A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

NOAA TM NWS ER-47

NOAA Technical Memorandum NWS ER-47

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

AN OBJECTIVE METHOD OF PREPARING CLOUD COVER FORECASTS

James R. Sims

Eastern Region
Garden City, N.Y.

August 1972

NOAA TECHNICAL MEMORANDA
National Weather Service, Eastern Region Subseries

The National Weather Service Eastern Region (ER) Subseries provides an informal medium for the documentation and quick dissemination of results not appropriate, or not yet ready, for formal publication. The series is used to report on work in progress, to describe technical procedures and practices, or to relate progress to a limited audience. These Technical Memoranda will report on investigations devoted primarily to regional and local problems of interest mainly to ER personnel, and hence will not be widely distributed.

Papers 1 to 22 are in the former series, ESSA Technical Memoranda, Eastern Region Technical Memoranda (ERTM); papers 23 to 37 are in the former series, ESSA Technical Memoranda, Weather Bureau Technical Memoranda (WBTM). Beginning with 38, the papers are now part of the series, NOAA Technical Memoranda NWS.

Papers 1 to 22 are available from the National Weather Service Eastern Region, Scientific Services Division, 585 Stewart Avenue, Garden City, N.Y. 11530. Beginning with 23, the papers are available from the National Technical Information Service, U.S. Department of Commerce, Sills Bldg., 5285 Port Royal Road, Springfield, Va. 22151. Price: $3.00 paper copy; $0.95 microfilm. Order by accession number shown in parentheses at end of each entry.

ESSA Technical Memoranda

ERTM 1 Local Uses of Vorticity Prognoses in Weather Prediction. Carlos R. Dunn. April 1965

ERTM 2 Application of the Barotropic Vorticity Prognostic Field to the Surface Forecast Problem. Silvio G. Simplicio. July 1965

ERTM 3 A Technique for Deriving an Objective Precipitation Forecast Scheme for Columbus, Ohio. Robert Kuessner. September 1965

ERTM 4 Stepwise Procedures for Developing Objective Aids for Forecasting the Probability of Precipitation. Carlos R. Dunn. November 1965

ERTM 5 A Comparative Verification of 300 mb. Winds and Temperatures Based on NMC Computer Products Before and After Manual Processing. Silvio G. Simplicio. March 1966

ERTM 6 Evaluation of OFDEV Technical Note No. 17. Richard M. DeAngelis. March 1966

ERTM 7 Verification of Probability Forecasts at Hartford, Connecticut, for the Period 1963-1965. Robert B. Wassall. March 1966

ERTM 8 Forest-Fire Pollution Episode in West Virginia November 8-12, 1964. Robert O. Weedfall. April 1966

ERTM 9 The Utilization of Radar in Meso-Scale Synoptic Analysis and Forecasting. Jerry D. Hill. March 1966

ERTM 10 Preliminary Evaluation of Probability of Precipitation Experiment. Carlos R. Dunn. May 1966

ERTM 11 Final Report. A Comparative Verification of 300 mb. Winds and Temperatures Based on NMC Computer Products Before and After Manual Processing. Silvio G. Simplicio. May 1966

ERTM 12 Summary of Scientific Services Division Development Work in Sub-Synoptic Scale Analysis and Prediction - Fiscal Year 1966. Fred L. Zuckerberg. July 1966

ERTM 13 A Survey of the Role of Non-Adiabatic Heating and Cooling in Relation to the Development of Mid-Latitude Synoptic Systems. Constantine Zois. July 1966

ERTM 14 The Forecasting of Extratropical Onshore Gales at the Virginia Capes. Glen V. Sachse. August 1966

ERTM 15 Solar Radiation and Clover Temperature. Alex J. Kish. September 1966

ERTM 16 The Effects of Dams, Reservoirs and Levees on River Forecasting. Richard M. Greening. September 1966

ERTM 17 Use of Reflectivity Measurements and Reflectivity Profiles for Determining Severe Storms. Robert E. Hamilton. October 1966

ERTM 18 Procedure for Developing a Nomograph for Use in Forecasting Phenological Events from Growing Degree Days. John C. Purvis and Milton Brown. December 1966

ERTM 19 Snowfall Statistics for Williamsport, Pa. Jack Hummel. January 1967

ERTM 20 Forecasting Maturity Date of Snap Beans in South Carolina. Alex J. Kish. March 1967

ERTM 21 New England Coastal Fog. Richard Fay. April 1967

ERTM 22 Rainfall Probability at Five Stations Near Pickens, South Carolina, 1957-1963. John C. Purvis. April 1967

WBTM ER 23 A Study of the Effect of Sea Surface Temperature on the Areal Distribution of Radar Detected Precipitation Over the South Carolina Coastal Waters. Edward Paquet. June 1967 (PB-180-612)

