Whether the Weather?

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National Weather Service Storm Spotter

Factors to Consider Before Spraying:

- Wind Speed
- Temperature
- Humidity and precipitation
- Surface Air Temperature Inversion

Weather Equipment

Weather Resources

Wind Speed

Most pesticides require a wind speed of between 3 – 10 mph to prevent drift. A few will permit applications up to 15 mph. None recommend an application at 2 mph or below due to the probability of an inversion existing.

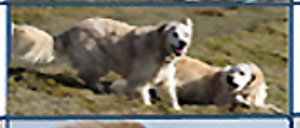
So…….how can you tell what the wind speed is in the field?

Beaufort Wind Scale

Force	Wind Speed	Characteristics
0	Under 1 mph	Smoke rises vertically, flags hang limp
1	1 - 3 mph	Smoke drifts with the wind, flags may stir
2	4 – 7 mph	Wind is felt on exposed skin, leaves rustle, flags occasionally extend
3	8 – 12 mph	Leaves and small twigs in constant motion, flags extend
4	13 – 18 mph	Dust and small papers raised, small branches begin to move, flags flap
5	19 – 24 mph	Small trees sway, flags ripple

Beaufort Scale

Compiled by :-
Bethan and Harry Hiley, Loweswater cam
(Credits to Rear Admiral Sir Francis Beaufort)

Beaufort number	Wind Speed (mph)	Seaman's term		Perceived Effects on Land
0	Under 1	Calm		Calm; good hair day, ears comply with gravity.
1	1-3	Light Air		Slight wind felt on head, finest hairs detect direction
2	4-7	Light Breeze		Breeze detected, still able to carry out Trig point bagging
3	8-12	Gentle Breeze		Hair Ruffles slightly when facing into Breeze
4	13-18	Moderate Breeze		Detectable wind, 'Port' side ear lifts when facing wind
5	19-24	Fresh Breeze		To avoid bad hair day, best to point stern into wind
6	25-31	Strong Breeze		Ears no longer controllable and do not comply with gravity
7	32-38	Moderate Gale		Time to seek shelter, and look for flying sticks
8	39-46	Fresh Gale		Ears and mouth distort when facing into 'gale'

Handheld Anemometers

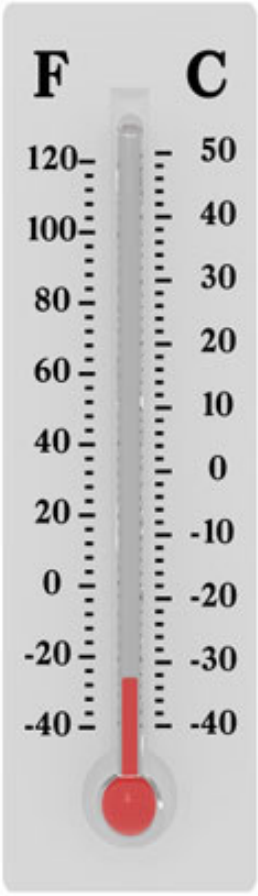
Temperature

- High temperatures call for larger droplet size. This helps to prevent atomization and evaporation before the target is reached. Also, consider lowering the boom to just above the plants.

- Some pesticides have minimum and/or maximum temperature ranges for application. Avenger™ is not effective below 50° F and 2, 4- D should not be applied above 90°F.

- In alfalfa production close attention to growing degree days (GDD) and field scouting will allow you to optimize the timing of insecticides for alfalfa weevil as well as Lygus. If dairy quality hay is a goal, GDD should be monitored in order to cut at the most opportune time that will result in the highest quality.

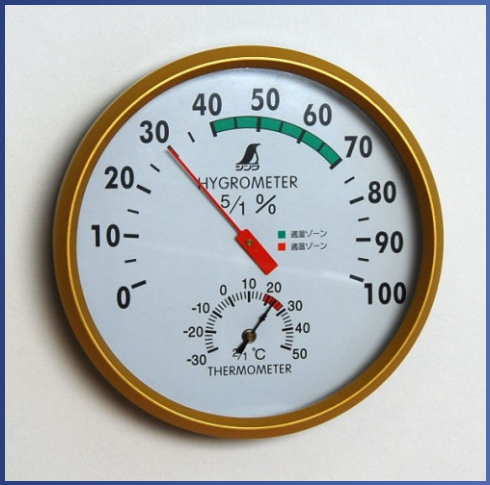
Thermometers



Humidity/Precipitation

- Low humidity calls for larger droplet size. This helps to prevent atomization and evaporation before the target is reached. Also, consider lowering the boom to just above the plants.
- Periods of high humidity resulting in dew or fog can indicate an inversion. Dew and fog can also increase the likelihood of pesticide runoff.
- Read the label! Know the effects of precipitation on your particular pesticide. Some can handle rain as soon as they dry, others cannot be applied with 48 hours of predicted rain. A few need precipitation or irrigation for maximum effectiveness. Know your pesticide as runoff is a form of drift.
- Soil fumigant rodenticides are best applied to moist soil.

Hygrometers



Surface Temperature Inversions

Surface Temperature Inversions:

- Are very common
- Are easy to recognize
- Affect the dispersal of very small spray droplets suspended in the air
- Can increase the potential for offsite affects & the distance at which affects can be observed

Atmospheric Stability

- Inversions cause STABLE atmospheric conditions
- The concept of atmospheric stability helps understand how inversions affect drift
- Close to the ground, atmospheric stability changes regularly between STABLE, NEUTRAL, & UNSTABLE

55° F

60° F

65° F

70° F

75° F

80° F

The large scale trend in the atmosphere is that temperature decreases with height

55° F

60° F

65° F

70° F

75 ° F

80 ° F

Where there is a decrease in temperature with height greater than the adiabatic rate the atmosphere is UNSTABLE

