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Snowfall Accumulation in Cold Bay, Alaska and Surface to Upper Level Wind Observations

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Introduction

Although snowfall is a common occurrence during Alaska winters, the complex topography and sparse data make forecasting a challenge. This is especially true over the Aleutian island chain where radar coverage is nonexistent and weather observations are scarce. The advent of IFPS and GFE has made the need for local precipitation studies even more urgent. The first step in alleviating this problem is to analyze the climatological data that is available.

Weather data in the Aleutian chain has been recorded since World War II when the armed services occupied the islands. However, the data have become sparser as many of the military posts have been abandoned. The one area that has maintained a surface weather observation station with personnel is Cold Bay in the eastern Aleutians.

A detailed sketch of winter precipitation patterns is possible for this site because of the availability of surface and upper air data. Observations of wind direction at the surface should help reveal any upslope effects, while upper air wind directions should expose the general position of low pressure centers relative to Cold Bay before and during the events.

Methodology and Data

Surface Data

Observations were obtained from the National Climate Data Center (NCDC) for October through March in the years 1973 to 1981 and 1998 to 2003. The years 1973 to 1981 were comprised of three hour raw LCD reports. Data from 1998-2003 were compiled from raw hourly observations.

Snow days were included if there was more than one surface observation of snow that was not mixed with liquid precipitation. Each snow day was required to have an accumulation of at least .01 inch and a measurable liquid precipitation equivalent of at least .01 inch. Additionally, observations were discarded if the winds were calm and, therefore, did not have an associated direction.

Using these criteria, from 1973-1981 there were 434 snow days with 1795 observations (Appendix A, NCDC, 2004). From 1998-2003, there were 327 snow days comprised of 3444 observations (Appendix B, NCDC, 2004).

The data were then separated into six categories based on snow accumulation. Category 1 includes events with 1.0-1.9 inches. Category 2 ranges from 2.0-2.9 inches; Category 3 from 3.0-3.9 inches, Category 4 from 4.0-4.9 inches, Category 5 from 5.0-5.9 inches and Category 6 includes events with 6.0 inches or more.

There were 165 event days in Categories 1 through 6 for 1973-1981 (Table 1). For 1998-2003, there was a total of 142 event days.

Table 1. Number of event days per accumulation category.

	1973-1981	1998-2003
Category 1	114	83
Category 2	25	24
Category 3	11	16
Category 4	9	8
Category 5	2	2
Category 6	4	9

Surface wind directions were recorded for all included snow event observations (Table 2). Directions were divided in the following manner: North – 337.6 to 22.5, Northeast – 22.6 to 67.5, East – 67.6 to 112.5, Southeast – 112.6 to 157.5, South – 157.6 to 202.5, Southwest – 202.6 to 247.5, West – 247.6 to 292.5, Northwest – 292.6 to 337.5.

Table 2. Wind directions broken down by category.

	Category 1		Category 2		Category 3		Category 4		Category 5		Category 6	
	1973-1981	1998-2003	1973-1981	1998-2003	1973-1981	1998-2003	1973-1981	1998-2003	1973-1981	1998-2003	1973-1981	1998-2003
North	182	289	37	56	22	57	24	30	2	0	12	39
Northeast	10	12	2	6	1	4	5	0	2	0	0	0
East	11	26	4	27	0	1	1	1	0	0	0	3
Southeast	52	87	11	47	6	36	0	18	1	2	0	14
South	31	22	6	6	3	6	2	4	1	0	5	1
Southwest	19	46	7	18	1	6	1	1	0	2	1	1
West	68	131	13	54	19	42	8	32	0	9	4	24
Northwest	126	402	35	104	7	81	12	25	0	19	0	70

Upper Air Data

Upper air soundings were unavailable for the years 1973-1981. Raw data were obtained from NCDC and Forecast Systems Laboratory (FSL), however, for snow days with accumulations over one inch in 1998-2003. The 00Z and 12Z soundings for the days the accumulation occurred on were chosen to reflect the synoptic scale set up for each event (Table 3). Wind directions were gathered from the 850mb, 700mb, 500mb, and 300mb levels in order to provide clues regarding the placement of low pressure systems relative to Cold Bay and the direction of temperature advection.

Table 3. Upper air wind directions for 00Z and 12Z soundings.

	850mb		700mb		500mb		300mb	
	00Z	**12Z**	**00Z**	**12Z**	**00Z**	**12Z**	**00Z**	**12Z**
North	24	20	17	21	10	12	11	12
Northeast	5	7	4	4	6	8	0	0
East	10	4	7	5	8	7	6	3
Southeast	11	10	13	4	8	7	5	5
South	11	14	14	20	17	16	18	24
Southwest	12	8	19	17	22	20	37	21
West	29	30	28	26	47	36	46	42
Northwest	38	40	36	36	20	27	17	24

Analysis and Results

Surface Observations

The predominant wind direction during snow events was north to west (Table 4). This held true for all categories (Table 5). Indeed, for events with accumulations of six or more inches, the north to west component was present in 85.63% of observations. Interestingly, the occurrence of southeast surface winds increased from the middle of January through March (Appendix A, B, NCDC, 2004). A possible explanation for this phenomenon is the increased need for moisture from the south as the cold season progresses. Air from the north is usually significantly colder and drier, with a fetch over ice covered waters in the Bering Sea and Bristol Bay by mid winter.

