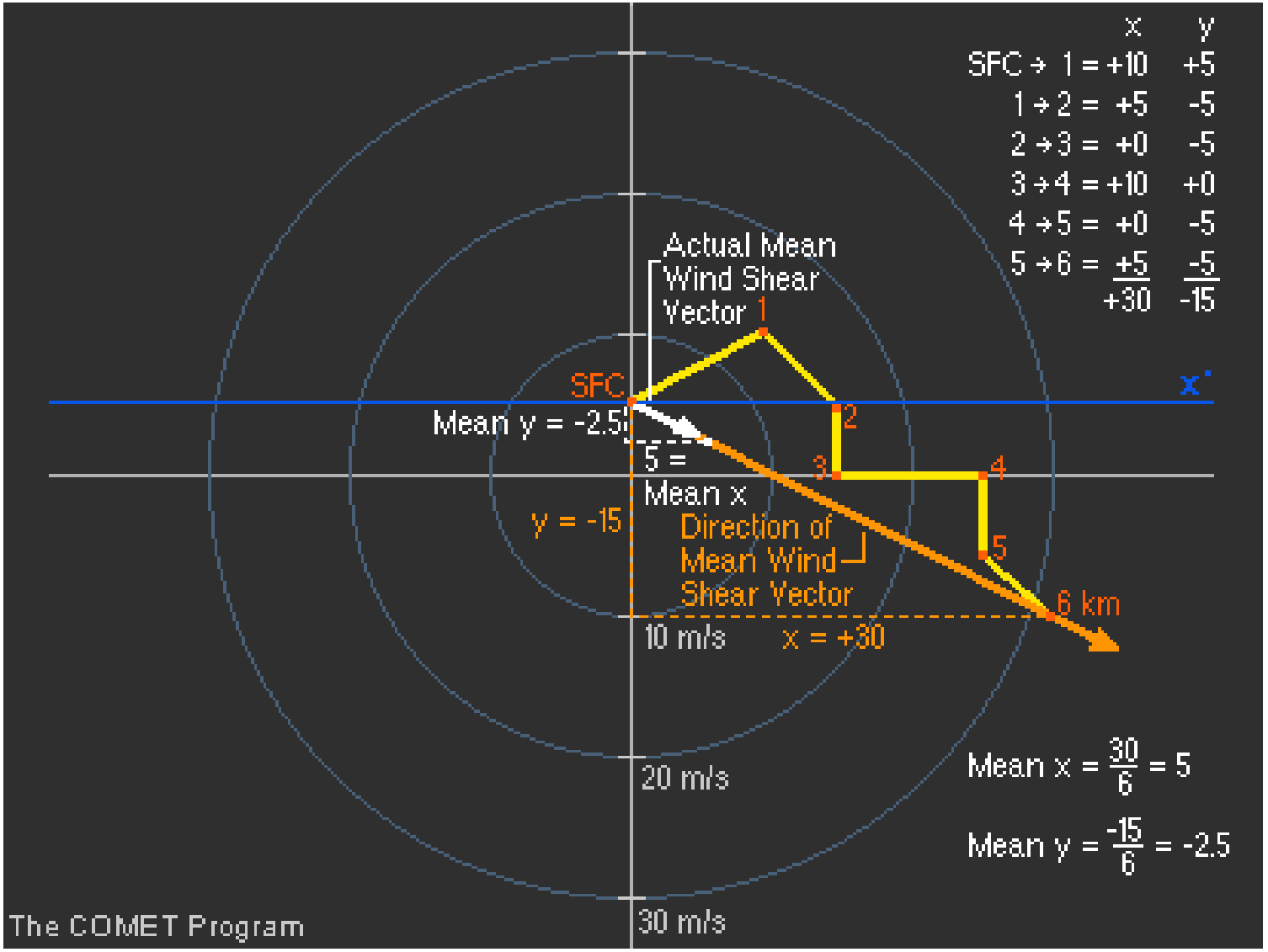




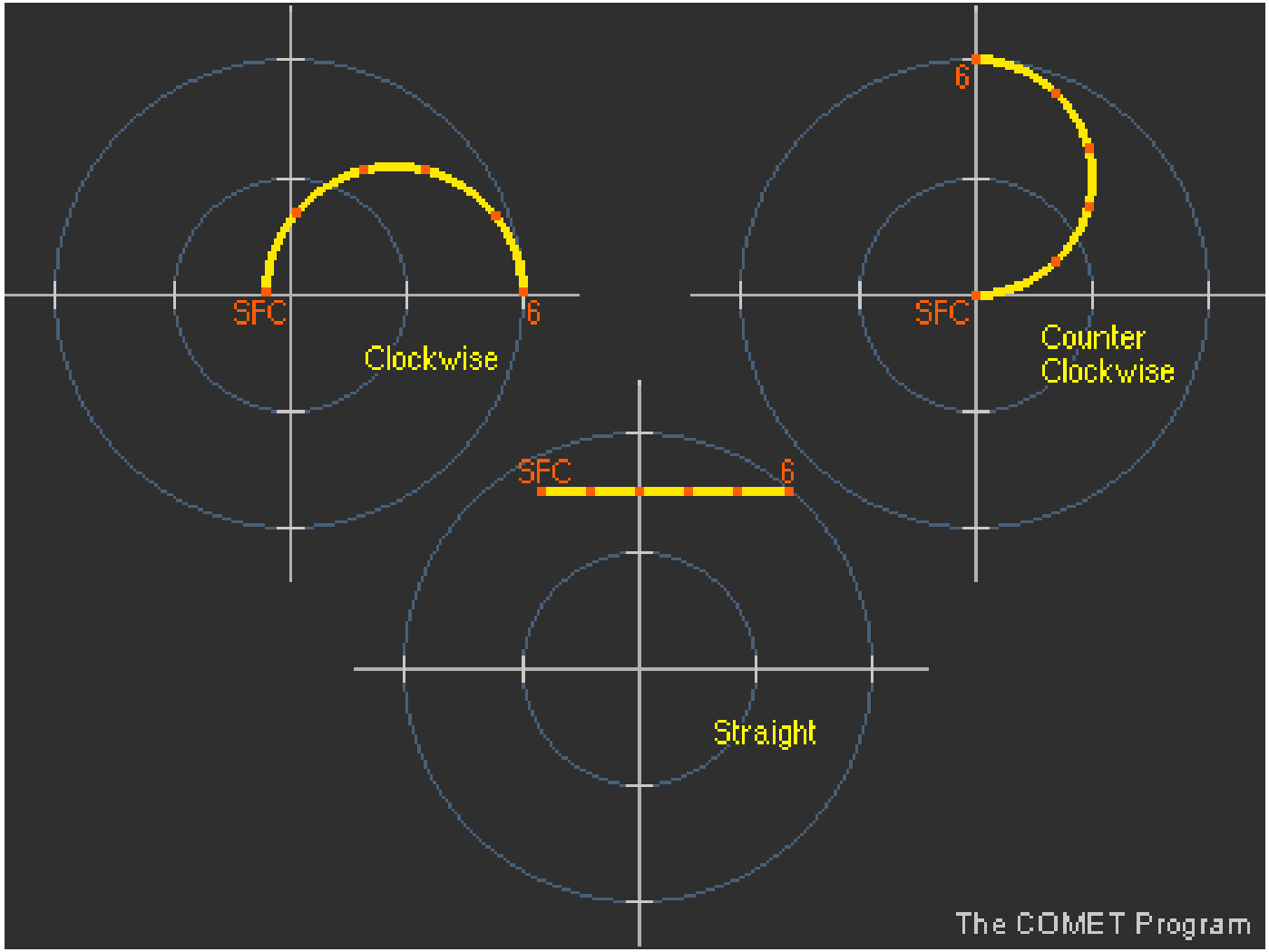
Shear distribution

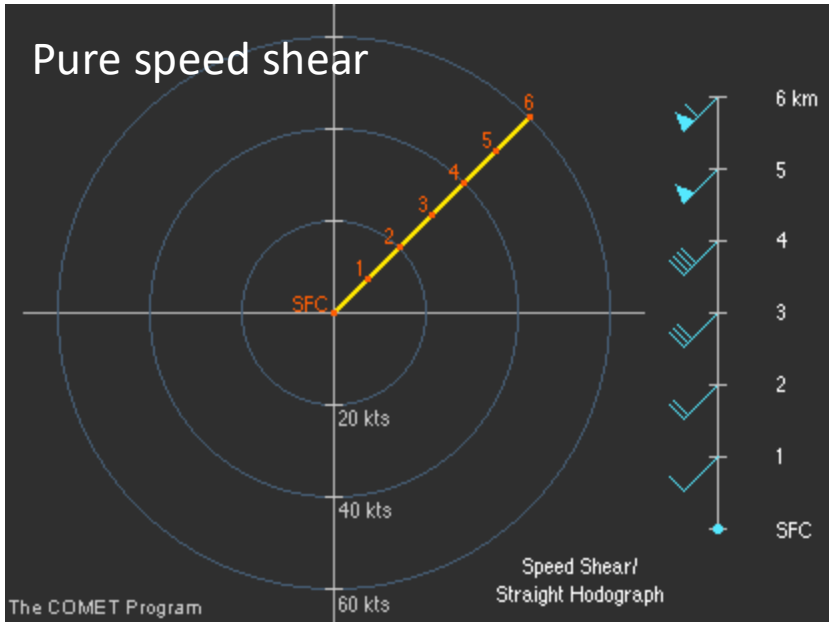


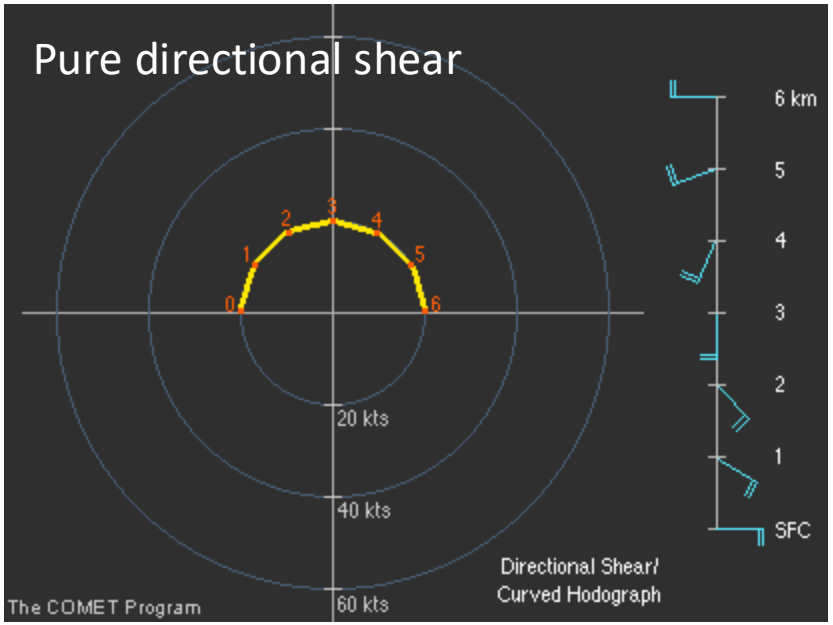
Mean wind shear vector



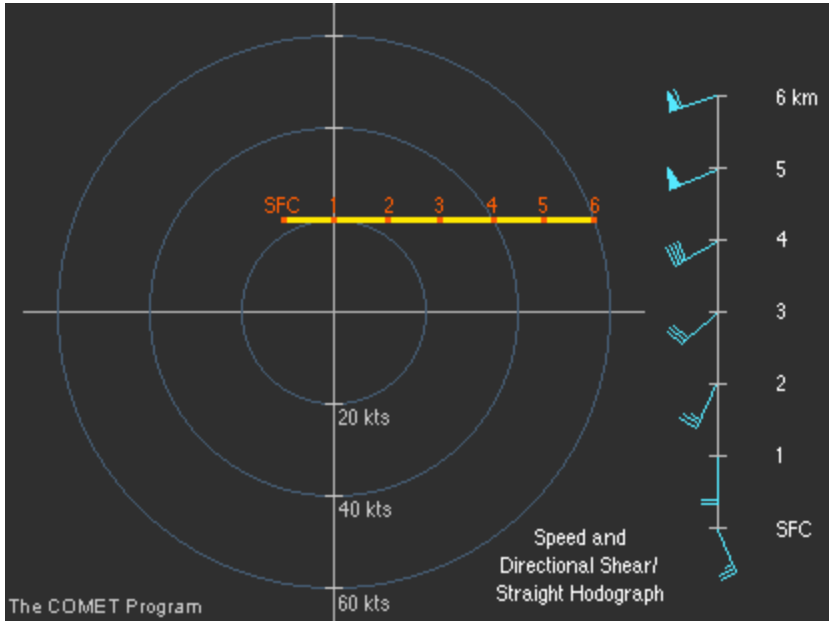