55° F

60° F

65° F

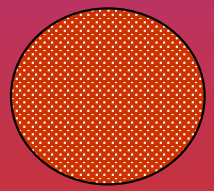
70° F

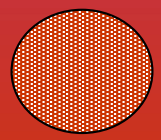
75 ° F

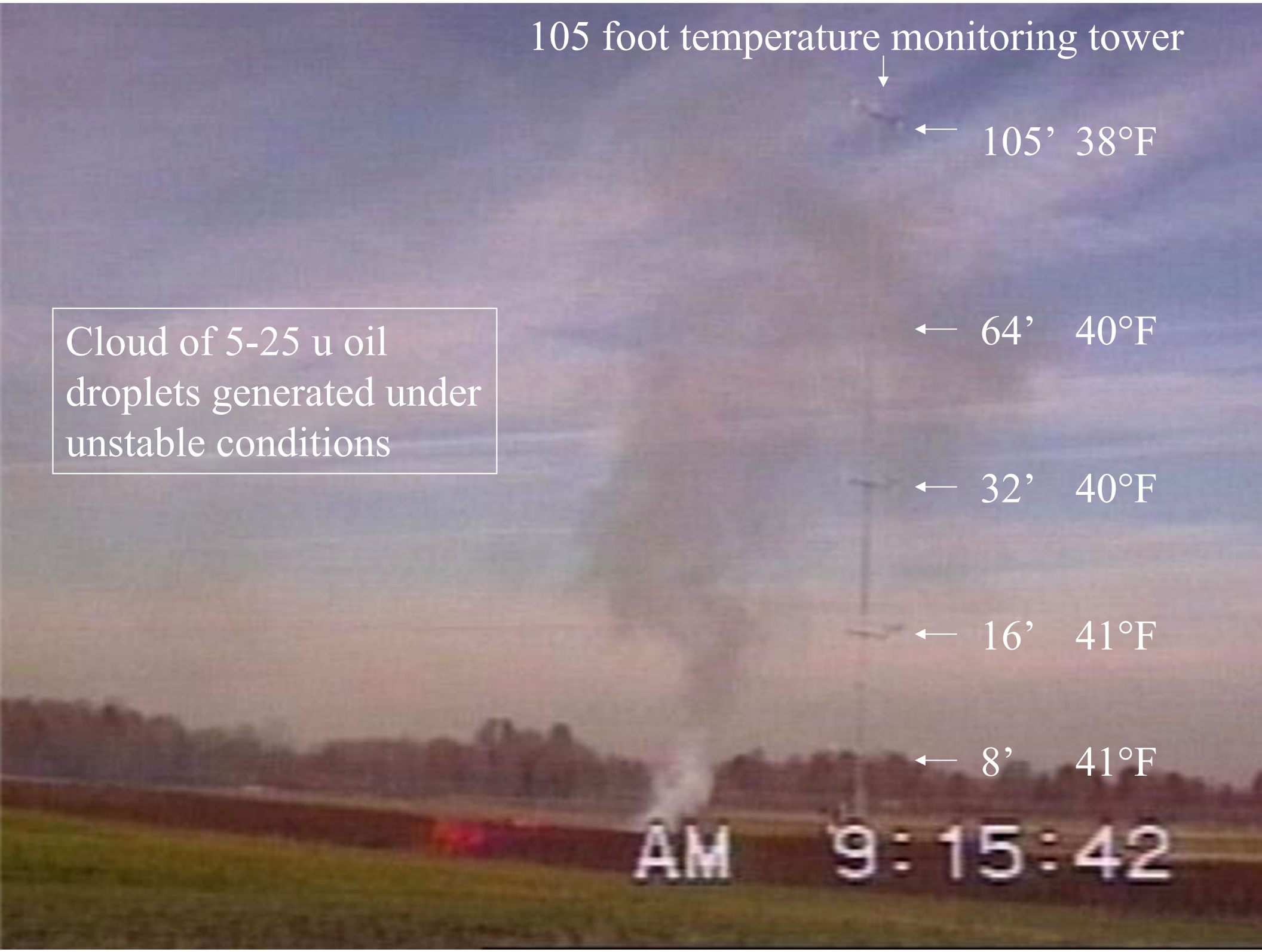
80 ° F

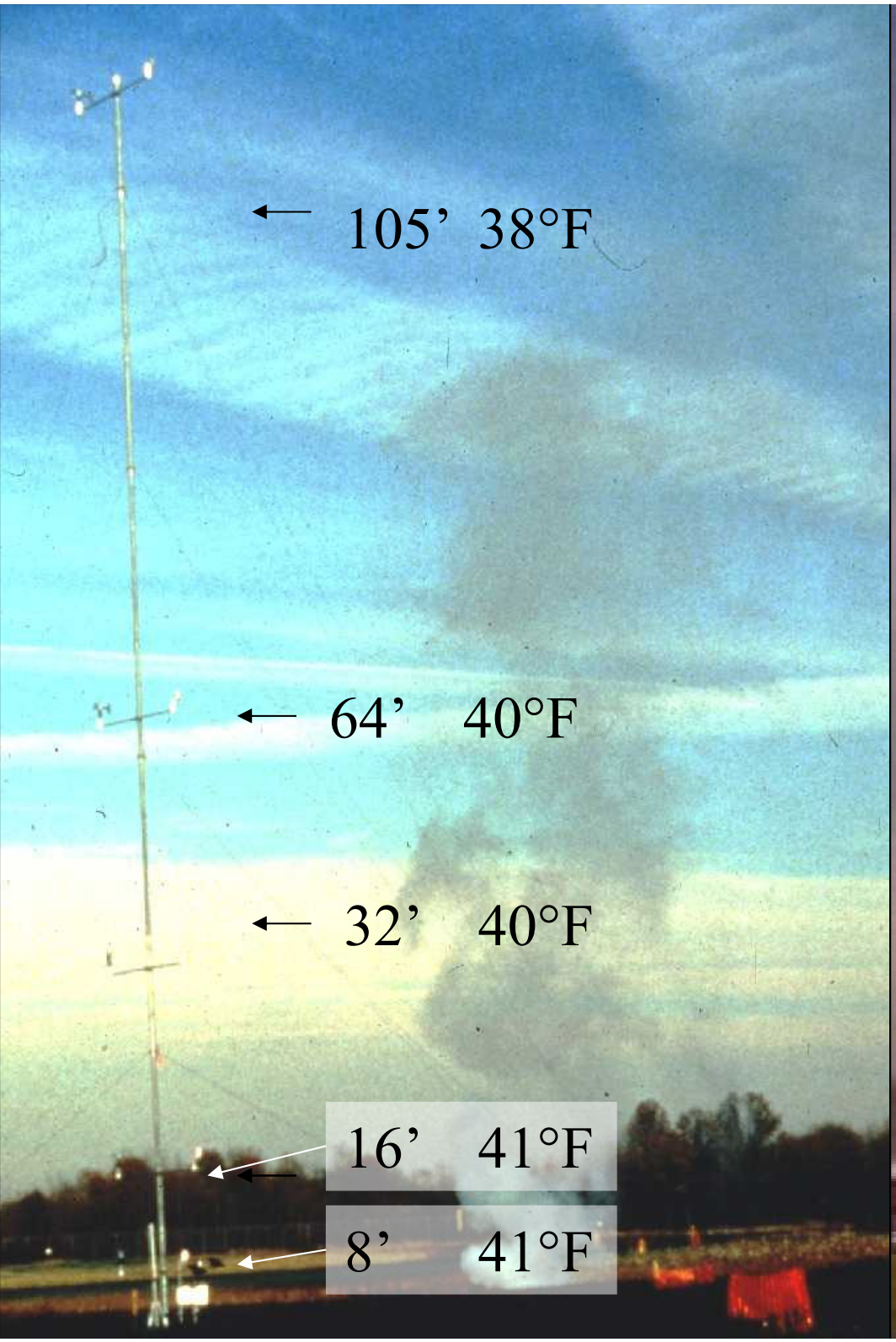
When the atmosphere is UNSTABLE air parcels near the surface will rise and expand because they are warmer & less dense than the air above

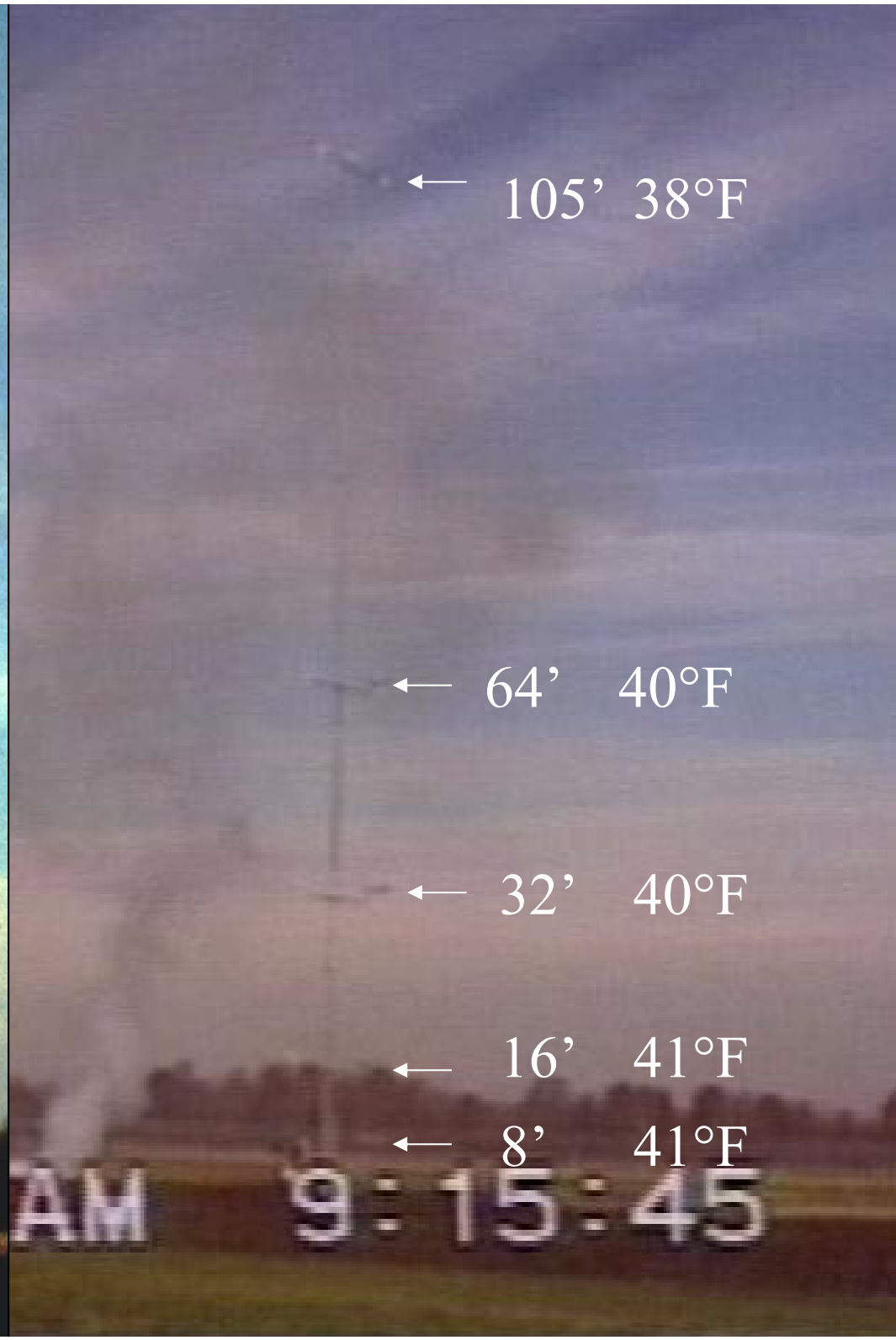
Droplets or particles suspended in the air will be dispersed/diluted






105 foot temperature monitoring tower
105’ 38°F
64’ 40°F
32’ 40°F
16’ 41°F
8’ 41°F
Cloud of 5-25 u oil droplets generated under unstable conditions
AM 9:15:42


105’ 38°F
64’ 40°F
32’ 40°F
16’ 41°F
8’ 41°F


105’ 38°F
64’ 40°F
32’ 40°F
16’ 41°F
8’ 41°F
AM 9:15:45

65 °F

60 °F

55 °F

50 °F

45 °F

40 °F

A temperature inversion is an area where temperature increases with height.

