Movement of Odors Off-Farm

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The simplest way to visualize odors moving off the farm is to think of a smoke plume. Smoke and odors rise in the air and move downwind. As the plume moves, it spreads vertically and laterally, sometimes with erratic and agitated motion, due to **turbulence** in the atmosphere. Turbulence is caused by heat rising from the earth's surface and by wind moving at different speeds above and below each other. Turbulence causes outside air to mix with the plume. Another term for the mixing caused by turbulence is **dispersion**. Odors are dispersed and diluted when outside air mixes with the plume. Odors are scattered far and wide under good dispersion conditions. Odor intensity decreases as one moves away from the cause of odors in a well-dispersed plume.

Weather Effects on Dispersion

Figure 1 shows how weather factors affect the shape of an odor plume. Plume shape roughly corresponds to the amount of vertical and lateral mixing in the plume. A smoke plume on the horizon is a fairly common sight in western Oklahoma. Think of the plume shapes in Figure 1 as smoke rising from a far off fire. If it were visible to the eye, the plume of odors rising from a field of freshly spread manure might look like a smoke plume rising from a burning pasture. The odors released by a relatively small source, such as a lagoon or storage pond, might resemble a trash fire or gas flare.

Weather factors can help predict dispersion of odors moving away from the farm. Categories of dispersion conditions, based on solar radiation, cloud cover, and wind speed, are given in Chart 1. The chart shows that weather factors cause dispersion to range from very poor (very little dilution of odors downwind) to excellent (odors are greatly diluted downwind). The following general statements can be made about atmospheric dispersion based on weather conditions:

1. Dispersion depends on both wind speed and the heating or cooling of the earth's surface.
2. With light to moderate wind speeds (less than 13 mph), the amount of heating or cooling of the earth's surface is the primary factor in dispersion. Dispersion conditions can range from very poor (VP) to excellent (EX) with light to moderate wind speeds. Dispersion is greatest during the day and, for a given wind speed, increases with the amount of solar radiation striking the earth's surface. Dispersion is poorest at night and, for a given wind speed, decreases as cloud cover decreases.

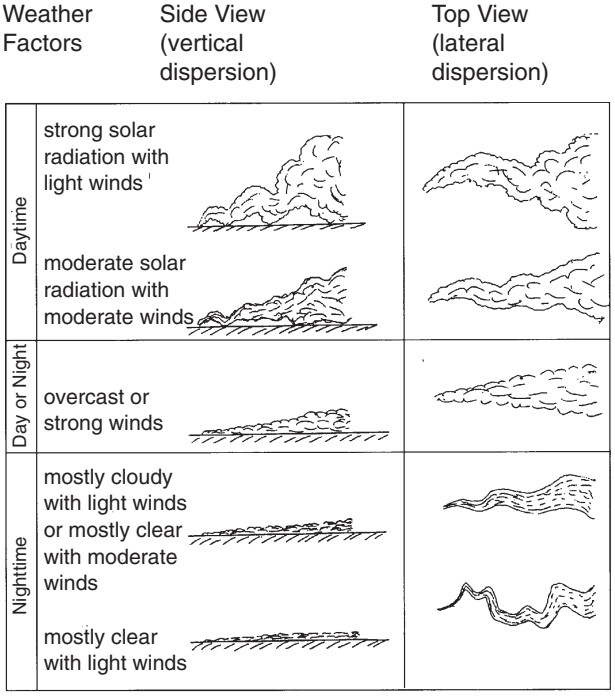

Figure 1. Variation in odor plumes caused by weather factors.

3. With moderate to high winds (greater than 13 mph), wind speed is the primary factor in dispersion. Dispersion conditions range from moderately good (MG) to excellent (EX), with the best conditions for a given wind speed occurring under strong solar radiation.

Terrain Effects on Dispersion

The plume shapes shown in Figure 1 assume the plume is travelling over a smooth, flat surface. Rarely is the terrain surrounding a farm perfectly flat and smooth. Landscape plays an important role in the movement of odor off-farm.

