5B.15 CLIMATOLOGY AND FORECASTING HAZARDOUS WEATHER IN CANADA'S ARCTIC

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1. INTRODUCTION

Meteorologists at the Meteorological Service of Canada's (MSC) Prairie Aviation and Arctic Weather Centre (PAAWC), Edmonton, are charged with issuing public weather warnings and forecasts for Canada's Northwest Territories (NWT) and Nunavut (NU). This paper provides an overview of the climatology of blizzards and strong winds for this area, the effect that hazardous weather has on the northerners, and preliminary work that has been done analyzing weather warning criteria.

2. HAZARDOUS WEATHER IN THE NORTH

The MSC has set targets for lead times for warnings of hazardous weather conditions, to be achieved by 2005: tornado (15 minutes), severe thunderstorm (60 minutes), blizzard (10 hours), freezing rain (10 hours), strong winds (18 hours), and heavy precipitation (24 hours). The two most common hazardous weather events in the north are blizzards and strong winds, and they occur primarily northeast of the tree line that roughly parallels the NWT/NU border.

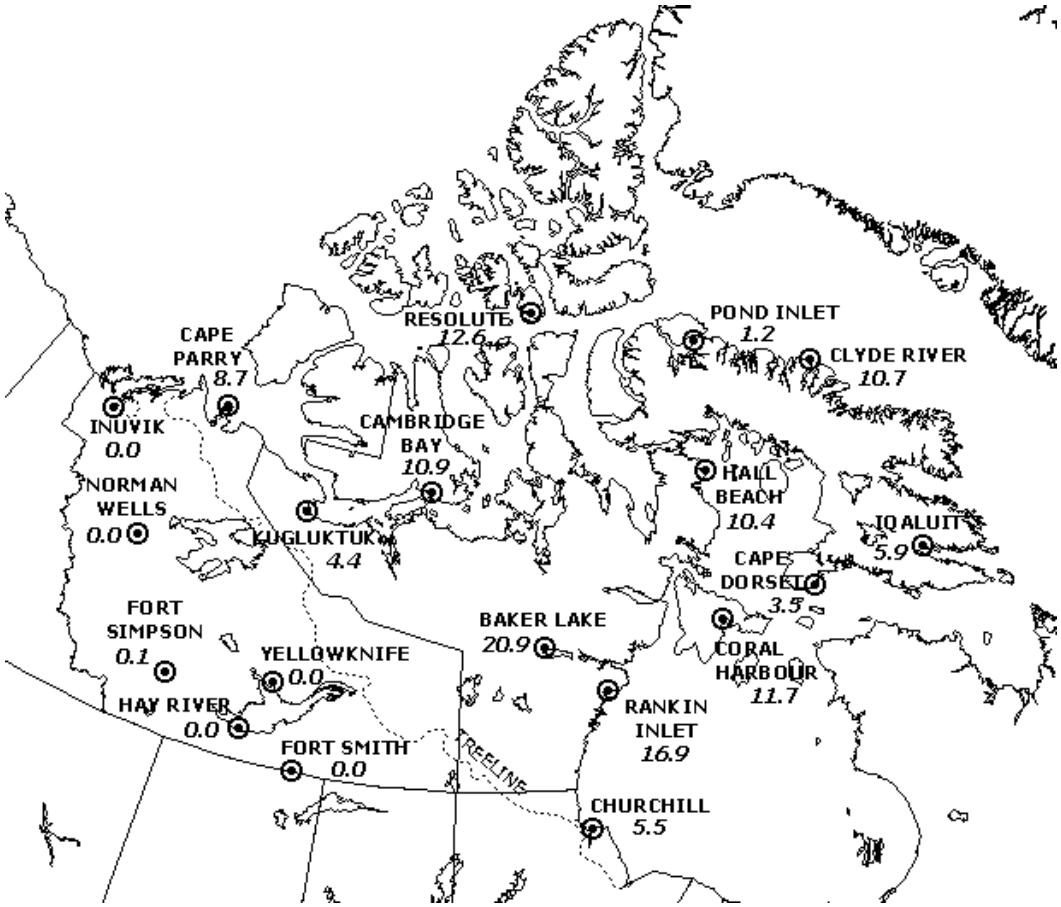

Figure 1. Average number of blizzard events per year for selected communities in the NWT and NU (1980 to 1999 except 1982 to 1999 Rankin Inlet and 1985 to 1999 Clyde River and Cape Dorset)

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a. Blizzards

The definition of a "blizzard" used by the PAAWC in Nunavut and the Northwest Territories is visibility of 1 km or less in blowing snow and/or snow, winds of 40 km h^{-1} or more and temperature below freezing; conditions lasting for at least 6 hours.

