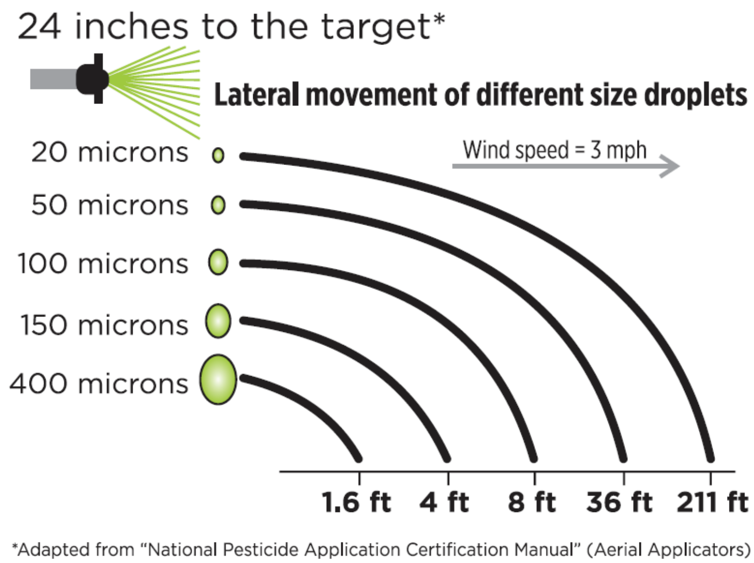
Air Temperature Inversions

Since the 1990's, industry and the U.S. EPA have recognized that off-target movement of pesticides can be amplified by air temperature inversions. Thus, pesticide labeling often contains cautionary language regarding making applications when an air temperature inversion is or will be in place. This language has evolved in recent years to strong prohibitions regarding applications of certain pesticides during air temperature inversions. Recently introduced, low volatility formulations of dicamba, used in over the top applications to tolerant soybean varieties, are now specifying prohibitions of applications from two hours before sunset to one hour after sunrise as a means to further reduce the impact of air temperature inversions.

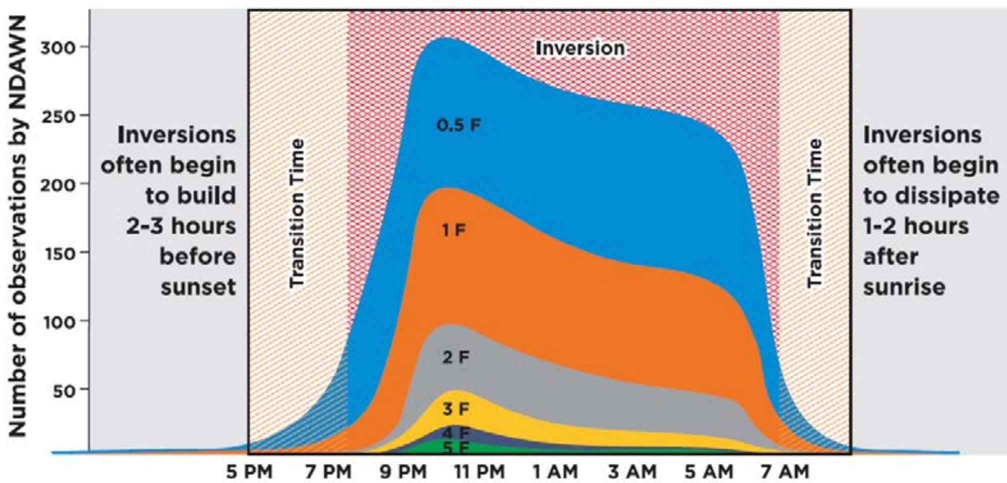
Air temperature inversions are an environmental phenomenon that have long been recognized to adversely impact the deposition of fine spray drops. The following graphic demonstrates that fine spray drops reach the target very slowly and this makes them more susceptible to lateral movement off target in light winds. Especially when they encounter dense, cooler air, near the ground, in an air temperature inversion.



Dense air suspends fine spray drops, and small ones can move large distances in low-wind conditions.

In addition, air stability near the earth surface allows for the accumulation of volatile pesticide molecules which may easily move down range in a light breeze to non-target sites. When this happens, sensitive plants and animals may be adversely impacted.

Multiple site observations of air temperature inversions have been collected in North Dakota since 2017. The following graphic from 2017 demonstrates that air temperature inversion begin to build two to three hours before sunset and then begin to dissipate 30 to 120 minutes after sunrise.



