Temperature Inversions: Their Impact On Pesticide Applications

When spraying with a 2 mph wind is worse than 20 mph
Presentation will be released to AAPSE Members:

First Half October, 2012

* Will include the PPTX
* Will include narrated PPTX video clips
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 trapped in a cool air inversion layer and move off target.
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.”
Inversion + Soil Fumigants = Hundreds Evacuated, Dozens Hospitalized
Short wave radiation
Long wave radiation
Radiation waves from objects move in all directions into the air.
Radiation into the atmosphere heats the air.

Objects lose heat, cool the air near the earth surface.
On a clear & calm 24 hour day, when will inversions begin and end?

![Graph showing relative intensity of inversions at different times of day. The graph peaks at Sunrise, indicating strong inversions.](image)
Early afternoon temperature profile on a hot day with 4 mph or less wind

- 105 degrees F at 4 inches
- 99.4 degrees F at 12 inches or 1 foot
- 95.5 degrees F at 24 inches or 2 feet
- 92.5 degrees F at 39 inches or 3.25 feet
- 90 degrees F at 60 inches or 5 feet

NDSU Weather Data—Courtesy of John Enz, Professor Emeritus
Early morning temperature profile with a strong inversion (calm & clear)

- 50 degrees F at 60 inches or 5 feet
- 48 degrees F at 39 inches or 3.25 feet
- 46 degrees F at 24 inches or 2 feet
- 45 degrees F at 12 inches or 1 foot
- 44 degrees F at 4 inches

Estimated!
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.

Warm air

Cold air
Temperature =

Coldest near the surface.

Warmer with altitude.
All the conditions we’ve talked about assumes very little wind.

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

- Sunrise
- Midnight
- Sunset
- Noon

Relative intensity:

- Strong
- Weak
Early afternoon temperature profile on a hot & windy day

<table>
<thead>
<tr>
<th>Depth (inches)</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>95.8</td>
</tr>
<tr>
<td>60</td>
<td>92.5</td>
</tr>
<tr>
<td>39</td>
<td>93.4</td>
</tr>
<tr>
<td>24</td>
<td>94.3</td>
</tr>
<tr>
<td>12</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>95.8</td>
</tr>
</tbody>
</table>

NDSU Weather Data—Courtesy of John Enz, Professor Emeritus
Early morning temperature profile with little or no inversion (windy & cloudy)

18th Hole

40.7 degrees F at 60 inches or 5 feet

40.4 degrees F at 39 inches or 3.25 feet

40.3 degrees F at 24 inches or 2 feet

40.1 degrees F at 12 inches or 1 foot

40 degrees F at 4 inches

Estimated!
There’s more to come so hang on!
Inversions that cause problems for pesticide applicators are like:

The Perfect Inversion Storm
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
Open row surface temperature *slightly* colder than bare ground.

Closed row surface temperature *much* colder than bare ground.
Wind Breaks

Trees will interfere with wind, inversion builds more quickly and cold air layer becomes trapped.

Tree shadow causes inversion earlier in the afternoon and will prevent dissipation longer into the morning.
What about time of the day?
Late Afternoon / Evenings
Mornings
When will an inversion impact my spray operation?

Pesticide spray droplets or vapors can become suspended and drift off target.

Relative intensity:
- Weak
- Strong

Time:
- Noon
- Sunset
- Midnight
- Sunrise

No impact

Strong
Exceptions

Stagnant air conditions, inversions may not dissipate for days
What happens when I spray during an inversion?

It depends on the type of application and the inversion intensity.
High percentage of fine drops is never good, but they are especially bad in an inversion.
Demonstration sprayer

Drift reduction nozzles

Standard droplet nozzles

Note fine drops misting off of the boom
Spraying during an inversion = trapping of fine droplets

- Driftable fine drops trapped
- Coarse drops reach target

*Warmer air*

*Coldest air*

Ground or height of the crop
Spraying during an inversion = trapping of fine droplets

Warmer air

Driftable fine drops trapped

Coldest air

Coarse drops reach target

Ground or height of the crop
Dust particles hang in the air

Visible dust particles are about 200 microns or more in size
Fine spray drops hang in the air

Tracer dye, late afternoon spray, conducted in early May
Fine pesticide laden droplets move off target
Create the best droplet pattern possible with the right nozzle

Operate them based on the nozzle manufacturer’s specifications!
Be wary of pesticides that are sensitive to vaporization

But then vaporizes or gasses off during or after application
Pesticide molecules mix with air

Light winds move the molecules off target
How do you know if a pesticide will volatilize?

Especially look for high temperature warning statements on the label like:

“Do not apply CRUISE CONTROL adjacent to sensitive crops when the temperature on the day of application is expected to **exceed 85°F** as drift is more likely to occur.”
While the actual A.I. may not be volatile, solvent odors can be
Clues
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

3. Begins in the mid to late afternoon and intensifies throughout the night until dawn. (The inversion will then dissipate into mid-morning.)
   – Especially 3-5 hours before sunset
   – Especially 2-3 hours after sunrise
A Perfect *Inversion* Storm

4. 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.
<table>
<thead>
<tr>
<th>Date</th>
<th>10/02</th>
<th>10/03</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hour (CDT)</strong></td>
<td>15  16  17  18</td>
<td>19  20  21  22  23  00  01  02  03  04  05  06  07  08  09  10</td>
</tr>
<tr>
<td><strong>Temperature (°F)</strong></td>
<td>58  58  57  56</td>
<td>51  48  45  41  39  38  37  36  35  35  34  34  35  37  40  44</td>
</tr>
<tr>
<td><strong>Dewpoint (°F)</strong></td>
<td>36  36  35  35</td>
<td>35  35  35  35  34  34  34  33  32  32  31  31  32  33  35  36</td>
</tr>
<tr>
<td><strong>Wind (mph)</strong></td>
<td>8   7   6   5</td>
<td>3   2   2   2   2   2   2   2   2   2   1   1   1   2   3   5  7  9</td>
</tr>
<tr>
<td><strong>Wind Dir</strong></td>
<td>NE  NE  NE  ENE</td>
<td>ENE  E  ESE  ESE  SE  SSE  SSE  SE  SE  SE  SE  SE  SSE  SSE  SSE</td>
</tr>
<tr>
<td><strong>Gust</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sky Cover (%)</strong></td>
<td>38  36  30  24</td>
<td>18  12  6  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0</td>
</tr>
<tr>
<td><strong>Rel. Humidity (%)</strong></td>
<td>44  43  44  46</td>
<td>53  60  69  78  81  85  89  89  88  88  88  88  88  88  88  86  82  74</td>
</tr>
</tbody>
</table>
www.weather.gov
Scroll Down & Select Tabular Forecast
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 (NDSU Stations). 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

“For all non-aerial applications, wind speed must be measured adjacent to the application site, on the upwind side, immediately prior to application.”
Smoke hangs in the air and does not dissipate or rise
Need to observe local conditions
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
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
Questions
Presentation will be released to AAPSE Members:

First Half October, 2012

* Will include the PPTX

* Will include narrated PPTX video clips