MOUNTAIN WEATHER FORECASTING IN BC FOR AVALANCHE SAFETY

Dr. Melinda Brugman,
Pacific Storm Prediction Centre, Pacific and Yukon Region,
Meteorological Survey of Canada, Environment. Canada, 401 Burrard St, Vancouver, BC. Mindy.Brugman@ec.gc.ca

ABSTRACT: A special weather bulletin is produced during the winter season at the Pacific Storm Prediction Centre (PSPC) in Vancouver to support avalanche forecasting efforts in British Columbia. This paper will present a history of this Canadian Avalanche Centre (CAC) bulletin and trace its usage. Verifications are examined. Major forecast busts and hits are examined for several situations related hazardous avalanche conditions in BC – most notably strong southwesterly flows and stalled frontal bands. Weather variables which are most important for improved avalanche safety are identified for each region and suggestions made for how probabilistic ensemble forecasting may improve weather forecasts. The value of direct communication with a trained forecaster is shown through the time-honored traditions of the technical synopses (short term and extended), confidence statements and daily phone briefings. Future improvements will depend on how well we can build upon existing expertise while better communicating new advancements to avalanche professionals and those whose safety depends on accurate mountain weather forecasts.

KEY WORDS: mountain, weather, forecasting, British Columbia, Environment Canada, verification, avalanche, probability, short term, long term, synopses.

INTRODUCTION

The CPCN63 bulletin is produced during the winter season at the Pacific Storm Prediction Centre (PSPC) in Vancouver to support avalanche forecasting efforts in British Columbia. This paper will present a history of this Canadian Avalanche Centre (CAC) bulletin and trace its usage. The layout of the bulletin will be presented and the rationale behind the forecast elements given. The forecast includes short and extended synopses, weather maps and information about surface and upper level winds, snowfall intensity, temperature variations, cloud cover, freezing levels and timing of major weather events. The coverage area of this bulletin is huge and diverse – from coastal to interior ranges over nearly a million square kilometers and delivery is at 5am. The value of direct communication with a trained forecaster is shown through the time-honored tradition of retaining the technical synopses (short term and extended), confidence statements and daily phone briefings. Preparation is normally done by single forecaster whose efforts must not contravene public forecasting responsibilities.

VERIFICATION METHODS

In this paper verification of this forecast bulletin is studied and results compared to verification statistics for public warnings and statements targeted for nearby valley and highways locations. Verifications are based on accident statistics, highway closures, meteorological data and mountain observations reported from a variety of

sources. In general the forecasts were reported to be very useful but detailed verifications are limited especially prior to 1998 Preliminary results suggest very low (i.e. poor) critical success index (CSI) values occurred during the very strong La Nina event year of 1998-1999. This was the year of record snow packs in many alpine sites with an all time official world record snowfall reached at Mount Baker (30 metres). Major forecast busts and hits are examined for several situations related hazardous avalanche conditions in BC – most notably strong southwesterly flows, stalled frontal bands, strong winds aloft, and conditions conducive to recrystalization of the snowpack and hoar crystal development (such as clear–cold-calm nights and the thickness of valley cloud (to help locate the typical interior valley 'bath-tub" ring).

DISCUSSION

A brief study of alpine snowpacks over the last century in southern BC is used to aid in verification analyses. Results indicate that BC valley snowfalls differ from alpine fluctuations. The alpine snow packs are reasonably well tracked by major climate variables climate variables (SOI or ENSO, AO, Volcanic Ash index, or solar variation). Suggested relationships between for these important climate indices and the success of mountain weather forecasts are examined. A time line of other factors is presented including:

1. Major changes may have occurred in data quality and quantity due to network reduction and changeover to new auto stations
2. Improved model physics including convective packages
3. Model resolution improvement,
4. Issuing office and area of responsibility.

Short term forecasts (6 to 48 hours) have greatly improved in recent years due to improved model resolution and data assimilation, reduction of the Pacific data void using satellite data, better physics and convective packages used, and more flexible ensemble analyses applied. Although there are still significant problems with boundary conditions (such as valley cloud) – and amount of precipitation (convective packages commonly overdo amounts) the models temperatures and general patterns are remarkably reliable in the short term but these UMOS statistics are fine tuned generally for valley locations verifications NOT alpine locations. To-date there is insufficient data to tune these regional models to alpine weather data.