Hodograph shape

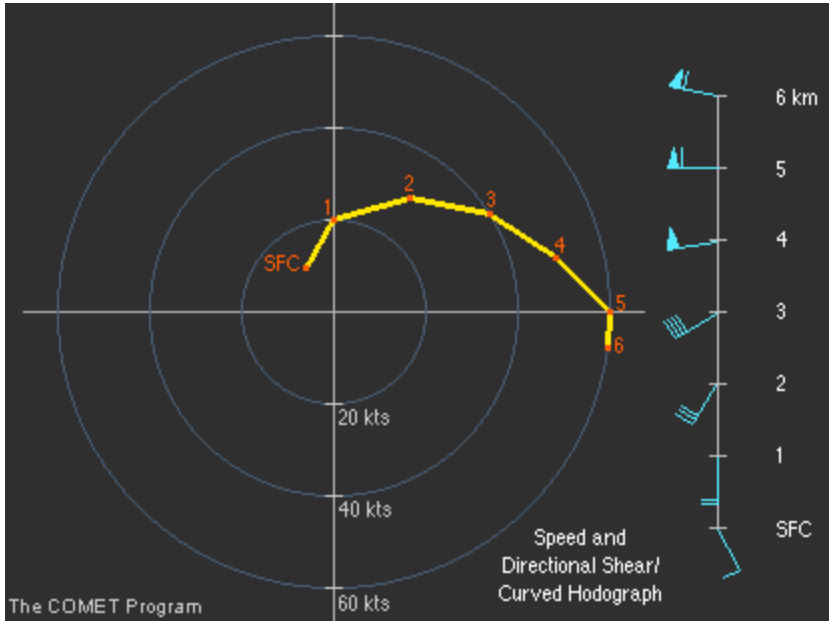


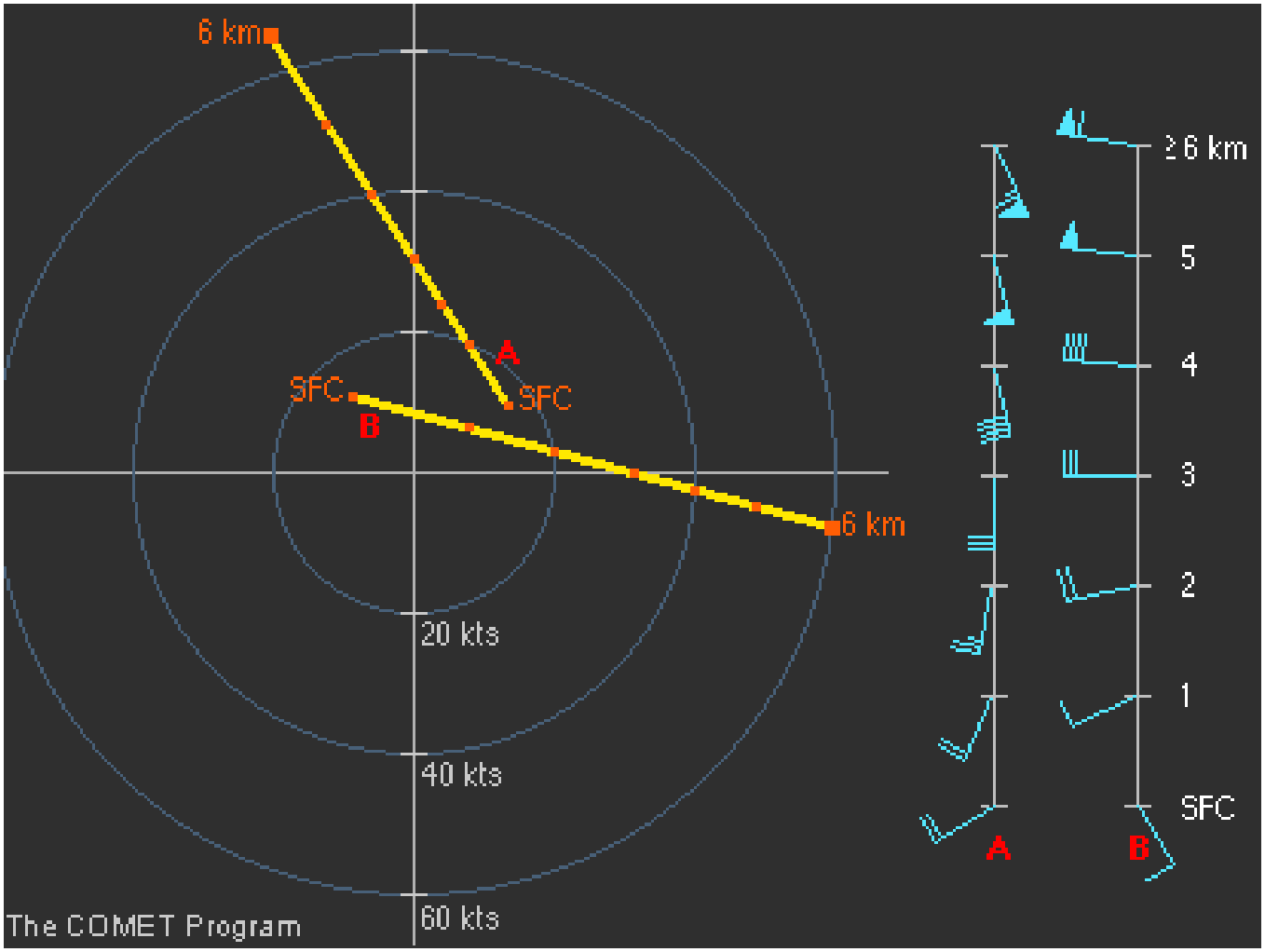




A mix of speed and directional shear may reasult in any shape

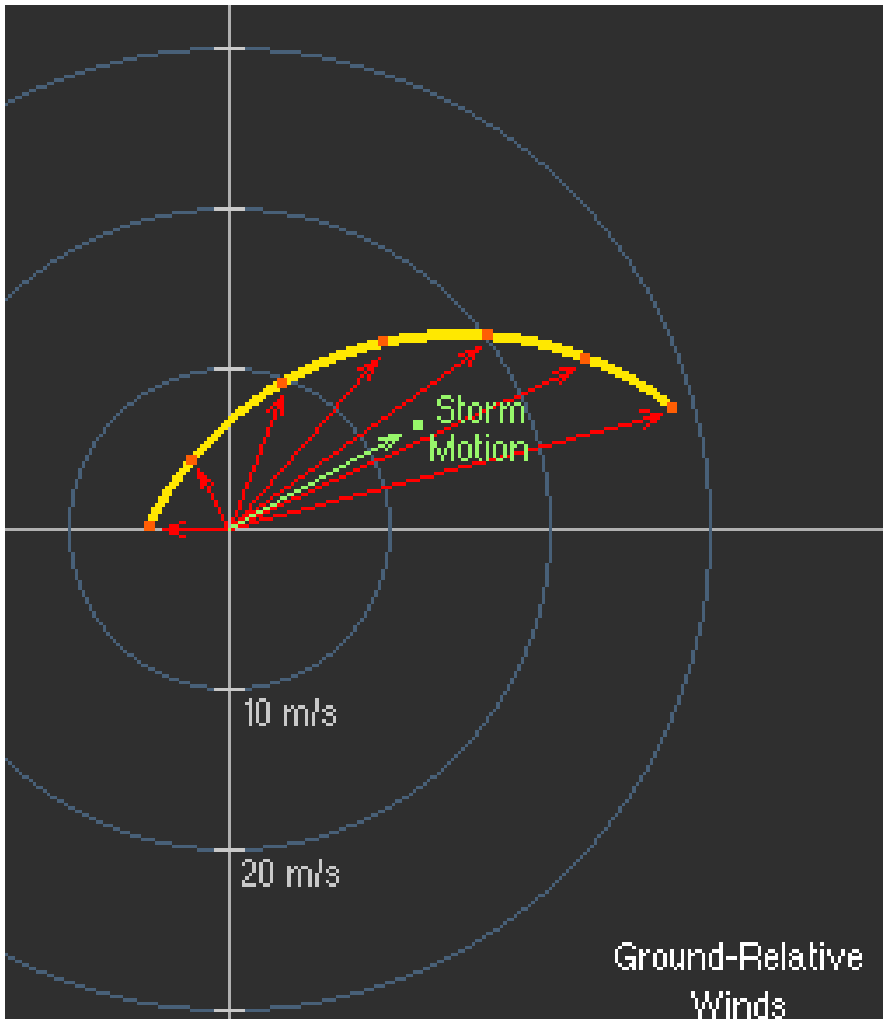


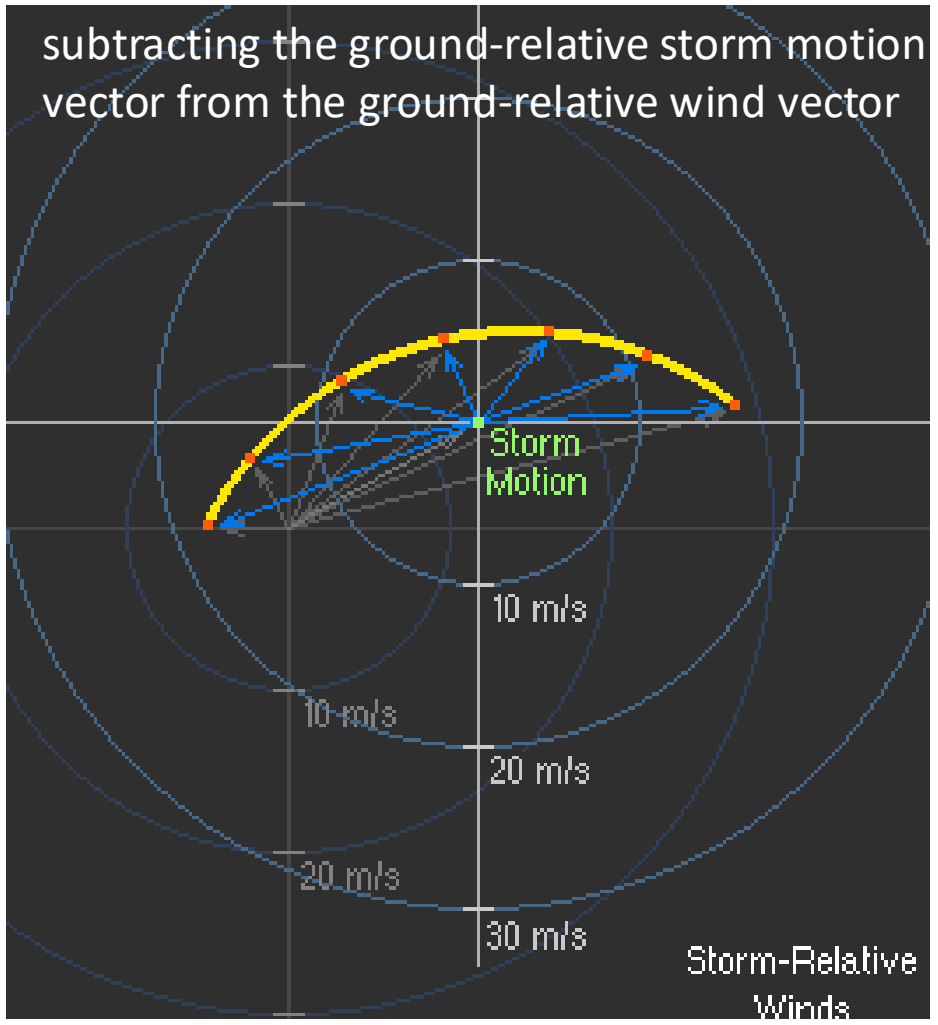