Increasing the roughness of the terrain with obstacles such as hills, trees, and buildings tends to increase dispersion in the odor plume. A filtering barrier, such as a row of trees placed downwind of the odor source increases turbulence, forcing the air to mix and lift odors upward. Land slope also changes the shape of the plume. Dispersion is increased if

Wind Speed (mph)	Daytime					Nighttime		
	Solar Radiation					Cloudiness		
	Strong	Moderate	Weak	Slight	Heavy Overcast	Heavy Overcast	Cloudy/ Mostly Cloudy	Partly Cloudy/Clear
1	G	G	MG	MP	P	P	VP	VP
3	EX	G	MG	MP	P	P	VP	VP
5	EX	G	MG	MP	MP	MP	P	VP
7	EX	EX	G	MG	MP	MP	P	VP
9	EX	G	G	MG	MP	MP	MP	P
11	G	G	MG	MG	MG	MG	MG	MP
13	G	G	MG	MG	MG	MG	MG	MG
15	G	G	MG	MG	MG	MG	MG	MG
20	EX	G	G	G	G	G	G	G
25	EX	G	G	G	G	G	G	G
30	EX	G	G	G	G	G	G	G

Chart 1. The effect of weather conditions on odor dispersion. Colors correspond to dispersion categories in the Oklahoma Dispersion Model (EX - excellent, G - good, MG - moderately good, MP - moderately poor, P - poor, VP - very poor). Note that the first four categories for solar radiation are functions of sun angle and cloudiness amount.

prevailing winds carry the plume up-slope. Down-slope or down valley winds tend to concentrate odors in lower lying areas.

A word of caution: the discussion about using topography and ground cover to increase dispersion assumes the presence of moderately good to excellent dispersion conditions and a breeze strong enough to carry the odor plume downwind. Under certain dispersion conditions—when the earth is cooling and winds are generally light—odors move by a process called **cold air drainage**. Gravity pulls the plume into valleys and low spots. Cold air drainage plays a very large role in the movement of agricultural odors. Most farmstead odors are heavier than air, increasing their tendency to settle in low-lying areas. Odors may travel great distance under such dispersion conditions, following the course of streams and valleys by cold air drainage.

Dispersion Information on the World Wide Web

The Oklahoma Dispersion Model, accessible on the World Wide Web at **radar.metr.ou.edu/agwx/models/**, is a tool farmers can use to assess appropriate times for planned odor releases such as manure spreading. The site features maps of current dispersion and weather conditions, as well as forecast conditions at three-hour intervals, two-and-a-half days into the future.

The Oklahoma Mesonet automated weather station network is used to create a "nowcast" map of current dispersion conditions using solar radiation, wind speed, wind direction, and temperature data. Figure 2 is an example of a "nowcast" map for 3 p.m. on April 16, 1998. Colors on the map correspond with the colors of the dispersion categories given in Chart 1. The user can also use a current weather map available on the Web site (Figure 3) to find current air temperature, relative humidity, wind speed, and wind direction. Wind travels in the direction from the barbed end of the staff toward the solid circle at the station site. Odor plumes would generally travel toward the south and southeast over much of Oklahoma at 3 p.m. on April 16, 1998 according to Figure 3.

Two-and-a-half-day Multiple Output Statistics (MOS) forecasts from the National Weather Service's Nested Grid Model (NGM) are used to create forecast maps of dispersion conditions in three-hour increments. Predicted wind speed, cloud cover, and ceiling height from the NGM are used to determine forecast dispersion conditions. An example of a forecast dispersion map is given in Figure 4. As with the current conditions map, colors correspond to the dispersion categories of Chart 1. This forecast is for 1 p.m. on April 17, 1998—22 hours after the current conditions shown in Figure 2. Forecast weather conditions maps are also available at three-hour intervals on the Web site (Figure 5). Forecast weather and dispersion conditions are also available in a tabular form for a limited number of MOS sites. Chart 2 is an example of forecast information for the MOS site located in

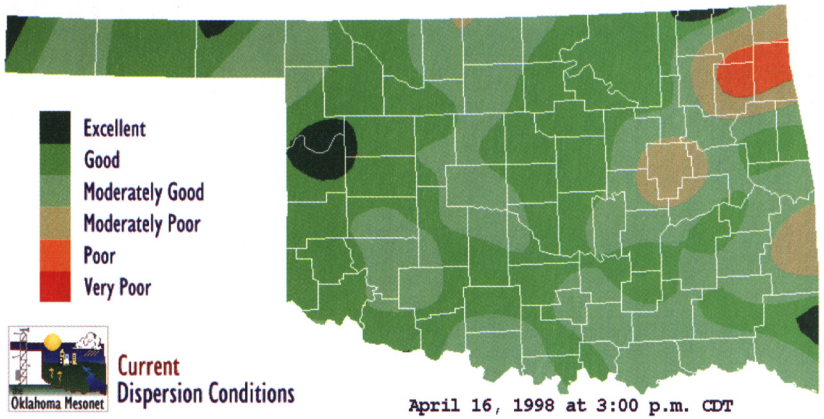

Figure 2. "Nowcast" map for dispersion conditions at 3 p.m. on April 16, 1998.

