FEWG – A WORKING GROUP FOR NCDFR MTM

NC SMP Technote 12 – December 28th, 2008

Low Visibility Occurrence Risk Index, Fog and Wildland Smoke

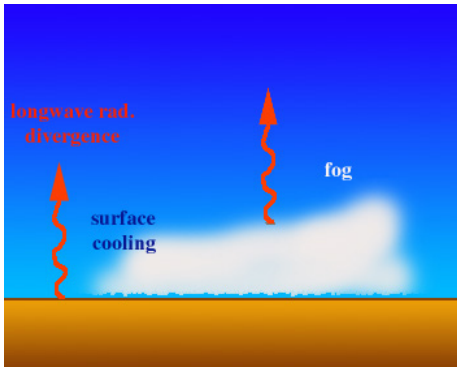
It is scientific knowledge that during high relative humidity conditions fine smoke particles and water nuclei in the air have an excellent affinity for each other. Just the formation of fog alone can reduce visibility to a point where driving along NC roadways is hazardous. However, the **synergistic combination of fog and smoke exasperates dangerous driving conditions**. The potential for life threatening vehicle accidents becomes very real. The safety and well being of the traveling public are greatly at risk.

The Low Visibility Occurrence Risk Index (LVORI) is a weather index developed to identify potential hazard levels for road visibility and the risk that fog presents to the possibility of automobile accidents. With the NC Division of Forest Resources goal to increase the use of prescribed fire opportunities, the ever occurrence of wildfires, and increasing population density, have compelled the Division to incorporate the use of the Atmospheric Dispersion Index (ADI) and LVORI in the Fire Weather Forecast (FWF) products provided by the National Weather Service (NWS). This information will further promote safety. It serves as an alert for first responders, prescribed burners, wildfire suppression personnel, and the public to the danger and risk on our roadways when fog formation is possible and smoke will be present. It provides the opportunity to take appropriate management response (APR).

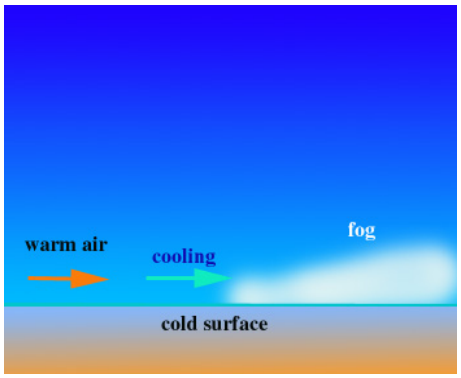
LVORI development was due to the effort of Leonidas G. Lavdas and Gary L. Achtemeier of the USDA Forest Service while at the Southern Research Station in Dry Branch, Georgia. For more information please refer to their publication: A FOG AND SMOKE RISK INDEX FOR ESTIMATING ROADWAY VISIBILITY HAZARD. Their research specifically addressed the risk of radiation and advection caused fogs and their association with automobile accidents. There are differences between fog formed by advection and radiation. **The data collected suggested that localized radiation fogs pose greater hazards than widespread advection fogs.** Apparently, drivers were able to adjust when fog is widespread, but were less successful when very low visibility is suddenly encountered. Radiation fog, a more local phenomenon, tends to occur around open fields or stream cuts in shallow depressions. Visibilities can change suddenly from near perfect to near zero. Driver responses can range from “continuing on blindly” to “slamming on the brakes” and often result in accidents, many of which are multiple car pileups.”

Fog is composed of fine droplets of water suspended in the air near the Earth's surface. These fine droplets act to scatter the light and thus reduce the visibility near the ground. The formation of a fog layer occurs when a moist air mass is cooled to its saturation point (dew point). This cooling can be the result of several processes:

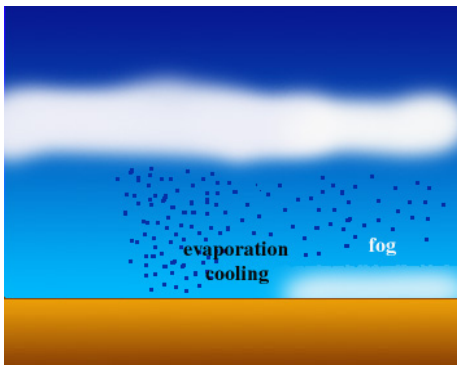
- 1. Radiation surface cooling (radiation fog),
- 2. Advection of warm air over cold surfaces (advection fog),
- 3. Evaporation of precipitation (precipitation or frontal fog),
- 4. air being Adiabatically cooled while being forced up a mountain (upslope fog),
- 5. Another means for radiation cooled air is during the evening on the slopes of topographical features. When this air becomes denser than its surroundings and eventually starts going down the slope. This results in the creation of a pool of cold air at the valley floor. If the air is cold enough to reach its dew point, fog formation occurs.



