Air Temperature Inversions:

Their Impact On Pesticide Applications

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PESTICIDE PROGRAM
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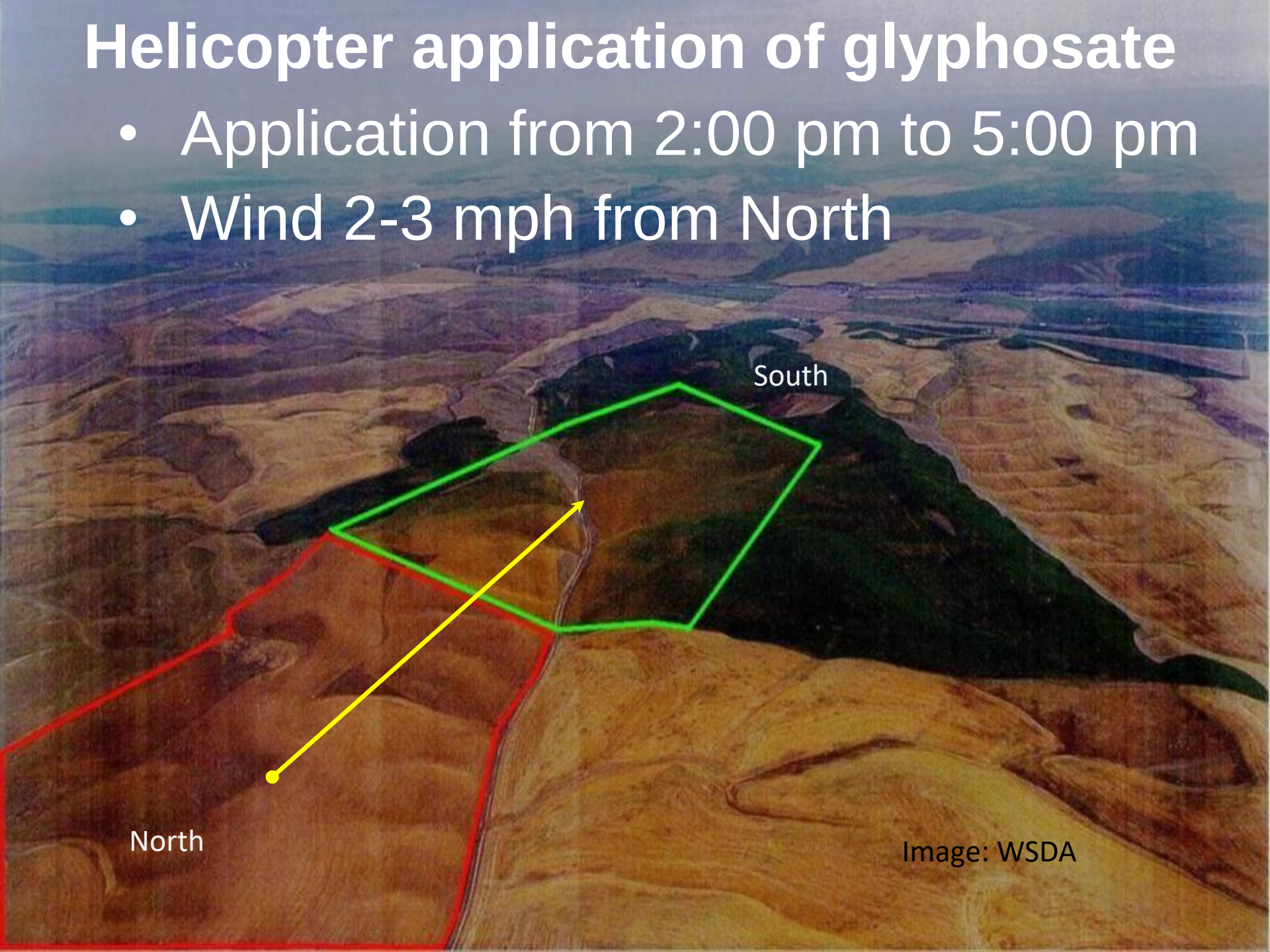
What's the big deal about inversions?

- They can dramatically impact the deposition of pesticide droplets and volatile pesticide gasses
- They are poorly understood by applicators
- Making an application during or before an inversion can result in significant off target movement
- Off target movement of pesticides can cause:
  - Exposure to people
  - Significant property damage or environmental harm
  - Violation of state and federal pesticide laws

Helicopter application of glyphosate

- Application from 2:00 pm to 5:00 pm
- Wind 2-3 mph from North



This is *physical drift*, the spray droplets, as they are discharged from the nozzle, become suspended in a cool air inversion layer and move off target.

FARM PRESS
TIMELY RELIABLE INFORMATION FOR DELTA AGRICULTURE

2,4-D herbicide drift damage stuns east Arkansas cotton

David Bennett
Aug. 11, 2006 4:00pm

The young, east Arkansas cotton farmer turns in a slow circle trying to find a plant within his line of sight that isn't "smoked" by herbicide drift. There isn't one — leaves in the top third of every plant are off-color, curling and blistered.

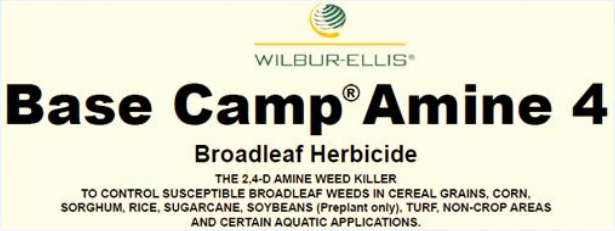
He says excuses won't cut it. He wants those responsible for the 2,4-D drift that's harmed more than half his crop held liable. After that, he suggests banning or restricting 2,4-D might be a good idea.

"This is beyond ugly and has got to stop," he says throwing up his hands in frustration. "We're trying to make a living and this bush-league (stuff) starts happening. It's the same story up and down the road here. It's on everyone's cotton.

This is easily seen in east Arkansas where multiple counties have been affected by the recent drift. After visiting with Extension agents and consultants, Bill Robertson says there's easily upwards of **200,000 to 250,000 acres** of damaged cotton in Craighead, Greene, Poinsett, Mississippi and Cross counties.

This is *likely* a combination of physical drift & *vapor drift* (the spray droplets reach the target but then vaporize off the foliage or soil and then become trapped in a cool air inversion layer and move off target.

