COMPARATIVE VERIFICATION BETWEEN GEM AND OFFICIAL AVIATION TERMINAL FORECASTS

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I will give a status report of the effort and some plans we have for the future for the Generalized Exponential Markov Model (GEM), a new statistical forecasting procedure.

GEM uses the local standard airways observation (SAO) to predict hour-by-hour the following elements: temperature; pressure; dew point depression; first and second cloud-layer height and amount; ceiling; total cloud amount; visibility; wind; and present weather conditions such as fog, haze, rain, snow, freezing rain, thunderstorms and their quantitative amounts. In other words, we forecast all of the elements which are in the SAO. To forecast, we use those same elements as predictors, one hour prior to the time of forecast. We collected 4 million SAOs from 41 stations around the country. We developed regression equations that enabled us to predict the probability of each category of these elements, and there were 228 predictors. Each equation had 228 coefficients, and there were 228 equations. The procedure took the one-hour forecasted probabilities and integrated them into the system to project out to the second hour, the third hour, and so forth, until it eventually settled down to climatology.

We have shown that GEM is superior to persistence at all projections for all elements in a large independent sample. By saying this, I imply that we forecast changes and are most frequently successful at hitting them. It has also been demonstrated that GEM performs better than MOS, the procedure that utilizes the LFM dynamical model inside six hours when the operational delays due to model computer run-time are considered. Recently we have finished a comparative study against the predominant conditions of the official National Weather Service terminal aviation forecast (FT). It performs better inside three hours than the FT; however, at three hours and beyond, the FT is better.

Presently we are involved through an interagency agreement with the FAA in an effort to produce a minute-by-minute GEM forecasting system utilizing the Automated Weather Observation System (AWOS). We have currently processed 400,000 AWOS observations in developing an AWOS GEM. Figure 1 shows the weather elements as observed once per minute by equipment similar to the FAA's AWOS.

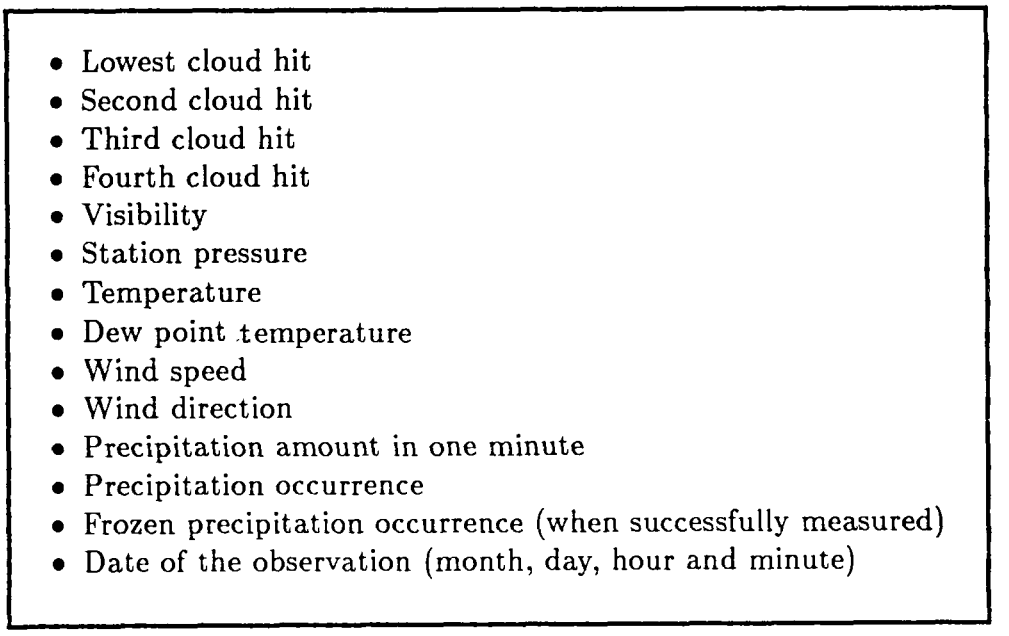

Figure 1. Data began to be collected at the National Weather Service's Techniques Development and Test Branch location at Sterling, Virginia, in April 1984.