Table 4. Percentage of all surface observations for each direction.

	All Surface Observations
North	28.78%
Northeast	1.93%
East	3.82%
Southeast	10.82%
Southeast	3.66%
Southwest	5.42%
West	14.93%
Northwest	30.83%

Table 5. Percentage of observations with a north to west component per category.

	North to West Component
Category 1	79.13%
Category 2	69.05%
Category 3	78.08%
Category 4	79.88%
Category 5	78.95%
Category 6	85.63%

Upper Air Soundings

The predominant wind directions at the 850mb to 300 mb levels were 270 to 010 degrees (Table 6). These directions were recorded on soundings 52% to 68% of the time. This north to west component showed a slight increase in frequency from the 00Z soundings, which often represented preconditions, to the 12Z soundings that occurred during or just before the snow events. However, surface observations indicated a north to west component greater than 69% of the time. The difference in percentage of occurrence is explained by a greater predominance of wind directions out of the southwest to south from the 700mb level to the 300mb level than at the surface.

Table 6. Percentage of observations with a north to west component per sounding level.

	00Z Sounding				**12Z Sounding**			
	850mb	**700mb**	**500mb**	**300mb**	**850mb**	**700mb**	**500mb**	**300mb**
North to West Component	65.00%	67.67%	58.27%	62.41%	55.40%	55.97%	52.86%	59.54%

The greater incidence of southerly flow in the upper levels than at the surface indicates the probability of “warm” air advection into Cold Bay. The warmer air would allow for greater moisture advection into the region, as well.

The wind directions on the upper air soundings point to low pressure systems that track from just northwest to just northeast of Cold Bay during the majority of the snow events. This would place the center of the lows in the Bering Sea or Bristol Bay when the accumulations occur. Low pressure systems are known to frequently follow this path across or along the Aleutian island chain during the cold season.

Conclusion

Forecaster memory is an important aspect of any meteorological process, but often it can be skewed to one significant event. Therefore, it is essential to analyze large volumes of historical data in order to prove or disprove widely held theories.

This study found that the predominant direction of surface and upper level winds during accumulating snowfall events in Cold Bay, Alaska was north to west, rather than the widely held belief of a northeast flow. The study also identified the favorable positions for low pressure system placement, as well as the tendency for surface winds to more frequently be out of the southeast during events that occur after the middle of

January. While there are always exceptions to general pattern recognition, this study should lead to more accurate snowfall accumulation forecasts during future events in Cold Bay.

References

raob.fsl.noaa.gov/temp/raob_soundings.tmp, Forecast Systems Laboratory and National Climatic Data Center. 2004.
www.ncdc.noaa.gov/servlets/ULCD, National Climatic Data Center. 2004.

Appendix A
Surface Observations for 1973-1981

Table 7. Surface Observations for 1973-1981 (National Climate Data Center, 2004)

Year	Month	Day	>= 1 in.	North	Northeast	East	Southeast	South	Southwest	West	Northwest
1973	10	13	1.7	2							2
1973	10	18									3
1973	10	19									3
1973	10	29								3	
1973	10	30								2	
1973	11	17								1	1
1973	11	25		2							
1973	11	26		6							1
1973	11	27		3							
1973	12	4		2							5
1973	12	5	1.8	1				1			1
1973	12	7	2.0	1	1				1		
1973	12	8					1	1			
1973	12	11		1							1
1973	12	12		5							2
1973	12	13		2							2
1973	12	14		3							4
1973	12	15		5							1
1973	12	16		3	1				1		1
1973	12	19	1.6	3			1				1
1973	12	21		1				1	1		
1973	12	26					2				
1973	12	27								1	1
1974	1	15		6							
1974	1	16	1.6	8							
1974	1	17	1.4	7							
1974	1	18									5
1974	1	19							2		
1974	1	27		5							
1974	1	31		3			1				
1974	2	1		3	1					1	1
1974	2	2		5							
1974	2	3	1.3				3				
1974	2	8		2			1				
1974	2	9						1		1	2
1974	2	13		7							
1974	2	14		7							
1974	2	17		4							
1974	2	18		8							
1974	2	19	7.4	8							

1974	2	20	4.0	7							
1974	2	21		4							
1974	3	6		1			1			2	
1974	3	7		3	1						
1974	3	15					3				
1974	3	21	3.4							5	1
1974	11	8		1							2
1974	11	14	2.0	2			1				
1974	11	17	2.3							2	
1974	11	18							1	2	
1974	11	19						2			
1974	11	21	1.3	4	1						
1974	11	22		3							1
1974	11	23		1	1	1		1			
1974	11	27	1.3	3	1						3
1974	11	28								1	3
1974	12	3	1.0	5							1
1974	12	4		1							1
1974	12	11	1.0					1	1	2	
1974	12	13	1.0							2	
1974	12	14		1							3
1974	12	16		2							
1974	12	17		8							
1974	12	18								1	5
1974	12	19		3						2	
1974	12	20		1		1					
1974	12	23	1.0				1	1			
1974	12	26		3			1				1
1974	12	27				1	1	1			
1974	12	31	1.4	5							1
1975	1	1		8							
1975	1	11	1.6	2							5
1975	1	12	1.0								7
1975	1	13		2							1
1975	1	14		5							
1975	1	15		1			1				
1975	1	20		3		1				2	
1975	1	21								3	2
1975	2	11		1							1
1975	2	12			1			1			1
1975	2	14		2							3
1975	2	15	1.6	3	1		1	1			
1975	2	17	1.4	5							2
1975	2	18	1.3					1		1	3
1975	2	19			1				2		
1975	2	20	1.6	4	1						2
1975	2	21	1.5	1							7
1975	2	22	1.3							2	4