Recognizing and dealing with an inversion is a label requirement

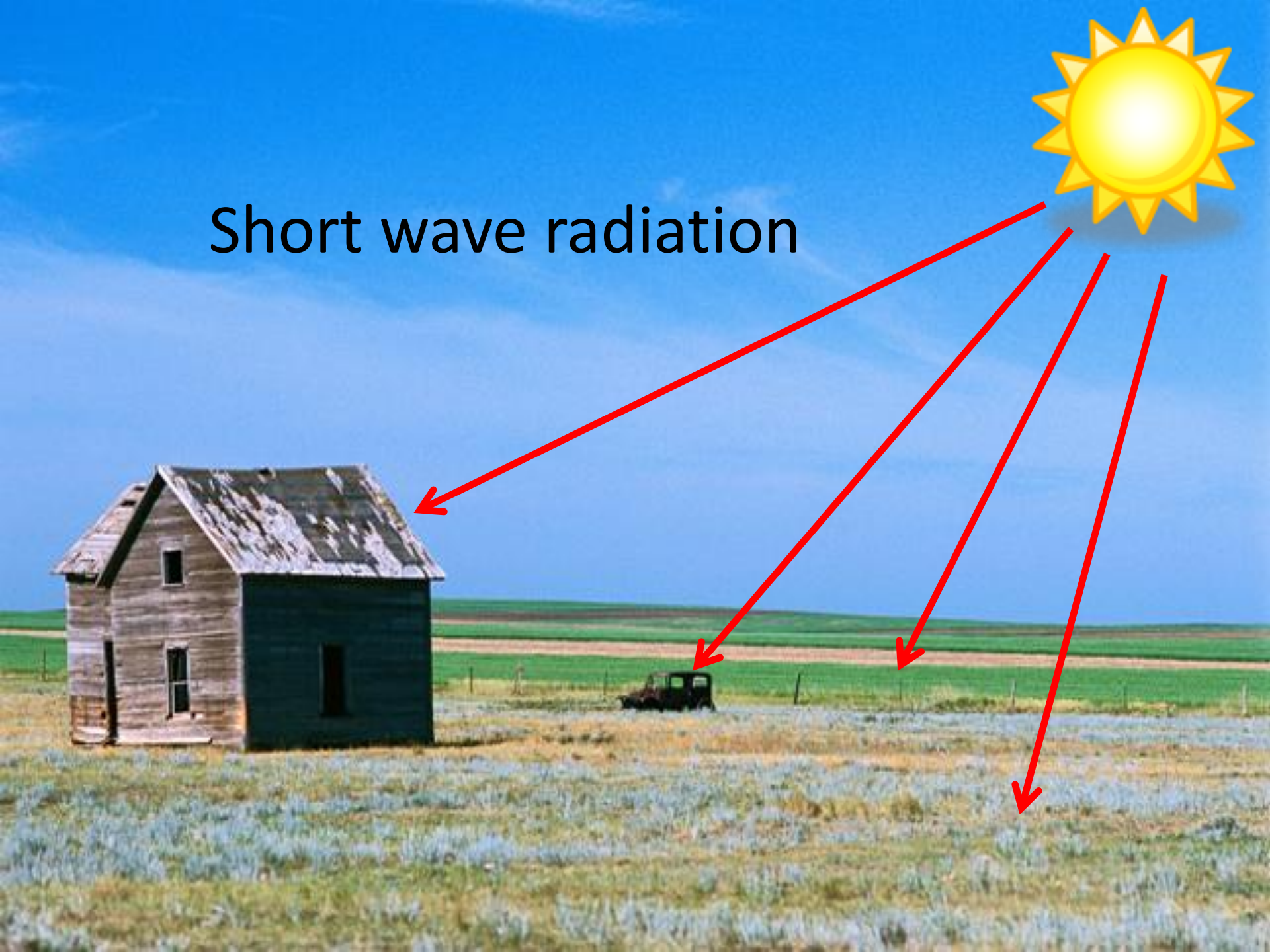


"Temperature Inversions

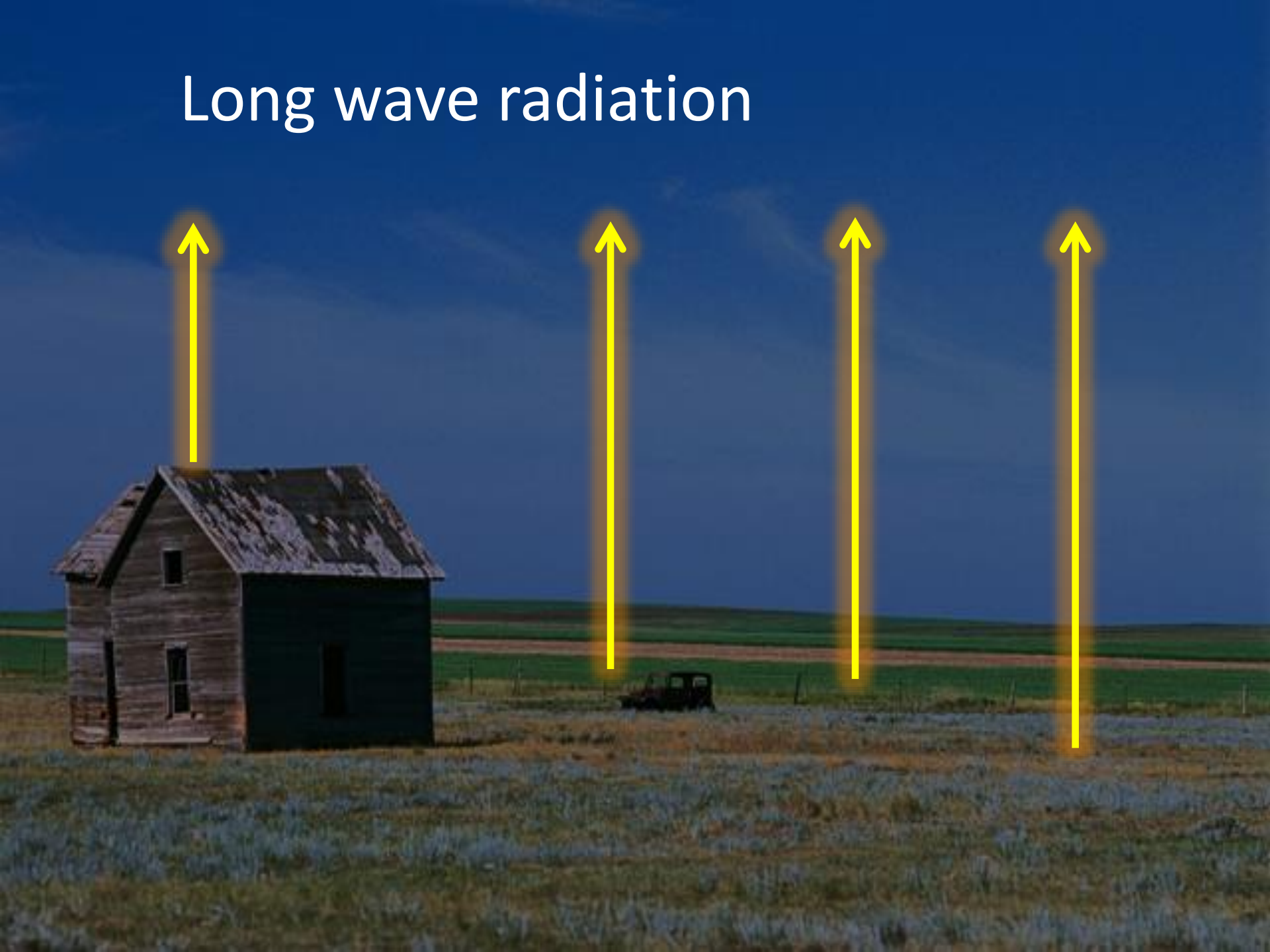
If applying at wind speeds less than 3 mph, the applicator must determine if:

a) conditions of temperature inversion exist, or
b) stable atmospheric conditions exist at or below nozzle height.

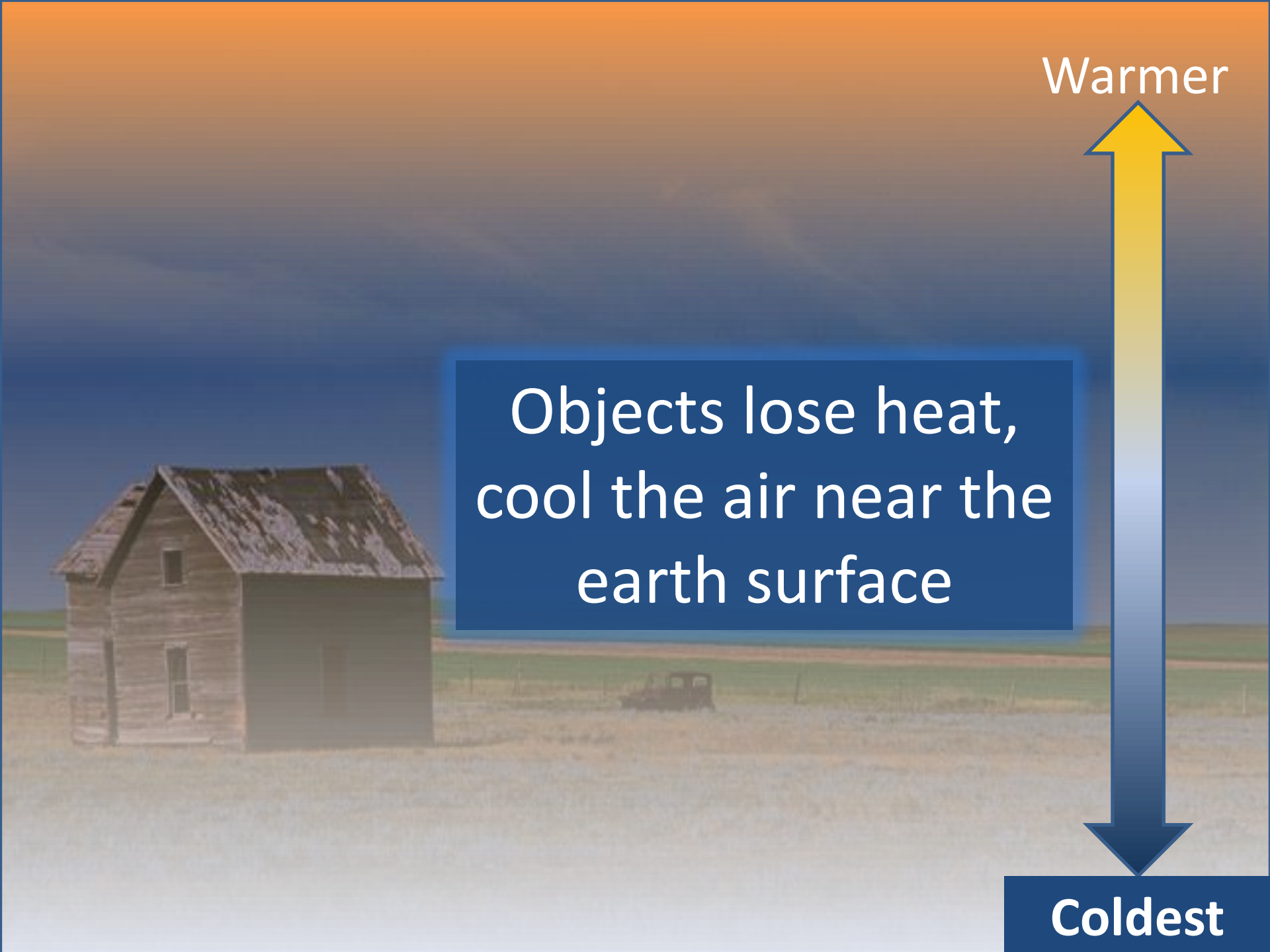
Do not make applications into areas of temperature inversions or stable atmospheric conditions."


