Preliminary Fog Morphology of Connecticut and Long Island Sound

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Introduction

Fog directly affects people by closing airports, hampering recreational activities, and making automotive driving hazardous. In 1986, the Connecticut State Police reported that a total of 600 accidents were fog related. However, fog formation is one of the most difficult atmospheric conditions to forecast and receives very little attention. Detected only by the human eye or by sophisticated scattering - electronic equipment, fog must be seen to be recorded and, additionally, must be sought out. At present, there is no ongoing fog research in the State of Connecticut; yet along the Connecticut River, barge captains are required to navigate from Long Island Sound to Hartford (or the reverse) under heavy fog conditions.

Although Connecticut is a small state, its boundaries cause some of its many diverse weather patterns; it has seven different climatic regions. In fact, at the extreme eastern edge, Nantucket and Block Islands have twice the heavy fog frequency of coastal Connecticut.

Previous analyses of heavy fog conditions within the United States span the period 1930 through 1970 and look at large regions covered by Class 1 NOAA stations. A survey of published annual heavy fog occurrence (visual range $\leq$ 1/4 mile) shows little variation since 1936 for the Connecticut coastal area (see listing below).

Source	Annual Heavy Fog Events
Stone (1936)	40 to 60
A. Court and R. D. Gerston (1966)	30 to 45
R. L. Peace, Jr. (1969)	30
W. C. Harwick (1973)	30

Additionally, there is no chance to look at variations along the coast and away from the coast.

Procedure

Class 1, WBAN data was obtained from the NOAA Climatological Center, Asheville, North Carolina. The sites studied for the period 1970-79 were Albany, LaGuardia, John F. Kennedy, New York, and Boston, Massachusetts. Later, Bradley International - Hartford, Bridgeport and New Haven, Connecticut were added.

All sites were analyzed for heavy fog (visual range $\leq$ 1/4 mile), temperature at fog onset, wind speed and direction, and current weather. This data was cast in different forms and plotted to see if there were major differences and/or major similarities among the sites.

Results

The fog temperatures for all sites at fog onset are predominately (> 95%) warm, T > 32^{o}F. Table 1 indicates the fact of maritimity for Boston, J.F.K. and LaGuardia stations. Albany, N.Y. has triple the percentage of cold fogs as compared to the maritime sites, which fact reflects its continentality and the lateness of its fog maxima in the

year, Table 2. This large percentage only represents a total of 34 cold fogs over a decade. Warm persistent fogs are the general rule. Table 2 shows the uniform percentage, of maritime sites, for heavy fog throughout the year with the maximum occurrence in the spring months, March through May. The spring maximum occurrence is brought out very clearly in Figure 1 where the maritime stations track each other very well and Albany (ALB), N.Y. shows the fall radiational fog maximum. In terms of the total number of heavy fogs over the decade, J.F.K. had 339 and LaGuardia (LGA) had 116. When the percentage of total heavy fog events for J.F.K. and LGA are plotted, Figure 2, it is seen that they track almost identically irrespective of the large difference between their total numbers of fogs over the decade. This phase relationship might be interpreted as the same physical mechanisms being responsible for fog formation at both sites. A check of specific dates of fog occurrence at both sites indicates that heavy fog was evident 29 times (25% of the total fogs) at LGA but not J.F.K. This percentage seems too large to be a random happening even though only 3 days per year on the average are involved. At this time, the parameters that differed between the two sites (approximately 20 miles apart) have not been investigated.

Tables 3-6 depict the average wind speed versus resultant wind direction at each Class 1 station. Boston fogs seem to be highly related to onshore winds (46% of total), as do the fogs at J.F.K. (66% of total). It is striking that LGA shows almost no onshore wind preference. For Albany, N.Y., calm and southerly flow (radiation and moisture respectively) affects fog formation (47% of total fogs).

The incorporation of New Haven (HVN), Bridgeport (BDG) and Hartford (BDL), Connecticut adds more information about fog variability along the coast and inland. Table 7 shows a typical maritime distribution as found previously in Table 2 with a spring maximum (March - May) except for Hartford, which has a fall maximum similar to Albany, N.Y. For Hartford, it is expected that cold drainage winds from higher elevation into the Connecticut River Valley provides a major impetus for fog formation. Radiational cooling and the advection of moisture from the coast or precipitation are also required for the onset of fog in the Connecticut River Valley.