1975	2	24	1.0	2			1	1			1
1975	2	25					1	1	1	2	
1975	2	26						2	2	1	
1975	2	27					2			2	
1975	3	7	7.0				4				
1975	3	9	1.3					2			
1975	3	10					1	1	1		
1975	3	13							1	1	
1975	3	14		6							
1975	3	16		6							1
1975	3	17		3							5
1975	3	19		2							
1975	3	20		2						1	2
1975	3	21		5							3
1975	3	22		3							2
1975	3	25		5	1		1				
1975	3	29	1.0				1	2			
1975	3	30		1							1
1975	3	31		3						1	
1975	10	17		2							
1975	10	18									2
1975	10	24								1	1
1975	10	29		5			1				
1975	10	31	2.3	2				1			1
1975	11	1		3	1						1
1975	11	2	1.1	4							2
1975	11	3					1		1		
1975	11	5							1	2	
1975	11	6	3.9						1	4	1
1975	11	9	3.0	1			2	1		3	
1975	11	10		4	1						
1975	11	11		4							1
1975	11	13		4							
1975	11	14									5
1975	11	16		3			1				
1975	12	3									4
1975	12	4		5							
1975	12	6		1							2
1975	12	7	1.2	8							
1975	12	16					2				
1975	12	17						3			
1975	12	21	7.0	4						4	
1975	12	22	3.3				1	2		1	1
1975	12	25	2.0	2							6
1975	12	26	1.4							6	2
1975	12	27								1	2
1975	12	29	1.3				2				
1976	1	4									3

1976	1	8	1.6				2	1			
1976	1	10	1.0	4							4
1976	1	11		1			1				1
1976	1	13		1	1	1					
1976	1	16					2				
1976	1	19		8							
1976	1	20	3.5	8							
1976	1	21	2.0	1							7
1976	1	22									5
1976	1	23				2					
1976	1	26	2.0				1	2	1	2	
1976	1	27						6			
1976	1	28		2		1				4	1
1976	2	1					3				
1976	2	5	1.0					1		1	
1976	2	6		3						2	
1976	2	7		7							
1976	2	8					2				
1976	2	11	2.1				2				
1976	2	12					2				
1976	2	14				2					
1976	2	15	2.7	3		3					2
1976	2	16		3							3
1976	2	17		1							5
1976	2	18	2.7	1			3				
1976	2	19		6							1
1976	2	20		2			1				
1976	2	21	1.5				3			4	
1976	2	22								1	6
1976	2	23		1							7
1976	2	24		3							5
1976	2	25		6							
1976	2	27				1		1			
1976	2	28			1		4	1			
1976	2	29				1	3	1			
1976	3	3	3.9				3			2	
1976	3	8					1	1	1		
1976	3	9	1.2	1		1	4				
1976	3	10		2							
1976	3	12						2			1
1976	3	13		2	1	1					
1976	3	14	1.7	7	1						
1976	3	16		7							1
1976	3	17		1							7
1976	3	18		4							1
1976	3	23		1	1						4
1976	3	24		2	1		1	1		1	
1976	3	30	1.8				1	1			

1976	10	11		1					1		1
1976	10	26	1.7	1							3
1976	10	27								1	5
1976	10	28			1						1
1976	10	29		2							1
1976	10	30	1.7	5							2
1976	10	31	1.4	7							
1976	11	1		5							
1976	11	4	3.0	4							
1976	11	10				1	1				
1976	11	20		3							
1976	11	21		5							
1976	11	22		5							
1976	11	23	1.6							2	1
1976	11	25			3						
1976	11	29		2							
1976	11	30								2	1
1976	12	1					2				1
1976	12	9		2							
1976	12	10	1.3	6							
1976	12	11	2.3	4					1	2	
1976	12	13	1.4						2	2	
1976	12	14	1.3						2	2	3
1976	12	15							2		
1976	12	18	1.3								2
1976	12	19	3.4	2						1	2
1976	12	20	4.6	2						3	3
1976	12	21	1.5							2	
1976	12	27	2.1	4							2
1976	12	28		1							2
1976	12	29					3				
1976	12	31								1	1
1977	1	12		3							
1977	1	14	1.5					3			
1977	1	16								2	
1977	1	17	1.0						2		
1977	1	20		3						1	1
1977	1	26			2						
1977	2	7				2					
1977	2	22	1.1					2		1	
1977	2	23					1	1		1	
1977	2	25	1.4			1	1				
1977	2	26	1.0						3	1	
1977	2	27					2				
1977	3	1				2	1				
1977	3	2	1.4	3	1		1		1		
1977	3	3	4.2	6					1		1
1977	3	4	1.2	1			2				4