Short wave radiation

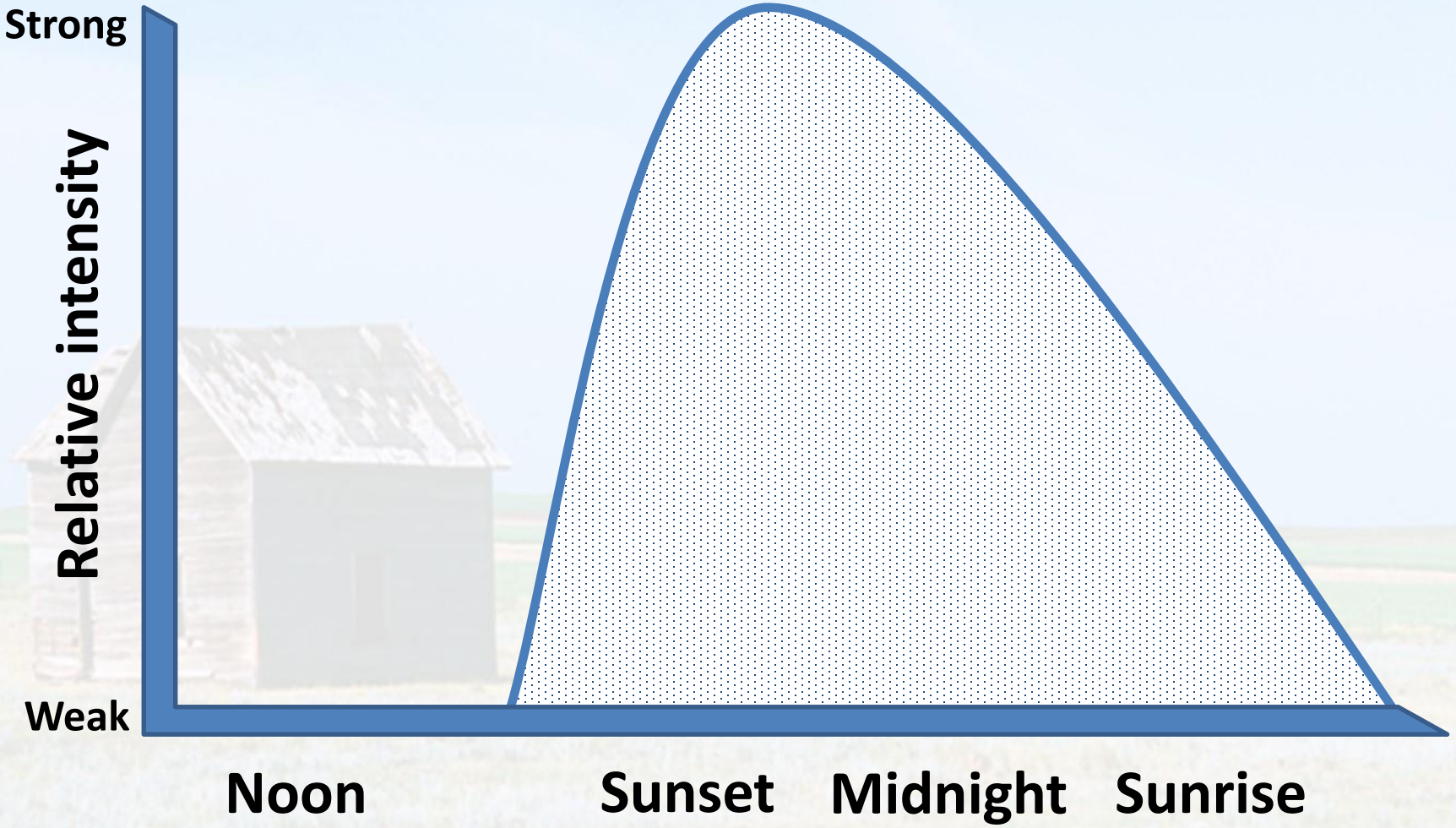
Long wave radiation



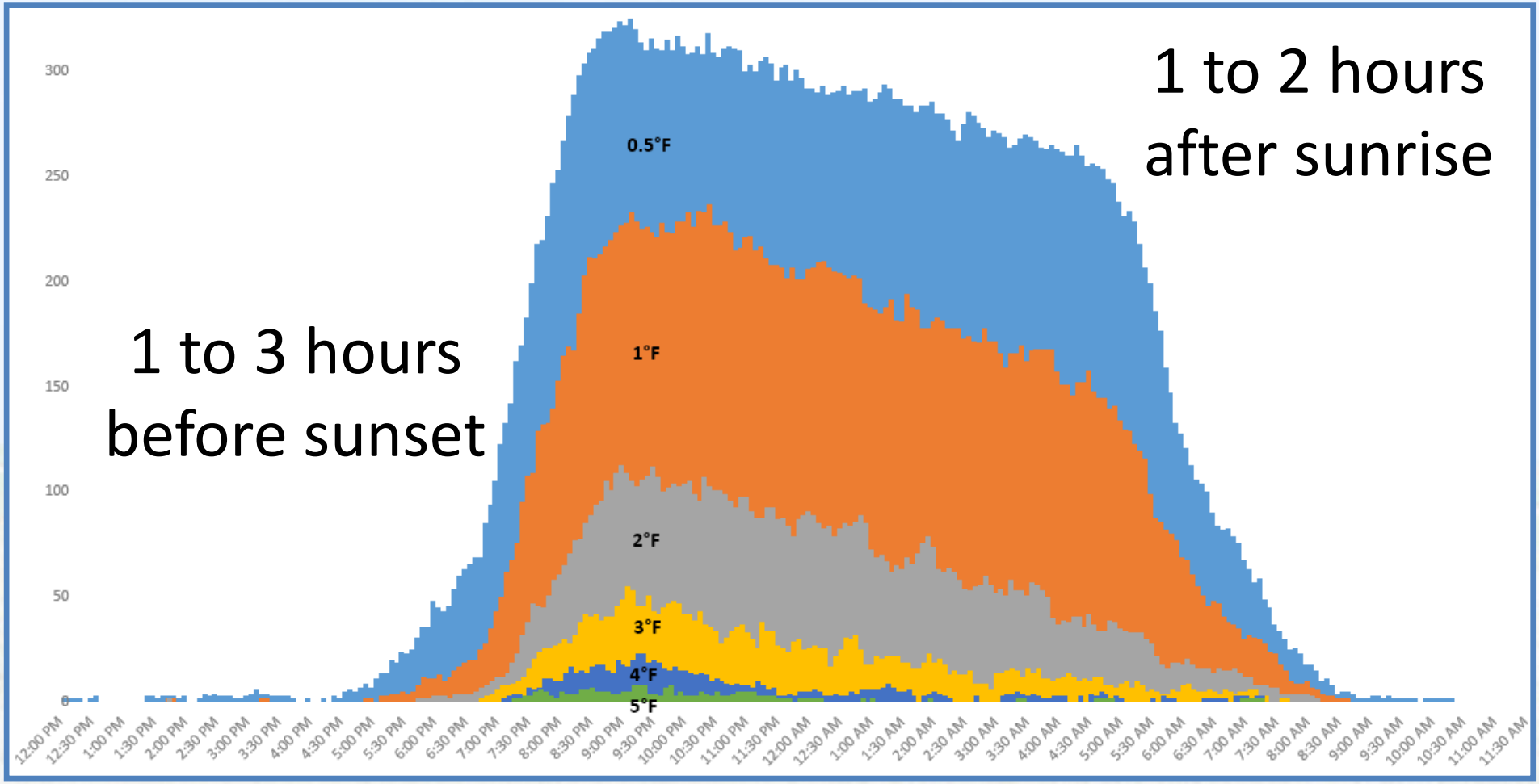
Radiation waves from objects move in all directions into the air


Warmer
Objects lose heat, cool the air near the earth surface
Coldest

On a clear & calm 24 hour day, when will inversions begin and end?



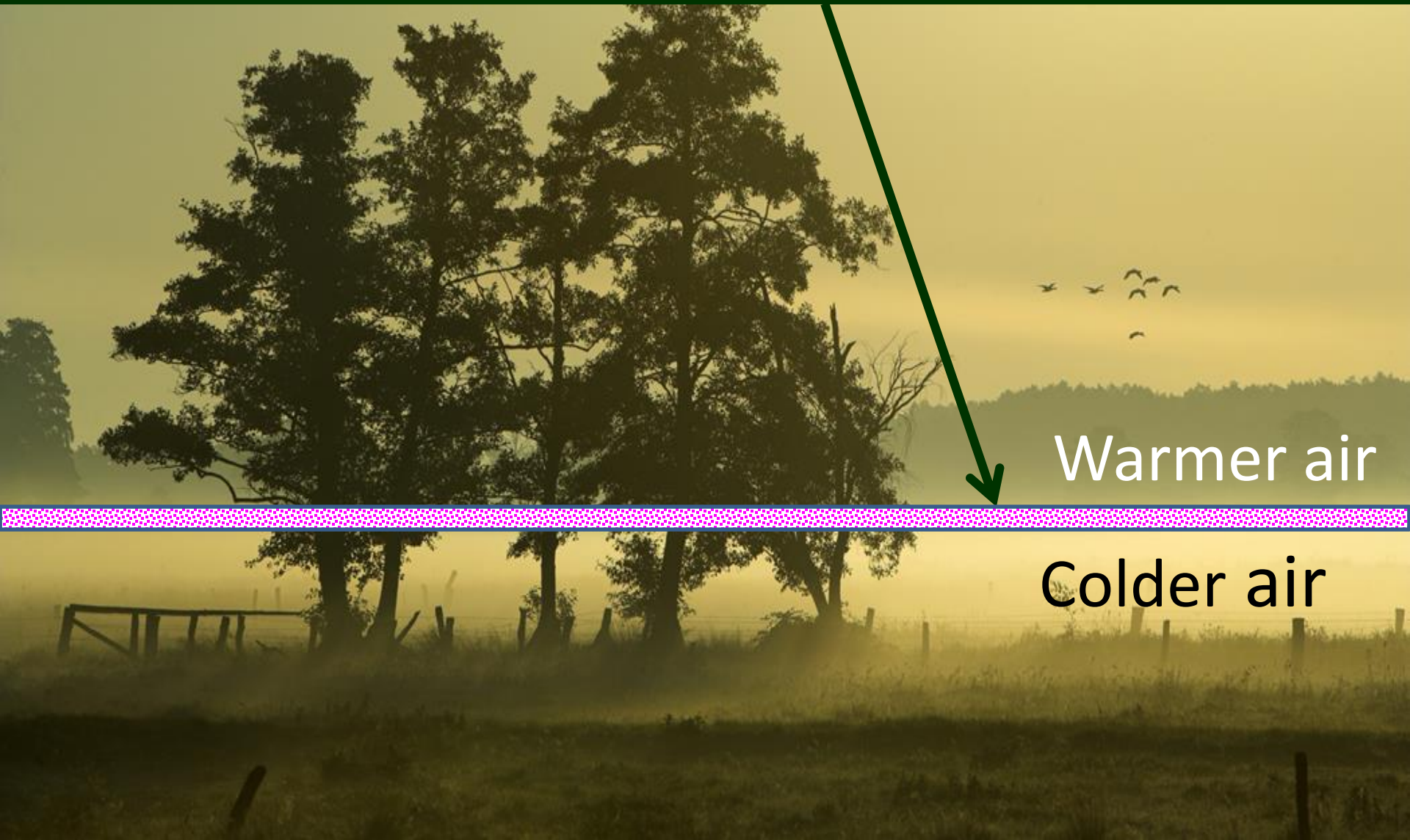
Distribution of Inversion Conditions

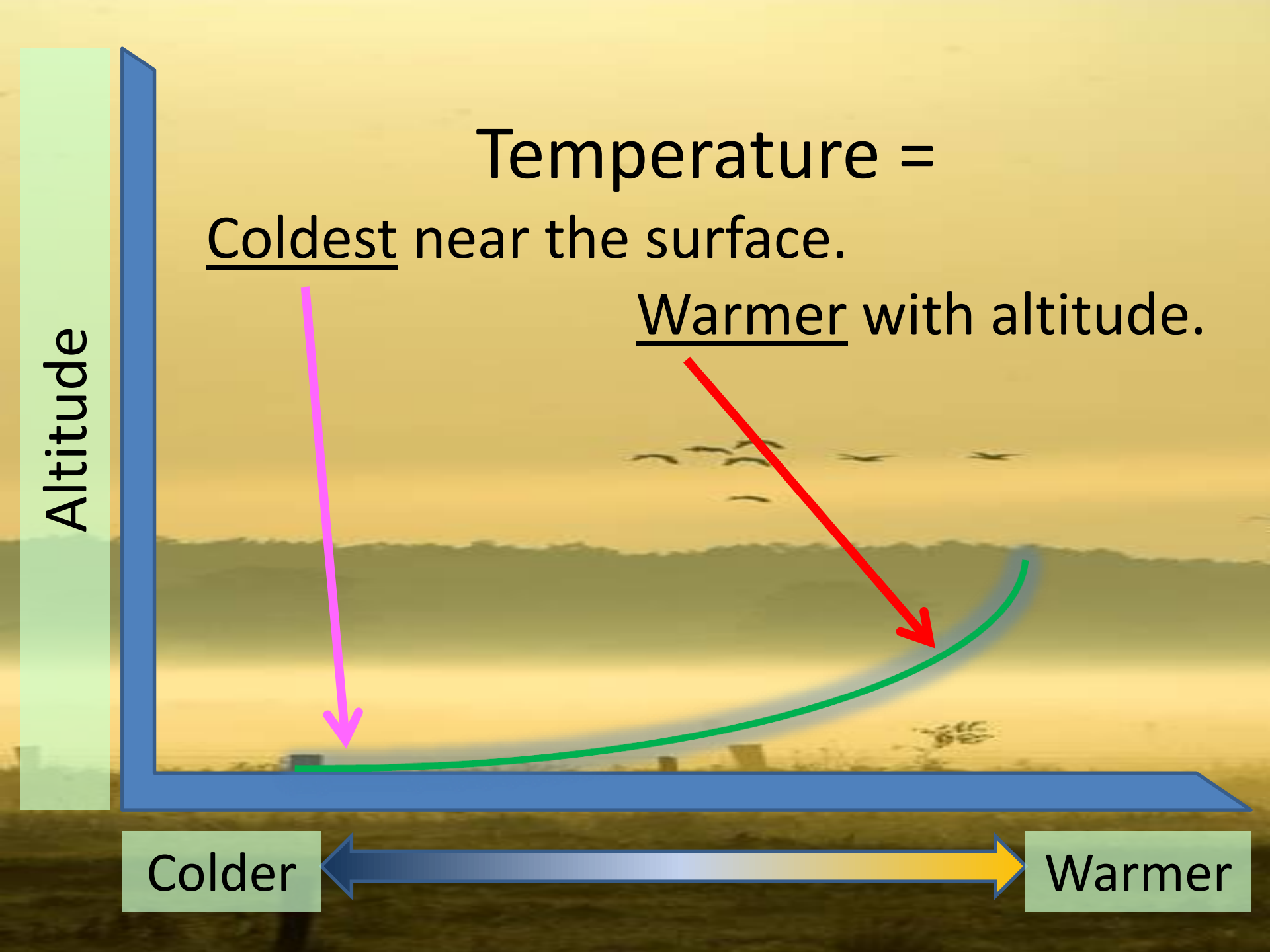


If there is sufficient moisture in the air, dew and frost will form because of cool air near the ground.

If there is sufficient moisture in the air, fog will also form.

If the light and fog reflect just so, one can actually see the inversion.




