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AUTOMATED PREDICTION OF SURFACE WINDS IN ALASKA--NO. 4

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1. INTRODUCTION

We have derived the final set of surface wind prediction equations that are currently needed for TDL's Alaskan objective guidance forecast system. These equations will be used during the fall season of September, October, and November. They are quite similar to the ones for the summer season (June, July, and August) described by Carter (1977).

2. PREDICTORS AND DEVELOPMENT OF FORECASTING EQUATIONS

Using the Model Output Statistics (MOS) approach (see Glahn and Lowry, 1972, we generated one set of prediction equations for the 0000 GMT cycle and another for the 1200 GMT cycle of the Primitive Equation (PE) model (Shuman and Hovermale, 1968). Each set includes equations to predict the U and V components and the wind speed, S, valid 12, 18, 24, 30, 36, 42, and 48 hr after the PE model's input data times of 0000 GMT and 1200 GMT. Separate equations were developed for each of the 14 stations shown in Table 1.

Table 1. Fourteen stations used to develop an automated surface wind forecasting system for Alaska.

Anchorage	Juneau
Annette	King Salmon
Barrow	Kotzebue
Barter Island	McGrath
Bethel	Nome
Cold Bay	St. Paul Island
Fairbanks	Yakutat

Table 2 shows the potential predictors we screened from the fall seasons of 1970 through 1976. These included several wind-related forecast fields from the PE model, plus the first and second harmonics of the day of the year. In addition, for the 12-, 18-, 24-, and 30-hr projections, we screened surface observations of wind, sky cover, and temperature available 6 hr after the PE model data input times. Backup equations which do not contain any observed predictors were also derived for these four projections.

We allowed for the selection of up to 12 predictors, but only as long as each one reduced the variance of any one of the three predictands (U, V, or S) by an additional three-fourths of one percent. Thus, many of the equations contain less than the full 12 terms. However, all of the equations contain at least four predictors.

Table 3 shows the Alaskan wind equations valid 24 hr after 0000 GMT at King Salmon. Here, eight PE forecasts, 0600 GMT observed winds, and the cosine of the day of the year reduced the variance of U, V, and S by 52, 61, and 38%, respectively. The three equations for U, V, and S all use the same 11 predictors, but of course, each equation has its own unique set of regression coefficients.

Table 4 is a ranking of predictors on the basis of frequency and order of selection in all the equations valid 12, 24, 36, and 48 hr from 0000 GMT. The predictors that are selected first and most often are ranked highest in Table 4. Observed weather elements are very important for the 12-hr projection, while PE boundary layer and geostrophic wind forecasts are dominant in the equations for the other three projections.

3. FUTURE WORK

We plan to rederive the Alaskan surface wind prediction equations in approximately 4 years. At that time, our developmental data sample for Alaska will also include forecasts from the Limited-area Fine Mesh (LFM) model (Howcroft and Desmarais, 1971).

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Table 2. Potential predictors available to the screening regression program for the fall season. The stars indicate that the field is smoothed over 5 (*) or 9 (**) grid points.

Predictors	Projection (hours from model run time)
a) PE Model Output	
U, V, S (Boundary Layer)	6, 12, 18, 24*, 36**, 48**
U, V, S (850 mb, 700 mb, 500 mb)	24
Geostrophic U, V, S (1000 mb)	12, 18, 24*, 36*, 48*
Geostrophic U, V, S (850 mb, 500 mb)	12, 18, 36*, 48*
Geostrophic Relative Vorticity (1000 mb, 850 mb, 500 mb)	12, 18*, 24*, 36**, 48**
Boundary Layer Wind Divergence	12, 18*, 24*, 36**, 48**
Constant-Pressure Height (1000 mb, 850 mb, 500 mb)	12, 18, 24, 36*, 48*
Thickness (500 mb Hgt-1000 mb Hgt)	12, 18, 24, 36*, 48*
Surface Pressure (P)	12, 24*, 36*, 48**
Surface Pressure Change	$P_{24} - P_{12}$, $(P_{36} - P_{24})$*, $(P_{48} - P_{36})$**
Mean Relative Humidity (1000 mb to 400 mb)	12*, 18*, 24*, 30**, 36**, 42**, 48**
Vertical Velocity (850 mb, 650 mb)	24**
Temperature (1000 mb, 850 mb)	12, 24*, 36**, 48**
Temperature (700 mb, 500 mb)	24*
Potential Temperature (Boundary Layer)	12, 18, 24, 36*, 48*
Stability (850 mb Temp - 1000 mb Temp)	12, 24, 36*, 48*
Stability (700 mb Temp - 850 mb Temp)	24
b) Other Predictors	
Sine and Cosine of the Day of the Year and Twice the Day of the Year	0
Surface Observations (Total Sky Cover, Temperature, U, V, S)	6