While similarly shaped hodographs may affect convective storm evolution in similar ways, their implications for larger-scale processes and for convective potential may differ substantially.

Storm Motion & Storm Relative Wind



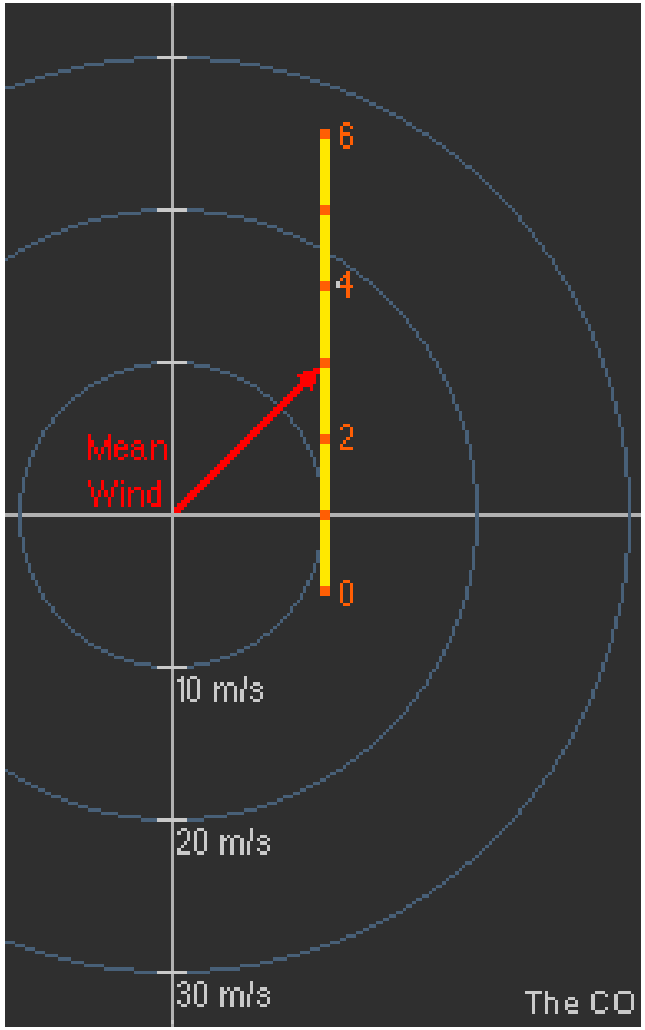


