NOAA Technical Memorandum ERL PMEL-51

SURFACE WINDS IN SOME ALASKAN PASSES

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March 1984

UNITED STATES
DEPARTMENT OF COMMERCE

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NOTICE

FOREWORD

Anyone who has tried to obtain meteorological information from some of Alaska's more remote zones knows how sparse the data coverage can be! This report is unique in that it contains information from the rugged Alaska Peninsula that was collected in the year that Alaska received her Statehood - 1959 - but is still relevant today. Meteorologists seeking general information about flow through mountain ranges will benefit as much from the material presented here as those seeking site-specific references.

This previously unpublished manuscript was written in the mid-60's by G. Philip Weber and presents a study of pass winds in the Alaska Peninsula during 1959. Mr. Weber was assigned to the Weather Bureau Airport Station in Anchorage from 1952 to 1971, first as aviation forecaster, then research forecaster, and finally as meteorologist-in-charge. The material was used as a forecast guide by the Alaska Region of the National Weather Service in Anchorage to aid in predicting pass conditions throughout the south part of Alaska. I came upon Mr. Weber's work when visiting the Anchorage Forecast Office in 1977 during a meteorological fact-finding trip throughout the region.

On several occasions I have found the need to cite Mr. Weber's work, but was unable to do so because of its unpublished status. Recently I received information from other scientists that they, too, would cite this paper. As the material is in keeping with the Pacific Marine Environmental Laboratory's Marine Services Project mission to conduct research in marine weather and ocean forecasting and to transfer the information to operational units in the National Weather Service and to other interested users, and as Mr. Weber has graciously granted permission to publish his manuscript, this work is finally and justly appearing in print.

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ABSTRACT

Estimated geostrophic winds from surface isobar spacing and orientation are compared with the winds actually encountered at Bear Creek, Alaska during the months January to March, 1959. The isobaric orientation (or direction) at which the flow through the pass reverses direction is noted.

One interesting result was that the wind through the pass reversed direction before the surface isobaric analysis indicated the pressure was higher on the upwind end of the pass. This apparently resulted from a piling up of air on the upwind side of the mountain range resulting in higher pressures than would be estimated from the surface chart and from a dearth of air (and lower than expected surface pressure) on the downwind side of the range. The same effect was later noted at Seward, Alaska. Wind speeds through Bear Creek Pass averaged near or slightly above the geostrophic indication, but maximum daily speeds were always higher than the geostrophic. Extreme daily maximum wind gusts exceeded the geostrophic estimation by 50 knots in a few cases.

Examination of winds at stations near the mouths of other coastal mountain passes gave speeds roughly one-half of the geostrophic indication, suggesting (in view of the smaller pass area above the mouth) that the speeds in the passes are roughly comparable to those found at Bear Creek.

INTRODUCTION

Because of the strong winds and poor weather encountered in a mountain pass, such a locale is not often used as a site for a weather observing station. From a meteorological point of view, it was particularly fortuitous when Humble Oil Company decided to investigate a promising oil structure in the Bear Creek area of the Alaska Peninsula (see Figure 1). In addition to maximum and minimum thermometers, the oil well drilling site was equipped with a company-owned wind recorder which provided continuous records of wind direction and speed. The recorder sheets were not available for this study, but daily observations of wind direction and speed telephoned to the Anchorage Weather Bureau Airport Station each morning at approximately 0800 Alaska Standard Time were available; in addition to the current wind, the observer also read from the recorder the maximum wind speed and direction during the preceding 24 hours.

The floor of the northwest-to-southeast pass is at an elevation of 200 to 400 feet above mean sea level for most of its 10-mile length, which extends from Lake Becharof on the northwest to Jute Bay on the southeast side of the Peninsula (see Figure 2). The observing site was less than ½ mile north of the center line of the pass and at an elevation of about 900 feet (approximately 500 feet higher than the floor level). The width of the pass between the 1,000-foot contours is slightly less than 1½ miles at the site location, which is 135 miles due west of Kodiak Naval Base. Some of the most severe winter storms in the Northern Hemisphere occur in the eastern Aleutians and the Gulf of Alaska, so very strong wind flow both from the southeast and from the northwest occurs through Bear Creek Pass each winter. The strongest wind reported to the Anchorage Weather

