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THE USEFULNESS OF LFM BOUNDARY LAYER FORECASTS AS PREDICTORS IN OBJECTIVE SURFACE WIND FORECASTING

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1. INTRODUCTION

The Model Output Statistics (MOS) technique (Glahn and Lowry, 1972) has been used to generate multiple linear regression equations which relate local observations of surface wind to the forecast fields of the National Meteorological Center's (NMC) numerical models. These equations are then employed to make objective weather predictions of surface wind direction and speed. Currently, MOS objective surface wind forecasts are generated twice daily and are disseminated to NWS forecasters for use as guidance in preparing aviation and public weather forecasts (National Weather Service, 1980). Unfortunately, degradation in the MOS forecasts is possible when the NMC models are altered, since the model data on which the regression equations were developed contain no history of alterations made after the equation derivation. Therefore, judicious predictor selection by each developer is necessary to try to protect MOS products from deterioration caused by model changes. This protection can be provided, to some degree, by eliminating model surface fields and sigma layer quantities as predictors. Presumably, if NMC changes the model topography or vertical structure, the characteristics of the meteorological fields as interpolated to constant pressure surfaces will change less than in the model layers themselves.

NMC has indicated that possible future changes in the Limited-area Fine Mesh (LFM-II) model (National Weather Service, 1977) may affect the LFM's boundary layer forecasts. This information, combined with the fact that the LFM boundary layer wind forecasts are generally the most important predictors in the MOS surface wind forecasting system, prompted an investigation. Specifically, we wanted to determine the accuracy of wind direction and speed forecasts produced by regression equations that do not contain boundary layer terms.

2. PROCEDURE

To assess the impact of boundary layer predictors in our objective surface wind forecasting scheme, we developed test sets of equations for the warm (April-September) and the cool (October-March) seasons. The control equation set (hereafter referred to as "BL") consisted of equations derived from a predictor list which included, among other fields, boundary layer and 1000-mb geostrophic winds. The second equation set (hereafter referred to as "GEO") was derived from the same predictor list as the control set, but without any boundary layer quantities. Equations were derived for 57 stations (Fig. 1) chosen to rep-

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resent the conterminous United States. Both the BL and GEO equation sets contained equations for the 18-, 24-, 30-, and 36-h forecast projections from 0000 GMT. Several seasons of data were used for the development of each equation. For the warm season equations, data from the warm seasons of 1975 through 1978 were used. The cool season equations were derived on data from the 1975-76, 1976-77, and 1977-78 cool seasons. After deriving the equations, we generated surface wind forecasts on about 165 days of independent data from the 1978-79 cool season, and about 140 days of independent data from the warm season of 1979. The forecasts were then verified both regionally and nationally. The regions in which these stations were grouped for verification purposes are shown in Fig. 1.

3. RESULTS

Three statistics, namely, mean absolute error (MAE) for wind speed and direction and Heidke skill score for speed, were used to compare the two sets of wind forecasts. Fig. 2 shows wind speed MAE's for the BL and GEO forecasts for each season. For both seasons, the national results are nearly identical for the two equation sets. Similarly, the regional plots for the warm season indicate that little difference, if any, exists between the BL and GEO forecasts in terms of wind speed errors. Note that the 30- and 36-h forecast projections from 0000 GMT are valid during the nighttime hours when the winds are generally light, and, hence, easier to forecast. This fact tends to explain why the BL and GEO forecast accuracies are so similar for both seasons and all regions at these forecast projections. During the cool season, however, an improvement of about .10 knots in the BL forecasts over the GEO forecasts is apparent in the Plains region at the 18- and 24-h projections. Also, the BL forecasts are slightly more accurate at each projection in the Northeast region during the cool months. This information seems to indicate that the boundary layer quantities are more important during the fall and winter in these sections of the country, when the winds are primarily influenced by organized synoptic-scale systems. During the spring and summer, when the wind is dominated by local heating and terrain effects, the 1000-mb geostrophic predictors appear to forecast the observed surface wind about as well as the boundary layer predictors in these regions. However, in the Western region, the BL set performs better in the warm season; the GEO set is better in the cool season. The reasons for this maverick behavior are not clear.

