CRH SSD
OCTOBER 1992

CENTRAL REGION TECHNICAL ATTACHMENT 92-20

FOG FORECASTING AT GRAND ISLAND, NEBRASKA

Matthew L. Gerard
National Weather Service Office
Grand Island, Nebraska

1. Introduction

The occurrence of fog at Grand Island, Nebraska is a forecasting problem that needs consideration year-round. Previous studies on fog for the Grand Island area have been in the form of guides for terminal forecasting, developed at least 30 years ago.

The purpose of this paper is to re-examine previously gathered climatological data and add new information. Some guidelines or "rules of thumb" that may be helpful in forecasting fog will also be presented.

2. Climatological Aspects

Grand Island, Nebraska is located near the center of the continental United States. The local terrain is low and flat, but generally rises from east to west. The Platte River and other small streams pass within five miles of the airport, where WSO Grand Island is located.

The main source of atmospheric moisture to central Nebraska is the Gulf of Mexico. Low level moisture moves north into the area on the backside of high pressure that has moved east of the Central Plains, or in advance of low pressure systems moving out of the Rockies. From May to September, the mean low level wind flow at Grand Island is from the south or southeast at least 40 percent of the time.

The main causes of fog at Grand Island are: radiational cooling, advection, and upslope. Radiation fog forms when the temperature of the air is cooled down to its dew point, usually during the late night hours.

Advection fog is formed by moist air moving over a cold surface. This type of fog occurs most often during the cool season when the atmosphere over the Central Plains is more dynamic, such as in the case of return flow of Gulf moisture.

Upslope fog occurs when air is moved over rising terrain, causing it to cool adiabatically. The terrain across central

Nebraska rises on the average of six feet per mile. Upslope fog conditions usually occur after a cool front passes to the south of the area, and easterly winds develop behind it. The north side of a quasi-stationary front or to the northeast of a developed surface low are other favorable locations.

3. Characteristics of Fog at Grand Island

A total of 428 fog events over a 10 year period from 1980 to 1989 were examined. It should be noted that only periods of fog were used when precipitation did not occur, or was very light and short-lived. This was due to the tendency of observers to carry fog whenever significant rain or snow is occurring.

Fog is primarily a night-time or early morning phenomenon at Grand Island. Table 1 shows that, during the spring and summer months, three fourths of all fog occurrences began between the hours of 3:00 and 9:00 a.m. LST. Table 2 shows the hourly breakdown of occurrences during the fall and winter. This table also shows a peak in the onset of occurrences during the late night and early morning hours. It also shows a greater percentage of onset times during the course of the day than observed during spring and summer.

Table 1

Percent of total fog occurrences by hour during the warm season (April through September, 1980-1989)

TIME OF ONSET

HOUR (CST)	PERCENT
00 - 03	17
03 - 06	65
06 - 09	10
09 - 12	0
12 - 15	0
15 - 18	0
18 - 21	3
21 - 00	6

Table 2

Percent of total occurrences by hour during the cold season (October through March, 1980 - 1989)

TIME OF ONSET

HOUR (CST)	PERCENT
00 - 03	14
03 - 06	27
06 - 09	38
09 - 12	4
12 - 15	1
15 - 18	4
18 - 21	3
21 - 00	8

Figure 1 shows a breakdown of the total number of fog occurrences, per month, during the 1980 through 1989 time period. This graph shows a distinctive peak during the months of July and August. The number of dense fog events is about 10 to 30 percent of the total.

While the summer months had the most occurrences, the average duration of the fog during these months was at its shortest. Figure 2 shows that average fog duration was about two hours. It increases to 11 hours during the middle of winter. This is attributed to longer nights, low sun angles, and a colder ground. The duration of dense fog events was half that of the total duration. It has been noted that a northeast wind is the most favorable direction for dense fog development, often in the case of back door cold fronts. Fog rarely formed when the temperature was below 10°F in the winter or above 71°F in the summer.

While fog can occur with winds from any direction, it occurred most often with a southeast or southerly flow. Figure 3 shows the number of occurrences for each direction at the onset of fog development. Southwest winds are downslope and least conductive to fog development. It should also be noted that there were 30 cases when the winds were calm at the onset. Overall, wind speeds were 5 mph or less at the onset in 38 percent of the cases. Winds were from 6 to 10 mph in nearly 50 percent of the cases and above 10 mph 13 percent of the time.

4. "Rules of Thumb"

There are several tools at the forecaster's disposal to look for potential fog development. A couple of these include satellite imagery and regional surface plots from the Central Plains. Real-time observations from ASOS and the wind profiler network can also prove to be useful for monitoring winds and dew point changes. "Rules of thumb" on fog development have been developed over the past several years for summer and winter situations, are listed below:

The amount of soil moisture is important for the development of fog. After periods of rain or thunderstorms followed by clearing skies, fog often develops. This is usually the case when boundary layer winds are light with no dry air advection. Haze is a sign of an abundance of condensation nuclei in the atmosphere. Hazy skies combined with high relative humidity around sunset is a very favorable condition for fog development.