1977	3	5	1.3	2	1	1	2	2			
1977	3	6					2			2	
1977	3	7							2	4	
1977	3	8	1.4						2	1	
1977	3	9	1.1							4	2
1977	3	10	1.5	2							1
1977	3	21		7							1
1977	3	23	1.5				3				
1977	3	25	2.5								6
1977	3	26	1.4					1			3
1977	3	29		3			1				
1977	3	30		3	1						
1977	3	31	4.1	3							
1977	10	17		2					2		2
1977	10	20	1.8	2						1	1
1977	10	21	2.7	3							1
1977	10	22	2.9	1							3
1977	10	24								1	1
1977	10	28					1	1			
1977	11	5	1.4						1	2	
1977	11	6	1.4						2	1	
1977	11	9	1.1	2			1				1
1977	11	12	1.6				2		1	2	
1977	11	13		2							
1977	11	14	2.3	1						2	1
1977	11	15	2.2					1		2	
1977	11	27		2							
1977	11	28	1.4	4							2
1977	11	29		6							1
1977	12	11		8							
1977	12	12	1.2	7							
1977	12	13		6							
1977	12	15		2							3
1977	12	18					2				
1978	1	9						1		2	
1978	1	12	1.0				1				
1978	1	13	1.0	1						1	
1978	1	18	1.3				2				
1978	1	19	2.8				1	1			
1978	1	20						2			
1978	1	21	5.8	1	2		1				
1978	2	5		3							
1978	2	6		6							2
1978	2	7		6							
1978	2	11					3				
1978	2	13	1.4	1					1		3
1978	2	20	5.8	1				1			
1978	2	21	4.5	1	4					1	

1978	3	6	3.0	6							
1978	3	7		1			3				1
1978	3	8	4.9	1						2	3
1978	3	9						3			
1978	3	12						3			
1978	3	13	2.1	2	1						1
1978	3	14		4							2
1978	3	16	2.7			1	1	1			
1978	3	26									2
1978	3	27								1	3
1978	3	28							1	1	1
1978	3	29	1.0			1	4				
1978	10	31	1.4								1
1978	11	5	1.0							1	1
1978	11	6	1.0								2
1978	12	13							1		1
1978	12	14								1	1
1978	12	15								1	3
1978	12	20	1.8				1	2		1	
1978	12	22								2	
1978	12	24						1		1	
1979	1	16							2	1	
1979	1	18	6.3				1		1		
1979	1	23				1	1		1		
1979	2	3		4							
1979	2	4		4							
1979	2	5	1.4	4							
1979	2	8		4							
1979	2	12								2	
1979	2	13								1	1
1979	2	18					1	1			
1979	2	25								2	1
1979	3	1	2.2	2						1	3
1979	3	3		3							
1979	3	4		1						1	2
1979	3	6	1.9	2						1	
1979	3	7	1.2	2							
1979	3	8		3							2
1979	3	10	1.9	1						2	2
1979	3	11							2	4	
1979	3	12		5							
1979	3	26								1	1
1979	11	16	1.7							1	1
1979	11	17	2.0							1	1
1979	11	20	2.1	2					1		
1979	11	23	1.0	1							1
1979	11	27	1.5	2							1
1979	12	2								2	

1979	12	6								2	
1979	12	7								1	1
1979	12	8								2	
1979	12	19		3							3
1979	12	20									5
1979	12	24	1.9							4	
1979	12	25	1.1					1		2	1
1979	12	26		5							2
1979	12	27		2							
1979	12	28		2						1	
1980	1	12	1.0	5							
1980	1	13	1.4	8							
1980	1	14	1.6	8							
1980	1	15		1						1	1
1980	1	16		1	1						
1980	1	17	4.7	3	1						3
1980	1	18									4
1980	1	20		2							2
1980	1	24					2	1			
1980	1	31		2							
1980	2	1		3							
1980	2	2	1.6	4							3
1980	2	3	1.3	1				1		1	3
1980	2	10	1.7	1							2
1980	2	20	1.3	6							1
1980	2	21		2						1	1
1980	2	22		2							
1980	2	23	1.4	1							3
1980	3	1					2				
1980	3	2	4.2	1				1			2
1980	3	7	4.3			1		1		2	
1980	3	9								1	1
1980	3	10								2	
1980	3	11			1						3
1980	3	14	1.8				2	2			
1980	3	16	1.1				2	1			
1980	3	23	1.4			1				2	
1980	3	24					2	2			
1980	3	27					2				
1980	3	29	1.7			1		1			
1980	3	30						2			
1980	3	31					2	1			
1980	11	1		2							
1980	11	2									2
1980	11	4									4
1980	11	5								4	
1980	11	18								1	1
1980	11	25	1.4						1	1	