It can begin at the ground.

65° F

60° F

55° F

50° F

45° F

40° F

When temperature increases with height the atmosphere is STABLE.

Vertical mixing of the air and dispersion of small droplets is suppressed.

65° F

60° F

55° F

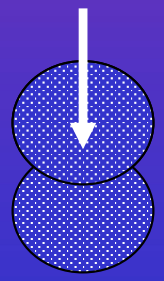
50° F

45° F

40° F

A parcel of air near the surface is always cooler & more dense than the air above, so it can't rise and disperse.

If forced down by a current of air, it will immediately rise back.



65° F

60° F

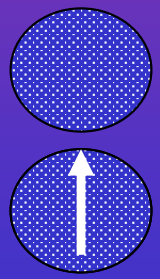
55° F

50° F

45° F

40° F

If forced up by a current of air, it will immediately sink back.



65° F

60° F

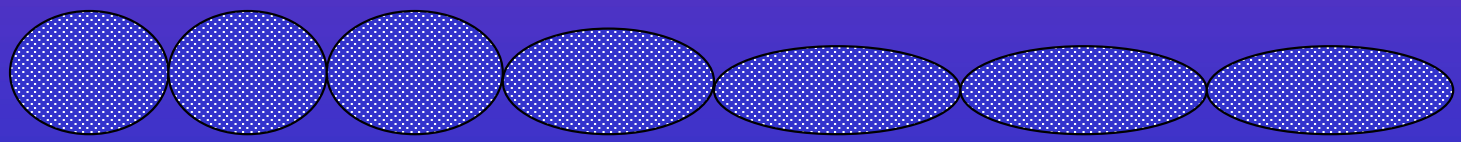
55° F

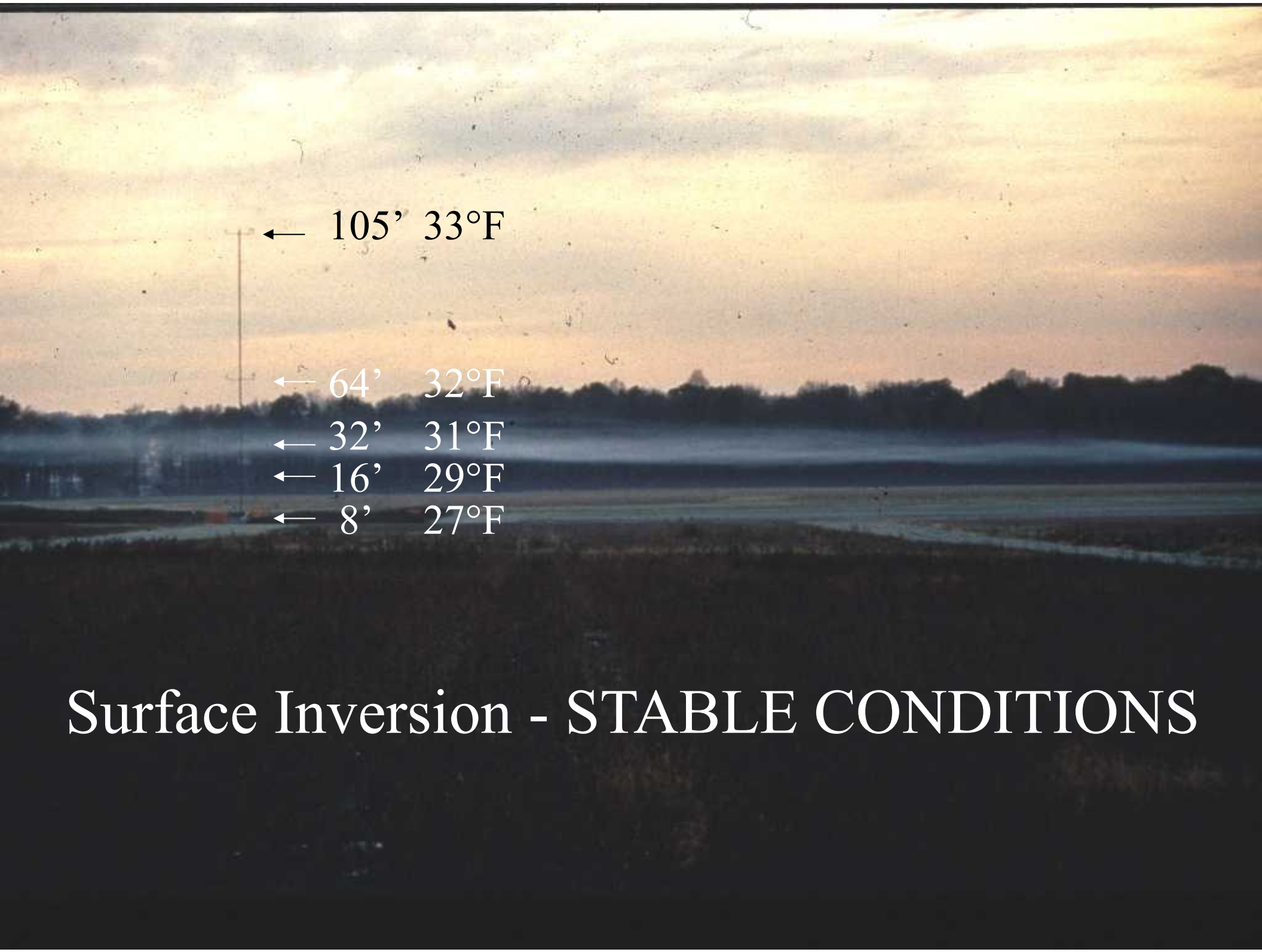
50° F

45° F

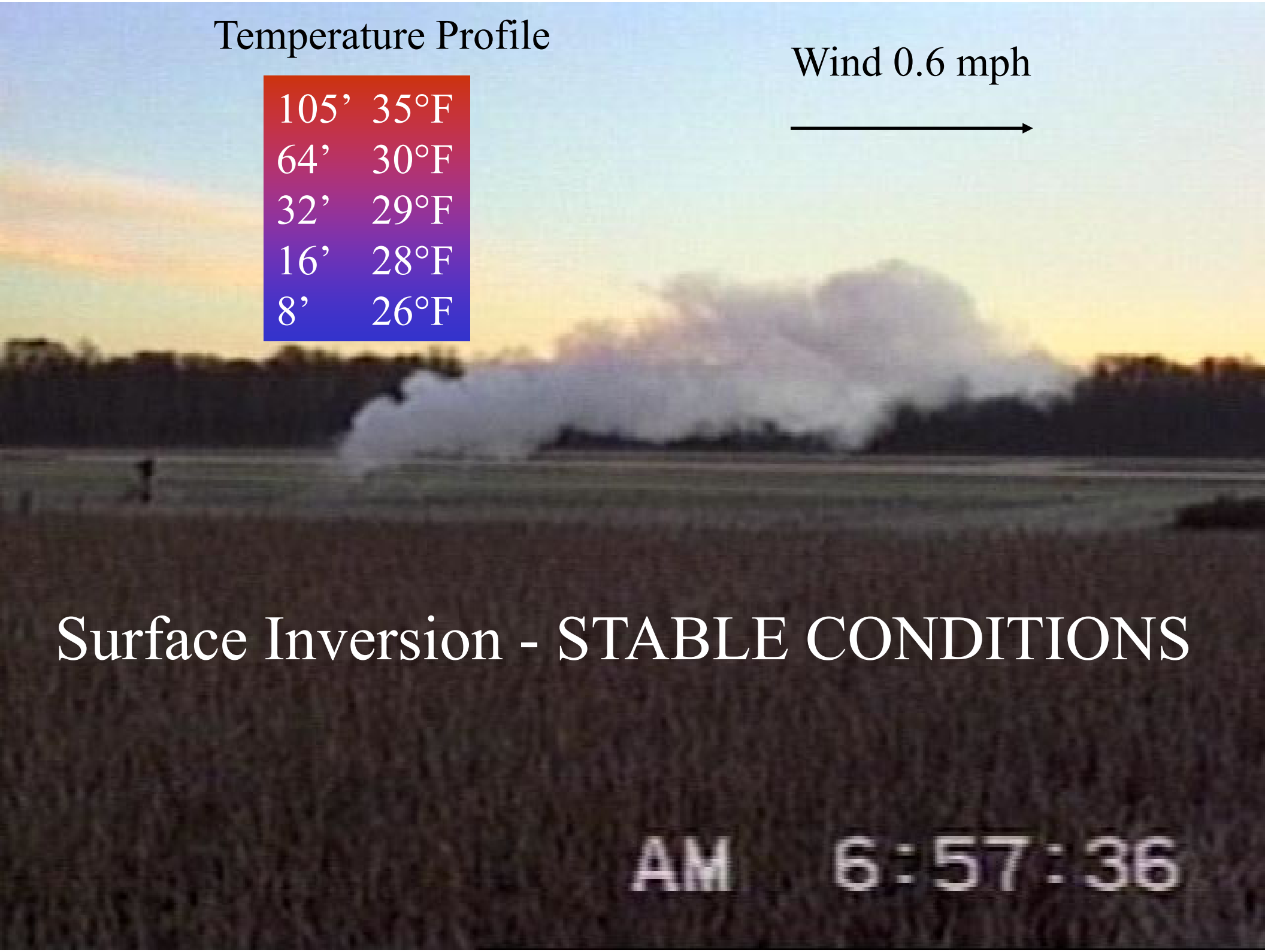
44° F

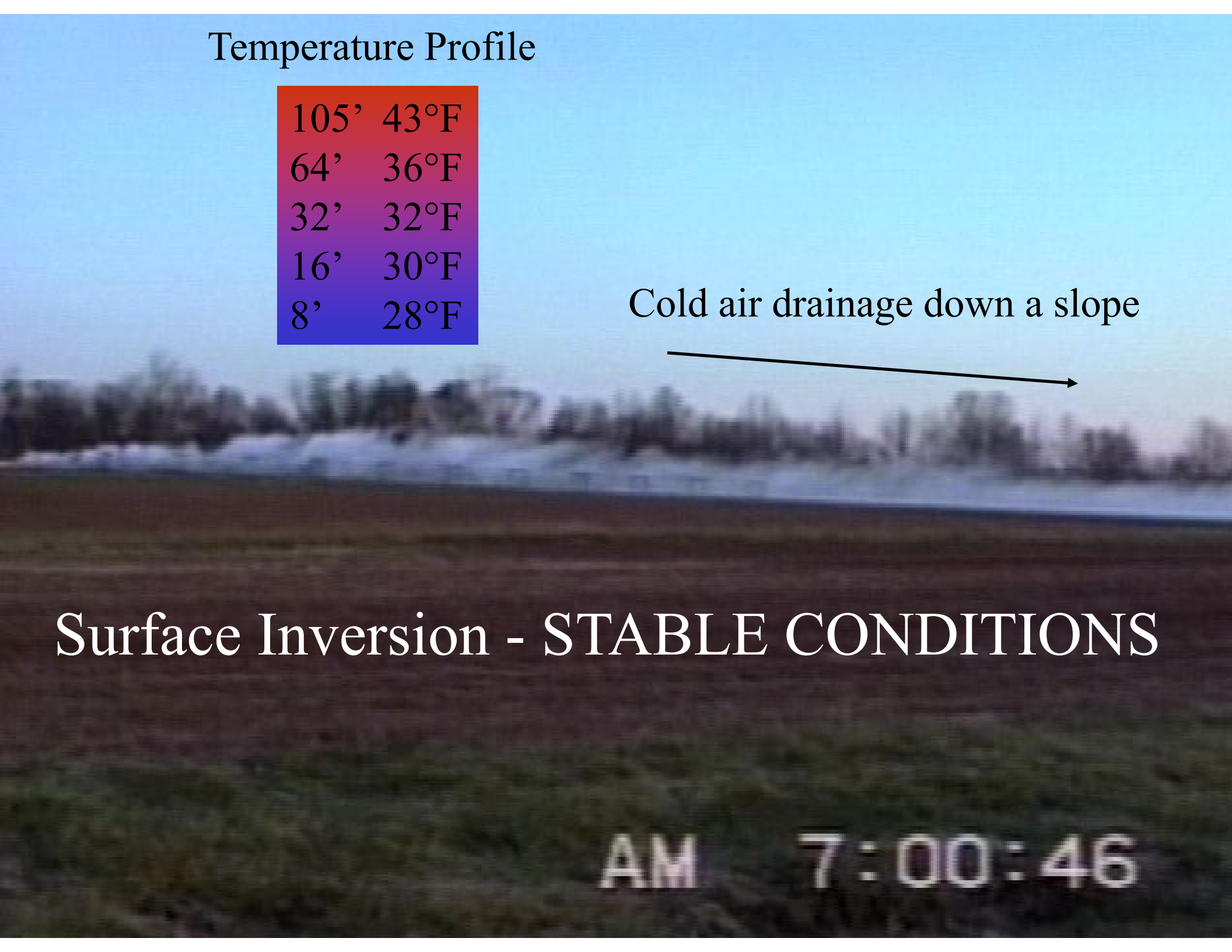
The parcel of air can't rise and disperse, but it can be move laterally in the light variable winds typical of a surface inversion





Surface Inversion - STABLE CONDITIONS


Temperature Profile
105’ 35°F
64’ 30°F
32’ 29°F
16’ 28°F
8’ 26°F
Wind 0.6 mph
Surface Inversion - STABLE CONDITIONS
AM 6:57:36


Temperature Profile
105’ 43°F
64’ 36°F
32’ 32°F
16’ 30°F
8’ 28°F
Cold air drainage down a slope
Surface Inversion - STABLE CONDITIONS
AM 7:00:46

