HAZARDOUS INVERSION FACT SHEET

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

NATIONAL
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Hazardous surface temperature inversion

Pesticide applications during hazardous surface temperature inversions can lead to spray drift causing severe damage up to several kilometres off target. Current regulations prohibit spraying of agricultural chemicals when hazardous temperature inversions exist.

KEY POINTS

- Spray applied at dawn, dusk and during the night is likely to be affected by surface temperature inversions.
- During hazardous inversions, air movement is much less turbulent than during the day.
- Weak turbulence leads to the accumulation of drift close to the surface.
- Airborne droplets can remain concentrated in the inversion layer for long periods of time.
- The direction and distance airborne droplets will move within a hazardous inversion is unpredictable and will vary depending on the surrounding landscape.

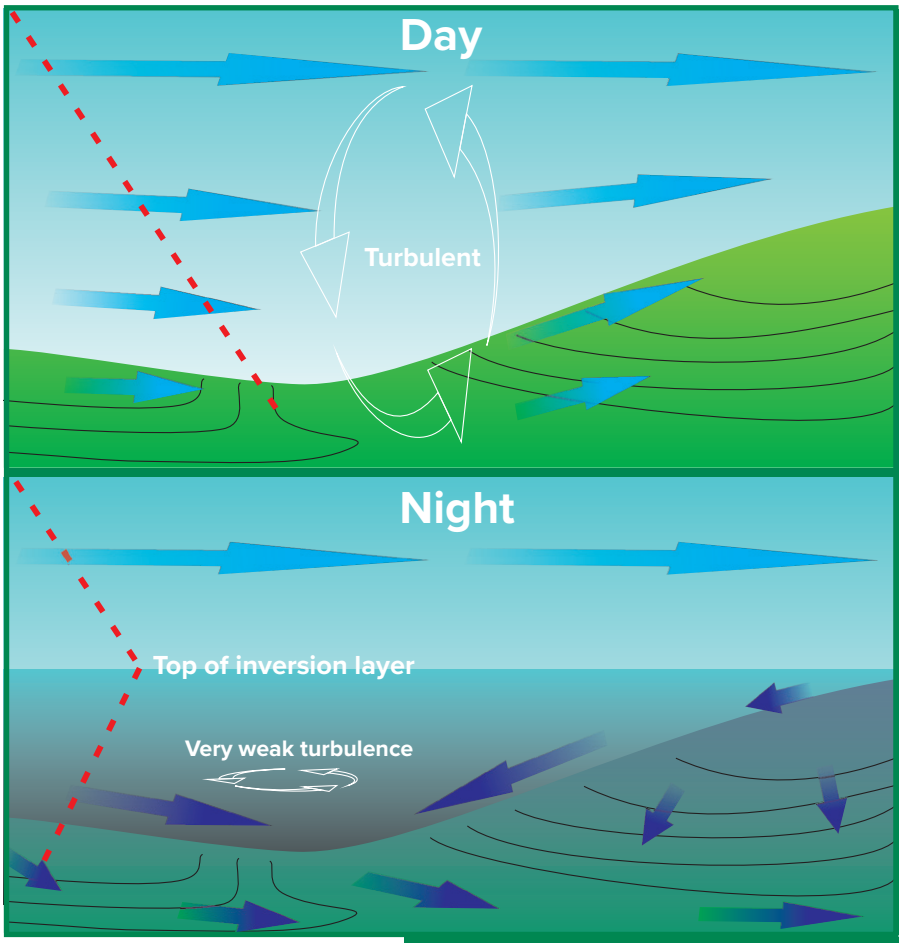

Figure 1: Typical vertical temperature profiles.

During the day: Temperature decreases with elevation (red dashed line). Winds flow across the landscape (light blue arrows). Turbulence is active to several thousand metres above the surface.

During the night: Temperature increases within inversions. Surface winds flow toward low lying regions. Turbulence is weak, intermittent and confined to narrow layers near the surface when hazardous inversions exist.

