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USE OF MODEL OUTPUT STATISTICS IN AUTOMATED PREDICTION OF SURFACE WINDS--No. 2

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Automated forecasts of surface wind have been available for use as guidance by National Weather Service (NWS) forecasters since May of 1973. The Techniques Development Laboratory (TDL) developed this method for producing objective estimates of surface wind for the conterminous United States for projections of 12 to 48 hours. Seasonal wind estimation equations were derived for 233 stations by use of Model Output Statistics (MOS), a technique which consists of determining a statistical relationship between a predictand and variables forecast by a numerical model.

This product is available on teletypewriter on a request/reply basis in the form depicted in Table 1. A heading which gives the day and time of the input data, as well as the valid day and time for each of the seven forecast projections, is provided. The letter M proceeding the initial projection forecast denotes the situation where necessary data from a surface report was missing and a backup equation was used. Eventually this product will also be available on a 4-panel facsimile chart.

Observed surface winds were statistically related to forecasts primarily from the National Meteorological Center's (NMC) Primitive Equation (PE) model by use of the screening regression technique. The developmental data consisted

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of three warm seasons (April-September) during 1970-72 and four cool seasons (October-March) during 1969-73. As shown in Table 2, potential predictors included U and V wind components, wind speed, geostrophic winds, constant pressure heights, relative vorticity, vertical velocity, mean relative humidity, temperature, potential temperature, and stability at various projection times and levels throughout the atmosphere. The sine and cosine of the day of the year were also included. Each of these predictors was interpolated to a point directly above each station, and only data at a given station were used for that station. Some of these predictors were space smoothed by 5, 9, or 25 points in order to eliminate small scale noise. The amount of smoothing was a function of element, level, and projection. In addition, U and V wind components, wind speed, and cloud cover from surface observations available 6 hours after PE model input time were screened for the initial projection.

One group of equations was derived for the warm season and another for the cool season, as well as one for the 0000 and one for the 1200 GMT runs of the PE model. Each group included wind estimate equations for 7 projections, with additional back-up equations free of observed predictors for the initial projection only.

Separate single-station regression equations, like the cool season one shown in Table 3 for Kansas City, were derived for U and V wind components and the wind speed. All equations were required to have exactly 10 terms; this decision was based on previous research by TDL. Also, in order to insure physical significance and overall consistency between stations and projections, some constraints were imposed on the selection of predictors. For any given station and projection, all 3 equations contain the same 10 predictors as illustrated by this equation. (They do, of course, have

different regression coefficients and constants.) Also, the first 3 predictors were forced to be the boundary layer U and V wind components and wind speed forecasts from the PE model for the valid time of the wind predictand. The remaining 7 predictors were selected by using at each step the meteorological variable which reduced the variance of any of the 3 predictands by the largest fractional amount.

In order to evaluate this system, warm season wind equations were derived for 20 widely distributed stations; cool season equations were derived for 20 different stations. The stations used for the cool season test are shown in Figure 1. The dependent data sample consisted of 449 days during the cool seasons of 1969-72. The forecasting equations were evaluated on independent data for each day in December 1972 and January 1973 for which data were available. Only the 0000 GMT runs of the PE model were used. The wind forecasts in the official terminal (FT) forecasts made at the NWS Forecast Offices were used for comparison purposes. The warm season equations were also tested in a similar manner.

Since the FT's do not mention wind if the speed is expected to be less than 10 knots, the comparison was made as follows. For all those cases where the FT's included wind and for which objective forecasts were available, the mean absolute error (MAE) of direction (computed from the U and V equations) and speed (direct from the speed equation) were computed. The results shown in Table 4 indicate that the objective forecasts were superior to the FT's for both direction and speed at 1800 and 2400 GMT. At 1200 GMT, the FT forecasts of direction were better than the objective estimates; however, the objective forecasts were better than the FT's for speed. These results are in close agreement with those obtained for the warm season objective and FT forecasts.

Based on the test results, seasonal equations were derived for all 233 stations and then operationally implemented. The operational forecasts will be verified in conjunction with the NWS combined aviation/public weather verification system. We also plan to put these objective wind forecasts on facsimile within the next few months.