Wind direction MAE's are presented in Fig. 3. The national plots indicate that the BL forecasts are about 1° better at all projections for both seasons. The margin of improvement of the BL forecasts over the GEO forecasts is larger during the cool season in the eastern half of the nation. Note, however, that the largest single improvement is only about 2°.

Skill scores[1] for the wind speed forecasts were computed from contingency tables of wind speed. The five categories in the tables were: less than 8, 8-12, 13-17, 18-22, and greater than 22 knots. In Fig. 4, the skill scores for the warm season show little overall difference between the BL and GEO forecasts in both the national and regional verifications. Again, note the somewhat larger differences between the BL and GEO forecasts in the Plains during the cool season at the 18- and 24-h projections. However, the GEO set outperforms the BL set in this region for the 30- and 36-h projections.

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[1] The skill score used throughout this paper is the Heidke skill score (Panofsky and Brier, 1965).

4. CONCLUSIONS

These test results indicate that no substantial difference in accuracy exists between surface wind forecasts generated by equations that use LFM boundary layer predictors and those that do not. In some regions of the country during the cool season, particularly in the Central Plains area, more accurate wind speed forecasts are produced by inclusion of the LFM boundary layer fields. However, the forecast accuracy of surface wind speed is improved in other areas (the West) by eliminating these boundary layer terms. Wind direction forecasts do not appear to be significantly affected by the elimination of boundary layer quantities. In view of these test results and because of the possibility of future changes in the LFM boundary layer, we derived all of the MOS surface wind equations without using LFM boundary layer or surface predictors. Cool season surface wind forecasts generated from equations which do not use boundary layer terms have been available since October 21, 1980. Similar equations for the warm season became operational on May 27, 1981.

REFERENCES

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National Weather Service, 1977: High resolution LFM (LFM-II). NWS Technical Procedures Bulletin No. 206, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, 6 pp.

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Panofsky, H. A., and G. W. Brier, 1965: Some Applications of Statistics to Meteorology. Pennsylvania State University, University Park, Pa., 224 pp.