WBTM ER 24 An Example of Radar as a Tool in Forecasting Tidal Flooding. Edward P. Johnson. August 1967 (PB-180-613)

WBTM ER 25 Average Mixing Depths and Transport Wind Speeds over Eastern United States in 1965. Marvin E. Miller. August 1967 (PB-180-614)

WBTM ER 26 The Sleet Bright Band. Donald Marier. October 1967 (PB-180-615)

WBTM ER 27 A Study of Areas of Maximum Echo Tops in the Washington, D.C. Area During the Spring and Fall Months. Marie D. Fellechner. April 1968 (PB-179-339)

WBTM ER 28 Washington Metropolitan Area Precipitation and Temperature Patterns. C. A. Woollum and N. L. Canfield. June 1968 (PB-179-340)

WBTM ER 29 Climatological Regime of Rainfall Associated with Hurricanes after Landfall. Robert W. Schoner. June 1968 (PB-179-341)

WBTM ER 30 Monthly Precipitation - Amount Probabilities for Selected Stations in Virginia. M. H. Bailey. June 1968 (PB-179-342)

WBTM ER 31 A Study of the Areal Distribution of Radar Detected Precipitation at Charleston, S. C. S. K. Parrish and M. A. Lopez. October 1968 (PB-180-480)

WBTM ER 32 The Meteorological and Hydrological Aspects of the May 1968 New Jersey Floods. Albert S. Kachic and William Long. February 1969 (Revised July 1970) (PB-194-222)

WBTM ER 33 A Climatology of Weather that Affects Prescribed Burning Operations at Columbia, South Carolina. S. E. Wasserman and J. D. Kanupp. December 1968 (COM-71-00194)

WBTM ER 34 A Review of Use of Radar in Detection of Tornadoes and Hail. R. E. Hamilton. December 1969 (PB-188-315)

WBTM ER 35 Objective Forecasts of Precipitation Using PE Model Output. Stanley E. Wasserman. July 1970 (PB-193-378)

WBTM ER 36 Summary of Radar Echoes in 1967 Near Buffalo, N.Y. Richard K. Sheffield. September 1970 (COM-71-00310)

WBTM ER 37 Objective Mesoscale Temperature Forecasts. Joseph P. Sobel. September 1970 (COM-71-0074)

NOAA Technical Memoranda NWS

NWS ER 38 Use of Primitive Equation Model Output to Forecast Winter Precipitation in the Northeast Coastal Sections of the United States. Stanley E. Wasserman and Harvey Rosenblum. December 1970 (COM-71-00138)

NWS ER 39 A Preliminary Climatology of Air Quality in Ohio. Marvin E. Miller. January 1971 (COM-71-00204)

(Continued On Inside Rear Cover)

UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE EASTERN REGION
Garden City, New York

NOAA TECHNICAL MEMORANDUM NWS ER-47

AN OBJECTIVE METHOD OF PREPARING CLOUD COVER FORECASTS

JAMES R. SIMS
WSO Hartford, CT

(Some of the work in this study was performed while Mr. Sims was a student at Florida State University, Tallahassee, Florida, with partial financial assistance provided by the Office of Naval Research.)

SCIENTIFIC SERVICES DIVISION
Eastern Region Headquarters
August 1972

AN OBJECTIVE METHOD OF PREPARING CLOUD COVER FORECASTS

ABSTRACT

Numerical 6-hourly output from the six-layer NMC PE model is used to predict the average daytime cloudiness in the spring for Boston, MA. The variables chosen as predictors are the PE model predictions of mean relative humidity for the surface to 500 mb. layer, and the 700 mb. vertical velocity. The cloud forecasts are obtained using a regression equation. The results demonstrate forecasting skill, in contrast to persistence, which is shown to be a poor predictor.

AN OBJECTIVE METHOD OF PREPARING CLOUD COVER FORECASTS

INTRODUCTION

Personnel turnover at weather stations creates a handicap to new forecasters who are unfamiliar with the factors that affect the local weather conditions. A solution to this problem is the availability of objective forecasting schemes. The objective forecast scheme may be based on statistical correlations between different parameters called predictors, and the parameter to be forecast, called the predictand.

This study presents an objective procedure to predict the average daytime cloudiness for Boston, MA, using as predictors the primitive equation (PE) model (Shuman, 1968) predictions of the mean relative humidity from the surface to about 500 mb., the 700 mb. vertical velocity, and the trend of the relative humidity through the 12-hour period of interest. The spring months of March, April, and May, 1970 made up the dependent data sample. Spring, the transition season, is a very difficult season in which to prepare forecasts for the Boston area.