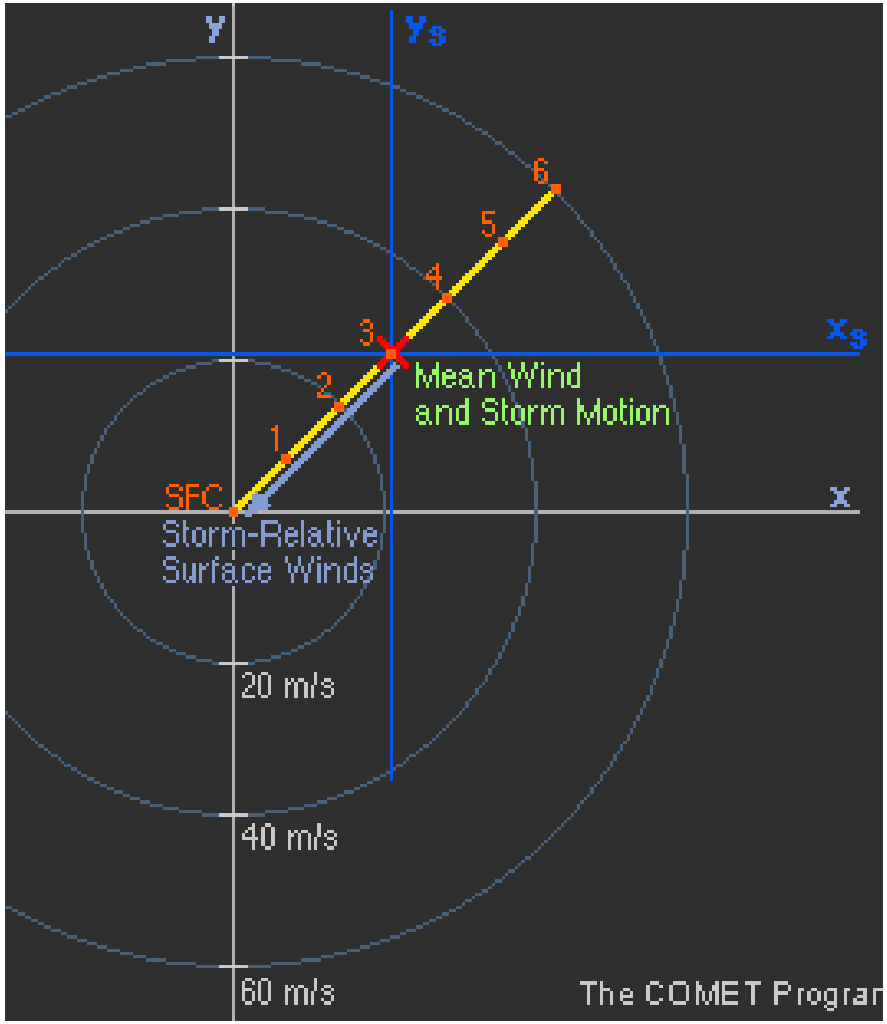
Storm relative Winds are to analyze the nature of the air making up the storm's inflow
It is the wind the storm experiences while it is moving in its environment
Often very different from the ground-relative winds