Table 1

Teletype Message for Surface Wind Forecasts

```
ZCZC
ROC
WIND FC22 SFC WIND FCSTS 240000
  DAY 24   24   25   25   25   25   26
  GMT 12   18   00   06   12   18   00
DCA  0205 0606 0807 0507 0306 0508 0806
BAL  3303 0608 0805 0305 0305 0708 0705
JFK M0304 1008 0908 0000 1202 1110 1208

NNNN
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Table 2

Potential Predictors for Surface Wind Forecasting Equations

Predictors	Valid Times (Hours from PE Run Time)
a) PE Model	
U Wind, V Wind, Wind Speed (Boundary Layer)	6*,12, 18, 24, 36, 48
U Wind, V Wind, Wind Speed (850-mb Geostrophic)	12, 18, 24, 36, 48
U Wind, V Wind, Wind Speed (850 mb, 700 mb)	24
Constant Pressure Height (1000 mb, 850 mb)	6*,12, 18, 24, 36, 48
Constant Pressure Height (500 mb)	12, 18, 24, 36, 48
Relative Vorticity (850 mb)	12, 18, 24, 36, 48
Vertical Velocity (850 mb, 650 mb)	24
Mean Relative Humidity (1000 mb to 400 mb)	12, 18, 24, 30, 36, 42, 48
Temperature (1000 mb, 850 mb)	12, 24, 36, 48
Temperature (700 mb)	24
Potential Temperature (Boundary Layer)	12, 18, 24, 36, 48
Stability (850-mb Temperature minus 1000-mb Temperature)	12, 24, 36, 48
Stability (700-mb Temperature minus 850-mb Temperature)	24*
b) Other Predictors	
Sine and Cosine (Day of the Year)	0
Surface Observations (Cloud Cover, U Wind, V Wind, Wind Speed)	6

* Unavailable to warm season equations

Table 3

Sample equations for estimating the U and V wind components and the wind speed 12 hours in advance (from 00Z) at Kansas City. Data sample consisted of 607 days from the cool seasons of 1969-73.

Predictor	Valid Time (GMT)	Cumulative Reduction of Variance			Cumulative Standard Error of Estimate (kts)			Coefficients			Units
		U	V	S	U	V	S	U	V	S	
Regression Constant	----	---	---	---	----	----	----	-1.368	-.835	.197	kts
1. Boundary Layer U Wind	1200	.593	.017	.003	3.56	7.32	4.03	.092	.080	.041	M x Sec^{-1}