Amount of cloudiness forecasting is not only of interest to the public; it is also of concern to meteorologists because of the influence of cloudiness on temperature, low level winds, turbulence, snow melt, and visibility.

PROCEDURE

The predictor values are obtained from a message called FOUS 1, available at approximately 0644 GMT on Service C teletype. This message is a printout of different parameters from the 0000 GMT 6-layer PE model run. A more detailed explanation of the FOUS 1 message can be found in ESSA Technical Procedures Bulletin No. 49.

A regression equation for predicting N, the mean hourly daytime (sunrise to sunset) sky cover in tenths (scale 0 to 10) was derived.[1]

$$N = 0.070\ RH + 0.077\ VV + 0.77\ TREND, \qquad (1)$$

---

[1] *NOTE: The regression equation derived for, and applied to, the dependent data had an RH coefficient of 0.078. In September 1970, the PE model was changed to inflate the RH by 11.1%. To make subsequent PE data compatible with the derived equation, the RH value for model runs after September 1970 had to be multiplied by 0.9. For ease of using the equations, the 0.9 factor was multiplied by the 0.078 to give the new coefficient for RH above.*

where RH is the time and vertically averaged forecast relative humidity, value in whole percent, VV is the time averaged forecast vertical velocity value as in FOUS 1, and TREND is the 12-hour forecast relative humidity trend. This RH value for "today" is the algebraic time average of the 12-hour, 18-hour and 24-hour forecasts for the vertically averaged humidity. The vertical velocity value for "today" is, similarly, the algebraic time average of the 12-hour, 18-hour, and 24-hour forecast values. The TREND value is derived from the algebraic subtraction of the 24-hour forecast value of vertically averaged relative humidity from the 12-hour forecast value of vertically averaged relative humidity. The TREND is then defined as -1 if the 12-hour forecast relative humidity change is equal to or algebraically less than -10 percent; as 0 if the 12-hour forecast humidity change is between -10 percent and +10 percent; and as +1 if the 12-hour forecast humidity change is equal to or algebraically greater than +10 percent.

Wasserman and Rosenblum (1972) find this relative humidity TREND a useful parameter for predicting the probability of precipitation and offer reasons for its usefulness. Adapted to the prediction of cloudiness, TREND should be included because: First, we are trying to predict the cloudiness for the 12-hour daylight period and not some instantaneous time; thus we should take into account large changes in the moisture during this time period. Second, we want to account for the approach or departure of weather systems, where large moisture changes are assumed to be associated with the movement of the system. Third, we want to take into consideration any bias in the PE model, such as consistent underprediction of the actual moisture in the atmosphere. Wasserman and Rosenblum (1972), however, suggest that these three parts could act in the same direction and thus be cumulative, or act in opposite directions and thus cancel each other.

Using typical values, the relative humidity can account for up to 7 tenths of the cloudiness, the vertical velocity can account for up to 2 tenths of the cloudiness, and the trend in humidity can add or subtract about 1 tenth of the cloudiness.

RESULTS

Equation (1) was applied to the dependent data used to develop the equation, and it was found to underpredict sky cover, especially in the middle ranges, by a maximum of 2 tenths. This bias could be due to the assumption of linearity implied in the equation. To correct for this bias, the value of cloudiness predicted by the regression equation was applied to an empirical parabolic fit to obtain a modified predicted value. This empiricism is:

$$N_{modified} = N + 2\frac{10N - N^2}{25} \qquad (2)$$

This empiricism, when the regression predicted cloudiness is zero, adds nothing; when the regression predicted cloudiness equals 10, again nothing is added. When the cloudiness equals 5, the empiricism adds a maximum of 2 tenths cloudiness.

Table 1 is the contingency table comparing the number of predicted cases versus the number of observed cases in cloud catagories clear (0-2 tenths), partly cloudy (3-7 tenths), and cloudy (8-10 tenths), for the dependent data sample using the regression equation without applying the empiricism.

		OBSERVED		
PREDICTED		CLEAR	PARTLY CLOUDY	CLOUDY
	CLEAR	10	9	4
	PARTLY CLOUDY	4	13	20
	CLOUDY	0	0	16

TABLE 1. Contingency table comparing the number of predicted cases versus the number of observed cases in the cloud catagories clear, partly cloudy, and cloudy, for the dependent data sample without using the empiricism.

Table 2 is a contingency table comparing the number of predicted cases versus the number of observed cases in the catagories, defined above, for the dependent data sample and applying the empiricism. Notice, when using the empiricism (Table 2), the diagonal dominance and the improvement over the predictions obtained without applying the empiricism (Table 1). Diagonal dominance indicates that, more times than not, the predicted and observed catagories of cloudiness are the same.