As mentioned earlier, there were 228 predictors for the hourly GEM forecast. Table 1 shows from where the 228 came. Each element was categorized on the average of around 10 categories per element producing 228. In the case of the AWOS, there are 88 variables used as predictors for forecast.

Plans for the future include the following:

- To complete the AWOS-GEM, to produce forecasts on demand utilizing a microcomputer, and to verify these forecasts on independent observation data. (The intent was to begin this on light forecasting in June 1985; at the end of April, one-year's data was accumulated, amounting to nearly 500,000 observations).

- To continue investigating the inclusion of nonlinear predictive information found to be contained in "Boolean" combinations of the raw AWOS elements. (Each of the 88 elements shown in Table 1 are binary variables, and there is a great opportunity to create "Boolean" combinations out of the data collected. Just recently we have discovered that there is a great deal of information here that has yet been untapped.)

- To evaluate the hour-by-hour GEM at the FAA's Flow Control Center with the help of Ray Stralka, NWS.

- To create an ASOS-GEM using the data which Steve Short set out in his paper on Observing Weather during the Overview Presentations section of this workshop.

Table 1. Predictor and predictand categories which specify the dummy variables used in GEM. Shown under the index column are the left-out categories not included because of redundancy.

Number	Weather Element	Category	Index
1	(Always unity)		1
2	Lowest cloud hit (00′)	0–1	2
3		2–4	3
4		5–9	4
5		10–29	5
6		30–60	6
7		61–UNL	Left out
8	Second cloud hit (00′)	0–1	7
9		2–4	8
10		5–9	9
11		10–29	10
12		30–60	11
13		61–UNL	Left out
14	Third cloud hit (00′)	0–1	12
15		2–4	13
16		5–9	14
17		10–29	15
18		30–60	16
19		61–UNL	Left out
20	Fourth cloud hit (00′)	0–1	17
21		2–4	18
22		5–9	19
23		10–29	20
24		30–60	21
25		61–UNL	Left out
26	Visibility (*miles*)	0–31/64	22
27		1/2–63/64	23
28		1–2 63/64	24
29		3–4 64/64	25
30		5–6 63/64	26
31		7–100	Left out
32	Station pressure (*inches of Eg*)	0–29.235	27
33		29.236–29.530	28
34		29.531–29.677	29

Table 1. (Continued)

Number	Weather Element	Category	Index
35		29.678–29.825	30
36		29.826–29.973	31
37		29.974–30.120	32
38		30.121–30.268	33
39		30.269–30.563	34
40		30.564–35.000	Left out
41	Temperature ($^{\circ}F$)	-30–4	35
42		5–14	36
43		15–24	37
44		25–34	38
45		35–39	39
46		40–44	40
47		45–49	41
48		50–54	42
49		55–59	43
50		60–64	44
51		65–74	45
52		75–84	46
53		85–94	47
54		95–110	Left out
55	Dew point depression ($^{\circ}F$)	0–1	48
56		2–7	49
57		8–15	50
58		16–25	51
59		26–99	Left out
60	Wind Speed (kn)	0–1	52
61		2–9	53
62		10–19	54
63		20–29	55
64		30–99	Left out
65	Wind direction (deg)	00–44	56
66		45–89	57
67		90–134	58
68		135–179	59

Table 1. (Concluded)

Number	Weather Element	Category	Index
69		180–224	60
70		225–269	61
71		270–314	62
72		315–359	Left out
73	Precipitation amount (*inches*)	.002–.100	63
74		.001–.0019	64
75		.000–.0009	Left out
76	Precipitation occurrence ($YorN$)	Yes	65
77		No	Left out
78	Frozen precipitation ($YorN$) (when successfully measured)	Yes	66
79		No	Left out
80	Month	January	67
81		February	68
82		March	69
83		April	70
84		May	71
85		June	72
86		July	73
87		August	74
88		September	75
89		October	76
90		November	77
91		December	Left out
92	Hour (LST)	00-01	78
93		02-03	79
94		04-05	80
95		06-07	81
96		08-09	82
97		10-11	83
98		12-13	84
99		14-15	85
100		16-17	86
101		18-19	87
102		20-21	88
103		22-23	Left out