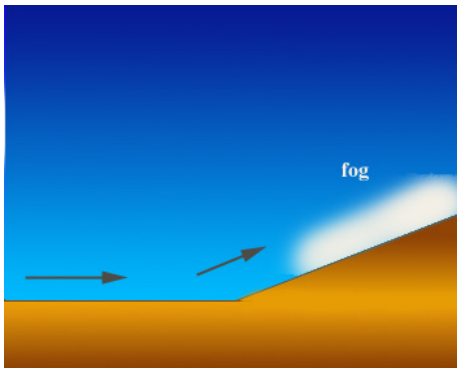
Radiation Fog



Advection Fog

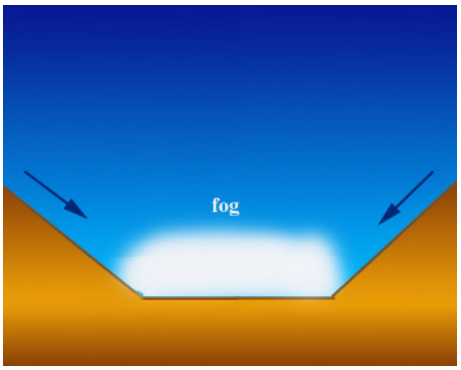


Precipitation Fog



Slope Fog

A fog layer is reported whenever the horizontal visibility at the surface is less than ½ mile. After sunset, a strong cooling occurs near the surface through the effect of long wave radiation divergence. As the cooling proceeds, the relative humidity increases until fog droplets are activated. The visibility drops rapidly toward its minimum value. Then the fog layer grows in the vertical through the interaction of radiative and turbulent processes. Dissipation occurs after sunrise as the solar energy warms the surface. This information on fog was obtained from **Interactions between aerosols and fog** prepared by *Robert Tardif* (University of Colorado Program in Atmospheric and Oceanic Sciences.



Valley Fog

The NWS is now providing in the FWF early and late values of both ADI and LVORI. Prescribed fire practitioners and wildfire suppression personnel will be able to attain morning and afternoon, evening and overnight. The Maximum LVORI was chosen for two reasons. It is consistent with what is being done in GA, and it lets the customer see the worst case scenario. If an average value was selected it would mellowed out the LVORI's of 10. It is the 10's that are what you need to know about. This is when the most severe or dense fog occurs.

The ADI is calculated using the NWS Tampa's office software. It has been reviewed and conforms to Lavdas's work. The solar angle work has been well handled. It has been adjust by the NWS Greenville Spartanburg's office to handle solar angles at NC's latitudes. If this software is ever used where the sun doesn't reach 17 degrees in winter, it will require another modification. The max average was used to yield the ADI. This averages the maximum values in a given zone to remove spikes within an area. This is similar to the wind forecasts where the spikes of Mt Mitchell's winds are accounted for. However, the Point Fire Weather Products is different. It is not an area or time average, it is clock hour ADI value. What is of great value is that even with max average ADI value you still get very low values in the morning, showing that dispersion really is minimized at that hour.

Presently this ADI value uses modeled ceiling data. All NWS offices are now producing gridded ceiling data for aviation products for the first 24 hours. The two sets of ceilings may not agree. The NWS is planning in time to incorporate gridded ceiling data for the first 24 to 36 hours and switching to model data thereafter. Presented below is an example of the FWF with ADI and LVORI.

	TODAY	TONIGHT	FRI
CLOUD COVER	CLEAR	CLEAR	MCLEAR
CHANCE PRECIP (%)	0	0	0
PRECIP TYPE	NONE	NONE	NONE
MAX/MIN TEMP	57	32	62
MIN/MAX RH %	20	93	28
WND20FT2MIN/EARLY(MPH)	LGT/VAR	LGT/VAR	LGT/VAR
WND20FT2MIN/LATE(MPH)	LGT/VAR	LGT/VAR	LGT/VAR
PRECIP DURATION	0	0	0
PRECIP AMOUNT	0.00	0.00	0.00
PRECIP BEGIN			
PRECIP END			
LAL	1	1	1
INVERSION(TEMP/TIME)	36/0900	2000	40/0900
HAINES INDEX	5	5	5
DSI	1		1
MIXING HGT(FT-AGL)	4800		4000
TRANSPORT WND (MPH)	N 5		N 3
VENT RATE (MPH-FT)	24000		12000
ADI EARLY	**12**	**8**	**11**
ADI LATE	**22**	**2**	**13**
MAX LVORI EARLY	**4**	**3**	**4**
MAX LVORI LATE	**2**	**5**	**2**

REMARKS...ADI IS ATMOSPHERIC DISPERSION INDEX BY LAVDAS.
LVORI IS LOW VISIBILITY OCCURRENCE RISK INDEX.