The relationships between Class 1 stations and the additional three stations in Connecticut are striking when Figures 3 and 1 are overlain, the in phase oscillations between the maritime sites are very striking. In a similar fashion, Figures 2 and 4, when overlain, are again in phase. New Haven has a total of 260 events over the decade and Bridgeport has 314 total events for the same period.

Only for New Haven in Table 8 was sufficient data available for an average wind speed vs. resultant wind direction analysis. Here southerly flow or calm conditions are prevelant as a requisite for fog formation (50% of total fog). This is the first data where calm conditions become a large fraction of the total fog events. Climatically for Connecticut the wind is southerly in the summer and northwest in the winter. Also, in the New Haven data, the advection of fog banks, formed over the sound, onto shore begins to be reported by the weather observer (17 times over the decade).

Conclusions

From this analysis it seems probable that the following statements describe fog characteristics over Long Island Sound and adjacent areas of Connecticut.

1) The fog is formed during every season of the year with a maximum in the Spring.

2) The physical mechanisms for fog formation based on phase relationships seem to be similar from J.F.K. and LGA to HVN.

3) Calm conditions and fog bank advection onshore become important and are first mentioned near New Haven, CT.

4) Southerly flow is required for fog formation or associated with fog formation about 50% of the time.

It seems likely that a sophisticated forecast model may not need to be tested for Long Island Sound. Possibly a water surface temperature or a land temperature in the afternoon at thermal sundown and a forecast dewpoint temperature are all that are required.

Table 1 FOG TEMPERATURE AT ONSET*

	COLD [≤ØC]	WARM [>ØC]
ALB	16.9	83.1
BOS	5.9	94.1
JFK	3.2	96.8
LGA	5.5	94.5

* as a percentage of mean annual heavy fog events

Table 2 MEAN SEASONAL FOG OBSERVATIONS* [1970-1979]

	DEC-FEB	MAR-MAY	JUN-AUG	SEP-NOV
ALB	13.9	13.9	19.9	52.2
BOS	20.7	31.5	26.6	21.2
JFK	24.6	36.0	22.9	16.3
LGA	30.4	41.1	16.4	12.3

*as a percentage of mean annual heavy fog events

Table 3 AVERAGE WIND SPEED VS. RESULTANT WIND DIRECTION*

[ALBANY, NY]

	CALM	N	NE	E	SE	S	SW	W	NW	TOT
CALM	61	0	0	0	0	0	0	0	0	61
1-2	0	12	11	2	1	5	2	2	2	37
3-4	0	16	12	3	3	18	3	2	1	58
5-6	0	8	0	1	3	15	0	1	0	28
7-8	0	0	0	0	1	5	0	0	0	6
9-10	0	3	1	0	1	1	0	0	0	6
11-12	0	0	1	0	0	1	0	0	0	2
>12	0	2	0	0	0	1	0	0	0	3
TOT	61	41	25	6	9	46	5	5	3	201

*per heavy fog event (wind speed in knots)

Table 4 AVERAGE WIND SPEED VS. RESULTANT WIND DIRECTION*

[LGA, NY]

	CALM	N	NE	E	SE	S	SW	W	NW	TOT
CALM	6	0	0	0	0	0	0	0	0	6
1-2	0	0	0	3	0	0	0	1	0	4
3-4	0	1	7	6	3	2	2	1	0	22
5-6	0	3	10	3	4	6	1	1	0	28
7-8	0	5	12	1	3	2	2	1	0	26
9-10	0	0	8	0	0	3	0	0	0	11
11-12	0	2	3	0	0	0	0	0	0	5
>12	0	2	7	0	0	4	0	0	1	14
TOT	6	13	47	13	10	17	5	4	1	116

* per heavy fog event (wind speed in knots)

Table 5 AVERAGE WIND SPEED VS. RESULTANT WIND DIRECTION*

[JFK, NY]

	CALM	N	NE	E	SE	S	SW	W	NW	TOT
CALM	5	0	0	0	0	0	0	0	0	5
1-2	0	0	0	0	0	0	0	0	0	0
3-4	0	0	5	15	11	9	7	1	0	48
5-6	0	3	8	16	12	26	15	5	1	86
7-8	0	3	4	6	14	22	18	3	0	70
9-10	0	0	4	9	2	16	9	1	0	41
11-12	0	0	7	1	0	13	2	0	0	23
>12	0	0	3	10	7	45	1	1	0	67
TOT	5	6	31	57	46	131	51	11	1	339

* per heavy fog event (wind speed in knots)