Table 3. Sample equations for estimating the U and V wind components and the wind speed, S, 24 hr after 0000 GMT at King Salmon. The PE forecast data sample consisted of 518 days from the fall seasons of 1970 through 1976.

Predictor	Forecast Projection (hr)	Cumulative reduction of variance			Coefficients			Units
		U	V	S	U	V	S	
Regression Constant	--	----	-----	----	-0.238	-3.748	3.017	kt
1. Boundary layer V	24	0.065	0.557	0.019	0.143	0.749	0.222	$m\ s^{-1}$
2. Boundary layer geostrophic U	24	0.468	0.561	0.040	0.574	0.107	-0.300	$m\ s^{-1}$
3. 1000-mb geostrophic S	24	0.470	0.570	0.271	-0.171	0.138	0.594	$m\ s^{-1}$
4. Cosine of day of year	--	0.470	0.575	0.315	-1.114	-2.000	-3.223	None
5. Boundary layer V	36	0.474	0.599	0.324	-0.248	-0.045	-0.553	$m\ s^{-1}$
6. 850-mb geostrophic U	36	0.495	0.601	0.333	0.311	0.278	0.260	$m\ s^{-1}$
7. 500-mb wind speed	24	0.507	0.602	0.349	0.089	0.050	0.086	$m\ s^{-1}$
8. 500-mb relative vorticity x 10^5	24	0.509	0.604	0.361	-0.117	0.200	0.319	s^{-1}
9. Observed U	6	0.516	0.606	0.364	0.157	-0.101	0.088	kt
10. Observed S	6	0.516	0.606	0.374	0.032	-0.026	0.144	kt
11. 850-mb geostrophic V	36	0.517	0.614	0.379	-0.149	0.428	0.210	$m\ s^{-1}$
Total standard error of estimate (kt)		5.75	5.68	4.50				

Table 4. Importance of PE forecast and 0600 GMT observed predictors on the basis of frequency and order of selection in the Alaskan fall season surface wind equations for the 0000 GMT forecast cycle. Predictors appearing first in the equations were assigned 12 points, while the second term variables were given 11 points, and so on. Points were summed for all the equations. The predictors were then ranked according to the total number of points accumulated. (Note: geo. = geostrophic, rel. vort. = relative vorticity, divg. = divergence, DOY = day of year.)

Rank	Forecast Projection (in hr from 0000 GMT) 12	24	36	48
1	Observed V	Bound. layer V	Bound. layer V	Bound. layer V
2	Observed S	Bound. layer U	Bound. layer U	850-mb geo. S
3	Observed U	1000-mb geo. s	1000-mb geo. S	1000-mb geo. U
4.	Bound. layer V	1000-mb geo. V	850-mb geo. S	Bound. layer U
5	Bound. layer U	Cosine DOY	1000-mb geo. V	1000-mb geo. S
6	Bound. layer S	1000-mb geo. U	1000-mb geo. U	Cosine DOY
7	1000-mb geo. U	Bound. layer S	850-mb geo. U	850-mb geo. V
8	1000-mb geo. S	Observed S	850-mb geo. V	500-mb geo. U
9	1000-mb geo. V	Observed U	Bound. layer S	Sine DOY X 2
10	850-mb geo. S	850-mb S	850-mb rel. vort.	850-mb geo. U
11	850-mb rel. vort.	Observed temp.	Cosine DOY	1000-mb geo. V
12	Bound. layer divg.	Mean rel. humidity	Sine DOY X 2	500-mb geo. S