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NGM PERFECT PROG GUIDANCE AND THUNDERSTORM PROBABILITIES

The following two summaries are excerpts from the latest (October-December 1986) "Techniques Development Laboratory Quarterly Progress Report".

The first excerpt describes TDL's efforts to develop and test perfect prog-based statistical guidance for the NGM. The committee on Analysis and Forecast Techniques Implementation (CAFTI) recently recommended implementation of NGM-based perfect prog guidance for max/min temperature, PoP cloud amount, and surface wind. The SSD Chiefs concurred with that decision provided LFM-based MOS guidance would continue to be provided. The new guidance will probably be transmitted on AFOS beginning in April 1987.

The second excerpt describes some verification of thunderstorm probabilities that TDL provides for the western U.S. based on the BLM lightning data (ALDS). It also explains what changes will be made for the upcoming 1987 warm season. These changes have been recommended for implementation by CAFTI. As was the case last year, forecasters will have to run an AFOS application program to unpack and contour these probabilities for display on AFOS.

New Objective Techniques (Jensenius)

a. Perfect Prog Applications (Jensenius, Dallavalle, Erickson, Gardner) - In the October Quarterly Progress Report, we explained the modified perfect prog technique which we plan to use to produce interim statistical guidance from the Nested Grid Model (NGM). Essentially, the perfect prog equations correlate an observed surface weather element to predictors that are analyzed by the 0000 or 1200 GMT Limited-area Fine Mesh (LFM) model. In turn, these equations are applied operationally by substituting appropriate NGM forecasts for the LFM-analyzed variables. For all of our work, the developmental sample was obtained from 7 years (October 1977-September 1984) of LFM data. About 2 years (October 1984-August 1986) of NGM data were available as an independent test. Recently, we've tested the impact of various predictors on the forecast equations. Unfortunately, one significant limitation of the perfect prog approach is that meteorological variables which are closely related to the predictand in the real atmosphere often cannot be used in the perfect prog regression equations due to biases in the dynamical model. Because we've assumed that the analyzed LFM variables represent the real atmosphere, large differences in the means of the NGM forecasts from these values can cause significant problems in the perfect prog forecasts.

Probability of precipitation (PoP) equations were developed to produce forecasts for the 12-24, 24-36, and 36-48 h periods from both 0000 and 1200 GMT. Perfect prog equations were derived both with and without surface observations as potential predictors. We also experimented with using model precipitation as a possible predictor. Tests were conducted for both the cool (October-March) and warm (April-September) seasons. While our results indicated that the use of surface observations did not significantly improve the predictions, the use of model precipitation as a predictor did produce more accurate forecasts. In comparing the NGM-based perfect prog forecasts with the operational, LFM-based MOS guidance, we found that during the cool season the MOS guidance was slightly better in terms of the Brier score at the 12-24 h projection while the perfect prog forecasts were slightly better for the 36-48 h period. In terms of forecast reliability, the NGM-based forecasts were slightly less reliable than the LFM guidance. During the warm season, the LFM-based MOS guidance was more accurate than the NGM-based perfect prog forecasts. In particular, for both cycles and all projections combined, the MOS forecasts averaged an improvement over climate in the Brier score of 29.7% as compared with 26.0% for the perfect prog. Again, the reliability of the NGM-based perfect prog PoP forecasts was slightly worse than that of the LFM-based MOS guidance.

We have also been developing a set of perfect prog max/min forecast equations. By using variables valid approximately 12 hours before the normal time of occurrence of the max or min, we were able to develop equations that could be applied to the NGM. However, biases in the low-level thermal quantities, such as the 1000-850 mb thickness, have virtually eliminated these variables from consideration. Instead, we've used thicknesses over deeper layers of the atmosphere or temperatures from the mid-troposphere as predictors.

In our latest experiments, we derived max/min equations for the summer (June-August) season. These relationships were then applied to the NGM for the period of July 24, 1986-August 31, 1986. During this time, the new NGM physics package that simulates a diurnal cycle was being used operationally. Perfect prog forecasts were generated for both the 0000 and 1200 GMT cycles and for four forecast projections. These forecasts were then compared with the operational, LFM-based MOS guidance for 93 stations. We found that the MOS max (min) forecasts averaged 2.3°F (1.2°F) mean absolute error more accurate than perfect prog when the 1000-850 mb thickness was used as a predictor. When this variable was removed from the regressions, the MOS guidance averaged 1.2°F (1.0°F) mean absolute error more accurate than perfect prog for the max (min) temperatures. Finally, by forcing the 1000-500 mb or the 850-500 mb thickness into all equations and by eliminating 850-mb variables from equations for stations in the Rocky Mountain region, we obtained perfect prog forecasts which were only 0.7°F (0.5°F) mean absolute error less accurate than the operational MOS max (min) temperature forecasts. At this point, we think the perfect prog approach for max/min temperature will produce useful statistical guidance from the NGM. In the future, in order to take advantage of the increased resolution and physics of the NGM, MOS equations will be developed as a replacement for the perfect prog system.