		OBSERVED		
PREDICTED		CLEAR	PARTLY CLOUDY	CLOUDY
	CLEAR	14	4	2
	PARTLY CLOUDY	8	13	8
	CLOUDY	1	5	30

TABLE 2. Contingency table comparing the number of predicted cases versus the number of observed cases in the cloud catagories clear, partly cloudy, and cloudy, for the dependent data sample and applying the empiricism.

It was found that the average observed cloudiness was 6 tenths for the dependent data cases. The average of the predicted value with the empiricism was also 6 tenths. (The average predicted value using just the regression equation was 4 tenths). With the empiricism included, the correlation coefficient between the predicted and actual values is 0.7, which indicates that 49 per cent of the variance in cloud cover amount is explained. The root mean square error, in tenths of cloud cover, without the empiricism is 2.9, and with the empiricism is 2.3.

Persistence by itself is a poor cloud cover predictor. The correlation coefficient on the dependent data sample between "yesterday's" cloud cover and "today's" observed cloud cover was only 0.22. Persistence thus accounts for only 4 or 5 percent of the variance in cloud cover amount from one day to the next.

The equation with the empiricism included was applied to an independent data sample for March, April, and May of 1971 and 1972. The contingency table comparing the predicted versus observed sky cover categories is presented in Table 3. This table shows no gross over- or under-prediction as evidenced by the fact that there are zeros in the upper right and lower left corners. The table is predominantly diagonally dominant. Nine of the 33 cases where the equations predicted partly cloudy and the observed condition was cloudy were actually a matter of the equations predicting 7 tenths cloud cover and the observed was 8 tenths. The observed sky cover averaged 7 tenths while the

predicted value using the empiricism averaged only 6 tenths cloud cover. The correlation coefficient between the predicted and observed cloud cover was .77 and the root mean square error was 2.2 tenths.

		OBSERVED		
PREDICTED		CLEAR	PARTLY CLOUDY	CLOUDY
	CLEAR	18	10	0
	PARTLY CLOUDY	8	32	33
	CLOUDY	0	5	56

TABLE 3. Contingency table comparing the number of predicted cases versus the number of observed cases in the cloud catagories clear, partly cloudy, and cloudy for the independent data sample and applying the empiricism.

CONCLUSION

"If you don't like New England weather, wait a minute" is a truism, and is verified well by the correlation between yesterday's mean cloud cover and today's. A good relationship has been shown between the observed daytime mean cloud cover in the spring for Boston, MA, and the PE model predictions of the mean surface to 500 mb. relative humidity, 700 mb. vertical velocity, and the predicted relative humidity trend through a 12-hour period. This relationship can be used as an aid by forecasters until some future time when new changes in the PE model may necessitate a recomputation of the regression coefficients.

REFERENCES

National Weather Service, *"Technical Procedures Bulletin, Number 49,"* 1970.

National Weather Service, *"Technical Procedures Bulletin, Number 55,"* 1970.

Eastern Region Headquarters, *"Eastern Region Staff Notes,"* July 1970.

Schuman, F. G. and Hovermale, J. B., An "Operational Sixlayer Primitive Equation Model," *Journal of Applied Meteorology*, Vol. 7, pp. 525-547, 1968.

Wasserman, S. E. and Rosenblum, H., "Use of Primitive Equation Model Output to Forecast Winter Precipitation in the Northeast Coastal Sections of the United States," *Journal of Applied Meteorology*, Vol. 11, pp. 16-22, 1972.

LIST OF EASTERN REGION TECHNICAL MEMORANDA

(Continued from inside front cover)

NWS ER 40 Use of Detailed Radar Intensity Data in Mesoscale Surface Analysis. Robert E. Hamilton. March 1971 (COM-71-00573)

NWS ER 41 A Relationship Between Snow Accumulation and Snow Intensity as Determined from Visibility. Stanley E. Wasserman and Daniel J. Monte. May 1971 (COM-71-00763)

NWS ER 42 A Case Study of Radar Determined Rainfall as Compared to Rain Gage Measurements. Martin Ross. July 1971 (COM-71-00897)

NWS ER 43 Snow Squalls in the Lee of Lake Erie and Lake Ontario. Jerry D. Hill. August 1971 (COM-71-00959)

NWS ER 44 Forecasting Precipitation Type at Greer, South Carolina. John C. Purvis. December 1971 (COM-72-10332)

NWS ER 45 Forecasting Type of Precipitation. Stanley E. Wasserman. January 1972 (COM-72-10316)

NWS ER 46 An Objective Method of Forecasting Summertime Thunderstorms. John F. Townsend and Russell J. Younkin. May 1972