Temperature =
Coldest near the surface.
Warmer with altitude.
Altitude
Colder
Warmer

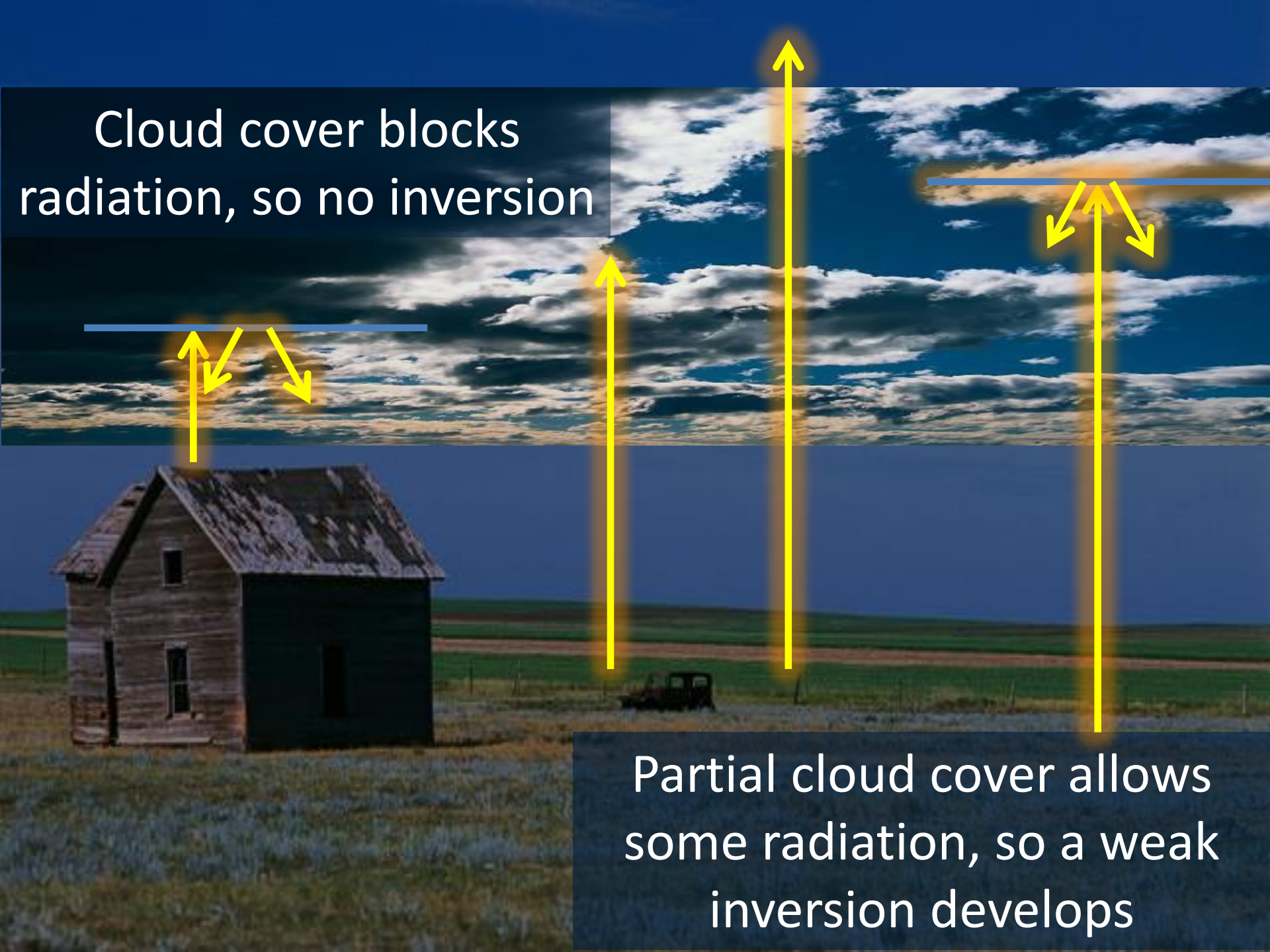
All the conditions we've talked about assumes very little wind.

Sufficient wind will mix the air, thus preventing or destroying the inversion.

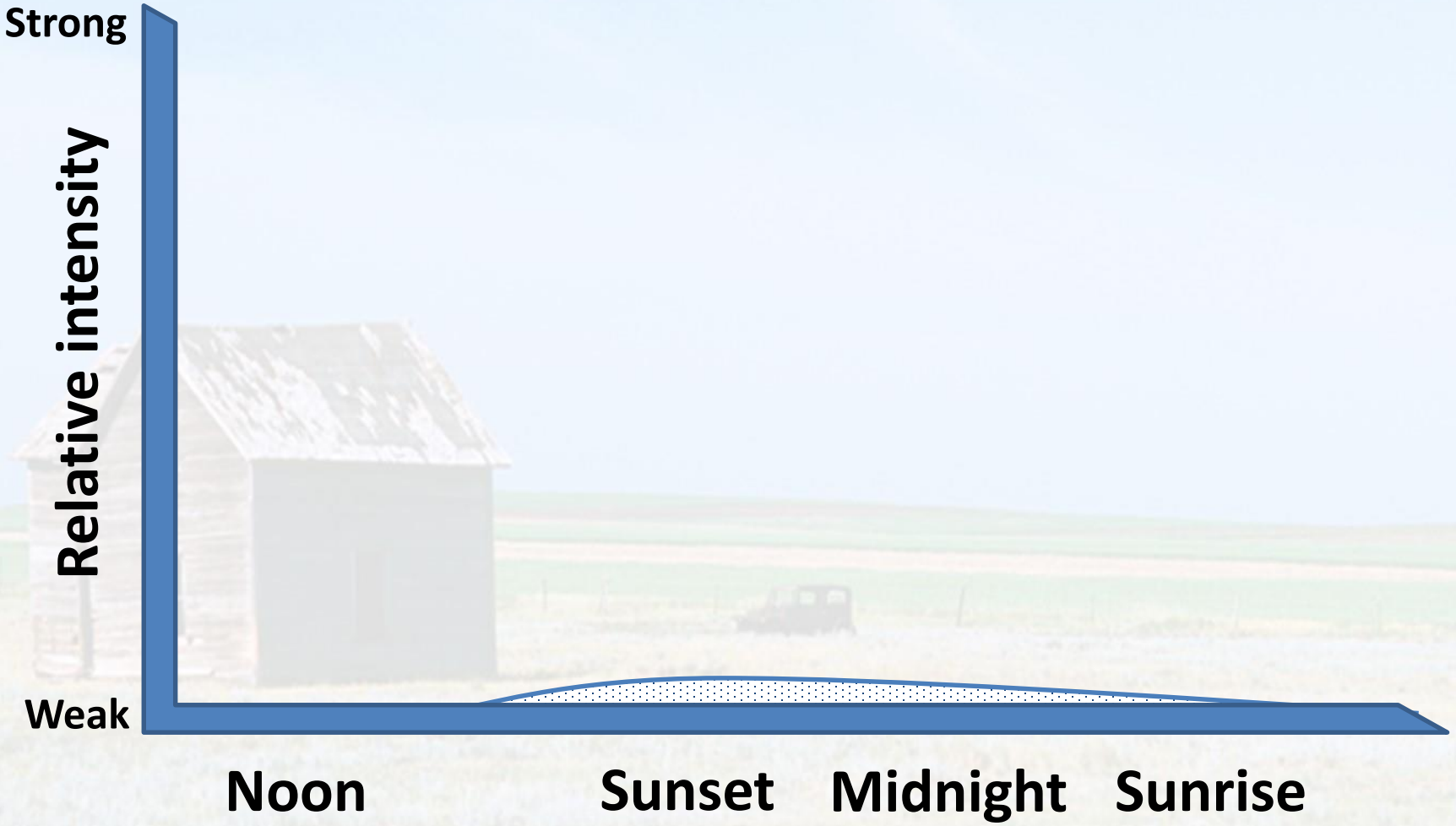
Significant Inversion Conditions can exist to wind speeds of ***6 MPH***

29	0.000%	0.000%	.000%	0.000%	0.000%
28	0.002%	0.000%	.000%	0.000%	0.000%
27	0.005%	0.000%	.000%	0.000%	0.000%
26	0.003%	0.000%	.000%	0.000%	0.000%
25	0.010%	0.000%	.000%	0.000%	0.000%
24	0.005%	0.000%	.000%	0.000%	0.000%
23	0.003%	0.000%	.000%	0.000%	0.000%
22	0.008%	0.000%	.000%	0.000%	0.000%
21	0.017%	0.003%	.000%	0.000%	0.000%
20	0.022%	0.000%	.000%	0.000%	0.000%
19	0.017%	0.003%	.000%	0.000%	0.000%
18	0.015%	0.005%	.000%	0.000%	0.000%
17	0.039%	0.010%	.000%	0.000%	0.000%
16	0.039%	0.002%	.000%	0.000%	0.000%
15	0.067%	0.003%	.000%	0.000%	0.000%
14	0.134%	0.010%	.000%	0.000%	0.000%
13	0.144%	0.015%	.000%	0.000%	0.000%
12	0.193%	0.022%	.000%	0.000%	0.000%
11	0.299%	0.020%	.000%	0.000%	0.000%
10	0.497%	0.077%	.000%	0.000%	0.000%
9	0.922%	0.089%	.000%	0.000%	0.000%
8	1.373%	0.190%	.000%	0.000%	0.000%
7	2.146%	0.381%	.000%	0.000%	0.000%
6	3.214%	0.757%	.000%	0.000%	0.000%
5	4.456%	1.474%	.000%	0.000%	0.000%
4	5.637%	2.827%	.000%	0.000%	0.000%
3	6.662%	4.799%	.000%	0.000%	0.000%
2	6.580%	5.598%	.000%	0.000%	0.000%
1	3.969%	4.088%	.000%	0.000%	0.000%
0	2.927%	3.573%	.007%	0.002%	0.000%
0.5	1	1.5	8.5	9	9.5
Wind MPH ^					
Inversion(F)->					

6	3.214%	0.757%
5	4.456%	1.474%
4	5.637%	2.827%
3	6.662%	4.799%
2	6.580%	5.598%
1	3.969%	4.088%
0	2.927%	3.573%
0.5	1	1.5
Wind MPH ^		
Inversion(F)->		


Cloud cover blocks radiation, so no inversion
Partial cloud cover allows some radiation, so a weak inversion develops

On a cloudy and/or windy 24 hour day, when will inversions begin and end?