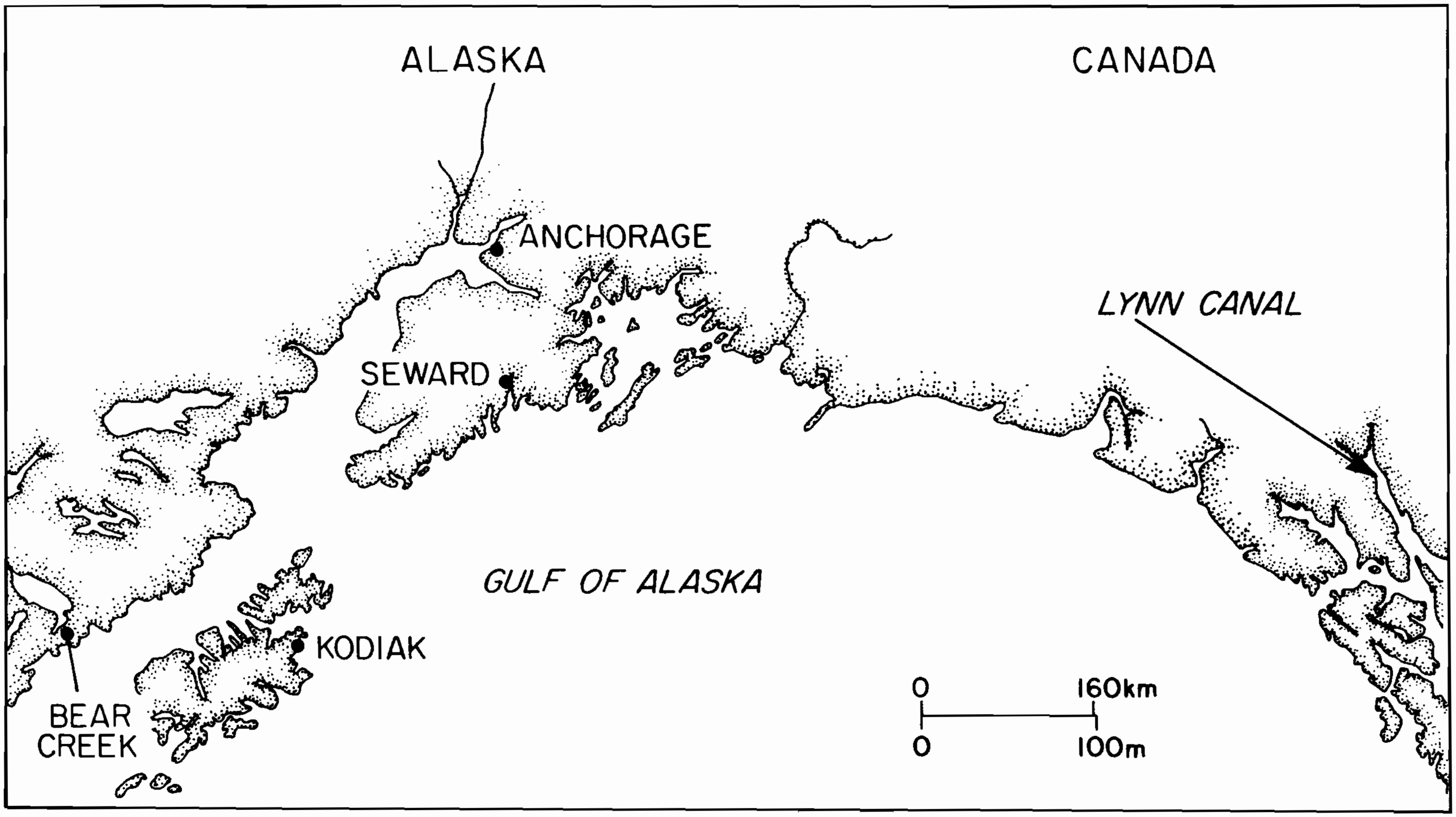

Figure 1. Location of observation sites.

Bureau was 156 miles per hour (135 knots) from the east in November, 1958; the strongest west-northwest wind of 120 miles per hour (104 knots) occurred in late September 1958. Table I shows the frequency of occurrence of maximum daily wind speeds for selected speed ranges and for the months October through March.

It is interesting that approximately 40% of the maximum daily gusts exceed 60 knots from both directions and though the strongest reported wind of 135 knots was from the east, only 13% of the east-southeast winds exceeded 80 knots while 20% of the west-northwest winds exceeded that value. A larger sample might even this out a bit, but it seems reasonable that the greater frequency of intense lows in the Gulf of Alaska as compared to the eastern Bering Sea, and portrayed in U.S. Weather Bureau Research Paper No. 40 (1957), is responsible for the greater frequency of strong west-northwest winds.