The strikingly close correlation between the above mentioned climate indices and BC mountain snowfall suggests that we may be able to improve our long range predictions (weeks to months). A similar relationship is implied for ENSO and air temperature especially in areas not affected as much by cloud cover effects (Mo, CMOS, 2006). These correlations may provide us with a "first estimate" of weather patterns days to 9 months in advance. We may assign more reliable probabilities to long term forecasts targeted for mountain weather in BC. Using past data we may be able to improve verification statistics by raising awareness in advance about typical patterns that occur during abnormal weather such as a strong La Nina year – and hopefully improve CSI values for certain years.

Results indicate poor verification statistics from 3 days onward despite the considerable effort applied to improve deterministic forecasts. Probabilistic forecasting for short and long term weather will make it possible to bring more extensive weather and model information in front of avalanche professionals. A clear presentation will be critical though if this information is to be useful. Although verification statistics may improve – the utility to the avalanche professional may degrade with the extra information that ensemble probabilities may provide and the hazard to the public may increase. Also the most severe and critical events may be smoothed out by the ensemble statistics, and polluted with "normal" climatology statistics, even if Bayesian statistics are applied. Thus forecasts longer than about 12 to 36 hrs will be degraded even if ensemble forecasting is used. A trained and experienced weather forecaster is still better at detecting major events even though the models are getting quite good in recent years.

SUMMARY

In summary, the avalanche weather forecast produced by Environment Canada for Pacific and Yukon region is time honored and provides improved information on conditions affecting avalanche safety mainly over in British Columbia. Weather conditions of importance to mountain avalanche professionals differ depending upon proximity to the coast, latitude and time of year. Verification statistics and surveys examined to-date indicate that these forecasts are highly valuable to the avalanche professionals but also there is room for improvement. The simple confidence statement and daily phone briefings remain some of the most valuable communication tools for avalanche and weather forecasters. The value of accurate mountain forecasts is still increasing because the number of people using the back country regions has grown leaps and bounds, the development in avalanche prone is expanding and mountain properties and economies are becoming more valuable, our transportation routes are increasingly sensitive to economic pressures caused by road and rail closures. At the same time, on the forecast desk - the tools, models, data and means of communicating with the user is also changing at break-neck speed.

More complexity does not always mean a better forecast and the avalanche professionals have long valued the role of a trained forecaster when evaluating the weather. The format of the bulletin produced by Environment Canada has not changed very much in recent decades despite the tremendous changes in forecast methodology. This was done to retain consistency and make the product most relevant for long time users. Future improvements will depend on how well we can build upon existing expertise while better communicating new advancements to those who desire accurate and timely mountain weather forecasts for avalanche safety.

APPENDIX
An example of this forecast for last year is provided below:

Bulletin issued 2005/01/08 13:06:13
CPCN63 CWLW 081320

Morning Forecast for the Canadian Avalanche Centre
issued by Environment Canada at 05:20 PST Saturday 8 January 2005.

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500 hPa contours and Surface Features:

http://avalancheinfo.net/WX/

Technical synopsis:
General Pattern.. Arctic high pressure over north central BC continues to feed cold arctic air southward across the entire province this morning. Arctic front has been pushed westward out over the Pacific and into northern Washington state. Meanwhile a southerly circulation of moist air aloft around a 500mb low just off the Washington coast is overriding the arctic air over the southern third of the province. This scenario will continue to maintain cloud and periods of light snow over Southern BC this morning. Northern and central BC will remain clear and cold under the influence of the arctic high.

Snow over the south will slowly taper off this afternoon and tonight as the coastal low weakens and moves southwestward and the arctic high pushes southward into central BC. By Sunday afternoon only extreme southern BC will be left with cloud and perhaps some light flurries.

Interior Ranges.. 5 to 10 cm of snow are expected over the south Columbias and south Rockies today 5 cm tonight and a further trace to 2 cm over extreme southern areas on Sunday. Over southern portions of the North Columbias 2 to 5 cm of snow is forecast for today. No precipitation is expected over the northern portions of the north Columbias the Cariboos and the Northern Rocky Mountains through Sunday.

Northeasterly winds of 60 to 90 km/h over the Northern Rockies will persist today before easing to easterly about 50 km/h tonight and then weakening to light on Sunday.

Further south over the rest of the interior ranges winds in the alpine should not be much of an issue as they are expected to generally be less than 30 km/h. Lower down in north-south oriented valleys northerly winds will continue in the 30 to 50 km/h range before easing to light on Sunday.

