# Some Observations of Alaskan Glacier Winds in Midsummer

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ABSTRACT. Characteristics of glacier winds observed at midsummer on the Worthington and Castner glaciers are described. In each case there is a diurnal double maximum in windspeed, one slightly before sunrise and the other in the mid-afternoon. When a daytime glacier wind is absent at Castner a very regular night downslope circulation is often observed.

RÉSUMÉ. *Quelques observations sur les vents de glacier de l'Alaska au milieu de l'été.* Les auteurs décrivent les caractères des vents de glacier observés au milieu de l'été pour les glaciers Worthington et Castner. Chacun présente un double maximum quotidien de vélocité, soit juste avant l'aurore et vers le milieu de l'après-midi. Lorsqu'il n'y a pas de vent de glacier diurne à Castner, on observe souvent une circulation nocturne très régulière et descendante.

РЕЗЮМЕ. *Некоторые данные наблюдений за ветрами на ледниках Аляски в середине лета.* Дается характеристика ветров на ледниках Уорфингтон и Кастнер в середине лета. В обоих случаях наблюдалось два суточных максимума скорости ветра, один незадолго до восхода солнца, другой в середине дня. При отсутствии дневного ветра на леднике Кастнер, часто наблюдалась весьма регулярная ночная циркуляция воздуха вниз по склону.

## INTRODUCTION

The mountainous and glacier-covered terrain which extends over a large part of Alaska often creates different types of local winds. The channelling of strong winds through mountain passes and river valleys, and the development of Föhn-type situations, have been described by Mitchell (1965) and Ehrlich (1953) for the region of Big Delta. In that locality the topography of the upper Tanana valley and the passes of the Alaska Range produce notably strong wind effects. The extensive loess deposits, ventifacts, and fossil dunes in that part of the Tanana valley (Péwé 1956) suggest that winds of similar strength and direction prevailed throughout the Pleistocene epoch when the glaciation of the Alaska Range was often more extensive than at present, though the greater part of the valley and the Yukon-Tanana upland to the north was not ice covered. The transport of fine dust material by the frequently observed strong winds which blow across the flood plain of the Delta River near its confluence with the Tanana is readily observed today in the dry summer months. Such winds, while essentially controlled by the general pressure gradient, were probably influenced in velocity, direction, and geographical extent during times of greater glaciation by the super-

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imposed glacier winds and the intensified katabatic flow in glacial valleys. Such influences may now be observed in their most pronounced form on the coast of Greenland and Antarctica.

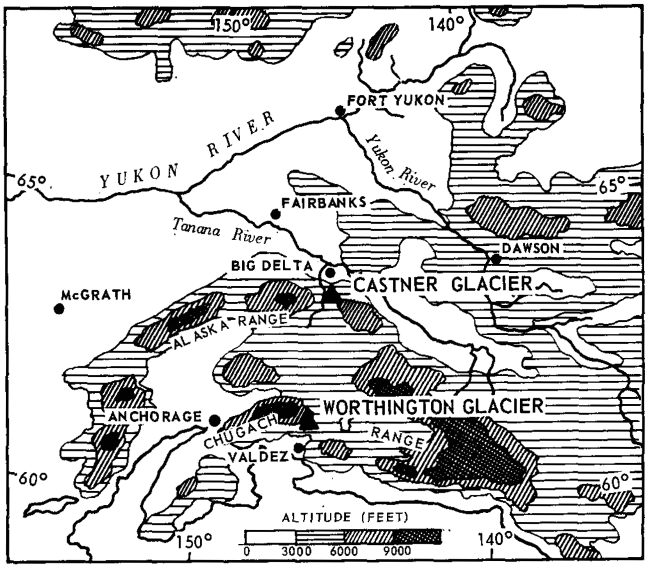


FIG. 1. Locality map: South Central Alaska.

During midsummer of 1967, wind observations were made on two glaciers in Alaska (Fig. 1) to examine the frequency and diurnal variation of glacier winds and the differences due to location and exposure.

## THE WORTHINGTON GLACIER

This glacier is located in the Chugach Range some 25 miles (40 km.) from Valdez in south-central Alaska. The glacier flows from a height of some 6,000 feet (1,830 m.) almost directly eastward; the tongue is at an elevation of some 2,700 feet (820 m.). The ice is surrounded entirely by exposed rock or outwash deposits and is some 8 km.$^2$ in area.

A Woefle-type anemometer, which records wind speed and direction on a mechanically wound paper trace, was used for the observations which were made between 16 July and 11 August 1967. The instrument was located on a mass of glacial debris within a few metres of the glacier tongue. At this site the terrain is exposed to maritime influences and the wind direction was quite variable. However, for some 15 days throughout the period the wind blew continuously from the glacier. Ten consecutive days (2 to 11 August) have been used for the examination of the daily course of windspeed (Fig. 2). This period was one of very light pressure gradients and the observed diurnal variation which is prominent on each day can therefore be attributed to the local circulation set up by the contrast between the temperature of the ice surface and that of the free air at the same altitude.