Table I

Frequency of Maximum Daily Wind Speeds during Winter at Bear Creek, Alaska

	East-southeast Winds (105 cases)	West-northwest Winds (95 cases)
less than 40 knots	29%	27%
40 - 60 knots	32%	34%
61 - 80 knots	26%	19%
81 - 100 knots	12%	16%
more than 100 knots	1%	4%

NOTE: Contours in hundreds of feet
(100 feet = 30.5m)

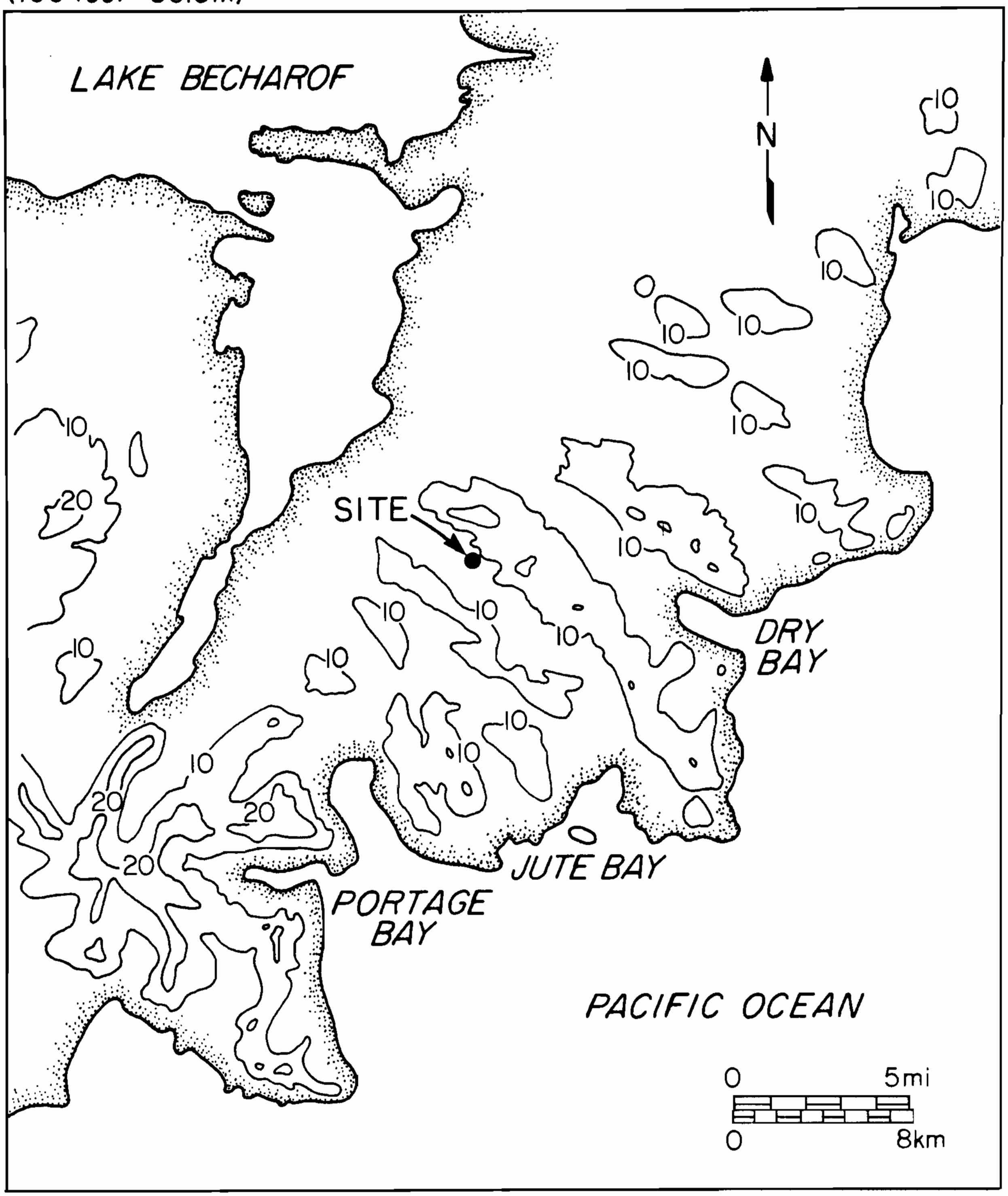

Figure 2. Topography of the Bear Creek, Alaska area.