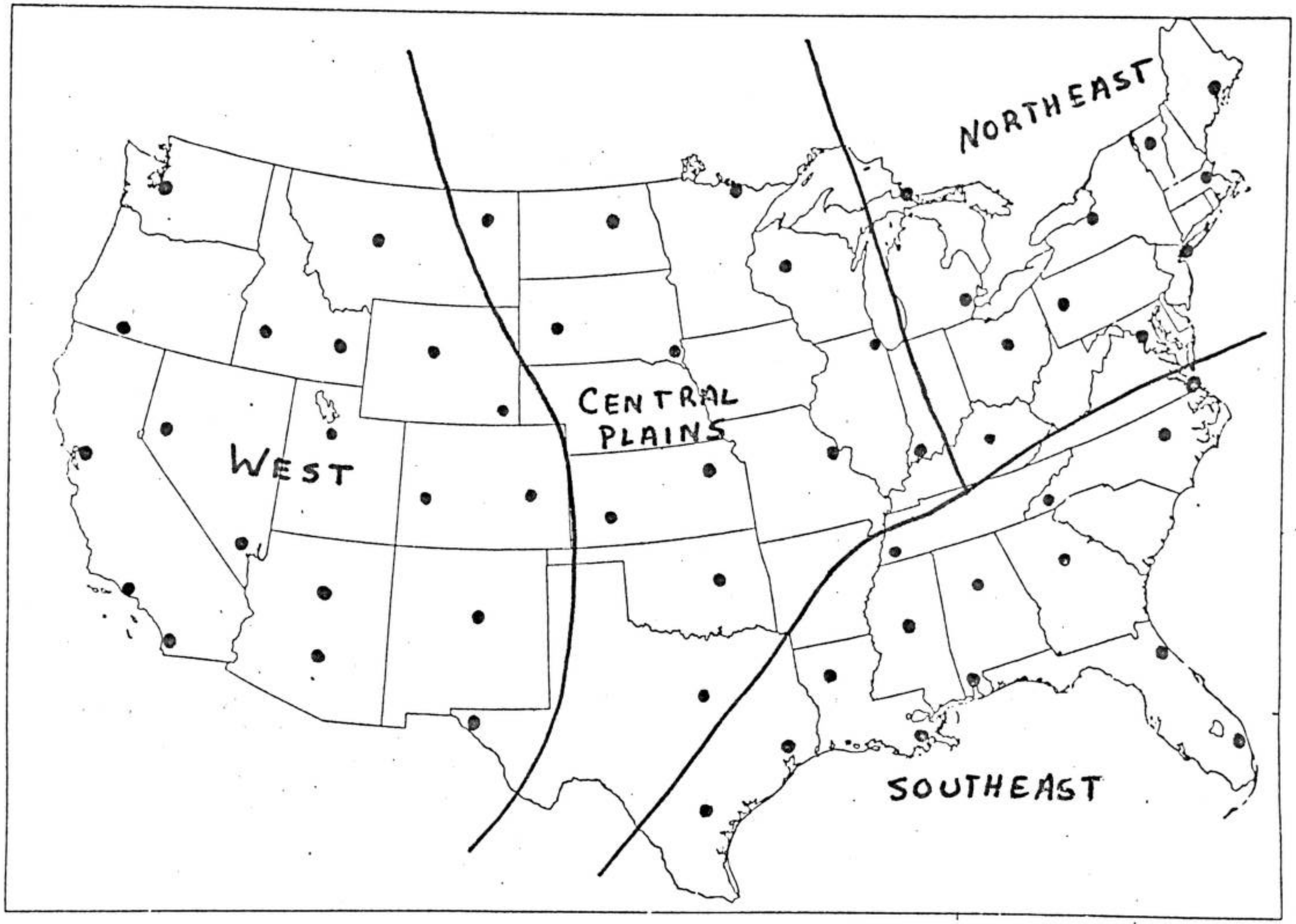

Figure 1. Stations and regions used for the wind verification study.