The evening raob plots can also be useful. If the mixing ratio increases with height in the boundary layer, then one should forecast fog. This assumes clear skies and no dry air advection. Mixing ratios decreasing with height are more indicative of dew or frost.

In winter advection fog situations, when ceilings and visibilities are down, they will stay down if upstream dew points are increasing. During the winter months in a stagnant high pressure pattern, fog can develop under the inversion. This type of fog situation can persist for days until a synoptic-scale system moves through and clears it out. Low sun angles in winter are not effective in burning off fog.

Look out for back door shallow cold fronts. The accompanying upslope flow and cold advection with these systems can enhance fog probability.

Snow cover, too, can have a significant effect on the development and dissipation of fog. Melting snow cover during the day can provide enough low level moisture to produce fog, especially when boundary layer winds are light.

Johnston (1978) showed how a band of low clouds and fog that had developed behind a weak cold front persisted through much of the day. This band, in South Central Nebraska, was over an area of snow cover that was left from a previous storm. A series of satellite pictures shows that during the course of the morning, the fog and low clouds dissipated from the periphery due to surface heating. Dissipation of the fog and low clouds over the snow covered area did not occur until the surface ridge moved east of the area and surface-heated air was advected into the area of snow cover.

While observing fog via satellite imagery can be difficult, there are some ways it can be made easier. Gurka (1980) showed that special enhancements in the warm end of infrared imagery can aid in the observation of fog. Areas of potential fog development can also be detected. This is possible because the ground under a moist airmass will cool more slowly than that under a dry airmass, resulting in a sharper contrast in the imagery between the warmer and cooler land temperatures.

Enhanced visible imagery (Gurka 1978) can be used to determine fog brightness, which infers thickness. By utilizing factors, such as varying fog thickness and the rate of dissipation with respect to fog thickness, forecasting the dissipation of fog is possible by using early morning enhanced visible imagery.

4. Conclusion

This paper has presented some aspects of local fog climatology. The formation of fog at Grand Island, Nebraska can occur any time of year. The number of occurrences seems to increase in the summer months. A couple of reasons for the increase in frequency would be an abundance of low-level moisture due to irrigation and moisture transported from the Gulf of Mexico. Fog tends to occur more often when winds are from the southeast or south, and least from the southwest.

Several "rules of thumb" for the forecasting of fog have also been listed. While these rules should prove helpful, it is important to remember that they may not work in every situation.

5. Acknowledgements

The author wishes to thank Steve Byrd, Lead Forecaster at WSFO Omaha, for comments and suggestions, and for reviewing this manuscript.

6. References

Gurka, J. J., 1980: Observation of Advection - Radiation Fog Formation from Enhanced IR Satellite Imagery. Proceedings of 8th Conference on Weather Forecasting and Analysis, Denver, CO, American Meteorological Society, Boston, MA, 108-114.

_____________, 1978: The Use of Enhanced Visible Imagery for Fog Detection and Prediction, Satellite Applications Information Note 78-4, National Weather Service/National Environmental Satellite Service, Kansas City, MO.

Johnston, E. C., 1978: Effects of Snow Cover on Dissipation of Fog and Stratus, Satellite Applications Information Note 78-5, available from National Weather Service/National Environmental Satellite Service, Kansas City, MO.

