OROGRAPHIC EFFECTS OF WIND AT STEVENS PASS SKI AREA

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ABSTRACT: It all starts with a forecast, but what does free winds at 1,524 meters (5,000 feet) mean to our area on the ground? For the last four winters, (01'-04'), observations have been made of the orographic effects of wind at Stevens Pass Ski Resort. This was accomplished by correlating data from the three ski area telemetry sites, the NW Avalanche Center forecasts, simultaneous compass readings from various locations, and visual observations of wind and its effects. Looking for consistency as well as anomaly between the various observations and data, this data was plotted on maps of Stevens Pass Ski area to get an overall picture of what does a free wind at 1,524 meters (5,000 feet) forecast really mean to our local area. Crown depths from short records were looked at to confirm suspected loading. When shot records were not available, "ski-pole" measurements were taken.
The findings have shown that not only large terrain features such as major mountain passes and ridges can effect wind direction, but also rows of trees and more subtle features such as gullies, small rises and depressions. Wind takes the path of least resistance. In other words, a west wind just might load a west slope. The knowledge gained has helped make operation decisions concerning which areas should be of priority focus when doing mid-day ski cutting or doing control work with a limited number of patrollers.

Keywords: wind, forecasts, avalanche control

1. INTRODUCTION

Located in the state of Washington, Stevens Pass is one of the major passes in the north central part of the North Cascade Mountain Range. The local relief, (measure of ups and downs), of this range exceeds any comparable breath of the U.S. Rockies or the Sierras, and approaches that of the European Alps. Excluding Alaska, the majority of the United States glaciers are found within this range.
With the close proximity to the Pacific Ocean, the North Cascades have a maritime snowpack, meaning lots of precipitation and relatively warm temperatures. Running from north to south, this range divides Washington State into two major climatic regions. Unique weather lies in the border tension between the cold mid-continental air mass of the east side and the warmer maritime air mass of the west side. The differences between these two air masses can create strong easterly winds through the passes when a storm is coming from the west, (which is the predominant direction most weather systems come from).

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2. OBJECTIVES

The objectives are to learn the basic wind currents and patterns at Stevens Pass Ski Area. To find what a wind forecast at 1,524 meters (5,000 feet) means on the ground surface. To be able to apply this knowledge gained for avalanche control decisions.

3. METHODS

Because the winds can shift direction many times in one day, only days with consistent winds could be chosen for case study. One of the techniques used was to simply sit in a specific area and record visual observations. Another technique

used was to enlist people to take simultaneous compass readings of the wind from various positions on the mountain. On these same days, the forecasted winds at 1,524 meters (5,000 feet) and pass level 1,219.2 meters (4,000 feet) winds were recorded and compared with data collected from the three locations of Stevens Pass telemetry, as well as compared with the data and observations collected. (figs.1-6). This information was then plotted on topography maps of the Stevens Pass region. Compilation maps were made of the different days with similar wind direction, thus showing the trend of wind patterns (figs. 7-9). If available, shot records were then looked at to confirm what slopes were loaded. On days with no avalanche control, simple "ski-pole" measurements were taken to confirm suspected loading. These observations were also plotted on topography maps as well.

4. RESULTS

With the data collected, the basic wind currents and patterns were established with some surprising results. Two specific regions within the ski area have the same wind direction and loading, no matter the direction of the prevailing wind at 5,000 feet. The orographic effect tends to channel the wind into the "corners" where two ridges are perpendicular to each other. Another interesting observation is that wind tends to flow like water, filling in spaces after going through a constriction in topography, such as a pass. As the wind goes through a pass, some wind will keep going in the same direction, while some of the wind will "spread" out in different directions, which can even be sometimes opposing directions. These winds can create cross slope winds, which seem to over take the winds coming down slope. Creating different type of loading farther down slope.
Trends were also found with the correlation of the 5,000 foot forecasted winds and the winds on the ground surface (fig.10). However, the correlations could not be made with out taking the pass level winds into account, because there are times when The 5,000-foot wind is opposite the pass surface wind.