Source: Graeme Tepper

During a hazardous inversion, very weak turbulence supports the transport of drift over long distances and widespread deposition at high concentrations. When a hazardous inversion has established, it acts like a barrier, isolating the inversion layer from the normal weather situation, especially the normal wind speed and direction (Figure 1).

Wind effects

In the cool and dense air of hazardous inversions, drift can be captured in laminar winds that glide smoothly down slopes, deviate around obstacles, flow parallel to contours and generally flow towards low-lying areas where they

"When application occurs in an area not covered by recognised inversion monitoring weather stations, all the surface temperature inversion conditions are regarded as hazardous."

Source: APVMA

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converge and concentrate; all the while transporting airborne material such as spray drift.

Winds should be measured at a height of two metres for spray records, as per Australian Pesticides and Veterinary Medicines Authority (APVMA) advice.

Within the inversion, wind speed often decreases, typically to a range of two to 11 kilometres per hour. It is not uncommon for wind speeds within inversions to be quite strong but rarely exceed 15km/h.

Do not spray if wind is calm or less than 5km/h or at any wind speed where consistency in direction is not assured, at any time of the day or night.

Drift distance and spread

In hazardous inversion conditions, a 5km/h wind has the capacity to shift drift in layers of high concentration for more than 30km over an Australian summer night. Greater wind speeds will shift drift further.

Meandering winds, often a feature of hazardous inversions, cause drift to fan out and be widely deposited over the landscape.

Cloud effects

Cloud cover may weaken inversion formation but does not prevent it. Transient clouds cause oscillations of surface temperature leading to intermittent fluctuations in vertical temperature difference (VTD) with height and thus the conditions present during the inversion.

Inversion wind speed example

Figure 3 presents three inversion events recorded from 8 to 11 November 2019 near Dalby, Queensland. Similar winds are often observed to occur across Australian agricultural regions while inversions exist.

Key features of these three examples include:

- Winds are rarely calm, even during an inversion.
- Inversions are commencing at least half an hour before sunset in winds greater than 15km/h (sunset 6.18pm).
- Cessation of inversions two and three has occurred about an hour after sunrise (sunrise 4.59am).
- Wind speeds decreasing towards evening signal inversion onset.
- While these examples do not show it, in some other regions inversions can be strongest near sunset rather than near sunrise.

Figure 2: Smoke plumes fumigate to the surface and combine within cool-air drainage within hazardous inversion conditions. The smoke motion and concentration mimics that of invisible pesticides drifting in similar condition.

Source: Pete Nikolaison (Masterton, NZ)

Clues to inversions

Caution: Visual and other clues may not be evident or only become evident hours after an inversion has become well established.

While it is reasonable to expect surface temperature inversions on most nights from dusk up to an hour or so after sunrise, forecasting and even observing the exact onset, overnight variations and cessation times is not simple.

Clues include:

- mist, fog, dew or frost occuring;
- smoke or dust hanging in the air and moving horizontally;
- wind speed is constantly less than 11km/h in the evening and overnight;
- cool off-slope breezes developing during the evening and overnight;
- distant sounds becoming clearer and easier to hear; and
- aromas becoming more distinct during the evening than during the day.

Guidelines for night spraying

Inversions can form and dissipate at any time of the night. To minimise the potential for damaging drift at night, it is suggested that growers always:

- read product labels carefully to check what spray drift restraints may be applicable;
- be aware of sensitive areas (including lower points in the catchment and where sea breezes occur) around the area to be sprayed;
- adhere to the buffer zone distances as set out on the product label in relation to sensitive areas;
- use the coarsest spray quality that will provide efficacy. Every nozzle can produce small, driftable droplets, and using coarser spray qualities reduces the amount of driftable droplets produced;
- avoid excess speeds, spray at a speed that does not result in spray particles lifting behind the machine;
- minimise boom height (while maintaining overlap) to limit atmospheric influence on spray droplets;
- avoid night-time spraying when winds are less than 11km/h when measured at a 2m height;
- monitor weather conditions, particularly wind speed, at the site of application. This should be done at least every 15 to 20 minutes if spraying at night. If the wind drops, spraying should stop;
- remain alert to changing wind directions; and
- pay close attention to weather forecasts (predicted differences in maximum and minimum temperatures, low overnight wind speeds and predictions of fog or frost).