Inversions that cause problems for pesticide applicators are like:

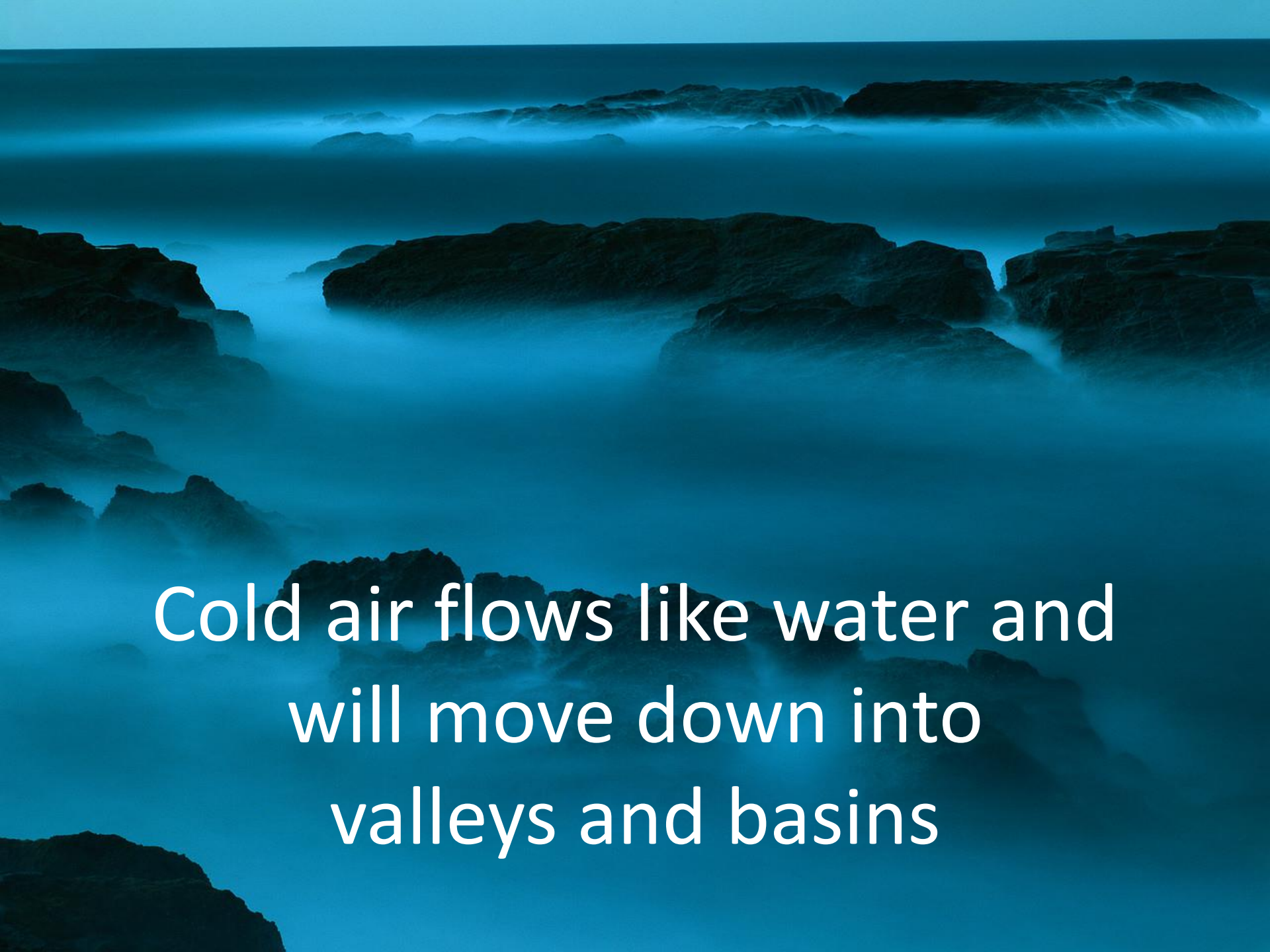
The Perfect <u>Inversion</u> Storm

A Perfect ***Inversion*** Storm

1. Requires radiation from surface objects into a cloudless or near cloudless sky
2. Requires light and variable winds with minimal mixing of the lower atmosphere.
3. Begins in the mid to late afternoon and intensifies into the night until dawn. (The inversion will then dissipate into mid-morning.)
4. Includes an unsuspecting applicator who does not recognize there is a problem until it is too late.

Environmental conditions making matters worse

- Topography—low lying area or a protected area shielded from the sun and / or wind.
- Stagnant and / or intense high pressure system
- Relatively low humidity conditions

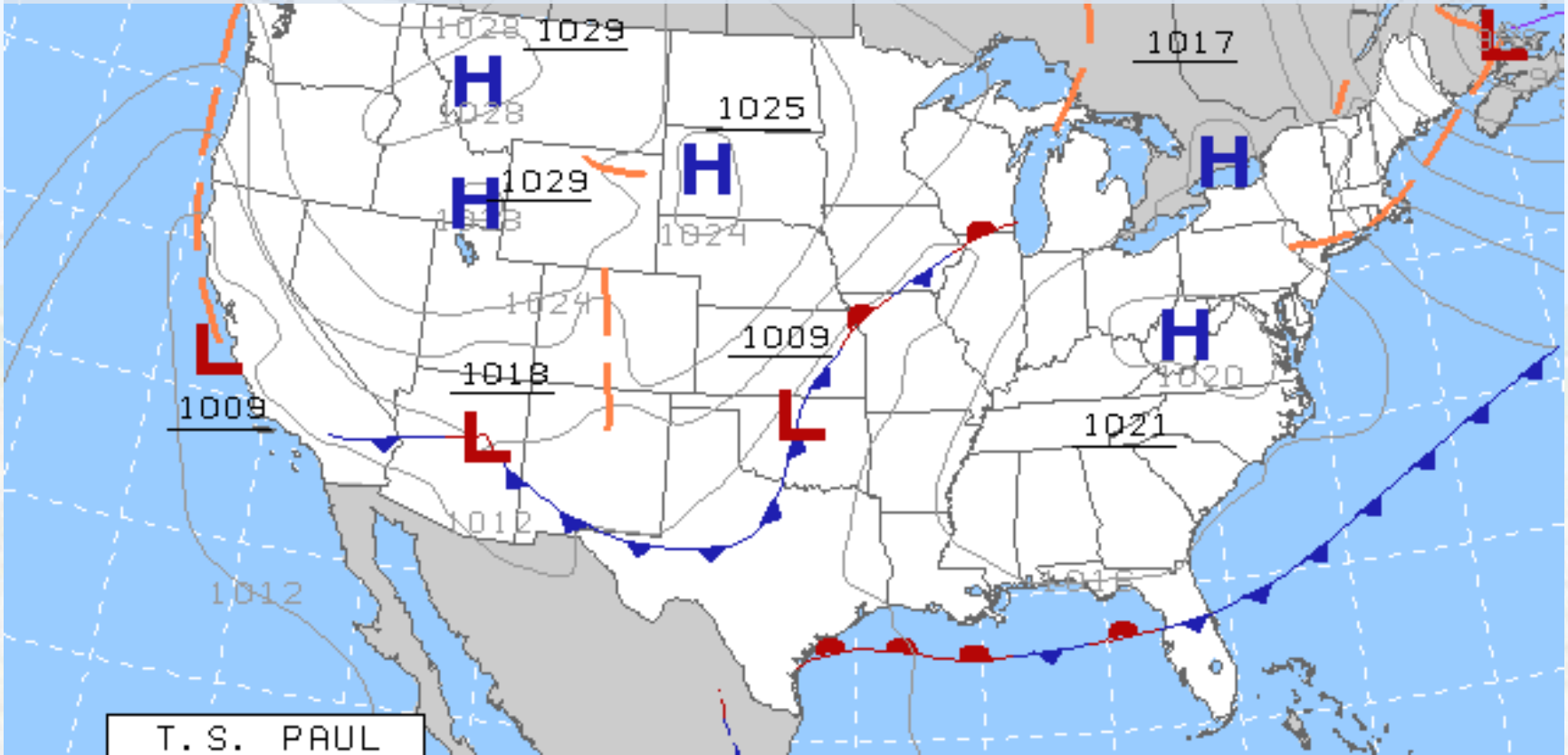

Cold air flows like water and
will move down into
valleys and basins

Cold air moves into a low lying pasture

Cold air moves into a low lying ditch

High Pressure Areas are associated with cool /dry air, clear skies & stable winds

Excellent ingredients for inversion formation



Humidity

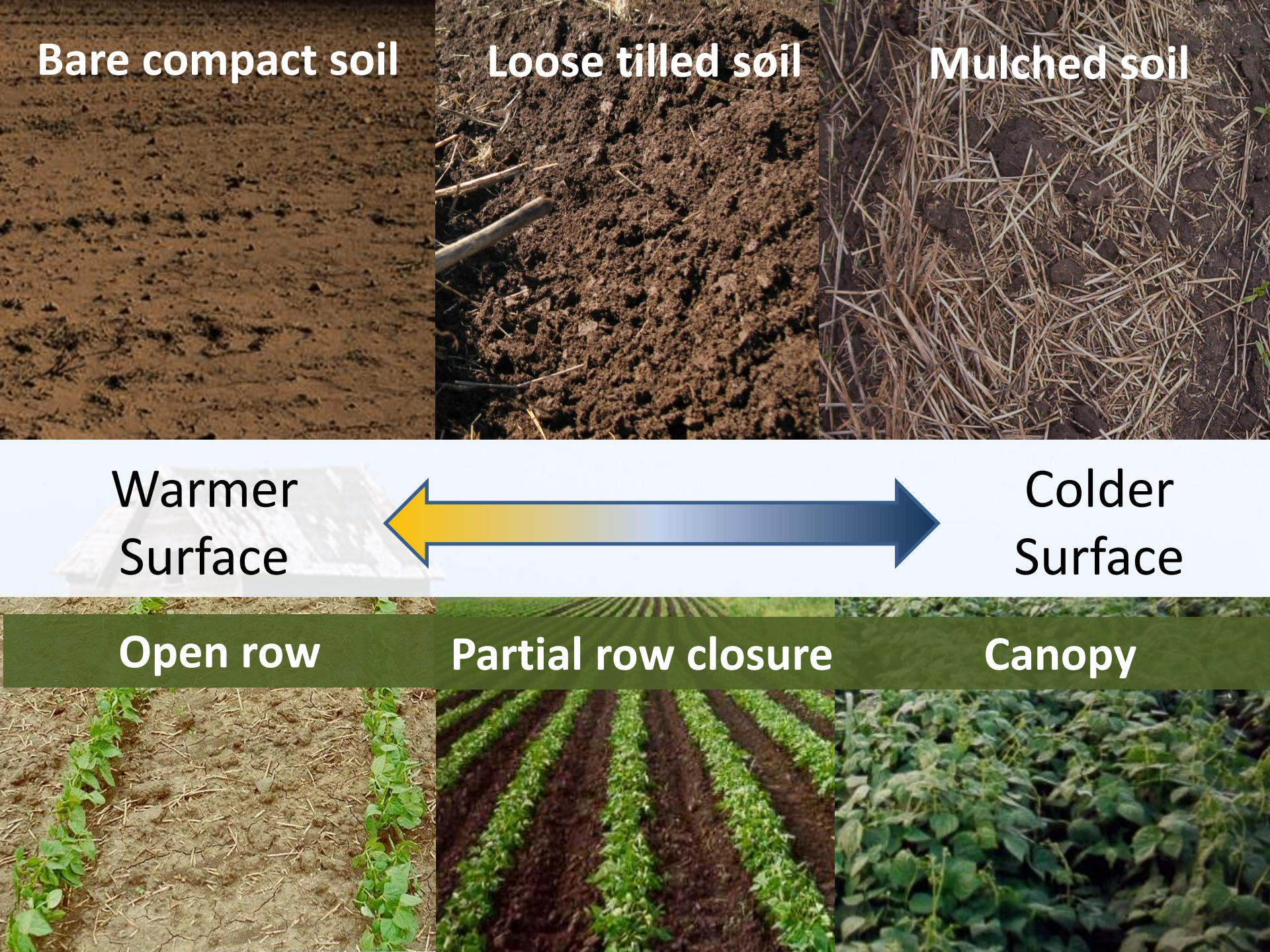
High humidity rainforest

Low humidity desert

- inversion builds faster
- intensity is greater
- dissipates faster

Surface conditions making matters worse

- Exposed soil that:
  - Has a low moisture content
  - Is sandy or coarse textured
  - Has been freshly tilled
- Soil that is heavily mulched and/or covered with heavy crop residue
- Closed crop canopy and or complete vegetative ground cover
- Wind breaks and/or shelter belts