These conditions occur often (see Figure 1), especially northeast of the treeline over Nunavut. Along a corridor extending from the west-central Arctic islands through Cambridge Bay to Baker Lake and into Hudson Bay, blowing snow, blizzards and strong winds are a frequent occurrence from November through March. Baker Lake averages one blizzard per week. The terrain across Baffin Island and the eastern Arctic Islands is complex and the orientation of the wind regime plays a significant role in dictating whether or not strong winds—and blizzard conditions—will be realized.

Blizzard duration is very site specific. Blizzards can last as long as 4½ days at Baker Lake and as long as 3½ days at Iqaluit, Resolute, Cambridge Bay, and Hall Beach. Phillips, 1990, cites a 7-day-long event at Iqaluit beginning February 8, 1979. This event, with -40°C temperatures and winds to 110 km h^{-1} and snow, kept residents indoors for 10 days. On average, Baker Lake has over 200 hours of blizzard conditions per year, Iqaluit has just over 100 hours and Yellowknife has less than 5 hours.

Southwest of the treeline (i.e. most of the Northwest Territories), blizzards are rare. They can develop after the passage of a cold front, but rarely last long enough to meet the 6 hour criterion.

b. Winds

The threshold for issuing warnings for strong steady winds, with a few exceptions, is 60 km h^{-1} across all geographic regions.

3. FORECASTING HAZARDOUS WEATHER IN THE NORTH

Blizzards have a significant impact on northerners, who adjust their activities accordingly (Table 1). Thus it's important to provide notice of these events.

Blizzard events for a 5½ year period between 1995 and 2000 were looked at, and the results are shown in Figure 2. (Results are based on the current rules; i.e. using a 6-hour lead time rather than 10.) The office is catching about 50-60% of events with the desired lead time (this is the Probability of Detection, or POD), and many warnings are being issued at, or after, the start of the event. The false alarm ratio (FAR) has been between 0.50 and 0.60.

Table 1. Recent extreme weather events and how they affected people

Event	**Wind** maximum 65G78 km h^{-1}
Location	**Cambridge Bay**
Date	9 January 2001
Spoke with	Royal Canadian Mounted Police
Comments	Only damage was sewage outlets freezing - depends on which way they face and which way wind blows

Event	**Blizzard** Visibility about ¼ mile, briefly down to 1/8 mile. (*Fort Simpson does not get many blizzards and the "blue sky" blizzards that frequent Nunavut are almost non-existent.)*
Location	**Fort Simpson**
Date	10 January 2001
Spoke with	Royal Canadian Mounted Police
Comments	Relatively small impact. No accidents. Most people stayed home.

Event	**Blizzard** Visibility down to zero for at least 7 hours, maximum wind 76G98 km h^{-1}
Location	**Baker Lake**
Date	22-23 January 2001
Spoke with	Royal Canadian Mounted Police
Comments	Roads blocked off. No poles down. School closed all day. Definitely need warning for this type of event.