Perfect prog cloud amount equations have also been derived from analyzed fields. In our initial testing of the NGM perfect prog forecasts, the skill scores for the 1984-85 and 1985-86 cool seasons were slightly less accurate than those for the operational, LFM-based MOS forecasts. The 1985 warm season perfect prog forecasts, however, were significantly worse than the MOS guidance. To investigate this problem, we examined several of the predictors that were frequently chosen for the warm season cloud forecast equations. We found that the mean value of the K-Index in the NGM was quite different from the analyzed LFM value. By omitting the K-Index as a predictor from the warm

For the 18-24 h projection (1100-1700 MST) following 0000 GMT, the most active period of the day for thunderstorm activity, we obtained verification scores that were better than scores previously obtained for the West or any other section of the country. For example, for a thunderstorm probability threshold of 20%, the verification statistics for the 18-24 h projection revealed a POD of 0.85, a FAR of 0.50, a CSI of 0.46, and an overall bias of 1.7. That is, on average, about 85% of the thunderstorms fell within the 20% probability isoline while about half the grid blocks within the forecast area had no thunderstorms. The FAR of 0.50 is reasonably low considering the relatively small size of the grid blocks (47.6 km on a side) for which the forecasts are made. The overall observed frequency of thunderstorms, i.e., 2 or more lightning flashes in a grid block, was 23.1% for the 18-24 h projection while the average forecast probability was 19.6%.

In addition to the objective verification, we are also employing the NOAA FR80 graphics package to generate contoured probability forecasts for each day of the 1986 summer season, including plots of the actual lightning strike locations. The forecasts plus observations will be used to subjectively assess the day-to-day performance of the forecasts, including any strengths or weaknesses.

At present, we are also deriving new operational probability equations for the West based on lightning data for the 1983-86 summer seasons and LFM and trajectory model output. The lightning data set for the West now contains over 6 million reports of cloud-to-ground flashes for the four summer seasons. Based upon requests received from the Western Region, two significant changes are being incorporated into the new development effort. They include replacement of the 0-6 h forecast projection by the 24-30 h projection and the development of probability equations for the 1200 GMT forecast cycle. Replacement of the 0-6 h projection by the 24-30 h projection will extend forecast coverage into the important 1700-2300 MST early evening period. In any case, the 0-6 h forecasts were of limited use due to late receipt in the field. Addition of the forecasts for the 1200 GMT cycle will obviously provide more timely coverage throughout the day.

season equations, we discovered that the skill scores of the perfect prog forecasts were much closer to those of the operational LFM forecasts. When tested on April-July 1986 data, the NGM-based perfect prog forecasts were slightly worse than the LFM guidance for most projections; however, for a few projections, the accuracy of the perfect prog cloud amount forecasts was the same as or slightly better than that for the corresponding LFM-based MOS guidance.

Because test results have shown that the perfect prog approach can provide useful guidance from the NGM, we're currently deriving operational equations to predict max/min temperature, PoP, cloud amount, and surface wind. Cool season (October-March) and warm season (April-September) equations will be developed for approximately 200 stations by using a 9-yr sample of LFM data. We will present test results at the January meeting of CAFTI and propose that a perfect prog guidance package based on the NGM be implemented during the spring of 1987. This interim system will produce statistical guidance from the NGM, but it is not intended to replace the existing LFM-MOS package. A complete NGM-based system will be developed in a couple of years after a sufficient data sample has been collected from a relatively stable future version of the NGM.

MESOSCALE WEATHER PREDICTION (MCGOVERN)

Severe Local Storms Forecasting (Reap)

a. Medium-Range (Reap, McDonald) - Recently we have received a new sample of cloud-to-ground lightning strike data from the Bureau of Land Management (BLM) automated lightning detection network located in the western United States. The data set contains more than 2 million reports of lightning flashes for the period from March 1, 1986 to September 30, 1986. The reports have been included in TDL's archive of lightning data for the West, which now covers the 1983-86 summer seasons.

The BLM lightning data for 1986 were used to provide an independent sample for verifying the 0-6, 6-12, 12-18, and 18-24 h probability equations for thunderstorms that were operationally implemented on May 21, 1986, as described in the July Quarterly Progress Report. To verify the operational forecast equations, we first generated probability forecasts for the 1986 summer season by applying the forecast equations, which are based on 1983-85 data, to archived numerical model output for 1986. Next, we produced categorical (yes/no) thunderstorm forecasts for a wide range of threshold values applied to the probability forecasts. Finally, the accuracy of the categorical forecasts for each threshold value was computed as a function of several standard verification scores including the critical success index (CSI), probability of detection (POD), false alarm ratio (FAR), and overall bias.