Since the wind flow through Bear Creek Pass is believed to be roughly representative of the flow through many of our coastal passes, it seemed wise to utilize some of the wind data and relate it to the surface isobar orientation and spacing so the practicing meteorologist can have the benefit of this knowledge in preparing wind forecasts through and opposite mountain passes.

PROCEDURE

In relating the actual wind flow through the pass to the isobaric orientation and spacing, data for the three months January through March, 1959 were studied in detail; in addition, selected strong wind cases which occurred in January and February, 1958 were included to increase the number of cases considered. Since surface charts were not available for 1958, it was necessary to plot and analyze these additional charts. To be consistent with the work charts used for 1959, surface isobars were drawn as if the Aleutian Mountain Range did not exist; no provision was made for the higher surface pressures which would prevail on the windward side and the lower pressures which would be expected to prevail on the leeward side of the range. A total of 67 surface charts were used in preparing Figure 3.

Figure 3 shows the average wind speed for each direction as a percentage of geostrophic speed (based on the spacing of surface isobars without correction for curvature); wind directions were computed to the nearest 10 degrees and because of the small number of cases with some directions, the values for each direction are actually a smoothed value based on three adjacent 10-degree wind directions. Even then, some of the values are based on as few as two or three cases; nevertheless, the logic

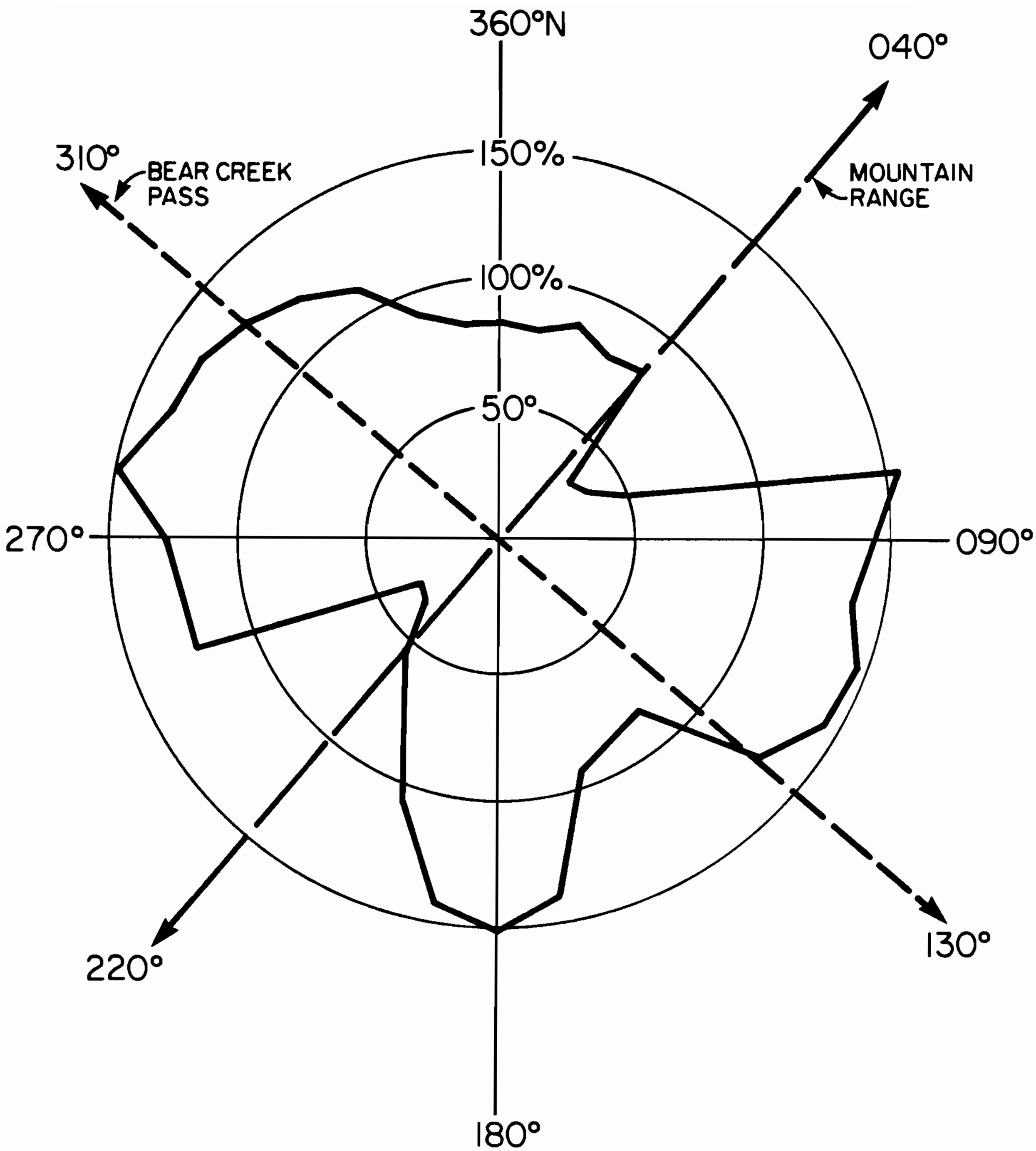

Figure 3. Actual wind speed as a percentage of the geostrophic wind speed for each geostrophic wind direction.