5. CONCLUSION

The knowledge gained has given a better understanding how different areas of the mountain are affected by the wind. This can thus be applied to making decisions concerning priorities for avalanche control,

6. REFERENCES

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Moore, M., 2001. Stevens Pass Climate, Stevens Pass Level II Avalanche Course.

FIG. 1 STEVENS PASS TELEMETRY

	Direction in degrees						
	1/20/2001	3/4/2001	3/10/2001	3/11/2001	3/13/2001	1/12/2002	3/28/2002
Location	9-10am	9-11am	8-10am	8-10am	9am-12p	9-11am	10am-12p
Tye Mill							
8am	106	82	287	285	343	281	246
9am	106	77	n/a	278	267	264	265
10am	114	74	288	286	301	272	281
11am	106	67	293	284	299	260	284
Noon	114	64	284	284	318	252	282
1pm	116	61	287	281	309	266	286
Brooks							
8am	105	78	241	233	276	290	263
9am	103	74	251	224	236	276	266
10am	101	78	259	226	262	271	275
11am	103	78	258	218	267	264	292
Noon	101	75	230	231	264	263	292
1pm	85	77	248	229	253	269	275
Grace							
8am	not collected		198	207	236	not collected	
9am			n/a	200	203		
10am			217	276	225		
11am			231	178	221		
Noon			188	190	225		
1pm			211	179	218		

	Direction in degrees					
FIG. 2	1/31/2003	2/1/2003	2/3/2003	2/9/2003	2/12/2003	2/15/2003
Location	11am-1p	9-11am	9-11am	8-10am	9-11am	11am-1p
Tye Mill						
8am	319	260	302	315	105	141
9am	297	260	299	311	96	n/a
10am	305	274	307	304	106	165
11am	284	276	299	308	118	195
Noon	275	269	304	283	117	158
1pm	303	283	304	271	117	147
Brooks						
8am	235	216	208	208	68	50
9am	223	214	200	198	82	60
10am	231	218	209	191	64	54
11am	222	218	208	207	55	48
Noon	263	220	215	229	59	45
1pm	248	217	215	231	59	35

FIG. 3 STEVENS PASS TELEMETRY

	Direction in degrees							
	12/14/2003	12/16/2003	1/7/2004	1/25/2004	130/2004	3/7/2003	3/29/2004	4/2/2004
Location	9-11am	9-11am	11am-3p	9-11am	9-12pm	9-12pm	10-1pm	9-12pm
Tye Mill								
8am	294	119	106	292	275	258	109	131
9am	261	117	109	296	278	266	110	123
10am	250	113	110	290	268	254	108	141
11am	248	119	114	285	239	273	114	167
Noon	246	117	118	285	247	269	125	155
1pm	241	115	121	279	258	nc	121	nc
Brooks								
8am	219	72	63	219	224	214	55	52
9am	220	64	68	214	231	225	52	53
10am	229	61	67	224	219	222	47	43
11am	227	59	73	231	225	214	48	24
Noon	228	62	72	237	229	215	31	19
1pm	225	60	67	230	225	nc	50	nc
Grace								
8am	231	140	1105	232	219	243	nc	94
9am	239	148	112	207	211	240	nc	65
10am	228	122	116	217	225	242	nc	62
11am	227	122	118	239	232	246	nc	56
Noon	236	121	115	237	241	246	nc	51
1pm	237	128	130	245	241	nc	nc	nc

FIG. 4 NORTHWEST AVALANCHE CENTER WIND FORECASTS

	Direction						
Elevation	1/20/2001	3/4/2001	3/10/2001	3/11/2001	3/13/2001	1/12/2002	3/28/2002
Pass							
a.m.	180	180	270	270	270	270	270
p.m.	180	180	270	270	270	270	270
5000'							
a.m.	135	135	315	315	270	225	315
p.m.	200	180	315	315	270	270	315
9000'							
a.m.	225	180	330	330	270	225	315
p.m.	225	225	330	330	270	270	315

