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A CLIMATOLOGY OF LIFR CONDITIONS IN THE UPPER MIDWEST STRATIFIED BY TYPE OF WEATHER

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1. Introduction

Low ceilings and fog are the most common weather-related factors in fatal general aviation accidents (Capobianco and Lee 2001). Flying from visual flight rules to instrument meteorological conditions and flight into adverse weather during the cruise phase are the most common probable causes of fatal weather accidents. Low ceilings accounted for 20% of the fatal accidents, while fog accounted for 14%. In addition, forecasting restricted ceilings and visibilities remains a challenge for NWS aviation forecasters. NWS aviation verification statistics (aviation/TAF stats on demand) were examined for twenty TAF sites in the Minneapolis Air Route Traffic Control Center - Center Weather Service Unit (ZMP) airspace for a one year period (January 1, 2003-January 1, 2004). Only probability of detection (POD) was reviewed (TAF vs. observation) and results indicate that considerable improvement in forecasts is needed. Most PODs were in the .200 to .300 range, with the lowest .133 at Pierre, South Dakota and the highest .408 at Marquette, Michigan. This paper documents 1,144 individual events in seven states in the Midwest during a five year period when low instrument flight rules (LIFR) conditions occurred. Daily ASOS-based METAR observations[1] from August 1998 through August 2003 were examined. In this paper, LIFR refers to ceilings of 200 feet above ground level (AGL) or lower and/or visibilities of 1 nautical mile (nm) or less. When an event affected multiple states, they were combined producing a total of 550 events. Prior research has dealt with the problem of low clouds and fog in the Midwest, most recently Roebber et al. (1998), and as far back as Hardwick (1973). This paper expands those studies to include snow and fog type that cause LIFR conditions.

[1]Plymouth (New Hampshire) State University Weather Center. website: http://vortex.plymouth.edu/sa_parse-u.html

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2. Methodology

A study was undertaken documenting all occurrences of LIFR conditions in the Minneapolis Air Route Traffic Control Center airspace. ZMP covers portions of nine states from the Plains to the Great Lakes (Fig. 1). The occurrences were stratified by state, month, and season. The occurrences were also stratified by cause: radiation fog (RAD), advection fog (ADV) and snow (SNOW). Only METAR observations were reviewed; no other data were used. If high pressure prevailed, winds were light and skies were clear before the fog developed, the fog type was considered radiation. If pressures were lowering, winds were increasing, especially from the south, and clouds were developing, then the fog type was considered advection. For the LIFR occurrence to be included in this study the following criteria needed to be met: 1) LIFR conditions had to occur for a minimum of two hours and affect at least five observation sites and two of the airports had to be at least 100 nm apart, 2) LIFR conditions were not produced by lake-effect snow, and 3) LIFR conditions did not occur in the Kansas or Missouri portion of the ZMP airspace (owing to the small portion of those states in the ZMP area of responsibility).

There are two concerns with this methodology that should be addressed: 1) having at least five observation sites is highly dependent on the density of the observing network. Minnesota, Wisconsin, Michigan, and Iowa have a dense observing network supplemented by state-owned systems. On the other hand, South Dakota, North Dakota, and Nebraska have a relatively sparse network so that getting five stations would require a large area to have fog, and 2) radiation fog can be very localized but still important to aviation.

Fig. 1. ZMP area of responsibility outlined in green shading (*courtesy FAA*).

3. Results

There was a total of 1,144 individual LIFR events in the ZMP airspace during the five year period from August 1998 through August 2003 (an average of 229 events per year). This included 208 RAD events, 549 ADV events, and 387 SNOW events. Occurrences were segregated by state and event type (Table 1).

Table 1 yields some interesting facts. For example, the number of LIFR conditions for fog was greatest in Minnesota; but for snow was greatest in North Dakota. The lowest number of LIFR events occurred in Nebraska.

STATE	MN	WI	ND	SD	MI	IA	NE	TOTAL
RAD	45	49	17	25	21	31	20	208
ADV	98	83	85	75	69	81	58	549
SNOW	65	70	83	58	57	26	28	387
TOTAL	208	202	185	158	147	138	106	1144
No. of observation sites (entire state)	72	47	12	17	57	50	34	289

Table 1. Total number of LIFR and weather events by type (RAD, ADV, or SNOW) for each state and the total number of observation sites each state.