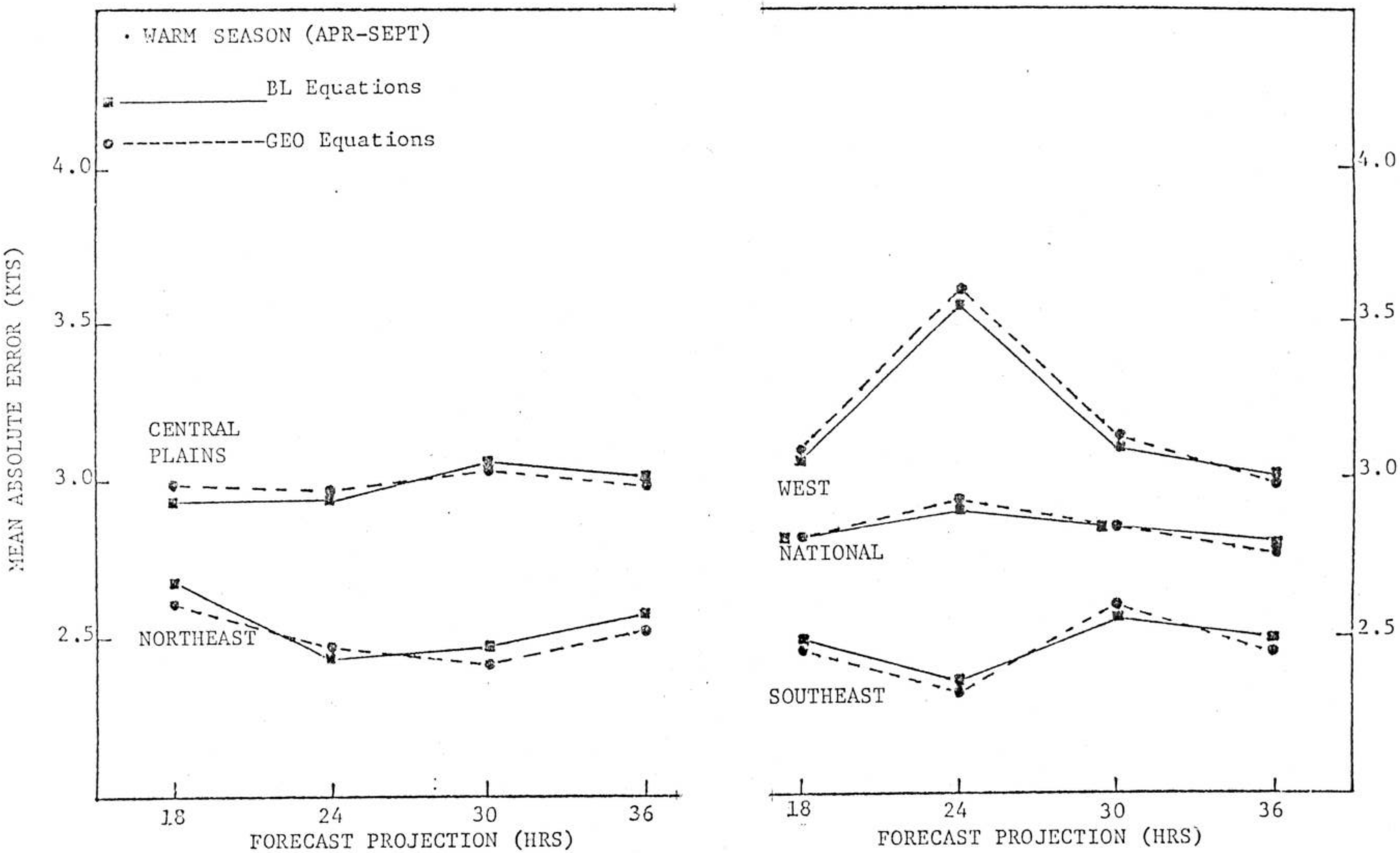

Figure 2a. Mean absolute error (knots) by region of the wind speed forecasts made by test equations for the 1979 warm season.

