EASTERN REGION TECHNICAL ATTACHMENT
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USE OF 6-HOURLY PE MODEL FORECASTS IN PREDICTING PRECIPITATION TYPE

At this time of the year, the forecasting of precipitation type (liquid versus frozen) can be a difficult problem. Forecasters are encouraged to review pertinent literature, including the following Technical Attachments to Eastern Region Staff Notes that were distributed last year:

1. *Technical Attachment No. 70-10-26, "Forecasting Winter Weather," October 26, 1970.*

2. *Technical Attachment No. 70-11-2, "An Application of the Younkin Method in Forecasting Snow at Greer, South Carolina," November 2, 1970.*

3. *Technical Attachment No. 70-30-11, "Use of 6-Hourly PE Forecasts in Predicting Precipitation Type," November 30, 1970.*

The Technical Attachment issued November 30, 1970, suggested a development effort which could lead to better utilization of PE model output in forecasting precipitation type. Mr. Jack Hummel, while Meteorologist in Charge at Syracuse, New York, carried out this development effort and has obtained interesting results.

Mr. Hummel has displayed on scatter diagrams the type of precipitation observed last winter at Syracuse, New York, as a function of 6-hourly PE model forecasts of mean boundary layer potential temperature and the 1000-500 mb. thickness. Separate scatter diagrams were prepared for PE model runs based on 0000Z initial data (fig. 1) and based on 1200Z initial data (fig. 2). A separate scatter diagram was also prepared for each 6-hourly forecast validation time, but to save space only results for 12-hourly forecast validation times are presented here.

Examining the scatter diagrams (fig. 1 and 2), it appears that for Syracuse, New York, a precipitation type of snow can be confidently forecast, even out to 48 hours, if the mean boundary layer potential temperature is 280°A or less *and* the 1000-500 mb. thickness is 5400 meters or less. These critical values agree very closely with those found in other studies. (See Technical Attachment No. 70-30-11 and references in Technical Attachment No. 70-10-26.) To illustrate the importance of both parameters, it can be noted for all data combined (fig. 1 and 2) that there were 13 cases in which the thickness forecast was equal to or less than 5400 meters, and the boundary layer temperature forecast was warmer than 280°A. In 9 of these cases rain occurred, either alone or mixed with snow or sleet. There were 50 cases in the data sample in which the boundary layer temperature was forecast to be equal to or colder than 280°A and the thickness was forecast to be warmer than 5400 meters. Snow occurred in only 18 (36%) of these cases and freezing rain, always difficult to forecast, occurred in 19 (38%) of the 50 cases. A majority of all freezing rain cases (69% for all forecast periods combined) occurred when the mean boundary layer temperature was forecast to be *colder* than 280°A *and* the 1000-500 mb. thickness was forecast to be *warmer* than 5400 meters.

Digressing slightly for a moment, it is appropriate to indicate that for 1969-70 winter storms, a bias had been found by Miss Colleen Leary, of Massachusetts Institute of Technology, in the PE model 36-hour 1000-500 mb. thickness predictions verifying at 1200Z (*Monthly Weather Review*, Vol. 99, No. 5, pp. 409-413). The forecast thickness values were too warm by an average value of 20 to 70 meters, depending on type of storm. An exception to this positive bias was for frontal waves for which thickness forecasts were too cold by an average of 40 meters. The article referred to above showed further that for 5 winter storms examined, each of which affected New York State in the winter of 1969-70, the 36-hour thickness forecasts, verifying at 1200Z, were found on the average to be too warm by 60 meters.

An analysis of the 1000-500 mb. thickness forecasts used in this study was made in an attempt to determine characteristics of these forecasts that could affect their use as a predictor of precipitation type. Mean predicted thickness values (Table 1) were determined for the forecasts that appear in each of the 8 scatter diagrams shown in fig. 1 and 2. It should be kept in mind that these thickness values are for precipitation situations only. Separate mean values were determined for each of the forecast hours (12, 24, 36, 48) and separately for forecasts verifying at 0000Z and 1200Z.