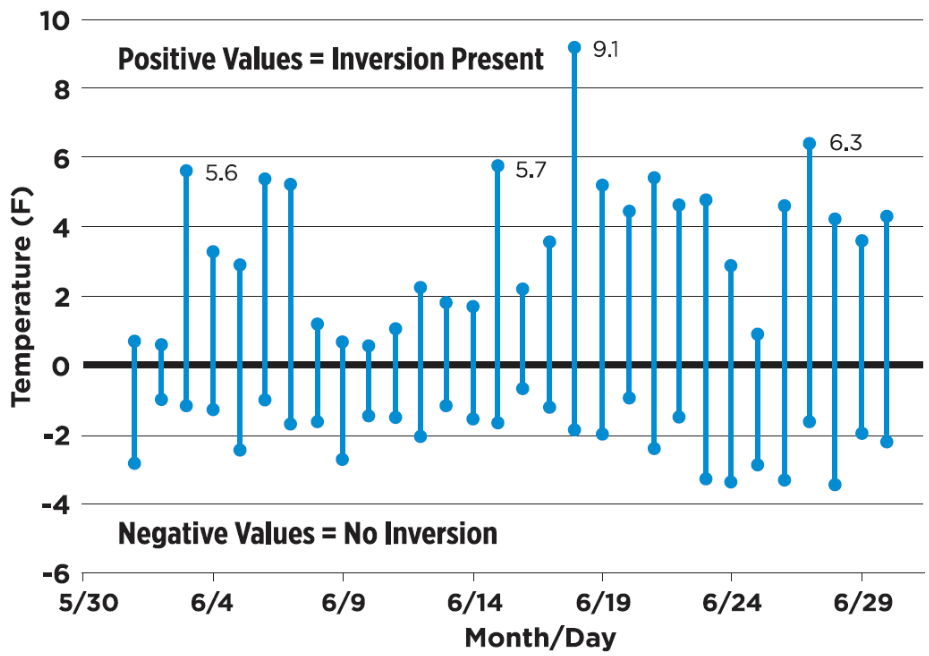
This is an accumulation of inversion data from 11 NDAWN locations in North Dakota during June, July and August 2017. This figure indicates that an inversion will begin late in the day before sunset, continue all night and begin to dissipate soon after sunrise, when the sun starts to heat the Earth.

While air temperature inversions are typically associated with wind speeds of zero to three miles per hour, our observations indicate that significant inversion conditions can exist at much greater speeds. See the following graphic:

Wind Speed (mph) \ Inversion (F)	0.5	1.0	1.5	2.0	2.5	3.0	3.5
15	0.07%	0.00%					
14	0.13%	0.01%					
13	0.14%	0.02%					
12	0.19%	0.02%	0.00%				
11	0.30%	0.02%	0.01%	0.00%			
10	0.50%	0.08%	0.00%	0.00%			
9	0.92%	0.09%	0.02%	0.01%			
8	1.37%	0.19%	0.05%	0.02%	0.00%	0.00%	
7	2.15%	0.38%	0.09%	0.03%	0.01%	0.01%	
6	3.21%	0.76%	0.24%	0.09%	0.09%	0.01%	0.00%
5	4.46%	1.47%	0.49%	0.28%	0.09%	0.04%	0.01%
4	5.64%	2.83%	1.24%	0.78%	0.47%	0.22%	0.11%
3	6.66%	4.80%	2.79%	1.82%	1.10%	0.71%	0.39%
2	6.58%	5.60%	3.74%	2.21%	1.35%	0.86%	0.40%
1	3.97%	4.09%	3.04%	1.91%	1.21%	0.70%	0.40%
0	2.93%	3.57%	2.95%	2.04%	1.37%	0.93%	0.52%

Significant inversion conditions can exist in wind speeds of 6 mph or more. This chart shows the percent of time that several NDAWN stations indicated an air temperature inversion. For example, 4.80% of the time an inversion of 1 degree existed with a 3 mph breeze.

Air temperature inversions can be measured on most 24 hour days. The observations from 2018 at Grafton, North Dakota illustrates this. However, there is wide variation regarding the intensity of inversions from day to day. Calm atmospheric conditions are usually associated with the most intense inversion observations.



Daily minimum and maximum inversion temperatures, Grafton, N.D., June 2018. Temperature difference was measured at 1 meter and 3 meters (F) above ground level at the NDAWN station. Details for June 2018 is available at: https://ndawn.ndsu.nodak.edu/station-info.html?station=77

A comprehensive explanation of air temperature inversions and their potential impact on pesticides can be found in the NDSU publication, "Air Temperature Inversions Causes, Characteristics and Potential Effects on Pesticide Spray Drift (AE1705 (Revised October 2019)). The publication is available on-line at: https://tinyurl.com/NDSU-Inversion-AE1705

Pesticide applicators now have excellent tools for identifying air temperature inversions. In North Dakota and in portions of Minnesota and Montana, NDSU operates the NDAWN Mesonet Weather System. Selected stations (131 as of October 2019) monitor actual air temperature inversion intensity by comparing air temperature at three meters and at one meter. Observations and recordings are made every five minutes and reported on the world wide web at: https://ndawn.ndsu.nodak.edu An Android and iPad app is available for reporting station readings and to send alerts when an inversion observation occurs. Details can be found here: https://www.ndsu.edu/ndscoblog/?p=4031 Finally, Innoquest, a developer of application spray equipment accessories makes a hand held tool for measuring air temperature inversions. You can find more information on their device here: https://innoquestinc.com