of the pattern lends support to the belief that the values obtained are of a reasonably correct order to fulfill the purpose of the study. As would be expected, there are two distinct lobes on the diagram - one associated with isobaric orientations which give a northwesterly flow, and the other with surface isobaric orientations which produce a southeasterly air flow through the pass. The wind direction reverses and the speed is very light when surface isobars indicate a gradient wind direction of 050-060° or 230-240°; an isobar with an orientation of 055° to 235° is almost parallel to the Aleutian Mountain Range in the Bear Creek area which is roughly on a line from 040° to 220° true direction. The 10-20° clockwise deviation from the parallel with the Range is believed to result from frictional effects; in fact, a study of the flow through other passes suggests that this deviation is probably nearer to 20-30° than the 10-20° obtained at Bear Creek. The diagram shows clearly that as soon as the isobaric orientation reaches an angle of about 40° with the parellel to the mountain range, the wind component across the Range becomes sufficient to establish a substantial flow through the pass. Figure 3 is based on the actual flow at 0800 AST and average speeds equivalent to 125 to 150% of the geostrophic wind speed are evident from several directions. The decrease in wind with directions 140° to 160° is interesting and probably results from local terrain effects in this particular pass. Figure 3 includes all cases without regard to the geostrophic wind speed, considering only the direction of the surface isobaric orientation across the area.

In Figure 4, the geostrophic wind speed has been related to the ratio of the actual surface wind speed to the geostrophic wind speed; curve A is for the observed 0800 AST wind speed and curve B is for the maximum daily