From the mean thickness values presented in Table 1, it can now be seen that *there is a systematic bias in the PE model forecasts of 1000-500 mb. thickness*, when precipitation occurs, at Syracuse, New York. This systematic bias in the model is a warming of one meter per hour. This is shown by comparing mean values of thickness forecasts that verified at the same time but were generated from different PE model runs. The means are for all forecasts of the same forecast length. These means are subtracted from each other to determine the change in bias as the length of the forecast increases.

TABLE 1. Mean 1000-500 mb. thickness forecasts computed for Syracuse New York, for precipitation situations only, for the period December 1, 1970, through March 31, 1971. Thickness forecasts are mean of PE model predictions that appear in FOUS 1 message for Albany, New York, and Buffalo, New York.

Mean 1000-500 mb. Thickness Forecasts (Meters)				
Forecast Hour	00Z Verification Time		12Z Verification Time	
	Initial Data Time	Thickness	Initial Data Time	Thickness
12	1200Z	5269	0000Z	5288
24	0000Z	5279	1200Z	5295
36	1200Z	5291	0000Z	5308
48	0000Z	5302	1200Z	5328
All Hours	All	5285	All	5305

We begin by noting that there appears to be no characteristic difference (in this data sample) between thickness forecasts generated from 0000Z initial data and those generated from 1200Z initial data. The mean height of all thickness forecasts generated from 0000Z data (5294 meters) is about equal to the mean height of all thickness forecasts generated from 1200Z data (5296 meters). The forecasts for which the means in Table 1 are compared verified for the same events except for a few cases in which a PE model forecast from a specific initial data run was not available.

Now if we compare the mean thickness of 12-hour forecasts generated from 0000Z (1200Z) initial data to the mean thickness of 48-hour forecasts generated 36 hours earlier from 1200Z (0000Z) initial data, we find that the 48-hour forecasts generated from earlier 1200Z (0000Z) initial data is 40 meters (33 meters) warmer. The mean of the two means, 40 meters and 33 meters, is 36 meters. This value of 36 meters in 36 hours or one meter per hour can be considered a warming bias in the model. Using a similar approach, a warming bias of 24 meters in 24 hours and 12 meters in 12 hours can also be shown using the data in Table 1. The 24-hour bias is determined by comparing mean thicknesses of 12 and 24-hour forecasts to mean thicknesses of 36 and 48-hour forecasts, respectively. The forecasts examined in the 24-hour comparison are generated from the same initial time, either 0000Z or 1200Z.

If this systematic error in the PE model is real, we would then expect that the critical 1000-500 mb. thickness *forecast* value for which there is a 50% chance of either liquid or frozen precipitation (assuming precipitation occurs) would increase by about 24 meters in 24 hours or 36 meters in 36 hours. Examining the data in the scatter diagrams (fig. 1 and 2), we do, indeed, find that the longer the forecast period, the higher the forecast thickness values for which snow occurs.

The results obtained here should be duplicated at other locations in order to arrive at a more definitive conclusion. At this time, however, forecasters should be concerned about this apparent one meter per hour warming bias in the PE model 1000-500 mb thickness forecasts, at least during precipitation situations.

By the way, we noted that the mean thickness for all forecasts verifying at 0000Z was 20 meters colder than those forecasts verifying at 1200Z. This may be due to several factors, including a real difference in the observed mean values for 0000Z and 1200Z or perhaps some characteristic of the PE model.

The value for users of scatter diagrams such as those presented in fig. 1 and 2 are obvious. Scientific Services has proceeded further by accepting computer assistance from the National Severe Storms Forecast Center in Kansas City. Using a method outlined by us, they are relating precipitation type to PE model output for all stations in the Eastern Region for which forecasts appear in the FOUS 1 and 2 messages. This was possible since the National Severe Storms Forecast Center had been collecting FOUS 1 and FOUS 2 message information on magnetic tape. Results are expected any day now, for use this winter.