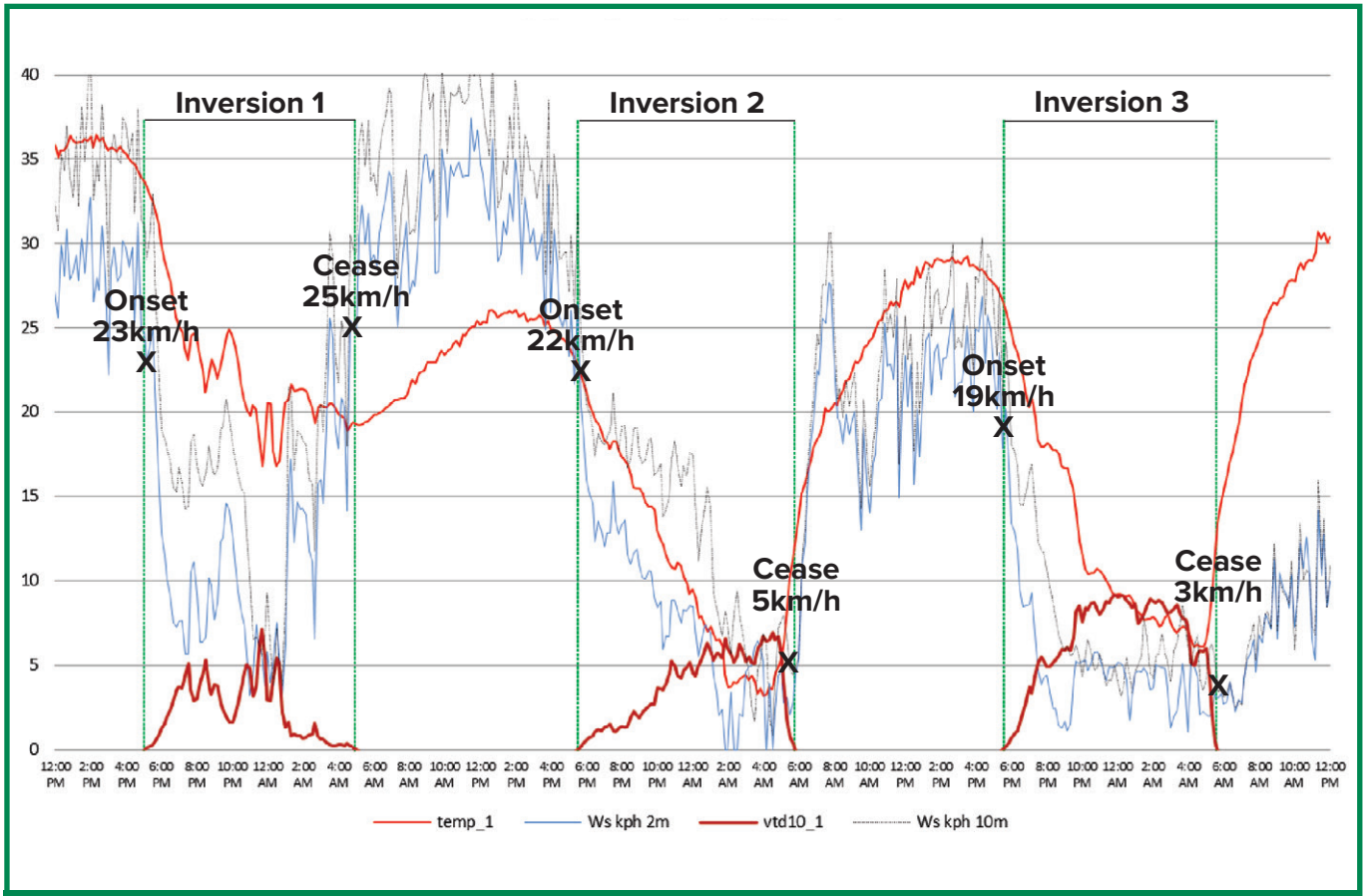

Figure 3: Three inversion events recorded for 8 to 11 November 2019 near Dalby, Queensland. Dark red line depicts (vtd10_1) vertical temperature difference: 10m minus 1.25m. Bright red line temperature at 1.25m (temp_1). Light grey line is wind speed km/h at 10m (ws_10). Blue line is wind speed km/h at 2m (ws_2).

FREQUENTLY ASKED QUESTIONS

What is a surface temperature inversion?

This refers to when the air at the ground level becomes cooler than higher air. Unlike warm air that rises, cool air is dense and remains at the surface. Sprays applied in these conditions can become trapped in this cool air layer where there is insufficient turbulence to disperse the suspended spray droplets. Once trapped, they can move in different directions than indicated by the general weather pattern.

Will a surface temperature inversion always occur at night?

You would expect a surface temperature inversion to occur unless conditions at night are overcast with heavy cloud cover that restricts overnight cooling by less than 5°C, or there has been continuous rain, or wind speed during the whole night is greater than 11km/h.

When is a surface temperature inversion likely to have dissipated?

After sunrise when the air temperature has risen by more than 5°C above the overnight minimum and wind speed has been constantly above 7km/h for more than 45 minutes.

What happens to my spray if I spray just before or as a temperature inversion is forming?

Pesticides already floating in the air can be trapped by the inversion. Pesticides trapped within a surface temperature inversion will tend to remain suspended within the inversion, typically moving to wherever the relatively slow moving air within the inversion layer ends up. This movement is likely to continue until the inversion breaks, which releases the trapped droplets. Often the air movement during an inversion will be towards the lowest part of the catchment, but as the inversion breaks the released droplets have the potential to go in almost any direction.

USEFUL RESOURCES

Weather essentials for pesticide application, grdc.com.au/GRDC-Booklet-WeatherEssentials