Table 6 AVERAGE WIND SPEED VS. RESULTANT WIND DIRECTION*

[BOSTON, MA]

	CALM	N	NE	E	SE	S	SW	W	NW	TOT
CALM	1	0	0	0	0	0	0	0	0	1
1-2	0	0	2	2	4	1	0	0	0	9
3-4	0	8	5	12	6	2	1	0	1	35
5-6	0	10	19	17	8	7	4	0	2	67
7-8	0	2	10	13	4	2	0	1	2	34
9-10	0	1	9	13	2	2	2	0	0	29
11-12	0	2	2	8	1	1	0	0	1	15
>12	0	4	1	5	0	0	0	1	2	13
TOT	1	27	48	70	25	15	7	2	8	203

* per heavy fog event (wind speed in knots)

Table 7 MEAN SEASONAL FOG OBSERVATIONS* [1970-1979]

	DEC-FEB	MAR-MAY	JUN-AUG	SEP-NOV
HVN	28.0	31.0	24.0	17.0
BDG	25.0	36.0	24.0	15.0
BDL	26.0	21.0	20.0	34.0

* as a percentage of mean annual heavy fog events

Table 8 AVERAGE WIND SPEED VS. RESULTANT WIND DIRECTION*

[New Haven, CT]

	CALM	N	NE	E	SE	S	SW	W	NW	TOT
CALM	57	0	0	0	0	0	0	0	0	57
1-2	0	0	3	4	1	0	0	1	0	9
3-4	0	4	4	9	9	11	12	2	1	52
5-6	0	9	5	15	17	8	9	6	1	70
7-8	0	2	0	5	10	12	9	0	0	38
9-10	0	0	0	2	3	1	6	0	0	12
11-12	0	1	0	1	1	0	0	1	0	4
>12	0	2	2	0	1	3	7	1	2	18
TOT	57	18	14	36	42	35	43	11	4	260

* per heavy fog event (wind speed in knots)

FIGURE 1 TOTAL HEAVY FOG EVENTS vs MONTH (1970-79)