N Coast.. No precipitation anticipated through Sunday. Northeasterly winds in the alpine of 60 to 90 km/h will continue today before easing to 50 km/h tonight and to light northerlies on Sunday.

S Coast.. A few flurries giving near 2 cm today will taper off tonight with a trace of additional precipitation. Northeasterly winds 40 to 60 km/h will persist through tonight and easing Sunday morning to 30 km/h.

Confidence: Good on overall pattern. Good to fair regarding precipitation amounts over southern BC.

Precipitation Intensity Forecast:

Light < 5 mm water equivalent/12 hours
Moderate 5 to 15 mm water equivalent/12 hours
Heavy 15 to 25 mm water equivalent/12 hours
Very Heavy > 25 mm water equivalent/12 hours

	Today 4am - 4pm	Tonight 4pm - 4am	Tomorrow 4am - midnight
North Coast:			
Terrace(YXT)	0	0	0
Smithers(YYD)	0	0	0
South Coast:			
Whistler(WAE)	2	0	0
Squamish(WSK)	2	0	0
Northern Rockies:			
Pine Pass(HPP)	0	0	0
Mackenzie(YZY)	0	0	0

Cariboo Mountains:

Valemount(FVA)	0	0	0

North Columbia:

Wells(HWE)	0	0	0
Cariboo Ridge(BCR)	1	0	0
Fred Laing(HFL)	2	0	0
Adamant Ridge(BAR)	3	0	0
Rogers Pass(BRP)	5	1	0

South Columbia:

Stagleap(HSP)	10	5	1

South Rockies:

Fernie(HFE)	10	5	2

Upper Air at 04:00 PST: (PR LVL: hPa; HGT: metres; TMP, DEW PT: Celcius; WND DIR: ten degrees; WND SPD: km/h)

PR LVL	HGT	TMP	DEW PT	WND DIR	WND SPD	PR LVL	HGT	TMP	DEW PT	WND DIR	WND SPD
Annette:						Edmonton:					
850	1344	-13	-26	NE	52	850	1385	-20	-22	NE	15
700	2799	-20	-40	NE	87	700	2804	-27	-29	E	22
500	5230	-31	-51	NE	143	500	5220	-32	-36	SW	39
Kelowna:						Prince George:					
850	1252	-12	-13	NE	22	850	1325	-17	-27	NE	67
700	2725	-17	-19	SW	17	700	2760	-22	-30	E	59
500	5190	-31	-34	S	28	500	5190	-34	-36	SW	35
Spokane:						Great Falls:					
850	1242	-5	-6	SW	52	850	1337	-16	-18	W	17
700	2743	-14	-15	SW	81	700	2803	-10	-13	SW	91
500	5210	-33	-36	SW	61	500	5320	-27	-32	SW	96
Quillayute:						Port Hardy:					
850	1193	-5	-5	S	44	850	1201	-11	-12	E	59
700	2694	-15	-16	S	54	700	2687	-16	-17	SE	22
500	5150	-35	-41	S	59	500	5150	-32	-35	S	13

Forecast winds (km/h) and temperatures valid at 12:00 :

	2000 m			3000 m			4000 m		
NW Interior	NE	37	-20	NE	61	-22	NE	94	-22
N Rockies	E	45	-23	E	43	-26	E	18	-30
Cariboos	E	11	-20	SE	17	-24	00	0	-28
N Columbias	00	0	-17	S	10	-21	SW	17	-27

S Columbias	00	0	-17	SW	12	-20	W	26 -27
S Rockies	00	0	-16	SW	24	-19	SW	32 -26
S Coast	SE	13	-12	S	23	-17	S	26 -25
N Coast	E	77	-19	NE	84	-22	NE	92 -26

Freezing Level:
__Interior Ranges>> Surface.

__N Coast>> Surface.

__S Coast>> Surface.

Extended forecast: A low pressure system is forecast to develop along the arctic front just west of the Alaska Panhandle early Monday. The low will move southeastward across the central interior Monday night and the southern interior Tuesday. This low has the potential to bring a widespread moderate snowfall along its track. The low will also bring a brief warming trend to southern ranges on Monday as some milder Pacific air is pulled inland to the south of the low. The warming trend will be short lived however as a strong northwest flow in the wake of the low will bring a fresh blast of arctic air across the province. By Wednesday skies are forecast to clear and temperatures will plummet as the arctic front is expected to once again be pushed offshore and south of the province.

end/GKP