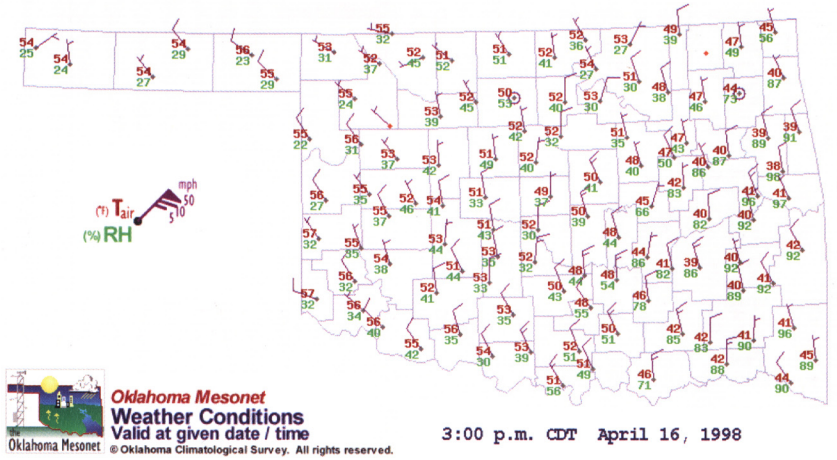

Figure 3. Weather conditions at 3 p.m. on April 16, 1998.

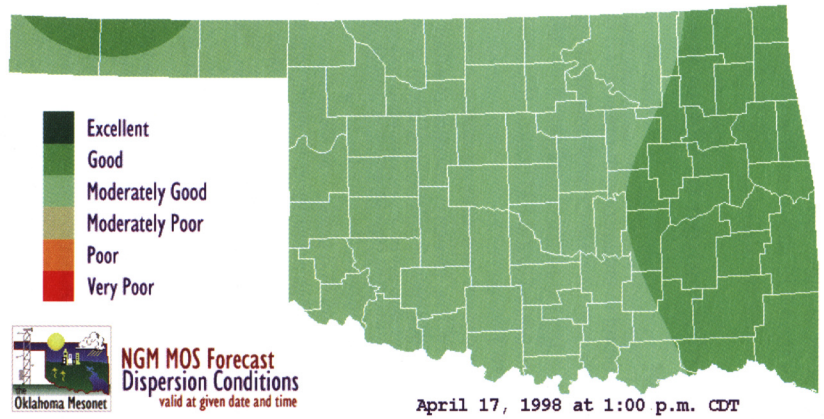

Figure 4. Forecast map for dispersion conditions at 1 p.m. on April 17, 1998.

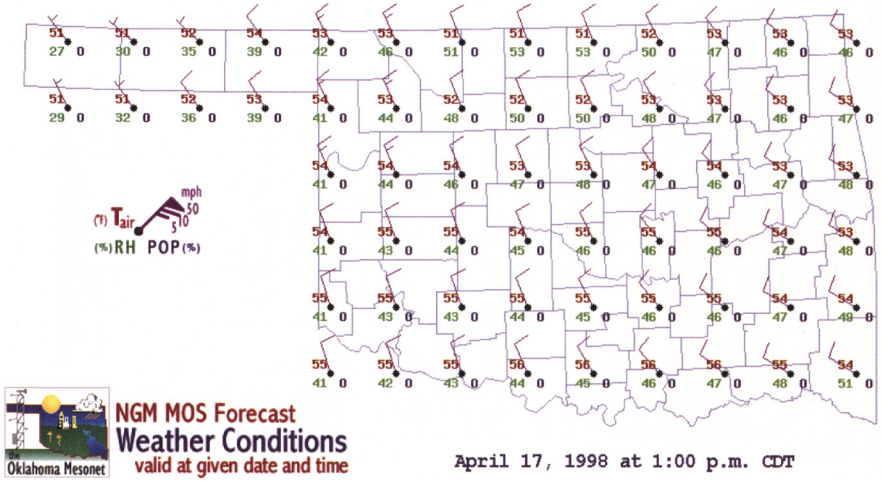

Figure 5. Forecast weather conditions at 1 p.m. on April 17, 1998.

