PACIFIC REGION TECHNICAL NOTES

82-024
December 13, 1982

Channeled Winds in Juan de Fuca Strait An Empirical Verification

CORRECTION

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PAGE 2

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An Empirical Verification

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INTRODUCTION

It is of common knowledge that sea level winds around the B.C. coast are strongly affected by the abrupt topography of the shoreline.

In a recent study by Overland and Walter (1981) it was shown that in Juan de Fuca Strait for instance the winds were not geostrophic but rather in approximate ageostrophic equilibrium between inertia and the imposed sea-level pressure gradient.

While forecasters are aware of this feature, its quantitative assessment is far from straightforward and "rules of thumb" are used to evaluate wind speeds in various situations, especially when regular observations are not available.

This study will compare a few of the rules or methods used to compute speeds from surface pressure gradients, with the help of a statistical ensemble of more than 130 cases of channeled wind in Juan de Fuca Strait.

PROPOSED METHODS

The most frequent used rule of thumb for estimating wind speeds (in knots) in the Strait is simply to multiply the pressure difference (in millibars) between Bellingham and Quillayute by 10.

These two stations are thought to be representative of the pressure difference between the extremities of the Strait.

This first metod of evaluation is then:

$$V = 10*(P.\ Diff.) \qquad (1a)$$

Another method that has been proposed, used the geostrophic approximation to relate the pressure gradient to the wind speed. For the same conditions as above that method becomes:

$$V = -(1/fd)*dP/dX = 12*(P.\ Diff.) \qquad (1b)$$

f = Coriolis parameter
d = air density

Both these methods are similar in the fact that they imply a linear relationship between pressure difference and speed. In what follows equation (1b) will be referred to as Method 1 (there is no need to analyse separately the results a) and b) since they differ only by a minor scaling factor).

If we tackle the problem from another angle and go back to the basic dynamical equation of horizontal motion we find a different relationship between pressure and wind speed. This is the approach mentioned in the work cited above and it is briefly outlined here. First:

$$\frac{dv}{dt} = fu - \frac{1}{d}\frac{2p}{2x} + Fr$$

where:
- x is a length coordinate along the Strait
- v is the velocity along the Strait
- u is the velocity perpendicular to the Strait
- f is the Coriolis parameter
- d is the air density
- Fr is the friction term

assuming perfect channeling both u and Fr are near zero, which gives:

$$\frac{dv}{dt} = -\frac{1}{d}\frac{2p}{2x}$$

and after integration we get:

$$v^2 = v_o^2 - (p - p_o)/d$$

which can be further simplified if we neglect initial velocity:

$$v = \sqrt{200*(P.\ Diff.)} \qquad (2)$$

where the same units and conditions as above are used. This is method 2.

In order to use equation (2) we have to assume that for both east and west winds the air parcels are accelerated from rest. While this is fairly reasonable for easterlies because of the barrier that the Coast and Cascade Mountain Range constitutes, it is not so obvious for westerlies. In that case however, a good gradient along the Strait corresponds generally to isobars that are roughly parallel to the outer coast (of Vancouver Island and Washington State), with a strong high pressure system offshore. The winds over the open sea are then almost parallel to the isobars because the lack of friction permits the establishment of geostrophic equilibrium. The east-west component of the winds is therefore negligible and the necessary condition is met.

RESULTS

In this section, 137 wind observations from the Strait of Juan de Fuca (mostly in January and June 1982) are compared with calculated wind speeds from the pressure difference between Quillayute and Bellingham, using both of the above methods. The results are presented in the form of plots of the difference between calculated and observed winds (Figures 1 and 2). In both cases the bias is positive (4 and 5) and the standard deviation relatively large (6 and 9). But if we take only the cases where the observed wind is above 15 knots, the results are more specific. Method 1 still has a bias of plus 4 and a large standard deviation (9, larger than for the whole sample) but Method 2 has almost no bias (0.7 knots) and a reasonable standard deviation (4.4 knots).

The relative inaccuracy of Method 1 in the case of significant winds can be explained by the fact that its use of a linear relationship is not based on valid physical principles. While a linear approximation is often a good first guess at a phenomenon like this one, it does not work here because the wind speed increases too fast with the pressure difference. Furthermore it can not be justified by the geostrophic approach because the channeled wind is totally ageostrophic (wind perpendicular to isobars). The square root dependance of Method 2 seems to fit the strong wind data much better by not increasing the results as much when the pressure difference gets large. It is interesting to note that both methods give the same results for winds in the vicinity of 20 knots. This may be the reason why Method 1 has enjoyed a lasting popularity...it is used often for that range of speeds (to determine if a Small Craft Warning is needed in summer for instance).