65° F

60° F

55 F

50° F

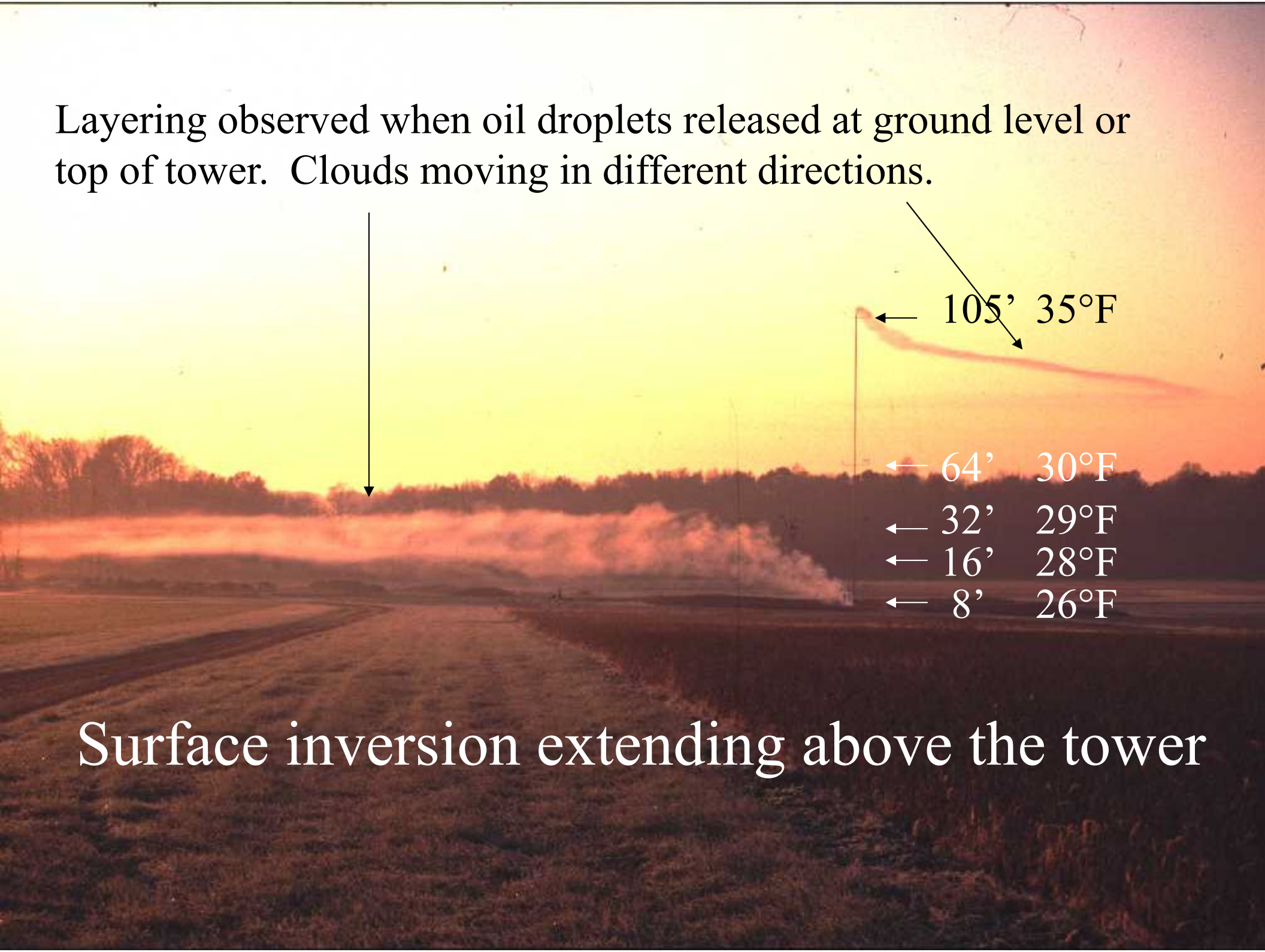
45° F

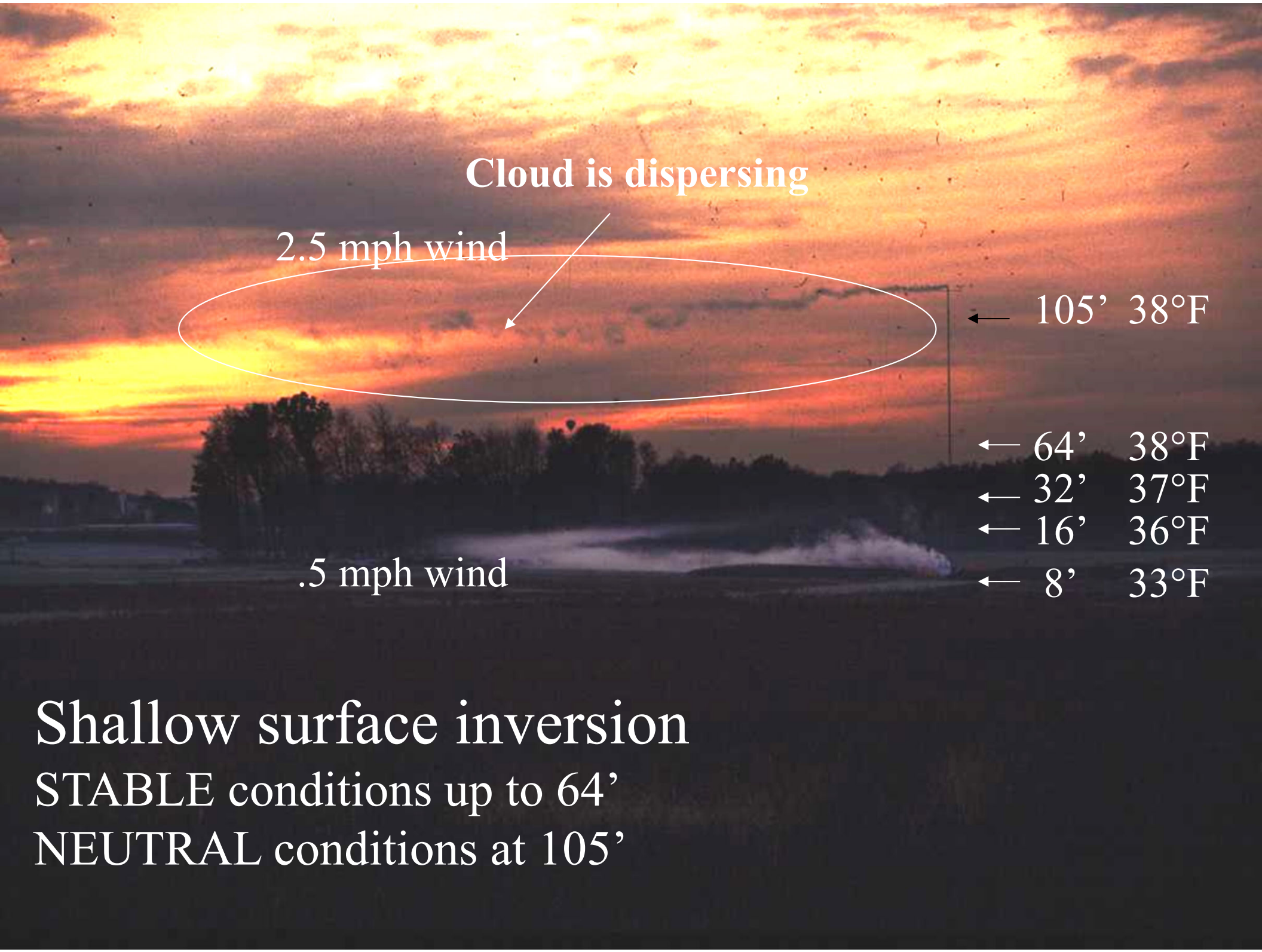
40° F

A Surface Inversion can extend upwards 5, 50, 100, 500 ft or more.

Height (of the inversion) doesn't matter:

If the application is made within the inversion it, the effects will be similar.


Layering observed when oil droplets released at ground level or top of tower. Clouds moving in different directions.
105’ 35°F
64’ 30°F
32’ 29°F
16’ 28°F
8’ 26°F
Surface inversion extending above the tower



Shallow surface inversion

STABLE conditions up to 64’

NEUTRAL conditions at 105’