Determining Storm Motion

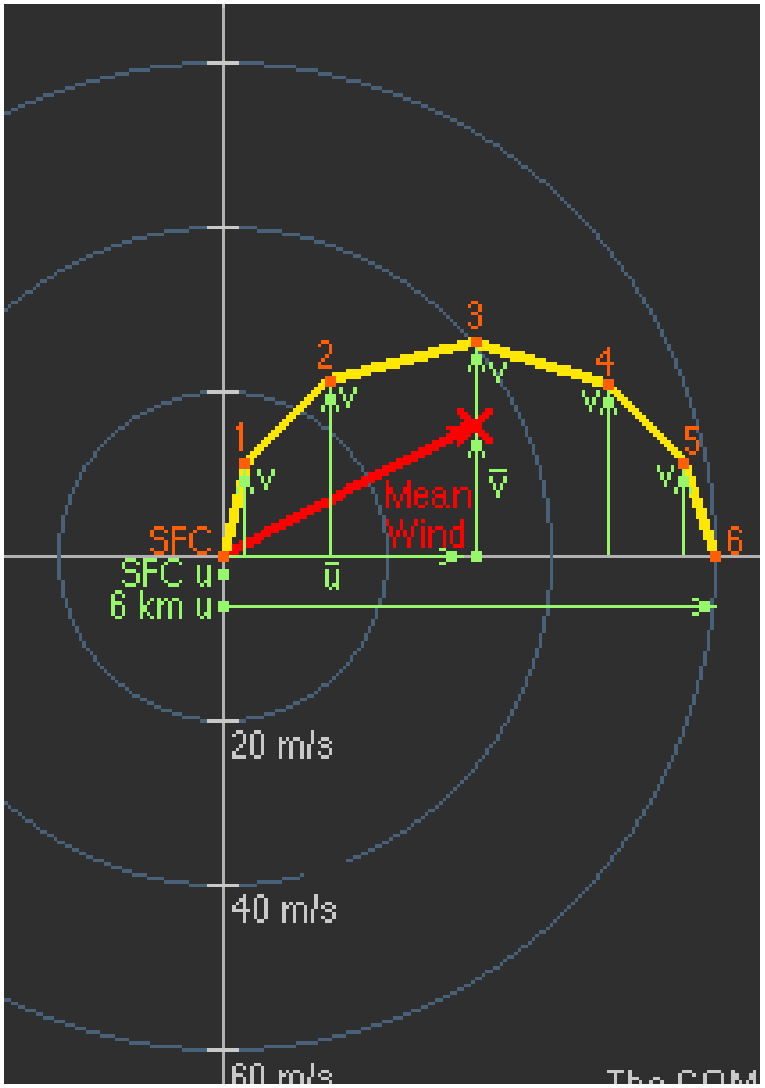
- Anticipate storm motion before storms exist or before the motion is apparent in the imagery,
- Assume that the storm will move with a velocity close to that of the mean wind through the depth of the storm.
- Model result and observations suggests the storm motion is the most sensitive to the wind at lower levels
- We use 0-6 km mean wind to estimate storm motion vector

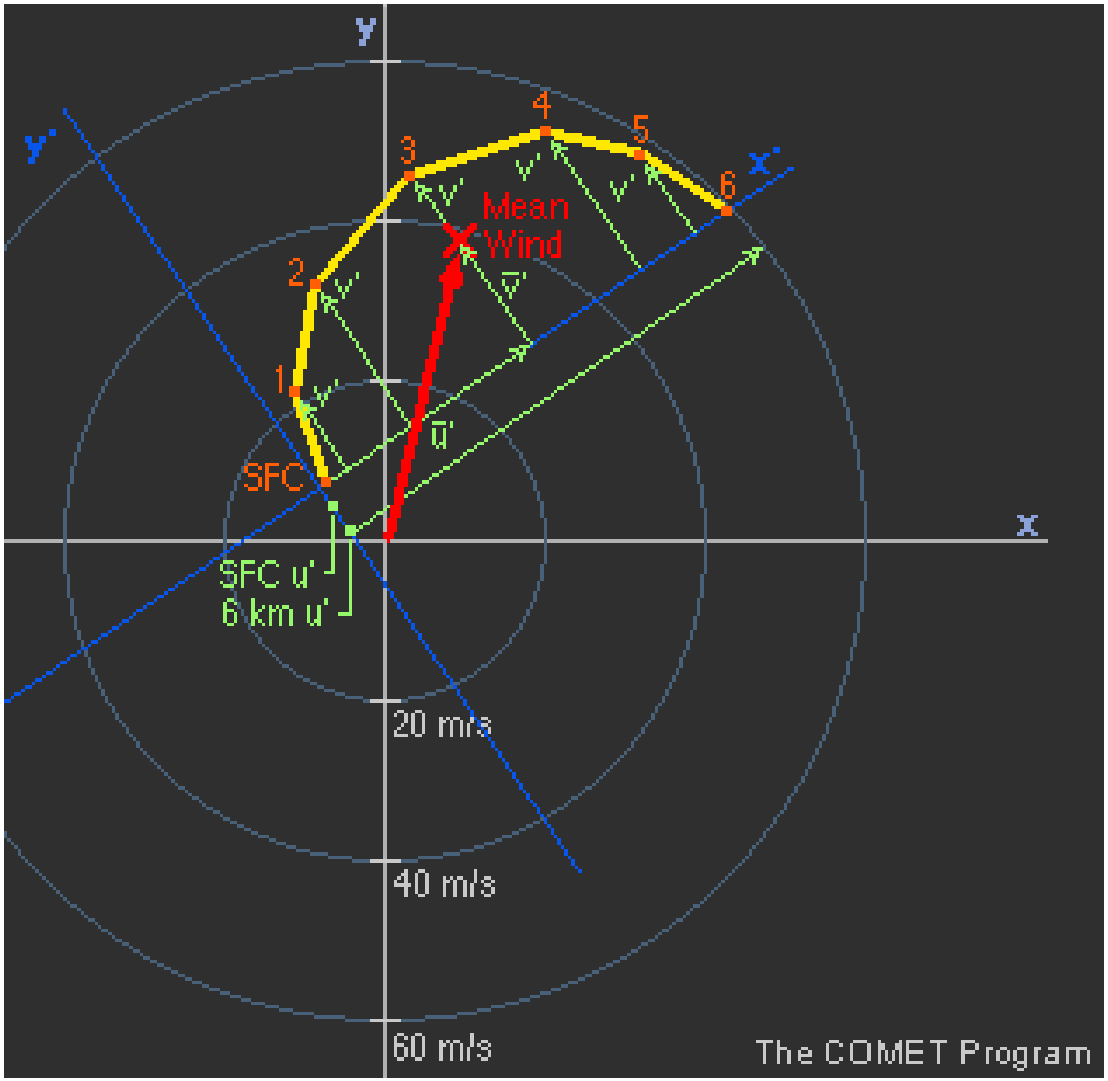
Estimating Storm Motion: Straight Hodograph