1980	12	12		5							
1980	12	13	2.6	6							1
1980	12	14	1.7	1						1	4
1980	12	28		3	1						
1980	12	30	1.9	3							1
1980	12	31	2.4						3	1	
1981	1	1									2
1981	1	8	1.2				3	1			
1981	1	10	1.4			2				1	
1981	1	11					2				
1981	1	12	1.7		1	1	1				
1981	1	14								5	1
1981	1	15							1	2	
1981	1	16		2							1
1981	1	17		4							
1981	1	18		1							2
1981	1	25							2		
1981	1	27		1			1	1			
1981	1	29								4	
1981	1	30				2					
1981	2	9	1.3	2							
1981	2	13		5	1						
1981	2	16		2							
1981	2	17		3							
1981	2	18									5
1981	2	19		5							
1981	2	20								1	3
1981	2	21	1.2				2			1	
1981	2	22								1	3
1981	2	23					2				
1981	3	3	1.7			1	2	1			
1981	3	4	3.4	1	1					4	1
1981	3	5							1	2	
1981	3	7	1.3		1	1					
1981	3	12			1	1					
1981	3	31					3				
1981	10	17									2
1981	10	29	1.9	2						1	2
1981	10	30		2							
1981	10	31		2							2
1981	11	1	3.0							1	1
1981	11	3	1.4	2							
1981	11	4	1.1							1	1
1981	11	13		2							2
1981	11	14	1.0	1							2
1981	11	28									2
1981	11	29	1.4	1	1						3
1981	11	30	1.6								5

1981	12	1	1.9							4	
1981	12	3		2							
1981	12	4									3
1981	12	5	1.0	1							7
1981	12	16									4
1981	12	17									5
1981	12	18	1.8							2	2
1981	12	25								2	2
1981	12	28								2	
1981	12	30	1.1							1	1
TOTAL				739	46	38	156	92	62	229	433

Appendix B
Surface and Upper Air Observations for 1998-2003

Table 8. Surface and upper air observations for 1998-2003 (NCDC and FSL, 2004)

Year	Month	Day	>= 1 in	North	Northeast	East	Southeast	South	Southwest	West	Northwest	850-00z	700-00z	500-00z	300-00z	850-12z	700-12z	500-12z	300-12z
1998	10	25	8.2					1	1	9	1	W	W	W	SW	S	S	SW	SW
1998	11	1							1	2									
1998	11	19		1						1									
1998	11	20							4	2									
1998	11	21	3.6							8	6	NW	NW	NW	N	NW	NW	W	W
1998	11	22	3.5						2	9	2	NW	NW	W	W	W	W	W	NW
1998	11	23	1.6	1							1	NW	W	W	NW	W	W	W	W
1998	11	24	4.0	6							8	NW	SW	W	SW	NW	W	W	NW
1998	11	25		1							16								
1998	11	26					5												
1998	11	27		1							2								
1998	11	28	3.2							3	15	N	NE	E	E	NW	NW	NW	NW
1998	11	29					6	2	2	1	1								
1998	11	30		2						2	2								
1998	12	1	2.5						3	8	2	NW	NW	W	W	NW	NW	W	W
1998	12	2					1	1	2	1									
1998	12	3							3										
1998	12	4							6	4									
1998	12	5	1.4	6	5							W	NW	W	W	W	W	W	W
1998	12	6	1.6	6							12	E	E	SE	S	N	NW	N	NW
1998	12	7		3	4						4								
1998	12	8		20															
1998	12	9		6	2														
1998	12	11		8		1				1									
1998	12	12	1.1	3							7	N	W	SW	W	NW	NW	NW	NW
1998	12	29								3	10								
1998	12	30	1.0	12	1					2	9	W	NW	NW	NW	NW	NW	NW	-----
1999	1	8	3.6	4						7	3	E	E	E	E	S	SW	N	N
1999	1	9	2.8							10	5	S	S	S	S	S	S	SE	S
1999	1	12	1.0				5	5				SW	W	SW	SE	SW	SW	SW	SW
1999	1	13	1.1						1	4		S	S	SW	SW	SW	W	SW	S
1999	1	14	1.1	1						4	6	W	W	W	W	W	W	NW	NW
1999	1	15	1.2				1		4	6	1	NW	W	W	SW	W	W	SW	SW
1999	1	16							1	1									
1999	1	21	4.6				6					SE	SE	E	SW	SE	SE	S	S
1999	1	23							5	1									
1999	1	24							7	1									

1999	1	25	1.4				4		2		1	W	W	W	W	-----	-----	-----	-----
1999	1	26								2	5								
1999	1	27		4							11								
1999	1	28									20								
1999	1	31	3.0	8	1							NW	NW	NW	W	N	NW	W	W
1999	2	1	1.8	11								E	S	SW	SW	NE	W	NW	-----
1999	2	3		6	3	3													
1999	2	5	2.7	19							4	N	N	W	W	NW	NW	NW	W
1999	2	6	2.7								19	NW	NW	NW	W	NW	NW	NW	NW
1999	2	7	2.0						1	6	5	NW	NW	N	NW	NW	NW	NW	NW
1999	2	12					2												
1999	2	13	1.9				7					SW	SW	S	S	S	S	SW	W
1999	2	14					3	1											
1999	2	15					2	5	1										
1999	2	16	1.6				5	2				S	S	S	S	S	S	W	S
1999	2	17								5									
1999	2	19	1.4				6					NW	SW	E	S	W	S	S	NW
1999	2	20	4.1				5	2	1			S	S	W	W	SE	S	S	S
1999	2	21						1	1	3									
1999	2	22							1	3									
1999	2	23							4	1									
1999	2	24					1	2		1									
1999	2	25	1.0	1						4	8	W	W	W	W	W	NW	W	W
1999	2	26	3.2	10							14	NW	NW	W	W	NW	NW	W	SW
1999	2	27	3.0	11							13	N	N	N	W	N	N	NW	NW
1999	3	3		1	2	1	6				1								
1999	3	8	1.0				4			1		S	W	W	W	S	SW	S	S
1999	3	9		3		5	2			2									
1999	3	10	1.6	20								SE	SW	W	W	E	NE	E	N
1999	3	11	1.5	2							22	N	N	W	W	NW	NW	NW	W
1999	3	12		1							15								
1999	3	13	3.7				7		2	1		NW	NW	NW	NW	SW	SW	W	W
1999	3	14	2.4				3		3	3	1	W	SW	SW	SW	SW	SW	SW	SW
1999	3	16					1	2		4									
1999	3	17	8.0				6			5		W	SW	SW	W	W	NW	NW	NW
1999	3	18	7.1			3	3					S	S	SW	SW	SE	S	S	S
1999	3	19							1	5									
1999	3	20	4.3							24		N	NE	E	S	W	NW	N	SE