Interpretation and Use of LVORI

LVORI is an index for the probability of low visibility, and ranges from 1 – 10, depending on relative humidity and atmospheric dispersion index. A value of 1 means there is almost "NO" chance of low visibility, while a value of 10 indicates low visibility is likely. This Index is a function of relative humidity and atmospheric dispersion index. The GA Forestry Commission operational experience is one should be VERY CAUTIOUS ABOUT BURNING if one of the following situations occurs:

1. When LVORI for a nighttime forecast period is 8, 9 or 10
2. When ACTIVE SMOKE from stumps logs, etc. is present during the night
3. When there is a roadway within three miles of a burn site with open fields, logging roads, or open streams that can provide an easy transit of the smoke from the burn site to the roadway.

LVORI values of ≥ 7 should be treated with caution when there is active smoke being produced during the night and the burn site is near a roadway. Index values of 8 through 10 are dangerous for smoke induced fog formation.

The Florida Division of Forestry where LVORI was developed uses the following guidance. It has been quantified in Florida that relative humidity (RH) and ADI are most closely associated with conditions that promote accidents due to smoke/fog.

LVORI	Forestry Division of Florida's Description of LVORI
1	Ideally low risks of accidents on highways due to smoke and/or fog formation
2,3	Relatively low risks of accidents on highways due to smoke and/or fog formation
4-6	Moderate risks of accidents on highways due to smoke and/or fog formation
7-10	Particularly high risks of accidents on highways due to smoke and/or fog formation

RH	Dispersion Index											
	>40	40-31	30-26	25-17	16-13	12-11	10-9	8-7	6-5	4-3	2	1
<55	1	1	2	2	2	2	2	2	2	2	2	2
55-59	1	1	2	2	2	2	2	3	3	3	3	3
60-64	1	1	2	2	2	2	3	3	3	3	3	3
65-69	1	3	3	3	3	3	3	3	3	3	3	4
70-74	3	3	3	3	3	3	3	3	3	3	3	4
75-79	3	3	3	3	4	4	4	4	4	4	4	4
80-82	3	3	3	3	4	4	4	4	4	5	5	6
83-85	4	4	4	4	4	4	4	4	5	5	5	6
86-88	4	4	4	4	4	5	5	5	5	6	6	6
89-91	4	4	4	4	5	5	5	5	6	6	7	7
92-94	4	4	4	5	5	5	6	6	6	6	7	8
95-97	4	4	4	5	5	6	6	6	7	8	8	9
>97	4	4	4	5	5	7	8	8	9	9	10	10

Dispersion Index Values; Lavdas 1986

Dispersion Index	Interpretation
>100	Very good (but may indirectly indicate hazardous conditions)
61-100	Good (typical-case burning weather values are in this range)
41-60	Generally good (climatological afternoon values in most inland forested areas of the U.S. fall in this range)
21-40	Fair (stagnation may be indicated if accompanied by persistent low windspeeds)
13-20	Generally poor; stagnation if persistent (although better than average for a night value)
7-12	Poor; stagnant at day (but near or above average at night)
1-6	Very poor (very frequent at night; represents the majority of nights in many locations)

Under the NCDFR FE research project, "Operational Research Evaluation Burns" prescribed burns were conducted with the ADI's as low as 27.

Notes of Importance

LVORI is an indicator only of relative risk and should not be used as a hard estimate of absolute risk of hazardous visibility.

- Favorable LVORI (≤3) needs to be validated in NC
- Unfavorable LVORI (≥7) needs to be validated in NC
- LVORI can be used to determine the degree of relative risk and with gauging the possibility of night time smoke production from Wildfires or Prescribed Fires an appropriate management response can be formed.
- LVORI is projected by the NWS PFM product and by US Forest Service Southern High Resolution Modeling Consortium @ website: http://shrmc.ggy.uga.edu/state_maps.php
  Select Field = Low Visibility Risk Index / Select North Carolina / Select Time = Loop All

In Summary

LVORI is not a perfect indicator of smoke induced low nighttime visibility problems on roadways. However, it is a sound tool for natural resource fire practitioners to estimate the potential of the atmosphere to contribute to low visibility. Other factors that should also be considered include:

- The fire is more than three miles from a road. Most nighttime visibility problems occur within three miles, but in exceptional cases may extend out to 30 miles from the fire.
- The vegetation is continuous and heavy between the burn and a road. Heavy vegetation acts as both as a filter, and slows the movement of smoke.
- Logging roads, power lines, streams, or similar features can provide an unobstructed pathway between the burn and a road.
- The road is at a higher elevation than the burn

This technical note was made possible and prepared from information obtained from NOAA NWS John Tomko, USFS-SHRMC Gary L. Achtemeier and A FOG AND SMOKE RISK INDEX FOR ESTIMATING ROADWAY VISIBILITY HAZARD, Georgia Forestry Commission Dan Chan and James Paul, Deborah Hanley Florida Division of Forestry and NCDFR FE Branch.