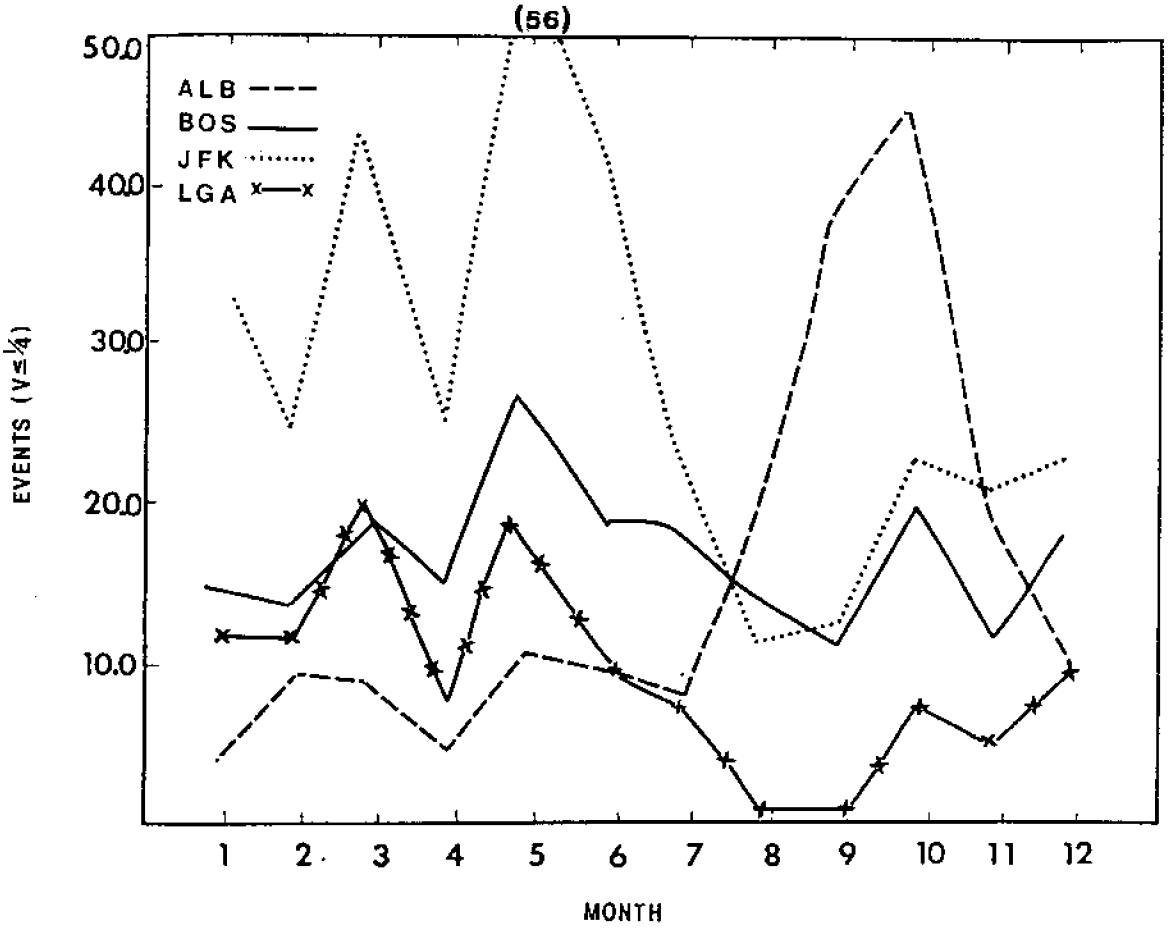

FIGURE 2 PERCENT OF TOTAL HEAVY FOG EVENTS vs MONTH

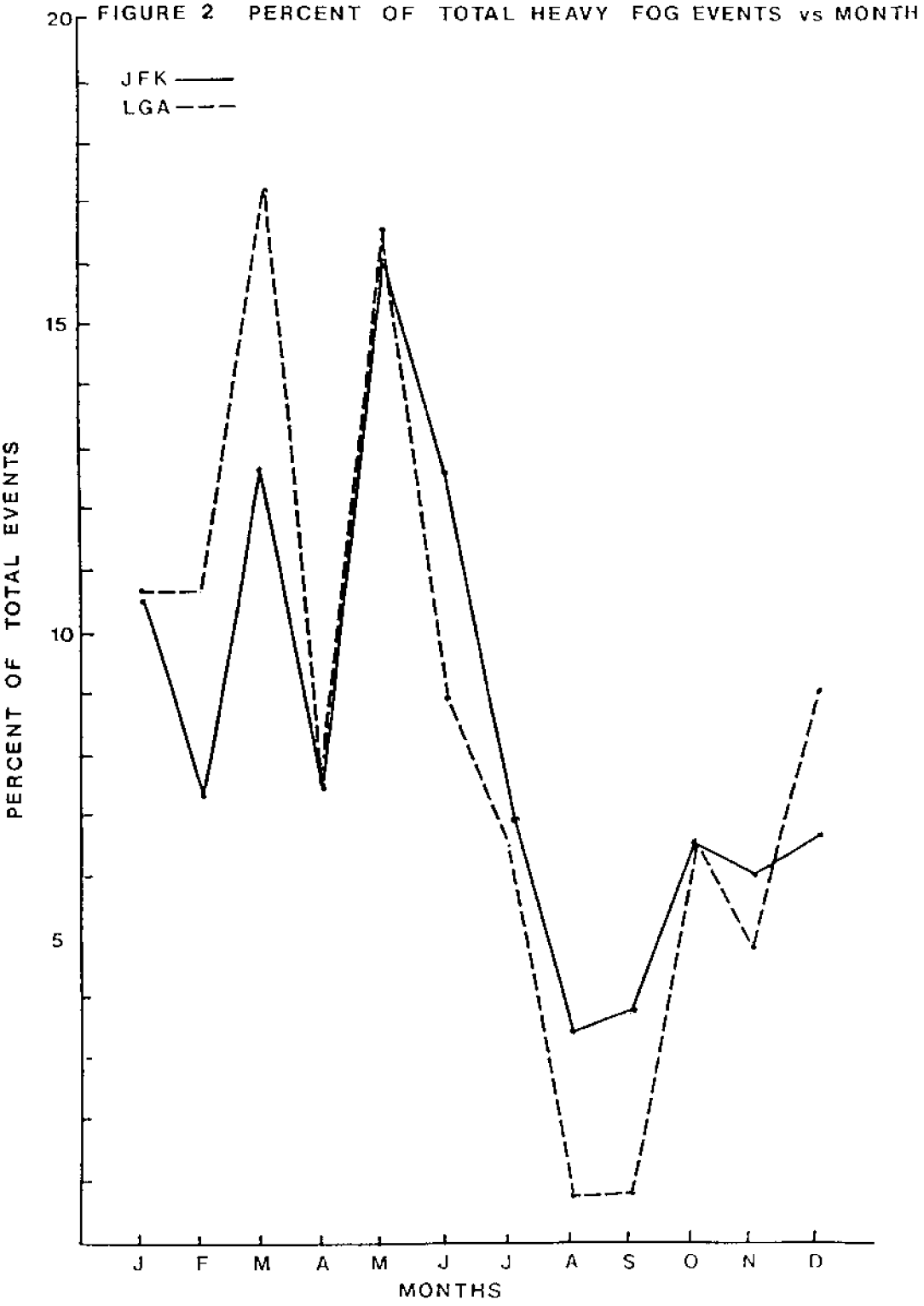