FIG. 5 NORTHWEST AVALANCHE CENTER WIND FORECAST

	Direction					
Elevation	1/31/2003	2/1/2003	2/3/2003	2/9/2003	2/12/2003	2/15/2003
Pass						
a.m.	270	270	270	270	90	90
p.m.	270	270	270	270	90	90
5000'						
a.m.	225	225	315	360	90	180
p.m.	245	300	315	315	90	180
9000'						
a.m.	245	245	315	360	225	225
p.m.	245	315	315	315	150	225

FIG. 6	**Direction**							
Elevation	12/14/2003	12/16/2003	1/7/2004	1/25/2004	1/30/2004	3/7/2004	3/29/2004	4/2/2004
Pass								
a.m.	270	90	90	270	270	270	90	90
p.m.	270	270	90	270	270	270	270	90
5000'				24				
a.m.	245	205	205	225	245	245	245	90
p.m.	270	225	225	270	270	245	245	90
9000'								
a.m.	270	225	225	225	245	245	225	25
p.m.	270	225	225	270	270	270	225	90

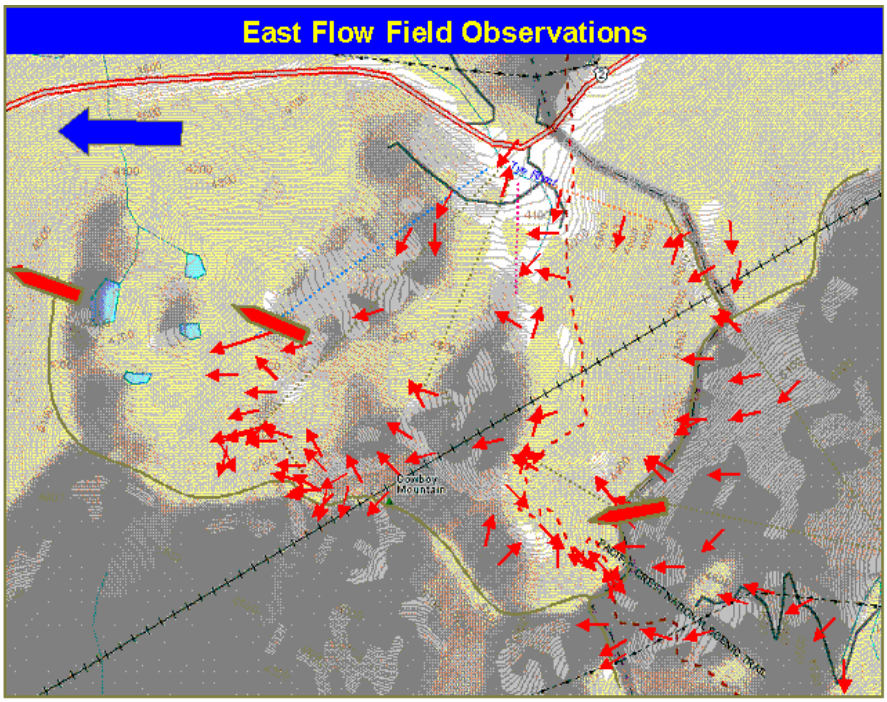
East Flow Field Observations
Cowboy Mountain