55° F

60° F

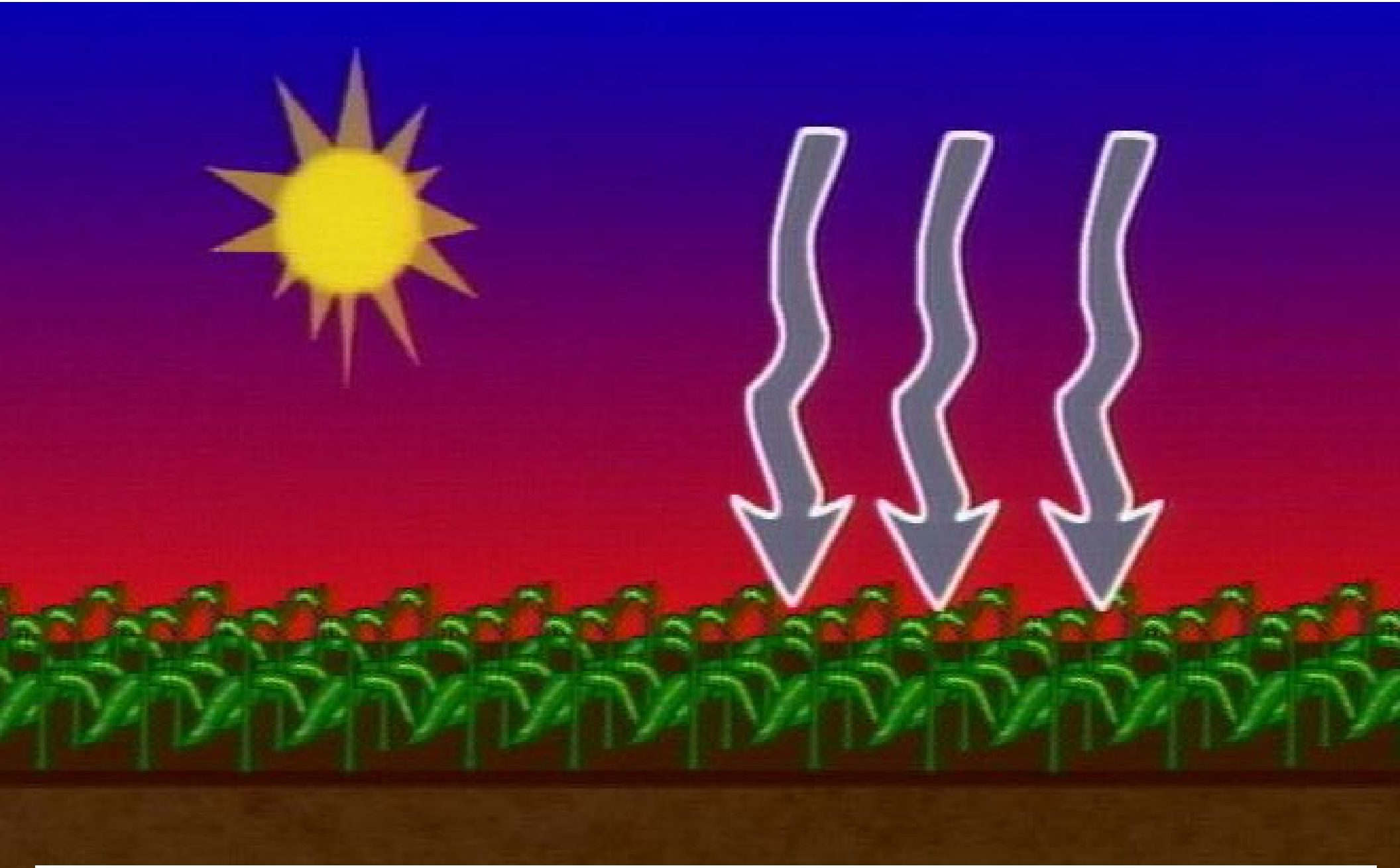
65° F

70° F

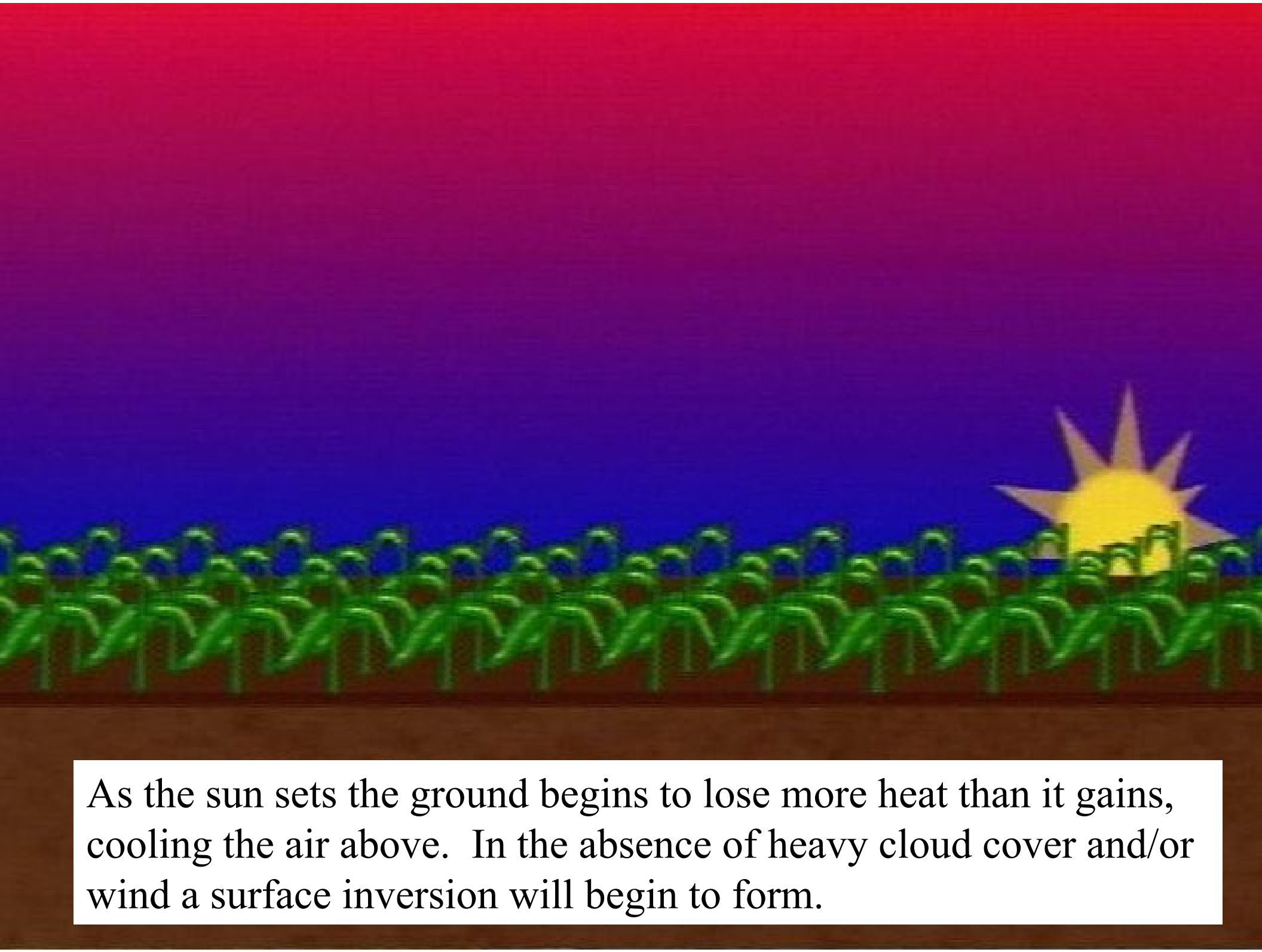
75° F

80° F

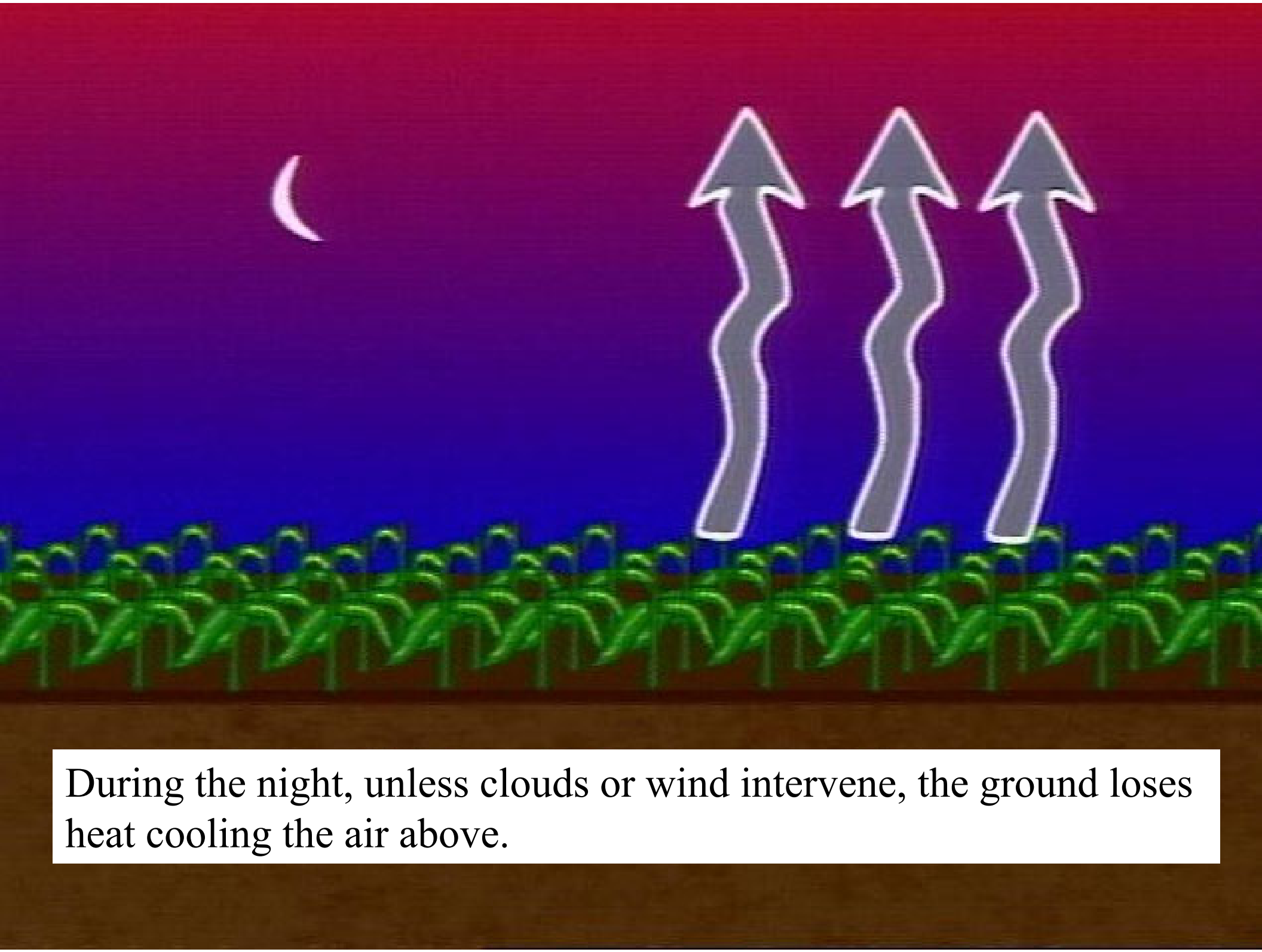
Surface Inversions are part of the daily cycle unless wind or cloud cover intervene



During the day when cloud cover is light, the sun heats the ground warming the air above. This causes in unstable conditions unless wind intervenes.