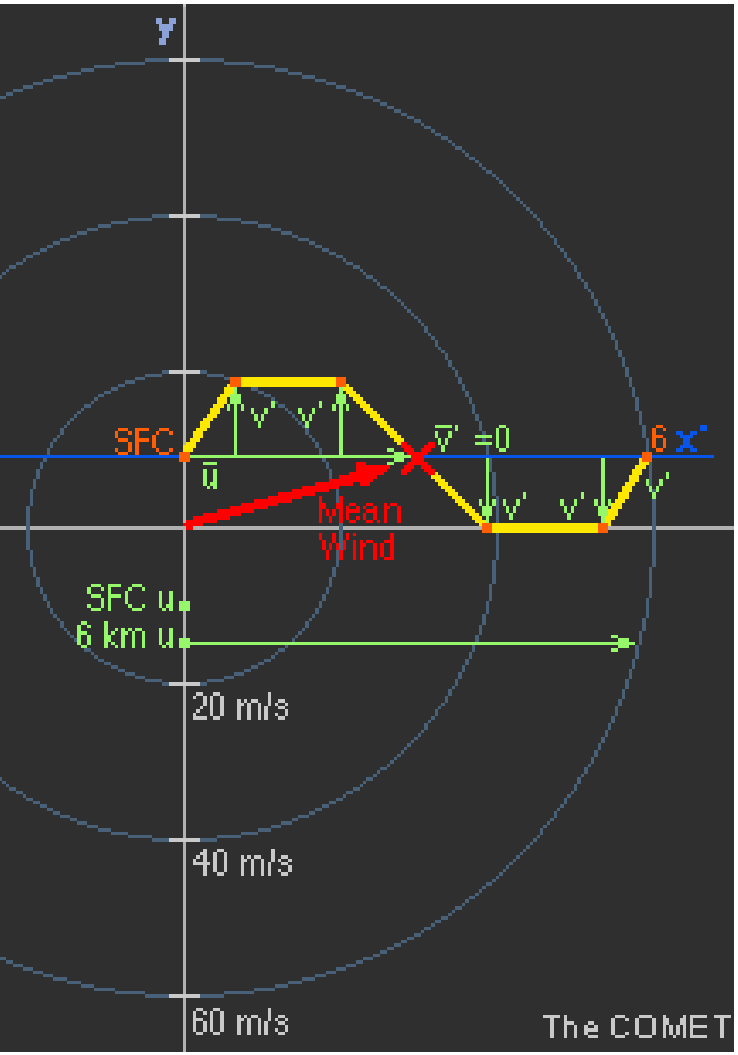
Estimating Storm Motion: Curved Hodograph