Events were stratified by type and total number per month for each state in the ZMP airspace in Table 2. This table serves as a reference for not only what types of events occurred, but also the total number of events by state and by month. By far the greatest number of total events was in March; the least number in June. Additional conditions can easily be extracted from Table 2; for example, LIFR conditions (over the seven state area and during the five year study period) in March totaled 159. In other words, March averaged 32 events of LIFR conditions in five years somewhere in the ZMP airspace.

	MN	WI	ND	SD	MI	IA	NE	TOTAL
JAN	1,9,12,22	2,3,21,26	0,8,13,21	0,7,10,17	0,2,17,19	3,9,6,18	0,2,6,8	6,40,85,131
FEB	0,10,15, 25	0,11,13,24	0,7,10,17	0,4,10,14	0,8,8,16	0,11,5,16	0,6,8,14	0,57,69,126
MAR	2,15,12,29	1,6,15,22	1,13,13,27	3,13,11,27	0,8,11,19	1,12,6,19	0,11,5,16	8,78,73,159
APR	0,10,9,19	1,8,8,17	1,7,15,23	0,7,7,14	0,7,3,10	0,5,3,8	0,6,2,8	2,50,47,99
MAY	0,6,0,6	0,6,0,6	1,6,3,10	2,5,0,7	0,6,0,6	0,1,0,1	0,4,0,4	3,34,3,40
JUN	1,2,0,3	0,5,0,5	0,4,0,4	1,4,0,5	0,6,0,6	0,3,0,3	1,4,0,5	3,28,0,31
JUL	5,4,0,9	6,7,0,13	1,5,0,6	2,1,0,3	2,2,0,4	3,2,0,5	2,2,0,4	21,23,0,44
AUG	25,7,0,32	22,8,0,30	3,4,0,7	11,4,0,15	8,7,0,15	15,8,0,23	11,2,0,13	95,40,0,135
SEP	3,8,0,11	8,6,0,14	1,7,0,8	1,5,0,6	4,3,0,7	5,8,0,13	5,7,0,12	27,44,0,71
OCT	4,13,2,19	7,6,2,15	5,10,2,17	5,8,1,14	7,6,1,14	1,6,0,7	1,2,1,4	30,51,9,90
NOV	3,5,7,15	2,5,7,14	3,11,11,25	0,7,10,17	0,5,5,10	3,5,1,9	0,2,1,3	11,40,42,93
DEC	1,9,8,18	0,12,4,16	1,3,16,20	0,10,9,19	0,9,12,21	0,11,5,16	0,10,5,15	2,64,59,125
TOTAL	45,98,65, 208	49,83,70, 202	17,85,83, 185	25,75,58, 158	21,69,57 147	31,81,26, 138	20,58,28, 106	208, 549, 387, 1144

Table 2. Types of events and total events per month by state. In each block, the first entry is number of RAD events, second entry is number of ADV events, third entry is number of SNOW events, and the fourth entry is total number of LIFR events.

Table 3 lists the month that had the most events per type and for each state. This can be used as a quick reference to find the most active months for different event types for each state.

	MN	WI	ND	SD	MI	IA	NE
RAD	AUG	AUG	OCT	AUG	AUG	AUG	AUG
ADV	MAR	DEC	MAR	MAR	DEC	MAR	MAR
SNOW	FEB	JAN	DEC	MAR	JAN	JAN, MAR	FEB

Table 3. The most active month per type of event per state (1998-2003).

Events were stratified by the specific season they occurred in (Fig. 2). In this study, the seasons were based on the meteorological definition, not astronomical. Thus, the fall season was September, October and November; winter season December, January and February; spring season March, April and May; and the summer season June, July and August. The winter months had the largest number of occurrences with a total of 382, while the summer had the lowest number with a total of 210. The results indicate that the majority of the SNOW and ADV events occurred in the winter and early spring, while the largest number of RAD events occurred in the late summer and fall.