Meteorological principles influencing pesticide application, grdc.com.au/meteorological-principles-influencing-pesticide-application-national

Weather and Networked DATA (WAND), wand.com.au

Conditions Over the Landscape (COtL), cotl.com.au

Bureau of Meteorology, bom.gov.au

SprayWise® Decisions, spraywisedecisions.com.au

Syngenta® Australia weather service, www.syngenta.com.au/weather

REGIONAL MONITORING AND FORECASTS

Hazardous inversions are best monitored by networks of observation towers detecting the intensity of turbulence in the atmosphere, along with the vertical temperature difference. GRDC and the Cotton Research and Development Corporation (CRDC) are supporting the establishment of such a system to deliver hazardous inversion real-time detection and forecasts for large regions of the central and southern Queensland and New South Wales grains and cotton belt.

ON-FARM INVERSION MONITORING

Where hazardous inversion monitoring systems are not available, all inversions must be considered hazardous and must be monitored in the paddock of operation. Reliable paddock detection of inversions requires vertically separated temperature sensors match calibrated and accurate to ±0.1°C, preferably at 1.25m and 10m. In-paddock guesswork, infrequent observation, inaccurate sensors or too little separation between sensors can lead to:

- false detection and lost opportunity to spray; or
- missed detection leading to spraying when an inversion exists, potentially leading to concentrated drift causing harm to crops, the environment and community.

Hazardous inversions over Australian broadacre cropping regions can be avoided by only spraying between 1.5 hours after sunrise, and one hour before sunset. This will also avoid the vast majority of weak inversions. Obviously this guidance places severe restrictions on summer spraying, but it should be considered in regions where it is difficult to spray slow and low with very coarse droplets and where good-quality observations and advice of hazardous inversion conditions are not available.

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