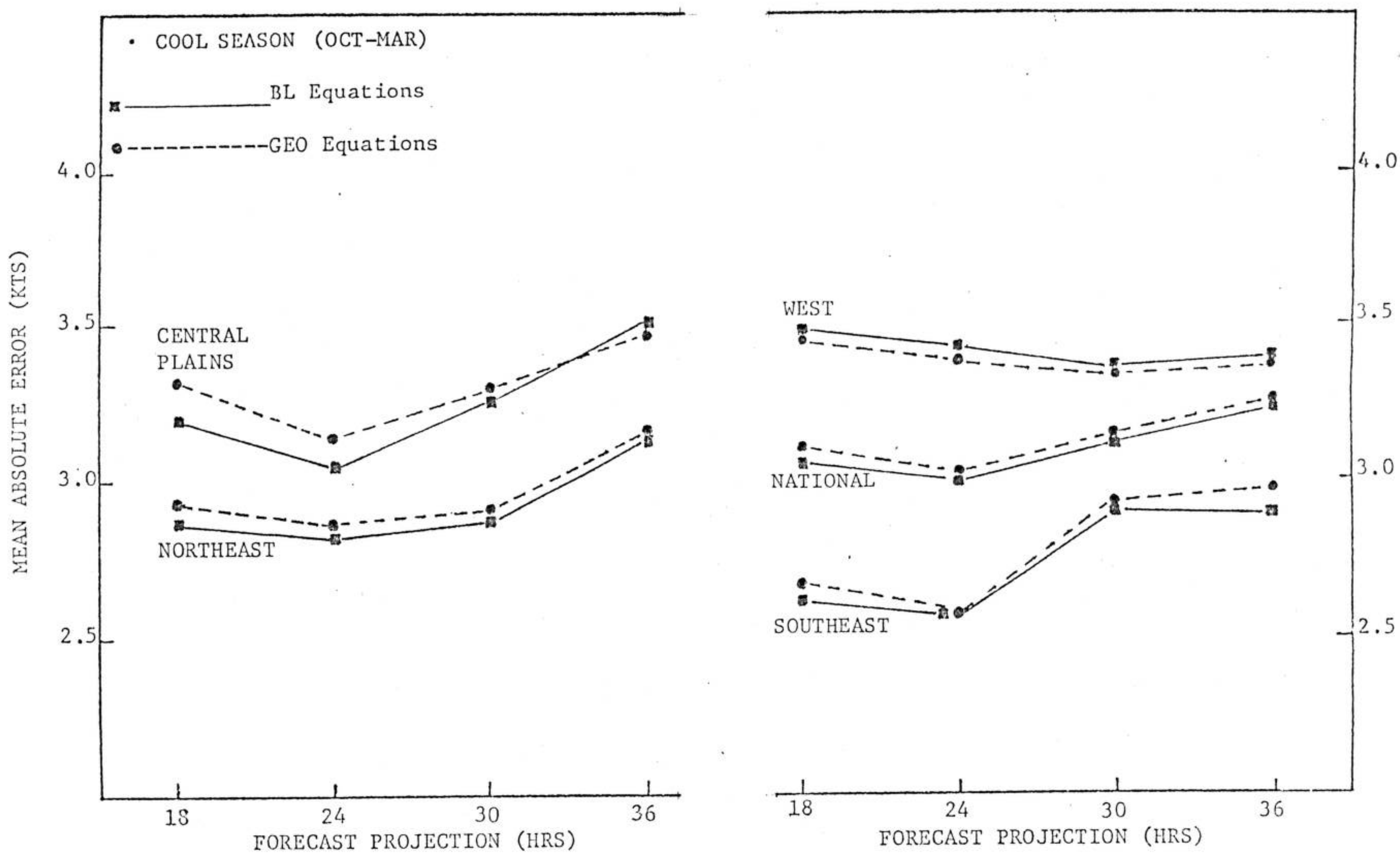

Figure 2b. Same as Fig. 2a except for the 1978-79 cool season.