Event	**Blizzard** Visibility down to ½ mile or less for 14 hours and zero for at least 3 hours, maximum wind 100G122 km h^{-1}
Location	**Iqaluit**
Date	22-23 February 2001
Spoke with	Fire Department
Comments	Schools closed. Seen worse for roads but it took a while to open town. Property damage included siding and roofing blown off houses and most satellite dishes in town

Event	**Blizzard but wind "main event"** 120G140 km h^{-1} (broke record)
Location	**Eureka**
Date	23-24 February 2001
Email from	MSC personnel
Comments	Blew over flag poles, bent light poles, blew open doors and ripped metal siding of buildings, 8 foot drifts

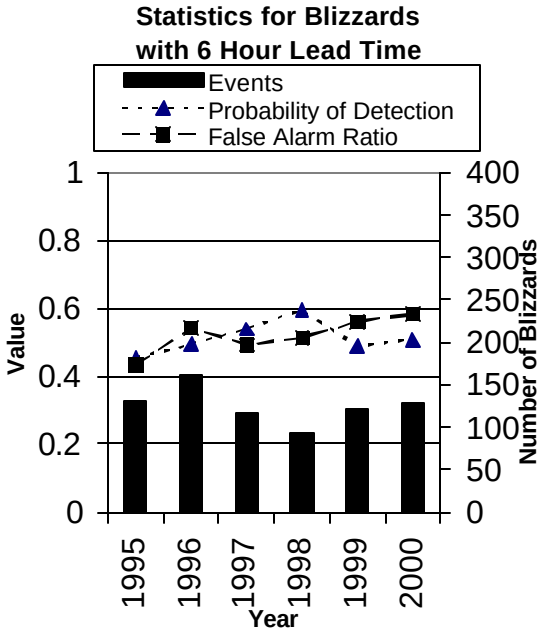

Figure 2. Verification of strong wind warnings over the period 1995-2000

A detailed look at Iqaluit and Yellowknife, the capitals of Nunavut and the Northwest Territories respectively, shows that at Yellowknife there were 6 freezing rain events (and no other events) in the 5½ years. Two events were missed completely and four events had negative lead times (i.e. warnings were issued after the event had started). At Iqaluit, there were 75 events: 42 blizzards, 21 wind, 5 weather, 5 freezing rain and 2 heavy snow. For Iqaluit, the POD was 0.35 and the FAR was 0.65

Clearly, there is room for improvement. The treeline, synoptic weather pattern, and topography all play a role in determining the likelihood of strong winds and blizzards. The initial challenge is determining the wind speed. The next challenge is predicting the effect that the wind will have on the snow, as the amount and state of the snow on the ground factor into the equation. Figure 3 shows how the visibility at Coral Harbour lowers as the wind speed increases. (The database includes all forms of restrictions to visibility, including blowing snow, snow and blowing snow, and/or ice fog).

A "rule of thumb" for the forecasters of the PAAWC is to *consider* forecasting blowing snow when the winds are 35 km h^{-1}, and to "go for it" when they are greater than 55 km h^{-1}. However, even winds of 55 km h^{-1} won't give blowing snow if the snow is packed very hard with no loose snow on top of it.

4. DETERMINING USEFUL WARNING CRITERIA

Communities that often get strong steady winds likely have adapted to these conditions (e.g. at Grise Fiord some houses have been "cabled" down) and therefore it would seem appropriate to use higher threshold levels for warning criteria. On the other hand, areas which do not experience strong winds very often may be less able to handle these conditions and might therefore require wind warnings to be issued at a lower threshold level.

It was thought that it would be useful to analyze the frequency of strong winds to determine appropriate criteria.

a. Evaluating different thresholds for wind speed and duration

The first step was to examine the frequency of strong winds by using different thresholds of wind speeds, using stations with at least 20 years of data. An "event" was defined as a day on which the maximum sustained wind speed exceeded the given threshold level.

The desire was to find a suitable threshold level for each area which would result in a "reasonable" occurrence of extreme events, where "reasonable" was defined as between one and five occurrences per

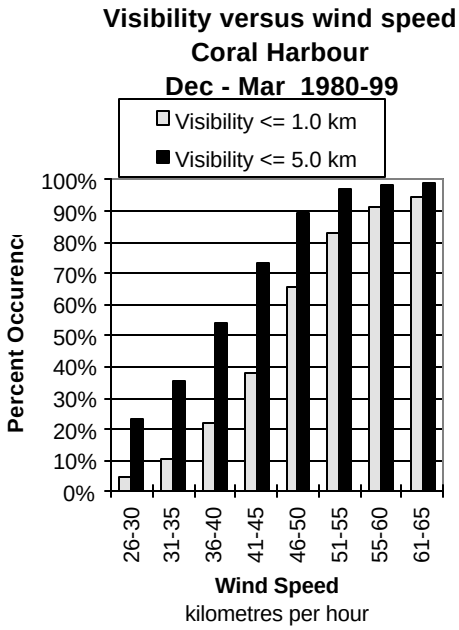

Figure 3. How the visibility at Coral Harbour, NU, varies as a function of wind speed

year, on average. That is, if the threshold is too high, warnings would never be issued; if too low, then the public would be inundated with warnings, reducing their effectiveness.