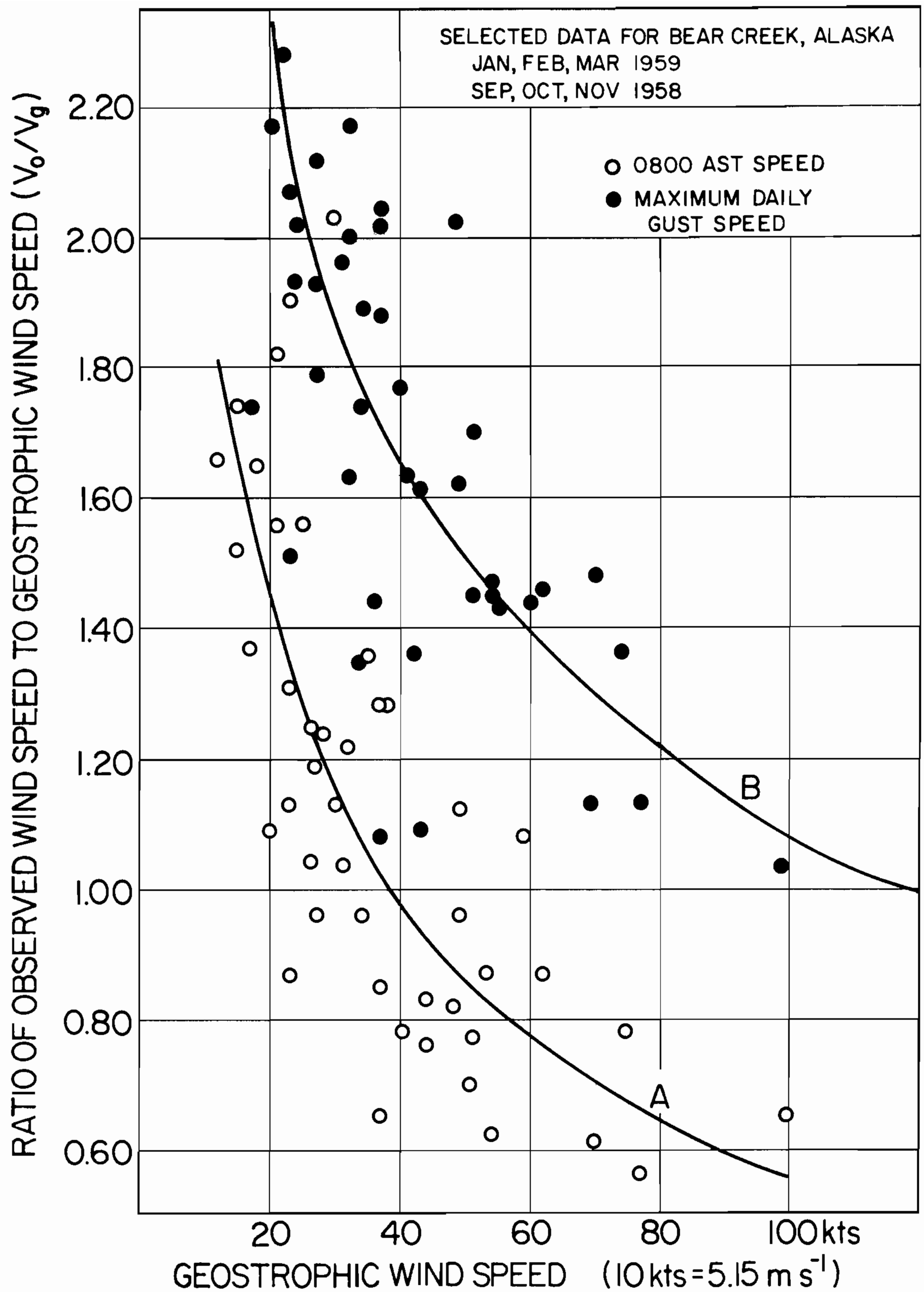

Figure 4. Relation between the observed wind speed and the geostrophic wind speed.

wind gust observed during the 24-hour period preceding the surface chart; individual cases are shown to furnish an idea of the variance experienced. The average speed of the 0800 AST winds used for curve A was 43 knots and the average error on the dependent data was 7 knots. The average speed of the observed daily maximum wind gusts used for curve B was 74 knots and the average error of the dependent data was 9 knots. These average errors of 12-15% are within the limits required in forecasting. In addition to the selected data for January through March, 1959, some additional cases from late September, October, and November, 1958 were utilized to construct the curves of Figure 4.

The results from Figure 4 have been combined on Figure 5 which can be used, along with Figure 3, in estimating wind speeds through Bear Creek Pass. Observations are no longer available from Bear Creek Pass. In forecasting, the first step is to line up the mountain range on Figure 3 parallel to the actual range; if the direction of flow (indicated by surface isobars) across the range lies within one of the two large lobes on Figure 3, the forecaster can use Figure 5 to estimate the wind speed through the pass; should the direction of flow across the range lie within one of the two minimums shown on Figure 3, the flow will be considerably less than shown by Figure 5 and the forecaster should be guided accordingly. Three curves have been entered on Figure 5. Curves A and B are taken from Figure 4. Curve A refers to the 0800 AST observed wind speed while curve B refers to the maximum observed wind gust during a 24-hour period.

The final curve on Figure 5 (curve C) shows the relationship found by Taylor (1915) over relatively smooth ground and reproduced by Petterssen (1956). Petterssen felt that the ratio of the observed wind to the geostrophic wind probably approximated 0.5 for wind speeds stronger than