FIG. 7

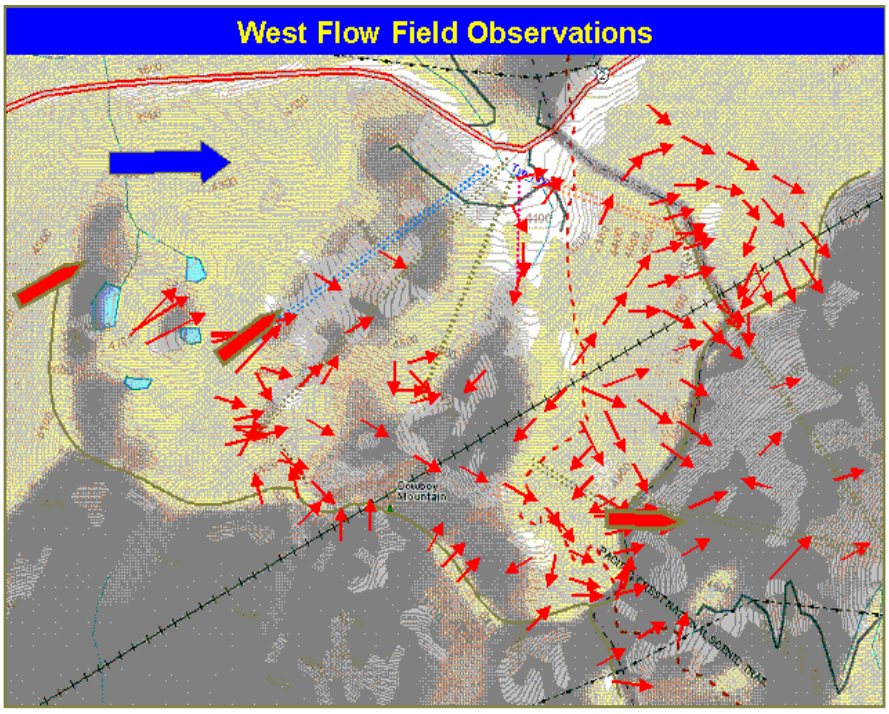
West Flow Field Observations
Cowboy Mountain

FIG. 8

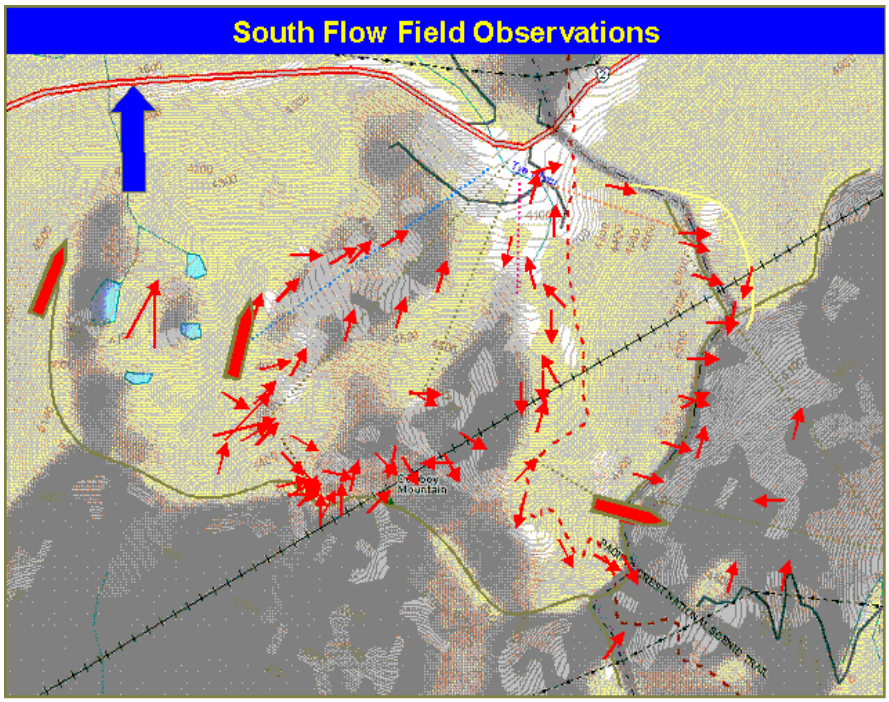

FIG. 9

FIG. 10 Forecasted Winds / Surface Winds

Forecast		Telemetry sites	
5,000'/Pass	Tye Mill	Brooks	Grace Lakes
West/East	SE	E/NE	E/SE
West/West	W	SW	SW
NW/West	SW to NW	W/NW	W/NW
SW/East	E/SE	NE	--
SW/West	NW to SW	S/SW	S/SW
East/East	SE	E	E