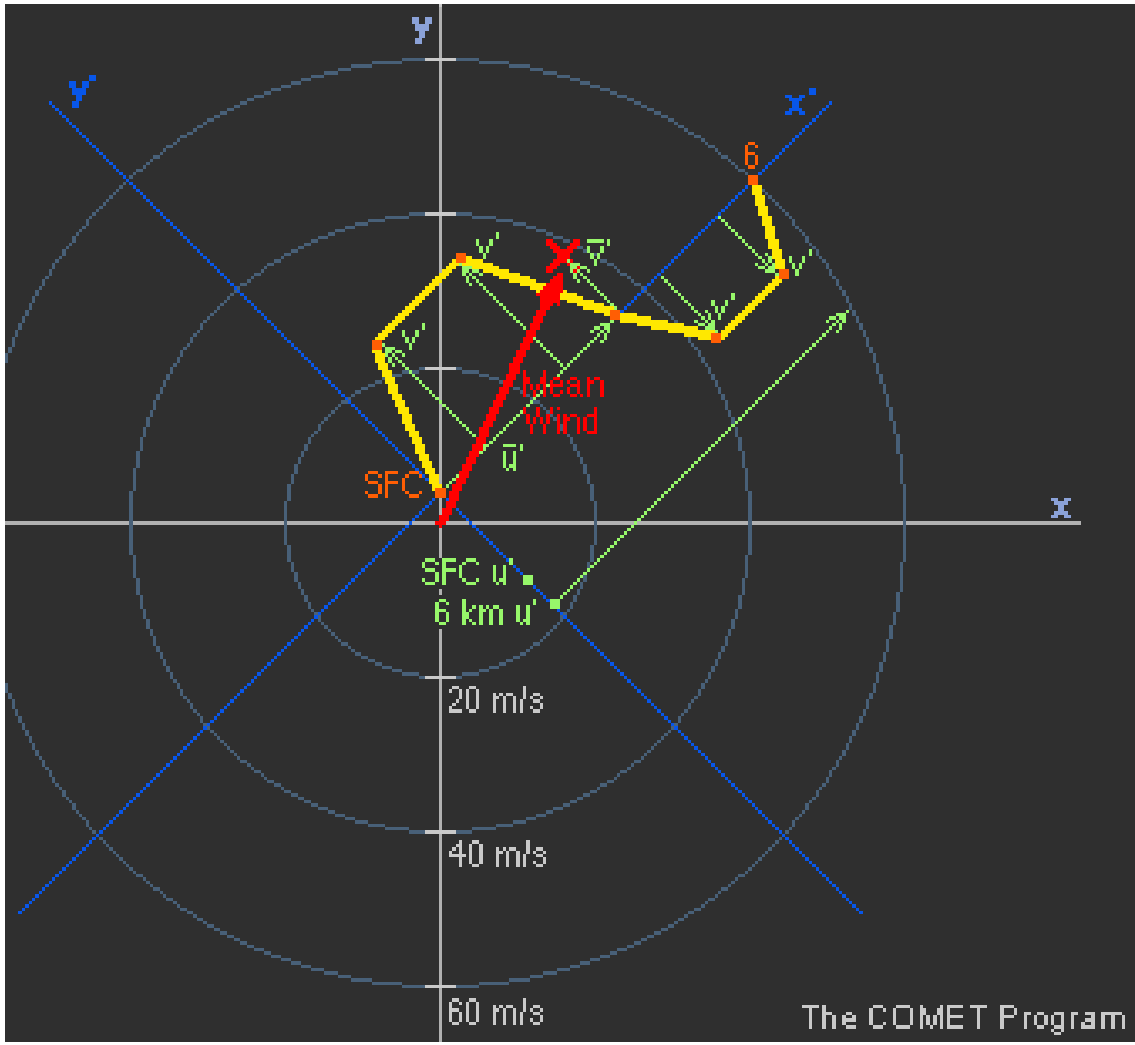




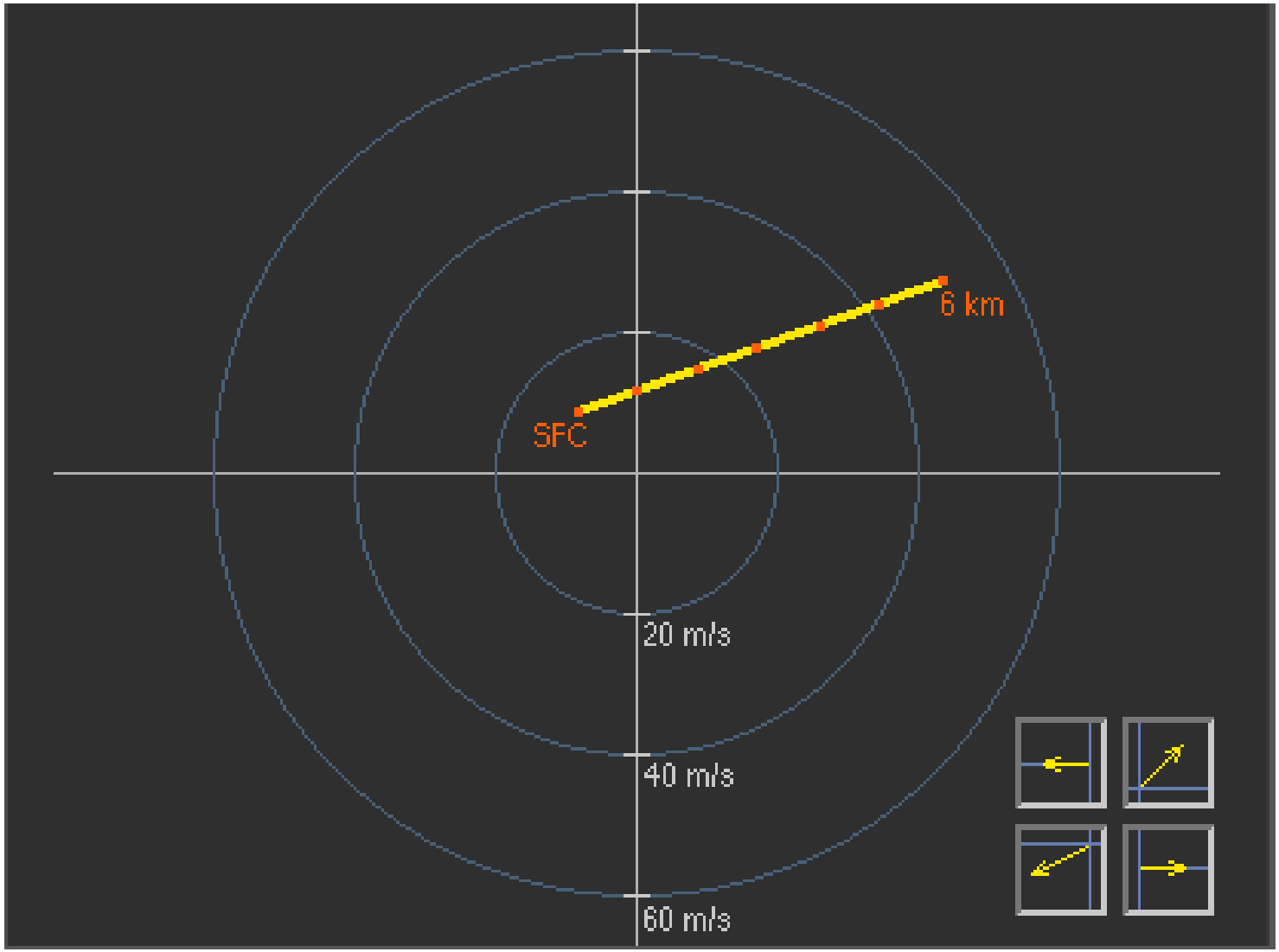
We average just the surface and 6-km (20-kft) winds. This assumes a fairly symmetric spacing of the winds along the hodograph