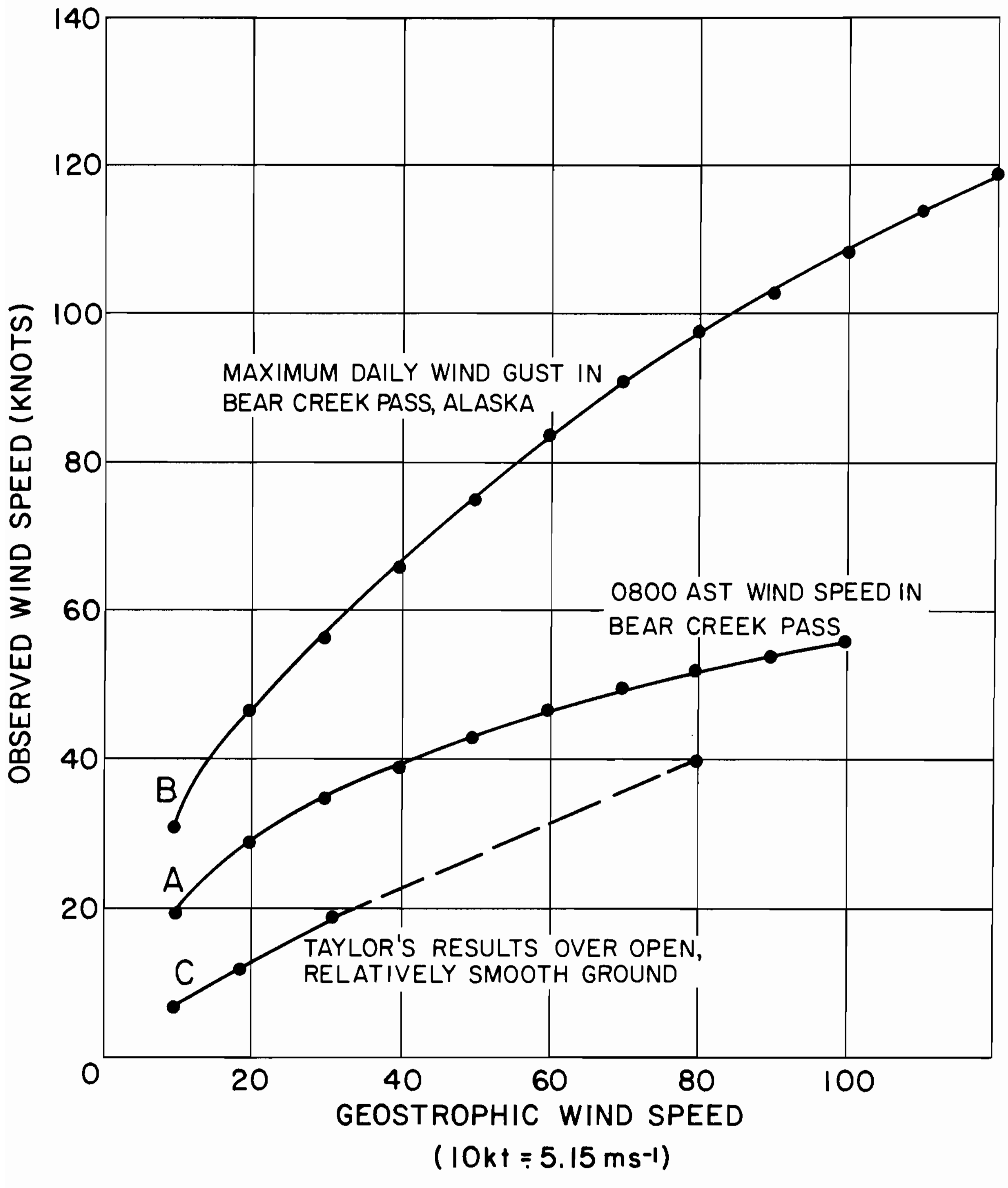

Figure 5. Relation between the observed wind speed and the geostrophic wind speed in a mountain pass.

those studied by Taylor; this value has been assigned to a geostrophic wind speed of 80 knots on curve C and Taylor's results have been extrapolated by the dashed line to this postulated value for comparison with the curves found for Bear Creek. As would be expected, the wind speeds through Bear Creek Pass are considerably stronger than those measured by Taylor over open, relatively smooth ground. The maximum daily gust is about three times as strong as Taylor's results for geostrophic wind speeds less than 50 knots and roughly two-and-a-half times as strong for geostrophic speeds of 80 knots. For very strong speeds, such as a geostrophic speed of 120 knots, the strongest daily gust is about twice the speed expected over open, relatively smooth ground.

SEWARD, ALASKA AIRPORT WIND

The airport at Seward is located near the middle of a valley approximately four miles wide. During north wind conditions, air feeds into this valley from the north (through Moose Pass and the Kenai Lake Pass) and from the northwest (through Resurrection River Pass). Contour maps suggest that the area of the passes as they approach Seward is about 2/3 that of the airport valley. Applying the results from Bear Creek for the 0800 AST wind speed and using 2/3 of this value, one would expect a geostrophic wind of 20 knots to result in a wind at Seward Airport of 19 knots, a geostrophic wind of 40 knots to result in a wind of 26 knots, a geostrophic wind of 60 knots in a wind of 34 knots, and a geostrophic wind of 80 knots in a wind of 35 knots. The actual results were 14 knots, 20 knots, 26 knots and 33 knots respectively; for the weaker gradients, the actual winds were only about 70-80% of those expected, but the actual value for the 80 knot geostrophic wind was very close. The data used for Seward Airport included 40 cases from year 1953 and 7 cases from 1954.