2. Boundary Layer V Wind	1200	.624	.639	.006	3.42	4.44	4.03	-.082	-.046	-.054	M x Sec^{-1}
3. Boundary Layer Wind Speed	1200	.630	.639	.388	3.40	4.44	3.16	.008	.145	.075	M x Sec^{-1}
4. Observed Wind Speed	0600	.634	.648	.521	3.38	4.38	2.80	.057	-.114	.447	M x Sec^{-1}
5. Observed U Wind	0600	.695	.648	.521	3.08	4.38	2.80	.408	-.058	-.006	M x Sec^{-1}
6. Observed V Wind	0600	.697	.688	.521	3.07	4.13	2.80	-.043	.414	.009	M x Sec^{-1}
7. Boundary Layer V Wind	1800	.698	.743	.522	3.07	3.75	2.79	.025	.406	.031	M x Sec^{-1}
8. Boundary Layer U Wind	1800	.730	.745	.522	2.90	3.73	2.79	.351	.117	-.056	M x Sec^{-1}
9. Boundary Layer Wind Speed	1800	.730	.745	.545	2.90	3.73	2.72	-.001	.012	.231	M x Sec^{-1}
10. Mean Relative Humidity	1200	.731	.747	.555	2.90	3.72	2.69	.012	-.016	.021	Per Cent

Table 4

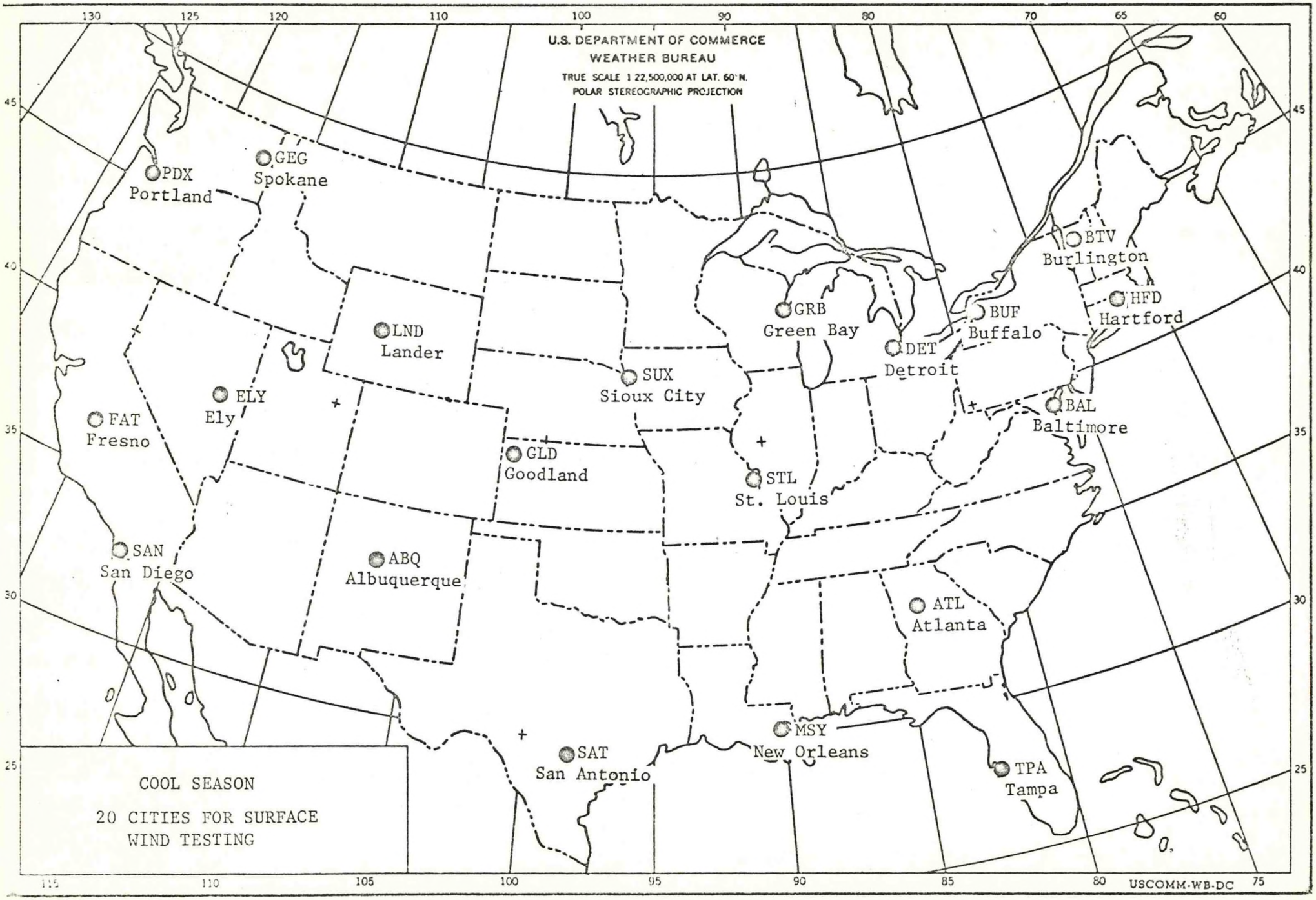
Comparison of FT and objective surface wind forecasts for 20 stations across the U.S. for December 1972 and January 1973.

Valid Time (GMT)	Projection (HR)	Forecasts	Direction MAE (DEG)	Speed MAE (KTS)	Number of Cases
12	6*	Objective	24	2.8	481
	3**	FT	21	3.3	
18	18	Objective	34	3.1	633
	9**	FT	38	3.9	
24	24	Objective	38	3.2	565
	15**	FT	48	4.7	

*Surface observations at 0600 GMT were used.

**The assumption was made that NWS forecasters had 0900 GMT surface observations available.

Figure 1


U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
TRUE SCALE 1:22,500,000 AT LAT. 60° N.
POLAR STEREOGRAPHIC PROJECTION
PDX
Portland
GEG
Spokane
LND
Lander
ELY
Ely
FAT
Fresno
SAN
San Diego
ABQ
Albuquerque
SUX
Sioux City
GLD
Goodland
STL
St. Louis
GRB
Green Bay
DET
Detroit
BUF
Buffalo
BTV
Burlington
HFD
Hartford
BAL
Baltimore
ATL
Atlanta
MSY
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SAT
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TPA
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COOL SEASON
20 CITIES FOR SURFACE
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