1999	3	21	4.3				1	1		6	1	NW	N	NW	SW	N	N	W	NW
1999	3	22	1.7				9	2				SE	S	W	W	S	SW	S	SW
1999	3	23	3.5				10	4				SW	SW	SW	SW	SW	E	NW	NW
1999	3	24						1	4	2									
1999	3	25						5	5										
1999	3	26						2	5	2									
1999	3	28		1						6	10								
1999	3	29		4			4				1								
1999	3	31				2	5			2									
1999	10	21		1							12								
1999	10	22		2							17								
1999	10	24	1.2	5						3	3	NW	NW	NW	NW	NW	NW	NW	NW
1999	10	25	2.0						3	7	7	NW	NW	NW	NW	-----	-----	-----	-----
1999	10	26								4	8								
1999	10	27	1.3	3						4	5	NW	NW	NW	NW	W	NW	NW	W
1999	10	28		6							8								
1999	10	29	3.6	2	2	1	3	1	2	6	1	NW	NW	NW	NW	NW	NW	NW	NW
1999	10	30		9						1									
1999	10	31	3.3	1			5	1				NW	W	W	W	N	NW	NW	W
1999	11	1		7							6								
1999	11	6		2	3	6					3								
1999	11	13									6								
1999	11	19								2									
1999	11	20	1.0							9		NW	NW	NW	W	W	W	W	W
1999	11	21	1.0						7	4		W	NW	W	W	W	W	W	W
1999	11	22	1.0						1	5	9	W	W	SW	W	W	NW	W	W
1999	11	23	1.4	1							17	NW	NW	W	W	NW	NW	NW	W
1999	11	26	1.1								13	NW	N	NE	NW	NW	NW	NW	W
1999	11	27		2							10								
1999	11	28					5	1		5									
1999	11	29					6		1										
1999	11	30						1	1										
1999	12	1	2.0						2	6		W	SW	SW	S	W	W	W	W
1999	12	3		5							10								
1999	12	6		9															
1999	12	7		1		1		3	1	2	1								
1999	12	8	1.3				9		1	1		W	W	W	W	-----	-----	-----	-----
1999	12	10								2	4								

1999	12	11	1.3	3					3	5	9	W	NW	W	W	NW	NW	W	W
1999	12	12	3.8	6							18	W	W	W	W	NW	NW	NW	W
1999	12	13	1.7	13							9	NW	NW	W	W	NW	NW	W	W
1999	12	14		10	1						7								
1999	12	15	2.3	7							11	N	N	NE	SW	NW	N	NW	W
1999	12	16							5	2									
1999	12	17		4					1	2									
1999	12	18	1.9	16						5	1	SW	SW	SW	SW	-----	-----	-----	-----
1999	12	19							1	14									
1999	12	21	6.1	16							8	NE	SE	S	S	N	SE	S	S
1999	12	26	1.5	8							11	N	W	S	S	NE	NE	E	SE
1999	12	27	1.6	1							18	NW	NW	W	SW	NW	W	S	S
1999	12	29			1	11	2												
2000	1	2	1.7	19							2	-----	-----	-----	-----	-----	-----	-----	-----
2000	1	5	6.7	22							1	S	SW	SW	SW	E	S	SW	SW
2000	1	6	1.2	1						1	20	E	SE	S	SW	N	W	SW	SW
2000	1	7	6.5							10	13	NW	SW	SW	SW	NW	NW	W	SW
2000	1	8	5.4							6	18	W	NW	NW	W	NW	NW	NW	W
2000	1	9	7.6	1							23	NW	NW	NW	NW	NW	NW	N	N
2000	1	10	13.4								24	NW	NW	NW	W	NW	N	N	NW
2000	1	11	1.4								18	NW	NW	NW	NW	NW	N	N	NW
2000	1	14							2	3	2								
2000	1	19								1	1								
2000	1	20	1.0				2					W	W	NW	NW	SW	W	SW	W
2000	1	25	2.6				13			7		SW	SW	SW	SW	S	SW	SW	SW
2000	1	26	1.1	9		2				1	8	S	S	S	SW	S	SW	SW	SW
2000	1	27	3.9	1	1		1			5	4	N	N	NE	SW	NW	NW	W	SW
2000	1	28	1.1	2	1						2	W	W	W	W	W	W	W	W
2000	1	31	1.2				3		1	3		SW	SW	W	SW	SW	W	W	SW
2000	2	1	4.1	2		1	6	1				NW	SW	W	NW	S	SW	SW	SW
2000	2	2	5.2				2		2	3	1	SW	S	SW	-----	W	SW	SW	S
2000	2	3	7.9				5					SW	SW	SW	S	SE	S	S	S
2000	2	4					3												
2000	2	5					1	1											
2000	2	8					3												
2000	2	14					9												
2000	2	16						5											
2000	2	17	2.4				6					S	S	W	W	SE	S	S	S