Bare compact soil
Loose tilled soil
Mulched soil
Warmer Surface
Colder Surface
Open row
Partial row closure
Canopy

Open row surface temperature *slightly* colder than bare ground

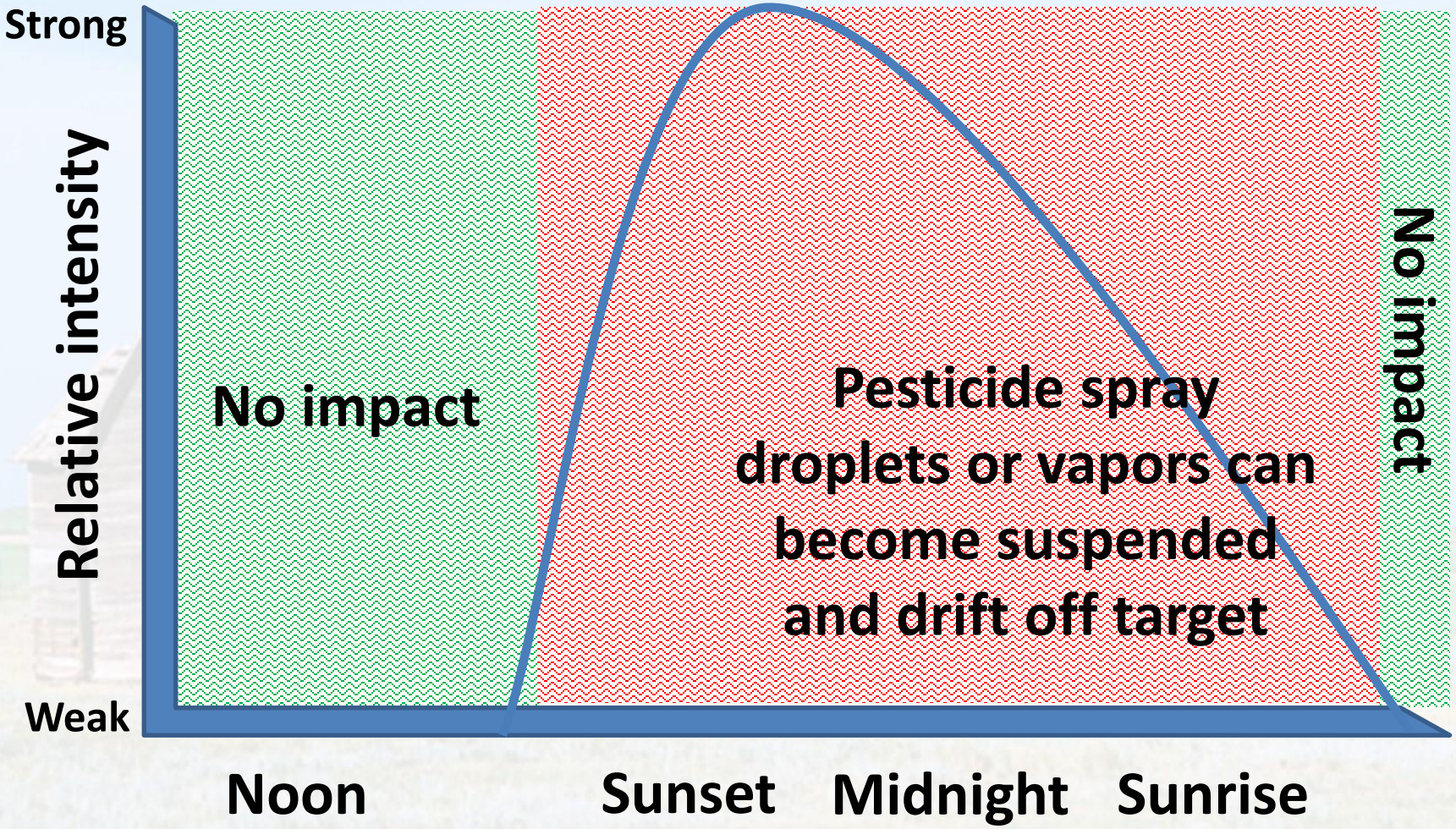
Closed row surface temperature *much* colder than bare ground

Wind Break Impact

Trees will interfere with wind, creating stable air conditions near earth surface

Tree shadow causes inversion earlier in the afternoon and will prevent dissipation longer into the morning

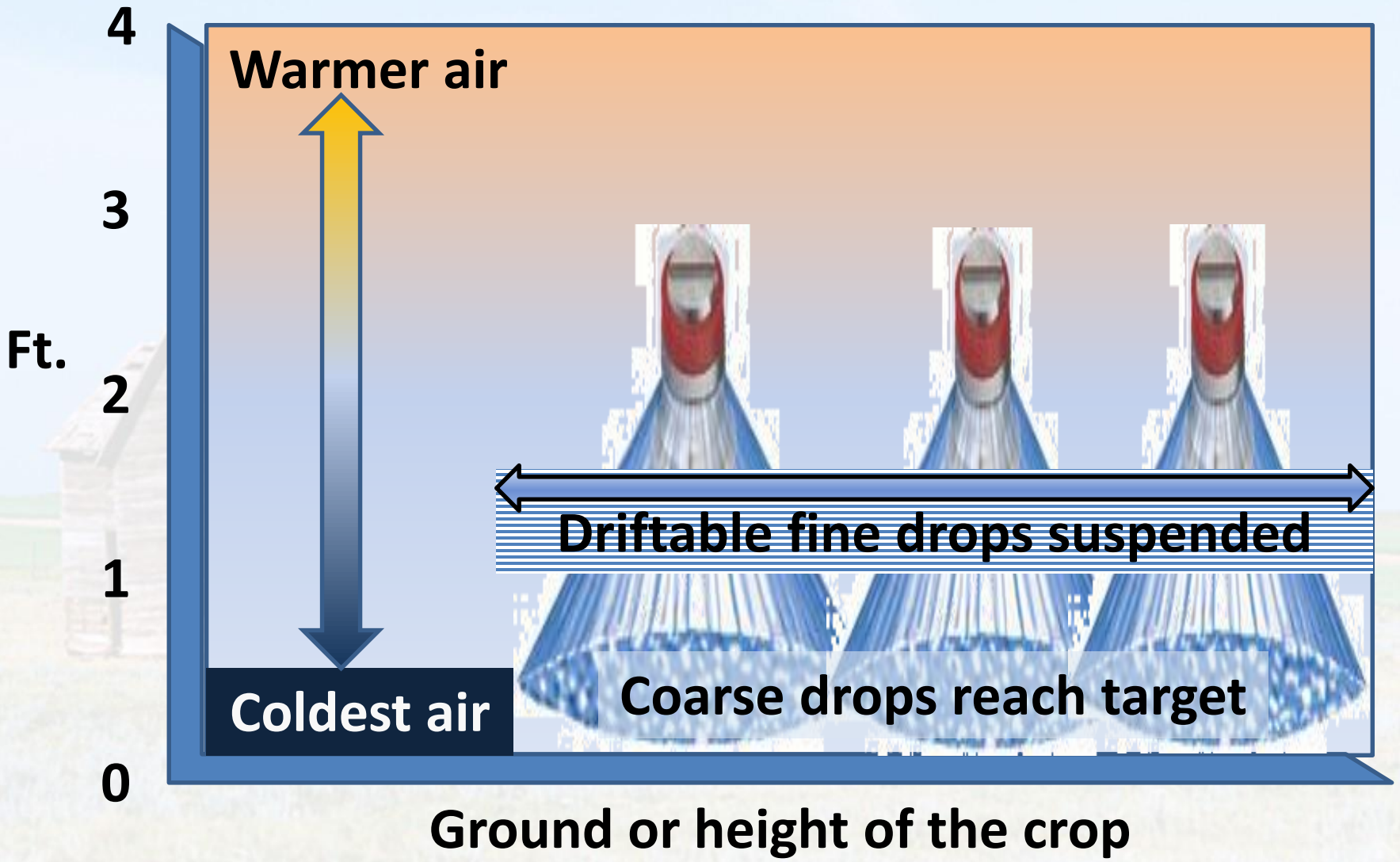
When will an inversion impact my spray operation?



What happens when I spray during an inversion?

It depends on the type of application and the inversion intensity.