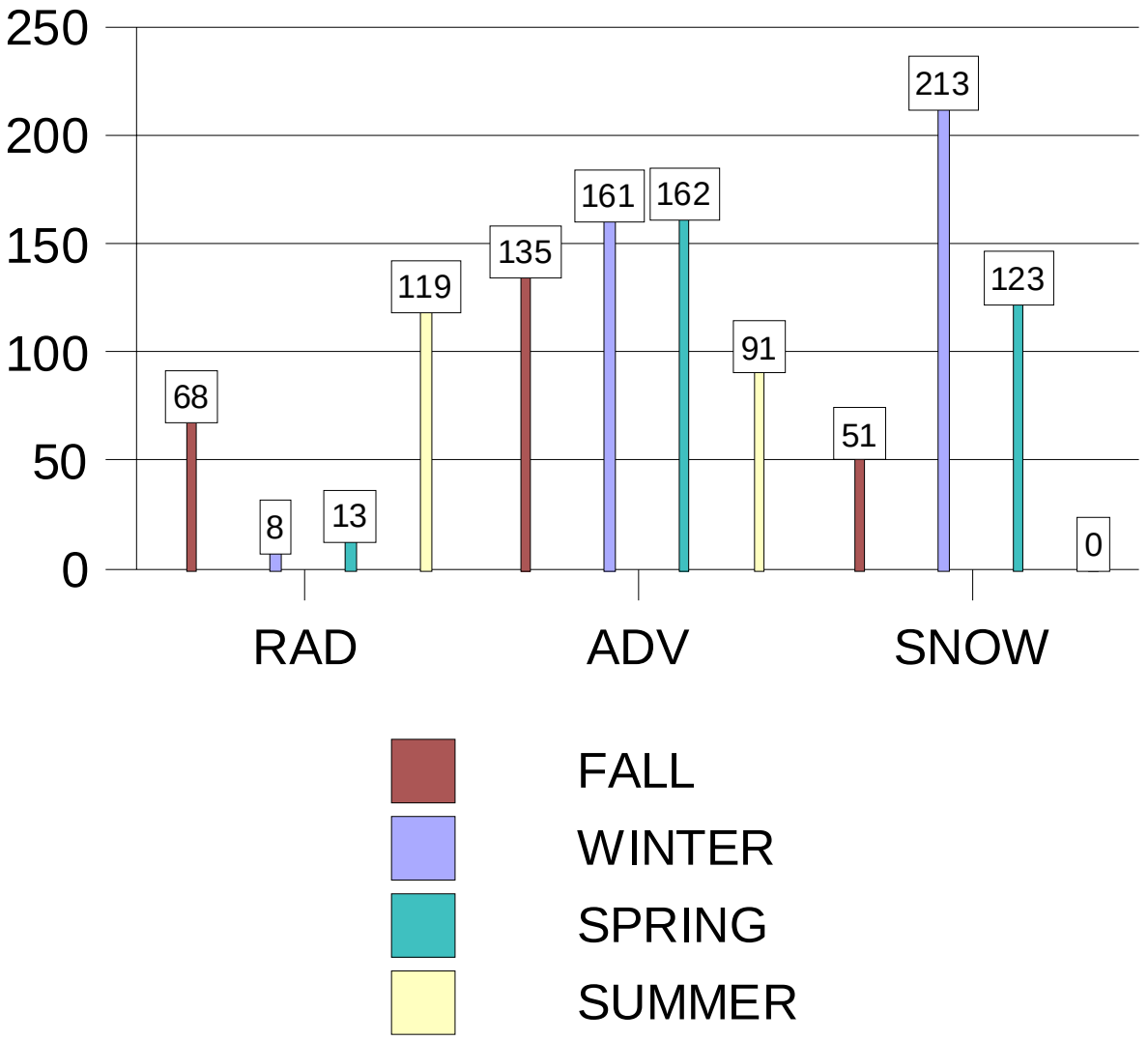

Fig. 2. Type of events by season.

Events were also stratified by each month they occurred in (Fig. 3). The results indicate that most RAD events occurred in August (95), most ADV events in March (78), and most SNOW events in January (85).