As the sun sets the ground begins to lose more heat than it gains, cooling the air above. In the absence of heavy cloud cover and/or wind a surface inversion will begin to form.



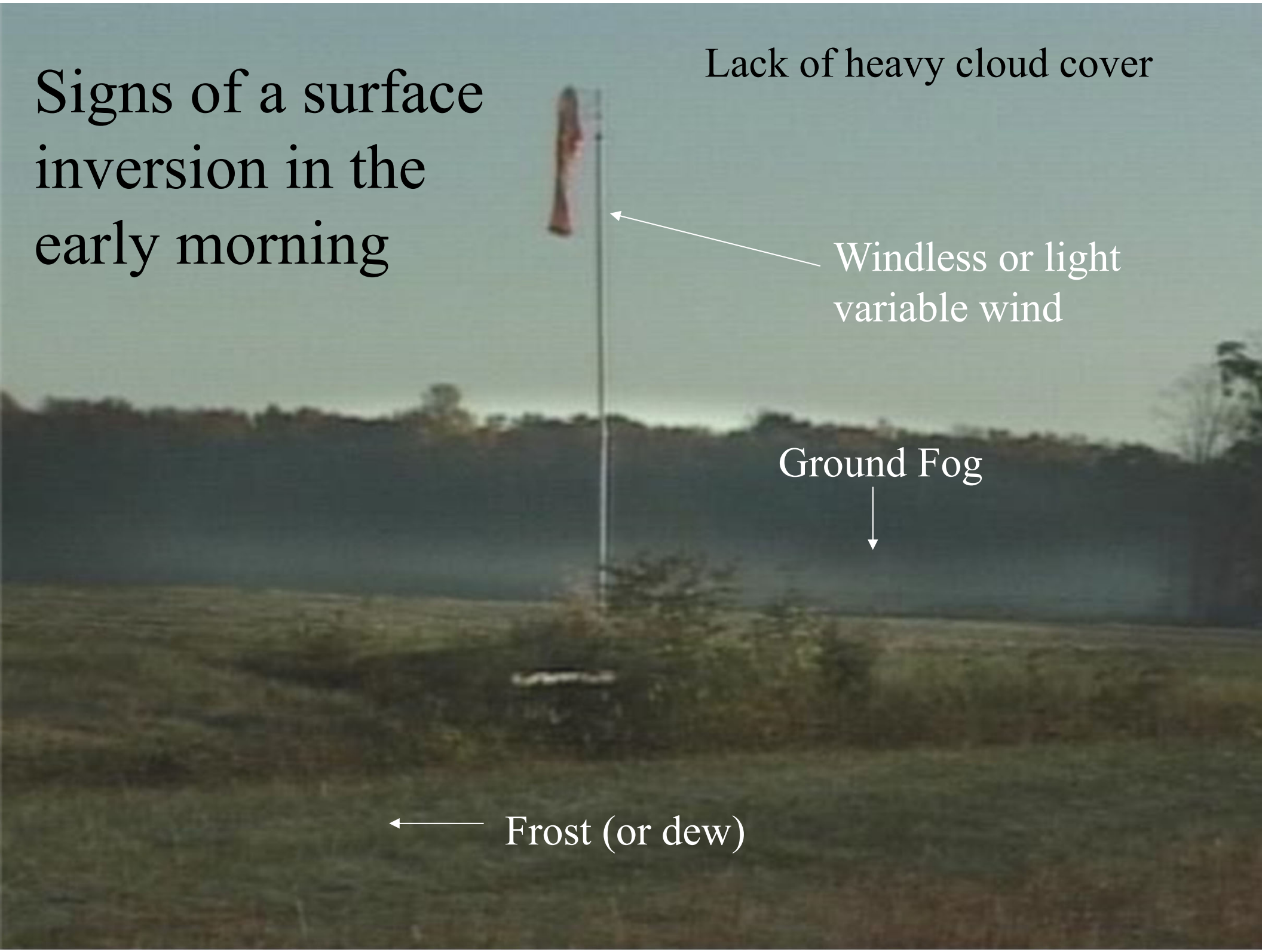
During the night, unless clouds or wind intervene, the ground loses heat cooling the air above.