2000	2	19						1	4	2									
2000	2	20					4	1	1										
2000	2	23				4	9												
2000	2	24					2	1		2									
2000	2	25	1.1				2			11		SE	SE	SE	SW	W	SW	W	SW
2000	2	26	1.7			3	7					W	S	SW	W	S	SW	W	W
2000	2	27					4												
2000	2	28					1		7										
2000	3	2	1.0			10	2					SE	SE	S	SW	E	SE	SE	E
2000	3	5					5												
2000	3	7					4												
2000	3	10				2	3												
2000	3	14	2.2	5	2	4	2					E	E	E	E	E	E	E	S
2000	3	16			1		1			2									
2000	3	19					2												
2000	3	22					4												
2000	3	25		18							1								
2000	3	26							1	7	8								
2000	3	27		10							1								
2000	3	28		11	1														
2000	3	29	4.0	4						2	16	E	E	E	SE	N	N	N	N
2000	3	30	1.8	1	1			1	2	3	5	NW	W	W	W	-----	-----	-----	-----
2000	3	31							1	2	1								
2000	10	6	1.0	1							6	N	N	N	NW	NW	NW	W	W
2000	10	7									11								
2000	11	17						2											
2000	11	25	1.1						1	1	4	N	N	N	NW	NW	N	NW	NW
2000	11	26	1.4				1	1				NW	NW	SW	SW	W	W	W	SW
2000	11	27		2							2								
2000	11	28		3							9								
2000	12	1					5												
2000	12	3							1	3									
2000	12	6						4											
2000	12	13	1.6	4		1				2		SE	SE	SE	SE	SE	S	SE	S
2000	12	15			1				3										
2000	12	16				2	2												
2000	12	27			2	1													
2001	1	3		1						3	1								

2001	1	5		7															
2001	1	6	3.3	12						3	7	E	E	S	S	NE	NE	NE	SE
2001	1	7	2.1						1	5	5	N	N	NW	N	W	N	N	W
2001	1	8								7	5								
2001	1	9								3	1								
2001	1	10	2.7			1	13					W	NW	W	W	S	SW	W	W
2001	1	11	1.3			1	2					SE	S	S	SW	SE	S	S	S
2001	1	13	1.3	4	1		1	2		1	5	SW	W	SW	SW	W	E	NE	E
2001	1	14								5	10								
2001	1	15							1	1									
2001	1	19						4											
2001	1	21							1	2									
2001	1	22					1			5									
2001	1	23					4												
2001	1	24	1.3			1	4	3				S	SE	SE	S	S	S	S	S
2001	1	26					1	4	2	2									
2001	1	27	1.5					4	2	3		SW	SW	SW	SW	W	W	W	W
2001	1	28					3		1										
2001	1	31	1.2		1				3	5		N	NW	W	SW	W	W	W	W
2001	2	1							6	1									
2001	2	2							8	3									
2001	2	3	2.2				5	5				W	W	W	SW	W	W	W	NW
2001	2	8					1		4										
2001	2	9					8												
2001	2	11								4	4								
2001	2	18		4							2								
2001	2	19		2	1		3			1									
2001	2	27					2		1	9	1								
2001	2	28	1.4				3		2	6	1	NW	W	SW	SW	SW	S	SW	SW
2001	3	11							2										
2001	3	23		2							10								
2001	3	24		4							15								
2001	3	26	2.2								23	NW	N	E	E	NW	N	E	E
2001	3	27								2	20								
2001	3	29		2					1	1	11								
2001	10	10		1					4	2	2								
2001	10	22						1		4	3								
2001	10	23								2	5								