Gage, Oklahoma (Ellis County), starting at 1 p.m. on April 16, 1998.

Using Website Information to Visualize Odor Movement

Chart 2 may be helpful in visualizing the predicted odor movement off-farm. The data given in Chart 2 begins at 1 p.m. on April 16, 1998. Note that Chart 2 uses military time for the hours. Twelve hours are added to the PM hours. (Noon = 12, 1 p.m. = 13, 4 p.m. = 16.).

Since the MOS forecasts are only updated every 12 hours, the initial times of the forecast usually overlap the current time. In this example, the prediction for 4 p.m. (16) on April 16 (NW winds at 6 mph and MG dispersion conditions) is close to the Mesonet observed dispersion (Figure 2) and weather (Figure 3) conditions at 3 p.m. The Mesonet shows winds at Gage out of the northwest around 10 mph, resulting in good (green) dispersion conditions. Odors will rise in a plume similar to the one shown second from the top of Figure 1, and they will drift to the southeast.

Look what happens at 7 p.m. (19 hrs). The sun goes down, the wind speed drops to 3 mph, and the wind direction begins to shift from northwest to west-southwest. Dispersion conditions are now very poor—clear skies and light winds at night. Throughout the night, odors will travel toward the east-northeast in a ground-hugging plume similar to the one shown on the bottom of Figure 1. As dawn arrives, the wind speed increases and becomes northwesterly. We can expect odors to move toward the southeast under moderately good dispersion conditions during the daylight hours of April 17. By early afternoon, the dispersion and weather conditions shown in Figures 4 and 5 should prevail—moderately good dispersion (light green), carrying odors to the south-southeast. At sundown, we expect a pattern similar to the day before to repeat—odors traveling close to the ground drifting to the east-northeast. However, with such light winds forecasted (2 to 4 mph), odor plumes in all but the flattest terrain will drain gravitationally to lower elevations, whichever direction that may be.

This dispersion-forecast information can assist livestock producers in planning timed odor generating activities, such as land application of lagoon effluent. The maps can give an idea of the duration of good and bad dispersion conditions. By avoiding application during poor dispersion conditions, the farmer may minimize negative odor impacts on his or her neighbors.

Forecast for Gage, OK based on data taken on April 16, 1998, at 07:00 a.m. CDT

	/April 16				/April 17						/April 18								
Hour of day (CDT)	13	16	19	22	01	04	07	10	13	16	19	22	01	04	07	10	13	16	19
Max Min Temps (F)							26				60				28				
Temperature (F)	51	59	47	35	31	29	30	37	54	59	47	38	34	32	31	37	56	63	52
Relative Humidity (%)	36	24	38	61	69	78	75	69	39	31	49	67	78	81	81	72	41	31	48
Wind Direction	WNW	NW	NW	WSW	WSW	W	WNW	NW	NNW	NW	WNW	SW	W	SW	SW	S	S	S	S
Wind Speed (MPH)	6	6	3	4	5	8	10	11	16	12	4	4	2	3	2	2	13	13	11
Dispersion Condition	MG	MG	VP	VP	VP	P	MP	MG	MG	MG	VP	VP	VP	VP	VP	MP	MG	MG	MP
Downwind Pollution Index	4	4	78	177	94	24	19	8	6	7	117	117	117	78	117	13	6	6	17
Sky Condition	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Ceiling	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Chance of Precip (%)			0		0		0		0		0		0		0		0		3
Amount of Precip (in)			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
Precip Type (if any)	R	R	R	R	R	R	R	R	S	R	S		R		R		R		R
Dew Point Temp (F)	25	23	23	23	22	23	23	28	30	29	29	28	28	27	26	29	33	32	33

Sky Condition	Precipitation Type
CL = Clear	R = Rain
SC = Scattered	Z = Freezing Rain
BK = Broken	S = Snow
OV = Overcast	

Dispersion Condition		Downwind Pollution Index
EX	Excellent	<2
G	Good	2 - 4
MG	Moderately Good	4 - 10
MP	Moderately Poor	10 - 23
P	Poor	23 - 53
VP	Very Poor	>53

Ceiling			
1 =			<200 ft
2 =	200	-	400 ft
3 =	500	-	900 ft
4 =	1000	-	3000 ft
5 =	3100	-	6500 ft
6 =	6600	-	12000 ft
7 =			>12000 ft

Chart 2. Multiple output statistics (MOS) forecast for Gage, Oklahoma.

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