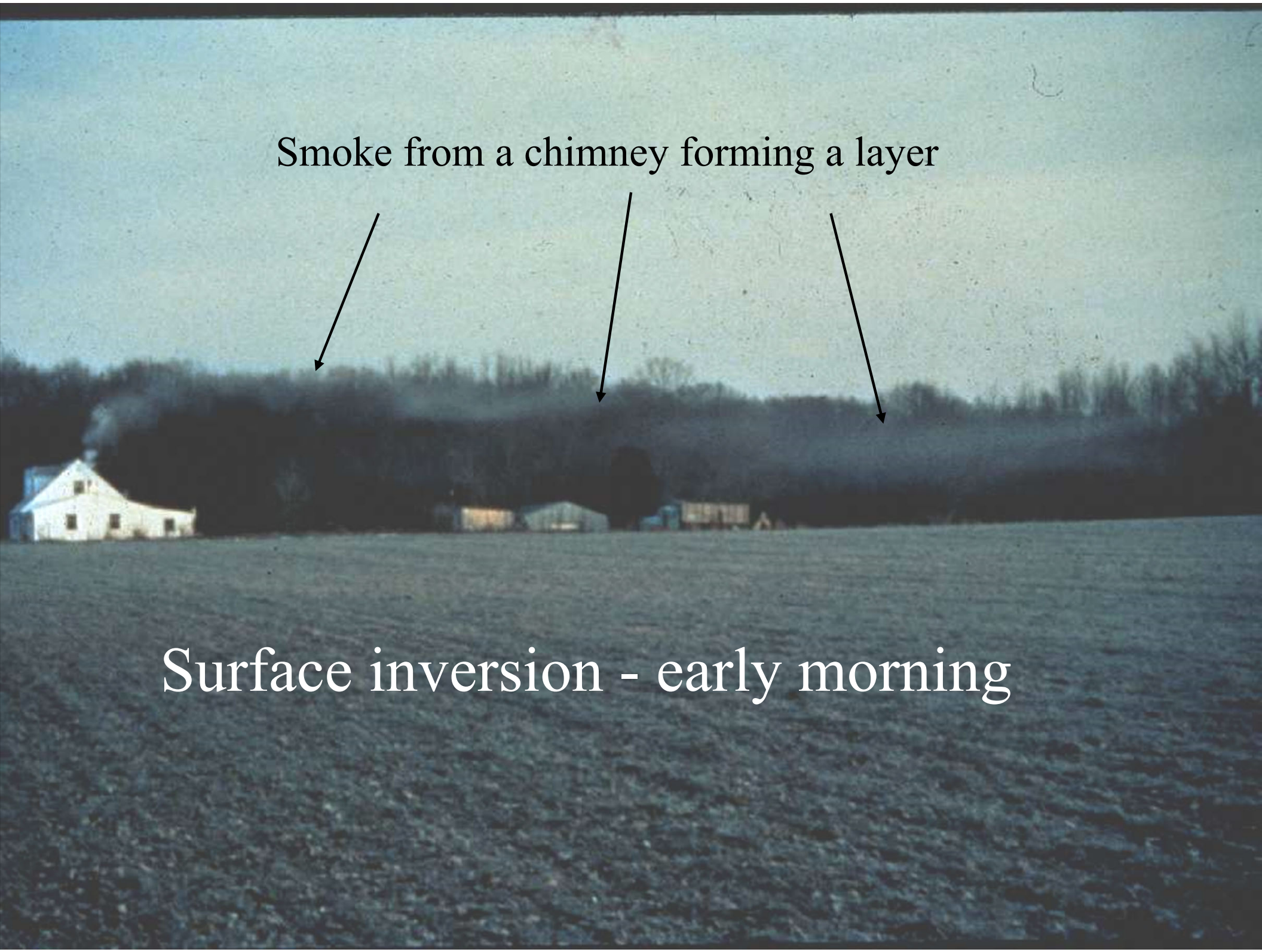
Unless wind intervenes the surface inversion will continue until the sun begins to heats the ground

Inversions in the lowest 5 feet of the atmosphere sometimes begin forming three to four hours before sunset according to the North Dakota State University Microclimate Research Station observations. Thus, evening inversions pose a greater risk for spray drift than morning inversions. This is because evening inversions are very persistent as long as the skies remain clear. The inversion will continue to intensify until shortly after sunrise. Usually only windy or cloudy conditions will weaken or disrupt it, and both of these usually require some significant weather or air mass change.

How to recognize a surface inversion

- Sunset to just after sunrise
- Wind speed is usually between 0 and 2 mph, but it can be upwards of 4 – 5 mph at the surface if the inversion is deep such as occurs in our mountain valleys.
- Clear to partly cloudy skies and calm air usually the result of a high pressure area.
- Frost, dew and fog are all warning signs that an inversion may exist if there is sufficient humidity. All of these require stable air to form.
- Smoke from a chimney forming a layer and dust hanging over a roadway


Signs of a surface inversion in the early morning
Lack of heavy cloud cover
Windless or light variable wind
Ground Fog
Frost (or dew)



Surface inversion - early morning

To confirm the presence of an inversion, air temperature should be measured at 6-12 inches above the spray surface and at a height of 8 -10 feet above the spray surface. When the temperature at the higher level is greater than the temperature at the lower level, an inversion exists. The greater the difference, the more intense the inversion, and the more stable the atmosphere.

Surface Inversions can:

- Decrease the dispersion of droplets too small to quickly settle out.
- Result in a higher air concentration of these small droplets.
- Increase the potential for off-target effects.
- Increase the distance at which off-target effects can be observed.
- Increase the size of the area affected.
- Cause the direction of drift to be unpredictable

Droplet Size and Spray Drift

Large spray droplets introduced in to a stable atmosphere with greater fall velocities will strike the surface in one to three seconds. Small droplets, 200 microns in diameter or less, introduced into a stable atmosphere will fall as little as a few inches per second and may float along with the air for long distances. Droplet drift is limited by evaporation, but the coolest air is near the surface and is often close to 100% humidity thus there is little evaporation.

- Use a lower pressure
- Use a coarse spray nozzle ASAE standard 572 or a volume mean diameter of 385 microns or greater for spinning atomizers.
- Use an anti-drift adjuvant

Reducing the effects of Surface Inversions on Spray Drift

- Minimizing production of very small drops
- Using equipment the minimizes the number of small drops suspended in the air
- Morning applications are likely to have shorter exposure to STABLE conditions than evening applications
- Use buffer zones