Estimating Storm Motion: Multiple Curved Hodograph

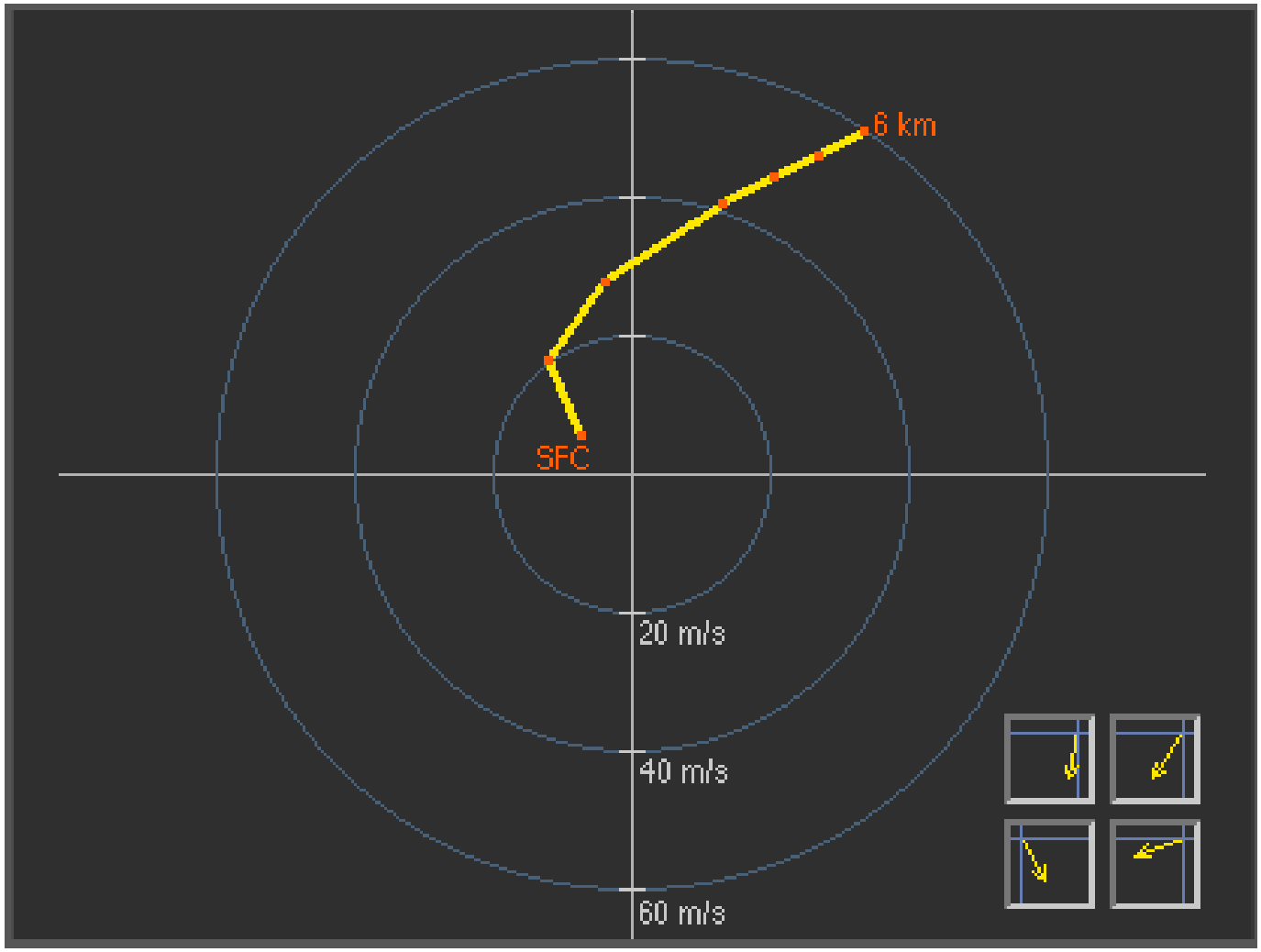




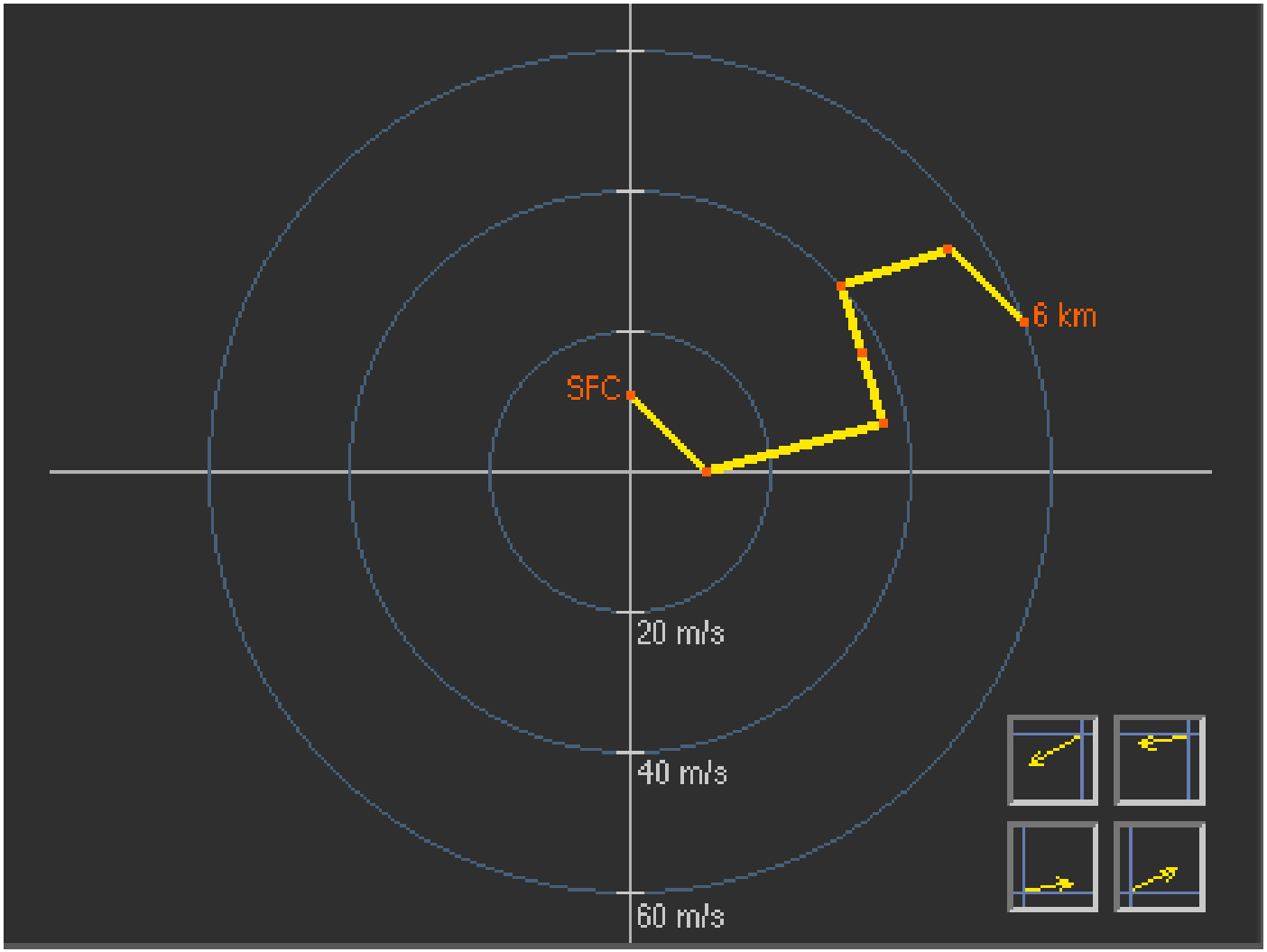
Practice: Determine storm relative wind at surface (1)



Practice: Determine storm relative wind at surface (2)



Practice: Determine storm relative wind at surface (3)



Summary of Hodograph

- Mainly aimed to reveal vertical wind shear
- Wind vectors are plotted on a polar coordinate chart. Then their endpoints are connected
- The total magnitude of vertical wind
  - The net length of the hodograph
- The mean wind shear vector
  - Averaging the x and y components of each of the single layer wind shear vectors

Summary of Hodograph

- Distribution
- Shape
  - Straight or curved.
  - Impact on storm, their implications for larger-scale processes and for convections
- Storm-relative winds
  - Often very different from the ground-relative winds

References

Principles of Convection I: Buoyancy and CAPE:
https://www.meted.ucar.edu/education_training/lessons/16

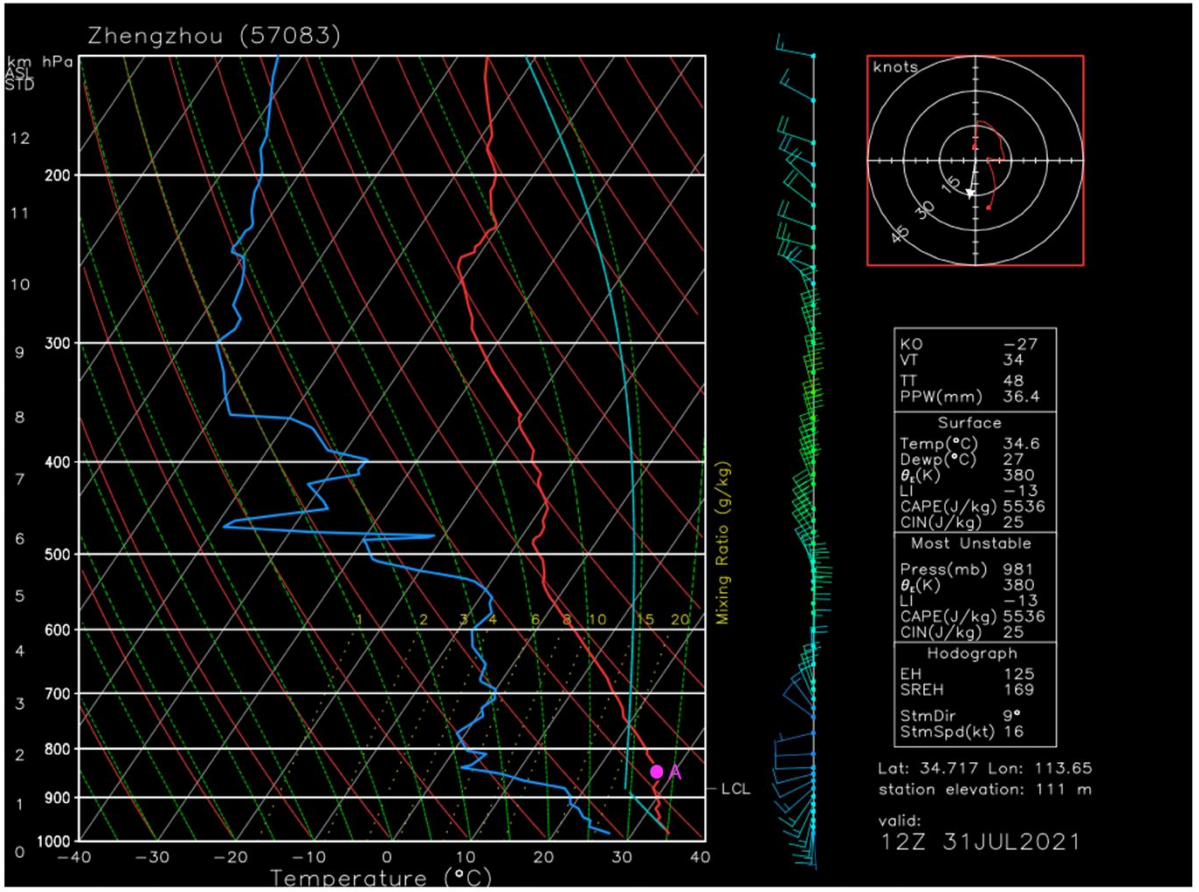
Principles of Convection II: Using Hodographs:
https://www.meted.ucar.edu/education_training/lessons/136

Principles of Convection III: Shear and Convective Storms
https://www.meted.ucar.edu/education_training/lessons/137

Homework 1 (deadline: Oct. 10)

1. Please write down the definition of the following parameters, and find their values for the dot A at the 850hPa level based on the Skew-T diagram (leave your drawing on the diagram).

(1) saturation mixing ratio, (2) mixing ratio, (3) relative humidity, (4) saturation vapor pressure, (5) vapor pressure, (6) virtual temperature, (7) potential temperature, (8) lifting condensation level, (9) equivalent temperature, (10) equivalent potential temperature, (11) convective condensation level, (12) convective temperature, (13) level of free convection, (14) equilibrium level, (15) wet-bulb temperature, (16) wet-bulb potential temperature, (17) freezing level, (18) CAPE, (19) CIN, (20) precipitable water (PPW).



2. Please draw the hodograph for the following case, write down the definition of (1) total shear magnitude, (2) mean wind shear vector, (3) storm motion, and (4) storm relative wind, and indicate them in the figure.