In Fig. 2 the mean daily course of the windspeed for the 10-day period is shown, the diurnal pattern on each day being very similar. Two marked maxima are evident, the major one in the mid-afternoon and the minor one just before sunrise. The winds are lightest just before noon and in the early evening. This daily variation is substantially similar to the diurnal variations found by Hoinkes (1954) at a number of sites in the Alps. The maxima appear at times when the gradient of temperature between ice and free air might be expected to be at a maximum, but unfortunately no measurements of temperature gradient are available for these series of unattended anemometer observations.

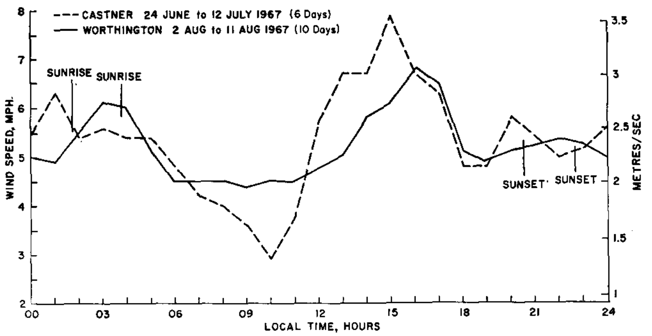


FIG. 2. Mean daily course of windspeed on the Worthington and Castner glaciers (Alaska) on days of glacier wind when the direction of the wind down the glacier is unchanged throughout the 24 hours.

## THE CASTNER GLACIER

The Castner Glacier (Nielsen and Post, 1953) is a much larger glacier (approx. 83 km.[2]) situated in the Alaska Range. It flows to the west-southwest from an altitude of over 7,000 feet (2,130 m.) with its valley joining that of the Delta River, which is here oriented roughly northwest to south, at 2,500 feet (770 m.). In its lower reaches the glacier occupies a narrow valley approximately 1 mile (1.6 km.) wide and 7 miles (11 km.) long, with the bordering mountains rapidly rising from 5,000 to 6,000 feet (1,520 to 1,830 m.).

The anemometer was located on the bank of the stream which flows from beneath the glacier tongue and some 100 m. from the ice which is very dirty here, covered with much glacial debris, and greatly eroded. The valley location at this point allows surface winds only from up and down the Delta River valley or up and down the Castner valley. The Delta valley in this region, however, is almost flat and is enclosed by mountains rising rapidly to over 5,500 feet (1,680 m.) on either side of its 1 mile (1.6 km.) width.

The observation period extended over 22 days from 21 June to 12 July, a period with almost continuous daylight. For 6 days the winds from the glacier (ENE) persisted and were recorded throughout the 24-hour period; the mean diurnal variation is plotted in Fig. 2. It will be noted that the peaks of the two maxima occur earlier than in the Worthington observations, but bear the same general relation to the times of sunrise and sunset. The sharper maximum and minimum for the Castner Glacier are probably related directly to the nature of its narrow enclosed valley in contrast to the more open site at the Worthington Glacier. The small rises in wind speed in the late evening at both locations were not observed in Hoinkes' data and do not seem to have any obvious physical interpretation. The observation series was short and it is possible that this late evening increase may be the result of chance fluctuations.

During the remainder of the period at Castner the wind that was channelled through the Delta River valley predominated, and the daytime wind was from the south or northwest. However, on 13 of the 22 days of observation there was a marked onset of the evening downslope flow shown either in the sudden increase in windspeed on 3 days of continuous glacier wind, or in a rapid change in direction to ENE on the other 10 days. The flow was so regular that a median time of onset of 2215 h. could be calculated with 10 of the onsets being distributed within a period of ±30 minutes from this time. This time is within 15 minutes of sunset for this latitude at sea level, so that in undisturbed conditions the downslope evening flow appears to coincide very closely with this time of reduction in incoming radiation. Similarly a median time of cessation occurred for these days at 0330 h. or 2 to 2½ hours after sunrise, 9 of the cessations being distributed within ±30 minutes of that time. The Castner valley faces to the west-southwest; this is probably the reason for the suddenness and regularity of the onset of the downslope wind near sunset, and for its continuing till well after sunrise when the sun has reached a sufficient elevation to warm the upper slopes and thus inhibit the circulation.

The evening downslope wind averaged 5.3 m.p.h. (2.3 m/s.) for the period and maintained a fairly steady speed. On the average, the temperature fell quite suddenly by about 3.3 deg. F. (1.8 deg. C.) on onset, and with overnight cooling a further drop of 3 deg. F. (1.7 deg. C.) took place by the time the wind had ceased.

On 7 July a very clear onset took place with NW winds of 7.5 m.p.h. (3.3 m/s.) being suddenly replaced by the ENE downslope wind of 5 m.p.h. (2.2 m/s.) on onset at 2330 h. and being maintained to 0330 h. when the NW wind again resumed at its original speed. At the same time, further up the Delta valley at Black Rapids some 8 miles (13 km.) distant, NW winds continued throughout the period.

It is interesting that no upslope wind was observed at either site; this was probably because the observation points were so close to the ice where the glacier wind circulation is apparently dominant at this time of year in the absence of strong synoptic gradients.

## CONCLUSION

Downflow winds appear to be a fairly regular feature on Alaskan glaciers in midsummer. A characteristic diurnal variation closely related to the times of sunrise and sunset is observed in periods of weak gradient wind. However, the orientation and topography of the glacier valley and its surroundings are important in determining diurnal variations in the winds at particular locations.

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