2,4 –D Drift Damage

Drift Damage

Paraquat damage on corn plants

Dicamba drift damage

80 °F

80 °F

80 °F

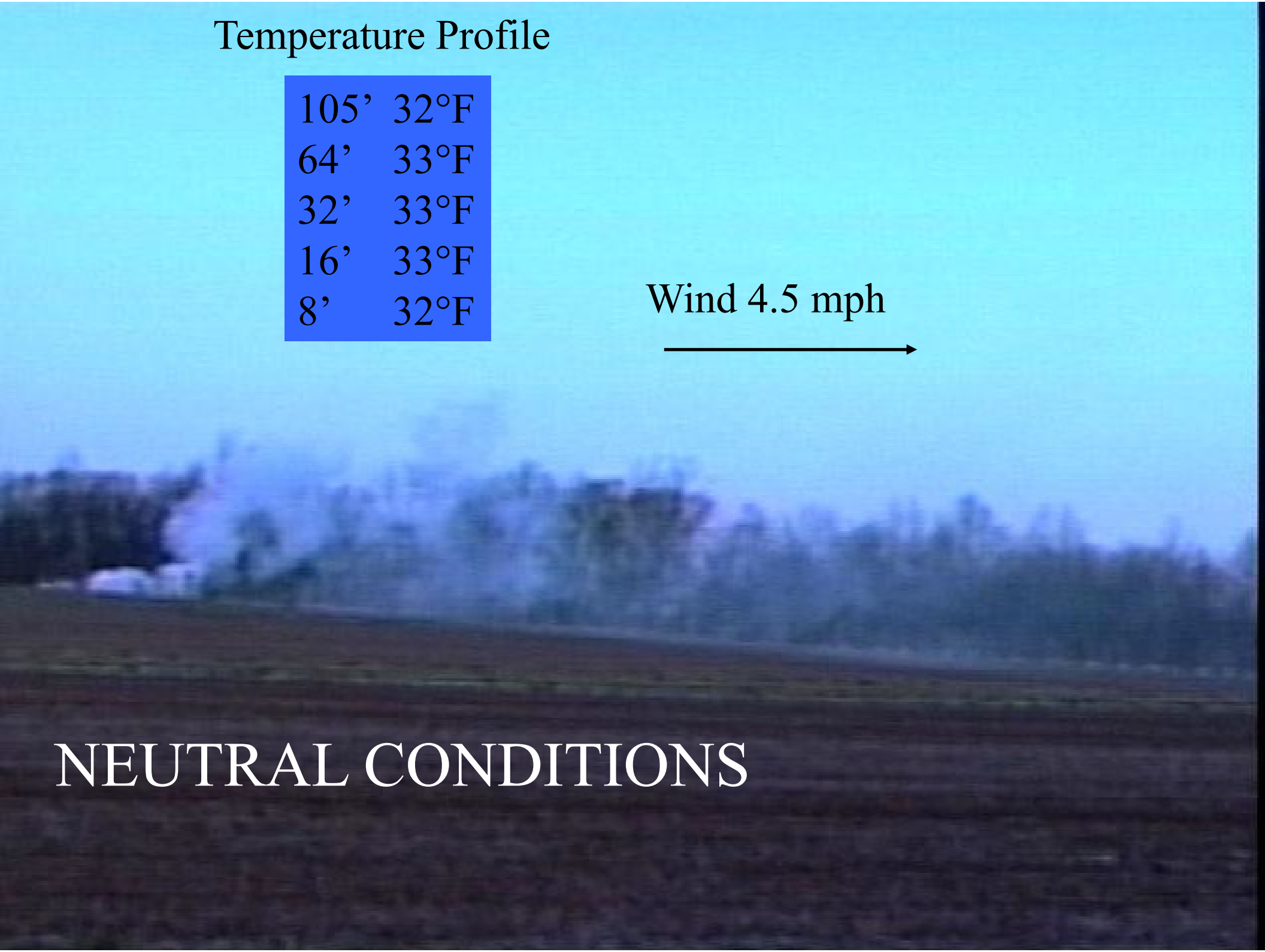
80 °F

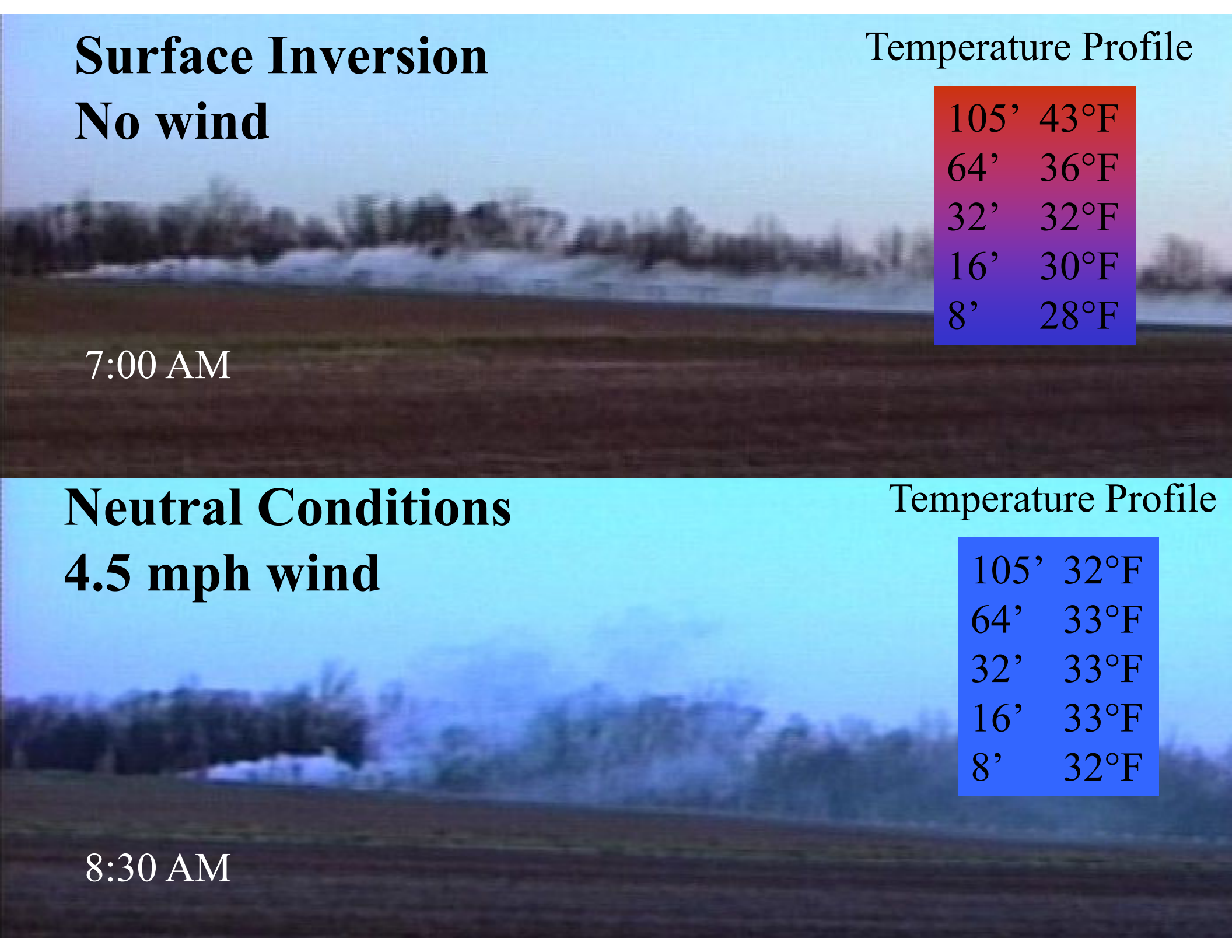
80 °F

80 °F

When the atmospheric stability is NEUTRAL, there is little or change in temperature with height. Low heavy cloud cover and/or wind contribute to NEUTRAL conditions.

Vertical mixing is not suppressed as under STABLE conditions, and the turbulence of even a 5 mph wind is effective in dispersing suspended small droplets.


Temperature Profile
105’ 32°F
64’ 33°F
32’ 33°F
16’ 33°F
8’ 32°F
Wind 4.5 mph
NEUTRAL CONDITIONS


Surface Inversion
No wind
Temperature Profile
105’ 43°F
64’ 36°F
32’ 32°F
16’ 30°F
8’ 28°F
7:00 AM
Neutral Conditions
4.5 mph wind
Temperature Profile
105’ 32°F
64’ 33°F
32’ 33°F
16’ 33°F
8’ 32°F
8:30 AM

Neutral conditions can be the best time to spray

- Wind direction is often consistent
- Good dispersion of droplets too small to quickly settle out.

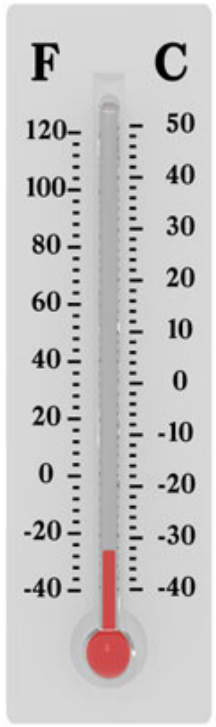
Surface Temperature Inversions:

- Are very common
- Are easy to recognize
- Affect the dispersal of very small spray droplets suspended in the air
- Can increase the potential for offsite affects & the distance at which affects can be observed

Temperature Inversion Warning on a Label

Applications should not occur during a local, low level temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable wind common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of the smoke from a ground source. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Weather Equipment – from simple



To elaborate

Useful websites

For Weather Station Equipment:
Davis Weather Instruments
http://www.davisnet.com/usecase/agriculture/
Weatherhawk Instruments
http://weatherhawk.com/agriculture-more

Weather Prediction/Forecast and Current Conditions:
National Weather Service
http://www.weather.gov/
Weather Underground
https://www.wunderground.com/
Farms.com
http://www.farms.com/weather/?&page=weatherlarge&zip=95971

Acknowledgements

Air Temperature Inversions – Causes, Characteristics and Potential Effects on Pesticide Spray Drift
North Dakota State University Cooperative Extension
https://www.ag.ndsu.edu/pubs/plantsci/pests/ae1705.pdf

Questions