2001	10	24		3							10								
2001	10	25		3							7								
2001	10	28		5			1				2								
2001	10	29	3.7	2								NW	NW	NW	W	SE	S	W	W
2001	11	1		4					1	2	1								
2001	11	2		8							9								
2001	11	3	1.8	6							16	NW	NW	NE	N	NW	NW	NW	NW
2001	11	4									11								
2001	11	13		11							10								
2001	11	14	1.2	10							14	NW	NW	W	W	NW	NW	NW	NW
2001	11	17		10															
2001	11	30		1							1								
2001	12	1					1		4										
2001	12	2					3												
2001	12	3							2										
2001	12	8				2	3	1											
2001	12	10					4												
2001	12	11								2									
2001	12	14	1.0	8					1		2	N	W	W	W	W	W	W	W
2001	12	15	2.0	7							9	NW	NW	W	W	NW	NW	NW	NW
2001	12	16	1.3	10							7	N	W	NW	NW	NW	NW	NW	NW
2001	12	17		7							7								
2001	12	18		6	1						6								
2001	12	19	1.3			8	4	1				N	NW	W	W	NE	S	SW	W
2001	12	20	1.4	3						11	2	SE	S	S	S	-----	-----	SE	S
2001	12	21								3	7								
2001	12	22	2.3					1	3		2	W	W	W	W	NW	W	W	W
2001	12	23	1.8				6	1				W	W	W	SW	S	SW	W	W
2001	12	24	2.1	3	4	10	3					SE	SE	S	SW	SE	S	SE	S
2001	12	26	1.4	6	2							E	SE	SE	SE	NE	E	E	SE
2001	12	27	2.8	14								NE	SE	S	SE	N	N	E	S
2001	12	28	4.8	18								N	SE	SE	W	NE	SE	S	SW
2001	12	29	1.1	8								NE	E	S	S	N	NE	E	SE
2002	1	7		4	2	2	1		5	2									
2002	1	8		1		1													
2002	1	9							3	13	5								
2002	1	12				4	2												
2002	1	18				1	4												

2002	1	22	2.0	2					2	2	1	SE	SW	W	W	W	SW	SW	-----
2002	1	23	1.8	6							13	W	W	W	SW	N	NW	SE	W
2002	1	29	1.8						1	4	10	SE	S	S	S	NE	N	S	W
2002	1	31				1	3			1									
2002	2	2				1	1												
2002	2	3					2												
2002	2	5						1		7	3								
2002	2	6				3	3		1										
2002	2	7	1.4	17							1	SW	SW	S	SW	NW	SW	SW	SW
2002	2	8		3	2	1													
2002	2	9	1.1	1						2	16	NW	NW	NW	NW	NW	NW	NW	NW
2002	2	11	1.9						4	6	7	-----	SE	S	SW	NW	S	SW	SW
2002	2	13								12									
2002	2	14							4	10	1								
2002	2	15	1.4						3	1		W	W	W	W	W	W	W	W
2002	2	16	1.0	2						3	3	SW	W	W	SW	W	SW	SW	SW
2002	2	17	1.2							3	12	NW	NW	W	W	W	W	NW	W
2002	2	18		1							19								
2002	2	19		1	1		2	1		1	2								
2002	2	20					7		1										
2002	2	21	3.5				10					S	S	SW	W	SE	S	S	S
2002	2	25				3	4												
2002	2	28					2	1	1										
2002	3	7				8	1												
2002	3	9				10	1												
2002	3	23					6												
2002	3	24					2												
2002	3	27							1	1	2								
2002	11	13		3							9								
2002	11	14							2										
2002	11	28	1.3	6							1	W	SE	S	S	NW	S	S	S
2002	11	29		2															
2002	12	9								2									
2002	12	11							3										
2002	12	18								1	1								
2002	12	21		1							1								
2002	12	22	2.2								8	N	E	SE	S	N	E	SE	S
2002	12	23							4	2									

2002	12	24	1.0						4	1		W	SW	SE	S	W	W	SW	W
2002	12	25	1.5						3	4	1	W	W	W	W	W	W	W	W
2002	12	28		1	1					3									
2002	12	31		2	1														
2003	1	2	1.5	6						1	6	E	-----	-----	E	N	N	NE	N
2003	1	3	1.7	7							12	NE	NE	NE	N	N	N	NE	S
2003	1	5	2.1	2		6	1				1	W	NW	W	SW	-----	-----	-----	-----
2003	1	6								1	1								
2003	1	7				9	2												
2003	1	19		2					1		1								
2003	2	1					5												
2003	2	4					1			1									
2003	2	5								5	2								
2003	2	14				1		1		1									
2003	3	4		3							2								
2003	3	5		8															
2003	3	8				2													
2003	3	10			1	2													
2003	3	13	1.1	17							2	N	N	N	N	N	N	N	N
2003	3	14	1.8	16							3	N	N	N	N	N	N	N	N
2003	3	15	1.2	6							9	N	N	N	N	NW	N	NE	N
2003	3	18		6							6								
2003	3	21								5	10								
2003	3	30					1	2											
2002	12	31			1														
2003	1	2	1.5							1	6	E	-----	-----	E	N	N	NE	N
2003	1	3	1.7								12	NE	NE	NE	N	N	N	NE	S
2003	1	5	2.1			6	1				1	W	NW	W	SW	-----	-----	-----	-----
2003	1	6								1	1								
2003	1	7				9	2												
2003	1	19							1		1								
2003	2	1					5												
2003	2	4					1			1									
2003	2	5								5	2								
2003	2	14				1		1		1									
2003	3	4									2								
2003	3	5																	
2003	3	8				2													

2003	3	10			1	2													
2003	3	13	1.1								2	N	N	N	N	N	N	N	N
2003	3	14	1.8								3	N	N	N	N	N	N	N	N
2003	3	15	1.2								9	N	N	N	N	NW	N	NE	N
2003	3	18									6								
2003	3	21								5	10								
2003	3	30					1	2											
TOTAL				769	55	162	411	100	222	553	1182								