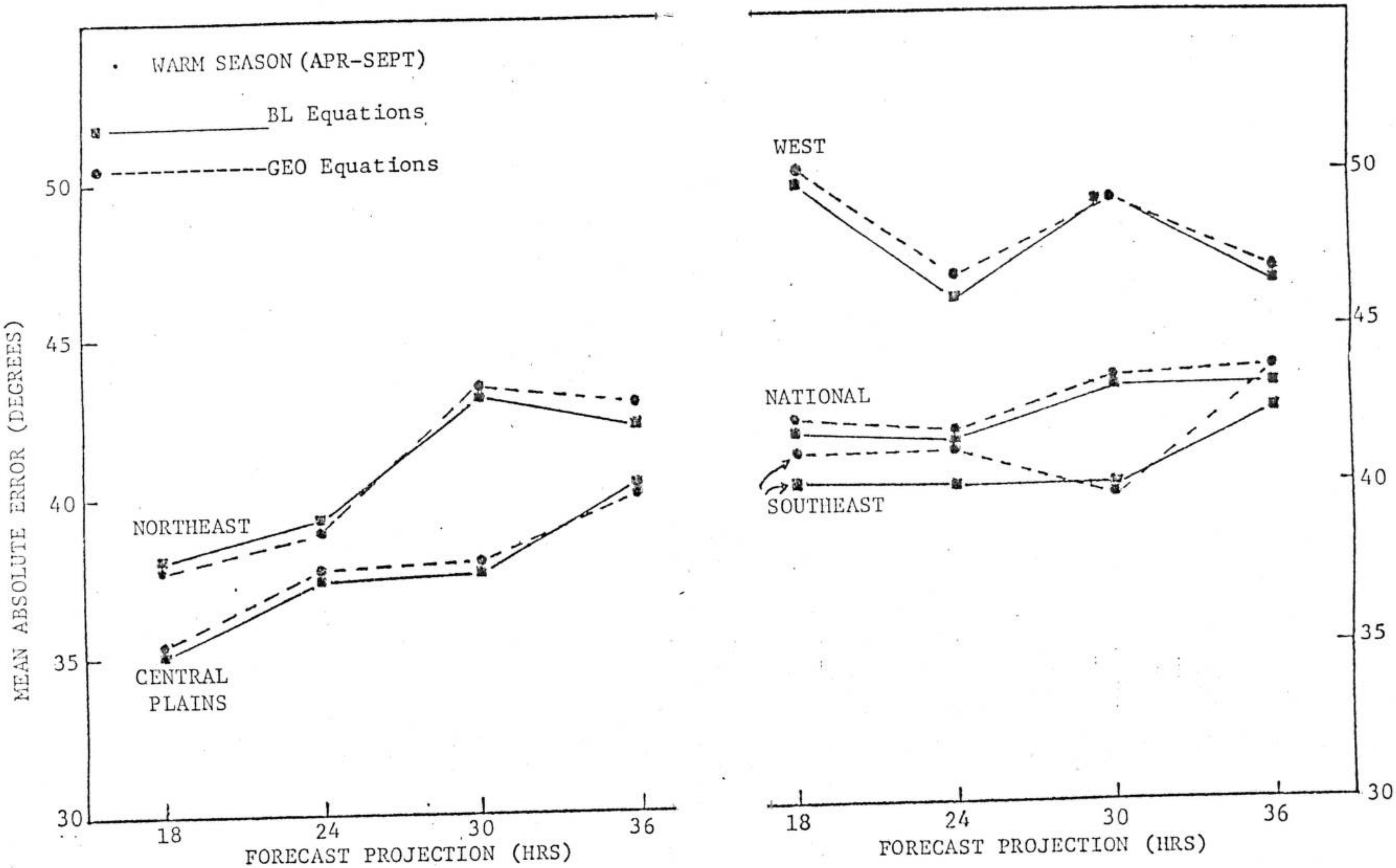

Figure 3a. Mean absolute error (degrees) by region of the wind direction forecasts made by test equations for the 1979 warm season.

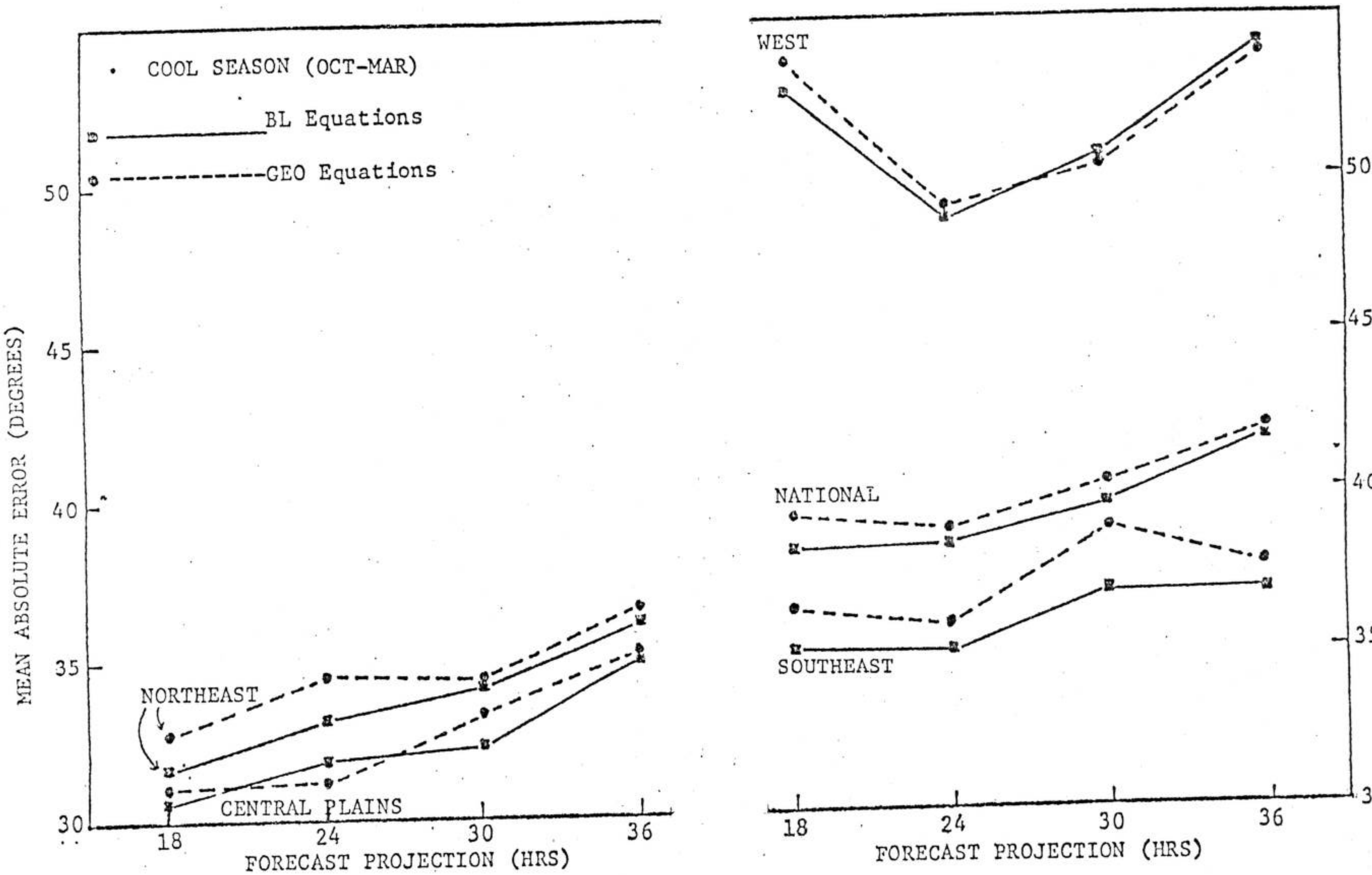

Figure 3b. Same as Fig. 3a except for the 1978-79 cool season.