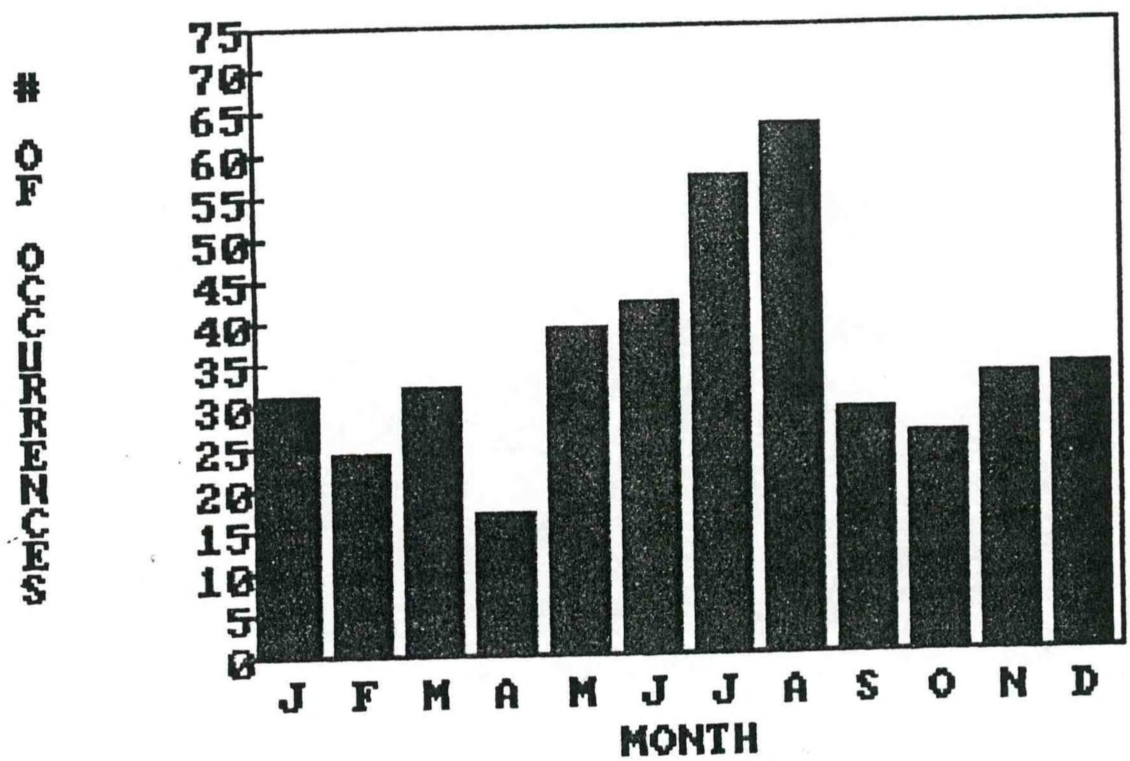

Figure 1. Monthly occurrence of fog, 1980-1989.

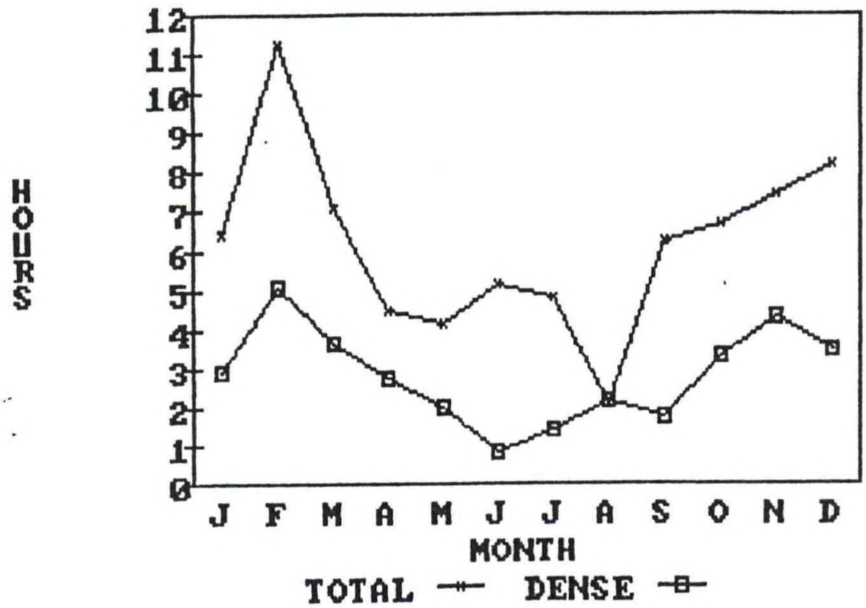

Figure 2. Average fog duration by month 1980-1989.

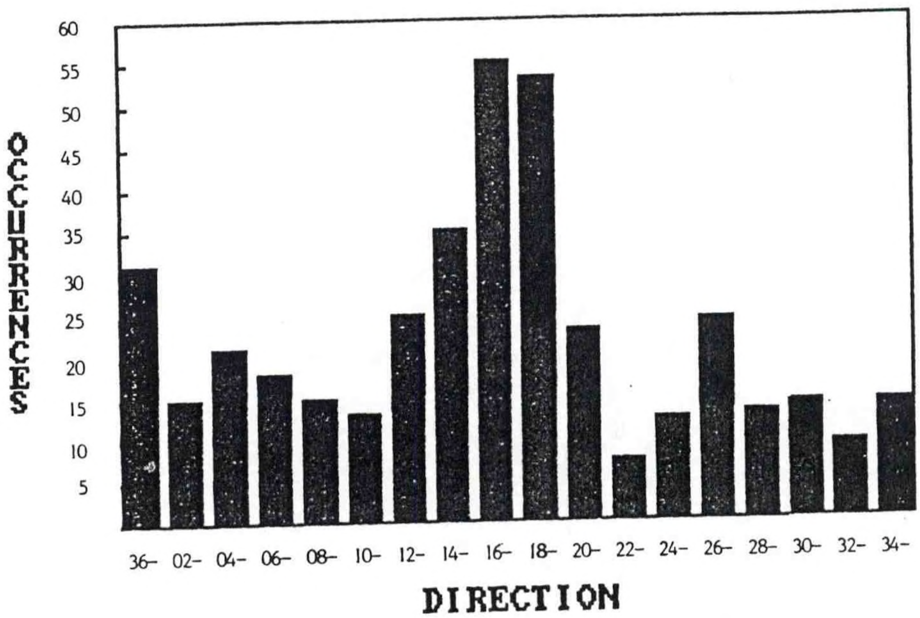

Figure 3. Distribution of the onset of fog by wind direction, 1980-1989.