SCIENTIFIC SERVICES DIVISION, ERH
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Attachments
(Figures 1 and 2)

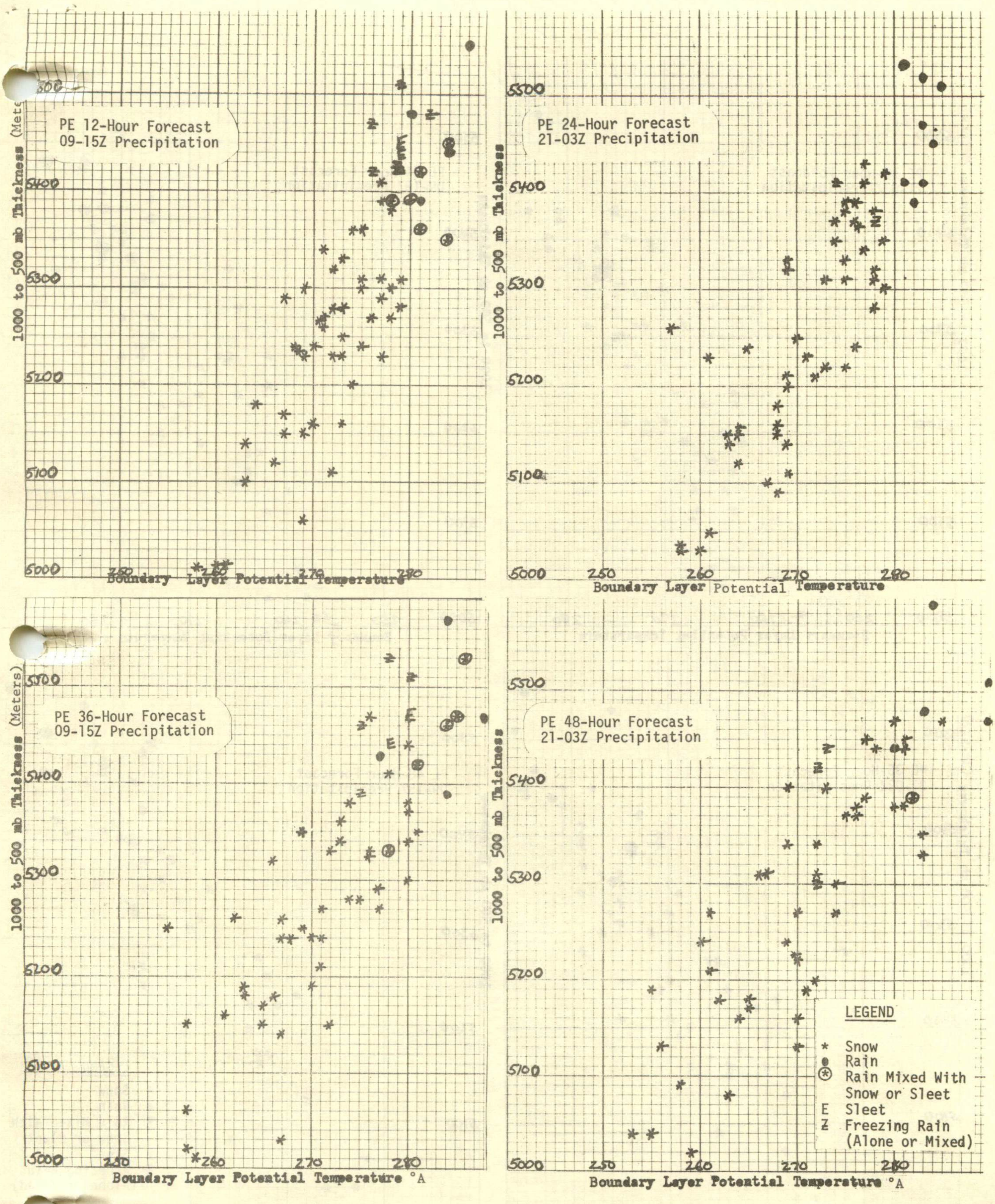

FIGURE 1. Precipitation type as a function of PE model forecasts of both 1000 - 500 mb. thickness and mean boundary layer potential temperature. Data is for Syracuse, N.Y., winter of 1970-71. PE model forecasts, taken from FOUS 1 messages, were generated from 0000Z initial data and are mean of predicted values for Albany, N.Y., and Buffalo, N.Y. Precipitation type was observed within plus or minus three hours of forecast valid time. *(Figure prepared by Mr. Jack Hummel, MIC, WSO, Burlington, Vermont.)*