Spraying during an inversion = suspension of fine droplets



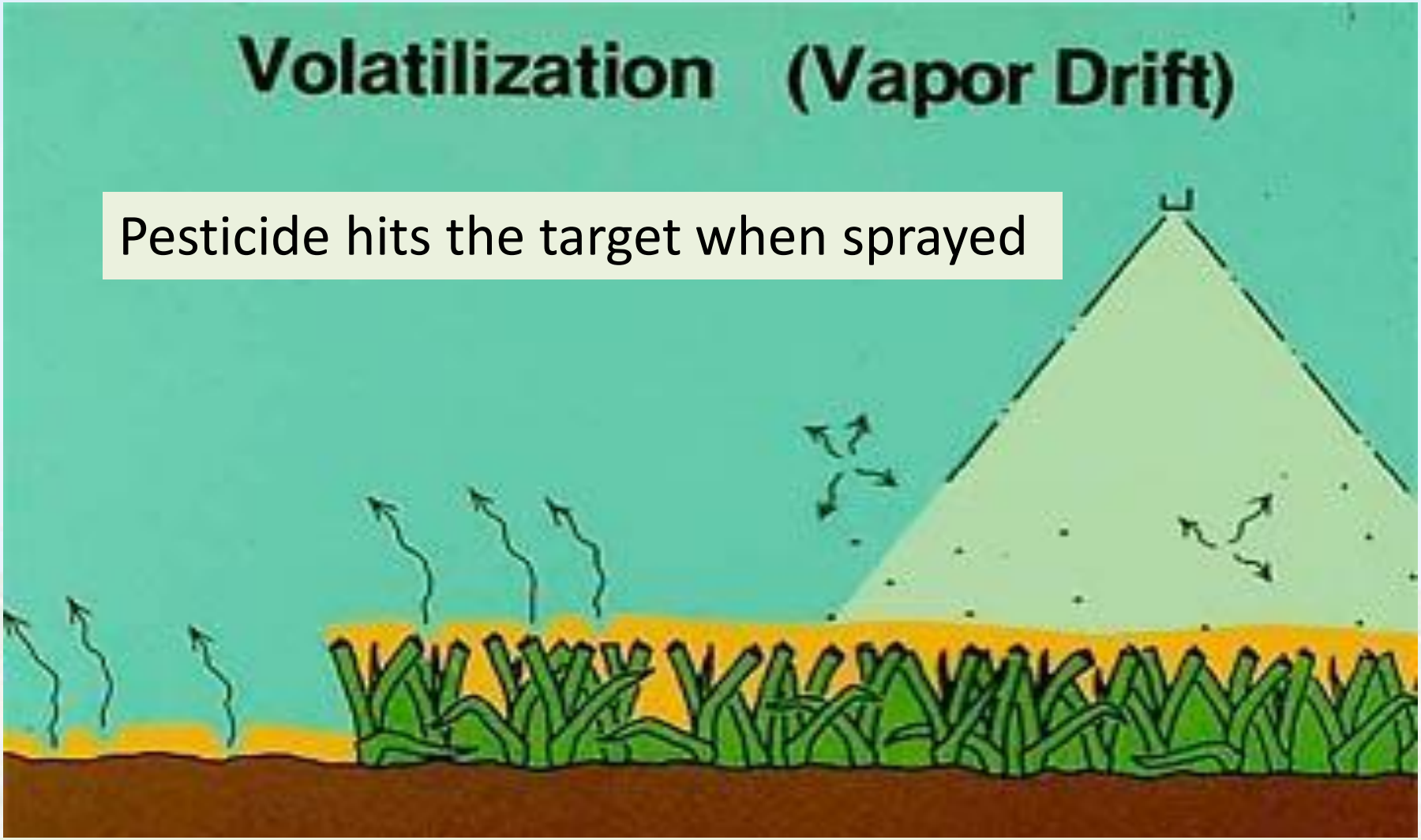
Fine spray drops hang in the air

Tracer dye, late afternoon spray, conducted in early May

Dust particles hang in the air

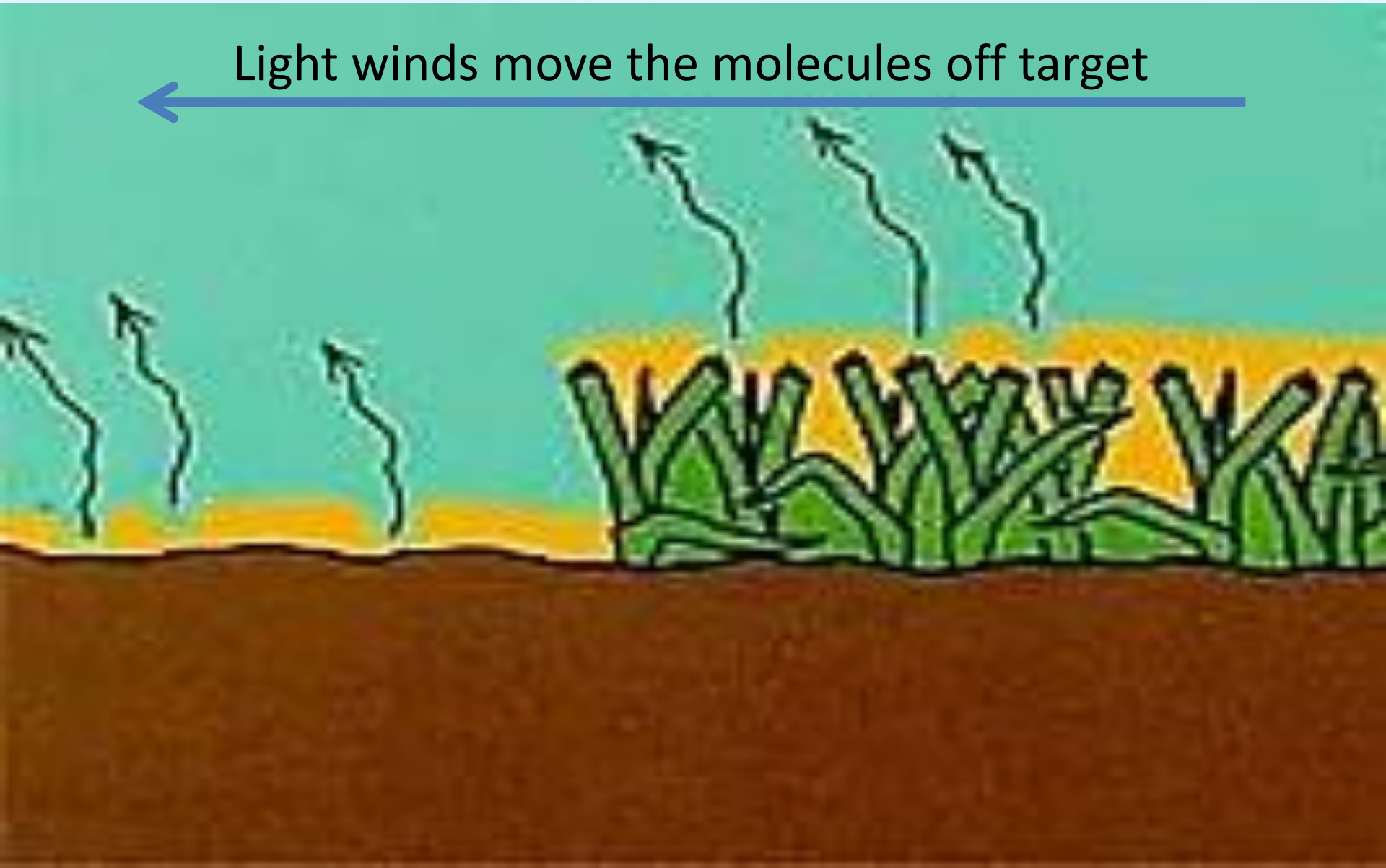
Visible dust particles are about 200 microns

Be wary of volatile pesticides



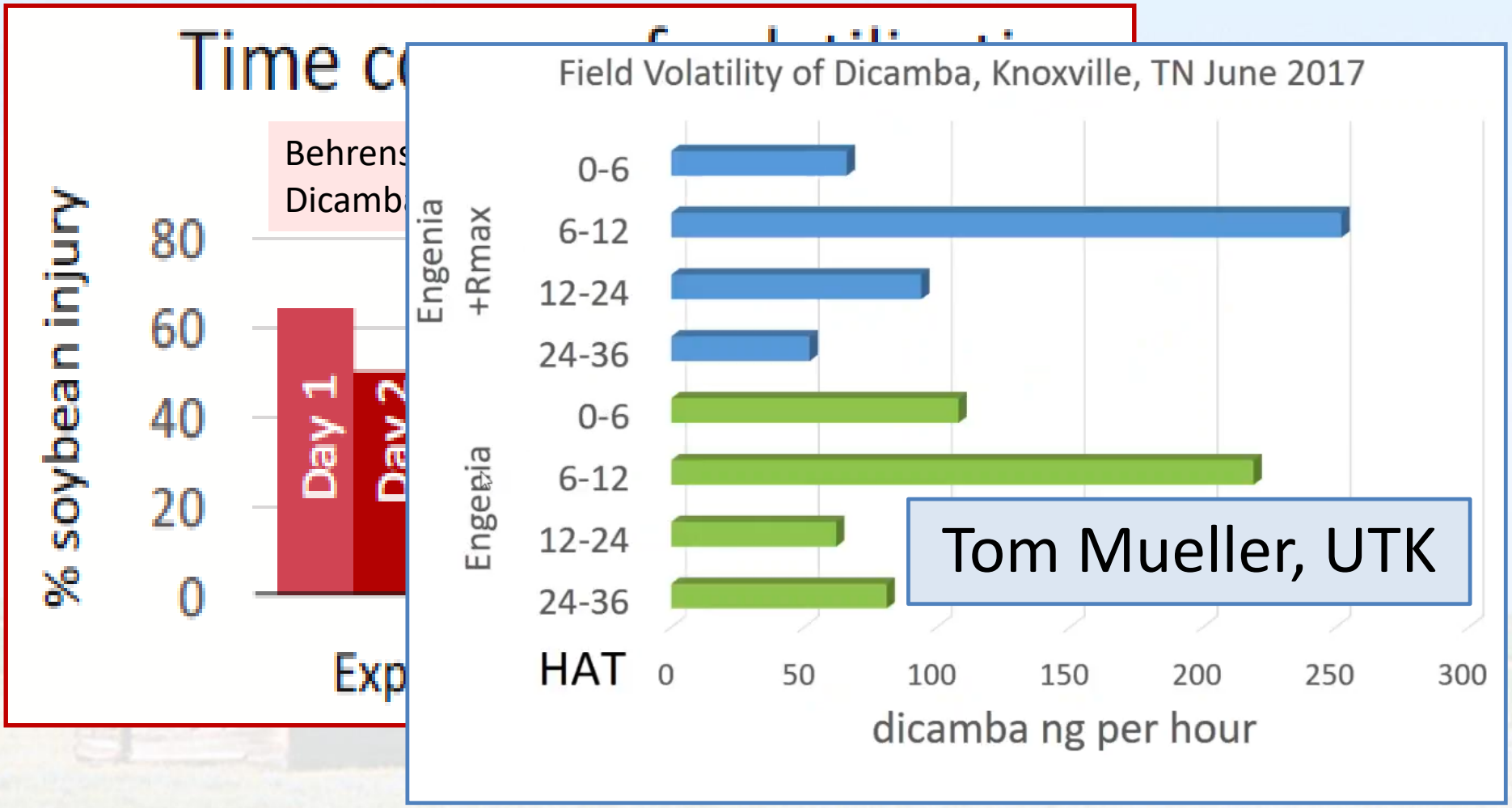
But then vaporizes or gasses off during or after application

Pesticide molecules mix with air



Volatility animation, University of Missouri

Volatile pesticides gas off over several days



thus they can become suspended in multiple inversion cycles

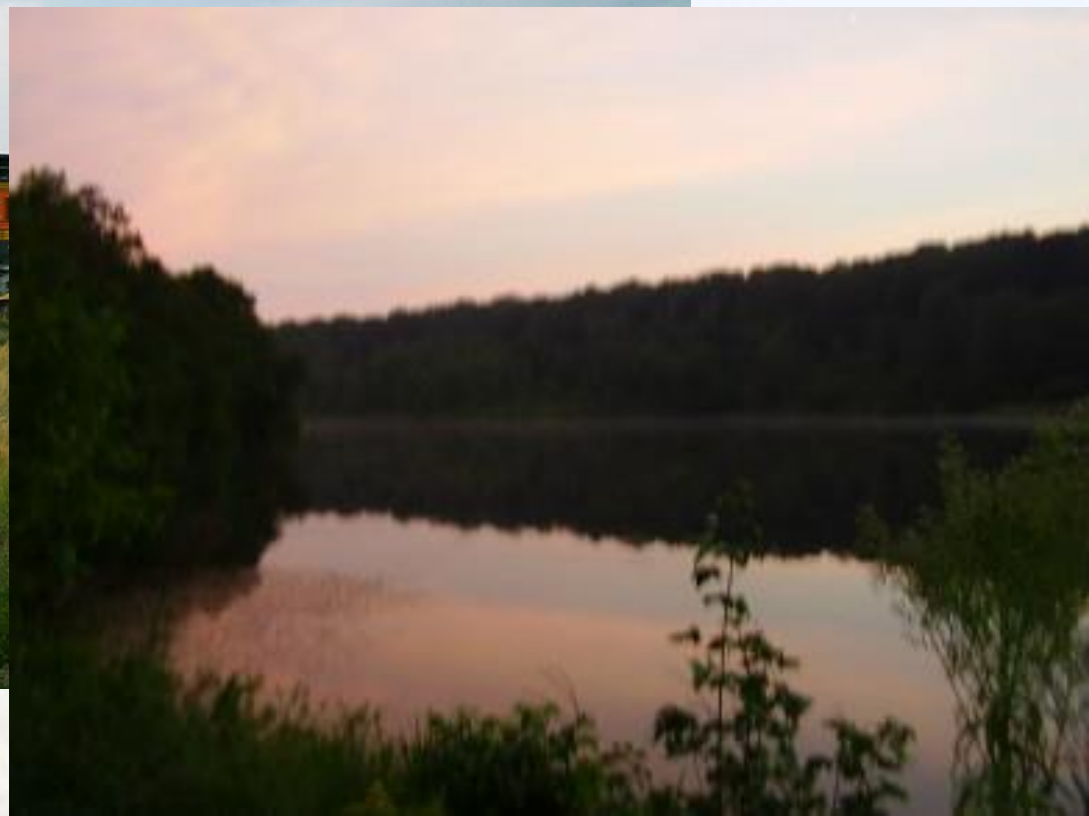
Clues about inversions

You can smell them


You can see it in a morning
or evening mirage


Dust from vehicles or farm machinery will hang in the air

You can hear it



A Perfect ***Inversion*** Storm

1. Requires radiation from surface objects into a cloudless or near cloudless sky
   - 25% or less cloud cover
2. Requires light and variable winds with minimal mixing of the lower atmosphere.
   - Especially 0 to 3 mph
   - Remain cautious with winds of ***4 to 6 mph***