FIGURE 3 TOTAL HEAVY FOG EVENTS vs MONTH (1970-79)

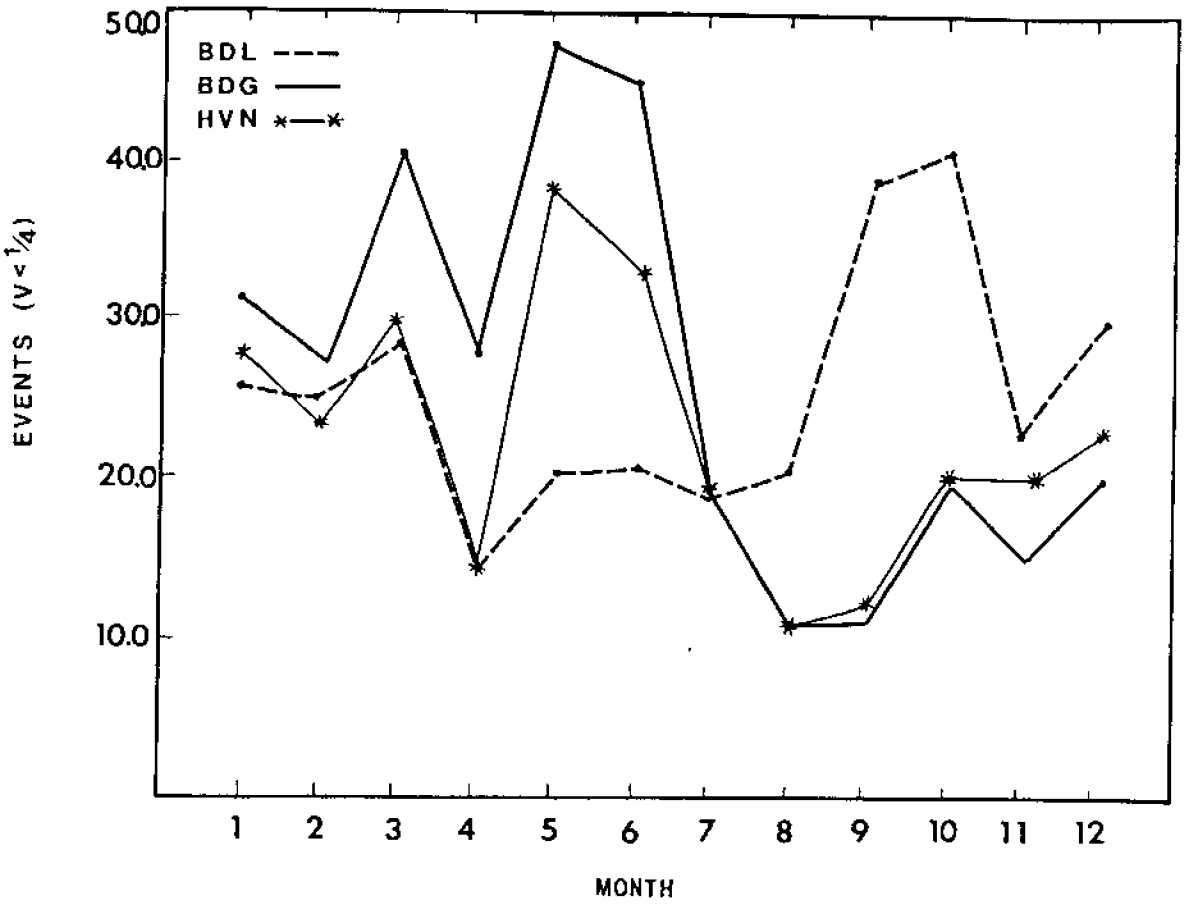

FIGURE 4 PERCENT OF TOTAL HEAVY FOG EVENTS vs MONTH