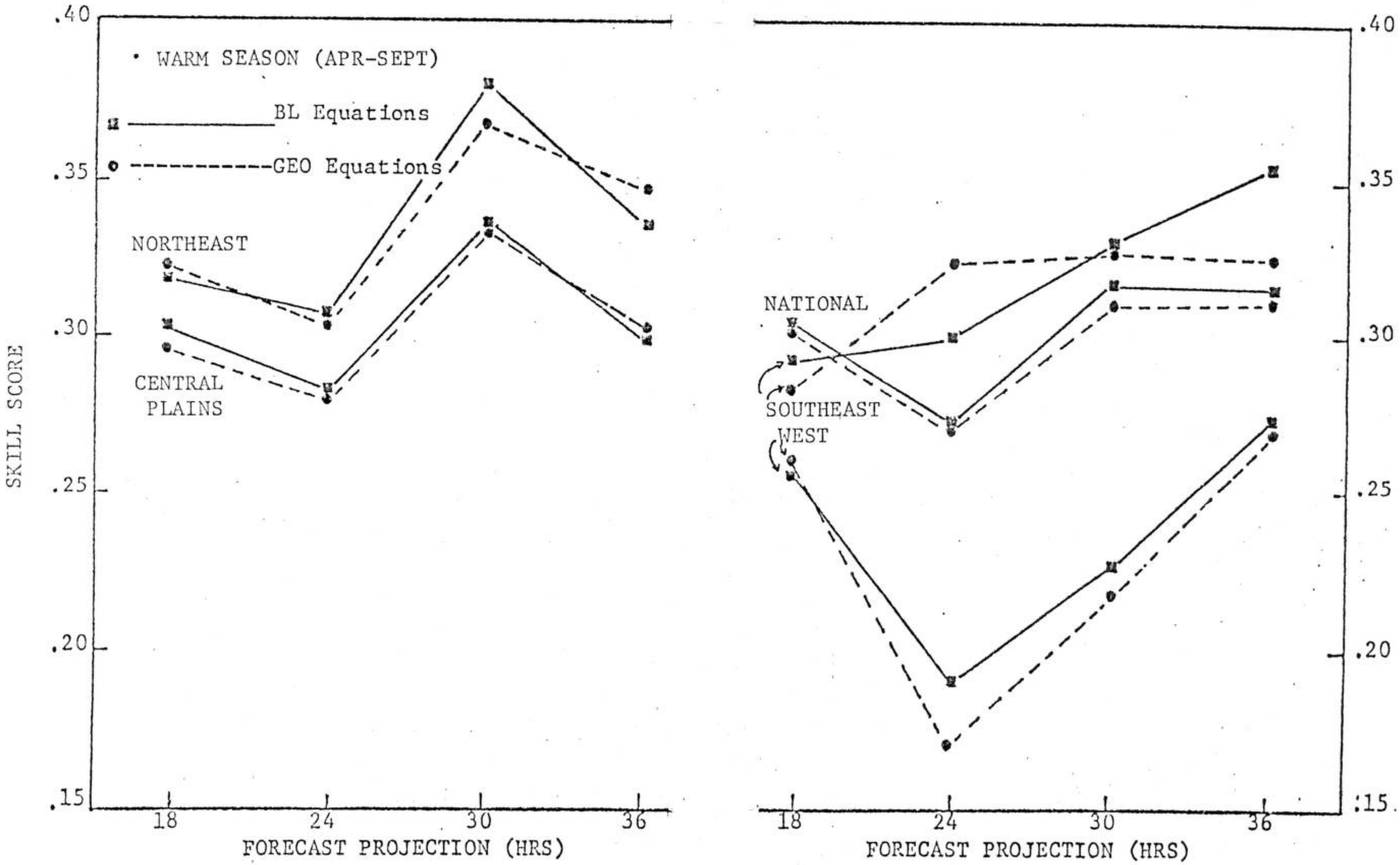

Figure 4a. Skill scores by region of wind speed forecasts made by test equations for the 1979 warm season.