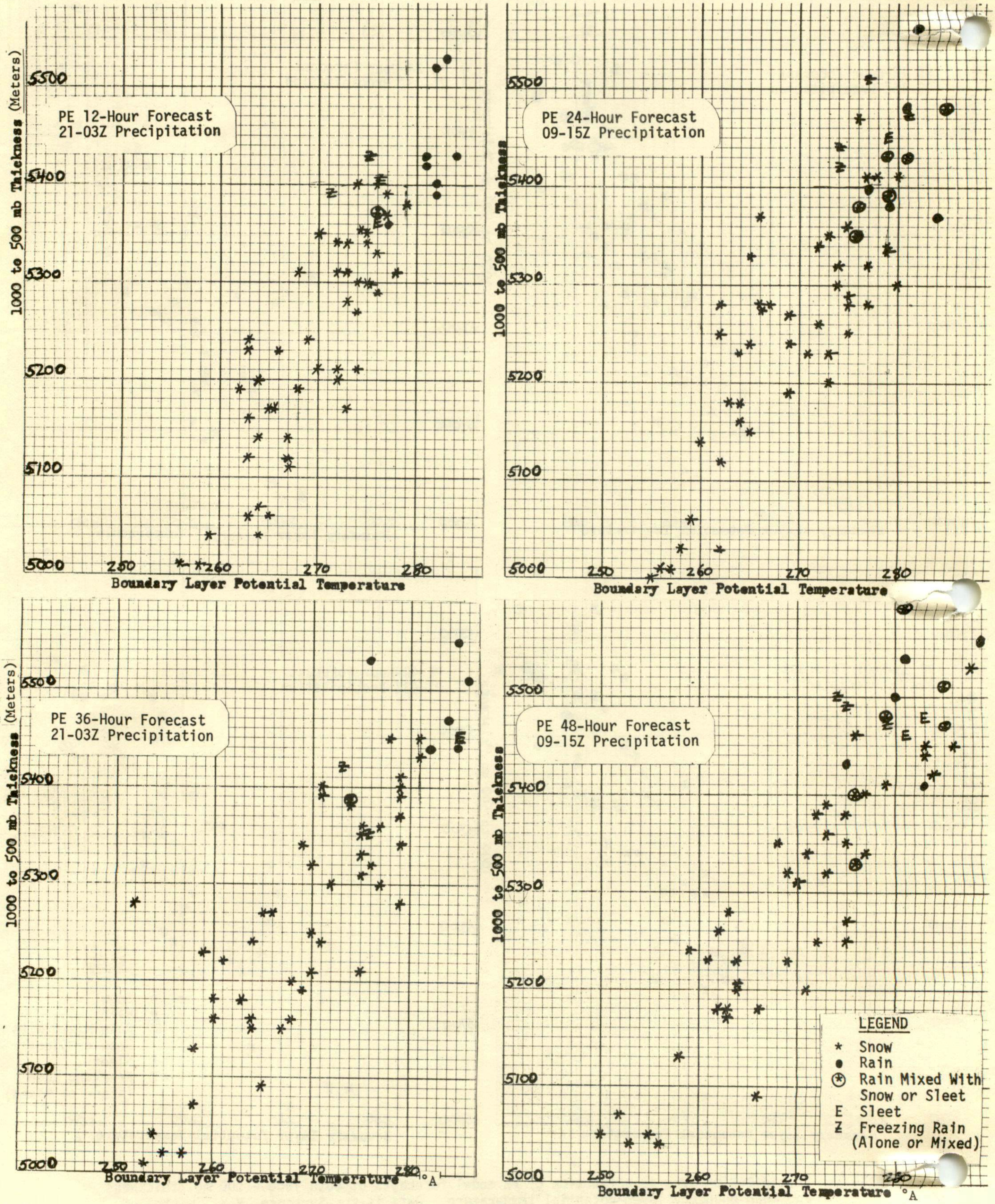

FIGURE 2. Same as Figure 1 except PE model forecasts were generated from 1200Z initial data.
(Figure prepared by Mr. Jack Hummel, MIC, WSO, Burlington, Vermont.)