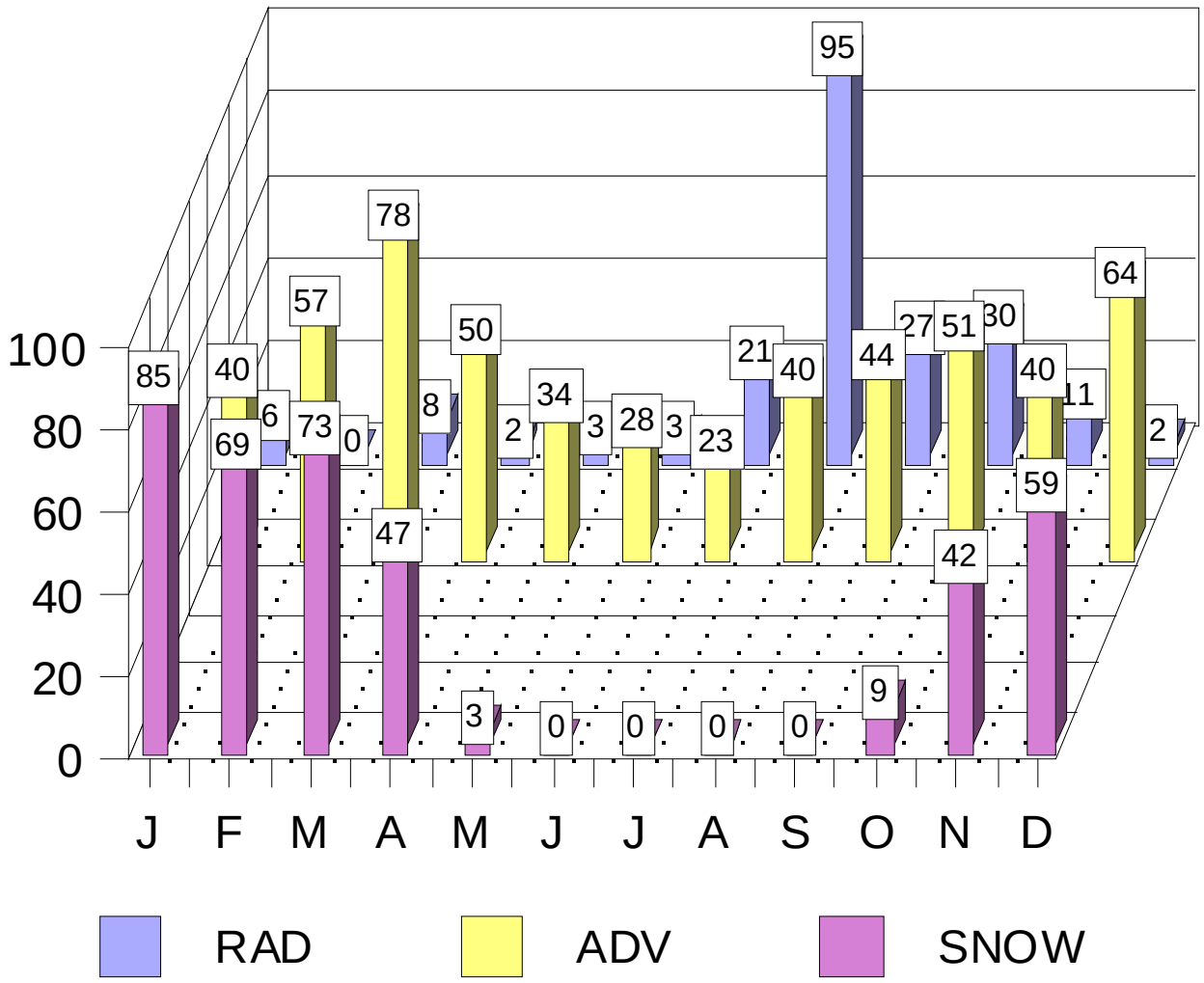

Fig. 3. Type of events by month.

4. Summary and Conclusions

A study was undertaken using five years of data for the seven states comprising most of the ZMP airspace to determine the number of occurrences of LIFR conditions due to radiation fog, advection fog and snow. These events were then categorized by season, month and state. Because low clouds and fog are common weather-related factors in fatal general aviation accidents and are forecasting challenges, this study can be used to determine the highest risk of LIFR event types by season, month and geography. LIFR conditions occurred most often in the winter season and that most events were in the state of Minnesota. The study also revealed that fog occurred nearly twice as often as snow when LIFR conditions were considered.

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6. List of Acronyms

AGL= above ground level
ASOS= Automated Surface Observing System
FAA= Federal Aviation Administration
LIFR= low instrument flight rules
METAR= meteorological aviation routine weather report
nm= nautical mile
NWS= National Weather Service
TAF= terminal aerodrome forecast
ZMP= Minneapolis Air Route Traffic Control Center - Center Weather Service Unit

7. References

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