While gathering the data for this study, I noticed that Method 2 worked best when the pressure gradient is truly parallel to the axis of the Strait (i.e. when the isobars are perpendicular to the Strait) and when no frontal or upper air disturbance is too close to the area. These features induce very peculiar situations where the vertical components of air motion become significant and perturb the horizontal wind pattern. There were cases where a pressure difference of more than 2 millibars along the Strait resulted in winds of 5 knots or less.

CONCLUSION

When the need arises to estimate wind speed in Juan de Fuca Strait from the surface pressure field, the following relationship should be used:

$$V = \sqrt{200*(\text{P. Diff.})}$$

V in knots
P. Diff. in millibars

Although the pressure difference between Quillayute and Bellingham can be used in the formula, a better result is obtained by drawing the local isobaric pattern to determine more precisely the pressure difference between the extremities of the Strait, and also to determine to what extent the orientation (degree of parallelism of the gradient with the axis of the Strait) favours reliable results from the method.

The wind speed obtained in this manner has almost no bias and can be considered accurate within 5 knots, in most cases where the result is between 15 and 35 knots. Outside of that range the simple equilibrium between pressure and speed is probably disturbed by non-negligible initial velocities and vertical air motions.

REFERENCES

Overland, J.E. and Walter, B.A. Jr., "Gap Winds in the Strait of Juan de Fuca", Mon. Wea. Rev., 109, 2221-2233 (1981).

FIGURE 1.

(CALCULATED WIND – OBSERVED WIND) VS OBSERVED WIND

METHOD 1 (Linear relation)