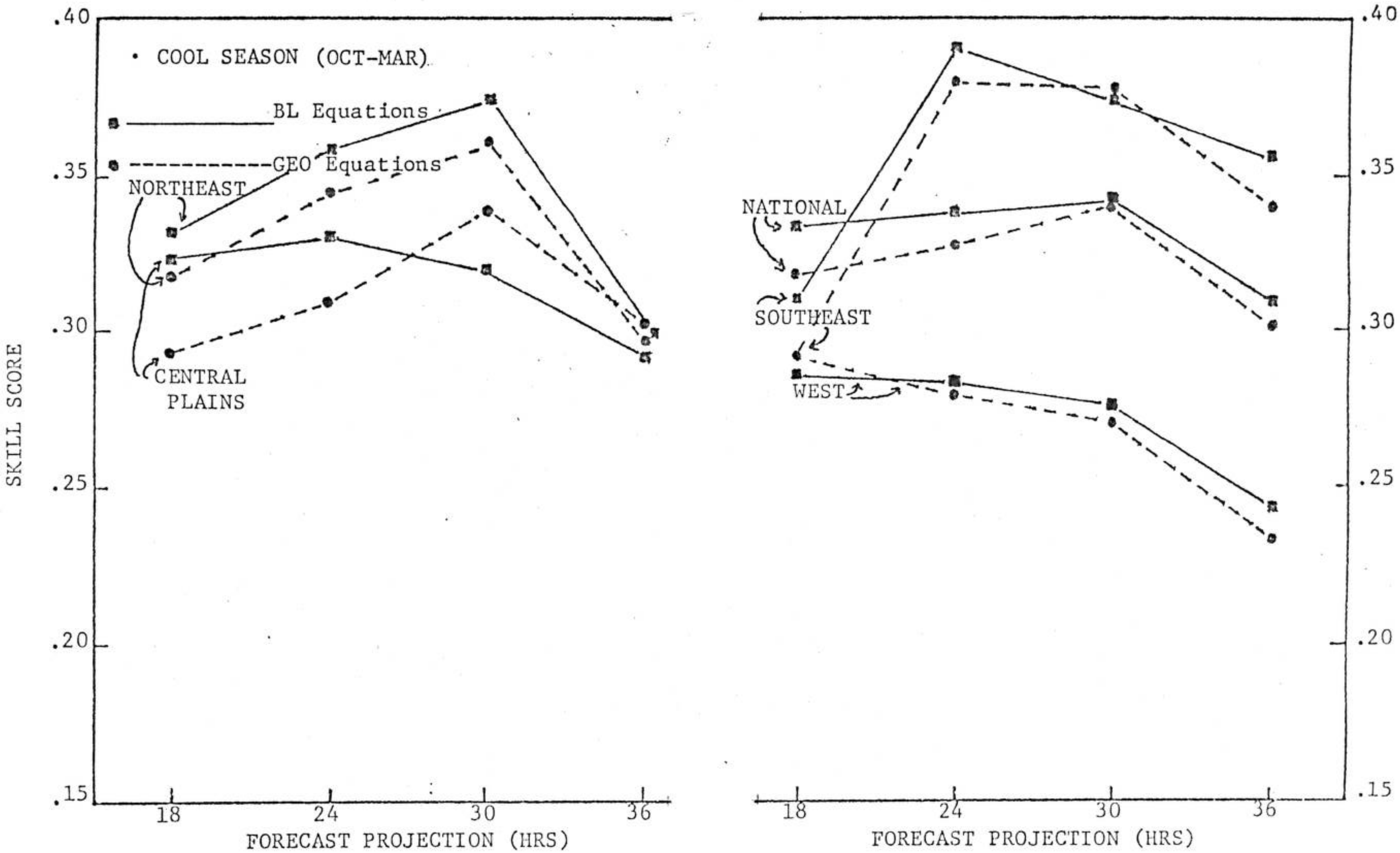

Figure 4b. Same as Fig. 4a except for the 1978-79 cool season.