Of these 47 cases, 30 had north to northeast geostrophic winds and 7 had south-southwest to east-southeast geostrophic winds; the former were always associated with northerly flow and the latter with southerly flow. To measure the effect of the surface pressure increase on the windward side of the range and decrease on the leeward side, analysis of the 37 surface charts was accomplished without reference to the Seward surface pressure, then the deviation of the actual pressure from that derived from the analyzed charts was determined. The results are summarized in Table II.

Table II

Deviation of Actual Surface Pressure at Seward, Alaska from Pressures Estimated from Surface Charts

(37 cases from 1953, 1954 data)

Pressure Deviation	Windward Cases	Leeward Cases
+2.1 to 3.0 mb.	1	
+1.1 to 2.0	2	
0.0 to 1.0	4	1
0.0 to -1.0		11
-1.1 to -2.0		10
-2.1 to -3.0		6
-3.1 to -4.0		1
-4.1 to -5.0		1
Average Error	+1.0 mb.	-1.4 mb.

LYNN CANAL

This inlet, located in extreme northern Southeast Alaska, is about 8 miles in width and is rimmed on each side by mountains rising rather abruptly from the water's edge to elevations of 5,000 to 7,000 feet; during winter, air from the Yukon Territory and extreme northwestern British Columbia streams southward through mountain passes of the Coastal Range down Lynn Canal toward normally lower pressures in the Gulf of Alaska. Again, using topographic maps of the U. S. Geological Survey, the area of Lynn Canal is approximately twice that of the passes to the north which feed air into the Canal. On the average, the wind speeds at a well-exposed observing site (Eldred Rock) are fairly close to 60% of the geostrophic wind speed. There is some indication that Lynn Canal begins to act like a mountain pass under strong gradient conditions - that is, the wind speeds attained are fairly close to those indicated by the curve for 0800 AST wind speed shown in Figure 4 for Bear Creek; however, the sample is too small to draw a definite conclusion. Furthermore, some of the strongest surface gradients are with isobar orientations fairly close to parallel with the mountain range; this no doubt results in decreasing the wind flow through the Canal. Strong geostrophic wind speeds from the east-northeast (normal to the Coastal Range) tend to give considerably stronger northerly winds through Lynn Canal than the more usual orientation of isobars nearly parallel with the Range.

SUMMARY

The surface wind flow through a mountain pass has been related to the geostrophic wind direction and speed. Excluding those geostrophic wind directions when the flow through the pass diminishes because of flow parallel with rather than across the mountain range, it was found that the average speed of the surface wind through the pass is stronger than the geostrophic wind speed on the average, but is less than the geostrophic speed with the stronger gradients. However, wind gusts considerably stronger than the geostrophic occur and the speed of these gusts exceeds the geostrophic indication even at very strong speeds. In forecasting winds through passes similar to Bear Creek, the meteorologist can furnish a rough estimate of average wind speeds from curve A of Figure 4, but he should amplify his forecast by indicating wind gusts to at least the values shown on curve B of Figure 4.

It was found at Seward, Alaska that pressures on the windward side of a mountain range will average about one millibar higher, and on the leeward side one to two millibars lower than the analyst would expect in the absence of observational data.

Wind speeds observed at both Seward Airport and through Lynn Canal suggest that wind speeds through the passes feeding these observing sites are probably of the same order as those encountered in Bear Creek under similar conditions. However, this is only a rough estimate; certainly the width of the pass and the height to which the mountains rise, as well as the sharpness of the rise, on each side of the pass are important considerations. While little quantitative data is available, it is a reasonably well-established fact that wind flow from the southeast through Portage Pass, located a short distance southeast of Anchorage is stronger, under similar isobaric conditions, than the flow through Bear Creek. Portage Pass is narrower and the confining mountains are higher. Therefore, the results of this study, while perhaps serving as a rough guide for other mountain passes, should be considered reliable only for

Bear Creek Pass; the fact that the observing site was not in the middle of the pass no doubt biased the results toward lower speeds than one would actually encounter in the center of the pass.

ACKNOWLEDGEMENTS

Publication of this study is a contribution to the Marine Services Project of NOAA's Pacific Marine Environmental Laboratory (PMEL). This report would not have come about without the co-operation of the Humble Oil Company and the dedication of their men and women of the Anchorage Weather Bureau Airport Station. Kerri Will and Joy Register of PMEL's Technical Support Division are appreciated for preparation of the manuscript and illustrations.

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