A Perfect ***Inversion*** Storm

4. Begins in the mid to late afternoon and intensifies into the night. (The inversion will then dissipate into mid-morning.)
   - Especially 1-3 hours before sunset
   - Especially 1-2 hours after sunrise

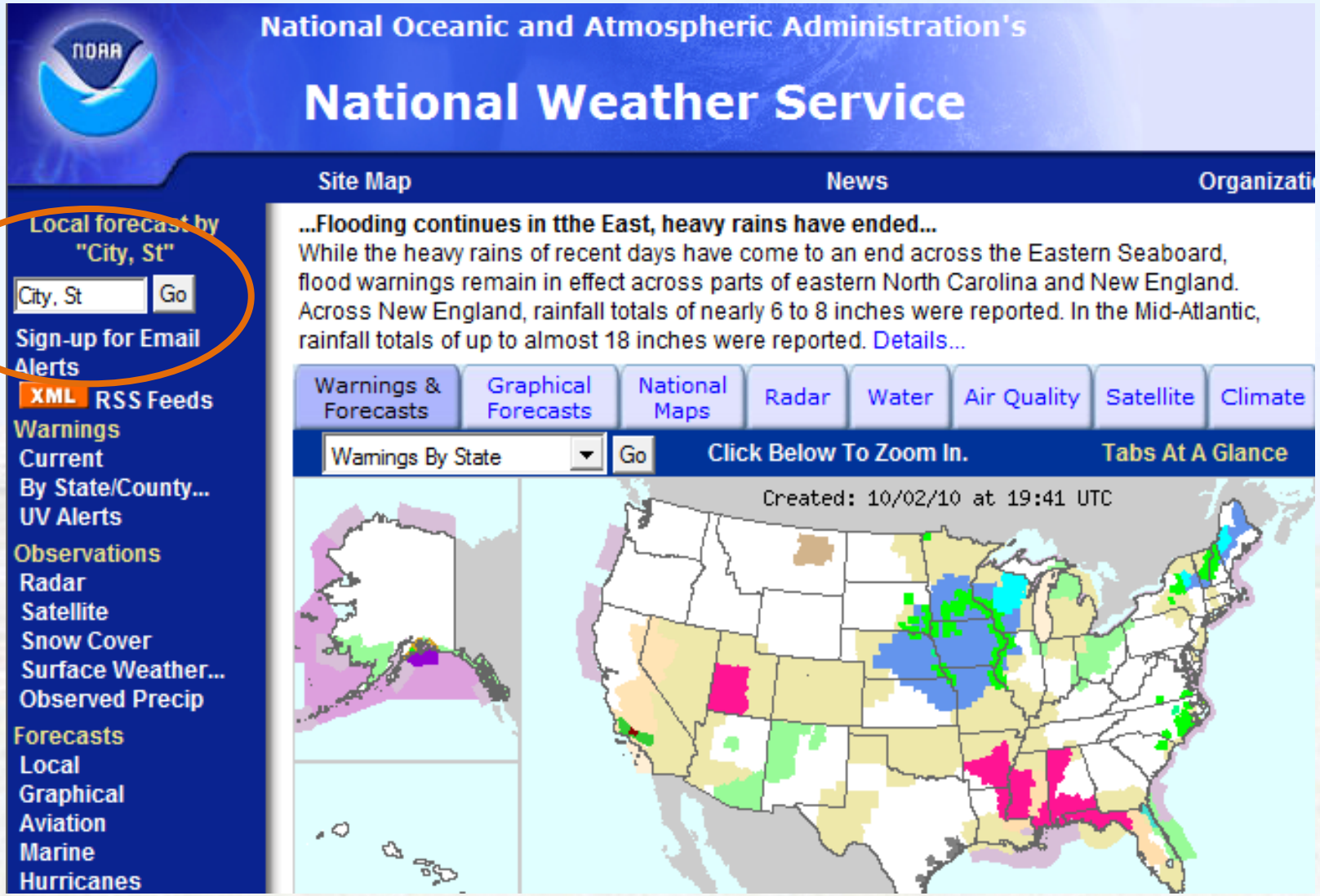
A Perfect ***Inversion*** Storm

5. Includes an unsuspecting applicator who does not recognize there is a problem:
   - Applicator who has been shut down for several days (due to high winds) and is desperately looking for an opportunity to spray
   - Applicator who is has been spraying for many hours and loses track of weather conditions, especially in the late afternoon / early evening

Late afternoon / evening spraying

Inversions during this time of the day could have serious consequences

www.weather.gov



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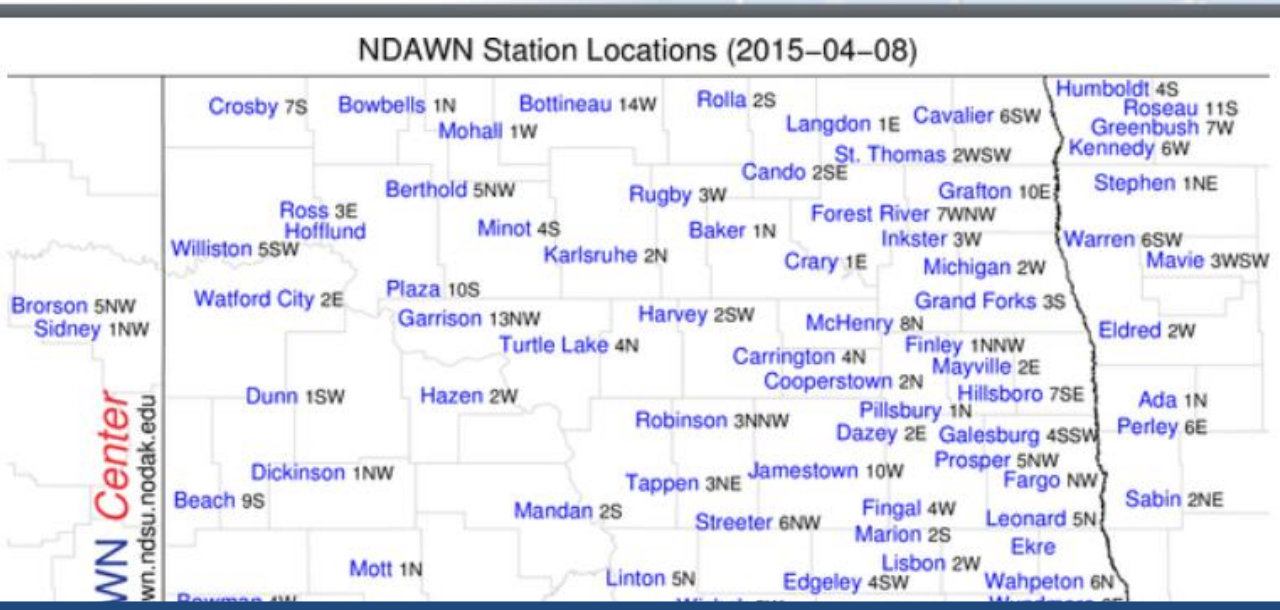

Station	Ag District	Last Updated	Air Temp	Wind Dir	Wind Speed	Peak Gust	Rel Hum	Dew Point Temp	Inversion 9/1.5 m	Inversion 3/1 m
Fargo NW	ND-EC	12 Sep 07:30 CDT	60°	SSE	6 mph	10 mph	80 %	54°	0.0°	0.2° !
Langdon 1E	ND-NE	12 Sep 07:30 CDT	59°	SSW	6 mph	8 mph	84 %	54°	0.5° !	0.5° !
Mooreton 3SW	ND-SE	12 Sep 07:30 CDT	55°	SE	4 mph	6 mph	96 %	54°	0.8° !	0.3° !
Carrington 4N	ND-C	12 Sep 07:30 CDT	65°	SW	6 mph	7 mph	88 %	61°	2.2° !	---
Bowman 4W	ND-SW	12 Sep 07:30 CDT	54°	WNW	4 mph	5 mph	77 %	47°	9.0° !	2.3° !
Ada 1N	MN-NW	12 Sep 07:30 CDT	56°	SE	2 mph	3 mph	82 %	50°	---	0.6° !

Using Weather Station Reports Are NEVER a Substitute for On-site Observations!

- Weather stations are miles away, even 70 to 80 miles
- Radio & television reports are time sensitive
- Wind is measured at 33 ft. for NOAA and 10 ft. for NDAWN. Wind speed at application height can be 20 to 25% slower
- Remote instrumentation can fail because of calibration or maintenance errors
- Labels are specifying on-site readings and state law often demands site of application data

Mandatory On-site Weather Readings

Bayer CropScience

GROUP	1	6	27	HERBICIDE

Wolverine™ Herbicide

For Selective Postemergence Control of Most Annual Grassy Weeds (Including Wild Oat and Foxtail Species) and Broadleaf Weeds in Wheat and Barley

ACTIVE INGREDIENTS:

Fenoxaprop-P-ethyl 4.47%

Pyrasulfotole 1.94%

Bromoxynil Octanoate 4.65%

Bromoxynil Heptanoate 4.79%

OTHER INGREDIENTS 80.85%

Total 100.00%

Contains petroleum distillates

Contains 0.42 pound Fenoxaprop-P-ethyl, 0.17 pound Pyrasulfotole, 0.42 pound, Bromoxynil Octanoate, and 0.41 pound Bromoxynil Heptanoate.

EPA Reg. No. 264-1075 EPA Est.

"For all non-aerial applications, wind speed must be measured adjacent to the application site, on the upwind side, immediately prior to application."

Need to look at what is happening at the site of application, boom height.

A means to quickly assess an inversion

Air Temperature Inversions

Causes, Characteristics and Potential Effects on Pesticide Spray Drift

John W. Enz
Professor Emeritus
Department of Soil Science

Vernon Hofman
Professor Emeritus
Department of Agricultural and Biosystems Engineering

Andrew Thostenson
Extension Pesticide Program Specialist

Pesticide spray drift always has been a costly and frustrating problem for applicators.

It's particularly frustrating because some of the seemingly best weather conditions for pesticide application are often the worst. That is because those conditions are caused by air temperature inversions. Air temperature inversions provide near-perfect conditions for tiny, aerosol-size droplets to drift away from their targets.

Understanding inversions is essential to following state and federal regulations that prohibit pesticide application during inversions, observing pesticide manufacturers' warnings about inversion conditions on product labels and preventing unintended pesticide contact with nontarget areas. An understanding of air temperature inversions – why they occur, their characteristics and their dissipation – requires a basic understanding of energy transfer at the Earth's surface and in the lower layers of the atmosphere.

NDSU EXTENSION SERVICE
November 2017

Don’t simply rely on easy apps on your phone!

Questions

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