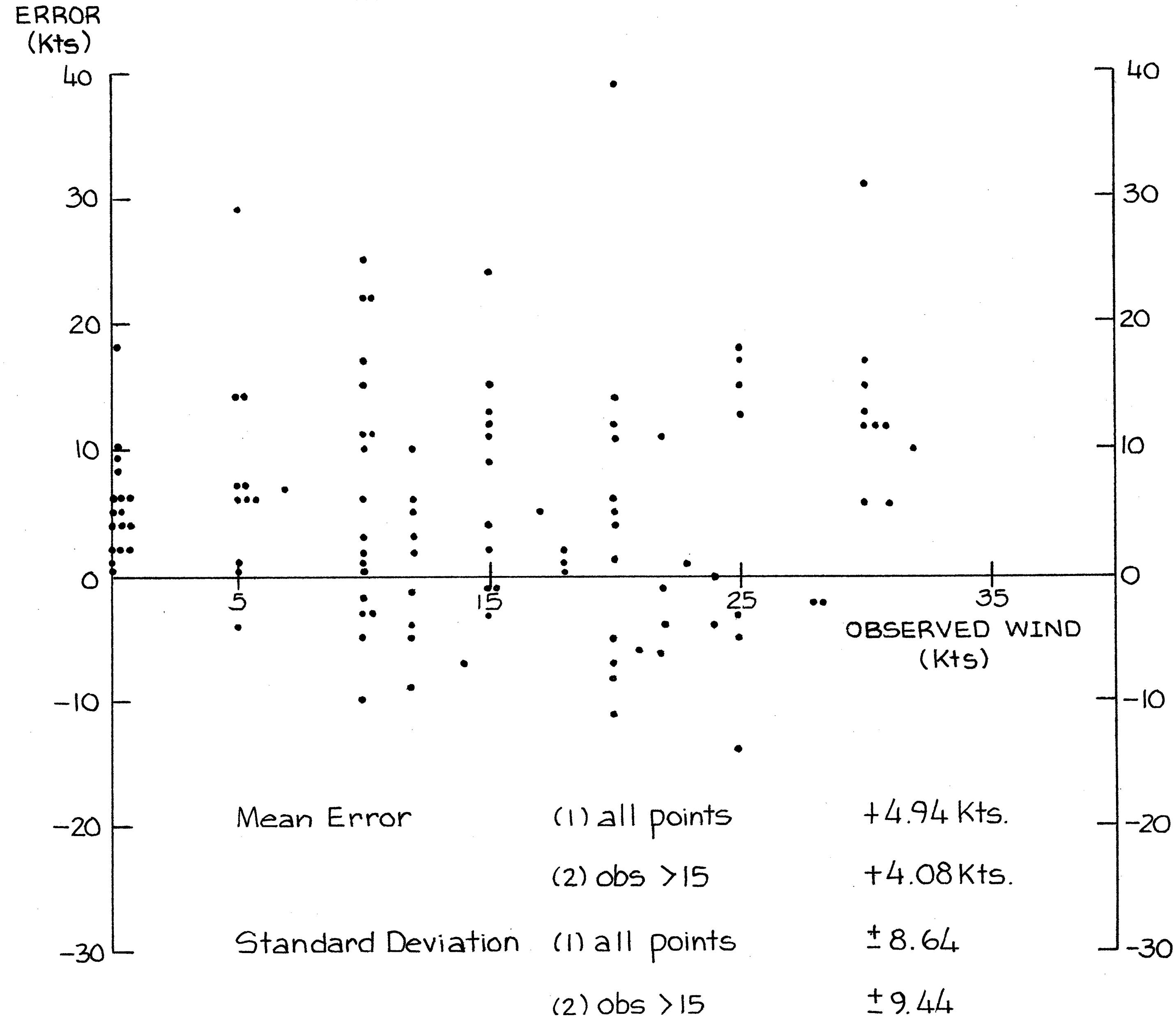
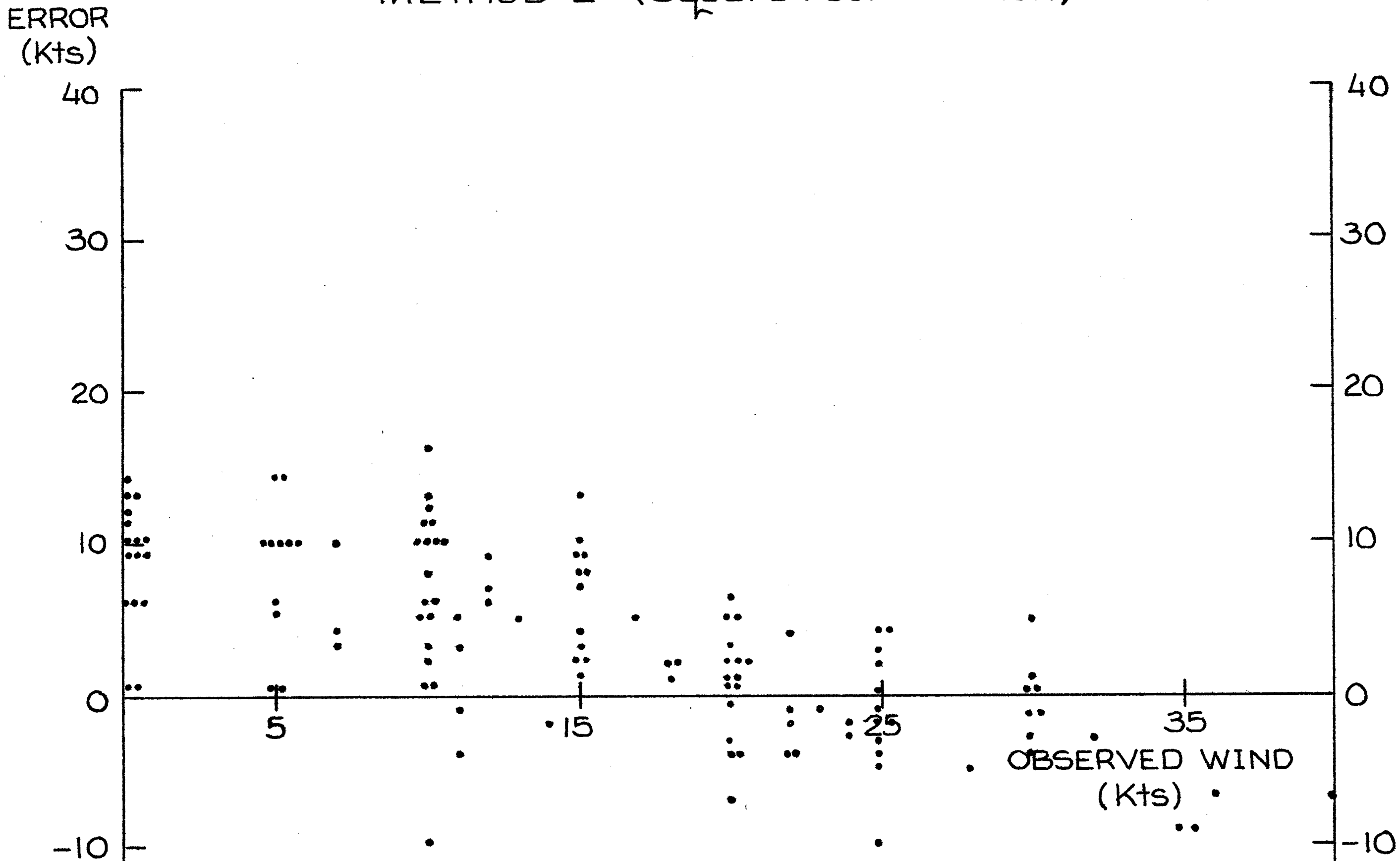


FIGURE 2.

(CALCULATED WIND - OBSERVED WIND) VS OBSERVED WIND

METHOD 2 (Square root relation)



Mean Error	(1) all points	+3.55 Kts.
	(2) obs >15	-0.71 Kts.
Standard Deviation	(1) all points	±6.2 Kts.
	(2) obs >15	±4.4 Kts.