Table 2. Results of using different thresholds for wind speed

Recommended Threshold	**Yellowknife** *Northwest Territories* ***60 km h^{-1}***	**Baker Lake** *Nunavut* ***70 km h^{-1}***	**Resolute** *Nunavut* ***80 km h^{-1}***
Summer Events (per year)	0.0	0.5	0.2
Winter Events (per year)	0.1	3.55	1.4

The results of the analysis are shown in Table 2, which suggests that using thresholds ranging between 60 and 80 km h^{-1} would be appropriate.

The study also examined the duration of wind events at various communities; i.e. for various values of the wind speed threshold, examine how long the strong winds persisted.

Again, an area which is unaccustomed to high winds may require a warning of winds exceeding 60 km h^{-1} even if they only last for an hour. On the other hand, an area which is accustomed to strong steady winds may require a warning of winds exceeding 60 km h^{-1} only if these conditions are expected to last for a longer period of time.

For this portion of the study, an "event" was defined as a period of high winds (at least 60 km h^{-1}) with breaks of no more than 1 hour long. "Duration" was defined as the total number of hours from the event's beginning to end, including breaks.

Earlier, it was mentioned that communities in the Northwest Territories were unaccustomed to strong steady winds; e.g. Fort Smith, Hay River, Yellowknife, Fort Simpson. Norman Wells, and Inuvik. For these areas, warnings should probably be issued for steady winds exceeding 60 km h^{-1} for any amount of time.

Elsewhere, there is no one single duration value which would result in all regions having a "reasonable" number of weather warnings each year. Rather, it would make sense to group the communities using different duration levels. Figure 4 shows what is being considered.

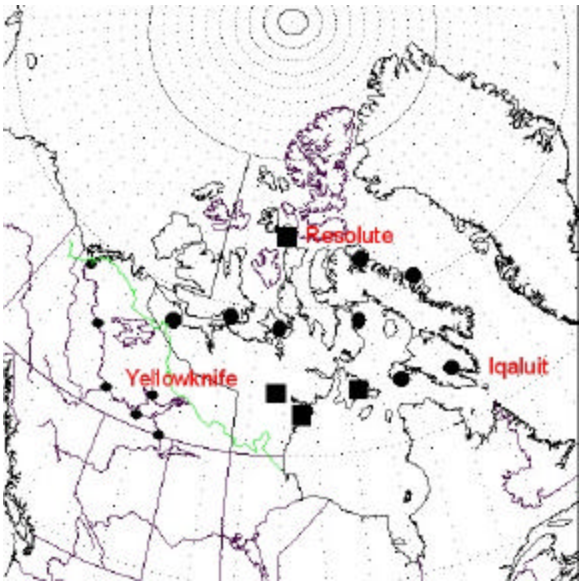

Figure 4. Suggested values for duration for wind warning criteria

- no duration limit
- duration 3-5 hours
- duration 6 or more hours

5. FUTURE PLANS

To forecast blizzards with more accuracy, more accurate wind guidance and a better understanding of how a given pressure pattern relates to the winds at a site is needed.

For winds, it may be wise to use warning criteria that would depend on the climatology of each region or community. Combinations of wind speed and wind event duration could also be combined. To develop this idea further, it will probably be necessary to examine more stations.

6. ACKNOWLEDGMENTS

This paper is a composite of work done by Sharyn Straathof, Don McGillivray, and other staff of the PAAWC.

7. REFERENCES

Phillips, D. 1990: Climates of Canada. Environment Canada, 176 pp.

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