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AN OBJECTIVE CLOUD FORECASTING SYSTEM

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by

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The Techniques Development Laboratory (TDL) has developed a system which produces objective forecasts of cloud amount for 231 stations in the contermious U. S.[1] The forecasts are in terms of the probability of occurrence of each of four categories, which correspond roughly to clear, scattered, broken, and overcast.[2] These probabilities are transformed into a categorical forecast in such a way that the percent of correct forecasts will be high with the restriction that the forecasts will be relatively unbiased.

To develop the system, we used the MOS (Model Output Statistics) approach (Glahn and Lowry, 1972). The MOS technique is the determination of the relationship of a predictand, in this case cloud amount, to variables forecast by a numerical model or models, in this case the PE (Shuman and Hovermale, 1968) and trajectory (Reap, 1968; Reap, 1972) models.

Forecasts from the 0000 GMT runs were used to determine cloud amount at 1800 GMT the same day; forecasts from the 1200 GMT runs were used to determine cloud amount at 1800 GMT the next day. These are, then, 18- and 30-hour forecasts, respectively, both verifying at the same time.

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[1]This work was partially supported by the Space Flight Meteorology Group of the Space Operations Support Division for use in support of NASA Project SKYLAB.

[2]Clear = Clear, partial obscuration, and thin scattered; scattered = scattered; broken = thin broken, broken, and thin overcast; overcast = overcast and obscured.

The development sample consisted of most days from April 1 through September 30 for the years 1970, 1971, and 1972. In order to account for local effects, a different forecast relationship was determined for each station and each projection.

Each equation contains eight predictors. The main predictors in the equations are measures of moisture at particular levels or integrated through the column, heights and height changes at constant pressure surfaces, measures of stability, and winds.

The equations were determined by least-squares regression. The four probabilities, one for each cloud category, for a particular station and valid time, sum to unity; however, the individual values are not bounded by zero and one. That is, a value can be negative or greater than one. Values outside the zero to one range do not, of course, meet the definition of probability. However, there is no practical difficulty with using such values; a negative value can be interpreted as a very low probability.

When transforming probability forecasts into categorical forecasts, one should keep in mind the method by which the forecasts are to be verified, because the verification scheme should reflect the way the forecasts are to be used. We have assumed that the verification would be on the basis of number (or percent) correct. This score can be maximized (theoretically, at least) by choosing for the categorical forecast the category with the highest probability. However, in so doing, unbiased forecasts are not assured. That is, category 1 may be forecast more (or fewer) times than it actually occurs. Since we felt that cloud forecasts should be relatively unbiased, we altered the transformation procedure slightly. We determined from the dependent data sample that if we multiplied the probability forecasts of categories 1, 2, 3, and 4 by the constants .84, 1.20, 1.04, and .94, respectively, and then chose the highest of the resulting values, the categorical forecasts would be relatively unbiased. That is the procedure we now use.

The MOS technique builds in, to some extent, the biases in the numerical models. However, a model "bust" will, of course, produce poor forecasts of surface weather no matter what diagnostic procedure is used.

References

Glahn, H. R., and D. A. Lowry, "The Use of Model Output Statistics (MOS) in Objective Weather Forecasting," Journal of Applied Meteorology, Vol. 11, No. 8, Dec. 1972, pp 1203-1211.

Shuman, F. G., and J. B. Hovermale, "An Operational Six-Layer Primitive Equation Model," Journal of Applied Meteorology, Vol. 7, No. 4, Aug. 1968, pp 525-547.

Reap, R. M., "Prediction of Temperature and Dew Point by Three-Dimensional Trajectories," ESSA Technical Memorandum WBTM TDL 15, Oct. 1968, 20 pp.

Reap, R. M., "An Operational Three-Dimensional Trajectory Model," Journal of Applied Meteorology, Vol. 11, No. 8, Dec. 1972, pp 1193-1202.